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## Article

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International Journal of Energy Economics and Policy

## Provided in Cooperation with:

International Journal of Energy Economics and Policy (IJEPP)

*Reference:* Anggono, Bayu Dwi/Wahanisa, Rofi et. al. (2023). Determinants of sustainable land use change in agricultural utilization and environmental performance. In: International Journal of Energy Economics and Policy 13 (3), S. 545 - 551.

<https://www.econjournals.com/index.php/ijeep/article/download/14443/7337/33336>.

doi:10.32479/ijeep.14443.

This Version is available at:

<http://hdl.handle.net/11159/631258>

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# Determinants of Sustainable Land Use Change in Agricultural Utilization and Environmental Performance

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**Received:** 14 February 2023

**Accepted:** 07 May 2023

**DOI:** <https://doi.org/10.32479/ijeeep.14443>

## ABSTRACT

This paper aims to analyze the determining factors in the use of sustainable agro-industry by implementing renewable energy and environmental management performance. The paper also aims to investigate environmental policies carried out by the local government to minimize land-use conversion of agricultural utilization to non-agricultural functions. This study uses a data driven empirical approach in examining agro-industrial utilization in land-use conversion in Boyolali, Indonesia. The nature of the study was by employing sociology of law to analyze policy aspects in social interactions in environmental performance and sustainability ideas in land-use conversion cases. The results of the study show that the orientation of economic growth by implementing a renewable system and preserving agricultural land is the basis for regional policies to protect agricultural land. The findings also highlight spatial planning as the most important aspect in technical implementation of sustainability practices in the cases of land-use conversion to non-agricultural functions. The findings would imply the need for optimization and control of agricultural land protection through environmentally-friendly local policies to control land-use conversion and maintain sustainable functions of land. The findings also imply to the importance of environmentally-friendly policies ranging from preparation of regulations, determination of regional spatial plans, environmental permits, and incentives in managing sustainability of environmental performance in land-use policy in local context.

**Keywords:** Land-use Conversion, Sustainable Environmental Performance, Agricultural Utilization, Spatial Planning, Environmental Management  
**JEL Classifications:** Q15; Q16; Q24

## 1. INTRODUCTION

The agricultural sector has a significant importance in many developing countries's economy and community livelihood, as it contributes significantly to the country's GDP, creates employment opportunities, and ensures a steady supply of domestic food (Bisht et al., 2020; Dixon et al., 2001). For Indonesia, despite the country's shift towards industrialization, people remain committed to maintaining their agricultural activities due to their awareness of this vital role. In implementing renewable energy to ensure the long-term preservation of the various benefits of agricultural land, an important national strategy is to exercise control over their ownership and use, as it plays a crucial role in sustaining the primary agricultural sector's capacity for food production and

minimizing socio-economic setbacks (Bappenas, 2015). When it comes to agricultural business, the primary focus should be on utilizing land in a manner that fosters agricultural development for the benefit of people, particularly through avenues that support the success of small, medium, and cooperative businesses. The agricultural industry is being confronted with a difficulty, which is the reduction in available farming land due to alterations in land use, also referred to as land-use conversion (Surya et al., 2021).

The conversion also occurs within the local context. For instance, in Boyolali, Indonesia, agricultural land is transformed into various purposes, such as housing, factories, shopping centers, and other facilities that are no longer used for agriculture. Along with increasing population growth, the demand for land is also

getting higher, especially the demand for housing. The demand for housing in the form of housing will eventually increase. Housing development will certainly require the availability of a large area of land. With the current condition of land being narrowed, developers will look to agricultural lands because the condition of agricultural land is relatively wide and flat, and looking at the location which is considered very strategic, this will make the developers so interested in using agricultural land. Land-use conversion has significant impacts on agricultural land, including soil degradation, loss of biodiversity, water pollution, and reduced crop yields (Reydon et al., 2020). Soil degradation is a major consequence of land-use conversion, as it leads to a decline in soil quality, nutrient availability, and soil fertility (Leul et al., 2023). This results in reduced crop yields, which can be disastrous for small-scale farmers who rely on agriculture for their livelihood (Lidzhegu and Kabanda, 2022).

Land use conversion activities have a significant impact on the carbon cycle and energy balance and will increase greenhouse gas emissions which in turn affect climate change. Climate change and environmental degradation need to be a concern because of the negative impacts it has. Therefore the application of renewable energy is needed to overcome this (Roy et al., 2022). Previous studies show that land-use conversion contributes to greenhouse gas emissions, especially carbon dioxide (CO<sub>2</sub>), which is the primary driver of climate change (Samie et al., 2020; Azadi et al., 2021). According to the Intergovernmental Panel on Climate Change (IPCC), deforestation and forest degradation as the results of land-use conversion account for about 10% of global greenhouse gas emissions (Miles and Kapos, 2008). Moreover, the loss of forests also reduces the capacity to sequester carbon through photosynthesis, thus increasing the concentration of CO<sub>2</sub> in the atmosphere (McLeod et al., 2011). The loss of agricultural land means that there is less land available for food production, leading to food insecurity (Chowdhury and Hossain, 2021). Thus, in order to examine land-use conversion in local context in relation with environmentally-friendly policies and the protection of agricultural functions, this paper aims to analyze determining factors in sustainable agro-industrial utilization and environmental management performance by taking Boyolali, Indonesia as the research object. There are various types of changes taking place in Boyolali, Indonesia, with agricultural land being converted into non-agricultural purposes such as residential, commercial, and industrial. The demand for land is increasing due to population growth, especially for housing. Specifically, The aim of this research was to examine the factors that influence the transformation of agricultural land to non-agricultural uses in Boyolali, and to evaluate the policy implemented by the local government to mitigate such land-use conversion.

## 2. LITERATURE REVIEW

Land-use conversion in agricultural land is a widespread phenomenon that involves various changes in land-use, whereby agricultural land is converted to other uses (Msofe et al., 2019). This phenomenon has many implications for environmental sustainability. Land-use conversion involves the permanent or temporary change in land-use from one type of land-use to another

(Souza et al., 2015). The conversion of agricultural land to other uses is driven by various factors, such as demographic changes, urbanization, industrialization, and changing economic conditions. The major drivers of land-use conversion are population growth, urbanization, and economic development (Egidi et al., 2021). The conversion of agricultural land to other uses has multiple environmental implications, such as deforestation, loss of biodiversity, soil degradation, water pollution, and climate change.

Land-use conversion also has environmental impacts which depend on the type of land-use that replaces agriculture. Tilahun et al. (2022) stated that the conversion of agricultural land to urban or residential land-use is associated with increased urban sprawl, habitat fragmentation, loss of wildlife habitats, and increased erosion and sedimentation. Furthermore, Xian et al. (2022) stated that urbanization results in increased stormwater runoff, water pollution, air pollution, and greenhouse gas emissions. On the other hand, the conversion of agricultural land to industrial or commercial land-use results in pollution, contamination, and degradation of soil and water resources (Akhtar et al., 2021).

Furthermore, because sustainable land use practices by implementing renewable energy are closely related to policy interventions, policymakers can implement a range of policy interventions, such as land-use planning, zoning, and regulation, conservation easements, transferable development rights, and payments for ecosystem services to promote sustainable land-use practices (Priyadarshini and Abhilash, 2020). Land-use planning and zoning can regulate the type, location, and intensity of land-use activities, whereas conservation easements and transferable development rights can provide incentives for farmers to keep their land in agriculture. Payments for ecosystem services can encourage farmers to adopt sustainable land-use practices that promote biodiversity conservation, soil and water quality improvement, and carbon sequestration.

Agricultural land use conversion has become a major issue in many parts of the world, particularly in developing countries (Aznar-Sanchez et al., 2019). The conversion of agricultural land to other uses, such as residential or commercial, has significant environmental and economic consequences. As a result, many studies have been carried out in examining control strategies for agricultural land use conversion, focusing on community participation. Paudyal et al. (2017) examined the effectiveness of community-based planning in controlling agricultural land use conversion. Quintas-Soriano et al. (2016), Hersperger et al. (2018) found that community participation in the planning process was key to successful control of agricultural land use conversion. Specific strategies included stakeholder participation, the inclusion of local knowledge, and the availability of technical expertise.

Figueroa and Sánchez-Cordero (2008) also examined community participation in agricultural land use conversion control. Ola et al. (2019) examined the role of payment for ecosystem services (PES) in controlling agricultural land use conversion. Kumar et al. (2014) found that incorporating PES into land use planning was an effective strategy for controlling agricultural land use conversion, as it provided financial incentives for farmers to maintain agricultural land. Specific strategies included the development of

PES schemes and the creation of market-based mechanisms for ecosystem services. Ardiyanto et al. (2022) suggest that community participation is a key strategy for controlling agricultural land use conversion. By incorporating local knowledge and values into the planning process, community-based approaches can lead to more effective and sustainable land use planning. In addition, combining community-based approaches with government regulation and enforcement, as well as market-based mechanisms such as PES, can further enhance the effectiveness of control strategies.

### 3. METHODS

This study analyzes how agro-industrial utilization affects land-use conversion in Boyolali, Indonesia using an empirical approach that relies on data. There are several data used in this research study, including land use data in Boyolali in 2021, agricultural land data in Boyolali from 2016 to 2021, and land use conversion data in Boyolali from 2015 to 2020. It also uses sociology of law to investigate how policy aspects impact social interactions in environmental performance and sustainability ideas in land-use conversion cases. Overall, this research aims to contribute towards a better understanding of the implications of land-use conversion for both the environment and society in Boyolali. This study uses a sociological juridical approach. Sociological juridical approach is a perspective that combines both sociological and legal frameworks in analyzing various social issues, including environmental sustainability. This approach recognizes that laws and regulations are not simply technical solutions to environmental problems but are also shaped by social, economic, and political factors. In this sense, it emphasizes the importance of understanding the social context in which environmental problems arise and the role that legal frameworks play in addressing land-use conversion and the protection of agricultural land in local context. The analysis for this study was by using descriptive analysis.

### 4. RESULTS

The results showed relevant policies and regulations which have been promulgated with the aim of preventing the increasingly massive rate of shifting from agricultural land to non-agricultural lands in Boyolali. However, the results also showed ineffective implementation due to inadequate data and proactive attitudes. Three basic obstacles are the reasons why land-use conversion control regulations are difficult to implement, namely: contradictory policies, limited scope of the policy and the consistency of spatial planning (Sahide and Giessen, 2015).

Table 1 indicates that the agricultural sector continues to hold the largest amount of land allocation in Boyolali, comprising 53.194 hectares, followed by a significant allocation of 26.632 hectares for settlements and housing. As agriculture is the primary source of economic growth in Boyolali, the high demand for housing to cater to the rapidly growing population has resulted in increased development in various regions, including housing. Consequently, there has been a surge in the demand for converted agricultural land for this purpose. Table 2 presents the area of agricultural land in Boyolali between 2016 and 2021.

According to Table 2, the agricultural land in Boyolali has been shrinking over the years. The agricultural land covered an area of 22.778 ha in 2016 but declined to 22.773 ha in 2017. In 2018, it further decreased to an area of 22.693 ha compared to the previous year, in 2019 it decreased to 22.390 ha. In 2020 it will decrease again to an area of 21,802 ha and in 2021 it will decrease to 21,340 ha. The practice of land-use conversion is not new to the community and has been happening for a significant period now. Land-use conversion refers to the process of changing the original use of the land to a different function, mostly acquired from extensive agricultural land. As the demand for land continues to grow, the limited land area becomes an issue.

The conversion of land use is primarily caused by population expansion, economic progress, and infrastructure expansion in the area, and these factors are perceived as significant influences in maintaining the ongoing transfer of functions. The areas experiencing quick economic growth are also prime instigators of land use alterations, with housing and industry contributing to the majority of these changes. The region of Boyolali is no exception, since agricultural land is being converted due to economic advancements. While it is natural for land use conversion to happen, the non-agricultural conversion of farmland is being instigated by intensive development alongside economic and industrial progress.

In order for both the government and non-government sectors to implement development, it is crucial to have access to a large amount of land. One type of development that addresses fundamental human needs is housing and settlement. Land-use conversion has been increasing due to various factors, including government policies. Although the government has created policies and regulations to protect agricultural land, they have not been effective in practice (Andriansyah and Satispi, 2020). Despite efforts to inform communities about the prohibition of land-use conversion set out in Law no. 41 of 2009, many individuals are not aware of it, including regulations such as Regional Regulation No. 17 of 2016 concerning the Protection of Sustainable Food Agricultural Land. Table 3 illustrates the changes in land use in Boyolali district between 2015 and 2020.

**Table 1: Land use in Boyolali in 2021**

No	Allotment	Area	Units
1.	Settlement	26.632	Hectare
2.	Industry	2.045	Hectare
3.	Agriculture	53.194	Hectare
4.	Plantation	11.252	Hectare

Source: Boyolali spatial planning, 2022

**Table 2: Agricultural land in Boyolali (2016-2021)**

Year	Area	Units
2016	22.778	Hectare
2017	22.773	Hectare
2018	22.693	Hectare
2019	22.390	Hectare
2020	21.802	Hectare
2021	21.340	Hectare

Source: BPS (2022)



**Table 3: Land-use conversion in Boyolali (2015-2020)**

No	Year	Agriculture			Other functions				
		Rice field	Moor	Total	Housing	Industry	Infrastructure	Commercial	Other
1.	2015	143.400	210.881	354.281	291.179	30.921	32.181	-	-
2.	2016	88.500	259.500	259.500	98.070	131.500	20.000	10.000	-
3.	2017	185.116	904.741	904.741	566.165	248.794	28.250	39.553	31.437
4.	2018	326.642	943.537	943.537	678.586	33.201	224.717	7.033	-
5.	2019	174.402	624.676	642.676	485.154	107.924	35.655	13.943	-
6.	2020	222.970	661.506	661.506	487.986	31.888	109.036	32.596	-

Source: Boyolali Land Office, 2020

Table 3 indicates that the most significant alteration in land usage in Boyolali is seen in the development of residential or housing areas, accounting for a percentage of 69% or an area of 2,607,140 m. The most substantial shift towards housing development occurred in 2018, comprising 678,586 m<sup>2</sup>. The utilization of industry accounts for 15% of land usage, encompassing an area of 584,228 m<sup>2</sup>, followed by infrastructure at 12% with an area of 449,839 m<sup>2</sup>, commercial purpose at 3% with an area of 103,125 m<sup>2</sup>, while other land utilization represents 1%, covering an area of 31,437 m. This indicates a substantial housing development year after year is expected to persist due to the growing population.

The reasons for the transformation of farmland to non-agricultural land in Boyolali include various factors. The first factor is related to population and demographic aspects. Secondly, the economic factor has a significant impact on the decision to alter the purpose of the land. He et al. (2014) mentioned that the shift from agricultural land to non-agricultural land is mostly driven by the competition for land use. The construction of infrastructure, such as toll roads, contributes to the economic growth of the community. Therefore, those who own agricultural land that is influenced by infrastructure development and receive substantial compensation tend to modify the function of their land. Additionally, the expansion of commercial spaces near toll roads encourages residents to change their agricultural land to non-agricultural uses.

The third element concerns the location of the land. As stated by Verburg et al. (2004), the conversion of land usage can be ascribed to two interconnected factors. Firstly, when building residential or industrial zones on agriculturally used land, the accessibility of the location improves, thereby fostering an augmented demand for land from investors or land speculators and eventually resulting in a rise in land prices. Secondly, the escalation in land prices motivates neighboring farmers to sell their land as well. This phenomenon also takes place in rural areas situated near the city center where agricultural lands are located. The nearer the sub-district is to the city, the higher the demand for converting agricultural land to non-agricultural uses, such as housing, industry, and services. The fourth element contributing to this conversion is social and cultural influences. The decisions of land-owning farmers, particularly those who inherit the land, play a significant role in this conversion. When the inherited agricultural land is limited in size, heirs are more likely to sell or transfer the land. Additionally, the younger generation's decreasing interest in working in the agricultural sector further drives the conversion of agricultural land. The fifth factor pertains to the unbalanced agricultural production outcomes in relation to the expenses

incurred, resulting in most farmers selling their agricultural land. This issue is also exacerbated by limited land ownership, which yields minimal agricultural outcomes. The sixth factor pertains to policies governing the conversion of agricultural land, which sometimes offer investment opportunities in various fields, particularly the non-agricultural sector like housing development. As a result, there is a growing trend of agricultural land being transformed into non-agricultural fields.

## 5. DISCUSSION

The results showed that changes in the use of agricultural land are linked to the specific policies implemented in various regions, aimed at regulating the transfer of such land to non-agricultural purposes. This highlighted that land-use policies play an important role in shaping the spatial distribution of land and its various uses. Land use conversion from agriculture to non-agricultural use is increasing globally, with implications for food security, rural livelihoods, and environmental sustainability. The results highlighted the challenges and opportunities associated with land-use policies governing land transfer from agriculture to non-agricultural use.

In the context of implementing this renewable energy, policies related to land conversion are announced as a strategic effort from the government to regulate and organize land use. The state as a power organization based on Article 2 of the Basic Agrarian Law as a manifestation of the mandate of Article 33 paragraph (3) of the 1945 Constitution is given the authority to regulate matters relating to land. As a control measure and a form of protection on land parcels against land-use conversion through a set of policies, it must be based on law. Legal and policy foundations related to land use change in general include Law No. 41 of 2009 concerning the Protection of Sustainable Food Agricultural Land. This law serves as protection for agricultural land with the consideration that agricultural land is used as much as possible for the prosperity of the people. This regulation is a guarantee for the availability of agricultural land in a sustainable manner, and the state has an obligation to guarantee food self-sufficiency, security and sovereignty. This Law provides protection for land that has been designated as sustainable food agricultural land is protected and prohibited from being converted except with other provisions that have been regulated in this law.

The transfer of land functions is closely linked to spatial planning and zoning system. Law No. 26 of 2007 on Spatial Planning defines spatial planning as a process that involves planning, usage, and control of land. This law mandates that agricultural land be protected as a form of land use that aligns with the Regional

Spatial Plan. Government Regulation No. 16 of 2004 on Land Use is an extension of the spatial planning law and is a means of regulating the use and utilization of land through institutional arrangements. Its aim is to ensure that land use is consistent with the area's function, promote order in land use, and ensure legal certainty for individuals, legal entities, or agencies with legal ties to the land. Lastly, Government Regulation No. 1 of 2011 on the Determination and Transfer of Land Functions for Sustainable Food Agriculture promotes the protection of agricultural land to achieve food independence, resilience, and national sovereignty.

Specifically, in Boyolali in terms of regulating agricultural land in addition to being based on the laws and regulations mentioned above, the Regency Government also makes regional regulations that technically regulate the protection of agricultural land in its territory, namely by Boyolali Regulation No. 8 of 2019 concerning Amendments to Boyolali Regulation No. 9 of 2011 concerning the Boyolali Spatial Plan for 2011-2031 as mandated by Law 26 of 2007 concerning spatial planning. The local government of Boyolali has an obligation to protect agricultural land through spatial regulations. Through this regional regulation the determination of agricultural land as protected land through a zoning system and in terms of changes in spatial use is determined through a licensing mechanism. Moreover, Boyolali Regulation No. 17 of 2016 concerning the Protection of Sustainable Food Agricultural Land as mandated by Law No. 41 of 2009 concerning the Protection of Sustainable Food Agricultural Land. The Boyolali government has taken serious steps to protect agricultural land through the establishment of protected agricultural land areas and optimizing the use of agricultural land, in order to maintain its sustainability and availability. Environmental policy strategies that focus on regulatory aspects that prioritize environmental preservation, pro-community support for these efforts, and prioritize the principle of sustainability, have a close relationship with the utilization of renewable energy sources and sustainable energy management efforts. Therefore, the implementation of this policy is expected to help achieve sustainable development goals.

In Boyolali, the regulation of agricultural land includes adherence to both national laws and regional regulations. Boyolali Regulation No. 8 of 2019 amends the Boyolali Spatial Plan for 2011-2031 to technically protect agricultural land, in accordance with Law 26 of 2007. The local government must safeguard agricultural land through spatial regulations, including designating protected areas through a licensing process. Boyolali Regulation No. 17 of 2016 further reinforces the protection of sustainable food agricultural land, as required by Law No. 41 of 2009. The Boyolali government has taken significant action to ensure the sustainability and availability of agricultural land by establishing protected areas and promoting optimal land use.

Also, to effectively manage and ensure the protection of agricultural land based on existing regulations, it is necessary to execute the control objectives. The government endeavors to limit the rate of function transfer by establishing regulations, regional spatial plans, permits, dispensations, and incentives. The Regional Development Planning Agency (*Bappeda*) in Boyolali plays a significant role in preventing uncontrolled land-use conversion by being a part of the local government unit authorized to decide whether or not to grant a function change permit, with Boyolali's spatial plan as the primary reference. Additionally, Bappeda conducts outreach programs to educate the community about the importance of comprehending the Regional Spatial Plan. Bappeda has also amended the Regional Regulation on spatial planning and continues to disseminate information to build legal awareness among the people. Furthermore, the Boyolali Land Office has a responsibility in assessing the technical aspects of converting agricultural land. Like the Bappeda, the Boyolali spatial plan is used as a primary reference to determine whether the conversion adheres to the spatial pattern in the rtrw. a team of various agencies is responsible for issuing land use change permits. To prevent and control the conversion of agricultural land into non-agricultural land, the Boyolali government implements policies that involve various stakeholders including individuals and groups that have a direct or indirect connection with the conversion process. This strategy, described in Figure 1, is implemented at all levels of society (Iqbal and Sumaryanto, 2007).

**Figure 1:** Strategy for controlling land-use conversion

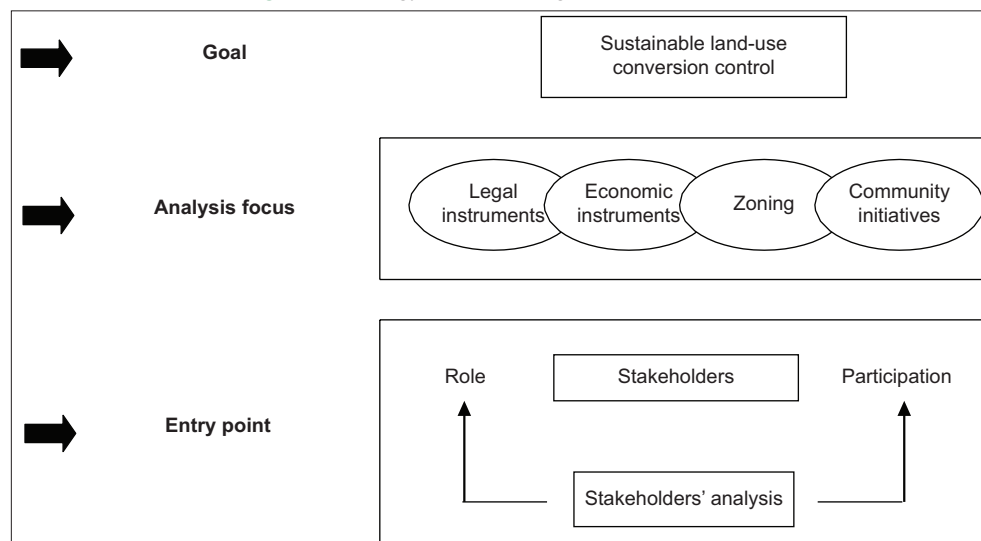


Figure 1 displays a three-step process for implementing a strategy to regulate the conversion of agricultural land based on community involvement. The first step involves engaging all stakeholders who have direct contact with the conversion process. The second step is to analyze the stakeholders' outlook on policy regulations, such as legal and economic instruments, and zoning restrictions, while also considering community initiatives through collective action participation. The third step is to achieve a sustainable and harmonious control over the conversion process. Stakeholder analysis is used to assess the stakeholders' involvement and participation, and it is conducted within an institutional social framework that includes institutional and social assessments. Stakeholder analysis serves as a logic framework for the design of participatory activities.

## 6. CONCLUSION

According to the findings, demographic, economic, socio-cultural, land location, imbalanced production results and policy factors all contribute to the conversion of agricultural land to non-agricultural land in Boyolali, Indonesia. However, the results showed that the implementation of two regional regulations in Boyolali, namely Regional Regulation No. 17 of 2016 concerning the Protection of Sustainable Food Agricultural Land (LP2B) and the Boyolali Regional Regulation No. 8 of 2019 concerning Amendments to the Boyolali Regional Regulation No. 9 of 2011 concerning the Boyolali Spatial Plan 2011-2031, has not successfully slowed down the trend of turning agricultural land into non-agricultural uses.

The results revealed that conversion of agricultural land into non-agricultural uses is driven by various factors, including urbanization, industrialization, and population growth. While the conversion of agricultural land to non-agricultural use may generate economic benefits, including employment generation, increased tax revenue, and infrastructure development, it also has negative social and ecological impacts that need to be considered. The results further find that land use policies play a critical role in shaping land use decisions and outcomes. However, the effectiveness of land use policies is dependent on factors such as institutional capacity, political will, and community participation. The result also shows that land use policies may be categorized into regulatory and incentive-based instruments. Regulatory instruments, such as zoning and land-use planning regulations, aim to control the type, location, and timing of land use change. Incentive-based instruments, such as tax breaks and voluntary certification schemes, aim to encourage desirable land use practices.

A sustainability orientation can also encourage the development of renewable energy and more sustainable energy management. Public support can encourage the use of renewable energy through subsidy programs or other incentives. The findings also highlight that land-use policies should consider equitable distribution of benefits and costs associated with land use change. Land-use policy should also aim to promote sustainable land-use practices that balance economic, social, and environmental needs. This requires a collaborative and participatory decision-making process that

involves all stakeholders, including farmers, local communities, government agencies, and interested parties. The findings shows that land-use policy is a critical tool for managing land use change from agriculture to non-agricultural use. Effective land-use policies should consider the social, economic, and ecological implications of land use change and aim to promote sustainable land-use practices while considering the needs of all stakeholders.

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