Global J. Environ. Sci. Manage. 13(1): 51-68, Winter 2027, Serial #49

Global Journal of Environmental Science and Management
(GJESM)

Homepage: https://www.gjesm.net/

Podcasts

ORIGINAL RESEARCH ARTICLE

The effect of agricultural taxes and local agricultural policies on enhancing food security and environmental sustainability

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ARTICLE INFO

Article History:
Received 15 April 2026
Revised 18 June 2026
Accepted 22 July 2026

Keywords:
Agricultural productivity
Agricultural tax policy
Environmental sustainability
Food security
Sustainable development goals

DOI:10.22034.gjesm.2027.01.03

ABSTRACT

BACKGROUND AND OBJECTIVES: Indonesia is currently working towards sustainability in line with Sustainable Development Goal 2 (Zero Hunger). Anticipated demographic growth to 10.8 billion by the year 2050 is expected to place unprecedented strain on global food security and production systems. The study objectives were to examine the biophysical factors, production inputs, economic conditions, socio-technological factors, agricultural business management, and agricultural tax policies regional agricultural policies and, ultimately, agricultural productivity.

METHODS: This quantitative study employed structured questionnaires administered to a sample of 200 farmers in Surabaya. The instrument used a one-to-five Likert scale covering biophysical factors, economic factors, tax policy, tax morale, and agricultural productivity. Data was analyzed using partial least squares-structural equation modeling version 3. The analytical procedure comprised three distinct phases: first, evaluating the outer model for convergent and discriminant validity; second, conducting reliability assessments; and third, testing the inner model via bootstrapping to determine the coefficient of determination, the effect size, and hypothesis significance. Hypothesis significance was determined using t-statistic values of at least 1.96 and p-values of no more than 0.05.

FINDINGS: Four hypotheses were rejected: economic factor on regional agricultural policy (p-value 0.557), agricultural taxation policy on tax morale (p-value 0.072), tax awareness on agricultural productivity (p-value 0.058), and tax morale on agricultural productivity (p-value 0.208). The findings reveal that regional agricultural policies are substantially driven by three key dimensions: biophysical factors (beta coefficient of 0.251, probability value of 0.000), production inputs (beta coefficient of 0.253, probability value of 0.002), and agricultural business management (beta coefficient of 0.228, probability value of 0.007). Agricultural tax policy significantly affects tax awareness (beta coefficient of -0.229, probability value of 0.000), while tax administration efficiency also significantly affects tax awareness (beta coefficient of -0.345, probability value of 0.000) and tax morale (beta coefficient of -0.634, probability value of 0.000), since clarity on procedures, benefits, and regulations fosters public responsibility and awareness of taxpayer obligations and rights.

CONCLUSION: Elevating agricultural output demands comprehensive frameworks characterized by active farmer participation, supportive regulatory policies, targeted outreach regarding tax frameworks, and enhanced coordination between industry stakeholders and governmental bodies. Regional agricultural policies and tax awareness significantly influence agricultural productivity. These findings offer practical insights for policymakers aiming to strengthen agricultural governance and tax compliance frameworks in support of sustainable rural development.

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NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
51	2	8

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Note: Discussion period for this manuscript open until March 01, 2027 on GJESM website at the "Show Article".

INTRODUCTION

Agricultural systems are facing climate change and environmental degradation, which can reduce agricultural production (Van *et al.,* 2026). Agriculture is also an important sector for human survival because it is a basic need and is related to food sources needed for survival (Bangun, 2024). The agricultural sector is fundamentally linked to national food security. Between 2001 and 2021, global agricultural output expanded by 54 percent (%), and production is projected to rise further in tandem with an anticipated population growth of 59% to 102% (Fukase and Martin, 2020). Food security is a top priority for all countries, especially developing countries where the population can grow faster than developed countries (Pawlak and Kołodziejczak, 2020). Therefore, the role of the agricultural sector is very important because it is the main line in achieving food security (Ndwiga *et al.,* 2025). Characterized by extensive scholarly investigation, sustainable agriculture has emerged as a prominent paradigm undergoing widespread implementation and conceptual evolution (Mufida, 2024; Hadi *et al.,* 2025). The agricultural sector can be the foundation of food security; if agricultural products run sustainably, the need for food can be met, and problems such as hunger and malnutrition can be avoided (Gil *et al.*, 2019). Furthermore, the agricultural sector is experiencing rapid expansion, with diverse technological innovations increasingly deployed to sustain community food requirements. Agriculture by relying on soil media alone will not be enough at this time, so new innovations have emerged that aim to realize sustainable agriculture, such as hydroponic techniques, vertical culture, and aeroponics to meet the increasing market demand (Garzón *et al.*, 2023). This goal is in line with the second Sustainable development goals (SDG) (zero hunger) and SDG 12 (responsible consumption and production) programs to end hunger, achieve food security, and realize sustainable agriculture (Bizikova *et al.*, 2020). Effective maintenance of food security promotes public health improvements and ensures the adequate intake of essential dietary nutrients (Pandey and Pandey, 2023). This is in line with the goal of SDG 3 (good health and well-being), which is to maintain health and improve fitness for all ages. Women play an important role in the agricultural sector, which aims to increase food security and nutrients contained in food ingredients as well as to market agricultural products (Abraham and Pingali, 2020). Furthermore, strengthening the agricultural sector indirectly advances SDG 5 (gender equality) by recognizing women as vital contributors alongside men in agricultural management (Arintyas, 2024). In addition, agriculture plays a crucial role in reducing climate change. The amount of vegetation that occurs can be one of the steps to protect the environment and reduce global, SDG 13 (climate action), which aims to keep climate change from changing to extremes, has become a global agenda to prevent other natural disasters (Castro *et al.*, 2019; Schaafsma *et al.*, 2019). According to the 2023 agricultural census conducted by Statistics Indonesia, individual agricultural holdings increased by 7.45%, rising from 29,342,202 units to 31,705,295 units (Statistics Indonesia, 2023). Although there is an increase in land ownership, it does not prevent the import of agricultural products to meet the consumption needs of the community. Even from January to February 2024, rice imports amounted to 880,820 tons worth United States Dollar (USD) 564.51 million. This volume has experienced a significant increase of 93% compared to January to February 2023. This challenge stems from a decline in agricultural output, which has failed to keep pace with the escalating consumption demands of the population. The situation related to agricultural imports also involves challenges that local farmer face. Despite expanded land ownership, local farmers often struggle to advance due to persistent reliance on outdated agricultural practices and technologies. The absence of innovation may result in reduced

productivity and inefficiencies in farming (Syarifudin and Saputra, 2024). Furthermore, the problem on the reduction of local productivity also poses threats to food security. The concurrent pressures of rapid global population growth and climate change on agricultural systems heighten the imperative for sustainable and efficient farming practices (Touch *et al.*, 2024). In the policy-making perspective, the pursuit of specific objectives often conflicts with some priorities (Benni *et al.*, 2024). To illustrate, although environmental conservation frameworks are essential for long-term sustainability, they may inadvertently constrain agricultural yields and concurrently drive up consumer expenditures. Furthermore, to implement the policy, one the most important thing is public acceptance (Sager and Gofen, 2022). A key factor of a high willingness of public to accept the agricultural initiatives lies in the diverse objectives encompassed by agricultural (Nguyen *et al.*, 2021). To achieve a strong level of public support, it is essential to ensure that the policy accepted by taxpayers and consumers (Benni *et al.*, 2024). Government can build trust and legitimacy among the public and simultaneously ensure the public support for the agricultural policies (Nguyen *et al.*, 2021). Agriculture is foundational to macroeconomic stability; wherein optimized land management serves as a critical driver for improving rural and domestic economic well-being. To put context, properly managed agricultural land can generate more returns, simultaneously increasing the livelihoods of farming communities' household income (Robinson, 2024). Achieving these objectives necessitates collaborative efforts between farmers and governmental bodies. Supportive agricultural policies can enhance productivity by facilitating access to essential resources, including quality seeds, markets, subsidies, and tax incentives. Nowadays various countries are widely applying taxation related to the environment. The move aims to improve land management, reduce pollution, improve energy efficiency, protect biodiversity, and reduce the effects of climate change (Fendrich *et al.*, 2022). The Agriculture for Development strategy can be used to overcome problems by using two approaches, the "supply side" and the "demand side" (Bridle *et al.*, 2020; Janvry and Sadoulet, 2020). Data on agricultural processes is used to support the potential increase that will likely arise in the future (Khan *et al.*, 2021). Economic instruments that can be provided to support the development of the agricultural sector can include taxes, subsidies, and emission relief allowances (Deboe, 2020). The financial incentives provided can also be subsidies and tax breaks (Oebel *et al.*, 2025). Fiscal instruments such as subsidies and tax relief are designed to mitigate agricultural operating costs, enabling producers to allocate additional resources toward production enhancement. Likewise, these financial tools may incentivize the farmers to have high quality equipment, techniques, seeds, and many more related to the operational of the farm. Additionally, incentive mechanisms can be utilized to evaluate the efficacy of transitions towards a sustainable food security framework. By that, incentives not only enhance the agricultural productivity but also encourage farmers to adopt with the innovative and environmentally friendly practices. Likewise, the good design of tax incentives may encourage the modern practices of agricultural making the process more effective and the goods produced in high quality (Pineiro *et al.*, 2020). Furthermore, the implementation of tax incentives can facilitate progress toward achieving higher-quality food production systems (Michalke *et al.*, 2023; Milošević *et al.*, 2020; Oebel *et al.*, 2025). Align with that, incentive programs must be regularly developed and evaluated to ensure the effectiveness towards farmers need and agricultural development. Kusuma and Simanungkalit, (2022) have researched how the provision of tax incentives in the form of reducing Income Tax by 25 instalments for corporate taxpayers is on the agenda for national recovery in Indonesia (Kusuma and Simanungkalit, 2022). This study investigates the policy implementation

variables proposed in the G Edwards III framework. Specifically, the research model incorporates communication, bureaucratic structure, resources, disposition, and implementation (Kusuma and Simanungkalit, 2022). Taing and Chang (2020) also researched tax compliance carried out by people in Cambodia. This study uses the theory of planned behavior (TPB) using three components, namely attitudes, subjective norms and perceived behavioral control, which is further developed into variables: tax morality, tax justice, tax complexity, tax information, and tax awareness. Empirical results demonstrate that citizen tax compliance in Cambodia is shaped by multiple determinants, including the efficacy of local authorities, institutional trust, access to tax information, and individual tax awareness (Taing and Chang, 2020). Furthermore, Yin *et al.* (2022) conducted research on how adequate policies and infrastructure can affect the sustainable improvement of agricultural land and aim to increase food security in China. Grounded in the extended theory of planned behavior, this investigation utilizes this theoretical framework to conceptualize and derive its key research variables. Socio-psychological factors, production inputs, improvement of biodiversity systems, attitudes, and environmental factors are studied and adjusted to the research context. The variables of this study use the modification of variables from previous studies (Khan *et al.*, 2021; Viaggi *et al.*, 2021; Oebel *et al.*, 2025; Michalke *et al.*, 2023; Milošević *et al.*, 2020; Kusuma and Simanungkalit, 2022; Taing and Chang, 2020; Yin *et al.*, 2022) to adapt to the context of the research being conducted and to maintain its relevance. Despite a growing body of literature on agricultural policy and tax compliance, empirical research remains scarce regarding how agricultural taxation frameworks and local governance collectively influence farmer behavior and productivity within a unified structural model across developing economies. This study aims to address this gap by integrating the TPB (Taing and Chang, 2020) and the G. Edward III (Kusuma and Simanungkalit, 2022) policy implementation model to examine: 1) how biophysical factors, production inputs, economic conditions, socio-technological factors, and agricultural business management influence regional agricultural policies; 2) how agricultural tax policies and tax administration efficiency shape tax awareness and tax morale among farmers; and 3) how regional agricultural policies, tax. This study was conducted in Surabaya, Indonesia in 2024, providing empirical evidence from an urban-agricultural context within a developing economy.

MATERIALS AND METHODS

A purposive sampling technique was employed to select participating farmers based on the following criteria: 1) aged 18 years or above, 2) currently working as farmers, and 3) owning agricultural land in the Surabaya area. (Fig. 1). The sampling frame was developed through coordination with local agricultural extension officers and farmer group leaders who maintained registers of active farmers in the study area. Prospective participants were recruited by enumerators at their respective agricultural holdings or via regional farmer association assemblies. The survey achieved an 85% response rate, corresponding to 200 completed questionnaires out of 235 individuals solicited. Based on the data collection results, respondents were dominated by people over 40 years old (56%), followed by age 21-30 (34.5%), and age 31-40 (9.5%). Most respondents were male (92.5%), with female respondents at 7.5%. Educational background was dominated by high school graduates (47%), followed by elementary school graduates (21.5%), applied bachelor's degree graduates (19%), and junior high school graduates (12.5%). Marital status: married (69%), unmarried (23.5%), and divorced (7.5%). Monthly expenditure: USD 55.56 - 222.22 (78.5%), more than USD 222.22 (13.5%), and less than USD 55.56 (8%). The selection of Surabaya as the study area is justified by its unique geographical profile. Despite its status as a largely urbanized

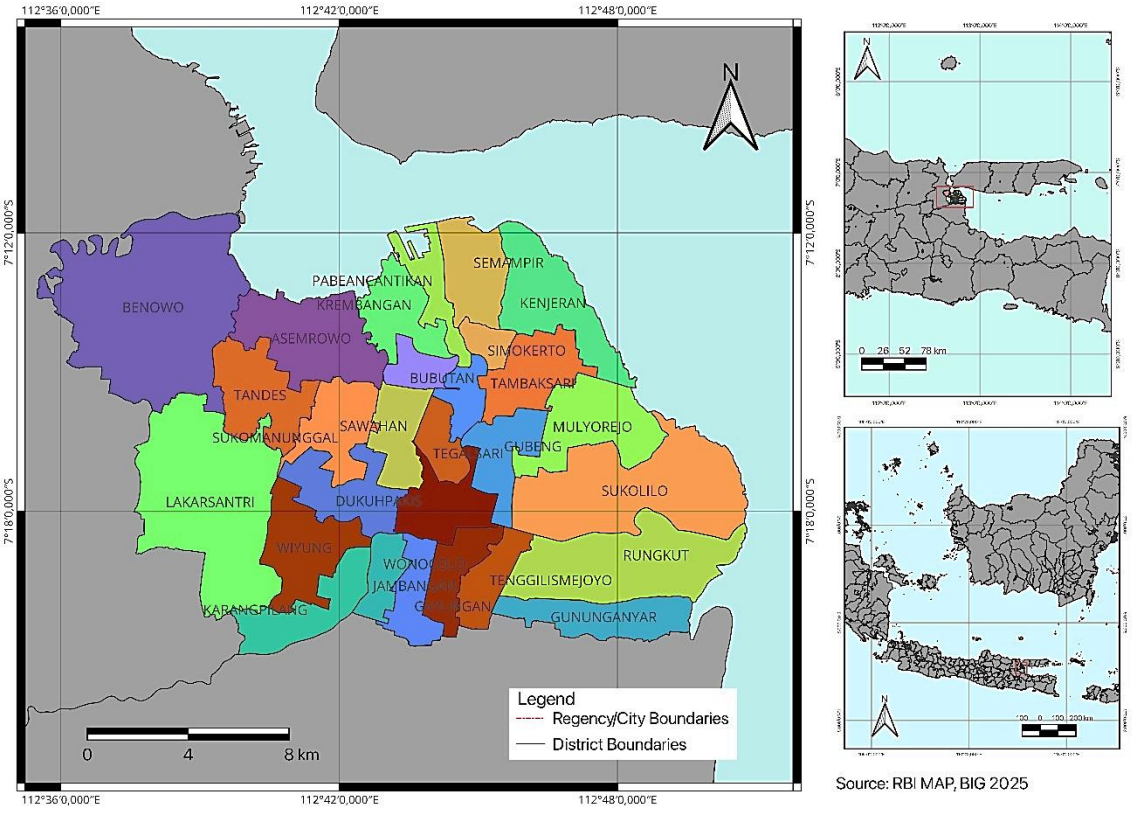

Fig. 1: Geographical location of the study area in the Surabaya, Indonesia

metropolitan territory, it contains peri-urban and suburban agricultural sectors that sustain persistent farming activities. Surabaya presents a unique setting where agriculture coexists with rapid urban development, highlighting challenges such as land conversion, market access, and technology adoption. Agricultural activities mainly include vegetable, fruit, and ornamental plant cultivation on small- to medium-sized farms. Evidence derived from this case study offers valuable implications for regional agricultural governance, elucidating both the obstacles and prospective advantages inherent in peri-urban agricultural systems. The marital status of the dominating respondents was married with 69%, unmarried with 23.5%, and divorced with 7.5%. The monthly expenditure of most respondents was in the range of USD 55.56 to USD 222.22, accounting for 78.5% of respondents, followed by those spending more than USD 222.22 (13.5%), while 8% of respondents spent less than USD 55.56 per month To appropriately contextualize the research and uphold the psychometric reliability and structural validity of the proposed model, necessary methodological modifications were incorporated into the research framework and measurement design to ensure consistency and robustness. The survey instrument is proposed to be able to collect information from respondents covering biophysical factors, production inputs, economy, social technology, agricultural business management, agricultural tax policy, tax administration efficiency, regional agricultural policy, tax awareness, tax morale, and agricultural productivity. This study uses a Likert scale of 1 until (–) 5 as a research indicator with 1 equal to (=) strongly disagree; 2= disagree; 3= neutral; 4= Agree; 5= Strongly agree (Table 1).

Table 1: Measurement items and scale of the study variables

Variable	Item code	Measurement Item	Scale
Agricultural business management (ABM)	ABM1	I implement effective production planning to improve farming efficiency and productivity.	1–5 Likert
	ABM2	I maintain proper financial management by recording farming income and expenditures.	
	ABM3	I use information technology to improve inventory and agricultural logistics management.	
	ABM4	I implement effective marketing strategies to improve product competitiveness.	
	ABM5	I have adequate capability to manage farming risks, including weather and market risks.	
Agricultural productivity (AP)	AP1	Agricultural productivity in my area has increased over time.	1–5 Likert
	AP2	The farming techniques and technologies I use improve crop yields and farming efficiency.	
	AP3	The quality of my agricultural products meets market standards and receives positive responses.	
	AP4	I manage my farmland effectively, including crop management, irrigation, and pest control.	
	AP5	My overall agricultural productivity is higher than the average productivity of surrounding farms.	
Agricultural taxation policy (ATP)	ATP1	The agricultural tax imposed on my harvest is fair and not burdensome.	1–5 Likert
	ATP2	The agricultural tax payment process is simple and easy.	
	ATP3	Information regarding agricultural taxation is easily accessible and understandable.	
	ATP4	The government provides attractive tax incentives for productive farmers.	
	ATP5	Agricultural tax revenues are used to finance programs that benefit farmers.	
Biophysical factors (BPF)	BPF1	The quality of agricultural land in my area is adequate to support crop cultivation.	1–5 Likert
	BPF2	The availability of irrigation water in my area is sufficient for agricultural activities.	
	BPF3	The climate in my area is suitable for cultivating the crops I grow.	
	BPF4	The soil fertility in my area is adequate to support crop growth.	
	BPF5	The elevation of my farmland affects the productivity of my crops.	
	BPF6	The drainage conditions of my farmland adequately support crop growth.	
	BPF7	Pests and plant diseases are often serious problems affecting agricultural production in my area.	
	BPF8	The topography (land contour) of my farmland influences soil erosion and crop productivity.	
Economic factors (EF)	EF1	The selling price of agricultural products in the local market affects my farming profits.	1–5 Likert
	EF2	Access to export markets influences my income and financial stability.	
	EF3	Increases in production costs, such as fertilizers and fuel, reduce my farming profit margins.	
	EF4	Market uncertainty and commodity price fluctuations influence my farming investment and production decisions.	
	EF5	Government policies related to subsidies, taxation, and agricultural regulations significantly affect my farm profitability.	
Production input factors (PIF)	PIF1	The availability of organic and inorganic fertilizers in my area is sufficient to meet my farming needs.	1–5 Likert
	PIF2	Access to and availability of high-quality seeds influence my crop yields.	
	PIF3	The prices of production inputs such as seeds, fertilizers, and pesticides are affordable for farmers in my area.	
	PIF4	Changes in the prices of production inputs frequently influence my farming decisions.	
	PIF5	The quality and availability of fuel for agricultural machinery affect the efficiency and productivity of my farm.	
	PIF6	The quality and availability of agricultural equipment and machinery influence farming efficiency.	
Regional agricultural policy (RAP)	RAP1	The local government provides adequate infrastructure to support agricultural activities.	1–5 Likert
	RAP2	The local government provides easy access to fertilizers, pesticides, and high-quality seeds.	
	RAP3	The local government provides beneficial agricultural extension services.	
	RAP4	The local government assists farmers in marketing their agricultural products.	
	RAP5	Current regional agricultural policies are fair and supportive of farmers.	
Socio-technological factors (STF)	STF1	The use of agricultural technology has improved my farming efficiency and productivity.	1–5 Likert
	STF2	Participation in farmer networks or local farmer groups facilitates knowledge sharing and improves my farming practices.	
	STF3	Environmental awareness and sustainability issues have influenced my farming practices.	
	STF4	Access to and use of social media has helped expand my agricultural business network and product marketing.	
	STF5	Training and education in modern agricultural technology have improved my ability to adopt new innovations.	
Tax awareness (TA)	TA1	I always try to calculate and report my income accurately for tax purposes.	1–5 Likert
	TA2	I understand the importance of the Indonesian tax system.	
	TA3	I recognize the importance of contributing to the country through tax payments.	
	TA4	I always make tax payments on time in accordance with the applicable regulations.	

Tax administration efficiency (TAE)	TAE1	The current agricultural tax administration procedures are simple and easy to understand.	1–5 Likert
	TAE2	The time required to complete agricultural tax administration is fast and efficient.	
	TAE3	Tax officers provide clear information and adequate assistance regarding agricultural taxation.	
	TAE4	The cost of completing agricultural tax administration is reasonable and affordable.	
	TAE5	Information regarding agricultural taxation is transparent and easily accessible.	
Tax morale (TM)	TM1	Paying taxes is my moral responsibility as a citizen.	1–5 Likert
	TM2	I believe that the taxes I pay are used appropriately for rural infrastructure development.	
	TM3	I would feel guilty if I failed to pay my taxes as required.	
	TM4	Paying taxes is my contribution to the development of society and the country.	
	TM5	Paying taxes reflects my compliance with laws and regulations.	
	TM6	I believe that the taxes I pay contribute to improving farmers' welfare.	

The following is the proposed research framework (Fig. 2). This study employs partial least squares-structural equation modeling (PLS-SEM), a well-established method for evaluating relationships between complex constructs (Lohmöller, 1989). PLS-SEM is widely applied across diverse disciplines to examine complex variables (Guenther *et al.*, 2023; Sarstedt *et al.*, 2022), and it is used here to test and analyze the proposed hypotheses. Furthermore, because PLS-SEM accommodates both intricate and straightforward model structures, it serves as a versatile analytical approach adaptable to various research frameworks. The software used in this study is smart partial least squares (SmartPLS) version 3, which includes testing the inner, outer, and bootstrapping models. Surabaya was selected as the study area because it represents one of Indonesia's largest urban-agricultural interfaces, where smallholder and commercial farming coexist alongside urban policy governance — a context well suited to examining the intersection of agricultural policy and tax compliance. Respondents were recruited via purposive sampling, targeting active farmers aged 18 or older who owned agricultural land within Surabaya. Prior to distributing the questionnaires, enumerators visited farming communities to outline the study's objectives and verify the eligibility of potential respondents. All participants provided informed consent; participation was voluntary and responses were collected anonymously to protect confidentiality. Ethical approval was obtained through the research governance framework of Universitas Indonesia. The 200 valid responses are sufficient for the proposed PLS-SEM model complexity (Hair *et al.*, 2017). PLS-SEM was selected over covariance-based SEM due to the model's complexity, the relatively small sample size, and the absence of a normality assumption for the data — conditions under which PLS-SEM demonstrates robust performance (Hair *et al.*, 2019b; Guenther *et al.*, 2023).

Hypothesis development

The hypotheses in this study are based on two theoretical frameworks. The TPB posits that personal conduct is governed by attitudinal, normative, and control constructs. Applied to the taxation domain, this implies that taxpayer attitudes, normative pressures regarding compliance, and perceived administrative ease dictate tax morale and awareness, thereby exerting a direct influence on compliance behavior (Taing and Chang, 2020). G. Edward III's policy implementation model states that the effectiveness of a policy depends on communication, resources, disposition, and bureaucratic structure; in this study, this means that how well agricultural and tax-related policies are communicated, resourced, and administratively structured determines their influence on regional agricultural policy and, ultimately, agricultural productivity, as per Kusuma and Simanungkalit (2022). Based on this framework, the following hypotheses are proposed:

H1: Biophysical factors significantly affect regional agricultural policy.

H2: Production input factors significantly affect regional agricultural policy.

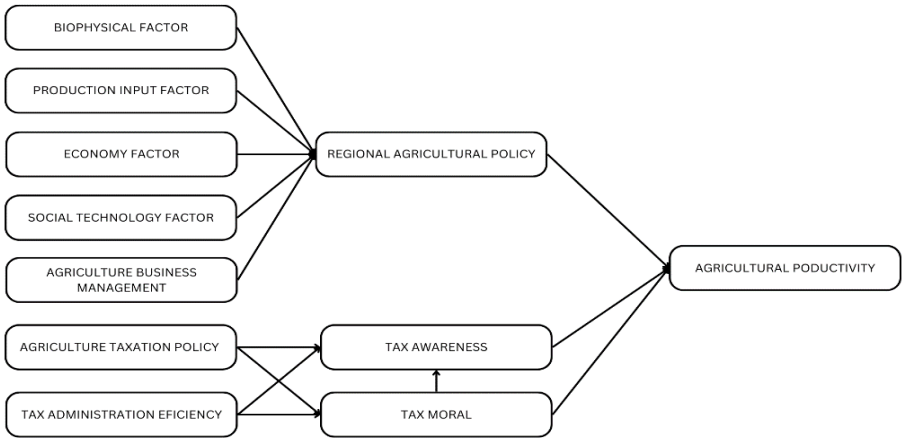

Fig. 2: Research framework

H3: Economic factors significantly affect regional agricultural policy.
H4: Socio-technological factors significantly affect regional agricultural policy.
H5: Agricultural business management significantly affects regional agricultural policy.
H6a: Agricultural taxation policy significantly affects tax awareness.
H6b: Agricultural taxation policy significantly affects tax morale.
H6c: Tax administration efficiency significantly affects tax awareness.
H6d: Tax administration efficiency significantly affects tax morale.
H6e: Tax morale significantly affects tax awareness.
H7a: Regional agricultural policy significantly affects agricultural productivity.
H7b: Tax awareness significantly affects agricultural productivity.
H7c: Tax morale significantly affects agricultural productivity.

RESULTS AND DISCUSSION

A series of tests were carried out in the study, including convergence validity tests, reliability tests, and discrimination validity tests. The convergence validity test consists of outer loadings and average variance extracted (AVE) values. To establish adequate convergent validity, individual indicator loadings ought to surpass the threshold of 0.7, thereby confirming that the latent variable explains a significant proportion of the variance associated with each measure (Hair *et al.*, 2012). Meanwhile, according to Chin (1998), the outer loading value is greater than 0.5 is quite adequate (Chin, 1998). If the outer loading value is below 0.5, it can be considered insignificant or weak, so it should be removed to improve the measurement model (Hair *et al.*, 2019a). In this study, several indicators have a value below 0.5, these indicators are removed to increase the significance value and to make sure there is no overlap indicator that may caused an error. Furthermore, AVE value exceeding 0.5 confirms convergent validity, indicating that a single latent variable accounts for more than half of the variance across its indicators (Bougie and Sekaran, 2019). The test results showed that the AVE value of each variable was eligible because the value showed more than 0.5. Furthermore, internal consistency reliability was evaluated using Cronbach's alpha to establish the lower bound of reliability, alongside composite reliability to assess the true reliability of the construct. The Cronbach alpha and Composite Reliability values must be at least 0.6. The Composite Reliability value so that if it shows a value above 0.7, the test variables' reality can be said to have a high value. In the study, all indicators are acceptable because they

have met the Cronbach Alpha (CA) and composite reliability (CR) standards. The validity and reliability results are fully summarized in Table 2. In addition, discriminant validity was evaluated using the Fornell-Larcker criterion, which requires the square root of the AVE for each construct to exceed its correlations with all other latent variables. The full results of the Fornell-Larcker and Heterotrit-Monotrait ratio (HTMT) test are shown in Tables 3 and 4. HTMT was used to validate the discriminant validity and the result shows that most construct pairs have met the recommended standard. Furthermore, three construct biophysical factor, economic factor, and agricultural business management—exhibited values exceeding 0.90, indicating a high degree of collinearity or association between constructs. This finding can be theoretically justified because these constructs are related to agricultural production systems. Furthermore, Fornell Larcker criterion, cross-loadings, AVE, CR, and CA are supporting the measurement model.

Structural models and hypotheses

The evaluation of the R^2 (variance) and f^2 (effect size) matrices was used to measure the structural model. The R^2 value is divided into three categories, namely 0.75 (firm), 0.50 (moderate), and 0.25 (weak) (Hair *et al.*, 2019a; Hair *et al.*, 2017). R^2 is also used to determine whether the tested model is good. In this study, all variables with R^2 values in the moderate category. Furthermore, the tax awareness construct yielded a value of 0.506, indicating that the independent variables account for 50.6 of the variance in the dependent variable, while the remaining 49.4% is explained by other extraneous factors. Other variables are regional agricultural policy, which has a value of 0.579, which means that independent variables can explain 57.9% of the distribution of dependent variables. In contrast, the remaining 42.1% cannot be explained by independent variables. The R^2 value of the agricultural productivity and tax moral requires further enhancement, as the obtained values fall below the acceptable threshold of 0.50. Meanwhile, the R square adjusted value is used to overcome if there is a problem that often occurs in the R square value, namely an increase in value if independent variables are added to the model. R square adjusted is also used to measure the confidence level in adding the correct independent variable to increase the model's predictive power. In this study, the variables of tax awareness and regional agricultural policy have a sufficient model predictive power because the R square adjusted value is more than 0.5. The comprehensive results detailing the coefficient of determination (R^2) and adjusted R^2 values are presented in Table 5. Meanwhile, the f^2 value with a value higher than 0.35 has a significant effect, higher than 0.15 has a moderate effect, and higher than 0.02 has a negligible effect. In this study, the regional agricultural policy variable greatly influences agricultural productivity because it has a value of 0.367 (greater than (>) 0.35) and tax administration efficiency has a great influence in tax morale because the result shows 0.446 > 0.35. Furthermore, tax administration efficiency and tax morale exert a moderate effect on tax awareness, as indicated by f^2 values exceeding 0.15. Tax awareness and tax morale moderately influence agriculture. Furthermore, biophysical, agricultural business management, social technology, and production input factors have a negligible influence on regional agricultural policy. Meanwhile other variables that has correlation also shows negligible influence because the results show > 0.02 and two correlated variable has no effect since the results are < 0.02. The complete results of the f^2 test are in Table 6. Predictive relevance test (Q^2) is useful to measuring the quality from a structural model and ability to predict data especially endogenous latent variables (Table 7). Q^2 is also used as a complement to R^2 test. According to Hair *et al.* (2012), $Q^2 \leq 0$ is indicated insignificant predictive relevance. $Q^2 > 0.02$ is indicated weak predictive relevance. $Q^2 > 0.15$ is indicated moderate predictive relevance. $Q^2 > 0.35$ is indicated strong

Table 2: Validity and reliability test results

Variables	Indicators	Outer loading	AVE	CA	CR	Status
Agriculture business management (ABM)	ABM3	0.895	0.835	0.804	0.910	Valid
	ABM4	0.932				
Agricultural productivity (AP)	AP1	0.805	0.671	0.760	0.859	Valid
	AP2	0.747				
	AP3	0.899				
Agriculture taxation policy (ATP)	ATP2	0.996	0.693	0.714	0.811	Valid
	ATP4	0.628				
Biophysical factor (BPF)	BPF3	0.791	0.674	0.518	0.805	Valid
	BPF8	0.850				
Economy factor (EF)	EF1	0.671	0.552	0.610	0.784	Valid
	EF4	0.674				
	EF5	0.866				
Production Input Factor (PIF)	PIF5	0.847	0.739	0.647	0.850	Valid
	PIF6	0.872				
Regional agricultural policy (RAP)	RAP3	0.810	0.746	0.669	0.854	Valid
	RAP5	0.914				
Social technology factor (STF)	STF1	0.801	0.591	0.772	0.852	Valid
	STF2	0.800				
	STF3	0.778				
	STF4	0.690				
Tax awareness (TA)	TA1	0.694	0.558	0.607	0.789	Valid
	TA3	0.670				
	TA4	0.862				
Tax administration efficiency (TAE)	TAE1	0.904	0.859	0.840	0.924	Valid
	TAE3	0.949				
Tax moral (TM)	TM1	0.786	0.582	0.860	0.893	Valid
	TM2	0.814				
	TM3	0.729				
	TM4	0.711				
	TM5	0.720				
	TM6	0.809				

Table 3: Fornell-Larcker test

Variables	AP	ATP	ABM	BPF	EF	PIF	RAP	STF	TAE	TA	TM
AP	0.819										
ATP	0.054	0.833									
ABM	0.740	-0.032	0.914								
BPF	0.569	0.108	0.552	0.821							
EF	0.576	0.096	0.486	0.344	0.743						
PIF	0.464	0.069	0.395	0.201	0.176	0.859					
RAP	0.653	-0.185	0.607	0.518	0.372	0.556	0.864				
STF	0.559	0.164	0.547	0.353	0.578	0.578	0.630	0.769			
TAE	-0.440	0.533	-0.530	-0.459	-0.479	-0.126	-0.576	-0.429	0.927		
TA	0.468	-0.490	0.527	0.521	0.308	0.181	0.570	0.238	-0.646	0.747	
TM	0.377	-0.256	0.489	0.422	0.585	0.287	0.446	0.421	-0.591	0.565	0.763

predictive relevance. Based on the results, tax morale (0.178 > 0.15), agricultural productivity (0.273 > 0.15), and tax awareness (0.259 > 0.15) have moderate predictive relevance. Concurrently, regional agricultural policy demonstrates robust predictive relevance within the structural model (0.416 > 0.35). Next step is testing the proposed hypothesis that uses bootstrapping techniques. For the hypothesis to be accepted, the minimum t-test value is 1.96, and the maximum probability value (p-value) 0.05. This threshold was adopted because it represents

Table 4: HTMT test result

Variables	AP	ATP	ABM	BPF	EF	PIF	RAP	STF	TAE	TA	TM
AP	1										
ATP	0.374	1									
ABM	0.958	0.276	1								
BPF	0.943	0.671	0.841	1							
EF	0.912	0.325	0.722	0.701	1						
PIF	0.599	0.405	0.533	0.357	0.516	1					
RAP	0.815	0.514	0.771	0.836	0.589	0.867	1				
STF	0.699	0.528	0.668	0.564	0.790	0.772	0.859	1			
TAE	0.577	0.520	0.607	0.639	0.633	0.155	0.749	0.498	1		
TA	0.660	0.557	0.771	0.895	0.560	0.297	0.864	0.465	0.823	1	
TM	0.447	0.298	0.563	0.589	0.711	0.484	0.559	0.470	0.619	0.704	1

Table 5: R Square results

Endogenous constructs	R^2	R^2 adjusted
Agricultural productivity	0.442	0.434
Regional agricultural policy	0.579	0.568
Tax awareness	0.506	0.498
Tax moral	0.354	0.347

Table 6: F square results

Variable	AP	ABM	ATP	BPF	EF	PIF	RAP	STF	TAE	TA	TM
AP											
ABM							0.064				
ATP										0.075	0.007
BPF							0.103				
EF							0.002				
PIF							0.092				
RAP	0.367										
STF							0.084				
TAE										0.119	0.446
TA	0.013										
TM	0.005									0.120	

Table 7: Q square results

Variables	SSO	SSE	Q^2 (=1-SSE/SSO)
Agricultural productivity	600.000	435.933	0.273
Regional agricultural	400.000	233.438	0.416
Tax awareness	600.000	444.463	0.259
Tax morale	1200.000	986.561	0.178

a widely recommended benchmark in PLS-SEM analyses, and the study utilized two-tailed hypotheses evaluated at a 95% confidence level. If the hypothesis test results do not meet the standards, the results are rejected. In this study, ten hypotheses meet the standards so that the hypothesis decision is accepted. Simultaneously, the other three hypotheses were rejected because the test results showed that they did not meet the set standards. Table 8 describes in detail the results of the bootstrapping tests that have been carried out.

Theoritical implication

Previous theories were adapted to form variables used to study social phenomena in this study. These variables are outlined in the form of a questionnaire distributed to farmers in Surabaya. Furthermore, the findings indicate that biophysical factors exert a significant effect on regional agricultural policy. This relationship is driven by environmental challenges, including climate change, resource scarcity, and deforestation, requiring proactive mitigation to sustain long-term agricultural productivity.

Table 8: Hypothesis results

Hypothesis	Original sample (O) or beta coefficient (β)	Sample mean (M)	Standard deviation (SD)	t-statistics (|O/SD|)	p-value	Decision
H1 biophysical factor → regional agricultural policy	0.251	0.253	0.060	4.210	0.000	Accepted
H2 production input factor → regional agricultural Policy	0.253	0.256	0.058	4.355	0.000	Accepted
H3 economy factor→ regional agricultural policy	-0.039	-0.029	0.067	0.588	0.557	Declined
H4 social technology factor → regional agricultural policy	0.293	0.290	0.076	3.846	0.000	Accepted
H5 agriculture business management → regional agricultural policy	0.228	0.227	0.084	2.717	0.007	Accepted
H6a agriculture taxation policy → tax awareness	-0.229	-0.234	0.065	3.546	0.000	Accepted
H6b agriculture taxation policy → tax moral	0.082	0.082	0.045	1.803	0.072	Declined
H6c tax administration efficiency → tax awareness	-0.345	-0.344	0.074	4.656	0.000	Accepted
H6d tax administration efficiency → tax moral	-0.634	-0.636	0.050	12.650	0.000	Accepted
H6e tax moral → tax awareness	0.303	0.304	0.048	6.248	0.000	Accepted
H7a regional agricultural policy → agricultural productivity	0.560	0.568	0.042	13.380	0.000	Accepted
H7b tax awareness → agricultural productivity	0.112	0.109	0.059	1.901	0.058	Declined
H7c tax moral → agricultural productivity	0.064	0.064	0.051	1.260	0.208	Declined

The existence of agricultural regional policies that serve to protect biodiversity is the opinion by Klitgaard (2020), which states that biophysical factors are related to the environment and energy; if the problems that arise are not appropriately addressed, it will be able to cause macro scale economic problems (Klitgaard, 2020). In addition, the second hypothesis testing the effect of production input factors on regional agricultural policy yielded statistically significant results. This outcome is attributed to the vital role of agricultural inputs—such as seeds, fertilizers, pesticides, and machinery, which serve as essential capital assets driving farming operations. The existence of innovations that support the development of agricultural inputs through research and development (RnD) can significantly improve the quality and quantity (Manogna, 2021). The production input factor is the basis for forming policies that can comprehensively regulate the price of seeds, fertilizers, and access to funding for farmers. Furthermore, the third hypothesis examining the effect of economic factors on regional agricultural policy yielded statistically non-significant results. This outcome suggests that prevailing economic conditions, including local market prices, export market access, and regulatory frameworks—have not generated equitable profitability for the farming community. Consequently, multi-perspective regional policies are necessary to bolster the economic welfare of farmers in Indonesia. The fourth hypothesis, social technology factor to regional agricultural policy, shows significant results. This result is due to the existence of public facilities, agricultural governance systems that have been integrated with technology, and intercommunity relations in agricultural product transactions that can be easily applied, especially in Surabaya, so it requires other aspects to be able to influence regional agricultural policies, previous research conducted by Khan *et al.* (2021) and Viaggi *et al.* (2021) on the use of data for public interest can be applied currently in the region Surabaya. In addition, the fifth hypothesis examining the

relationship between agricultural business management and regional agricultural policy yielded a statistically significant effect. This indicates that sound management practices in the agricultural sector serve as a foundational mechanism for formulating and strengthening regional policies. After all, with business management applied to agriculture, the management of the purchase of production inputs, finance, and distribution as stated in the previous study by Viaggi *et al.* (2021). Furthermore, Agriculture Taxation Policy to Tax Awareness have a significant effect. The existence of a tax policy that has a legal basis can be the basis for the public to know how regulations work so that morals to pay taxes are formed, and awareness to pay taxes grows by research conducted by Taing and Chang (2020). Concurrently, Agriculture Taxation Policy to Tax Moral has no significant effect because individual morale regarding tax shaped through their attitude and perception. Tax administration efficiency to tax awareness and tax administration efficiency to tax moral have a significant effect because a well-organized administrative system can realize the efficiency of administrative services to serve tax payments so that it can foster morale and tax awareness as a study conducted by Lencucha *et al.* (2020). Tax moral exerts a statistically significant effect on tax awareness. This relationship is grounded in the psychological dimensions and intrinsic motivation associated with tax compliance, fostering a heightened sense of obligation toward tax payments, consistent with previous findings by Taing and Chang (2020). Regional agricultural policy to agricultural productivity, is accepted because there are consistent regulations and can regulate the needs of farmers well to bring macro impacts, can increase agricultural productivity because all necessary access can be easily reached as a study conducted by Liu *et al.* (2020). Tax awareness affects agricultural productivity and has insignificant results because productivity in agriculture have no correlation with individual awareness about tax. Despite considering dimensions such as procedural knowledge of tax payment and anticipated benefits, these factors may not exert a statistically significant effect on enhancing agricultural productivity, largely owing to fluctuations in subsidies and fiscal incentives. The last hypothesis, tax moral affects agricultural productivity, is rejected because it does not have a significant effect, although tax morality may trigger awareness to implement tax obligations.

Practical implications

The tax applied to the agricultural sector is an effort made by the government to reduce carbon emissions and realize a sustainable life. Both biophysical factors and production inputs exert a statistically significant effect on agricultural policy. These dimensions serve as a critical foundation for governmental policy refinement, as they address essential environmental, energy, and land needs such as seeds, fertilizers, and pesticides—vital for agricultural production. The sustainability implications of agricultural production are also closely associated with the management and reuse of water resources, particularly where wastewater is considered as an alternative source for agricultural production and is evaluated from both weak- and strong-sustainability perspectives (Rosas Baños and García Salazar, 2026). Economic factors have not been able to significantly affect regional agricultural policies because economic effects such as selling prices in the local market, access to export markets, and government policies on regulations have not increased the profitability that can be felt, so the need for other aspects that can be applied to increase the effects that can be felt. Furthermore, social and technological factors exert a significant effect on regional agricultural policies. This relationship is driven by advanced data applications, the internet of things (IoT), artificial intelligence (AI), and sensors, which enhance societal well-being, optimize environmental outcomes, and substantially boost community-wide economic development. Such technological and policy-oriented approaches are particularly relevant to climate-resilient

agricultural systems, where the management of underutilized climate-resilient crops can contribute to the sustainability and adaptive capacity of farming systems (Ismail *et al.,* 2026). However, this factor can be a record of the government's foundation to make policies that support the improvement of public facilities for agriculture. Furthermore, business management to manage agriculture is also important because the production, harvesting, packaging, and distribution processes will be well integrated. Regional agricultural policies designed to safeguard agricultural business processes can be effectively formulated to ensure the streamlined distribution of agricultural products from producers to consumers. In this context, the integration of environmental, social, and economic indicators into land-use planning provides an important basis for developing agricultural policies that balance productivity with broader sustainability objectives (Freire-Granda *et al.,* 2026). The existence of an excellent agricultural tax policy affects tax awareness and tax morale because a well-regulated policy will clarify how the community should take steps to carry out tax payment obligations. An excellent agricultural tax policy supported by suitable administrative frameworks, foster operational efficiency. This environment cultivates tax awareness by facilitating accessible payment procedures and highlighting tangible benefits for taxpayers. Meanwhile, agriculture tax policy has no significant effect on tax morale because this behavior comes from individual reasons. Regional agricultural policies correlate to increase agricultural productivity because the ease of access that is protected and provided through policies will significantly make it easier for farmers to carry out agricultural processes, from production to distribution to consumers. Furthermore, neither tax awareness nor tax morale exerts a statistically significant effect on agricultural productivity, as this factor is primarily governed by external determinants such as biophysical factors. Through available data, the government can help small-scale farmers to get the necessary subsidies. Finally, tax morality cannot significantly affect agricultural productivity. Because tax morality functions primarily as an attitudinal encouragement rather than an operational mechanism, it fails to generate observable empirical changes in productivity outcomes.

Limitations and further research

This study has several limitations. First, since the data collection was restricted to Surabaya—a predominantly urban metropolitan area—the findings possess limited generalizability to agricultural regions characterized by distinct socioeconomic and institutional profiles. Consequently, subsequent studies should broaden its geographic scope and increase sample size. Second, cross-sectional design prevents causal inference; longitudinal research is recommended. Third, the reliance on self-reported Likert-scale perceptions across all constructs—rather than objective metrics such as yield per hectare or farm income—raises potential concerns regarding measurement validity and common method bias. Consequently, subsequent investigations should incorporate procedural safeguards alongside objective productivity indicators. Fourth, the analysis did not assess mediation, moderation, or subgroup differences, which may limit insight into boundary conditions of the model. Fifth, four hypotheses were rejected — economic factors, agriculture tax policy on tax moral, tax awareness on agriculture productivity, and tax moral on agriculture productivity— suggesting the need for additional variables or refined instruments to capture these relationships more fully.

CONCLUSION

This study integrated the TPB and the G. Edward III policy implementation model to examine determinants of regional agricultural policy and agricultural productivity among farmers in Surabaya, Indonesia. Using PLS-SEM with 200 respondents, 10 of 13 hypotheses were supported. Economic factors do not significantly affect regional agricultural policies (β=-0.039, t-

statistics=0.588, p-value=0.557) because they have not maximized all necessary economic aspects, and the effects felt by the community have not been significant. Consequently, it is recommended that economic considerations—integral components of policy formulation be duly integrated to ensure that the resulting socioeconomic benefits permeate the broader community. Steps taken to improve significant outcomes on economic factors. Agricultural taxation policy factors do not significantly affect on tax morale (β=0.082, t-statistics =1.803, p-value=0.072). The existence of agriculture tax policy is an external factor comparing individual morals to applied tax. The morale (β=0.066, t-statistics=1.260, p-value=0.208) and awareness (β=0.064, t-statistics=1.901, p-value=0.058) hypothesis of taxes also does not significantly affect agricultural productivity because moral perception has yet to take the form of action and can only trigger the desire to implement taxes. Furthermore, relationships demonstrating statistically significant effects require careful management and continuous monitoring to ensure that their socioeconomic benefits remain sustainable for the community. For instance, biophysical factors (β=0.251, t-statistics=4.210, p-value=0.000) warrant careful consideration as they encompass critical environmental, energy, and macroeconomic dimensions. Production inputs (β=0.253, t-statistics=4.355, p-value=0.000) that are capital for the sustainability of agricultural production so that all farmers can access easy access through policies that are milestones. Social technology factor (β=0.293, t-statistics=3.846, p-value=0.000) because developed technology can help many factors such as tax administration more effective and efficient. Agricultural business management is vital for farming communities, as it encompasses both production and distribution channels, thereby exerting a significant effect on the continuous refinement of regional agricultural policies. Agricultural tax policy (β=-0.229, t-statistics=3.546, p-value=0.000 on tax awareness) and the efficiency of tax administration (β=-0.345, t-statistics=4.656, p-value=0.000 on tax awareness; β=-0.634, t-statistics=12.650, p-value=0.000 on tax moral) can have a significant effect on morale and tax awareness because there is clarity about the flow, benefits, and regulations of implementation can be easily understood by the public, forming a sense of responsibility, carrying out their obligations as taxpayers, and knowing what rights will be received if they obey tax regulations. Furthermore, tax morals encourage taxes so that tax awareness emerges and does what taxpayers should do. Finally, neither tax morale nor tax awareness exerts a statistically significant effect on agricultural productivity, given that productivity growth relies heavily on biophysical conditions rather than individual awareness and moral factors. Future research should replicate and extend this model using longitudinal designs, objective productivity measures, and samples drawn from diverse agricultural regions to enhance generalization.

AUTHOR CONTRIBUTIONS

M.S. Setyowati, the corresponding author, has contributed to data curation, investigation, resources, writing review and editing project administration. R.K. Hanum, has contributed to methodology, writing, original draft preparation, writing and review and editing, visualization, and supervision, and funding acquisition. All authors have read and agreed to the published version of the manuscript.

ACKNOWLEDGEMENT

The authors would like to thank to Directorate of Research and Development, Universitas Indonesia and member of the cluster research which facilitates this study to run well. This work was supported by the Hibah Publikasi Terindeks Internasional (PUTI) Q1 2024, Directorate of Research and Development, Universitas Indonesia [Grant numbers NKB-193/UN2.RST/HKP.05.00/2024].

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this

manuscript. In addition, ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

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During the preparation of this work the author(s) have used Artificial Intelligence (AI) [Quillbot] to [grammar checking]. After using this tool/service, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication.

ABBREVIATIONS

%	Percent
–	Until
=	Equal to
>	Greater than
β	Beta coefficient
|O/SD|	T statistics
ABM	Agriculture business management
AP	Agricultural productivity
ATP	Agriculture taxation policy
AI	Artificial Intelligence
AVE	Average variance extracted
BPF	Biophysical factor
CA	Cronbach alpha
CR	Composite reliability
EF	Economy factor
f^2	Effect size
FAO	Food and Agriculture Organization
IoT	Internet of things
HTMT	Heterotrit-Monotrait ratio
M	Sample mean
O	Original sample
NGOs	Non-governmental organization
p-value	Probability value
PIF	Production Input Factor
PLS-SEM	Partial least squares-structural equation modeling
R^2	Variance
RAP	Regional agricultural policy
RnD	Research and Development
SDGs	Sustainable development goals
SD	Standard Deviation
SmartPLS	Smart partial least squares
STF	Social technology factor
TA	Tax awareness
TM	Tax moral
TPB	Theory Of Planned Behaviour
USD	United States Dollar

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HOW TO CITE THIS ARTICLE:
Setyowati, M.S.; Hanum, R.K., (2027). The effect of agricultural taxes and local agricultural policies on enhancing food security and environmental sustainability. Global J. Environ. Sci. Manage., 13(1): 51-68.

DOI: 10.22034/gjesm.2027.01.03
URL: https://www.gjesm.net/article_735498.html