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CONVERGENCE IN THE AGRICULTURAL ECONOMIC INDUSTRY IN INDONESIA: A DYNAMIC
KONVERGENSI PADA INDUSTRI EKONOMI PERTANIAN DI INDONESIA: SEBUAH DINAMIKA

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ABSTRACT

In addition to labor, investment, consumption, government spending, and exports, this work attempts to include elements of health, education, and technology which are seen as important in strengthening the agricultural sector. The paper aimed to assess the relationship between labor, investment, consumption, government spending, and exports on agricultural GDP based on two formats. First, modeling without health, education, and technology. Second, modeling includes health, education, and technology. A series of data series were observed in simultaneous and partial regression modeling. The case study is Indonesia, where testing was conducted during 2010–2022. The empirical findings conclude two points: (1) involving health, education, and technology, results are better on agricultural GDP growth than without including all three; and (2) although initially health, education, and technology were very essential, only health has positive implications for GDP growth. Without these three variables, in the short term, labor, investment, consumption, government spending, and exports also play a role in the development of the agricultural economy in Indonesia. Thus, labor, consumption, and exports remain to be increased for the future of agricultural GDP by optimizing human capital through health, education, and technology.

Keywords: GDP of agricultural, income growth, data series regression, Indonesia

ABSTRAK

Selain tenaga kerja, investasi, konsumsi, belanja pemerintah, dan ekspor, karya ini mencoba untuk memasukkan elemen kesehatan, pendidikan, dan teknologi yang dipandang penting dalam memperkokoh sektor pertanian. Tujuan makalah yang ada adalah melakukan penilaian dalam hubungan antara tenaga kerja, investasi, konsumsi, belanja pemerintah, dan ekspor terhadap PDB pertanian berdasarkan dua format. Pertama, permodelan tanpa kesehatan, pendidikan, dan teknologi. Kedua, permodelan dengan memasukkan kesehatan, pendidikan, dan teknologi. Serangkaian data series diobservasi pada permodelan regresi simultan dan parsial. Kasus penelitian adalah Indonesia, dimana pengujian dilakukan sepanjang 2010–2022. Temuan empiris menyimpulan dua poin: (1) dengan melibatkan kesehatan, pendidikan, dan teknologi, hasilnya lebih baik terhadap pertumbuhan PDB pertanian ketimbang tanpa memasukkan ketiganya; serta (2) meski semula kesehatan, pendidikan, dan teknologi sangat esensial, tetapi hanya kesehatan yang berimplikasi positif terhadap pertumbuhan PDB. Tanpa ketiga variabel ini, untuk jangka pendek, tenaga kerja, investasi, konsumsi, belanja pemerintah, dan ekspor juga berperan terhadap pembangunan ekonomi pertanian di Indonesia. Dengan demikian, tenaga kerja, konsumsi, dan ekspor tetap harus ditingkatkan untuk masa depan PDB pertanian dengan mengoptimalisasi modal manusia melalui kesehatan, pendidikan, dan teknologi.

Kata kunci: PDB pertanian, pertumbuhan pendapatan, regresi *data series*, Indonesia

INTRODUCTION

In any nation, agriculture is a guarantee of human survival. In the development landscape, agriculture plays a primary role in driving other sectors. Take an example in developing markets, for example from Indonesia, where the majority of agricultural capabilities are still conventional. When talking about the conventional system, the added value of Indonesian agriculture is increasingly losing competitiveness compared to other product maneuvers such as manufacturing and services (Utomo *et al*., 2023). Naturally, agricultural productivity is supported by investment, labor, consumption, government spending, and export volume (Amare *et al*., 2021; Arifah & Kim, 2022; Blanco & Raurich, 2022; Borsari & Kunnas, 2020; Edeh *et al*., 2020; Hamilton *et al*., 2022; Kipruto & Nzai, 2018; Liu *et al*., 2022; Nyiwul & Koirala, 2022; Petre & Ion, 2019; Siaw *et al*., 2018; Wangusi & Muturi, 2015; Xing *et al*., 2023). However, advances in ecosystems and the existence of agriculture also need to change traditional ways to become more modern. Nolte & Ostermeier (2017) and Saleh *et al*. (2022) claim that to encourage agricultural aggressiveness, professional worker insights must be improved. Even so, agricultural governance also requires expansive technological stimulation (Self & Grabowski, 2007; Sinha, 2019).

From the era of reform to democracy, agricultural inequality lies in the adoption of technology and the level of mastery or knowledge surrounding intense planning, business incubation, procedures and strategies. Sometimes, agriculture is only used as a popularity project without thinking about long-term progress. At the same time, the obstacles to the revival of agriculture are the weakness of health, education, and innovative technology (Bawono & Widarni, 2021). Ironically, this contrasts with the agricultural portrait of nations that have spectacular agriculture. Agricultural progress is not only created by economic factors, but also brought about by education, farmer health, and strategic quality of technology. Superiorly, the benefits of an agricultural economy focused on revolutionizing technological capital, healthcare, and human resource competencies play evidence of being inclusive of well-being in China and the United States (Huffman, 2001; Huffman & Orazem, 2007; Kang & Hu, 2018).
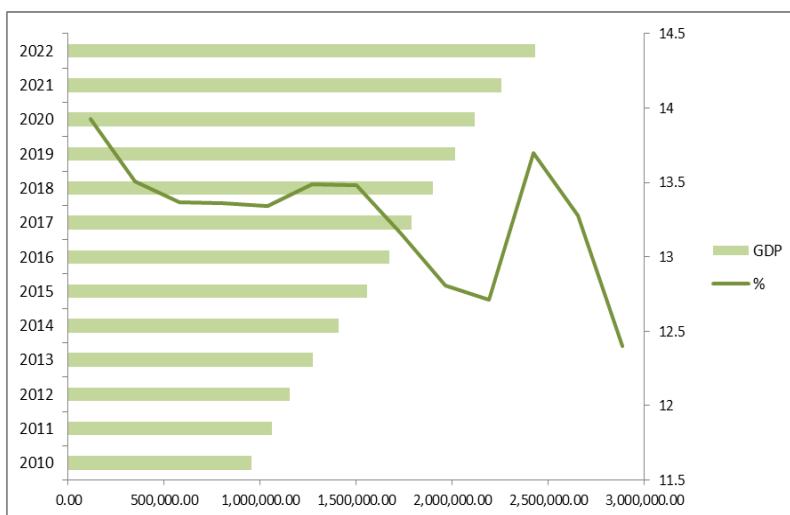
Source: Central Bureau of Statistics-Indonesia (2023a,b).

Graph 1. Profile of the GDP and Economic Growth of Agricultural in Indonesia

From year to year, the current price Gross Domestic Product (GDP) and Indonesia's agricultural economic growth are positive. In quantitative terms, the average nominal

value reached IDR 1,659,876.92 billion with an average growth of 13.27 percent. Until 2022, there will be a significant increase in the contribution of agricultural GDP. When viewed based on growth, there is an inconsistent polarization. The downward trend in growth in 2010–2014, to be precise, was from 13.93 percent to 13.34 percent. Then, it rose again to 13.49 percent in 2015 and contracted again in 2016–2019, where it was shown by 13.48 percent to 12.71 percent. Then, it increased by 13.7 percent in 2020 and decreased again since 2021-2022 which was confirmed to grow from 13.28 percent to 12.4 percent. Indonesia's agricultural GDP production capacity is indeed impressive, but it has not been matched by comprehensive growth. The peak of relatively rapid growth was detected in 2010 reaching 13.93 percent, while the smallest in 2022 was 12.4 percent (see Graph 1).

The lack of disbursed investment has triggered uncertainty about the future of agriculture in Indonesia. Smaller access to capital indicates lower agricultural performance, including the socio-economic resources used. In a more holistic lens, the premise built is how agriculture can absorb employment, attract investment, stimulate consumption, motivate the government to provide loans and guide partnerships, and establish collaboration in trade ties with exporters. So far, the focus on resolving the agricultural polemic has only been oriented towards its potential, but the main key is centered on a structure that accommodates and emphasizes the urgency of health, education and technology.

Nowadays, scientific magazines are still limited to identifying the role of the economic and financial dimensions of agricultural GDP. As is the case from Pakistan (Cloud & Alam, 2015; Chandio *et al*., 2016; Khan *et al*., 2021), Ethiopia (Emeru, 2023; Ketema & Negeso, 2020), Indonesia (Nugroho, 2017), Tanzania (Epaphra & Mwakalasya, 2017), Nigeria (Verter & Bečvářová, 2016), and developing countries (Nugroho *et al*., 2021) that the labor force, investment, consumption, government spending, and exports can grow agricultural GDP systematically. In other words, there are other endogenous aspects that are not investigated, giving rise to conceptual gaps. In the context of human capital, Czyżewski *et al*. (2021), Mehdi (2011), Wang *et al*. (2022), Zaika & Gridin (2020), and Zubović *et al*. (2009) argued that the pillars of health-education-technology are crucial for the agricultural chain. Ideally, the interactions between the three are also integrated and become an integral part of the agricultural economic corridor.

The benefits of the paper can inspire policy makers and academics. The results of the investigation are useful for evaluating agricultural programs. Stakeholders can determine the direction of agricultural policy through two options. First, opening and facilitating broad access to health, education and technology for agriculture. By channeling the right policies, the agricultural sector has bright prospects. Second, this paper does not review agricultural development at a macro level, but also in the field around the root of problems and obstacles in the agricultural sector (such as health, education and technology). By proposing these three factors, it is hoped that further studies can expand the scope beyond economics to enable performance improvement in the agricultural sector. Referring to the theoretical foundation, terminology, and relevance from an agricultural perspective, this work inspires the following two object. First, exploring collective causality between labor, investment, consumption, government spending and exports to agricultural GDP without elements of health, education and technology. Second, analyze the implications of labor, investment, consumption, government spending and exports on agricultural GDP in synergy with

health, education and technology. The contents of the paper are organized into six points: 1–Background introducing the purpose and objectivity of the research; 2–Materials and methods of mapping data design, variable instruments, and econometrics; 3–Results and discussion show empirical findings and to explore studies with literature-comparative arguments; 4–Conclusion reinforces evidence, proposes policy recommendations, simulates long-term ideas, and clarifies weaknesses in studies that invite new scientific treasures; and 5–Reference detailing bibliography.

RESEARCH METHODS
Database and Core of Variables

In general, the focus on the agricultural sector includes three subs: (1) agriculture, animal husbandry, hunting, and agricultural services; (2) forestry and logging; and (3) fisheries. The composition of the data is within thirteen periods or is set throughout 2010–2022. The observation component adapts, collects, and compiles secondary data. Data information materials are taken from official government documents. The statistical data authority sorted by the Central Bureau of Statistics-Indonesia publishes annual data via the website in several versions according to the data format. The standard operationalization of the variables is described below (see Table 1).

Table 1. Key of Variables

Variable Names	Unit	Indicators
GDP	Percent	Agricultural GDP at current prices
Labor force	Farmers (including laborers)	Workers aged 15 and over who work in the agricultural sector
Investment	IDR billion	Realization of domestic investment in agriculture
Consumption	Index	The exchange rate of farmers in consuming machinery expenditure, labor wages, land rent, transportation, wages, equipment, seeds and fertilizers, as well as other needs in the agricultural business
Government spending	IDR billion	Central government spending allocated to agriculture
Exports	Percent	Growth in exports of agricultural products
Health	Age	Life expectancy at birth on an agricultural scale
Education	Years	Average length of schooling for agricultural activists
Technology	Percent	Proportion of computer use and information skills in agricultural commodities

The nine variables have different arithmetic measures. Each variable describes its characteristics and definition, so it is useful to describe the construction of indicators. In essence, to understand the shape of the variable, it is broken down into two packages. GDP reflects the dependent variable which is controlled by independent variables including: labor, investment, consumption, government spending, exports, health, education, and technology. In principle, the independent variables are categorized to cover GDP.

Statistical Models

After the compilation phase, the data is modified and processed using data series regression. This technique aims to tabulate, verify data, and present an analysis that elaborates on whether there is a change or vice versa in the relationship between the linked variables. Basic statistics combines four mechanisms: descriptive statistics–analysis of variance (ANOVA)–coefficient of determination and correlation–partial effects. Fundamentally, the equation function of labor, investment, consumption, government spending, and exports to GDP were written as follows:

$$GDP_t=\alpha_0+\beta_1 \ln LAB_t+\beta_2 \ln INV_t+\beta_3 \ln CON_t+\beta_4 \ln GOV.SPE_t+\beta_5 EXP_t+e_1 \qquad (1)$$

For the second formulation, facilitating additional variations (health, education, and technology) expressed as follows:

$$GDP_t=\alpha_0+\beta_6 \ln LAB_t+\beta_7 \ln INV_t+\beta_8 \ln CON_t+\beta_9 \ln GOV.SPE_t+\beta_{10} EXP_t+\beta_{11} \ln HLT_t+$$
$$\beta_{12} EDU_t+\beta_{13} TECH_t+e_2 \qquad (2)$$

Where:

β_0	= Intercept
$\beta_1,..\beta_{13}$	= Slope coefficient
ln	= natural logarithm
t	= Time/period
e	= Error
GDP	= Gross domestic product
LAB	= Labor force
INV	= Investment
CON	= Consumption
$GOV.SPE$	= Government spending
EXP	= Exports
HLT	= Health
EDU	= Education
$TECH$	= Technology

Furthermore, relying on the function equation above, the decision-making hypothesis is transformed as follows:

$Null\ hypothesis = \rho > 5\ or\ 1\ percent \qquad (3)$

$Alternative\ hypothesis = \rho < 5\ or\ 1\ percent \qquad (4)$

The articulation of the two hypotheses offers: if the degree of significance is above 0.05 or 0.01, then the null hypothesis is accepted and the alternative hypothesis is rejected. Conversely, if the significance level is below 0.05 or 0.01, then the alternative hypothesis is accepted and the null hypothesis is rejected.

RESULTS AND DISCUSSION
Descriptive Statistics

The first parameter is descriptive statistics. Table 2 highlights the items in the descriptive statistics including: mean, standard deviation, minimum, and maximum. Uniquely, of all the variables, there are two (investment and government spending) and three (GDP, exports and technology) which have the same benchmark. On the other hand, the other four variables: labor, consumption, health, and education have different units of measurement.

Table 2. Descriptive Statistics from Variables

Variables	Mean	Std. Dev.	Min.	Max.
Labor	40,302,137.77	1,405,167.29	38,296,298	42,825,807
Investment	214,202.72	141,342.01	37,799.8	447,063.6
Consumption	106.22	4.88	98.3	112.67
Government spending	259,194.01	152,718.45	57,359	511,338.1
Export	2.57	7.94	-9.98	14.02
Health	70.86	.63	69.81	71.85
Education	8	.42	7.46	8.69
Technology	60.69	24.14	27.59	93.21
GDP	1,659,876.92	473,309.4	956,119.7	2,428,900.5
N	13	13	13	13

Source: Analysist result, 2024

Table 2 displays the three items in the descriptive statistics: mean and maximum for all variables sorted from highest to lowest score. Starting from labor, GDP, government spending, investment, consumption, health, technology, education, and exports. The standard deviation and minimum scores are exactly the opposite, where there is an anomaly between the two items. Hierarchically, the level of consumption which was previously ranked 5th in terms of mean and maximum, specifically in terms of the standard deviation, obtained 4.88 or was ranked seventh and health, which was originally ranked 6th, is now ranked eighth with a score of 0.63. Likewise, education is found in rank 7, in the standard deviation it is in the lowest position with a score of 0.42. In substance, at the minimum value, exports are the smallest and consistent with the mean and maximum values. There is a recession to export growth which is explained by the minimum score of -9.98. Interestingly, fantastic changes to the consumption and health of the minimum items. In outline, the authentic sample is 13.

ANOVA

In this subchapter, we dedicate an ANOVA test that examines the interrelationships of factors in agricultural GDP growth including: labor, investment, consumption, government spending, and exports without health, education, and technology or with these three dimensions. Concretely, the parallel effects among the variables are summarized in Table 3. Implicitly, Table 3 confirms that labor, investment, consumption, government spending, and exports have an effect on GDP. This is justified by a positive F-statistic score (*F-statistic = 2.056*) and a probability below 5 percent *(ρ = 0.024)*. This means that without health, education and technology initiatives, Indonesia's agricultural GDP could be significantly boosted by labor, investment, consumption, government spending and exports.

Table 3. Simultaneous levels excluding hHealth, eEducation, and tTechnology

Model	Sum of Squares	Mean Square	F-statistic	Sig.
Regression	1.432	.286	2.056	.024*
Residual	.656	.094		
Total	2.088			

(*) Significant level at 5%.
Source: Output from SPSS v.29.

Table 4. Simultaneous Levels with Health, Education and Technology Approaches

Model	Sum of Squares	Mean Square	F-statistic	Sig.
Regression	1.788	.224	3.986	.008**
Residual	.299	.075		
Total	2.087			

(**) Significant level at 1%.
Source: Output from SPSS v.29.

The results of the second evaluation still address employment, investment, consumption, government spending and exports on GDP growth, but take initiatives to empower health, education and technology. An ANOVA test targeting the relationship of labor, investment, consumption, government spending, and exports complemented by health, education, and technology proves a dominant influence (*F-statistic = 3.986*; *ρ = 0.008*) or below 1 percent. The aspects of health, education and technology present more positive effects than without these three elements, thus allowing for a significant influence on increasing Indonesia's agricultural GDP (see Table 4).

Coefficient of Determination and Correlation

The strength of the relationship between variables, grouped into two. First, the coefficient of determination tests the critical level and error value in a relationship. Second, the attention of the correlation coefficient to correct the sensitivity of the relationship of the independent variable to the dependent. Table 5 and Table 6 give signals on the determination and correlation scores.

Table 5. Correlation and Determination (excluding Health, Education and Technology)

Model	R	R-Square	Adjusted R-Square	Std. Error of the Estimate
1	.828	.686	.461	.30612

Source: Analysist result, 2024.

Table 6. Correlation and Determination (including Health, Education and Technology)

Model	R	R-Square	Adjusted R-Square	Std. Error of the Estimate
1	.926	.857	.570	. 27360

Source: Analysist result, 2024.

The results of both classifications show that labor, investment, consumption, government spending, and exports (excluding health, education, and technology) have a determining power of 82.8 percent, of which it is undeniable that there are still confounding factors reaching 17.2 percent. Unfortunately, this was also followed by the acquisition of a correlation whose coefficient score reached 68.6 percent indicating that the preference for the model built was "moderate". Normally, the critical point of the relationship in agricultural GDP is reached by interconnected lines, where it has not been shown by integrative linkages.

In the second model, the strength of the relationship in employment, investment, consumption, government spending, and exports to GDP growth upgraded by health, education, and technology is concluded to be "high". This superiority is indicated by a coefficient of determination of 92.6 percent and a correlation score of 85.7 percent. Rationally, by applying health, education and technology, labor, investment, consumption, government spending and exports are the most reasonable options to boost Indonesia's agricultural GDP. With a residual score of 7.4 percent, it is considered outside the variables that support GDP growth.

Partial Estimation

Individually, Table 7 examines the interrelationship of variables without the mediation of health, education and technology in the GDP growth cycle. The constant implies short-term causality, which is positive ($\beta = 209.496$; $\rho = 0.039$). Yet, flows of investment and government spending have had a negative impact on agricultural GDP. Unstandardized coefficients and significance on investment ($\beta = -0.678$; $\rho = 0.405$) and government spending ($\beta = -0.166$; $\rho = 0.795$) describe inequality. The suitability of the hypothesis is actually shown by labor ($\beta = 11.084$; $\rho = 0.001$), consumption ($\beta = 1.720$; $\rho = 0.029$), and exports ($\beta = 0.017$; $\rho = 0.006$) which have a significant impact on Indonesia's agricultural GDP in the long term.

Table 7. Partial Prediction without HET and using HET

Model	Without HET		Using HET	
	β (ρ-value)	t-statistic (SE)	β (ρ-value)	t-statistic (SE)
Constant	209.496*	2.054	-292.808	-.831
	(.039)	(101.989)	(.453)	(352.472)
ln_Labor	11.084**	1.847	1.648*	1.630
	(.001)	(.061)	(.019)	(.131)
ln_Investment	-.678	-.885	.766	.696
	(.405)	(.765)	(.524)	(1.100)
ln_Consumption	1.720*	2.226	2.696**	3.019
	(.029)	(.156)	(.000)	(.242)
ln_Government spending	-.166	-.270	2.121*	1.437
	(.795)	(.614)	(.042)	(.476)
Export	.017**	1.201	.054*	2.066
	(.006)	(.014)	(.028)	(.026)
ln_Health	–	–	74.467**	1.465
			(.007)	(.389)
Education	–	–	-.240	-.179
			(.867)	(1.342)
ln_Technology	–	–	-7.045	-2.055
			(.109)	(3.429)
Obs.	13	13	13	13

(*) Significant level at 5% and (**) Significant level at 1%; Abbreviation: HET (health, education and technology) and SE (std. error).
Source: Analysist result, 2024

With the involvement of health, education and technology, it is proven that it does not guarantee short-term effects in influencing Indonesia's GDP. Table 7 also presents a decreasing trend when including elements of health, education, and technology in agricultural GDP productivity, where the slope is constant, and the probability is negative ($\beta = -292.808$; $\rho = 0.453$). Of the variables selected in the second model, five variables were found that had a significant effect on agricultural GDP growth. These

variables are labor ($\beta = 1.648$; $\rho = 0.019$), consumption ($\beta = 2.696$; $\rho = 0.000$), government spending ($\beta = 2.121$; $\rho = 0.042$), exports ($\beta = 0.054$; $\rho = 0.028$), and health ($\beta = 74.467$; $\rho = 0.007$). Practically, investment ($\beta = 0.766$; $\rho = 0.524$), education ($\beta = -0.240$; $\rho = 0.867$), and technology ($\beta = -7.045$; $\rho = 0.109$) which are validated do not significantly affect GDP. Education and technology have proven not to actualize Indonesia's agricultural GDP in the long term. Too, the status of the two around the variable model also indicates that they cannot replace the role of the other five endogenous factors.

The wave of globalization allowed the economy to open up to agricultural markets. Besides that, it is at the same time risky and raises a fatal alarm if it is not followed by permanent cross-layer optimization. As this work illustrates, even though the acceleration of agriculture in Indonesia is not only handled by elements of labor, domestic investment, consumption, government spending, and exports, but also includes aspects of health, education, and technology, the results are inconsistent with an integrated commitment. Therefore, it cancels the growth of the agricultural economy. The consequences of the human capital development program are contradictory in quality, triggering a crisis towards the planned mission. Surprisingly, although the simultaneous effect of concluding naturally and post-implementing health, education, and technology can boost GDP growth, it contrasts with the partial effect. The statistical output actually concludes that the inclusion of education and technology in the regression model is proven to reduce agricultural GDP.

From the existing papers, there are few empirical examinations that link or combine health, education, and technology into the factors that affect national agricultural income. In general, the discussion is limited to the relationship between labor, investment, consumption, government spending, and exports to agricultural GDP. Nevertheless, the role of these factors is very vital and allows for better changes in agricultural economic performance. Health, education, and technology plays an important role in the relationship between labor, investment, consumption, government spending, and exports on agricultural economy. Additionally, this study finds that labor has significant implications for agricultural GDP growth (either with the support of health, education and technology or vice versa). In comparison, it proves that improvements, agricultural technology and health play a role in developing farmers' resources. The transition from traditional to modern agriculture in the majority of poor and middle-income countries, especially India, is characterized by improvements in farmer skills mediated by health systems, educational investments, and technology (Huffman & Orazem, 2007; Sharma *et al*., 2024). As a result, labor in the agricultural sector experienced a surplus, thus making farmers' living standards (including real income per capita) higher over time. From other literature, Priyagus *et al*. (2024) links the role of government spending (health, education and technology) on the prosperity of Indonesian farmers. As a result, government initiatives through improving access to health, scholarships and technology have a positive relationship to farmers' exchange rates. Whether supported by health, education and technology or vice versa, investment still does not have a significant effect on agricultural GDP growth. This is in conflict with the study of Siddique *et al*. (2018), where investment in education and health facilities has a progressive interaction with economic growth. Meanwhile, technological capital has an inverse relationship to economic growth.

Furthermore, the relevance of consumption to agricultural GDP with or without health, education and technology is positive. This indicates that consumption in both

models can influence agricultural economic growth. As is known, industrial production in Kazakhstan is highly dependent on energy prices. Likewise, Kazakhstan's economy is generally controlled by agricultural production. Seeing this complex situation, Abdibekov *et al*. (2024) tested the relationship between the two. The statistical results visualize a positive connection between the two of them on GDP growth. Meanwhile, education and health enable widespread trade openness through technology transfer. Like conditions in developing markets, technology transfer can be integrated into public investment and can change the productivity of economic growth towards better social welfare (Yu *et al*., 2022). Finally, with policy interventions in the fields of health, education and technology or not supported by these three, the study found that exports have a significant effect on agricultural GDP in Indonesia.

Charlton *et al*. (2021) reveal that the growing agricultural labor market will bring transformation to the environment. Innovative health services are able to boost labor supply to achieve an inclusive economy (Chen *et al*., 2021). In principle, public health influences agricultural production inputs, including the efficiency of labor use (Venkataramani *et al*., 2010). From this version of the study, neither education nor health are able to create added value for economic productivity in the agricultural sector. Substantively, this is in contrast to some of the publication in previous editions. Ninh (2021) states that through quality education, economic welfare for farming households in rural areas located in the Mekong River Delta–Vietnam is increasing. In economic development, one alternative policy to stimulate investment in human resources in the agricultural sector is through education. Imbalances in prosperity can be changed with planned preparedness, especially education. Luh (2017) states that education provides concrete evidence of agricultural production of certain commodities in East Asia. To reduce economic discrimination in the agricultural sector, it can start from village development. Education has a significant influence on agricultural productivity. Kabiru & Arshad (2019) argue that education has positive implications for agricultural productivity in Katsina State–Nigeria. Another issue that is also highlighted is how technology adoption can stimulate agricultural growth significantly. In Sub–Saharan Africa, there is a positive relevance of the digital economy to agricultural productivity (Wang *et al*., 2024). In the case of Shandong Province–China, digital-based agricultural technology has multiplied and is complementary to job absorption in the agricultural sector (Li & Zhang, 2023). In a national setting such as China, the increasing trend of the digital economy in the operation of agricultural technology innovation has an integral impact on the agricultural environment (Zhang *et al*., 2023). Technically, technology plays a crucial role in the transformation of supply chain management in the agricultural sector (Abdullahi *et al*., 2024). In its actualization, the use of technological innovation systems is a determinant in maintaining economic growth in the agricultural sector in Bihar–India (Sinha, 2019).

The analogy above has been discussed by Kabiru (2020), Lin & Wu (2021), Ninh (2021), Njura *et al*. (2020), O'Donoghue & Heanue (2018), Pingali *et al*. (2019), and Yu *et al*. (2023) explained that educational creativity and technology transfer will determine continuous agricultural management. From Katsina–Nigeria, Vietnam, Kenya, Ireland, China and India, the more these two pillars are enhanced, the more they shape agricultural effectiveness. The level of agricultural maturity in a particular area is highly dependent on educational participation. By providing an equitable education, acceptance of technology is easily accepted. Ease of technology and education can also

reduce some of the work, especially for those who have low understanding in operating agriculture.

From the existing issues, innovation in the world of health nutrition awakens farmers to take opportunities, learn, behave and stimulate better physique in the management of agricultural land. As a result, food security is a priority. Agriculture cannot be ignored as if it is a non-formal form of routine, but this profession can be developed and even open up employment opportunities widely. For the global case, middle and low income countries, India, rural areas–Ethiopia, and in Bima–Indonesia, prosperity is realized by a two-way connection between health and agricultural income (Donham & Thu, 1993; Hawkes & Ruel, 2006; Tenriawaru *et al*., 2021; Thow *et al*., 2018; Ulimwengu, 2009). By controlling the internal environment, conducive agricultural targets can be highlighted.

CONCLUSION

The synopsis of this work is related to clusters affecting agricultural GDP. The test links the effects of labor, investment, consumption, government spending, and exports on agricultural GDP and assumptions involving health, education, and agricultural technology. The regression results conclude that without the attributes of health, education, and technology, labor, consumption, and exports significantly influence agricultural GDP growth. Here, the most conspicuous variable is exports. In other schemes, apart from government spending and health, these three variables also have a significant impact on Indonesia's agricultural GDP. Regardless of health, education and technology, fixed investment has no effect on GDP. Unfortunately, through the involvement of health, education and technology does not change agricultural economic growth in a positive direction.

Realizing the facts, we criticize policies that often overlap among agricultural stakeholders in overseeing regulatory forums, technocratic planning, and a literacy mindset. The reason is, for thirteen periods, actors in macroeconomic policy have neglected education and technology in agriculture. Only health is able to bridging the relationship in the agricultural economic model. The rest, education and applied technology, also do not create an investment climate. In the future, practical suggestions are proposed to regulators to prioritize the harmonization of the investment framework and remuneration for farmers. Besides that, the sustainability of agricultural sector which is increasingly sinking, must also be improved in a competitive manner. The limitations of scientific work lie in the less comprehensive variables of agricultural education and technology. Based on this experience, advanced expectations can think logically and review the actual indicators outside the analysis model to lead to a shining agriculture.

REFERENCES

Abdibekov, S. U., Gridneva, Y. E., Kaliakparova, G. S., Amankeldi, N. A., Perneyeva, G. A., Kulbay, B. S., & Myrzabekkyzy, K. (2024). The relationship between energy consumption, agricultural and industrial production, and economic growth: ARDL border value approach in the Case of Kazakhstan. *International Journal of Energy Economics and Policy, 14*(3), 79–86. https://doi.org/10.32479/ijeep.15844

Abdullahi, H. O., Mohamud, I. H., & Abdirazak Osman Mohamud Gele, A. O. M., & Kafi, A. (2024). The role of technology in transforming agricultural supply chain management: Systematic literature review. *Journal of Logistics, Informatics and*

Service Science, 11(1), 239–251. https://doi.org/10.33168/JLISS.2024.0116

Amare, M., Shiferaw, B., Takeshima, H., & Mavrotas, G. (2021). Variability in agricultural productivity and rural household consumption inequality: Evidence from Nigeria and Uganda. *Agricultural Economics, 52*(1), 19–36. https://doi.org/10.1111/agec.12604

Arifah, K. F., & Kim, J. (2022). The importance of agricultural export performance on the economic growth of Indonesia: The Impact of the COVID-19 pandemic. *Sustainability, 14*(24), 16534. https://doi.org/10.3390/su142416534

Awan, A. G., & Alam, Q. (2015). Impact of agriculture productivity on economic growth: A case study of Pakistan. *Industrial Engineering Letters, 5*(7), 27–33.

Bawono, S., & Widarni, E. L. (2021). Human capital, technology, and economic growth: A case study of Indonesia. *Journal of Asian Finance Economics and Business, 8*(5), 29–35. https://doi.org/10.13106/jafeb.2021.vol8.no5.0029

Blanco, C., & Raurich, X. (2022). Agricultural composition and labor productivity. *Journal of Development Economics, 158*, 102934. https://doi.org/10.1016/j.jdeveco.2022.102934

Borsari, B., Kunnas, J. (2020). Agriculture Production and Consumption. In: *Leal Filho, W., Azul, A.M., Brandli, L., özuyar, P.G., Wall, T. (eds) Responsible Consumption and Production*. Encyclopedia of the UN Sustainable Development Goals. Springer, Cham. https://doi.org/10.1007/978-3-319-95726-5_78

Central Bureau of Statistics-Indonesia. (2023a). PDB seri 2010 (milyar Rupiah), 2010. Retrieved from https://www.bps.go.id/indicator/11/65/13/-seri-2010-pdb-seri-2010.html

Central Bureau of Statistics-Indonesia. (2023b). Distribusi PDB triwulanan seri 2010 atas dasar harga berlaku (persen), 2022. Retrieved from https://www.bps.go.id/indicator/11/106/1/-seri-2010-distribusi-pdb-triwulanan-seri-2010-atas-dasar-harga-berlaku.html

Chandio, A. A., Jiang, Y., Rehman, A., & Jingdong, L. (2016). Impact of government expenditure on agricultural sector and economic growth in Pakistan. *American-Eurasian Journal of Sustainable Agriculture, 16*(8), 1441–1448. https://doi.org/10.5829/idosi.aejaes.2016.16.8.12991

Charlton, D., Rutledge, Z., & Taylor, E. (2021). Chapter 77 - Evolving agricultural labor markets. *Handbook of Agricultural Economics, 5*, 4075–4133. https://doi.org/10.1016/bs.hesagr.2021.10.003

Chen, C., Zhang, Y., Bai, Y., & Li, W. (2021). The impact of green credit on economic growth-The mediating effect of environment on labor supply. *PloS one, 16*(9), e0257612. https://doi.org/10.1371/journal.pone.0257612

Czyżewski, B., Sapa, A., & Kułyk, P. (2021). Human capital and eco-contractual governance in small farms in Poland: Simultaneous confirmatory factor analysis with ordinal variables. *Agriculture, 11*(1), 46. https://doi.org/10.3390/agriculture11010046

Donham, K. J., & Thu, K. M. (1993). Relationships of agricultural and economic policy to the health of farm families, livestock, and the environment. *Journal of the American Veterinary Medical Association, 202*(7), 1084–1091.

Edeh, C. E., Eze, C. G., & Ugwuanyi, S. O. (2020). Impact of foreign direct investment on the agricultural sector in Nigeria (1981–2017). *African Development Review, 32*(4), 551–564. https://doi.org/10.1111/1467-8268.12460

Emeru, G. M. (2023). Effect of public expenditure on economic growth in the case of

Ethiopia. *The Scientific World Journal, 2023*, 9305196. https://doi.org/10.1155/2023/9305196

Epaphra, M., & Mwakalasya, A. H. (2017). Analysis of foreign direct investment, agricultural sector and economic growth in Tanzania. *Modern Economy, 8*(1), 111– 140. http://dx.doi.org/10.4236/me.2017.81008

Hamilton, S. F., Richards, T. J., Shafran, A. P., Vasilaky, K. N. (2022). Farm labor productivity and the impact of mechanization. *American Journal of Agricultural Economics, 104*(4), 1435–1459. https://doi.org/10.1111/ajae.12273

Hawkes, C., & Ruel, M. (2006). The links between agriculture and health: An intersectoral opportunity to improve the health and livelihoods of the poor. *Bulletin of the World Health Organization, 84*(12), 984–990. https://doi.org/10.2471/blt.05.025650

Huffman, W. E. (2001). Human capital: Education and agriculture. *Handbook of Agricultural Economics, 1*(Part A), 333–381. https://doi.org/10.1016/S1574-0072(01)10010-1

Huffman, W. E., & Orazem, P. (2007). The role of agriculture and human capital in economic growth: Farmers, schooling, and health. *Staff General Research Papers Archive 12003*. Iowa State University, Department of Economics. Retrieved from https://dr.lib.iastate.edu/entities/publication/861025d6-3c5b-41e5-88c1-6b16b6858dd2

Jiuhardi, J., Hasid, Z., Darma, S., & Darma, D. C. (2022). Sustaining agricultural growth: Traps of socio–demographics in emerging markets. *Opportunities and Challenges in Sustainability, 1*(1), 13– 28. https://doi.org/10.56578/ocs010103

Kang, J-M., & Hu, J-Y. (2018). Impact of information technology human capital on agricultural economic growth. Advances in Economics, Business and Management Research (AEBMR), volume 60. *Proceedings of the 4th Annual International Conference on Management, Economics and Social Development (ICMESD 2018)*. https://doi.org/10.2991/icmesd-18.2018.164

Kabiru, S. A. (2020). The relationship between education and agricultural productivity: The moderating effect of NGO. *Universal Journal of Educational Research, 8*(3), 866–871. https://doi.org/10.13189/ujer.2020.080317

Kabiru, S. A., & Arshad, R. (2019). The effect of education on agricultura productivity: Implication for rural development. *Journal of Management and Economic Studies, 1*(6), 28–35. https://doi.org/10.26677/TR1010.2019.152

Ketema, A. M., & Negeso, K. D. (2020). Effect of climate change on agricultural output in Ethiopia. *Jurnal Perspektif Pembiayaan Dan Pembangunan Daerah, 8*(3), 195– 208. https://doi.org/10.22437/ppd.v8i3.9076

Khan, Z. A., Koondhar, M. A., Khan, I., Ali, U., & Tianjun, L. (2021). Dynamic linkage between industrialization, energy consumption, carbon emission, and agricultural products export of Pakistan: An ARDL approach. *Environmental Science and Pollution Research International, 28*(32), 43698–43710. https://doi.org/10.1007/s11356-021-13738-4

Kipruto, T. A., & Nzai, C. (2018). Effect of government expenditure on agriculture output performance in Kenya. *International Journal of Economics, Commerce and Management, 6*(10), 190–202.

Li, F., & Zhang, W. (2023). Research on the effect of digital economy on agricultural labor force employment and its relationship using SEM and fsQCA methods. *Agriculture, 13*(3), 566. https://doi.org/10.3390/agriculture13030566

Lin, B., & Wu, C. C. (2021). Study on the impact of agricultural technology progress on grain production and farmers' income. *Open Access Library Journal, 8*(11), 1–9. https://doi.org/10.4236/oalib.1107991

Liu, W., Long, S., Wang, S., Tang, O., Hou, J., & Zhang, J. (2022). Effects of smart agricultural production investment announcements on shareholder value: Evidence from China. *Journal of Management Science and Engineering, 7*(3), 387–404. https://doi.org/10.1016/j.jmse.2021.12.007

Luh, Y-H. (2017). The Impact of education on agricultural productivity: Evidence from East Asian economies. *International Journal of Food and Agricultural Economics, 5*(4), 11–24. https://doi.org/10.22004/ag.econ.266460

Mehdi, S. (2011). The effects of human capital on agricultural sector: The case of Iran. *European Journal of Experimental Biology, 1*(4), 55–65.

Ninh, L. K. (2021). Economic role of education in agriculture: Evidence from rural Vietnam. *Journal of Economics and Development, 23*(1), 47–58. https://doi.org/10.1108/JED-05-2020-0052

Njura, H. J., Kubai, K. I., Taaliu, S. T., & Khakame, K. S. (2020). The relationship between agricultural teaching approaches and food security in Kenya. *Education Research International, 2020*, 8847864. https://doi.org/10.1155/2020/8847864

Nolte, K., & Ostermeier, M. (2017). Labour market effects of large-scale agricultural investment: Conceptual considerations and estimated employment effects. *World Development, 98*, 430–446. https://doi.org/10.1016/j.worlddev.2017.05.012

Nugroho, A. D., Bhagat, P. R., Magda, R., & Lakner, Z. (2021). The impacts of economic globalization on agricultural value added in developing countries. *PLoS ONE, 16*(11), e0260043. https://doi.org/10.1371/journal.pone.0260043

Nugroho, P. E. (2017). Government expenditure, agricultural productivity, and poverty reduction in Indonesia: A simultaneous equations approach. *Journal of the Graduate School of Asia-Pacifc Studies, 34*, 39–54.

Nyiwul, L., & Koirala, N. P. (2022). Role of foreign direct investments in agriculture, forestry and fishing in developing countries. *Future Business Journal, 8*(1), 50. https://doi.org/10.1186/s43093-022-00164-2

O'Donoghue, C., & Heanue, K. (2018). The impact of formal agricultural education on farm level innovation and management practices. *Journal of Technology Transfer, 43*(4), 844–863. https://doi.org/10.1007/s10961-016-9529-9

Petre, I. L., & Ion, R. A. (2019). The impacts of the investments in agriculture on economic growth in rural communities in Romania. *Economics of Agriculture, 66*(4), 955–963. https://doi.org/10.5937/ekoPolj1904955L

Pingali, P., Aiyar, A., Abraham, M., Rahman, A. (2019). Agricultural technology for increasing competitiveness of small holders. In: *Transforming Food Systems for a Rising India*. Palgrave Studies in Agricultural Economics and Food Policy. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-030-14409-8_9

Priyagus, P., ZA, S. Z., Widayanti, N., & Darma, D. C. (2024). Do agricultural reforms increasing the prosperity of Indonesian farmers?. *Jurnal AGRISEP: Kajian Masalah Sosial Ekonomi Pertanian Dan Agribisnis, 23*(1), 1–22. https://doi.org/10.31186/jagrisep.23.01.1-22

Saleh, H., Surya, B., Annisa Ahmad, D. N., & Manda, D. (2020). The role of natural and human resources on economic growth and regional development: With discussion of open innovation dynamics. *Journal of Open Innovation: Technology, Market, and Complexity, 6*(4), 103. https://doi.org/10.3390/joitmc6040103

Self, S., & Grabowski, R. (2007). Economic development and the role of agricultural technology. *Agricultural Economics, 36*(3), 395–404. https://doi.org/10.1111/j.1574-0862.2007.00215.x

Sharma, R., Gupta, S., Khetre, R. D., Sakthibala, S., Ramasamy, R., & Lal, S. K. (2024). Modern education techniques and technology for economical growth of India. *Educational Administration: Theory and Practice, 30*(4), 6199–6205. https://doi.org/10.53555/kuey.v30i4.2374

Siaw, A., Jiang, Y., Pickson, R., & Dunya, R. (2018) Agricultural exports and economic growth: A disaggregated analysis for Ghana. *Theoretical Economics Letters, 8*(11), 2251–2270. https://doi.org/10.4236/tel.2018.811147

Siddique, H. M. A., Mohey-ud-din, G., & Kiani, A. (2018). Health, education and economic growth nexus: Evidence from middle income Countries. *Global Social Sciences Review, 3*(4), 68–86. http://dx.doi.org/10.31703/gssr.2018(III-IV).05

Sinha, J. K. (2019). Influence of technologies on the growth rate of GDP from agriculture: A case study of sustaining economic growth of the agriculture sector in Bihar. *Statistical Journal of the IAOS, 35*(2), 277–287. https://doi.org/10.3233/SJI-180436

Tenriawaru, A. N., Yustisia, I., Arsyad, M., Jamil, M. H., & Kawamura, Y. (2021). The linkages between health and agriculture sectors through regional expenditure review. *Gaceta Sanitaria. 35*(Supplement 2), S596–S600. https://doi.org/10.1016/j.gaceta.2021.10.093

Thow, A. M., Verma, G., Soni, D., Soni, D., Beri, D. K., Kumar, P., Siegel, K. R., Shaikh, N., & Khandelwal, S. (2018). How can health, agriculture and economic policy actors work together to enhance the external food environment for fruit and vegetables? A qualitative policy analysis in India. *Food Policy, 77*, 143–151. https://doi.org/10.1016/j.foodpol.2018.04.012

Utomo, R. P., Kuleh, Y. & Darma, D. C. (2023). Conventional vs modern: Which approach is better for the success of agricultural cooperatives?. *Agricultural and Resource Economics*, *9*(4), 26-49. https://doi.org/10.51599/are.2023.09.04.02

Ulimwengu, J. (2009). Farmers' health and agricultural productivity in rural Ethiopia. *African Journal of Agricultural and Resource Economics, 3*(2), 83–100.

Venkataramani, A. S., Shanmugam, K. R., & Ruger, J. P. (2010). Health, technical efficiency, and agricultural production in Indian Districts. *Journal of Economic Development, 35*(4), 1–23.

Verter, N., & Bečvářová, V. (2016). The impact of agricultural exports on economic growth in Nigeria. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis, 64*(2), 691–700. https://doi.org/10.11118/actaun201664020691

Wang, J., Lin, Q., & Zhang, X. (2024). How does digital economy promote agricultural development? Evidence from Sub-Saharan Africa. *Agriculture, 14*(1), 63. https://doi.org/10.3390/agriculture14010063

Wang, S. L., Hoppe, R. A., Hertz, T., & Xu, S. (2022). Farm labor, human capital, and agricultural productivity in the U.S. *ERR-302*. U.S. Department of Agriculture, Economic Research Service. Retrieved from https://www.ers.usda.gov/webdocs/publications/103267/err-302.pdf?v=8829

Wangusi, C. N., & Muturi, W. (2015). Impact of agricultural public spending on agricultural productivity: Case study of Kenya. *International Journal of Sciences: Basic and Applied Research, 24*(4), 180–187.

Xing, X., Zhang, Q., Ye, A., & Zeng, G. (2023). Mechanism and empirical test of the

impact of consumption upgrading on agricultural green total factor productivity in China. *Agriculture, 13*(1), 151. https://doi.org/10.3390/agriculture13010151

Yu, Q., Wu, Y., Chen, X., Zhang, L., & Liang, Y. (2023). Do China's national agricultural science and technology parks promote county economic development? An empirical examination based on multi-period DID methods. *Agriculture, 13*(1), 213. https://doi.org/10.3390/agriculture13010213

Yu, Y., Alvi, S., Tufail, S., Nawaz, S. M. N., Peng, M. Y-P., & Ahmad, N. (2022). Investigating the role of health, education, energy and pollution for explaining total factor productivity in emerging economies. *Humanities and Social Sciences Communications, 9*(1), 79. https://doi.org/10.1057/s41599-022-01083-x

Zaika, S., & Gridin, O. (2020). Human capital development in the agricultural economy sector. *Technology Audit and Production Reserves, 1/4*(51), 30–36. https://doi.org/10.15587/2312-8372.2020.194444

Zhang, Y., Ji, M., & Zheng, X. (2023). Digital economy, agricultural technology innovation, and agricultural green total factor productivity. *Sage Open, 13*(3), 1–13. https://doi.org/10.1177/21582440231194388

Zubović, J., Domazet, I., & Stošić, I. (2009). Development of human capital as a tool for improving productivity of agricultural sector – Case of Serbia. *Paper prepared for presentation at the 113th EAAE Seminar "The Role of Knowledge, Innovation and Human Capital in Multifunctional Agriculture and Territorial Rural Development"*. Belgrade, Republic of Serbia, December 9-11, 2009. Retrieved from https://core.ac.uk/download/pdf/6689993.pdf