Land Conversion: An Economic Boon or Bane in Central Luzon's Agricultural Sector

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Abstract— *This study explores the economic impact of land conversion on the agricultural sector in Central Luzon from 1981 to 2021, using the Cobb-Douglas production function as the analytical framework. Employing key econometric tools—such as the Augmented Dickey-Fuller (ADF) test for stationarity, Johansen cointegration for long-term relationships, and Ordinary Least Squares (OLS) regression—the analysis shows that all variables are stationary. Farm size is positively correlated with rice output, while labor use and the man-land ratio negatively affect production. The findings highlight the vital role rice production plays in the household income of Central Luzon, indicating that while it has contributed to modest but steady economic growth, land conversion has acted as an economic boon, promoting development opportunities in the region. The study concludes by urging policymakers to craft strategies that enhance agricultural productivity and ensure sustainable income for farmers, contributing to broader economic prosperity. Future research should examine the specific types of land being converted from agriculture, assess the long-term impacts on different crops, and consider how land conversion affects the region's overall agricultural sustainability. This will provide a more comprehensive understanding of the broader implications of land use changes on Central Luzon's economy.*

Keywords— Arable Land, Central Luzon, Employment Rate, Man-land Ratio, Land Conversion.

I. INTRODUCTION

Urbanization has proven to be a vital tool for ensuring a healthy economy in every country (Pradhan et al., 2021). In a study by Magazzino and Mele (2021), improving transportation by putting road-building projects across western counties in more than 15 areas is one strategy to support economic growth in China. However, Shaban et al. (2022) assert that the impact on economic growth may differ depending on the degree of urbanization and economic development of a particular nation. The possible causes of urbanization include a natural increase in the man-land ratio, which refers to the number of farmers who have lost their jobs due to land conversion, rural-to-urban migration, which affects the employment and income opportunities of the people, and the productivity of the land that determines the capability of the farmland to be transformed. Because there is a hope of having a better standard of living in the urban areas, people are starting to migrate, causing a continuous increase in the population.

As a result, it is necessary to meet the needs of the people in terms of housing, work, and educational prospects, in addition to providing easier access to social services and more chances for social and cultural activities (OLCreate, n.d.). However, while civilization causes towns and cities to thrive, it also has negative implications regarding agriculture since it affects the lands, particularly in the rural areas, through land conversion. For this to occur, urbanization considers the farmland values and their determinants, such as location, distance, travel time, size, farm income, soil productivity, and the like (Tavares et al., 2022).

Transforming agricultural lands into non-agricultural or manufacturing ones is considered as industrialization. According to Harini et al. (2018), demand for land rises along with population growth and socioeconomic activity. Without keeping pace with land supply, agricultural land will decline, leading to decreased agricultural production in an area. Hence, it is evident how it typically occurs in less-developed countries such as the Philippines since there is a need for commercial, residential, and industrial development, especially in the country's rural areas (Fulgar, 2023). However, it also mentioned how it affected the food security and livelihoods of the people relying on the agricultural sector. In a study by Bravo (2017), significant land conversion brought about by urbanization and industrialization altered the agricultural environment of the Metropolitan Manila area. It substantially decreased the amount of land used for crop production. Additionally, it put pressure on the periphery of cities, which made land use conversion in cities inevitable.

According to a study by Dait (2023), because rice, or palay, has always been at the core of Philippine agricultural policy, it is regarded as a highly political commodity in the nation. The country's rice basket, which is located in Region III, or Central Luzon, and is made up of the provinces of Aurora, Bataan, Bulacan, Nueva Ecija, Pampanga, Tarlac, and Zambales, is often the site of farmland conversion because it is a thoroughfare and a popular destination for real estate developers seeking more reasonably priced housing outside of Metro Manila (Fair Finance Asia, 2021). Based on the report of the Department of Agriculture (DA), from several years ago up to now, Central Luzon is classified as the top producer of palay in the Philippines, specifically in Nueva Ecija. The province is known as the “Rice Granary of the Philippines” since it is the country's number one producer of palay, producing 13,499.54 thousand metric tons from 4006.4 in 2003 (Santos et al., 2018). Also, in an article by Tecson (2023), the region has been a consistent top producer during recent years by producing 867,084 metric tons of palay, contributing 18.1 percent to the country’s agricultural output. However, since farm inputs are continuously increasing in price, farmers tend to use chemical fertilizers and pesticides and, worse, sell their lands to commercial developers, which are privately owned, just like in Candaba Swamp in Pampanga, leading to a threat to biodiversity and food security (Costamero, 2023).

In an article written by Navales in 2019, he said land use conversion projects such as roads and industrialized areas have been covering productive lands in the region, threatening the livelihood of the farmers, food security, and self-sufficiency of the people in the area. Moreover, the presence of the North Expressway during 1981 was very noticeable in that it transformed 9.07 hectares of land into asphalted or cemented streets. In 1991, an average of ten percent (10%) of agricultural land in Plaridel, Bulacan, was converted to residential, commercial, or institutional areas per year, covering 361.27 hectares of total land area to roads and built-up areas (Nantes, 2011). Large national real estate firms have developed and are currently developing several housing developments and subdivisions in Bulacan, including three San Jose del Monte subdivisions and a 300-hectare residential property in Malolos (Arceo-Dumlao et al., 2021).

Therefore, it will be difficult for recognized beneficiaries of land-use conversion to get a statewide ban on it in order to conserve the rice fields of Central Luzon. An act from the Office of the Secretary of the DA (2019), regarding land conversion in the country, the “2002 Comprehensive Rules on Land Use Conversion,” states that conversion of agricultural land to non-agricultural uses shall be strictly regulated and may be allowed only when certain conditions are met. As approved by the Department of Agrarian Reform (DAR), land use conversion alludes to the act or process for converting a piece of agricultural land from its existing physical use—such as cultivating soil, planting crops, or growing trees—to another usage or for an agricultural purpose other than farming and reaping its produce.

Cobb and Douglas’ (1928) production theory shall serve as a foundation for this study. It states that there is a relationship between the units of factors of production and the units of output of goods and services. It also demonstrated that if the number of inputs used changes, the units of output produced will likewise change. In this research, it explores how the independent variables will cause a change in the dependent variable.

Several studies have been conducted regarding the relationship of several factors of the agricultural sector such as arable land, employment opportunities, and man-land ratio on how it influences rice output. Most of these studies are focused primarily on the national level, with a few focusing on Central Luzon. In addition, only a limited number of studies have concentrated on whether the agricultural sector, through rice production, is beneficial to the economy.

This study will benefit society and agricultural communities since they will know whether land conversion boosts economic growth and productivity. Moreover, the current undertaking hopes to contribute to the existing knowledge in the academe pertinent to the effects of land conversion on agricultural production and consequently to people, specifically to the farmers’ average income. As a business economics student, this research will allow the researcher to apply the principles and theories learned inside the classroom and apply them on a vital sector of the economy that significantly impacts the nation as a whole. Lastly, this will benefit municipal and national policymakers as they will have information intended for the agricultural sector in the region. The researcher will further explore the relationship between the variables involved in this study. Hence, this educational endeavor hopes to provide an extensive and exhaustive perspective on the effects of land conversion in the agricultural sector in Region III.

This research aims to identify and explore the presence of Cobb-Douglas production theory in the Philippines, specifically in Central Luzon's agricultural sector. It investigates the effects of (IV1) quantity of arable land available, (IV2) employment rate, and (IV3) man-land ratio to (DV1) rice output and (DV2) average income earned. Specifically, this study seeks: To determine how the quantity of arable land, employment ratio, and man-land ratio affect rice output in Central Luzon; To determine whether the changes in the level of rice output is a boon or bane in Central Luzon as measured by the average income earned by the farmers. This data analysis will be carried out across all the provinces in the region to ensure thorough analysis and conclusion.

This study limits itself to the Philippines, particularly Central Luzon (Aurora, Bataan, Bulacan, Nueva Ecija, Pampanga, Tarlac, and Zambales), as the country's notable palay producer. Data will come from secondary sources and publicly available statistics. This study will only validate the impact or relationship between the three (3) independent variables, quantity of arable land, employment rate, and man-land ratio on rice output. The effects or consequences of these independent factors will not be covered. The question of whether or not land conversion benefits the local economy, based on its agricultural sector, will also be covered. Furthermore, the data covered in this study spans 41 time periods, commencing from 1981 to 2021. Hence, the study's findings might only partially reflect the present situation or effectively anticipate future trends.

II. REVIEW OF RELATED LITERATURE

Industrialization through land conversion is one way to boost the economic growth of a country; hence, understanding the factors influencing it will help determine whether it is advantageous to the economy or not. This proposal shall be anchored on Cobb and Douglas' (1928) production theory, which explains how production factors affect the output units. This study will focus on agricultural production factors such as land and labor such as arable land, employment rate, and man-land ratio. Specifically, this aims to identify how the three factors, the farm size, labor use, and man-, will affect rice output and, consequently, the average income earned by the farmers in Central Luzon.

2.1 Rice Output:

The agriculture industry is under pressure to supply the growing demand for food due to the growing population (Shah and Wu, 2018). Chen et al. (2019) emphasized that to guarantee food security in China, 120 million hectares of arable land—the so-called "red line" for food security—must be preserved, and crop yield must be increased to assure domestic production and self-sufficiency. Various elements affect crop productivity, but different approaches affect the crops differently (Ochieng et al., 2016). Porciuncula et al. (2015) state that rice production, with onion, corn, and vegetables grown as supplementary crops, is the most productive crop in the provinces of Nueva Ecija, Pampanga, and Zambales. Based on the findings of the study by Gollin et al. (2014), world income inequality can only be fully understood by first recognizing agricultural productivity.

2.2 Arable Land:

A range of factors, including soil quality, construction quality, space quality, eco-environmental quality, and beauty and cultural quality, can be categorized as arable land quality, according to Du et al. (2016). The quality of arable land is determined by the interplay of the natural system, the use system, human demand, and it also represents the full range of services performed by the farmland ecosystem (Ye et al., 2022). A study by Pozza and Field (2020), land access is essential in rural communities and that soil health is necessary to prevent land degradation. Since soil erosion is one cause of degradation that impacts around 20% of the world's arable systems (Prăvălie et al., 2021).

2.2.1 Quantity of Arable Land Available on Rice Output:

Arable land is the most critical agricultural output component (Tsue et al., 2014). However, as development demands rise, competition for land has resulted in the conversion of many agricultural lands. In addition, even if there is an increase in agricultural land, various issues have arisen such as a million hectares of land being converted into urban use in such a short period of time (Kong, 2014). A study by Han et al. (2020) noted that one of the most critical tools for macro-controlling urban expansion has always been land use regulation, which can directly impact a city's land values and subsequently influence the linked urban economic well-being. Land demand rises with population growth and socioeconomic activity, potentially resulting in arable land and productivity decline as economic and physical factors drive most land conversions (Kong, 2014; Harini et al., 2018; Farah et al., 2019). For instance, in Shanghai, China, industrial land grew from 1947 to 1993 but declined from 2002 to 2016 because of land prices, existing industrial land, distance to the central transport station, and economic development level (Fan et al., 2020). Also, from 1987-2010, there was a reported 34.8% of total cropland loss due to built-up land expansion

(Ju et al., 2018). Lastly, (Abubakari, Anaman, & Ahene-Codjoe, 2022) established that 48.7% of Ghana's accessible land area in 2020 was made up of built-up areas.

Urbanization and industrialization are economic growth drivers typically involving land conversion (Pradhan et al., 2021; Opoku & Yan, 2018). It caused many tensions and complaints among those affected, such as agricultural workers, while other stakeholders, such as government agencies and state-owned enterprises, found it profitable (Phuc et al., 2014). Converting agricultural land to urban areas can pose social, cultural, environmental, and economic challenges due to the need to accommodate more people in a smaller space while meeting their demands for resources and services (Peerzado et al., 2019; Kovács et al., 2019). As such, it is essential to weigh the benefits and drawbacks of both rural and urban growth, as arable land is essential for livelihoods (Tavares et al., 2022).

Since land availability is limited, it is a must for efficient land use. In European Union (EU) countries, the population continues to expand, which means more food is needed in the future, a reason to maintain arable lands needed for crop production (Némethová et al., 2022). Furthermore, in a study by Nilsson (2018), more crops can be grown if enough land is available. There are instances where agricultural land is situated in highly inappropriate and unsuitable places, which results in low productivity and environmental impact such as small farm sizes, slow growth rates, poor access to financing, post-harvest losses, and low levels of mechanization and commercialization, preventing cropland from expanding to boost output. (Mesgaran et al., 2017; Ngowi 2022). Negative implications of this agricultural and industrial land conversion, such as issues between the State, investors, and farmers whose land is acquired, show unfair benefit-sharing among the stakeholders, making farmers the least benefited (Nguyên et al., 2016). This demonstrates how industrialization can conflict with people's needs, goals, and preferences (Utami et al., 2022).

As Pia (2021) reported, 89.031 agricultural lands in Butuan City, Philippines, from 2014 to 2016 were converted into non-agricultural use. Furthermore, more arable lands in Central Luzon were being transformed into commercial and residential areas due to urbanization and industrialization, according to reports by German et al. (2022). In Ifugao rice terraces, mountainous agricultural landscapes tend to undergo frequent land cover changes which includes agricultural abandonment and afforestation (Estacio et al., 2022). A reason for this is when the area has been urbanized, and the land would have a higher economic value for residential, commercial, or industrial uses, or when the land is no longer economically viable and sound for agricultural purposes (Arceo-Dumlao et al., 2021). Accordingly, the study by Navarro (2023) comes to the conclusion that implementing a National Land Use Agreement (NaLUA) through a suitable institutional mechanism can aid in resolving land use issues in the country.

2.3 Employment Rate:

Sustainable farming should maintain natural ecosystems and services while simultaneously producing nutritious meals and a means of livelihood for farmers (Giller et al., 2021). But even in cases where population growth is low, research by Tschirley et al. (2015) and Yeboah and Jayne (2020) indicates that the percentage of employment in farming is steadily declining. In most developing countries, it is evident how the agricultural output due to the workforce is seriously decreasing, which potentially harms the price and availability of food for the poverty (Alston & Pardey, 2014).

Preparing the youth, aged 15 to 24, for the workforce is one of the Philippines' biggest developmental concerns, where the leading industry is agriculture (Budhrani et al., 2017). A study by Palis (2020) mentioned that most farmers do not want the same type of job for their children, which can result in unemployment in the farming sector.

2.3.1 Employment Rate on Rice Output:

It is necessary to use inputs such as land, labor, capital, and entrepreneurship when producing output. Traditional agricultural production relies on two main inputs: land and labor, which are the primary tools for increasing output. As a result, farmers' work and their land are essential for crop production. The production style, crop variety, and previous land usage affect direct employment and may help prevent smallholder farmers from being forced out of the market (Nolte & Ostermeier 2017). However, despite their crucial role in production, the quantity of farmlands is decreasing, and farmers are not adequately compensated. For instance, in the barangay of Lumbia in Cagayan De Oro, farmers face economic difficulties such as poverty, income, education, and housing tenure that lead to land conversion (Navarro et al., 2017). A study by Ghatak and Mookherjee (2014) mentioned that farmers lease land from private wonders or local governments with a sharecropping contract before ownership.

Most jobs are in the non-farm sector, such as civil-service employees (Jayne et al., 2016). Das and Paul (2021) employed a thorough literature review to determine the possible impacts on urban growth, followed by charts and graphs to illustrate and OLS test using R Programming for necessary recommendations. So, it has always been a global issue as employment shifts away from agriculture as the world's population grows. Although agriculture employs most people in Asian countries, it decreased by 20.68% in South Asia and 28.82% in East Asia between 1991 and 2019 (Das & Paul, 2021).

Nguyen et al. (2016) estimated the degree of variability in economic benefits among stakeholders and analyzed changes from conversion through a bottom-up approach, finding that agricultural land conversion for urban development is a significant process in many cities' surrounding areas. However, numerous landless farmers are a significant part of the rapidly expanding urban population (Tang et al., 2016). Such developments provide unequal benefits among different stakeholders, with farmers benefiting the least from urban development due to the many difficulties associated with transitioning from agricultural to non-agricultural livelihoods, such as sustaining non-agricultural activities, finding stable alternative income activities, and using compensation for capital investments. Also, it causes a threat to the livelihood of individuals leaving the farming industry because they have to deal with a higher workforce, and factors of knowledge and expertise make non-agricultural employment more challenging for farm workers, causing a decline in agricultural employment (Suharyanto et al., 2021). It increased the number of land-lost farmers at risk of unemployment; a few continue to work in agriculture, but the well-being primarily become unemployed (Yong, 2019; Siciliano, 2013).

The shift in employment structures in rural areas has caused non-agricultural labor incomes to increase because of the increase in non-agricultural employment opportunities for farmers as a result of the urbanization process (Coulibaly & Li, 2020). Overall, the increase in urban land expansion diminishes the availability of land among farmland households near urban areas, consequently negatively affecting their livelihood and overall well-being.

According to Sims et al. (2019), using panel regression models and estimated with heteroskedasticity robust standard errors, found that land protection positively affects employment. Similar to Zambia, where policies related to land administration and agricultural spending have resulted in the emergence of 95% of farming households (Sitko and Jayne, 2014). As a result, Ge et al. (2020) stated that it is critical to support the rural transformation to provide employment opportunities that are appropriate for meeting the needs of the area and attracting rural migrants to return and establish businesses in the area.

According to Das and Paul (2021), when a country is heavily urbanized, a declining employment in agriculture will be observed and this is observed in Asian countries which contribute to most of the agricultural sector. During the past two decades, urbanization in the Philippines has reached and increased more in rural areas, resulting in significant land conversion of agricultural lands and decreased employment in the agricultural sector due to shift of sectors (Bravo, 2017).

2.4 Man-land Ratio:

Man-land ratio, a key metric in our study, represents the quantity of land production per person. It serves as a measurement of agricultural wealth and conversion's social and economic impacts on the conditions of any particular region, particularly those agrarian (Meena and Gadekar, 2020). In the rural man-land relationship system, the two main components are population and residential land use and this study by Liu et al. (2022) of the man-land relationship in rural regions dramatically depends on the link between the rural people and residential land. Furthermore, the man-land ratio demonstrates a negative relationship with total fallow land, implying that the higher the availability of the workforce, the less the area of arable land (Kshettry et al., 2020).

2.4.1 Man-Land Ratio on Rice Output:

Land depends on man for survival and protection; man can also affect land (Tope, 2022). Man-land relationship is deeply affected by externalities, such as social, economic, and geographical factors (Meena and Gadekar, 2020). The relationship between natural and human resources was determined by dividing the efficiency of man by the efficiency of land, which is the formula used to calculate the man-land ratio. Man and land have a substantial link, as evidenced by the degree of land cover, the pattern of land use, and the demographic composition of the people in the area, as analyzed by (Bindu & Jayapal, 2017). For instance, rapid population growth led to an imbalance in the man-land ratio, human activities, and changes in land usage (Santra et al., 2018). Similar to the study of population explosion, urbanization, and industrialization, the rapid growth of the regional economy, agricultural structure adjustments, environment degradation, market, and globalization are the significant drivers of the man-land ratio (Zhao et al., 2023). In addition, specific government initiatives brought upon by industrialization resulting in agricultural to non-agricultural land, rural-to-urban migration, and regional disparities in rural areas have affected the man-land ratio (Peng et al., 2016). Numerous factors influenced the man-land ratio estimates based on mean and mapping using modern methods, yet land conversion remains prominent. This is because as time progresses, the population grows, and the demand for land increases (Chakraborty & Ghosh, 2016). As a result, land degradation and conversion rates increase, affecting the man-land ratio.

Cultivated land not used for agriculture, food, or abandonment reflects changes in land-use structure and way (Liu, Hu, & Li, 2014; Tu & Long, 2017). Long et al. (2018) argue that urbanization alters man-land interactions and land use transitions through the per capita construction land area (PCCA - m2 /person) and per capita farmland area (PCFA - ha/person) and three (3) times standard deviation test. It also demonstrates how land use shifts are triggered, causing a dramatic loss in farmland and resulting in threats to man-land connections. For example, urbanization has converted farmland in developing countries into various non-agricultural uses. This leads to a loss of agricultural production and challenges the man-land ratio, as farmers face job losses and land expropriation (Yong, 2019).

2.5 Average Income Earned:

The agricultural sector plays a significant role in the economy of emerging countries and its priority is to increase agricultural productivity through achieving sustainable yield improvements, advancing agricultural technology and management, enhancing groundwater, and post-harvest management (Irvan and Yuliarmi, 2019). Also, Arifin et al. (2021) stated how farmers' income also makes way for the quality of food, and these foods are mainly produced on small lands. Nevertheless, due to either landlessness or inadequacy of land owned or leased, people are experiencing poverty due to agricultural revenue received from seasonal wage employment (Abas, 2016). As a result of low yield, poor food quality, and significant post-harvest losses, low income is the main problem that millions of farmers in the Philippines, who cultivate 4.81 million hectares, are dealing with.

However, most agricultural output in developing nations is linked to low productivity and low income because of a heavy reliance on low-tech subsistence farming and limited market access (Nguyen et al., 2015). Paul (2018) mentioned that despite generating income in this sector, some still need to earn a living wage enough for a particular household. Income of local non-farm jobs and tourism income dividend accounts for 70.8% and 17.8%, while agriculture just plays a slight role in improving household income (Zhang et al., 2019)

2.5.1 Average Income Earned on Industrialization and Land Conversion:

According to Haraguchi et al. (2019), there are several reasons to continue pushing industrialization, particularly in low-income nations. According to Davis et al. (2014), it is because of adequate employment opportunities. The decline in part-time employment led to increased work hours in places where salaries were lower (Bhorat et al., 2014). Sustainable agricultural productivity, such as non-farm activities providing a household's income and a source of investment capital, reduces the income gap between rural and urban areas (Adelekan & Omotayo, 2017), 2017; Yao & Jiang, 2021). Newfarmer et al. (2018) stated that approximately 50% of the productivity gains made by developing nations, primarily in East Asia, between 1950 and 2006 came from increased manufacturing productivity and structural shifts away from agriculture. This was supported by Arouri et al.'s (2017) study, stating that salaries have increased in non-farm activities, increasing total household income and consumption expenditure.

The income of the affected farmer households, using the test of difference between paired sample means, has been negatively and significantly impacted by land conversion, and this decline in household income is related to the reduction in farming land (Nurpita et al., 2017; Wang et al., 2019). Smallholder farmers' income needs to be increased to support their families; in the absence of credit constraints, households' income may rise to 7.3 and 5.1 (Amanullah & Wang, 2022). In that case, they might have to engage in other income-generating activities rather than depending entirely on traditional agricultural methods (Debela et al., 2020). Hence, a study by Su et al. (2015), with the utilization of Kuznets theory, Breush and Pagan's (1980) Lagrange test for cross-sectional dependency, slope homogeneity test, and panel causality test using Granger causality proved that urbanization significantly impacts the urban-rural income gap. Also, Research by Poulsen et al. (2015) suggested that, despite low harvests, urban agriculture can be a significant source of income for households. Lastly, aside from urbanization, "townization" is concluded to improve and promote farmers' income, especially farmers' transfer income (Huang et al., 2021).

However, because of a decline in agricultural operations, the overall loss of agricultural revenue in India during 2008 amounted to 3.9 billion (Azadi et al., 2018). After deducting the cost of inputs and hired labor wages, farmers' revenue from farming activities has grown at varying rates, from low to high growth throughout the previous three decades, based on the Tendulkar methodology (Chand et al., 2015). A study by Davis et al. (2017) mentioned that most countries consider specialization in farming activities rather than focusing on industrialization. Likewise, rapid urbanization and the transfer of labor from the low-productivity agricultural sector to the productivity in other sectors brought about challenges such as progress in well-paying jobs, poverty and inequality, and food security (Woldemichael et al., 2017; Popkin, 2014). As cited by Simon Kuznets (1955), Kuznets' hypothesis supported these various theories by mentioning that income disparity rises and then declines in industrializing nations.

Raising wages in the agricultural sector or finding them better-paying jobs outside of it are two ways to increase the income of Filipino farm laborers (Briones, 2017). Notwithstanding the ongoing increase in agricultural income, the primary source of income for agricultural households is and has always been nonfarm revenue (Briones, 2022). According to a study by Quimba and Estudillo (2021), there are four (4) modernizing forces at work in Central Luzon: increasing urban influences, land reform implementation, population pressure on the closed land frontier, public infrastructure expansion, and growing urban influences accelerated by advancements in transportation and telecommunications. These factors, combined with modern technology, have raised household income and prevented poverty from rising in the region. Thus, to avoid both low-level rural economic development and an extensive property income gap between citizens and farmers, it is recommended that urban and rural development be balanced (Wu et al., 2019).

The agricultural sector has been correlated with the number of lands available, the employed persons in this industry and the man-land ratio. For instance, numerous studies have reported a limited number of lands that need to be maintained for crop production since it has a positive correlation. Consequently, more crops can be grown if enough land is available (Nilsson, 2018). In addition, if there is arable land, there must be farmers. Based on studies, the labor force tends to sell their lands because of rising difficulties in maintaining lands and income generation. This proves that the workforce tends to leave the agricultural industry as the land decreases. Lastly, as man depends on land for survival, man also affects the land (Tope, 2022). Studies mentioned that various elements contribute to the man-land ratio and that land degradation and conversion values have affected the relationship of man-land and agricultural production. Central Luzon has been classified as a notable palay producer, giving its residents excellent crops.

In this proposal, the researcher hopes to determine how the level of rice output affected Central Luzon's agricultural sector based on the average income earned by the farmers. Studies show that depending on the type of country, income earned shall be generated in various circumstances. In most developing countries, such as the Philippines, income has been associated with farming (Davis et al., 2017). However, it is still important to note that there is more income outside the farming sector.

Certain factors forced land conversion to take over the world. Due to the continuous increase in population, more housing, infrastructure, and facilities are needed, leading to issues regarding agricultural lands and production. Studies have mentioned that population growth and socioeconomic activity increase the demand for land, which may reduce productivity and arable land since most land conversions are driven by physical and economic factors (Harini et al., 2018; Farah et al., 2019). Because of this, several studies have noted the issues that arise if this conversion is advantageous to the economy or not. For example, conflicts may emerge regarding food security, affecting the condition of food provided for the people (Costamero, 2023). Still, it was noted that one of the primary drivers of economic expansion is land transformation (Pradhan et al., 2021; Opoku & Yan, 2018).

2.6 Theoretical Framework:

The Cobb-Douglas Production Function will be used by the researcher to demonstrate how variations in the inputs impact the amount of output generated. According to Kamanga et al. (2000), selecting a function and determining which elements to use, including selecting the inputs that influence a production function's output, requires some judgment. As a result, a general form of the Cobb-Douglas Production Function will be utilized for this study:

$$Y = AX_1^{a1}, X_2^{a2}, X_3^{a3}, \dots X_n^{bn} \tag{1}$$

Where Y is the quantity of output, X_i are the inputs or the vectors of variable resources with i being 1, 2, 3,...,n. Lastly, A and a_i with i = 1,2,3,...,n where a_i estimates the elasticity or transformation ratio for the inputs X_i.

In this study, Y is rice output, which is Palay Production in Central Luzon as the output. While the X_i are the levels of inputs that affect the level of corresponding output or crop productivity. Specifically, these will be the Quantity of Arable Land, Employment Rate, and Man-land Ratio.

The basis of using the Cobb-Douglas production function stems from its reasonable simplicity and ease of interpretation. Moreover, Cobb-Douglas production function bias can be eliminated by transforming the equation by calculating both sides' logarithms (Muraya, 2017).

$$\log Y = \log A + a_1 \, logX_1 + a_2 \, logX_2 + a_3 \, logX_3 + \cdots + b_n \, logX_n \qquad (2)$$

III. MATERIALS & METHODS

Cobb and Douglas' (1928) production theory states that there is a relationship between production factor units and output units of goods and services. It also demonstrated that as the number of inputs changes, so do the units of output produced. The positive signs in the variables, arable land as measured by farm size and employment rate through the labor use for rice production, indicate a positive relationship with the dependent variable, rice output. Additionally, the negative sign in the man-land ratio suggests a negative relationship with the dependent variable. Rice output, therefore, affects the household income earned from rice production, justifying whether land conversion is beneficial to the people in the agricultural sector of Central Luzon.

This theory shall serve as the foundation for the proposed research topic, including a time-series analysis for 41 periods from 1981 to 2021. The proposed research framework examines the relationship between farm size, labor use for rice production, man-land ratio, rice output, and household income from rice production. It would investigate the effects of farm size, labor use, and man-land ratio on agricultural productivity, focusing on Central Luzon. It would assess whether land conversion has been beneficial or detrimental to the economy based on household income earned.

Since the man-land ratio, employment rate, and amount of arable land all impact Central Luzon's agricultural production, the researcher will examine how these independent factors vary. Here, the movement of the data collected from the average farmer's income will help decide whether or not land conversion are economically advantageous.

3.1 Data:

The data to be used in this proposal will be secondary data with 52 observations for each variable. This is to align with the 42 time period from 1981-2021. Data for the IV1 or the Quantity of Arable Land, measured by Farm Size (Hectares), and the IV3 or the Man-Land Ratio, were collected from the Central Luzon Loop Survey by the International Rice Research Institute (IRRI) which can be found on the book Emerging-Economy State and International Policy Studies. Data for IV2 or the Employment Rate measured by the labor use for rice production as well as the earlier years (1981-2004) of DV1 or Average Income Earned were collected in Changes in rice farming in the Philippines: Insights from five decades of a household-level survey by IRRI. DV1 or Crop Production, measured through Palay Production in Metric Tons, as well as DV2 or Average Income, measured by estimated monthly per capita income and percentage distribution income, was collected from the PhilRice website by the Department of Agriculture, wherein data sources are from the Philippine Rice Information System, PSA, PalayStat, World Bank, and DOST-FNRI.

3.2 Research Design:

Quantitative research will be employed in this proposed study. Using the time-series analysis, this study will examine the impact of the farm size, labor use for rice production, and man-land ratio on the rice output in Central Luzon, which will aid in identifying its effect on the average income earned by Filipino farmers in region three.

3.3 Model:

This study aims to determine the relationship between the indicated production factors and the output, as well as the impact of the quantity of arable land, employment rate, and man-land ratio on rice output. This will also determine how agricultural output will affect the average income earned of the farmers. Thus, the researcher employed the following econometric models:

$$RO = \beta 0 + \beta 1FS + \beta 2LU - \beta 3ML + e \qquad (3)$$

$$HHI = \beta 0 - \beta 1RO + e \qquad (4)$$

Where RO refers to rice output, FS refers to farm size, LU refers to labor use for rice production, ML refers to man-land ratio, and HHI refers to household income from rice production.

This study will now employ an ordinary least squares model, specifically a multiple linear regression, following the completion of the augmented dickey fuller test. Muraya (2014) states that determining the individual or combined contribution of inputs to outputs necessitates the establishment of a production function. The general neoclassical production function: Y = F (X1, X2, X3,….Xn) where Y is the output level, Xs are the inputs; in this study it is the arable land, employment rate and man-land ratio, respectively for the first model while rice output will be the input in the second model.

Moreover, Muraya (2014) states that the formula can be transformed by taking the logarithm of both sides in order to remove the bias from the Cobb-Douglas production function. The Cobb-Douglas production function is less flexible than the transcendental logarithmic function or trans-log. It is, therefore, better suited for evaluating intricate production relationships. The ordinary least squares (OLS) method can estimate this converted function. Now that the model's parameters are linear, it may be estimated by ordinary least squares (OLS). This creates a double log model with all the variables in logs, as the theoretical framework specifies.

A double logarithmic regression will be used to determine the theoretical framework. This will allow it to confirm the percentage change in the output or DV for rise and decrease for each 1% increase in the input (IV). As a result, the double logarithmic regression will look like this:

$$Log\ Rice\ Output = \beta 0 + \beta 1 \log Farm\ Size + \beta 3 \log Labor\ Use\ for\ Rice\ Production - \beta 2 \log Man - land\ Ratio + e \quad (5)$$

The study by Muraya (2014) and Ameh et al. (2017), which investigated the effect of agricultural input on agricultural productivity and is similar to the current study, will be used as a reference for the tests that will be performed.

3.3.1 Augmented Dickey Fuller Test:

A time series test will be employed in this study because it can be used to identify and address non-stationarity in a time series. In particular, the Augmented Dickey Fuller (ADF) test will be used in this investigation. Here it will determine whether rice production is stationary or non-stationary throughout the years. Furthermore, the relationship between the independent variables and the dependent variables within the time series will be determined by means of this time series test. Artlova & Fedora (2016) studies the unit root test, specifically the formulation of ADF test to come up with the equation as follows:

$$\Delta Y_t = (\emptyset_1 - 1)Y_{t-1} + \sum_{t=1}^{p-1} Y_i \Delta y_{t-1} + \varepsilon_t \quad (6)$$

Where ϕ_1 is the autoregression parameter, ε_t is the random error term, assumed to follow a white noise process. However, a key problem with this test is selecting the appropriate number of lags p. With this, Schwert (1989) recommends using the maximum lag length, as choosing p too small may introduce autocorrelation, while selecting p too large can reduce the statistical power of the test.

3.3.2 Johansen-Granger Cointegration:

The Johansen Cointegration method will be employed to estimate the long-term relationship between agricultural production and the relevant variables. However, as noted by Ameh et al. (2017), cointegration itself does not reveal the direction of causality between the variables. To address this, Granger causality analysis will also be used to assess whether one variable can predict another. The Johansen Cointegration approach is based on a vector autoregression (VAR) model of order p, expressed as:

$$Y_t = \mu + A_1 + Y_{t-1} + \cdots + A_p Y_{t-p} + \beta x_t + \varepsilon_t \quad (7)$$

Where A represents the autoregressive matrices, while Y_t is a vector of endogenous variables. The parameter matrices are denoted by B and X_t refers to the deterministic vector.

3.3.3 Test for Autocorrelation:

Autocorrelation test is used to validate the regression analysis as presented in a study by Suphannachart and War (2011) in their study investigating the effects or impact of inputs on agricultural production or productivity. This test will be determined through assuming that the model has no serial autocorrelation and the alternative hypothesis is that the model has a serial autocorrelation. If the value exceeds the p-value, then the null hypothesis is accepted, however, if it is less than the p-value, null hypothesis is rejected, while alternative hypothesis will be accepted. This is to verify that the errors in the model are unrelated or that the error for one observation does not influence the error of another observation (Burton, Mladenoff, & Forrester, 2011). Breusch-Godfrey Test has been shown superiority to other autocorrelation tests for models with lagged dependent variables. The equation will be:

$$Y_t = \beta_1 + \beta_2 X_t + u_t \quad (8)$$

3.3.4 Test for Heteroskedasticity:

The heteroskedasticity test was also employed in the previously described studies to confirm the validity and reliability of the regression analysis. Heteroskedasticity will be determined by whether the null hypothesis states that the model is homoscedastic or not, and the alternative hypothesis states that the model is heteroskedastic. The null hypothesis can be rejected if the log of the error term and the explanatory variable show a statistically significant relationship.

Classical linear regression assumes that the error terms should have a constant spread across all data points, a condition known as homoskedasticity. However, when this assumption is false, and the spread of errors varies across different levels of the data, it results in heteroskedasticity. Mills (2014) explored this phenomenon, presenting heteroskedasticity in the following manner:

$$V(u_i) = E\ (u_i^u)\sigma^2 \tag{9}$$

3.3.5 Test for Multicollinearity:

The alternative hypothesis, which claims that the model has multicollinearity, will be compared to the null hypothesis, which claims that the model has no multicollinearity. This will allow for the determination of multicollinearity. If the value is less than five, the null hypothesis will be accepted since the VIF method's strictest rule will be followed. When the value is more than five, the alternative hypothesis is accepted and the null hypothesis is rejected. In a study by Sanaullah et al. (2020), Variance Inflation Factor (VIF) was utilized in their study with an equation as follows:

$$VIF = \frac{1}{1-R_j^2} \tag{10}$$

The coefficient of multiple correlation, denoted as R_j, represents the strength of the relationship between variable j and the other regressors in the model. When a variable has little to no correlation with the other variables, the minimum value of R_j is 1.0. According to Neter, Wasserman, and Kutner (1983), a VIF exceeding 10 typically indicates a high degree of collinearity. Therefore, it is advisable to examine the highest VIF as a diagnostic measure for potential collinearity issues.

3.3.6 Test for Specification Error:

The Ramsey RESET Test will be used in this study. There is no specification error in the null hypothesis, but there is one in the alternative hypothesis. The null hypothesis is accepted if the value is greater than the p-value. The alternative hypothesis is accepted, and the null hypothesis is rejected if the value is less than the p-value. Prabowo, Suhartono, and Prastyo (2020) presented the equation in this test as follows:

$$Y_i = \lambda_i + \lambda_2 X_i + u_i \tag{11}$$

IV. RESULTS & DISCUSSION

TABLE 1
JOHANSEN COINTEGRATION TEST RESULTS

Rank	EigenValue	Trace Test	p-value	Lmax test	p-value
0	0.36372	33.281	0.5457	16.276	0.6489
1	0.24096	17.005	0.6479	9.9253	0.7538
2	0.11964	7.08	0.5746	4.5871	0.7902
3	0.066904	2.4929	0.1144	2.4929	0.1144

The Johansen Cointegration test, conducted for both the linear and double-logarithmic models, produced identical results. In both cases, the alternative hypothesis was accepted across all ranks, indicating the presence of cointegration. This suggests that the variables in the models have a long-term relationship. Even if short-term shocks cause temporary deviations, the variables are expected to eventually converge over time.

TABLE 2
AUGMENTED DICKEY FULLER TEST RESULTS

Variable	t-statistics	Prob.*
(First-Difference) Rice Output	-8.25589	8.76E-14
(First-Difference) Farm Size	-4.52301	0.0001739
(First-Difference) Labor Use for Rice Production	-3.9863	0.001488
(First Difference) Man-land Ratio	-6.14301	5.38E-08

The long-run regression analysis begins with conducting unit root tests to assess the stationarity of each model variable using the Augmented Dickey-Fuller (ADF) test. The results from the ADF test indicated that both models produced consistent findings. Specifically, the test showed that none of the variables were non-stationary at their levels, and as such, the null hypothesis of non-stationarity could not be rejected. This implies that the variables remain stable and do not exhibit changes in response to shifts over time or across different conditions.

TABLE 3
MODEL 1: OLS LINEAR RESULTS AND DOUBLE LOG RESULTS ON RICE OUTPUT, FARM SIZE, LABOR USE, AND MAN-LAND RATIO FROM 1989-2020 (T = 32)

	coefficient	std.error	t-ratio	p-value
const	21.498	1.78225	12.06	1.32e-012 ***
Farm Size	1.84766	0.582814	3.17	0.0037 ***
Labor Use	-0.584891	0.296437	-1.973	0.0584 *
Man-land Ratio	-1.16772	0.325202	-3.591	0.0012 ***

Mean dependent var	14.70661	**Schwarz criterion**	5.141973	**P-value(F)**	0.000287
Sum squared resid	1.426649	**rho**	0.640963	**Akaike criterion**	-0.720971
R-squared	0.485223	**S.D.dependent var**	0.298998	**Hannah Quinn**	1.222429
F (3, 28)	8.797484	**S.E. of regression**	0.225725	**Durbin Watson**	0.718774
Log-likelihood	4.360486	**Adjusted R-squared**	0.430068		

The Ordinary Least Squares (OLS) analysis yielded several significant insights regarding the factors affecting rice output. The intercept (y0) value of 21.4980 suggests that, in the absence of the key variables—farm size, labor use, and man-land ratio—rice output would still amount to 21.4980 metric tons. Notably, an increase of 1 hectare in farm size leads to an additional 1.84766 metric tons of rice output, highlighting the positive impact of land area on production. However, the study reveals that for every 1% increase in labor used for rice production, there is a corresponding decline of 0.584891 metric tons in output. Similarly, a 1% increase in the man-land ratio results in a reduction of 1.6722 metric tons of rice output.

These results partially validate the initial hypotheses. As expected, farm size has a positive impact on rice production, underscoring the importance of maintaining and efficiently managing arable land to optimize yields. This finding is consistent with previous studies by Nemethova et al. (2022), Nilsson (2018), and Tavares et al. (2022), all of which emphasize the critical role of farm size in enhancing agricultural productivity. The positive relationship between farm size and output reflects the need for policies that support the preservation and sustainable use of agricultural lands, particularly in regions where rice is a staple crop.

Contrary to expectations, labor use exhibited a negative effect on rice output, which can be attributed to multiple challenges within the agricultural sector. As noted by Ghatak & Mookherjee (2014), Navarro et al. (2017), and Suharyanto et al. (2021), farmers face numerous obstacles, including labor shortages, limited access to technology, and inefficiencies that inhibit productivity. Additionally, Das & Paul (2021) highlight the growing trend of workers transitioning from farm-related jobs to non-farm sectors, further exacerbating labor constraints in agriculture. This shift likely explains the observed negative relationship between labor use and rice output, as the diminishing agricultural workforce struggles to maintain productivity.

The negative impact of the man-land ratio on rice output is also aligned with findings from Santra et al. (2018) and Chakraborty & Ghosh (2016), who emphasize that urbanization and population growth are contributing to the reduction of farmland. As land resources become more limited, managing the balance between agricultural productivity and competing land uses becomes increasingly vital. These results point to the need for strategic land management practices to ensure that rice production can meet growing demand while addressing the challenges posed by demographic and spatial changes.

TABLE 4
DIAGNOSTIC TEST ON RICE OUTPUT, FARM SIZE, LABOR USE, AND MAN-LAND RATIO

	Breusch-Godfrey	White's Test	Breusch-Pagan	Normality of Residual	RESET
Test Statistic: Chi-square (2)	20.7866	6.486	1.00485	1.06945	3.287196
p-value	0.0136	0.690463	0.800079	0.585832	0.0534

Diagnostic tests are crucial for evaluating the model to ensure unbiased and more accurate results. Several tests were conducted to assess the model, including the Breusch-Godfrey test for autocorrelation, White's and Breusch-Pagan tests for heteroscedasticity, normality tests, and Ramsey's RESET test (Table 4). The Breusch-Godfrey Serial Correlation LM test yielded a value greater than the alpha level of 0.01, indicating no significant first-order autocorrelation in the regression output. Similarly, the Durbin-Watson statistic, being higher than the alpha threshold, confirms the absence of correlation errors.

Moreover, the p-values from White's and Breusch-Pagan tests were both greater than 0.01, signifying that heteroscedasticity is not present in the model. Regarding the normality of residuals, the alpha level exceeds the test statistic, confirming that the residuals are normally distributed. Lastly, the RESET test's p-value, being above the alpha level, indicates no evidence of misspecification errors in the model.

TABLE 5
OLS LINEAR RESULTS ON HOUSEHOLD INCOME AND RICE OUTPUT FROM 1981-2020 (T = 41)

	coefficient	std.error	t-ratio	p-value
const	−12.4942	2.84743	−4.388	0.0001 ***
Rice Output	0.79952	0.195639	4.087	0.0003 ***

Mean dependent var	−0.860207	**Schwarz criterion**	34.31797	**P-value(F)**	0.000252
Sum squared resid	4.480947	**rho**	0.687366	**Akaike criterion**	31.15093
R-squared	0.329405	**S.D.dependent var**	0.436939	**Hannah Quinn**	32.25631
F (1, 39)	16.70123	**S.E. of regression**	0.363032	**Durbin Watson**	0.626545
Log-likelihood	-13.57547	**Adjusted R-squared**	0.309681		

The Ordinary Least Squares (OLS) analysis on the relationship between household income and rice output revealed several critical insights. The intercept (y0) coefficient of -12.49 indicates that, in the absence of rice output, household income decreases by 12.49%. Conversely, a 1% increase in rice output results in a modest 0.79% increase in household income. With p-values of 0.0001 and 0.0003, these results are statistically significant, confirming the reliability of the model.

These findings highlight the crucial role that rice production plays in supporting household income in rural areas. Without rice output, household income experiences a marked decline, underscoring the importance of maintaining agricultural productivity. This aligns with Arifin et al. (2021), who stress the critical connection between farmers' income and the quality of food produced, suggesting that income stability in farming is key to ensuring food security and sustainability. Similarly, Nurpita et al. (2017) and Wang et al. (2019) link the reduction in household income to a decrease in farming activities, reinforcing the idea that lower agricultural output has direct financial consequences for rural households.

The results further resonate with Davis et al. (2014), who emphasize that many countries prioritize agricultural specialization over industrialization, particularly in rural economies, where farming remains a vital source of livelihood. However, while rice output continues to positively impact household income, several studies (Woldemichael et al., 2017; Popkin, 2014; Briones, 2017; Arouri et al., 2017) suggest that non-farm income opportunities are increasingly significant in rural regions. As a result, although rice production remains essential, there is growing recognition that diversifying income sources beyond agriculture could offer more stable and potentially higher earnings for households.

TABLE 6
DIAGNOSTIC TEST ON HOUSEHOLD INCOME AND RICE OUTPUT

	Breusch-Godfrey	White's Test	Breusch-Pagan	Normality of Residual	RESET
Test Statistic: Chi-square (2)	17.128428	3.97166	1.48434	15.5925	3.44308
p-value	0.0349	0.137267	0.223096	0.0004	0.0425276

The second model was subjected to several diagnostic tests to ensure its validity and accuracy. The Breusch-Godfrey test for autocorrelation yielded a result greater than the alpha level of 0.01, indicating no significant autocorrelation. Similarly, both the White's and Breusch-Pagan tests produced p-values exceeding 0.01, confirming the absence of heteroscedasticity in the model. However, the normality test indicated that the residuals are not normally distributed, as the p-value was below the 0.01 threshold. Additionally, the Ramsey's RESET test revealed no evidence of model misspecification, and the Durbin-Watson statistic confirmed the absence of correlation errors. In summary, the model passed most diagnostic tests, with the exception of the normality of residuals.

V. CONCLUSION

Rice remains a staple food for over half of the global population, with Asia accounting for 90% of its production (Fukagawa & Ziska, 2019). In 2010, the Philippines allocated 4.4 million of its 10 million hectares of agricultural land to rice cultivation. Despite this, the country still relies heavily on rice imports to meet the growing demand from its rapidly increasing population, earning it the recognition as the world's largest rice importer. This study aimed to assess the effects of farm size, labor usage, and the man-land ratio on rice output and their subsequent impact on farmers' household income, particularly in Central Luzon. Additionally, it applied the Cobb-Douglas production function to explore how these factors influence production and income generation.

Findings of this study highlights that farm size has a positive impact on rice output, emphasizing the critical role of maintaining arable land for agricultural productivity. The preservation and effective management of farmland are essential to ensuring food security and addressing the rising demand for rice in the Philippines. On the other hand, labor usage showed a negative effect on rice output, contrary to expectations. This can be attributed to the various challenges farmer's face, such as labor shortages, inadequate access to technology, and inefficiencies that hinder productivity.

In addition, man-land ratio was also found to negatively impact rice production, supporting the hypothesis that imbalances in land distribution and increasing urbanization reduce available farmland. This trend is exacerbated by population growth, which increases demand for land for non-agricultural purposes. The shrinking of farmland underscores the need for efficient land management practices to sustain agricultural productivity and prevent further declines in rice output.

In conclusion, the results suggest that rice production still serves as an economic boon in some areas of Central Luzon. In regions where rice output is absent, household incomes decline significantly, while areas with rice production experience a modest but important increase in farmers' income. However, the economic benefits are limited, and the region's heavy reliance on rice farming may contribute to economic stagnation rather than growth, making it an economic bane for many farmers. This highlights the need for a balanced approach that supports both agricultural productivity and diversification of income opportunities.

Hence, it is recommended that the government take proactive measures to secure farmers' incomes and make farming a more viable and attractive occupation, especially for younger generations. Policies should be developed to address income security, improve access to resources, and encourage sustainable agricultural practices. Additionally, future research should focus on investigating the types of land being converted from agriculture and examining the broader impacts of land conversion on various crops and regions. By promoting effective land management and prioritizing agricultural preservation amidst increasing urbanization, the Philippines can enhance the sustainability of its farming sector and strengthen its contribution to the country's economic development.

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