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Comparative advantages and factors affecting agriculture production and income in the food estate area on the Indonesia–Timor-Leste border

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ABSTRACT

The Indonesian government has created a food estate area in Belu Regency, supported by the construction of the Rotiklot Dam, in the expectation that it would increase agricultural production and income, as well as stimulate the economy of the border region. The study aims to analyze (i) the comparative advantage of agricultural commodities in the food estate area and (ii) the effect of social characteristics and physical inputs on increasing farmers' production and income in the food estate area in the border region. The data used consisted of primary data obtained from interviews with 300 respondents, selected through purposive sampling from a population of 4500, and secondary data from related agencies. The data analysis employed location quotient (LQ) and the partial least squares approach to structural equation modeling (SEM-PLS). Social input was reflected by 5 variables and physical input by 3 variables, while production was reflected by 6 variables and income by 7 variables. The LQ results show that maize and rice production in the food estate area is superior to other areas, and maize grows faster than rice crops. The comparative advantage is due to physical and social factors; based on the results of SEM-PLS, physical factors have direct and indirect effects on production and income, while social factors have an indirect effect on farmers' income through agricultural production. Expansion of the planting area by utilizing water from the Rotiklot Dam and increasing the motivation of farmers through input subsidies are needed to optimize the increase in farmers' production and income.

Contribution/Originality: The research findings demonstrate how the comparative advantage of rice and maize is influenced by physical and social factors in the food estate area. This study found that physical factors have direct and indirect effects on income, while social factors only have an indirect effect on income.

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1. INTRODUCTION

Border areas are areas that border other countries and which have resources that must be managed in order to improve welfare. These natural resources often take the form of agricultural potential, which requires infrastructure development to support the development of innovation to improve the economy of border communities (Meyer, Howe, Stollberg, & Gerlitz, 2021).

One of Indonesia's border areas is Belu Regency, East Nusa Tenggara Province, which borders Timor-Leste. Belu Regency is a tropical region with a short rainy season and a long dry season of 7-8 months (Meteorological & Geophysical Agency, 2022). The construction of the Rotiklot Dam offered a solution for the availability of water to increase agricultural production.

The agricultural sector contributed 22% to the Regional Gross Domestic Product of Belu Regency (Statistics of Belu Regency, 2021), but farmers tend not to specialize in certain agricultural commodities because they do not know which commodities have a comparative advantage in their area. The government has established a food estate area within the reach of the Rotiklot Dam to realize the specialization of agricultural commodities through increased production of paddy and maize to increase the incomes of the people around the dam. Regional specialization provides opportunities for increased regional development and economic growth (Li, Zheng, & Zhao, 2017; Song, Wang, Wang, & Zhou, 2021).

The policy of specialization in agricultural areas through the food estate in Kakuluk Mesak District, Belu Regency, and the construction of the Rotiklot Dam as supporting infrastructure contribute to an increase in paddy and maize production. However, in 2019-2021, paddy production output in Belu Regency fluctuated, while maize production decreased. The data on paddy and maize production (in tons) compiled by the Statistics of Belu Regency (2022) are as follows: rice 27,079 (2019), 9,310 (2020), 25,417 (2021) and maize 51,312 (2019), 49,605 (2020), 49,096 (2021).

Firmansyah, Widodo, Karsinah, and Oktavilia (2017) and Stellian and Danna-Buitrago (2019) stated that specialization in agricultural commodities is useful for increasing the comparative advantage. The food estate area in Kakuluk Mesak District as a center for rice and corn production in Belu Regency indicates a comparative advantage. The comparative advantage is achieved through several natural and social factors: natural resources, mastery of technology, community competence, available labor in sufficient quantities, market proximity, high accessibility, concentrations of similar activities, and an agglomeration economy.

The previous studies on comparative advantage by Semin and Namyatova (2019) and Kurmanova, Sukhanberdina, Kim, and Urazova (2021) focused on analyzing physical characteristics, such as land area, which have a relationship with increased agricultural production. Other studies have analyzed the influence of empowerment of human resources, the added value of agricultural products, and increased investment on increasing production and incomes (Baidoo, Yusif, & Anwar, 2016; Chen, Rizwan, & Abbas, 2022; Elzbieta & Dziwulski, 2021; Firmansyah, Pusparini, Vivero, & Lababit, 2021; Zwolak, 2016). Furthermore, the effects of customs and culture on the social costs of farming and farmer participation in farmer groups have been investigated (Christyanto & Mayulu, 2021; Dewi & Yustikaningrum, 2018; Sipayung, Fobia, Taena, & Joka, 2021; Syuhudi, 2020; Vu, Minh, Nguyen, Van Dung, & Lan, 2020).

This research fills the research gap regarding the synthesis of comparative advantage in the food estate area and the direct and indirect effects of its determinants (physical and social factors) on production and income. The study aims to analyze (1) the comparative advantage of agricultural commodities in the food estate area and (2) the effect of physical input and social characteristics on increasing the production and income of farmers in the food estate area in the border region.

2. MATERIALS AND METHODS

2.1. Research Sites

The research was conducted in Belu Regency, specifically the food estate area of Kakuluk Mesak District, which is in the border region of Indonesia and Timor-Leste, as shown in Figure 1. Figure 1 illustrates the location of the Rotiklot Dam and its service area in the border area of Indonesia and Timor-Leste.

2.2. Data Collection

The study used both primary and secondary data. Secondary data were obtained from the Nusa Tenggara II River Basin Center, the Ministry of Public Works and Public Housing, the Indonesian Geophysical Climatology Meteorology Agency, and the Indonesian Central Statistics Agency. Primary data was obtained through in-depth interviews and observations. Interviews were conducted with 300 respondents, selected by random sampling from 5400 families. The correct sample size was determined to ensure the study's level of truth (Hamed, 2017).

2.3. Data Analysis

The data were analyzed by first assessing production and price data to pre-analyze the value of food crop production in Kakuluk Mesak District and Belu Regency. The value of agricultural production of food crops was analyzed using a location quotient (LQ) to find out the comparative advantage, which is determined by the physical and social factors of the region. These two groups of factors were reflected by various variables to determine agricultural production and income, which were analyzed using the partial least squares approach to structural equation modeling (SEM-PLS). The data analysis framework is visualized in Figure 2.

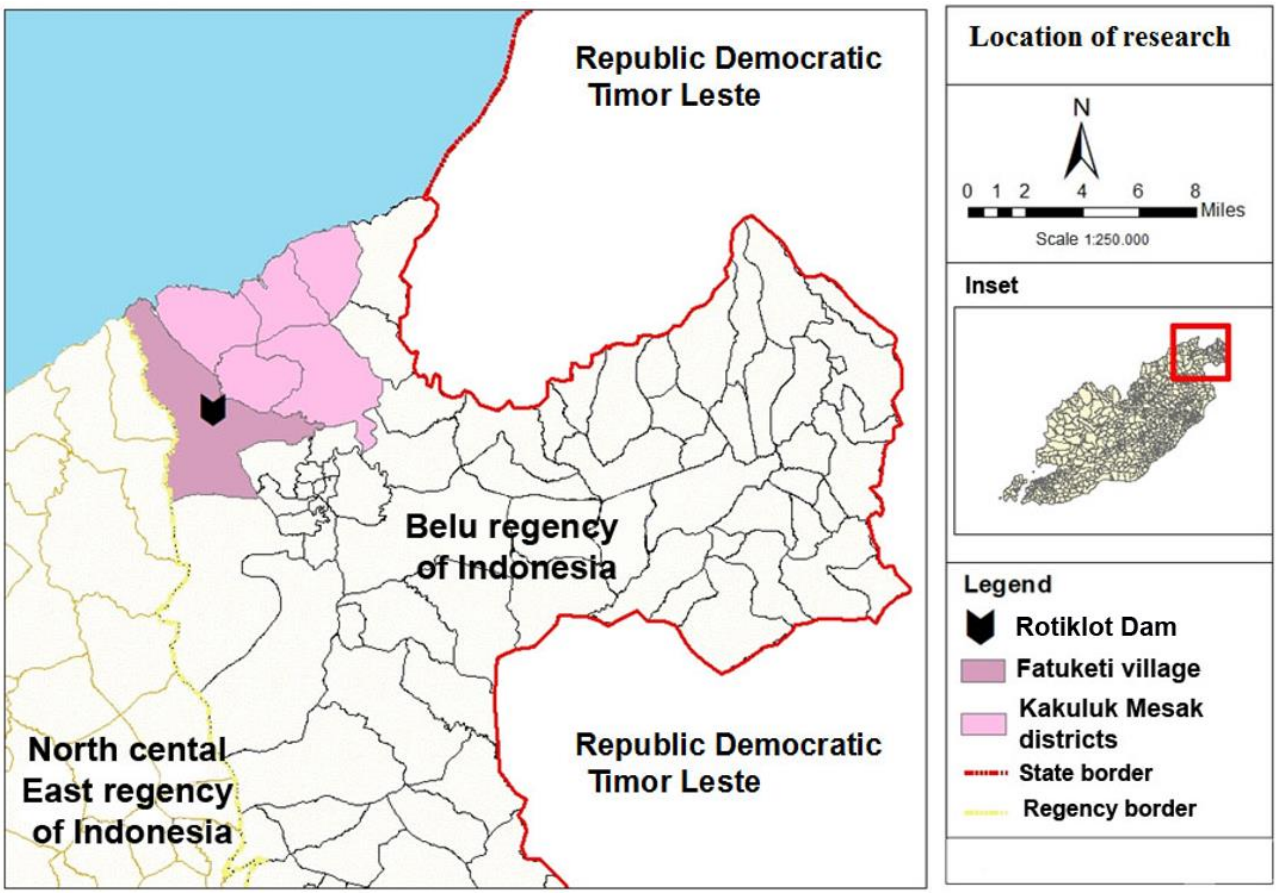

Figure 1. Map of research location.

Source: INA geoportal.

2.3.1. Location Quotient (LQ)

The location quotient aims to measure the comparative advantage in the food estate area. The formula used was in accordance with Raqib and Rofiuddin (2018):

$$LQ = \frac{Vik/Vk}{Vip/Vp} \quad (1)$$

Where:

LQ: Value of location quotient.
Vik: Production value of the i-th food crop in the food estate area.
Vk: Total value of food crop production in the food estate area.
Vip: Production value of the i-th food crop in Belu Regency.
Vp: Total value of food crop production in Belu Regency.

Equation 1 presents the comparison between the value of certain food crops and the total value of food crops in the food estate area and Belu Regency, which is in the border area. The results of the location quotient can be classified according to the following criteria:

1. LQ >1 indicates comparative advantage.
2. LQ <1 indicates no comparative advantage.
3. LQ = 1 indicates a balance.

2.3.2. Analysis Using Structural Equation Modeling-Partial Least Squares (SEM-PLS)

Analysis of the effects of social characteristics and physical inputs on agricultural production and income was conducted using SEM-PLS and SmartPLS3 software. This method can analyze models with small samples and predict composite models (Hair, Sarstedt, & Ringle, 2019). Reflective constructs are used in the agricultural production and income models. The variables used in this study included the production variables land area (P1), number of seeds (P2), amount of fertilizer (P3), labor (P4), production difference (P5), and availability of agricultural machinery (P6). The income variables were farm income (Q1), agricultural product marketing costs (Q2), seed costs (Q3), pesticide costs (Q4), fertilizer costs (Q5), labor costs (Q6), and agricultural machinery costs (Q7). The variables measuring social characteristics were motivation (S1), farmer group activity (S2), ability to cooperate (S3), independence (S4), and ability to access information (S5). The physical input variables were water discharge (H1), planted area (H2), and rainfall (H3).

3. RESULTS AND DISCUSSION

3.1. Comparative Advantage

The comparative advantage shows the specialization of the food estate area, which is supported by the construction of the Rotiklot Dam infrastructure. This specialization has an impact on the community's behaviors, socio-economic characteristics, and ability to adapt technologies so as to support increased agricultural production and income, which in turn increases regional income (Alhader, 2020; Gracheva & Sheludkov, 2021). Prior to the establishment of the food estate in Kakuluk Mesak, agricultural commodities with comparative advantages (LQ>1) were rice (1.01), cassava (1.30), sweet potatoes (1.20), and peanuts (1.72). This condition occurred because farmers used land with limited rainfall and water availability. After the establishment of a food estate area supported by the construction of the Rotiklot Dam, agricultural commodities with a comparative advantage (specialization) are rice (1.09) and corn (1.12) due to the use of marginal land, water from the dam and the introduction of agricultural technology. As stated by Sikandar, Erokhin, Wang, Rehman, and Ivolga (2021), agricultural commodity specialization and direct investment have a positive impact on economic activity through the use of marginal land, increased human resource competence, and technological adaptation.

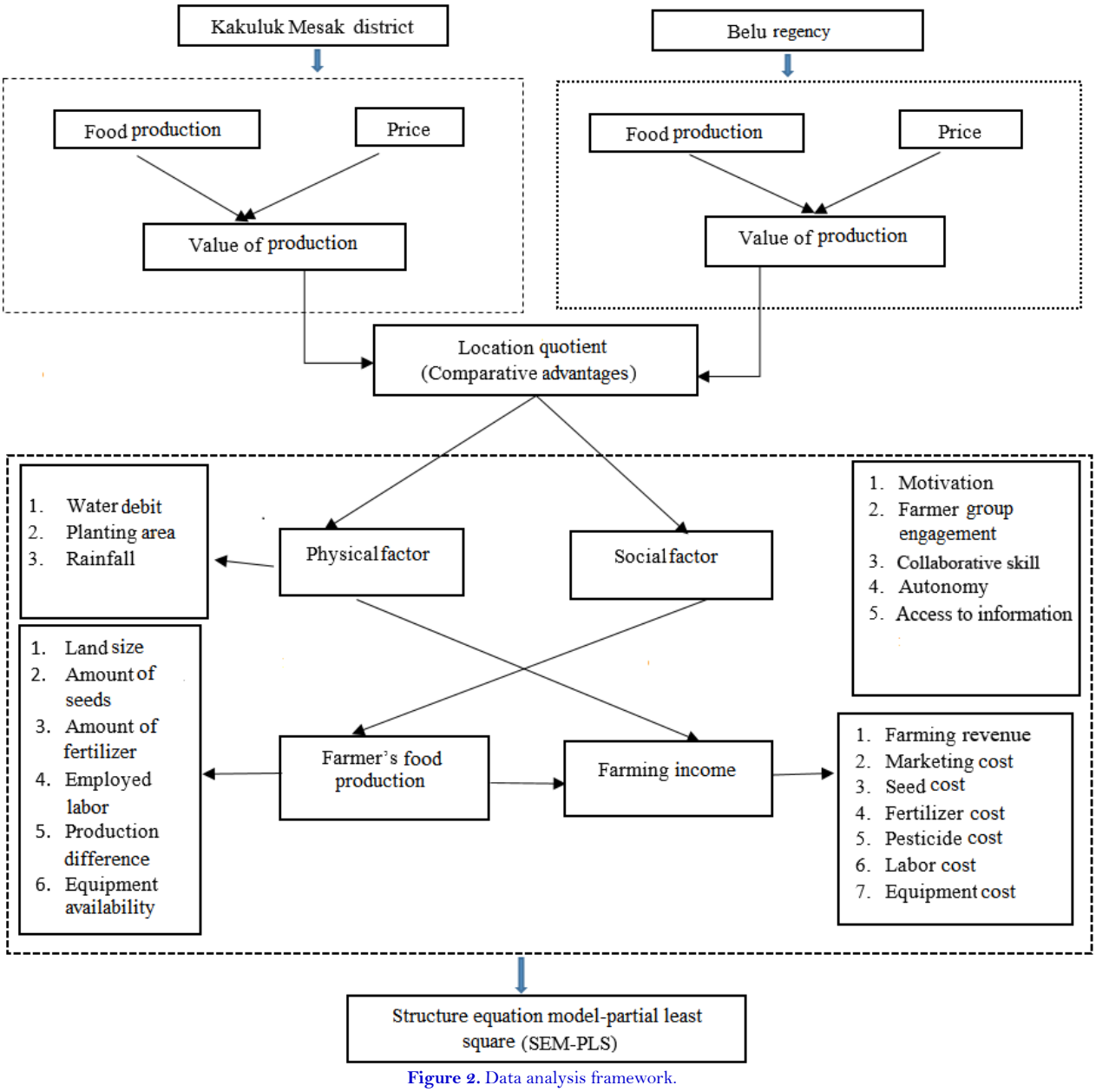

Figure 2. Data analysis framework.

Therefore, the food estate area will increase agricultural production and people's incomes by improving the marketing of these commodities both domestically and abroad (Timor-Leste). Specialization of agricultural commodities, in turn, affects production and income (Kazambayeva, Aiesheva, & Yesengaliyeva, 2019; Romão, 2020; Sultanova, Dossanova, & Gabbasova, 2021). The LQ values can be seen in Table 1.

Agricultural commodities that have comparative advantages (rice and corn) are an indication of the physical and social potential of the region (Daulika, Peng, & Hanani, 2020; Jayadi & Aziz, 2017). The physical potential of the food estate area includes water resources from the Rotiklot Dam, large planting areas, and rainfall, while the social

potential of the region includes motivation, farmer group activity, ability to cooperate, independence, and ability to access information. Further analysis is needed to find out how much these factors influence agricultural production and income in the food estate area.

Table 1. Location quotient value of food crops in food estate area.

Food commodity	LQ	
	Before the creation of the food estate area	After the creation of the food Estate area
Paddy	1.01	1.09
Maize	0.90	1.12
Cassava	1.30	0.85
Sweet potatoes	1.20	0.64
Peanuts	1.72	0.63
Beans	0.09	0.05

Source: Statistics of Belu Regency (2022).

3.2. The Influence of Physical and Social Factors on Production and Income in the Food Estate Area

3.2.1. Outer Model

3.2.1.1. Convergent Validity

The measurement of the validity of the latent variables with indicators uses the outer loading value of each indicator, which means that each indicator reflects the latent variable. The outer loading value of each indicator is valid if > 0.5, meaning that it is maintained in the following analysis, whereas if the value does not reach 0.5, it is invalid and the indicator is eliminated (Hair et al., 2021). The results of the analysis reveal some valid outer loading values (> 0.5), as can be seen in Table 2, while the other indicators were eliminated and are not included in Table 2 because their outer loading value was weak. The indicators include 2 indicators of physical variables, 3 indicators of social variables, and 4 indicators of production and income variables.

Table 2. Outer loading value of indicators affecting agricultural production and income in the food estate area.

Variable	Indicator	Symbol	Outer loading value	Description
Physical	Planting area	H2	1	Valid
Production	No. of seeds	P2	0.675	Valid
	Labor employed	P4	0.859	Valid
Revenue	Marketing cost	Q2	0.912	Valid
	Seed cost	Q3	0.624	Valid
	Labor cost	Q6	0.872	Valid
Social	Farmer association activeness	S2	0.98	Valid
	Autonomy	S4	0.673	Valid

Source: Primary data, 2022.

3.2.1.2. Composite Reliability

The reliability of each variable was measured using the composite reliability value. Consistent and stable composite reliability value as a model measuring tool requires a value > 0.7 (Hair et al., 2021). The results of the analysis show that all the variables met the minimum required value and were thus reliable, as shown in Table 3.

Table 3. The composite reliability factors affecting agricultural production and income in the food estate area.

Variable	Composite reliability	Description
Physical	1	Reliable
Revenue	0.851	Reliable
Production	0.745	Reliable
Social	0.823	Reliable

Source: Primary data, 2022.

3.2.2. Inner Model

After the model was declared valid and reliable, an analysis of the structural model (inner model) was carried out. The inner model was measured using the value of R-squared, the level of relevance (Q2), f-squared, and the t-statistics of the path coefficient (Hair et al., 2019). The results of the structural model analysis are shown in Table 4.

3.2.2.1. Testing the Model's Goodness-of-Fit (R-Squared, Q^2, and F-Squared)

The value of the production variable's coefficient of determination is weak (16.2%), while that of the income variable is 92.7%, which means it is classified as strong. Furthermore, the physical input variable and the production variable each have a strong effect on the income variable, with f-squared values of 0.567 and 8.391. Physical input variables have a moderate effect on production variables, while social variables have a weak effect on production and income variables (Hair et al., 2021). Exogenous variables also have a large predictive relevance for income (Q2 =

0.581), while production is classified as weak (Q2=0.076). Subsequently, to ensure the effectiveness of each variable, a t-statistic test was carried out.

3.2.2.2. T-Statistic Test for Path Coefficients

A t-statistic test was used to determine the effect of or relationship between all the variables. The results of the analysis are shown in Table 4 and are discussed below.

a. Effect of Physical Variables on Production and Income

The results of the statistical tests show that physical variables have a significant direct effect on production and income at 1%. Likewise, the indirect effect of physical variables on income through production is significant at 1%. The area of cultivated land, which is a physical input variable, affects the need for seeds and labor, thereby increasing production and income (Lestari, Hanani, & Syafrial, 2019; Mohr & Kühl, 2021). The increase in production and income further contributes to the improvement of the regional economy (Daniel, 2021; Susilastuti, 2018), so that the interaction of the people of the border areas of Indonesia and Timor-Leste can be optimized to increase income through marketing surplus agricultural produce from the food estate.

Table 4. The analysis results of factors affecting agricultural production and income in the food estate area.

Path and goodness of test	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
Physical input-> Income	0.221	0.216	0.035	6.276	0.000[a]
Physical input-> Production	0.381	0.393	0.078	4.885	0.000[a]
Production-> Income	0.857	0.865	0.029	29.518	0.000[a]
Social-> Income	−0.015	−0.014	0.016	0.954	0.34
Social-> Production	0.112	0.114	0.066	1.689	0.092[b]
Physical-> Production-> Income	0.327	0.339	0.068	4.825	0.000[a]
Social-> Production-> Income	0.096	0.099	0.058	1.656	0.098[b]
R-square	Production	0.162			
	Income	0.927			
F-square	Physical-income	0.567			
	Production-income	8.391			
	Social-revenue	0.003			
	Physical-production	0.173			
	Social-production	0.015			
Q^2	Income	0.581			
	Production	0.076			

Note: a and b indicate significance at α= 1% and 10%, respectively.
Source: Primary data, 2022.

b. Effect of Social Variables on Production and Income

The results of the analysis reveal that social variables do not have a direct significant effect on income but do have a significant effect on production at 10%. The results of the t-statistical test also show that social variables have an indirect effect on income through production, which is significant at 10%. Farmers in the food estate area on the Indonesia–Timor-Leste border tend to work together because they have strong social capital. Social capital has a beneficial effect on the availability of labor, the need for funds for farming, and the exchange of information about technology and marketing agricultural products (Anh & Bokelmann, 2019; Sitaker et al., 2020). The facts in the food estate area show that farmers' costs are the same for different land areas. This condition causes the social costs incurred by farmers to be greater than the income obtained from their farming, so that there is no direct influence of social variables on income. Farmers are stuck with unproductive conditions in which to run their farms (Le Coent, Préget, & Thoyer, 2021). Farmers' social capital, in the form of mutual cooperation in farming in the food estate area, can increase production and income if it is efficient, as previously noted by Syarifudin and Ishak (2020), who stated that social spaces are needed for farmers to interact and share knowledge on efficient use of inputs and ways to increase agricultural production and productivity. Social capital improves networks to facilitate access to agricultural information.

c. Effect of Production on Income

The results of the PLS analysis show that production affects income at a 1% level of significance. Agricultural production in the food estate area is related to input efficiency and production costs. Chen et al. (2022) stated that farmers' technological adaptability and ability to access information, including input costs and output prices, increase the relationship between production and income.

3.3. Recommendations for Developing the Food Estate Area

Anik, Rahman, and Sarker (2017) and Soltanisehat, Alizadeh, and Mehregan (2019) stated that research is a source of innovation, which, in turn, has an impact on the economic growth of a region. Based on the analysis of comparative advantage and the structural model of production and income, several recommendations for innovation are made that should be implemented to sustainably increase production and income in the food estate area on the border of Indonesia and Timor-Leste.

First, the planting area for rice and corn should be expanded. Expansion of agricultural land (agricultural extensification) is possible because sufficient land is available. The cultivated land area is 159 ha, while the marginal land is 300 ha. For the expansion of agricultural land (from 159 ha to 459 ha), a large amount of water is needed, which can be supplied by the Rotiklot Dam. The volume of water available in the Rotiklot Dam is 2,935,000 m^3, while the water demand for corn and rice is relatively small (less than 0.5% of available water). These conditions provide opportunities for the expansion of planting areas, especially on marginal land. Qureshi (2017) stated that the sustainable use of marginal land can increase agricultural production and food security. Furthermore, Cervelli, Scotto di Perta, and Pindozzi (2020) emphasized that marginal land is a resource for the entire region and can become an engine of economic growth.

Second, corn crops should be rotated every two growing seasons. Corn and rice have a comparative advantage in food estate locations because they can be cultivated for two growing seasons a year, using water from the Rotiklot Dam. Crop rotation in a suitable food estate area can increase agricultural production, efficiency, and income, as stated by Ciaian, Rajcaniova, Guri, Zhllima, and Shahu (2018). The crop rotation that can be carried out in the food estate area is as follows: (a) Rice (first season) - Rice (second season); (b) Rice, Corn (first season) – Rice (second season); (c) Rice (first season) - Rice, Corn (second season); (d) Rice, Corn (first season) - Rice, Corn (second season).

Third, input efficiency should be increased. Agricultural income can be increased through an increase in the production output, and/or a decrease in production inputs. Production inputs in the food estate area are social factors, especially labor, where certain stages (such as fertilization, control of pests and diseases) that do not require many workers must be carried out independently by farmers, while certain stages (such as planting and weeding) that require a lot of labor are carried out through mutual cooperation. In line with the findings of Syarifudin and Ishak (2020), an adaptive social space is needed for productive interactions to occur through equalizing perceptions and sharing knowledge. In addition, physical input efficiency can be realized through irrigation development and maintenance, which can reduce irrigation water losses so that there is an efficient use of inputs. Daniel (2021) found that input efficiency contributes to an increase in agricultural production and income.

Fourth, the adoption of agricultural technology innovations by farmer groups should be increased. Susilastuti (2018) stated that this would increase agricultural production and income growth. The use of uniform agricultural technology (land processing, seeds, use of fertilizers, pest and disease control, harvesting and post-harvesting) would increase production and income at food estate locations by ensuring consistent product quality. This would make it easier to brand and market agricultural products. Agricultural technology innovations are more easily adopted by farmers who are active in farmer groups, and Ovharhe, Odemero, Folunsho, and Oghenefejiro (2020) stated that farmers who are actively involved in groups have an increased ability to become independent farmers.

Fifth, surplus production should be utilized for the border market. The increase in rice and corn production in the food estate area has given the two commodities a comparative advantage, not only domestically but also abroad (especially in Timor-Leste). Thus, there is an opportunity for trade between countries; Pawlak (2021) stated that the liberalization of bilateral food trade occurs due to the comparative advantage between two countries or trade areas.

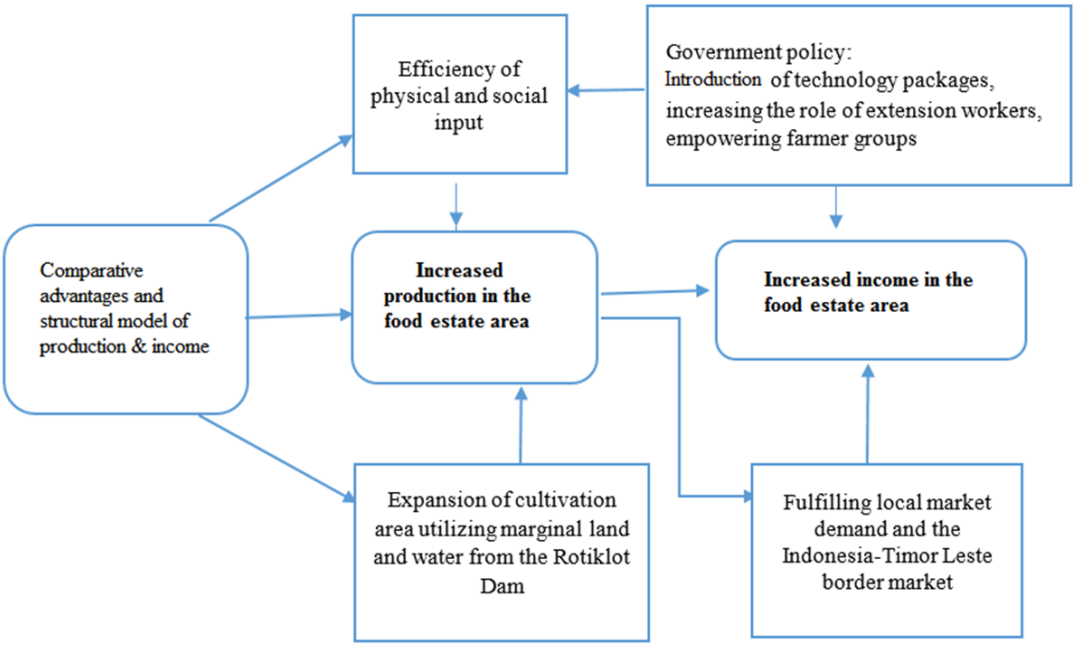

Figure 3. Flowchart of recommendations for the development of food estate areas in the Indonesia–Timor-Leste border area.

The recommendations for innovations in the food estate area of the Indonesia–Timor-Leste border area are summarized in Figure 3. Agricultural extensification by utilizing marginal land and water from the Rotiklot Dam, the efficient use of inputs through the adoption of agricultural technology innovations, increasing the role of extension workers, and empowering farmer groups will increase agricultural production in the food estate area. The increase in agricultural production is expected to be well able to meet local market demand and serve the Indonesia–Timor-Leste border market, thereby increasing income. Adeniyi and Dinbabo (2020) and Fadillah and Loilatu (2021) stated that input efficiency increases food production and distribution in food estates, which has the effect of increasing farmers' incomes and reducing food availability gaps.

4. CONCLUSION

The specialization of the food estate area provides a comparative advantage for rice and corn due to physical characteristics that have direct and indirect effects on income, while social characteristics have an indirect effect on income through production.

It is necessary to expand the planting area because the availability of water from the Rotiklot Dam, input and cost efficiency, and increased motivation of farmers through input subsidies and technology transfer will then be able to increase agricultural production and income.

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