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Analysis of the Rice Value Chain in Bobonaro Municipality, Tmor-Leste

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Abstract

The aim of this article is to analyse the rice value chain in Bobonaro, Timor-Leste, from the producer's point of view, for this purpose, the *Data Envelopment + Analysis* (DEA), *Tobit and* Regression. The sample consisted of 200 rice producers in one municipality, namely Bobonaro. The results showed that the production scale presented increasing returns in about 96%. Only 3% of the sample surveyed showed an efficient scale and about 1% presented a production scale with decreasing returns. The results of multiple linear regression analyses show that the model has a degree of adjustment of 10.6%, and the model is statistically significant. The estimated coefficients are statistically significant for Land, Seeds, Capital and IR8 Variety. There are many factors that influence the decision-making of producers when selling their rice products. Rice distribution chains operate through various channels, including traders, companies, wholesalers, retailers and agents.

Keywords

Rice, Value Chain, Bobonaro, Timor-Leste

1. Introduction

The agri-food chain's mission is to promote the analysis of the relations between the sectors of production, processing and distribution of agricultural products, aiming to promote quality and balance in the food chain. The analysis of information on the food price index seeks to contribute to improving information to consumers, public authorities and market operators and, consequently, transparency along the food value chain.

Rice is one of the most produced and consumed cereals in the world. It is the

main food of more than half of the world's population. In Asia, in particular, it ensures about 60% to 70% of the caloric intake of more than 2 billion people, both in its original form and in its by-products (Juliano & Villareal, 1993; Muthayya, Sugimoto, Montgomery, & Maberly, 2014).The authors mentioned above indicate that more than 50% of the world's population consumes rice, although this is one of the most important cereals in Asian countries. In Timor-Leste, agriculture is a source of income for more than 70% of urban and rural families, with rice being the staple food (Noltze, Schwarze, & Qaim, 2013; Deus, 2019; Templeton, 2012; Jesus, Henriques, Laranjeira, Narciso, & Carvalho, 2015).

Although the domestic production of rice is totally destined for domestic consumption, it is insufficient to guarantee the supply of the basic food needs of the population, either for reasons associated with production reductions resulting from climatic adversities, or by the constant decrease in productivity, or also by the increase in the population. Agriculture plays a key role in Timor-Leste's development and social progress by occupying and sustaining the majority of the population (Loly, 2014). Despite the changes in consumption habits observed in the Timorese population, and in the current economic patterns in relation to the land, everything indicates that the trend of rice consumption will continue for a long time.

In terms of organization, structure and functioning, the agri-food chain of Timorese rice is almost non-existent, insipient and heterogeneous. The total number of producing families has been reducing (in the years 2004 to 2010 it went from 60,966 to 45,672 thousand producers), although the average production areas have increased from 0.5 hectares to 0.9 hectares (DNE, 2006; DNE, 2011). The main actors in the agri-food chain are importers, commission agents, wholesalers and retailers, with producers being the least involved. Both the production and the marketing of rice in the domestic market, even the imported, are managed by the public sector, lacking research and development institutions, market promotion and extension. The role of the private sector is limited. The rice agri-food chain offers job opportunities in the country, especially in market-related activities. Production planning and management, harvesting, processing, packaging and other post-harvest operations are not part of these employment opportunities.

The planted area of rice in Bobonaro municipality, which in 2015 was 2516.17 hectares, has been increasing, rice fields currently with improvements in infrastructure and productive practices, even though there is no export of rice or manufacturing industry (MAP, 2015). Although production and processing have the potential to contribute to the sustainable development of Bobonaro municipality, there are several challenges related to all levels of the agri-food chain, from production, to marketing, including imports, which reduce the value of rice to consumers and the profitability of participants in the agri-food chain. On the production side, the average yield of the hectare of rice is about 2 - 3, 53 tons in husk per hectare (MAP, 2015), which is very low compared to the world av-

erage that holds more than 4 tons, in husk, per hectare (Gadal, Shrestha, Poudel, & Pokharel, 2019). This situation can be attributed to adverse weather conditions, poor management and lack of knowledge and technical skills in its production and harvesting. Various pests and diseases, combined with inadequate measures for their control and adverse climatic conditions, cause significant losses of rice production. It is estimated that 22.5% of rice production, valued at about US$ 1.065, 48 per year (MAP, 2015), is wasted due to inadequate harvesting, packaging and handling practices. This not only affects domestic gains and increases imports, but also generates waste that induces sanitation/environmental problems.

Like other agricultural subsectors, the rice agri-food chain also faces problems of overuse and degradation of resources such as soil, water scarcity and energy scarcity and this has an additional effect on rice productivity. In addition to production, the marketing of rice in Bobonaro is non-existent in the case of domestic production and is inefficient, in the case of imported rice, due to the involvement of numerous intermediaries, lack of market dynamism and the absence of modern infrastructure and logistical support, such as cold storage, transportation and other equipment. Although modern retail formats, such as supermarkets, exist in Boboraro, rice is distributed through traditional channels that create little value for consumers (Cruz et al., 2016). Moreover, the distribution of profits among the participants of the chain is uneven, with producers receiving a relatively low portion of the price paid by consumers or, even none, if rice is imported.

The country is dependent on imported rice to meet its domestic demand. Vietnam, Thailand and Indonesia are the largest exporters of rice to East Timor. In addition to the complexity of customs legislation, the high tax burden on imported products, inefficient infrastructure and insufficient Timorese ports, airports and highways, and also the oscillation of acquisition costs due to fluctuating exchange rates, the logistics and transport cost of imported rice is high (Fleury, Wanke, & Figueiredo, 2009). According to Machado (2014), these costs reduce the competitiveness of companies that carry out import operations and have a direct impact on the country's economic development by reducing the generation of jobs and income in the domestic market. Companies often need to practice higher prices to minimize the possible losses caused by exchange rate variation, thus reducing their competitiveness in the face of domestic competition and improving the value chain of agri-food imports.

2. Literature Review

Any agri-food product, when it reaches the final consumer, has travelled a certain path, from the origin that precedes its production to the final destination. From the producer to the consumer, there is a multitude of activities that transform the raw material and make it easier for the final consumer to have access to this product Fernández (2013). Although there is no consensus in the literature

regarding the definition and denomination of the value chain, which is considered according to different perspectives, it is also designated as a supply chain, demand chain and supply chain.

Porter was one of the first authors to propose a new paradigm in the mid-1980s, stating that activities that develop in an ancillary way to the flows of goods and financial flows create added value to the chain (Porter, 1985). This added value, created by a set of activities developed along the different steps, can be seen as the consumer's willingness to pay for a product or service, the final cost of which is higher than the initial execution cost. In addition, Porter (1985), classifies activities that produce added value and create competitive advantage in a value chain in primaries, ranging from product development and production, to logistics, marketing and after-sales services, and primary support activities such as human resource management, purchase of goods and services, technological development, and business infrastructure (finance, accounting, quality management, public relations, legal advice, among others).

According to Mentzer, DeWitt, Keebler, Min, Nix, Smith, & Zacharia (2001) and Lambert & Cooper (2000), regardless of the type of chain, there are activities in the management of value chains with common characteristics, namely integrated behaviour, sharing information among members of the chain, sharing of risks and benefits or rewards, cooperation, common goal and equal guidance to serve the consumer and process integration.

Although the definitions of value chain are numerous, there is consensus among several authors: Lee, 1992; Lee & Billington, 1993; Mentzer, 1993; Mentzer et al., 2001; Frazelle, 2002; Hunkaa, Huckab, Kasikb, & Vymetalc, 2011. Mentzer et al. (2001) understand it as a set of three or more entities (organizations or individuals) that are directly involved in the two-way flow of products, services, financial resources and information: from the initial source (suppliers of raw materials) to the final consumer. In addition, all players in the value chain interact with each other to offer a product or service to the final consumer, establishing links between material flows (Ellram, 1991). Donovan, Franzel, Cunha, Gyau and Mithöfer (2015) review different definitions of value chains in terms of a set of strategic activities, actors and networks that best respond to consumer demand.

The value chain thus comprises the set or network of organizations or entities and facilities involved in the functions of acquisition of materials or raw materials, their transformation into intermediate and finished products, and their distribution to end customers (Hunkaa, Huckab, Kasikb, & Vymetalc, 2011; Lee & Billington, 1993; Frazelle, 2002; Busch, 2002). For Waters (2003), the existence of organizational barriers and restrictions on information flows can lead to complete, undesirable centralized control of material flows in a value chain.

Webber and Labaste (2010) focus mainly on the links of a value chain, including vertical links and interdependent processes that generate value for the consumer, as well as horizontal links to other value chains that provide intermediate goods and services. The authors note that a value chain implies value crea-

tion in both of these processes.

Planning, supplying, using/transforming and delivering are some of the processes integrated into the value chain, which covers all interactions and transactions from the raw material supplier to the customer (Roussel, 2005). For Mentzer et al. (2001) there are three degrees of complexity in the value chain, depending on its size or depth, which can be direct, extended and complete. The direct chain consists of an organisation or supplier and a customer who are not involved in the flows of products, services, finance and/or information upstream and/or downstream. The extended includes all of these (suppliers and customers involved in the flows of products, services, finance and/or information, from the point of origin to the point of consumption). In full, all participants interact directly or indirectly in the flows of products, services, finance and information from the initial supplier of raw materials to the final consumer.

According to Briz, De Filipe, & Briz (2010), the agri-food value chain, with a global focus, from producer to consumer, can be analysed based on the method of analysis of the competitiveness of porter diamond (1980) and/or, based on the method of sectoral organization. They consider the agri-food chain as a value network, formed by companies in the agri-food sector (Briz, De Filipe, & Briz, 2010, 2012).

For Lambert & Cooper (2000), the agri-food chain is like a tree where suppliers represent the roots and the network of customers are the branches and, where the position of a given member in a given position implies a differentiating function.

For Hobbs, Cooney and Fulton (2000), from an organizational perspective, the structuring elements that are the key to the functioning of the agri-food chain are: formulation of common objectives, management of the flow of information and evaluation of the income obtained in the chain that guarantees tangible results/benefits to all participants, which builds relationships of cooperation and trust. These elements differ from those that Mentzer et al. (2001) consider to be the most important in the agri-food chain, which are integrated behaviour, i.e. the sharing of information in a coordinated manner, the sharing of risks and results, cooperation, process integration and the construction and maintenance of long-term relationships. For Fernández (2013) all these aspects lead to improvements in income and competitive advantages in the sector where they develop, since both risks and benefits should be shared symmetrically and a focus on the same objective and customer service fosters cooperation and promotes the efficiency and sustainability of the agri-food chain in the long term.

Application of the Rice Agri-Food Chain

The study was carried out between 2008 and 2012 in the rice agri-food chain sector by Henriksen, Riisgaard, Ponte, Hartwich and Kormawa (2010), in a province of southern Vietnam. The analysis of the rice value chain focused on three main areas: 1) the level of participation of poor farmers; 2) opportunities to improve operational deficiencies; and 3) improvement in vertical and hori-

zontal articulation. Overall, improvement interventions were recommended for all stages of the rice value chain. The results of the qualitative analysis were made available in workshops and focus groups, including systemic restrictions, forming the critical basis for the follow-up of the project. This group was led by a panel composed of members of experienced representatives of provincial functional agencies. The main activities consist of updating production for farmers, such as investments in minimal infrastructure or improvement in rice varieties. Companies are indirectly benefited by project support to provide business development services in the industry.

The studies by Sharma, Giri and Rai (2013) deal with the practical issues existing in the rice chain in India. To remain competitive, the rice processing plant needs to adopt the latest supply chain strategies. It matters coordination, collaboration with farmers and customers for a smooth flow of processed rice. Demand consolidation improves reserve reduction. You must pay attention to the design of the distribution channel. It is essential to redesign the rice supply chain to achieve better company performance as well as better customer service. The current structure of the rice supply chain in India operates in a traditional structure that involves many intermediaries, both in supply and distribution. This chain shows a lack of efficiency and needs reform. The traditional supply chain structure faces inventory management problems as there is overbooking, increasing supply chain costs. In this way, the excess reserve is lost, which results in lost sales. They conclude by stating that the various structures and strategies for supply, procurement, collaboration and distribution, including logistics strategies for the supply chain member at all stages, have to be carried out according to their nature, type, size and format of work.

Soullier (2017) studied the rice value chain in the Senegal river valley, considering the contribution of agri-food chains to food security in developing countries. The results presented point to the need to modernize the Senegalese rice value chain, in line with what is happening in Asia. Therefore, in Senegal 1) the reference situation is a cash transaction (not a linked production and credit transaction) for processors to harvest husked rice before modernisation; 2) credit policies contribute directly to the change in management; and 3) the modernisation of the rice value chain does not make it competitive in relation to imports of ground rice. The second result shows that small producers take part in contracts to secure agricultural financing, and the third result points to differentiation in the effects of the small farmers' contracts.

Trevor and Lewis (2015) reviewed the rice value chain, the third most important food crop in Tanzania. The results showed that weaknesses lie in low production per hectare (1.5 t/ha), compared to 2.5 t/ha for the rest of Africa and 4.4 t/ha in Asia. The low production is linked to a production predominantly dry, limited adoption and availability of improved crops, minimal use of fertilizers, traditional planting techniques and limited irrigation areas. Rice production for small producers has high labor requirements which, together with a small amount

of mechanization, results in high production costs.

Kisanga (2015) examined the profit and the agri-food chain of rice in Kahama district, Shinyanga Region. The results indicate that there were many people involved, i.e. producers, intermediaries, traders, millers, wholesalers, retailers and ultimate consumers. The structure conduct and performance in the rice market were analysed. Profits along the rice value chains were also calculated. The study showed that 77% of farmers store their rice paddies in places that can maintain their quality and therefore offer good prices. In addition, it was found that 65.5% of traders buy rice through intermediaries at a fair price, since they already had information on price movements in different markets. The study recommends strengthening the market information system, improving agricultural input supply systems to increase production, productivity and the reinforcement of good agricultural practices for farmers. In addition, there are key marketing matters that will lead to sustainable rice cultivation, not only in the Tanzania area but also in other areas.

Ilu (2015) studied the Kano River Irrigation Project (KRIP) in Kano State, Nigeria. The result indicated that the average farmland was 2.6 hectares, with a yield of about 2.9 t/ha. Over 80% of the estimated 189,630 tons of rice produced in the study area are sold. The remainder is used for domestic consumption and seeds. About 156,000 tons of rice are introduced into the market by retailers (65%), rural associations (15%) and rural intermediaries (2%). After going to millers for milling, the rice is sold to urban and rural retailers who make it available to consumers. Rice production was profitable in the study area. Low rice prices, limited access to credit, labour shortages, irregular electricity supply, high fertilizer costs and marketing were the main constraints that had a negative impact on the people involved in the rice value chain in the study area. Price is the most important variable that influenced consumer's preference. Development agencies should make efforts to reduce the business's costs along the value chain, to increase the local rice demand.

3. Methodology

The methodology, which provides knowledge of reality to the researcher (Denzin & Yvonna, 1994), includes the operational procedures used and the techniques and tools for data collection and its processing.

A multidimensional and complex approach using quantitative and qualitative paradigms was used to analyse the rice agri-food value chain (Taylor, 2005). The analysis made it possible to determine the structure and dynamics of the value chain and power influences as well as the performance of the people who took action in the chain and the competitiveness of the sector (Petersen et al., 2015). It was also useful for identifying constraints affecting the value chain performance to determine sectoral strategies for food security (Crittenden et al., 2011; Banson et al., 2015).

In the quantitative analysis's context, descriptive techniques will be used in

the data collected by a questionnaire to know the profile of those who respond, whether or not they are producers. For producers, the Data Envelopment Analysis (DEA) technique will be applied to assess the relative efficiency of the involved producers, based on the output (rice production) versus the inputs used in that production (capital, land, energy, human resources). In an attempt to know the determinants of this efficiency, appropriate regression models will be used, in particular Tobit models.

Data Envelopment Analysis (DEA) is a non-parametric approach that relies on mathematical programming, specifically linear programming, to analyse the efficiency of the rice producing units' value chain (Coelli, Rahman, & Thirtle, 2002; Balcombe, Fraser, Latruffe, Rahman, & Smith, 2008). In the literature related to DEA models, a producing unit is treated as a DMU (Decision Making Unit), since from these models comes a measure to evaluate the agri-food value chain's efficiency of decision-making units. A producer unit is any production system that turns inputs into products.

Multiple regression analysis is a multivariate statistical technique that can be used to analyse the relationship between a single dependent variable and several independent variables (Sukati, Hamid, Baharun, & Yusoff, 2012; Han, Chen, Qiao, Liu, Fan, & Zhang, 2020). The estimated coefficients denote the relative contribution of the independent variables to the dependent variable, in other words, each variable's influence is present on the explanation of the phenomenon under analysis (Meeusen & van Den Broeck, 1977). Y is the dependent variable related to rice production; β0 indicates the constant; We also have the independent variables, representing the factors of production: land in hectare, seeds in kg, workers in people, capital in U.S. dollars, warehouse in square meters, school years in years, the variety IR64 in kg, the membrane variety in kg, the local variety in kg, the variety IR8 in kg and the variety *nakroma* in kg; Finally, the βi are the parameters to be estimated. However, aspects more dynamic related to the estimates obtained with the method of correction, and also with the traditional approach of estimating concurrent equations, show that the same approach of estimating concurrent equations causes coefficients of market supply and demand (Greene, 2008; Parajuli, Zhang, & Chang, 2016). The multiple linear regression model used can be the following:

$$\begin{aligned} \mathrm{LnY_i} = {} & \mathrm{Ln\beta_0} + \mathrm{Ln\beta_1 Ter} + \mathrm{Ln\beta_2 Sem} + \mathrm{Ln\beta_3 trab} + \mathrm{Ln\beta_4 Cap} \\ & + \mathrm{Ln\beta_5 Arm} + \mathrm{Ln\beta_6 Anoses} + \mathrm{Ln\beta_7 IR64} + \mathrm{Ln\beta_8 Mem} \\ & + \mathrm{Ln\beta_{10} Varloc} + \mathrm{Ln\beta_{11} IR8} + \mathrm{Ln\beta_{12} Nak} + \varepsilon \end{aligned}$$

Y = Production
Ter = Soil
Sem = Seeds
Trab = Workers
Cap = Capital
Arm = Storage
Anoses = Years of schooling

IR64 = IR64 Variety
Mem = *Membrano* Variety
Varloc = Local Variety
IR8 = IR8 Variety
Nak = *Nakroma* Variety
ε = Error variable

In this research, the quantitative research method was used, and the data was collected by a questionnaire made to producers. With that data, a poll was conducted. The questionnaires were tested (pilot questionnaire) and the results of this "pilot study" were used to review the initial questionnaires, which were subsequently carried out on a sample of 200 rice producers. The questionnaire was executed in person by the researcher. The analysis of the questionnaires was done using the Statistical Package for the Social Science (SPSS 24.0) software. In order to analyse the efficiency of the production link and its determinants, is used the DEA (Data Envelopment Analysis) technique and the multiple linear regression. Stata 14 software is used in this context.

The study takes place in the municipality of Bobonaro. The investigation was carried out between August 20 and December 15, 2021, and before starting the interview there were meetings with the Suco chiefs, extensionists, directors and heads of relevant departments in the municipality in order to obtain direct information on the total number of rice producers related to the rice agri-food chain in Bobonaro. It was used the method of visiting each producer, before making the random choice. This study follows a survey research design, which is useful for solving problems when the process is guided by one or more specific research problems. The population of this study covers four hundred (400) rice producer in Bobonaro, East Timor. Based on the above population, the sample size of the study is therefore determined using the Yaro Yamane (1967) sample determination technique,

Where; N = Population size; n = sample size; e = Error of margin (0.05)

$$n = N \Big/ \left(1 + Ne^2\right)$$

$$n = 400 \Big/ \left(1 + 400 \times 0.05^2\right) = 200 \text{ producers}.$$

The sampling method used was the simple random sampling method, being a sampling process that gives the same opportunity to each element of the population to become a member of the sampling. The members of the population were randomly selected one by one (all populations have the same chance to be selected). The surveys were selected taking into account the criterion of location: farmers would have to be residents of the selected area. The sample was selected after, according to the direct approach to the respondents, under the supervision of the researcher. An interview was conducted with the respondents to obtain more in-depth information, as part of the analysis of the agri-food chain of rice in Bobonaro. Observations were used to identify the facts that occurred in the study area. This observation was made directly by the researcher in the study

area already identified, since the data was obtained from producers who actually developed agricultural activities, especially rice producers. The interview represents a method of obtaining information through a question-answer scheme. In the interview process the researcher used the questionnaires and discussed with the interviewees the major problems/difficulties they experienced in the agri-food chain of rice.

4. Results and Discussion

This section presents the empirical results obtained from the research. It begins with the characterization of rice producers in Bobonaro municipality, taking into account the research sample. The descriptive statistics of the production factors and the efficiency of the rice agri-food chain are presented below. The variables (input and output) of the DEA and Tobit models are exposed to the efficiency measures of value chain and possible interpretations. The factors around the decision-making process of the sales, the appropriate time to sell, the destinations of the products obtained, the training used in the selling process, and the factors around the logistics and distribution of rice are described.

In this part of the research work, we intend to present a characterization of the 200 producers who answered the questionnaire, those who represent our sample. They are mostly men, about 156 (78%), while women represent 22% of the respondents. In the rice production activity in Bobonaro the majority, 89%, uses its own area and 11% uses rented area for agricultural activity.

Table 1 presents some statistics regarding the factors of production and income of rice producers. We should highlight the differences and the opposition between the costs of personal and leased areas, and the large dispersion in most of the variables taken into account, in particular production, initial capital and amount of seed used per hectare. This discrepancy shows the diversification of methods and forms of rice production in Bobonaro, which may translate into significant differences, not only in quantity but also in quality.

The efficiency of the food chain and the scale of rice producers in Bobonaro were considered in the variable returns of scale (DEA BCC), with output orientation. It is important to note that, as in Giuffrida & Gravelle (2001); Huang, Bruemmer, & Huntsinger (2016); Devkota, Pasuquin, Elmido-Mabilangan, Dikitanan, Singleton, Stuart, & Listyowati (2019), those who achieved efficiency levels between 0.90 and 1 were considered efficient producers, and those who achieved levels below 0.9 were considered inefficient producers.

Presented in Table 2, 192 producers (96%) have a scale of production with increasing yields, which translates into the efficiency of the rice agri-food chain. For those with constant yields, only six producers in the total sample had such a yield, i.e., only 3% had an efficient scale of the riceagri-food chain. Finally, two producers had decreasing yields, which corresponded to 1% of the total sample, highlighting that the level of efficiency would be higher if they had a smaller scale of production.

Table 1. Producer yield and production factors.

	Minimum	Maximum	Average	Standard Deviation
Own agricultural area (hectare)	0.6	15	2.2645	1.88619
Leased agricultural area (hectare)	0.8	15	1.4516	2.54413
Total areas used in production (hectare)	0.4	5	1.121	0.55686
Payment of leased area (dollars)	120	400	201.3793	86.17773
Production of each hectare (tonne)	1	6	2.4825	0.60939
Total workers (people)	7	129	31.91	15.26
Non-family workers (people)	4	125	29.14	14.982
Family workers (people)	2	8	3.06	1.662
Cost of workers' wages (dollars)	3.5	6	5.075	0.5496
Seed used per hectare	14	60	32.3867	9.12477
Seed used in the production season (kg)	10	200	39.3917	20.81145
Rice selling in tonne	0.2	4	0.672	0.5066
Prices of shelled grains (dollars)	0.4	0.55	0.4051	0.01732
Shelled grain prices (dollars)	0.5	1.5	0.8574	0.08509
Initial capital (dollars)	150	950	408.56	160.4833
Cans or bags (kg)	12	80	44.9333	28.3344
Quantity per hectare (tonne)	840	10,350	2709.447	1257.83914

Table 2. Rice producers' distribution in relation to the type of return.

Production scale	Producers numbers	%
Growing income	192	96
Constant income	6	3
Decreasing income	2	1
Total	200	100

Table 3 shows a comparison between the six most efficient and the six least efficient producers, with output orientation within the Bobonaro rice agri-food value chain. The values of the six least efficient producers represent the values that should be diminished from inputs in order for these producers to become efficient, based on benchmarking.

Table 3. Comparison between the six most efficient and the six least efficient rice producers in Bobonaro.

Ranking	Results	DMU	Production (Kg)	Land (m^2)	Seeds (Kg)	Workers (People)	Capital (UDS$)	Return
1°	1	4	4750	14,000	30	177	100	Constant
2°	1	8	5500	10,000	10	134	250	Constant
3°	1	22	9600	20,000	80	288	450	Constant
4°	1	58	9800	20,000	70	250	790	Constant
5°	1	63	10,000	20,000	72	233	900	Constant
6°	1	150	4350	15,000	67.5	184	15	Constant
195°	0.4096	86	820	7000	25.2	90.3	370	Growing
196°	0.4041	14	2260	15,000	67.5	216	470	Growing
197°	0.3926	180	1300	10,000	40	149	415	Growing
198°	0.3877	16	6200	40,000	160	512	900	Growing
199°	0.387	84	640	8000	24	113.6	345	Growing
200°	0.3263	7	5320	50,000	225	605	500	Growing

The six efficient producers, i.e., those who obtained a result equal to 1.0, thus serving as benchmarks for the other rice producers, were DMUs 4, 8, 22, 58, 63 and 150, all of which presented constant yields of scale. For the six least efficient producers, it was observed that in order to increase the amount produced by the owner, through the optimal use of inputs, some changes in the producers´ expenses would be necessary. The less efficient producer had increasing yields of scale, so an increase in inputs would lead to a more than proportional growth in production. Thus, a better use of all these inputs in production would lead to a decrease in inputs and consequently a higher efficiency of the agri-food value chain for rice producers in Bobonaro.

Before estimating the coefficients of the regression model, the form adopted to measure the variables should be presented. The dependent variable, degree of the value chain analysis, and the independent variables, except the last one, were measured according to procedures already explained before. Using the minimum squares method, the results are presented in **Table 4**, showing that the model presents an adjustment of 10.6%, being the model statistically significant. The estimated coefficients are statistically significant for Land, Seeds, Capital and IR8 Variety, so to increase its production it would be necessary reductions in Land, Seeds, Capital and IR8 Variety (Li, Nanseki, Chomei, & Yokota, 2018). We can conclude that there is a linear relation between the independent variables and the dependent variable (total rice production). The variables Work-

ers, Warehouse, Schooling years, IR64 Variety, *Membrano* Variety, Local Variety and *Nakroma* Variety are not statistically significant.

The agri-food chain of rice is a process in which producers bring their products to consumers through marketing. It begins with the production but is not limited to that. It also goes through processing, buying, selling and logistical activities. This dynamic of production, to remain in the market, implies that producers have volume, quality, diversity and regularity of supplies, because the consumers need to eat daily, and suppliers must be shaped for the agri-food value chain of rice offer in Bobonaro.

Rice marketing channels in Bobonaro can be divided into direct and indirect. There are at least six distribution channels, depending on whether they are intermediaries in the relations that rural producers establish with the market. Producers sell their rice through more traditional channels or modern channels. In the traditional channels, the traditional retail and wholesale intermediary institutions operate, while in the modern channels there is a faster and more efficient marketing, a more organized production and the appearance of processed products (**Figure 1**).

Table 4. Values of the regression coefficients for the rice production function.

	Coefficients	Standard Error	Test's Value	P-Value
Constant	0.71645	0.07551	9.48815	1.18E−20
Land	0.00435	0.00123	3.53659	0.011118
Seeds	0.00221	0.000562	3.9323843416	0.012046
Workers	−0.00036	0.000611	−0.58197	0.561042
Capital	−0.00033	2.51E−05	−13.14741	3.59E−06
Warehouse	−0.07918	0.066089	−1.19814	0.231853
Schooling Years	−0.00637	0.006192	−1.02873	0.304475
IR64	0.004745	0.005327	0.890594	0.373893
Membrane	−0.00301	0.009315	−0.32344	0.746598
Local Variety	−0.00349	0.005896	−0.5925	0.553982
IR8	−0.01743	0.0012852	−13.56209	0.179368
Nakroma	0.007313	0.005585	1.309321	0.191473
Statistic F			5.845321	0.000103
R Square			0.60631949	
Observations			200	

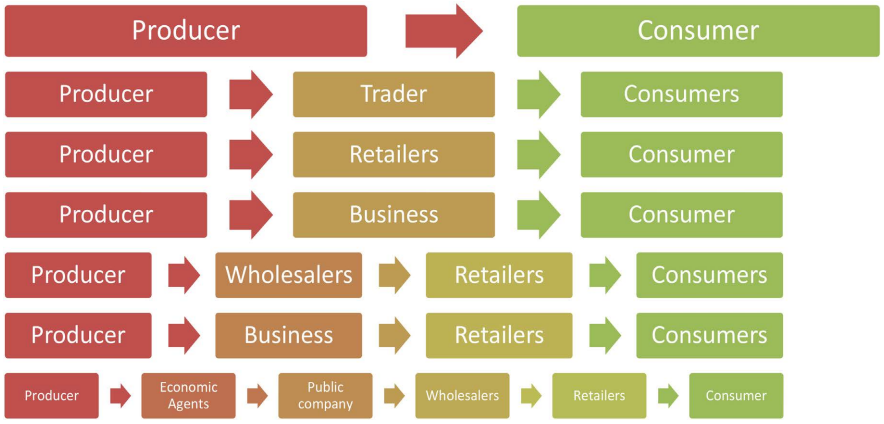

Figure 1. The rice agri-food chain in Bobonaro.

5. Conclusion

The results of this article present the agri-food value chain of rice in Bobonaro. It was found that only six producers show an efficient scale in the value chain, while around 192 rice producers, with the scale of production of increasing returns, could improve their rice production efficiency in the rice agri-food chain.

The DEA model makes it possible to measure the efficiency of organizational units in the rice producers' agri-food chain. The results of multiple linear regression analysis revealed that the linear least-square fit is simultaneously significant. The independent variables that influence rice production are land, Seed, Capital and IR8 variety, therefore statistically significant. It was verified which marketing channels were used by the producers to sell their rice products through intermediaries (retailers, wholesalers, companies and agents). The producers consider that the most important factors in the decision-making process are the appropriate time and destination of the products obtained for the rice's sale. The producers consider minor importance the various forms of promotion used in selling the rice. However, all activities in the rice distribution process (logistics) are considered very important for producers in order to ensure a quantity and quality standard of the traded products.

6. Political Implications

These results have political implications for the rice value chain in Bobonaro to promote sustainable agri-food industries. Consumer concerns, post-harvest losses, excessive and unregulated use of chemicals, waste generation and unhygienic conditions in the wholesale and retail markets are evidence of this lack of policy. This also explains why value chain practices are not in line with sustainable development requirements. Given these existing issues such as a rapidly growing population, urbanization, changes in living standards and strict international compliance requirements, government policies in general and agricultural policies in particular in the rice value chain. Sustainable development in the rice industry value chain has captured the attention of government policy plan-

ners in Bobonaro.

An opportunity for participants in the value chain to develop and strengthen their chains, improves practices that offer adequate levels of quality and safety and develop collaborative relationships along the chain of government policies in Bobonaro. A significant portion of value seekers are preferred to buy in traditional and modern stores, suggesting an opportunity for value chain participants to redirect their efforts to meet modern retail standards. The actors in the value chain, especially producers, need a good policy from the government of Bobonaro municipality to improve the quality attributes of their rice fields, aligning their practices to the specific needs of consumers.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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