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A CONCEPTUAL FRAMEWORK OF MALAYSIAN RICE POST HARVEST LOSSES MANAGEMENT BEST PRACTICES ADOPTION

(Rangka Kerja Konsep Pelaksanaan Amalan Baik Pengurusan Kerugian Lepas Tuai Beras di Malaysia)

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ABSTRACT

Strengthening the food value chain through minimizing the losses is crucial in the post-production stage as these activities are significant in obtaining production efficiency. One of the key strategies is to adopt good agricultural practices (GAPs). The GAPs encompass combinations of principles to apply during food production processes to assure food safety, quality, and environmental sustainability. Its implementations in the food value chain involved on-farm production and post-production, including in the post-harvest losses (PHLs) activities. We develop a conceptual framework of PHLs best practices adoption based on the binary logit and probit model for Malaysia's paddy and rice industry. This framework covers PHLs sequence activities from harvesting, transporting, drying, milling, and storing. Therefore, the appropriate policies or regulations of the GAPs compliance related to PHLs activities could be improved, where the imperative is given to minimizing the losses that occur along the PHLs value chain while obtaining production efficiency. These efforts would also help the nation to empower its food security agenda and attaining sustainability rice development.

Keywords: good agricultural practices; post-harvest losses; production efficiency; binary model; food security

ABSTRAK

Pengukuhan rantaian nilai makanan menerusi pengurangan kerugian adalah kritikal di peringkat pengeluaran susulan aktiviti ini memainkan peranan penting untuk mencapai kecekapan pengeluaran. Salah satu strategi utama adalah dengan mengaplikasi amalan pertanian baik (APB). APB merangkumi gabungan prinsip-prinsip untuk dilaksanakan ketika proses pengeluaran makanan bagi menjamin keselamatan makanan, kualiti, dan persekitaran lestari. Pelaksanaan ini meliputi peringkat ladang dan pasca ladang, termasuk aktiviti kerugian lepas tuai (KLT). Kami bangunkan sebuah konsep rangka kerja berhubung penggunaan amalan baik KLT berdasarkan model binari probit dan logit bagi industri padi dan beras di Malaysia. Konsep rangka kerja ini merangkumi aktiviti berturutan KLT bermula daripada aktiviti penuaian, pengangkutan, pengeringan, pengilangan, dan penyimpanan. Oleh yang demikian, polisi atau peraturan-peraturan berhubung pematuhan APB terhadap aktiviti KLT dapat ditambahbaik, keutamaan dapat diberikan kepada mengurangkan kerugian yang berlaku di sepanjang rantaian nilai KLT disamping mencapai kecekapan pengeluaran. Usaha-usaha ini juga membantu negara untuk memperkasa agenda sekuriti makanan dan mencapai kelestarian pembangunan beras.

Kata kunci: amalan pertanian baik (APB); kerugian lepas tuai; kecekapan pengeluaran; model binari; sekuriti makanan

1. Introduction

Food losses or wastes can occur along the food value chain, from the early stage of agricultural production until final household consumption (FAO 2011; Parfitt *et al.* 2010). Besides the efforts made to increase the food production at the farm level, food losses problems that occur at the post-farm or post-production stage have triggered global concerns as the world population is predicted to hit 9.8 billion by 2050, and the need for food will increase to 60% from the current consumption according to the projection by Food Agriculture Organization of United Nations (Da Silva n.d.). There are many factors that contribute to food waste, such as inefficient production systems, climate change, natural disasters, human behaviors, disease attacks, etc. Moreover, the attention regarding food management production to reduce the losses has risen over the past decades, particularly in the food value-chain systems related to post-harvest management, which involves on-farm production and post-production processes.

According to FAO, a postharvest system can be defined as “the delivery of a crop from the time and place of harvest to the time and place of consumption, with a minimum loss, maximum efficiency and maximum return for all involved” (Spurgeon 1976). Additionally, the expression “postharvest loss” (PHLs) refers to measured quantitative and qualitative food loss in the postharvest system (De Lucia & Assennato 1994). This system consists of interrelated activities that begin with agricultural harvesting and continue through crop processing, marketing, and food preparation to the consumer’s final decision to eat or dump the food (Bourne 2014).

In recent years, the emergence and development of global value chains, as well as the renewed focus on efficiency and food safety, have resulted in a significant paradigm shift in the transition of the postharvest system from a collection of independent components to an integrated value chain connecting producers and consumers through local and international trade (Hodges *et al*. 2011). In grains production, i.e., rice, postharvest losses (PHLs) in rice production can be deemed as an integral component, involving a series of technical activities developed to minimize losses and to increase the value of the harvested paddy. These technical activities consist of harvesting, threshing, drying, cleaning, storing, processing, and packaging and occur alongside economic activities, such as transporting, marketing, and controlling quality and administration (Samaddar & Azam 2017).

Efficient PHLs management is crucial to control the waste to the minimum level. In other words, the minimum the losses occur, the efficient the PHLs management system is. The reduction would help to improve the productivity of the current food system while minimizing environmental degradation (Smil 2004). For instance, Smil (2004) also estimates the China’s rice production suffered approximately 70 million tonnes (Mt) of losses from 450 Mt total production in 2004 (about 15% of losses from the total production), which can be translated to feed 200 million people. This scenario reflects that there should be a balance between the efforts to increase food production while at the same time minimizing the losses to battle against hunger around the world.

Generally, the standard operating procedures (SOPs) for PHLs best practices of the crops are prepared by the agricultural agencies or divisions from the Ministry of Agriculture because they are linked to the national agrofood policy (NAP) or government regulations to ensure food safety and quality. However, adopting these PHLs best practices is a prolonged issue since there are shortcomings regarding the compliance of the SOPs, whether there is a drawback in terms of the policy itself or at the implementation levels. The assessment regarding the adoption of PHLs best practices during the production processes is necessary for reducing the losses while achieving production efficiency and enhancing the productivity level in the long run. However, to the best of our knowledge, there is a lack in evaluating the PHLs best practices adoption of the target groups, which mainly consists of farmers and rice service providers. Therefore, this study aims to fill this gap by developing a conceptual framework using Malaysian paddy and rice PHLs management through a mathematical modelling approach.

Specifically, the following sub-section discusses the Malaysian rice PHLs background that motivates this study. Section 2 presents a literature review regarding the good agricultural practices (GAPs), including the PHLs best practices. Section 3 establishes the conceptual framework for PHLs best practices adoption in the Malaysian paddy and rice industry. Section 4 concludes this study approach for NAP improvement based on the conceptual framework that has been developed in Section 3.

1.1. *Malaysian rice PHLs status*

The awareness of adopting rice production best practices including in postharvest handling, has risen in the Southeast Asia (SEA) countries because it helps to maximize the profits by minimizing the inefficient rice processing activities. It was reported that among the earliest comprehensive study regarding the status of the rice PHLs in SEA was conducted in 1974 involving Indonesia, Malaysia, the Philippines, and Thailand (De Padua 1974). In general, the rice PHLs vary between 15-25% (Gummert 2013). These losses reflect the approaches taken, whether the rice is produced on a small or big scale. Nevertheless, since then, there was not much information regarding the PHLs development in this region because the resources were given to the rice development at the farm level.

In 1988, it was revealed by the Malaysian Agricultural Research and Development Institute (MARDI) regarding the PHLs performance between small mills (<2 MT) versus large mills (>2 MT), which the study indicated that the large capacity mills were more efficient in handling the losses than small mills. This is generally because the large mills are well equipped with losses control mechanisms than the small mills (Samsudin & Hashifah 1988).

Subsequently, after more than two decades, in 2015, MARDI took another initiative to examine the current Malaysian rice PHLs performance. This study was conducted through a collaboration with other government agencies and private sectors such as Integrated Agricultural Development Areas (IADA's), Muda Agricultural Development Authority (MADA), Kemubu Agricultural Development Authority (KADA), and PadiBeras Nasional Berhad (BERNAS). It was found that the recent average losses of the Malaysian paddy and rice industry could be as high as 557,000 MT in a single year, or 28.5% losses from the total combinations of the PHLs activities. This figure, if we translated to the monetary value, is equal to Malaysian Ringgit (MYR) 276 million (Hamzah 2017).

These losses reduce the country ability to increase its production efficiency, and in the long run, it would decrease productivity growth. Moreover, the national agrofood policy (NAP) 2011-2020 to obtain at least 80% of self-sufficiency ratio might not be realized during the policy term implementation. Therefore, the focuses were given to minimize the losses during the harvesting, transport, drying, milling, and storing activities. Each activity best practices to reduce losses were identified, and the data were carefully recorded. These best practices standards were then aggregated to produce a comprehensive rice PHLs industrial standards guideline. However, the challenges remain to ensure these best practices can be adopted at the industry scale to optimize the PHLs efficiency that would be beneficial to many parties. The adoption or non-adopt of PHLs standards data is crucial for policymakers and planners to establish an effective strategic approach to formulate an efficient policy regarding PHLs best practices in the country. Perhaps, with these PHLs standards, the government can solve the prolonged issue of the rice PHLs practices, which mainly refers to unstandardized grading that causes the country to suffer from high losses and affects the farmers' income.

2. Literature Review

Good agricultural practices, commonly known as GAPs, involve a sequence of standard procedures that determine food production safety and quality. It encompasses the activities at the farm level and post-farm level and involves several parties such as farmers, service providers, producers, retailers, and other stakeholders in the food industry.

GAPs adoptions play a vital role in food production as this standard is accepted worldwide. The study conducted by Tilman *et al*. (2001), Keating *et al*. (2010), and Shennan *et al.* (2017) found that shifting from conventional agricultural practices to GAPs adoption helps to obtain eco-efficient in agriculture production that is closely linked to minimizing the environmental impacts while maximizing the profits. In the long run, GAPs can also help to increase productivity growth. For instance, the combination between improved crops varieties and agronomic practices, which can consider as part of the GAPs, encompassing activities such as optimal cultivation time, crops population, row spacing, and agricultural inputs (i.e., NPK fertilizers, seed, pesticides, etc.) resulting in the crops yield increase by more than two-fold, as shown in the soybean study in Malawi (Van Vugt *et al.* 2017). Additionally, more than 80,000 smallholders have gained access to good quality seeds of improved soybean varieties along with complementary training on agronomic practices (Tufa *et al*. 2019).

Next, GAPs implementation as part of the quality assurance (QA) has also expanded to a broader set of crops such as horticultural industry (fruits and vegetables) in Australia and staple food production, mainly rice in many Southeast Asia countries. This QA is due to the international demand for safe quality of food to accommodate export requirements along with workers' health and safety (Premier & Ledger 2006). Vietnam and Thailand which are considered the two largest rice exporters' countries, have consistently established and improved the GAPs of their rice industry to meet the international standards. The Government of Vietnam had introduced 1M5R (One Must Do Five Reduction) or 'Mot Phai, Nam Giam' as part of their national agrofood policy to promote the best management practices in lowland rice cultivation (Stuart *et al.* 2018). The objectives of the 1M5R are to encourage the farmers in Mekong Delta (MKD) to adopt the GAPs along the rice value-chain by utilizing the good quality of seeds (the one must do) and to reduce (the five must reduce) the seed rates, pesticides use, fertilizer inputs use, water use, and the PHLs. Also, this program emphasized rice quality rather than quantity of rice production. The adoption of 1M5R practices has increased farm yields and profits in the MKD. Similar to Thailand, the government introduced Q-GAP to standardize rice production quality and improve competitiveness among farmers by encouraging them to participate in the Q-GAP program. As a result, farmers who took part in Q-GAP were able to reduce the cost of cultivation and improve quality by freeing their products from chemical residues and off-type rice (Srisopaporn *et al*. 2015).

The study on GAPs related to integrated pest management (IPM) adoption by farmers has been extensively conducted to examine the determinants of IPM adoption. This program aims to attain cost-effectively and environmentally friendly through reducing the pest population (Despotović *et al.* 2019). The recent study by Babendreier *et al.* (2019) showed that farmers perception towards IPM practices in Southern China, Laos and Myanmar was positive. However, more training, demonstration plots and awareness program are required to accelerate the best practices in IPM.

Optimal fertilizer usage is one of the essential components in GAPs since it is nearly linked to crop yield and environmental degradation. For example, after the success of the Green Revolution strategy to increase rice production, in most rice-producing countries, the governments have consistently allocated fertilizer subsidies besides investments in irrigation infrastructure and agricultural research on rice (Cassman & Pingali 1995). However, rice productivity has shown a decreasing trend (Rosegrant & Pingali 1994). The challenges regarding the environmental preservation due to excessive usage of chemicals, including fertilizers, have shifted the use of conventional fertilizer to Green Fertilizer Technology (GFT). Later, the GFT has become an essential aspect in GAPs since its application reduces environmental degradation and helps to achieve sustainable agricultural development. Nevertheless, the adoption rate of GFT is relatively low in most developing countries because of the high production costs, which causes unfavourable perceptions (Adnan *et al.* 2018).

Subsequently, despite many studies regarding the GAPs adoption impacts focusing at the farm level chain as previously discussed, there is a lack of GAPs study at the post-farm level. Kader and Rolle (2004), in their review, found that farm-level cover about 95% of total works, and only 5% of the studies examines the post-farm level for the last 30 years, particularly the GAPs adoption impacts during PHLs activities. However, the awareness of efficient PHLs activities has risen as a result of these activities significantly contributes to increasing food production by minimizing waste. Additionally, the efforts to increase food production by concentrating the resources at the farm level would be meaningless if the food producers failed to minimize the losses in the food processing stages. Therefore, the GAPs adoption at the PHLs stage is momentous in the food value-chain system, weighted equally to the efforts to increase the production at the farm stage.

In staple food processing, i.e., rice, several recent studies regarding post-harvest efficiency related to GAPs have been conducted to improve the production processes. Majiwa *et al*. (2018) assess Kenya's rice processing at the post-production stage involving two main activities: drying and milling using combinations between network data envelopment analysis (DEA) and bootstrap DEA. The study found lower efficiency scores when using a network DEA approach than conventional DEA. Furthermore, the determinants or best practices to improve the efficiency scores were storage space and distance to market as having an impact on drying efficiency. Meanwhile, experience, age of mill, servicing, and energy type influence milling efficiency. In the case of Bangladesh's rice production and its post-harvest system, there exists the potential for rice production's technical efficiency improvement using current technologies and inputs. At the same time, farm size, education, experience, microcredit, training, and extension were variables that play a significant role in influencing technical efficiency scores. In terms of reducing losses, the availability of extension services could help to minimize the inefficient of PHLs activities (Majumder *et al.* 2016). Additionally, proper monitoring control of PHLs activities could also increase the value of rice quality (Samaddar & Azam 2017).

3. PHLs Best Practices Adoption Conceptual Framework

This section explains the proposed conceptual framework (CF) to design PHLs best practices adoption to be utilized as a mathematical guide tool for the rice post-production stage. Most of the best practices selections that players consider in their decision making are of a 'utilize or non-utilized' nature (Mariano *et al*. 2012). Our model investigates PHLs best practices adoption separately, where the decisions to adopt, or non-adopt the best practices are done by each stage of PHLs activities (harvesting, transport, drying, milling, and storing). In other words, we examine the PHLs best practices adoption or non-adoption starts from the first activity, which is harvesting and repeat the same procedures for the following stages.

Further, we treat the PHLs best practices for each activity as a single technology so that the binary logit and probit models can be employed to test the functional relationship between the adoption decisions and its determinants such as socioeconomic variables, organizational structures and biophysical factors (Mariano *et al.* 2012). Additionally, the decisions to adopt best practices in the PHLs activities are determined by a set of variables that are closely related to environmental, social, human, physical, and financial factors (Adusumilli *et al.* 2014; Prokopy *et al.* 2008). Figure 1.0 shows the rice PHLs best practices adoption conceptual framework.

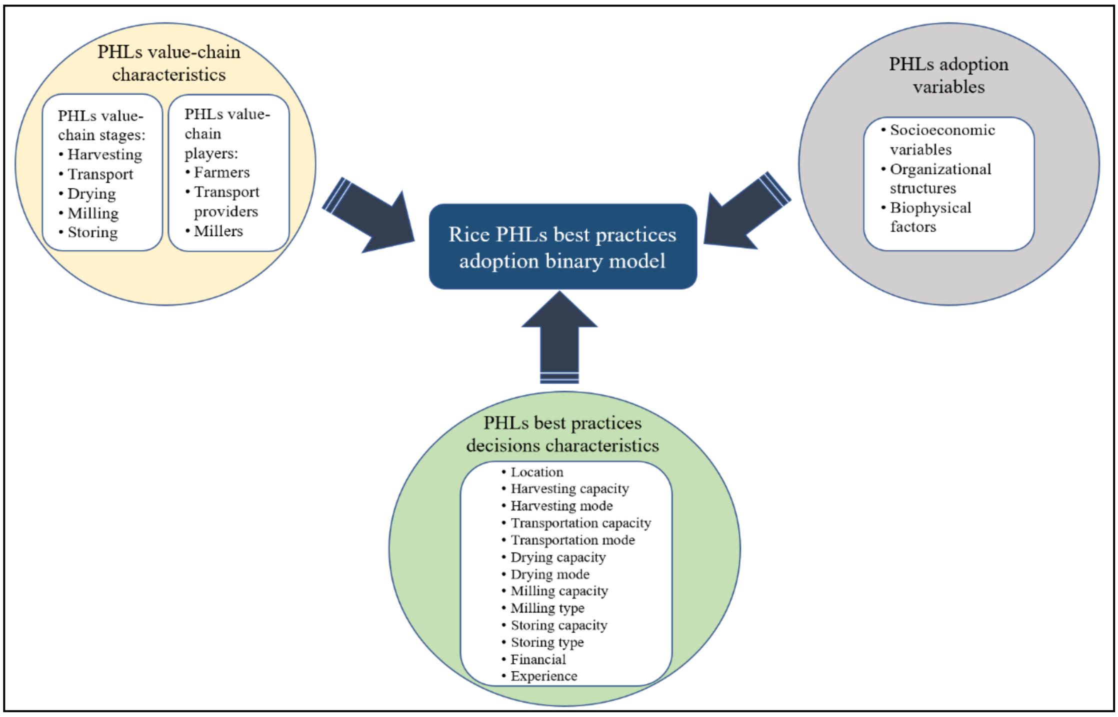

Figure 1: Rice PHLs best practices adoption conceptual framework

Players in this study are asked whether they utilize the PHLs best practices or not. This is done to examine which factors are influencing the decision process. Besides, the factors that determine the players choice are essential to investigate because it affects the decision (adoption of the PHLs best practices). In this binary model, like most empirical studies, the observed yes/no decision to use PHLs best practices is portrayed as the outcome of the model. Specifically, it can be expressed as the dummy variable:

$$y_i = \begin{cases} 1 \text{ if the player adopts the PHLs best practices} \\ 0 \text{ if the player rejects the PHLs best practices} \end{cases}$$

For each PHLs activity, which refers to harvesting, transport, drying, milling, and storing, the probability of the player, i = 1,2,3…, adopting the PHLs best practices (let say harvesting best practices) is denoted as $P = P[y_i = 1]$, while the probability for non-adopting (reject) is $1 - p = P[y_i = 0]$. This binary model has a probability function $f(y) = p^y(-p)^{1-y}$ for each PHLs activity. We repeat the same procedures for the different PHLs activities, i.e, transport, drying, etc. The econometric equations approaches utilized in this study are derived from Greene (2005) and Hill *et al*. (2011).

4. Conclusion

We establish a binary model framework of the Malaysian rice PHLs best practices adoption developed by MARDI based on logit and probit approaches to examine to what extent these best practices, which comprises harvesting, transport, drying, milling, and storing activities adopted by the industrial players. The conceptual framework of Malaysian rice PHLs best practices adoption consists of three main components, which are PHLs value chain characteristics, PHLs adoption variables, and PHLs best practices decision characteristics. Each component is deemed vital in PHLs best practices adoption in Malaysian paddy and rice industry development.

The paper also highlighted that most of the previous studies focused on increasing the efficiency at the farm level but lacked in post-production aspects. Therefore, it is crucial to balance the production efficiency between production (farm) and post-production stages (post-farm) to obtain a comprehensive production efficiency of the rice production.

Next, to empower the food security agenda of the nation. The overall losses at the national level of rice production are considered high (MYR276 million loss in a single year) and affect national food security. Thus, it is essential to strengthening the PHLs value-chain to increase production because these efforts are significant for sustainable rice development in the long run.

Subsequently, the government has allocated a massive budget for its paddy and rice development through its agricultural agencies, including in PHLs handling. The national PHLs standards adoption could benefit many parties in the country and increase the budget efficiency of the Malaysian paddy and rice industry program. At the same time, it can help the nation to improve its rice quality.

Finally, the information regarding the PHLs best practices adoption is essential for policymakers and planners to design an inclusive national agrofood policy (NAP) for future paddy and rice development.

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