

Tapping the Potential of Rice Research for Sustainable Agricultural Development: Lessons from Malaysia's Public Research Institutions

Mengenal Pasti Potensi Penyelidikan Padi untuk Pembangunan Pertanian Lestari: Pengajaran daripada Institusi Penyelidikan Awam di Malaysia

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ABSTRACT

This paper explores the achievements, implications, and future potential of rice research to achieve sustainable agricultural development in Malaysia according to the Quadruple Helix Innovation Model. The case study on Malaysian Agricultural Research and Development Institute (MARDI) reveals that there are three elements that drive food security and sustainable rice research and development – quality research by Public Research Institutions (PRIs), cooperative private firms in supporting national agricultural agenda and productive farmers in delivering high-yields farming. This paper claims that the presence of public-driven objectives in rice research is the crucial pivot in achieving national food security. The study also found that the cooperation from private firms is key in steering national agricultural agenda towards self-sustaining. The study also found the potential of civil society organisations (CSOs) to transform farmers into more active key players in sustainable agricultural development.

KEYWORD

Sustainable agriculture, rice research, innovation model, public research institutions, Malaysia

Received: Feb 27, 2021

Accepted: Apr 11, 2021

Published: May 30, 2021

ABSTRAK

Kertas kerja ini meneliti pencapaian, implikasi dan potensi masa depan penyelidikan padi dalam mencapai pembangunan pertanian lestari di Malaysia berdasarkan Model Inovasi Quadruple Helix. Kajian kes di Institut Penyelidikan dan Pembangunan Pertanian Malaysia (MARDI) menjelaskan bahawa terdapat tiga elemen yang mendorong keterjaminan makanan dan penyelidikan padi yang mampan - penyelidikan berkualiti oleh Institusi Penyelidikan Awam (PRI), agensi penyebaran yang cekap dalam menyebarkan pengetahuan kepada petani, kerjasama syarikat swasta dalam menyokong agenda nasional dan petani yang produktif dalam menghasilkan hasil pertanian. Kertas kerja ini mendapati bahawa matlamat yang didorong oleh kepentingan awam dalam penyelidikan padi adalah teras utama dalam mencapai keterjaminan makanan nasional. Kajian ini juga mendapati bahawa kerjasama daripada syarikat swasta adalah kunci dalam memacu agenda pertanian nasional ke arah kemandirian sumber. Kajian ini juga menemui potensi organisasi masyarakat sivil (CSO) untuk mengubah petani menjadi pemain utama yang lebih aktif dalam pembangunan pertanian yang lestari.

KATA KUNCI

Pertanian lestari, penyelidikan padi, model inovasi, institusi penyelidikan awam, Malaysia

1.0 Introduction

The selected case study – Malaysia, has a long history of agriculture and this sector was the main contributor to its economy. Concurrent with the global agricultural transformation, the nation reroutes its economy into service sectors. Still, due to its long olden times in farming and harvesting, there are about 300,000 farmers involved in rice-paddy production but only 30 percent of them are full-time farmers (Mohd Rashid Rabu & Mohd Dainuri Mohd Shah, 2013). The rest of them could not sustain their families solely with the income they gain from rice production, thus choosing to do off-farm work as side income. The study is driven by the fact that Malaysian rice farmers are still vulnerable and highly depending on government assistances such as subsidies on fertiliser, pesticide and other welfare assistances (Ministry of Agriculture and Food Industry Malaysia, 2011). They are the groups that will be affected the most when it comes to economic crisis. In fact, besides the nation's need for more farmers to accommodate the demand for its main staple diet, the dependency on imported rice, inefficiency in its rice production and low generated income for farmers caused the nation billions of dollars to invest in incentives and subsidies just to ensure every Malaysians have enough rice on their plates (Rosnani Harun et al., 2016). Hence, this research seems to be critical to be explored due to the national food security and the welfare of its farmers and consumers.

The Quadruple Helix Innovation Model suggests the synergy of four entities, namely government, universities, industries and civil society in forming a well-configured knowledge economy and society (Carayannis & Campbell, 2009). In this innovation model, government is playing a critical role in providing supporting roles and advisory services in terms of formulation and implementation of innovation related programmes. In this context, as one of the main entities in government, Public Research Institutions (PRIs) play significance roles in ensuring scientific discoveries accommodate societal needs. Hence, this paper contributes to two main ideas. Firstly, the paper fills literature gap in the synergy of government, research institution, industry and civil society in steering national policy regarding to food security and sustainable agriculture development, according to the Quadruple Helix Innovation Model. Secondly, the paper proposes lessons in reinforcing the role of PRIs in disseminating technologies, private firms in supporting national agenda and CSOs in empowering Malaysia's farmers, through the case study of MARDI.

The paper is organized in six sections. Section 2 provides the conceptual basis and research framework of this paper. Section 3 explains the research method used in obtaining the empirical evidence to address the main research questions. Section 4 presents the main findings. This is followed by discussions in Section 5. This paper ends with a short conclusion.

2.0 Conceptual Basis

2.1 Sustainable Agricultural Development: Concepts and Elements

There are no precise and absolute definitions on sustainable agriculture because the term 'sustainability' itself is a complex and contested concept. For instance, the term is commonly used to imply not damaging or degrading natural resources among the environmentalist or continuing economic growth that does not harm the natural resource base among the economists. Subsequently, sustainable agriculture does not prescribe to a concretely defined set of technologies, practices or policies (Pretty, 1995). In this paper, we define sustainable agriculture as farming activities that comply with the principles of communally supportive, economically feasible and environmentally rigorous. Although these principles are interrelated and equally important, the focus of this paper is mainly on the element of community (or societal) supportive in the context of government-researchers–farmers-industries partnership. This definition is consistent with concept of Quadruple Helix Innovation Model that we attempt to adopt throughout this study in shaping the conceptual basis for these multilateral linkages.

In the context of developing countries, the small nature of smallholders in agriculture sector often caused the end-users to be misperceived as incompetent, incapable and low skilled. Yet, several case studies on developing economies showed that community is the backbone of public-driven sector such as agriculture (e.g. Ng et al., 2017; Wu, 1995) and resource-based industry (e.g. Ng et al., 2012; Loebis and Schmitz, 2005). In this context, the partnership between community as the consumer and industry player as the producer is close and both parties utilise their social capital and mutual understanding to develop the technological capabilities of the industry. Besides, community-driven development is preferred as social capital in the community is crucial for the innovation. The community behind industry is not only functioning as consumers, but their active involvement and feedback act as a catalyst to technology transfer and innovation diffusion. Thus, end users (such as farmers) in developing countries could no longer be presumed as inactive and incapable innovation actors, but their contribution could be a significant denominator for successful social innovation.

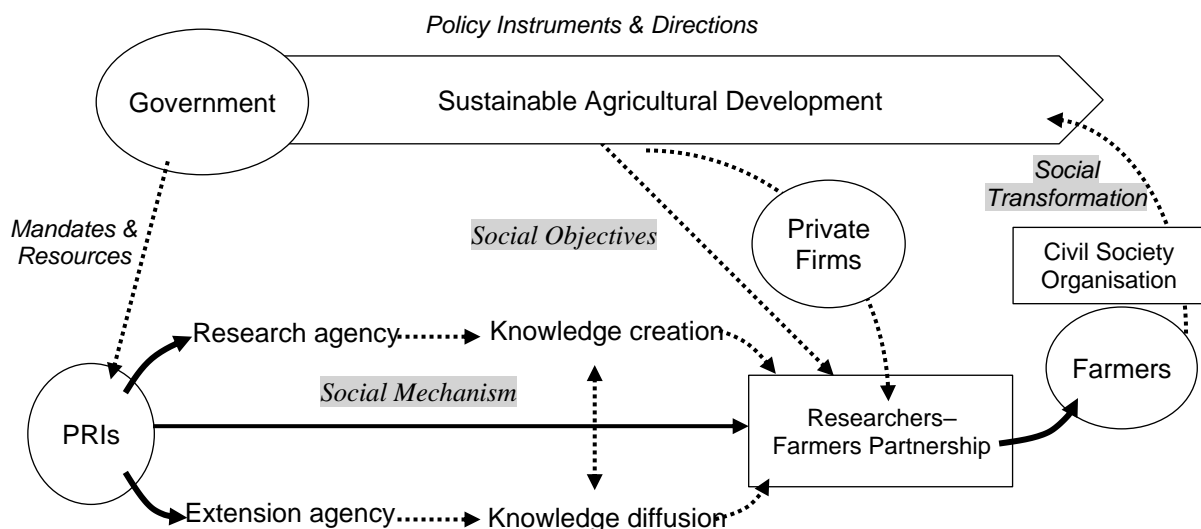


Figure 1: Conceptual Framework (Adapted from Nur Hanis et al., 2020).

The first element in the concept of sustainable agricultural development is social objectives. The framework shows that to achieve social objectives, government often initiate policies in fostering and strengthening the production and innovation capabilities of the farmers. This includes, improving income generation of farmers, providing novel solution that is more efficient to benefit farmers and performing changes in governance system and organisation. Nonetheless, due to the lack of internal resources of the government, PRIs that are equipped with capabilities in conducting research and performing extension services, is acknowledged as one of the more efficient and effective actors to realise these innovation initiatives.

The second element - social mechanisms could be observed through the synergy of researchers-farmers partnership that representing PRIs as science-based knowledge creator, and farmers as end-user of scientific knowledge. This is a key driver to leverage the potential of sustainable agriculture. Indeed, this is about the co-creation model that give more autonomy to non-scientific community to innovate (McKelvey & Zaring, 2018). The underlying principle of this framework is the researchers-farmers partnership is communally supportive, that is, one of the main principles of sustainable agriculture.

The third element is social transformation. Social transformation often refers to the changes in (rural) society as the consequences of innovations. In this respect, social change is implied through the crossing of rural-urban relationship in which social innovation takes place (Bock, 2012). The United Nations Educational, Scientific and Cultural Organisation (UNESCO) refers social transformation in social sciences as the change of society's systemic characteristics and this incorporates the change of existing parameters of a societal system such as technological, economic, political and cultural restructuring (Genov, 1999). The idea is supported by Prasad (2016) in his case study of India's agricultural sector that examined the crucial role of Civil Society Organisations (CSOs) in driving collective action by Indian farmers.

3.0 Research Method

3.1 Case Study and Process

In this study, we employed the method of single organisation – Malaysian Agricultural Research and Development Institute (MARDI) with multiple case studies (i.e., MARDI's divisions and programmes), and a series of in-depth interview sessions has been performed to obtain empirical evidence from the relevant stakeholders. The interviews covered two main functions of MARDI as a PRI, i.e., the research division and service division. The two criteria in selecting departments or divisions for interviews are (1) the department that deals with end-user in any of their programmes, and (2) they are managing or producing rice-paddy variety and its implementation. Conclusively, this research focuses on the commodity of rice-paddy and farmers as the end-user. Thus, the respondents selected will be the actors that involve in (1) the production and distribution of the rice varieties, (2) the production and selling of rice in the market, and (3) implementation and regulation of any MARDI's rice varieties. Respondents are selected based on their (1) expertise, (2) involvement in any specific project, (3) experience and (4) position and involvement in any organisation or society.

Table 1 and 2 detail all the 30 interview sessions that have been conducted during the period of May 2018 until early November 2018. For MARDI, the interview sessions have successfully covered the centres that related to rice-paddy industry in Malaysia, namely Rice and Paddy Research Centre (RI), Engineering Research Centre (ER), Economics and Social Science Research Centre (ES), Technical Service and Technology Commercialisation Centre (TS), and Promotion and Business Development Centre (PB). We also interviewed officers from the Department of Agriculture (DoA) – a key agriculture extension agency of Ministry of Agriculture and Agro-Based Industry. The selected farmers for the

interviews were from two main rice granary areas in Malaysia, i.e., Jitra that located at Muda Agricultural Development Authority (MADA) in the State of Kedah, and Sungai Panjang that located at Integrated Agricultural Development Area-Barat Laut Selangor (IADA-BLS) in the State of Selangor.

The interviews were performed in two stages and the interview protocols suggested by Yin (2003) were followed strictly. For the first stage, the findings are gathered by semi-structured interviews conducted with Research Officers (ROs) from MARDI and DoA (refer Table 1). The interviews covered questions related to MARDI's intermediary roles in performing technological transfer and the possible researchers–farmers partnership in the rice-paddy industry. Content analysis on institution's documents also been conducted to examine MARDI's standard operation procedure or policy related to sustainable agricultural development and engagement with the end user. The second stage focused on farmers or end user involved as shown in Table 2. Observation and site visits also have been performed to understand the nature of government-researchers–farmers-industries partnership and to identify the issues related to the partnership. The interviews covered questions related to engagement and interactions between farmers and MARDI's researchers and factors that influenced the interaction. It also covered the factor of territorial influence as the groups of farmers were divided into two different localities.

Table 1. MARDI and extension service respondents and their expertise/professions (Group 1)

No	Field of study	Responsibility within MARDI	Centre
R1	Mechatronic engineering	RO for precision farming	ER
R2	Agricultural business	RO for agro-business, marketing & international trade	ES
R3	Chemical engineering	RO for post-harvest technology & food processing	ER
R4	Tech. transfer commercialisation	& RO for technology commercialisation	TS
R5	Tech. transfer commercialisation	& RO for technology commercialisation	TS
R6	Tech. impacts & assessment	RO for technology commercialisation	TS
R7	Tech. transfer commercialisation	& RO for scale development	PB
R8	Tech. transfer commercialisation	& RO for entrepreneur development	PB
R9	Nanotechnology	Senior RO for promotion & technology transfer	PB
R10	Technology transfer	Research assistant in Tanjung Karang	RI
R11	Plant breeding & genetics	Senior RO for molecular breeding in Seberang Perai	RI
R12	Electrical & electronic engineering	RO for precision farming in Seberang Perai	ER
R13	Crop production	RO for agronomy in Seberang Perai	RI
R15	Plant breeding & genetics	Policy maker regarding paddy & rice industry	RI
R16	Agriculture	Extension service	DoA
R17	Agriculture	Extension service	DoA

Note: RI = Rice and Paddy Research Centre, ER = Engineering Research Centre, ES = Economics and Social Science Research Centre, TS = Technical Service and Technology Commercialisation Centre, PB = Promotion and Business Development Centre, DoA = Department of Agriculture, RO = Research Officer

Table 2. End-user/respondents and their backgrounds (Group 2)

No	Profession	Background	Location
R18	Farmer	Over 10 years in paddy farming and active in civil society organisation. A farmers' representative (North of Peninsular Malaysia). In his forties.	Jitra
R19	Farmer	A role model and appointed as rice seeds cultivator. In his forties.	Jitra
R20	Farmer	Over 20 years in farming and involves in civil society organisation. In his forties.	Jitra
R21	Farmer	Over 30 years experiences in paddy framing and a farmer representative for extension services. In his sixties.	Jitra
R22	Farmer	Over 40 years in paddy framing. In his sixties.	Jitra
R23	Farmer	Over 40 years in paddy framing. In his sixties.	Jitra
R24	Farmer	Over 30 years in framing and active in civil society organisation. A farmers' representative (Northwest of Peninsular Malaysia). In his fifties	Sg. Panjang
R25	Farmer	A role model for farmers in Sg. Panjang. In his thirties	Sg. Panjang
R26	Farmer	A role model for farmers in Sg. Panjang. In his thirties	Sg. Panjang
R27	Farmer	Inherits paddy fields from his family. In his thirties	Sg. Panjang
R28	Farmer	Inherits paddy fields from his family. In his thirties	Sg. Panjang
R29	Farmer	Inherits paddy fields from his family. In his thirties	Sg. Panjang
R30	Staff for pesticide company	Over 5 years experiences in an international pesticide company. Assigned to conduct trial in paddy plot in Sg. Panjang.	Sg. Panjang

Note: Jitra is in Kedah, North of Peninsular Malaysia; Sungai Panjang is in Selangor, Northwest of Peninsular Malaysia

3.2 Scope and Limitations

The focus of this study is on rice variety research. It is important to note that besides rice varieties research; MARDI's research activities are extensive and covers all aspects of rice-paddy industry. MARDI also undertakes research to introduce techniques to sustain soil nutrition and mechanisation of farming, as well as provides advice on appropriate pesticides and fertilisers in rice-paddy industry. Each of these aspects operates on its distinctive value chain. Nonetheless, these dimensions are not covered in this paper.

In the context of government-researchers-farmers-industries partnership, this paper is more concerned about formal mechanism and platform that provide a collaborative networking between the parties in a sustainable form. Although occasionally there are public and community programmes organised by MARDI (e.g., open days, shows and exhibitions), such programmes in our view are not a sustainable productive platform in forging the partnership. We are looking for more targeted communication (e.g., open dialogue, workshop, mentoring and discussion) to enable MARDI's researchers to engage and interact with farmers formally. The platform should enhance the relationship among the stakeholders and improve social capital and community cooperation between farmers, scientific community and industry players.

4.0 Data and Findings

4.1 Achievements from Rice Varietal R&D

In the year of 1967 and 1968, before the establishment of MARDI's, the selective breeding program and the development of new varieties were undertaken by DoA. To begin with, the primary focus of varietal development in Malaysia was to produce varieties that were in line with current conditions and problems, in addition to produce high yield varieties that are resistant to major diseases and pests for paddy. The varieties were also consistent with the current agricultural practice system introduced at that time. For example, Malaysia used to practice harvesting season once in a year due to the low-yield rice seedlings, in addition to the high labour intensity to manage paddy plots. At that time, the paddy plants also susceptible to the risk of disease and flood. Over time, researchers can develop rice varieties that are resistant to disease and climate change, have shorter maturation period and require less labour intensity.

Besides that, most of the varieties used in the 1970s are bred from local and traditional breeds that had been produced in DoA's selective breeding program. The well-known varieties at that time were Malinja, Mahsuri, Ria and Bahagia. After the year 1971, the selective breeding program for domestic rice varieties was handed over to MARDI. Today, according to MARDI, there are more than 95 percent of Malaysia's granary areas use rice varieties that had been produced by the institution (MARDI, 2018). These varieties helped farmers in MADA, KADA, Kerian and other granary areas to increase their agricultural output, thus contributing to the nation's economic performance. Since 1964 until 2018, MARDI has successfully produced and declared a total of 49 rice varieties. These include 36 white rice, four fragrant rice, three glutinous rice, two coloured rice, two herbicide tolerance which are MR 220 CL1 & MR 220 CL2, one black glutinous and one aerobic rice. CL1 and CL2 is the latest collaboration of MARDI with private company, BASF in creating new weedy-rice-resistant varieties. Table 3 listed the white rice varieties, which is the main rice varieties in Malaysia that had been produced and declared by MARDI since the year 1964 until 2018.

Table 3: List of 36 white rice varieties produced by MARDI.

No.	Varieties	Released Year	Potential Yield (t/ha)	Average Maturation Period (days)
1	Malinja	1964	N.A.	142
2	Mahsuri	1965	N.A.	136
3	Ria	1966	N.A.	126
4	Bahagia	1968	5.3	141
5	Murni	1972	N.A.	138
6	Masria	1972	N.A.	125
7	Jaya	1973	3.7	125
8	Sri Malaysia 1	1974	7.3	140
9	Sri Malaysia 2	1974	6.5	129
10	Setanjung	1979	3.2	139
11	Sekencang	1979	2.3	123
12	Sekembang	1979	4.5	143
13	Kadaria	1981	3	129
14	Muda	1984	5.0	129
15	Seberang (MR77)	1984	5.3	134
16	Makmur	1985	N.A.	135

17	MR 84	1986	5.1	131
18	MR 81	1988	5.1	135
19	MR 103	1990	6.4	132
20	MR 106	1990	7.1	133
21	MR 123	1991	5.1	117
22	MR 127	1991	6.3	124
23	MR 159	1995	4.1	132
24	MR 167	1995	5	127
25	MR 185	1997	7.6	116
26	MR 211	1999	9.6	100
27	MR 219	2001	8.6	108
28	MR 220	2003	10	109
29	MR 232	2006	N.A.	108
30	MR 253	2010	5.6	109
31	MR 263	2010	8.3	111
32	MR 269	2012	7.5	107
33	MARDI 284	2015	9.2	108
34	MARDI SIRAJ 297	2016	8.6	113
35	MARDI SEMPADAN 303	2018	10	105
36	MARDI SEBERNAS 307	2018	10	108

Note: N.A. = not available. Due to lack of complete data, complete information for all the 36 white rice varieties is not able to be captured. Source: Compilation of various sources.

Production cost for their rice production is the main concern for the farmers. This includes labour cost and input cost such as fertilisers, herbicide, and rice seeds. Therefore, by having rice varieties with higher potential yield and shorter maturation period, the farmers could reduce the production cost and increase their net profit. The same explanation also given by the MARDI's top management that has been interviewed. Since 1960s, MARDI has assisted farmers to have more cultivation seasons for paddy, from two seasons per year to three seasons per year. This means that Malaysian farmers achieved a high productivity in their annual rice yield, and it is crucial as the high productivity indicates a good secure of our national food supply.

Figure 2 shows the potential yield from MARDI's white rice varieties. Paddy varieties with high potential yield is favoured by the farmers. In addition to its purpose to increase farmers' income, high-potential-yield varieties also contribute to the nation's economy. Despite fulfilling domestic demand for the staple food, the excess supply of rice could be imported, thus increasing the nation's gross domestic product (GDP). Over time, MARDI has created varieties with higher potential yield. Despite decreasing size of granary areas in Malaysia, MARDI's researcher has concluded that they need to breed rice varieties that do not need much area to be planted, yet still produce huge amount of output.

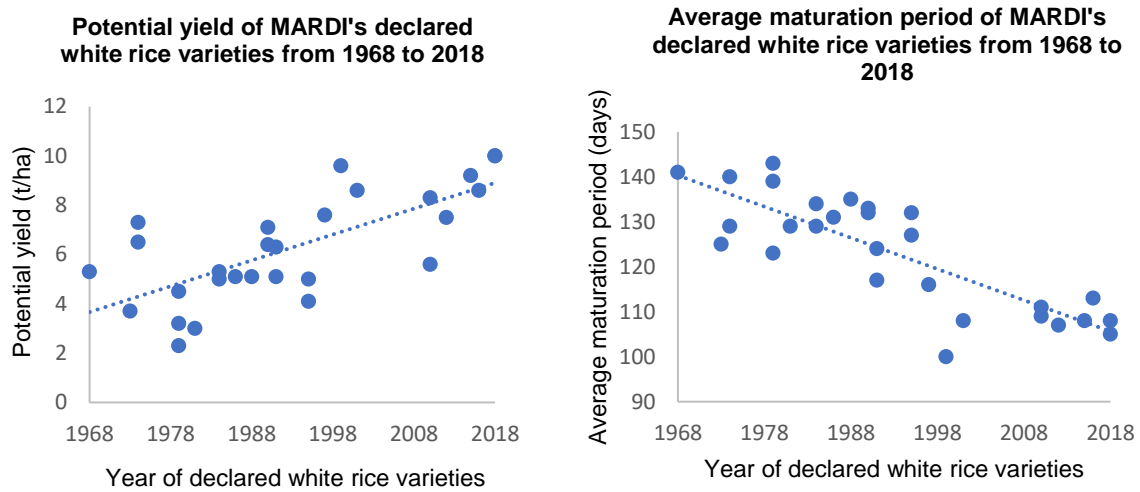


Figure 2: MARDI's declared white rice varieties and its' potential yield. Note: Each dot on the chart indicates a new variety introduced in the particular year. Source: Author's compilation.

It is important to note that besides producing rice varieties that are with higher potential yield and shorter maturation period, MARDI's R&D on rice varieties also aim to increase the other aspects of quality paddy and rice such as resistant to disease and pests, length and fragrance, and consumers' preference. The next section will discuss on the latest weedy-rice-resistant white rice varieties that MARDI has successfully produced, MR 220 CL1 and MR 220 CL2, together with a private pesticide company, BASF (Malaysia).

4.2 Challenges from MR 220 CL1 and MR 220 CL2

Clearfield Production System (CPS), is a research collaboration between MARDI and BASF Malaysia Sdn Bhd. Since 1989, the MNC was focusing on the production of chemicals for the application in these industries, agriculture, oil and gas, construction, automotive, paint and coatings, home and personal care, packaging and food and nutrition industries. BASF was known for its pesticide called 'On Duty' (imidazolinone) that is widely used as paddy herbicide by Malaysian farmers. Yet, in 2010 the company decided to establish a joint venture with MARDI to develop rice varieties that are specifically designed to address a common problem for farmers in the nation – weedy rice (*padi angin*).

Based on the mandate granted to MARDI through the Laws of Malaysia (Act 11) MARDI Act 1969, MARDI is the only institution that has the right to produce and declare rice varieties that are used by Malaysia farmers. The exclusive access is due to the protective nature towards the industry to prevent any monopoly or misuse of illegal rice varieties. Therefore, we can conclude that MARDI-BASF collaboration is a win-win situation for both parties as BASF got the access to the farmers and MARDI could retain its self-sustainability. This is a good example of public-private partnership in delivering public goods in the industry of agriculture. As a matter of fact, MARDI and BASF had successfully developed weedy-rice resistant varieties of MR220 CL1 and CL2 and helped to combat the problem.

However, the implementation of the new technology has been distorted after a few seasons due to incapability of farmers in following the instructions as the varieties need supplemented package of pesticide and maximum period of usage. As a result, during the interviews, the farmers in Kodiang and Sungai Panjang expressed their concerns on the high cost to use MR 220 CL1 and MR 220 CL2, and their decreasing efficiency over time that caused more problems like decrease the quality of soil and increase weed resistance towards pesticide.

This is because MR 220 CL1 and MR 220 CL2 were designed to be used together with an herbicide named 'OnDuty' that is produced by the same company, BASF. The estimated cost for an acre of paddy field that needs three packets of 'OnDuty' herbicide and three bags of paddy seeds of MR 220 CL1 or MR 220 CL2 is RM330. On the other hand, if the farmer uses other varieties such as MR 219 or MR 220 that does not require the usage of the herbicide, he just needs to spend RM90. That is almost quadruple amount of money the farmer needs to spend. The farmers could not maximise their profits due to the expensive cost for the seeds and herbicide. According to a report conducted by MARDI regarding to Clearfield Production System (CPS), the profit gained by the farmers were still depending on government's subsidies. "The average output for CPS increases by 28% from 6.5 t/ha to 8.4 t/ha. If CPS was conducted with the help of subsidy, farmers gained net profit of RM2,085, 2,421 and RM1,483.4 for MADA and BLS. On the other hand, if CPS was conducted without subsidy, farmers gained lower net profit of RM601.33, RM804.78 and RM206.45 for MADA dan BLS" (Rosnani Harun, Tapsir Serin, & Azmi Man, 2013).

A farmer also responded with the statements, "*For me, the MARDI-BASF collaboration could cost the farmers more. The price for the Clearfield herbicide is irrelevant for us (farmers). CL paddy from MARDI's collaboration with BASF only sustains for one to two seasons. After that they (paddy) already tolerated. Even for the weeds, we could not use the 'Onduty' herbicide because of the resistance*" (Personal communication, 29th July 2018). Secondly, most of the farmers agreed that 'OnDuty' herbicide had successfully eliminated the paddy threat and increased the output. Yet, another problem could exist over time as weeds are becoming tolerant towards the chemical when the usage of the herbicide exceeds the time frame set by the manufacturer. In fact, farmers could lose more in the next season compared to before when they use the CL varieties and 'OnDuty' herbicide. As a result, the objective of eliminating weedy rice has been achieved for a short period of time, yet due to imprecision in monitoring its implementation, the varieties had created another problem (i.e., weed resistance towards herbicide and soil damage).

4.3 Potentials from Civil Society Organisation and Social Media

The Innovation Model of Quadruple Helix emphasises the importance of integrating the perspective of the media-based and culture-based public into innovation system (Carayannis & Campbell, 2009). In this respect, this study found that both groups of farmers in Kedah and Selangor have strong ties with each other and they utilise the social capital to form their own CSOs. In fact, one of the farmers did mentioned their close relationship can be called as "brotherhood", thus describing their strong relationship. A farmer stated that, "*Today, Malaysian farmers are more intelligent than before. We are friends to each other and could establish an organisation by ourselves*" (Personal communication, 29th July 2018).

For example, Padi Rescue, a CSO established by a group of farmers is making their big steps by engaging or inviting to engage with policy makers from the Ministry of Agriculture and Food Industry (MAFI). Padi Rescue was founded in 2015 and it was started as a Malay manufacturers' organisation. Later, the CSO was joined by other Malay miller companies, farmers, and local leaders. Today, Padi Rescue is progressing forwards by collaborating with other CSOs such as Majlis Tindakan Ekonomi Melayu (MTEM), a well-known Malay-oriented CSO in the country. This milestone is achievable due to the power of social media that manage to gather farmers around the nation. Recently, Padi Rescue has launched and publicised a petition to request government to act in improving the socioeconomic aspect of Malaysian farmers.

Social media has become the platform to direct end users into one agenda that pushes for civil movement to gain attention from policy makers. Padi Rescue has proved their effort as MAFI and other

authority bodies finally engage with their requests as stated in Padi Rescue's Facebook page. MARDI has realised farmers' social media awareness and they decided to launch mobile applications to ease end users to access needed information. For example, in 2017 MARDI launched an application named MARDI MyPerosakPadi (or in direct translation - My Pests of Paddy) as a knowledge hub to inform farmers about paddy pest and disease. Over a year, more than one thousand mobile users downloaded the application. The application also listed MARDI's officers for farmers to connect. Hence, social media and civil society organisations could become driving factors in forging researcher-farmer partnership due to its efficiency and transparency. The partnership might not be the conventional face-to-face interaction, but to a certain extent that is a good beginning for everyone to share their sides of stories.

5.0 Discussions

Social objective has been accomplished though the mandate of MARDI. This aspect has been legalised in Malaysia and in any matter, the core business of MARDI to provide the need of social objective is preserved. Interaction and partnership among innovation actors (e.g., MARDI, private companies, CSO, farmers) are crucial in developing a sustainable paddy-rice industry. These elements of sustainable agricultural development; social mechanism and social transformation not only create external value for MARDI such as efficiency in technology transfer, but it also created internal value for the institution like MARDI get royalty from partnership with private company to fund internal R&D.

PRIs like MARDI indeed are the intermediaries used by the government to achieve social objectives of the national sustainable agricultural agenda. Through the policy instruments and directions, PRIs like MARDI provides novel solution that is more efficient to benefit farmers. PRIs that are equipped with capabilities in conducting research and performing extension services, is acknowledged as one of the more efficient and effective actors to realise these social innovation initiatives. Other actors are private firms and CSOs. Through public-private partnership and civil society organisation, these entities perform all the elements of sustainable agriculture, social objective, mechanism and transformation. Farmers groups and supporting civil society organisation should be empowered as they help the community to grow and improve.

6.0 Conclusion

This paper has examined the concept and elements of sustainable agricultural development in the case of rice research in Malaysia, according to the Quadruple Helix Innovation Model. It discovered the roles of PRIs in public innovation and comprehended the transformation of social relations among stakeholders (e.g., farmers and researchers in agricultural sector). It also discovered the supportive role of private sectors in directing agricultural policy towards public-oriented. This paper also found the potential of CSOs to transform farmers into more active innovation actors in agricultural innovation system.

Acknowledgments: We would like to acknowledge the financial support provided by the Ministry of Higher Education Malaysia, Fundamental Research Grant Scheme (FRGS) (FP036-2016). We would like to thank MARDI, Department of Agriculture Malaysia and all the interviewees who have provided their valuable inputs during the interview sessions.

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