INTERMEDIARY ROLES OF PUBLIC RESEARCH INSTITUTIONS IN SOCIAL INNOVATION: THE CASE OF MALAYSIAN AGRICULTURAL RESEARCH AND DEVELOPMENT INSTITUTE

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2020

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DISSERTATION SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE

DEPARTMENT OF SCIENCE AND TECHNOLOGY STUDIES
FACULTY OF SCIENCE
UNIVERSITI MALAYA
KUALA LUMPUR

2020

UNIVERSITI MALAYA

ORIGINAL LITERARY WORK DECLARATION

Name of Candidate: **NUR HANIS BINTI MOHAMAD NOOR**

Matric No: **SMA170015**

Name of Degree: **MASTER OF SCIENCE**

Title of Project Paper/Research Report/Dissertation/Thesis ("this Work"):

INTERMEDIARY ROLES OF PUBLIC RESEARCH INSTITUTIONS IN SOCIAL INNOVATION: THE CASE OF MALAYSIAN AGRICULTURAL RESEARCH AND DEVELOPMENT INSTITUTE

Field of Study: **POLICY & MANAGEMENT OF SCIENCE & TECHNOLOGY**

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INTERMEDIARY ROLES OF PUBLIC RESEARCH INSTITUTIONS IN SOCIAL INNOVATION: THE CASE OF MALAYSIAN AGRICULTURAL RESEARCH AND DEVELOPMENT INSTITUTE

ABSTRACT

Studies on Public Research Institutions (PRIs) have been extensively explored by scholars in recent decades. The significant role of the PRIs in ensuring scientific discoveries to accommodate societal needs is very critical. Although PRIs are vital for the government to implement policy and regulation, studies on the institutions are still limited especially when it comes to the context of social innovation. Like any other public-driven institutions, PRIs have limited resources such as capital and labour. Yet, they are expected to perform multiple roles ranged from research and development (R&D) to social development that includes capacity building, knowledge generation and technology dissemination. Thus, the main objective of this study is to explore the intermediary roles of Malaysian Agricultural Research and Development Institute (MARDI) as social innovator in performing the elements of social innovation in Malaysia's agriculture sector. It also attempts to determine the issues and challenges of MARDI in performing social innovation and proposing policy directions to strengthening the institution's roles. This is an empirical study by using a single-case design. Interviews, focus group discussions and observations were performed and 30 interview sessions were conducted during the period of seven months from May 2018 until December 2018. The study applied inductive approach to interpret data obtained from the interviews. For data validation, the preliminary findings were validated by using triangulation method. This includes comparing the findings with other sources of empirical evidence such as archival record and observation. The study also consulted and integrated the insights of MARDI's top management on the findings. The study found that MARDI's intermediary roles in

performing social objectives of social innovation are achieved through the mandated MARDI Act 1969. Through its varietal R&D activities, MARDI is the producer of innovation that has successfully increased the potential rice yield output and reduced maturation period of paddy. Besides, MARDI acts as a bridging organisation that connects private industry with the end user through its public-private partnership with Baden Aniline and Soda Factory (BASF) – a multinational herbicide company. The partnership has successfully provided a solution to weedy rice problem by introducing Clearfield Production System (CPS). However, a main challenge in performing social mechanism of social innovation is the lack of researcher-farmer partnership between MARDI and farmers. Currently, the collaborative engagement is heavily depending on agricultural extension agencies such as Department of Agriculture (DoA) and other regional agencies. The study also found the potential of social media and civil society organisations (CSOs) to transform Malaysian farmers into more an active innovation actor in agricultural innovation system. Based on the findings, the study proposed several policy directions to revise the conventional Triple Helix innovation model to the Quadruple Helix innovation model that emphasize on the synergy of four entities, namely government, industry, academia and civil society. As a conclusion, for a sustainable agriculture to be achieved in Malaysia, it needs (a) quality research by PRIs, (b) efficient extension agencies in disseminating knowledge to the farmers, (c) productive farmers in delivering high yield farming, and (d) communal support by CSOs and media.

Keywords: Public research institutions, social innovation, agricultural innovation system, MARDI, paddy

PERANAN SEBAGAI PERANTARA INSTITUSI PENYELIDIKAN AWAM DALAM INOVASI SOSIAL: KES DI INSTITUT PENYELIDIKAN DAN KEMAJUAN PERTANIAN MALAYSIA

ABSTRAK

Kajian terhadap Institusi Penyelidikan Awam (PRIs) banyak diterokai oleh para sarjana sejak beberapa dekad yang lalu. Peranan penting institusi ini dalam memastikan penemuan saintifik memenuhi keperluan masyarakat adalah sangat kritikal. Meskipun PRIs amat penting dalam usaha kerajaan melaksanakan dasar dan peraturan, kajian terhadap PRIs masih terbatas terutama dalam konteks inovasi sosial. PRIs sepertimana institusi dalam sektor awam mempunyai sumber yang terhad, terutamanya dalam aspek modal dan tenaga buruh. Akan tetapi, institusi ini digesa untuk menjalankan pelbagai peranan yang merangkumi penyelidikan dan pembangunan (R&D) sehingga pembangunan sosial seperti pembangunan kapasiti, pengembangan pengetahuan dan penyebaran teknologi. Sehubungan itu, objektif kajian ini adalah untuk meneroka peranan PRIs dalam melaksanakan inovasi sosial dalam sektor pertanian. Kajian ini juga bertujuan untuk menentukan cabaran dan isu yang timbul berkenaan dengan peranan Institut Penyelidikan dan Kemajuan Pertanian Malaysia (MARDI) dalam melaksanakan inovasi sosial, seterusnya mencadangkan polisi dalam memperkukuh fungsi insitusi tersebut. Kajian ini merupakan kajian empirikal dengan menggunakan pendekatan kajian kes. Temubual, perbincangan berkumpulan serta pemerhatian telah dilakukan. Sejumlah 30 sesi temubual telah dijalankan dalam kajian lapangan yang berlangsung selama tujuh bulan dari Mei 2018 sehingga Disember 2018. Kajian ini menggunakan pendekatan induktif dalam menganalisa data daripada transkrip temubual. Untuk pengesahan data, hasil dapatan awal kajian yang disimpulkan telah disahkan dengan menggunakan kaedah triangulasi. Ini termasuk membandingkan penemuan dengan sumber primer seperti

laporan tahunan dan rekod arkib. Kajian ini juga mengintegrasikan pandangan daripada pihak pengurusan tertinggi MARDI. Kajian ini mendapati bahawa peranan perantara MARDI dalam melaksanakan objektif sosial dalam inovasi sosial dicapai melalui Akta MARDI 1969. Melalui aktiviti R&D, MARDI bertindak sebagai penjana inovasi dalam memberi impak kepada meningkatkan hasil output padi dan mengurangkan tempoh kematangan padi. MARDI juga bertindak sebagai organisasi perantara yang menghubungkan industri swasta dengan pengguna melalui kerjasama dengan *Baden Aniline and Soda Factory* (BASF) – sebuah syarikat racun perosak padi multinasional. Kerjasama tersebut telah berjaya menyelesaikan masalah padi angin menerusi Sistem Pengeluaran Clearfield (CPS). Akan tetapi, cabaran utama dalam perlaksanaan mekanisme sosial dalam inovasi sosial adalah perkongsian penyelidik-petani yang terhad antara penyelidik MARDI dan petani. Kolaborasi ini didapati amat bergantung kepada agensi pengembangan pertanian seperti Jabatan Pertanian (DoA) dan agensi tempatan yang lain. Kajian ini juga mengenalpasti potensi media sosial dan organisasi masyarakat sivil (CSOs) dalam membangunkan petani Malaysia sebagai aktor inovasi yang lebih aktif dalam sistem inovasi pertanian. Berdasarkan penemuan tersebut, kajian ini mencadangkan beberapa polisi untuk mengkaji semula model inovasi *Triple Helix* kepada model inovasi *Quadruple Helix* yang menekankan sinergi di antara empat entity – kerajaan, industri, akademik dan masyarakat sivil. Sebagai kesimpulan, pertanian lestari di Malaysia memerlukan (a) penyelidikan berkualiti oleh PRIs, (b) agensi pengembangan yang cekap dalam menyebarkan pengetahuan dan teknologi kepada petani, (c) petani yang produktif dalam menghasilkan output pertanian tinggi, dan (d) sokongan komuniti oleh CSOs dan media.

Kata kunci: Institusi penyelidikan awam, inovasi sosial, sistem inovasi pertanian, MARDI, padi

ACKNOWLEDGEMENT

Alhamdulillah, all praises to Allah for His guidance and mercy for giving me the emotional strength that I need to complete this journey. Indeed, it is a challenging path, but every step I am taking is precious and priceless as it shapes who I am today. I would like to express my appreciation to my dedicated supervisor, Dr. Ng Boon Kwee that never loses hope in his supervisee. Thank you so much for your trust and commitment. You are a very great mentor. I also would like to thank Mr. Mohd Johaary bin Abdul Hamid, consultant from MARDI, for providing insights as the MARDI consultant throughout this study, and not to forget all my respondents from their respective institutions. The list will never end as their contribution and trust is limitless. Thank you for giving me the chance to understand MARDI, its vision and its people. A huge gratitude is wished to other respondents as well, especially Mr. Firdaus from *Padi Rescue* and farmers from Kodiang and Sungai Panjang. Thank you for opening your stories up to me. Last but not least, my sincere gratitude to my husband, Hafizul Faiz Mohd Azizi for his endless support and love in this journey. His presence meant a lot for me. Not to forget, my family, in-laws, friends and acquaintances. Thank you for all your supports. I am here because of your never-ending support and care.

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LIST OF ABBREVIATIONS

AIS	:	Agricultural Innovation System
AYT	:	Advanced Yield Test
BASF	:	Baden Aniline and Soda Factory
BERNAS	:	Padiberas Nasional Berhad
CPS	:	Clearfield Production System
CSOs	:	Civil Society Organisations
IADA	:	Integrated Agricultural Development Area
KADA	:	Kemubu Agricultural Development Authority
LVT	:	Local Variety Trial
MADA	:	Muda Granary Area
MARDI	:	Malaysian Agricultural Research and Development Institute
MLT	:	Multi Location Trial
MNC	:	Multinational Corporation
MoA	:	Ministry of Agriculture and Agro-based Industry
MPOB	:	Malaysian Palm Oil Board
MRB	:	Malaysian Rubber Board
NASA	:	The National Aeronautics and Space Administration
OECD	:	Organisation for Economic Co-operation and Development
PRIs	:	Public Research Institutions
PPK	:	Pertubuhan Peladang Kawasan
PYT	:	Preliminary Yield Test
R&D	:	Research and Development
SSL	:	Self-Sufficiency Level
S&T	:	Science and Technology

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CHAPTER 1: INTRODUCTION

1.1 Introduction

The Quadruple Helix innovation model suggests the synergy of four entities, namely the government, industry, university and civil society in forming a well-configured knowledge economy and society (Carayannis & Campbell, 2009). In this innovation model, the government is required to provide the ideal ecosystem, that includes legislation and policies to enable collaborative engagement between industy and university. In comparison with the former Triple Helix innovation model, civil society has been included in forming a more inclusive partnership in the innovation ecosystem. Its role of providing local context or grassroot's input is essential in supporting the basis of having the bottom-up approach.

However, in the context of this study, as one of the main entities in the government, Public Research Institutions (PRIs) play significance roles in ensuring that scientific discoveries will accommodate societal needs. PRIs acts as an intermediary between the collaborative engagement of industry-government-university, industry-government-civil society or even for university-government-civil society. This role is consistent with the concept of social innovation that always prioritises societal benefit in the innovation model that encourages collaborative engagement among stakeholders.

In fact, the word "public" in the context of PRIs received special attention while the policymakers are determining the respective institutions' mission, roles and programmes. However, the mandate to foster social development is often exaggerated on the PRIs' mission, without realising the institutional and resources limitations of the institutions. Thus, the agenda of social innovation needs to be carefully formulated by considering the natures of PRIs as well as the stage of technological development of a nation and the type of sectoral activities that the respective PRIs are located.

In the context of Malaysia, agriculture has been driven by the public, either the farmers or consumers. Even though the country has transformed its economy from agricultural-based economy to industrial-based economy, and now with the introduction to the knowledge-based economy, the nation puts food security in its top list of concerns. Therefore, a competent ecosystem of scientific research and knowledge transfer to the civil society is crucial. An agro-based PRI like Malaysian Agricultural Research and Development Institute (MARDI) is needed to perform those mandates and as legislated in MARDI Act 1969, MARDI is the sole public provider for scientific and technological advancement in Malaysia's paddy industry.

This study aims to scrutinise the elements of social innovation in Malaysia's agricultural landscape and the intermediary roles played by an agriculturally based PRI in performing social innovation. As the concept of social innovation has been mainstreamed in developed countries (Lundvall et al., 2002), this qualitative research aims to contextualise the discourse on public driven social innovation into the developing economy by proposing a revised framework through a case study of MARDI. This includes an examination on the elements of co-create and co-produce concepts among farmers, scientific communities and policymaking in the framework of Agricultural Innovation System (AIS). Hence, this study will be a steppingstone to uplift the profession of farmers as co-producer of social innovation in agriculture, as they represent the actor of civil society in the Quadruple Helix innovation model.

Based on these backgrounds, the introductory chapter provides insights into the problem statements and the rationales of this research. Research objectives and research questions are outlined based on the research gaps which exist in current literatures and agriculture policies in Malaysia. Later, the scope and limitations of the study, the

significance of the study, the definition of terms and organisation of the study are also explained in this chapter.

1.2 Problem Statements

A better understanding on PRIs is needed as the literatures regarding the functions of PRIs are heterogeneous and there is no consensus on how PRIs should behave (Lauritzen, 2017; Mazzoleni & Nelson, 2007; Ngongoni et al., 2017). Although PRIs are vital for the government to implement policy and regulation, studies on the institutions are still limited especially when it comes to the context of social innovation. For instance, most of the existing works on PRIs are focusing on the impact of their research and development (R&D) on industrial dynamics and innovation, e.g. studies on the Industrial Technology Research Institute (ITRI) in Taiwan, Electronics and Telecommunication Research Institute (ETRI) in South Korea, and A*STAR Singapore (Hsu, 2005; Peng et al., 2006; Priyadarsini et al., 2014). Besides, a large number of studies tends to focus on the medium and high-tech industries such as electrical and electronics. On a similar note, studies on social innovation tend to understand the unique natures of social innovation (Mulgan et al., 2007; Pol & Ville, 2009). An in-depth understanding of how social innovation can be achieved via the intervention of innovation intermediaries such as PRIs is rarely captured in the literature.

This results in a lack of understanding of the intermediaries' process of PRIs in the formulation of a sound policy direction toward social inclusiveness. Societies are not enlightened on the entry point which they can undertake in developing their capabilities. Consequently, the real impacts of PRIs on social innovation could not be fully understood and be appreciated when the processes of these intermediaries are not well explored. Thus, there is a need for more empirical studies to perceive innovation as a process and not merely as an event or product (Voorberg et al., 2015).

From the policy and managerial perspectives, PRIs like any other public-driven institutions have limited resources such as capital and labour. Yet, they are expected to perform multiple roles ranged from R&D until social development, for example, capacity building, knowledge generation and technology dissemination. Therefore, it is important for policymakers and top-level management of PRIs to identify the best practices they could adopt to ensure the priority of social benefit is still retained. However, lack of empirical study on PRIs hinders policymaking process, thus emphasising the needs for more personal, bottom-up and qualitative measures.

In the context of Malaysia, the study is driven by the fact that Malaysian rice farmers are still vulnerable and highly depending on government assistance such as subsidies on fertiliser, pesticide and other welfare assistance (Ministry of Agriculture and Agro-based 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).

In Malaysia, there are about 300,000 farmers involved in 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 their side income. Hence, this research seems to be critical to be explored due to national food security and the welfare of its farmers and consumers.

1.3 Research Objectives

Based on the above viewpoints and the case study of agricultural sector in Malaysia, this study aims to achieve the following main objectives:

a) To explore the intermediary roles of MARDI as social innovator in performing the elements of social innovation in Malaysia's agriculture sector,
b) To determine the issues and challenges of MARDI in performing social innovation, and
c) To propose policy directions to strengthening MARDI's roles in performing social innovation in agricultural systems in Malaysia

1.4 Research Questions

In order to achieve the mentioned objectives and based in the case study of MARDI, this research addresses the following main research questions:

a) How does MARDI play its intermediary roles in meeting societal objectives, social mechanism and social transformation in agricultural system?
b) What are the institutional and resources constraints that hinder the roles of MARDI in social innovation?
c) What are the proposed policy directions in promoting participatory research model on the collaborative engagement between researchers and farmers in co-producing innovation in Malaysia's agriculture system?

1.5 Scope of the Study

This study is about social innovation in public sector which is different from social innovation in corporate business and industry. The former revolves around public goods such as education, health care and public-driven sector like agriculture. This type of innovation prioritises societal benefit, thus putting more emphasis on the reason of

scrutinising social innovation. Despite the existence of numerous PRIs and extension agencies to deal with numerous types of crops and commodities, this study is designed to understand agro-based PRIs based on the case studies of MARDI.

This study employs a single case study method specifically on MARDI to provide an in-depth understanding of PRIs' roles in the context of agriculture in developing countries. Hence, the intermediary roles such as knowledge generation, capacity building and policy advisory of PRIs like MARDI is prioritised throughout this study, and the perspectives will be contextualised into the application of social innovation. This includes in focusing on the process of innovation such as social interactions between innovation actors as suggested by both literary and working concepts of social innovation. The rationale is that throughout this study social innovation is not perceived merely as a product of innovation that can be consumed by the end user. Instead, the process on innovation involves accumulation of social interaction, knowledge and experience sharing that should be acknowledged in the research. Thus, the learning processes and accumulation of experiences (know-how) are given greater focus in this study.

The scope of the study also limits to Malaysia's paddy industry. The country has several food commodities that include fruits, vegetables, seafood and dairy products that are counted to the Self-Sufficiency Level (SSL). But the study focuses to paddy as the commodity has a large pool of end-users; the farmers and a long history within the nation. Besides that, MARDI also performs other extension services and scientific research regarding to other commodity and sectors like entrepeneurship in agro-based products. However, the context of this study only involves with MARDI's centres that deal with paddy-rice research and its value chain.

1.6 Significance of Study

Generally, the outcome of this study contributes in providing ideas and empirical evidences for policy making and top-level management of PRIs, especially regarding the needs to determine the roles of PRIs in fostering social innovation. This is particularly important when result-driven framework has been a prominent value in most societies including Malaysians. It is important to note that every institution have limited resources to achieve their designated performance indicators.

In most cases, the society is overemphasising on the tangible result without giving a fair appreciation to innovation as a process of learning. An in-depth understanding of social innovation (or innovation as general) as a continuous process that involves multiple phases before it reaches to end users is needed to be understood.

Based on this principle, the case study provides insightful empirical evidence on the following two broad perspectives on social innovation, such as the level of researchers-farmers interactions, and the capability-building and learning processes in improving agricultural practices. Specifically, the significance of this study to literature, policymaking and society like farmers are as the followings:

a) The research contributes to filling in the current gaps in both works of literature of social innovation and PRIs in the innovation system. The case study of MARDI will extend current works of literature in the realm of the nature of social innovation (Mulgan et al., 2007; Mumford, 2002; Voorberg et al., 2015) and intermediary roles of innovation (Dalziel, 2010; Howells, 2006) in terms of their contexts of discussion regarding developing economy. Although such literature has provided excellent account in explaining the unique natures of social innovation that are driven by societal needs and bottom-up in decision-making, the processes needed in creating such formation are not clearly captured by the existing

works of literature. Thus, this research contributes to filling this literature gaps by exploring the participatory research model and co-production, that provides new insights into understanding the process of social innovation. The study also provides additional empirical evidence and information in the literature on PRIs. The exploration on the best practices from the case study and examination on the respective role of various actors in the process of social innovation will provide useful insights for the evidence-based policymaking in Malaysia, particularly for MARDI. It gives them insights on their current social innovation policy, thus assisting them in improving their public services to the society. More importantly, this study acknowledges and records the critical contribution of MARDI as a PRI in driving social innovation agenda in the nation. Other PRIs especially in the agricultural sector such as Malaysian Palm Oil Board (MPOB) and Malaysian Rubber Board (MRB) could learn some lessons from the case study.

b) As for the farmers, this study provides information on the status of Malaysia's farmers in terms of their capacity development, acceptance and ability for technology dissemination from MARDI, and generating knowledge from their interaction with MARDI's researchers. The study also contributes to promoting active roles for farmers, thus encouraging them to become the active participant in social innovation process rather than being the consumer or end user. The farmers could gain insight on their contributions to the nation's agricultural system; that their merits are not solely on the percentage of rice SSL, but their knowledge and capacity in building the economy. This aspect contributes to a more sustainable AIS as every innovation actor is acknowledged and their interactions and learning process are further explored.

1.7 Definition of Terms

There are several terminologies applied in this research and by understanding them assists the reader to comprehend the arguments stated throughout the study:

a) Social innovation - social innovation is defined as *"the creation of long-lasting outcomes that aim to address societal needs by fundamentally changing the relationships, positions and rules between the involved stakeholders, through an open process of participation, exchange and collaboration with relevant stakeholders, including end-users, thereby crossing organizational boundaries and jurisdictions*" (Voorberg et al., 2015, p. 1334).

b) Public Research Institutions (PRIs) - PRIs are defined as "*public and semi-public research institutions (excluding pure university institutes), regardless of their statistically-defined sector (government, higher education, business or private non-profit)*" (OECD, 2011, p. 27), and *"their activities vary widely according to their mission and type. Some perform "blue sky" science or basic research that often has a long-time horizon and carries high risks with uncertain returns, while others focus on more short-term market-oriented research, development work, problem solving and technical assistance. Some PRIs specialise in mission-oriented research such as biotechnology or telecommunications, while others cross the scientific spectrum. Other roles include providing technology services, education and training activities (e.g. supervision of PhD candidates and hosting post-doctorate researchers, skills development and on-the-job learning), technology transfer (e.g. physical transfer of technology, prototypes and process and or "know-how"), the development of new instrumentation or laws and regulations (e.g. environment, health, safety, etc.)"* (OECD, 2011, p. 20).

c) Agricultural Innovation System (AIS) - AIS *"involves a wide range of actors, who guide, support, create, transfer or adopt innovation, and who advise and inform*

farmers and the public about innovation"(OECD, 2013, p. 13) and *"while science and technology (S&T) is still a major component in AIS, innovation also includes institutional and organisational innovation"* (OECD, 2013, p. 14). Thus AIS could be summarised as an *"integrated systems of diverse institutional actors, institutional learning and institutional innovation, and overall institutional set-up in the national context"* (Hall et al., 2002, pp. 159-160)

d) Researchers-farmers partnership – this partnership is described as *"more user orientation, more decentralized dissemination of research and results, openness towards informal modes of experimentation, more externalization of tacit knowledge and more respect for farmers' opportunity costs"* (Hoffmann et al., 2007, p. 356).

e) Innovation intermediaries – This type of innovation actors is defined as *"organizations or groups within organizations that work to enable innovation, either directly by enabling the innovativeness of one or more firms, or indirectly by enhancing the innovative capacity of regions, nations, or sectors. They do so by intermediating on the interorganizational level by creating and nurturing interorganizational networks, and by intermediating on the intercommunity level by conducting and supporting technology development activities in the innovation gap between the business and research communities"* (Dalziel, 2010, pp. 3-4).

1.8 Organisation of the Thesis

The study is organised into five chapters. Chapter 1 is the introductory chapter to explain the background of the research. In this chapter, research objectives and research questions will be outlined based on research gaps stated. The chapter also will summarise definitions of terminologies used throughout the study as a guide for the readers. Chapter 2 provides a critical review on the works of literature in three main perspectives, namely the nature of social innovation, PRIs for social innovation, and social innovation in

agricultural activities. Research gaps will be explored in detail throughout the chapter as well as the construct of the research framework. Chapter 3 discusses the research methodology used in this study. It details the research scope and limitations of the study. This is followed by Chapter 4 that discusses the main research findings and discussions. Finally, Chapter 5 concludes the study and propose several relevant policy implications and future directions derived from the research.

1.9 Chapter Summary

The main philosophy of this study is that agriculture is no longer driven by the advancement of S&T, but the capacity building among its stakeholders including the farmers. The need to contextualise into developing economy context like Malaysia justifies the application of qualitative case study approach. In fact, the framework that will be suggested by the end of this study will attempt to challenge the current social innovation framework. Based on the case study of MARDI, this study aims to improvise the framework of social innovation that can be applied in other sectors like agriculture. This effort is timely as PRIs in Malaysia is highly dependent of the government's support and the urge to scrutinise their roles in developing farmers' capacity is important. The explanation in this chapter brings us a relevant concluded question – does the way we perceive social innovation today is irrelevant, thus putting more barriers between the scientific community with the farmers? Therefore, to answer the question, further explanations about social innovation, especially related to the concept of co-create and co-production is indeed important, and this will be outlined in Chapter 2.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The main purpose of this chapter is to provide a critical review on works of literature related to the research topics, thus leading to the establishment of the research framework for this study. This chapter also attempts to contextualise the literary concept of social innovation into the context of a developing country. The focus of the review is divided into two streams of literature. The first is on social innovation studies that encompasses two broad sub-themes; (a) nature of social innovation in developing countries and (b) social innovation in agricultural activities. The second is reviewed works of literature on PRIs and its intermediary roles in supporting social innovation agenda.

2.2 Nature of Social Innovation in Developing Countries

2.2.1 Concepts of Social Innovation

Generally, social innovation performs almost the same function as another type of innovation in solving people's problems. However, compared to business innovation that prioritises profit maximisation and technological innovation that focuses on technology advancement, the main principle of social innovation extensively lies on the social perspective of innovation-related activities (Pol & Ville, 2009). The first aspect of this concept is that social innovation puts societal benefit before individual interest (Mulgan et al., 2007; Phills et el., 2008; Pol & Ville, 2009). In this respect, Parra (2013) postulated that there is a crucial need to define societal needs in facilitating social innovation to take place. In doing this, these societal needs must be defined collectively, and the community requires to put an effort into fulfilling the needs. Parra's suggestion is sensible as the definition of societal needs might be misunderstood if the interpretation is mainly approached through top-down policy decision. The societal needs should be defined by the community itself and the effort to fulfill the needs should be done by interacting with other innovation actors including policymakers and PRIs like MARDI.

The second element of 'social' in the setting of social innovation is understood as the existence and participation of different stakeholders in the innovation process (OECD, 2011). More importantly, social innovation process is expected to initiate transformation in social relations among the various participants. The innovation actors involved then eventually develop their income; asset or infrastructure and capabilities; knowledge, skills, networking or institutions (Caulier-Grice et al., 2012). Conclusively, social innovation should be able to bridge the gap that exists between innovation actors and utilises the partnership to benefit the end user, which in this case, the society at the bottom of the pyramid. Thus, the next question that will be asked – is there any difference for social innovation in developing nations?

In the context of developing countries, the small nature of smallholders in the industry 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 a public-driven sector such as agriculture (Ng et al., 2017; Wu, 1995) and resource-based industry (Himanen et al., 2005; Loebis & Schmitz, 2005). Thus, the partnership between the community as the consumer (or end user) 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, through social innovation, the community should be transformed as community-driven development is preferred as social capital for the innovation. The community behind the industry is not only functioning as consumers but their active involvement and feedback act as a catalyst to technology transfer and innovation diffusion. In this respect, end users (such as farmers in the context of this study) 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.

Additionally, "social and territorial logics" must be acknowledged in social innovation analysis, thus signifying the foundation that researchers-farmers partnership is worth to be explored (MacCallum et al,. 2009). Farmers in developing economies do have the willingness and want to be part of the innovation process. For example, farmers in India are stated to have the desire to contribute to scientific findings as citizen scientists, meanwhile in Honduras and Ethiopia, the farmers were interested in information sharing (Beza et al., 2017). Based on the above viewpoints, this study opts to the concept of social innovation suggested by Voorberg et al. (2015) as a guideline to answer the determined research questions. This proposed concept suggests that social innovation should address its fundamental concept of relationship, position and rules changes between the involved stakeholders, through unrestricted access to participation and collaboration. These claims are parallel with the principle of co-creation and co-produce in the innovation process that was supported by Gallouj et al. (2018).

However, these scholars did highlight the fact that the involved stakeholders (especially the groups of end users) should be empowered and have the capability to get involved in the innovation process. This is the research area that the study attempts to explore through the case study of MARDI, that is, whether the farmers in Malaysia's agricultural sector are capable to co-create, co-produce and co-deliver social innovation. Parra (2013) suggests that it is important in defining societal needs according to specific societal context and social innovation should portray the effort to fulfill the needs through its product and process. In line with this suggestion, this study on the case of MARDI will lead to the discussion on the effectiveness of MARDI as a PRI in satisfying the societal needs that are defined from the perspective of farmers.

Table 2.1 summarises the main concepts of social innovation proposed by various scholars in two broad dimensions, namely social benefit and social relation. In general,

the element of social benefit seeks for the satisfaction of social needs and demand; while social relation emphasises the aspects of social interactions and relationships among innovation actors.

2.2.2 Social Innovation and Participatory Research in Agriculture

Bock (2012) is one of the scholars that explored the idea of social innovation in the agricultural sector. She explained it clearly that social innovation is rarely connected to agriculture in the literature. However, the concept is widely explored in other areas like sustainability and rural development. It is found that in research related to agricultural innovation system, rural development, and sustainability, there is a similar characteristic among these three research areas in which their end users consist of farmers or groups that supported agricultural activities. The dimensions of social innovation in 'sustainability' and 'rural development' could be implemented in the agricultural sector.

There are three attributes of social innovation in agriculture as suggested by the scholars; (a) social objectives – responsiveness to market failure and unmet social needs, (b) social mechanisms – co-production of rural innovation, and (c) social transformations – changing (rural) society (Bock, 2012; Moulaert, 2016; Mulgan et al., 2007; Mumford, 2002; Westley & Antadze, 2010):

Table 2.1: Summary of the concepts of social innovation.

Dimensions	Literatures	Features
a) Social objective		
• *Satisfaction of societal needs*	Mulgan et al. (2007)	Social innovation is different from business innovation which is motivated by profit maximisation and technological innovation that focuses on technology advancement, social innovation prioritises societal benefit.
	Phills et al. (2008)	Social innovation as a novel solution that is more efficient to benefit society rather than private individuals.
	Pol and Ville (2009)	Social innovation should give positive impact on the quality and/or quantity of life.
b) Social mechanism		
• *Transformation of social relations*	Mumford (2002)	Social innovation requires willingness to restructure existing social relationship to solve societal problem.
	Cajaiba-Santana (2014)	Collective social action needed to drive social innovation for social change.
	Voorberg et al. (2015)	Social innovation should address its fundamental concept of relationship, position and rules changes between the involved stakeholders, through unrestricted access of participation and collaboration.

Table 2.1, continued.

	Moulaert (2016)	Change in governance system and organisation as one of the transformations.
	Gallouj et al. (2018)	Concept of co-creation and co-produce in social innovation.
c) Social transfomation		
• *Empowerment*	Caulier-Grice et al. (2012)	Social relation transformed should improve income and capabilities of stakeholders.
• *Territorial implemented*	Moulaert and Sekia (2003)	Social innovation in integrated area development approach which emphasises territorial factor.
	Westley and Antadze (2010)	Distinctive model of system transformation to upscale social innovation.
• *Cultural & Institutional Change*	Turker and Vural (2017)	Institutional voids stimulate social innovation at institutional and incremental level.

- *Social objectives* – Social objectives put societal benefit before individual interests (Mulgan et al., 2007). These societal needs must be defined collectively, and the community needs to put an effort into fulfilling the needs. The societal needs also should be defined by the community itself and the effort to fulfill the needs should be done by interacting with other innovation actors including policy makers and PRIs like MARDI.
- *Social mechanisms* – Social mechanisms in the setting of social innovation are understood as the existence and participation of different stakeholders in the innovation process (OECD, 2011). These social mechanisms should be able to bridge the gap that exists between innovation actors and utilises the partnership to benefit the end user, which in this case, is the society at the bottom of the pyramid.
- *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 the 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. This example explains the social mechanism suggested by Bock (2012) that is needed in social innovation – it needs empowered people to make it happens, thus emphasising the element of social transformation in social innovation. Social mechanisms, social objectives and social transformations should not be separated,

they are interdependent entities in social innovation, especially when it comes to agriculture.

These three elements of social innovation could be observed in the case of PRIs like MARDI by adapting the conceptualisation of the Quadruple Helix innovation model suggested by Carayannis and Campbell (2009). The Quadruple Helix innovation model proposed relationships (helices) among government, universities, industry and media and culture-based public. Each of these entities performs important roles in co-create innovation and knowledge sharing, which is one of the elements in this conceptual framework.

Before the concern, whether the farmers in Malaysia's agricultural sector are capable to co-create, co-produce and co-deliver social innovation or not, a clear understanding of how social innovation can be cooperated in agriculture should be understood. In agriculture, the conventional linear research model is a form of research that involves researchers, extension agencies and end users. In this conventional model, the researchers produce innovation, later extension agencies will disseminate the product or knowledge, and end users act as the recipients or consumers in the relationship.

The relationship is explained in Figure 2.1 and this conventional model was generally used during the Green Revolution in the 1980s. Interestingly, it was found that some developing countries had adopted this simple linear model from the United States before they realised that the model could be problematic in their national context (Warren et al., 1995).

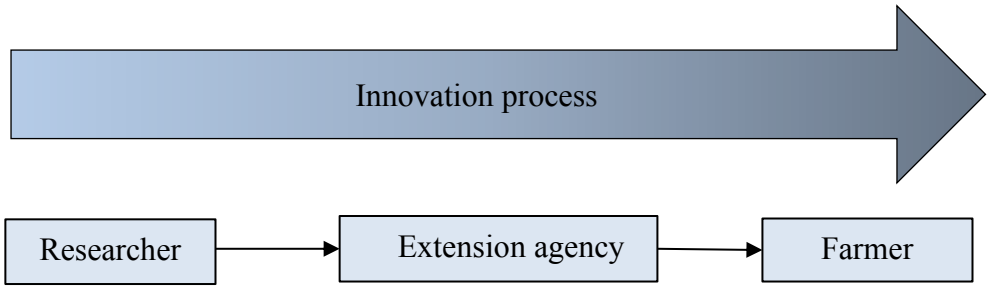


Figure 2.1: Flow of conventional research in agriculture.

Source: Warren et al. (1995)

Instead of the conventional linear research model, this research adopts the concept of participatory research and attempts to incorporate it with the concept of social innovation that is illustrated in Figure 2.2. In contrast to this conventional linear research model, a participatory research model emphasises on the collaboration between researchers-farmers in co-producing innovation. In this regard, the links between all the participated stakeholders, in this context group of farmers, researchers and extension agencies are interactive and there is no clear starting point of this innovation process.

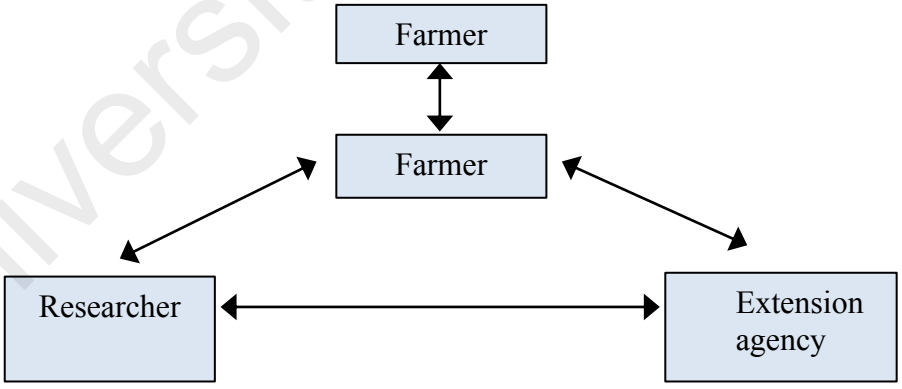


Figure 2.2: Flow of participatory research in agriculture.

Source: Warren et al. (1995)

For Warren et al. (1995), farmers who participated in this learning process not only benefit from their interaction with another two different stakeholders; they also accumulate ground knowledge from their peers who were also farmers. However, participatory approach has several limitations. The approach heavily depends on the willingness of farmers to cooperate and participate. It also depends on the willingness of other innovation actors like extension officers and researchers to take part in the process. Often time, the farmers found that by participating in a participatory research, it does not give any benefit such as monetary benefit and the farmers have to spend their time, hence this approach needs appealing factors to attract the interests of involved stakeholders (Cornwall & Jewkes, 1995).

As a part of social innovation, researchers-farmers partnership has been extensively explored in works of literature. In agriculture, the terminologies such as participatory design approaches, collaborative design, co-design and co-innovate are used to describe researchers-farmers partnership (Berthet et al., 2018). On the other hand, collaborative design, co-design and co-innovate are not distinctive to each other. These concepts tend to replicate the participatory approach and the works of literature often use the terminologies interchangeably. What is more concerning is that it depends on when and how the intervention, for example, dialogue, communication and engagement happens during the innovation process (Barcellini et al., 2015).

Conclusively, participatory research can fill in the gap left by the conventional research that Malaysia is currently using. However, each study needs its own customised participatory approach in forging researchers-farmers partnership and this study is needed to fill in the potential gap by introducing the case study of MARDI. Table 2.2 shows the comparison between conventional and participatory research. Based on two major research gaps explained in the previous section; social innovation in fulfilling societal

needs and social relation among social innovation actors, there are several significant differences between conventional and participatory research that the study should focus on.

Table 2.2: Comparison between participatory and conventional research.

	Participatory research	**Conventional research**
What is the purpose of the research?		
• What is the research for?	Action	Understanding with perhaps action later
• Who is the research for?	Local people	Institutional, personal and professional interests
• Whose knowledge counts?	Local people's	Scientists'
• Topic choice influenced by?	Local priorities	Funding priorities, institutional agendas, professional interests
• Methodology chosen for?	Empowerment, mutual learning	Disciplinary conventions, 'objectivity' and truth
Who takes parts in the stages of research process?		
• Problem identification	Local people	Researcher
• Data collection	Local people	Researcher, enumerator
• Interpretation	Local concepts and frameworks	Disciplinary concepts and frameworks
• Analysis	Local people	Researcher
• Presentation of findings	Locally accessible and useful	By researcher to other academics or funding body
• Action on findings	Integral to the process	Separate and may not happen
• Who takes actions?	Local people, with or without external support	External agencies
• Who owns the results?	Shared	The researcher
• What is emphasised?	Process	Outcome

Source: Cornwall & Jewkes (1995, p. 1669)

There are two observations and interpretations that can be derived from Table 2.2. Firstly, the target audience for participatory research is the people, in comparison with conventional research that puts institutional, personal and professional interests as the target audiences. Therefore, this difference shows that participatory research design uses the bottom-up approach in identifying the research problem. This alternative is valuable in acknowledging the voice from civil society and ensuring the research action taken is solving a societal problem. Secondly, participatory research is conducted by the people, with or without external agencies. This ensures the adoption of technology and innovation created is maximised. Meanwhile, in conventional research, external agencies are fully responsible for conducting the research.

Besides, it is advised that the variables created during the research might not be similar when it is implemented in the field, i.e. it should be field and area specific. Some challenges in implementing the participatory research include, among others, lack of appealing factors such as monetary benefit to the end users, and the approach demands the involved end users to be competent to conduct the research and they have to be informed with the research objectives (Cornwall & Jewkes, 1995). Additionally, the researchers also have to be honest in delivering the research findings, rather than solely promoting participation to meet the criteria of the research (Pain & Francis, 2003).

2.3 PRIs in Social Innovation

2.3.1 Government in Social Innovation

In recent years, public innovation is focusing on partnerships that enable public sector to draw on other organisations' capabilities in creating innovative new services (Baxter et al., 2010; O'Byrne et al., 2014). Respectively, public innovation aims to search for new ideas and concepts, technologies, techniques and methods, forms, systems and procedures to form meaningful interactions between public entities and society to address societal

challenges (Bekkers et al., 2011). While existing research on public innovation tends to be focused on the administrative efficiency of government machinery, for example, outsourcing, privatisation and procurement, the role of public innovation in tackling the actual emerging social challenges of communities at the bottom of the pyramid, which is public social innovation, are not clearly articulated in the works of literature (Baxter et al., 2010; Rana et al., 2014). Additionally, the growing demands for people-centred public policy towards inclusive development are currently on the focal point of both academia and policy discourses. Notably, good governance is characterised as successful partnerships between public entities and the citizens, or public participation is considered a characteristic of good governance (O'Byrne et al., 2014).

Public entities are crucial in ensuring the public receive substantial societal benefits from public good such as education, infrastructure and technology. Government as the main public agency plays several essential functions for this purpose. OECD (2013) in their report on AIS outlined the roles of government in delivering innovation to the people. This includes the governance of national R&D and innovation system, investment in innovation, facilitate knowledge flows and interaction within the innovation system, and strengthen international co-operation in agricultural innovation. The list could be a potential blueprint for national AIS, thus explaining how government should operate in delivering innovation to the people. Yet every nation has its distinctive governance system and each of them demonstrates different levels of government interventions. For example, a study conducted by Wang (2018) compares between two countries with distinct governance systems, Hong Kong and Singapore in terms of the impact of government intervention towards innovation. Surprisingly, his findings showed that the protectionism of the Singaporean government in their innovation system indeed gives a positive impact on their innovation creation and adoption. The strong control of their government in innovation sector can steer all the industry players to move into the same

direction of agendas. Meanwhile, the opposite observation could be seen in the free market governance of Hong Kong. However, the conclusion made by the scholar is considered too oversimplified to be generalised to other countries. Different countries have their own contextual needs and it depends on the structure of their societies.

Similar arguments proposed by Voorberg and Bekkers (2018) that debate on the differences in the adaptation and implementation of social innovation in the case of four countries; Estonia, Germany, the Netherlands and the United Kingdom. In their findings indeed showed that the country's governance system influences the diffusion of social innovation in the countries. For example, a newly formed republic like Estonia is more receptive to the nature of social innovation, which celebrates the transparency of social relationship between citizen and government. Together with the work by Wang (2018), these empirical studies showed the relevancy of government involvement in performing social innovation. Yet, the government could not do all the works by themselves. They need the assistance of its supporting agencies at the operational level. Hence, in the next section, the research will explore PRIs as one form of government agencies that perform public policies and deliver the benefits of social innovation to the people.

2.3.2 PRIs and Intermediary Roles in Social Development

PRIs are defined as "*public and semi-public research institutions (excluding pure university institutes), regardless of their statistically-defined sector (government, higher education, business or private non-profit)*"; and "*their activities vary widely according to their mission and type*" (OECD, 2011, p. 27). In this respect, "*some of the PRIs perform "blue sky" science or basic research that often has a long-time horizon and carries high risks with uncertain returns, while others focus on more short-term market-oriented research, development work, problem solving and technical assistance*" (OECD, 2011). "*Some PRIs specialise in mission-oriented research such as biotechnology or*

telecommunications, while others cross the scientific spectrum. Other roles include providing technology services, education and training activities (e.g. supervision of PhD candidates and hosting post-doctorate researchers, skills development and on-the-job learning), technology transfer (e.g. physical transfer of technology, prototypes and process and or "know-how"), the development of new instrumentation or laws and regulations (e.g. environment, health, safety, etc.)" (OECD, 2011, p. 20).

Another crucial mandate of PRIs is to create knowledge. As knowledge is a source of future sustained growth that is non-excludable and non-rivalrous in its application, this makes PRIs a crucial actor to increase nation's productivity, economic growth and employment (Yang & Jung, 2016). Besides, in the context of sustainable agriculture, PRIs act as agricultural extension services to the farmers in providing advice, information and other support services to farmers to enable them to improve their productivity and income. They are also key players in executing governments' rural development policies and programmes (Adebayo et al., 2015). Their roles as agriculture extension agencies are similar to the concept of innovation intermediary in delivering social innovation. In the realm of innovation studies, the most common terms used by scholars to describe innovation intermediaries are brokers and intermediaries. The word "brokers" causes confusion as innovation intermediaries conduct more roles than act as brokers or agents between two parties (Dalziel, 2010). In certain cases, innovation intermediaries provide the services by themselves to the client without involving any third party (Howells, 2006).

Besides that, the word "intermediary" is often used to address technology, information or knowledge acquirement of the target group from certain parties. Intermediaries often find themselves as a bridging agent or connector between supplier and user. The same concept could be implied to the role of PRIs in regional coordination mechanisms to deliver innovation-related activities to the end users (Ng et al., 2016). For Bessant and

Rush (1995), the role of bridging innovation can be played by consultants that can fill in managerial gaps that exist in technology transfer. This point of view might be limited to firms or organisations that do conduct technology transfer. Alternatively, other scholars that use agriculture as their case study, the term "broker" is still used to describe the intermediary role in that sector. Yet, when it comes to knowledge brokering, the scholars found out that "broad systemic support beyond knowledge brokering" is crucially needed as the innovation took place in "networks of heterogeneous actors" (Kilelu et al., 2011).

As a conclusion, based on the scholars mentioned above, there are three words that can be discussed to create a framework on the mandates and institutional settings of PRIs in social innovation; PRIs as intermediaries, brokers and bridging organisations in capacity building, knowledge generation and technology dissemination. These mandates correlate with the features of social innovation through the case study of MARDI. Therefore, Table 2.3 lists the possible functions and regional activities of intermediaries performed by PRIs in four dimensions, namely information and know-how sharing, managerial capability development, network development, technological competency building, and policy advisory.

Table 2.3: Possible functions and regional activities of intermediaries.

Functions	*Regional activities*
a) Information & know-how sharing	• Assess knowledge gaps and fill gaps in information and know-how • Facilitate and coordinate the diffusion and exchange of information • Interface management and providing space and platforms • Articulate experiential and indigenous knowledge • Initiate peer exchange and demonstrations • Locate key sources of knowledge
b) Managerial capability development	• Initiate organisation and maintain group dynamics • Build managerial skills training and competency • Work on attitude and practice • Facilitate changes in rules and regulations • Determine accreditation, certification and standards • Strengthen project management competency
c) Network development	• Link collaborators and form partnerships • Effect change with science networks and local collectives • Build trust, manage conflicts and complementary assets sharing
d) Technological competency building	• Develop technical skills and ability in the selection of appropriate techniques • Develop new application for new technologies • Transfer and exploit technology
e) Policy advisory	• Formulate research policy that orients the science system to socio-economic objectives • Align agendas and link science, policy and practice • Articulate the specific needs and support the dissemination of knowledge to society • Evaluate outcomes

Source: Ng et al. (2016)

2.3.3 Driving and Hampering Factors

Even though PRIs as public entities are responsible in performing and disseminating social innovation to the public, there are factors that catalyse or hinder the production and process of innovation. An interesting case study conducted by Mazzucato and Robinson (2018) on The National Aeronautics and Space Administration (NASA), a United States' public agency found that the public-private partnership in space R&D changes the role of NASA as the director of innovation into a facilitator in the process. This is due to the existence of many private companies in the sector such as Space X and Boeing compared to decades ago when NASA started its operation. These private entities assist NASA in co-deliver innovation into space-exploration sector and surely becomes the driving factor for NASA to perform social innovation.

In this case, the ecosystem of innovation could be expanded by taking private sectors into account, thus creating a healthy and diverse ecosystem that can work towards the same agenda. The argument is supported by Robin and Schubert (2013) that concluded that the impact of cooperation between private companies with PRIs does give positive effects to firms' innovativeness. Therefore, public-private partnership in R&D has the potential to drive social innovation and these two entities should not be separated.

The second driving factor of PRIs in social innovation is the application of open and networked innovation. Perkmann and Walsh (2007) discussed the concept of open innovation in university-industry collaborations and they showed that open and networked innovation contribute to capacity building and learning motives rather than a tangible outcome. Besides, firms also expect benefits from the partnership over the whole innovation process, not only the initial supply of inventions (Perkmann & Walsh, 2007). However, collaborations between different agencies and organisations could be a hampering factor for PRIs as well. According to a comparison study conducted by Robin

and Schubert (2013), the difference in science policies in France and Germany demonstrates the influence of the countries' science policy to research collaboration. For example, in Germany the support for public research in the country is decentralised. Hence, research institutions found it challenging to identify potential partners for research collaborations. Furthermore, the allocation for resources is dispersed, thus resulted in inefficiency and less support for public research.

The second hampering factor for PRIs in social innovation is research capital, for example monetary capital and human resources. Lockett et al. (2005) gave a good example on this factor by explaining the need to recruit "technology transfer officers with an appropriate private sector background, including experience of starting a business". Thus, the extension officers especially in agriculture are able to "sell" their innovation even though they are in public sectors. Conclusively, the driving factors for PRIs in performing social innovation could be listed as public-private partnership in R&D, and open or networked innovation. Meanwhile, the hampering factors for PRIs explained in the literatures are research capital, such as human and monetary resources and national science policy such as dispersion of research management and resources. Therefore, the study should look on the types of social innovation conducted in the sector of agriculture and the research will propose a conceptual framework in exploring intermediary roles of PRIs in social innovation.

2.4 Framework of Agro-based PRIs in Social Innovation

Figure 2.3 illustrates the conceptual framework used in this study. The framework is adapted from the review on the concept of social innovation provided in Section 2.2. The framework shows that in order to achieve social objectives of the national sustainable agriculture agenda, social innovation is commonly used as one of the government's initiatives in fostering and strengthening the production and innovation capabilities of the

farmers. This includes improving income generation of farmers, providing a 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 social innovation initiatives.

Meanwhile, the social mechanisms of social innovation 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 social innovation. Indeed, this is about the co-creation model that gives more autonomy to the non-scientific community to innovate (McKelvey & Zaring, 2018).

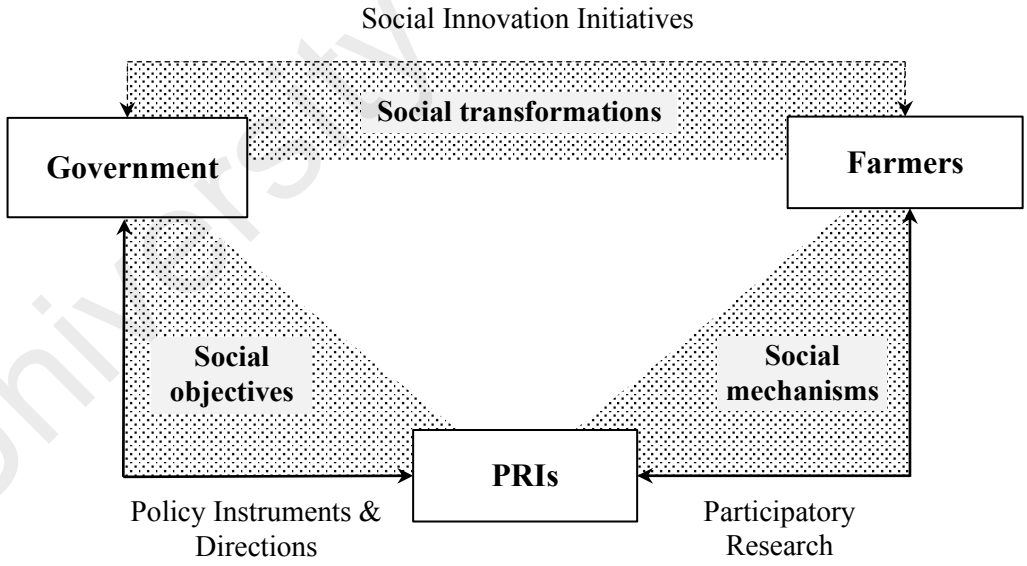


Figure 2.3: Conceptual framework for this study.

The underlying principle of this framework is the researchers-farmers partnership is communally supportive, that is, one of the main principles of sustainable agriculture. In this respect, social innovation aims to transform the society; farmers as active players in the industry and no longer as passive recipient. Rather than act as consumers, they are prosumers (producer and consumer) (Beza et al., 2017; Mumford, 2002).

This concept is also explained by Tether and Tajar (2008) whether the knowledge gained from external knowledge providers is complementing or substituting the knowledge created by the users themselves. In other words – can end user creates knowledge and innovate without depending on external sources like PRIs? There are two aspects that can be examined; end user's participation in rice varietal development, and transfer of knowledge for both scientific and know-how between researchers and farmers. Therefore, there are questions that we try to answer by using the framework – how farmers and researchers engage with each other during rice varietal development process? Are farmers being active participants in this interaction? To what extent do researchers utilise their networks with farmers in their innovation? Do they co-deliver innovation as suggested in social innovation?

The framework is not only acknowledging the existence of other elements in innovation system like social partnership and networks, but it also refocuses the end goal of innovation, and technology is the progress in society's quality of life, not merely technology advancement that benefits a certain group of people. Especially when it comes to the microenvironment in social innovation such as emotion and motivation, evaluation on social relations among innovation actors are needed when social disparity is obvious to be observed (Wijk et al., 2019). In fact, consistent with the goals of social innovation, strong ties among innovation actors indeed will speed up the process of technology

transfer, rather than weak ties that only helps to improve the knowledge within an institution (Hansen, 1999).

2.5 Chapter Summary

Social innovation is a wide concept to be explored. Based on the research objectives and research questions listed in Chapter 1, a detailed explanation on social innovation is outlined in this chapter. The chapter started by explaining the basic concepts and principles of social innovation and the types of social innovation activities in agriculture. Later, the discussion is refined into the context of developing countries. Then, the chapter outlined the roles of government in performing social innovation by mandating PRIs as innovation intermediaries. The section discussed the intermediary roles of PRIs according to works of literature and determined the driving and hampering factors of the roles. At the end of the chapter, the research proposed a conceptual framework that will be used throughout the study on MARDI. The next will discuss the research methodology of this thesis.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

The challenge to conduct a qualitative study is to link the context of the research into a larger perspective that can contribute to policymaking (Marshall & Rossman, 2011). Therefore, the selection of a case study should be carried out carefully so that the findings could deliver useful insights that could improvise evidence-based policymaking. This chapter provides detailed explanations on qualitative research methodology used in this study. This includes the process of selecting a case study and the process of developing interview questions that are in line with the research objectives and research questions. Besides that, the data interpretation and validation will be described in detail.

3.2 Research Design

As stated in the scope of the research in Section 1.5 in Chapter 1, the focus of this qualitative research is on the rice-paddy varieties R&D performed by MARDI. MARDI is the sole PRI that is given the national mandate to increase the quality of rice-paddy varieties in Malaysia. Based on this research scope, the study was designed based on the research questions listed below:

a) How MARDI plays its intermediary roles in meeting societal objectives, social mechanism and social transformation in agricultural system?
b) What are the institutional and resources constraints that hinder the roles of MARDI in social innovation?
c) What are the proposed policy directions in promoting participatory research model on the collaborative engagement between researchers and farmers in co-producing innovation in Malaysia's agriculture system?

A qualitative research based on a case study approach is used due to the advantage of this approach in answering the "how" questions outlined in the research questions (Yin, 2003). The method is efficient in providing empirical evidence to connect the literary concept of social innovation to its application in the context of MARDI as a PRI in agriculture. In addition, the qualitative nature of the study provides in-context understanding on the process of social innovation in Malaysia's agricultural landscape. In this respect, a case study within a single organisation was conducted to understand MARDI's policy regarding their rice varietal R&D. MARDI is selected as the case study due to the nature of the rice-paddy industry in Malaysia that needs further attention from scholars and MARDI is the only PRI mandated in rice varietal R&D.

The method of in-depth interviews was used throughout the study as it is "*a targeted and insightful method*" (Yin, 2014, p.106). A total of 30 interviewees and informants were selected based on their expertise and experience. In order to maintain the reliability of the research outcomes, the interview questions and the selection of the respondents were verified with the research supervisor and MARDI's consultant. Subsequently, the research findings were validated via a triangulation method based on the multiple sources in documentation, archival records and focus group discussion.

The rationale of choosing interviews as the main source of information is because social innovation by PRIs is still an under-explored literary concept in Malaysia, specifically in agriculture. Hence, by gaining insights from the respondents, a better framework for the interview questions in this study could be achieved. This gives an advantage to the semi-structured interview approach compared to any predetermined quantitative method such as conducting a survey. Overall, the research design and its flow are illustrated in Figure 3.1.

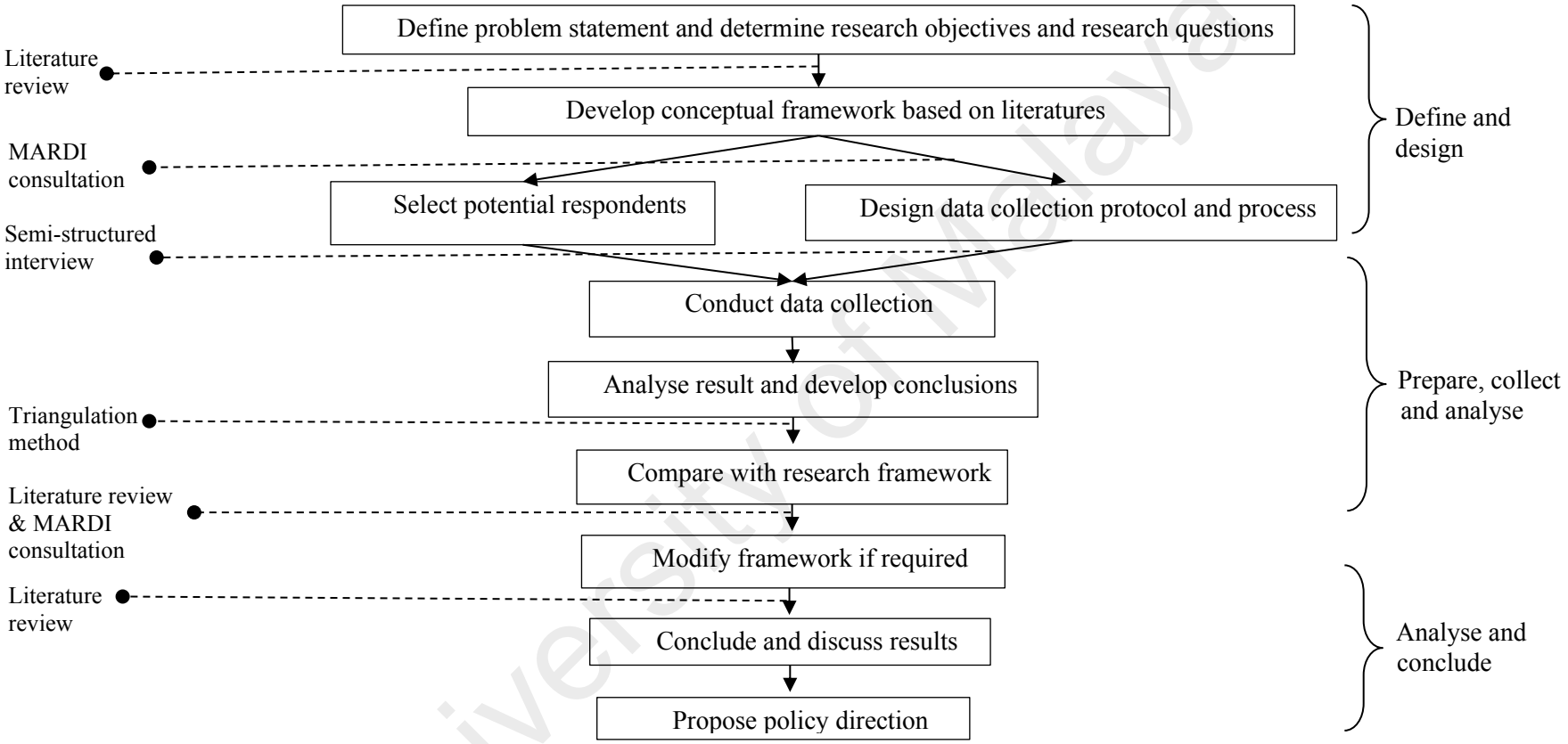


Figure 3.1: Research design.

Source: Adapted from Teegavarapu & Summers (2008)

3.3 Instrument and Data Collection

3.3.1 Case Study Approach

The study was constructed by adopting a single-case study approach. A method that focuses on a case study and attempts to draw conclusions based on the detailed observations made. A single-case study is a good option as torough observation and analysis could be conducted to understand an organisation like MARDI. The difference between a single-case study approach and multiple case studies approach is the number of cases included in the study. The latter is performed to make comparisons between multiple cases, or in the context of this research is multiple organisations besides MARDI. However, in a single-case study like this research, multiple embedded units could be included in the case study to gain a better understanding on the single case (Yin, 2011).

Hence, the rationale for selecting this approach is because MARDI is the only PRI in Malaysia's rice-paddy industry. Its functions in performing innovation according to the framework of social innovation are yet to be understood. In fact, research on this industry seemed to be complicated as it involves an extensive network of innovation intermediaries, even before the outcomes from R&D reach the end users. Whether the innovation intermediaries are catalysing or hindering social innovation is still a worthy question to be explored throughout the study.

At the same time, the rice-paddy industry is mainly a public-driven sector, hence by exploring the significance of MARDI's intermediary roles will benefit scholars' understandings on the nature of social innovation. Even though the single-case design has several limitations compared to multiple-case design, for example, the latter could provide comparison insights from selected case studies which the former could not provide, yet the critical value that MARDI has as a case study justifies the research

method (Yin, 2003). MARDI could provide insights on the best practices and lessons that other agro-based PRIs could learn.

3.3.2 Identification and Selection of Interviewees

The selection of the interviewees and informants was based on both the research and service centres in the organisational structure of MARDI. The two selection criteria are:

a) The centres that deal with end users directly in any of their innovation process, and
b) The centres that manage and produce rice variety and its transfer to the farmers.

In this regard, five out of seventeen research and services centres were finally selected. The centres are:

a) Paddy and Rice Research Centre (RI)
b) Engineering Research Centre (ER)
c) Economy and Social Science Research Centre (ES)
d) Promotion and Business Development Service Centre (PB)
e) Technical and Technology Commercialisation Service Centre (TS)

The interviewees were divided into three groups: research officers (ROs), MARDI's policy makers and farmers. They were divided based on their projected perspectives; the ROs as the producers of the innovation, the MARDI's policy makers as the group that drives the policy direction and the farmers as the end-users. By segregating the groups, the study should be able to capture a holistic and detailed finding, regarding to the research questions listed. This entails with the nature of the innovation model and the case study that involves networks of different levels of stakeholders.

The interviewees were selected based on their positions and experiences in MARDI. They should have experience and access to end users in any of MARDI's roles especially involving rice-paddy industry. For ROs and policymaker from MARDI, the names of the interviewees are both recommended by MARDI consultant and extracted from MARDI's database. In this part, the technique of snowball is applied. The study also interviewed a list of interviewees from other external actors that involve directly in supporting the rice-paddy industry including DoA and farmers. They were selected based on their expertise, experience and positions in the rice-paddy industry. For the interviewees from DoA and farmers, both groups were selected based on their accessibility to Lembah Klang and their information were extracted from the website of *Padi Rescue,* a civil society in the farming community. Most of the farmers that had been interviewed in this study are the members of *Padi Rescue*.

The researcher has successfully conducted a total of 30 interviews session during the period of seven months (from May 2018 until December 2018). Table 3.1 specifies the list of interviews from MARDI as well as extension service agency, that is, the Department of Agriculture (DoA) Malaysia in Kerian District, Perak. Notably, MARDI and DoA are separate entities under the Ministry of Agriculture and Agro-based Industry (MOA) Malaysia. Table 3.2 lists the interviews from the targeted group of end-users who are mainly the rice-paddy farmers in two rice granaries of Peninsular Malaysia – Kodiang at the State of Kedah and Sungai Panjang at the State of Selangor. An interview with a staff from a pesticide company was also conducted.

Table 3.1: List of interviewees from MARDI and extension agencies.

Coding	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	Technology transfer & commercialisation	RO for technology commercialisation	TS
R5	Technology transfer & commercialisation	RO for technology commercialisation	TS
R6	Technology impacts & assessment	RO for technology commercialisation	TS
R7	Technology transfer & commercialisation	RO for scale development	PB
R8	Technology 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

Table 3.2: List of interviewees of end users.

Coding	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.	Kodiang
R19	Farmer	A role model and appointed as rice seeds cultivator. In his forties.	Kodiang
R20	Farmer	Over 20 years in farming and involves in civil society organisation. In his forties.	Kodiang
R21	Farmer	Over 30 years' experiences in paddy framing and a farmer representative for extension services. In his sixties.	Kodiang
R22	Farmer	Over 40 years in paddy framing. In his sixties.	Kodiang
R23	Farmer	Over 40 years in paddy framing. In his sixties.	Kodiang
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

3.3.3 Interview Questions, Process and Protocol

The interview questions in this study were designed according to the research objectives. Each question should be able to answer the research questions by providing insights from different groups of interviewees. There are two themes based on the research questions; (1) the intermediary roles of MARDI as social innovator in paddy-

rice industry. Every interviewee was asked about their understandings on the concept of social innovation. Later, the semi-structured interviews will discuss (2) the issues and challenges for MARDI to perform its roles, according to their expertise and experience. This includes any motivation or challenges when they are dealing with MARDI. Table 3.3 provides the list of interview questions used for the three different groups of interviewees:

a) Officers from MARDI and extension agencies such as Department of Agriculture (DoA) (i.e. ROs, administrators, etc)
b) MARDI policymakers (i.e. top management officers)
c) Farmers (i.e. end-users of MARDI's rice-variety related R&D)

The interview process was conducted by making appointments with the selected interviewees. Most of the interviewees were informed by email except for the group of farmers, which were informed by using social media such as WhatsApp. This is due to inconvenience on their behalf. The interviewees were also informed on the objective of the study and were requested for their consent. This includes by informing MARDI's deputy directors or superiors when the interviews were conducted in their premises and involved their officers.

Each interview sessions took approximately 75 minutes to be completed. The interviews were recorded by phone with permission and the interviewees will be referred for any unclear explanation during the interview process. More importantly, the interviewees were ensured that their identity will not be disclosed, and all data and information collected will be presented in an aggregated form. Nevertheless, the study requested consent to disclose the brief background of the interviewees for data credibility purposes.

Table 3.3: Interview questions.

Research questions	Interview questions
Group 1: Officers from MARDI and DoA	
a) How MARDI plays its intermediary roles in meeting societal objectives, social mechanism and social transformation in the agricultural system?	• What do you understand by the term social innovation in the context of your job scope? • In what aspects your research activities contribute to social innovation? • Do you interact with other parties/agencies in performing your designated tasks? Who and how? • Which type of interaction is most effective? Why? • Are there any challenges during the interactions? Why?
b) What are the institutional and resources constraints that hinder the roles of MARDI in social innovation?	• As a researcher in MARDI, are you directly involved in performing the following tasks in between MARDI-farmers' relationship: (i) knowledge generation; (ii) technology dissemination; and (iii) capacity building? Can you give specific examples? • How are the perceptions of farmers towards your involvement?
c) What are the proposed policy directions in promoting participatory research model on the collaborative engagement between researchers-farmers in co-producing innovation Malaysia agriculture system?	• What would you suggest to MARDI's leadership in order to assist the better performance of your involvement?

Table 3.3, continued.

Research questions	**Interview questions**
Group 2: MARDI's policy makers	
a) How MARDI plays its intermediary roles in meeting societal objectives, social mechanism and social transformation in the agricultural system?	• Do you see the need for MARDI to perform the following roles in between MARDI-Farmers relationship: (i) knowledge generation; (ii) technology dissemination; and (iii) capacity building? Can you give specific examples? • Do you think MARDI's role as a PRI is limited to these aspects? Why? Are there any other roles that MARDI should venture? • What do you think of the concept of co-produce, co-design and co-create in between MARDI and other agencies (including the farmers) in helping the farmers?
b) What are the proposed policy directions in promoting participatory research model on the collaborative engagement between researchers-farmers in co-producing innovation Malaysia agriculture system?	• How MARDI ensure the elements of social innovation are constantly captured in its policymaking? Can you elaborate by giving examples? • What are the main challenges in formulating a social innovation-embedded policy/action plans for MARDI? How about its' implementation?

Table 3.3, continued.

Research questions	**Interview questions**
Group 3: Farmers	
a) How MARDI plays its intermediary roles in meeting societal objectives, social mechanism and social transformation in agricultural	• Can you name three main problems that you encountered during your farming activities? Are these problems also appearing in other regions in the country? What are the root causes of these problems? • How do you find MARDI? Are they helpful in addressing these main problems? Why? • Do you have any problems and opportunities to interact with MARDI? • Who do you interact with in MARDI? What is your expectation from them?
b) What are the institutional and resources constraints that hinder the roles of MARDI in social innovation?	• In more specific, is MARDI helping you in increasing your knowledge, technology and skills in farming? How? Can you give examples?
c) What are the proposed policy directions in promoting participatory research model on the collaborative engagement between researchers-farmers in co-producing innovation Malaysia agriculture system?	• Overall, how you rate MARDI? What would you suggest to them to foster a better MARDI-farmers' relationship?

3.4 Data Interpretation and Validation

The study applied inductive approach to interpreting the data from the interviews. The data were collected, and patterns were analysed according to the topic of interest. This includes by categorising the data according to research questions:

a) Elements of social innovation; social objective, social mechanism and social transformation.
b) Issues and challenges regarding to the implementation of social innovation in a collaborative engagement ecosystem.
c) Intermediary roles of MARDI in social innovation.
d) Policy direction of MARDI's roles as PRIs.

Then, based on the patterns, relevant theories and findings were concluded. The findings also should be able to explain the patterns and be consistent with the conceptual framework that has been proposed. For data validation, the concluded theories were validated by using the triangulation method. This includes comparing the data with other sources of empirical evidence such as MARDI's annual reports, research papers and MoA's open database. The study also consulted MARDI's top management on the findings and integrate their insights. Other than that, any unclear interpretation of the data will be validated by the respondents to avoid misinterpretation and over generalisation.

3.5 Chapter Summary

This chapter explains how the study could provide strong empirical evidences by conducting a qualitative research methodology. The single-case study design was selected as the research method because it could explain the "why" and "how" phenomenon as stated in the research questions. It is also supported by the fact that MARDI is a critical case study for scholars to understand the nature of PRIs and social innovation in developing countries. Besides that, in-depth interviews were performed throughout the

study and this chapter describes the interview questions, process and protocols that need to be followed to achieve valid results. Later, this chapter demonstrates how the results were interpreted and validated. Triangulation and validation from respondents were used to validate the findings. Next, Chapter 4 will present the main findings and discussion of this study.

CHAPTER 4: FINDINGS AND DISCUSSION

4.1 Introduction

This chapter presents the main findings and provides discussions to the main themes derived from the case study. The chapter is organised into two main parts based on two themes, namely institutional perspective and implementation perspective.

The theme on institutional perspective provides the background of MARDI in terms of its roles and performance in rice-variety related R&D. It begins with an overview on the institution's mandates, organisational structure and roles in Malaysia's rice-paddy industry. This includes an analysis on MARDI's institutional setting as an agro-based PRI, its roles in rice-paddy industry especially in terms of R&D and extension services, as well as the impacts of MARDI's rice varietal R&D to farmers. An in-depth examination on MARDI's experiences in the varietal R&D with specific reference to the MR220 CL1 and MR 220 CL2 varieties is also conducted. This in-depth examination demonstrates the effectiveness of MARDI's role in public social innovations particularly in achieving its determined social objectives.

Meanwhile, the theme on implementation perspective elicits the case studies carried out at two rice-paddy granaries in Peninsular Malaysia, namely the case of Kodiang in Kedah and Sungai Panjang in Selangor. These two cases provide evidence and deliver lessons on MARDI's intermediary roles in public social innovations. In this regard, the geographical and demographical background of the two selected granaries are discussed, and the pattern of researchers-farmers partnership between MARDI (as knowledge generator) and the farmers (as end-user) are determined and analysed. This chapter also highlights the potential roles that can be performed by CSOs and social media within public social innovations. Issues and challenges pertaining to researchers-farmers collaborative model are also identified and discussed at the end of this chapter.

4.2 Institutional Perspective: Mandates, Roles and Performances

4.2.1 MARDI as an Agro-based PRI

A case study of MARDI – an agro-based PRI that has devoted decades of their service to serve the public can develop our understanding on how institutions, especially public entities, should behave in performing social innovations. Its prominent reputation as the leading PRI in Malaysia's agriculture since the year 1969 fits to be the ideal case study for the research. MARDI's organisational functions is subjected to Laws of Malaysia (Act 11) MARDI Act 1969. The functions of MARDI include the following (Commisioner of Law Revision, 2006, pp. 6-7):

a) Performs research in term of scientific, technical, economic and social aspects regarding to production, consumption and processing of crops (except rubber, palm oil and cocoa), livestock and food, and mixed plantation.
b) Acts as the centre of collection and dissemination of information and consultation regarding to scientific, technical and economic aspects of food industry, agriculture and agro-based industry. The function should be conducted in the form of publication of reports, periodicals reports, paper works, exhibitions, conferences, lectures and seminars.
c) Being a centre that provides specialist services in the food and agriculture industry as well as agro-based industries such as consulting services, analysis laboratories, quality assurance and contract R&D.
d) Provides diverse types of training to develop the food and agriculture industry and the agro-based industry.
e) Provides grants for R&D in the field of pure science, applied science, technical and economic regarding to the agricultural industry.

f) Builds and preserves relationship with public or private domestic and international organisations in scientific research, technical, economic and social aspects regarding to food and agriculture industries, as well as agro-based industry.
g) Conducts research and production to be commercialised.
h) Develops, promotes and exploits the findings of research.
i) Provides extension services to food and agriculture industries as well as agro-based industries.

Appendix A provides excerpts on the institute and functions of MARDI enacted in Laws of Malaysia (Act 11) MARDI Act 1969. Generally, the mandates and roles of MARDI are extensive. It ranges from scientific R&D to dissemination of their research outcomes to the end-users in the agro-based industries (ranged from agricultural crops, livestock and food, and mixed plantation) by providing extension services. It also covers both on-station and on-farm research. Nonetheless, it is important to note that MARDI's roles does not cover some agricultural commodity crops such as rubber, palm oil and cocoa which are under the purview of Malaysian Rubber Research and Development MRB, MPOB and Malaysian Cocoa Board (MCB).

In the year 1992, MARDI Act 1969 was amended to allow the institutions to commercialise its research products. Hence, MARDITech Corporation Sdn. Bhd. was established and its job scope in commercialisation was expanded. MARDITech is a wholly owned subsidiary of MARDI which is entrusted to accelerate the uptake of R&D outcomes from MARDI. As a non-profit oriented PRI, the profit gained from the commercial activities are used to support MARDI's main mandate for R&D. Hence, its main objective to serve societal needs is still preserved. For example, most of service charges provided by MARDI to help end users like entrepreneurs are relatively low in comparison to other private business entities.

It is important to understand that in the scope of paddy and rice, a non-profit public agency, MARDI is not allowed to commercialise or transfer their research outputs to the farmers. However, MARDI also conducts commercialisation activities in other areas of their mandates, such as food production and entrepreneurship. This includes technical and industrial training, and consultation services to cater the needs of entrepreneurs to gain knowledge and access to hands-on experience. MARDI also conducted a specific mentorship program named *Program Usahawan Bimbingan MARDI* or MARDI Guidance Entrepreneur Program. This program has been established for over fifty years and a good number of entrepreneurs had successfully developed their enterprises throughout this program.

Besides, MARDI is playing a leading role in the evolvement of Green Revolution since its establishment in Malaysia, in which its key organisational mission is to increase the level of food SSL in the country. The basic idea of Green Revolution was to produce enough food for the increasing global population. Hence, the agenda was imported from the Western countries and since then developing countries are improving their agricultural output to meet their domestic demands for staple food. **Appendix B** provides background on the Green Revolution in Malaysia.

In term of institutional setting, MARDI operates under the preview of the MoA Malaysia. Generally, MARDI's operational structure is divided into two divisions – research and service. Its organisational structure is illustrated in Figure 4.1. The research division comprises of nine centres that perform R&D related to various aspects of agricultural industries. The nine centres are listed as below:

a) Biotechnology & Nanotechnology Research Centre (BT)
b) Food Technology Research Centre (FS)
c) Paddy & Rice Research Centre (RI)

d) Engineering Research Centre (ER)

e) Horticulture Research Centre (HR)

f) Livestock Science Research Centre (LS)

g) Agrobiodiversity & Environment Research Centre (BE)

h) Plant & Soil Science Research Centre (SS)

i) Economics & Social Science Research Centre (ES)

On the other hand, the service division consists of eight management and supporting centres as listed below:

a) Promotion & Business Development Centre (PB)

b) Human Resource Management Centre (HM)

c) Development & Asset Management Centre (AM)

d) Financial Management Centre (FM)

e) Technical Service & Commercialisation Centre (TS)

f) Information Management Centre (IM)

g) Quality Corporate Communication Centre (CC)

h) Gene Bank & Seeds Centre (GB)

Besides its involvement in rice-paddy R&D, MARDI also involves in R&D and entrepreneurship in processed food and other types of agricultural products and livestock, except for oil palm, rubber and cocoa livestock commodities.

4.2.2 Roles in Rice-paddy Industry

The rice-paddy industry in Malaysia is under the purview of the MoA. In general, the strategic R&D agenda of the industry are divided into two initiatives. Firstly, to perform quality research to increase the scientific and technological knowledge and also

techniques in farming. Secondly, to disseminate research outcomes to farmers with the ultimate objective to increase the agricultural output or the crop yields.

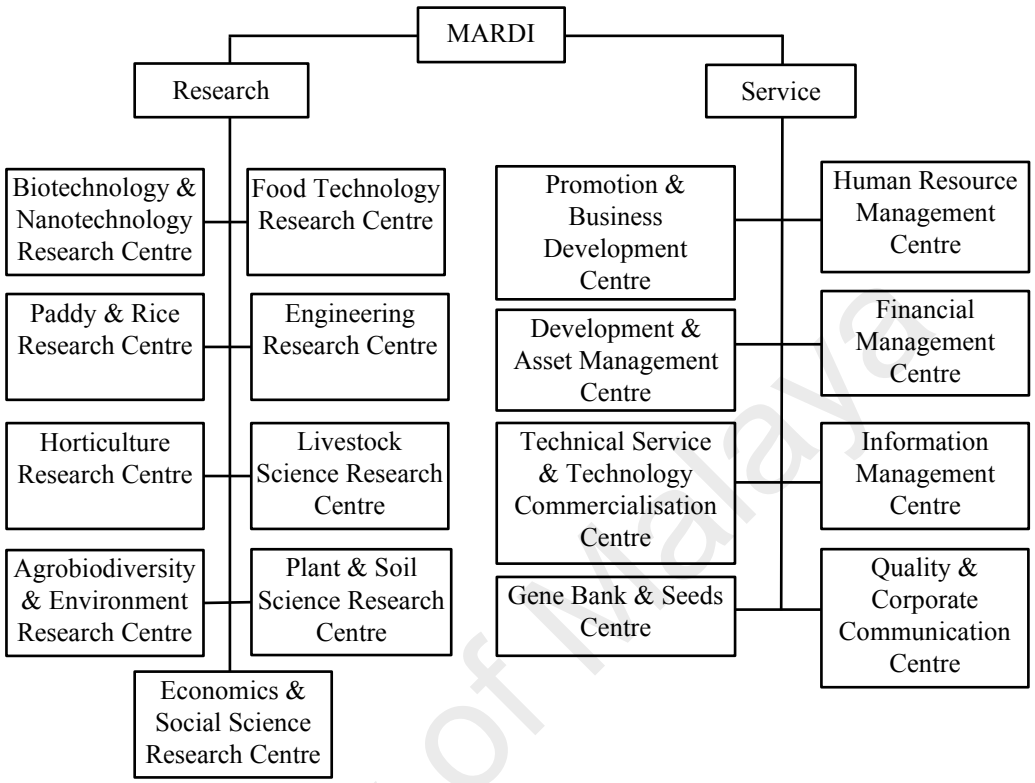


Figure 4.1: MARDI's organisational structure.

Source: MARDI

By referring to the Laws of Malaysia (Act 11) MARDI Act 1969, the functions of MARDI should encompass both initiatives. As for the first initiative; MARDI's research-related division that conducts research on better quality paddy varieties. As for the second initiative; the service-related division that provides support in sharing and promoting new knowledge and techniques of farming to farmers is mainly supported by extensive extension agencies under the MoA such as DoA and other relevant ministries like Ministry of Rural Development. In this respect, MARDI conducted limited extension services for paddy industry in relative to DoA. The service mainly focuses on providing expert consultation through workshops and seminars. More extensive services could be observed in other niches of MARDI's research in food and agro-based industries. For

example, in Promotion & Business Development Centre (PB) of MARDI, they provide consultation services for entrepreneur of food and agro-based businesses. This includes providing them with information regarding to financial, marketing and development assistances for their products. This niche differentiates MARDI with other PRIs as its job scopes are more than producing new innovation, instead MARDI also performs consultation services like any other extension agencies in the industry. In fact, the complex nature of Malaysia's rice industry needs a precise and detailed explanation to be understood. First, MARDI as the PRI has the most significant role in rice-paddy industry. Its role is to explore and produce high quality new varieties of paddy.

Over the past 40 years, MARDI has successfully introduced more than 40 paddy varieties. Both research divisions and service divisions in MARDI are participating in the research and production of new paddy varieties as following:

a) *Research division* – Research on rice varieties is conducted by MARDI's researchers in the laboratory of Rice and Paddy Research Centre (RI). The Engineering Research Centre (ER) focuses on the engineering development of farming mechanism such as precision farming and mechanisation. The Biotechnology and Nanotechnology Research Centre (BT) studies and develops new breeds using hybrid technology and breeding. At the same time, the Economics and Social Science Research Centre (ES) focuses on the socio-economic dimension of the industry such as farmers' behaviour and return on investments. The main outcome of the researchers' is the improved rice varieties that will be cultivated into foundation seeds by MARDI's Gene Bank and Seed Centre (GB). GB as gene bank also collects and stores the collection of all the rice varieties produced by MARDI.

b) *Service division* – The two centres in MARDI's service division that were covered in our interviews are, namely the Promotion & Business Development Centre (PB) and Technical Service & Technology Commercialisation Centre (TS). PB focuses on promoting MARDI's research outcomes based on the principle public goods whereas TS is towards business commercialisation. These two departments contribute more into internal value creation towards MARDI's own researchers and cover another aspect of paddy and rice research. For example, the department of TS leads the institution in collaborating with private companies through licensing and research collaboration which brings capital to MARDI that can be used back to fund its R&D activity. Conclusively, TS is the business mind of MARDI.

Then, another service department, PB which focuses more into assisting entrepreneurs in food processing industry. PB is not directly involved in paddy industry, yet the department is crucial in propagating MARDI's role in public research as its researchers also involved in producing technologies for other agricultural industries besides paddy. Conclusively, the mandates entrusted by MARDI since 1969 are socially driven and social objective has become their mantra in conducting scientific research. Although MARDI was set-up as a R&D agency, its research encompasses both scientific and socio-economic research, which is clearly reflected in the paddy varieties R&D. In fact, they established a department specialises in social development research (i.e. Economic and Social Science Research Centre (ES)) to provide internal value to the institution and drives other research centres to prioritise societal benefit. Every rice variety produced by the institution must ensure its importance in solving farmers' problems and prioritising their benefits. Both elements of science and social science are considered in the formulation of MARDI's research programme and to

this end, MARDI has entrusted as a PRI that attempts to serve the public social innovation. The question on how this can be done will be explored in the following sections.

4.2.3 R&D and Extension Services in Rice Industry

Rice and paddy R&D are the core businesses of MARDI. Yet, rice-paddy industry in Malaysia is a complex context to be understood as it involves networks of both public and private agencies. Since the establishment of MARDI in 1969, Malaysia adopts protective management regarding to its paddy and rice industry. Besides Laws of Malaysia (Act 11) MARDI Act 1969, the country also asserts (Act 522) Paddy and Rice Control Act 1994 that regulates illegal possession on uncertified seedlings or rice.

Appendix C provides excerpts on matters related to the release or disposal of paddy and rice, as well as offences, penalties and unlawful possession of paddy or rice. The protection towards the industry comprises the comprehensive standard operating procedures on the release of new rice varieties. Underpinned by this national agenda, MARDI undertakes Policy on Registration of New Varieties and Breeds to ensure its paddy varieties are high quality and beneficial to the farmers and the overall national rice-paddy production. The effort is attained by establishing an organised and efficient procedure in the process of breeding, evaluation, seed production and the registration of the rice varieties. **Appendix C** also provides the complete document on MARDI's Policy on Registration of New Varieties and Breeds (or *Dasar Pengisytiharan Varieti dan Baka Baru MARDI* in Malay).

One of the important elements of social inclusiveness of the policy is that it should stress more on the need to involve farmers in the research by gathering their feedbacks on the new rice varieties. MARDI is entrusted to make efforts to ensure the successfully registered seeds are sufficient for distribution to the targeted farmers. This includes

conducting several discussions and partnerships with MoA and its extension agencies. As stated in Section 4.2.2, R&D on new rice varieties is led by RI centre of MARDI. The processes can be generally divided into two stages which are on-station and on-farm research. The following descriptions provide a detail account on these two stages of processes:

a) *On-station research* – The first stage of on-station research is carried out at the Preliminary Yield Trials (PYT) stations. Several rice lines are selected for early evaluation for PYT. The trials were performed solely by MARDI's researchers to ensure the uncertified breeds are not taken out from PYT station without permission. PYT will be conducted for two seasons with the main purpose to determine the selected rice lines in terms of its production capability and the nature of uniformity as a population. Based on the PYT results, the breeders (i.e. MARDI's researchers) will recommend quality rice lines for Advanced Yield Trials (AYT). At AYT stations, which is also the second stage of on-station research, the researchers will subsequently examine the characteristics of the rice lines in terms of yield production and stability. The rice lines are also going through screening processes on plant diseases and pests. Like PYT, in order to prevent seed leakage, visitors are not allowed to enter the AYT trials box without being accompanied by the breeders. AYT is conducted for two seasons and the quality rice lines will be selected by all the breeders by consensus for first stage of on-farm research – Multi Location Trials (MLT).
b) *On-farm research* – During MLT, MARDI's researchers will examine the varieties' capability to survive on real paddy fields. This test will be performed on multiple granary areas and farmers' paddy plots will be rented as the trial plots. Only MARDI researchers performed the test at this stage whereas the farmers are not involved in any of the procedures. MLT plots will be monitored for three to

four seasons before their physiological features are recorded. Besides to obtain the best varieties, MLT also functions as a platform for farmers to explore the new research from MARDI. It is important as it could increase the visibility of MARDI's reputation in leading innovation in paddy industry. Nevertheless, in order to avoid the information leakages of the varieties, the location chosen for the trial plots are not located at the areas that are easily accessible by the public. After MLT, two or three best varieties will be chosen for Local Variety Trials (LVT) in all the granaries in Malaysia for another two to four seasons. The major difference between MLT and LVT is the extent of farmers' involvement in the tests. MLT rents farmers' plots as a test plot without any involvement of the farmers whereas LVT needs the farmers to conduct the test on their own plot. The chosen farmers will be given an agronomy package to help them to plant the new varieties. At the end of MLT, the farmers are required to report on their production yield, height of paddy and its resistance towards pest and disease, and also the farmers' opinions on the new varieties. The objectives of LVT is to see whether the new rice varieties are suitable and adaptable by the farmers in that areas. Therefore, the selection for farmers that will conduct LVT will be based on their capabilities to oblige to the guidelines given by MARDI. Hence the only variable that will influence the success rate of the new varieties will be the environment. LVT will be measured based on these conditions; production yield, plant height and plant's resistance towards pest and disease. In fact, the involvement of farmers in LVT are indeed important as it is a compulsory condition for the varieties to be certified. After the chosen variety passed on-farm research; MLT and LVT, MARDI will conduct a market research to gather consumers' feedback on the taste and characteristics of the newly created rice. If the variety accepted, the Breeder'

Seed will be given to MARDI's Gene Bank (GB) to produce Foundation Seeds. The Foundation Seeds will be certified by RI.

The endorsed Foundation Seeds then will be sold to seed producers' companies for them to produce Registered Seeds. DoA, an agriculture extension agency under the MoA, will certify the Registered Seeds. The main role of DoA is to transfer technology, information and knowledge from MARDI to farmers. DoA also acts as an intermediary between these two parties and ensure farmers' needs such as hands-on practice and training are well-informed to MARDI. The Registered Seeds then handed over to seed producers' companies. These seed producers' companies are government-appointed companies for multiplication of Registed Seeds. The endorsed Registered Seed then will be multiplied as Certified Seed and again, DoA will perform the certification through the Paddy Seedlings Verification Scheme – a scheme to certify the genetic purity and variety identification of the seeds.

The Certified Seeds will be distributed by *Pertubuhan Peladang Kawasan* (PPK) to ensure equal distribution to all farmers in different regions throughout the country. The objective of PPK's establishment is to improve economic and social status of Malaysian farmers by providing support, networking and knowledge. In this case, PPK plays the role as the distributor of the Certified Seeds to ensure every farmer in each regions of Malaysia's Granary Areas get equal access to paddy seeds produced by MARDI. The farmers also could buy the Certified Seeds for farming from government-appointed companies. It is important to note that the rice-paddy industry is highly controlled by the government and only appointed seed producers, which are the appointed companies, are allowed to issue the Certified Seeds to the farmers. This is to make sure farmers only use genuine seeds and not contaminated or infected by dangerous pest and disease (Ng et al., 2018).

Besides, DoA also plays its roles in preparing Observation Plot to enable its officers to learn and observe the seed's physiological needs. The officers will produce a feedback report to MARDI's researchers. After Observation Plot, DoA will perform Promotion Plot to attract farmers to implement the new Certified Seeds. Through DoA's Promotion Plots Programme, the farmers also received support in a form of free seedlings for one hectare of paddy field. Finally, the farmers will then sell their yields to the purchasing centres of *Padiberas Nasional Berhad* (BERNAS) – a government-linked company, or other private rice millers. BERNAS is a company that involves in the procurement and processing of paddy; as well as the importation, warehousing, distribution and marketing of rice in Malaysia. The rice millers will process the harvested paddy and distribute the rice products to the market.

At the same time, the service division of MARDI also provides internal value by providing to the research division with information on the current market in the industry. The division also provides external value by establishing partnerships with other agencies. The whole process explained is summarised in Table 4.1. Figure 4.2 illustrates MARDI rice varieties research and the rice-paddy value chain in Malaysia.

Table 4.1: Explanation on stages of rice varietal R&D.

Stages of R&D	**Description of Activities**
On-station research (MARDI)	
Preliminary Yield Test (PYT)	The first test conducted by rice breeder (i.e. MARDI research division) to select several best varieties from a rice line according to their potential yield and capability to survive. The test performed is still confidential and end users have no access to the facility.
Advanced Yield Test (AYT)	The next test after PYT. The selected varieties will be tested again according to their potential yield and capability to survive. The test performed is still confidential and end users have no access to the facility.
On-farm research (MARDI)	
Multi Location Trial (MLT)	The selected varieties will be tested in different locations (i.e. MARDI stations) to assess their compatibility in different regions. The end users have access to observe the tests conducted by the researchers.
Local Variety Trial (LVT)	Selected farmers will conduct the trials themselves. MARDI will rent their plots and provide an agronomic package to the selected farmers. The selection will be according to the farmers' ability to follow and obey the guidelines provided by MARDI.
On-farm promotion and technology transfer (DoA)	
Observation Plot	DoA attempts to plant the new declared varieties in their own plots to enable its officers to learn and observe the seed's physiological needs. The officers will produce a report as a feedback to MARDI's researcher.
Promotion Plot	DoA will perform Promotion Plot to attract farmers' interest in using the new Certified Seeds. Through DoA's Promotion Plots Programme, farmers are also received support in a form of free seedlings for one hectare of paddy field.

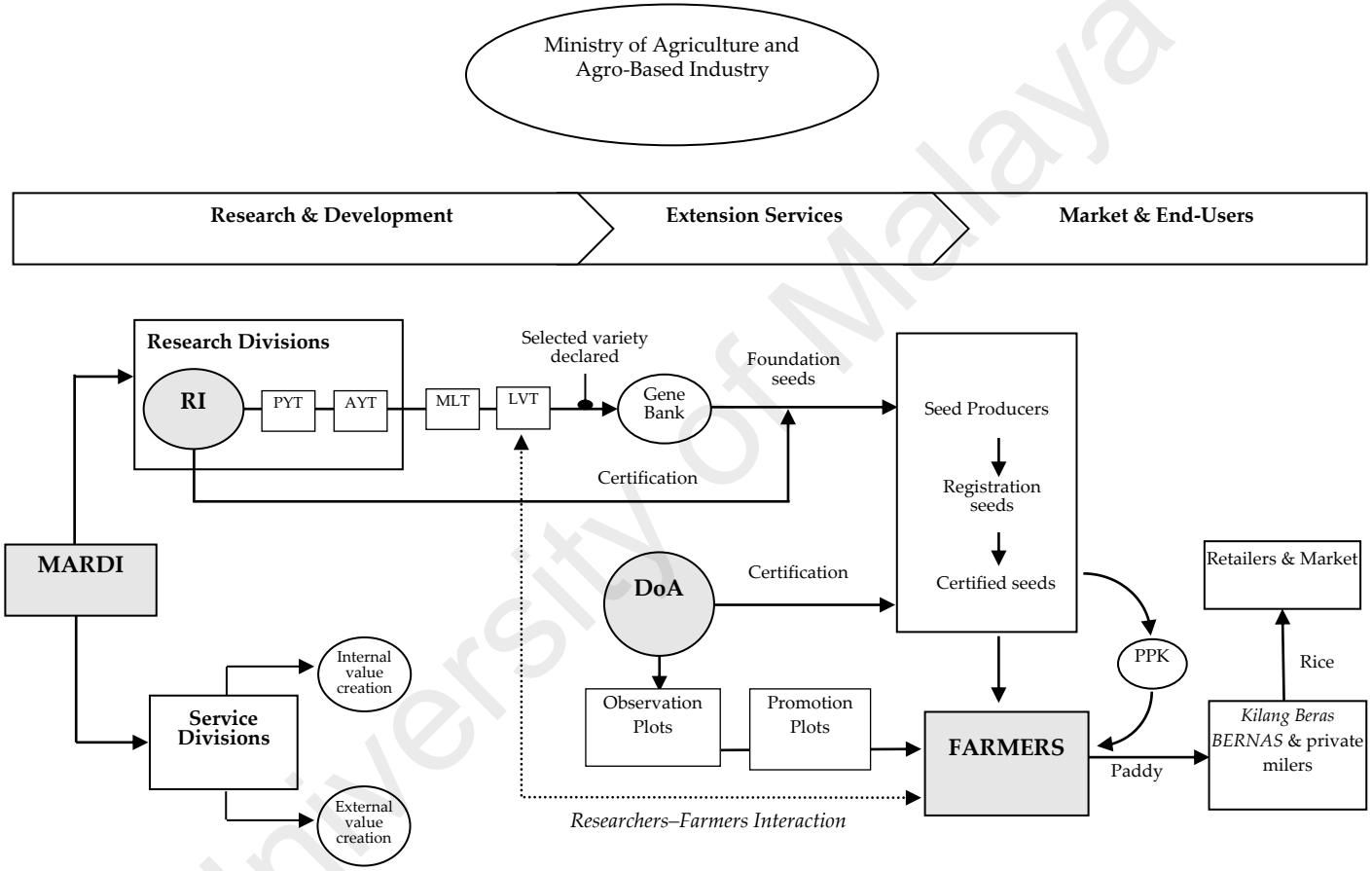


Figure 4.2: MARDI's varietal R&D and Malaysia's rice-paddy value chain.

In summary, there are two main observations that could be derived from our understanding on MARDI's roles in the rice-paddy industry value chain in Malaysia. Firstly, as a non-profit PRI in rice-paddy R&D, MARDI does not deal with or enter into the market directly to avoid any conflict of interests. This is due to the nature of the industry that consists of various government agencies. The division of job scope and roles among the agencies should ensure the delivery of innovation to farmers is efficient, especially for MARDI's research for public goods – as it is a part of the national social innovation agendas.

Secondly, the only direct and formal platform for MARDI researchers to engage with farmers before the new variety reaches the target group is through the LVT. After that, the scientific experts only interact with farmers through workshops that were conducted by extension agencies. This is different with other research centres in MARDI like Engineering Research Centre (ER) which its researchers could engage directly with their clients which are entrepreneurs. These observations will be further validated by conducting a case study on farmers in two different locations, Kodiang in Kedah and Sungai Panjang in Selangor in section 4.3.

4.2.4 Impacts of Rice Varietal R&D

In the year of 1967 and 1968, before the establishment of MARDI, 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 labor intensity to manage paddy plots. At that

time, the paddy plants were also susceptible to the risk of disease and flood. Over time, researchers are able to develop rice varieties that are resistant to disease and climate change, have shorter maturation period and require less labor 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 that use rice varieties 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 included 36 white rice, four fragrant rice, three glutinous rice, two coloured rice, two herbicide tolerance which are MR220 CL1 & MR220 CL2, one black glutinous and one aerobic rice. MR220 CL1 and MR220 CL2 were the latest collaboration of MARDI with private company, BASF in creating new weedy-rice-resistant varieties. Table 4.2 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.

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.

Table 4.2: 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

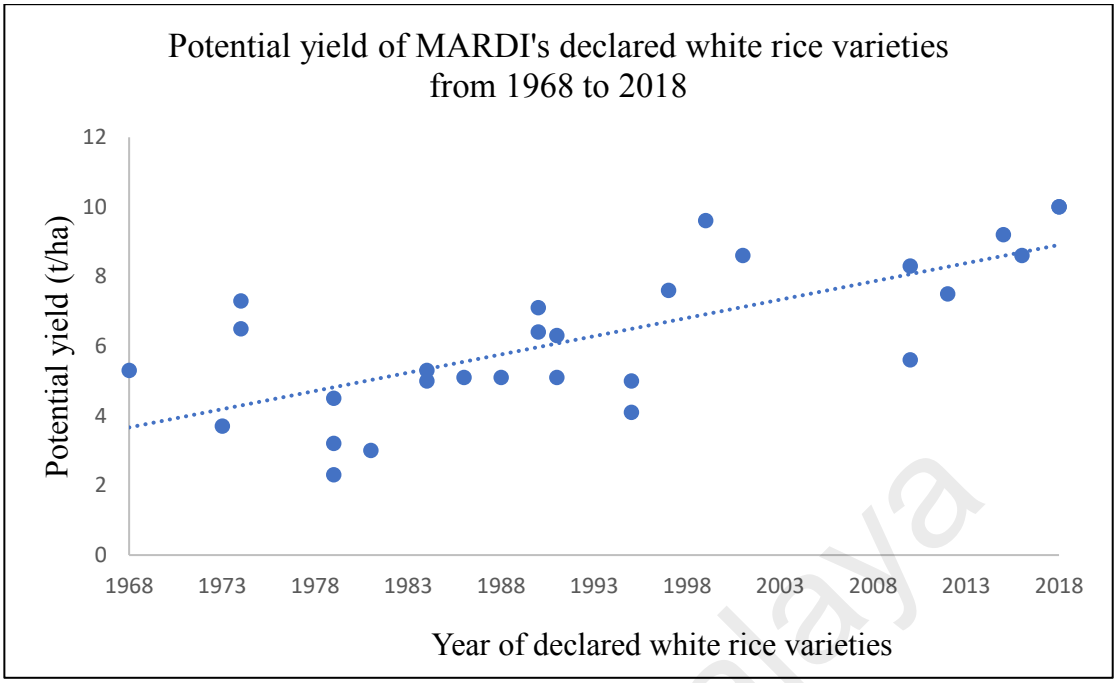
Note: N.A. = not available. Due to lack of complete data, complete information for all the 36 white rice varieties is not able to be captured.

Source: Compilation of various sources

The same explanation also verified 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 4.3 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.

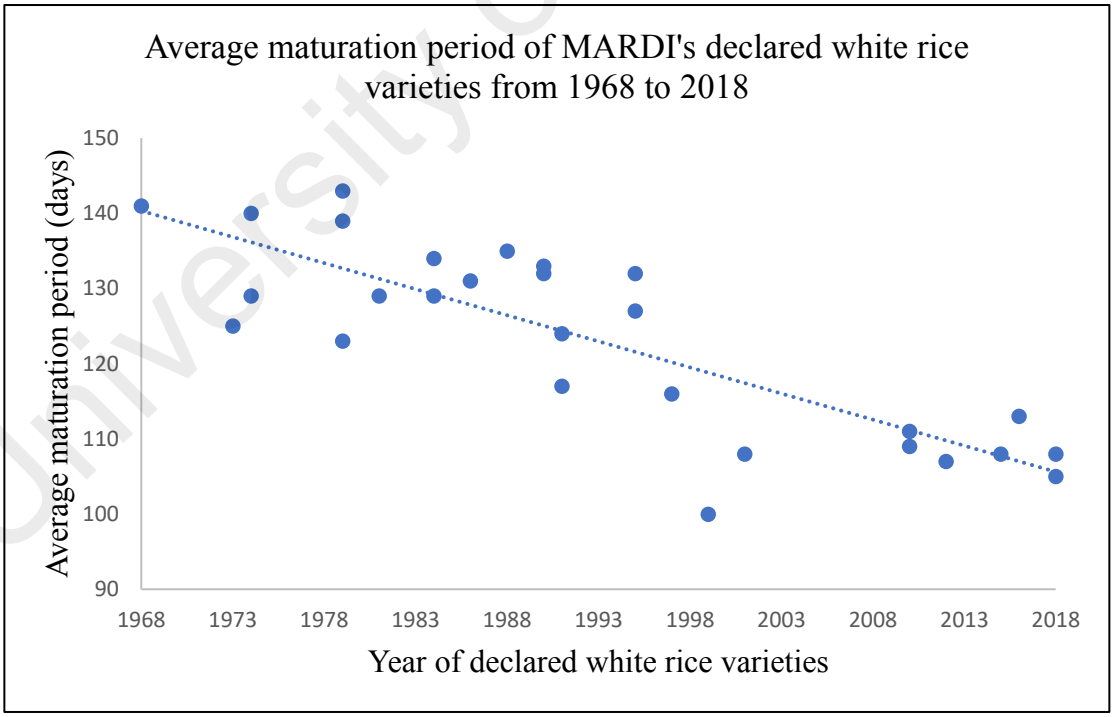
Figure 4.4 shows the average maturation period of MARDI white rice varieties. Faster maturation period is favoured due to higher productivity of rice plantation by the farmers. Today, farmers need less time to harvest their crops compared to before. This is important as fast-ripening rice varieties means the farmers could double up their income and increase their productivity. In fact, Malaysia used to have only one rice growing season per year, yet the country could experience two to three seasons per year due to MARDI's contribution in rice varietal development.



Note: Each dot on the chart indicates a new variety introduced in the particular year.

Figure 4.3: MARDI's declared white rice varieties and its' potential yield.

Source: Author's compilation



Note: Each dot on the chart indicates a new variety introduced in the particular year.

Figure 4.4: Declared white rice varieties and average maturation period.

Source: Author's compilation

It is important to note that besides producing rice varieties with higher potential yield and shorter maturation period, MARDI's R&D on rice varieties also aims to increase the other aspects of quality paddy and rice such as resistance to disease and pests, improvement in terms of rice length and fragrance, and catering to 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.

4.2.5 Lessons from MR 220 CL1 and MR 220 CL2

At first, R&D of MR 220 CL1 and MR 220 CL2 were driven by the crucial need to address the problem of weedy rice in two evergreen and well-known varieties of MR 219 and MR 220. Even though MR 219 and MR 220 were declared in the year 2001 and 2003 respectively, over decades the varieties are still being used by all farmers across the country. Its favourable characteristics put the varieties on top of the list of the most favoured rice varieties by Malaysian farmers. They prefer to use rice varieties that requires less input like fertiliser and pesticide, and maintenance cost like weed resistance, thus MR 219 and MR 220 fit the criteria. The lower the input costs the farmers, the more net profit they will gain. This has been emphasised by one of the farmers during the interview:

> *"These are the varieties that we, as farmers are still using. For example, MR 219. Some of the farmers keep the seeds of these varieties because they are good varieties. Their yields are high, but it is susceptible to diseases"* (Personal communication, 29th July 2018).

The high acceptance level of MR 219 and MR 220 is evidenced in DoA's report as shown in Table 4.3 and Table 4.4.

Table 4.3: Hectarage of paddy varieties for wetland paddy in granary area, 2015.

JELAPANG PADI *Granary Area*	KELUASAN BERTANAM (HEKTAR) *Planted Area (Hectares)*	VARIETI PADI (HA) *Paddy Varieties (Ha)*									
		MR 219	MR 220	MR 220 CL1	MR 220 CL2	MR253	MR 263	MR 269	MR 276	MRQ 76	LAIN-LAIN *Others*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
MADA	191,853	42,349	426	-	134,294	-	14,069	715	-	-	-
KADA	51,675	1,138	-	-	16,893	-	29,693	3,951	-	-	-
IADA KERIAN	41,944	2,600	544	8,300	30,500	-	-	-	-	-	-
IADA BLS	38,114	1,040	866	-	33,437	-	1,559	1,212	-	-	-
IADA P. PINANG	25,564	3,339	4,721	3,224	6,218	-	6,103	1,959	-	-	-
IADA SEB. PERAK	27,697	2,150	-	-	18,200	-	5,200	2,097	-	-	50
IADA KETARA	9,752	1,439	1,039	240	2,478	-	2,638	1,918	-	-	-
IADA KEM. SEMERAK	7,468	451	204	-	1,644	-	4,835	334	-	-	-
IADA PEKAN	6,763	-	-	-	733	-	4,659	764	-	-	607
IADA ROMPIN	5,218	-	-	-	1,341	-	1,851	1,926	-	-	100
JUMLAH *Total*	406,048	54,506	7,800	11,764	245,738	-	70,607	14,876	-	-	757

Source: Department of Agriculture Malaysia (2016)

Table 4.4: Hectarage of paddy variety for wetland paddy by state, 2015.

NEGERI/DAERAH *State/District*	KELUASAN BERTANAM (HEKTAR) *Planted Area (Hectares)*	VARIETI PADI (HA) *Paddy Varieties (Ha)*									
		MR 219	MR 220	MR 220 CL1	MR 220 CL2	MR253	MR 263	MR 269	MR 276	MRQ 76	LAIN-LAIN *Others*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
JOHOR	3,010	300	-	310	682	-	-	1,548	-	150	20
KEDAH	215,065	71,934	16,277	114	106,677	1,266	18,129	668	-	-	-
KELANTAN	72,389	2,335	564	-	23,525	-	40,311	5,606	-	30	18
MELAKA	2,734	260	-	-	1,569	325	-	580	-	-	-
N. SEMBILAN	2,017	270	666	-	525	-	52	504	-	-	-
PAHANG	12,410	-	-	-	2,227	-	6,540	2,876	-	60	707
PERAK	81,714	3,920	544	8,300	55,608	-	9,502	3,840	-	-	-
PERLIS	52,072	1,135	2,562	-	46,501	-	1,725	149	-	-	-
P. PINANG	25,564	3,339	4,721	3,224	6,218	-	6,103	1,959	-	-	-
SELANGOR	38,114	1,040	866	-	33,437	-	1,559	1,212	-	-	-
TERENGGANU	16,336	2,524	1,589	71	3,322	-	4,449	4,131	-	250	-
SEM. MALAYSIA *Pen. Malaysia*	521,425	87,057	27,789	12,019	280,291	1,591	88,370	23,073	-	490	745

Source: Department of Agriculture Malaysia (2016)

Based on Table 4.3 and Table 4.4, it could be observed that 80 percent of the granary areas in Malaysia use MR219 and MR220 as their preferred rice varieties. This includes MADA as the largest granary area in the country. However, due to its susceptibility to disease, weedy rice problem has infested most paddy rice plots in the regions. Weedy rice (*padi angin*) has been a global agricultural problem, including for several rice producer countries like Thailand and Philippines. The common features that weedy rice has (i.e. morphological features) compared to other cultivated rice (e.g. white rice) make it challenging for farmers to prevent it. In fact, the plant costed farmers numerous loss due to its nature of prone to falling over before the cultivation period. Generally weedy rice looks alike other cultivated rice. Until it reaches its maturation period, the farmers then realise the problem due its characteristics of prone to fall over during harvesting.

In several field trips conducted throughout the research, there were significant differences that could be observed between paddy fields that practiced good practices of using herbicide to prevent weedy rice and the ones which do not. The former with good agricultural practice have consistent height of paddy plants and the colours of the views are consistent, and the latter without good agricultural practice showed inconsistent visual observations for those aspects. Rathore et al., (2013) has identified the global damage caused by weedy rice as shown in Table 4.5. It shows that in the year 2013, Malaysia is one of the most affected countries for weedy rice in the world. 74 percent of crop yield are infested and the farmers loss millions of Ringgits during the period.

Table 4.5: Weedy rice infestation towards crop yield (%) across the world in 2013.

Country	Infestation towards crop yield (%)
Europe	40-75
Brazil	40
Senegal	55
Costa Rica	60
USA (Arkansas)	60
Italy	70
Malaysia	74
Cuba	80

Source: Rathore et al. (2013)

This shows that weedy rice was the main concern for the national agricultural sector, and it has been the cause for BASF, a multinational corporation (MNC) that focusing on the production of chemicals, to come out with the idea of weedy-rice-resistant variety at that time. In order to do that, the company has to get direct access to the farmers and the only way it could be done was through a joint venture with MARDI - the only PRI that mandated to produce and declare rice varieties in the country. The collaborative story between MARDI and BASF in combating the issues of weedy rice is provided in **Appendix D**.

Hence, MR 220 CL1 and MR 220 CL2 were used to solve the problem of weedy rice that most farmers faced at the time. The varieties also preferred by the group as the paddy seeds are better in their yield production and have better resistant to weedy rice problem. The case of MR220 CL1 and MR220 CL2 demonstrates the significance of open innovation in solving social problems. These criteria are consistent with the concept of social innovation that prioritises social partnerships in delivering social benefit to the end-users. Nevertheless, the implementation of MR220 CL1 and MR220 CL2 is no without

problems. The lessons learned from drawbacks from its implementation will be discussed in Chapter 5.

4.3 Implementation Perspective: Lessons from MADA and IADA B.L.S.

4.3.1 Backgrounds

This second part of the chapter attempts to provide more in-depth understanding on the implementation of social innovation, specifically on researcher-farmer collaboration engagement. The discussions are based on the case studies conducted on two main granary areas of the country, namely Kodiang in Muda Granary Area (MADA) and Sungai Panjang Northwest Selangor Granary Area (IADA B.L.S.). Figure 4.7 shows the exact location of these two and other granary areas in Malaysia. Based on Figure 4.5, there are ten granary areas in Malaysia's peninsular as listed below:

a) Muda Agricultural Development Authority (MADA), Kedah
a) Integrated Agricultural Development Area (IADA), Pulau Pinang
b) Integrated Agricultural Development Area (IADA) Kerian, Perak
c) Integrated Agricultural Development Area (IADA) Seberang Perak, Perak
d) Integrated Agricultural Development Area (IADA) Barat Laut Selangor (B.L.S.), Selangor
e) Integrated Agricultural Development Area (IADA) Rompin, Johor
f) Integrated Agricultural Development Area (IADA) Pekan, Pahang
g) Integrated Agricultural Development Area (IADA) Ketara, Terengganu
h) Integrated Agricultural Development Area (IADA) Kemasin Semerak, Kelantan
i) Kemubu Agricultural Development Authority (KADA), Kelantan

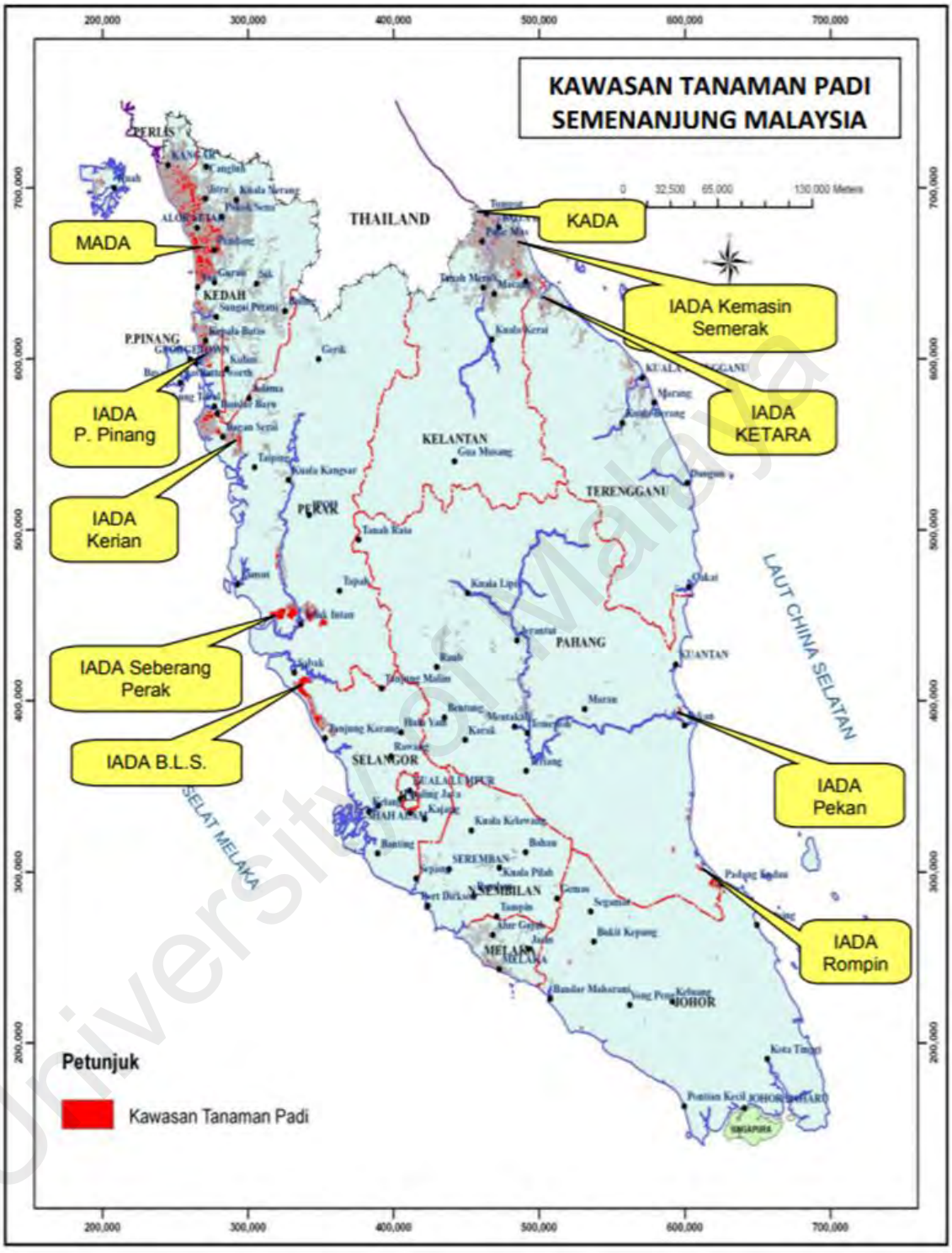


Figure 4.5: Map of Malaysia's granary areas.

Source: Department of Agriculture Malaysia

On-site face-to-face interviews, focus group discussions and observations were performed on the interviewees listed in Chapter 3. The case studies are mainly to examine the implementation of social innovation in rice-paddy industry. Therefore, the listed concerns below provide direction to understand the nature of social innovation in two different granary areas in Malaysia; Kodiang and Sungai Panjang.

a) To what extent farmers in both locations interact directly with MARDI's researchers regarding to rice and paddy?
b) To what extent MARDI's researchers perceive farmers and utilise their interaction in their research activities?
c) How do other innovation actors (e.g. extension officers, millers) play roles in the interactions?
d) Is there any difference between the pattern of interactions that could be observed in farmers in Kodiang and farmers in Sungai Panjang? If there are differences, how do the difference could happen?

The following sub-sections provides our main findings on these two case studies.

4.3.2 Geographical and Demographical Perspectives

Kodiang is located at the north-west side of the state of Kedah, the largest granary state in Malaysia. Even with its small size, Kodiang is the best representative of farmers in the North of Malaysia due its Malay-domination and ageing population. In fact, Kodiang could be perceived as the ideal platform for any varietal location trials due to its limited resources for irrigation, human labour and capital labour. These limitations are crucial to ensure any varietal trials are performed in the worst condition to produce the best rice variety with good adaptability and quality. This includes by selecting poor-resources farmers to test new varieties on their paddy plots.

Most of the respondents in our focus group discussions were in the age of 50s and 60s and they are depending on foreign labour force to manage their paddy fields. Due to the long tradition of farming, the community in Kodiang inherit their paddy fields from their family for two or three generations. Besides that, the agricultural practices performed in these areas are generally learned from the previous generations and the practices had been established for years. Another interesting point to be taken is that community in Kodiang are struggling with its young generation – that is not only lose interest in farming, they are also struggling in their socio-economic aspect, for example education level, employment and social influence. One of the farmers described his struggle to sustain his family's living expenses by comparing their situation ten years ago compared to today:

> *"Ten years ago, we did not have much to complain about. The input cost (e.g. fertilisers and pesticide) for paddy at that time was much lower, the cost of living is still reasonable, and the percentage of output reduction by BERNAS is low. But today everything is expensive and BERNAS imposes a much higher deduction for our rice"* (Personal communication, 29th July 2018).

Figure 4.6 below shows the geographical location of Kodiang in Peninsular Malaysia while Figure 4.7 shows the geographical boundary of Kodiang from Google Earth. MADA is the largest granary area in Malaysia and it is located across both states of Kedah and Perlis. The location is distant from the Strait of Malacca, the source for irrigation. This is one of the problems for farmers in Kodiang compared to those in Sungai Panjang. Figure 4.8 and Figure 4.9 show the scenery of Kodiang town.

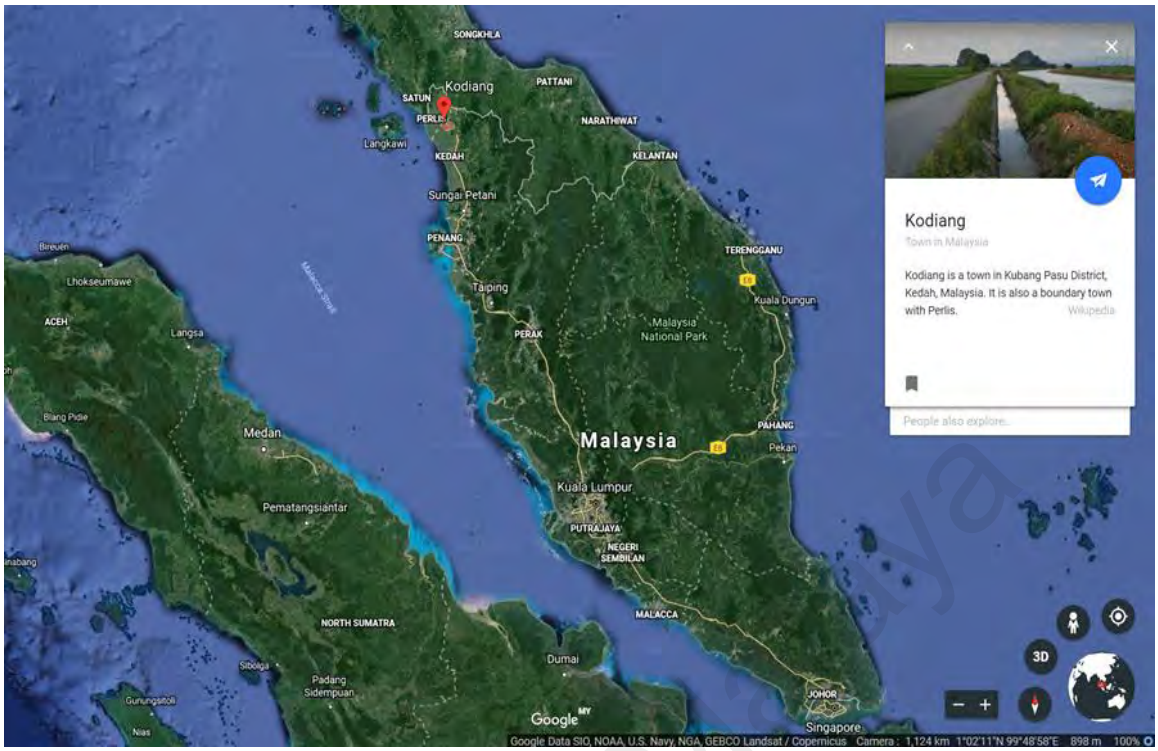


Figure 4.6: Geographical location of Kodiang.

Source: Image captured from Google Earth

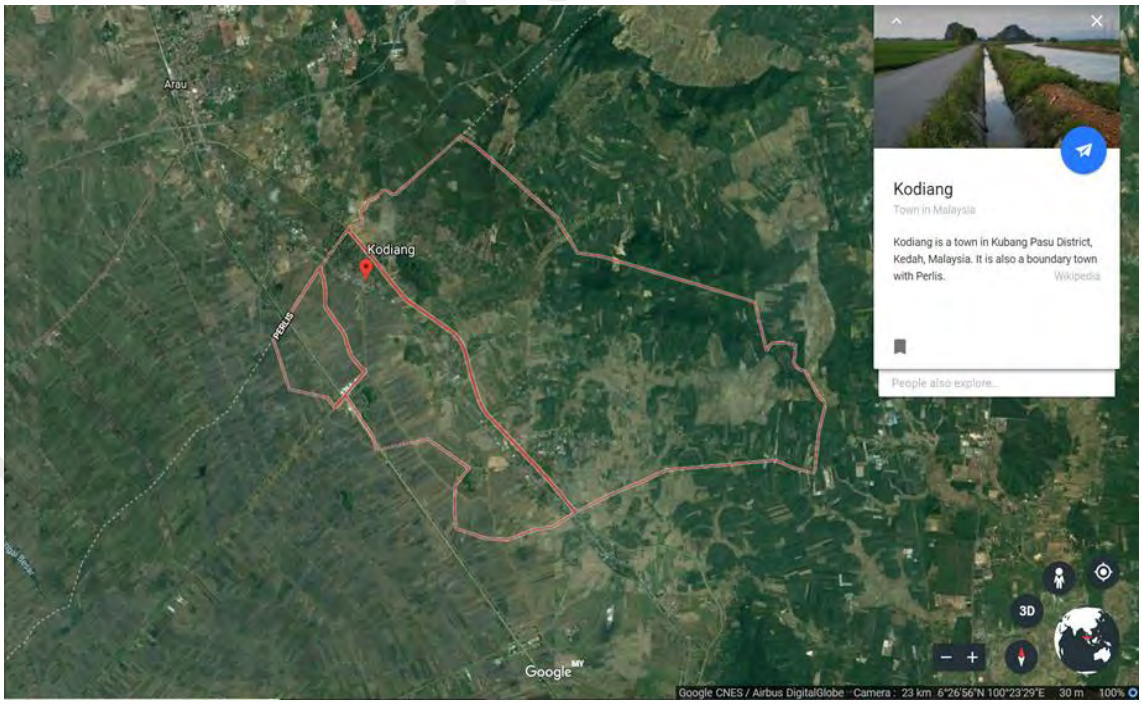


Figure 4.7: Geographical boundary of Kodiang.

Source: Image captured from Google Earth

Figure 4.8: Scenary of Kampung Megat Dewa, Kodiang.

Source: Author's compilation

Figure 4.9: Paddy plots in Kodiang.

Source: Author's compilation

On the other hand, Sungai Panjang, in IADA B.L.S. is blessed with good infrastructures such as a good irrigation system, strategic locations which is near to Klang Valley and Straits of Malacca and natural resources like alluvial soils and mangrove forest. These advantages help in attracting young generation to settle in the area and choose farming as their careers. Most of the respondents involved in this research were in their 30s and chose to become farmers due to their passion. In fact, financial security has become one of the reasons why they chose to do the job. This is because most of the young population in Sungai Panjang chose not to become farmers and migrate to big cities. A young farmer states this during the interview:

> *"If we have twenty plots (keping) of paddy and half of them are loss, we still have another half for our income. One in twenty youth here decided to continue the tradition of farming. The rest of them prefer to work in the cities. So, it is less competitive for land here"* (Personal communication, 6th September 2018).

However, there is one shortcoming of Sungai Panjang compared to Kodiang – the size of the granary areas. MADA is comparatively larger than IADA B.L.S. The productivity of rice output per hectare in MADA is lower than IADA B. L. S., but it is still producing larger total output than IADA B.L.S. It is reported that the averages of rice output per hectare in the year 2018 are 5,892 kg for MADA and 6,512 kg for IADA B.L.S. (Department of Agriculture, 2018). Henceforth, the small area of Sungai Panjang has created an ideal competitive platform for the farmers. The more commitment and efficient the farmer, the higher the profit he will get. In fact, the multiracial nature in that place resulted in more competitive environment. This atmosphere certainly influences the way farmers in Sungai Panjang work in their daily basis. Besides that, because of its location near to Klang Valley, farmers get more access to facilities such as government institutions

and research centres. Firms are also founded performing their R&D trials in this area that benefits the farmers and this is supported by an interviewee:

> *"Many companies (e.g. companies that do R&D in paddy and rice) prefer to do trials here (Sungai Panjang) due to its location near to Klang Valley"* (Personal communication, 4th July 2018).

These aspects certainly differentiate farmers in Sungai Panjang with their counterparts in Kodiang. Yet, we could see some differences between these two groups in the context of social mechanism of social innovation. This includes farmers' capabilities in developing partnerships to build their skills and knowledge. The younger generation of farmers in Sungai Panjang definitely showed more openness and willingness to new environment and collaboration in their jobs. The older generation of farmers in Kodiang is more conventional and reserve. They prefer to remain to their traditional agricultural practices. Figure 4.10 and Figure 4.11 show the geographical location of Sungai Panjang which is located in the district of Sabak Bernam in the south-west of Peninsular Malaysia. Sabak Bernam is a perfect district for farming due to its strategic location next to the Straits of Malacca. The soil is alluvial soil which is perfect for farming. The location also helps in term of having an efficient irrigation system. Figure 4.12 and Figure 4.13 show the scenery of paddy plots and irrigation systems in Sungai Panjang town.

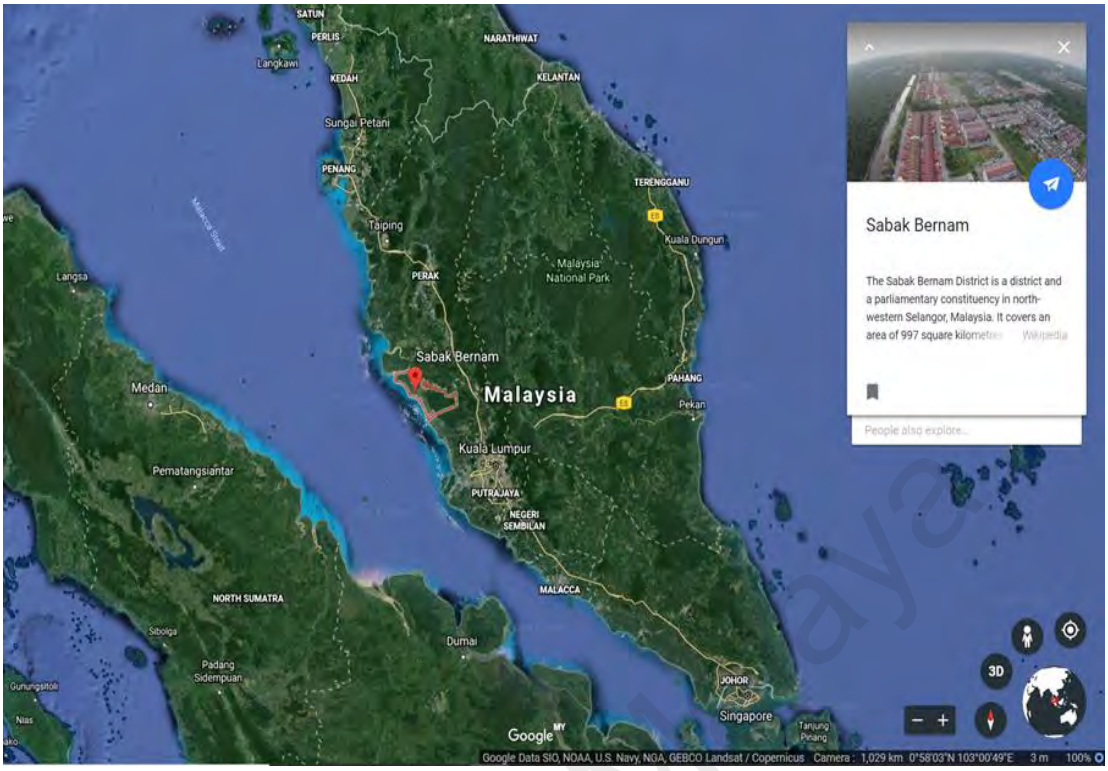


Figure 4.10: Geographical location of Sungai Panjang.

Source: Image captured from Google Earth

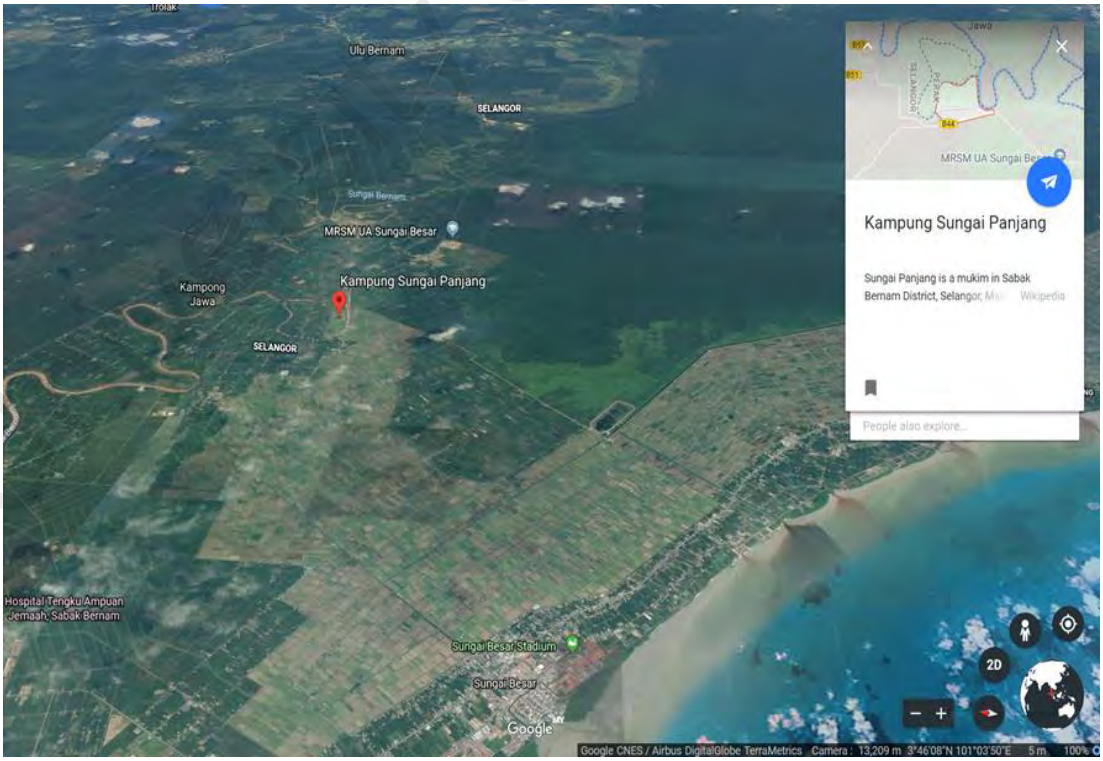


Figure 4.11: Location of Sungai Panjang in Sabak Bernam.

Source: Image captured from Google Earth

Figure 4.12: Paddy plots in Sungai Panjang.

Source: Author's compilation

Figure 4.13: Irrigation system in Sungai Panjang.

Source: Author's compilation

4.3.3 Forms of Researcher-Farmer Partnership

For both locations; Kodiang and Sungai Panjang, MARDI's researchers have the chance to engage with farmers directly through workshops and seminars conducted by extension agencies; DoA, MADA and PPK. A MARDI officer stated that:

> *"In MADA we have PPK that can gather farmers in their areas, and they will invite us (MARDI's officers) to give talks. From there we interact directly with the farmers. Whenever MARDI declared new varieties, they also will invite us to brief on the new varieties"* (Personal communication, 31st July 2018).

PPK is one of the extension agencies in the rice-paddy industry. However, its role is limited and bounded as it accommodates farmers according to regions. Often PPK involves in discussions conducted by regional development authorities like MADA and KADA. The discussion involves other intermediaries including MARDI. Due to its nature and access to the farmers, PPK is given the mandate as the distributor of rice seedlings from MoA. The agency also develops close relationship with farmers and local associations. During any engagement session, MARDI researchers can explain their innovation and other information needed for the farmers to utilise the knowledge and technology.

Based on our interviews, there is no other formal platform for MARDI's researchers to interact with farmers directly without went through any extension agencies, except during MARDI's exhibition. Even if there are issues like pest and disease in paddy field, the standard operating procedure explained that the farmers should make a report to DoA before the information reaches MARDI's researchers. The bureaucracy, however, tends to cause farmers to handle the issue themselves which sometimes caused more damage like spread of plant disease and development of resistance towards pesticide.

A MARDI officer stated that:

> "*In the case of pest and disease, sometimes there are occasions that farmers found new disease, but they did not report it to DoA. They prefer to report it directly to MARDI. There are some of the farmers prefer DoA, but there are also some of them that know us personally will skip the bureaucracy and ask MARDI directly*" (Personal communication, 31st July 2018).

In some cases, the farmers are able to communicate with MARDI researchers directly. However, this engagement only occurs within their personal network which is informal. This is evidenced in the response by a MARDI researcher:

> "*Some of the farmers also communicate directly with MARDI's researchers, especially in the research of pest and disease to inform their problems and seek for consultation, if they know the experts personally*" (Personal communication, 31st July 2018).

At the same time, MARDI researchers did mention that:

> "*Hope to make all of her innovations such as paddy machineries to become public goods to benefit the farmers*" (Personal communication, 22nd May 2018).

> "*Social innovation means the innovation that he produced is for the benefit of the farmers*" (Personal communication, 30th July 2018).

Almost all the farmers who have been interviewed recognised the contribution brought by MARDI's scientific knowledge and findings. None of the farmers had any formal agricultural or other scientific training, thus they are wholly relying on MARDI's scientific research on the rice varieties. Since 1969, MARDI has declared over 49 rice varieties, as indicated in Table 4.2 to be used by Malaysian farmers and the varieties

developed by its researcher are well known for their reputation. In fact, most farmers in Malaysia peninsular still use evergreen rice varieties like MR219 and MR220 produced by MARDI in the year 2001 as they suited farmers' preferences in term of its low input and maintenance cost. At the same time, farmers are looking forward to the advancement of agricultural technology brought by the institution. For example, the latest rice varieties, MR220 CL1 and MR220 CL2 that were produced by MARDI's collaboration with a chemical company, BASF (Malaysia). These varieties are well accepted by most farmers and they acknowledged the benefit they gained from these new varieties. The productivity of the paddy farming has increased, and the problem of weedy rice has been elucidated. A farmer stated that:

> *"We have used the Clearfield pesticide with the CL seedlings, but we are no longer using it because of its price. But our paddy yield is getting better and there is no problem of weedy rice"* (Personal communication, 29th July 2018).

In sum, all researchers we met really hoped that their innovations are utilised fully for the benefit of the end users, without mentioning about their individual interest or even MARDI's profit, and all farmers we met showed their interests to engage and participate more in innovation process. The high level of confidence of farmers on MARDI's research is indeed important for the technological adoption in the rice-paddy farming. Thus, the main question that has been highlighted throughout the interview sessions is - there should be a better mechanism that could be created to meet these two interests, without relying on third parties, and in this case extension agencies? This question will be further explored in the subsequent subtopic.

4.3.4 Civil Society Organisation and Social Media

The Quadruple Helix Innovation Model emphasises the importance of integrating the perspective of 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 CSO. 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 step by engaging or inviting to engage with policy makers from the MoA (see Figure 4.14). Padi Rescue was founded in 2015 and it was started as a Malay manufacturers' organisation. Later on, 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. The petition requested matters as below:

a) Re-establish *Lembaga Padi Negara* (LPN)
b) Increase national SSL for paddy to 100 percent
c) Prioritise domestic output of paddy and less dependence on imported rice
d) LPN should take over import quota for rice
e) Reinforcement of Malay rice manufacturer

f) Abolish the monopoly of rice production from certain parties
g) Revise the level of purification (pemotongan pemutuan) for rice
h) Revise subsidies for paddy and rice
i) LPN, IADA, KADA and MADA should take over the responsibility of giving out subsidy to farmers and not private entity like BERNAS
j) Abolish Good and Service Tax (GST) for agricultural inputs
k) Subsidy for agricultural inputs should be in the form of cash to allow farmers to choose better inputs
l) Establish a special task force to deal with paddy's pest and disease problem
m) PPK are given the right as wholesaler and retailer
n) Prevent any status exchange for paddy plots as agricultural land

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 MoA and other authority bodies finally engage with their requests as stated in Padi Rescue's Facebook page. Besides that, MARDI also 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, see Figure 4.15) 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.

Figure 4.14: A screenshot of *Padi Rescue's* website.

Source: Padi Rescue (Available at http://www.padirescue.com.my/)

Figure 4.15: *MyPerosakPadi* application from MARDI.

Source: MARDI

4.3.5 Issues and Challenges

As a non-profit PRI, there are certainly numerous issues and challenges encountered by MARDI in performing their social innovation initiatives. The following sub-sections provide discussions on the top-five challenges determined during the interviews and field visit sessions.

a) *Regulation on the restriction for direct researcher-farmer engagement* – The restriction of not allowing direct engagement between MARDI researchers and farmers in the context of rice varieties R&D has raised interesting debates among the interviewees. Most of MARDI's researchers interviewed showed their concern towards direct engagement with farmers as it will cause redundancy with current job scope of other extension agencies such as DoA, LPPK, IADA and MADA:

> "*We cannot deal directly with farmers. We have to use the extension agencies that we have, such as DoA, KADA and MADA. The role of these extension agencies is to transfer the knowledge and technology to the farmers. But sometimes because of lacking in resources (for extension agencies), MARDI also perform some of the extension services. There are some redundancies in term of the standard operating procedure, but not in innovation*" (Personal communication, 5th June 2018).

This concern is understandable due to the nation's rice industry that is quite protective regarding its rice varieties. Direct engagement between MARDI's researchers and farmers could cause intellectual property issues such as information leakage, release of unauthorised rice varieties, unethical and integrity issues, exploitation and manipulation of market. Even so, researchers-farmers partnership is still vital to establish a more efficient and sustainable way to transfer knowledge and information and to ensure farmers follow the guidelines and

recommendations given by the researchers. This claim is justified as the farmers expressed their interests in gaining knowledge and information about MARDI innovation from the researchers themselves. They prefer to consult primary sources which are scientific experts about their issues in the paddy fields and they prefer to have access to information as easy as possible and do not depend on the bureaucracy and tedious procedure. In addition, after the rice varieties were released to the farmers through the selected companies, the researchers are no longer in control of their innovation. With the hope that their innovation will benefit farmers the most, the researchers are depending on extensions services to transfer the technology and knowledge (both scientific and know-how). Likewise, the researchers also depend on extension service to deliver feedback from the end users after the innovation has been used. In this context, the lack of direct interaction platform between researchers and farmers has somehow resulted in uncertain researchers-farmers partnership.

b) *Decreased in services quality by extension service agencies* – This is a critical issue to be rectified as some of the farmers felt concern over the decreasing quality of services delivered by extension services agencies in recent years. In this respect, a farmer kept repeating one phrase in most of his responses during the interview:

> "*Previous extension officers we used to work with were closer to the community in the village…… Previous extension officers we used to work with were more knowledgeable*" (Personal communication, 6th September 2018).

The strong ties between researchers, extension officers and farmers were used to be the norm in Malaysia's agricultural landscape during 1980s and 1990s when

the sector was driving the nation's economy. Extension officers were part of the community and became their personal consultants regarding to issues in paddy fields. However, nowadays the extension officers are burdened with heavy administrative tasks and this had reduced their consultation time with the farmers:

> "*Generation gap and lack of resources (i.e. numbers of officers) do exist in DoA. During 1980s we have training and visit systems (2L – Latihan dan Lawat) systems). However, due to lack of staffs, there are redundancy in our job scope and more workload than before. Before this about 70-80% of our job is 2L and we have more hand-on workshops compared to now*" (Personal communication, 5th November 2018).

c) *Lack of commitment in adaptation and implementation among the farmers* – MARDI's researchers are sceptical towards the commitment showed by their fellow end users – the farmers. The scepticism is not towards the acceptance level of rice varieties they developed, but towards its adoption and implementation. For example, farmers in Kedah are known for their long tradition for agricultural practices and sometimes the practices do not suit the standard guidelines given by MARDI, for example disoblige with fertilisers and water schedule. This situation certainly gives challenges to researchers to take the societal context into account and in the case study, it is the role of extension agencies to make sure the farmers follow the guideline and ensure the researchers include farmers' need into their priority. This challenge is highlighted by one of the interviewees:

> "*Our farmers' mentality is that if they do not encounter any problem, they will not follow the guidelines from the agencies. Whenever we give advice, they will say that we do not understand their situation because we are not the one that do the farm job. We were advising based on theory, so in*

practical the farmers should implement it. So, if there are issues happen on their paddy fields, then they will listen to us. It is a quite controversial issue when it comes to implementation and regulation because it has to involve many agencies" (Personal communication, 4th July 2018).

Based on the case study of MARDI, a significant lesson could be drawn from the example of MR220 CL1 and MR220 CL2 rice varieties. Consistent with its mandate which is to meet farmers' needs, MARDI's collaboration with BASF aims to solve farmers' problem of weedy rice. 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 MR220 CL1 and MR220 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 MR220 CL1 and MR220 CL2 were designed to be used together with an herbicide named OnDuty that is produced by the same company, BASF. According to Figure 4.16, the estimated cost for an acre of paddy field that needs three packets of OnDuty herbicide and three bags of paddy seeds of MR220 CL1 or MR220 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.

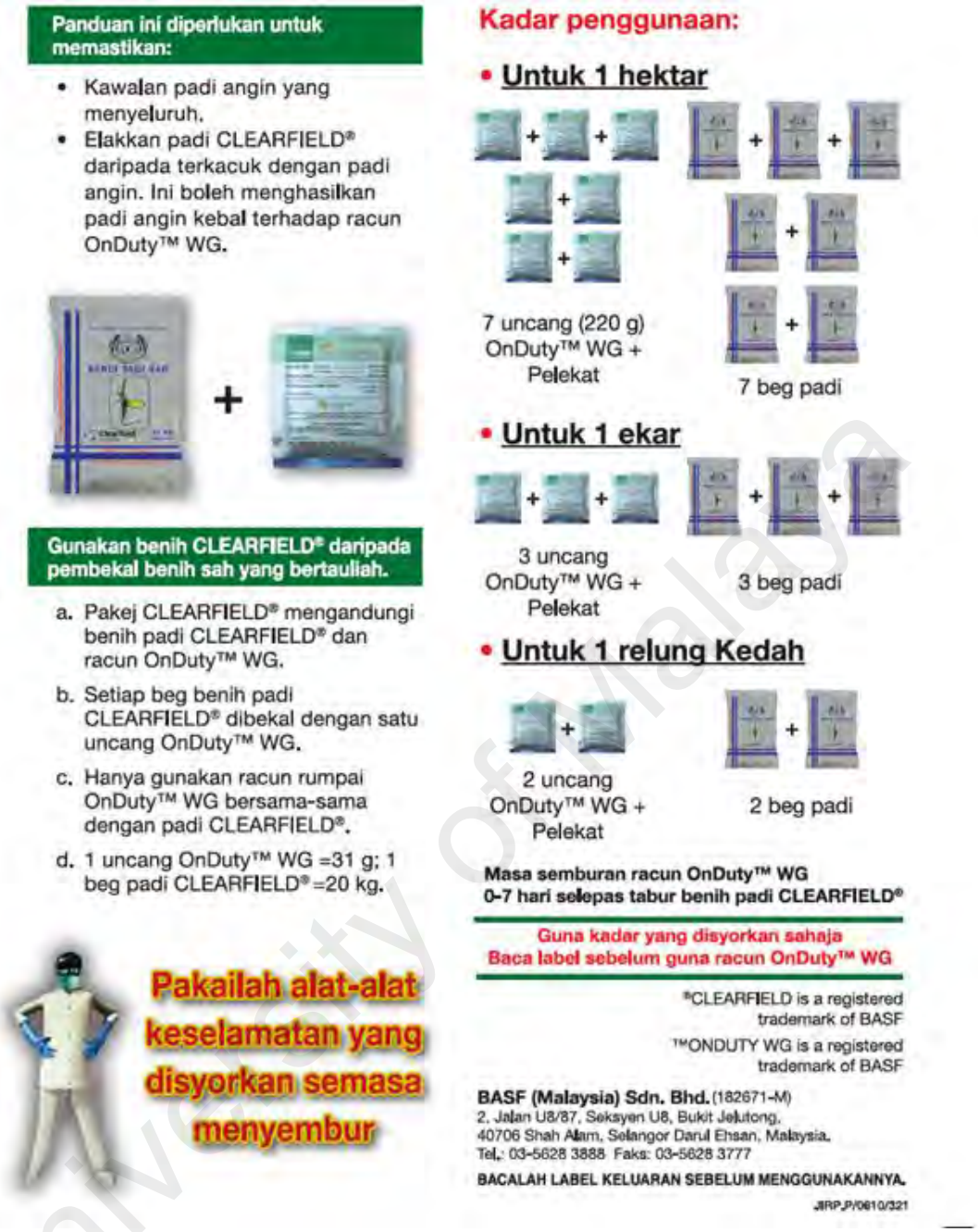


Figure 4.16: Marketing brochure for Clearfield Production System.

Source: BASF (M) Sdn. Bhd. (Available at www.basf.com/my/en.html)

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 et al., 2013).

A farmer also responded with the statement:

> "*For me, the MARDI-BASF collaboration could cost the farmers more. The price for the Clearfield herbicide is irrelevant for us (farmers)"* (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). A farmer stated that:

> "*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).

Therefore, even though the mandates and roles performed by MARDI as a PRI eventually managed to solve problems faced by the farmers, for example weedy rice, societal needs in the context of the industry should be refined according to the end users such as labour and resources of the farmers.

d) *Gaps in human capital* – In terms of human capital, MARDI is currently experiencing a significant generation gap among its researchers. While most experienced officers were retired, they brought away their expertise and social capital from the institutions. Majority of MARDI's officers are now in their 30s and early 40s, and they are still building networks and experience during their early phase of career. This concern can be seen across the extension agencies too and indirectly it affects their social capital with the local farmers as the relationship needs time to build trust. Social capital is important as know-how knowledge could be transferred through informal interaction and engagement. In fact, the farmers are more willing to share their feedbacks when they have good relationships with researchers. Realising the situation, MARDI unites its new generation of researchers with former officers occasionally through workshops and seminars. Besides that, they are also connected through social media to enhance discussions. However, the limited human resources with the increasing job scopes is becoming a challenge for PRIs like MARDI. A MARDI researcher stated that:

"For now, most of the experts on paddy had retired. So, we held workshops for MARDI researchers and invite MARDI's retirees to comment on our reports. Now, MARDI experiences generation gap because of the high number of retirees and new researcher that are coming in. So, we usually will hire our retirees on contract basis to help our new researchers (Personal communication, 17th May 2018).

e) *Social media as emerging new challenges* - Farmers are now much closer to social media and the internet. Often, they consulted their peers and shared their experiences about agricultural practices through the platform. For example, the biggest farmers' Facebook group, *Padi Oh Padi* is participated by more than 32

thousand farmers around the nation. Peer consulting has become the culture for Malaysian farmers to gain knowledge, build networks, share experience and even to consult on agricultural problems. However, based on our meeting with MARDI's researchers this trend could be problematic as illegal market for unauthorised paddy seeds could happen without a proper monitoring from the authority. A MARDI researcher stated that:

> *"Now we have social media like FB page Padi Oh Padi. We as MARDI officers have to monitor some of the content on that page to ensure farmers get the correct information"* (Personal communication, 30th July 2018).

Therefore, authority bodies and MARDI researchers should engage in social media as there are less limitation and boundary between them and the farmers. Farmers need direct and fast access to primary sources of information, and inability of government agencies to provide the convenience resulted to the scenario of illegal market and distorted information in the industry.

Conclusively, Table 4.6 summarises the research findings explained throughout the chapter. The table also integrates literary concepts elaborated in Chapter 2. Hence, the dimensions of social innovation together with its characteristics are outlined with the evidences from the two themes; Theme 1 – institututional framework and Theme 2 – implementation framework.

Table 4.6: Summary of institutional framework and implementation framework.

Dimensions of Social Innovation	Characteristics of the Dimensions of Social Innovation	Evidence from MARDI based on institutional framework and implementation framework
Social objective	• Focuses on technological advancement • Prioritises societal benefit • A novel solution that is more efficient • Gives positive impact on the quality and/or quantity of life	*Technological competency building* 1) The government has outlined and regulated MARDI's functions under Laws of Malaysia (Act 11) MARDI Act 1969 that focuses on scientific, technical, economic and social aspects of rice-paddy industry. 2) MARDI through its RI center performed on-station research; both PYT and AYT to select the best rice lines in term of yield production and stability. The center also certifies the best rice variety to produce Foundation Seeds. 3) MARDI has produced a total of 49 rice varieties since the year of 1968 to 2018 and managed to increase rice potential yield from 3 t/ha to 10 t/ha, and to reduce average maturation period from 142 days to 100 days. 4) MARDI solved weedy rice problem in year 2013 with the innovation of MR220 CL1 and MR 220 CL2 rice varieties.

Table 4.6, continued.

Social mechanism	• Willing to restructure existing social relationship • Collective social action • Unrestricted access of participation and collaboration • Change of governance system and organisation • Co-create and co-produce	*Information & know-how sharing* 1) The government has passed Laws of Malaysia (Act 522) Paddy and Rice Control Act 1994 to regulate illegal possession on uncertified seedlings or rice. The act restricted innovation actors, especially farmers that could participate in the innovation process of producing rice variety and seedlings. 2) MARDI through its RI center performed on-farm research; both MLT and LVT that involves farmers. However, the involvement was limited to renting farmers' plots and selecting resource-rich farmers to perform the agronomy package. On-farm research also includes market research that gathers consumers' feedback. 3) Extension agencies assist MARDI to distribute the rice variety; DoA certifies the Registered Seed and conducts Observation and Promotion Plot. 4) No formal platform for MARDI's researchers to interact with farmers directly without went through extension agencies. Informal interaction happened under circumstance of personal relationship between the researchers and farmers.

Table 4.6, continued.

		Network development 5) MARDI through its RI center performed on-farm research; both MLT and LVT that involves farmers. However, the involvement was limited to renting farmers' plots and MARDI collaborates with private firms, BASF to produce new weedy-rice resistant varieties; MR220 CL1 and MR220 CL2. However, the innovation is not sustainable in terms of economic value.
Social transformation	• Improves income and capabilities • Emphasises territorial factor • Upscales social innovation Stimulates at institutional and incremental level	*Network development* 1) PPK distributes the paddy seeds in each regions of granary areas to ensure equal access to MARDI's innovation. 2) The technology transfer of MARDI's rice varieties has showed distinctive difference between MADA Kodiang and IADA Sungai Panjang. Geographical and demographical perspectives affected territorial capability in adopting innovation. The younger generation of farmers in Sungai Panjang showed more openness and willingness to collaboration engagement with MARDI.

Table 4.6, continued.

		Network development 3) The establishment of Malaysia rice farmers CSOs, Padi Rescue in the year 2015 proves the transformation of civil society in the rice-paddy innovation model. Malaysian farmers managed to mobilise their capital and resources. 4) The utilisation of social media platform by MARDI through their mobile application, MyPerosakPadi connects researchers with end users, the farmers**.**

4.4 Chapter Summary

Conclusively, Chapter 4 explains MARDI's intermediary roles in paddy and rice industry. Firstly, the social objective of social innovation is delivered through the roles of MARDI as a producer in varietal research and development. Rice varieties produced by MARDI had helped farmers to increase their crop yields and reduce maturation period through the example of MR220 CL1 and MR220 CL2 in MARDI's partnership with private company, BASF. In this regard, MARDI acts as both producer and bridging organisation in performing social innovation.

The chapter also explains MARDI's intermediary roles in social mechanism of social innovation through its partnership with the farmers. The case study on farmers in Kodiang and Sungai Panjang explains the indirect interaction between researchers and farmers. Current mechanism is heavily depending on extension agencies. The chapter also discover new alternatives to researcher-farmer partnership in Malaysia which are social media and CSOs. Further connection between research finding and literary concept on intermediary roles of MARDI, as well as its implications will be provided in Chapter 5.

CHAPTER 5: CONCLUSION AND IMPLICATIONS

5.1 Introduction

This final chapter synthesises the main findings derived from the case studies and subsequently highlights its key policy implications. The main findings are recapitulated in accordance to the three main potential attributes of public social innovation that could be performed by MARDI as a PRI, namely societal objectives, social mechanism, and social transformation. This chapter summarises the intermediary roles of MARDI in performing social innovation – which is one of the main objectives of this study. The chapter also provides several salient viewpoints on how MARDI's roles as an intermediary could lead to sustainable agriculture development, particularly in the case of rice-paddy farming. This chapter ends by outlining several research limitations throughout the study and suggestions for future research.

5.2 MARDI and Social Innovation

The conceptual framework of this study, as shown in Figure 2.3, suggests that public efforts to achieve social innovation are heavily driven by three elements, namely clear societal objectives, effective social mechanism, and impactful social transformation. The works of literature inform us that societal objectives in social innovation puts social benefit before individual profit whereas social mechanism encourages partnership and collaboration among stakeholders in innovation process. On the other hand, social transformation is the elevation of society from a passive end user into a more active participant in the process. The sub-sections below conclude the main findings derived from the case studies in accordance to these three elements of social innovation.

5.2.1 Societal Objectives

Parra (2013) suggests that it is important to define societal objectives according to specific societal context. Social innovation should portray the effort to fulfil the needs through its product and process. In this study, societal objective is achieved through the roles of MARDI in its rice varietal R&D activity. The government has mandated the roles through policy instruments and directions. There are several conclusions that could be drawn from MARDI's mandates, roles and performance, and from the case study of MR220 CL1 and MR220 CL2. The conclusions are summarised as follows:

a) According to Laws of Malaysia (Act 11) MARDI Act 1969, in which social objectives have been clearly regulated in the operation of MARDI, the mandates and roles of MARDI are ranged from scientific R&D to dissemination of their research outcomes to the end-users. This includes providing extension services to entrepreneur in agri-business industry. In the year 1992, MARDI's job scope in commercialisation was expanded. Yet, the profit gained from the commercial activities are used to support MARDI's main mandate for R&D but not for commercialisation profits. Its main objective to serve societal needs is still preserved.
b) The mandates are regulated via MARDI's programmes on rice varieties R&D. MARDI as the producer of innovation; rice varieties gave impacts in increasing potential yield output and reducing maturation period for paddy plant, besides providing other solutions such as meeting the market's need for speciality rice. This includes MARDI's partnership with BASF to solve weedy rice problem through MR219 CL1 and MR220 CL2 rice varieties that gave high rice yield to the farmers.
c) Public-private partnership as an alternative platform in sourcing firms' supports and technology in solving farming problems. In the case of weedy rice problem,

MARDI acted as a bridging organisation that connects private industry with the end users which are farmers through its public-private partnership with BASF. The partnership supports MARDI's need for financial support and external value creation, besides providing solutions to the problem of weedy rice by introducing the CPS.

5.2.2 Social Mechanism

Voorberg et al. (2015) suggested that social innovation should address its fundamental concept of relationship, position and rules changes between the involved stakeholders, through unrestricted access of participation and collaboration. However, the research findings did not recognise any direct platform for researcher-farmer partnership without going through any extension agencies. Therefore, extension agencies in agricultural systems are vital in mediating PRI like MARDI with the end users. There are several conclusions that could be drawn from the case study of farmers in Kodiang, Kedah and Sungai Panjang, Selangor. The conclusions are summarised as follows:

a) MARDI's intermediary roles in performing social mechanism of social innovation are not achieved through the current researcher-farmer partnership. In most cases, MARDI researchers are using the other existing extension services agencies such as DoA, PPK, MADA and IADA to reach out to farmers. The co-production approach that suggest farmers participatory research is hardly to be achieved in this context.
b) MARDI only performed the role as an information broker in disseminating information to increase knowledge and skills of the end user by interacting with the farmers through workshops. There was regulative restriction that discouraged direct engagement between researcher and framers in rice variety R&D.

c) LVT and MLT phases in declaring new rice varieties were the only formal mediums that allow farmers to connect with MARDI's rice breeders. However, the current practices only focused on resource-rich farmers, thus limiting the trials from the most extreme cases on paddy plots. The new rice varieties should be developed according to limitations exist in each granary areas with the participation of both resource-poor and resource-rich farmers. Each granary area has its own needs and limitation and, by including all types of farmers, the probability of acceptance and adoption of new varieties produced by MARDI is high. Therefore, the selection of farmers that involve in the trials should taking resource-poor farmers into account.

d) Malaysian farmers prefer access to the primary source of the knowledge which is from MARDI's researchers. This is because, Malaysian farmers are now having more access to information through the internet and they demand for more updated information that could be provided by MARDI researchers only, but not DoA officers or other extension agencies. In order to ensure every scientific discovery done by MARDI are well-delivered to the end user, extension agencies such as DoA, PPK, MADA and IADA are required to have enough capacity and capability to deliver both scientific and know-how knowledge to the farmers.

5.2.3 Social Transformation

In the case of PRIs in agriculture sectors, the main mandate of the institutions is to serve societal needs. Every innovation that had been produced aims to improve the well-being of the end users which are the farmers. However, in a complex ecosystem like rice-paddy industry, PRIs alone could not sustain good adoption and implementation of innovation. Agricultural systems in Malaysia is depending on other innovation intermediaries like extension agencies and farmers' support groups to transfer innovation and know-how knowledge, and also to define relevant societal need. Therefore, a good

actor network in needed in agricultural system. CSOs and social media have the potential in assisting in that matter. Gallouj et al. (2018) highlighted that the involved stakeholders (especially the groups of end users) in social innovation should be empowered and have capability to get involved in the innovation process. Based on the case study, Malaysian farmers have developed their own capacity to mobilise all types of resources such as monetary, networking and human resource. They are able to be transformed from being a passive group of end users into a more active group of innovation actors. The research findings are summarised as below:

a) CSOs and social media had transformed Malaysian farmers community. Peer consulting has become a culture among farming community in the country. This has changed the environment of the industry as farmers are becoming more active players in the sector.
b) The gap between MARDI's researchers and farmers due to the changes in farmers' preferences in primary source for knowledge. MARDI attempts to fill in the gaps by introducing mobile application like *MyPadi* to allow more communication and social interaction between its researchers and end users.
c) The industry setting for paddy and rice in this country has evolved into the Quadruple Helix Innovation Model. The emergence of community and media as the fourth actor in the current model has transformed the concept of social innovation as a whole. In the previous model; Triple Helix Innovation Model connects the link between government, university and industry. Yet, through the case studies that had been conducted in this research, farmers community as end users and media had contributed as active participants in the innovation process; rice varietal R&D. The transformation of Malaysian farmers contributed to the social transformation aspect of social innovation in this matter.

5.3 Intermediary Role of MARDI

PRIs are defined as "*public and semi-public research institutions (excluding pure university institutes), regardless of their statistically-defined sector (government, higher education, business or private non-profit)*" (OECD, 2011, p. 27); and "*their activities vary widely according to their mission and type. Some perform "blue sky" science or basic research that often has a long-time horizon and carries high risks with uncertain returns, while others focus on more short-term market-oriented research, development work, problem solving and technical assistance. Some PRIs specialise in mission-oriented research such as biotechnology or telecommunications, while others cross the scientific spectrum. Other roles include providing technology services, education and training activities, for example supervision of PhD candidates and hosting post-doctorate researchers, skills development and on-the-job learning, technology transfer such as physical transfer of technology, prototypes and process and or "know-how", the development of new instrumentation or laws and regulations such as environment, health and safety*" (OECD, 2011, p. 20).

There are other possible roles of intermediary that includes; (a) information and know-how sharing, (b) managerial capability development, (c) network development, (d) technological competency building, and (e) policy advisory (Ng et al., 2016). In the case of rice-paddy industry, MARDI's role as the producer of innovation is more prominent. This is due to the fact that its service division; PB and TS centres are not dealing directly with end users in the sector. Through its research division; RI centre, MARDI involves in the roles of technological competency building. For example, the innovation produced by the centre gave impacts in increasing potential yield output and reducing maturation period for paddy plant, besides providing other solutions like fill the need for speciality rice. This includes in performing network development as MARDI also acts as an intermediary that connect private industry with the end user through its public-private

partnership with BASF, and solved farmers' weedy rice problem through its service division; TS centre.

Besides that, MARDI also performs the role as a broker in increasing knowledge and know-how skills for the end user by interacting with the farmers through workshops. However, the interaction is limited even though the farmers opted for primary sources which are the researchers as their reference. Based on the interviews, the farmers acknowledged MARDI's scientific role as the producer of rice variety in this country. They also expressed their concerns on the limited number of extension officers that are able to be on-site, and their incompetence in knowledge regarding to rice and paddy. The opinion is supported by the extension officers that had been interviewed. Currently, the extension officers are burdened with administrative tasks, thus reducing their time to build relationship with farmers by visiting paddy fields. The weaknesses in the extension agencies cause the farmers opted to refer to MARDI's researchers for solutions. When it comes to technical problems such as bacterial infection to the paddy plants or new pest disease in their paddy fields, the farmers prefer primary sources for information and solution. This proved the role of information & know-how sharing of MARDI as the key sources of knowledge. Table 5.1 explains intermediary roles of MARDI based on case studies that had been conducted in this research.

Table 5.1: Intermediary roles of MARDI.

Functions	***MARDI contributions***
a) Information & know-how sharing	• *Facilitate and coordinate the diffusion and exchange of information* – Through its service division (i.e. PB centre), MARDI provides knowledge sharing to entrepreneurs in agri-business industry, but the division does not engage with paddy farmers. Entrepreneurs could participate in the sharing through workshops and seminars held by MARDI. • *Provide key sources of knowledge* – In the case of MARDI's research division (i.e. RI centre), rice breeders and researchers are invited as experts in giving information sharing. The sessions are conducted by extension agencies. • *Articulate experiential and indigenous knowledge* – Researchers could engage with farmers during MLT and LVT phases and incorporate new insights.
b) Managerial capability development	• *Based on the interviews conducted and MARDI's website, there is no managerial capability development could be observed. This role could be in the form of internal-value creation that is not disclosed for public.*

Table 5.1, Continued.

c) Network development	• *Link collaborators and form partnerships* – Through its service division (i.e. TS centre), MARDI builds partnerships with private entities. The partnerships could provide internal value for MARDI such as royalty payment in the case of research collaboration with BASF. • *Effect change with science networks* – In the case of MARDI's research division, the researchers are able to develop their networks by attending conference locally and internationally, but it depends on the allocation from MARDI. • *Build trust, manage conflicts and complementary assets sharing* – MARDI initiative in launching its own application and social media has proved their efforts in building trust by engaging farmers through media and technology.
d) Technological competency building	• *Develop technical skills and ability in selection of appropriate techniques* • *Develop new application for new technologies* – Through MARDI's research division, RI centre is observed to perform these roles. They also provide paid laboratory service to third party. • *Transfer and exploit technology* – Through MARDI's service division, TS centre is observed to perform these roles. This could be seen the case of MR 220 CL1 and MR 220 CL2.
e) Policy advisory	• *Formulate research policy that orients the science system to socio-economic objectives* • *Align agendas and link science, policy and practice* • *Evaluate outcomes* – Through MARDI's research division, ES centre is observed to perform these roles.

Conclusively, based on the case study, MARDI played a prominent role as a producer in technological competency building in meeting social objectives. But, its roles as a broker in information and know-how sharing in meeting social mechanism and social transformation is limited. They are still depending on extension agencies. Yet, through its service division, the objectives could be achieved through the role of network development. Hence, a more sustainable policy direction is needed regarding to this matter.

5.4 Policy Implications

Based on Table 5.1 explained in previous section, the listed intermediary roles of MARDI shaped the concept of social innovation employed in the country. This section will illustrate policy implications based on the case studies that had been conducted.

5.4.1 Public Social Innovation for Sustainable Agriculture

The proposed framework for public social innovation for sustainable agriculture is illustrated in Figure 5.1. Social mechanism and social transformation are the main determinant for social innovation in Malaysia's rice-paddy industry. The limitation observed throughout the study could be deduced based on these two aspects. On the other hand, 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, CSOs, farmers) are crucial in developing a sustainable paddy-rice industry. These elements of social innovation; social mechanism and social transformation not only create external value for MARDI such as efficiency in technology transfer, it also created internal value for the institution like MARDI get royalty from partnership with private company to fund their internal R&D activities.

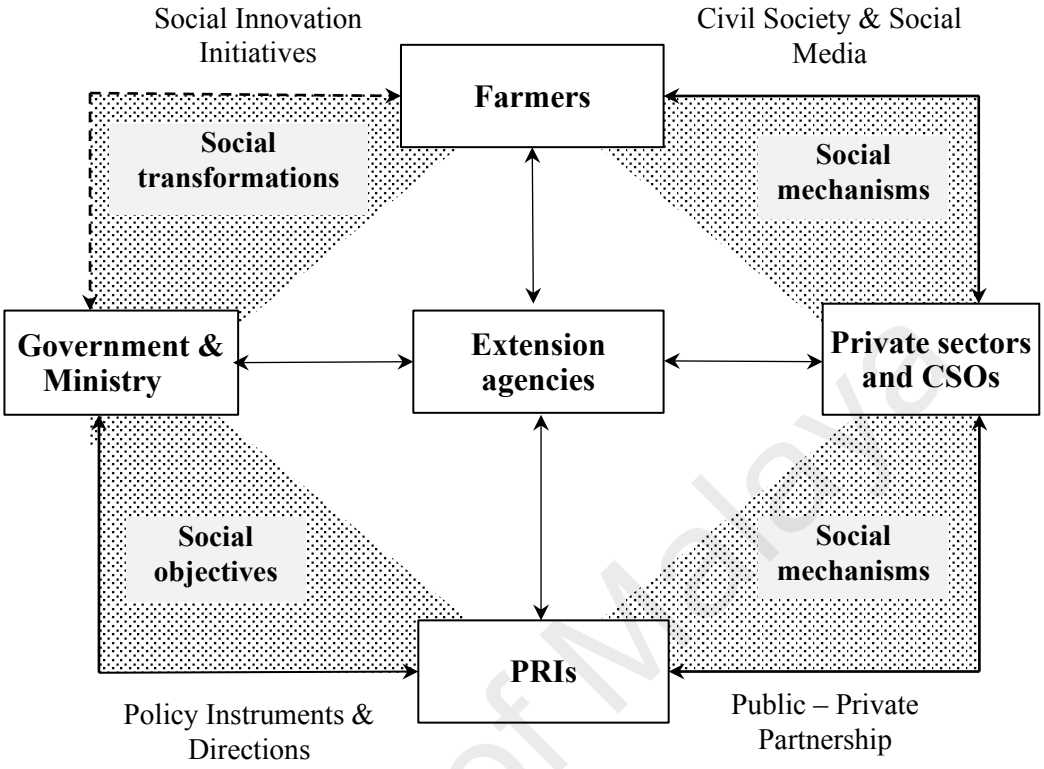


Figure 5.1: Public social innovation for sustainable agriculture.

Figure 5.1 illustrates the framework of public social innovation for sustainable agriculture. The framework is adapted from the conceptual framework proposed in Figure 2.3. The framework shows that PRIs 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.

However, in order to access to the farmers as end-users, the presence of extension agencies is introduced in this diagram. Extension agencies; DoA, PPK, IADA and MADA is the crucial pivot in disseminating technology and knowledge in the industry. These

actors are the centre in the concept of social innovation in Malaysia. They have the direct access to the farmers and become the intermediary between PRIs-farmers and government-farmers. Hence, these are the actors that should be uplifted and ensured their capabilities in performing their roles. Limitations in these aspects will hinder MARDI's role to disseminate their R&D.

Another new actor introduced in this figure are private sectors and CSOs. Through civil society and social media, these entities perform social mechanism of social innovation. This is a key driver to leverage the potential of social innovation. Farmers groups and supporting civil society organisation should be empowered as they help the community to grow and improve.

The underlying principle of this framework is the researchers-farmers partnership is communally supportive, that is, one of the main principles of sustainable agriculture. In this respect, social innovation aims to transform the society; farmers as active players in the industry and no longer as passive recipient. Rather than act as consumers, they are prosumers (Beza et al., 2017; Mumford, 2002). This concept is also explained by Tether and Tajar (2008) whether the knowledge gained from external knowledge providers is complement or substitute the knowledge created by the users themselves

5.4.2 Operational Structure of Researchers-Farmers Partnership

Figure 5.2 shows the operational structure of researchers-farmers partnership for sustainable agriculture by studying social innovation initiatives in MARDI. It is discovered that the roles of PRIs in social innovation and comprehended the transformation of social relations among stakeholders such as farmers and researchers in agricultural sector. Previous work of literature had emphasised these aspects and explained that social relation transformation like community supportive is needed to perform changes in governance system and organisation (Moulaert, 2016). In fact,

willingness to restructure existing social relationship to form collective social action are crucial for social change, thus solving societal problem (Cajaiba-Santana, 2014; Mumford, 2002). Therefore, this study examined the factor of community supportive in paddy industry and the roles of MARDI as a PRI in catalysing social innovation. It also covered the opportunities and challenges existed in the industry and attempted to proposed relevant policy recommendations.

The scenario of related researchers-farmers partnership derived from case study on MARDI is illustrated in Figure 5.2. At the management and policy making levels, the partnership between MARDI's researchers and farmers will inform the decision makers the actual needs and constraints of the farmers on the ground and research programmes can be charted in accordance to the root cause of the problems. There is not much significant direct engagement between the researchers and farmers at the researchers' level; on-station research and on-farm experimentation. Even if there is little engagement in terms of on-farm referral of problems, it seems to have only benefits the selected resource-rich farmers who are more organised.

Most of the farmers are seemed as passive recipients of the certified rice varieties through workshops and seminars, or some technology transfer programmes organised by DoA. This is a typical transfer-of-technology (ToT) model that focuses on resource-rich farmers that is often having difficulties to be translated or implemented into the resource-poor farmers. Nonetheless, it is observed that farmers in Malaysia are progressing towards more independent in term of their knowledge creation and information sharing. They are more "tech-savvy" compared to the generation before them.

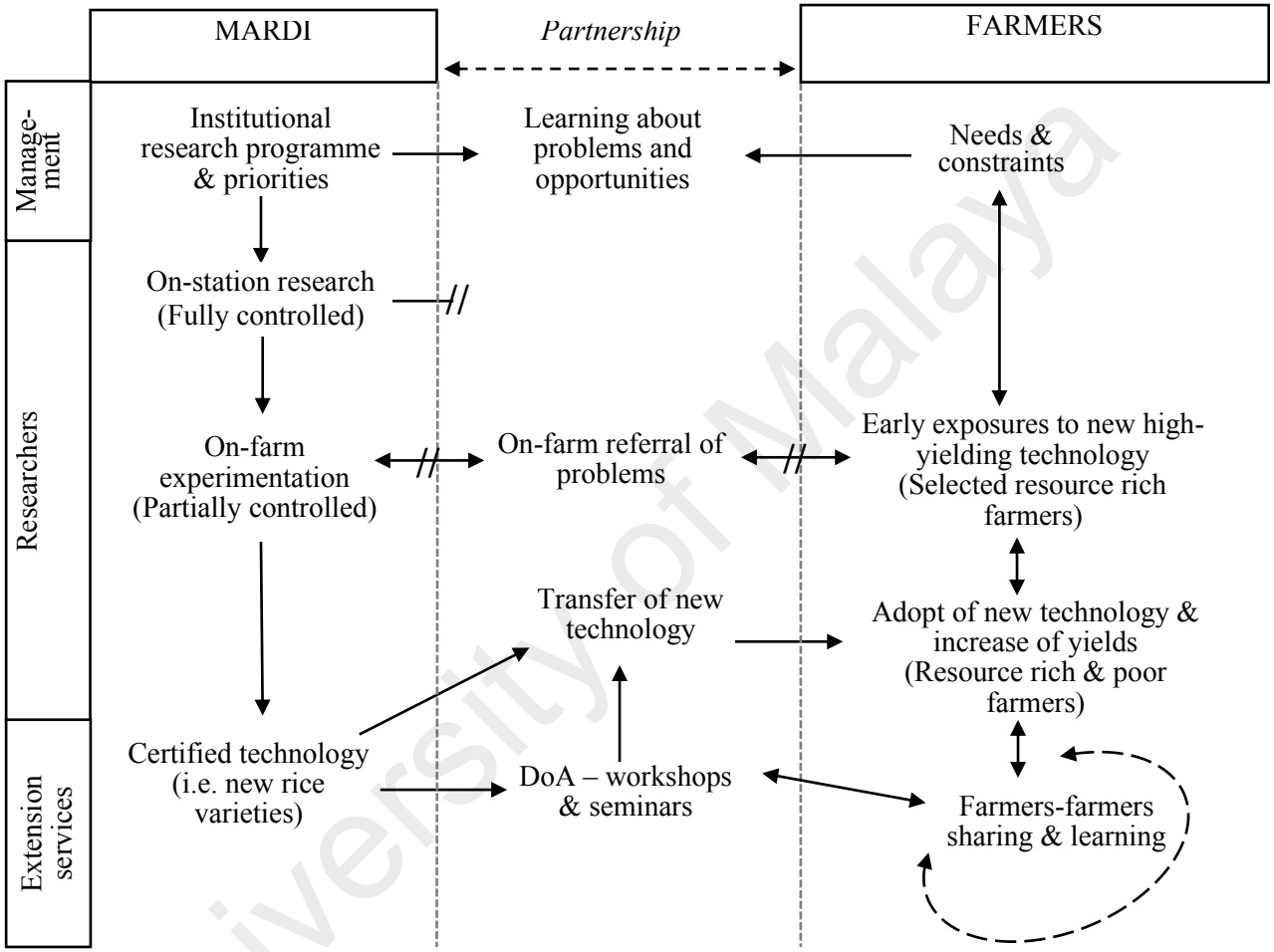


Figure 5.2: Operational structure of researchers-farmers partnership.

Source**:** Modified from Chambers & Ghildyal (1985)

5.4.3 Actors of Agricultural Public Social Innovation

There are four actors that drive sustainable agriculture – PRIs, agriculture extension agencies, farmers, and CSOs together with media. Sustainable agriculture can be achieved if there are (a) quality research by PRIs, (b) efficient extension agencies in disseminating knowledge to the farmers, (c) productive farmers in delivering high yields farming, and (d) communal support by CSO and media. Even though in conventional technology transfer in agriculture, extension agency is the crucial pivot in ensuring the innovation reaches the target group, this study claimed that the presence of partnership between researchers in PRIs and farmers is as much as important. It serves as a platform for researchers to be aware of the farmers' constraint and there is a need for the farmers to receive first-hand knowledge in farming. Hence, the researchers could know the effects of their research outcomes and farmers could appreciate the contributions of the scientific findings. These objectives are parallel to the concept of social innovation, which are meant to give positive impact on the quality and quantity of life, to initiate novel solution that is more efficient to benefit society rather than private individuals, and to improve income and capabilities of stakeholders (Caulier-Grice et al., 2012; Phills et al., 2008; Pol & Ville, 2009).

However, several issues pertaining to researchers-farmers partnership needs to be highlighted and rectified. The main findings from this study show that the partnership between MARDI's researchers and farmers is limited. The only productive and formal channel for MARDI's researchers to reach the farmers is through the agriculture extension agency; DoA. Although MARDI has its own service divisions, however, these divisions are focusing to provide support and internal value creation to MARDI and are not directly deal with farmers. As a result, although MARDI has successfully produced high quality rice-paddy varieties that eventually benefit the farmers in the nation, it does not guarantee the effectiveness of technology transfer and adoption to farmer. In our

findings, the lack in human capital like number of officers, knowledge, social skills and number of times spent with farmers across agricultural agencies especially in DoA distorted the process of transfer and adoption for new varieties. Therefore, Malaysian farmers are tending to rely on peer consulting compared to choose experts as their reference.

Besides, as suggested in the quadruple helix of innovation model, the synergy of four entities, namely government, universities, academia and civil society in forming a well-configured knowledge economy and society is crucial (Carayannis & Campbell, 2009). The quadruple helix explains the co-existence and co-evolution of different knowledge and innovation paradigms and integrates the concept with a new element of "media-based and culture-based public". This model improves the existing Triple Helix Innovation Model; university-industry-government. In this study, it shows that the farmers in Malaysia are progressing towards more independent in term of their knowledge creation and information sharing. They are more "tech-savvy" compared to the generation before them. Therefore, they need reliable references or platforms to validate any new method or practices. This platform could not be provided by DoA including the companies because research is not the core mandate of these entities. Moreover, the number of DoA officers are limited and they are also burdened with heavy tasks on extension services, regulatory and enforcement. This makes them unable to provide quality times with the farmers. Thus, if there is an action plan to establish researchers-farmers partnership in rice-paddy industry, it must involve MARDI. MARDI's researchers are needed to fill in this gap.

5.4.4 Suggested Policy Directions

As a final point, this study suggests following policy directions in fostering the researchers-farmers partnership in agriculture through PRIs. The study has provided extensive insights into the expected roles of PRIs as intermediaries in social innovation in agro-based industry. But there are also various issues and challenges that hinder the performance of PRIs in this context. Hence, the study suggests several salient policy directions that can be adopted by policymakers as well as MARDI as a PRIs in performing public social innovation as follows:

a) *Adopting active participatory approaches* –

PRIs could improve the current participatory approaches such as improvement in LVT for MARDI to introduce new varieties to farmers to enhance community support in disseminating the outcomes of public R&D. The new participatory approaches do not necessarily have to create new idea by acknowledging new local context, but it could be a better management of current local knowledge with a better integration with scientific knowledge. For example, MARDI could adopt "Mother and Baby Trial Design" which suits the concept of MLT and LVT. This approach requires researchers to test new varieties on-site (mother trial) and farmers could replicate the experiment according to their capacity and constraint (baby trials). The farmers are not only benefiting by observing the mother trial directly, but it also encourages them to engage with researchers to learn new techniques on the new varieties. At the same time, the researchers could understand and comprehend the constraints experienced by the farmers and improve their innovation to meet the needs. Participatory approaches also ensure the partnership forged includes as many farmers as possible; the advanced large-scale farmers and small-scale farmers.

b) *Promoting and recognising researchers-farmers partnership –*

PRIs should come out with an alternative to motivate their own researchers, especially the one who are willing to work directly with farmers. Research grant, achievement award, job promotion, media publicity and opportunities to grow in their career could make the best option for the incentives. Their social contribution especially in engaging with farmers should be recognised in their annual performance assessment. PRIs also should explore better and more opportunities to utilise the existing extension service agencies and allocate special funding on community engagement.

c) *Strengthening effective scientific communication skills –*

Researchers in PRIs should acknowledge that scientific communication is crucial in delivering their innovation. Researchers should be able to convey scientific knowledge to farmers in layman words to be understood by the audience. Scientific communication workshops could be conducted to train researchers the social skills needed to promote their products. Even though, the nature for PRIs is public goods, it is still important to deliver their products to attract the end users. Researchers in RI centre should learn from the officers in service centres of MARDI, especially from PB and TS centres. Besides MARDI's core business as the producer of technology, the institution also provides services. Therefore, it is not exaggerating to say that researchers in MARDI should adopt the mindset of "service provider" to their clients which are the farmers, even though in a public-driven setting like agriculture that is non-profit based. This philosophy will assist researchers to do their best effort in delivering R&D to the farmers.

d) *Optimising the use of social media –*

Finally, based on the findings in this study, MARDI should make use of social media platform. Their current mobile application for paddy, MyPerosakPadi could be improved and publicised, not only to the farmers but also to the public. Another limitation that could be observed in the application is that the medium is used to deliver general knowledge on certain issues such as pest and disease and it only serves as a one-way interaction. So far, there is no platform for two-way interactions via mobile application for MARDI. MARDI could venture in building a database that allow farmers to access information instead of building multiple mobile applications.

5.5 Limitations of Research

Even though the study has achieved its objectives, there are several limitations during the research activities. This includes as follow:

a) The study has limitations due to the selectivity of the respondents. Even though the core mandate of MARDI is rice varietal R&D, the institution also involves in other types of agro-based industry such as food processing and entrepreneurship. Hence, the study did not able to capture all MARDI's R&D programs. However, by focusing on certain groups of respondents will be able to narrow down on MARDI's best practices in rice-paddy industry that could be learn by other PRIs.

b) The study did not use any quantitative method approach such as surveys and questionnaires as this study is designed to understand the qualitative perspective of the PRIs roles in public social innovation. In fact, the data available at the Economy and Social Science Research Centre in MARDI is limited to provide in-depth understanding on the research topic.

c) Due to limited knowledge of the researcher in the scientific terminologies of rice breeding process as well as the layman's term used by the farmers, some limitations in analysing data might occurred, especially when it involves jargon related to biotechnology. On the same note, with any other qualitative studies, it becomes a challenge to deal with farmers' personal emotion during the interview sessions.

d) Due to the nature of single case study, the research needs to be careful in generalising of its research findings. Besides that, it should be aware that the study attempts to propose broad-based policy directions and not for specific action plans. Hence, it provides general insights for future studies in the research topic, rather than specific suggestion to improve the current mechanism used by MARDI in achieving its social innovation.

5.6 Direction of Research

In conclusion, the study has achieved the objective to explore the intermediary roles of MARDI in performing the elements of social innovation in Malaysia's agriculture sector. The study also managed to determine the issues and challenges of MARDI in performing the task and propose policy directions to strengthen the institution's roles. For future research, it is recommended to study other research activities of MARDI to gain a better picture on its intermediary roles. Besides paddy, MARDI performs very well in other sectors like agro-based entrepreneurship. The concept of social innovation could exist in that areas of research. Another suggestion is that, there are potentials in gaining insights for social innovation in different PRIs. A better example could be the role of Malaysian Palm Oil Board (MPOB) as a PRI in palm oil industry and how the synergy among government agencies like Federal Land Development Authority (FELDA) in empowering farmers in the industry of palm oil.

Despite the extensive research findings and discussion that had been explained throughout the study, the main message of this research is concisely summarised – the landscape of the rice and paddy industry in the country needs to be revisited and revised. The dominance of certain actors in the ecosystem; industry players and private companies) needs to be balanced with the crucial role of farmers and CSOs. Agriculture is a public-driven sector, thus the public; farmers should have a say in directing the future of the industry.

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LIST OF PUBLICATIONS AND PRESENTATIONS

Publication

1. Ng, B. K., Mohamad, Z. F., Chandran, V. G. R., & **Mohamad Noor, N. H.** (2019). Public policy interventions for grassroots innovations: are we getting it right? *Asian Journal of Technology Innovation*, *27*(3), 338-358.