5 CONCLUSIONS

5.1 Introduction

This study was set out with the objective of determining the successful factors that facilitated the implementation of new IPM technology and innovation. A hypothesis was formulated in Chapter 3 to evaluate the presence of the six key variables being critical in leading to the successful implementation of IPM technology and innovation. This success of IPM technology and innovation diffusion was greatly influenced by the strength of the KAP level of the agricultural extension officers. An exploratory study was conducted using various methodologies such as; experience surveys, case study, in depth interviews and also focus group interviews on the two largest rice granaries in Malaysia, viz., MADA and KADA.

In this chapter, the focus was drawn to identify the general conclusions from this study so that an assessment could be made to identify the extent to which the research objectives were achieved and also to draw meanings from these key conclusions. Besides, this chapter would highlight some limitations of this study and also throw light onto some future research that could be spearheaded from this study.

5.2 General Conclusions

From this study the key conclusions for MADA were;

- With respect to the research objectives, all the six key variables (top management; structure and culture; social system; communication system; intermediaries' role; and innovation attributes) were present in both the rice granaries. In MADA, it was evident that all the six variables played the role of being 'drivers' to the successful implementation of IPM technology and innovation, and they were greatly influenced by a strong KAP level of the agricultural extension officers in MADA. This was evident in the first time period of 2001 as well as the same findings were discovered in the second time frame of 2007.
- This meant that the agricultural extension officers in MADA worked in an environment which had the six key variables supporting them. This in turn supported a higher level of efficacy of IPM technology and innovation diffusion.
- The agricultural extension officers showed a higher level of IPM knowledge; they also possessed higher scores for their attitude and practice constructs that were measured. This was indicative that the agricultural extension officers from MADA were more knowledgeable with respect to the IPM practices; they possessed a better attitude towards IPM innovation and instilled a higher level of adoption of the IPM practices.
- Consequently, it was deemed that armed with higher scores for KAP, would mean that these agricultural extension officers tend to become more formidable in their role as change agents and early adopters. They would be a stronger influence on the rice farmers, to influence their decision making and behaviour change to adopt the new IPM technology and innovation in the farmers' rice fields.

- This would enable the rice farmers to reap higher yields and experience lower pest attacks as well as reduce their usage of pesticides, herbicides and rodenticides.
- A set of performance indicators were used to measure the successful implementation of IPM technology and innovation. They were; the pest attack levels yield levels and pesticides usage levels. In the case of MADA, there was a positive indication that the yield levels had increased, while the pesticides usage levels had decreased overall. However, there was a haphazard pattern for the pest attack levels and hence the figures were inconclusive.

From this study the key conclusions for KADA were;

- In the case of KADA, all of the six key variables were 'inhibitors' in the first time period of 2001, with the exception of the key variable 'structure'. This meant that the agricultural extension officers in KADA worked in an environment that lacked the six supportive variables. This would affect the efficacy of the IPM technology and innovation diffusion.
- Consequently, the lack of a supportive environment would also affect the strength of the influencing variable of the level of KAP among the agricultural extension officers in KADA.
- The agricultural extension officers showed a lower level of IPM knowledge; they also possessed lower scores for their attitude and practice constructs that were measured. This was indicative that the agricultural extension officers from KADA were less knowledgeable with respect to the IPM practices; they possessed a

weaker attitude towards IPM innovation and did not have a high level of adoption of the IPM practices.

- They would not be strong change agents or early adopters to influence the decision making and behaviour change among the rice farmers.
- In the second time period of 2007, however, there was a lot of improvement. All of the six key variables converted from 'inhibitors' to become 'drivers'. With the presence of these six key variables, the efficacy of IPM technology and innovation diffusion would become successful.
- The presence of the six key variables would also enhance the strength of the KAP level among the agricultural extension officers in KADA. They would become a stronger influence to the rice farmers in KADA and encourage their decision making and behaviour to change to adopt the new IPM technology and innovation. This was because a higher level of KAP would make them more formidable change agents and early adopters.
- A set of performance indicators were used to highlight the successful implementation of IPM technology and innovation. They were; pest attack levels, yield levels and pesticides usage levels.
- In the case of KADA, there were no records maintained for the pest attack levels or pesticides usage levels. Hence no comparison or conclusions could be drawn. However, with respect to the yield, they were significantly lower than MADA's yield levels, with the exception of the Merdeka Farms.
- In the Merdeka Farms, the yield increased over the years and this amount was comparable to the MADA rice granary statistics. This was because these farms

were managed by a group of agricultural professionals who upheld strong farm management principles and were held accountable for the performance of the farms by the owners.

Hence the overall general conclusion that could be drawn was that the efficacy of IPM innovation diffusion was relatively higher in MADA than in KADA. The key reasons being that in MADA, the six key variables were present in the environment and they were classified as 'drivers'. This supportive environment enabled a higher level of efficacy of IPM technology and innovation diffusion. This helped to strengthen the KAP levels of the agricultural extension officers leading to a strong change agent and early adopter level. This strong level became a strong force to influence the rice farmers to adopt the new prudent IPM technology and innovation in their rice fields. Some performance indicators of IPM efficacy were also witnessed in MADA.

Contrastingly, in KADA, the six key variables were virtually non-existent, notably in 2001 although a drastic change was witnessed in 2007. Hence, in 2001, these six key variables were not 'drivers' rather 'inhibitors' to the successful implementation of IPM technology and innovation. Consequently, this affected the strength of the KAP level among the agricultural extension officers. Weak KAP levels made them weak change agents or early adopters. Hence they were not in a strong position to influence the rice farmers to adopt the new prudent IPM technology and innovation. However, things took a turn for the better in the second time period of study, 2007. Now the six key variables became 'drivers' and hence improved the probability of successfully implementing the IPM technology and innovation. More supportive environment

will induce stronger KAP levels and hence make the agricultural extension officers stronger change agents and early adopters. Hence they will become a more powerful and influential force to modify the behaviour and decision making patterns of the rice farmers towards adopting the new and prudent IPM technology and innovation.

Additionally, even the performance indicators endorsed the new situation in KADA, notably with the performance indicators of the Merdeka Farms, which were specially managed by a team of farm management experts. Hence this project did enjoy strong IPM performance indicators.

Overall, the conclusion drawn is that the six key variables play a crucial role in enhancing the efficacy of IPM technology and innovation diffusion as it influences the KAP levels of the agricultural extension officers which in turn will show the effects in selected key performance indicators.

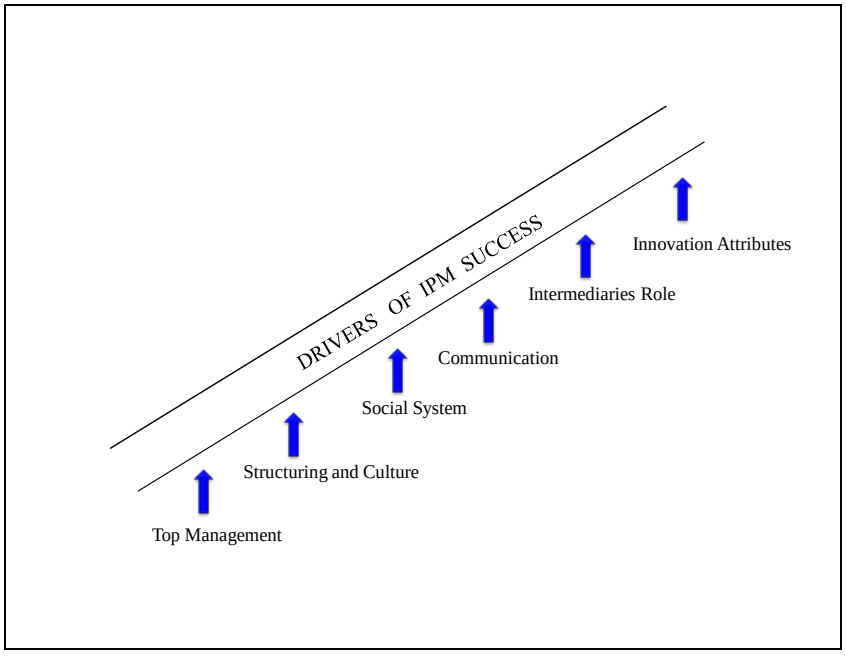
5.3 Theoretical Implications

From a theoretical viewpoint, linkages could be drawn to the underpinning theory on diffusion of technology and innovation as created by Rogers (1995). This model was used in this research study (Figure 2.1) as the basic framework to focus on the five key stages that traced the behavioural patterns of potential adopters until they made a decision to either adopt the innovation or reject it. This model also highlighted the most critical step, that is; the 'Knowledge' level among the change agents or early adopters. By enhancing the knowledge level, the change agents or early adopters had strong influential control over the end-users of the system, viz., the rice farmers in this case, as they could persuade them to adopt the new

technology and innovation. Hence when a larger proportion of the users adopted the new technology and innovation, then this would mean that there was a smaller group for the late majority and also the laggards. From this research we identified that the need to strengthen the 'knowledge' level of the agricultural extension officers was extremely imperative for a higher level of efficacy in the implementation of IPM technology and innovation diffusion.

Additionally, the originality of this research was to lead to the development of a systematic and prescriptive model of adoption and diffusion that led to a higher level of efficacy and successful implementation of IPM. The model included constructs as listed below in Figure 5.1.

Figure 5.1 : IPM Success - Drivers



From Chapters 2 and 4, we have understood the significant roles played by these six 'drivers' for IPM success. Some of these 'drivers' could be controlled by the government via instituted

policies so as to ensure that prescribed processes were in place to ensure IPM success. This was decisive in Malaysia, as there was a heavy dependence on rice for its local consumption.

In 2009, as cited in the research "*Incorporating Integrated Pest Management into National Policies*" conducted the Consultative Group for International Agricultural Research (CGIAR) System wide Program on IPM (SP-IPM), it highlighted the significant role of the government in institutionalising IPM so as to maintain existing yield gains and to support more productive and prudent agricultural practices.

An example of a noteworthy area for policy institution was the promotion of high-yielding crop varieties. Policies need to be instituted that promoted the use of inputs such as fertilizers and the reduction in the usage of synthetic pesticides, which brought about environmental damage and poor health effects on the farmers. Hence, a range of policy and regulatory tools need to be constituted for IPM, to upgrade the existing plant protection policies coupled with safeguarding a wider national and global policy environment. The 2009 research also provided policy makers in developing countries with a succinct and practical insight to the process of incorporating IPM into national policy. Such examples could be adopted in Malaysia also.

5.4 Practical Implications

From a practical perspective, it can be substantiated that the Malaysian government was extremely serious in its attempt to uplift the status of agriculture and its contribution to the Gross Domestic Product of the country. This was evidenced when the Malaysian government unveiled the economic transformation program on September 21, 2010. The ultimate objective of this plan was for a comprehensive economic transformation plan that would help propel Malaysia's economy into a high income economy. The program would lift Malaysia's Gross National Income (GNI) to US$523 billion by 2020, and raise per capita income from US$6,700 to at least US$15,000, meeting the World Bank's threshold for high income nation. From this perspective, the agriculture industry played a pivotal role as it was included as one of the 131 entry-point projects that were identified under the 12 national key economic areas.

In view of the significant role of agriculture, the two largest rice granaries of MADA and KADA need to 'up' their impetus and play their role to facilitate the growth of the Malaysian economy by encouraging prudent rice farming practices as endorsed by IPM technology and innovation, thus leading to higher yields and greater returns for the rice farmers, specifically and for the country as a whole.

In MADA, a new dimension of farming called 'Precision Farming' had been endorsed. This represented prudent farm practices that addressed the gap between potential and actual yield that was caused by improper farm management practices. By instituting 'precision farming', improvements were seen in the whole agriculture process from tillage, water management, fertiliser management, weed management and integration of practices to suit local conditions.

In KADA, exemplary farm management practices were witnessed in the Merdeka Farms which were managed by a group of agricultural professionals who upheld strong farm management principles and were held accountable for the performance of the farms by the owners. Hence the yield increased over the years and this amount was comparable to the MADA rice granary statistics. This excellent farm management practices could be extended to the other farmers who were too old to tend to their rice farms or who faced an uphill struggle to secure good workers to cultivate their land or even those whose children refused to help till their farms with them.

Overall, in both these two largest rice granaries, breakthroughs in prudent farm management practices were experienced, as narrated above. With the support from the regulatory body of the government, stronger control and enforcement would be highly commended. This would be congruent with her endorsement of prudent IPM practices so as to ensure safety to the agricultural environment coupled with high yields to feed the local consumption needs, initially and for export, later.

5.5 Recommendations

Based on this research study of MADA and KADA, many 'gaps' were identified. An attempt was made to provide some recommendations so as to address the gaps that were highlighted. These included;

- Successful dissemination of IPM innovation and technology depended heavily on the six key variables. These variables played a vital role and proved to be the drivers of augmenting the efficacy of IPM implementation. An insight as to augment the role played by each of these drivers were as follows;

1. Effort had to be expended to ensure that top management provided the critically needed support in terms of leadership, commitment, vision and resources, as was evidenced from the MADA rice granary. The efficacy of IPM implementation in MADA was leaps and bounds ahead of KADA because of this critical success factor.

2. Additionally, with a strong endorsement from top management, a conducive and stimulating culture could be created to drive the agricultural extension officers towards a higher level of efficacy.

3. A strong network of organisations possessing similar agendas had to be structured and coordinated among the various nations endorsing IPM practices. This was critical as continuous support from experts in the field was essential to provide relevant knowledge to address new issues related to IPM implementation of technology and innovation.

This was also echoed by Aitken et. al., (1995), who said that although short term success in IPM implementation was easier to achieve, what was more critical was seeking ways to ensure long term success. One recommendation was through the establishment of a high quality network with key players so that coordinated strategies that addressed critical issues at all relevant levels of influence could be created. The frequency and importance of interactions with network members was critical to diffusion success. The more tightly members were tied into a network (the more dense), the more they were affected by group standards and the higher was the group's cohesiveness (Wang, et. al., 2011).

4. A system of effective communication channels had to be structured so that these channels provided succinct sources of information speedily during times of crisis to the users. This could be done through multiple channels such as; people, newsletters, mass media, TV, radio, direct mail, videos, colour charts to help pest recognition, case study reports, professional association networks and publications. No single way would suffice. A system of user feedback was also highly recommended as the users would be able to present their ideas on how the IPM technology could be improved or extended into new areas.

5. To become more effective change agents, the agricultural extension officers needed a platform to be created so they could provide accurate feedback to the IPM researchers regarding the latest IPM research findings and technology, with respect to its trial ability, complexity, compatibility and relative advantage. Rogers (1985) had recommended an extension model called the "Farmer First" model of extension, where the agricultural

extension officers, farmers and the scientists collaborated through conducting mutual experiments and learnt from each other. Through this process, research would be decentralised, differentiated and versatile. This bottom-up process emphasised on bringing about changes that farmers would endorse readily, leading to a more successful IPM dissemination process by the relevant users.

6. Another critical factor for the successful dissemination of IPM innovation and technology depended heavily on the agricultural extension officers' level of knowledge, attitude and practice. Effort had to be expended to ensure that the agricultural extension officers' level of knowledge was to be elevated to a level known as 'rice field scientist'. This would mean that they were able to answer any question thrown to them from the rice farmers regarding their farming concerns and problems. Hence a structured system of training was seriously needed to rectify and improve the level of knowledge among the agricultural extension officers.

According to Feder et. al., (2011) they analysed the role that private sector played in agriculture extension work and recommended that the government should play a more regulatory role to ensure that extension effort is strengthened. One of the ways would be allocation of funds to enhance the training for the agriculture technicians so that they can improve in the areas of identification of pests, natural enemy, diseases, pests monitoring and pests detection coupled with the analysis of ecology in the farmers' field. Training had to include aspects of marketing the crop protection products so that the promotion of products complements the implementation of IPM activities. In the longer term, this would help maintain successful IPM implementation notably when the next generation of

agricultural extension officers was trained in IPM technology at school.

7. Another recommendation for successful dissemination of IPM innovation and technology was the attitude of the agricultural extension officers. Their attitude should gravitate towards a level of possessing a thirst for knowledge, a high level of curiosity and being proactive to try out the new IPM technology and innovation. Top management had an arduous mission to ensure that the recruitment exercise attracted the correct personnel with these attributes and attitude.

8. Another recommendation for the enhancement of the efficacy level of IPM dissemination process was the role of the government. In Malaysia, the government played an integral role in the evolution process of rice from the input stage of seed (quality, disease-resistant, pricing, etc) to endorsing policies on crop protection (pesticides pricing, pesticide subsidies, pesticide registration, enforcement policies on pesticides imports, licensing, registration and control) to the quality of the rice plants, among others.

With a pragmatic view of the forces influencing the efficacy of pest management dissemination, it was clear that efforts to increase IPM implementation were likely to be most effective when there was a coordinated strategy, which was strongly controlled by the government. (Wearing,1988). Hence, the government could enhance their integral role further by instituting a National IPM policy and seize better control over the IPM activities in Malaysia.

5.6 Limitations of the Study

- In Malaysia, there were eight rice granaries, and due to the time and cost constraints of this study, only the largest two granaries were selected, viz. MADA and KADA. This proved to be a limitation as the situation in the other granaries rice growing regions in Malaysia possessed a distinct culture of their own. This was completely overlooked in this study. A fuller and richer picture would have been obtained if the other granaries were included in a study on the IPM system in Malaysia. A profound understanding of the IPM success factors coupled with the ramifications of the impediments to IPM implementation could have been secured.

- Much of the work was based on questionnaire data or interviews which did not provide extensive room for understanding the dynamics of innovation. According to Freeman (1998), longitudinal case studies would enable the researcher to gain a much fuller understanding of the complexity associated with innovation. Hence it was strongly believed that there should be far more emphasis placed on the detailed qualitative approaches to the collection of data to enhance the quality of such research.

- IPM innovation evaluation may be a daunting task as there was the issue of time lag between implementation and results being visible. Additionally, there could be a lack of relevant performance indicators. Short term measurable effects may produce incorrect results notably if the IPM innovation evaluation failed to capture processes that would have led to a much higher level of KAP in the future.

- Currently, there was the traditional approach to IPM implementation called the Technology Transfer Model (Rogers, 1983). This involved a top-down application where scientists would pass their findings on the latest IPM innovation and technology to the agricultural extension officers who would consequently pass them to the farmers to adopt in their rice fields. However, little or no effort was made to study the preferences, attitude and knowledge of the farmers. The scientists felt that their researched and generated new innovations were good for farmers and passed them on to the agricultural extension officers (Chambers, 1983). This model may be too top-down heavy that the farmers did not feel that their feedback was considered or valued. Hence this could be identified as a limitation to this study.

- Another limitation of this study was the lack of information or documentation in the rice granary of KADA. For example, there were no statistics on the level of pest attacks, level of pesticides usage, which were key performance indicators used in the previous chapter to show the status of successful implementation of IPM technology and innovation. Another example was the lack of documentation of the 'minutes' of the meetings conducted at KADA extension office for the period of study.

- The responses received from the interviews may have been biased due to the sensitive nature of some of the interview questions, for example, the attitude of the

agricultural extension officers towards the IPM technology and innovation. Some of their responses could be skewed towards what they felt was the 'right' response so as not to implicate themselves.

- Another key limitation was the focus of this study was on the agricultural extension officers rather than on the rice farmers. The key reason being that they were the drivers behind the IPM technology and innovation dissemination process to the farmers. Hence an assessment had to be made to track their level of knowledge, attitude and practices of IPM. This revelation would spearhead and validate the extent of remedial work that needed to be undertaken to address the 'gap', if any. However, the efficacy of IPM technology and innovation dissemination could be assessed at a different level and angle, if the study was conducted with the rice farmers who were the actual users of the IPM.

Overall, we can state that there were some limitations in undertaking this study and all conclusions drawn from this research should be derived after these limitations were taken into account.

5.7 Future Research

From this research study it was indicated that there was potential for future research to be conducted. Some of the areas could include;

- Research on the socio-economic level of the rice farmers was needed to be further studied, so as to assess the acceptability and applicability of the IPM

recommendations made to them. Detre, et. al.,(2011) also studied on how to increase the profitability of farms and since agriculture is a dynamic process, it would influence the farmers' choice of how best to enhance their farm profitability through the adoption of IPM recommendations. Hence it was important to understand the farmers' perceptions of the pest problems and current practices of pest control, as a pre-requisite to developing an appropriate IPM pest control programme.

- The role biotechnology could play in the future development of strong strains of rice plants giving better yields and also providing better resistance to insects. To endorse this, a new stance was adopted by the scientists at the International Rice Research Institute (IRRI) in the Philippines with the message that high yield agricultural techniques were expensive in terms of agrochemicals usage and negative environmental impact. Instead, they suggested that genetic manipulation through biotechnology could act as a panacea to many of the current agricultural issues. Hence, effort could be expended to research the viability of this suggested solution and its ramifications on the efficacy of IPM dissemination process. This can be achieved, according to Egyir,et. al., (2011), as they recommend the moving away from agrochemical dependency.

- Gibbons et. al., (1994) had suggested changes to the current scientific research model that was riddled with many shortcomings, with a new model as highlighted in Table 5.1 below. In their new model, scientific research could be enhanced and the research output could be more valuable when many aspects of the current

traditional research model were isolated. Some of their suggestions included; having multidisciplinary teams working within a transient structure that allowed mobility of the research teams and faster communication feedback systems to upgrade their current research projects, coupled with speedier decision making done at regional levels rather than at the centralised office. Further research could be conducted to evaluate if this new model could redeem scientific research in the eyes of the users, as it was hoped that results from the research should become succinct, timely and indispensable.

Table 5.1: New Approach to Scientific Research and Acquisition of Knowledge

Current Approach	Future Approach
Traditional, disciplinary science	Multi-disciplinary and participatory
Homogeneity	Heterogeneity of Focus
Hierarchical	Transient structures
Quality control by peers	Quality control through social, economic and political accountability such that there was production of knowledge rather than science
Economy of scale within disciplines	Economy of scope across disciplines such that solutions were beyond any single discipline
Communication through institutional channels of technology transfer	Communications through the involvement of others
Research staff on permanent employment	Research staff are transient, regrouping for particular issues
Management by control	Management by facilitation
Agencies have defined roles and objectives	Agencies have fuzzy boundaries and move in and out of alliances
National and Centralised decision making	Regional and / or catchments-based decision making

- Another potential area for future research would be to discover methods of sustaining the rice industry as there was an issue of migration of the young to the cities and their reluctance to work in the primary sector Snyder and Chern (2008). This area of research was aggravated with the advanced age of the current rice farmers. Future research could present excellent solutions to address this pressing and escalating problem evident in the rice industry.
- Another area of research worth considering was the creation of a 'Code of Best Practices'. Further research could be conducted to discover from all the various

rice granaries in Malaysia and in the Asian region, if there were any specific system of conducting their daily tasks that render that system to be deemed as 'Best Practices'. This could act as a guideline for the rice farmers who were serious in increasing their yields and productivity of their rice farms.

- Wide scale adoption of IPM by farmers and other users of crop protection and pest control products required the collaboration and support of the global crop protection industry with government and non-government organisations. Hence another area of future research could be to investigate the roles played by the international research-based companies, national associations, distributors, dealers and retailers. Was their range of skills in the crop protection industry (e.g. technical, research, development, marketing, education and training), their experience, resources, products and infrastructure, relevant to the goal of transforming IPM into a reality in the hands of agricultural extension officers and farmers? The findings from this research would highlight excellent insights and valuable information to enhance the component members' roles further.

As an overall conclusion, the level of the KAP among the agricultural extension officers from both the rice granaries of MADA and KADA were investigated. The results indicated various factors as being 'drivers' while other factors were classified as 'inhibitors' as indicated in the exploratory framework. Evidence from this study supported the view that for the KAP level of the agricultural extension officers to be enhanced, the facets of the exploratory framework created in this research study, needed to be upheld, notably, the six key variables of top

management support, supportive structure and culture, closely networked social system, good communication channels, strong change agents and early adopters as well as good innovation attributes. Without the presence of these six key variables, the likelihood of improving the efficacy of IPM technology and innovation dissemination is virtually impossible.

The limitations that existed in this study were also raised and numerous recommendations were proposed as to overcome these weaknesses. Some potential areas for future research were highlighted. It was hoped that this study helped to provide new insights into the prevalent situation and gave some guidance as to what issues needed to be addressed urgently so as to ensure the successful implementation of IPM in the Malaysian rice industry. This would then become a stimulant to the agricultural extension officers and encourage them to become truly IPM supportive change agents and early adopters so as to enhance the efficacy of IPM technology and innovation diffusion in Malaysia.