1 INTRODUCTION

1.1 Introduction

The term innovation referred to the newness of products, processes or markets. This newness could be addressed to either, the company (Carlsson, 2006; Johannessen, et. al., 2001), or newness to the market (Liu and Zou, 2008, Cooper, 1993; Kotabe and Swan, 1995; Cooper and Brentani, 1991) or newness to the industry (Motohashi and Yun, 2007). Innovation had been characterised as a process of commercialisation of newly developed products, processes, practices or even markets (Ehigie and McAndrew, 2005; Freeman, 1982; Dickson and Hadjimanolis, 1998; Johne, 1999). With respect to Integrated Pest Management (IPM) innovation, this referred to the use of new chemical, biological, and cultural controls in an organised methodology to maintain the harmony of the ecological environment. It involved a disciplined and knowledgeable approach to reducing the pest population, with emphasis on synchronizing these new approaches with the natural environment to cause the least amount of disruption to ecological systems.

IPM was considered an important innovation in agricultural practice as it provided a solution to a problem. According to Rogers (1995), an innovation in this perspective, needed to be a useful and novel one, rather than being a new idea only. IPM innovation and technology endorsed the diffusion of knowledge and offered solutions to those who were willing to adopt them and make the appropriate changes.

Because of the complexity of the ecological systems, a total elimination of any pest population had proven to be environmentally unsound. The balance of nature was sensitive and intricate, and the manipulation of one variable profoundly affected all other variables. Therefore, the entire system must be regarded holistically, with extreme consideration given to the impact on the delicate interplay within it. So the role of IPM innovation and technology became critical, as it was to enhance the role of the natural regulatory mechanisms in the ecosystem. Its goal was not to eradicate pests entirely but rather to manage the population so that economic damage does not occur. It stressed conservative and accurate application of chemicals, as well as the employment of naturally derived pesticides. This would help crop farmers to produce an economically and socially acceptable yield, coupled with no adverse effects on the physical, human, and biological environment (Passioura, 2007; Teng, 1993).

In addition, the term "pest" as it applied to crop-care could be defined as anything that was unwanted; insects, weeds, fungi or viruses, so a pesticide may be anything that limited this unwanted growth. The term also included herbicides, which were used solely on crops to reduce crop diseases, as well as rodenticides that were used to eliminate rodents in the fields.

IPM innovation and technology employed a highly extensive variety of sophisticated and refined methods, techniques and strategies. The need for such extensive and sophisticated methodology was due to the fact that the balance of nature was sensitive and intricate. IPM also involved a series of approaches that synchronised various crop protection technologies. It was a crop protection system that was based on rational and unbiased information that led to a balance of non-chemical and chemical components, moving pesticide levels of usage away from their present political optimum towards a social optimum as propagated in the context of welfare theory (Pimentel, 2005; Waibel, 1986; Zadoks, 1992).

Among the manifold pest management methodologies prevalent in modern times, the predominant ones included the following; the **chemical controls**, the **biological controls** and the **cultural controls**. A certain altitude of emphasis was made under each of these pest management methods so as to distinguish their individual area of prominence.

One of the key methodologies of IPM encompassed the use of **chemicals** to control pest. IPM asserted that sufficient effort needed to be taken to ensure that a selective and responsible approach towards chemical usage was made (Stern et al., 1959). Even though chemical pesticides seemed to be more efficient, more cost effective and more convenient, however, they could inadvertently create a multitude of complications, such as an abuse of chemical control usage. One of the panacea to this abuse as proposed by IPM was that users of these chemical controls adopted a conservative and accurate application of these chemical controls, as well as ensured that the chemicals employed were of naturally derived pesticides. Through this, the risk of environmental damage would be considerably reduced, and at the same time ensured that there would be effective control over the pest population while using these chemicals.

IPM innovation and technology also encompassed the use of **biological** controls in the natural environment. Biological controls included the introduction of predators, parasites, or diseases into the environment. Examples of predators included ladybugs, praying mantises or tiny wasps called parasitoids. The key purpose of introducing these biological controls was to reduce and control any antagonistic species that may cause severe damage to the crops (Schooler, et. al., 2011; Gallagher et al., 1994). These deadly species could however be eliminated through chemical controls. Through the biological method, unnatural and potentially environment-disruptive agents such as chemical controls could be drastically reduced. Although biological controls may be less intensive than chemical controls, the benefits merited its implementation. Through this IPM methodology, the balance between chemical and biological controls in the environment was attained.

Cultural controls were part and parcel of the IPM innovation and technology. Cultural controls stressed the need for a holistic attitude towards pest management. IPM’s cultural control involved starting with proper plant selection based on the knowledge of a plant's origin, habitat, and environmental requirements. It meant choosing species and varieties that possessed the most resistance and inhibited the rise of potential pest populations, through the use of indicator plants, soil preparation and other techniques. All of these methods worked in conjunction with the natural environment, reducing the need for chemical application or other unnatural and potentially disruptive methods, as recommended under prudent pest management practices (Reganold, 1995; Waibel, 1986).

Overall, IPM innovation and technology employed an extensive variety of methods, techniques and strategies, with consideration to all environmental factors and conditions. It was highly sophisticated and refined, requiring comprehensive knowledge and expertise. Although IPM required more overall thought, foresight and vigilance in dealing with challenges, it could be more effective, cost-efficient and sensitive to the environment in the end. Despite its complexities, IPM was a necessary approach that recognised and appreciated the imperative balance of nature while allowing for manipulation of the environment when needed. This led to the conclusion that the adopters of IPM needed to acquire excellent comprehensive knowledge of IPM and gain a keen expertise on the various methodologies, before they could fully utilise and reap the maximum benefits of IPM.

1.2 The Problem Statement

Chemical dependency in the agricultural industry had its roots in the Green Revolution. International agricultural research centres together with the Food and Agriculture Organization (FAO) in the 1960s had focused on increasing production en masse. The main criticism against the chemical-intensive Green Revolution was that it did not decrease the number of hungry, but in fact, had caused environmental pollution and soil degradation and made farmers including rice farmers, dependent on expensive inputs produced by agro chemical multinationals (February 8th 2010; March 29, 1999, The STAR).

Dr George Hendrichs, head of the Insect and Pest section of the joint FAO and Atomic Energy Agency Division of Nuclear Techniques, declared that pesticides were not the panacea they were thought to be. Not only have they not solved many pest problems, but also, in many cases, the problem became worse because pesticides caused ecological upsets, which gave insects the upper hand, especially when applied in the early stages of the rice crop (October 29, 1997, New Straits Times). This was because the natural mortality and natural enemy abundance usually built up from the early crop stages to mid season (Tilman, 2001; Kenmore et. al., 1984; Fowler et.al., 1990; Heong et al., 1992).

Besides that, more potent ecological damage was accrued with poor pest management practises such as using pesticide sprays. Some of them as exemplified in the research literature included the following;

- the promotion of secondary pest problems (Tilman, 2001; Kenmore, 1980; Heinrichs and Mochida, 1984)
- the disruption in the dominance-diversity relationships of herbivore and predator populations (Bakker and Olff, 2003; Gallagher et. al., 1994; Schoenly, et. al., 1997)
- the shortening of the mean chain length of the food web (Schoenly et. al., 1997)
- and a delay in the build-up of natural enemy populations.

The above mentioned issues had such a powerful adverse effect to the ecological environment that it propelled the researchers to hasten their analysis and findings to recommend a panacea to control the poor pest management practices among the farming community. In addition, the research literature surfaced findings that pesticides were not economically advantageous (Reganold, 1995; Waibel, 1986) and could cause ecological disruptions that encouraged secondary pest problems (Heong and Schoenly 1997). This also led to serious indirect health consequences to farmers (Ho, et.al., 2009; Rola and Pinglali 1993). These findings led to critically important shifts in pest management thinking regarding the role of insecticides. This resulted in the penultimate conclusion that pests were to be critically assessed and proven “guilty” before any pesticide could be applied or used in any way (Way and Heong 1994).

In addition, the literature revealed that when the intensive monoculture of growing high- yielding crop-variety was introduced, there was a massive switch to high-usage levels of fertilisers and this made adoption of pesticides a cost-effective choice. More and more emphasis was being placed on reaping profits as soon as possible, irrespective of internationally recommended prudent pest management practices. Farmers continued to rely heavily on pesticides which they applied routinely on their crops to ensure high yields. However, the situation acerbated when the farmers indiscriminately used the pesticide sprays even when pest damage was only slightly visible. This marked the rise of the usage of pesticides among the farming community which was totally in violation of prudent pest management practices which were vehemently propagated by the technological experts in food production. With alarming disappointment, the technological experts concluded that the usage of pesticides had still not reduced to the desired recommended levels.

Due to the existence of a glaring gap between IPM knowledge as researched and publicised by the technological experts versus the adopted pest management practices by the crop farmers, an attempt was mooted in this research to identify and highlight some of the underlying reasons for this prevalent ‘gap’, coupled with the intention of securing an in -depth understanding of the struggles faced by the key stakeholder in this research, viz., the agricultural extension officers. The key role of the agricultural extension officers was to explain the theory and practice of IPM innovation and technology as well as to disseminate the IPM technological research and innovation of pest management practices to the farming community, who were the executors or users of the IPM recommended prudent pest management practices.

Some of the underlying reasons for the prevalent gap were;

1.2.1 The Role of the Agrochemical Organisations

In the 1970's era, agrochemical organisations played a vital role in the development of pest management practices, such as the sponsoring of chemical-oriented research. These research findings influenced the decision making process of commercial institutions as well as public institutions, with respect to various pest management practices, notably with the level of usage of chemical-based pesticides. Consequently, these agrochemical organisations promoted prophylactic use of chemical-based pesticides in rice production (Shetty, 2004; Rossiter, 1975). This was witnessed when farmers were encouraged by these agrochemical organisations to use pesticides as necessary inputs by granting them government subsidies, agricultural loans and insurance schemes, all aimed at reducing the costs to be incurred from the purchase of chemical-based pesticides (Tilman, 2001; Kenmore et. al.,1987; Conway and Barbier, 1990; Conway and Pretty, 1991).

1.2.2 Issue of Operationalising the Research Findings

Farmers and agricultural extension officers were unable to easily absorb or translate into reality the IPM research findings as discovered by the technological experts. These experts worked in their laboratories and studied methods and ways of improving the yield of the crops while at the same time, trying to reduce the usage of chemical-based pesticides. Another key reason for the crop farmers' inability of operationalising the research findings was that the IPM procedures developed by these researchers were too sophisticated and complicated for these simple-minded crop farmers (Matteson, 2000; Goodell 1984). These crop farmers would initially need certain skills and knowledge in a myriad of areas, such as taxonomy, diagnosis, measurements and ecology before they could embark on appreciating the technology experts' research efforts and then utilising the research benefit for themselves and on their crops.

1.2.3 Decision-Making Skills of the Crop Farmers

The farmers were the ultimate pest management decision makers who were heavily dependent on the guidance of the agricultural extension officers' knowledge, as to the selection of the "best mix of pest controls". This was critical as there was no single pest control method that would be successful over a long period of time (Tilman, 2001; Kenmore et. al., 1984). The farmers had to perform an analysis of a number of factors including their crop and farm conditions, before they could make a decision as to the choice of the most appropriate control measures that were to be utilised. Some of the other pertinent factors that were to be considered in the crop farmers' analysis included; the nature of the pest attack, the damage it caused, the range of protection measures and the information available (Ho, et.al., 2009; Rola & Pingali 1993). All this proved to be a daunting task for the crop farmers.

1.2.4 Research Laboratory Focused

IPM research and development of new technology by the technology experts used the 'technology push' approach when undertaking the research, rather than solving the crop farmers real problems (Matteson, 2000; Conway and Barbier, 1990). Although the new technology worked well in the laboratory and exhibited excellent results under controlled conditions, the research findings fared poorly when executed in the crop farmers' fields as the IPM research findings were too laboratory focused (Birch, et. al., 2011; Foster, et. al., 1996).

1.2.5 Skills in Computing Economic Threshold Levels

According to Heong et al., (1994), a critical underlying philosophy of successful IPM implementation, was that crop pests needed to be controlled only when their pest populations reached the economic damage level or commonly known as the economic threshold. Pandey (1990) defined the economic threshold to be the level at which the pest population produced incremental damage equal to the cost of preventing the damage through prudent pest management practices. Below that pest population density or economic threshold, the cost incurred in using pest control measures, exceeded the value of losses from the damage done by the pests.

According to Naylor, et. al., (2007) and Pingali (1992), when such a situation arose, then no pest management intervention should be taken at that low density level. Matteson (2000) and Norton (1993) reiterated that crop farmers found great difficulty in understanding the ramifications of the economic threshold level computations, despite the coaching provided by the agricultural extension officers. The crop farmers had the burden of ensuring that their calculations were accurate as it validated their decision-making process of whether to use pest management practices to counter-attack the pests, as these interventions would incur additional costs.

1.2.6 Crop Farmers Socio-Economic Issues

Studies related to issues faced by the rice farmers revealed that their socio-economic position was relatively more critical to them as compared to the pest management innovation and technology adoption (Normiyah et al., 1995). This study also revealed that the rice farmers strongly agreed that prudent pest management practices were genuinely warranted, and this could be achieved through a good understanding of the biological and ecological processes of the agro-ecosystem. However, in comparison of these two factors, their socio-economic status was even more critical to them. This led to the conclusion that the agricultural extension officers' efforts in upgrading the IPM knowledge and adoption of prudent pest management practices among the farmers would be mitigated, unless these critical socio-economic issues as perceived by the rice farmers were first addressed. Some of the critical socio-economic farmer issues that were hampering the agricultural extension officers' IPM diffusion work included;

The need to instil a new perception or 'mindset' to adopt more economical property management systems as this would lead to an increase in crop yield, and consequently improve their socio-economic status. According to Prof Abdul Aziz Abdul Rahman, Director of the Centre for Policy Studies in Universiti Putra Malaysia, he highlighted that "smallholdings are, by and large, uneconomic holdings which lack; scale economies, good management, agronomic skills and the capacity to commercialise". Effort needed to be undertaken to alleviate this critical socio-economic imbalance among the rice farmers in Malaysia, notably among the rice-farming community. Malaysia's aim of not having to import rice by 2015 may be realised when two major rice-growing areas of the Muda Agriculture Development Authority (MADA) and Kemubu Agriculture Development Authority (KADA) can raise production by between five per cent and 10 per cent. This view was expressed by the Agriculture and Agro-Based Industry Deputy Minister Datuk Wira Mohd Johari Baharum. He also reiterated that Malaysia was importing 30 per cent of its needs for rice or 700,000 tonnes from other countries annually. "If we can increase rice production in the two major areas (MADA and KADA), I am confident we don't need to import rice by 2015" (Bernama, February 8th 2010, The STAR).

a. The above mentioned socio-economic issue of the rice farmers was further exacerbated when it was discovered that their farms were dispersed widely. This made it virtually impossible to integrate them into bigger, more economical co-operative farms. As a result, these farms were victims of a downward spiral, viz.,

- Becoming uneconomical in size and producing low yields, it started to sentence the rice farmers to a life of poverty, such that their children opted out of farming. This led to the ageing crop farmers to become even less productive and eventually they abandoned the land and left it idle (Tuesday, January 5, 1999, The STAR).

b. Another critical socio-economic issue that the crop farmers faced was the fact that a large majority of their productive rice farms were on the fringe of populated towns. The crop farmers were pressured into converting their farmlands to residential or commercial land, as this proved to be an irrefutable lucrative option. In Malaysia, more than one million hectares of agriculture land remain idle, as the farm owners have found a more lucrative source of income, without tilling their land, but by either selling their farm lands or by renting them out. (Tuesday, January 5, 1999, The STAR).

1.2.7 Ambit of IPM Research

Besides the socio-economic issues of the crop farmers, notably, rice farmers, another concern of the agricultural extension officers was the ambit of IPM research conducted by the technology experts. A good majority of such research have been criticised as being directed towards prescribing general solutions as opposed to addressing the critical needs of the crop farmers, notably the rice farmers. These rice farmers faced locality-specific problems, to which no panacea was forthcoming from the technology experts (Heong & Escalada, 1997). This led to an inexcusable mismatch or a gap between the providers of IPM knowledge from the technology experts and the end-users of the IPM technology, viz. rice farmers through the agricultural extension officers.

1.2.8 Lack of Appropriate Infrastructure

In many situations, the newly researched and formulated IPM technology and innovations could not be adopted quickly by the end-users, that is, the rice farmers, due to the lack of capital or lack of supporting infrastructure. These were critical to the agricultural extension officers, notably to enable them to facilitate the smooth diffusion of the latest IPM prudent pest management practices to the rice farmers (Heong, 1996).

1.2.9 Crop Farmers' Lack of Good Agronomic Practices

One of the key pinnacles of IPM technology as advocated by the technology experts was to promote healthy and bountiful yields using good soil. Among the myriad of agriculture techniques existing, there was no technique that was superior to the power of good soil. To ensure soil's long-term fertility, the soil should be devoid of any type of pollution such as pollution through fertilisers, herbicides or pesticides. All these agrochemicals would cause harsh effects to the soil by depleting the soils' natural nutrients. One of the biggest hurdles for the agricultural extension officers was to convince the rice farmers to eliminate the use of agrochemicals. A further challenge being faced by the agricultural extension officers was to enable the rice farmers to adopt sustainable good agronomic practices.

As a conclusion, the above discussion was indicative of an exploration of some of the key issues that had brought about a glaring gap between IPM knowledge and prudent pest management adoption, as researched and proclaimed by the technological experts. In the 1990's era, a mounting interest in rice farmers' pest management decision making was indicative that IPM innovation and technology adoption was far from optimal. This concern was exacerbated with the increasing demand for rice in the world economy, notably in Asia, where the rice production levels were not keeping pace with the rapidly increasing population rates. These concerns were validated in the studies conducted by Birch et. al., (2011), Shetty (2004), Matteson (2000), Tilman et. al., (2001), Heong et al.,(1994) and (1995) and Escalada and Heong (1993). These studies revealed that the rice farmers did not adopt the IPM technology because they still perceived or believed that the adoption of the new pest management innovation and technology were unlikely to bring about any economic returns to them.

This was also evidenced in the findings as published by Lim & Heong's study (1994), where the rice farmers' pattern of poor pesticide usage, such as indiscriminate insecticide sprays, did not change significantly in the last 10 years. Hence, this current research was mooted to investigate some of the key underlying issues that have led to the gap and to study the reasons behind these underlying issues.

1.3 Research Objectives

An understanding of some of the obstacles that had created the gap between the rice farmers' IPM knowledge and its translation into adoption of IPM innovation and technology, as described in the previous section, led to the development of the research objectives for this study.

The general objective of this study was to;

> To identify the multiple factors as exemplified in the literature that would help to facilitate the successful diffusion or adoption of IPM technology and innovation to the end-users. Hence the multiple factors became the key variables of this study that played an influencing role for the successful diffusion of IPM innovation and technology.

Consequently, this general objective was then refined into specific objectives. The specific objectives of this study zeroed in on the six factors as identified from the literature review that had an impact on the successful diffusion of IPM innovation and technology. However, it became apparent that the successful diffusion of IPM innovation and technology was heavily influenced by the role played by the agricultural extension officers. These officers were trained experts in knowledge transfer and learning facilitation who were able to pass on systematic knowledge to the rice farmers. They were not only knowledge managers drawing on science-based research but also change agents, fostering the desire for knowledge transfer through organised workplace learning (Cash, 2001; Ebun-Cole, 1992; Rogers, 1993). In order to fulfil their tasks effectively, they needed a high level of IPM knowledge, a supportive attitude and good IPM practices so they could facilitate and upgrade the farmers' knowledge on the latest IPM innovation and technology.

Additionally, Green & Hevner (2000) researched and concluded that a positive correlation existed between the knowledge, attitude and practices (KAP) with the successful diffusion of technology and innovation adoption. Hence in this research, the KAP of the agricultural extension officers became the determining variable that was being influenced by the six key variables and subsequently it influenced the performance indicators.

As a summary, the specific research objectives in this study highlighted the six variables, viz., the role of top management, the structure and culture, the social system, the communication system, the role of intermediaries and the innovation attributes. These specific objectives were formulated as follows;

- To determine if top management provided its commitment towards IPM with respect to financial resources, leadership and their commitment to augment the level of knowledge, attitudes and practice (KAP) of the agricultural extension officers, as they were the front-liners to the end-users, namely the rice farmers.
- To determine if the organisational structure and culture in their respective organisations supported the agricultural extension officers acquiring an understanding of new IPM innovation knowledge so as to promote their level of KAP.
- To determine if the social system, comprising the various inter-related organisations needed for the complete support of the IPM innovation diffusion helped to boost the KAP of the agricultural extension officers such that they increased their momentum on the diffusion process of IPM to the farmers.
- To determine if the communication system within their respective organisations, that is, MADA and KADA, was sufficiently supportive to amplify the KAP of the

agricultural extension officers such that they were able to deploy the IPM diffusion process well, to the farmers.

- To determine if the role of the intermediaries' (the change agents and the 'early adopters' or farmer leaders) was enhanced such that they accelerated and facilitated the IPM innovation adoption process.
- To determine if the attributes of the innovation assisted in improving the process of facilitating the smooth diffusion process of IPM to the farmers level.

In addition, the determining variable, the KAP level of the agricultural extension officers was formulated into another specific objective, as follows;

- To determine if the KAP of the agricultural extension officers was at a favourable level that it helped to facilitate the successful diffusion of IPM innovation and technology, as measured by the performance indicators

Based on the above discussion, a conceptual framework was modelled and utilised in this study of the two largest rice granaries in West Malaysia, viz., Muda Agricultural Development Authority (MADA) in the state of Kedah and Kemubu Agricultural Development Authority (KADA) in the state of Kelantan. This framework would become the basis for the research methodology developed and the foundation for the research instrument designed for this study. This conceptual framework was further elaborated under section 2.7

1.4 Significance of the Study

According to Lim and Heong (1994), rice farmers' decision making which was based heavily on farmers' underlying beliefs, have remained largely unchanged in the last 10 years. Additionally, since IPM was not simply a single decision rule but rather a set of inter-linked concepts, farmers' decisions were hampered by a large knowledge gap between what farmers knew or perceived and what farmers needed to know in order to make effective pest management decisions that were beneficial to them. Heong et. al., (1994) posited that IPM adoption by the farmers should not be viewed as a binary variable (adopt/not adopt) with a fixed effect on input demand or on production efficiency. Rather, IPM knowledge should be viewed as a dynamic continuum, implying a more complex relationship between knowledge acquisition and farmer practice. Therefore, there was a critical need to move from philosophy to reality, notably in IPM research and implementation of IPM innovation and technology.

In order to improve pest management practices and adopt IPM innovation and technology, there was a need for policy makers, researchers and adopters of IPM innovation to address issues related to poor pest management practices and initiate a re-engineering process. This led to a critical review of;

- the various organisations related to improving pest management adoption practices in Asia, such as; the IPM extension departments, namely, the IPMNet, the NGOs and the Farmers' Cooperatives. Their primary duty was to diffuse the findings from the research conducted by the International Rice Research Institute (IRRI), universities, national research institutes and the private sector; to the farmers through the agricultural extension officers.

- the internal organisational structures, the internal process structures, the usability of the latest innovation products by the farmers and the diffusion processes utilised by the agricultural extension officers.

The significance of this study was in line with Matteson's study (2000), where he felt that the new thinking in IPM was to empower farmers with decision-making knowledge and skills. He believed that farmers held one of the keys to enhancement of pest management processes, as pest problems were season specific and required micro level decisions. No single pest control method could be successful over a long period of time and therefore farmers needed to be educated so they would be able to make better decisions by selecting "the best mix of controls" (Dasgupta, et. al., 2007; Kenmore et. al. 1984). There was a need for individual farmers to make their own decisions on how to handle each problem as it arose. They had to be equipped with the knowledge and required skills, to enable them to take the appropriate action that would be beneficial to the ecosystem as well as to their productivity and welfare.

With this approach in mind, IPM would not only enhance the role of the natural regulatory mechanisms in the ecosystem, but would also help rice farmers produce an economically and socially acceptable yield with no adverse effects on the physical, human, and biological environment. Consequently, armed with a good understanding, effective solutions could be coined up to address and tackle any difficulties, to ensure that the final recipients of the IPM innovation, viz., the rice farmers, would reap the maximum benefits from the technological advancements in IPM.

1.5 Scope of the Study

The focus in this study was diverted from the rice farmers to the extension agents, viz., the agricultural extension officers from the two largest rice granaries in Malaysia, i.e., MADA in Kedah and KADA in Kelantan. The key reason was that extensive research had been conducted on rice farmers, studying their KAP and issues faced by them in implementing or adopting IPM technological advancements. Many key researchers studied the insect management beliefs and practices of rice farmers in China (Huang et. al., 2005) ; Heong, et. al.,(2002) in Laos; Joshi, et. al., (1986) whose study focussed on the golden apple snails in The Philippines; IRRC (2007) that studied the measurement of site specific nutrient management; Leitao et.al., (2007) that analysed spatial and temporal variability in Mediterranean rice fields; PETRRA (2004) that researched on the issue of poverty elimination through rice research assistance for the rice farmers ; Ros et.al., 1997, who studied the effect of nursery applications on rice among the farmers, among others. The conclusions drawn indicated that the success rate of farmers implementing IPM had been disappointing or far from the optimal level. In many cases, farmers did not adopt IPM because they perceived that the practice could not benefit them (Dasgupta, 2007; Ricker-Gilbert, 2008).

Hence, in this research the focus was diverted from the rice farmers to the agricultural extension officers, even though this proved to be a limitation to this study, as the final adopters of the IPM technology and innovation were the rice farmers. This study was skewed towards the agricultural extension officers because they played a key role in the successful dissemination or diffusion of

IPM and effort had to be expended to study the same problematic IPM issues at the level of the agricultural extension officers.

Moreover, this was in line with the concept of social capital and the notion that social relationships between the agricultural extension officers and the rice farmers had value. One of these values was the stock of active connections between the rice farmers and the agricultural extension officers. This stock would lead to trust, mutual understanding, shared values and behaviour that helped to bind the rice farmers and the agricultural extension officers to make cooperative action possible (Putnam, 2000; Cohen and Prusak, 2001). In addition, the agricultural extension officers would highlight and take effective action if any bottle-necks surfaced in the IPM innovation diffusion process.

1.6 Organisation of Chapters

Chapter 2 provided details of the literature review examined regarding the six key variables highlighted in the theoretical diffusion models. From the literature analysis, we were able to identify the various factors that facilitated or impeded the successful implementation of the IPM innovation. Some of the issues examined included; the structure of the organisations under which the IPM innovation was facilitated, the type of business environment in which the IPM innovation was diffused, the perceived success factor of the IPM innovation itself, the KAP of the agricultural extension officers towards the IPM innovation, among others.

Additionally, an attempt was made to develop a conceptual framework that would facilitate our understanding of the multiple issues that endorsed the diffusion of IPM innovation with success.

In Chapter 3, an attempt was made to describe the exploratory research methodology process that was employed to assemble the information required to build up this research. Some of the contents of this chapter included; the research questions being studied, a description of the research instrument used to collect the information from the respondents, the multiple methods utilised to collect information in this exploratory research. Additionally, the time-line was also described, viz., the initial interview period of 2001 and the subsequent interview period of 2007. The latter set of interviews had an aim of securing an update on the two rice granaries, MADA and KADA, with respect to the latest developments on the IPM innovation and technology adoption success, so that a comparative analysis could be made, after a period of 6 years.

Chapter 4 offered a summary of the regional areas identified to be the case-study subjects for this research study, viz., MADA (Muda Agricultural Development Authority) and KADA (Kemubu Agricultural Development Authority) coupled with an analysis of the information collected from the respondents of the MADA and KADA rice granaries. In addition, this chapter displayed the results from the exploratory research from the two granaries with respect to the 6 key variables under study and also the KAP of the agricultural extension officers, which was treated as the determining variable that was influencing the performance indicators of IPM success.

Chapter 5 indicated the general conclusions drawn from the study and highlighted the limitations as well as presented some proposals and recommendations for enhancing the success of IPM innovation diffusion. Some suggestions of potential future research areas, with the objective of enabling greater success in the implementation and adoption of the IPM innovation and technology, were also provided.