The Adoption of Sustainable Agricultural Practices:

An Integrative Approach for Malaysian Vegetable Farmers

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Abstract

Sustainable agricultural practices (SAPs) have been promoted as a mechanism for improving sustainable development in agriculture. Their adoption, however, has been low in many countries. Motivated by this phenomenon, a better understanding of the adoption of SAPs is provided in this thesis, using the Malaysian vegetable production sector as a case study.

This thesis is guided by an integrative framework encompassing the theory of interpersonal behavior and the theory of diffusion of innovation. Consistent with the literature, this framework addresses adoption as a complex behavior, which develops from both economic and psycho-social considerations. Applying this framework, focus groups were conducted to explore research hypotheses, and to assist questionnaire design and survey operations. The subsequent questionnaire was used to interview 1,168 randomly selected vegetable farmers from all five regions in Malaysia.

Confirmatory factor analysis indicates that farmers' perceptual structure was built by four attributes of SAPs: relative advantage, compatibility, complexity, and trialability. Guided by their relative importance, extension efforts can be designed accordingly. Among these attributes, relative advantage was rated poorly. This requires corrective measures since excellence in the core attribute is the key to convincing potential adopters. These corrective measures may include education on SAPs' agronomic and economic potentials, marketing sustainable produce as a premium product, and financial incentives.

Structural equation modeling of the overall framework shows that adoption was determined by both economic and psycho-social considerations. As no single aspect offers the best explanation, a wider understanding is necessary prior to policy development.

Nevertheless, the economic aspect seemed more influential. Thus, policy and research efforts should pay attention to the economic motivations underpinning adoption in SAPs' promotion.

Focusing on the economic aspect, logistic regression reveals that adoption depended on a range of socio-economic, agro-ecological, institutional, informational, and psychological factors as well as the perceived attributes of SAPs. Policy understanding in this regard should, therefore, be multidimensional. Additionally, the more influential factor was the resource distribution across geographical locations, followed by financial capital, workforce size, information usefulness, ethnicity, and the perceived relative advantage of SAPs. Such relative importance informs a knowledge base for guiding policy emphasis, such as promoting SAPs to prioritized places and segments through tailored information, education, and financial measures.

A two-stage regression model highlights that the use of intercropping and organic fertilizers/composts resulted in greater farm profits, as these SAPs are more effective in cost savings and productivity than other SAPs. Such evidence suggests how policymakers can design an economically attractive package of SAPs for potential adopters to increase adoption rates.

Overall, the findings of this thesis suggest a strategic extension plan for advocating SAPs. Profitable SAPs form an economically attractive package of products. Underperforming attributes require educational and promotional efforts to aim at improving performance realistically or perceptually. Characteristics of potential adopters identify productive segments and targets. Geographical endowments (e.g., uplands/lowlands, regions) and information sources favoring adoption depict places on which to focus.

Declaration

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List of Abbreviations

ASEAN	Association of Southeast Asian Nations
ASI	Adelaide Scholarship International
AVE	Average variance explained
CAP	Conventional agricultural practice
CAT	Coding analytical toolkit
CETDEM	Centre for Environment, Technology & Development, Malaysia
CFA	Confirmatory factor analysis
CFI	Comparative fit index
CR	Construct reliability
DOA	Department of Agriculture
DOI	Diffusion of innovation
FAMA	Federal Agriculture Marketing Authority
FAO	Food and Agriculture Organization of the United Nations
FGD	Focus group discussion
GAP	Good agricultural practice
GFP	Gross farm profit
GOF	Goodness-of-fit
IPM	Integrated pest management
MAFC	Malaysian AgriFood Corporation
NGOs	Non-governmental organizations
PhD	Doctor of Philosophy
RMSEA	Root mean square error of approximation

SAPs	Sustainable agricultural practices
SC	Standardized coefficient
SEM	Structural equation model
SEU	Subjective expected utility
SPSS	Statistical Package for the Social Sciences
ST	Structuration theory
TIB	Theory of interpersonal behavior
TLU	Tropical livestock unit
TPB	Theory of planned behavior
TRA	Theory of reasoned action
UC	Unstandardized coefficient
UMS	*Universiti Malaysia Sabah*
UNAPCAEM	The United Nasions Asian and Pacific Centre for Agricultural Engineering and Machinery
UPM	*Universiti Putra Malaysia*
UNCED	United Nations Conference on Environment and Development
USA	United States of America
WSSD	World Summit on Sustainable Development
χ^2	Chi-square
R^2	R-square

Chapter 1: Introduction

ABSTRACT

This chapter provides the motivation for investigating the adoption of sustainable agricultural practices (SAPs), using the Malaysian vegetable production sector as a case study. Though many attempts have been made to understand why the adoption rates of SAPs are low, there remain four research gaps. Responding to these, the objectives of this thesis are: (1) to assess the structure of perceived attributes of SAPs; (2) to investigate both economic and psycho-social factors influencing the adoption of SAPs jointly; (3) to identify the relative importance of factors influencing the adoption of SAPs; and (4) to examine the relative impact of adoption of SAPs on farm profitability. The outcomes will produce an improved understanding of farm-level adoptive behavior, thereby providing refined policy guidance for augmenting the adoption of SAPs.

1.1 INTRODUCTION

Improving agricultural sustainability is one of the most important goals for the near future (WSSD 2002; FAO 2002; UNCED 1993). Though prevailing agricultural practices are the key to food security, some of them are considered unsustainable. For example, monocropping is the economically efficient practice of growing a single crop on the same land overtime. It degrades soil quality and increases crop vulnerability to pest outbreak. Therefore, monocropping may be productive in the short term, but its long-run result is an increased dependency on synthetic fertilizers and pesticides (Clay 2004). Such non-renewable inputs are designed for plant growth and crop protection; they cause negative externalities when

used excessively and inappropriately. Excessive use of synthetic fertilizers degrades soil pH, topsoil, soil humus, and water retention ability and restrains plant absorption systems from getting the nutrients necessary for human health (Batie and Taylor 1989). Such degradations intensify soil compaction, soil erosion, and food nutrition problems. Inappropriate application of synthetic pesticides disrupts pest resistance and attracts new pests (Georghiou and Saito 1983). As a result, more applications or new pesticides are needed for pest control, exposing farmer health and food safety to higher risk. In addition, both synthetic fertilizers and pesticides are prone to runoff and leaching. Biodiversity, the environment, and water quality are reportedly depleted and public health is being jeopardized (Siebert et al. 2010; Ommani and Noorivandi 2003; Robinson and Sutherland 2002).

The previous discussion suggests that unsustainable agricultural practices are problematic. At farm level, they reduce soil and crop quality and endanger farmer health. When these factors are negatively affected, so is farm productivity (Antle and Pingali 1994). At off-farm level, water pollution and food contamination comes with substantial environmental and health care costs, respectively (Pimentel et al. 2005). These issues are further intertwined with food security and poverty issues (Altieri 2002; Tait and Morris 2000). Therefore, a formidable case is generated for realizing sustainable agricultural development.

The need for sustainable agricultural development has become a national and international agenda. According to FAO (1995), sustainable agricultural development is defined as "the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations." This agenda attracted international socio-political attention in the Millennium Ecosystem Assessment (2005) and the International Assessment of Agricultural Science and Technology

for Development (2008). It has also stimulated blueprints emphasizing a balance between environmental wellbeing with productivity exploitation in both developed and developing countries. In that direction, relevant policies aim to change farmer behavior in voluntarily adopting sustainable agricultural practices (SAPs).

1.1.1 Sustainable agricultural practices (SAPs)

SAPs are environmentally non-degrading, resource conserving, socially acceptable, technically appropriate, and economically viable (FAO 1995). In general, SAPs are directed to the efficient use of natural resources. Cutting down reliance on synthetic inputs minimizes environmental and social externalities. Adoption of conservation tillage, cover crops and mulches, as well as organic fertilizers and composts intensifies crop production in part due to increased retention of organic matter and decreased risk of soil erosion (Chan and Pratley 1998). Use of intercropping, crop rotation, and integrated pest management (IPM) enhance crop protection partly because of the disruption of pest cycles and reduced thread of pest outbreaks (Taylor et al. 1993). While these are just some examples, SAPs are clearly seen as offering versatile benefits and, at the same time, promoting productivity and sustainability.

The promotion of SAPs has been tailored to reflect the particular locales of individual regions or countries. For example, in response to the European soil degradation issue, conservation tillage, cover crops and mulches, and crop rotation have all been packaged under the label ‘conservation agriculture’ by the European Conservation Agriculture Federation (Knowler and Bradshaw 2007). These conservation practices and other sustainable practices (e.g., intercropping, organic fertilizers and composts, IPM, precision technologies, and waste-nutrient and water-related systems) are known as ‘best management practices’ to overcome general production-based sustainability issues in the United States

(Baumgart-Getz et al. 2012; Prokopy et al. 2008). In that general context, these practices have been promoted as SAPs in other countries (e.g., Malaysia).

1.1.2 Current state of sustainable agricultural practices (SAPs)

Adoption rates of SAPs have been low in both developed and developing countries (see Table 1). Developed countries are among the pioneers in the structural promotion of SAPs. However, the U.S. best management practices have been reportedly used in a limited fashion (Caswell et al. 2001; Prokopy et al. 2008; Rodriguez et al. 2009; Baumgart-Getz et al. 2012; Reimer et al. 2012); the Australian adoption trend has been described as slow in many regions (D'Emden et al. 2006, 2008); other European countries have not witnessed more than 10% of their farmland being cultivated using SAPs (FAO 2011).

Widespread use of SAPs has not eventuated in developing countries. African countries have had little success in their SAPs promotion (Ndaeyo et al. 2001). Some South American countries have shown relatively positive development, but their progress remains unsatisfactory. Though official statistics are not available for Asian countries, similar observations have been noted by researchers: Iran (Karami and Mansoorabadi 2008), Pakistan (Sheikh et al. 2003; Hussain et al. 2011), the Philippines (Lapar and Pandey 1999; Lapar and Ehui 2004), and Malaysia (Mad Nasir et al. 2010).

To this end, the observed levels of SAPs adoption have not sufficiently justified billions of dollars and significant effort that have been devoted to promoting their benefits. Policymakers have expressed disappointment, and have pleaded to understand the phenomenon (Pannell et al. 2006). Therefore, the motivation for this thesis is the potential for greater understanding of farmer behavior within which SAPs adoption decisions are being made. Using the Malaysian vegetable production sector as a case study, opportunities will be

revealed to increase the extent of SAPs adoption in the country, thereby having broad implications for other countries, especially developing ones.

Table 1. Adoption of sustainable agricultural practices (SAPs) in selected countries

Countries	2007/08*	Countries	2007/08*
North America		*South America*	
Canada	25.85	Chile	10.45
The United States of America	15.31	Venezuela	8.96
Europe		Mexico	0.08
Finland	8.83	*Asia and the Pacific*	
Kazakhstan	5.7	Australia	38.31
Spain	3.76	New Zealand	31.03
Germany	2.93	*Africa*	
Switzerland	2.08	South Africa	2.38
Portugal	1.5	Kenya	0.57
France	1.04	Ghana	0.41
Italy	0.82	Zimbabwe	0.39
Slovakia	0.71	Mozambique	0.19
United Kingdom	0.39	Tunisia	0.16
Ukraine	0.3	Sudan and South Sudan	0.05
Hungary	0.17	Lesotho	0.04
Ireland	0.01	Morocco	0.04

Note: *Percentage of total area planted using conservation tillage, cover crops, and crop rotation

Source: FAO (2011)

1.2 BACKGROUND

Malaysia (Figure 1) is made up of two split landmasses: Peninsular Malaysia and East Malaysia. Its 13 states and three federal territories form five regions, four of which are in Peninsular Malaysia and one in East Malaysia: (1) the East coast region (Kelantan, Pahang, and Terengganu), (2) the Northern region (Perlis, Kedah, Pulau Pinang, and Perak), (3) the Central region (Selangor, Negeri Sembilan, and federal territories of Kuala Lumpur and

Putrajaya), (4) the Southern region (Melaka and Johor), and (5) the Eastern region (Sabah, Sarawak, and the federal territory of Labuan).

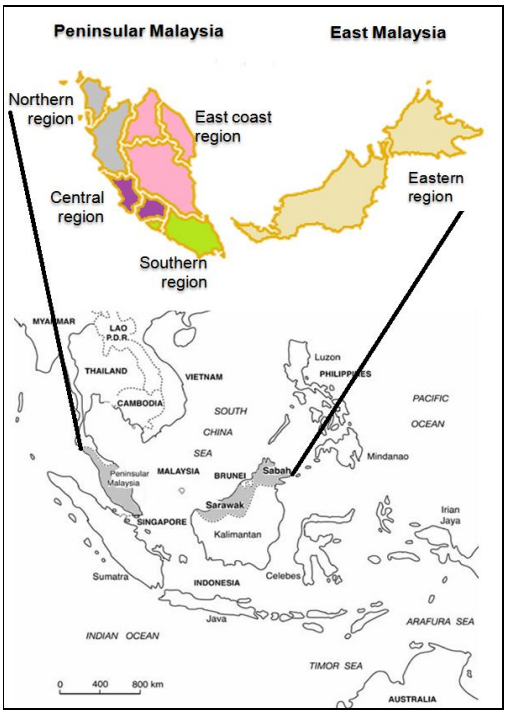


Figure 1. Map of Malaysia

Source: Adapted from Kaur (2004)

1.2.1 The Malaysian vegetable production sector

As a tropical country, Malaysia has an average temperature ranging from 23°C to 32°C (Asadi et al. 2011). Given this climatic variability, tropical types of vegetable are planted in the lowlands and temperate ones are cultivated in the uplands. Altogether, about 50 types of vegetable are grown commercially (Nik Fuad et al. 2000). The seven most popular types are chili, cucumber, cabbage, long bean, spinach, corn, and mustard (Ministry of Agriculture and Agro-Based Industry 2011a).

The vegetable production sector plays an important role in the Malaysian economy. It is an income source to some 46,000 farmers (Ministry of Agriculture and Agro-Based Industry 2010). According to the Ministry of Agriculture and Agro-Based Industry (2011a), vegetables are planted across all regions, producing about 870,300 metric tons from approximately 52,800 hectares of farmland in 2010. Part of the production, which was valued at RM487.65 million (US$162.55 million), was exported to ASEAN (Association of Southeast Asian Nations) countries. On the other hand, Malaysia imported some RM334.52 million (US$111.51 million) of vegetables from the same sources. This was because locally marketed vegetables met only 41 percent of domestic demand or fulfilled 22.6kg out of 55kg per capita consumption. Moving forward to 2020, its production is targeted to be doubled and fulfill 68 percent of domestic demand (Ministry of Agriculture and Agro-Based Industry 2011b). However, lying ahead are sustainability-related challenges to the development of the Malaysian vegetable production sector.

1.2.2 Sustainability issues in the Malaysian vegetable production sector

In the Malaysian vegetable production sector, the main challenge to sustainability concerns soil erosion (Taylor et al. 1993; Midmore et al. 1996; Freeman 1999; Nik Fuad et al. 2000; Faridah 2001). Most vegetable farms operate on open farming (Aminuddin et al. 2005). Their field preparation involves land clearing and earthwork. Because farmlands are not covered, soils are prone to erosion. Moreover, farmlands are used intensively, with two to three cropping cycles a year (Ministry of Agriculture and Agro-Based Industry 2011b). After the preceding cycle, farmlands are immediately prepared for the next cropping cycle. Such exhaustive use of farmlands increases soil erosion. Other factors contributing to soil erosion include heavy rainfall, land slope, and the interception of rain-shelter.

Another critical challenge to sustainability is related to the negative effects of intensive farming methods used in the Malaysian vegetable production sector (Barrow et al. 2010; Aminuddin et al. 2005; Barrow et al. 2005; FAO 2004; Zainal Abidin et al. 1994). Commercialization of vegetable cultivation has made synthetic fertilizers, pesticides, and herbicides necessary to sustain crop yields. In the decision-making about soil maintenance, crop protection, and weed control, local farmers always face difficulties in determining the types, frequency, and quantity of inorganic fertilizers, pesticides and herbicides, respectively (Taylor et al. 1993). Consequently, these inputs are often applied inappropriately.

Both of the abovementioned sustainability issues have caused some serious negative externalities. Soil fertility and water quality are degraded due to soil erosion (Midmore et al. 1996). Eroded soil collectively leads to silting of irrigations. Soil and river systems are contaminated resulting from the runoff and leaching of synthetic fertilizers, pesticides, and herbicides (Barrow et al. 2010). These events often serve as the inciting cause of greater application of various unsustainable production practices. Such excessive application exposes their users (farmers) to health hazards and risks consumer health with residue contamination on fresh produce (Wan Abdullah et al. 2005). While these are just some examples, there are more externalities associated with unsustainable production practices in exchange for productivity. Nevertheless, it is clear that the negative externalities of unsustainable production practices have serious impact on agricultural sustainability and corrective measures are vital.

1.2.3 Promotion of sustainable agricultural practices in the Malaysian vegetable production sector

In response to various externalities, there has been a concerted effort to promote sustainable development in the Malaysian vegetable production sector. Sustainability has been set as a blueprint in the Mega-Science Framework (2011-2050) (Academy of Sciences of Malaysia 2010). The government has formulated the New Economic Model (2011-2020) (National Economic Advisory Council 2009) and the National Agrofood Policy (2011-2020) (Ministry of Agriculture and Agro-Based Industry 2011b) to guide the long-term change; the Tenth Malaysian Plan (2011-2015) to propel sustainability progress in the short term. The basis of the relevant policy measures is made up of versatile SAPs, including conservation tillage, intercropping, cover crops/mulches, crop rotation, organic fertilizers/composts, and IPM. These SAPs are also being promoted, along with other requirements, in Malaysia's Good Agricultural Practices Scheme and its Organic Scheme. Being a voluntary action, vegetable farmers are free to choose whether to adopt or ignore these SAPs.

The promoted SAPs aim to compensate for external inputs (e.g., synthetic fertilizers, synthetic pesticides, machinery, and so forth) by using locally available natural resources more efficiently (Lee 2005). Their benefits include soil enhancement (particularly through management of organic matter and soil biotic activity), crop and environment protection (mainly through diversification of species and genetic resources), and the management of biological interactions. Based on these features, these SAPs do not compromise either productivity or environmental health. However, they do require improved use of farm management practices since their application is complex (Lee 2005). For instance, intercropping and crop rotation involve a range of management decisions: choosing particular crop species from an array of alternatives; evaluating their relative agronomic and economic

advantages; deciding the optimal combinations and rotations of crop species; planning both the timing and the use of labor inputs; and modifying marketing strategies. Other SAPs are similarly knowledge, skill, and labor demanding.

In addition, the Malaysian government has imposed some legal restrictions to control hazards that impact the environment, food safety, and worker health and safety. Environmental Quality (Control of Suspended Solids) Regulations 2011, for example, aims to protect and maintain the quality of soil and water (Department of Environment 2012). Under such regulation, farmers are required to take measures to minimize erosion and manage storm water at all time. In worst case, a directive will be issued to farmers for taking the necessary measures to mitigate, minimize or control erosion from their premises. At the time of writing this thesis, measures for ensuring resource quality remain voluntary: farmers remain free to choose whether to use SAPs.

Thus far, there is a consensus that SAPs have not been widely adopted by Malaysian vegetable farmers (see Table 2). In view of the paucity of the relevant information, officers of the Ministry of Agriculture and Agro-based Industry suggested that the adoption rate of intercropping, cover crops/mulches, and organic fertilizers/composts should be within 35-45 percent, and a lower rate should be seen for crop rotation, conservation tillage, and IPM (for details, see Appendix 3). When compared with other countries, such achievements are considered modest as some vegetable farmers still possess local indigenous technical farming knowledge and skills. However, the progress of Malaysia's Good Agricultural Practices Scheme and its Organic Scheme has been far below satisfactory. When compounding these pictures together, the use of unsustainable production practices has remained indisputably significant just like other sectors and countries (Aminuddin et al. 2005).

Based on the above, it is vital to understand the adoptive behavior concerning SAPs in the Malaysian vegetable production sector. Though a case study, this thesis is committed to

seeking broader implications for advancing the progress of sustainable agriculture in other sectors and countries. Such insights are valuable given that all quarters generally encounter similar experiences in this area (Charlton 1987).

Table 2. Adoption rate of sustainable agricultural practices and schemes in the Malaysian vegetable production sector

Sustainable agricultural practices / schemes	**Adoption rates (%)**
Conservation tillage*	25-35
Intercropping*	35-45
Cover crops/mulches*	35-45
Crop rotation*	30-40
Organic fertilizers/composts*	35-45
Integrated pest management*	25-35
Good Agricultural Practices Scheme^	<1
Organic Scheme^	<1

Sources: * the Ministry of Agriculture and Agro-based Industry as reported in Tey et al. (2012); ^ the Department of Agriculture (2013)

1.3 RESEARCH GAPS

In the past, the adoption of SAPs has been considered to be a result of straightforward decision-making (Carr and Wilkinson 2005). Often the underlying assumption is that the recommended practices are appropriate and profitable, and that rational farmers would adopt them after being informed of them (Karami and Keshavarz 2010). Based on this assumption, a body of research has attempted to understand what factors lead to the adoption of SAPs using economic theories. A limitation in such research direction is in its omission of the non-economic consideration and fundamentals of the need for SAPs: environmentally non-degrading, resource conserving, and socially acceptable solutions. For example, farmers have

been observed to rely on personalized intuitive expert system in farm management (Nuthall 2012).

As sustainability features reflect non-economic benefits, adoptive decision-making should be understood beyond the economic perspective: economic theories are inadequate in analyzing adoptive behavior consistently with observations (e.g., Lynne et al. 1988; Costanza et al. 1993; van den Bergh et al. 2000; Bayard and Jolly 2007; Feola and Binder 2010). Furthermore, another strand of studies has investigated the behavior structure involved in the adoption of SAPs using psycho-social theories.

Developing from both economic and psycho-social principles, understanding of the issue should view the adoption of SAPs as a complex decision-making process (Reimer et al. 2012).

The complexity of adoptive behavior towards SAPs has been demonstrated by a number of review studies, which synthesized significant findings from both economic and psycho-social approaches. Pannell et al. (2006) revealed that adoption depends on a range of socio-economic, agro-ecological, institutional, information, and psychological factors as well as the perceived attributes of SAPs. In Knowler and Bradshaw (2007), nearly 170 significant factors have been summarized and only a small subset of which concerned economic criteria.

In the U.S., a comprehensive list of significant factors has been compiled by Prokopy et al. (2008). Among these factors, education, financial capital, incomes, farm size, access to information, environmental attitudes and awareness, and social networks are often associated with adoption. Their review was followed-up by Baumgart-Getz et al. (2012). In particular, access to information, the quality of information, financial capacity, and social networks have been identified as having a great impact on adoption practices.

Mixed conclusions have been drawn in various review studies. Some scholars believe that this body of research may have reached its limit in contributing to a refined

understanding, particularly in respect of the voluntary uptake of SAPs (Knowler and Bradshaw 2007). They argue this because the current state of knowledge is not easily transposed to policy (Higgins and Foliente 2013). Nevertheless, the results as to which factors consistently determine SAPs adoption are clearly inconclusive (Prokopy et al. 2008). It is this conclusion that calls forth additional research for generating greater insights and clearer policy directions in this area. For achieving that, this thesis is designed in such a way by identifying and narrowing relevant research gaps.

1.3.1 Research gap 1

Attributes of SAPs are perceived subjectively prior to experiment and full application (Abadi Ghadim and Pannell 1999). Typical attributes are those classified as offering relative advantage, compatibility, complexity, trialability, and observability (Rogers 2003). Though these attributes are objectively appealing, farmer perceptions toward them may still remain less favorable. Negative ones are likely to hinder adoption.

Nevertheless, attributes of SAPs are not homogenously perceived across potential adopters (Tatlidil et al. 2009). Such perceptual difference is a conundrum, but the information is essential to identify and modify misperceptions where they exist. In this important assessment, a systematic method has not been developed to contribute to an understanding of perceptions that lead towards sustainable development (Probert et al. 2005). Therefore, *the first research gap* of this study is a response to the weakness of unstructured perception assessment in the past.

1.3.2 Research gap 2

As noted earlier, separate approaches have been taken to identify what economic and psycho-social factors motivate farmers to adopt SAPs voluntarily. The former is known as a "factor" approach, given their interest in economic variables that affect adoption directly; the latter is known as "process" approach, which explains the processes shaping adoptive behavior. The "factor" approach offer insights for various extension purposes, including the characteristics of potential adopters for target segmentation, communication channels for effective information distribution, and institutional settings for facilitating adoption (Tey and Brindal 2012). The "process" approach is useful in generating cues to behavior formation and change (Kotler 2003; Peter and Olson 2009; Schiffman and Kanuk 2009).

Both "factor" and "process" approaches garner limited help as to what to emphasize in relation to encouraging adoption (Reimer et al. 2012). They offer different insights and are rarely made available at the same time. There is a danger that policymaking could be biased without more complete information. Based on this argument, *the second research gap* of this study concerns the inadequacy of both approaches in explaining adoption. An integrative attempt is needed not only to evaluate the significance of both economic and psycho-social principles, but also to render a clearer picture on their relative importance in influencing the adoption of SAPs.

1.3.3 Research gap 3

A shortcoming of integrative research is its inability to address a greater number of explanatory factors due to framework complexity. This limitation has been empirically demonstrated in an integration of the theory of planned behavior and the theory of diffusion

of innovation (Tutkun et al. 2006; Reimer et al. 2012) for investigating the adoption of SAPs; an incorporation of the theory of reasoned action and the pest-belief theory (Heong and Escalada 1999; Heong et al. 2002); a combination of the theory of interpersonal behavior (TIB) and structuration theory (Feola and Binder 2010) for understanding pesticide application.

There are, in fact, a greater number of factors that may lead to the adoption of SAPs (see Pannell et al. 2006; Knowler and Bradshaw 2007; Prokopy et al. 2008; Baumgart-Getz et al. 2012). Most of these review studies have treated that all statistically significant factors are important, but Baumgart-Getz et al. (2012) have set an exemplar of effect size across statistically significant factors. They have been shown to possess different impact size on adoption. Such a development leads to *the third research gap* of this study, which advances the pursuit of its predecessor: little is known about the relative importance of a greater range of factors that belong to the economic or psycho-social principle. Based on the evidence of which principle is more important, an additional analysis must consider a greater range of its factors and prioritize the impact of statistically significant factors on the adoption of SAPs.

1.3.4 Research gap 4

Though adoption is a reasonably complex and voluntary behavior, economic sustainability in terms of profitability is a main concern to most farmers (Pannell et al. 2006). Given that sustaining profitability is crucial for farm survival and farmer wellbeing, SAPs should be widely adopted when they are more profitable in comparison with competing practices. Low adoption rates of SAPs, therefore, suggest that farmers are not fully convinced that SAPs will result in better financial returns than prevailing production practices (Osei et al. 2012).

The point outlined above is reinforced by mixed findings in a dearth of research (Uematsu and Mishra 2012). For example, lower profitability is found when yield declines in response to some SAPs (e.g., Helmers et al. 1986; Dobbs and Smolik 1997; Hanson et al. 1997). Because SAPs also incur higher production costs (e.g., labor), there is no significant difference in profitability even when yield is sustained (Uematsu and Mishra 2012). Higher profitability is only realized when yield vis-à-vis total farm output is improved (Akinola and Sofoluwe 2012). Most critically, previous attempts do not offer a clear answer as to *which* SAPs will result in higher net returns and this, in turn, points to *the fourth research gap* of this study. This research gap emphasizes that the impact of SAPs adoption on farm profitability also needs to be well understood in addition to unpacking adoptive behavior.

1.4 OBJECTIVES

In this thesis, the adoption of SAPs is hypothesized to involve complex decision-making. Therefore, this study aims to produce a better understanding of the issue, using an integrative framework for the Malaysian vegetable production sector. This is achieved by responding to the four research gaps identified in the earlier section. Specifically, the objectives of this thesis are:

(1) to assess the structure of perceived attributes of SAPs;

(2) to investigate both economic and psycho-social factors influencing the adoption of SAPs jointly;

(3) to identify the relative importance of factors influencing the adoption of SAPs; and

(4) to examine the relative impact of adoption of SAPs on farm profitability.

1.5 SIGNIFICANCE

Achieving an improved understanding of farm-level adoptive behavior will offer refined policy directions for augmenting the adoption of SAPs. This need is crucial because a major limitation in the literature remains in highlighting what to emphasize in SAPs and in translating the lessons of such understanding to policymakers. Therefore, this thesis seeks to advance previous efforts by narrowing the abovementioned research gaps and fulfilling the research objectives.

1.5.1 Significance of Objective 1

The assessment of the structure of perceived attributes of SAPs (Objective 1) will produce empirical inputs for future campaigns to focus on important attributes that matter to farmers. Gaining knowledge of farmer perceptions is important in this regard because “perception is reality” (Peter 1985). In other words, as posited by paradigm innovation, a major shift in thinking may cause a change in adoptive behavior. This work will deploy a systematic method to identify important attributes as well as misperceptions and negative perceptions. The important attributes will form the basis for a structured guide to assist extension organizations and agribusiness firms in implementing a formatted assessment across different areas, if a cluster of SAPs has been promoted within a large geographical area. Qualifying the information on heterogeneous perceptions will additionally enable the concerned parties to counteract against unfavorable ones by developing effective communication messages and campaign strategies (Escalada and Heong 1993).

1.5.2 Significance of Objective 2

The joint investigation of both economic and psycho-social factors (Objective 2) will provide a fundamental understanding of the adoption of SAPs from multiple perspectives. Such an integrative approach is imperative because any reasonably complex, voluntary behavior is a multifaceted issue. In particular, sustainability-related behavior should be considered beyond economic rationales (Stern 2000). This investigation will use an integrative framework to examine both economic and psycho-social factors, and the relative importance of statistically significant factors. The findings will indicate economic and/or psycho-social principles should be fundamentally understood by policymakers. They also will highlight which principle and its underlying factors have a larger influence on adoption. Their compounding implications will call upon a greater emphasis on the more important principle and factors in local policy development and follow-up studies in this area.

1.5.3 Significance of Objective 3

The identification of the relative importance of explanatory factors (Objective 3) will generate more in-depth understanding of the adoption of SAPs from a relatively important principle. As a follow-up to Objective 2, this work will assess the statistical significance and prioritize a greater number of factors, which formed the respective dimensions, within the selected aspect. The findings will ultimately lend clarity as to which statistically significant factor(s) are more important. It is likely that important factors may come from multiple dimensions since farm decision-making involves multidisciplinary considerations (Conway 1985). Prioritization of statistically significant factors can indicate which of them is more important, thus demanding more attention. When complemented with the findings of

Objective 2, policymakers will then be equipped with a hierarchical understanding (principle–factor) of the issue. With such a knowledge base, policy development in this area will have an opportunity to target the more important areas. After all, the creation of policies which resonate with farmers and locales will, in turn, enhance the adoption of SAPs (Pretty 1995).

1.5.4 Significance of Objective 4

The examination of the relative impact of adoption of SAPs on farm profitability (Objective 4) will indicate which SAPs will result in higher net returns. This pursuit is necessary since agriculture is a business or a source of income. Moreover, there are varied establishment costs and functions across SAPs. In these aspects, the findings will provide empirical answers as to what factors lead to adoption of individual SAPs and adoption of which SAPs generally yield greater earnings. When certain SAPs are found to be more profitable, they can be promoted as an attractive "starter pack" to potential adopters. With this empirical evidence, it is hoped that more farmers will have confidence to invest in sustainable agriculture. The promotion of the "starter pack" (formed by the more profitable SAPs) can be guided by factors that are associated with their adoption. Therefore, the outputs of this study not only generate clarity on the investment return of different SAPs, they also help identify the characteristics of potential adopters and promotion strategies.

1.5.5 General significance of the thesis

In general, this thesis will contribute a more complete and clearer picture on issues surrounding the adoption of SAPs. The key research orientation is to garner policy insights in

relative terms: (1) what attributes of SAPs are more important, (2) which principle is more influential, (3) what factors are more impactful, and (4) which SAP is more profitable. This valuable information will assist policy development in this area and act as a guide for effective local management in the Malaysian vegetable production sector. Despite being a case study, this thesis will also have broader policy implications for countries that share similar conditions and, importantly, researchers can then have better tools to generate better guides for aiding domestic SAPs promotion.

1.6 THESIS OUTLINES

The format of this thesis is different from a traditional one. Most of its chapters are crafted in publication style according to individual journal formats. Opening and ending chapters are intended to pull together disparate chapters in order to cover the whole development of this thesis. This is not a thesis on contesting individual sustainable agricultural systems (e.g., low-input agriculture, precision agriculture, organic agriculture, and so forth). There are many texts covering these topics and others which are similar. Rather, this is a case study concerning the adoption of common SAPs in the Malaysian vegetable production sector. It sets examples, demonstrates means, and enables replication for producing an improved understanding of the issue in line with individual nuances.

As written in this chapter, this thesis starts by introducing the shortfall in the adoption of SAPs. It provides a basis for choosing the Malaysian vegetable production sector as a case study, justifying and setting research directions and objectives, and highlighting their significance.

Chapters 2–3 are concerned with literature review. In Chapter 2, factors (variables) influencing the adoption of SAPs are systematically reviewed and summarized using a vote

count method. The count number indicates the importance of factors. Important factors are discussed and call for greater attention in the design of this thesis. The next chapter concentrates on reviewing research approaches and paradigms used in the literature. Their strengths and weakness in addressing the complexity of adoptive decision-making are discussed. The discussion leads to the conceptualization of an integrative framework for this thesis. As such, both chapters reason what the key factors are and how they can be investigated using the integrative framework.

The primary data collection involved in thesis is recorded in Chapters 4–5. In Chapter 4, the procedures of focus groups that were conducted prior to the survey were reported. Tips for efficient survey generating from focus groups are also highlighted. Following that, the processes concerning questionnaire design, sampling, pre-testing, survey, and data entry are recorded in Chapter 5. Issues that encountered are also discussed. Though these two chapters are concerned with survey data of Malaysian vegetable farmers, their details are designed to help researchers deal with the complexity of data collection in a multicultural context.

Chapters 6–9 correspond to Objectives 1–4 respectively. As such, each research gap is narrowed by meeting its focus objective. Therefore, their respective literature is reviewed and that leads to the specific investigation within the integrative framework. In Chapter 6, confirmatory factor analysis is used to assess the structure of perceived attributes of SAPs. This method helps to reduce the number of items under consideration and produce an empirical basis for constructing latent factors of SAP attributes. These refined attributes are discussed. In Chapter 7, structural equation modeling is employed to investigate both economic and psycho-social factors influencing the adoption of SAPs jointly. Their standardized coefficients are compared in order to have a knowledge base of either the economic aspect or psycho-social aspect plays a more important role in affecting adoptive decisions. As the economic aspect has been found more influential, its set of variables are

included in other chapters. In Chapter 8, logistic regression model is applied to identify the relative importance of a set of economic factors influencing the adoption of SAPs. Slightly different from the literature, both standardized and unstandardized logistic regression coefficients are estimated. Significant variables are prioritized and discussed. In Chapter 9, two-stage estimation method is used to examine the relative impact of adoption of SAPs on farm profitability. The results indicate which SAP is more profitable than others.

The final chapter synthesizes and concludes the findings of this thesis. It also reemphasizes the policy implications for local management in Malaysia and other areas. Being a case study, broader policy implications for other contexts are discussed. Then, research limitations are compiled and future research areas are recommended.

At the end of this thesis, a number of appendices provide additional information on this study. Appendix 1 provides the questionnaire used in the primary data collection of this study. The information on selected variables (in the questionnaire) is summarized in Appendix 2. Appendix 3 is a published article on the progress of SAPs adoption, particularly in the Malaysian vegetable production sector. Appendix 4 represents a published work on adapting definition of sustainable agriculture to the selected study area. It should be noted that Appendices 3 and 4 are additional publications that were yielded from focus group discussions. Though they are not the essence of this study, they do contribute general ideas about the issue, particularly in the selected study area.

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Chapter 2: Factors influencing the adoption of sustainable agricultural practices in developing countries: a review

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Chapter 3: Conceptualizing the adoption of sustainable agricultural practices: an integrative framework

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Conceptualizing the adoption of sustainable agricultural practices: an integrative framework

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ABSTRACT

Adoption of sustainable agricultural practices (SAPs) is crucial to improve agricultural sustainability. Collective findings from disparate studies have revealed that their adoption is a result of multi-dimensional considerations: (1) socio-economic factors, (2) agro-ecological factors, (3) institutional factors, (4) informational factors, (5), the perceived attributes of SAPs, and (6) psycho-social factors. However, previous efforts have lacked theoretical support to enable a sufficiently comprehensive inquiry. To fill this gap, this paper

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conceptualizes an integrative framework for the adoption of SAPs whereby the theory of interpersonal behavior is integrated with the theory of diffusion of innovation. This integrative framework is similar to the subjective expected utility model in economics. It assumes that farmers are rational and choose the "best" production practices in order to optimize their utility. More importantly, it helps advance our understanding from a multidisciplinary perspective. Its applicability in research contexts and their analytical methods are also highlighted.

Keywords: adoption; sustainable agricultural practices; theory of interpersonal behavior; theory of diffusion of innovation; integrative framework

INTRODUCTION

Unsustainable agricultural practices are criticized for weighing short-term economic goals over environmental and social goals (Allen et al. 1991). On farms, excessive use of inorganic inputs is destructive to the environment (e.g., destroying soil humus and water retention ability) and the health of the farming community (e.g., causing malaria in the short run and cancers in the long run) (Batie and Taylor 1989; Jeyaratnam 1990). Off the farm, residues of chemical inputs cause environmental degradation (e.g., water quality and biodiversity) and jeopardize public health (Ruttan 1999; Lichtenberg 1992).

The mechanisms by which to improve agricultural sustainability have become a worldwide issue (Gao and Zhang 2010). One answer is through sustainable agricultural development. As defined by the FAO (1995), this is "the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present

and future generations". In other words, improving agricultural sustainability requires the adoption of a set of dynamic sustainable agricultural practices (SAPs) that are environmentally non-degrading, resource conserving, socially acceptable, technically appropriate, and economically viable. Examples of SAPs include mulching and cover crops, organic fertilizers, intercropping, crop rotation, conservation tillage, and integrated pest management.

Much effort has been made to promote SAPs at national and international levels. However, the adoption of SAPs has been limited. Not only have such limitations taken place in developing countries (Barrow et al. 2010), they have also occurred in developed countries (Horrigan et al. 2002). As an example, the adoption rate of conservation tillage, cover crops, and crop rotation in developing countries was reported to be lower than 10 percent, whilst in developed countries they recorded slightly a higher range within 15-40 percent (FAO 2011).

Many studies have attempted to explain why some farmers have or have not adopted SAPs. This strand of research has recently been reviewed by Knowler and Bradshaw (2007), Baumgart-Getz et al. (2012), and Tey and Brindal (2012). By synthesizing findings from fragmented studies, their review has revealed that adoption is a result of multi-dimensional considerations. Notwithstanding that, they have encountered difficulties in extrapolation based on the fragmentation, which has an individual focus and therefore does not apply to the general case sufficiently to be of use in research and policy.

To account for multiple dimensions in adoptive decision-making, Tey and Brindal (2012) have called for the building of an integrative framework in future work. Other studies have also pointed to such a need (e.g., Park and Seaton 1996; Renting et al. 2009). Responding to this call, it is the objective of this paper to conceptualize an integrative framework, which can be used to gain comprehensive knowledge of complex adoptive decision-making in respect to SAPs. In Section 2, we rearrange the factors of adoption that

have been synthesized by Knowler and Bradshaw (2007), Baumgart-Getz et al. (2012), and Tey and Brindal (2012). The next section discusses the research frameworks used in the literature and checks their ability to enable multi-dimensional investigations. Doing so opens the door to modeling an integrative framework in the subsequent section. All important points will be summed up in the section for research implications and conclusions.

FACTORS INFLUENCING THE ADOPTION

Adoption is the ultimate objective of diffusion. According to Rogers (2003), adoption is "a decision to make full use of an innovation as the best course of action available." In respect to SAPs, the decision-making involves multi-dimensional considerations (Knowler and Bradshaw 2007; Baumgart-Getz et al. 2012; Tey and Brindal 2012). They can be grouped into (1) socio-economic factors, (2) agro-ecological factors, (3) institutional factors, (4) informational factors, (5), perceived attributes, and (6) psycho-social factors.

Socio-economic factors refer to the social and economic conditions relevant to the farm decision-maker. They represent human capital. Farmer capacity and ability clearly influence his/her adoptive decisions (Nuthall 2009). Commonly significant factors include age, education, and farming experience. Older farmers have a shorter career horizon (Roberts 2004). This results in a diminished incentive to change and they are less inclined to adopt SAPs. More highly educated farmers have a better understanding of the use of SAPs (Abdulai and Huffman 2005). They are more likely to use SAPs. Greater farming experience generates confidence in judging SAPs and represents better knowledge of their application in the field (Kshirsagar et al. 2002). This induces more generally risk-averse farmers to apply SAPs.

Agro-ecological factors embody both on-farm natural endowments and farm operation variables. Erosion, land tenure, farm size, and farm income are typical significant

factors. Soil erosion jeopardizes soil fertility (Tenge et al. 2004). To conserve land, erodible soil is likely to lead to the adoption of SAPs. Whilst rented land is exposed to the risk of tenant discontinuation; self-owned land will be passed to future generations (Tatlidil et al. 2009). Therefore, farmers are likely to manage self-owned land in a sustainable format. Larger farms tend to have a more professional management and a trained labor force and possess economies of scale (Diederen et al. 2003). Because the rate of return on adoption is higher for larger farms, they are likely to make the favorable decision. Farms with higher incomes have greater capacity to bear the risk of testing and using a new production practice (Ogunlana 2004). Hence, greater farm income is likely to be positively related to the adoption of SAPs.

Institutional factors are off-farm organizational endowments. Farm location, financial access, and farm distance are generally significant factors. Farm location is used to capture data on heterogeneous natural resources (Fernandez-Cornejo et al. 2007). Farms in resource-rich areas are likely to maintain conditions and adopt SAPs. Financial access enables farmers to obtain credit or loans, either as a capital for investment in a new practice or a back-up for overcoming failure costs (El-Osta and Morehart 1999). When such access is available, the probability of investing in SAPs is higher. Greater distances of farms from input suppliers incur higher transportation costs, which add to the already costly chemical inputs (Bamire et al. 2002). Under such a setting, farmers are likely to reduce input costs by turning to SAPs.

Informational factors relate to knowledge acquisition. Access to information and its sources are general explanatory factors. Information plays a vital role in diffusing knowledge of environmental issues, the need for SAPs, and their beneficial functions (D'Emden et al. 2006). The information may come from one or more sources, such as extension services, being a member of an association, and program participation. Informed farmers are likely to make favorable decisions.

Perceived attributes refer to farmer subjective evaluation of innovation characteristics. Important attributes include relative advantage, compatibility, and complexity. Relative advantage concerns whether SAPs are seen as more beneficial than its competing practice (Reimer et al. 2012). An optimistic perception of this attribute is likely to lead to adoption. SAPs are subjectively assessed for their compatibility with the existing values, past experiences, and needs of potential adopters (Rogers 2003). Fitting more of these criteria is likely to result in adoption. SAPs could be seen as difficult to understand and/or use (Sattler and Nagel 2010). Greater complexity is likely to eschew their adoption.

Psycho-social factors depict mental attitude formations towards a behavior. Widely studied factors include attitude and intention. A positive attitude represents a favorable response towards an object (Willock et al. 1999a). Such a mental state is positively linked to adoption. In a stronger position, intention indicates that farmers are willing to perform a behavior. Therefore, expression of intentionality is likely to see farmers realize the behavior.

PREVIOUS RESEARCH FRAMEWORKS

By summing up the findings of past studies, it is now clear that adoption is the result of multi-dimensional considerations. This fits with the reality that farming decisions are multi-disciplinary (Conway 1985). Focusing on one particular dimension does not seem justified in explaining the complexity of decision-making. It is, therefore, necessary to discuss previous research frameworks as to whether or not they are able to handle the complexity whilst being grounded theoretically.

By synthesizing the reviewed studies, previous research frameworks can be grouped into two categories: economic and psycho-social (Table 1). These have been created to explain the adoption of SAPs from different perspectives. An individual perspective, in

addition, is split into sub-components or frameworks. These frameworks have been used to hypothesize that selected dimension(s) can advance our understanding of the issue.

Table 1. Previous research frameworks

Categories	Research frameworks	Dimensions					
		Socio-economy	**Agro-ecology**	**Institution**	**Information**	**Psycho-social**	**Perceived attributes**
Economic	The innovation-diffusion	√			√		
	The economic constraint	√	√	√	√	√	
	The adopter perception	√	√	√	√	√	√
Psycho-social	The theory of reasoned action					√	
	The theory of planned behavior					√	

Source: Authors' compilation from the literature

The economic category

Research in the economic category is based on branches of an economic theory. Despite slight variations in their assumptions, they are all built upon utility maximization theory. The theory explains that farmers choose the "best" production practices in order to achieve a utility with their limited resources. The theory is less restrictive than a profit maximization framework (Lynne et al. 1988). Hence, profit may not be a total representation of utility. In fact, an emerging utility is a hybrid of movements, thinking, and action towards achieving income and environmental sustainability. Here, farmers are seen as rational, trying to optimize their particular utility out of their available resources. Economic research is, therefore, based on a decision algorithm for individual farmers. The branches of the theory can be grouped into three major paradigms: (1) the innovation-diffusion paradigm, (2) the economic constraint paradigm, and (3) the adopter perception paradigm.

Firstly, the innovation-diffusion paradigm posits that access to its information is the key factor in determining adoptive decisions (Argawal 1983). This paradigm is based on the concept of diffusion of innovation (DOI) (Rogers, 2003). It assumes that an innovation is appropriate and profitable, leaving adoption as a function of communication of the relevant information to the potential adopters (Adesina and Zinnah 1993; Makokha et al. 1999). Rational farmers would want to adopt them after being informed. The paradigm has worked well for profit-oriented innovations but less for SAPs. This is because their orientation is different. As such, it is questionable whether the assumption of this paradigm has been met for SAPs. This argument is supported by a consistent finding in a number of studies: the insignificant relationship between access to information and the adoption of SAPs (e.g., Gamon and Scofield 1998; Diebel et al. 1993; Napier and Camboni 1993; Warriner and Moul 1992). This is the case even though farmers have had adequate access to information. Therefore, this paradigm is less successful in explaining the adoption of SAPs (Alonge and Martin 1995; Wandel and Smithers 2000).

Secondly, the economic constraint paradigm contends that adoptive decisions are affected by the asymmetrical distribution of resource endowments (Aikens et al. 1975). Resource endowments here not only represent resources (e.g., credit access, farm size, and information) but they also describe inherent qualities (e.g., education and farm location) of the potential adopters. Based on a utility maximization concept, farmers are assumed to be rational in decision-making while being constrained by resource endowments. Their adoptive decision is a function of factors in socio-economy, agro-ecology, institution, and information. Adoption should happen when a farmer possesses better resource endowments but their effects are inconsistent across cases of SAPs (Schreinemachers et al. 2009). As such, investigation of the issue should include non-economic factors (Norris and Batie 1987). Among others, attitude as a psychological factor play an important role when SAPs do not

offer direct benefits immediately (Lynne et al., 1988). This has been evidenced by a number of studies (e.g., Wilson 1997; Willock et al. 1999a, b). However, its inclusion could be conceptually incorrect (Beedell and Rehman 2000). This is because an emotional attachment (attitude), as reasoned by behavioral theories, does not explain behavior directly.

Thirdly, the adopter perception paradigm asserts that perceived attributes of an innovation are important explanatory factors to adoptive decisions (Adesina and Zinnah 1993). Assumption of this framework is an extension to the economic constraint paradigm by counting in subjective preferences, which derived from the concept of DOI (Rogers 2003). Farmer decision-making, therefore, is a function of factors in socio-economy, agro-ecology, institution, information, psycho-social, and perceived attributes. This seems to offer the best explanation for adoption, but one of its dimensions remains open to debate: the inclusion of attitude is lacking in theoretical support. Notwithstanding this, SAPs are likely to be adopted when their attributes are viewed favorably (Pannell et al. 2006).

The psycho-social category

Research in the psycho-social category is based on a school of psychological theories. They focus on mental processes that move toward behavior modification. Adoptive decisions are assumed to be rational although they are entirely left to consideration processes by the individual farmer. Two popular theories have been used in behavioral research: (1) the theory of reasoned action (TRA) and (2) the theory of planned behavior (TPB).

The TRA reasons that behavior can be explained by the intention to perform the behavior (Ajzen and Fishbein 1980). Intention is, in turn, a function of attitude and subjective norm. In other words, they have an indirect relationship with behavior. A positive attitude that illustrates a farmer's disposition towards SAPs is likely to contribute to a mental

readiness to use them. A farmer is also susceptible to a range of social pressures. Expression of stronger subjective norms means conformance to social standards or expectations. Intention, therefore, represents readiness to perform a behavior. Such intentionality has worked well for one-off types of behavior (e.g., voting). It is, however, inadequate as a predictive tool for repeated or sustainable behaviors (e.g., application of SAPs) (Charng et al. 1988). This is because the latter requires human capability to carry out the behavior for a longer term.

The TPB is similar to the abovementioned theory and posits that intention is an explanatory factor of behavior. As such, its main criticism lies in its primary emphasis on psycho-social factors. Nevertheless, intention is formed by attitude, subjective, and an additional component – perceived behavioral control. This component is intended to capture the fact that human capability is not completely under one's control (Ajzen 1985). Non-motivational factors (e.g., time and capital) and resource restrictions may indeed pose a constraint to his/her handling quality. Intention is, therefore, the cognitive output of careful considerations of social, motivational, and non-motivational factors that influence the behavior (Ajzen 1991). Greater intentionality means higher willingness to perform a behavior over which an individual has actual control. For this reason, this improved theory is popular in the literature (e.g., Zubair and Garforth 2006; Karami and Mansoorabadi 2008; Wauters et al. 2010).

CONCEPTUALIZING AN INTEGRATIVE FRAMEWORK

From the discussion in the preceding section, it is obvious that a singular framework is not able to address the multi-dimensional issue. While efforts have been made to cover as many dimensions as possible, a major weakness remains in the absence of a theoretical framework

for linking multiple dimensions to the decisions. In order to overcome this, Lynne et al. (1988) have classically pointed out a future direction: an integrative framework, drawing on economics and psycho-social theories.

To understand adoption (behavior), as suggested above, the core of an integrated framework should be a behavioral theory (Spencer and Blades 1986; Kitchin et al. 1997). This is because behavioral theories offer flexibility for merging with other theories (Jackson 2004). Such empirical work can be found in a number of farmer behavior studies. For understanding pest application, the TRA has been co-joined with pest-belief theory (e.g., Heong and Escalada 1999; Heong et al. 2002) and structuration theory (ST) has been incorporated in the theory of interpersonal behavior (TIB) (Feola and Binder 2010a). Closer to our subject, the TPB has been integrated with the theory of DOI (e.g., Reimer et al. 2012; Tutkun et al. 2006)

However, not all integrative frameworks can render a robust explanation for the adoption of SAPs. There has been a common weakness in those partially framed by the TRA and the TPB. As an example, Reimer et al. (2012) have aimed to explain the influence of perceived attributes on adoption using an integration of the TPB and the theory of DOI. Though the latter stresses a direct link between the variables, they have been conceptualized as related in an indirect way. Such a framework has left intention as a single explanatory factor of the behavior.

In contrast, Feola and Binder's (2010a) integrative framework, which is a merger of TIB and ST, is seen as an attractive proposition for our conceptualization work. Their objective has been to understand the system dynamics in pesticide application. While the ST has been intended to capture feedback processes of human action, the TIB has been used as the core component to understand decision-making for the farm input. The latter is similar to our focus but a slight variation exists in the object of research. For this reason, we pay

attention to the TIB and carefully check their underlying assumptions and ability to handle complexity in the explanatory dimensions.

The theory of interpersonal behavior (TIB)

The TIB explains mechanisms of behavior resulting from complex interpersonal encounters within and outside an individual (Triandis 1977). It assumes that behavior formation is a course of rationality. Behavior is jointly determined by facilitating factors, habits and intentions (see un-shaded boxes in Figure 1). Intention, in turn, is influenced by expectations, subjective norms, and affection. Any behavior leads to consequences and they can be evaluated subjectively and objectively.

The TIB posits two additional and heurestic sub-components to explain behavior whist simultaneously recognizing intention as an important factor. While the latter is similar to the TRA and the TPB, the TIB goes beyond their weakness in providing for a theoretical inclusion of facilitating factors. Facilitating factors can comprise a list of conditioning factors in a research context (Feola and Binder 2010a). On the other hand, behavior is often habit bound. A behavior is likely to be repeated when it has become a routine.

Ultimately, the TIB offers a more robust framework than its competing theories (the TRA and the TPB). Similarly, empirical findings have indicated its superiority of higher explanatory power to other behavioral theories across research fields. Some examples are medical studies (e.g., Gagnon et al. 2003), sexual studies (e.g., Milhausen et al. 2006), information and management studies (e.g., Pee et al. 2008), and environmental studies (e.g., Bamberg and Schmidt 2003). It has also worked well when integrating with another theory (e.g., Feola and Binder 2010b, c). These studies have lent support to its functionality in a range of research areas and its flexibility in integrative modeling.

Subsequently, the TIB is considered applicable to the adoption of SAPs. This is supported by three key points. Firstly, the TIB offers a comprehensive and heuristic framework that can work in different situations. It can also be used flexibly like the TRA and the TPB for modeling an integrative framework (Jackson 2004). Secondly, the assumption has been met as a behavior is the result of rationality. Thirdly, it provides a theoretical base to capture multiple dimensions in decision-making. The psycho-social dimension is represented by intention and habit. The latter could be important because environmental behaviors are a matter of personal habit (Stern 2000). Adoption as a form of behavior change, indeed, requires a break of routine and an establishment of new production practices. Other dimensions (socio-economy, agro-ecology, institution and information) are placed within the field of facilitating factors. We should, however, note that the dimension of perceived attributes does not fit within the sub-component.

The theory of diffusion of innovation (DOI)

Incorporation of the dimension of perceived attributes in the TIB requires the behavioral framework to be integrated with another theory. To do so, it is best to look back to its derivation – the theory of DOI. Notwithstanding that, we should qualify the theory for modeling purpose. For doing this, we pay attention to their underlying assumption and fit for integration.

The theory of DOI is defined as "the process by which an innovation is communicated through certain channels over time among the members of a social system (Rogers 2003). One of its main elements is innovation. The element posits that the perceptions of its attributes affect adoptive decisions. It assumes that an individual has subjective evaluation, marking rationality in decision-making.

An innovation may be desirable for one situation, but undesirable for other potential adopters. Here the DOI starts to overlap with the TIB from two perspectives (see Figure 1). Firstly, according to Rogers (2003), perceived attributes can be classified into five main categories: relative advantage, compatibility, complexity, trialability, and observability. These perceptions are affected by the characteristics of the potential adopters (Rogers 2003). The characteristics are those from socio-economy, agro-ecology, institution, and information. They have commonality with those framed in the "facilitating factors" of the TIB. Secondly, perceptions lead to beliefs (Pannell et al. 2006). Perceived attributes may affect expectations, which are the beliefs about the outcomes, toward the use of an innovation.

It is now obvious that we have integrated the theory of DOI with the TIB. Support for the integration of the theory of DOI with a behavioral theory can be found in a number of adoption research papers. These include information technology (e.g., Yi et al. 2006; Nor and Pearson 2007), technology (e.g., Chen et al. 2007; López-Nicolás et al. 2008), and agricultural innovations (e.g., Tutkun et al. 2006; Reimer et al. 2012). They have empirically demonstrated the functionality of their integrated framework in different research areas. In particular, Reimer et al. (2012) have conceptualized the pre- and post-dimensions of perceived attributes in a similar fashion to our proposed framework.

THE INTEGRATIVE FRAMEWORK

Resulting from the integration is an integrative framework (Figure 1) that can be used to advance our understanding of farmer behavior: adoption of SAPs in our case. According to Lynne et al. (1988), such integration, drawn on economics and psycho-social is similar to the subjective expected utility (SEU) model in economics. This is partly because socio-economic factors, agro-ecological factors, institutional factors, information factors, and perceived

attributes have already been understood in determining utility optimization. An additional part is psycho-social factors wherein (1) intentions towards using SAPs are another way of saying that a farmer anticipates gaining from the adoption and (2) habits are modified in exchange for gain. Thus, the integrated concept is not greatly different from the SEU model, assuming that farmers tend to optimize their utility whilst being constrained by multi-dimensional endowments.

Adoptive behavior is conceptualized as a function of facilitating factors (socio-economy, agro-ecology, institution, and information), perceived attributes, habit, and intention. This concept of adoption, therefore, has captured multiple dimensions that are involved in farm decision-making. According to Triandis (1977), the dependent variable can be represented by intensity or probability of occurrence. Intensity can be used to measure the degree of adoption (e.g., how many practices have been adopted). Otherwise, probability of occurrence can be counted for individual practices.

Facilitating factors are those external factors outside of an individual's control. They include those factors in socio-economy, agro-ecology, institution, and information. They may either facilitate or impede action. This is possible because the asymmetric distribution of resource endowments may affect adoptive decisions (Aikens et al. 1975). When knowledge is armed by information, an individual is likely to make a guided decision (Rogers 2003). Positive facilitating factors are likely to result in adoption.

Habit represents a repeated behavior. It is traditionally measured by the number of times that a behavior has been carried out by an individual (Triandis 1977). While such quantification is difficult for agricultural practices, duration of use can be used to describe the variable. A farmer can be expected to repeat a behavior if it has already been carried out many times or for a long duration of time.

Perceived attributes refer to the mental persuasion towards characteristics of an object within an individual. It is predetermined by various facilitating factors, such as those in socio-economy, agro-ecology, institution, and information. They represent a state of rationality by undergoing self-evaluation in the forms of perceived relative advantage, perceived compatibility, perceived complexity, perceived trialability, and perceived observability (Rogers 2003). Favorable subjective evaluation means the subject is self-convinced and is likely to result in adoption.

Intention represents a cognitive instruction to carry out an act (Triandis 1977). A general intention, such as "to improve soil quality for continuous income" can lead to "the adoption of sustainable practices". This is determined by expectations, social factors, and affect. Firstly, expectations can be understood as the beliefs about the outcomes of a behavior. They are developed from perceptions. Secondly, social factors ascribe similarities and differences to what a society thinks about a behavior. They include social norms, roles, and self-image. Social norms are a meaningful concept in specific societies, in which they are the established behavior patterns for members of a social system (Rogers 2003). According to Triandis (1977), they form beliefs that certain behaviors are appropriate, correct, or desirable as viewed by the agent's social groups. Roles refer to a set of behaviors, which are appropriate, in relation to the farmer's particular position in the social system. An opinion leader, as an example, is always innovative and tends to try something new before others. Self-image traits determine who an individual is. If an individual is a "land keeper", land is likely to be farmed responsibly. Thirdly, affect refers to an individual's emotions toward a behavior. It may include positive or negative and strong or weak feelings. If application of animal waste is disgusting, there will be unfavorable intentions towards the practice.

Consequences are the outcomes of each behavior. They are interpreted by an individual objectively or subjectively (Triandis 1977). Objective interpretation includes

quantifiable results (e.g., profitability). Subjective interpretation (e.g., perception) concerns qualitative changes (e.g., environmental quality). Either form (objective or subjective) represents a way to assess the consequences of an intended behavior.

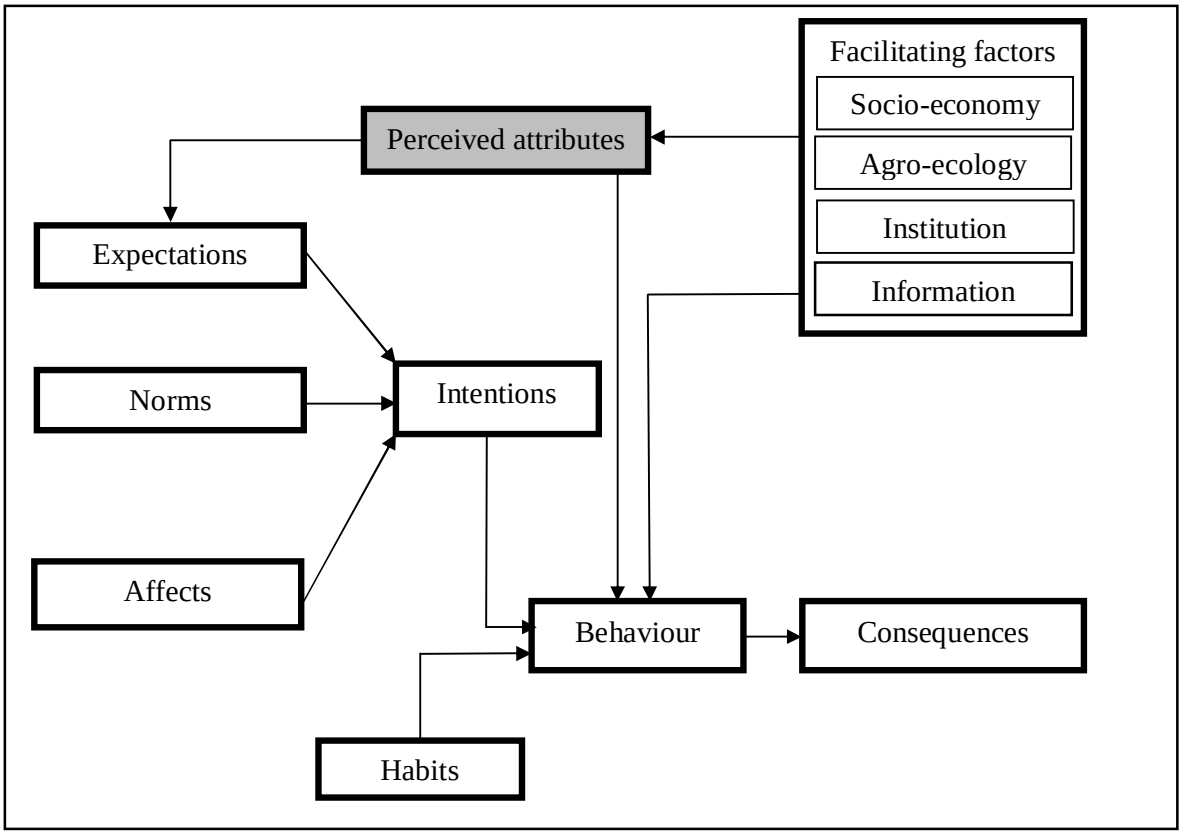


Figure 1. The integrative framework

Notes: the un-shaded boxes are adapted from Triandis' (1977) theory of interpersonal behavior; the shaded box is sourced from Rogers' (2003) theory of diffusion of innovation

CONCLUSIONS AND RESEARCH IMPLICATIONS

To improve agricultural sustainability, heavy investment has been made to promote SAPs. However, the current state of adoption achievement is less than successful. Fragmented studies have attempted to advance the understanding of this phenomenon. Their collective

findings have suggested that adoption is a result of multi-dimensional considerations. They are (1) socio-economic factors, (2) agro-ecological factors, (3) institutional factors, (4) informational factors, (5), perceived attributes, and (6) psycho-social factors. However, previous research frameworks have lacked theoretical support to provide comprehensive insights. To fill this gap, it has been the intention of this paper to conceptualize an integrated framework for future inquiry into the adoption of SAPs.

Integrative modeling is not uncommon in farmer behavior studies. Because the focus is on "behavior", they share a similarity: using a behavioral theory as the core framework. Such a theory is flexible for integration but most resultant frameworks cannot render a robust explanation. A single exception has been identified for Triandis' (1977) TIB. It posits that comprehensive sub-components (intentions, habits, and facilitating habits) can explain a behavior better. While the former represents psycho-social factors, the latter is expandable to include those factors in socio-economy, agro-ecology, institution, and information. To capture the dimension of perceived attributes, the TIB is integrated with Rogers' (2003) theory of DOI.

Towards this end, we have conceptualized an integrative framework (Figure 1). This framework is theoretically based and in line with the modeling direction provided by scholars (e.g., Spencer and Blades 1986; Lynne et al. 1988; Kitchin et al. 1997). It is similar to the SEU model in economics, assuming that farmers are utility optimizers while constrained by multi-dimensional endowments. More importantly, it has the potential to offer multi-disciplinary insights to advance our understanding of the issue. To add more weight to its future application, we highlight its future application in research contexts and their relevant analytical methods below.

Firstly, our integrative framework can also be rendered to process investigation. The interest of this approach is to explain the processes involved in shaping adoption at a

particular time or over time (Kurnia and Johnston 2000). The latter requires longitudinal data and further integrative modeling effort for understanding dynamics of decision-making. Otherwise, a cross-sectional data deems fit to analyze our integrative framework. As psycho-social concepts are unobservable, the main challenge lies in the accuracy of their interpretation. This issue can be overcome by referring to questionnaire used in past investigations. Collected information can be analyzed using two multivariate analytical methods:

1.1 A structural equation modeling (SEM) analytical method examines the structure of multiple and interrelated dependence relationships among constructs (concepts) (Hair et al. 2010). It is used to explain the entire set of relationships of unobservable concepts and a minimal amount of observable variables. Operating in such a way, it is more focused on theoretical confirmation. Researchers should, however, be warned that the analysis is sensitive to model complexity (especially when there are too many observable variables) and divergence of measures that are used to represent a concept.

1.2 A partial least squares analytical method is a popular alternative to SEM. It is used to predict the interrelationships among constructs and observable variables. Because its emphasis is more on exploration, it is a robust method that allows for the inclusion of more observable variables and handles problematic measures of a concept (Hair et al. 2010).

Secondly, our integrative framework can be used in future research that is based on a factor approach. This approach assumes that adoption is explained directly by explanatory factors at a particular time (Kurnia and Johnston 2000). Such an assumption simplifies the

investigation and explains the popularity of this approach in the literature. More importantly, it is an effective way to identify influential factors for policy implications through cross-sectional data. According to Tey and Brindal (2012), the investigation can be analyzed using different methods, depending on how "adoption" is being conceptualized:-

2.1 A logistic or probit analytical method is employed when adoption concerns the probability of occurrence or binary choice of decision. Both are discrete choice models in which the dependent variable describes a farmer facing a dichotomous choice – adoption and non-adoption. The probit model should be applied when the assumption of normal distribution is met. Otherwise, the logistic model is appropriate and more robust when the assumption is not met. This makes its application work well in many situations (Hair et al. 2010).

2.2 A tobit analytical method is used when adoption is conceptualized as an intensity of use. The dependent variable describes not only that a farmer has to make an adoptive decision, he/she also has to decide its usage (Feder and Umali 1993). Considerations in regard to the latter include "how much to use" for quantifiable practices (e.g., composts) and "frequency of use" for non-quantifiable practices (e.g., conservation tillage).

2.3 A poisson or negative binomial analytical method is used when adoption is a concept of the degree of adoption. Both are count data models in which the dependent variable describes the number of adopted practices. The poisson model assumes that each occurrence is independent of the number of previous occurrences (Sturman 1996). It is inconsistent with the heuristic underlay of our integrative framework. Therefore, the negative binomial model is more appropriate.

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Chapter 4: Qualitative methods for effective agrarian surveys: a research note on focus groups

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Chapter 5: A research note on agrarian survey in Malaysia

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A research note on agrarian survey in Malaysia

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ABSTRACT

Empirical efforts to understand farmer behavior in relation to agricultural sustainability requires primary data from on-farm surveys. In contrast with other social surveys, targeted specifications are needed for agrarian surveys in view of the fact that most farmers have not received higher education. Additionally different institutional frameworks and cultural endowments exist in different countries. A number of publications have started to fill this gap but they are still not sufficient in number or scope to cater for context specific fieldwork. As a start-up effort, this paper provides a note on procedures for undertaking an agrarian survey in

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Malaysia. It is derived from our research project on the adoption of SAPs in its vegetable sector. Important considerations in each of the six stages of survey design – (1) sampling design, (2) questionnaire design, (3) pre-test, (4) interviewer recruitment and training, (5) fieldwork management, and (6) data management – are discussed. Special remarks are also made on the contribution of a focus group discussion, which is recommended prior to the survey design and in selected stages of the survey design. Future work could be tailored for other specific social contexts.

Keywords: Agrarian survey; Malaysia; face-to-face interview

INTRODUCTION

Improving sustainability of agricultural systems is an important goal for the near future (FAO 2002). Unsustainable production practices cause destruction to the environment, the social order, and the economy. Such externalities are often intertwined with food security. Meeting the present need must not compromise the ability of future generations to meet their own needs (World Commission on Environment and Development 1987). Hence, sustainability exists as a key component in agricultural policies at the international and national levels.

Agricultural systems consist of two interdependent subsystems: ecology and social (Conway 1987). Their interdependence can be described through their feedback processes. For example, agricultural activities are constrained by the state of the environment, and the health of the environment depends upon agricultural activities (Conway 1990). As agriculture is a managed system, farmers (in the social subsystems) are integral agents making decisions to modify those systems (Matthews and Selman 2006). In other words, one way to improving the sustainability of agricultural systems is through a change in farmer behavior.

Understanding farmer behavior within their social subsystems will point towards useful policy directions for increasing agricultural sustainability. Many social studies, therefore, have appeared within agricultural research. Studies on the adoption of agricultural innovations, as an example, have recently been inventoried: 10 studies on precision agricultural technologies in Tey and Brindal (2012), 23 peer reviewed papers on conservation practices in Knowler and Bradshaw's (2007) review, 37 and 32 published papers on agroforestry innovations in Mercer (2004) and Pattanayak et al.'s (2003) stock take respectively.

Such studies are largely quantitative, i.e. based upon primary data at the farm level. As their interest is in farmer behavior, the target respondents are farmers, farm households, or farm decision-makers.

Surveys are a popular primary data collection method for social research within the agricultural context. In designing a survey, research methods in other social fields (e.g., marketing) provide some general guidelines. However, agricultural researchers must be cognizant of an important peculiarity among their target respondents: most farmers have not received higher education when compared with consumers undertaking marketing research or managerial personnel in management research. Not only should the difference be taken into the account in survey design, it also of importance during the implementation stage. Therefore, agrarian surveys should be designed and implemented in a slightly different manner; if not, the reliability of the collected primary data is likely to be questionable.

Agrarian surveys are specialized. While some consumer-orientated textbooks in agribusiness (e.g., Baker et al. 2001) and agricultural marketing (e.g., Kohls and Uhl 2001) offer some survey directions, their focus is not on farmers. More specialization is needed in respect to agrarian surveys. To begin filling the gap, a handbook like Benedetti et al.'s (2010) *Agricultural Survey Methods* is dedicated to census collection. More specifically, a

guidebook by the United States Department of Agriculture's (2008) *Understanding American Agriculture* has been published for local agricultural Resource Management Surveys. It draws attention to differences in institutional frameworks and cultural endowments when researching in a particular social context.

As an initial step in bridging the aforementioned gap, while, at the same time, considering agricultural peculiarities, the aim of this paper is to provide a specific research note on agrarian surveys in Malaysia through an explanation of our recent fieldwork. By taking the Malaysian vegetable sector as the study sample, the survey aimed to collect information explaining why farmers have or have not adopted sustainable agricultural practices (SAPs). Our notes will provide context specific tips for overcoming challenges in collecting data from farmers. In addition, it also highlights important considerations in the study area, which has complex institutional frameworks and cultural endowments. Part of those considerations comes from an earlier note (see Tey et al. 2012a), which suggests that focus group discussion (FGD) can generate insights into techniques for survey operation. As such, both notes are complementary and should be used together.

STUDY AREA

Malaysia is made up of two split landmasses – Peninsular Malaysia (the Malay Peninsula) and East Malaysia (Figure 1). Its 13 states and three federal territories form five regions, four of which are in Peninsular Malaysia and one in East Malaysia: (1) the East Coast region (Kelantan, Pahang, and Terengganu), (2) the Northern region (Perlis, Kedah, Pulau Pinang, and Perak), (3) the Central region (Selangor, Negeri Sembilan, and federal territories of Kuala Lumpur and Putrajaya), (4) the Southern region (Melaka and Johor), and (5) the Eastern Malaysia (Sabah, Sarawak, and federal territory of Labuan).

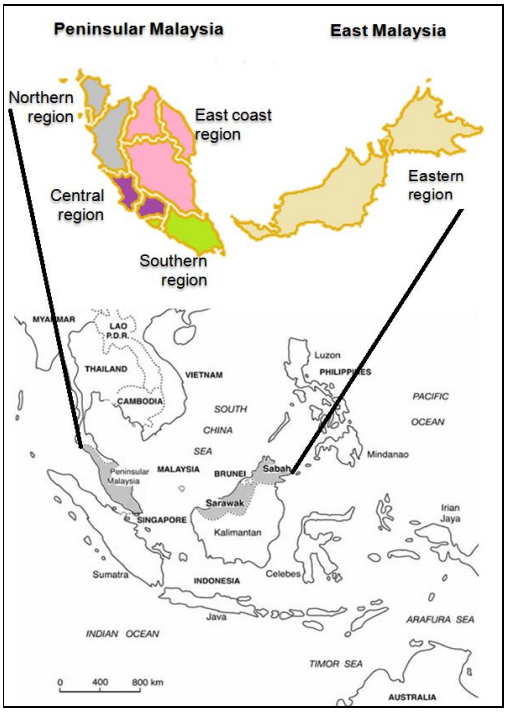


Figure 1. Study area – map of Malaysia

Source: Adapted from (Kaur 2004)

Malaysia's central administration is overseen by the federal government. It has considerable governance power over the states on the Peninsular Malaysia (the Malay Peninsula). However, the individual state governments of Sabah and Sarawak have greater administrative autonomy. Hence, the institutional framework differs between Peninsular Malaysia, Sabah, and Sarawak. Taking agricultural industry as an example, the focus of the Department of Agriculture (DoA) Malaysia is on Peninsular Malaysia whereas the DoA Sabah and the DoA Sarawak oversee agricultural development in their own states.

Malaysia is ethnically diverse. It is comprised predominantly by Malays, with significant Chinese and Indian populations. Though Bahasa Malaysia is the national language, other ethnic groups also learn their mother tongue. They practice a multilingual culture in their daily life.

The agriculture industry is the fourth largest economic contributor to Malaysia's gross domestic product (Economic Planning Unit 2012). Among all agricultural sectors, the vegetable sector has been identified as a segment in the National Key Economic Area of the Economic Transformation Program, which is a wheel within the New Economic Model, to transform Malaysia into a high-income nation (Prime Minister's Department Malaysia 2010).

As a tropical country, Malaysia has an average temperature ranging from 23°C to 32°C (Asadi et al., 2011). Given these climatic conditions, Malaysia produces largely tropical varieties in the lowlands. Temperate varieties of vegetable are also cultivated in uplands. Although the uplands area used for such activity is small, the agricultural practices are carried out on an intensive basis (Ghulam 2002). In general, about 50 varieties of vegetables are grown commercially (Nik Fuad et al. 2000). The seven most popular are chili, cucumber, cabbage, long bean, spinach, corn, and mustard (Ministry of Agriculture and Agro-Based Industry 2011).

To serve local markets, vegetables are planted across all regions in Malaysia. According to the Agrofood Statistics (2011), about 53,000 hectares of agricultural land were worked by some 46,000 farmers, producing 970.000 metric tons of vegetables in 2010. The major population of vegetable farmers came from the Eastern Malaysia region (41 percent) and the East coast region (34 percent). They were followed by the Southern region (12 percent), the Northern region (9 percent), and the Central region (4 percent). Part of the nation's production, valued at US$160 million, was exported to ASEAN countries. Nevertheless, Malaysia imported vegetables since it meets only 59 percent of local demand itself.

SURVEY GUIDELINES

An agrarian survey is intended to achieve a research objective. It is guided by a conceptual framework, which provides direction for the empirical investigation. Common means of collecting survey information include web-based questionnaires, mail-outs questionnaires, telephone interviews, and face-to-face interviews.

While designing an effective survey is not easy, researchers can transpose such knowledge from another social field to agriculture. Surveying, indeed, is a common data collection method in marketing research. Marketing research textbooks (e.g., Zikmund and Babin 2009; Mazzocchi 2008) offer general guidelines for designing a survey. Moreover, one of the sub-fields in marketing research emphasizes human (consumer) behavior. Its reference books (e.g., Solomon 2010; Schiffman and Kanuk 2009) provide specialized notes for specific subjects. Guided by these general and specialized sources, the procedures involved in the agrarian survey being discussed can be divided into six stages:-

(1) *Sampling design*: Past studies in a local context often offer useful references for decision-making at this stage. This stage involves the selection of a suitable sample of a population, which has the knowledge and information required to answer a research questionnaire. To test hypotheses about the population, the target population must be well defined. Characteristics which qualify an individual to be a prospective respondent within the population must be explicit. Such characteristics can be identified through a sampling frame (a list of contactable members of the target population). Researchers, then, determine a sample size representative of the population. Such determination can be made based either upon the desired degree of representative accuracy from a statistical point of view or the time and the cost from

the research project's timeframe and finance perspectives. When the sampling frame is available, researchers have a base from which to select a probability sampling method (e.g., random sampling). Otherwise, a non-probability sampling method (e.g., convenient sampling) is an alternative.

(2) *Questionnaire design*: Typically, past studies offer useful guides to questionnaire design. More guides can be obtained from practical books on *Questionnaire Design*, such as Brace (2008). With a defined research objective, a questionnaire is used to answer a specific research inquiry in a structured format. Questions should be based upon variables/constructs identified in the conceptual framework. In turn, the identified variables/constructs determine what type of questions (e.g., closed- or open-ended) are to be asked and their measurement scales (e.g., the Likert scale or a numerical scale). When developing questionnaire instruments, technical terminologies must be explained or simplified and ambiguity should be avoided. Clear presentation of questions, with appealing font sizes and formats on a sectional basis, prevent questionnaires from having a crowded layout.

(3) *Pre-test*: Pre-testing the questionnaire is an essential exercise before committing to a large-scale survey, regardless of whether the questions are new, have been tested in past studies, or have been adapted. This exercise reviews the designed questionnaire, in terms of reliability (e.g., word choice, ease of understanding, and logical sequence) and validity (e.g., capability to answer and sufficiency of answer options).

(4) *Interviewer recruitment and training*: With the exception of web-based and mail-out questionnaires, other survey means (e.g., intercept interviews, telephone

interviews, and face-to-face interviews) require trained interviewers. Students are popular candidates to be recruited as interviewers. They can be selected both according to the nature of their study and the characteristics of the target respondents. Not only must interviewers be thoroughly trained in the use of the questionnaire, they should also be exposed to the background of the study, methods for approaching prospective respondents, ways to handle uncooperative respondents, and guidelines for reporting to the survey administrator.

(5) *Fieldwork management*: This is a critical stage of primary data collection. Effort must be expanded to verify that the selected sampling method is followed, survey procedures are adhered to, and the number of respondents approaches a desired target within the survey's timeframe. Among these management concerns, supervision of interviewers is crucial to minimize and correct errors (e.g., asking biased questions or interviewing the wrong target) in the field. When such errors become increasingly significant, additional training is deemed necessary.

(6) *Data management*: Each returned questionnaire is given an identity number. By doing this, respondents can be kept anonymous. Data must be entered, accurately, into computer software. When an error is found in any particular case, the identity number will be used to trace the questionnaire and to cross-check whether the data has been correctly entered. The raw dataset must be kept safe while, at the same time, ensuring its confidentiality.

A SPECIFIC NOTE ON MALAYSIA

As noted in the earlier section, institutional frameworks and cultural endowments are peculiar in our study area – Malaysia. The same has also been noticed by Tey et al. (2012a). Hypothesis revision was a major purpose of the FGDs. In addition, information was also obtained for questionnaire development and the survey operation. Input into the FGDs helped us to design and carry out a more effective survey in the context of our specific interests. Researchers are, therefore, encouraged to conduct an FGD prior to the design and implementation of a survey (Rea and Parker 1997).

Among the available methods of sample surveys, face-to-face interviews were selected for our study. Considering that most farmers have not received higher education, self-administered sample surveys (e.g., web-based and mail-out questionnaires) would not produce optimal results. Telephone interviews, by their nature, are not suited to a long questionnaire.

In fact, face-to-face interviews allow interviewers to administer technical questionnaires and to explain questions. Indeed, our earlier FGDs with farmers revealed that visual aids (individual pictures of SAPs) were particularly useful in the elaboration of practical terms, such as conservation tillage, intercropping, and crop rotation. By choosing face-to-face interview techniques over others, our interviewers had greater flexibility to deal with the complexity of the questionnaire.

Sampling design

To investigate why some farmers have adopted SAPs while others have hesitated, the Malaysian vegetable sector was chosen as the focus of our study. This was on the basis of

limited adoption of SAPs in the sector albeit that holistic promotion of SAPs had been attempted through two certification programs: (1) Malaysia's Organic Scheme and (2) Malaysia's Good Agricultural Practices Scheme (Tey et al. 2012b). Because our purpose was to explain the decisions (behavioral changes) in applying SAPs as production practices, vegetable farmers were the target population. More precisely, they were the main decision-makers on the farms which grew vegetables for commercial purposes in Malaysia, regardless of their topography, farm size, and cultivated varieties.

In selecting a subset to represent the population of the Malaysian vegetable farmers, a sampling frame was required. As noted earlier, the institutional framework in the DoA differs for Peninsular Malaysia, Sabah and Sarawak. Therefore, we approached each of these departments through contacts given by the DoA Malaysia in our earlier FGD. The sampling frame listed a total of 8,141 vegetable farmers who were registered with the departments: 6,257 vegetable farmers in Peninsular Malaysia (including the federal territory of Labuan), 1,191 vegetable farmers in Sarawak, and 693 vegetable farmers in Sabah. It should be noted that, at this point, the number of vegetable farmers from the lists did not match with the number of vegetable farmers reported in the Agrofood Statistics (2011). This occurred because registration with the department was voluntary. However, we had to rely on their lists in order to identify and contact prospective respondents. The lists contained information on region, state, district, farmer name, farm/home address, and telephone. Additional information on farm size and involvement in project/association was available for Sarawak and Peninsular Malaysia. While such information proved useful, we were prudential in its use, in particular concerning farmers' rights to privacy and its possible misuse for other purposes.

Since our focus was on the Malaysian vegetable sector, we attempted to achieve a generally representative grouping by sampling vegetable farmers from all five regions in

Malaysia. While determining a sample size can be based on statistical theory, our sampling was constrained by budget. Because each face-to-face interview would incur a considerable cost (payment of RM20 or about US$6.67 to the interviewer and compensation of RM15 or about US$5 to each interviewee), a target sample size of 1,200 vegetable farmers was considered financially realistic. From another perspective, this sample size was relatively large and, hence, more representative than past studies which had sampled vegetable farmers in the country (e.g., Arumugam et al. 2011; Mad Nasir et al. 2010; Barrow et al. 2010). Achieving this sample size would represent about 15 percent of registered vegetable farmers or three percent of the total vegetable farmers in Malaysia. This constitutes a significant fair representative sample.

With the sampling frame, we had to choose one probability sampling method in order to achieve the targeted sample size of 1,200 vegetable farmers. To carry out this task, we reviewed sampling methods used in past studies within the local agricultural context. There were three commonly used probability sampling methods: (1) the convenience sampling method (e.g., Barrow et al. 2010), (2) the stratified random sampling method (e.g., D'Silva et al. 2012; Che Mat et al. 2012; Tiraieyari et al. 1999), and (3) the random sampling method (e.g., Boniface et al. 2012; Arumugam et al. 2011; Wong et al. 2009). Among these studies, Arumugam et al. (2011) was seen as relevant to our study. Not only was their focus on vegetable farmers, their survey also covered a wider area than other local studies. Their experience was considered a valuable adjunct for our sampling method. As such, a random sampling method was selected to conduct face-to-face interview with 1,200 vegetable farmers in the five regions of Malaysia.

Questionnaire design

From the outset, a screening question as to whether a farmer were the main decision-maker in the vegetable farming enterprise was asked to determine whether he qualified as the defined respondent. Other questionnaire instruments were based on an integrative framework. To address the complexity in farmers' adoptive decisions, the framework integrated two theories: Triandis' (1977) theory of interpersonal behavior and Rogers' (1962) theory of innovation diffusion. Altogether, constructs included within the framework were (1) farmer behavior, (2) perceived consequences of using/not using SAPs, (3) perception of the characteristics of SAPs, (4) belief, (5) expectation, (6) role, (7) self-concept, (8) social norm, (9) affect, (10) habit, (11) intention, (12) socio-economic, (13) agro-ecology, (14) institution, (15) information. Questions were developed according to the theories and, at the same time, adapted from their application in past studies (e.g., Feola and Binder 2010a, b; Gagnon et al. 2003).

Constructs (2)–(11) are psychologically-based and cannot be observed directly. They were probed in a set of statements, where interviewees were asked to express their degree of agreement with each statement. Each set had at least four statements in order to provide sufficient coverage of the construct's theoretical domain and identification for the construct in the statistical analysis by structural equation modeling (Hair et al. 2010). Each degree of agreement was given a numerical value from 1 (extreme disagreement) to 7 (extreme agreement). As these statements were not phrased in a manner that suggested a particular reply, they were not leading questions (Kerlinger 1986).

On the other hand, other constructs were observable. Questions relating to observable constructs were developed in a mixed format containing a mixture of opened-ended and closed-ended enquiries. The latter was measured by a measurement scale of discrete choice.

One major concern in interviewing farmers as respondents was related to their understanding of technical terminologies. Knowing that we had to view our questions from the farmers' point of view, input from participants (farmers and officers of the DoA) in our earlier FGDs helped with technical simplification. Drafts of the questionnaire were peer reviewed by lecturers and students in the school's research group. Among other things, these reviews pointed to the need for some negatively framed statements, thereby, breaking the routine of commonality in response. The numeric scores for such negative statements would need to be reversed.

The questionnaire was originally drafted in English. Given that Bahasa Malaysia is the national language and that the Chinese language is commonly used by Chinese farmers, active translation was needed to 'speak' to them. This active translation was done by one of our research team members who has diverse language proficiency. Then, both translated versions were back-translated by a native speaker of the individual languages, who had an educational background in agriculture. Thus, we have sought to ensure that all questions were asked in the same way (Usunier and Lee 2005). While minor mismatches of word choice were noticed, questions were generally interpreted in a similar fashion.

The layout of the final Malay and Chinese versions of the questionnaire was based on A4 sized paper. Using font size 10 and using the typeface "Times New Roman", both versions of the questionnaire were 8 pages long. Allowing for its length, each interviewer was expected to take less than 60 minutes to complete the interview.

Pre-testing

A number of questions in the questionnaire were adapted from past studies. Though they had been tested, they had mostly been used in the Western regions of the world. Examining the

functionality of these questions was deemed essential in our study area, in order to check the type of language (such as word choice, simplification of terminologies, localization of terms) to use in order to carry out the 'conversation' with respondents in a way that they would understand and so provide relevant answers (Rea and Parker 1997).

The translated questionnaires were pre-tested in the first half of October 2011. In order to get first-hand information, the pre-test was carried out by members of the research team. Through a random sampling method, a total of 24 vegetable farmers in the state of Negeri Sembilan were interviewed: 15 Malay and nine Chinese farmers were interviewed using the translated questionnaires. These respondents were also asked to evaluate the translated questionnaires, in terms of formatting, wording, clarity, and ease of understanding. The comments received were generally positive. In particular, visual aids were found to be effective in explaining the various terminologies associated with SAPs.

While pre-testing the translated questionnaires was the main emphasis, three main notes were also taken for the survey operation. Firstly, vegetable farmers' working lifestyles had changed. They worked on farms in line with an earlier sunrise. This had an impact on their break/free time, which in turn determined the interview timing. 9am-3pm and 7pm-9pm were noticed to be appropriate for the purpose. The former would be a fit for farm visits; the latter would be ideal for house visits. Secondly, a couple of safety issues were noted. Some farms were located in inner areas. They were also guarded by dogs. While local people or a global positioning system device would help in locating a selected farm, a collapsed umbrella could be used for self-protection against dogs and rain. Thirdly, some farms were managed and operated by foreign workers despite being owned by landholders or private investors. Since the target respondent was the main decision-maker of the farm, in this case, a foreign worker who was the farm manager would be interviewed. However, attention needed to be paid to his language proficiency and understanding of the questionnaire: The Malay language

is similar to the mother tongue of Indonesian workers but the language is poorly practiced by foreign workers in general. When encountering this problem, the subjects would not be interviewed.

Interviewer recruitment and training

To carry out the nationwide survey, we needed to recruit interviewers (students) on a regional basis. In early October 2011, attempts were made by putting up recruitment notices in (1) *Universiti Sultan Zainal Abidin* for the East coast region, (2) the *Universiti Utara Malaysia* for the Northern region, (3) *Universiti Putra Malaysia* (UPM) for the Central region and the Southern region as well as (4) *Universiti Malaysia Sabah* (UMS) and *Universiti Malaysia Sarawak* for Eastern Malaysia. However, we received applications from only two universities – UPM and UMS. Fortunately, these applicants' hometowns were located in various regions. The applications were then screened on the basis of whether they attended a course/subject in agriculture. In total, 51 applications from UPM and 14 applications from UMS were approved. They represented a good mix, formed by a majority of Malay students, followed by Chinese and Indian students. This, allowed us to collect information from the multi-ethnic population of vegetable farmers by multi-ethnic interviewers.

The recruited interviewers were trained. The first round of training was designed for the first half of the survey period (the end of October–the end of December 2011). Another round of revisionary training was conducted for the second half of the survey period (early January–early March 2012). Training basically focused on the background of the study, random selection of respondents within the sampling frame, self-introduction to respondents, visual aids, and the use of the questionnaires, payment arrangements, and logbook reporting as well as ways of approaching and interviewing farmers. Derived from pre-test experience,

special remarks about ideal interview timing, safety issues, and locating and identifying the main decision-maker of the farm were also made. In addition, research team members' contact details, which acted as a helpline, were given out during the training.

It should be mentioned here that the sampling frame given to interviewers was a trimmed version, providing only farm/house address. That was done, on the one hand, to protect farmers' privacy. On the other, some information was saved for our verification work, particularly to check whether interviews were actually carried out using the specified procedures.

Fieldwork management

As mentioned in the earlier section, the survey was conducted from October 2011 to March 2012. A total of 1,168 respondents from all five regions of Malaysia were interviewed using a random sampling method. The majority of the respondents came from the East coast region (31 percent), followed by the Northern region (24 percent), the Central region (16 percent), the Eastern Malaysia region (16 percent), and the Southern region (13 percent). Against the distribution share of the national vegetable farmers presented in the Section 2, significant differences were observed for the Northern, the Central, and the Eastern Malaysia regions. This was attributed to the selected sampling method, which was intended to interview respondents randomly without imposing a quota control on a certain region.

In general, the response rate of the survey was about 86 percent. The response rate indicated that a total of 1,168 out of 1,583 questionnaires were completed and returned. While refusal to be interviewed was the main reason for failure to complete, other screening decisions also contributed to the non-response rate. To avoid getting unreliable data, those vegetable farmers approached, for whom language was a barrier to an effective interview,

were filtered. Typical of these were foreign farm managers who spoke little Bahasa Malaysia. When non-Chinese interviewers approached Chinese famers, the national language could be the language medium for communication. However, not only did the latter (particularly the old ones) have difficulty in understanding the questionnaire but also found it hard to express their comments in Bahasa Malaysia. Consequently, there was a minor shortfall in our respondent size (1,168) compared with the initial target of sample size (1,200).

Another major task in the field management was respondent verification: that is, to avoid having falsified interviews, where interviewers did not contact respondents but filled in fake answers (Zikmund and Babin 2009). On-farm verification was carried out by following interviewers to farm visits while, at the same time, supervising whether interview procedures were adhered to. Off-farm verifications were done by referring to the list for compensation, which recorded respondent details, including farmer name, identity card number, farm address, telephone number, and signature. As only the farm address was given in the trimmed version of the sampling frame to interviewers, the other information provided in the list for compensation was used for verification purposes. In addition, telephone calls were made to respondents on a random basis. As these verification measures were highlighted in the interviewer training sessions, falsification was not detected in our survey.

Data management

Individual questionnaires were assigned a unique identity number. The conventional data entry method used the spreadsheet program of Microsoft Excel®. Such a method opens the possibility of miscoding data due to the program's auto-repetitive function. For example, a farm size of "11" hectares for *i*th case were entered earlier. When attempting to record a farm

size of “1” hectare for *j*th case, it might appear as “11” instead of “1”. Reviewing such errors reduces data cleaning work in the later stage.

Considering this potential problem, we created an online data entry form on Google Forms®. The form was designed to have the same appearance as our paper-based questionnaire. Any data entry personnel, regardless of their understanding of our questionnaire, could easily handle the task. More importantly, the system saved us from encountering the possible error mentioned earlier. To enhance database protection, Google Forms® offers an option limiting access to specified research team members.

In addition, the online data entry system, as designed, also offered a preliminary, yet important, data screening function. As the entered data would be saved on an online spreadsheet of Google Docs®, its automatic “Text Filters” function would enable the data entry team to recognize mis-entered information immediately. Taking an example of “Yes” and “No” options, only these two categories of answer should appear in the “Text Filters”. A miss-entered piece of data, say “10” that came from the answer of the next question, would appear as an additional category in the function box. Ticking the additional category would filter and limit the case to where the error was keyed. This offered a rapid way to correct information through referring back to the identified questionnaire.

Exporting the spreadsheet dataset to SPSS®, “Explore” also facilitated an additional error check. Though a number of errors were identified, they were not serious. The majority of these were attributed to the preliminary cleaning work of the spreadsheet during the data entry. At that time, answers for negatively framed questions were reversely recoded. That was, to make sure all items were scored in the same direction (Zikmund and Babin 2009). All procedures on SPSS® were carried out using its command language (syntax).

CONCLUSIONS

Researchers rely partly on primary data for conducting empirical analyses to explain social phenomena within agricultural systems. On-farm information is largely collected via agrarian surveys. Fundamental design characteristics share similarities with other social surveys (e.g., marketing). However, the object of agrarian surveys is general farmers who have often received little higher education. This small but distinctive characteristic could lead to a large difference in data reliability. Agrarian surveys, hence, need to be slightly modified and uniquely designed. To begin filling this gap, a number of textbooks have been published. However, institutional frameworks and cultural endowments also play a key role in agrarian surveys. This paper has, therefore, provided a note specifically on Malaysia, and is derived from our recent experience which was gained from our research project on the adoption of SAPs in its vegetable sector.

Fundamental design of an agrarian survey can be based on general guidelines from other social fields. Considering farmers' education level as well as the difference in institutional and cultural factors, specifications are required in various design stages of a context-specific survey. If one were not aware of these particularities, conducting an FGD with the prospective respondents and/or local agricultural officers prior to survey design would generate these insights. In other words, insights from FGDs are useful in various design stages of an agrarian survey.

Our hands-on experience in Malaysia has provided valuable insights into ways of designing an agrarian survey and conducting face-to-face interviews with farmers. Though the experience is context specific, these insights have highlighted important considerations when a study area is institutionally and culturally complex. Special notes should be taken of:-

(1) *Sampling design*: The characteristics of the target population must be specified. They must be identifiable through the use of a sampling frame. An official list can be obtained from the federal government if its administrative power is centralized or local governments if the governance system is decentralized. When the target population size is known, the determination of the sample size should be based on a statistic or limited by financial constraints. Probability sampling methods are deemed appropriate when a sampling frame is available. If uncertainty exists, closely related local studies could provide useful reference points for decision-making at this stage. Otherwise, an FGD could also generate useful guides for the purpose.

(2) *Questionnaire design*: Questionnaire instruments must be based on a defined research framework. Though underlying theory is the key reference point, its use in past studies can provide tested questions for direct application or adaptation. Because questions are designed to collect data for future empirical analyses, researchers must have knowledge as to whether they could provide sufficient information and meet the requirements of statistical tests. On the other hand, questions should be simple and peer-reviewed. The questionnaire should be translated according to the target respondents' common language(s), which knowledge could be gained through an FGD or past studies. It should also be back-translated to ensure that questions will be asked in the manner intended.

(3) *Pre-test*: Pre-testing of the questionnaire is strongly recommended. It is typically used to check the reliability and validity of the questionnaire. It also provides a good opportunity to look into how to conduct an efficient survey (e.g., whether visual aids are needed), when to approach farmers, what safety issues need to be taken care of,

and what practical issues might be encountered by interviewers. In order to be able to discuss these, particularly in interviewer training, researchers should carry out the pre-testing themselves. If they choose to skip the pre-test, these concerns should be addressed in an FGD that is held earlier.

(4) *Interviewer recruitment and training*: Researcher should have confidence that their recruited manpower can achieve the sample size target. Recruiting an interviewer should be based on their exposure to the field, ability to carry out an effective interview, and location. The latter, in particular, is crucial when a survey is to be conducted in large and scattered-scales. Students tend to be good interviewers as they are receptive to training. Not only the training is intended to inculcate interviewers with survey procedures, it is also a platform to share the pre-test experience (particularly on difficulties and ways of handling). Interviewers should be cautioned that the research team has built in measures to verify their work.

(5) *Fieldwork management*: Though achieving the target sample size is important, it must not be compromised at the expense of data reliability. The latter can be avoided by ensuring that survey procedures are adhered to. One way for conducting verification is through the supervision of on-farm interviews. Other off-farm measures (e.g., calls to respondents) can also be taken for this purpose.

(6) *Data management*: Data entry using conventional methods is likely to encounter miscoding errors. A number of online platforms offer improved methods for data entry. Not only do they minimize the possibility of error, they also ease the data entry workload. They have a function for error identification, so immediate remedies,

therefore, can be taken during the entry stage. It will certainly reduce any future burden in respect to data cleaning. The dataset must be kept secured.

Future notes should be made for agrarian surveys in other countries. This is because social research within agriculture is context specific. So, specifics on the domestic institutional frameworks and cultural endowments are needed before considering survey design. The ultimate intention is to get reliable data for empirical analysis and yield insight into social phenomena within agriculture.

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Chapter 6: A structured assessment on the perceived attributes of sustainable agricultural practices: a study for the Malaysian vegetable production sector

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Chapter 7: Economic and psycho-social factors influencing the adoption of sustainable agricultural practices: an integrative approach for Malaysian vegetable farmers

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Economic and psycho-social factors influencing the adoption of sustainable agricultural practices: An integrative approach for Malaysian vegetable farmers

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ABSTRACT

There is a general consensus that sustainable agricultural practices (SAPs) have not been widely adopted by farmers. Previously, separate approaches have been taken to understand economic factors and psycho-social factors in influencing SAPs adoption. However, their individual insights offer limited help on what to emphasize in SAPs promotion. To narrow this knowledge gap, this study aims to investigate both economic and psycho-social factors

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concurrently. Guided by an integrative framework of theory of interpersonal behavior and the theory of diffusion of innovation, the survey data about the Malaysian vegetable production sector is analyzed using structural equation modeling. The findings indicate that adoption is influenced by a range of economic and psycho-social factors. Among them, economic factors tend to be more influential on SAPs adoption. Driven by these findings, policymaking in this area should be based on multidisciplinary considerations. In particular, local policy development and follow-up studies should have a greater emphasis on economic factors.

Keywords: Sustainable agriculture, adoption, Malaysia, structural equation model

1. Introduction

Land and resource degradation has serious implications for environmental health which agricultural activities depend on (Conway, 1990). Their compounding effects can potentially strike at the heart of food security and economic development (Tey et al., 2012a). Concern over these issues has stimulated policies aiming to change farmer behavior in adopting sustainable agricultural practices (SAPs). SAPs are environmentally non-degrading, resource conserving, socially acceptable, technically appropriate, and economically viable (FAO, 1995). Despite widespread promotion of these benefits, their adoption rates have so far been low in many countries.

A body of research has attempted to understand what leads to the adoption of SAPs using economic theories. This is known as a "factor" approach, given their interest in economic variables that affect adoption directly. Review studies (e.g., Baumgart-Getz et al., 2012; Tey and Brindal, 2012; Prokopy et al., 2008; Knowler and Bradshaw, 2007; Pannell et al., 2006) reveal that a range of socio-economic, agro-ecological, institutional, and

information factors as well as the perceived attributes of SAPs have an impact on adoptive behavior. These studies offer useful information for various extension purposes, including the characteristics of potential adopters for targeting of communication channels and for the effective distribution of information (Tey and Brindal, 2012).

In addition, an increasing number of studies have investigated the behavior structure involved in the adoption of SAPs. This is known as a "process" approach, which explains the processes shaping adoptive behavior. The need for this type of investigation is motivated by the inadequacy of economic theories in analyzing behavior consistently with observations (e.g., Feola and Binder, 2010a; Bayard and Jolly, 2007; van den Bergh et al., 2000; Costanza et al., 1993; Lynne et al., 1988). This is because sustainability-related behavior is beyond economic consideration, encompassing psycho-social aspects as well (Stern, 2000a). Research suggests that farmer attitudes, habits, subjective evaluations and social norms may influence adoptive behavior. These psycho-social factors are useful in generating cues to behavior formation and change (Peter and Olson, 2009; Schiffman and Kanuk, 2009; Kotler, 2003).

It is clear that different insights are offered by the separate approaches in the literature. The first approach draws attention to the economic factors and the second approach concentrates on the psycho-social factors. Consequently, their insights are rarely made available at the same time. That also means their individual insights offer limited help on what to emphasize in relation to encouraging adoption (Reimer et al., 2012). There is a danger that policymaking could be biased without more complete information.

Responding to the knowledge gap outlined above, this study aims to examine economic factors and psycho-social factors concurrently. This study will be guided by an integrative theoretical framework comprising both economic and psycho-social principles. Structural equation modeling technique will be deployed to analyze survey data from

Malaysian vegetable farmers. The findings of such technique will not only evaluate the significance of economic and psycho-social factors, but will also render a clearer picture on their relative importance. In such format, this study departs from past studies by generating a greater range of implications for steering future SAPs promotion.

2. Literature review

As noted above, the literature on the adoption of SAPs is split into two streams. The first research group is interested in economic factors influencing adoptive behavior. The second research cluster examines psycho-social factors that affect the behavior structure involved in adoption. While these are separate approaches in their own right, we review the relationship between their factors in seeking empirical support for the use of an integrative theoretical framework in this study.

Common economic factors that could lead to the adoption of SAPs have been reviewed by Baumgart-Getz et al. (2012), Tey and Brindal (2012), Prokopy et al. (2008), Knowler and Bradshaw (2007), and Pannell et al. (2006).

A group of socio-economic factors reflect farmer capacity, which can be defined as the capability to perform farming activities (Lee, 2005). As the application of the full spectrum of SAPs is complex, older farmers are likely to encounter difficulty in dealing with them, and better educated farmers are likely to have greater ability to manage them. Because investment incurs some costs and possesses certain risks, SAPs adoption is likely to be facilitated by a bolstered financial capacity. This capacity can be represented by higher financial capital, the presence of livestock and larger farm size, or it can be raised through off-farm employment and access to finance.

Agro-ecological factors affect adoptive decisions through their asymmetric distribution (Ervin and Ervin, 1982). A farm that is owned is more likely to be operated sustainably and passed to successors. Differences in resource quality across regions determine the need for SAPs. Therefore, the effect of farm region upon adoption cannot be known *a priori*.

Other common factors influencing the adoption of SAPs include organizational membership, information, and perceptions. Members of farmer associations and cooperatives exchange information with each other. A sustainable farm is likely to serve as a role model and influence other members to implement similar management. Farmers also learn the benefits and technical knowledge of SAPs by accessing the relevant information. Through such access, farmers are empowered to manage SAPs. Properly managed SAPs have beneficial impacts on farm profits, the environment, and resource quality. Positive perceptions of these relative advantages are in turn likely to lead to adoption (Rogers, 2003).

Considering the psycho-social factors, any reasonably complicated, voluntary behavior is determined by individuals' intention to perform that behavior. Intention to adopt SAPs has been demonstrated to be the immediate determinant of whether farmers will realize that behavior (Reimer et al., 2012; Calkins and Thant, 2011).

The antecedents of intention include affects, norms, heuristics and cognition. These psycho-social factors affect the adoption of SAPs through intention. Affective responses (feelings) about SAPs can be favorable or unfavorable. Positive ones are likely to stimulate a stronger intention-behavior relationship (Veisi, 2012). Normative beliefs reflect farmers' perceptions of what other people want them to do. When SAPs use is seen as a norm, a stronger intention is aroused, triggering behavior to meet the standard (Wauters et al., 2010; Yeo and Hirst, 2010). Heuristics exist as common sense: when SAPs have been in practice, a simple choice is to continue using them as a matter of course (Greiner et al., 2009; Escalada

and Heong, 2004). Cognition refers to farmers' thinking. An example is their beliefs, where placing some confidence in and expectations of SAPs reinforces intention and adoption (Feola and Binder, 2010a, 2010b).

Among the discussed antecedents of intention to adopt SAPs, the cognitive aspect aims to capture the mental structures and processes in thinking, understanding, and interpreting relevant stimuli (Peter and Olson, 2009). To illustrate these, it is necessary that farmers develop certain expectations of and beliefs in the various benefits of using SAPs. Their expectations will have developed from their perceptions about the relative advantages of SAPs (Pannell et al., 2006). Such subjective evaluation may consider the impact(s) of SAPs on farm receipts, environmental health, resource quality and/or social wellbeing. How well these features are evaluated depends on economic factors, including socio-economic and agro-ecological factors, organizational membership, and information quality (Reimer et al., 2012). In sum, the cognitive aspect is a proposition connecting economic factors, perceptions, expectations, intention, and behavior.

To address the key focus in this section: the proposition outlined above suggests a link between various economic factors and the thinking processes. This link opens a window for building an integrative theoretical framework in this study. Guided by it, both economic and psycho-social factors can be investigated and evaluated concurrently.

3. Theoretical framework

In the literature, a number of integrative theoretical frameworks have been used to understand farmer behavior. Recent examples include an integration of the theory of planned behavior (TPB) and the theory of diffusion of innovation (DOI) (Reimer et al., 2012; Tutkun et al., 2006) for investigating the adoption of SAPs; an incorporation of the theory of

reasoned action (TRA) and the pest-belief theory (Heong et al., 2002; Heong and Escalada, 1999); a combination of the theory of interpersonal behavior (TIB) and structuration theory (Feola and Binder, 2010b) for understanding pesticide application. These frameworks share one similarity: behavioral theories (TPB, TRA, and TIB) act as the core structure to merge with another theory. Therefore, Triandis' (1977) TIB is used as the base to integrate with Rogers' (2003) theory of DOI in our integrative theoretical framework (Figure 1).

The TIB proposes that any reasonably complex, voluntary behavior is determined by economic factors coupled with individuals' habits and intentions to perform that behavior. Economic factors may facilitate or impede a behavior. For example, wealthier farmers have greater financial capacity to invest in SAPs. When the habit of an action is established, the selected behavior becomes a natural choice (heuristic). An intention to engage in a behavior is the outcome of the psycho-social process of selecting the behavior that will lead to the most desirable consequences. In the choice process, individuals consciously consider the consequences of each behavior in question. They tend to perform behaviors that are felt favorably (affective), popular with other people (normative), and thought beneficial (cognitive).

As noted earlier, a link is required to connect the economic factors to the cognitive process. Rogers' (2003) theory of DOI is sought to provide a theoretical ground for that purpose. One of its elements – the perceived attributes of innovations – is posited to affect adoptive behavior. That takes place through subjective evaluations of relative advantage, compatibility, complexity, trialability, and/or observability. These perceptions are influenced by economic factors (Rogers, 2003). On the other hand, they lead to beliefs, which embody the cognitive content of expectations about the outcomes of a behavior (Pannell et al., 2006). That is, these pre- and post-components of perceived attributes cohere with thinking

processes. Such links are also empirically supported by Reimer et al.'s (2012) integrative framework.

The TIB and the theory of DOI are compatible (Jackson, 2004). Together, their premises are consistent with the complexity of behavior, which is not completely bounded by economic rationality but is also dependent on psycho-social considerations. The integrative theoretical framework used in this study is shown in Figure 1.

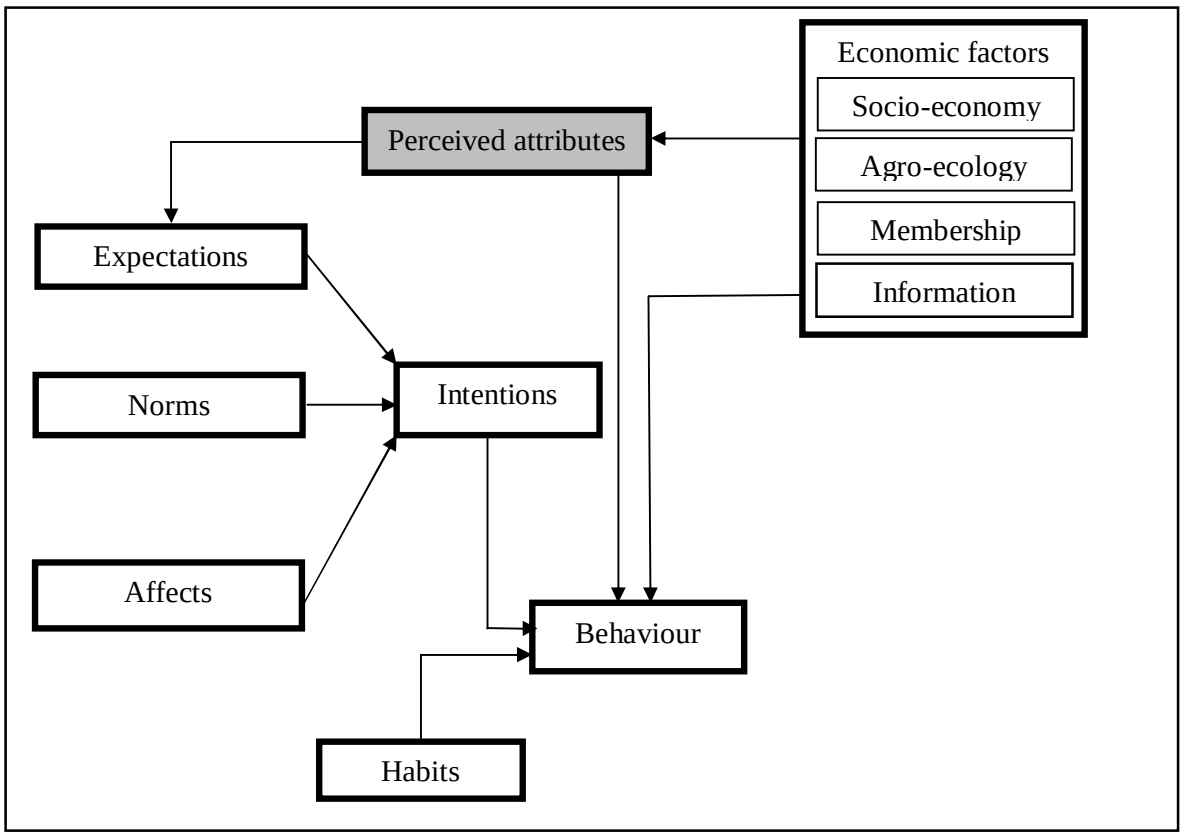


Figure 1

The integrative theoretical framework.

Notes: the un-shaded boxes are adapted from Triandis' (1977) theory of interpersonal behavior; the shaded box is sourced from Rogers' (2003) theory of diffusion of innovation.

4. Methodology

Followed the direction set by Bayard and Jolly (2007), our theoretical framework (Figure 1) was translated into a subjective expected utility model that contains multiple functions involving dependence relationships:

$$A = f(EF, I, PA, H) \quad (1)$$

$$I = f(EX, AF, N) \quad (2)$$

$$EX = f(PA) \quad (3)$$

$$PA = f(EF) \quad (4)$$

where A is the probability of adoption of a SAP, EF is a vector of economic factors, I is a vector of intention, PA is a vector of perceived attributes, H is a vector of habits, EX is a vector of expectations, AF is a vector of affects, and N is a vector of norms. Based on these functions, we argue that there exist economic and psycho-social factors in limiting or facilitating the adoption of SAPs, directly and indirectly. Adoption is likely to happen when the subjective expected utility of the selected behavior is greater than that of its competitor.

4.1 Estimation methods

Structural equation modeling technique was employed to address the set of interrelated functions outlined above. Using common factors in the literature, the functions were specified and estimated simultaneously as:

$$ADOPT_i = a_i AGE + b_i EDUC + c_i \log(FINCAP) + d_i TLU + f_i OFFJOB + g_i FINACC + h_i FARMSZ + j_i TENURE + k_i EAST + l_i MEMBER + m_i INFOUSE + n_i HABIT + o_i RELAD + p_i INTENT \quad (5)$$

$$INTENT = a_2 EXPECT + b_2 AF + c_2 NORM \quad (6)$$

$$EXPECT = a_3 RELAD \quad (7)$$

$$RELAD = a_4 AGE + b_4 EDUC + c_4 \log(FINCAP) + d_4 TLU + f_4 OFFJOB + g_4 FINACC + h_4 FARMSZ + j_4 TENURE + k_4 EAST + l_4 MEMBER + m_4 INFOUSE \quad (8)$$

where *ADOPT* is the adoption status of *i*th SAP, *AGE* is farmer age, *EDUC* is education levels, *FINCAP* is financial capital, *TLU*[*] is tropical livestock unit, *FINACC* is access to finance, *FARMSZ* is farm size, *TENURE* is land ownership, and EAST is East Malaysia, *INFOUSE* is the usefulness of information on SAPs, *HABIT* is habits in using SAPs, *RELAD* is the perceived relative advantage of SAPs, *INTENT* is the intention to use or continue using

[*] Tropical livestock unit (TLU) standardizes the body weight of livestock: one TLU is equivalent to 250kg of live weight (FAO, 1999). Followed Mass et al. (2012) and Ghirotti (1993), the number of livestock was converted into TLU using the following conversion factors: cattle (0.70), sheep and goat (0.10), pig (0.20), and poultry (0.01).

SAPs, *EXPECT* is expectations toward the impacts of SAPs, *AF* is affects attached to SAPs, and *NORM* is social norms.

While most of the aforementioned independent factors were measured directly, others (*INFOUSE*, *HABIT*, *RELAD*, *INTENT*, *EXPECT*, *AF*, and *NORM*) were unobservable. Multiple items were used to represent their respective constructs approximately. In such a format, these constructs formed a measurement model, which is also known as a confirmatory factor analysis model. Guided by Hair et al. (2010), we checked for its general goodness-of-fit, specific individual-item reliabilities within a construct, and convergent and discriminant validities for each construct. First, a valid measurement model exists when the chi-square (χ^2) test is statistically insignificant, the root mean square error of approximation (RMSEA) value falls within 0.03-0.08, and/or the comparative fit index (CFI) value is above 0.90. Second, a reliable item is one having a factor loading of above 0.5 for its respective construct. Otherwise, it should be removed. Third, convergent validity appears when the construct reliability (CR) exceeds 0.5 and the average variance extracted (AVE) surpasses 50 percent. Discriminant validity is obtained when the square root of each AVE is greater than its inter-construct correlations.

Following the valid and reliable measurement model, a structural model was established to test the theoretical relationships as depicted in Figure 1. A direct effect was likely to exist between economic factors, habits, intentions, and the perceived relative advantage of SAPs and behavior. An indirect effect was likely to present along the paths of economic factors—perceived relative advantage—expectations—intentions—behavior; of norms—intentions—behavior; of affects—intentions—behavior. Mathematically, their relationships were as those specified in Equations (5-8). They contained the observable variables and the refined constructs. The structural model was estimated using the Maximum Likelihood Bootstrapping procedure in AMOS. This procedure was deployed to obtain

standard errors for indicating the significance of the standardized coefficients and the standardized total effects, which summed up corresponding direct and indirect effects (Byrne, 2010).

A structural model is said to be valid when satisfying either of the goodness-of-fit requirements (χ^2, RMSEA, and CFI) previously defined. Progressing from the valid model, significant standardized coefficients were interpreted. Standardized coefficients provide a standard interpretation for and comparison across natural and non-natural metrics. They indicate how many standard deviations of change in a dependent variable are associated with a standard deviation of change in the independent variable (Menard, 2011).

Recalling Figure 1, there are direct and indirect paths linking independent variables to dependent variables. For example, in addition to the possible direct effect of the perceived relative advantage of adoption, the independent variable also has an indirect effect on the dependent variable, through the perceived relative advantage, expectations and intentions. Multiplying the standardized coefficients along this indirect path produces an estimate of the standardized indirect effect of the independent variable on the dependent variable. Summing up the standardized direct and indirect effects generates an estimate of the standardized total effect of the independent variable on the dependent variable. Its magnitude may indicate a small (<.10), moderate (.10 to .24), or large (>.25) effect of the independent variable on the dependent variable, in total (Keith, 2006). Also, given such standardization, the effect size of the factor is comparable against other factors. Based on these two points, our integrative investigation will generate more comprehensive insights for fostering SAPs.

4.2 Study area and data

This study was carried out in all regions (the Northern, Central, Southern, East coast, and Eastern) of Malaysia[*]. The country has some 8,250 commercial vegetable farmers. Tropical vegetables are grown in the lowlands and temperate species in the uplands. Both types of vegetables are largely produced using intensive methods in open farming. Open farming exposes soils to runoff and erosion. There are additional negative impacts associated with chemical inputs, which are often applied excessively. These conventional management practices can cause land degradation, chemical runoff, and residue contamination. All these externalities have serious implications for environmental, economic, and social health.

In Malaysia, sustainability is a key objective in the Tenth Malaysia Plan (2011-2015), the National Agro-Food Policy (2011-2020), and the New Economic Model (2011-2020). This objective aims to balance environmental conservation with productivity exploitation. To achieve this objective, concerted effort is being placed into promoting the voluntary adoption of six generic SAPs (conservation tillage, intercropping, cover crops/mulches, organic fertilizers/composts, crop rotation, and IPM), which were not coordinated in the past (Tey et al., 2012b). To advance their progress, it is timely to understand the adoptive behavior concerning these SAPs in order to enhance their future promotion.

In this study, a probabilistic survey was conducted from October 2011 to March 2012. A list of vegetable farmers who were registered with the Departments of Agriculture Malaysia, Sabah, and Sarawak was used in the survey. Through random selection, a total of 1,168 farm main decision-makers were interviewed.

[*] Malaysia is made up by two split landmasses – Peninsular Malaysia (the Northern, Central, Southern, East coast regions) and East Malaysia (the Eastern region).

A structured questionnaire was used for the interview. It was initially developed through a literature review to collect information for the empirical application of the theoretical framework (see Figure 1). Then it was refined through focus group interviews (for details, see Tey et al., 2012c). As shown in Table 1, high adoption rates were recorded for organic fertilizers/composts, conservation tillage, and crop rotation; moderate adoption rates were indicated for intercropping and cover crops/mulches; and a low adoption rate for IPM. On average, respondents were 50 years old, had received eight years of formal education, had RM78,210 (±US$26,070) financial capital, cultivated vegetables on 4.4 hectares of land, and had 9 tropical livestock units. About 27 percent, of them had an off-farm job, 27 percent had access to finance, 54 percent owned the farmland, 16 percent were located in East Malaysia, and 41 percent were members of a farmer's organization.

Other sections of the questionnaire included a number of structured statements eliciting farmers' perceptions of the usefulness of information on SAPs, perceptions of the relative advantage of SAPs, expectations about the impacts of SAPs, affects attached to SAPs, norms in using SAPs, habits in using SAPs, and intentions to continue using or to begin using SAPs. Responses for these factors were measured on a 7-point Likert scale as to what degree the respondents agreed with a set of statements. Higher values indicated greater agreement, and vice versa. Their descriptive statistics are shown in Table 1.

Table 1.

Descriptive statistics of observed variables and measurement items.

	Variables / observed items	Description / units	Mean	Standard deviation
Dependent variables	Conservation tillage	Adopted=1; No=0	.835	.372
	Intercropping	Adopted=1; No=0	.548	.498
	Cover crops/mulches	Adopted=1; No=0	.471	.499
	Crop rotation	Adopted=1; No=0	.766	.424
	Organic fertilizers/composts	Adopted=1; No=0	.850	.357
	Integrated pest management	Adopted=1; No=0	.086	.281

Table 1.

Continued

	Variables / observed items	Description / units	Mean	Standard deviation
Independent variables	Age	Years	49.739	13.495
	Formal education	Years	7.884	4.357
	Financial capital	RM	78,210	230,914
	Tropical livestock unit	Unit	9.298	35.814
	Off-farm employment	Have off-farm employment=1; No=0	.274	.446
	Access to finance	Have access to finance=1; No=0	.272	.445
	Farm size	Hectares	4.438	10.323
	Land ownership	Self-owned farmland=1; No=0	.544	.498
	East Malaysia	Located in East Malaysia=1; No=0	.164	.371
	Membership	A member of farmers organization=1; No=0	.408	.492
Measurement items	Inf1	Information gained on SAPs from extension services is useful	4.82	1.501
	Inf2	Information gained on SAPs from farmers association is useful	4.44	1.280
	Inf3	Information gained on SAPs from mass media is useful	4.47	1.277
	Inf4	Information gained on SAPs from friends is useful	4.87	1.309
	Rel1	I think SAPs produce good looking produce	5.82	1.131
	Rel2	I think SAPs are beneficial to the environment	5.89	1.054
	Rel3	I think SAPs improve a farmer's reputation in the market	5.76	1.054
	Rel4	I think SAPs enhance a farm's landscape	5.58	1.144
	Rel5	I think SAPs protect natural resources for future generations	5.84	1.055
	Rel6	I think SAPs make vegetables more acceptable to consumers	5.85	1.117
	Exp1	SAPs will enhance the food safety level of my produce	5.79	1.041
	Exp2	SAPs will improve the overall safety of my farm workers	5.72	1.071
	Exp3	SAPs will enhance the environment surrounding my farm	5.73	1.105
	Exp4	SAPs will enhance resources surrounding my farm	5.76	1.076
	Att1	For me to use SAPs is risky*	4.42	1.768
	Att2	For me to use SAPs is troublesome*	4.59	1.626
	Hab1	Using SAPs is common to me	4.82	1.378
	Hab2	I use SAPs regularly	4.70	1.465
	Hab3	I am used to SAPs	4.71	1.453
	Hab4	Using SAPs is natural to me	4.73	1.466
	Nor1	As a farmer, I would use SAPs	5.42	1.038
	Nor2	My farm workers would approve the use of SAPs	5.48	1.048
	Nor3	As a responsible farmers, I would use SAPs	4.71	.735
	Int1	I plan to use SAPs	5.46	1.305
	Int2	I intend to use SAPs	5.47	1.273
	Int3	I will use SAPs	5.37	1.319
	Int4	I want to use SAPs	5.47	1.303
	Int5	I wish to use SAPs	5.56	1.288

Notes: Respondents were asked to rate their agreement (using 1-7 scale) on all measurement items; * scores were inversely recoded for negative statements

5. Results

The results of the confirmatory factor analysis of the measurement model are presented in the Appendix. First, the overall model fit was achieved. This was supported by the CFI and the RMSEA although the χ^2 does not indicate so. The CFI had a value of 0.947, exceeding its guidelines of greater than 0.90; and the value for RMSEA was 0.057, falling within the 0.03-0.08 rule of thumb. Second, all constructs were found to be valid. Their respective items were reliable, with a factor loading of above 0.5 after removing deficient ones. Convergent validity existed where all the values of CR and the AVE were at or above the 50 percent requirement. Discriminant validity was obtained as the square root of each AVE was greater than its inter-construct correlations.

Given the valid and reliable measurement model, the structural model was estimated. Its results are presented in Table 2. While the χ^2 was significant, values for CFI and RMSEA were 0.903 and 0.052 respectively. The latter statistics suggest an acceptable overall fit of the model. More specifically, R-square values of the simultaneous regressions (see Equations 5-8) ranged from 0.038 to 0.581. Less than 10 percent of the variance was explained for the six adoption regressions. Comparable R-square values are common in the literature (e.g., Sharma et al., 2011; McBride et al., 2004; McBride and El-Osta, 2002; Rajasekharan and Veeraputhran, 2002; Okoye, 1998; Napier and Camboni, 1993; Shortle and Miranowski, 1986).

The standardized coefficients of the SEM model are listed in Table 3. They represent the direct effect of independent variables on their respective dependent variables. Their indirect effect can be obtained by multiplying the standardized coefficients along their indirect path (see Figure 1). For example, the indirect effect of education on IPM adoption (through perceived relative advantage, expectations and intentions) was -0.00041 (-0.004 x

0.675 x 0.188 x 0.080). When summed with its direct effect (0.057), the total effect of the variable was 0.0566 and its effect size was small. Due to our particular interest in the total effect, its estimates are presented in Table 3 and discussed along with Table 2.

Respondents with greater education levels were significantly more likely to adopt cover crops/mulches, crop rotation, and IPM. This variable had a small total effect on most SAPs. A single exception was its moderate total effect on cover crops/mulches. Despite that, these findings conform to the general expectation that better educated farmers will exercise discriminative judgment with regard to the pros and cons of SAPs. They are also more capable in farm management, especially given that SAPs are complex and challenging. However, a negative effect appeared for education in the adoption of conservation tillage. This could be related to the large degrees of freedom that sometimes yield a minor inconsistency in statistical outputs.

Table 2.

Standardized coefficients of the structural equation model.

Independent observed variables / latent factors	Dependent observed variables / latent factors								
	Conservation tillage	**Intercropping**	**Cover crops / mulches**	**Crop rotation**	**Organic fertilizers / composts**	**Integrated pest management**	**Intentions**	**Expectations**	**Relative advantage**
Age	-.024	.010	.033	.011	-.046	-.059			-.029
Formal education	-.053*	-.018	.150***	.092***	.003	.057*			-.004
Financial capital	.113***	.027	-.030	.079**	.025	.035			.003
TLU	-.003	-.067**	-.033	-.035	-.044	-.003			.031
Off-farm employment	.007	-.027	-.021	.008	.011	-.076***			.021
Access to finance	.080**	.028	.067**	.032	.035	.042			-.040
Farm size	-.008	.028	.057**	.019	.030	.076			.002
Land ownership	-.008	-.010	.028	-.019	-.039	-.007			-.087***
East Malaysia	.191***	.082**	.082***	-.005	.002	-.072***			.043
Membership	.027	.022	.016	-.028	.059*	.006			.038
Information usefulness	.182***	.186***	.189***	.100**	.036	.061*			.432***
Relative advantage	-.095**	.090**	-.097**	.069	-.046	-.009		.675***	
Habit	.046	-.045	.064	-.041	.120***	.058			
Intention	.001	.042	-.001	-.019	.046	.080*			
Expectations							.188***		
Attitudes							.080*		
Norm							.686***		
R-squared	.093	.076	.077	.035	.038	.053	.581	.456	.201
Chi-square=3,348 based on 807 degree of freedom; p-value=.000									
CFI =.903; RMSEA=.052									

Note: *** significant at .01 level (two-tailed *t* value >2.576); ** significant at .05 level (two-tailed *t* value >1.960); * significant at .10 level (two-tailed *t* value >1.645)

Table 3.

Total effects of factors influencing the adoption of sustainable agricultural practices.

Independent observed variables / latent factors	Conservation tillage	Intercropping	Cover crops / mulches	Crop rotation	Organic fertilizers / composts	Integrated pest management
Age	-.022	.008	.036	.009	-.045	-.059
Formal education	-.053*	-.018	.151***	.092***	.003	.057*
Financial capital	.113***	.027	-.030	.080**	.025	.035
TLU	-.006	-.064**	-.036	-.033	-.045	-.003
Off-farm employment	.005	-.025	-.023	.009	.010	-.076***
Access to finance	.084***	.024	.071**	.030	.036	.042
Farm size	-.008	.028	.057**	.019	.030	.076
Land ownership	.001	-.018	.037	-.025	-.035	-.007
East Malaysia	.187***	.086**	.078**	-.002	.000	-.072***
Membership	.023	.026	.013	-.025	.057*	.006
Information usefulness	.141***	.227***	.147***	.129***	.019	.061*
Relative advantage	-.095**	.095**	-.098**	.066	-.040	.001
Habit	.046	-.045	.064	-.041	.120***	.058
Intention	.000	.042	-.010	-.019	.046	.080**
Expectations	.000	.008	-.002	-.004	.009	.015*
Attitudes	.000	.003	-.001	-.002	.004	.006
Norm	.000	.029	-.007	-.013	.032	.055**

Note: *** significant at .01 level (two-tailed *t* value >2.576); ** significant at .05 level (two-tailed *t* value >1.960); * significant at .10 level (two-tailed *t* value >1.645); <.10=small effect; .10-.24= moderate effect; >.25=large effect

Source: Calculated from standardized coefficients of the structural equation model

Financial capital had a significantly positive, moderate total effect on conservation tillage adoption and a small total impact on crop rotation uptake. These indicators are consistent with past studies that focused on conservation practices (e.g., Lamba et al., 2009; Somda et al., 2002; Saltiel et al., 1994; Pampel and van Es, 1977). Being conservation-based, these SAPs do not offer immediate and tangible benefits. They undergo a transition before functioning optimally in the long term. Therefore, the greater the financial capital of a farmer, the more he or she can afford to invest in and take financial risks with or accept that the benefits will be realized further down the track.

TLU was significantly negative and marginally associated with intercropping adoption. Against the general expectation, this finding suggests that as the number of livestock increases, the lower the likelihood of intercropping adoption becomes. Nevertheless, this finding is reinforced by Adesina and Chianu (2002). They argued that farmers prefer to invest more in livestock than cropping when the former is the major activity. In addition, farmers also have to spend more time on livestock management when livestock size increases. Both of these explanations point to direct competition between livestock and cropping efforts.

Involvement in off-farm employment significantly reduced the likelihood of IPM adoption, but only to a small extent. This is consistent with Cramb (2005) and Rajasekharan and Veeraputhran (2002) that the need to work off-farm often keeps the labor force away from the farm. The additional financial gain is certainly earned at the expense of farmers' time available for, attention to, and physical capacities for farming. In particular, IPM is complex and requires an intensive use of management inputs (Lee, 2005). Its application requires evaluation of the principles, species, local environment, what, how much, and when to apply (Taylor et al., 1993). It can be concluded that the off-farm activity reduces the management resources available for the adoption of SAPs.

Respondents who had access to finance were more likely to adopt conservation tillage and cover crops/mulches. Though the total effect on these two SAPs was small, these findings are consistent with *a priori* expectations. Their adoption is likely to be encouraged through the farmers' ability to raise their financial capacity. The access allows farmers to pay for the purchasing costs of equipment for conservation tillage and cover crops/mulches (composted manure or straw). In addition, as their benefits are time distant, the access to finance also bolsters farmers' financial capability to undertake the risks of the investment.

Farm size had a significantly positive but small total influence on the adoption of cover crops/mulches. This finding is supported by Neil and Lee (2001), who found that smaller farms are reluctant to risk productive area with the SAP; those with additional land can afford to spare part of their cultivated areas for that investment. More importantly, the latter type of farm is more specialized and possesses a stronger financial capacity to absorb the possible losses.

Respondents in East Malaysia were significantly more likely than those in Peninsular Malaysia to adopt conservation tillage, intercropping, cover crops/mulches, and IPM. This variable had a moderate total effect on conservation tillage adoption and a small total impact on other SAPs. Such regional difference could be attributed to asymmetric distribution of resources (D'Emden et al., 2006). This shows the need to distinguish amongst local farming systems: East Malaysian farms typically rely on traditional methods and Peninsular Malaysian farms are mostly mechanized. Because of that, East Malaysian farmers by and large still preserve indigenous farming knowledge, which is highly relevant to these particular SAPs.

Members of farmer organizations had a significantly higher probability of adopting organic fertilizers/composts. Such membership had a small total effect on the adoption of this SAP. Along the same line as Kassie et al.'s (2009) findings, members learn the experiences of this SAP from other farmers in their social network. Its fruitful application among adopters is likely to be followed by other members.

The usefulness of the relevant information on SAPs led significantly to the adoption of conservation tillage, intercropping and cover crops/mulches to a moderate extent, and of IPM to a marginal degree. Consistent with general expectation, these findings suggest the importance not only of access to the relevant information, but also the quality of that information. Given that these SAPs are complex, they are not confined to a single formula in

their application. Therefore, well-presented information enhances information processing and meets the learning demands of farmers.

The perceived relative advantage of SAPs had a significantly mixed relationship with the adoption of conservation tillage, intercropping, and cover crops/mulches. Though their total effect was invariably small, the only sign of this variable on intercropping falls within our expectations. For those that fall outside of our expectation, no explanation is readily available in the literature. Notwithstanding that, it is noted that respondents did not rate this attribute as highly important (refer to Table 1). This is not uncommon, as the high score of relative non-economic advantage is often offset by the low score of relative economic advantage (Tey et al., 2013). Therefore, it is not surprising that the direction of relative advantage was inconsistent across these significant cases.

Habits in using SAPs had a significantly positive and moderate total effect on the adoption of organic fertilizers/composts. Similar findings have also been advanced in environmental studies (Stern, 2000a, b). Specifically with this SAP, habits result in familiarity and an inclination towards continuity in farming (Jaza, 2005). This is because this SAP reemphasizes the role of humus and organic components of soil, acting slowly and steadily. Habits are often shaped by aiming to get optimum results, which are only possible through their frequent application over a long period. As a course of action, this SAP is likely to be used repeatedly.

The intention to adopt or continue using SAPs was significantly and positively linked to IPM use, to a small degree in total. This finding is similar to Heong and Escalada (1999), who also found that this psychological factor plays a role in pest management decisions. A slight difference lies within the formation of our respondents' intention, which significantly derived from a comprehensive consideration of motivational (positive expectations and attitudes) and non-motivational factors (conformation to norms). Nevertheless, the

importance of intention is noted. Pesticides are no longer largely used to kill pests, they are often proactively applied to prevent pest outbreaks whilst, simultaneously triggering pest resistance. Because the net effect of pesticides is always unclear, a strong intention is likely to be followed by action.

As the antecedents of intention, expectations and norms about SAPs had a significantly positive but small total effect on IPM use. These findings suggest that optimistic mental beliefs about future results, and willingness to subscribe to a social standard, will increase the likelihood to adopt IPM. In particular, expectations were preceded by the perceived relative advantage of SAPs, which were significantly associated with land ownership and the usefulness of information on SAPs. These results underscore that the cognitive path linking economic factors to thinking processes was significant.

6. Conclusions and implications

Adoption rates for SAPs have been low in many countries. In this regard, separate research efforts have been made to understand the effect of economic factors and psycho-social factors on adoption. However, their individual insights offer limited help as to what to emphasize in SAPs promotion. Aiming to narrow that knowledge gap, this study has investigated both economic and psycho-social factors concurrently, in influencing the adoption of SAPs. These two streams of factors must be considered together so as to learn which one requires more attention. In order to achieve that, an integrative theoretical framework has been used as a guide.

Structural equation modeling technique was deployed to analyze survey data from Malaysian vegetable farmers. The findings have demonstrated that the adoption of SAPs was influenced significantly by a range of economic and psycho-social factors. They imply that

adoption is a multifaceted issue and develops from both rational and non-economic considerations (Sambodo and Nuthall 2010). As no single aspect can completely explain adoption, general policymaking should be based on multidisciplinary understanding.

In addition, the total effects have revealed the relative importance of significant factors across SAPs. A small total effect has been found in most cases for a range of economic factors (education, financial capital, off-farm employment, access to finance, farm size, regional location, organizational membership, and the perceived relative advantage of SAPs). The same small effect has also been evidenced in IPM for psycho-social factors (intention to use or continue using, expectations, and norms toward SAPs). On the other hand, a moderate total effect has been identified for the usefulness of information on most SAPs; for education on cover crops/mulches; for financial capital and regional location on conservation tillage; and for habit on organic fertilizers/composts. It is clear that economic factors are more often statistically significant and have a larger total effect than psycho-social factors on the adoption of SAPs.

Overall, our findings can be used to enhance the general promotion of SAPs. This general approach is seen to be relevant since it is hoped that sustainable agriculture will be realized on a large scale. Guided by our findings, policy development should have a greater emphasis on economic factors:

- In particular, special attention should be paid to the usefulness of information on SAPs. The question then is how to provide farmers with useful information to help manage SAPs. According to our earlier focus group participants, most farmers do not face difficulty in accessing information. Rather, they stressed the need to refine the current information, which is said to lack simplicity, localization, contextualization,

and supportive follow-up. As pointed out, these could be the keys that make information more valuable for farmers.

- Another primary focus could be on education, financial capital, and regional difference while, at the same time, taking into account a single important psycho-social factor: habit. The results imply that policies to improve adoption rates could include: providing better training programs, direct and indirect financial incentives, different SAPs packages for different regions, and inducements to establish a routine.

Although economic factors have been found more important than psycho-social factors, more research efforts are needed to understand the adoption of SAPs fully. First, insights from this study are derived from a limited number of selected economic factors. Empirically, there is a greater range of economic factors that may impede or facilitate adoption (e.g., Baumgart-Getz et al. 2012; Tey and Brindal 2012; Prokopy et al. 2008; Knowler and Bradshaw 2007; Pannell et al. 2006). This paper calls for follow-up studies in Malaysia, considering a broader range of economic factors. Second, this is specifically a case study of Malaysia. Efforts to promote sustainable agriculture in other countries will have to be tailored according to the particular conditions of individual locales (Knowler and Bradshaw 2007), with consideration of both economic and psycho-social principles.

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Appendix

Results of the confirmatory factor analysis (measurement model)

Observed items	Standardized factor loadings (regression weights) of latent factors						
	Information usefulness	Relative advantage	Expectation	Attitude	Habit	Norm	Intention
Inf1	.68						
Inf2	.77						
Inf3	.79						
Inf4	.61						
Rel1		.78					
Rel2		.76					
Rel3		.70					
Rel4		.67					
Rel5		.64					
Rel6		.77					
Exp1			.81				
Exp2			.83				
Exp3			.90				
Exp4			.89				
Att1				.81			
Att2				.84			
Hab1					.87		
Hab2					.92		
Hab3					.93		
Hab4					.85		
Nor1						.75	
Nor2						.75	
Nor3						.62	
Int1							.87
Int2							.90
Int3							.92
Int4							.93
Int5							.87
CR	.60	.52	.74	.68	.80	.50	.81
AVE	.52	.60	.77	.72	.81	.59	.82
Square root of AVE	.72	.72	.71	.82	.89	.71	.90
Correlation range	-.06–.40	.29–.70	.26– 61	-.06–.33	.29–.58	.26–.70	.27–.67
Chi-square=1,570 based on 329 degree of freedom; p-value=.000							
CFI=.947; RMSEA=.057							

Note: CR=construct reliability; AVE=average variance extracted; CFI=comparative fit index; RMSEA=root mean square error of approximation

Chapter 8: The relative importance of factors influencing the adoption of sustainable agricultural practices: a factor approach for Malaysian vegetable farmers

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Chapter 9: The relative impact of adoption on profitability of sustainable agricultural practices: a study for Malaysia vegetable farmers

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The relative impact of adoption on profitability of sustainable agricultural practices: A study for Malaysian vegetable farmers

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Abstract

There has been no clear answer as to the adoption of *which* sustainable agricultural practices (SAPs) is more profitable. Motivated by that knowledge gap, this study aims to (1) identify factors that influence their adoption and (2) assess their relative impact on farm profitability, using data from the Malaysian vegetable production sector. The first element involves an adoption-decision model for six individual SAPs. Their findings suggest that adoption is influenced by a range of socio-economic, agro-ecological, institutional, informational, and psychological factors as well as the perceived attributes of SAPs. This implies that policymaking should be based on multidisciplinary considerations. The second element analyzes an adoption-profitability model. Among SAPs, intercropping and organic fertilizers/composts are associated with higher farm profits. Guided by our findings about

their potential adopters, a combination of these SAPs can be promoted as an attractive "starter pack".

Keywords: adoption, profitability, sustainable agricultural practices, Malaysia

Introduction

Sustainable agricultural practices (SAPs) have been promoted under the umbrella of "sustainable agriculture". Common SAPs include conservation tillage, intercropping, cover crops/mulch, crop rotation, organic fertilizers/composts, and integrated pest management (IPM). According to the FAO[1], SAPs are environmentally non-degrading, resource conserving, socially acceptable, technically appropriate, and economically viable. Given these features, SAPs have been posited as an approach to improve environmental, social, and economic sustainability in agriculture.

Economic sustainability in terms of profitability is the most important concern to most farmers[2]. Profitability exists when farm revenue exceeds production costs. With the use of SAPs, farm revenue can be sustained or improved through higher yields, greater consumer acceptability, and improved marketability; production costs can be reduced through curtailed chemical applications and enhanced soil and water quality[3]. From this theoretical perspective, the adoption of SAPs should lead to profitability, or at least to the long-term economic sustainability of the farming enterprises.

Sustaining profitability is crucial for farm survival and farmer welfare. The profitability of SAPs compared with competing practices is, therefore, regarded as the decisive factor leading to adoption[4-10]. This premise indicates that SAPs should be widely adopted when they are more profitable. However, their adoption rates have been relatively

low in both developed and developing countries[11]. This general consensus suggests that farmers are not fully convinced that SAPs will result in better financial returns than conventional production practices[12].

To understand why high adoption rates have not eventuated, research has largely focused on identifying factors influencing the adoption of SAPs. The collective findings, as reviewed in several studies[2,13-16] suggest that adoption depends on a range of socio-economic, agro-ecological, institutional, informational, and psychological factors as well as on the perceived attributes of SAPs. Among these factors, the perceived profitability of SAPs is widely accepted as having a major impact on adoption[2]. When the actual positive financial consequence of SAPs is demonstrated, it should be possible to influence these more subjective factors.

However, there is a dearth of empirical research on the net returns from the adoption of SAPs[17]. Past findings have been mixed. For example, lower profitability is found when yield declines in response to some SAPs[18-20]. Because SAPs also incur higher production costs (e.g., labor), there is no significant difference in profitability even when yield is sustained[17]. Higher profitability is only realized when yield vis-à-vis total farm output is improved[21].

The research outlined above offers no clear answer as to the adoption of *which* SAPs will result in higher net returns. It is our objective to narrow this knowledge gap by responding to the two elements in question. The first element concerns identifying factors that lead to adoption. The second element aims to assess the relative financial effect of the adoption. When certain SAPs are found to be more profitable, they can be promoted as an attractive "starter pack" to potential adopters. Information associated with different adoption factors can be used to guide their promotion. Therefore, the outputs of this study not only generate clarity on the investment return of different SAPs, they also help identify the

characteristics of potential adopters and promotion strategies. To examine these elements closely, survey data from Malaysian vegetable farmers is analyzed to yield a range of insights for steering the future promotion of sustainable agriculture.

Literature review

In the literature, there are some common factors influencing the adoption of SAPs and farm profitability. They can be categorized as socio-economic, agro-ecological, and institutional factors. In addition to these general categories, adoption is also affected by informational factors, psychological factors, and the perceived attributes of SAPs; profitability also depends on a range of efficiency measures and production practices that reflect the adoption type in question.

Socio-economic factors influence the management capacity of farm operators, a fundamental feature of farm operation due to its complexity. The adoption of SAPs is shown to relate to human capital: gender, ethnicity, age, and education[13]. Age and education are also influential factors in farm profitability[22,23]. Female farmers often have limited access to, and control over, resources, especially in developing countries[3]. Informal farming knowledge could be culturally rooted according to ethnicity[24]. Consequently, adoption is more likely among male farmers and certain ethnic groups. With greater management ability, higher education levels always induce adoption and better farm returns. However, a shorter career horizon and diminished desire for efficiency among older farmers are likely to limit adoption and financial performance.

Labor is an important input in farm operation. As an internal source of labor, a large household is assumed to have access to many family laborers. Such family farms are expected to meet labor requirements at a lower cost, intensifying the adoption of labor-

intensive SAPs and farm profits. Otherwise, external labor can be recruited. A larger hired workforce is predicted to have the same effect upon adoption but at the expense of farm earnings[25].

Fiscal capacity determines the ability to undertake the costs and risks of farm investment as well as to spur farm growth. Higher financial capital is expected to facilitate adoption, and generate greater net farm incomes, under the rule of "investing money to make money". Additional farm income or savings can be derived from composted livestock manure. Livestock ownership is likely to have a positive impact on SAPs adoption and farm returns. Alternatively, financial capacity for SAPs investment can be bolstered through off-farm employment and access to credit. However, the off-farm focus may compete with on-farm efforts[26] and the interest on the credit may be burdensome, affecting farm financial performance negatively. Larger farms often have greater financial capacity for adoption and higher net incomes through economies of scale and greater production. Net incomes are also directly affected by the selling price of farm produce.

Agro-ecological factors describe the asymmetry of resource qualities on which farm operation depends. Farms in highlands are more prone to erosion and inputs runoff. The same problems are also intensified on steeper farms. In these topographies, SAPs are likely to be used for protecting land and avoiding waste. However, susceptibility of these farms to input runoff may complicate the assessment of potential impact of SAPs on farm financial performance. A farm that is owned will be passed to successors and does not incur a fixed cost (rental). It is likely to be operated sustainably and at a lower cost, resulting in a higher net worth. Given the difficulty of capturing all farm-specific characteristics, farm region is used as a conceptual factor to depict the differences in resource quality across regions[27]. The effect of farm region upon adoption cannot be known *a priori*.

Institutional factors exemplify the force of external structures in influencing farm management. First, farmer associations and cooperatives serve the interests of their members: production, purchasing, marketing, socialization, and information-exchange services[28]. A common production practice used by the majority of members is likely to be adopted by other members. Their bulk demand for agricultural input and capacity to bundle the output of agricultural produce, enables greater bargaining power on behalf of individual members. Hence, the financial consequence of membership is likely to be positive. Second, institutional arrangements (e.g., contract farming) enforce timely payment for and supply of produce with certain quality standards. Participants are unlikely to risk the arrangement by making a new investment. Some institutions also sell farm inputs and offer credit. Given these mixed functions of institutional arrangements, the impact of their operation on farm profit is uncertain.

Information disseminates knowledge and harnesses the adoption of SAPs. The information can be learned from many sources (e.g., extension services and other farmers). Though access is the key, practical messages are critical to keep farmers abreast of the benefits and techniques of SAPs. When information is seen to be useful, farmers are assumed to have access to particular sources, understand the information, and be able to make use of it[29]. Highly useful information on SAPs is likely to guide their adoption.

Attributes of SAPs are perceived subjectively prior to adoption. Three common attributes assessed in the literature are relative advantage, compatibility, and complexity. According to Rogers[30], *relative advantage* describes the degree to which SAPs are seen as more beneficial than competing practices; *compatibility* considers the degree to which SAPs are consistent with existing values, past experiences, and needs; *complexity* centers on the difficulty in understanding and use of SAPs. A higher degree of perceived relative advantage and compatibility is likely to be linked to adoption. The greater the perceived complexity of

the SAPs, the less likely it is to be adopted. The key factor is the levels of these subjective evaluations.

Psychological factors may also be crucial in adoption, since the consequences of SAPs are time distant[31]. Intention is formed after a comprehensive consideration of motivational (e.g., expectations and positive feelings) and non-motivational factors (e.g., time and capital)[32]. A strong intention represents a sturdy plan to realize the behavior in question. The behavior may be a matter of personal habit[33]. An established practice of SAPs is likely to be used as a matter of course.

Efficiency affects farm financial performance directly[34]. Common efficiency measures are farm yield that represents productivity; chemical expenses per hectare that capture the average input costs; farm size per laborer that corresponds to labor efficiency. Greater revenues can be generated through higher yields and input savings. As such, farm profit is expected to be positively linked to farm yield and farm size per laborer; and negatively associated with chemical expenses per hectare.

In summary, adoption refers to the full use of a new production practice as the best course of farming and livelihood. The financial performance will be improved when the new practice can potentially generate higher productivity and/or savings. However, these general features of SAPs are realized differently across SAPs. For example, intercropping does not incur significant establishment cost and reduces input application by suppressing weeds, limiting pest outbreak, and providing natural nutrients and soil organisms. Organic fertilizers/composts are self-made or purchased to enhance soil quality through improved water retention ability, soil fertility, and organic matter. Given varied establishment costs and functions, the impact of adoption is likely to be different across SAPs. Therefore, it is the main contribution of this study to identify the relative impact of adoption on the profitability of SAPs.

Conceptual framework

Our investigation of the impact of the reviewed factors on the adoption of SAPs and farm profitability uses a conceptual framework (see Figure 1) which is guided by Triandis'[35] theory of interpersonal behavior (TIB) and Rogers'[30] theory of diffusion of innovation (DOI). Both theories are compatible[36]. The TIB offers a core framework to capture socio-economic, agro-ecological, institutional, informational, and psychological factors as well as efficiency measures for adoptive behavior and its financial consequence. The theory of DOI is sought to gain a theoretical base for understanding perceived attributes.

In the conceptual framework, we are interested in the determinants of adoption and its financial consequences. This is known as a factor approach, which identifies independent variables that explain a dependent variable directly[37]. The approach is an effective method for generating policy implications. As such, our investigation involves a two-stage procedure.

First, the adoption of each single SAP is measured as a dichotomous choice. The decision depends on socio-economic, agro-ecological, institutional, informational, and psychological factors (habit and intention) as well as on the perceived attributes of SAPs. These factors may either facilitate or impede adoption due to their asymmetrical distribution. The use of a SAP is likely to become habitual. Likewise, a strong intention to use or keep using a SAP is likely to see it continue in practice. Favorable perceived attributes of a SAP are expected to have a positive association with adoption.

Second, farm financial performance is represented by gross farm profit (GFP). Following the Malaysian Financial Reporting Standards[38], the GFP is measured by the subtraction of gross farm operating expenses from gross farm revenue. It is a function of socio-economic, agro-ecological, institutional, and efficiency factors vis-à-vis the adoption of farm practices. Efficient farms are likely to be effective without wasting resources, translating

into greater financial success. The adoption of one or more productivity- or/and savings-based SAP(s) is anticipated to produce a similar result.

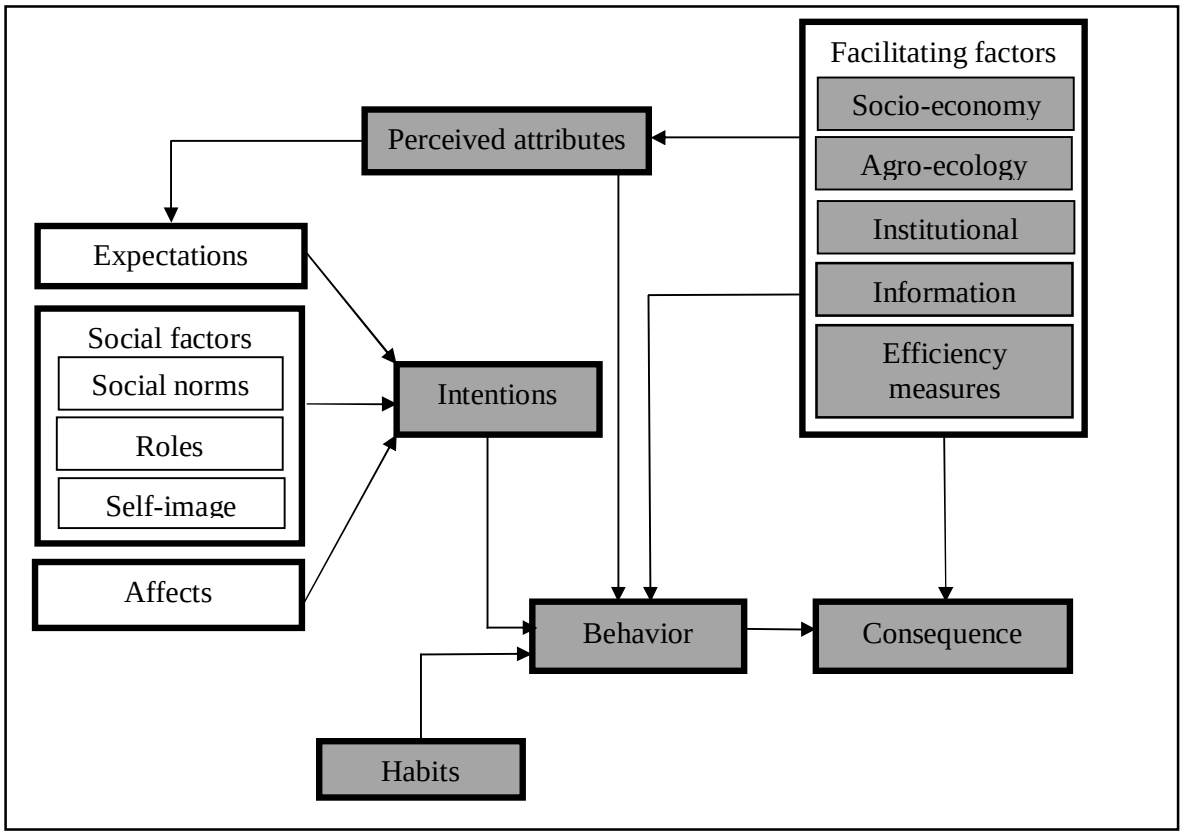


Figure 1. Conceptual framework for examining factors influencing the adoption of SAPs and farm profitability through the lens of Triandis' (1977) theory of interpersonal behavior and Rogers' (2003) theory of diffusion of innovation.

Note: Shaded dimensions are included in the factor approach.

Methodology

As outlined above in the discussion of our conceptual framework, a two-stage analytical procedure was carried out to assess the impact of the adoption of SAPs on farm profitability. Such working procedure is consistent with the empirical approach used by Stefanides and Tauer[22], Foltz and Chang[39], McBride and El-Osta[23], McBride et al.[9], and Akinola and

Sofoluw[21]. The first and second stages involve an estimation of adoption-decision and adoption-profitability models, respectively.

Estimation methods

Building upon the past studies mentioned above, the two-stage procedure was necessitated by the potential endogeneity of the adoption variables. To illustrate this, we first considered the following adoption-profitability regression equation:

$$P = \beta se + \beta ae + \beta it + \beta em + \gamma A + \varepsilon \quad (1)$$

where P indicates farm gross profit, se is a vector of socio-economic variables, ae is a vector of agro-ecological variables, it is a vector of institutional variables, em is a vector of efficiency measures, and A is binary variables for a set of SAPs (if a SAP is adopted=1; otherwise=0), and ε is a random disturbance assumed to be normally distributed. As γ is to measure the impact of SAPs adoption, farmers should be randomly assigned as adopters and non-adopters. However, the assignment is indeed a self-selection: farmers themselves make adoptive decisions. Adopters are commonly characterized as more productive and profitable farmers than non-adopters, even prior to using SAPs[2]. Hence, the difference between adopters and non-adopters is regarded as systematic. Treating A as an exogenous variable would result in a potential self-selection bias and inconsistent parameter estimates. A solution to that is to estimate the adoption-decision model in the first stage, and incorporate its predicted probability in the second stage of the adoption-profitability model.

In the adoption-decision model, we conceptualized that farmers make a decision to adopt or not to adopt a single SAP. This model can be translated into a subjective utility

model[10]. A SAP is likely to be adopted when its subjective utility is greater than that of its competitor. Given such binary choice, a probit model is used to explain the probability of adoption. The binary model can be presented as:

$$A^* = \delta se + \delta ae + \delta it + \delta if + \delta ps + \delta pa + \mu \quad (2)$$

where A^* is a latent variable explaining the probability of adoption of a SAP, *se* is a vector of socio-economic variables, *ae* is a vector of agro-ecological variables, *it* is a vector of institutional variables, *if* is a vector of informational variables, *ps* is a vector of psychological variables, *pa* is a vector of perceived attributes, and μ is the error term assumed to be normally distributed with a zero mean and a variance of 1. In A^*, the observed decision to adopt is $A=1$ when $A^*>0$; the observed choice not to adopt is $A=0$ when $A^* \leq 0$. The probability of adoption is $\text{prob}(R=1)=\text{prob}(R^*>0)=\text{prob}(Z\delta + \mu > 0) = \text{prob}(\mu < Z\delta) = \phi(Z\delta)$, where ϕ is the cumulative distribution function of the standard normal distribution. The predicted probabilities of adoption, $\phi(Z\delta)$, are used as the instrumental variable for *A* in Equation 1.

In the adoption-profitability model, we incorporated the probabilities of adoption ($\hat{A}^*$) of each SAP as a set of explanatory variables along socio-economic (*se*), agro-ecological (*ae*), institutional (*it*), and efficiency (*em*) variables to explain farm financial performance (*P*). It can be rewritten as:

$$P = \beta se + \beta ae + \beta it + \beta em + \gamma \hat{A}^* + \varepsilon \quad (3)$$

Study area and data

This study was conducted in pan-Malaysia, covering five regions: the Northern, Central, Southern, and East coast and Eastern regions where about 8,250 farmers are estimated to be involved in commercial vegetable cultivation. Commercial vegetables include tropical and temperate varieties that can be grown in the lowlands and uplands, respectively. While most of these are marketed locally, some of them are exported to neighboring countries (e.g., Singapore and Brunei) on a daily basis.

Under commercialism, vegetables are produced intensively in open farming. Chemical inputs are often applied excessively, resulting in land degradation, runoff, and food safety issues[40]. Harvested fields are also immediately prepared for the next crop without fallow. Such intensive cropping cycles expose chemical inputs and soils to runoff. They have serious implications for environmental health, on which agricultural activities depend.

Sustainability is a key element in the National Agro-Food Policy (2011-2020), the Tenth Malaysia Plan (2011-2015), and the New Economic Model (2011-2020). This policy focus aims to improve environmental wellbeing whilst exploiting vegetable productivity. To achieve that, these policies put concerted effort into further encouraging the voluntary adoption of six generic SAPs (conservation tillage, intercropping, cover crops/mulches, organic fertilizers/composts, crop rotation, and IPM), which have been promoted disjointedly in the past (for details, see Tey et al.[11]). These SAPs promote efficient resource management for beneficial results, including productivity through land rehabilitation and conservation as well as input savings via natural soil fertility and crop protection.

A random sample survey was carried out between October 2011 and March 2012. This sampling method relied on a sampling frame, which is a list of registered farmers, provided by the Departments of Agriculture Malaysia, Sabah, and Sarawak. The main farm decision-makers were then selected as respondents. In total, 1,168 vegetable farmers were interviewed.

The interview was conducted using a structured questionnaire guided by the Conceptual Framework (see Figure 1). The questionnaire was developed through a literature review and focus group interviews. The purposes of the latter were two-fold: to check the relevance of common factors identified in the literature; and to elicit techniques for the survey operation (for details, see Tey et al.[41]). Overall, our proposed factors were reaffirmed and expressed in simpler terms.

Table 1 shows the descriptive statistics of the dataset. The dataset shows varied results in the adoption of the six selected SAPs: high adoption rates were recorded for organic fertilizers/composts, conservation tillage, and crop rotation; moderate adoption rates were indicated for intercropping and cover crops/mulches; low adoption rates for IPM. Average annual gross farm profit was about RM39,000 (US$13,000).

Table 1. Descriptive statistics of variables (*n*=1,168)

Variables and units	Mean	Standard deviation	Cronbach's alpha
Dependent variables			
Adoption of conservation tillage (0/1)	.835	.372	-
Adoption of intercropping (0/1)	.548	.498	-
Adoption of cover crop / mulches (0/1)	.471	.499	-
Adoption of crop rotation (0/1)	.766	.424	-
Adoption of organic fertilizers / composts (0/1)	.850	.357	-
Adoption of integrated pest management (0/1)	.086	.281	-
Average gross farm profit over three years (RM)	38,908	96,141	-
Socio-economic factors			
Male (0/1)	.680	.467	-
Age (years)	49.739	13.495	-
Chinese (0/1)	.161	.368	-
Formal education (years)	7.884	4.357	-
Farming experience (years)	16.530	13.591	-
Household size (persons)	6.470	3.642	-

Table 1. Continued

Variables and units	Mean	Standard deviation	Cronbach's alpha
Number of full-time laborers (persons)	2.659	5.209	-

On-farm working hour (per week)	38.290	18.826	-
Financial capital (RM)	78,210	230,914	-
Keep livestock on farm (0/1)	.166	.373	-
Off-farm employment (0/1)	.274	.446	-
Married (0/1)	.896	.306	-
Access to finance (0/1)	.272	.445	-
Farm size (hectares)	4.438	10.323	-
Average produce price over three years (RM per ton)	4,570	11,388	-
Agro-ecological factors			
Flat land (0/1)	.918	.275	-
Lowlands (0/1)	.846	.361	-
Presence of environmental degradation (0/1)	.137	.343	-
Duration of land used for farming (years)	13.381	14.409	-
Practice organic farming (0/1)	.393	.489	-
Southern region (0/1)	.129	.336	-
Central region (0/1)	.157	.364	-
Northern region (0/1)	.239	.427	-
East coast region (0/1)	.164	.371	-
Land ownership (0/1)	.544	.498	-
Institutional factors			
Organizational membership (0/1)	.408	.492	-
Participation in a certification program (0/1)	.068	.251	-
Participation in an institutional arrangement (0/1)	.637	.481	-
Informational factor			
Usefulness of information (1-7 agreement levels)	4.512	.982	-
Perceived attributes			
Relative advantage (1-7 agreement levels)*	5.775	.816	0.873
Compatibility (1-7 agreement levels)*	5.330	.968	0.863
Complexity (1-7 agreement levels)*	2.670	1.183	0.890
Psychological factors			
Intention to adopt or continue using (1-7 agreement levels)*	5.462	1.199	0.957
Habit (1-7 agreement levels)*	4.741	1.325	0.809
Resource efficiency			
Average yield over three years (ton per hectare)	4.53	31.87	-
Average chemical expenses per hectare over three years(RM)	409.30	671.92	-
Farm size per laborer (hectare)	2.01	3.64	-

Notes: * Average point of multiple items was calculated. Their internal consistency was attained according to the values of Cronbach's alpha.

Findings

Adoption-decision model

A Probit regression (Equation 2) was estimated for each of the six selected SAPs. Their results (see Table 2) show an acceptable model fit: (1) the McFadden R-square values vary from 0.09 to 0.34; (2) correct prediction of adoptive decisions range between 65 percent and 92 percent.

The dummy variable for males had a significant but different influence on the likelihood of intercropping and cover crops/mulches adoption. This mixed finding is reinforced by Somda et al.[42] who found that cost-related SAPs are more affordable for male farmers and vice versa. While cover crops/mulches require some monetary input, the establishment of intercropping is costless. Therefore, our finding is consistent with the gender argument of resource access and control: male and female farmers are more likely to adopt cover crops/mulches and intercropping, respectively.

Chinese farmers had a higher probability of adopting conservation tillage, intercropping, and IPM. Support for this finding is in Barrow et al.[43] who observed an increasing investment in these SAPs among Chinese farmers. This ethnic group is said to be more aware of and concerned about environmental quality, which determines agricultural productivity.

Respondents with higher education levels were significantly more likely to adopt cover crops/mulches, crop rotation, and IPM. Consistent with general expectation, education empowers the management of these complex SAPs. For instance, an application of IPM requires the evaluation of principles, species, the local environment, what, how much, and when to apply[44]. A single variation in any of these factors could lead to a different solution.

A greater number of farm laborers significantly reduced the likelihood of adoption in the conservation tillage and crop rotation models. This finding is against expectation but is not unreasonable in the Malaysian context. These SAPs are labor intensive and cannot be mechanized. As Malaysian farm labor is costly, labor is more often assigned to effective production activities.

Various finance-related variables had significantly positive relationships with their respective SAPs. Those respondents with greater financial capital had a higher probability of adopting conservation tillage, crop rotation, and organic fertilizers/composts. Livestock presence was linked to the adoption of cover crops/mulches and IPM. Holding off-farm employment increased the odds of intercropping adoption. Access to finance was associated with the adoption of conservation tillage, organic fertilizers/composts, and IPM. These finance-related variables suggest that the adoption of SAPs is likely to be encouraged through greater financial capacity and the ability to raise funding. Financial capacity not only enables the investment, it also offers a buffer against the risks of the investment.

Farms located on flat lands were significantly less likely to adopt crop rotation and IPM. In other words, conservation-based crop rotation is likely to be seen on steeper plots, which face greater erosion risk. A different explanation, however, is required for IPM: its adoption could be the result of the extensive promotion of IPM on steeper plots for some decades[44].

Table 2. Probit regression coefficients in the adoption-decision model of the six selected SAPs

Variables	Conservation tillage	Intercropping	Cover crops / mulches	Crop rotation	Organic fertilizers / composts	IPM
	Coefficients	**Coefficients**	**Coefficients**	**Coefficients**	**Coefficients**	**Coefficients**
Intercept	0.257	-1.555**	-1.833**	-0.811	0.514	-3.204**
Socio-economic factors						
Male	-0.069	-0.235*	0.242*	-0.141	0.205	0.274
Age	-0.009	0.003	0.004	0.003	-0.003	-0.004
Chinese	0.626**	0.466**	0.316	0.330	-0.098	0.978***
Formal education	-0.019	-0.009	0.046***	0.030*	-0.008	0.046*
Household size	-0.003	-0.004	0.014	0.034	-0.002	-0.044
Number of full-time laborers	-0.057**	-0.024	-0.008	-0.041*	-0.019	0.003
Financial capital	0.001**	0.001	0.001	0.001***	0.001*	0.001
Keep livestock on farm	0.219	0.219	0.316**	-0.034	-0.186	0.405*
Off-farm employment	0.193	0.203*	-0.025	0.031	-0.018	-0.307
Access to finance	0.420**	0.122	0.163	0.168	0.410**	0.395*
Farm size	0.023	0.008	0.003	0.013	0.002	0.006
Agro-ecological factors						
Flat land	-0.376	-0.335	-0.255	-0.609**	-0.279	-1.109***
Lowlands	0.236	-0.078	-0.431***	-0.111	0.344*	-0.048
Southern region	-0.180	0.903***	-0.527***	0.140	0.216	1.494***
Central region	-0.094	0.808***	-0.315*	-0.229	-0.085	0.030
Northern region	0.551**	0.575***	-0.154	0.115	0.578**	0.033
East coast region	1.056***	0.607***	0.343**	-0.386**	0.090	-0.559
Land ownership	0.117	-0.085	0.214*	0.025	-0.011	-0.201

Table 2. Continued

Variables	Conservation tillage	Intercropping	Cover crops / mulches	Crop rotation	Organic fertilizers / composts	IPM
	Coefficients	**Coefficients**	**Coefficients**	**Coefficients**	**Coefficients**	**Coefficients**
Institutional factors						
Organization member	0.226	-0.084	0.268**	-0.148	0.384**	-0.308
Participation in an institutional arrangement	-0.232	-0.094	0.216*	-0.045	-0.474**	-0.006
Informational factor						
Usefulness of information	0.222***	0.306***	0.074	0.129*	0.034	0.340***
Perceived attributes						
Relative advantage	-0.242**	0.064	-0.061	0.172*	-0.216*	-0.114
Compatibility	0.162	0.038	-0.008	0.061	0.113	-0.155
Complexity	0.028	-0.089	0.072	0.105	0.033	-0.217**
Psychological factors						
Intention	0.103	0.018	0.068	-0.069	0.116	0.320**
Habit	0.023	-0.043	0.112**	-0.015	0.106	0.186*
McFadden R-Square	0.18	0.13	0.11	0.09	0.10	0.34
Log-likelihood	-237.94	-401.84	-413.55	-323.97	-214.68	-131.71
Average correct prediction	85%	68%	65%	78%	86%	92%

Notes: *** = one percent significance level; ** = five percent significance level; *=10 percent significance level

In significant cases, farms in lowlands had different associations with cover crops/mulches and organic fertilizers/mulches. On reflection, it is understandable that in the highlands which are prone to runoff and erosion, cover crops/mulches are used to conserve soil quality; organic fertilizers/mulches are avoided to reduce waste.

Those respondents who owned the land had a higher likelihood of adopting cover crops/mulches. This finding is borne out by Sheikh et al.[45] who observed that tenant farmers prefer conventional production practices for the short-term economic benefits over soil conservation for long-term farm productivity.

East Malaysia (the Eastern region) was used as the baseline comparison with those in Peninsular Malaysia (the Northern, Central, Southern, and East coast regions). There was a significant difference between various regions in Peninsular Malaysia and the Eastern region in the probability of adoption across SAPs. On average, their results indicate that Peninsular Malaysian respondents were more likely to adopt SAPs than those in East Malaysia.

Organizational members had greater odds of adopting cover crops/mulches and organic fertilizers/composts. As outlined by Lee[28], this finding is consistent with the role of information sharing and learning in farmer associations and/or cooperatives as well as the role of shared standards among members.

Participation in an institutional arrangement (e.g., contract farming) had a significantly mixed impact on the adoption of cover crops/mulches and organic fertilizers/composts. Participants were more likely to adopt cover crops/mulches but unlikely to use organic fertilizers/composts. Though these findings do not lend themselves to an easy explanation, their significance implies that production requirements set in an institutional arrangement can affect inclination towards certain practices.

Respondents who received useful information on SAPs were significantly more likely to adopt conservation tillage, intercropping, crop rotation, and IPM. Similar to Robertson et

al.[46] and Larson et al.[29], these findings underscore that on top of access to the relevant information, its usefulness is also critical. In particular, the application of these SAPs is complex since there is no single solution to soil conservation issues, how to "mix-and-match" various crops, and to pest problems.

Intention and habit had a significantly positive impact on IPM adoption. Habit was also found to lead to the use of cover crops/mulches. As expected, these findings suggest that sustainable behavior emerges from a strong plan and an established routine. This applies especially to current adopters. They tend to maintain these SAPs due to familiarity and an interest in continuity in their farming activities[47].

Significant perceived attributes were of relative advantage in the conservation tillage, crop rotation, and organic fertilizers/composts models as well as complexity in the case of IPM. Among these, the sign of relative advantage in conservation tillage and organic fertilizers/composts is against our expectation. In this regard, there is no explanation available from past studies.

Adoption-profitability model

An ordinal least squares regression (Equation 3) was estimated to assess the impact of SAPs adoption on farm profitability (in logarithm form). In Table 3, the statistically significant F-statistic indicates that this model is valid. This model has a good fit, explaining about 92 percent of the variance in farm profitability.

Household size was statistically significant and positively associated with farm profits, implying that a cheaper family workforce would lead to higher returns. This finding is different from Dartt et al.[48] who argued that family labor is more costly than hired labor. Family members only choose to be farm workers when the pay is higher than or equal to off-

farm employment. However, this argument does not apply to Malaysia, which depends heavily on foreign labor for agricultural activities. Foreign labor is imported at a substantial cost and hired for a limited period. Renewal of employment visas is rare; recruitment and training impose additional costs and risks to farm enterprises. Under these considerations, family labor is a cheaper and more viable option in the long-term.

Off-farm employment had a significantly negative influence on farm profits. As expected, their inverse relationship suggests a trade-off of on-farm efforts and off-farm incomes. Often the latter is more stable and serves as a supplement to household incomes. However, this additional income is earned at the expense of reduced on-farm working hours as well as diminished mental and physical capacities. These losses have serious implications for farm development since agriculture requires an intensive use of management input[28].

Financial capital had a significant, positive relationship with farm profits. This finding is similar to that of Ostrom and Jackson-Smith[49] who found high capital farms enjoy lower investment and costs per unit production. In turn, this economy of scale results in higher incomes and profits. On the other hand, where the costs and returns are fixed, farm profits would rise proportionately to the investment capital. Both scenarios point to the power of financial capacity in stimulating farm growth.

Table 3. Coefficients of ordinary least squares estimates in the adoption-profitability model

Variables	Unstandardized coefficients	Standard errors
Intercept	-0.723	.412*
Age	-0.003	0.002
Formal education	-0.001	0.006
Household size	0.022	.008***
Number of full-time laborers	-0.009	0.009
Keep livestock on farm	0.027	0.06
Off-farm employment	-0.09	.048*
Access to finance	-0.056	0.053
Farm size	0.004	0.005
Log (financial capital)	0.918	.016***
Log (average price of produce)	0.001	0.001
Average yield	0.001	0.001
Flat land	0.021	0.11
Lowlands	0.1	0.076
Land ownership	0.005	0.047
Organizational member	0.104	.049**
Participation in an institutional arrangement	-0.048	0.054
Chemical expenses per hectare	-0.001	0.001
Farm size per laborer	-0.014	0.017
Conservation tillage^	0.15	0.12
Intercropping^	0.144	.047***
Cover crops/mulches^	-0.029	0.062
Crop rotation^	-0.225	0.182
Organic fertilizers/composts^	0.688	.313**
IPM^	-0.093	0.117
R-square	0.918	
F-statistic	184.704***	

Notes: ^ predicted probabilities of a SAP adoption from its respective adoption-decision model; *** = one percent significance level; ** = five percent significance level; * = 10 percent significance level.

Organizational members were found to achieve significantly higher farm profits than non-members. While this variable was non-significant in Gillespie et al.[50], various functions of the Malaysian farmer associations and cooperatives have positive financial implications for their members. Members exchange information, learn and use beneficial methods of farming. Members then share a degree of similarity, at least in terms of general input (fertilizers, pesticides, and machinery) and crop varieties. Collectively, farmer organizations help their members to purchase the general inputs at lower prices and sell their produce at competitive prices. As such, farm profits could be increased through lower input costs and/or higher revenues.

Intercropping use had a significant and positive impact on farm profits. This finding suggests that farmers who grow multiple crops in proximity earn more than non-adopters this SAP. Intercropping does not involve additional set-up costs. Rather, it diversifies the product and reduces the risk of crop failure: if a crop fails, other companion crops may survive. When compatible crops are selected, intercropping offers various agronomic benefits as these crops use resources (e.g., light, fertility, and soil moisture), suppress weeds, and provide nutrients in complementary ways[51]. Hence, properly managed intercropping improves soil conservation, biodiversity, inputs savings, and crop yields.

The use of organic fertilizers/composts had a significantly positive influence on farm profits. This result demonstrates that the adopters of this SAP have higher returns than non-adopters who rely heavily on synthetic fertilizers. Comparatively, organic fertilizers/composts are cheaper since they are made from organic waste. In its physical aspect, this SAP restores soil organic matter and, in turn, improves soil structure, soil moisture, nutrient cycling, pest control, and disease suppression. In its chemical aspect, the organic matter supplies nutrients, stabilizes soil pH, and enhances water infiltration. In its biological aspect, this organic amendment intensifies micro-organism activities in

mineralizing nutrients from organic matter and producing antibiotics against soil diseases. From these three aspects, adding organic fertilizers/composts to production practices can reduce soil loss, water runoff and synthetic inputs, while raising soil fertility and crop yields.

Conclusions and policy implications

The profitability of SAPs is the main concern for most farmers. While many studies have focused on what leads to the adoption of SAPs, they lack clarity about whether the action results in higher returns. This study has identified factors that influence different SAPs' adoption and their relative impact on farm profitability, based on survey data from Malaysian vegetable farmers. These two elements (adoption and impact) must be considered together so as to correct for self-selection bias. Because of this statistical consideration, adoption-decision models have been estimated in the first stage, and their predicted probabilities have been used as a set of instrumental variables within the adoption-profitability model in the second stage.

In the first stage, an adoption-decision model has been used for each of the six selected SAPs (conservation tillage, intercropping, cover crops/mulches, crop rotation, organic fertilizers/composts, and IPM). The findings have generally demonstrated that the adoption of SAPs is influenced by a range of socio-economic, agro-ecological, institutional, informational, and psychological factors as well as the perceived attributes of SAPs. They imply that adoption is a complex issue and no single dimension can offer the best explanation. Consequently, general policymaking should also be based on multidisciplinary understandings and considerations.

In the second stage, an adoption-profitability model that has been incorporated with a set of predicted probabilities of the adoption of the six selected SAPs, has been used. The

findings have indicated that farm financial performance is affected by household size, off-farm employment, financial capital, organizational membership, as well as by the use of intercropping and organic fertilizers/composts. Most of these factors share similar functions in cost savings (e.g., cheaper family labor, economies of scale, cheaper input cost, and curtailed input use) and promoting productivity (e.g., farming efforts, marketing, soil conservation and fertility, and higher yields). Though these functions are also theoretically shared by conservation tillage, cover crops/mulches, crop rotation and IPM, the results suggest that adopters did not make additional profits using these SAPs. However, there is no clear explanation for this variation. Further detailed analysis would be necessary to understand this result fully.

Recommendations for a "starter pack" in the promotion of SAPs

Our findings have underlined that the adoption of different SAPs is not equally profitable. Intercropping and organic fertilizers/composts have been found to be relatively more profitable. They can be promoted individually or together as a "starter pack", since implementing one or more SAPs can form a dynamic sustainable agricultural system. With this head start, it is hoped that more farmers will have the confidence to invest in sustainable agriculture.

To advocate sustainable agriculture, future campaigns may concentrate more on the two profitable SAPs. Policies could be guided by our findings on the driving forces for such adoption. To illustrate this, consider a "marketing" plan for putting the right "product" in the right place, at the right "price", with the right promotion. The "product" here, as identified above, is intercropping and organic fertilizers/composts, as the "starter pack". The financial

impact of their use can be used as a “selling” point. Decisions to “market” them separately or in combination would affect other elements in the “marketing” plan.

With a sole focus on intercropping, our findings on prospective adopters suggest that future campaigns could be based in Peninsular Malaysia, and should target female farmers, Chinese farmers, and those who have an off-farm job. It should be made clear that intercropping does not incur additional setup costs. Together with other points, relevant information (e.g., how to “mix-and-match” crop varieties) should be made easy to understand and useful.

With respect to organic fertilizers/composts, their potential adopters are likely to come from the Northern region, and lowlands, richer farmers, members of farmer organizations, and those not engaged in institutional arrangements. Farmers need to purchase inputs for this SAP if self-production is not feasible. Though the SAP’s average market price is low, its application could be costly. This is mainly due to the need for frequent application over the long term to get optimum results. Ways to address this may include financial facilities (e.g., credit) and assistance in its promotion. Promotion messages should also aim to improve farmer perceptions of relative advantage. One means to do this is by relating its non-economic benefits to profitability, such as using “credence attributes” to signal the quality of produce and benefits to the environment in relation to the use of organic fertilizers/composts[52].

Up until now, we have discussed just one approach, which focuses on those who are more likely to become adopters. Our findings have implied split strategies for promoting intercropping and organic fertilizers/composts. However, this approach could prove to be an expensive use of limited resources; as well, the risk of failure is high by focusing on one strategy. An alternative approach is needed to run concomitantly for general groups since it is hoped that sustainable agriculture will be realized on a large scale. Given these

considerations, it is better to promote these profitable SAPs together as an attractive "starter pack", for two main reasons.

First, intercropping and organic fertilizers/composts promote cost savings and productivity but in different ways. If one of them is seen to be unfeasible or has been in use, the other component could still be adopted.

Second, and most importantly, insights into the potential adopters of intercropping and organic fertilizers/composts can be used to complement each other to cover a wide range of farmer groups. Combining the insights produces a wide coverage for segmentation and targeting purposes. To foster the "starter pack" among these targets, promotion strategies could include providing financial facilities and assistance as well as useful information and demonstration of their relative advantage. In such a mass format, the limited resources intended for promoting sustainable agriculture would be used more efficiently. Though the "starter pack" is meant for Malaysian vegetable farmers, similar research efforts should also be made in other countries and sectors.

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Chapter 10: Conclusions and implications

ABSTRACT

This final chapter concludes this thesis. Motivated by the global phenomenon of low adoption rates of sustainable agricultural practices (SAPs), this thesis aimed to narrow down the four identified gaps in this research area. Following this research and resulting directly from it are policy insights focusing on the Malaysian vegetable production sector while, at the same time, offering broad implications for other countries and contexts. Future research directions are also offered through research implications and limitations.

10.1 CONCLUSIONS

Sustainable agricultural practices (SAPs) are a mechanism for improving agricultural sustainability in terms of farm productivity, environmental health, and social wellbeing. SAPs have not been voluntarily adopted by most farmers in many countries despite considerable investment and public policies being formulated. Motivated by this phenomenon, the Malaysian vegetable production sector has been chosen as a case study.

This thesis has been dedicated to generate a greater understanding of the farmer behavior under which SAPs adoptive decisions are being made by Malaysian vegetable farmers. This has been achieved by fulfilling the four objectives of this thesis:

(1) to assess the structure of perceived attributes of SAPs;

(2) to investigate both economic and psycho-social factors influencing the adoption of SAPs concurrently;

(3) to identify the relative importance of factors influencing the adoption of SAPs; and

(4) to examine the relative impact of adoption of SAPs on farm profitability.

The adoption of SAPs has been synthesized as a function of socio-economic, agro-ecological, institutional, information, and psycho-social factors as well as their perceived attributes (e.g., Pannell et al. 2006; Knowler and Bradshaw 2007; Prokopy et al. 2008; Baumgart-Getz et al. 2012). In view of such complexity, this thesis has been driven by an integrative framework: the theory of interpersonal behavior (TIB) and the theory of diffusion of innovation (DOI). This integrative framework links various factors underlying economic and psycho-social principles for economic decisions.

Guided by the integrative framework, two stages of data collection followed. Firstly, focus groups were conducted to generate useful information on questionnaire design and survey operations. Secondly, face-to-face interviews via a survey were conducted in Malaysia between October 2011 and March 2012. A total of 1,168 randomly selected vegetable farmers were interviewed.

10.1.1 Farmer perceptions toward the attributes of sustainable agricultural practices

In this study, the findings on perceptual structure suggest that the attributes of SAPs are similar to those generalized for profit-driven innovations in Rogers' (2003) theory of innovation diffusion. The perceptual structure was formed by four more important attributes: compatibility, complexity, trialability, and relative advantage. Though descriptive items underlying each attribute referred specifically to SAPs, they shared common concerns with each attribute of general innovations. In this case, SAPs were seen as compatible with farmer

attitudinal acceptance, farm physical conditions, and farm operations; SAPs were viewed as easy to understand and use; SAPs were conceived as experimental on a divisible basis.

Among the four attributes, relative advantage is a potential underperforming attribute. Within this attribute, SAPs were perceived as offering more non-economic advantages than economic benefits. This is not surprising since the inherent focus of SAPs is on natural resource management. As it is necessary for SAPs to be seen as profitable in a successful promotion, failure to reposition SAPs attractively is likely to impede adoption (Pannell et al. 2006).

10.1.2 Factor influencing the adoption of sustainable agricultural practices

At the initial stage, the structural equation model of the integrative framework indicates that adoption was influenced by a range of economic and psycho-social factors. Adoption was found as a result of complex decision-making, supporting the hypothesis of this thesis. Nevertheless, the economic aspect had a greater influence across the use of SAPs as suggested by a number of economic variables (the usefulness of information on the adoption of most SAPs; for education on cover crops/mulches; for financial capital and regional locations on conservation tillage).

Given that the economic aspect was more influential, a set of economic factors influencing the adoption of SAPs was investigated using logistic and probit regression models. The results of the logistic regression model indicate that adoption was influenced by a range of socio-economic, agro-ecological, institutional, informational, and psychological factors as well as the perceived attributes of SAPs. In particular, geographical location was a dominant factor, and followed by financial capital. Other relatively important factors were the usefulness of information, workforce size, ethnicity, and the perceived relative advantage of

SAPs. Though such a prioritization exercise was not carried out for the probit regression model, these economic factors were commonly significant across the use of SAPs.

As demonstrated above, the objectives of this thesis are interrelated. They are components of the same motivation to generate greater understanding of farmer behavior within which SAPs adoption decisions are being made. This major issue has been investigated using three different models: structural equation model, logistic regression model, and probit regression model. Nevertheless, their findings share two main similarities.

Firstly, all the empirical models only explained a small portion of the variability of adoptive decisions. Comparable findings are common in the literature (e.g., Sharma et al. 2011; McBride et al. 2004; McBride and El-Osta 2002; Rajasekharan and Veeraputhran 2002; Okoye 1998; Napier and Camboni 1993; Shortle and Miranowski 1986). This shows that the adoption of SAPs is a complex issue. There are more variables that have been captured to explain the farmer behavior. This begs the question of what other factors need to be investigated. In this regard, future research may consider more economic factors (e.g., market prices of and consumer demand for sustainable produce) and psychosocial factors (e.g., awareness, extension need, and perceptions toward and attitudes of extension agents). Nevertheless, as warned by Knowler and Bradshaw (2007) and demonstrated in this thesis, the possibility arises that research progress has reached a limit if previous research models are adhered. An improved model should be used for future investigation.

Secondly, the empirical findings suggest that economic motivations are necessary for facilitating sustainable farm management. This suggestion is in line with the conclusion made by various review studies (Baumgart-Getz et al. 2012; Lahmar 2010; Prokopy et al. 2008; Knowler and Bradshaw 2007; Pannell et al. 2006). Within the economic aspect, geographical location, financial capital, and the usefulness of information factors have been consistently appeared as the relatively important factors across statistical models. Their priority has

highlighted areas demanding special attention in explaining SAPs adoption. For example, geographical endowment recognizes that farms are unlikely to be managed in the same way given variability in natural resources (e.g., soil quality, climate, and rainfall) across locales. Financial capacity determines a farm's capability to invest in SAPs and tolerance level to potential losses. Quality information is the key to convince the potential users. Such understanding reinforces the relative importance of factors influencing the adoption of SAPs, and gives rise to clarity on directions that are likely to accelerate the use of SAPs.

10.1.3 Profitability of sustainable agricultural practices

The findings of the two-stage estimation method show that farm financial performance was affected by household size, off-farm employment, financial capital, organizational membership, and the type of SAPs under consideration. The inherent characteristics of these factors, in sum, relate to cost savings and productivity. Such characteristics are shared by SAPs, but two particular SAPs were more profitable: intercropping and organic fertilizers/composts. In other words, adopters of these SAPs had higher returns than non-adopters.

In addition to cost savings and productivity features, intercropping and organic fertilizers/composts also help reduce the risk of crop failure. Proper intercropping increases diversity in the cropping system. Its benefits include risk spreading, weed control, and the decrease of pest and disease incidence. Compatible crops also offer various agronomic benefits, including the supply of nutrients in complementary ways. To reap these benefits, it is important not to have crops competing with each other for resources (e.g., nutrients, water, or sunlight). Organic fertilizers/composts are important source of soil organic matter. Restoring the soil quality intensifies micro-organism activities in mineralizing nutrients and

producing antibiotics against diseases and pests. It also improves soil structure and water infiltration. In turn, properly processed organic fertilizers/composts reduce the risks of yield loss and erosion. Therefore, intercropping and organic fertilizers/composts are multifunctional and strategic SAPs in risk management.

Having established that intercropping and organic fertilizers/composts are more effective at reducing input costs and increasing yields, the research underlines that sustainable agriculture also contributes to economic sustainability. This evidence is vital since farm profitability is the primary concern for most farmers (Pannell et al. 2006). From this economic point of view, there are opportunities to overcome the weakest segment (economic benefits) in the attributes of relative advantage of SAPs.

10.2 POLICY IMPLICATIONS

The findings of this thesis offer policy implications for augmenting the adoption of SAPs. A policy becomes effective when it is built upon a widely shared consensus (Röling and Pretty 1997). This thesis has pointed out important areas, which are seen as common restraints of adoption. Consequently, this case study is valuable not only in facilitating local management in Malaysia, but also in offering implications of such research in other countries.

10.2.1 Economic consideration in policy development

Policy development in this area should acknowledge that the adoption of SAPs is a reasonably complex set of behaviors. It involves both economic and psycho-social considerations (Feola and Binder 2010; Bayard and Jolly 2007; van den Bergh et al. 2000; Costanza et al. 1993; Lynne et al. 1988). As no single aspect can completely explain the

voluntary action, general understanding from a multidisciplinary perspective is necessary prior to policymaking in this area.

Note that the economic aspect often offers better understanding of the adoption of SAPs. As laid out in the principle, asymmetric resource distribution is the root cause of non-adoption. Common resources determining adoption include the usefulness of information on SAPs, education, financial capital, and the quality of natural resources across areas (Baumgart-Getz et al. 2012). In particular, as implied by the information factor, extension efforts demonstrating simple, local, and contextualized applications of SAPs as well as follow-up are likely to be effective at increasing the likelihood of SAPs' adoption. Other measures may provide better training programs, direct and indirect financial incentives, and individual measures for different regions.

Moving forward, policy attention should be on factors demonstrating a greater influence on the adoption of SAPs. For example, Malaysia should pay special focus on resource availability and quality across geographical locations. To address the particular conditions of individual locales, tailored efforts are needed in sustainable agriculture promotion (Knowler and Bradshaw 2007). The local policy should also emphasize financial mechanisms in enabling investment in, and the buffer management of SAPs. Additional areas that demand policy highlight are the workforce size, the usefulness of information, ethnicity, and the relative advantage of SAPs. Therefore, policies to improve adoption rates could include granting longer working visas to foreign laborers; reviewing and improving the quality of current information; promoting ethnically based sustainability cultures; and relating the non-economic benefits of SAPs to profitability. As a whole, such relative importance drives policy emphases in promoting SAPs to prioritized places and segments through tailored information, education, and financial measures.

10.2.2 Promoting sustainable agriculture as an economically viable farming system

Profitability is a main concern to most farmers (Pannell et al. 2006). As SAPs were seen as less economically attractive, its relevant attribute – relative advantage – should be the main focus of extension efforts. This often happens because farmers do not have a good understanding on their potential in minimizing input costs and maximizing productivity. Moreover, sustainable agriculture has largely been promoted in local areas using standardized information that designed by the central agents (e.g., extension parties). The spatial variability of resources, which affect the viability of SAPs application, has not commonly been taken into account. In fact, a subset of SAPs might be more relevant to certain crops in specific areas. Sustainable agriculture should not be promoted as a one-size-fits-all solution.

An improved approach should seek to reposition sustainable agriculture as an economically viable and relevant farming system. In order to do so, this approach is necessarily multipronged given the complexity of farm decision-making and farming systems. For example, farmers' field school or participatory research is effective in local farm demonstration and delivering extension message where farmers can learn SAPs and see clear economic advantages (Pangborn et al. 2011). Efforts should also be made to engage farmers in the emerging market of sustainable produce as consumers are increasingly willing to pay higher prices to acquire these agri-food products (Loureiro and Umberger 2007; Loureiro et al. 2002b; Loureiro et al. 2002a; Darby et al. 2008; Froelich et al. 2009). Sustainable agriculture will give farmers a competitive edge. Alternatively, one or more short-term financial initiatives (e.g., subsidies, tax reduction, cuts in interest rates, and complimentary technical services) could also reshape farmer perceptions towards the profitability of SAPs and improve actual farm profitability (Tey and Brindal 2012).

In addition, certain SAPs can be promoted as an economically attractive "starter pack" to potential adopters. The "starter pack" contains a set of lucrative SAPs and provides the essential instructions for implementing the recommended practices for the first time users. In this case, intercropping and organic fertilizers/composts should be highlighted in the promotion of SAPs to Malaysian vegetable farmers. Careful consideration should be given prior to recommending compatible crops for intercropping and specific type organic fertilizers/composts. Such a customization effort is important to reflect the particular conditions of individual locales. The relevance of the "starter pack" to the reality will instill farmer confidence and allow farmers to start investing in sustainable agriculture at a lower risk. When proved successful, farmers can adopt more relevant SAPs progressively.

10.3 CONSIDERATIONS FOR FUTURE RESEARCH

Beyond this thesis, the range of farm issues that can be studied under the banner of adoption is enormous given the range agricultural innovations available for consideration. Some recent research interests relate to production practices (precision technologies, organic methods), inputs (hybrid seeds, genetically modified seeds) and climate change adaptive measures. Their aims are focused on various natural resource and environmental management issues, as identified by varied human institutions (e.g., government, consumers) across a range of spatial settings (e.g., country, region). Relevant research questions in relation to a particular innovation can be framed from different contextual angles. They can be studied with the help of available research methods and techniques, and by overcoming research limitations in this thesis.

10.3.1 Research methods

Researchers should review the available literature systematically prior to designing a research. Besides the vote count method, meta-analysis is another method to gauge what a strand of study finds. While both methods are somewhat complex, they lead to a knowledge bank of what is known and what needs to be studied.

Farm decision-making involves complex considerations. An integrative approach is, therefore, necessary to understand adoption from a multidisciplinary perspective. Such an approach offers a theoretical basis from which to analyze adoptive behavior, which is a result beyond economic consideration, more consistent with detailed observation. In such a research direction, integrative frameworks are likely to render a better explanation for farmer behavior.

Qualitative methods complement primary data collection. Focus groups, in particular, help explore research hypotheses. This method also produces a range of input for assisting with questionnaire design and planning survey operations. Pre-testing a questionnaire offers an opportunity to look into how to conduct an efficient survey, when and how to approach farmers, safety issues, and practical issues. This information is crucial for enumerator training and fieldwork management.

10.3.2 Research techniques

More investigations are needed to understand perceptions that lead towards sustainable management (Probert et al. 2005). Research in this regard can be exploratory or guided by a specific theory. The former is unsystematic, but eventually reveals the perceptual structure. For example, Sattler and Nagel (2010) suggest that additional features of sustainability-

related practices include perceived costs, risks, and time need; and they may fall under the flexible attribute of relative advantage. Therefore, any initial investigation is recommended to start using a general-wide model. After refining, the outputs highlight which attribute is most valued and which is the weakest.

Adoptive behavior is complex and likely to be better addressed by an integrative model. Such model, however, has a limitation in analyzing a greater range of factors. For example, Knowler and Bradshaw (2007) have inventoried more than 50 factors that may explain the adoption of SAPs. To allow a robust investigation, future research should carefully select and analyze a greater range of factors using a flexible statistical analysis (e.g., partial least squares and stepwise regressions).

Clarity for policy emphasis is needed since there are many factors influencing the adoption of SAPs. In order to achieve this, future research should compare the effect size of statistically significant factors. Such a prioritization exercise reveals which factor is more influential. The findings, in turn, highlight important areas that require policy attention. .

There needs to be more empirical evidence on the profitability of SAPs. Though proper management of SAPs should result in profitability, they generate different financial returns in both the short and long term. More future studies are recommended, with additional attention to the time-frame in question. Proof on short term profitability will indicate which SAP is more result-effective, thus, attracting new adopters. Information showing which SAP leads to long term economic sustainability will appeal to adopters to keep using SAPs.

10.3.3 Limitations and suggestions for future research

Being a case study, this thesis has been based on a limited sample size in Malaysia. The survey covered all five regions, but the farthest Perlis state in the Northern region was not

included. Therefore, future local research should aim to initiate wider survey coverage. Beyond the generalized findings of this thesis, future research should also seek to produce local insights for individual settings (e.g., countries, states and sectors).

A drawback of this thesis is in the focus on identifying the characteristics of "more likely" adopter groups. Though their prioritization as an exercise yields a policy focus on such targets, this research does not evaluate "less likely" adopter groups. Such an understanding is equally important if sustainable agriculture is to be realized on a large scale. Perceiving sustainable agriculture as a marketable product, separate marketing strategies have to be tailored to the "more likely" and "less likely" consumer segments. The former aims to establish consumption and loyalty; and the latter targets the augmentation of awareness and trial. From this illustration, different approaches are needed to reflect the particular characteristics of the "less likely" adopter groups. Therefore, researchers are encouraged to generate insights into both the "more likely" and "less likely" adopter groups.

This thesis is also limited in rendering insights into the relationship amongst SAPs. Recent research has shown that their adoptive decisions are interrelated (Teklewold et al. 2013). For example, conservation tillage and compost have been found to complement on another (Kassie et al. 2009). Other SAPs (e.g., cover crops/mulches versus organic fertilizers/composts) could be substituted. However, it is unclear how and why SAPs are used in such formats. Future participatory studies should aim to understand their practicality in the hope that this might result in better guides for promoting sustainable agriculture.

Although profitability is an important criterion, there are other financial means in comparing the impacts of conventional techniques relative to SAPs. That being said, it would be insightful to have a better understanding of other financial variables, such as costing, debts, equity, and yields. As a new agricultural system takes many years to reach a new equilibrium in a biological system, relevant information should be collected across times in

order to enable time dependent investment analysis. The subsequent annual financial ratios (e.g., rate of return and return on investment) are useful to compare the efficiency of different techniques and investments under a range of time frame. Such outputs will help farmers to make guided decisions.

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Appendix 1: Questionnaire

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ID					

The Adoption of Sustainable Agricultural Practices among Vegetable Farmers in Malaysia

Name of enumerator: _____	***Date:*** _____
Sub-area: _____ ***Postcode:*** _____	***Time:*** _____

The purpose of this study is to understand the adoption of sustainable agricultural practices among vegetable farmers in Malaysia. Sustainable agricultural practices refer to ways of growing food on your farm without degrading the environment, harming the society, and reducing farm incomes.

i. Are you the main decision maker of the farm? ☐ Yes ☐ No

This interview will take about 1 hour to complete. Your participation is voluntary. During the interview, you are free to not answer any of the questions. Your valuable input will help us improve the promotion of sustainable agriculture.

All your answers will be strictly confidential and anonymous.

Thank you in advance for participating in this interview. If you have any questions or comments, please contact us as follows:-

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SECTION A

This section is intended to know your current usage of sustainable agricultural practices.

No	Practices	Is it suitable to your farm?		Have you ever used it in the last 5 years?		Are you still using it?		If you are still using it, for how many years have you used it?	If it is not in use, why is it so?
		Yes	No	Yes	No	Yes	No		
A1.1	Conservation tillage								
A1.2	Contour planting								
A1.3	Inter-cropping								
A1.4	Cover crops / mulches								
A1.5	Crop rotation								
A2.1	Organic fertilizers								
A2.2	Eco friendly chemical fertilizers								
A3.1	Recycled water								
A3.2	Treated water								
A3.3	Sprinkler irrigation								
A4.1	Biological control								
A4.2	Mechanical and physical controls								
A4.3	Cultural control								
A4.4	Eco friendly chemical pesticides								

SECTION B

Please let us know what you think about the current situations on and surrounding your farm.

No.	I think…	Strongly disagree			Neutral			Strongly agree
B1	…my farm's input costs are high.	1	2	3	4	5	6	7
B2	…my farm is profitable.	1	2	3	4	5	6	7
B3	…my produce is safe for consumption.	1	2	3	4	5	6	7
B4	…my farm (& family) workers are safe.	1	2	3	4	5	6	7
B5	…the environment (air) in the area surrounding my farm is degraded.	1	2	3	4	5	6	7
B6	…resources (soil & water) in the area surrounding my farm are depleted.	1	2	3	4	5	6	7

SECTION C

Your sources of information on sustainable agricultural practices and their usefulness.

No.	Have you ever got information on sustainable agricultural practices from…	Yes	No	*If YES*, on average for how many times in the last 3 months?^
C1.1	…extension (agriculture) officers from the Department of Agriculture?			
C1.2	…other government agencies (e.g. FAMA)?			
C1.3	…research bodies (e.g. MARDI)?			
C1.4	…universities?			
C1.5	…workshops / seminars / forums?			
C1.6	…farmers association?			
C1.7	…input suppliers?			
C1.8	…mass media (e.g. newspapers, radio, magazines)?			
C1.9	…friends?			
C1.10	…your family members?			
C1.11	…field trips?			

Note: ^ except festival month

No.	Information gained on sustainable agricultural practices from…	Strongly disagree			Neutral			Strongly agree
C2.1	…extension (agriculture) officers is useful.	1	2	3	4	5	6	7
C2.2	…other government agencies is useful.	1	2	3	4	5	6	7
C2.3	…research bodies is useful.	1	2	3	4	5	6	7
C2.4	…universities is useful.	1	2	3	4	5	6	7
C2.5	…workshops / seminars / forums is useful.	1	2	3	4	5	6	7
C2.6	…farmers association is useful.	1	2	3	4	5	6	7
C2.7	…input suppliers is useful.	1	2	3	4	5	6	7
C2.8	…mass media is useful.	1	2	3	4	5	6	7
C2.9	…friends is useful.	1	2	3	4	5	6	7
C2.10	…your family members is useful.	1	2	3	4	5	6	7
C2.11	…field trips is useful.	1	2	3	4	5	6	7

SECTION D

Please rate your agreement on your expectation towards outcomes of sustainable agricultural practices.

No.	I expect sustainable agricultural practices to…	Strongly disagree			Neutral			Strongly agree
D1	…increase my farm's input costs.	1	2	3	4	5	6	7
D2	…increase my farm profit.	1	2	3	4	5	6	7
D3	…enhance the food safety level of my produce.	1	2	3	4	5	6	7
D4	…improve the overall safety level of my farm (& family) workers.	1	2	3	4	5	6	7
D5	…enhance the environment (air) in the area surrounding my farm.	1	2	3	4	5	6	7
D6	…enhance resources (soil & water) in the area surrounding my farm.	1	2	3	4	5	6	7

SECTION E

Please rate your agreement on the behaviour that is considered appropriate for your position in a social group.

No.	I should adopt sustainable agricultural practices…	Strongly disagree			Neutral			Strongly agree
E1	…as a farm owner/supervisor.	1	2	3	4	5	6	7
E2	…as a member of farmers association.	1	2	3	4	5	6	7
E3	…as a household head.	1	2	3	4	5	6	7
E4	…as a village member.	1	2	3	4	5	6	7
E5	…as a community member.	1	2	3	4	5	6	7

SECTION F

Do you think the following will approve the use of sustainable agricultural practices?

No.	Statements	Strongly disagree			Neutral			Strongly agree
F1	My farm (& family) workers would approve the use of sustainable agricultural practices.	1	2	3	4	5	6	7
F2	My friends would approve the use of sustainable agricultural practices.	1	2	3	4	5	6	7
F3	My family members would approve the use of sustainable agricultural practices.	1	2	3	4	5	6	7
F4	Members of farmers association would approve the use of sustainable agricultural practices.	1	2	3	4	5	6	7
F5	My consultant/guru would approve the use of sustainable agricultural practices.	1	2	3	4	5	6	7

SECTION G

Please let us know what you think about sustainable agricultural practices.

No.	I think sustainable agricultural practices…	Strongly disagree			Neutral			Strongly agree
G1.1	…are compatible with my preferred practices.	1	2	3	4	5	6	7
G1.2	…are compatible with my agricultural concept.	1	2	3	4	5	6	7
G1.3	…are compatible with my farming experience.	1	2	3	4	5	6	7
G1.4	…are do-able under my farm conditions.	1	2	3	4	5	6	7
G1.5	…can easily be integrated into my farm operation.	1	2	3	4	5	6	7
G1.6	…are compatible with my agricultural needs.	1	2	3	4	5	6	7
G1.7	…are compatible with my client's requirements.	1	2	3	4	5	6	7
G1.8	…are compatible with previously introduced practices.	1	2	3	4	5	6	7
G1.9	…are compatible with land owner's values.	1	2	3	4	5	6	7
G1.10	…are compatible with my farming community's values.	1	2	3	4	5	6	7
G2.1	…can easily be carried out.	1	2	3	4	5	6	7
G2.2	…can easily be understood.	1	2	3	4	5	6	7
G2.3	…are technically simple.	1	2	3	4	5	6	7
G2.4	…require additional training for a farmer.	1	2	3	4	5	6	7
G2.5	…require additional training for farm (& family) workers.	1	2	3	4	5	6	7
G2.6	…are challenging.	1	2	3	4	5	6	7
G3.1	…depend on new sophisticated technology.	1	2	3	4	5	6	7
G3.2	…cause legal issues.	1	2	3	4	5	6	7
G3.3	…can be trialed on selected plots.	1	2	3	4	5	6	7
G3.4	…can be trialed during selected periods.	1	2	3	4	5	6	7
G3.5	…can be trialed on selected varieties.	1	2	3	4	5	6	7
G3.6	…can be trialed without modifying farm operation.	1	2	3	4	5	6	7
G4.1	…produce good looking vegetables.	1	2	3	4	5	6	7
G4.2	…are beneficial to the environment (e.g. air).	1	2	3	4	5	6	7
G4.3	…produce uncontaminated products.	1	2	3	4	5	6	7
G4.4	…fertile the soil.	1	2	3	4	5	6	7
G4.5	…improve a farmer's image in society.	1	2	3	4	5	6	7
G4.6	…enhance a farm's landscape.	1	2	3	4	5	6	7
G4.7	…protect natural resources (e.g. soil & water) for future generations.	1	2	3	4	5	6	7
G5.1	…make vegetables more marketable.	1	2	3	4	5	6	7
G5.2	…improve a farmer's reputation in the market.	1	2	3	4	5	6	7
G5.3	…fetch higher ex-farm prices for vegetables.	1	2	3	4	5	6	7
G5.4	…make vegetables more acceptable to consumers.	1	2	3	4	5	6	7
G5.5	…increase a farm's outputs.	1	2	3	4	5	6	7
G5.6	…increase a farm's incomes.	1	2	3	4	5	6	7
G5.7	…are safe to farm (& family) workers.	1	2	3	4	5	6	7
G5.8	…increase the occurrence of plant diseases.	1	2	3	4	5	6	7
G5.9	…improve vegetable quality.	1	2	3	4	5	6	7
G5.10	…increase the occurrence of pest outbreaks.	1	2	3	4	5	6	7
G5.11	…increase weeds problem.	1	2	3	4	5	6	7
G5.12	…require additional farm investments.	1	2	3	4	5	6	7
G5.13	…increase farm (& family) workers' healthcare bills.	1	2	3	4	5	6	7
G5.14	…require additional labour recruitment.	1	2	3	4	5	6	7
G5.15	…require additional working hours.	1	2	3	4	5	6	7
G5.16	…increase chemical inputs.	1	2	3	4	5	6	7
G5.17	…save more time for a farmer's family.	1	2	3	4	5	6	7
G5.18	…save more time for a farmer's hobbies.	1	2	3	4	5	6	7

SECTION H

Please rate your expectation toward the likelihood of outcomes of sustainable agricultural practices.

No.	Using sustainable agricultural practices will…	Extremely unlikely						Extremely likely
H1	…increase my farm's input costs.	1	2	3	4	5	6	7
H2	…increase my farm profit.	1	2	3	4	5	6	7
H3	…enhance the food safety level of my produce.	1	2	3	4	5	6	7
H4	…improve the overall safety level of my farm (& family) workers.	1	2	3	4	5	6	7
H5	…enhance the environment (air) in the area surrounding my farm.	1	2	3	4	5	6	7
H6	…enhance resources (soil & water) in the area surrounding my farm.	1	2	3	4	5	6	7

SECTION I

General questions about your farm operation.

No.	Questions	Yes	No
I1.1	Is your farm certified / to be certified under SALM?		
I1.2	***If NO***, do you plan to participate in SALM in the next 3 years?		
I2.1	Is your farm operated using organic methods?		
I2.2	***If YES***, is your farm certified / to be certified under SOM?		
I2.3	***If NO***, do you plan to participate in SOM in the next 3 years?		
I3.1	Is your farm operated / to be operated under contract farming?		
I3.2	***If NO***, do you plan to participate in contract farming in the next 3 years?		
I4.1	Does your farm supply to a few main customers?		
I4.2	***If NO***, do you plan to supply to a few main customers in the next 3 years?		
I5.1	Does your farm export produce to foreign markets?		
I5.2	***If NO***, do you plan to export produce to foreign market in the next 3 years?		
I6.1	Does your farm supply to super- or hypermarkets?		
I6.2	***If NO***, do you plan to supply produce to super- or hypermarkets in the next 3 years?		
I7	Are you a member of cooperative(s)?		
I8	Are you a member of farmers association(s)?		
I9	Do you have credit access for input supplies?		
I10	Do you have loan access for farm investments?		
I11	Do you receive incentive / subsidy from the government?		

SECTION J

Please rate your agreement on your ideas about who you are in adopting sustainable agricultural practices.

No.	Statements	Strongly disagree			Neutral			Strongly agree
J1	I am a conservative farmer who would adopt sustainable agricultural practices.	1	2	3	4	5	6	7
J2	I am a responsible farmer who would adopt sustainable agricultural practices.	1	2	3	4	5	6	7
J3	I am a modern farmer who would adopt sustainable agricultural practices.	1	2	3	4	5	6	7
J4	I am an innovative farmer who would adopt sustainable agricultural practices.	1	2	3	4	5	6	7
J5	I am a pro-active farmer who would adopt sustainable agricultural practices.	1	2	3	4	5	6	7

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SECTION K

General questions about your farm conditions.

K1 How big is your farm? _____ acre (2.5 acre = 1 hectare)

K2a How many years have the land been used for agriculture? _____ years

K2b Will you continue cultivating on the land in the next 3 years? ☐ Yes ☐ No

K3 Your farm is located in ☐ highlands ☐ lowlands

K4 Your farm land is
☐ flat (less than 6 degrees) ☐ steep (at or more than 6 degrees)

K5 Do you think there is enough rainfall for your farm? ☐ Yes ☐ No

K6 What are the sources of your water input? (*can choose more than one*)
☐ river ☐ pond ☐ water company

K7 Are there soil erosion issues on your farm? ☐ Yes ☐ No

K8 How far is your farm away from local inputs market? _____ km

K9 How far is your farm away from your main customers/collectors? _____ km

K10a Most of your farmland is ☐ self-owned ☐ rented ☐ TOL

K10b ***If SELF-OWNED***, will it be passed on to next generation? ☐ Yes ☐ No

K11a How many full-time farm workers do you employ? _____ persons

K11b How many full-time farm workers are your family members? _____ persons

K12a How many part-time farm workers do you employ? _____ persons

K12b How many part-time farm workers are your family members? _____ persons

K12c How many total hours do part-timers work in a week? _____ hours / week

K13 Do you have difficulty in hiring farm workers? ☐ Yes ☐ No

K14 What are the main vegetables cultivated on your farm? 1. _____ 2. _____ 3. _____

K15 How much was your average farm production in the last 3 months? _____ ton / month (1 ton = 1,000kg)

K16 Other than vegetables, do you grow other crops (e.g. fruit)? ☐ Yes ☐ No

K17a Do you practice integrated farming system (with livestock)? ☐ Yes ☐ No

K17b ***If YES***, how many heads of livestock do you keep?
_____ heads of chicken _____ heads of duck _____ heads of goat _____ heads of cattle

K18 How much was your average farm operation (all) cost in the last 3 months? RM_____ / month

K19 How much is your financial capital? RM_____

K20 Do you think your farm is an arable land? ☐ Yes ☐ No

K21 What is the color of soil on your farm? ☐ Dark ☐ Light

SECTION L

Your feelings toward the use of sustainable agricultural practices.

No.	For me to use sustainable agricultural practices is…	Strongly disagree			Neutral			Strongly agree
L1	…risky.	1	2	3	4	5	6	7
L2	…beneficial.	1	2	3	4	5	6	7
L3	…troublesome.	1	2	3	4	5	6	7
L4	…disgusting.	1	2	3	4	5	6	7
L5	…interesting.	1	2	3	4	5	6	7

SECTION M

Please rate your agreement on your habits in using sustainable agricultural practices.

No.	Statements	Strongly disagree			Neutral			Strongly agree
M1	Using sustainable agricultural practices is common to me.	1	2	3	4	5	6	7
M2	I use sustainable agricultural practices regularly.	1	2	3	4	5	6	7
M3	I am used to using sustainable agricultural practices.	1	2	3	4	5	6	7
M4	I think twice before using sustainable agricultural practices.	1	2	3	4	5	6	7
M5	Using sustainable agricultural practices is natural to me.	1	2	3	4	5	6	7

SECTION N

This section asks about your awareness and concern about various sustainability issues.

No.	Statements	Strongly disagree			Neutral			Strongly agree
	Environmental issues (air pollution) in general							
N1a	I am aware	1	2	3	4	5	6	7
N1b	I am concerned	1	2	3	4	5	6	7
	Resource degradation issues (soil infertility, water pollution) in general.							
N2a	I am aware	1	2	3	4	5	6	7
N2b	I am concerned	1	2	3	4	5	6	7
	Economic return of farm investments in general.							
N3a	I am aware	1	2	3	4	5	6	7
N3b	I am concerned	1	2	3	4	5	6	7
	Food safety issues in general.							
N4a	I am aware	1	2	3	4	5	6	7
N4b	I am concerned	1	2	3	4	5	6	7
	Safety issues of farm workers in general.							
N5a	I am aware	1	2	3	4	5	6	7
N5b	I am concerned	1	2	3	4	5	6	7

SECTION O

No.	Statements	Strongly unlikely						Strongly likely
O1	I plan to use sustainable agricultural practices.	1	2	3	4	5	6	7
O2	I intend to use sustainable agricultural practices.	1	2	3	4	5	6	7
O3	I will use sustainable agricultural practices.	1	2	3	4	5	6	7
O4	I want to use sustainable agricultural practices.	1	2	3	4	5	6	7
O5	I wish to use sustainable agricultural practices.	1	2	3	4	5	6	7

SECTION P

This section asks you some general questions about your background. Please fill-in or tick your answer.

P1a What is your main goal of farming? (*can choose more than one*)
☐ For income ☐ For lifestyle ☐ For hobby ☐ Other: _____

P1b What is your household's main goals of farming? (*can choose more than one*)
☐ For income ☐ For lifestyle ☐ For hobby ☐ Other: _____

P2 When were you born? _____

P3 What is your gender? ☐ Male ☐ Female

P4 What is your marital status? ☐ Single ☐ Married

P5 How many years of formal schooling (starting from Standard 1) did you receive? _____ years

P6 How many years of farming experience do you have? _____ years

P7a How many household members (including you) do you have? _____ members

P7b How is the composition of your household?

Number of person	Age groups
	1-10 years old
	11-20 years old
	21-30 years old
	More than 31 years old

P8 How many total hours do you work on the farm in a week? _____ hours / week

P9a Do you have off-farm employment? ☐ Yes ☐ No

P9b ***If YES***, how many total hours do you work off-farm in a week? _____ hours / week

P9c ***If YES***, how much is your last year's off-farm income (before tax)? RM_____

P10a Does your household have off-farm employment? ☐ 1. Yes ☐ 2. No

P10b ***If YES***, how much is your household's last year's off-farm income (before tax)? RM_____

P11 How much is your last year's farm revenue (before tax)? RM_____

P12 How much is your last year's farm profit (before tax)? RM_____

P13 What is your cultural background?
☐ Malay ☐ Chinese ☐ Indian ☐ Other: _____

SECTION Q

We plan to have a follow-up study in order understand how farmers develop their decision over time.

Q1. Would you be interested to be our ***FUTURE*** respondent? ☐ Yes ☐ No

Q1a ***If YES***, please fill up the following for future correspondence.

Name: _____ Contact number: _____

Home address: _____

Thank you for your co-operation

Appendix 2: Descriptive statistics of selected variables

Variables	Mean	Standard deviation
Adoption of sustainable agricultural practices		
Conservation tillage (0/1)	.835^	.372
Intercropping (0/1)	.548^	.498
Cover crops/mulches (0/1)	.471^	.499
Crop rotation (0/1)	.766^	.424
Organic fertilizers/composts (0/1)	.850^	.357
Integrated pest management (0/1)	.086^	.281
Socio-economic factors		
Male (0/1)	.680^	.467
Age (years)	49.739	13.495
Chinese (0/1)	.161^	.368
Formal education (years)	7.884	4.357
Farming experience (years)	16.530	13.591
Household size (persons)	6.470	3.642
Number of full-time laborers (persons)	2.659	5.209
On-farm working hour (per week)	38.290	18.826
Financial capital (RM)	78,210	230,914
Keep livestock on farm (0/1)	.166^	.373
Off-farm employment (0/1)	.274^	.446
Married (0/1)	.896^	.306
Access to finance (0/1)	.272^	.445
Farm size (hectares)	4.438	10.323
Agro-ecological factors		
Flat land (0/1)	.918^	.275
Lowlands (0/1)	.846^	.361
Presence of environmental issue (0/1)	.137^	.343
Duration of land used for farming (years)	13.381	14.409
Practice organic farming (0/1)	.393^	.489
Southern region (0/1)	.129^	.336
Central region (0/1)	.157^	.364
Northern region (0/1)	.239^	.427
Eastern region (0/1)	.164^	.371
Land ownership (0/1)	.544^	.498

Variables	Mean	Standard deviation
Tropical livestock unit	9.298	35.814
Average gross farm profit over three years (RM)	38,908	96,141
Average produce price over three years (RM per ton)	4,570	11,388
Institutional factors		
Organizational membership (0/1)	.408^	.492
Participation in a certification program (0/1)	.068^	.251
Participation in an institutional arrangement (0/1)	.637^	.481
Informational factor		
Information gained on SAPs from extension services is useful	4.82	1.501
Information gained on SAPs from farmers association is useful	4.44	1.280
Information gained on SAPs from mass media is useful	4.47	1.277
Information gained on SAPs from friends is useful	4.87	1.309
Usefulness of information (on average)	4.512	0.982
Perceived attributes		
Relative advantage^^	5.775	.816
Compatibility^^	5.330	.968
Complexity^^	2.670	1.183
Trialability^^	5.203	1.066
I think increase a farm's profitability more than conventional agricultural practices.	5.62	1.24
I think SAPs increase chemical inputs more than conventional agricultural practices.	3.77	1.74
I think SAPs require additional working hours compared to conventional agricultural practices.	4.42	1.71
I think SAPs are safer to farm (and family) workers than conventional agricultural practices.	5.81	1.16
I think SAPs save more time for a farmer's hobbies than conventional agricultural practices.	4.85	1.46
I think SAPs improve a farmer's image in society compared to conventional agricultural practices.	5.76	1.05
I think SAPs increase the occurrence of pest outbreaks more than conventional agricultural practices.	3.89	1.80
I think SAPs increase weeds problem more than conventional agricultural practices.	3.85	1.83
I think SAPs are more beneficial to the environment than conventional agricultural practices.	5.89	1.05
I think SAPs are compatible with land owner's values.	5.25	1.17
I think SAPs are compatible with my farming community's production values.	5.31	1.09
I think SAPs are compatible with my agricultural needs.	5.42	1.15

Variables	Mean	Standard deviation
I think SAPs are do-able under my farm conditions.	5.42	1.21
I think SAPs can easily be integrated into my farm operation.	5.23	1.24
I think SAPs can easily be carried out.	2.65	1.30
I think SAPs can easily be understood.	2.60	1.28
I think SAPs are technically simple.	2.77	1.34
I think SAPs require additional training for farm (and family) workers.	2.75	1.55
I think SAPs can be trialed without modifying farm operation.	5.28	1.31
I think SAPs can be trialed on selected plots.	5.11	1.28
I think SAPs can be trialed during selected periods.	5.20	1.26
I think SAPs can be trialed on selected varieties.	5.24	1.30
I think SAPs protect natural resources for future generations.	5.84	1.05
I think SAPs produce good looking vegetables.	5.82	1.13
I think SAPs enhance a farm's landscape.	5.58	1.14
I think SAPs make vegetables more acceptable to consumers.	5.85	1.12
I think SAPs improve a farmer's reputation in the market	5.76	1.054
Psychological factors		
I plan to use SAPs	5.46	1.305
I intend to use SAPs	5.47	1.273
I will use SAPs	5.37	1.319
I want to use SAPs	5.47	1.303
I wish to use SAPs	5.56	1.288
Intention to adopt or continue using SAPs^^	5.462	1.199
Using SAPs is common to me	4.82	1.378
I use SAPs regularly	4.70	1.465
I am used to SAPs	4.71	1.453
Using SAPs is natural to me	4.73	1.466
Habit (on average)^^	4.741	1.325
SAPs will enhance the food safety level of my produce	5.79	1.041
SAPs will improve the overall safety of my farm workers	5.72	1.071
SAPs will enhance the environment surrounding my farm	5.73	1.105
SAPs will enhance resources surrounding my farm	5.76	1.076
For me to use SAPs is risky^^^	4.42	1.768
For me to use SAPs is troublesome^^^	4.59	1.626
As a farmer, I would use SAPs	5.42	1.038
My farm workers would approve the use of SAPs	5.48	1.048
As a responsible farmers, I would use SAPs	4.71	.735

Variables	Mean	Standard deviation
Resource efficiency		
Average yield over three years (ton per hectare)	4.53	31.87
Average chemical expenses per hectare over three years (RM)	409.30	671.92
Farm size per laborer (hectare)	2.01	3.64

Source: Survey sample in Malaysian vegetable sector, 2011-2012

Notes: ^ The estimate is interpreted in percentage in relation to those who answered "Yes=1". ^^ Average point of multiple items was calculated. ^^^ scores were inversely recoded for negative statements

Appendix 3: Adoption rate of sustainable agricultural practices: a focus on Malaysia's vegetable sector for research implications

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Author Contributions

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Name of Principal Author (Candidate)	Yeong Sheng Tey		
Contribution to the Paper	- Analyzed and interpreted the data - Wrote the manuscript - Acted as corresponding author		
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Contribution to the Paper	- Supervised development of work - Helped to interpret the findings - Helped to evaluate the manuscript - Helped to edit the manuscript		
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Contribution to the Paper	- Helped to interpret the findings - Helped to evaluate the manuscript - Helped to edit the manuscript		
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Full Length Research Paper

Adoption rate of sustainable agricultural practices: A focus on Malaysia's vegetable sector for research implications

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Sustainable agriculture practices (SAPs) have been widely promoted to improve the sustainability of agricultural systems. The promotion of SAPs is intended to encourage their voluntary adoption. Therefore, the development of sustainable agriculture can be understood through the adoption rate of recommended SAPs. However, little is known about the progress of sustainable agriculture, particularly in Asian countries. To fill part of the knowledge gap, this exploratory study identifies, as a starting point, the current adoption rate of SAPs in the Malaysian vegetable sector. Because the information is not officially collected, a synthesis of ground level information was conducted through a focus group discussion with the Department of Agriculture. The findings suggest that there are varied adoption rates across SAPs. The outputs also point out that the adoption of SAPs is currently at a low level, like most countries. The phenomenon should be investigated from a multi-disciplinary perspective within agricultural systems, integrating (1) socio-economic factors, (2) agro-ecological factors, (3) institutional factors, (4) informational factors, (5) perceived characteristics, and (6) behavioral attributes. By such means, future investigations should be based on a system-orientated integrative framework.

Key words: Sustainable agricultural practices, adoption rate, Malaysia, vegetable sector.

INTRODUCTION

Improving agricultural sustainability is an important goal (FAO, 2002). This imperative has arisen because conventional agricultural practices (CAPs), which are widely employed at the present time, are widely criticized for jeopardizing sustainability (Poursaeed et al., 2010). Notable among the problems that are associated with CAPs are environmental degradation, resource depletion, water deterioration, biodiversity loss, and social disruption (Amsalu and De Graaff, 2007; Bayard and Jolly, 2007; Shiferaw et al., 2009). In the wake of various undesirable externalities, many holistic efforts have been devoted to promoting sustainable agriculture in developed and developing countries. "Sustainable agriculture", as defined by the FAO (1995), is "the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations". Therefore, this alternative ensures multi-dimensional sustainability.

Sustainable agriculture involves a dynamic set of sustainable agricultural practices (SAPs). Common SAPs

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include conservation tillage, contour farming, crop rotation, inter-cropping, cover cropping, organic fertilizers, and integrated pest management (IPM). SAPs that are considered appropriate in one area might be unsuitable to other areas where the underlying conditions are different (Zhen and Routray, 2003). In other words, sustainable agriculture cannot be reduced to one concretely defined set of practices (Pretty and Hine, 2000).

However, little is known about the current state of progress in sustainable agriculture. One approach that might lead to such understanding is to gain insight into the adoption rate of SAPs. As defined in Rodriguez et al. (2009), adoption is the implementation and continued use of a practice. It is different from trial or experiment. Many studies have asserted a limited adoption of SAPs (Bayard et al., 2007; Caswell et al., 2001; Horrigan et al., 2002; Karami and Keshavarz, 2010; Norman et al., 1997; Pretty, 1994). However, the information has neither been specifically collected through an agricultural census nor officially published in most countries. Therefore, there is a knowledge gap in our understanding of the current state of adoption of SAPs at the sectoral, national, and regional levels (Rodriguez et al., 2009).

In response to this gap, this study is intended to qualify the current adoption rate of SAPs. Some of the information has been collected by FAO (2011) for conservation based SAPs (conservation tillage, cover crops, and crop rotation) in selected countries, but the knowledge gap remains throughout Asian countries. Moreover, farmers generally encounter similar experiences in these areas (Charlton, 1987). As a starting point to fill the other part of the gap, the context of Malaysia forms the basis of this study. To shed some light on the adoption rate, we also selectively discuss various relevant factors. Our work will hopefully lead to a meaningful leap forward in the knowledge base for this topic and for future studies.

LITERATURE REVIEW

As embedded in the FAO's (1995) definition, realizing sustainable agriculture requires a shift toward adopting SAPs. Hence, their adoption can be used as a means to understand the progress of sustainable agriculture. Generally, it is difficult to quantify the adoption rate of SAPs based on observation. In contrast, agricultural surveys, census collections, and syntheses of ground level information are better means to gain such insight. Using one of these methods, part of the information has been collected in a number of countries around the world and reported by the FAO (2011). The collected information mostly represents only those SAPs (such as conservation tillage, cover crops, and crop rotation) that have conservation features. Their aggregate adoption rate in selected countries, covering five continents, is presented in Table 1.

North American countries are among the pioneers in the structured promotion of sustainable agriculture. For example, SAPs have been largely promoted under the national Sustainable Agriculture Research and Education program by the U.S. Department of Agriculture since the late 1980s. However, the adoption of these practices remains largely limited, standing at 26% in Canada and 15% in the United States of America. At a disaggregate level, Rodriguez et al. (2009) also found a low adoption of general SAPs in the southern region of the United States of America.

In contrast, a number of South American countries (including Argentina and Uruguay) have recorded better success. The central emphasis of these countries is on conservation tillage, as their farmers understand that direct seeding is possible when the land is not ploughed. Derpsch and Friedrich (2009) attribute Argentina's success in promoting conservation tillage to historical expert-farmer collaboration (as early as 1977/1978), the intensive promotion by the Argentinean Association of No-till Farmers, and the availability of seeding machineries.

European and African countries have had little success. Invariably, these countries have not witnessed more than 10% of their farmland being cultivated using the selected SAPs. While one can understand that African countries lack official programs or resources, the phenomenon in advanced European countries is puzzling.

In Asia and the Pacific, Australia and New Zealand show relatively positive development. Much of the promotion of SAPs in Australia is carried out by the Department of Sustainability, Environment, Water, Population, and Communities and the Department of Agriculture, Fisheries and Forestry. More success is expected following the recent launch of Australia's National Framework for Environmental Management Systems in Agriculture.

However, it is obvious that little is known about the adoptive status of other SAPs (for example, intercropping, organic fertilizers, and IPM). Additionally, the knowledge gap remains throughout Asian countries. As filling the gap requires insight from individual countries, Malaysia is chosen as a starting point to build up the database.

Malaysia

Malaysia's agricultural policies have been primarily economically orientated. The First National Agricultural Policy (1984 to 1991) and the Second National Agricultural Policy (1992 to 1997) promoted the efficient use of local resources for maximizing farm income (Murad et al., 2008). Under these policies, SAPs were individually promoted by change agencies. For example, an individual program was designed to encourage the

Table 1. Adoption rate of sustainable agricultural practices (SAPs) in selected countries.

Country	2007/2008 (percentage of total area planted using SAPs*)
North America	
Canada	25.85
The United States of America	15.31
South America	
Argentina	77.43
Paraguay	55.81
Uruguay	39.16
Chile	10.45
Venezuela	8.96
Mexico	0.08
Europe	
Finland	8.83
Kazakhstan	5.70
Spain	3.76
Germany	2.93
Switzerland	2.08
Portugal	1.50
France	1.04
Italy	0.82
Slovakia	0.71
United Kingdom	0.39
Ukraine	0.30
Hungary	0.17
Ireland	0.01
Asia and the Pacific	
Australia	38.31
New Zealand	31.03
Africa	
South Africa	2.38
Kenya	0.57
Ghana	0.41
Zimbabwe	0.39
Mozambique	0.19
Tunisia	0.16
Sudan and South Sudan	0.05
Lesotho	0.04
Morocco	0.04

*Aggregated adoption rate of conservation tillage, cover crops, and crop rotation. Source: FAO (2011).

uptake of IPM (Taylor et al., 1993). It was not until the Third National Agricultural Policy (1998 to 2010) that a different approach was taken to integrate each SAP into one package. As a whole, the SAPs were promoted to improve agricultural sustainability.

Among agricultural sectors, the Malaysian vegetable sector has undergone the holistic promotion of sustainable agriculture under the Third National Agricultural Policy. Therefore, the sector can be used as a basis for knowledge on the adoption of SAPs in the country. The promotion is in the form of two certification schemes: (1) the “Malaysia’s Organic Scheme”, which

Table 2. Selected sustainable agriculture practices (SAPs) for the focus group discussion.

SAPs	Descriptions
Mulches and cover crop	^Mulch is an organic material spread over the soil surface. Cover crop is a crop sown to cover the soil. Both of them prevent soil erosion and evaporative losses.
Organic fertilizer	^Organic fertilizer is made from dead or decaying animal wastes or plant matter. It has multiple beneficial impacts on the soil and plant health.
Intercropping	^Intercropping means the growing of mixed crops, which have different characteristics and requirements, on the same land at the same time. It contributes to pest control.
Crop rotation	^Crop rotation refers to the growing of crops, which have differing nutrient needs and management, sequentially. It impedes the spread of pests and benefits the soil.
Conservation tillage	^Conservation tillage aims to plough the soil as little as possible. It prevents erosion, saves energy, and improves biodiversity.
Integrated pest management	^IPM is an ecological approach to pest (animal and weed) control. It utilizes multi-disciplinary knowledge for biological control, mechanical and physical control, and cultural control of pests.
Netting and shelter	^ Netting is a feature and shelter is a structure that provides crop protection from wind, sun, rain, and other undesirable weather conditions.

^Dictionary of Agriculture (2006).

was introduced in 2001, and (2) the “Malaysia’s Good Agricultural Practices (GAPs) Scheme”, which was implemented in 2002 (Department of Agriculture, 2010). Both voluntary certification schemes recommend taking the initiative to adopt SAPs along with other compulsory (non-production) practices, such as farm records, human welfare, and legal aspects. Up to the end of 2010, less than one percent of approximately 46,000 vegetable farmers were certified under these schemes (Department of Agriculture, 2010; Ministry of Agriculture and Agro-Based Industry, 2010).

However, the record of both schemes does not specifically indicate the prevalence of the practice of SAPs even in those certified farms. For those not listed in the schemes, the presumption cannot be made that they have not adopted one or more SAPs. Indeed, past studies have observed some adoption of SAPs in domestic vegetable cultivation (Barrow et al., 2005, 2010; Nasir et al., 2010). Therefore, to advance our understanding of the development of sustainable agriculture, we should gain better insight into the adoption rates within the sector through the change agency (that is, the Department of Agriculture).

METHODS

More than 20 SAPs have been promoted under “Malaysia’s Organic Scheme” and “Malaysia’s GAPs Scheme” (Department of Agriculture, 2009a, b). These SAPs can be divided into specialized practices, such as contour farming for uplands, and generic practices, which can be applied to most farmlands, regardless of their underlying conditions.

Under the consideration of their general application, our focus was limited to seven SAPs: (1) conservation tillage, (2) mulches and cover crop, (3) crop rotation, (4) organic fertilizer, (5) intercropping, (6) netting and shelter, and (7) IPM. These selected SAPs are also commonly recommended in the literature (Tripp, 2006). While it was difficult to standardize their definitions, reference to the Dictionary of Agriculture (2006), as presented in Table 2, provided the common descriptions and functions for these SAPs. Because the Malaysian agricultural survey did not collect data on the adoption of the selected SAPs, a synthesis of ground level information was helpful to the interest of this paper. A similar data collection method was employed by Rodriguez et al. (2009). In this approach, the adoption rate was selected as one of the topical issues in our focus group discussion (FGD) with the Malaysian Department of Agriculture (DoA) in May 2011. Other topical issues were intended to gain insight into why farmers have or have not adopted SAPs. Some of these useful insights were also selectively picked for the purpose of our discussion.

The FGD involved eight voluntarily participants who worked in the headquarters, which collects and processes on-ground information and plans the national promotion of agricultural practices. As the Malaysian national language, Malay was primarily used in the FGD. English was also allowed to express some technical terms, such as crop rotation and IPM. Tey et al. (2012) gives further details.

Approximately one eighth of the 90-min FGD was devoted to the focus of this paper. These participants were asked to write down and present their perceived adoption rate of the selected SAPs. When presenting their adoption rates, their answers were debated for justification and agreement. Much of the debate was driven by the relevant information that was made available to the participants

Table 3. Adoption rate of selected sustainable agricultural practices (SAPs) in the Malaysian vegetable sector.

No.	SAPs	Adoption rate (%)
1	Mulches and cover crop	35-45
2	Organic fertilizer	35-45
3	Intercropping	35-45
4	Crop rotation	30-40
5	Conservation tillage	25-35
6	Integrated pest management	25-35
7	Netting and shelter	5-15

by the DoA's ground officers across the states in Malaysia. Though the perceived adoption rates were not consistent across participants, their answers were not greatly varied. As such, the information offered various agreed and reasonable range of adoption rates for the selected SAPs in the vegetable sector at the present time.

RESULTS

The adoption rate of selected SAPs in the vegetable sector of Malaysia is presented in Table 3. These SAPs have not been fully implemented by all vegetable farmers. Some farmers have adopted SAPs, while others have hesitated, which means that decisions to adopt vary across individual farmers. Furthermore, the adoption rates vary across these SAPs, ranging from 5 to 45%. This result can be interpreted as follows: a range between 5 and 45% of the total vegetable farmer population has used one or more of the recommended SAPs; in other words, some SAPs are preferred over others by individual farmers.

Given that these findings are sector specific, they cannot be directly compared with the adoption rate of selected SAPs in other countries, as discussed earlier. Nevertheless, the latter can serve as a benchmark to determining how well Malaysia has progressed in realizing sustainable agriculture. For this purpose, special attention is paid to the adoption rate of mulches and cover crop, crop rotation, and conservation tillage, which are seen as being used by approximately 35 to 45%, 30 to 40%, and 25 to 35% of Malaysian vegetable farmers, respectively. These achievements are considerably modest, as many countries, including both developed and developing countries in our earlier review, have recorded little success.

The modest achievements could be partly attributed to the inheritance of local indigenous technical farming knowledge, though these skills have largely been lost to mechanization. For example, Malaysia, alongside Japan and Sri Lanka, had a high rate of their farmlands cultivated using no-tillage throughout 1973/1974 and 1983/1984 (Derpsch et al., 2006). However, statistics were not recorded thereafter. Under these circumstances, their current achievements could be related to the recent holistic promotion of their application in "Malaysia's Organic Scheme" and "Malaysia's GAPs Scheme". For instance, mulches and cover crops are included in both schemes as primary options for soil erosion control. In addition, these practices offer similar benefits, such as increasing water infiltration, enhancing soil moisture, and reducing weed growth.

The adoption rate of organic fertilizer and intercropping is also found to be within the range of 35 to 45%. Between these practices, the adoption of organic fertilizer in the form of processed chicken manure commenced since the 1980s (Barrow et al., 2010). Other common organic fertilizers include compost as well as processed cow dung and guano (Safie and Ishak, 2008). Due to the growing concern of health risks and the increasing prices of synthetic fertilizers, organic fertilizer has emerged as a close substitute (Mohamed, 2009). In both certification schemes, organic fertilizers are also packaged as a multifunctional input, offering improvements in soil structure, soil microbial activity, and soil biodiversity.

IPM has been adopted to a limited degree by some 25 to 35% of Malaysian farmers. Though its official promotion can be dated back to the 1960s (Taylor et al., 1993), the use of synthetic pesticides is still significant (Aminuddin et al., 2005). One possible explanation for this lack of progress may rest with the nature of IPM, which is knowledge demanding. Indeed, the application of IPM involves a complex decision-making process in judging the need to spray pesticides, what type of pesticides to use, and when to spray the selected pesticides (Mohamed et al., 1994).

Among these selected SAPs, netting and shelter has only been adopted by a small number of farmers, ranging between 5 and 10%. The adoption rate remains small even after 20 years of observation, which was made in the early 1990s (Midmore et al., 1996). Shelters can be built using plastic or netting material. The primary function of these shelters is to control rain-related soil erosion. Because shelters normally last up to 2.5 years, the need to reinvest in shelters has certain economic implications for farmers (Aminuddin et al., 2005). As such, they are only used for the cultivation of high-value vegetables.

DISCUSSION

Despite being exploratory, our study also attempts to understand the variability of adoptive decisions across individual farmers. Derived from the other topical issues that discussed why farmers have or have not adopted SAPs, factors that have contributed to the variance can be ascribed to six groups: (1) socio-economic factors, (2) agro-ecological factors, (3) institutional factors, (4) informational factors, (5) perceived characteristics, and (6) behavioral attributes.

Socio-economic factors refer to the main decision maker and farm household characteristics. Among other factors, educational attainment was mentioned as a clear distinction in the adoption of SAPs. A higher (formally) educated farmer is suggested to be more likely to adopt SAPs. With greater knowledge, the farmer becomes less risk-averse when evaluating an SAP. In other words, the farmer is more willing to accept innovation that requires alteration in farm operation. However, empirical findings on the influence of education level on the adoption of SAPs have been mixed: (1) insignificant (Ogunlana, 2004; D'Emden et al., 2006), (2) significantly positive (Rahm and Huffmam, 1984; Wang et al., 2000) and (3) significantly negative (Okoye, 1998; Erbaugh et al., 2010). Other significant characteristics might include age, farming experience, and off-farm employment (Ajewole, 2010; D'Emden et al., 2008; Napier, 2001).

Agro-ecological factors refer to the farm biophysical characteristics. In particular, land tenure was suggested to be one of the decisive factors in the adoption of SAPs. As the renewal of a farm lease is subject to review every year, failure to obtain it will result in the termination of farm activities on that land. Due to the uncertainty of future farming activities on the leased land, a farmer is less likely to adopt SAPs. This suggestion has been supported by past studies (Neill and Lee, 2001; Tenge et al., 2004). However, some studies have refuted it (Fuglie, 1999; Mad et al., 2010) while others found no significant relationship (Adesina and Chianu, 2002; He et al., 2008). Other agro-ecological factors, such as farm size, land location, and soil quality, might also play an important role in a farmer's decision-making processes (Asrat et al., 2004; D'Emden et al., 2006; Kassie et al., 2009).

Institutional endowments are factors that support or limit social behavior. The unavailability of government subsidies and incentives was highlighted as a major barrier to the adoption of SAPs. Financial assistance enhances a farmer's fiscal capacity to cope with economic uncertainty during the transitional process toward sustainable agriculture. It can also be viewed as a financial inducement. This factor has been found leading to adoption (Napier and Camboni, 1993; Folefack, 2008). However, it has also been revealed as an insignificant factor in the literature (Soule et al., 2000; Napier, 2001). Other influential endowments might include government policies, credit access, and customer requirements (Lambert et al., 2007; Wandel and Smithers, 2000).

Informational factors concern the distribution of relevant messages and knowledge. Usefulness of information was specifically acknowledged to be an important influence in the adoption of SAPs. Thus, the presumption cannot be made that all relevant information on SAPs is useful. Useful information gained by a farmer is more likely to help the farmer develop positive adoptive decisions. In the literature, this factor has largely been overlooked. Past studies (Shiferaw and Holden, 1998; Bekele and Drake, 2003) have demonstrated that access to information, which is assumed to be useful, is the key to adoption. Information might come from one or many sources, such as extension services, social association, and training/workshops (Pannell et al., 2006; Wang et al., 2000). However, access to information alone will not encourage adoption if the disseminated information is inaccurate or inappropriate (Agbamu, 1995).

Characteristics of innovation, as perceived by individuals, can develop their subjective preferences for SAPs. Perceived economic return was stressed as a major impediment, limiting the spread of SAPs, largely because the adoption of one or more SAPs is not rewarded through immediate profit increases. SAPs that are perceived as offering greater relative profitability are more likely to be adopted. This factor has been known as perceived relative advantage in the literature. It has been commonly linked with adoption (Ogunlana, 2004; Napier, 2001). However, two out of three analyses in Rajasekharan and Veeraputhran (2002) have found perceived relative advantage to be an insignificant factor. Other commonly perceived characteristics include compatibility, complexity, trialability, and observability (Adrian et al., 2005; Amsalu and De Graaff, 2007).

Behavioral attributes are psychologically based factors that modify adoptive decision-making. The attitudes of farmers was said to be central to their dispositions and responses toward SAPs. A conservative farmer is less open-minded, is reluctant to break with habits, and is reluctant to try new practices. In contrast, a positive attitude is more likely to result in adoptive decisions on SAPs. Similar findings have been evidenced in past studies (Willock et al., 1999; Cutforth et al., 2001). However, Karami and Mansoorabadi (2008) study has recently found the opposite. Other attributes, such as social norms and behavioral intention, might also shape behavior as a whole (Beedell and Rehman, 2000; Calkins and Thant, 2011; McGinty et al., 2008).

RESEARCH IMPLICATIONS

What we have covered so far is the progress of sustainable agriculture in the Malaysian vegetable sector. Further efforts are still needed to account for other sectors, countries, and regions to build a comprehensive database. While a synthesis of ground level information has been demonstrated as playing a part in contributing to the database, the technique is always challenged by questions related to the completeness and reliability of the collected information made available to the information center. Alternatively, official data collection methods, such as agricultural surveys and censuses, are credited for their wide coverage and standardized reporting formats. Databases such as those published by international agricultural organizations are useful to serve as a basis for future actions.

Like many countries, as in our earlier review, the

Malaysian vegetable sector has experienced a low adoption rate of SAPs, which implies that only a portion of vegetable farmers have adopted SAPs while many have not. Further investigation is needed to explain the phenomenon, especially the variations in farmers' adoptive decisions. Our brief discussion has suggested that adoption can be readily seen as a complex decision-making process and findings in past studies are inconclusive. The complex decision-making can be affected by one or many factors, including (1) socio-economic characteristics, (2) agro-ecological conditions, (3) institutional endowments, (4) informational factors, (5) innovation characteristics, and (6) farmer behavioral attributes. Accordingly, future research on the phenol-menon should attempt to integrate these factors, as adoption is the result of multi-disciplinary consi- derations (Conway, 1985).

However, past studies are largely fragmented (Karami and Keshavarz, 2010), having narrowed the multi-disciplinary consideration within the confines of one or two specific discipline(s). These fragmented approaches have dissected and ignored the interrelations of these factors as a whole. These approaches have neither explained the differences in farmer behavior adequately (Galt, 2008) nor generated useful operational knowledge for policymakers (Dent et al., 1995).

To overcome these limitations, an integrative framework should be developed. Not only should such a framework attempt to integrate multiple aspects, but it should also operate within the concept of sustainable agriculture (Gliessman, 2005). We posit these recommendations because the implementation of sustainable agriculture practices evolves from social learning, which involves interaction and feedback processes between socio-economic subsystems and ecological subsystems within agricultural systems (Pretty and Hine, 2000). Therefore, a system-orientated inte-grative framework, which functions as a whole for agricultural sustainability, must be devised (Park and Seaton, 1996).

Conclusions

Because the realization of sustainable agriculture requires the adoption of SAPs, the development of sustainable agriculture can be deduced from the adoption rate of SAPs. However, little is known about the latter, particularly in Asian countries. To fill part of the knowledge gap in the progress of sustainable agriculture, we have identified, as a starting point, the current adoption rate of SAPs in the Malaysian vegetable sector.

Given that agricultural surveys and the census do not collect this information, we chose to synthesize ground level information through FGD with the DoA. The elicitation of outputs in the FGD has demonstrated varied adoption rates across SAPs in the Malaysian vegetable sector. In general, these statistics have suggested that the adoption of SAPs has been at a low level, as claimed in past studies (Caswell et al., 2001; Horrigan et al., 2002), and they imply different adoptive decision-making rationales among individual farmers.

While we have covered the Malaysian vegetable sector, official efforts, whether in the form of an agricultural survey or a census, should be devoted to the collection of information to provide a knowledge base for policymaking and research initiatives. The latter is, indeed, required to investigate the phenomenon. The investigation should be consistent with its multi-disciplinary nature within its contextual system. Because these requirements are less likely to be met by current fragmented approaches, modeling work should be devoted to develop a system-orientated integrative framework.

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Appendix 4: Refining the definition of sustainable agriculture: an inclusive perspective from the Malaysian vegetable sector

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