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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 integrative 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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