International Food Research Journal 23(5): 2271-2279 (2016)
Journal homepage: *http://www.ifrj.upm.edu.my*

Factors influencing the adoption of bundled sustainable agricultural practices: A systematic literature review

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Article history

Received: 3 August 2015
Received in revised form: 28 December 2015
Accepted: 13 January 2016

Keywords

Bundled sustainable agricultural practices
Adoption
Systematic review

Abstract

Farm sustainability issues are diverse but interconnected and complex. Many organizations have begun to promote packaged sustainable agricultural practices (SAPs). Some of these bundled SAPs (i.e. organic agriculture and integrated pest management) have long been employed by farmers, and studied by scientists seeking to understand their response to these alternative agricultural approaches. This paper reviews and synthesizes recent research in this area. It identifies key explanatory factors, which frequently lead to the adoption of bundled SAPs. Vote count analysis reveals that variables implying economic motivation and facilitation regularly explain farmers' behaviour. In addition, a new finding emerged, in which factors inferring higher learning and superior management capacity provided further indicators to adoption. In particular, the training that provided by non-governmental organizations and rural institutions complements change agents (i.e. public extension services). While this finding is novel, more research is required to generate better understanding of farmer reaction to bundled SAPs, particularly dynamic ones (i.e. private standards) in which farm business sustainability depends upon good agricultural practices being implemented.

Introduction

The concept of sustainable development has been widely promoted in agriculture. It is vital to ensure that contemporary resource use will not so deplete in order to enable future generation to utilize them in continuity. An obvious path to improve agricultural sustainability is through the uptake of either individual or bundled sustainable agricultural practices (SAPs). Individual SAPs are often promoted under a banner, which serves a specific purpose. For example, conservation tillage, composts, cover crops, and mulches are commonly used to control soil erosion. They are complementary and can be used interchangeably and/or conjunctively (i.e. compost can be used as a mulch).

Many attempts have been made to understand the factors motivating the uptake of individual SAPs. For instance, 23 studies of conservation agriculture were reviewed by Knowler and Bradshaw (2007); 55 and 46 contributions to the literature of best management practices were synthesized by (Baumgart-Getz *et al*., 2012) and Prokopy *et al.* (2008) respectively. Similar summation work was carried out by Pannell *et al.* (2006) in respect to conservation practices and Lee (2005) and Tey *et al.* (2015) for SAPs. Review of these studies found that economic considerations play a pivotal role in adoptive decision making in relation to SAPs.

Bundled SAPs take a relatively more holistic approach to improve agricultural sustainability in general. As a package, for example, good agricultural practice (GAP) and organic certification schemes incorporate various SAPs for soil and water conservation, soil fertility management, pest management, and waste management. Such combinations are multi-functional and promote long-term soil fertility, increased farm productivity, resource conservation, environmental maintenance, food safety, and worker health and safety as a whole.

Despite the attractions and, indeed, the monetary incentives often presented to farmers, limited adoption of bundled SAPs in many countries has, thus far, been recorded. One strand of investigation has been devoted to deducing the determinants underlying the adoption of bundled SAPs (Kersting and Wollni,

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2012; Läpple and Kelley, 2013; Lemeilleur, 2013; Chatzimichael *et al.*, 2014; Ganpat *et al.*, 2014). To our best knowledge, the findings offered by the adoptive literature of packages of SAPs have not been synthesized. We are, therefore, motivated to add to the knowledge base in this particular area.

In an attempt to bridge this knowledge gap, this paper aims to review the literature devoted to the adoption of bundled SAPs. In so far as previous review studies have entirely been focused on individual SAPs, this paper provides a fresh direction: bundled SAPs, including organic farming, integrated pest management (IPM), soil conservation, and GAP, are considered in this review exercise. Our findings will be relevant and provide important implications for various change agents, including policymakers, governmental bodies, sponsorship or funding agencies, extension agents and non-governmental agencies.

Through the identification of converged factors that consistently influence adoption, it is hoped that this review study will serve as a significant knowledge base. It is our hope that it will provide information which can be used in either predicting the reactions of potential adopters to bundled SAPs or to modify either the bundles themselves or the way in which they are presented so as to be more congruent with the motivational triggers of potential adaptors.

Bundled sustainable agricultural practices

In the seminal work of Rogers' (1962) "Diffusion of Innovations", a cluster of practices or technologies is conceptualized as innovations that are interrelated and designed to coexist. The option provided to potential adopters is a package comprising multiple recommendations. Applying such notion to agriculture, bundled SAPs are flexibly formed by two or more individual SAPs. Each sustainable practice should complement another sustainable practice, thus addressing multiple pressing local farming issues. Consequently, bundled SAPs function holistically and ameliorate agricultural sustainability.

IPM is one of the earliest large-scale promoted SAPs. According to FAO (2015a), IPM "means the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment." It is an ecosystem approach to crop protection combining biological, mechanical, cultural, physical, and chemical controls without relying solely on pesticides. Through pesticide risk reduction, this bundle is regarded as a pillar of both sustainable crop intensification and production. Consequently, IPM is being mainstreamed in many countries.

Conservation agriculture is "a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment" (FAO, 2015b). In general, it is made up by three key principles: (1) minimum tillage, (2) mulching, and (3) crop rotation. Minimum tillage is essential to maintaining minerals, preventing water loss from occurring within the soil and reducing erosion. Mulching achieves much the same outcomes as minimum tillage in so far as it addresses soil protection by managing the topsoil and reducing soil erosion. However, additionally, it adds an enrichment component to soil nutrition. Crop rotation inhibits insect proliferation or weed development patterns in specific crops and, in turn, guards against yield loss and infestation.

From the two sample bundles above, it is clear that these are problem-specific bundled SAPs. They are limited in so far as they address a particular issue. In fact, however, each farmer is faced with multiple farming dilemmas. Additional examples include production costs, food safety, and worker health and safety. These issues, in general, challenge both the continuity of any farm enterprise and farmers to produce sustainable crops efficiently. To help overcome such complexity, more SAPs are being integrated into holistic packages.

Organic farming "is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity" (FAO, 2015c). Diminishing farm reliance on synthetic inputs, it emphasizes management practices of on-farm resources, which use, where possible and appropriate, agronomic, biological, and mechanical methods, to maintain the health of crops, ecosystems, and consumers. Common SAPs being practiced in organic farming include minimum tillage, intercropping, crop rotation, IPM methods, composts, and organic fertilizers. Such SAPs are incorporated within organic certification programs.

Another bundle of SAPs that is gaining international recognition is GAP certification. This has arisen due to the globalized food economy and consumers' increasing concern in respect to food production, safety and quality. Such programs set standards of production (i.e. minimum tillage, intercropping, crop rotation, IPM methods, composts, mulches, cover crops, chemical storage, recording, and worker safety and health) that optimally utilize farming inputs or resources in a sustainable manner. When GAP principles are rigorously followed, farmers enjoy environmental, monetary, and social benefits (Tilman *et al.*, 2002).

As we have demonstrated, in order to become more sustainable, the adoptive decision-making faced by farmers' pivots on whether to holistically adopt a particular bundled SAPs. This does not necessarily mean that farmers have to implement the recommended SAPs blindly. Rather, a mix and match of SAPs with congruence to local conditions and issues is necessitated. In our minds, bundled SAPs should be considered dynamic and farmers must accept the fact that agricultural sustainability can only be achieved in situe by addressing local issues and improving local deficiencies.

Methodology

Vote counting offers a structured method to systematically review a pool of literature. It involves quantitative procedures for research synthesis. In its simplest form, the findings of empirical studies are sorted into three categories: (1) those that report significant results in the positive direction, (2) those that yield significant results in the negative direction, and (3) those that generate non-significant results. Their frequency is counted and compared: the number of positive studies with the number of negative studies and the number of non-significant studies.

The vote counting method has advantages over other synthesis methods (i.e. meta-analysis and narrative review). As discussed, it is a relatively straightforward method focusing on qualified past studies. In contrast, narrative reviews "lump together" too many studies. Such a process is messy and hazes the relevance of the selected past studies to the objective (synthesis) (Cwikel *et al*., 2000). Another advantage of the vote counting method is its flexibility in accounting for unlimited sample sizes (published studies). This is especially so when compared to meta-analysis (Prokopy *et al*., 2008). This enables researchers to analyse a larger pool of published studies.

Empirically, the vote counting method has been applied in recent review studies. For example, this method has been used to synthesize factors leading to the adoption of conservation practices, best management practices, and SAPs in Knowler and Bradshaw (2007), Baumart-Getz *et al.* (2012), and Tey *et al*. (2015) respectively. As demonstrated by these studies, the method works well in similar subject areas. Therefore, the vote counting method was used in this review exercise.

Data collection

Inputs in this study include past studies investigating a binary choice: whether bundled SAPs have or have not been adopted. These past studies were pooled through a comprehensive search of three main platforms, namely Scopus, Google Scholar, and references listed in selected journals.

Key words used in the search were (1) adoption/uptake/affectation/application and (2) sustainable agricultural practices (integrated pest management/organic farming/soil conservation measures/good agricultural practices). The search resulted in more than 100 published papers, including those categorized as original research articles, review articles, proceedings, conference papers, and non-peer reviewed articles. Since our target was peer reviewed publications, it was necessary to filter irrelevant results. A total of 24 papers qualified through the subsequent review processes; the others were retained in another library for reading and reference.

Review procedures

The initial step was to generate a general background understanding of the 24 qualifying publications. Their information were classified by (1) authors, (2) country of study, (3) type of bundled SAPs (4) sample size, (5) theory (6) analytical method and (7) significance or goodness-of-fit.

The descriptive information gleaned from the 24 studies is depicted in Table 1. There is a fair distribution of studies across bundled SAPs, but the balance of the papers dealing with developed, as compared to developing countries is skewed.

Most studies employed utility maximization theory to explain farm decision-making. Although there are many branches to this economic theory, the unified assumption is that the choice of farming practices relies upon the expected utility (i.e. profit) of the subject under examination exceeds the next best option. Such considerations were commonly expressed as a binary response and analysed through Logit and Probit models. Different attempts have also been made through psychosocial theories. Studies in this stream argued that behaviour is developed through a complex process involving normative and cognitive concerns. Using such a premise, analyses were necessarily incremental. Unanimously, all of the reviewed papers concurred that the adoption of a bundled SAPs is regarded as a rational course of action.

Having understood the background of these

Table 1. Summary of 24 studies on the adoption of bundled sustainable agricultural practices

Author(s)	Country	SAP bundle	Sample size	Theory/Assumption	Statistical model	Significance/goodness of fit
Timprasert *et al.* (2014)	Thailand	IPM	220	Utility maximization	Logit	R^2=0.554
McNamara *et al.* (1991)	United States	IPM	376	Diffusion of innovation	Logit	Correct prediction= 0.764
Blake *et al.* (2007)	United States	IPM	217	Profit maximization	Stepwise regression	R^2=0.655
Moser *et al.* (2008)	Israel, Italy & Germany	IPM	106	Utility maximization	Logit	R^2=0.230
Hashemi and Damalas (2010)	Iran	IPM	90	Utility maximization	Logit	R^2=0.337
Kassie *et al.* (2013)	Tanzania	Soil conservation	681	Rational choice theory / utility maximization	Multivariate probit	$\chi2$= 249.51
D'Souza *et al.* (1993)	United States	Soil conservation	600	Utility maximization	Logit	R^2 = 0.10
Teklewold *et al.* (2013)	Ethiopia	Soil conservation	898	Utility maximization	Multivariate & ordered probit	$\chi2$ =119.553
Mbaga-Semgalawe and Folmer (2000)	Tanzania	Soil conservation	300	Profit maximization & Sociological decision	Logit	R^2= 0.40
Bekele and Drake (2003)	Ethiopia	Soil conservation	145	Utility maximizing	Multinomial logit	$\chi2$ = 277.2
Wauters *et al.* (2010)	Belgium	Soil conservation	160	Theory of planned behavior	Logit	R^2=0.538
Marenya and Barrett (2007)	Kenya	Soil conservation	123	Random utility	Multivariate probit	R^2=0.25
Voh (1982)	Nigeria	Soil conservation	541	Behavioral theory	Stepwise regression	R^2= 36.61
Wollni and Andersson (2014)	Honduras	Organic farming	241	Spatial dependence	Probit	$\chi2$= 229.17
Mzoughi (2011)	France	Organic farming	243	Moral-social theory	Multinomial logit	R^2= 0.17
Thapa and Rattanasuteerakul (2011)	Thailand	Organic farming	172	Diffusion of innovation	Linear & logistic regression	Correct prediction = 83%
Läpple and Kelley (2013)	Ireland	Organic farming	546	Utility maximization & behavioral theory	Multinomial logit	Correct prediction= 65%
Parra-Lopez *et al.* (2007)	Spain	Organic farming	322	Diffusion of innovation	Logit	R^2= 0.89
Best (2009)	Germany	Organic farming	657	Theory of rational choice	Logit	$\chi2$ = 129.3
Chatzimichael *et al.* (2014)	Greece & Germany	Organic farming	282	Utility maximization	Probit	R^2= 0.5144
Ganpat *et al.* (2014)	Trinidad	GAP	196	Farming systems model	Categorical regression	R^2= 76.1 %
Mankeb *et al.* (2014)	Thailand	GAP	189	Theory of planned behavior	Stepwise multiple regression	R^2=0.557
Kersting and Wollni (2012)	Thailand	GAP	231	Utility maximization	Bivariate probit	Correct prediction= 71%
Lemeilleur (2013)	Peru	GAP	228	Utility maximization	Probit	R^2=0.450

selected studies, the next task was to review the findings on factors influencing adoption of bundled SAPs. To do this we focused on their table of findings and description of variables. This exercise saved us from mistaking purported reverse variables. The variables investigated in individual studies were then progressively examined and discussed to ensure precision. Each variable was assigned a vote according to its significance and sign of association with the dependent variable: positively significant, negatively significant or insignificant. In the end, the variables were conjoined to form a summarized inventory.

Since there were many diverse variables, it was pivotal to group affine variables into specific categories. Using the template of Knowler and Bradshaw (2007), the variables were grouped into four main categories that explain adoption. As consistency is a critical part of generalizing a category, categorization was conducted on the basis of careful reading of all the selected publications and a well thought rationale was applied. Finally, the four most investigated variables were tabulated in reference to analytical methods, the region or country in which the study was carried out, and the bundled SAPs in question.

Findings

Factors influencing the adoption of bundled sustainable agricultural practices

Outputs in respect to the frequency of analysis are presented in Table 2. From the 24 studies, as many as 50 factors were inventoried. Based on the definition of these factors, they were categorized into (1) farmer and household factors, (2) biophysical factors, (3) behavioural factors, and (4) exogenous factors.

Farmer and household factors

The ability to understand the intricacies of bundled SAPs is crucial in planning for change in farm operation. Farmers' learning and management capacities are often correlated with age, formal education, and farming experience. The frequency of these three (3) factors indicates that they were commonly investigated.

Farmer age is skewed towards having negative significance. Older farmers have shorter career horizons. Their incentive to invest in future sustainability thus declines (D'Souza *et al.*, 1993; Marenya and Barrett, 2007). Therefore, they are less willing to modify existing farming practices, which is a result of long experience. They have come to regard it as routine. There was one exception to this

Table 2. Factors influencing the adoption of bundled sustainable agricultural practices

Category	Variables	Sig (+)	Sig (-)	NS	Total	Status
Farmer and household factors	Education level (formal)	16	2	4	22	
	Age	4	12	5	21	
	Farming experience	4	5	2	11	
	Education (religious)	1	0	2	3	*
	Off-farm job	4	2	3	9	
	Assets	4	1	0	5	
	Crop type	1	0	3	4	*
	Income diversification &insurance	2	1	1	4	
	Livestock ownership	2	0	1	3	*
	Income increment	1	0	1	2	*
	Mode of transportation to market	1	0	1	2	*
	Lack of farm inputs	1	1	0	2	
	Household size	5	3	2	10	
	Gender	9	1	0	10	
	Household labour	4	0	1	5	*
	Family dependence	2	1	1	4	
	Cost of labour	0	3	1	4	*
	Race	1	0	1	2	*
	Marital status	1	1	0	2	
	Kin transfer	1	1	0	2	*
Biophysical factors	Farm size	7	4	1	12	
	Total cultivated land	6	0	2	8	*
	Distance to market	0	5	1	6	*
	Farm structure	3	0	1	4	*
	Improvement of soil fertility	1	1	1	3	
	Slope of plot	2	0	1	3	*
	Land ownership rights	3	2	2	7	
Behavioural factors	Effect to environment	9	0	1	10	*
	Yield	6	0	1	7	*
	Technical attributes	5	0	2	7	*
	Profitability of technology	2	1	0	3	
	Effect to health	1	1	1	3	
	Competitive advantage	2	0	1	3	*
	Pest and disease occurrence	2	1	0	3	
	Reduced impact of chemical pesticide	2	0	1	3	*
	Risk management	3	1	1	5	
	Leadership role	1	0	2	3	*
	Attitude of farmer	1	1	0	2	
	Progressiveness	1	0	1	2	*
	Social conformity	2	0	1	3	*
	Social capital	2	1	0	3	
Exogenous factors	Extension services	13	0	1	13	*
	Training (NGO/Rural institutions)	14	0	0	14	**
	Opportunity for group discussions	3	0	1	4	*
	Source of information	4	0	1	5	*
	Participation of women	1	0	2	3	*
	Training institution	1	2	0	3	*
	Sponsorship/Funding	1	0	1	2	*
	Public /private sector involvement	1	0	1	2	*
	Access to credit	2	1	1	4	

Notes: Sig represents significant; NS denotes non-significant; * indicates that the variable has a mixed significance but always depicts the same sign when it is significant; ** indicates that the variable is always significant and depicts same sign.

principle: older farmers who still practice or value indigenous farming methods are more receptive to the idea of using SAPs as a package when compared to others in their cohort.

The provision of education is an important adjunct towards comprehending the intricacies and functionality of many SAPs. Supporting this conviction, this factor was found to be of positive significance. Education enables farmers to be more open to new ideas. Farmers who obtained higher educational levels often display greater learning ability and capacity. They are able to understand complex information and handle management-intensive SAPs.

Experienced farmers are generally skilled in judging the associated risks and managing farming practices (Thapa and Rattanasuteerakul, 2011). They are often acquainted with farm sustainability since SAPs like soil conservation and composts were practiced prior to the dominance of chemical inputs. It must be relatively easy for them to revert, or otherwise they would have lost their indigenous farming knowledge to modern agricultural practice adoption. Such considerations help explain the mixed association between experience in farming and the adoption of bundled SAPs in empirical studies.

Sustainability outcomes resultant from the adoption of bundled SAPs are spatially separated from cost inputs (which are current investments). Key indicators which point to farmers' financial capacity are off-farm employment and assets. Farmers who possess assets have a buffer against the potential risk inherent in new investment. Those lacking the necessary asset buffer may rely on supplementary income from off-farm employment to finance the investment. This source of income, however, is a double-edged sword since that additional economic activity distracts farmers from farming activities. Therefore, a clear empirical relationship between off-farm employment and the uptake of bundled SAPs was not discerned.

Labour is an essential input in the implementation of bundled SAPs. SAPs have not, generally, been mechanized. General indicators of labour availability include gender, household size, family labour, and labour cost. In some cases, the negative association between labour availability and the adoption of SAPs suggests that the opportunity costs of labour sometimes favour lucrative non-agricultural activities. Otherwise, the adoption of bundled SAPs was more likely to materialize in circumstances where greater labour forces were available and especially if they came at a lower cost.

Biophysical factors

Farm biophysical conditions are heterogeneous. While they represent varied input needs, SAPs are often location-specific. Consequently, biophysical factors play a role in influencing the patterns of their adoption. Distance between the farm and the market, farm structure, and soil fertility are among key determinants towards the adoption of bundled SAPs. Their adoption often has its genesis in addressing location-specific constraints or resource scarcity faced by farmers. For example, isolated farms are more likely to use locally available resources compared to farmers who enjoy better access to external inputs because of their proximity to markets. The need to address soil erosion on sloping topography has stimulated the adoption of soil conservation.

In most cases, farm size and area under cultivation converged to display a positive relationship towards the adoption of SAPs. Farmers who possessed larger sized farms and/or cultivated area enjoy greater flexibility in decision-making and thus have more capacity for resource allocation. They are able to allocate a small proportion of their farmlands for trials and experiments. When implementing any scheme at full scale, the risk is spread across larger areas. The potential for loss would be more manageable than small farms, which often are the sole source for subsistence farmers. Regardless of the scale of operation, the tendency to adopt SAPs is diminished if the land right lacks security. Short-term lease holders must focus on immediate returns rather than accruing the longer-run benefits of sustainability.

Psychosocial factors

Farm decision-making also involves mental processes. In particular, cognitive evaluation is the process by which all farmers weigh the perceived relative advantages of bundled SAPs against their prevailing farm practices. Farmers' inclination towards adoption increased when SAPs were seen as superior in terms of environmental impact; yield response, ease of operation, and economic return. The positive environmental impacts that are associated with SAPs are valued. This is largely because a healthy environment should lead to yield improvement and, in turn, higher income. Another perspective of cognitive thinking concerns managing the risks inherent in the application of SAPs. Farmers were shown to favour adoption when a particular bundled SAPs was perceived to help prevent or minimize risks associated with their conventional farming practices.

Individual farmers both play and have a role in society. Their behaviours are shaped by their role and the social environment. Farmers who hold formal leadership positions or are regarded as the community leaders are thought to demonstrate a strong desire to acquire knowledge and experiment with bundled SAPs. However, in this case, the evidence is weak since only one instance was noted in our work. Thapa and Rattanasuteerakul (2011) observed that the leadership role gains prominence especially in places where extension services are inefficient. Under such circumstance, they do not just serve as the opinion leader, but also as a key reference point. When sustainability is highly valued in the social environment, fellow farmers were proved likely to conform to the general movement and fit in with the society norm. The paucity of writings in this area, leads us to suggest that this area merits further and more detailed work since confirmation of the correlation would have particular relevance for policy makers

Exogenous factors

Bundled SAPs display complexity. The methods by which information is designed and disseminated are especially critical to the success of changing famers' behaviour. In such synthesis, effective pathways for diffusion included extension services, group discussion in farmer associations, multiple unofficial information sources, and training workshops.

There was a clear positive association between access to and/or visits of extension agents and the adoption of bundled SAPs. Extension services play a special role in developing rural agriculture particularly in less developed economies. Due to the high poverty and illiteracy rates, the various complementary services that are provided by extension agents are both critical to motivating farmers towards innovation and in guiding them in their implementation. The delivery of quality services motivates farmers to adopt bundled SAPs. Unfortunately, however, the foci of public extension services are generally pre-occupied with productivity rather than sustainability.

Sustainability issues are pursued with greater zeal by non-governmental organizations (NGOs) in the African and Asian regions. Often, their mantra is to ensure sustainable agricultural development. They are resourceful and complement the limited nature of the public extension services with regard to sustainable agriculture. For example, NGOs are often able to reach remote areas in where local settings obstruct the delivery of public extension services. Having putting in such an extraordinary effort, NGOs are well respected and trusted by farmers. As noted by our review, when training has been given by their professional representatives who know how to farm more sustainably, farmers consistently modified their routines and farmed more sustainably. We believe that this finding is new and has not been documented in previous review articles.

Although both general and technical information are delivered through training workshops, a common weakness of such institutional support is said to be its inability to factor into the workshops specific locality specific advice. This issue can be compensated for through subsequent group discussion in local farmer association. Neighbouring farmers are well versed with local peculiarities. Interaction with such local change agents enables one to share with and learn from other members.

Through our review exercise, sponsorship and public-private partnerships have emerged as new factors leading specifically to GAP adoption (Kersting and Wollni, 2012). These external supports are invaluable in helping resource deficient and financially constrained farmers. Easily available funding or sponsorship provides a critical facility for financing the preliminary investments, dealing with deferred benefits. Such buffers are crucial especially in the event of failures. Public-private partnerships serve as a bridge linking local farmers to broader market opportunities and so to meet the global demand for sustainable produce.

Discussion and Conclusions

Adoptive decision-making with regard to bundled SAPs was significantly tied to economic capacity of individual farmers. This trend became evident, not because it was examined as a set of category but rather by the convergence of numerous variables. Measures like assets, farm size, and size of cultivated land are indicative of a farmers' ability to raise capital for farm investments and hedge against risks and losses. Any investment decision depends on how profitable (through cost saving and/or improved productivity) bundled SAPs are perceived to be. Household labour gives a cost advantage and eases the burden of labour intensive SAPs. The allocation of these human resources is rationally driven and they are only applied when SAPs are seen to improve yield or profitability of crops.

It is clear that economic sustainability is fundamental to farm decision-making. Support for this conclusion is offered by various review studies on individual SAPs (Pannell *et al*., 2006; Knowler and Bradshaw, 2007; Prokopy *et al*., 2008; Baumgart-Getz *et al*., 2012; Tey & Brindal, 2012; Tey *et al*., 2014). These works posit that profitability is the most deterministic factor. Typical policy prescription in this regard centres on incentivizing farmers. Popular measures like subsidies and incentives are provided in the short-term to give farmers a kick-start. When they expire, there is a danger that farmers are likely to withdraw and revert to previous practices unless increased profitability has already been established. Both the quantum and the duration of subsidies are critical to the successful adoption of SAPs.

Therefore there needs to be a better economic paradigm to motivate farmers and sustain them in using packages of SAPs. Policymakers and researchers should make greater efforts to link their sustainable production to higher levels in the value chain. Not only does that promise greater returns, farmers would subsequently play a more prominent role in recruiting both peers and consumers into the philosophy of sustainability. This value chain approach is just one option among the many that need to be explored. Only when a successful methodology is developed will it be possible for sustainable agriculture to be mainstreamed.

As a difference between our work and many of the papers mentioned previously, we have synthesized the empirical findings of determinants underlying the adoption of multiple SAPs grouped as a bundle. Because of our unique perspective, learning and management capacities (farmers' education, age, farming experience, extension services, training, and information variables being indicators) were unmasked as reliable signals of the predisposition to adopt SAPs.

Learning and management capacity are

interconnected to how well farmers can comprehend the functions and operation of either single or multiple SAPs. Education was found to play a critical role in their learning journey which generally involved mix and match and trial and error processes. To undertake such challenging processes, rapid and continuing learning, management and flexibility are essential. For example, ageing farmers who have short career horizons were shown to be resistant to new ideas. For some other farmers, however, their learning capacity is insufficiently developed due to a deficiency in their formal education.

The sustainability imperative has pressed researchers and policymakers to actively seek effective learning experiences that will develop the capability of individual farmers to devise and refine farm specific sustainable practices. The options that were proved most efficacious in our review were extension services, training, and engagement with farmer associations. Among these, out-reach programs organized by NGOs and rural institutions (i.e. farmer field schools) were as influential, in resource poor areas, as public extension services. We believe this finding to be significant since it adds a new option to the existing range of diffusion channels, which previously relied heavily on public effort. Volunteers from social organizations can complement the various shortcomings of public extension agents.

Our findings are encouraging and call for emphasis to develop active and collaborative learning approaches as opposed to passive and individualistic learning. Education programs using these proven approaches are necessarily multipronged, involving farmer organizations, scientists, extension educators, and other change agents. The success of such initiatives relies on their quality and especially on their success in building relationships, communicating across lines of difference, tolerance with ambiguous situations, analysing farmers' perspectives, organizing fieldwork, problem solving, and follow up. Such success is, however, essential to convince farmers and influence their behaviour. Additional aspects such as language barriers, locality and specific conditions should also be considered.

Hopefully this review has added value to the existing body of knowledge. In addition to economic motivation, learning and management capacities have been unmasked and provide additional understanding of farmer behaviour. Specifically, training that is provided by NGOs and rural institutions are posited to add power to existing effective change agents (i.e. public extension services). Nevertheless, most explanations of farm decision-making remain inconclusive. It seems likely that a pattern of knowledge will emerge in tandem with increasing empirical research. Such research is particularly critical for a new innovation: private standards (i.e. GAP). Our analysis showed that this new area is understudied although more and more nations, NGOs, trade regulators, and private companies are joining the forces to set SAPs as a main component of private standards. They give rise to an obvious need for more empirical knowledge to understand farmers' reaction to this kind of new setting, which impinges both on farming practice and farm business.

Acknowledgement

This study was funded by Universiti Putra Malaysia Grant (Putra Grant) under Vote 420000.

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