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Adoption of Sustainable Agricultural Practices Among Smallholder Dairy Farmers in Malaysia: Contributing Factors and Smart Farming Prospects

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Abstract

Adoption of Sustainable Agricultural Practices (SAP) among smallholder dairy farmers in developing countries, especially within the Asia Pacific region remains low. This is probably attributable to the fact that psycho-social factors are not considered during the adoption process. The current study was carried out in order to increase the adoption of SAP in Malaysia, by investigating psycho-social factors among dairy farmers. It adopted the enhanced Theory of Planned Behaviour to investigate smallholder dairy farmers' intention to uptake SAP in Malaysia. This study applied the Partial Least Squares Structural Equation Modelling (PLS-SEM) to model how psycho-social factors influence farmers' SAP adoption decisions. A key finding of this study was that farmers who are equipped with the right attitude and belief have the ability to adopt SAP and are inclined to adopt SAP in their farms. Hence, it was proposed that a holistic approach is recommended towards formulating policies and drawing intervention strategies that focus on the farmers' needs and abilities. This would motivate farmers to make choices that would lead to a change of behaviour towards adopting SAP. Additionally, the producer-led approach adopted in this study provided insights into smallholder dairy farmers' beliefs and behaviour.

Keywords

Sustainable agriculture practices; Theory of Planned Behaviour; Smallholder; Partial Least Squares-Structural Equation Model; Smart dairy farming; Malaysia

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1 Introduction

Predominantly, livestock is strongly associated with agriculture as most farmers are involved in mixed farming practices (crops and livestock)[1]. Apart from food and nutritional sources, livestock generates income, employment opportunities and economic stability to farms and households[2]. In developing countries, this industry contributes to increasing income and population growth as well as changing diets[3]. A similar observation was reported by Ahuja and Mehta[4] within the Asia Pacific region, depicting that population growth, rising disposable income and urbanization have spurred the rapid growth of animal-based food. With the shift of diet, livestock production becomes even more challenging as a large portion of the population in this region depend on this industry for their livelihoods and survival[5]. In Malaysia, the livestock industry is an integral component of the agricultural sector in which it contributes significantly to the nation's economic growth. In 2019, the livestock industry contributed 14.9 per cent to the Malaysian agricultural sector's gross domestic product[6].

Dairy is a good source of income especially to small and marginal farmers since consumers purchase fresh milk on a daily basis[7]. This can be seen in the increase of milk consumption growth among Malaysians between the year 2011 from 18.90 million litres to 62.80 million litres of milk consumption in 2017[8,9]. The rising awareness on the nutritional benefits of dairy-derived products has to offer increases consumer preferences toward dairy products and such demand has grown over the years[10,11]. According to Ahuja et al.[12], milk production growth in Asia has intensified compared to other countries globally. In Malaysia, while the scenario is similar, consumption growth is much more rapid than production growth. Milk consumption has increased by 51.70 million litres between 2011 and 2019[13]. In 2011, milk consumption was at 18.90 million litres, and it experienced a sharp increase to 68.80 million litres in 2019, registering an annual growth rate of 29% between the 9-year period[13]. While the demand for milk is increasing, Malaysia is facing issues with milk supply[14,15]. Local milk production registered at 25.4 million litres in 2011 and in 2019 increased to 40.6 million litres, depicting an increment of 15 million litres between the 9-year period. With an annual growth rate of 7% over the 9-year period, it is evident that supply is inadequate to satisfy the growing demand of consumers (Figure 1).

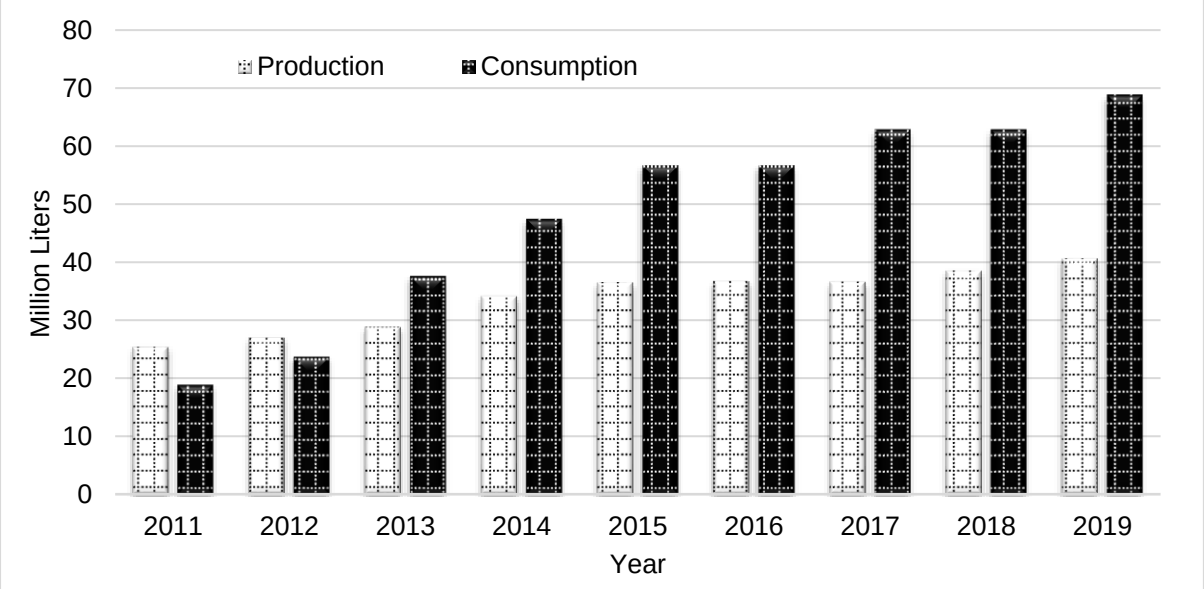

Figure 1. Production and consumption of milk in Malaysia. (Source: Department of Veterinary Services[16,17])

Studies suggest that productivity improvement could assist in narrowing the gap between milk production and consumption. Efficient dairy practices and,

farm and herd management practices such as nutrition, milking procedure, sanitation and housing are often cited as crucial factors towards improving dairy farm productivity[14,18-20]. These practices also add value to the management of natural resources and food systems, supporting the principles of sustainability.

1.1 Sustainable Agriculture and Good Agricultural Practices

Food supply is not increasing in tandem with population growth, and as a result, agricultural practices are compromised to increase the production of food. Dissatisfied with the misbalance between food demand and supply, stakeholders from diverse socio-economic backgrounds pressured policy makers for transformation and behaviour change towards the environment in the Earth Summit, held in Rio de Janeiro in 1992. The outcome of the Earth Summit led to the adoption of Agenda 21, an action blueprint on promoting sustainable agricultural practices.

Sustainable agriculture is defined as an approach to promote economic, social, and ecological sustainability[21]. It refers to practices that are harmless to the environment, concerns towards the wellbeing of workers and animal welfare, and at the same time offering better earnings for farmers and rural communities[22]. Sustainability practices do not only focus on farm animals' welfare but the outcome of such practices produce better product that improves income stability and security of the farm and those who depend on it[5].

The Food and Agriculture Organization (FAO) took the lead upon the call for Agenda 21 drawn during the Earth Summit in initiating FAO Good Agricultural Practices (GAP) in 2001[23]. The guiding principles of GAP are applying available knowledge on sustainable utilization of natural resources to produce safe and healthy food, and non-food agricultural products in a humane manner towards attaining social stability and economic viability.

The move taken by FAO spurred countries worldwide, including Malaysia to formulate and implement national GAP programs as a move towards supporting sustainable agricultural practices. The national GAP guidelines and programs cover production safety standards for horticultural field crops and livestock. With the changing roles from regulatory authorities to consumers on advocating for food safety and quality production initiatives, GAP assists farmers to implement and adopt food and agricultural practices so as to comply to the demand and needs of consumers concerning food and non-food products.

1.1.1 Good Dairy Farming and Hygiene Practices (GDFHP)

In Malaysia, dairy farms are classified based on the number of adult female cows on a farm. A smallholder farm consists of 30 or less adult female cows while semi-commercial farms have between 31 and 49 adult female cows. Large-scale farmers, commonly known as commercial farmers, manage 50 and more adult female cows[8]. Majority (85%) of dairy farms in Malaysia are smallholders[24]. The farm management practices among these various scales of operations differ based on the skill-set, experiences and knowledge of the farm owner. Smallholder farmers gained dairy management skill-set and knowledge from their grandparents and parents, which were passed on to them.

The dairy farming system in Malaysia comprises both intensive and semi-intensive, which differs in farm management, animal handling, productivity, yield and etc. Semi-intensive system offers animals the opportunity to graze and move freely on land that is also used for crop production whereas in an intensive system, animals are confined to an area where they are fed on stored feed following a schedule[25]. Based on previous literature and observation on the ground, it is found that studies on sustainable agricultural practices (SAP), specifically concerning GAP in livestock, i.e., GDFHP are lacking in Malaysia, an indication that there is a need to address the lack of SAP adoption among dairy farmers. Although the Malaysian GAP (MyGAP) was launched in 2013, the adoption rate has been rather low (if any)[26]. Compromised GDFHP affects the

food systems, public health as well as the welfare of farmers and livestock. With the recent COVID-19 pandemic that has affected billions of people worldwide, it becomes even more crucial for livestock farmers to understand and adopt SAP in their farms so as to minimize the risk of infection, contamination and the spread of diseases[27]. Balancing social and economic goals without jeopardizing the environment or natural ecosystems remains a challenge to livestock farmers. As such, striking a balance among these GAP goals is crucial and deemed even more necessary now as the world move towards adapting to a new normal life as a result of the COVID-19 pandemic.

The low adoption rate of SAP among dairy farmers in Malaysia requires more understanding on the situation on the ground as studies concerning the acceptance of SAP among Malaysian farmers are lacking[28]. Till date, studies on relevant SAP pertaining to dairy cattle in Malaysia focused mainly on cattle breeding, resulting in a gap on issues concerning dairy farm management and hygiene practices[10]. Thus, the current study was carried out among smallholder dairy farmers – the primary stakeholder concerning livestock management. The aim of the study was to understand the farmers' intention towards the adoption of SAP in the dairy sector. Obtaining a clear picture on the determinants influencing the willingness of dairy farmers to adopt SAP would offer insights to policy makers on formulating dairy policies and developing effective intervention strategies to increase the adoption rate of MyGAP.

2 Literature Review and Hypotheses Development

2.1 Theory of Planned Behaviour

A clear understanding of psychosocial variables that influence dairy farmers' intention of adopting sustainable dairy farming practices is required to develop effective interventions. Therefore, it is important to discuss the theoretical framework that provides structure to the identification of factors influencing dairy farming practices.

The Theory of Planned Behaviour (TPB) model is founded by Ajzen[29]. It was designed to explain and predict human social behaviour. The theory argues that human behaves according to rational choices. Intentions and behaviour are based on a cognitive and affective foundation that consists of three sets of beliefs (i.e., attitude, subjective norms, and Perceived Behavioral Control (PBC)) that are readily accessible in memory at the time of the behaviour. Attitude is based on the perceived consequences of performing the behaviour. According to Ajzen and Fishbein[30], a person performs a favourable behaviour if he believes that behaviour will lead to positive outcome and vice versa. Subjective norms are based on normative beliefs – "beliefs about the behavioural expectations of important individuals and groups in the person's life multiplied by motivation to comply with these social referents"[31(p.4)]. Perceived behavioural control is a function of control beliefs such as a person's belief to how easy or difficult the behaviour performance is likely to be. According to Chen and Hung[32], adding predictors to TPB assist in increasing its explanatory ability. Thus, this study included knowledge and awareness as an additional factor in the proposed model to examine farmers' intention to adopt SAP. The overall essence towards the adoption of sustainable farming practices lies on the knowledge, attitude, and perception of farm workers[33-35].

2.2 Knowledge and Awareness

The ability to feel, perceive and be conscious of events and objects is related to awareness[36]. For a positive change to take place effectively, farmers need to have sufficient knowledge about management strategies, diseases, and hygiene practices to reduce transmission. As stated by Bruijnis et al.[37], knowledge of dairy foot-health management increases the intention for farmers to take action. Low knowledge level and skills of dairy farmers concerning dairy farm management, hygiene practices and milking techniques have been cited as among the contributing factors that affect milk quality[10], which ultimately affects the sustainability of a dairy farm.

The study by Lindahl et al.[38] found that majority of farmers have not heard of some zoonotic diseases such as brucellosis and thus they are unaware of its symptoms and how it spreads. In the same vein, the study by Kothalawala et al.[39] reported that the Sri Lankan farmers' awareness towards the spread of brucellosis through buying and selling infected animals were relatively low. Although these farmers were reported to adopt satisfactory hygienic practices, the awareness of zoonotic diseases, i.e., brucellosis transmission-related practices were not satisfactory. As a result of poor knowledge, specifically among smallholder farmers, the need to acquire skills pertaining to efficient milk production becomes more challenging[40]. A recent study by Suit-B. et al.[41] mentioned that knowledge and experience of zoonotic disease influence dairy farmers' practice decisions.

In Malaysia, majority of dairy cattle are managed by smallholder dairy farmers[8] and the concept of sustainability practices among these farmers is relatively new[42]. Farmers play a vital role in sustainability practices; however, farmers are seldom compliant with best animal husbandry practices[41,43]. This could be attributable to the fact that farmers in Malaysia lack the understanding of sustainable agriculture practices and the benefits it has to offer in assisting farmers to sustain their farms[28]. The lack of adoption of dairy farming sustainable practices lies primarily on farm workers. They lack skills and experiences, vary in socio-economic background and seek information concerning GAP from varied informal sources. The study by Fuentes et al.[44] found that due to the lack of training and awareness, smallholder farmers often neglect the adoption of recommended milking practices. Additionally, the low awareness among farmers concerning the possible source of entry of pathogens might lead to milk contamination[45]. Based on the above, it is predicted that:

H1: Knowledge and awareness is positively related to the intention of adopting SAP

2.3 Attitude

Attitude is the extent to which a person has a favourable or an unfavourable evaluation of a behaviour[30]. Apart from knowledge and awareness, having a positive attitude among livestock farmers could have a crucial impact on the reduction of many zoonotic infections as well as increased sustainability practices[38,46]. It is reported that farmers who possess favourable attitude toward sustainable practices tend to adopt practices that would translate into profits[28]. Botaro et al.[47] suggested that the decision to adopt an appropriate milking practice is dependent on the farmers' attitude towards their expectations and outcomes, e.g., producing premium quality milk. Based on the above, it is proposed that:

H2: Attitude is positively related to the intention of adopting SAP

2.4 Subjective Norm

Pressure from the society and subjective norms may have positive impacts on the sustainability practices among dairy farmers, how farmers are influenced and about the role of other actors within their direct social circle. The importance in analysing social influence is to understand and explain how thoughts, feelings, and behaviour of these farmers in dairy sustainability practices are influenced by the actual, imagined, or implied presence of others[48]. Through their daily interaction and relationships, such social norms express social values on their perception and thoughts as well as normative judgments – psychological commitments to 'what should have been' by looking at the consequences of not complying with the societal norms. Social norms are defined as social conformity and neighbour's acceptance, adoption by neighbour(s), encouragement of family, friends and neighbours, as well as support from active conservation districts, sales people, and local agency offices[49]. Sa'ari et al.[42] found factors such as performance expectancy and social influence increase the adoption of sustainable practices. This suggests that the farmers are willing to accept sustainable practices when the gain is higher, and risks associated with these

practices are low. Additionally, the influence of other farmers (social norm) would inspire them to follow suit. This could also be due to societal pressure for farmers to be involved in sustainable practices especially when farmers are not prepared to conform to new ways of farming[50]. The study of Múnera-Bedoya et al.[51] indicated that farm workers are influenced by the availability of tools and relationships between farm workers and manager. The setback of the current situation is that lack of successful role models limits farmers to be inspired in adopting such good practices[52]. Based on the above, it is proposed that:

H3: Subjective Norm is positively related to the intention of adopting SAP

2.5 Perceived Behavioural Control (PBC)

Perceived behavioural control is the belief in self-efficacy or confidence to complete a behaviour to which Bandura[53(p.18)] defined as 'the belief in one's capabilities to organize and execute the courses of action required to produce given levels of attainments'. The belief in one's ability to succeed is known as PBC in TPB[29]. As a general rule, the intention to act is stronger when attitude and subjective norm are more favourable, and when PBC is greater[54]. Perceived behavioural control and self-efficacy are influenced by a person's belief that they have sufficient knowledge to accomplish the task, that they can overcome habitual behaviour, and the perceived feasibility of the recommendation. In accordance with Liu et al.[48], employees with better attitudes and knowledge generally demonstrate greater perceived behaviour control. Translating this into farming scenario indicates that farmers who believe in their capability to succeed in implementing a recommendation is a necessary step towards the adoption of sustainability practices. Besides having the knowledge and skills, farmers can only control their behaviour if the context allows for change. For instance, support from their organization would facilitate changes (organic farming; sustainability farming practices)[43]. In addition, the availability of resources (i.e., money, time) as well as one's confidence in performing desired behaviour would enhance PBC[32]. The study by Bruijnis et al.[37] postulated that the positive PBC does promote farmers' adoption of management strategies. Having knowledge and awareness of cow's lameness would also increase employees' PBC[55,56]. The same was reported by Jansen and Lam[57] in which employees' PCB increase concerning mastitis prevention on Dutch dairy farms when they were equipped with the knowledge and awareness of mastitis control strategies. In another study, calf managers experienced a reduction in calf mortality rates due to the awareness concerning the adoption of good calf management practices and the willingness to adopt such practices[58]. Based on the above, it is proposed that:

H4: PBC is positively related to the intention of adopting SAP

2.6 Intention

The TPB assumes the intention of a person to perform a certain behaviour is influenced by their attitude, subjective norm and PBC. In accordance with the theory, individuals' intention to behave in a certain way is believed to be a precondition to adopt a desired behaviour. In return, the intention is determined by the attitude towards the behaviour (whether favourable or unfavourable), belief that the behaviour can be realized (PBC), and the feedback of others (subjective norm). However, Hansson and Ferguson[59] expressed that having too many 'voices' or opinions would result in uncertainties, thereby disrupting the farmers' intentions to change management practices. The study of Bruijnis et al.[37] found that almost 70% of respondents in a dairy farm study had the intention of taking action towards improving dairy cow foot health through the adoption of cost-effective measures, and improved labour efficiency. Another study by Kauppinen et al.[60] concerning dairy farmers demonstrated that caring for animal health and treating them humanely ranked the most popular intention among farmers. They reported that caring for animals does not incur additional cost and is relatively easy to be carried out. Hence it is proposed that Knowledge and Awareness, Attitude, Subjective Norm, and PBC are positively related to the intention of adopting SAP.

3 Methodology

A survey was conducted with smallholder dairy farmers from the Southern Zone of Peninsular Malaysia, comprising Johor, Melaka and Negeri Sembilan. This zone generates the highest milk production among smallholders, amounting to 7,005 litres of milk in one day[24]. Data was collected via the use of a questionnaire. The questionnaire was developed in reference to Malaysian Good Agricultural Practice (MyGAP) guidelines[26], Guide to Good Dairy Farming Practice jointly developed by the Food and Agriculture Organization of The United Nations and International Dairy Federation[23], Guidelines on Good Farming Management Practices by Department of Veterinary Services, Malaysia[61], Guidelines to Milk Hygiene and Safety Practices for Dairy Entrepreneur developed by the Department of Veterinary Services, Malaysia[62] and literature discussed above. These documents served as reference source for promoting the adoption of GDFHP. The constructs formulated in this study were adopted from previous established research and reference documents[33-35] which were customized to fit the context of this study in eliciting responses from dairy farmers on their intention to adopt SAP. A five-point Likert scale was used to measure the items for five constructs and the anchors ranged from strongly disagree (1) to strongly agree (5). This study analysed the following dimensions: knowledge and awareness (4 items), attitude (5 items), subjective norm (4 items), perceived behavioural control (4 items) and intention to adopt good dairy farming and hygiene practices (4 items). The questionnaire was pre-tested with livestock extension agents and dairy farmers (n = 40), and feedbacks received were incorporated into a finalized version that was utilized for the purpose of this study.

Two hundred and fifty (250) farmers were approached to participate in this study and 67 agreed to participate. Majority declined to participate in the survey due to their unfamiliarity with SAP and outstanding farm tasks that needed their urgent attention. G*Power analysis was used to estimate the minimum sample size required for this study. Recent studies have also suggested sample size should be determined using power analysis[63]. To obtain a power of $(1 - \beta) = 95\%$, margin error of 5%, effect size of 0.35 at 95% confidence interval, with a maximum of four number of predictors in a priori power analysis, the G*Power analysis suggested a minimum sample size of 59. The number of respondents in this study was 67, depicting that the sample size of this study (67) met the minimum requirement set (59). Furthermore, this amount exceeds the 'rule of thumb' suggested by Hair et al.[64] whereby the sample size is equal or ten times larger than the highest number of structural paths of formative indicators in measuring a single construct. As illustrated in Figure 2, there are four exogenous indicators directed to a single endogenous construct, hence amounting to a minimum of 40 sample size.

The respondents who agreed to participate in the survey were briefed on the confidentiality of the survey and informed that their responses would be compiled and aggregated for research and reporting purposes. Upon obtaining consent from the respondents, the survey was carried out. The study team carried out the survey via a one-to-one face interview. This approach provided farmers the opportunity to clarify uncertainties with project team members through an informal data gathering process. The collected data was recorded in an Excel sheet, which was later transferred to Partial Least Squares-Structural Equation Modelling (PLS-SEM) 3.0 for data analysis.

4 Results

Table 1 displays the demographic information of the dairy farmers in the Southern Zone of Peninsular Malaysia. Majority of the farmers are male (94%) and above 40 years old (38%). Majority of the farmers attained secondary school education. Eighty-four percent (84%) of the farmers operate on a full-time basis with 43% of them having less than 10 years of experience in this industry. They obtained informal training on milk production and practise semi-intensive farm systems.

Table 1. Demographic profile of dairy farmers.

Items	Frequency	Percentage (%)
Gender		
Male	63	94
Female	4	6
Age		
≤ 30 years	14	21
31- 40 years	15	22
41- 50 years	19	28
> 50 years	19	28
Education		
Primary education	9	14
Secondary education	41	61
Higher education	17	25
Dairy Farming Status		
Full time	56	84
Part time	11	16
Dairy farming experience		
≤ 10 years	28	43
11 - 20 years	13	19
21 - 30 years	17	25
> 30 years	9	13
Training Type		
Formal	8	12
Informal	59	88
Farming system		
Intensive	21	33
Semi-intensive	42	67

4.1 Partial Least Squares-Structural Equation Modelling (PLS-SEM)

PLS-SEM is a causal-predictive approach that emphasizes prediction in estimating statistical models[65]. It is designed to test the causal relationships between constructs with multiple measurement items. To empirically examine the research model depicted in Figure 2, SmartPLS 3.0 was employed to assess the measurement and structural models for reflective constructs.

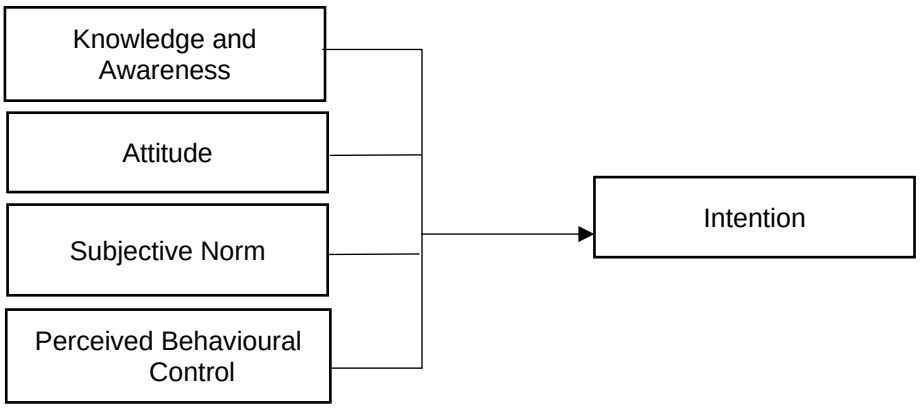

Figure 2. Conceptual framework.

4.2 The Measurement Model

The measurement model's outer loadings, composite reliabilities, convergent validity, discriminant validity and multicollinearity were assessed. First, the assessment of the reliability and validity of the key latent variables and indicators was carried out. To measure the internal consistency reliability of the constructs (i.e., how closely related a set of items are as a group), the Cronbach's alpha and composite reliability (CR) were looked into. To measure the average amount of variance in variables that a construct is able to explain (convergent validity), this study measured the average variance extracted (AVE). This was done by comparing the square root of the AVE values with the other latent variable correlations. This study also examined the variance inflation factor (VIF) to assess multicollinearity. Multicollinearity issue exists when there is a high correlation between the independent variables, which would complicate the interpretation of the constructs (if multicollinearity exists) due to the difficulties in ascertaining the effect of any single variable, owning to their interrelationship[66]. According to Diamantopoulos and Siguaw[67], a VIF value of more than 3.333 indicates the existence of multicollinearity. Hair et al.[65] reported that a value of 5 or lower is an indication that collinearity is not a problem. Additionally, the study also used the Fornell-Larcker approach to evaluate the discriminant validity in order to investigate if the similar concepts or measurements are actually distinct[68]. The square root of each construct's AVE in this study is greater than other constructs; vertically and horizontally[68]. This indicates that a latent construct explained the variance of its own indicator better than the variance of other latent constructs.

Table 2 shows the composite reliability, Cronbach's alpha, AVE and VIF measures for each of the six constructs. All six constructs' composite reliability exceeded the thresh-old value suggested by Nunally and Bernstein[69] which was 0.7 and also by Fornell and Larcker[68] which was 0.6. The Cronbach's alpha for all constructs in this study range is above 0.80. According to Gliem and Gliem[70], the closer the composite reliability and Cronbach's alpha values are to 1, the greater is the internal consistency of the indicators in the constructs. Hence, from our results in Table 2, both composite reliability and Cronbach's alpha demonstrated high internal consistency of the indicators in all the constructs[65], indicating that the questionnaire was indeed a reliable instrument used in this study. The composite reliability (CR) values for all constructs exceeds 0.708 as per suggested by Hair et al.[71], which indicates that the indicator's variance is explained more than 50 per cent by the construct tested. It is further claimed that CR is the upper limit of measuring reliability, hence superseding Cronbach's Alpha's values.

The convergent validity for the six constructs, measured by AVE showed values above 0.50. An AVE of ≥ 0.5 suggests a satisfactory convergent validity as it indicates that the latent construct explains 50% or more of the variance of its items[65]. The results in this study indicated that multicollinearity is not a concern in this study since all VIF values were less than 3.333 (the threshold values suggested).

As shown in Table 3, further analyses were carried out to assess discriminatory validity. The discriminant validity was achieved in the study since the square roots (quadratic values) of AVEs were higher than the correlation coefficient between the latent variables[68] (Table 3).

Table 2. Construct validity measurements.

Determinants	Indicator	Indicator loadings	Cronbach's alpha	Composite reliability	*AVE	#VIF
Knowledge and awareness	K1	0.437	0.733	0.824	0.555	1.436
	K2	0.663				
	K3	0.917				
	K4	0.866				
Attitude	A1	0.899	0.918	0.938	0.752	1.676
	A2	0.890				
	A3	0.877				
	A4	0.849				
	A5	0.820				
Subjective norms	SN1	0.728	0.709	0.812	0.521	1.718
	SN2	0.675				
	SN3	0.647				
	SN4	0.824				
PBC	PBC1	0.833	0.869	0.912	0.722	1.640
	PBC2	0.907				
	PBC3	0.909				
	PBC4	0.738				
Intention	INT1	0.930	0.921	0.944	0.809	
	INT2	0.855				
	INT3	0.950				
	INT4	0.860				

Note: *AVE = Average variance extracted; #VIF=variance inflation factor

Table 3. Discriminant validity.

	Attitude	Intention	Knowledge & awareness	PBC	Subjective norms	AVE
Attitude	0.867					0.752
Intention	0.696	0.900				0.809
Knowledge and Awareness	−0.410	−0.503	0.745			0.555
*PBC	0.528	0.637	−0.475	0.850		0.722
Subjective Norms	0.565	0.565	−0.471	0.511	0.722	0.521

Note: *PBC = Perceived Behavioural Control

4.3 The Structural Model

The structural model examines the significance of the respective relationships (inner model) whereby path coefficient and t-values were looked into. Table 4 shows the path coefficient and its corresponding *t*-values for the direct relationships whereby *t*-value > 1.96 is equivalent to a significant relationship ($p < 0.05$). The relative importance of the exogenous constructs in predicting dependent constructs is shown in Table 4 and Figure 3. Therefore, it can be inferred that two relationships were supported and two were not supported in this study.

According to Falk and Miller[72], the R^2 values should be equal to or greater than 0.10 in order for the variance explained of a particular endogenous construct to be deemed adequate. In this study, the R^2 value of 61.3, meets the adequacy requirement of Falk and Miller[72] and that the variances are considered substantial in the intention to adopt good dairy farming dan hygiene practices[73].

Table 4. Path coefficient in the structural model.

	Path Coefficient	Std. Error	*t*-value	*p*-value	Result	R^2	f^2	VIF
Knowledge and awareness on intention	–0.14	0.10	1.35	0.176	Not significant	0.613	0.035	1.436
Attitude on intention	0.42	0.12	3.66	0.000	Significant		0.275	1.676
Subjective norms on intention	0.11	0.16	0.70	0.486	Not significant		0.019	1.718
PBC on intention	0.29	0.13	2.22	0.027	Significant		0.133	1.640

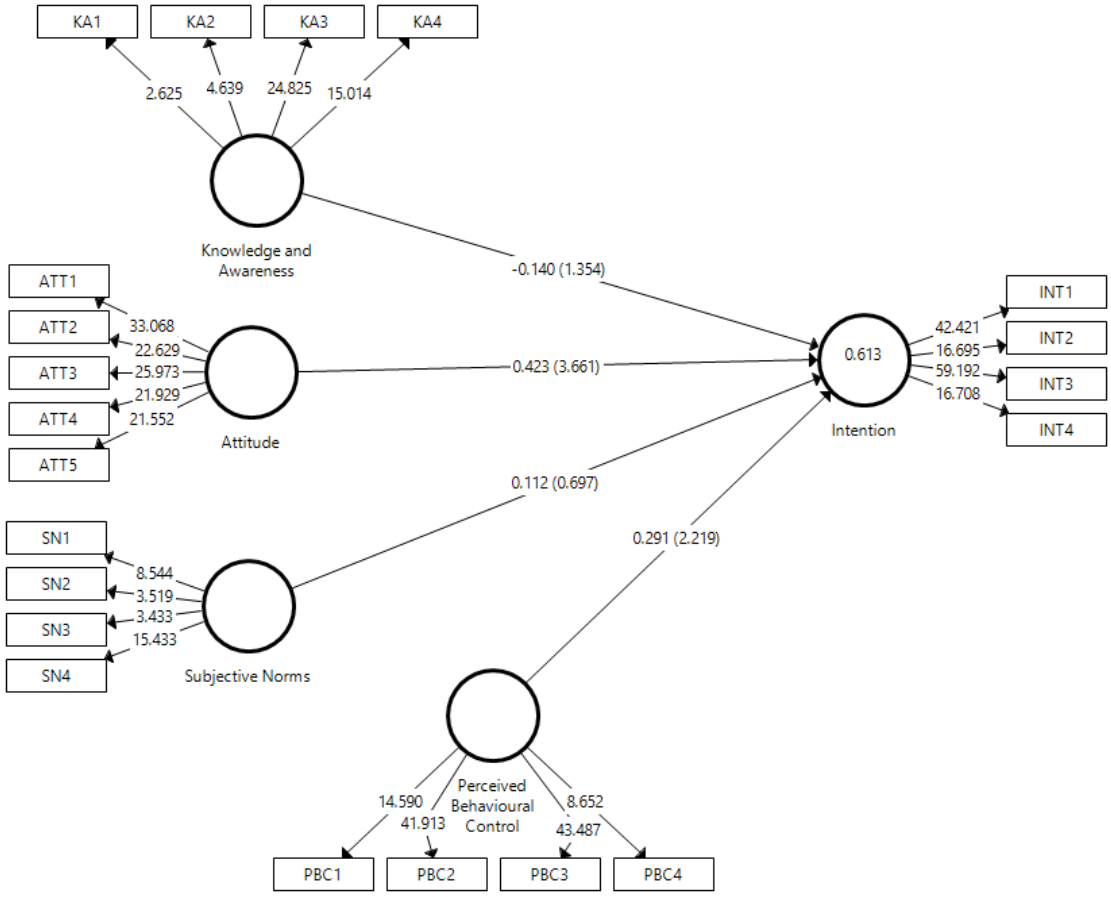

Figure 3. Bootstrap results from PLS-SEM.

5 Discussion

Upon running the data using PLS-SEM, this study found that out of four relationships, only attitude (β = 0.42, *t*-value = 3.66) and PBC (β = 0.29, *t*-value = 2.222) were found to be significant, whereas knowledge and awareness (β = –0.14, *t*-value = 1.35), and subjective norms (β = 0.11, *t*-value = 0.70) were not significant towards farmers' intention in adopting SAP.

5.1 Significant Hypotheses

This study found that attitude plays a significant role towards farmers' intention in adopting SAP. It is in agreement with the findings of the study by Mutyasira et al.[32]. The authors reported that attitude has a significant role towards SAP, implying that it is central to shift farmers' attitudes in promoting the adoption of SAP. The study of Shaw et al.[74] also reported that attitude is a prerequisite in changing behaviour towards adopting SAP. Farmers' attitude

plays an important role on controlling mastitis (one of the most widespread and costly disease of dairy cows), by implementing hygienic handling practices[51]. Therefore, when farmers have a positive attitude toward SAP, they will be inclined to engage in such practices.

This study also revealed that the PBC showed a positive and significant relationship towards farmers' intention in adopting SAP. This is in line with previous literature[37,55,56,58] which reported that dairy farmers have high intention to adopt sustainability management practices only when these farmers believe that they have the ability to perform such practices. PBC is often assessed by the ease or difficulty of the behaviour. As such, the belief that dairy farmers have on themselves, based on past training and skill-sets acquired to perform the practices would motivate farmers to adopt SAP.

5.1 Insignificant Hypotheses

The insignificant relationship of knowledge towards the intention to adopt SAP appeared to be in line with other sustainability studies in the past. Stuiver et al.[75] mentioned that without knowledge, the awareness of sustainability practices in agriculture would be low. According to Devaki and Mathialgan[76], farmers tend to rely on undocumented traditional knowledge that was passed on through generations, in which is a hindrance in applying for certification. This is because unrecorded information and data would pose risk in the certification process[77]. In a study among floriculture growers, it was reported that although majority of the growers adopted sustainable floriculture practices as they were aware of its impact on the environment, they were not keen in applying it for certification as their knowledge on the certification programs and processes was rather limited[78]. This clearly shows that having knowledge on sustainability practices alone is insufficient for farmers to apply for sustainability certification.

The subjective norms in our study showed insignificant result pertaining to the farmers' intention towards adopting SAP. Our findings are in conformity with many other studies, which reported that societal pressure alone is not enough to drive farmers to adopt sustainability farming practices[33,79]. There are other challenges that contribute to the lack of adopting sustainability practices. This includes risks of switching costs, long term benefits, efforts and resources involved. Another separate study by Rodriguez et al.[52] showed that the intention to adopt sustainable practices is low when conventional practices are already proven to be effective in achieving sustainability.

5.2 Potential Implications for Smart Farming

The uptake of SAP will open up opportunities for smart farming. Smart farming features a data-driven approach by leveraging on frontier technologies such as Internet of Things (IoT), Artificial Intelligence (AI), sensors, robotics and big data analytics to optimize production holistically based on real-time data. These technologies are crafting systems, which are derived from applying AI algorithms on the big data generated from the numerous sensors and IoT deployments in the dairy farm. Specifically, Smart Dairy Farming (SDF) is aimed at not only improving milk yields but also enhancing the efficiency of the dairy process. At the product level, SDF strives to increase milk production efficiency by deploying robotic milking systems that milk the cow, analyse the milk quality, process the milk and preserve it. At the process level, SDF allows for monitoring of cow movement, feed and health, hence improving the welfare of the cow.

6 Conclusion

Our study is the first to be undertaken among smallholder dairy farmers in Malaysia, utilizing the novel approach of investigating the psycho-social factors of the enhanced-TPB model, i.e., knowledge and awareness, attitude, subjective norm and PBC towards the adoption of SAP. This study found that amongst the four factors; attitude and PCB, respectively, have a significant positive relationship with farmers' intention to adopt SAP, consistent

with the findings of other studies. Our findings provide a pathway in tackling the lack of adoption of SAP among smallholder dairy farmers, who form the landscape of milk production in Malaysia. With the right attitude and belief that they have the ability to adopt GDFHP on their farms, smallholder dairy farmers are more inclined to adopt SAP. Understanding the psycho-social factors underlying smallholder dairy farmers' willingness to adopt SAP provides a better picture on the behaviour of these farmers in making choices concerning the sustainability of their farms. Hence, we believe our findings, based on the adoption of a producer-led approach, contribute to the design and formulation of a holistic SAP policy recommendation, and pragmatic intervention strategies that would motivate smallholder dairy farmers to uptake SAP on their farms, and potentially further inspire them to harness the benefits of SDF.

Conflict of Interest

The authors declare that there is no conflict of interest.

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Author Contribution

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