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Use of the knowledge, attitude, and practice (KAP) model to examine sustainable agriculture in Thailand

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Sustainable agriculture plays an important role in achieving sustainable development goals with regard to food security and environmental conservation. Sustainable agriculture relies on sustainable farming practices that reduce greenhouse gas production, the wise use of local natural resources, and reductions in negative impacts on the environment and human health. Sustainable farming practices can be driven by various factors, such as the socio-environmental setting, socio-cognitive factors, agricultural institutions, and policy. This study used the knowledge, attitude, and practice (KAP) model to examine farmers' knowledge, attitudes, and practices in the area of sustainable agriculture. It also considered the factors affecting farmers' knowledge, attitudes, and practices. Two different socio-environmental contextual settings in Surin Province (a Thai-Cambodian border province) of Thailand are considered. The results show that there are differences between the two different socio-environmental contextual settings with regard to farmers' sustainable agricultural practice perceptions, knowledge, and attitudes. Farmers' perceptions of environmental degradation, the number of years of agricultural experience, and agricultural policy drive farmers' attitudes and individual sustainable practices. Another major result of the study is that individual farmers' attitudes and practices promote collective sustainable agricultural behaviors. The implication of these findings is that it is necessary to improve the learning ability of individual farmers on the environment and sustainable agricultural practices through social learning and scientific knowledge dissemination, so as to produce sustainable collective development behaviors.

1. Introduction

Today's agricultural systems are facing a broad range of social and environmental challenges, including farm-size transitions (Rigg et al., 2018), urbanization (Martellozzo et al., 2014), agricultural policies (Concepción et al., 2007), natural hazards (Chapagain and Raizada, 2017), environmental pollution (Mireri et al., 2007), and climate change (Ali and Erenstein, 2017). Sustainable agriculture has evolved to be recognized worldwide in recent decades (Harwood, 1990; Lichtfouse, 2009). Sustainable agriculture is environmentally non-degrading, technically appropriate, economically viable, and socially acceptable (Velten et al., 2015). Although sustainable agriculture has attracted global attention in recent decades, various sustainable agriculture practices have been suggested since the late 1930s. Examples include the introduction of biodynamic farming in Austria (Preiffer, 1938), natural farming in Japan (Fukuoka, 1978),

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permaculture in Australia (Mollision and Holmgren, 1978), and organic agriculture and conservation agriculture in the United States (Radale, 1942; FAO, 2011).

Agricultural systems are a "complex, interrelated matrix of soils, plants, animals, power, labor, capital, and other inputs" that are controlled or influenced by institutional and socio-economic factors at multiple levels (Dixon et al., 2001; Nguyen et al., 2019). Therefore, agricultural systems are complex social-ecological systems, involving farming activities that are associated with and constrained by broad scales of socio-ecological patterns and processes, such as bio-physical circumstances, policy and institution support, socio-economic characteristics, and farmers' willingness and ability of sustainable agriculture (Redman et al., 2004; Virapongse et al., 2018). Farmers' adoption of sustainable agriculture practices is driven by intrinsic factors, such as perceptions, attitudes, knowledge (Meijer et al., 2015), and social capital, such as farmers' networks, a sense of community, and norms and values (Rivera et al., 2019). Previous studies (e.g., Lucas et al., 2019) suggested that individual and collective sustainable agriculture practices play vital roles in the successful implementation of sustainable agriculture at the on-farm level. However, these individual and collective sustainable agriculture practices are influenced by farmers' perceptions, knowledge, and attitudes (Šūmane et al., 2018), which are shaped by four elements: (i) experiences, (ii) memory, (iii) definition, and (iv) expectations (Taylor et al., 1988).

Many studies have attempted to assess how sustainable agriculture can improve ecosystem services for the agricultural environment (e.g., Petersen et al., 2000; Hobbs et al., 2008). In addition, a handful of empirical studies have recognized the critical role of intrinsic farmer-related factors in the transition from conventional agriculture to sustainable agriculture (e.g., Menozzi et al., 2015; Adnan et al., 2017; Petway et al., 2019). Until recently, however, little research has focused on the intrinsic factors of farmers, i.e., perceptions, knowledge, and attitudes, which can affect individual and collective sustainable agriculture practices. Therefore, there is an urgent need to identify the related intrinsic factors in the context of the social and environmental challenges in the 21st century. Through an empirical study conducted in two different socio-environmental contextual settings, the two agricultural sub-districts of Dan and Naengmut in Surin Province (a Thai-Cambodian border province) of Thailand, this study sought to: (i) examine individual and collective sustainable agriculture practices by assessing farmers' perceptions of changes in agricultural environment-related interactions, knowledge, and attitudes of sustainable agriculture, and (ii) determine the cognition factors that affect individual and collective sustainable agriculture practices in the context of intensive agricultural development. Three hypotheses were made as follows:

H1. There are differences in farmers' socio-economic settings, perceptions of socio-environmental changes, knowledge and attitudes of sustainable agriculture, and sustainable agriculture practices among the two sub-districts (Dan and Naengmut).

H2. Socio-environmental contextual settings have significant influences on farmers' perceptions, knowledge, and attitudes towards sustainable agriculture practices.

H3. Socio-economic and cognitive factors have significant influences on individual and collective sustainable agriculture practices.

This study contributes to the development of more effective and specific sustainable agriculture development strategies and policies at multiple levels under similar contexts in Southeast Asia.

2. Theoretical framework: the knowledge, attitude, and practice (KAP) model

This study used the KAP model to examine farmers' knowledge, attitudes, and practices of sustainable agriculture, as suggested by Nguyen et al. (2019). Knowledge, attitudes, and practices are critical components of behavioral change models. Knowledge is the understanding of the information, which is the conscious and non-symbolic perception of meaning (Wessman, 2006). According to Hulme (2018), there are four categories of knowledge: (i) scientific and social scientific knowledge; (ii) local knowledge; (iii) tacit knowledge; and (iv) self-reflective knowledge. Attitude refers to a positive or negative evaluation of an objective (Ajzen and Fishbein, 2000). Practice refers to regular activities that are influenced by widely shared social norms and beliefs (Bourdieu, 1990).

The KAP model process is originated from learning theory (Bandura, 1976) and diffusion of innovation theory (Roger, 1995). According to Roger (1995), members of a social system accept innovation through four stages over time. The stages include knowledge acquisition, persuasion, decision, and confirmation. In addition, Bandura (1976) suggested that individual behaviors are learned through social context. Another perspective used to consider behavior changes is the theory of planned behavior by Ajzen (1991), which provides a framework for understanding the relationship between behavioral intention and behavioral attitudes.

Previous studies have identified many interconnections among knowledge, attitudes, and practices (e.g., Valente et al., 1998). In terms of knowledge-practices relationship, Hungerford and Volk (1990) proposed that knowledge of issues and possession of skills are required for behavioral change. For the relationship between attitudes and practices, Ajzen (1991) suggested that an individual holds positive attitudes and behaviors she/he would have better motivative intention towards an issue. Ajzen (1991) further defined subjective norms and noted that perceived behavior control would lead to the formation of behavioral intention. Subjective norms refer to individual receipt of social influences from peers or other important people who wish that the individual would engage in a particular behavior. Perceived behavior control refers to the perceptions of the ease or difficulty of performing the behavior of interest, such as the availability of or ability to implement a new farming practice. Generally, the more ability an individual has to control the three components (i.e., attitudes towards a behavior, subjective norms, and perceived behavior control), the more a behavior intention will be carried out. Meanwhile, several external factors, such as the characteristics of the farmer and environmental conditions, also help to shape certain farming practices (Meijer et al., 2015).

Originating from the fields of family planning and population studies in the 1950s, the KAP model was developed and recognized as popular survey instruments in the field of social research; it can be used to assess the relationship among knowledge, attitudes, and practices (Vandamme, 2009). The KAP model is a structured, standardized questionnaire completed by a target population that can quantify and analyze what is known (knowledge), believed (attitudes), and done (practices) with regard to a topic of interest (Nguyen et al., 2019; Andrade et al., 2020). As such, the KAP model data can help to identify knowledge gaps, attitudes barriers, and practices patterns that may facilitate understanding and actions regarding a particular issue (World Health Organization, 2008). In addition, integrating qualitative methods, such as interviews, can enhance the viability and reliability of the survey (Launiala, 2009).

3. Research methods

3.1. Study area

The agricultural sector of Thailand has long been called the backbone of the country, so it was selected for this study. Agriculture is the most important economic sector in the country. It provides a livelihood to approximately 40% of the population and contributes about 10% of GDP (Wiggins, 2011). The country has positioned itself as the "kitchen of the world" and the world leader in rice export (Supaphol, 2010). Empirical data collection was performed in two sub-districts, Dan and Naengmut in the Kap Choeng district of Surin Province in northeastern Thailand. Surin Province lies on the border with Cambodia, where agriculture is the predominant sector.

Surin Province is one of the poorest provinces in Thailand. Like many impoverished regions in Southeast Asia, it has borne large impacts from climate change and socio-economic transformation, including rural out-migration (Nguyen and Sean, 2021). Dan has a total land area of 120 km^2 and a population of 12,613, whereas Naengmut covers an area of 128 km^2 and has a population of 11,107. The two selected sub-districts belong to the tropical monsoon climate zone, which is characterized by a long dry season, with annual precipitation of approximately 1406.20 mm and average temperatures of 23 °C during the dry season (November to May) and 34 °C during the rainy season (June to October). Most of the arable soils in the sub-districts are typical tropical sandy soils. These soils are sandy, saline, and acidic with poor fertility and low water retention. Human activities, such as agricultural land-use practices and deforestation, have accelerated soil degradation (Hartmann and Chinabut, 2005; Vityakon, 2007).

Both Dan and Naengmut have diverse agricultural activities (e.g., intensive rice and cassava farming and extensive vegetable systems) that are representatives of the region. Although Dan and Naengmut are located in the same district, they are different with respect to natural resources and social capital. Dan has suffered from water scarcity during the dry season due to frequent, intense droughts and a lack of irrigation and water conservation infrastructure, whereas Naengmut has better water availability due to the surrounding rivers and streams. A strong organic farming and self-sufficiency economy theory movement was found in Naengmut (Piboolsravut, 2004).

3.2. Data collection

3.2.1. Phase 1: semi-structured interviews

In December 2019, semi-structured interviews were conducted with 25 farmers to capture their attitudes, knowledge, and practices of sustainable agriculture. We selected interviewees based on their different farming systems, socio-demographic characteristics, and information in a farmer list recommended by the Agricultural Department of Kap Cheong District. This number of interviewees was chosen because it is the sample size recommended for achieving saturation and redundancy in grounded theory studies that use in-depth interviews to perform social science research (Dworkin, 2012). The interview questions were open-ended and aimed to study (1) farmers' perceptions of the surrounding environment, (2) farmers' awareness and attitudes towards sustainable agriculture, and (3) farmers' practices of sustainable agriculture.

3.2.2. Phase 2: questionnaire survey

To confirm whether the larger population had the same knowledge, attitudes, and practices of sustainable agriculture, we designed a subsequent questionnaire survey based on indicators coded from six sections within the semi-structured interview data. The questionnaire covered (1) socio-economic demographics, (2) perceptions of environmental issues, (3) knowledge related to sustainable agriculture, (4) attitudes towards sustainable agriculture, (5) individual sustainable agriculture practices, and (6) collective sustainable agriculture practices. Five-point Likert scale (Likert, 1931) questions (i.e., 1 = strongly disagree, 2 = disagree, 3 = uncertainty, 4 = agree, and 5 = strongly disagree) and yes/no questions were deployed to examine respondent agreement levels regarding the above issues.

This study used power analysis (Cohen, 1992) to estimate the number of participants needed for a given effect size (significance level $P = 0.05$, medium effect size $f^2 = 0.15$, statistical power = 0.80). The total farmers' populations in Dan and Naengmut were 12,613 and 11,017, respectively. Thus, we distributed 270 questionnaires proportionally among the investigative farming systems in the two sub-districts in March 2020. Later, 236 valid questionnaires were received back. The response rate was 87% ($n = 236$, with 80 rice farmers, 79 cassava farmers, and 77 vegetable farmers in total). Each sub-district returned 118 questionnaires.

3.3. Data analysis

3.3.1. Qualitative data analysis

All interview data were recorded in the Thai language, then translated and transcribed into English. Either initial coding or open coding was used to develop indicators for each module in the questionnaire surveys. This coding method examines and compares the connections (i.e., similarities and differences) between codes and semi-structured interview data by breaking the data down into discrete parts (Strauss and Corbin, 1998). The purpose of open coding is to stay open to all possible theoretical directions that reflect researcher interpretations of the semi-structured interview data (Charmaz, 2006).

Table 1
Descriptions of the variables included in the simple linear regression models.

Variable	Description and unit of measurement
Collective farmers' sustainable agriculture practices (Y)	The mean frequency of collective sustainable agriculture practices (Five-Likert scale)
Age (X_1)	Age of the respondents (year)
Educational level (X_2)	Education level of the respondents (1 = higher than no schooling, 0 = no schooling)
Farming system (X_3)	Farming system of the respondents (1 = vegetable system, 0 = other farming systems)
Total land size (X_4)	Total agricultural landholding size (hm^2/household)
Household size (X_5)	Number of total household members
Total household income (X_6)	Total household income in one year (USD)
Farmers'perceptions of environmental changes (X_7)	Mean farmers' perceptions of perceived ecological deterioration issues (Five-Likert scale)
Farmers' perceptions of agricultural institution services (X_8)	Mean farmers' perceptions of agricultural institution services (ranging from −1 to 1)
Farmers' sustainable agriculture knowledge (X_9)	Overall farmers' sustainable agriculture knowledge scores (ranging from 0 to 6)
Farmers' sustainable agriculture policy knowledge (X_{10})	Overall farmers' sustainable agriculture policy knowledge scores (ranging from 0 to 6)
Farmers'attitudes towards sustainable agriculture (X_{11})	Average farmers' attitudes toward sustainable agriculture (Five-Likert scale)
Individual farmers' sustainable agriculture practices (X_{12})	Mean individual farmers' sustainable agriculture practices (Five-Likert scale)

Note: Multiple regression assumptions were tested before the multiple regression models were run. The model appeared, in most senses, to be both accurate and universal. $R^2_{\text{Individual practices}} = 0.141$ and $R^2_{\text{Collective practices}} = 0.398$ ($P < 0.05$) of the model were found relatively lower than the suggested value (see Appendix), however, these values were acceptable in social science research (Hagquist and Stenbeck, 1998; Moksony, 1999) because the significance of the interested variables was observed.

3.3.2. Quantitative data analysis

All quantitative data obtained from questionnaire surveys were subject to statistical analyses as follows: (1) descriptive statistics to summarize variable frequencies; (2) non-parametric tests, i.e., the Chi-square test of homogeneity was used to determine whether two sub-groups within a population shared the same distribution of a single categorical variable (e.g., socio-demographic characteristics and the knowledge, attitudes, and practices of famers); (3) the Mann–Whitney test to compare the mean rankings of farmers' knowledge, attitudes, and practices in the two sub-districts; and (4) multiple linear regression for detection of the determinants of individual and collective sustainable agriculture practices. The multiple linear regression model used to characterize the determinants of farmers' sustainable agriculture knowledge, attitudes, and practices is specified as follows:

$$Y = \alpha + b_1X_1 + b_2X_2 + \cdots + b_nX_n, \tag{1}$$

where Y is the dependent variable; α is the constant; b_1, b_2, …, b_n are the beta coefficients for independent variables; and X_1, X_2, …, X_n are the independent variables (see Table 1).

4. Results and discussion

4.1. Socio-economic demographics of farmers

Table 2 depicts the surveyed farmers' socio-economic demographic profiles. More female farmers than male farmers participated in the study: 60% of the respondents in Dan ($n = 118$) and 52% in Naengmut ($n = 118$), respectively, are women. The average age of farmers in the two sub-districts is 52 years old. Respondents in Naengmut tend to be older than those in Dan ($\chi^2 = 9.372$, $df = 3$, $P = 0.025$). There is no difference between the respondents from the two sub-districts with regard to age, marital status, education, years of farming experience, farm size, and farming system. Most farmers have their own land. The average land size per family is 2.59 (±2.33) hm^2 (2.46 (±1.87) hm^2 in Dan and 2.71 (±2.70) hm^2 in Naengmut), which indicates that most respondents are smallholders. Conventional agriculture (a farming system that uses agrochemicals, synthetic compounds, and genetically modified organisms intensively for production) and mixed agriculture (a farming system that contains both sustainable and conventional agriculture practices) are common on their farmland. The farmers of Dan are less likely to illegally occupy land than the farmers of Naengmut ($\chi^2 = 15.277$, $df = 3$, $P = 0.002$), and the farmers in Dan are more likely to have a larger household size than those in Naengmut ($\chi^2 = 10.323$, $df = 2$, $P = 0.006$).

4.2. Farmers' perceptions and attitudes towards the socio-ecological environment and sustainable agriculture

The majority of the farmers interviewed claim that their farming situations have experienced changes over time. The changes described in the farmers' narratives can be grouped into two main categories: institutional agricultural services and environmental deterioration. Therefore, the researchers used a set of relevant indicators from the outcomes of the interview data analysis to assess farmers' perceptions regarding such perceived changes in the socio-ecological environment among a larger population.

4.2.1. Farmers' perceptions of socio-environmental changes

The indicators that reflect farmers' perceptions of environmental changes address drought, water pollution, air pollution, pest outbreaks, deforestation, and soil degradation. The perception of most (84%) farmers surveyed ($n = 236$) has changed. Natural hazards, namely pest outbreak (75%) and drought (69%), account for the largest proportion of perceived problems. In addition, most of the

Table 2
Comparison of respondent socio-economic demographics.

Indicators	Sub-district				Statistic	*df*	*P*-value
	Dan ($n = 118$)		Naengmut ($n = 118$)				
	Number	Percentage (%)	Number	Percentage (%)			
Farming system					$\chi^2 = 0.327$	2	0.849
Rice	38	32%	42	36%			
Cassava	41	35%	38	32%			
Vegetables	39	33%	38	32%			
Gender*					$\chi^2 = 1.629$	1	0.202
Male	46	39%	57	48%			
Female	69	58%	61	52%			
Age*					$\chi^2 = 9.372$	3	0.025
20–35 years	13	11%	3	3%			
36–45 years	23	19%	18	15%			
46–55 years	39	33%	44	37%			
Above 55	36	30%	50	42%			
Education level*					Fisher's exact test = 4.745		0.276
Primary school	79	67%	74	63%			
Secondary school	19	16%	12	10%			
High school	16	14%	24	2%			
Bachelor and above	3	3%	5	4%			
No schooling	0	0%	1	1%			
Marital status*					$\chi^2 = 1.663$	2	0.435
Married	101	86%	103	87%			
Single	7	6%	3	3%			
Separated/devoiced/widowed	10	8%	11	9%			
Types of farming practice*					$\chi^2 = 2.344$	2	0.310
Sustainable agriculture	19	16%	15	13%			
Conventional agriculture	40	34%	50	42%			
Mixed agriculture	55	47%	46	39%			
Farming experience*					Fisher's exact test = 2.070		0.591
No more than 5 years	6	5%	2	2%			
5–10 years	16	14%	17	14%			
11–15 years	5	4%	6	5%			
More than 16 years	87	74%	88	75%			
Category of land*					$\chi^2 = 15.277$	3	0.002
Self-owned land	98	83%	97	82%			
Rented land	15	13%	23	19%			
Illegal owned land	2	2%	8	7%			
Household size*					$\chi^2 = 10.323$	2	0.006
Less than 2 people	7	6%	20	17%			
2–5 people	52	44%	75	64%			
More than 5 people	35	30%	23	19%			

Note: Significance level at the 95% confidence level ($P < 0.05$). * indicates that there were some missing data (approximately 2%–8% of the respondents were not willing to express their personal socio-economic and demographics).

farmers observe deforestation (63%) and soil degradation (62%). Over half of them tend to agree with environmental pollution, including air pollution (65%) and water pollution (51%).

The data obtained from the questionnaire surveys show that farmers in Dan have a higher level of agreement regarding environmental changes, while farmers in Naengmut perceive more drought (Fig. 1). The Mann–Whitney test confirms a significant difference in the mean value of the perceptions of environmental changes, which were calculated from individual scores in the two sub-districts (4.01 (±0.52) in Dan and 3.21 (±0.84) in Naengmut; $U = 3162.50$, $z = -7.265$, $P = 0.000$).

4.2.2. Farmers' perceptions of agricultural services

The selected indicators of farmers' perceptions of agricultural institutional services consider the provision of agricultural inputs, provision of agricultural credits and funds, agricultural extensions, formation of agricultural cooperatives, and promotion of organic agriculture. According to data obtained from the questionnaire survey, most farmers (87% in Dan and 74% in Naengmut) have received agricultural extension services. Organic farming has been promoted in both sub-districts, but farmers in Naengmut tend to receive more assistance regarding agricultural input, agricultural credits, and organic farming training than those in Dan.

The differences in the perceptions of the farmer groups may be associated with personal experiences, interpretation of changes, and expectations of future farming activities, rather than actual environmental changes observed via scientific data (Taylor et al., 1988; Allan et al., 2013; Nguyen et al., 2016). The results show that most surveyed farmers perceive socio-environmental changes that affect their farming; however, the perception of socio-environmental changes between the two sub-districts is heterogeneous. Farmers construct their farming systems according to their farm characteristics and resource availability (Berger and Luckmann, 1967; Greider and Garkovich, 1994; McCown, 2002). Thus, farmers might prioritize or normalize related or unrelated facts linked to their agricultural

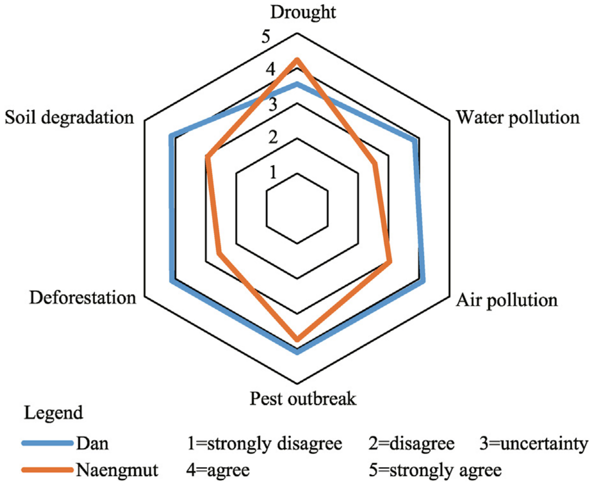

Fig. 1. Farmers' perceptions of environmental changes (n = 236). The low-level perception score is between 1.00 and 2.50, the medium-level perception score is between 2.60 and 3.50, and the high-level perception score is greater than 3.50.

activities based on the availability of natural and social capital and various socio-economic factors (e.g., age, land ownership status, and household size). This finding has also been highlighted in similar studies. For example, farmers in Southern Brazil perceive landscape changes and the socio-environmental issues associated with such changes, but different farmer groups perceive different landscape changes (Leite et al., 2019).

4.2.3. Farmers' knowledge of sustainable agriculture

Although the statistics reveal that over half (52%) of the surveyed farmers have good levels of sustainable agriculture knowledge, the distribution of farmers' sustainable agriculture knowledge varies between the two sub-districts. In general, farmers in Naengmut tend to hold a higher level of knowledge regarding sustainable agricultural concepts. The majority of farmers in both sub-districts (over 80%) refer to sustainable agriculture as self-reliance of the rural community, while more than 90% farmers in Naengmut consider sustainable agriculture to be the sustainable integration of environmental, economic, and social resources, conservation of the environment, and protection of human health (Fig. 2).

The Chi-square test also detects significant differences in the distribution of farmers' sustainable agriculture knowledge levels between the two sub-districts ($\chi^2 = 27.21$, $df = 2$, $P < 0.001$). Farmers in Naengmut tend to possess a higher level of sustainable agriculture knowledge. Approximately 70% of farmers in Naengmut exhibit a good level of sustainable agriculture knowledge, whereas only 36% of farmers are at this level in Dan.

Our results show that most surveyed farmers have good levels of sustainable agriculture knowledge, and approximately 30% of them have good levels of sustainable agriculture policy awareness. However, the distribution of farmers' sustainable agriculture knowledge among the two sub-districts is heterogeneous. The heterogeneity of sustainable agriculture knowledge and sustainable agriculture policy awareness is another form of knowledge (Beckford and Barker, 2007). The farmers in this study obtain sustainable agriculture

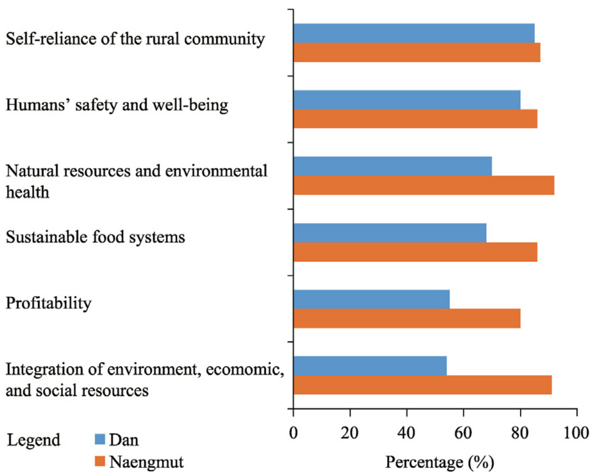

Fig. 2. Farmers' knowledge regarding sustainable agriculture by percentage of the respondents (n = 236).

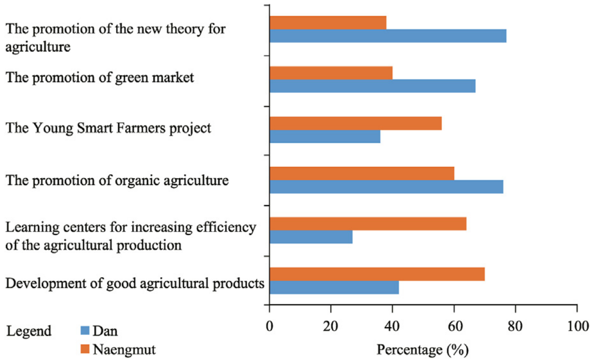

Fig. 3. Farmers' awareness of sustainable agriculture policy by percentage of the respondents (n = 236).

knowledge from two main sources. Farmers learn about sustainable agriculture from their peers and family members within homogenous groups and intra-community networks, as well as from heterogeneous groups and extra-community networks (e.g., agricultural institution extension officers) by attending training, site visits, meetings, etc. In this regard, most surveyed farmers in two sub-districts exhibit high levels of sustainable agriculture knowledge. The former knowledge source enhances informal and experiential knowledge sharing within farming sub-districts, whereas the latter knowledge source enables greater access to formal research-based knowledge about new technology and practices and innovative experience from multiple activities and actors. Diverse forms of learning activities and participants enhance farmers' understanding of current knowledge and create an environment appropriate for integration of new knowledge (Nguyen et al., 2014; Šūmane et al., 2018; Cofré-Bravo et al., 2019). Because there is a strong organic farming movement in Naengmut, famers in this sub-district are more easily involved in various types of learning networks. This might objectively push them to receive more concepts and information about sustainable agriculture. As such, farmers in Naengmut tend to achieve better sustainable agriculture knowledge learning outcomes than their counterparts.

4.2.4. Farmers' awareness of sustainable agriculture policies

In general, only approximately one-quarter of the surveyed farmers have good levels of sustainable agriculture policy awareness, but the majority of them know about the promotion of organic agriculture (Fig. 3). There is no significant difference between Dan and Naengmut with regard to the distribution of sustainable agriculture policy awareness levels (χ^2 = 4.75, df = 2, P = 0.093). The distribution of farmers' sustainable agriculture policy awareness between the two sub-districts is heterogeneous. Most farmers in Naengmut are aware of the new theory for agriculture (Piboolsravut, 2004) and local green market initiative, whereas only around 40% of farmers in Dan have such sustainable agriculture policy awareness. On the other hand, over half of the surveyed farmers in Dan know the Young Smart Farmers project development of food agriculture products, and the learning center for increasing efficiency of the agriculture production, while only some (27%–42%) of farmers in Naengmut are aware of these policies.

Sustainable agriculture policy knowledge among farmers flows mainly via top-down structured networks (e.g., agricultural institutions) in both sub-districts. Although this type of network structure can enable access to new knowledge, it may hinder mutual learning and implementation of new knowledge (Tiwana, 2008; Cofré-Bravo et al., 2019). Consequently, only a few of the surveyed farmers demonstrate good levels of sustainable agriculture policy knowledge, and there is no significant difference between the two sub-districts with regard to the distribution of such knowledge. This was highlighted in a study of sustainable agriculture by Saint Ville et al. (2016) that addressed smallholder farming sub-districts in the Caribbean. Different types of farmer' networks facilitate knowledge exchange among farmers and increase the opportunities for farmer access to information.

4.3. Farmers' attitudes towards sustainable agriculture

Although most of the surveyed farmers express positive attitudes towards sustainable agriculture, farmers' attitudes vary significantly between the two sub-districts in some respects (see Table 3). With respect to economic viability, farmers in the two sub-districts do not exhibit significantly different attitudes on "sustaining economic profitability to maintain life" and "minimizing agriculture marketing risks". However, they exhibit significant differences when asked about "reducing agricultural costs and resource requirements" (U = 4527.00, z = –4.87, P < 0.001). With respect to their attitudes towards the stewardship of human and natural resources in farming systems, farmers in Dan tend to agree more than their counterparts about "contributing to sustainable farming systems" (U = 3682.50, z = –6.50, P < 0.001), whereas farmers in Naengmut hold more positive attitudes towards the ability of sustainable agriculture to achieve the "making full use of natural resources" (U = 5957.00, z = –2.08, P = 0.038) and "strengthening cooperation and cohesion within the community" (U = 5609.00, z = –2.61, P = 0.009). In terms of food security, farmers in Dan are more in favor of "sustaining productivity" (U = 5817.50, z = –2.35, P = 0.019), whereas farmers in Naengmut prefer "ensuring food sufficiency at the household level" (U = 2695.0, z = –8.86, P < 0.001). With regard to a quality life for farmers and society, farmers in Naengmut generally show more positive attitudes towards "Sustaining healthy and safe of food production" (U = 4906.50, z = –4.24, P < 0.001), "ensuring farmers' health and safety", (U = 4833.50, z = –2.08, P < 0.001), and "feeling happy and proud after practicing sustainable agriculture" (U = 4843.00, z = –4.87, P < 0.001). In terms of values and traditions, farmers in Naengmut tend to agree more

Table 3
Farmers' attitudes towards sustainable agriculture.

Attitudes towards sustainable agriculture	Indicators	Mean ± SD		Mann–Whitney test		
		Dan	Naengmut	U	z	P-value
Economic viability	Reducing agricultural costs and resource requirements	3.93 ± 0.85	3.19 ± 1.24	4527.00	−4.87	<0.001
	Sustaining economic profitability to maintain farmers' livelihoods	3.91 ± 0.70	3.85 ± 0.79	6756.50	−0.43	0.670
	Reducing agriculture marketing risks	3.96 ± 0.79	3.75 ± 0.95	6004.50	−4.32	0.070
Stewardship of both human and natural resources in farming systems	Making full use of natural resources	4.12 ± 0.69	4.23 ± 0.96	5957.00	−2.08	0.038
	Contributing to sustainable farming systems	3.85 ± 0.74	2.82 ± 1.29	3682.50	−6.50	<0.001
	Strengthening cooperation and cohesion within the community	3.44 ± 0.10	3.78 ± 1.06	5609.00	−2.61	0.009
Food security	Ensuring food sufficiency at the household level	3.47 ± 0.97	4.49 ± 0.62	2695.00	−8.86	<0.001
	Sustaining productivity	4.10 ± 0.76	3.81 ± 0.96	5817.50	−2.35	0.019
Quality of life for farmers and society	Sustaining healthy and safe of food production	3.91 ± 0.87	4.32 ± 0.88	4906.50	−4.24	<0.001
	Ensuring farmers' health and safety	3.81 ± 0.92	4.28 ± 0.91	4833.50	−2.08	<0.001
	Feeling happy and proud after practicing sustainable agriculture	3.86 ± 0.83	4.32 ± 0.69	4843.00	−4.87	<0.001
Values and tradition	Developing sustainable agriculture sequentially	3.56 ± 0.72	3.90 ± 1.12	4890.00	−4.02	<0.001
	Feeling difficult to practice sustainable agriculture	3.16 ± 1.35	3.64 ± 1.33	5470.00	−2.82	0.005
	Following a traditional lifestyle	3.98 ± 0.90	4.28 ± 0.91	5456.00	−3.12	0.002

Note: Mean values were calculated from individual scores. 1 = strongly disagree; 2 = disagree; 3 = uncertainty; 4 = agree; 5 = strongly agree. The score of negative attitude is between 1.00 and 2.50, the score of neutral attitude is between 2.60 and 3.50, and the score of positive attitude is greater than 3.50.

about "developing sustainable agriculture sequentially" (U = 4890.00, z = –4.02, P < 0.001), "feeling difficult to practice sustainable agriculture" (U = 5470.00, z = –2.82, P = 0.005), and "following a traditional lifestyle" (U = 5456.00, z = –3.12, P = 0.002) than farmers in Dan.

Individuals form their attitudes based on the accessibility of relevant beliefs (Fishbein, 1963; Ajzen and Fishbein, 2000). In this study, the positive farmers' attitudes towards sustainable agriculture reflect their high expectations that practicing sustainable agriculture could maintain their well-being, farming systems, and culture and tradition. This is consistent with similar findings of Zeweld et al. (2017) that most surveyed Malaysian farmers have positive attitudes towards sustainable agriculture when it is applied to certain goals, such as improving agricultural productivity, enriching biodiversity, and improving their livelihoods and incomes. However, accessible beliefs may or may not accurately reflect reality (Ajzen and Fishbein, 2000). Therefore, the different attitudes of farmers towards sustainable agriculture in the two sub-districts generally reflect their different expectations of sustainable agriculture. Although common interests are the starting point for sharing information and beliefs about sustainable agriculture, farmers from different groups may have different common interests that encourage them to form homogenous attitudes towards sustainable agriculture. Moreover, culture, values, and socioeconomic status also play important roles in attitude formation. Compared with Naengmut, Dan has more young farmers, more stable land ownership status, and a larger household size. Thus, farmers in Dan are more proactive and future oriented in evaluating sustainable agriculture.

4.4. Individual and collective sustainable agriculture practices

Fig. 4 summarizes the various sustainable agricultural practices adopted by two farmers groups. The results show that the application of organic fertilizers is the most common individual sustainable agriculture practice in the two farmer groups. Although most farmers in this study are smallholder farmers, whose behavior is characterized by the maximization of the benefits that flow from limited agricultural resources, Naengmut has suffered more serious socio-environmental issues than Dan due to the large-scale planting of cash crops, such as cassava and sugarcane. The impacts of the socio-environmental issues are reflected in their individual farming practices. The resulting practices are divided into the following two types.

(1) Farmers in the two sub-districts focus differently on individual sustainable agriculture practices based on the settings of the farming systems. For example, farmers in Naengmut focus on soil health management (62%), whereas farmers in Dan concentrate on intercropping (55%).

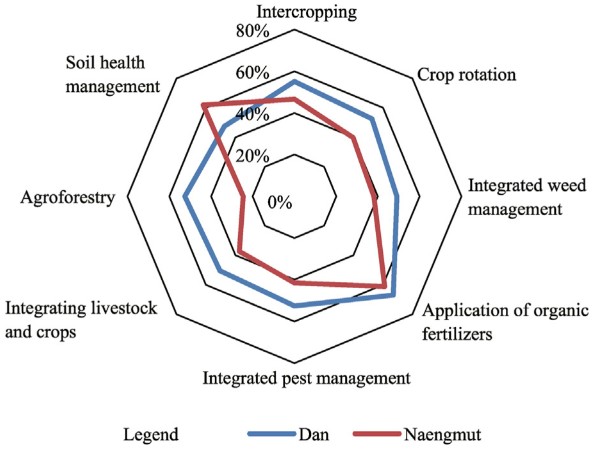

Fig. 4. Sustainable agriculture practices of individual farmers by the percentage of the respondents.

(2) There are significant gaps in the response rates regarding individual sustainable agriculture practices. Moreover, the gap between the individual sustainable agriculture practice response rates between the two sub-districts is considerable. In Dan, approximately 47%–67% of surveyed farmers have undertaken individual farmers' sustainable agriculture practices, whereas only 25%–62% of farmers in Naengmut have performed the same farming practices. The Mann–Whitney test also demonstrates significant differences in the mean value of individual farmers' sustainable agriculture practices, which were calculated from individual scores in the two sub-districts (3.63 (±0.60) in Dan and 3.47 (±0.73) in Naengmut; $U = 5546.50$ $z = -2.705$, $P = 0.007$).

4.4.1. Collective sustainable agriculture practices

The surveyed farmers also emphasize cooperation and interaction within the community, such as participation in social networks, in order to build knowledge and the capacity to cope with the uncertainties of socio-environmental changes (Fig. 5). There is a significant gap between the collective sustainable agriculture practice response rates in Dan and Naengmut. In general, farmers in Dan perform a higher rate (41%–68%) of collective sustainable agriculture than farmers in Naengmut (14%–31%). In addition, the Mann–Whitney test confirms significant differences in the mean value of the collective sustainable agriculture practices, which were calculated from individual scores in the two sub-districts (3.67 (±0.57) in Dan and 2.87 (±0.75) in Naengmut; $U = 2856.00$, $z = -7.852$, $P < 0.001$).

4.4.2. Determinants of individual and collective sustainable agriculture practices

The regression results show that the socio-economic factors affecting individual sustainable agriculture practices include age ($\beta = 0.01$, $P = 0.003$), farming system type ($\beta = 0.27$, $P = 0.006$), education level ($\beta = 0.27$, $P = 0.002$), and awareness of sustainable agricultural policy ($\beta = 0.009$, $P = 0.005$). Farmers may make decisions based on their experience, knowledge, and education (Carney, 1998; Snapp and Pound, 2017). Older farmers seem to have more farming experience and thus are more adaptive when facing changes in marginal agriculture systems. Meanwhile, an extensive farming system (i.e., vegetable farming system) has fewer risks and much more resilience. Farmers who use this system are thus more likely to choose sustainable agriculture practices to balance the investments

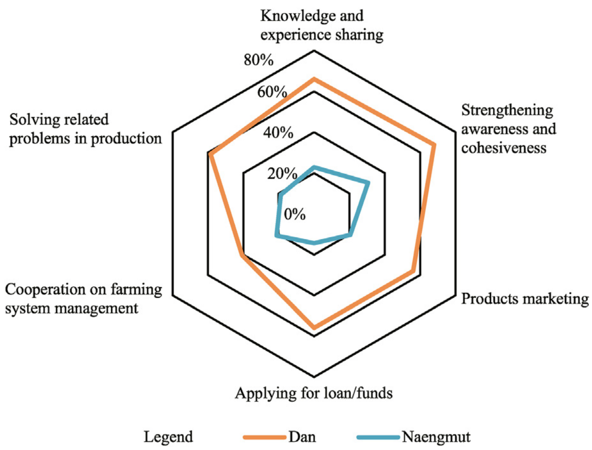

Fig. 5. Collective sustainable agriculture practices by the percentage of the respondents.

Table 4
Coefficients of the independent variables included in the multiple regression models.

Variable	Individual practices			Collective practices		
	β	*t*	*P*	β	*t*	*P*
Constant (α)	1.756	3.216	0.002	−0.740	−1.353	0.178
Age	0.014	2.985	0.003	−0.004	−0.743	0.459
Household size	0.024	0.578	0.564	0.101	2.460	0.015
Farming system	0.270	2.781	0.006	0.218	2.257	0.025
Educational level	0.274	2.340	0.020	0.029	0.254	0.799
Total land size	0.002	0.416	0.678	0.005	1.433	0.154
Total household income	−4.296E–7	−0.841	0.401	1.701E–7	0.340	0.734
Farmers' perceptions of environmental changes	0.090	1.543	0.125	0.167	2.911	0.004
Farmers' perceptions of agricultural institution services	−0.151	−1.434	0.153	−0.205	−1.975	0.050
Farmers' sustainable agriculture knowledge	0.029	0.759	0.449	−0.057	−1.558	0.121
Farmers' sustainable agriculture policy knowledge	0.090	2.829	0.005	0.041	1.274	0.204
Farmers' attitudes towards sustainable agriculture	0.045	0.462	0.645	0.281	2.955	0.004
Individual farmers' sustainable agriculture practices	–	–	–	0.512	7.225	0.000

Note: $R^2_{\text{Individual practices}} = 0.141$; $R^2_{\text{Collective practices}} = 0.398$.

and the risks. In addition, education and knowledge about sustainable agriculture policy enable them to easily adapt to new farming practices because of broader information sources regarding the climate, policy changes, and new agricultural product trends.

The factors that influence collective sustainable farming practices are the household size (β = 0.10, $P = 0.015$), type of farming system (β = 0.22, $P = 0.025$), perceptions of environmental changes (β = 0.17, $P = 0.004$), attitudes towards sustainable agriculture, and individual farming practices (β = 0.51, $P < 0.001$) (Table 4). Farmers who live in larger households and practice vegetable farming are more likely to practice sustainable agriculture collectively. This is contrary to individual sustainable farming behaviors. This might be because small-scale vegetable farming is a type of integrated farming system that requires the wide use of limited resources to increase productivity and reduce damage at the farm level (Jitsanguan, 2001; Joshi and Piya, 2021). A larger household size provides the opportunity for vegetable farmers to work and cooperate collectively at the household level (Kuivanen, et al., 2016).

Our results also confirm that more positive individual practices would increase collective behaviors (Bandura, 1976; Steyaert and Jiggins, 2007; Reed et al., 2010). In this study, farmers have limited resources, thus cooperation with regard to farming practices and management is thus an inherently optimal choice for them. Naziri et al. (2014) confirmed that culture and beliefs also influence farming practices in Vietnamese, where small farmers engage in collective practices to provide safer vegetable production, mainly due to concerns about food safety rather than market forces.

5. Conclusions

The agricultural sector remains a major source of rural livelihood in developing countries. Environmental challenges such as climate change have been and will continue to affect the productivity characteristics of various activities in this sector. The literature suggests a wide array of adaptive development strategies for farmers, including changing crop varieties, changing farm management practices, and implementation of carbon finance activities. However, to reduce their vulnerability to environmental challenges, the worldviews, needs, and cognition of farmers also must be addressed. Recent empirical evidence from various regions confirms this concern.

To address this concern, this study provide an assessment of farmers' knowledge, attitudes, and practices with regard to sustainable agriculture in the context of socio-environmental changes. The results provide evidence that (i) the differences in perceptions, attitudes, knowledge, and behaviors among farmer groups are the results of the interactions between social and environmental changes from multiple processes and multiple scales; and (ii) relationships among farmers' cognition (i.e., perceptions, attitudes, and knowledge), sustainable agriculture practices, and the associated socio-environments are both reciprocal.

Based on the results of this study, the authors suggest that attentions should be paid to multiple approaches to enhance sustainable agriculture practices. Some suggestions are summarized as follows: (i) facilitating and creating spaces for social learning in each farmer group and utilizing these spaces to share and co-produce hybrid knowledge, so as to enhance farmers' awareness of sustainable agriculture; and (ii) developing corresponding sustainable agriculture policies and institutions according to the characteristics (strengths and vulnerabilities) of each farming system.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.regsus.2022.03.005.

References

Adnan, N., Nordin, S.M., Bakar, Z.A., 2017. Understanding and facilitating sustainable agricultural practice: a comprehensive analysis of adoption behaviour among Malaysian paddy farmers. Land Use Pol. 68, 372–382.

Ajzen, I., 1991. The theory of planned behavior. Organ. Behav. Hum. Decis. Process. 50 (2), 179–211.

Ajzen, I., Fishbein, M., 2000. Attitudes and the attitude-behavior relation: reasoned and automatic processes. Eur. Rev. Soc. Psychol. 11 (1), 1–33.

Ali, A., Erenstein, O., 2017. Assessing farmer use of climate change adaptation practices and impacts on food security and poverty in Pakistan. Clim. Risk Manag. 16, 183–194.

Allan, C., Nguyen, T.P.L., Seddaiu, G., et al., 2013. Integrating local knowledge with experimental research: case studies on managing cropping systems in Italy and Australia. Ital. J. Agron. 8 (2), 15. https://doi.org/10.4081/ija.2013.e15.

Andrade, C., Menon, V., Ameen, S., et al., 2020. Designing and conducting knowledge, attitude, and practice surveys in psychiatry: practical guidance. Indian J. Psychol. Med. 42 (5), 478–481.

Bandura, A., 1976. Social Learning Theories. Prentice Hall, New Jersey, p. 247.

Beckford, C., Barker, D., 2007. The role and value of local knowledge in Jamaican agriculture: adaptation and change in small-scale farming. Geogr. J. 173, 118–128.

Berger, P.L., Luckmann, T., 1967. The Social Construction of Reality: A Treatise in the Sociology of Knowledge. Penguin Press, London, p. 240.

Bourdieu, P., 1990. The Logical of Practice. Stanford University Press, California, p. 333.

Carney, D. (Ed.), 1998. Sustainable Rural Livelihoods: what Contribution Can We Make?. Department for International Development of United Kingdom, London, p. 213.

Chapagain, T., Raizada, M.N., 2017. Impacts of natural disasters on smallholder farmers: gaps and recommendations. Agric. Food Secur. 6, 39. https://doi.org/10.1186/s40066-017-0116-6.

Charmaz, K., 2006. Constructing Grounded Theory: A Practical Guide through Qualitative Analysis. SAGE Publications, London, p. 416.

Cofré-Bravo, G., Klerkx, L., Engler, A., 2019. Combinations of bonding, bridging, and linking social capital for farm innovation: how farmers configure different support networks. J. Rural Stud. 69, 53–64.

Cohen, J., 1992. Quantitative methods in psychology: a power primer. Psychol. Bull. 12 (1), 155–159.

Concepción, E.D., Díaz, M., Baquero, R.A., 2007. Effects of landscape complexity on the ecological effectiveness of agri-environment schemes. Landsc. Ecol. 23, 135–148.

Dixon, J., Gulliver, A., Gibbon, D., et al., 2001. Farming Systems and Poverty: Improving Farmers' Livelihoods in a Changing World. World Bank Group, Washington, D.C, p. 420.

Dworkin, S.L., 2012. Sample size policy for qualitative studies using in-depth interviews. Arch. Sex. Behav. 41 (6), 1319–1320.

FAO, 2011. Save and Grow, a Policymaker's Guide to Sustainable Intensification of Smallholder Crop Production. Food and Agriculture Organization of the United Nations, Rome, p. 112.

Fishbein, M., 1963. An investigation of the relationships between beliefs about an object and the attitude toward that object. Hum. Relat. 16 (3), 233–239.

Fukuoka, M., 1978. The One-Straw Revolution. An Introduction to Natural Farming. Review Books, New York, p. 200.

Greider, T., Garkovich, L., 1994. Landscapes: the social construction of nature and the environment. Rural Sociol. 59 (1), 1–24.

Hagquist, C., Stenbeck, M., 1998. Goodness of fit in regression analysis–R2 and G2 reconsidered. Qual. Quantity 32, 229–245.

Hartmann, C., Chinabut, N., 2005. Management of Tropical Sandy Soils for Sustainable Agriculture: "A holistic approach for sustainable development of problem soils in the tropics." [2021-01-14]. https://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers16-03/010066536.pdf.

Harwood, R.R., 1990. A history of sustainable agriculture. In: Edwards, C.A., Lal, R., Madden, P., et al. (Eds.), Sustainable Agricultural Systems. CRC Press, Boca Raton, p. 17.

Hobbs, P.R., Sayre, K., Gupta, R., 2008. The role of conservation agriculture in sustainable agriculture. Phil. Trans. R. Soc. 363 (1491), 543–555.

Hulme, M., 2018. Gaps" in climate change knowledge: do they exist? Can they be filled? Environ. Humanit. 10 (1), 330–337.

Hungerford, H.R., Volk, T.L., 1990. Changing learner behavior through environmental education. J. Environ. Educ. 21, 8–21.

Jitsanguan, T., 2001. Sustainable Agriculture Systems for Small-Scale Farmers in Thailand: Implications for the Environment. Food and Fertilizer Technology Center, Kawana, Japan, 1–11.

Joshi, N.P., Piya, L.N., 2021. Determinants of small-scale commercial vegetable farming among vegetable growers in Nepal. Sage Open. 11 (2). https://doi.org/10.1177/21582440211010168.

Kuivanen, K.S., Alvarez, S., Michalscheck, M., et al., 2016. Characterizing the diversity of smallholder farming systems and their constraints and opportunities for innovation: a case study from the Northern Region, Ghana. NJAS - Wageningen J. Life Sci. 78,, 153–136.

Launiala, A., 2009. How much can a KAP survey tell us about people's knowledge, attitudes and practices? Some observations from medical anthropology research on malaria in pregnancy in Malawi. Anthropol. Matters 11 (1), 1–13.

Leite, S.K., Vendruscolo, G.S., Renk, A.A., et al., 2019. Perception of farmers on landscape change in southern Brazil: divergences and convergences related to gender and age. J. Rural Stud. 69, 11–18.

Lichtfouse, E., 2009. Sustainable Agriculture Reviews 31 (1 edtion). Springer, Berlin, p. 322.

Likert, R., 1931. A technique for the measurement of attitude. Arch. Psychol. 22 (140), 1–55.

Lucas, V., Gasselin, P., van der Ploeg, J.D., 2019. Local inter-farm cooperation: a hidden potential for the agroecological transition in northern agricultures. Agroecol. Sustain. Food Syst. 43 (2), 145–179.

Martellozzo, F., Ramankutty, N., Hall, R.J., et al., 2015. Urbanization and the loss of prime farmland: a case study in the Calgary–Edmonton corridor of Alberta. Reg. Environ. Change 15 (5), 881–893.

McCown, R.L., 2002. Changing systems for supporting farmers' decisions: problems, paradigms, and prospects. Agric. Syst. 74 (1), 179–220.

Meijer, S.S., Catacutan, D., Ajayi, O.C., et al., 2015. The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa. Int. J. Agric. Sustain. 13 (1), 40–54.

Menozzi, D., Fioravanzi, M., Donati, M., 2015. Farmer's motivation to adopt sustainable agricultural practices. Bio Based Appl. Econ. 4 (2), 125–147.

Mireri, C., Atekyereza, P., Kyessi, A., et al., 2007. Environmental risks of urban agriculture in the Lake Victoria drainage basin: a case of Kisumu municipality, Kenya. Habitat Int. 31 (3–4), 375–386.

Moksony, F., 1999. Small is beautiful. The use and interpretation of R2 in social research. Szociológiai Szle, Special Issue 130–138.

Mollision, B., Holmgren, D., 1978. Permaculture One: A Perennial Agriculture System for Human Settlements, vol. 128. Corgi, Melbourne.

Naziri, D., Aubert, M., Codron, J., et al., 2014. Estimating the impact of small-scale farmer collective action on food safety: the case vegetables in Vietnam. J. Dev. Stud. 50 (5), 715–730.

Nguyen, T.P.L., Sean, C., 2021. Do climate uncertainties trigger farmers' out-migration in the Lower Mekong Region? Curr. Res. Environ. Sustain. 3, 100087. https://doi.org/10.1016/j.crsust.2021.100087.

Nguyen, T.P.L., Seddaiu, G., Roggero, P.P., 2014. Hybrid knowledge for understanding complex agri-environmental issues: nitrate pollution in Italy. Int. J. Agric. Sustain. 12 (2), 164–182.
Nguyen, T.P.L., Seddaiu, G., Virdis, S.G., et al., 2016. Perceiving to learn or learning to perceive? Understanding farmers' perceptions and adaptation to climate uncertainties. Agric. Syst. 205–216.
Nguyen, T.P.L., Seddaiu, G., Roggero, P.P., 2019. Declarative or procedural knowledge? Knowledge for enhancing farmers' mitigation and adaptation behaviour to climate change. J. Rural Stud. 67, 46–56.
Petersen, P., Tardin, J.M., Marochi, F., 2000. Participatory development of non-tillage systems without herbcides for family farming: the experience of the center-south region of Paraná. Environ. Dev. Sustain. 1, 235–252.
Petway, J.R., Lin, Y.P., Wunderlich, R.F., 2019. Analyzing opinions on sustainable agriculture: toward increasing farmer knowledge of organic practices in Taiwan-yuanli township. Sustainability 11 (14), 3843. https://doi.org/10.3390/su11143843.
Piboolsravut, P., 2004. Sufficiency economy. ASEAN Econ. Bull. 21 (1), 127–134.
Preiffer, E., 1938. Bio-Dynamic Farming and Gardening: Soil Fertility Renewal and Preservation. Anthroposophic Press, New York, p. 212.
Radale, J.I., 1942. Introduction to organic farming. Org. Farming Gard. 1 (1), 3–5.
Redman, C., Grove, M.J., Kuby, L., 2004. Integrating social science into the long term ecological research (LTER) network: social dimensions of ecological change and ecological dimensions of social change. Ecosystems 7 (2), 161–171.
Reed, M.S., Evely, A.C., Cundill, G., et al., 2010. What is social learning. Ecol. Soc. 15 (4). https://doi.org/10.5751/es-03564-1504r01.
Rigg, J., Salamanca, A., Phongsiri, M., et al., 2018. More farmers, less farming? Understanding the truncated agrarian transition in Thailand. World Dev. 107, 327–337.
Rivera, M., Knickel, K., María Díaz-Puente, J., et al., 2019. The role of social capital in agricultural and rural development: lessons learnt from case studies in seven countries. Sociol. Rural. 59 (1), 66–91.
Roger, E.M., 1995. Diffusion of Innovations. Free Press, New York, p. 576.
Saint Ville, A.S., Hickey, G.M., Locher, U., et al., 2016. Exploring the role of social capital in influencing knowledge flows and innovation in smallholder farming communities in the Caribbean. Food Secur. 8 (3), 535–549.
Snapp, S., Pound, B. (Eds.), 2017. Agricultural Systems: Agroecology and Rural Innovation. Academic Press, London, p. 400.
Steyaert, P., Jiggins, J., 2007. Governance of complex environmental situations through social learning: a synthesis of SLIM's lessons for research, policy and practice. Environ. Sci. Pol. 10, 575–586.
Strauss, A., Corbin, J., 1998. Basics of Qualitative Research. Sage Publications, Thousand Oaks, p. 456.
Šūmane, S., Kunda, I., Knickel, K., et al., 2018. Local and farmers' knowledge matters! How integrating informal and formal knowledge enhances sustainable and resilient agriculture. J. Rural Stud. 59, 232–241.
Supaphol, S., 2010. Status of food safety and food security in Thailand: "Thai's Kitchen to the World.". J. Dev. Sustain. Agric. 5 (1), 39–46.
Taylor, J.G., Stewart, T.R., Downton, M., 1988. Perceptions of drought in the Ogallala aquifer region. Environ. Behav. 20 (2), 150–175.
Tiwana, A., 2008. Do bridging ties complement strong ties? An empirical examination of alliance ambidexterity. Strat. Manag. J. 29 (3), 251–272.
Valente, T.W., Paredes, P., Poppe, P.R., 1998. Matching the message to the process: the relative ordering of knowledge, attitudes, and practices in behavior change research. Hum. Commun. Res. 24 (3), 366–385.
Vandamme, E., 2009. Concepts and Challenges in the Use of Knowledge-Attitude-Practice Surveys: Literature Review, vol. 1. Department of Animal Health. Institute of Tropical Medicine, pp. 1–7.
Velten, S., Leventon, J., Jager, N., et al., 2015. What is sustainable agriculture? A systematic review. Sustainability 7 (6), 7833–7865.
Virapongse, A., Brooks, S., Metcalf, E.C., et al., 2018. A social-ecological systems approach for environmental management. J. Environ. Manag. 178, 83–91.
Vityakon, P., 2007. Degradation and restoration of sandy soils under different agricultural land uses in Northeast Thailand: a review. Land Degrad. Dev. 18 (5), 567–577.
Wessman, W.L., 2006. The Nature of Thought: Maturity of Mind. University Press of America, New York, p. 78.
Wiggins, S., 2011. Thailand's Progress in Agriculture: Transition and Sustained Productivity Growth. Oversees Development Institute, London, pp. 1–30.
World Health Organization, 2008. Advocacy, Communication and Social Mobilization for TB Control: A Guide to Developing Knowledge, Attitude and Practice Surveys. World Health Organization, Switzerland, p. 46.
Zeweld, W., van Huylenbroeck, G., Tesfay, G., et al., 2017. Smallholder farmers' behavioural intentions towards sustainable agricultural practices. J. Environ. Manag. 187, 71–81.