International Journal of Agricultural Technology 2023 Vol 19(4):1939-1952
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Factors affecting decision-making on greenhouse farming and cost-benefit analysis of greenhouse vegetable crops and melons in the northeastern region of Thailand

Wiseansart, A.*

Faculty of Technology, Udon Thani Rajabhat University, Udon Thani, Thailand.

Wiseansart, A. (2023). Factors affecting decision-making on greenhouse farming and cost-benefit analysis of greenhouse vegetable crops and melons in the northeastern region of Thailand. International Journal of Agricultural Technology 19(4):1939-1952.

Abstract Northeastern Thai farmers in three provinces: Udon Thani, Nongkhai and Nong Bua Lamphu stated that healthiness was the foremost factor affecting their decision-making on greenhouse farming. Furthermore, cost and benefit of cultivating greenhouse vegetable crops and melons by these farmers were differently differed. In terms of greenhouse vegetable crop farming, it showed that its averaged total cost was 1,965.50 baht/production cycle, and this cost was divided into the averaged variable cost of 1,561.83 baht/production cycle and the averaged fixed cost of 403.67 baht/production cycle; moreover, its net profit was averaged of 1,060.75 baht/production cycle. In greenhouse melon farming, it indicated that its averaged total cost specified 7,595.50 baht/production cycle was based on the averaged variable cost of 6,521.33 baht/production cycle together with the averaged fixed cost of 1,074.17 baht/production cycle; in addition, its averaged net profit was 6,504.50 baht/production cycle. Comparing these results, cost and benefit of cultivating greenhouse vegetable crops and melons were significantly different at a statistical level of 0.05.

Keywords: Healthiness, High-value plant, Net profit, Revenue

Introduction

The increasing of global warming is caused by the greenhouse effect, e.g. fuel combustion, industrial gas emissions, deforestation and forest burning, and decomposition of organic substance and animal manure (Taranet *et al.*, 2022) brings about the rise of global temperature affecting the climate variability on the rainfall, water resources, the sea level and drought (Jain, 1993). These changes transform agricultural production processes as well as agricultural yields. That means farmers must rely on more technology that helps control factors affecting the plant growth such as sunlight, ventilation, temperature and humidity. Among vaious technology, greenhouse farming is beneficial in this regard.

* **Corresponding Author**: Wiseansart, A.; **Email**: a.wiseansart@gmail.com

The greenhouse farming, as mentioned earlier, is effective in controlling several factors affecting the plant growth (Badji *et al.,* 2022). With the greenhouse farming, farmers are able to cultivate their plants throughout the year, giving higher yields. To reduce the use of pesticides also increases because the greenhouse farming helps mininize insect pests rather than the open field farming (Sookananta *et al.,* 2021). The acquired crop yields, therefore, are safe from the pesticide residues. The greenhouse farming is fruitful in many ways, so promoting it by starting from building a greenhouse should be carried out.

In the northeastern region of Thailand, the greenhouse has become more and more popular nowadays owing to its uncomplicated structure. In other words, farmers are capable of building the greenhouse by themselves. Generally, they use the greenhouse plastic film to cover the greenhouse roof whereas the body of the greenhouse is encycled with an anti-insect net. The greenhouse structure is built from different materials depending on their budget, knowledge and environment. Different greenhouse styles are found: a wooden greenhouse with a wooden structure (Figure 1A), a steel greenhouse with the steel structure (Figure 1B), an evaporative cooled greenhouse with the steel structure equipped with the Evaporative Cooling System (Figure 1C), a greenhouse with a steel roof and cement columns (Figure 1D), and a greenhouse with a wooden roof and cement columns (Figure 1E). Among these greenhouses, the evaporative cooled greenhouse is found the least as the construction cost is so high that it is beyond the farmers' affordability. This kind of greenhouse is built in a university campus or in a huge farm of an agricultural company, mostly focusing on cannabis cultivation (Department of Agriculture, 2021). However, no evidence has demonstrated which greenhouse style is the most popular in the northeastern region of the country.

Figure 1. Greenhouses in the northeastern region of Thailand: (A) a wooden greenhouse; (B) a steel greenhouse; (C) an evaporative greenhouse; (D) a greenhouse with a steel roof and cement columns; (E) a greenhouse with a wooden roof and cement columns

With reference to the greenhouse plants, the farmers in this region prefer cultivating leafy vegetable crops such as cabbage, lettuce, kale, coriander, mint, celery, pak choi and basil. Besides, tomatoes, melons, sweet peppers and grapes are also grown. These greenhouse plants are now in the increasing demand of the consumers who are looking for the foodstuffs that help improve their health and wellness. This increase leads to the expansion of the greenhouse farming use in many ways (Karanisa *et al.*, 2022). First, it helps increase crop yields because the farmers can control the optimal climate for the plant growth as well as cultivate more plants per square foot than the open field farming. Second, it reduces production risks because the plants are in the protected place, so a sudden change of temperature or harmfulness from birds is trivial. Third, it prevents plant diseases and pests due to the enclosed space. Only a few people are allowed to work in the greenhouse, so plant diseases carried by human beings decreases. Last, the plants can be cultivated all year round, not seasonally. These advantages not only inspire the farmers to perform the greenhouse farming in an increasing rate but also encourage them to pay more attention to the consumers' health.

Although the greenhouse farming is advantageous, its cost at the beginning stage is higher than the other kinds of farming (Jaikrajang, 2020). The cost comes from the greenhouse construction including other production such factors as irrigation system and plant pots or planting bags. As a result, the plant selection to cultivate in the greenhouse is the most crucial consideration for the farmers. Formerly, the farmers preferred growing the greenhouse vegetable crops in general. However, nowadays many of them have turned to cultivate melons, and it seems to increase continuously. The objectives were to find out factors affecting the farmers' decision-making on greenhouse farming, and to determine cost and benefits of cultivating greenhouse vegetable crops and melons.

Materials and methods

The experiment was designed as quantitative research and applied a structured interview by making use of questionnaires, descriptive statistics (frequency, percentage, mean and standard deviation) and inferential statistics (t-test) to find out factors affecting the farmers' decision-making on greenhouse farming as well as to determine cost and benefits of cultivating greenhouse vegetable crops and melons. Details of materials and methods were described as the following.

The study area

Udon Thani, Nongkhai and Nong Bua Lamphu are the three northeastern Thai provinces selected as the target areas to be developed in the strategic plan of Udon Thani Rajabhat University. In order to continue to develop these target areas, they were then purposively selected as the study sites of this research.

The population and sample size

Selection of the population and samples was carried out in two phases according to the research objectives. The population and samples in the first phase were for examining factors affecting the farmers' decision-making on the greenhouse farming. In this phase, the population were altogether 180 farmers who did the greenhouse farming, comprising 60 from each of the study sites: Udon Thani, Nongkhai and Nong Bua Lamphu provinces. To select the samples, the Krejcie and Morgan's table (1970) was used, and it showed that the suitable sample size was 123. To achieve the 123 samples, the quota sampling was utilized, and it indicated that 41 farmers of each province were selected as the samples of this phase. Besides, the accidental sampling was also used to acquire the complete samples.

In the second phase, the population and samples were for discovering the cost and benefits of the greenhouse vegetable crops and melons. The population of this phase were like the first phase: the 180 farmers who did the greenhouse farming within the study sites. However, only 24 of them who owned a steel greenhouse with the identical size were purposively selected as the samples of this phase. These samples included 12 farmers owning the greenhouse vegetable crops and 12 owning the greenhouse melons.

Data collection

The data collection was carried out in two phases. The first phase was to explore the factors affecting the farmers' decision-making on the greenhouse farming, and the second phase was to examine the cost and benefits of the greenhouse vegetable crops and melons.

The first phase was collected from November to December of 2021 through face-to-face interviews together with a questionnaire as the research instrument. The questionnaire consisted of two parts: general information of the farmers and factors affecting the farmers' decision-making on the greenhouse farming. The questionnaire was validated by three experts. Then, it was tried out with 30 farmers in an area close to the study sites. The results of the try-out

stage were later examined to determine the reliability. Based on the Cronbach's alpha coefficient, the reliability of the questionnaire was 0.89 which assured that the questionnaire was reliable to use with the 123 samples of this phase.

The second phase was undertaken from January to March of 2022. The face-to-face interviews together with a questionnaire as the research instrument were utilized in this phase. The questionnaire consisted of two parts: general information of the farmers and cost and benefits of the farmers' greenhouse vegetable crops and melons. This phase was completed by 24 farmers, and the obtained data were compared to find which plant was more valuable in terms of the cost and benefits.

Data analysis

Analyzing the obtained data was mostly based on the descriptive statistics. The first part, the general information of the farmers, was analysed by using frequency and percentage. The second part, the factors affecting the farmers' decision-making on the greenhouse farming, was analysed through mean and standard deviation. Because the second part was the five-point Likert scale, the interpretation of the score was as follows.

Score	Scale Limits	Description
5	4.21 – 5.00	Highest
4	3.41 – 4.20	High
3	2.31 – 3.40	Moderate
2	1.80 – 2.30	Low
1	1.00 – 1.79	Lowest

The last part, the cost-benefit analsis of the greenhouse vegetable crops and melons, was analysed through frequency and percentage. Besides, the five formulas (Kay *et al.*, 2016) were also used to achieve the effective results.

The total cost = the total variable cost + the total fixed cost
The total variable cost = the cash variable cost + the non-cash variable cost
The total fixed cost = the cash fixed cost + the non-cash fixed cost
The total revenue = the total products × the selling prices
The net profit = the total revenue – the total cost

Hypothesis testing

Testing the hypotheses was to find differnces between the greenhouse vegetable crops and melons in terms of the total cost, the yields, the prices, the

revenue and the net profit. They were tested and compared by using the independent sample t-test at the statistical level of 0.05. The hypotheses were as the following. H_0 was the average of the total cost, the yields, the prices and the revenue, and the net profit of the greenhouse vegetable crops and melons were not different. H_1 was the average of the total cost, the yields, the prices and the revenue, and the net profit of the greenhouse vegetable crops and melons were significantly different.

Results

General information of the farmers

The results of the general information of the farmers were divided into three parts. The first part was the general information of the farmers in Nongkhai Province. It was found that 22 were female farmers (53.66%) and 19 male farmers (46.34%). In this group, 20 farmers aged between 51 and 60 (48.78%), followed by 15 farmers aged between 41 and 50 (36.59%), 3 farmers aged between 30 and 40 (7.32%), and 3 farmers aged over 60 (7.32%), respectively.

In the second part, the general information of the farmers in Udon Thani Province, it revealed that 26 were female farmers (63.41%) and 15 male farmers (36.59%). Among them, 18 farmers aged between 51 and 60 (43.90%), followed by 14 farmers aged between 41 and 50 (34.15%), 7 farmers aged over 60 (17.07%), and 2 farmers aged between 30 and 40 (4.88%), respectively.

As for the third part, the farmers in Nong Bua Lamphu Province, it showed that 30 were female farmers (73.17%) and 11 male farmers (26.83%). In respect of their age, 20 farmers aged between 41 and 50 (48.78%), followed by 10 farmers aged between 51 and 60 (24.39%), 9 farmers aged over 60 (21.59%), and 2 farmers aged between 30 and 40 (4.88%), respectively.

Factors affecting the farmers' decision-making on the greenhouse farming

The six factors were examined regarding the farmers' decision-making on the greenhouse farming:- the healthiness, the support from the government sectors, the greenhouse effectivenss, the marketing, the revenue, and the cost. The results showed that the farmers of Udon Thani, Nongkhai and Nong Bua Lamphu reported that the healthiness affected their decision-making on the greenhouse farming at the highest level, and the mean scores were 4.68, 4.68 and 4.37, respectively. The support from the government sectors affected the decision-making of the farmers in Nongkhai at the highest level (=4.62),

followed by those in Udon Thani (=4.36) and those in Nong Bua Lamphu (=3.75), respectively. The greenhouse effectiveness affected the decision-making of the farmers in Nongkhai at the higest level (=4.39), followed by those in Udon Thani (=4.22) and Nong Bua Lamphu (=4.11), respectively. The marketing affected the farmers' decision-making in Nongkhai at the highest level (=4.35) whereas those in Nong Bua Lamphu and Udon Thani were 4.06 and 4.05, respectively. The revenue affected the decision-making of the farmers in Nongkhai at the higest level (=4.34), followed by those in Udon Thani and Nong Bua Lamphu with the mean scores of 4.10 and 3.97, respectively. The cost affected the decision-making of the farmers in Nong Bua Lamphu at the highest level (=4.23), and it influenced those in Nongkhai (=4.17) and those in Udon Thani (=3.88), respectively (Table 1).

Table 1. Factors affecting the farmers' decision-making on the greenhouse farming

Variables	Average scores		
	Nongkhai (N = 41)	**Udon Thani (N = 41)**	**Nong Bua Lamphu (N = 41)**
1. The healthiness	Highest (4.68±0.47)	Highest (4.37±0.70)	Highest (4.68±0.55)
1.1 The greenhouse farming reduces the use of insecticide and is safe for the farmers.	Highest (4.75±0.44)	Highest (4.43±0.67)	Highest (4.68±0.53)
1.2 The greenhouse plants are without the insecticide residues and safe for the consumers.	Highest (4.60±0.50)	Highest (4.30±0.72)	Highest (4.68±0.57)
2. The support from the government sectors	Highest (4.62±0.55)	Highest (4.36±0.77)	High (3.75±0.80)
2.1 The farmers acquire knowledge of the greenhouse construction and farming from the government sectors.	Highest (4.60±0.55)	Highest (4.43±0.75)	High (3.85±0.86)
2.2 The farmers acquire agricultural budget and materials from the government sectors.	Highest (4.63±0.54)	Highest (4.28±0.78)	High (3.65±0.74)
3. The greenhouse effectiveness	Highest (4.39±0.60)	Highest (4.22±0.66)	High (4.11±0.73)
3.1 The greenhouse protects different insect pests to get inside and damage the plants.	Highest (4.48±0.54)	Highest (4.28±0.64)	High (4.18±0.78)
3.2 The greenhouse helps the farmers grow the plants in the rainy season.	Highest (4.58±0.59)	Highest (4.43±0.71)	High (4.25±0.71)
3.3 The construction workers in the farmers' community could build and repair a greenhouse.	High (4.10±0.67)	High (3.95±0.64)	High (3.90±0.71)

Table 1. Factors affecting the farmers' decision-making on the greenhouse farming (Cont.)

Variables	Average scores		
	Nongkhai (N = 41)	**Udon Thani (N = 41)**	**Nong Bua Lam Phu (N = 41)**
4. The marketing	Highest (4.35±0.75)	High (4.05±0.80)	High (4.06±0.67)
4.1 The farmers' greenhouse yields are in the market demand.	Highest (4.32±0.81)	High (4.03±0.80)	Highest (4.09±0.70)
4.2 The greenhouse yields give the farmers a better price than the open field yields.	Highest (4.38±0.68)	High (4.07±0.79)	High (4.02±0.64)
5. The revenue	Highest (4.34±0.64)	High (4.10±0.74)	High (3.97±0.79)
5.1 The greenhouse yields give the farmers income throughout the year.	High (4.18±0.71)	High (4.05±0.78)	High (3.85±0.77)
5.2 The greenhouse farming saves space and gives a high return.	Highest (4.50±0.56)	High (4.15±0.70)	High (4.08±0.80)
6. The cost	High (4.17±0.91)	High (3.88±0.78)	Highest (4.23±0.77)
6.1 A greenhouse with cheap construction reduces the cost.	High (3.98±0.95)	High (3.60±0.81)	High (4.07±0.79)
6.2 The greenhouse farming reduces the labor wages and the cost.	Highest (4.35±0.86)	High (4.15±0.74)	Highest (4.38±0.74)

The cost analysis

With reference to the greenhouse vegetable crops, the average of the total cost was 1,965.50 baht, and it was divided into the total variable cost at an average of 1,561.83 baht (79.46%), and the total fixed cost at an average of 403.67 baht (20.54%). Regarding the greenhouse melons, the average total cost was 7,595.50 baht, and this cost came from the total variable cost at an average of 6,521.33 baht (85.86%) and the total fixed cost at an average of 1,074.17 baht (14.14%) (Figure 2).

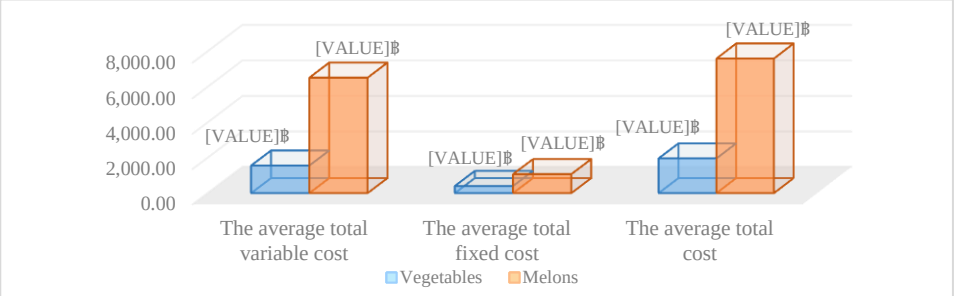

Figure 2. The average total cost of the greenhouse vegetable crops and melons

Details of the cost and the fixed cost of the greenhouse vegetable crops and melons were described elaborately. In terms of the greenhouse vegetable crops cultivated in a steel greenhouse with the same size (4.5 m wide×10 m long×3.3 m high), it revealed that the highest cost was for the harvest labor wage which was 345.83 baht (17.60%), followed by the cost for the soil preparation and planting wage 316.67 baht (16.11%); 280.83 baht (14.29%) for the greenhouse vegetable care; 107.50 baht (5.47%) for the packaging bags; 105.83 baht (5.38%) for the hydrated lime powder; 92.50 baht (4.71%) for the seeds; 58.08 baht (2.95%) for the freight; 57.08 baht (2.90%) for the water; 47.08 baht (2.40%) for the compost; 36.67 baht (1.87%) for the electricity; 36.25 baht (1.84%) for the wood vinegar; 27.5 baht (1.40%) for the black rice husk; 17.09 baht (0.87%) for the cattle manure; 16.67 baht (0.85%) for the chicken manure; and 16.25 baht (0.83%) for the rice husk, respectively. Concerning the fixed cost, it was found that the greenhouse depreciation cost was 345.42 baht (17.57%), and the depreciation of the water pipe system cost was 58.25 baht (2.96%).

The greenhouse melons cultivated in the steel greenhouse with the same size of the vegetable greenhouse showed that the highest cost was the freight which was 1,171.50 baht (15.42%), followed by 810.92 baht (10.68%) for the wage for the greenhouse melon care; 804.17 baht (10.59%) for the seeds; 713.42 baht (9.39%) for the harvest labor wage; 613.17 baht (8.07%) for the soil preparation and planting wage; 337.92 baht (4.45%) for the coco peat; 333.32 baht (4.39%) for the packaging bags; 245.83 baht (3.24%) for the compost; 198.32 baht (2.61%) for the chemical fertilizers; 189.17 baht (2.49%) for the black rice husk; 183.33 baht (2.41%) for the chicken manure; 180.83 baht (2.38%) for the water; 172.50 baht (2.27%) for the cattle manure; 112.08 baht (1.48%) for the pesticides; 109.58 baht (1.44%) for the electricity; 69.17 baht (0.91%) for the hydroponic fertilizers; 62.50 baht (0.82%) for the wood vinegar; 59.58 baht (0.79%) for the biological pesticides; 46.25 baht (0.61%) for the calcium boron hormone; 46.10 baht (0.61%) for the hydrated lime power; 45.42 baht (0.60%) for the peat moss; and 16.25 baht (0.21%) for the rice husk, respectively. In addition, the highest fixed cost was the depreciation of the melon greenhouse which was 566.67 baht (7.46%), followed by 227.50 baht (3.00%) for the water pump depreciation; 184.17 baht (2.42%) for the depreciation of the melon planting equipment and plant pots; and 95.83 baht (1.26%) for the depreciation of the drip irrigation system, respectively.

Results of the benefit analysis

The benefits of the greenhouse vegetable crops and melons per production cycle were interesting. According to the greenhouse vegetable

crops, the average yield was 48.42 kg/production cycle, and the average price was 62.50 baht/kg. In general, the farmers preferred dividing their greenhouse vegetable crops into small bundles for selling in their communities because they could gain a higher retail price. The average retail price was 3,026.25 baht/production cycle, leading to the net profit of 1,060.75 baht/production cycle. On the contrary, the wholesale price for the middlemen gave the farmers a lower price as it was only 20-30 baht/kg. About the greenhouse melons, the average yield was 120 kg/production cycle, and the average price was 117.50 baht/kg. The farmers earned the average revenue of 14,100.00 baht/production cycle and the net profit of 6,504.50 baht/production cycle.

The year-round revenue and net profit the farmers gained from the greenhouse vegetable crops and melons showed that the greenhouse vegetable crops could be cultivated six times/year, bringing about the revenue of 18,157.50 baht/year and the net profit of 6,364.50 baht/year. Additionally, the greenhouse melons could be cultivated three times/year, giving rise to the revenue of 42,300.00 baht/year and the net profit of 19,513.50 baht/year.

Hypothesis testing

The independent sample t-test at the statistical level of 0.05 indicated that the greenhouse vegetable crops and melons in terms of the cost, the yields, the prices, the revenue and the net profit were significantly different ($p<0.05$) (Table 2).

Table 2. Comparison of the cost, the yields, the prices, the revenue and the net profit of the greenhouse vegetable crops and melons

Items	No. of farmers		S.D.	t	P-value
1. The cost					
1.1 The average total cost of the greenhouse melons	12	7,595.50	461.11	41.38	0.00*
1.2 The average total cost of the greenhouse vegetable crops	12	1,965.50	97.32		
2. The yields					
2.1 The average total yields of the greenhouse melons	12	120	15.95	14.63	0.00*
2.2 The average total yields of the greenhouse vegetable crops	12	48.42	5.73		

Table 2. Comparison of the cost, the yields, the prices, the revenue and the net profit of the greenhouse vegetable crops and melons (Cont.)

Items	No. of farmers		S.D.	t	P-value
3. The prices					
3.1 The average total price of the greenhouse melons	12	117.50	15.45	9.99	0.00*
3.2 The average total price of the greenhouse vegetable crops	12	62.50	11.18		
4. The revenue					
4.1 The average total revenue of the greenhouse melons	12	14,100.00	2,588.79	14.36	0.00*
4.2 The average total revenue of the greenhouse vegetable crops	12	3,026.25	636.89		
5. The net profit					
5.1 The net profit of the greenhouse melons	12	6,504.50	2,706.95	6.79	0.00*
5.2 The net profit of the greenhouse vegetable crops	12	1,060.75	630.52		

*P<0.05

Discussion

The six factors affecting the farmers' decision-making on the greenhouse farming and cost-benefit analysis of the greenhouse vegetable crops and melons were investigsated. The healthiness factor affected the farmers' decision-making on the greenhouse farming at the highest level because it reduced the usage of insecticides which safety for the farmers themselves as well as the consumers. This is in line with Jiracheewee *et al.* (2008) who tested the efficiency of hydroponic greenhouses, revealing that a greenhouse having an anti-insect net reduced the usage of chemical pesticides. Chaiubon *et al.* (2020) examining factors influencing the farmers' decision-making on the organic, GAP and chemical rice cultivation in the northeastern region of Thailand found that the health is the most important factor to encourage the farmers to grow the organic and GAP rice at the highest level. The second factor, the support from the government sectors, affected the decision-making of the farmers in Nongkhai and Udon Thani at the highest level. Acquiring the knowledge of greenhouse farming strengthens the farmers' confidence to complete the farming; besides, supporting the materials from the government sectors also reduces the cost of the greenhouse construction. This is consistent with Molkesari *et al.* (2014) who studied the factors affecting the greenhouse owners' performance, showing that a support from the government affected the greenhouse owners on their effectiveness. The greenhouse effectiveness as the third factor was affected the decision-making of the farmers in Nongkhai and Udon Thani at the highest level. The greenhouse prevented the insect pests

from getting inside and damaging the plants, so the farmers were able to cultivate the year-round plants. This is in line with Kürklü *et al.* (2018) who reviewed hydroponic greenhouse cultivation for sustainable agriculture, confirming that the hydroponic greenhouse cultivation not only supported the year-round plant cultivation but also reduced the usage of insecticides.

The fourth factor, the marketing affected the decision-making of the farmers in Nongkhai at the highest level because the greenhouse plants were found to be the consumers' demand, and the greenhouse gave higher yields and prices than the open field plants. This is consistent with Likitswat (2021) who explored opportunities and challenges of developing greenhouse business in the Bangkok metropolitan region, stating that cultivating plants in a greenhouse enables the owners to fix the higher price than the open field plants, particularly in the urban area. The fifth factor as the revenue affected the decision-making of the farmers in Nongkhai at the highest level. It could be explained that greenhouse farming used less cultivated area but gave a higher return; therefore, the farmers can gain the revenue throughout the year. This conforms to Kavga *et al.* (2021) who carried out innovative training on smart greenhouse technologies for economic and environmental sustainability, indicating that a greenhouse is a technology that helped to reduce the production cost but gave high yields and return. It was eco-friendly and reduced a risk from the climate change. The last factor as the cost affected the decision-making of the farmers in Nong Bua Lamphu at the highest level. The highest cost of the greenhouse farming came from building a greenhouse to reduce the cost which was useful for the farmers. Fortunately, Udon Thani Rajabhat University has provided them with some materials, e.g. greenhouse plastic films and anti-insect nets, so the farmers spent less budget completing the remaining of the greenhouse construction. This is in line with Anan-aue (2021) who studied the possibility to invest in smart cultural farms for producing organic vegetable crops in Chiang Rai Province of Thailand, specifying that doing greenhouse farming at the early stage brings about high cost due to the greenhouse construction and irrigation system. Therefore, it would be better if there is an innovation to reduce the cost.

With reference to the cost-benefit analysis of the greenhouse vegetable crops and melons, the greenhouse vegetable crops were firstly mentioned. The average total cost of the greenhouse vegetable crops was 1,965.50 baht, coming from the total variable cost at an average of 1,561.83 baht (79.46%) and the total fixed cost at an average of 403.67 baht (20.54%). The highest variable cost was from the labor wage whereas the greenhouse depreciation was the highest fixed cost. This is consistent with Suttiprasit and Chantuk (2016) who examined the cost and sensibility analysis of hydroponic vegetable business in Bangkok, revealing that the greenhouse contruction and the irrigation system

are the highest cost of the greenhouse vegetable crops. The greenhouse melons was averaged the total cost of 7,595.50 baht which was from the total variable cost at an average of 6, 521.33baht (85.86%) and the total fixed cost at an average of 1074.17 baht (14.14%). In this case, the labor wage was the highest variable cost, and the greenhouse depreciation was the highest fixed cost. This is in line with Sophakham *et al.* (2017) who studied the payback period analysis of cantaloupe cultivation in greenhouse, showing that the labor wage was the highest variable cost while the greenhouse depreciation was the highest fixed cost.

In respect of the net profit, the average yield of the greenhouse vegetable crops was 48.42 kg/production cycle with the average price of 62.50 baht/kg. The farmers gained revenue at an average of 3,026.25 baht/production cycle and the net profit at an average of 1,060.75 baht/production cycle. The average yield in melons was 120 kg/production cycle with the average price of 117.50 baht/kg. The average revenue was 14,100.00 baht/production cycle, and the net profit was 6,504.50 baht/production cycle. This is in accordance with Sodawang *et al.* (2022) who performed a financial analysis of melon production in the lower southern region of Thailand, finding that the average weight of the greenhouse melons was 1.50 kg/melon, and the average price was 155 baht/kg. Based on these data, the greenhouse melons gave a higer return than the greenhouse vegetable crops, and selected the plants that gave high yields and value that should be considered because it may lead to higher benefits and rapid payback. This conforms to Asci and Vansickle (2014) who surveyed the risk in investment decision-making and greenhouse tomato production expansion in Florida, and they found that the risk in cost, prices and yields affected the farmers' decision- making on agricultural investment.

It concluded that the greenhouse melons gave a higer return than the greenhouse vegetable crops. Moreover, the six factors supported from the government sectors, the greenhouse effectivenss, the marketing, the revenue and the cost should be implemented for the farmers' decision-making on the greenhouse farming. The results focused on the greenhouse vegetable crops and melons. Consequently, it would be better to compare other greenhouse plants because it may be useful for database for developing the greenhouse farming in the northeastern region of Thailand.

Acknowledgements

The author would like to offer particular thanks to Udon Thani Rajabhat University for supporting in the local development campaigne indicated in the university's strategic plan. Also, the author would like to thank all the participants who always give useful information and participate in all the activities. Without these persons, this study would not be complete.

References

Anan-aue, P. (2021). Feasibility study of investment in smart agricultural farm to produce organic vegetagles in Chiang Rai Province. Academic Journal Uttaradit Rajabhat University Sceince and Technology (for Local Development), 16:27-39.

Asci, S. and Vansickle, J. J. (2014). Risk in investment decision making and greenhouse tomato production expansion in Florida. International Food and Agribusiness Management Association, 17:1-25.

Badji, A., Benseddik, A., Bensaha, H., Boukhlifa, A. and Hasrane, I. (2022). Design, technology, and management of greenhouse: A review. Journal of Cleaner Production, 373:133753.

Chaiubon, A., Wiseansart, A. and Pensuk, V. (2020). Factors influencing decision making on organic, GAP or chemical rice cultivation of farmers in Ban Nong Sok Dao Subdistrict, Nonsung District, Udon Thani Province. Udon Thani Rajabhat University Journal of Sciencecs and Technology, 8:201-215.

Department of Agriculture (2021). Farmers' handbook: cultivation of cannabis sativa L. for medical and industrial benefits. Bangkok, Office of the Senior Experts, Department of Agriculture, pp.85-87.

Jaikrajang, B., Jitmung, G., Khun-in, J., Suntrarachun, C. and Petkeree, N. (2020). Comparison of revenue and expenses of melon and hydroponic vegetable plantings in greenhouse of agriculturalists in Surat Thani province. Khon Kaen Agricultural Journal, 48:719-726.

Jain, P. C. (1993). Greenhouse effect and climate change: scientific basis and overview. Renewable Energy, 3:403-420.

Jiracheewee, N., Kupawanichpong, W., Chansrakoo, W. and Horasart, V. (2008). Testing on efficiency of hydroponic greenhouses. Thai Agricultural Research Journal, 26:176-189.

Karanisa, T., Achour, Y., Ouammi, A. and Sayadi, S. (2022). Smart greenhouses as the path towards precision agriculture in the food-energy and water nexus: Case study of Qatar. Environment Systems and Decisions, 42:521-546.

Kavga, A., Thomopoulos, V. and Pantelis, B. (2021). Research on innovative training on smart greenhouse technologies for economic and environmental sustainability. Sustainability, 13:1-22.

Kay, R. D., Edwards, W. M. and Duffy, P. A. (2016). Farm management (8th ed.). McGraw-Hill Education: New York, pp.152-170.

Krejcie, R. V. and Morgan, D. W. (1970). Determining sample size for research activities. Educational and Psychological Measurement, 30:607-610.

Kürklü, A., Ghafoor, A., Khan, F. A. and Ali, Q. (2018). A review on hydroponic cultivation for sustainable agriculture. International Journal of Agricultural Environment and Food Sciences, 2:59-66.

Likitswat, F. (2021). Urban farming: Opportunities and challenges of developing greenhouse business in Bangkok metropolitan region. Future Cities and Environment, 7:8.

Molkesari, E. F., Allahyari, M. S. and Amirteimoori, A. (2014). Factors effecting greenhouse owners' performance. International Journal of Vegetable Science, 20:329-339.

Sodawang, T., Kiatpathomchai, S. and Thongrak, S. (2022). Financial analysis of melon production in lower southern region of Thailand. Economics and Business Administration Journal Thaksin University, 14:43-62.

Sookananta, B., Pusayatanont, M., Camharn, T., Pisurach, N. and Chaothai, A. (2021). Development of greenhouse and monitoring system using IoT. Journal of Engineering and Innovation, 14:132-143.

Sophakham, S., Surkee, A., Seerakhun, P., Wiangngoen, K. and Wiseansart, A. (2017). Payback period analysis of cantaloupe cultivation in greenhouse. Khon Kaen Agriculture Journal, 45:1430-1435.

Suttiprasit, N. and Chantuk, T. (2016). Cost and sensibility of hydroponic vegetable business in Bangkok. Veridian E-Journal, Silpakorn University, 9:1627-1638.

Taranet, P., Phophan, P. and Hlaporm, K. (2022). Role of biochar in soil carbon sequestration and mitigation of greenhouse gases emission in agricultural land. Khon Kaen Agricultural Journal, 50:1233-1253.

(Received: 4 October 2022, accepted: 27 May 2023)