MAFF
Ministry of Agriculture,
Forestry and Fisheries

Report

on

Project for Supporting Agricultural Survey on Promoting Sustainable Agriculture in ASEAN Region (SAS-PSA)

(Thailand)

Submitted by

Center for Agricultural Information

Office of Agricultural Economics

31 August 2021

Contents

Abstract

Sustainable Development is universally a multi-dimensional concept. The 2030 Agenda for sustainable development provides the prototype to end poverty, protect the planet and promote peace and prosperity to everyone. To achieve the Sustainable Development Goals (SDGs) indicator 2.4.1 in Thailand, the Center for Agricultural Information (CAI), Office of Agricultural Economics (OAE), Thailand is in collaboration with the ASEAN Food Security Information System (AFSIS) proposed the project for Supporting Agricultural Survey on Promoting Sustainable Agriculture in ASEAN Region (SAS-PSA). This project is aimed at developing an appropriate survey method for data collection, conducting a pilot survey in sub-national area and analyzing survey data. A questionnaire rectified and associated with agricultural contexts in Thailand was applied in a survey. The valid sample size was 135 and the statistical techniques suggested by FAO have been used in the analytical process.

The empirical results are as the following: characteristics of respondents represent that the majority of respondents have become an aging community. No gender discrimination and illiterate person were reported. Most of them acquire legal possession and tenure rights in land as well as internet access. The economics dimension comprehended land productivity, profitability, and resilience. Although the agricultural holdings can sustain their livelihood income-generation mechanism and be adjustable to market volatility and natural shocks, the critical improvement should focus on land productivity. Another key finding is that the environments are weakening due to the inappropriate uses of pesticides and ineffective biodiversity management. The social dimensions would probably be considered as an inconsequential concern since food security, food security under the spreading of COVID-19, and tenure rights themes achieve desirable and acceptable criteria. However, some possible risks may arise for unskilled labors in the future.

Future research suggestions include; 1) the double sampling design and stratification technique are crucial for future farming survey, 2) the appropriated sample size and the important cash crops are also essential to capture the actual picture of the agricultural sector in Thailand, 3) the questionnaire should be simplified and covered all agricultural activities in Thailand contexts so that it will not put a burden on both enumerators and respondents, 4) some sub-indicators can be obtained through agricultural census done by National Statistical Office, 5) the discussion on the inclusion of aquaculture sector in the questionnaire should be done for the completion of future agricultural survey.

Chapter 1 Introduction

1.1 Background

The Sustainable Development is a multi-dimensional concept in all global development initiatives. The concept highlights the economic growth, social developments, and environmental protection for future generations. In 2015, the Sustainable Development Goals (SDGs) are ratified as a universal call to end poverty, protect the planet and promote peace and prosperity to everyone by the year 2030. In order to reach the goals and targets in a 15-years plan as a part of the 2030 Agenda for Sustainable Development (Agenda 2030), the UN Member States adopted the 17 Sustainable Development Goals, accordingly. They are (1) No Poverty, (2) Zero Hunger, (3) Good Health and Well-being, (4) Quality Education, (5) Gender Equality, (6) Clean Water and Sanitation, (7) Affordable and Clean Energy, (8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure, (10) Reducing Inequality, (11) Sustainable Cities and Communities, (12) Responsible Consumption and Production, (13) Climate Action, (14) Life Below Water, (15) Life On Land, (16) Peace, Justice, and Strong Institutions, (17) Partnerships for the Goals.

The custodian and contributing agencies are responsible for SDG indicators, the lead to manage and coordinate the report on behalf of the stakeholders by providing technical assistance for countries to demonstrate the availability and management of databases for global reporting. FAO was allocated custodianship of 21 SDG indicators including indicators 2.4.1 and 12.3.1 which measure sustainable agriculture and food loss, subsequently, the Thai Ministry of Agriculture and Cooperatives (MOAC) is responsible for those two indicators. As a result, the request for technical assistance from FAO for SDG indicators 12.3.1 and 2.4.1 were made via FAO's Technical Cooperation Programme (TPC) in 2021.

SDG indicator 2.4.1 Proportion of Agricultural Area under Productive and Sustainable Agriculture measures the three distinct dimensions of sustainability: environmental, economic, and social. It observes 11 themes on land productivity, profitability, resilience, soil health, water use, fertilizer pollution risk, pesticide risk, biodiversity, decent work, food security, and land tenure. However, a recent prominent report suggested that one of the most urgent targets was SDG indicator 2.4.1 (Chon et al, 2018). In order to improve this target, the Center for Agricultural Information is in collaboration with the ASEAN Food Security Information System (AFSIS) proposed the project for Supporting Agricultural Survey on Promoting Sustainable Agriculture in ASEAN Region (SAS-PSA) for the achievement of SDGs indicator 2.4.1. This project will develop the method for data collection using reliable statistics to tackle agricultural productivity improvement and promotion of agricultural sustainability and the required results will be implemented as substantiating data for decision making. This project, therefore, will support and strengthen the AFSIS's activities which contribute to monitoring the food security situation throughout the ASEAN region for providing accurate and comparable agricultural statistics data collection using a unified survey method.

1.2 Objective

1.2.1 to develop an appropriate survey method for data collection related to SDG indicator 2.4.1.
1.2.2 to analyze and to understand the SDG indicator 2.4.1.
1.2.3 to conduct a pilot survey in a sub-national area.

1.3 Scope of Study

The targeted area is Chachoengsao Province where the variances of Agricultural activities and the vicinity of the area are taken into consideration.

1.4 Timeframe

1.4.1 Period of the project: October 1st, 2020 to August 31st, 2021 (11 months)[1]

1.4.2 Period of the study: December 1st, 2020 to August 31st, 2021 (9 months)

1.5 Definition of Terms

1.5.1 Farmer One refers to the digital agricultural database. It primarily provides Government Integration for the efficacy of data management. Registrational data set from various sources is in the newly Agriculture Data Exchange standard dataset: ADX dataset which is ground under the Data Governance for Government.

1.5.2 Project for Supporting Agricultural Survey on Promoting Sustainable Agriculture in ASEAN Region (SAS-PSA) is known as the project which is advocated by the Ministry of Agriculture, Forestry and Fisheries (MAFF) through the AFSIS project for supporting and promoting sustainable agriculture under SDG indicator 2.4.1 during 2020 – 2022.

1.5.3 Coronavirus (COVID-19), according to the World Health Organization (WHO), is an infectious disease caused by a newly discovered coronavirus.

1.6 Methodology

1.6.1 Data Source Type This research uses two sources of data: 1) quantitative data is analyzed using calculable statistical methods, 2) qualitative data is expressed through descriptive analysis and categorization.

1.6.2 Data Collection Method

1) The study employs the paper-based survey using the questionnaire as a research instrument. This questionnaire has been rectified and associated with agricultural practices in ASEAN and the exceptional circumstance of the COVID-19 pandemic.

2) The data collection 2.1) sampling frame is predicated from Farmer One. 2.2) the planned sample size is 240 samples, 169 samples of questionnaires collected, 135 samples of valid responses.

3) After acquiring the sample size, the data collection conducts via personal interview using a simple random sampling method.

4) Data analysis process, the data is to be evaluated by analysts using statistical techniques via excel and R program.

1.6.3 SDG indicator 2.4.1 Proportion of Agricultural Area under Productive and Sustainable Agriculture captures 3 dimensions of sustainable production: Economic, Environmental, and Social. FAO initiated a process of methodological development that involved 11 themes and sub-indicators. These sub-indicators for tackling the SDG indicator 2.4.1 are as follows;

[1] **Remark:** The initially plan was October 1, 2020 to June 30, 2021. However, the project period was postponed to August 2021 as the project implementation in Thailand was affected by the COVID-19 pandemic.

Figure 1 three dimensions of sustainable production: Economic, Environmental, and Social

No.	Theme	Sub-indicator
1	Land productivity	Farm output value per hectare
2	Profitability	Net farm income
3	Resilience	Risk mitigation mechanisms
4	Soil health	Prevalence of soil degradation
5	Water use	Variation in water availability
6	Fertilizer pollution risk	Management of fertilizers
7	Pesticide risk	Management of pesticides
8	Biodiversity	Use of biodiversity-supportive practices
9	Decent employment	Wage rate in agriculture
10	Food security	Food insecurity experience scale (FIES)
11	Land tenure	Secure tenure rights to land

Note. The table is reprinted from SDG Indicator 2.4.1 – Proportion of agricultural area under productive and sustainable agriculture, by FAO, 2020a.

In this study, the sustainability criteria and thresholds will be applied which the results of each sub- indicator are presented as - Desirable (green) , - Acceptable (yellow) , and - Unsustainable (red).

1.7 Outcomes

1.7.1 Survey method for SDGs Indicator 2.4.1. and a prototype of SDGs indicator 2.4.1 at the national level.

1. 7. 2 Supporting data for academic and policy making communities and sharing experiences on the agricultural survey to all stakeholders.

1.7.3 Presentation and publication of the empirical results on the survey through the Project for Supporting Agricultural Survey on Promoting Sustainable Agriculture in ASEAN Region (SAS-PSA) in the relevant meetings and on the AFSIS website.

1. 7. 4 This reliable statistics data which is available, accessible, transparent, and used for supremacy decision making is essential for the successful implementation of Agenda 2030.

Chapter 2 Rationale of the project

2.1 Background of Thailand

The agricultural sector has been a major contributor not only to Thailand Economy but also to global communities in terms of providing basic and processed agricultural products. That contribution to Thai economy can be seen by the fact that the Agricultural sector accounts for 5.93 % of the Gross Domestic Product (GDP), (table 2.1), with approximately one-third of Thailand's total workforce engaged in this sector (table 2.2). The agricultural sector has also considerably supplied the domestic and international demand for food and generated exporting incomes. The Thai government has played a critical role in the forefront of augmented productivity by 1) setting up institutions, incorporating international trade agreements, agricultural-related laws and regulations, agricultural product standards, and land development etc. 2) implementing policies for development of profitable and sustainable agriculture and incentives for farmers to adopt new technology and to increase agricultural productivity. 3) providing and ensuring the access of water supply and irrigation for farmers. Concomitant with this trend has been the adoption of a sustainable development scheme which is a desirable implement to achieve agricultural sustainability.

Table 2.1 Gross Domestic Product Chain Volume Measures, 2018-2020

(Million Baht)

Whole Kingdom	2018r	2019p	2020p	%
Agriculture	675,335	671,012	648,092	5.93
Non-Agriculture	10,096,775	10,351,766	9,697,138	94.07
Total	**10,259,939.89**	**10,689,790.22**	**10,932,065.20**	**100.00**

Note. The table was adapted from Gross Domestic Product Chain Volume Measures, by the Office of the National Economic and Social Development Council, 2021.

r: revised

p: preliminary

Table 2.2 Employment by sectors, 2018-2020

(1,000 persons)

Whole Kingdom	2018	2019	2020	%
Agriculture	11,810	11,821	12,168	32.14
Non-Agriculture	25,870	25,793	25,696	67.86
Total	**37,680**	**37,613**	**37,865**	**100.00**

Note. The table was adapted from employment by economic sectors, by National Statistics Office, 2020.

The sustainable development goals in Thailand have substantially become significant after the submission of the UN Partnership Framework or UNPAF 2017-2021 in July 2017. Thailand has shown remarkable effort on the achievement of the Agenda 2030. It can be encouragingly seen that the SDGs goals have been incorporated with the National Strategy at country level (Thailand's 20-Year National Strategy 2018 – 2037). Subsequently, Thailand has expressed the drastic success in SDG 1 eradicating poverty in all forms. However, efforts are

ongoing to facilitate the implementing of national strategy on Eco-friendly development and growth and there will be the necessities for technical cooperation activities on the following goals: SDG1.3 on expanding the reach of social protection; SDG2.3 value of production per labor unit; SDG 2.4 Percentage of agricultural area under sustainable agricultural practices; SDG3.4 tackling non-communicable diseases; SDG 4.1 education for all, with a focus on migrant children; SDG 5.5 advocacy for greater participation of women in political decision making; SDG 8.3 support small to medium-sized enterprises and youth innovation; SDG 8.5 Unemployment rate by sex, age group and disability; SDG 9.5 R&D expenditure as percentage of GDP, etc.

The Aforementioned SDG 2 Zero hunger is still an ongoing activity in South East Asia. The spreading of COVID-19, therefore, has been one of the impediments on the progress of SDG 2. Accordingly, Thailand requires the acceleration of progress on the achievement of SDG 2.the Project for Supporting Agricultural Survey on Promoting Sustainable Agriculture in ASEAN Region has been supported by the Ministry of Agriculture, Forestry and Fisheries (MAFF). Thailand has launched the pilot project under the cooperation of ASEAN Food Security Information System Secretariat and the Center for Agricultural Information (CAI). The CAI serves as administering agricultural data and information services for the country and also as an opportunity for reviewing progress and promoting the assessment of SDG indicator 2.4.1 for the explicit SDG commitments made by Thailand. This pilot project will, subsequently, support and strengthen the ASEAN Food Security Information System (AFSIS) activities as well as provide an applicable survey method for data collection to assess SDG indicator 2.4.1 percentage of agricultural area under sustainable agricultural practices.

2.2 General information of Chachoengsao province

The total land area in Thailand is reported at 51.31 million hectares. Agricultural land is 23.88 million hectares which is responsible for 46.54 % of the total land area, the forestland is 16.40 million hectares which accounts for 31.96% of all land. The other land use is 11.03 million hectares with 21.50% of all land.

Chachoengsao, located in the vicinity of Bangkok province, is in the eastern part of Thailand. Its area is approximately 5,351 km^2 which is ranked as the 40^{th} largest province in Thailand. Chachoengsao province is the target area for this study basically because it gains the reputation of various agricultural practices and eases the quality control of the project. As mentioned earlier, Chachoengsao has highly diversified agricultural activities with particular strength in crops, livestock, and fisheries.These businesses have played distinctively important economic and socio-cultural roles for the well-being of farming households, such as food security, supporting local livelihood household income-generation process, a form of saving, a social status and sources of employment. A recent statistic by the National Statistics Office at the Ministry of Digital Economy and Society reports that, the agricultural production is attributable to just over 4%of the total Gross Provincial Products (GPP) (Table 2.3).

Table 2.3 represents a decline in the share of agricultural production over the particular period shown. In 2019, the agricultural production dropped by 0.80 percent compared with that in 2018.

Table 2.3 Gross Provincial Product Chain Volume Measures by agriculture and non-agriculture, 2017-2019

(Million Baht)

Chachoengsao	2017r	2018r	2019p	%
Agriculture	11,554	11,624	11,531	**-0.80**
Non-Agriculture	240,726	269,166	266,170	**-1.11**
Total	**252,280**	**280,790**	**277,700**	**-1.10**

Note. The table was adapted from Gross Provincial Product Chain Volume Measures, by National Statistics Office, 2021

r: revised

p: preliminary

Table 2.4 Diversification of agricultural production by selected commodities, 2019-2021

(Million Baht)

Chachoengsao	2019	2020	2021	%Δ2021/2020
Crops	8,411	7,398	9,015	**21.85**
Livestock	9,816	13,264	12,932	**-2.51**
Fishery	3,580	3,302	3,532	**6.96**
Forestry	241	246	250	**1.42**
Agricultural services	1,808	1,700	1,787	**5.11**
Total	**23,856**	**25,911**	**27,515**	**6.19**

Note. The table was created from agricultural production, by Office of Agricultural Economics, 2021.

Table 2.4 shows statistics published by the Office of Agricultural Economics of the Ministry of Agricultural and Cooperatives, Thailand that from 2019 – 2021, the agricultural production in the livestock sector makes up a large portion of total GPP in agricultural sector. There has been a dip in the agricultural production for crop sector, starting from 8,411 million baht in 2019 then decreasing to 7,398 million baht in 2020 before increasing rapidly to 9,015 million baht in 2021, but the forest sector, which makes up the least portion of total GPP in the agricultural sector, has seen a remained stable during the similar period.

The livestock species are also of considerable importance for farm families through providing a means of generating income, satisfying household energy requirements, and supporting food supply for consumption of products.

During the last three years, the agricultural production of livestock has reached a peak at 13,264 million baht in 2020, before dropping to 12,932 million baht in 2021, lesser by 2.51 percentage point.

The fishing sector is therefore crucial for socio-economic development in local areas as a contribution for livelihood mechanisms and food resources. The agricultural production of fisheries has seen a steep decline during the past three years. The GPP of the

fisheries sector in 2020 dropped strongly at 3,302 million baht, lesser by 6.96 percentage points compared with 3,532 million baht in 2021.

According to statistics reported by Farmer One, the total farm households pertaining to the agricultural sector in 2021, is 66,283 households and the total farm population is 95,327 people. In examining the farm activities (table 2.5), it is noticeable that the agricultural households operate diversified livelihood systems includes: crops exclusively, crops and livestock, livestock, crop and aquaculture, aquaculture exclusively, crops, livestock and aquaculture, and livestock, aquaculture. The largest portion of the total farm households, 41.27 % falls in crop activity, compared with the smallest portion of that falls in crops, livestock, and aquaculture activities, 2,453 households, the percentage of 3.70.

Table 2.5 Diversification of agricultural activities

(Households)

Chachoengsao	Households							total
	Livestock and aquaculture	Crops, livestock aquaculture	Aquaculture	Crop and aquaculture	livestock	crop and livestock	crops	
Mueang Chachoengsao	126	278	872	1,803	931	722	4,007	**8,739**
Bang Khla	150	280	601	1,217	429	315	1,748	**4,740**
Bang Nam Priao	64	390	129	519	1,710	2,935	5,604	**11,351**
Bang Pakong	118	86	1,395	276	380	141	365	**2,761**
Ban Pho	248	298	774	563	480	180	648	**3,191**
Phanom Sarakham	18	90	110	277	974	1,357	5,220	**8,046**
Ratchasan	21	86	87	174	260	538	1,378	**2,544**
Sanam Chai Khet	1	57	4	140	672	1,345	8,249	**10,468**
Plaeng Yao	2,714	674	34	691	66	10	33	**4,222**
Tha Takiap	6,713	154	4	642	99	2	29	**7,643**
Khlong Khuean	1,540	60	193	186	512	12	75	**2,578**
Total	**11,713**	**2,453**	**4,203**	**6,488**	**6,513**	**7,557**	**27,356**	**66,283**

Note. The table was reprinted from number of households registered by Farmer One, 2020.

The irrigation system is widely used in Chachoengsao. Surface and ground water resources are available for public consumption. The surface water resources are categorized into 1. The irrigation area contributes to 0.15 million hectares and 2. the reservoirs and natural water resources are amount to 6,588.8 hectares. A substantial river is Bang Pakong river, while the subsurface water consists of 663 artesian wells.

Agriculture's share in land use

In consideration of the total land in 2019, Chachoengsao had 0.53 million hectares (OPSMOAC, 2019). Total agricultural land was 0.31 million hectares, making up 57.52% of the total amount of land, the forestland was 0.08 million hectares, 15.43% of the total land use. Other land use was 0.14 million hectares with 27.05% of the total land.

Table 2.6 diversification of agricultural land utilization, 2017-2019

(Hectares)

Chachoengsao	2017	2018	2019	%Δ2019/2018
Paddy land	122,111	122,200	122,214	**0.01**
Upland field crop	83,362	83,325	83,273	**-0.06**
Fruits and Perennial trees	42,689	42,718	42,687	**-0.07**
Vegetable, Cut flowers and Ornamental plant	3,171	3,224	3,222	**-0.06**
Fishery*	19,904	24,695	29,381	**18.98**
Others	36,485	31,706	26,996	**-14.85**
Total agricultural land	**307,772**	**307,867**	**307,773**	**-0.03**

Note. The table was adapted from agricultural data, by Office of Agricultural Economics, 2021

Source: * Department of Fisheries, 2021

Table 2.6 shows the total agricultural area that remained stable during the three-year period. The proportion of land grown rice slightly increased by 0.01 percentage points between 2018-2019, likewise, the proportion of land cultured aqua-animals rose rapidly by 18.98 percent points during the same period. However, the percentage of planted land reporting cultivated field crops inconsiderably declined of 0.06 percent during the particular period, as well as, the rest also experienced a marginal diminishing trend.

Table 2.7 diversification of planted and cultured areas by selected commodities, 2018-2020

(Hectares)

Rank	Commodities	Planted area			
		2018	2019	2020	%Δ2020/2019
1	Rice	101,163	97,519	97,573	**0.05**
2	Cassava	34,239	34,469	35,146	**1.97**
3	Rubber	32,272	34,616	33,529	**-3.14**
4	Oil palm	5,310	5,897	6,240	**5.82**
5	Penaeus vannamei	3,399	3,716	3,733	**0.45**
6	Jumbo Tiger Prawn	53	38	39	**1.67**
7	Nile Tilapia	2,197	2,290	2,267	**-1.02**
8	Walking catfish	131	132	129	**-2.31**

Note. The table was adapted from agricultural data, by Office of Agricultural Economics, 2021

Table 2.7 represents the largest proportion of cultivated area in rice which slightly increased from 95,519 hectares in 2019, to 97,573 hectares in 2020, a rise of 0.05 percentage points, similar trends can be seen in Cassava and Oil palm. However, Rubber has experienced a significant drop in cultivated area over the particular period, the area plunged steadily from 34,616 hectares in 2019 to 33,529 hectares in 2020, a drop of 3.14 percentage points.

In 2020, The total land use for Vannamei climbed slightly to 3,733 hectares higher by 0.45 percent from 3,716 hectares in 2019, similarly, an upward trend can be seen in Jumbo Tiger Prawn.

In examining the production, table 2.6 reveals the total production for rice dropped constantly to 352,499 tons in 2020, by 6.49 percent from 376,965 tons in 2019. In addition, two crops, cassava and rubber, also underwent a steep decline in production from 833,373 tons and 33,964 tons in 2019 to 785,894 tons and 31,857 tons in 2020, respectively.

The most prominent breeds of livestock raised in this particular area are swine, broiler, layer hens, and cattle. The total production for broiler rises enormously to 49,118,873 heads, higher by 8.77 percentage points from 45,160,098 heads in 2019. Cattle production met a sharp rise during the same year. While the others were in the contracting trend.

The most well-known species of fish cultured in Chachoengsao are Penaeus vannamei, Jumbo Tiger prawn, Nile tilapia, and walking catfish. The total production for Jumbo Tiger Prawn steadily rose to 270 tons, higher by 7.57 percentage points from 251 tons in 2019. Whereas, Vannamei, Nile tilapia, and walking catfish production experienced a significant reduction, lesser by 4.21, 2.15 and 4.03 percentage points, respectively during the same year.

Table 2.8 diversification of production by commodities, 2018-2020

Commodities	**Production**			
	2018	**2019**	**2020**	**%Δ2020/2019**
Rice (ton)	406,957	376,965	352,499	**-6.49**
Cassava (ton)	713,794	833,373	785,894	**-5.7**
Rubber (ton)	32,828	33,964	31,857	**-6.2**
Oil palm (ton)	50,635	55,353	58,134	**5.02**
Swine (Head)	588,444	619,975	606,657	**-2.15**
Broiler (Head)	46,081,732	45,160,098	49,118,873	**8.77**
Hen eggs (100 Units)	27,162,909	27,110,302	26,674,598	**-1.61**
Cattle (Head)	5,495	5,662	6,341	**11.99**
Penaeus Vannamei (ton)	24,803	27,767	26,598	**-4.21**
Jumbo tiger prawn (ton)	268	251	270	**7.57**
Nile Tilapia (ton)	7,113	7,441	7,281	**-2.15**
Walking catfish (ton)	1,599	1,614	1,549	**-4.03**

Note. The table was adapted from agricultural data, by Office of Agricultural Economics, 2021

Table 2.8 illustrates the changes in price during the three-year period. The price of key commodities increased by approximately 2 – 12 percentage points between 2019 and 2020. However, the price of two commodities (cassava broiler Nile tilapia and walking catfish) experienced a negative trend during the same period.

Table 2.9 diversification of price by agricultural commodities, 2018-2020

Price at farmgate	2018	2019	2020	%Δ2020/2019
Rice (Baht/ton)	7,734	7,609	8,492	**11.60**
Cassava (Baht/kg.)	1.81	2.15	1.79	**-16.74**
Rubber (Baht/kg.)	42.86	44.59	48.43	**8.61**
Oil palm (Baht/kg.)	2.87	2.39	4.16	**74.06**
Swine (Baht/kg.)	60.21	69.67	77.53	**11.28**
Broiler (Baht/kg.)	33.84	36.73	34.95	**-4.85**
Hen Eggs (Baht/100 units)	264.00	278.00	286.00	**2.88**
Cattle (Baht/head)	32,037	30,687	31,405	**2.34**
Penaeus Vannamei (Baht/kg.)	155.00	153.00	156.00	**1.96**
Jumbo Tiger Prawn (Baht/kg.)	291.90	304.53	381.67	**25.33**
Nile tilapia (Baht/kg.)	32.67	36.85	35.74	**-3.01**
Walking catfish (Baht/kg.)	27.31	32.76	31.00	**-5.37**

Note. The table was adapted from agricultural data, by Office of Agricultural Economics, 2021

Having determined gross value production, it is worth to point out that a Penaeus Vannamei, livestock, rubber, and oil palm are substantial contributions to small-scale food producer economy, according to table 2.10, the gross value production of all those have shown an upward direction between 2018 and 2020 shown. Whereas, rice and Jumbo tiger prawn has undergone a rapid dip in gross value production during the same period.

Table 2.10 diversification of gross value production by selected commodities, 2018-2020

(Million Baht)

Rank	Commodities	2018	2019	2020	%Δ2020/2019
1	Penaeus Vannamei	3,292.36	3,553.27	3,639.32	**2.42**
2	Swine	2,905.28	3,541.88	3,856.80	**8.89**
3	Rice	3,147.41	2,868.33	2,993.42	**4.36**
4	Broiler	1,964.85	2,090.00	2,163.05	**3.50**
5	Rubber	1,407.01	1,514.45	1,542.83	**1.87**
6	Cassava	1,291.97	1,791.75	1,406.75	**-21.49**
7	Hen Eggs	717.10	753.67	762.89	**1.22**
8	Nile tilapia	448.53	527.40	506.29	**-4.00**
9	Oil palm	145.32	132.29	241.84	**82.80**
10	Cattle	176.04	173.75	199.14	**14.61**
11	Jumbo Tiger Prawn	97.20	73.09	93.13	**27.42**
12	Walking catfish	22.31	26.96	24.92	**-7.56**

Note. The table was calculated by production multiply by average price in the particular year, by Center for Agricultural Information, 2021.

Chapter 3 Methodology

3.1 Survey Method

3.1.1 Observational units and target population

Thailand has some distinctive characteristics in the matter of agriculture as it is extremely competitive, diversified and professional, for example, Thailand is a leading rice exporter, in addition, poultry farms and hog enterprises navigate domestically and internationally demand .Undoubtedly, the country has various farming systems .Although the SDG 2.4.1 indicator is designed to measure three dimensions in relation to sustainability at the national level, the pilot project was primarily conducted in a selected area) Chachoengsao Province .(The observational unit focused on farming households and target population is household exclusively . This project has been done as a comprehensible project for data collection and the development of a survey method.

3.1.2 Sampling units and frame

The sampling unit is an individual household pertaining to agricultural activities.

The sampling frame is an agricultural household registered. The frame is predicated from Farmer One which reports the list of agricultural households. This list comprehends the necessary information to characterize the holding, for example, name, address, planted area, title document of farmers, and etc. The sample selection is based on specific random sampling.

3.1.3 Sample size

The sample size in this study was determined at the meeting by the Center of Agricultural Information (CAI) and the Japanese expert. The sample size was 240 agricultural households. 169 samples of questionnaires collected, 135 samples of valid responses.

3.1.4 Sampling design

The sampling design for Agricultural households began after obtaining the agricultural database from Farmer One, the multistage sampling technique was applied in this survey to identify the farming households. Four-stage were taken into consideration as follows.

At the first stage, ranking the first five districts where the number of farmers is substantially high using proportional to size sampling. Five districts which are Phanom Sarakham, Sanam Chai Khet, Bang Nam Priao, Ban Pho, and Mueang Chachoengsao.

At the second stage, choosing one sub- district from an individual district using specific sampling where it has the maximum number of farmers. Five sub- districts are Ban Song, Tha Kradan, Mon Thong, Bang Toei, Sip Et Sok.

At the third stage, simple random sampling is used in order to get the number of villages in each sub-district.

Lastly, the four to six households per village are applied. Households are selected by simple random sampling. The total number of samples is classified as following: 66 farmers in Ban Song, 62 farmers in Tha Kradan, 44 farmers in Mon Thong, 39 farmers in Bang Toei, and 29 farmers in Sip Et Sok. Therefore, these stages have excluded the out- of- scope sample in this survey (Figure 3.1).

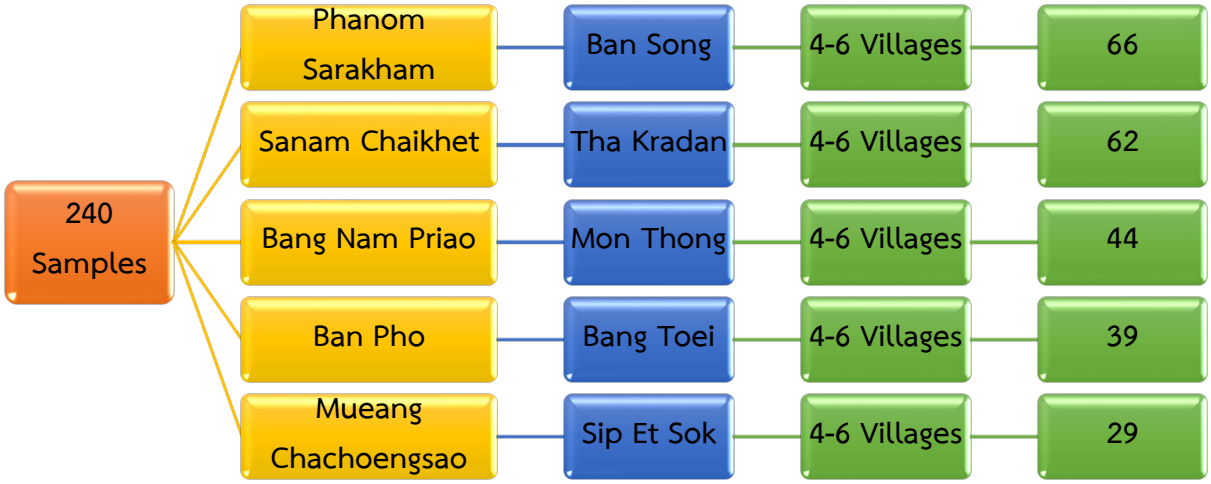

Figure 3.1 multistage sampling for agricultural households

3.1.5 Sample allocation

There are 10 enumerators are assigned to collect data from 240 agricultural households and a supervisor is deputed to monitor and supervise the data collection of 2 enumerators within 7 – 9 villages. The length of time spent on each questionnaire was one hour. For the convenience of the operational issue, a total of 169 questionnaires for farming households were administered during the survey.

3.2 Action Plan and Actual Activities

3.2.1 Action plan

Table 3.1 action plan for farm survey

Activities	Month
1. Sampling Design	December 2020
2. Field Survey	
- Training for enumerators	December 2020 - January 2021
- Field survey	December 2020 - March 2021
3. Tabulating and editing data	April 2021
4. Analyze data	May - July 2021
5. Data Analysis Training	May 2021
6. Draft report	June- July 2021
7. Wrap-up Meeting	July 2021
8. Final Report	August 2021

3.2.2 Actual Activities

Table 3.2 actual plan and activities for farm survey

Activities	Month
1. Sampling Design	Consultative Meeting on 23rd November 2020
2. Field Survey	
- Training for enumerators	23rd December 2020
- Review and discussion	13rd January 2020
- Field survey	24th-29th December 2020
- Field survey	15th-21th March 2021
3. Tabulating and editing data	
- Data entry training	25th February 2021
4. Data Analysis	
- Data Analysis Training	6th May 2021
- Calculation platform created by the Japanese expert	April - May 2021
- Training for data analysis by FAO	28th June – 1st July 2021
- Analysis	May - July 2021
5. Draft report	June - August 2021
6. Wrap-up Meeting	August 2021
7. Final Report and Financial submission	August 2021

Table 3.1 and 3.2 show the action, actual plan and activities done by the CAI for the SAS-PSA. The sampling design has been assigned on 23rd November 2020 at the consultative meeting. The pilot survey, the training for enumerators, and training for key-in activity have done accordingly in four months' time (December 2020 – March 2021). The analysis includes training for data analysis and creation of program R have done during April – May. The draft report has been released during June – August 2021. Finally, the wrap-up meeting and the final report will be held in August 2021.

3.2.3 Activity Logistics

1) Consultative Meeting
Date: 23rd November 2020
Time: 1.30 p.m. – 4.30 p.m.
Meeting venue: Center for agricultural information meeting room
Attendees: 23 persons
Meeting purpose: Discussion for further planning of the SAS-PSA project implementation in Thailand.
Meeting document: Presentation of details of the SAS-PSA project and Chachoengsao Province

Meeting Agenda:

Item	Topic	Presenter
1	**Introduction**	Deputy Secretary General, Office of Agriculture Economics (OAE)
2	**Matter of Report** 2.1 Background of the SAS-PSA project	 CAI
3	**Matter of Consideration** 3.1 Target province of a pilot survey 3.2 The population and observation 3.3 Questionnaire and type of questionnaire 3.4 Enumerator training and Data Analysis training 3.5 Fields survey 3.6 Program for tabulate and analyze results of pilot survey	 CAI CAI AFSIS Secretariat and the Japanese Expert AFSIS Secretariat and the Japanese Expert CAI Japanese Expert
4	**Other Matters**	

2) Training for enumerators
Date: 23rd December 2020
Time: 9.00 a.m. – 4.30 p.m.
Meeting venue: Center for agricultural information meeting room
Attendees: 23 persons
Meeting Materials: SDG 2.4.1 Questionnaire and Enumerator Manual (Thai Version)
Training purpose: In order to clarify an overview of concept and purpose of each question to ensure that all enumerators have a clear understanding on questions response code applying the SDG indicator 2.4.1 method based on FAO Survey Module.

3) Field survey (1st enumerator group)
Date: 24th -29th December 2020
Location: Sanam Chai Khet district, Chachoengsao province
Number of surveyors: 2 enumerators (2 officials from Regional Office of Agricultural Economics 6: ROAE6)
Number of appointments with farmers: 31 farmers
Requirement: 1 car, 6 days/5 nights
Surveying instruments: Questionnaires and Manual of enumerator

4) Reviewing and discussion on a pilot survey of 1st Enumerator group
Date: 13rd January 2021
Time: 9.30 a.m. – 12.00 p.m.
Meeting venue: Agricultural Economics Operation Center meeting room
Attendees: 22 persons

Virtual Meeting organizer: The CAI staff hosted and organized a meeting through Zoom program
Meeting Equipment: Projector (To communicate with remote participants)
Meeting Materials: Questionnaire, Enumerator Manual, Comments of enumerators
Meeting purpose: To share field survey experiences of the 1st Enumerator group (2 officials from Regional Office of Agricultural Economics 6: ROAE6) in Sanam Chai Khet district, Chachoengsao province on 24-29 December 2020 and discuss on any issue occurs during a survey to enhance a pilot survey of other group of enumerators.

5) Field survey (2nd enumerator group)
Date: 15th -21st March 2021
Location: Mueang and Ban Po district, Chachoengsao province
Number of surveyors: 2 enumerators from Center for Agricultural Information
Number of appointments with farmers: 41 farmers
Requirement: 1 car, 7 days/6 nights
Surveying instruments: Questionnaires and Manual of enumerator

6) Field survey (3rd enumerator group)
Date: 15th -20th March 2021
Location: Phanom Sarakham district, Chachoengsao province
Number of surveyors: 2 enumerators from Center for Agricultural Information
Number of appointments with farmers: 33 farmers
Requirement: 1 car, 6 days/5 nights
Surveying instruments: Questionnaires and Manual of enumerator

7) Field survey (4th enumerator group)
Date: 15th -20th March 2021
Location: Phanom Sarakham district, Chachoengsao province
Number of surveyors: 2 enumerators from Center for Agricultural Information
Number of appointments with farmers: 33 farmers
Requirement: 1 car, 6 days/5 nights
Surveying instruments: Questionnaires and Manual of enumerator

8) Field survey (5th enumerator group)
Date: 22nd -27th March 2021
Location: Sanam Chai Khet district, Chachoengsao province
Number of surveyors: 2 enumerators from Center for Agricultural Information
Number of appointments with farmers: 31 farmers
Requirement: 1 car, 6 days/5 nights
Surveying instruments: Questionnaires and Manual of enumerator

9) Data entry Training
Date: 25th February 2021
Time: 1.30 p.m. – 4.30 p.m.
Meeting venue: Agricultural Economics Operation Center meeting room
Attendees: 15 persons
Virtual Meeting organizer: The CAI staff hosted and organized a meeting through Zoom program
Meeting Materials: Calculation platform created by the Japanese Expert and Questionnaire
Training purpose: In order to teach enumerators on how to enter response code and survey data from questionnaires into the SDGs 2.4.1 calculation platform provided by the Japanese Expert

10) Data analysis training
Date: 6th May 2021
Time: 9.30 a.m. – 4.30 p.m.
Meeting venue: Virtual Meeting by Zoom Program
Attendees: 10 persons
Virtual Meeting organizer: The CAI staff hosted and organized a meeting
Meeting Materials: Calculation platform and sub-indicator calculation manual created by the Japanese Expert, Questionnaire, R and RStudio program for sub-indicator 10 calculation
Training purpose: In order to teach enumerators on how to enter response code and survey data from questionnaires into the SDGs 2.4.1 calculation platform provided by the Japanese Expert

11) FAO Virtual Trainings on SDG indicator 2.4.1
Date: 28th June – 1st July 2021
Time: 10.30 a.m. – 13.30 p.m. (Each day)
Meeting venue: Virtual Meeting by Zoom Program
Attendees: 8 persons from CAI (26 countries and regions in Asia Pacific)
Virtual Meeting organizer: SDG 2.4.1 Team from Food and Agriculture Organization (FAO)
Meeting Materials: Presentation of SDGs 2.4.1 concept, Methodological Note, Questionnaire, Sampling guidance, Enumerator manual, Guidelines on Data Analysis and Reporting. Presentation of AGRIS Implementation in Indonesia. Excel file for example of 10 sub-indicators calculation.
Training purpose: The overall objective of this virtual training is to provide (government officials responsible for monitoring SDG indicator 2.4.1) capacity development on the methodology, data collection and analysis relevant to sustainable food and agriculture and how to asses data gaps starting from available national and subnational (farm-level) information and associated reporting processes.

12) In-country wrap up meeting
Date: 17th August 2021
Time: 9.00 a.m. – 12.00 p.m.
Meeting venue: Virtual Meeting by Zoom Program
Attendees: Staff from Internal Bureau of Office of Agricultural Economics (OAE), regional office of OAE, Relevant agencies are Department of Agricultural Extension, Provincial Agricultural Extension Office Chachoengsao), Ban Pho District Agricultural Extension Office,

Department of fisheries, Department of Livestock, Department of Agriculture, Office of the permanent secretary for ministry of agriculture and cooperatives. Total 43 persons
Virtual Meeting organizer: The CAI staff hosted and organized a meeting
Meeting Materials: Presentation and paper of agenda
Meeting purpose: To present the summary of the SAS-PSA project in Thailand which are included Action plan, survey results and outcomes and also discuss on the limitations and challenge during pilot survey.

Meeting Agenda:

Item	Topic	Presenter
1	**Matters of the Chairman notifying the meeting**	Deputy Secretary General, Office of Agriculture Economics (OAE)
2	**Matters of the Chairman notifying the meeting** 2.1 Background of the Agricultural Survey Project to Support and Promote Sustainable Agriculture 2.2 Methods for surveying information under the project	Director of the Agricultural Information Center
3	**Matter of Consideration** 3.1 Survey results	CAI
4	**Other Matters**	

3.3 Data Analysis (SDG 2.4.1 Calculation manual)

3.3.1 List of sub-indicators

The proposed list of themes and sub-indicators was obtained through consultations. The list of selected themes and sub-indicators is provided in Figure 3.1. In total 11 themes are included.

Figure 3. 1 the list of themes and sub-indicators of sustainable production: Economic, Environmental, and Social

No.	Theme	Sub-indicator
1	Land productivity	Farm output value per hectare
2	Profitability	Net farm income
3	Resilience	Risk mitigation mechanisms
4	Soil health	Prevalence of soil degradation
5	Water use	Variation in water availability
6	Fertilizer pollution risk	Management of fertilizers
7	Pesticide risk	Management of pesticides
8	Biodiversity	Use of biodiversity-supportive practices
9	Decent employment	Wage rate in agriculture
10	Food security	Food insecurity experience scale (FIES)
11	Land tenure	Secure tenure rights to land

*Note.*The table was reprinted from SDG Indicator 2.4.1 – Proportion of agricultural area under productive and sustainable agriculture, by FAO, 2020a.

3.3.2 Assessing sustainability performance for each sub-indicator

For each sub- indicator, criteria to assess sustainability levels are developed. The concept of sustainability implies an idea of continuous progress and improvement towards better performances across all themes and such performances can therefore be more or less sustainable. In order to capture the concept of continuous progress towards sustainability, a "traffic light" approach is proposed, in which three sustainability levels are considered for each sub-indicator (FAO,2019, 2020a, 2020b):

- Green: desirable
- Yellow: acceptable
- Red: unsustainable.

While a certain level of subjectivity is unavoidable, this approach allows identification, for each theme, of conditions of critical unsustainability (red), conditions that can be considered desirable (green) and, in between, intermediate conditions that are considered acceptable but would need to be scrutinized in terms of possible improvements (yellow). This approach also acknowledges the trade- offs existing between sustainability dimensions and themes, and the need to find an acceptable balance between them.

Each sub- indicator is assessed at the level of the agricultural households. The sustainability level is then associated with the agricultural land area of the agricultural households. All sub-indicators for a given farming household therefore refer to the same agricultural land area.

3.2.3 Calculation procedure of the sub-indicators

The calculation of the 11-sub indicators involves the following steps:

1. Classification of the farm and the agricultural area it manages as sustainable or non-sustainable for each sub-indicator using the respective sustainability criteria.

2. For each sub- indicator, calculate the proportion of agricultural area that is sustainable (green), acceptable (yellow) and unsustainable (red), as a percentage of total agricultural area of the country.

The calculation procedure of each sub-indicator can be generalized according to the following formula:

$$Sub - indicator_i = \frac{agricultural\ area\ of\ sustainable\ farms}{total\ agrciultural\ area}$$

$$Sub - indicator_i = \frac{agricultural\ area\ of\ acceptable\ farms}{total\ agrciultural\ area}$$

$$Sub - indicator_i = \frac{agricultural\ area\ of\ unsustainable\ farms}{total\ agrciultural\ area}$$

With i equals to i - th the sub-indicator and i going from 1 to 11.

The calculation procedure for each sub-indicator is presented as follows:

- Description
- Sustainability criteria
- Calculation steps

A. Economic dimension

Sub-indicator 1: Farm output value per hectare

Description: The sub-indicator measures and classifies the agricultural area based on farm output value per hectare and its distance from the frontier, as defined by the sustainability criteria (see below). More in detail, the sub-indicator is described as farm output value per hectare (crops and livestock).

Information on farm outputs and agricultural area should be standard information available from farm surveys thus providing a good basis for assessment at farm level.

- Farm output: The volume of agricultural output at farm level generally takes into consideration production of multiple outputs, e.g. crop types and crop and livestock combinations, etc. Since the volume of agricultural outputs is not measured in commensurate units. A simple way to enable aggregation is to reflect the multiple outputs produced by a single farm in terms of values (i.e. quantity multiplied by prices).
- Farm agricultural land area: defined as the area of land used for agriculture within the farm1 the agricultural land area of the holding could comprise land owned, rented and other types of land tenure. Nomadic pastoralism and common land are out of scope as well as other agricultural activities not associated with land.

The farm output value is defined as the total volume of agricultural output i.e. quantity of produced commodities (i.e. crop and livestock) at farm level multiplied by the respective market/constant prices and is expressed in local currency units.

The agricultural land area is defined as the area of land used for agriculture within the farm.
The second step is to classify farms according to their sustainability status:

Sustainability criteria:

- Green (desirable): Farm output value per hectare is ≥ 2/3 of the corresponding 90th percentile.
- Yellow (acceptable): Farm output value per hectare is ≥ 1/3 and <2/3 of the corresponding 90th percentile.
- Red (unsustainable): Farm output value per hectare is <than 1/3 of the corresponding 90th percentile.

Definition of the 90th percentile

A percentile is a measure used in statistics indicating the value (for instance the value of farm output value per hectare) below which a given percentage of observations in a group of observations fall. For example, the 90th percentile of the FOVH indicator is the value below which 90th of the observations are found. The 90th percentile can be calculated using the following formula:

90th Percentile = 0.9 * Total number of surveyed farms

The farm output value per hectare of each farm is then sorted from the lowest to the highest. The value of farm output corresponding to the 90th percentile is the one associated with the farm positioned 122th (n=135) in the ranking.

Calculation steps:

According to the calculation procedure, the first step implies calculating the farm output value per hectare, for each farm, as per formula below.

$$\textbf{\textit{Farm output value per hectare}}_i = \frac{\textbf{\textit{farm output value (LCU)}}_i}{\textbf{\textit{farm agricultural land area (hectare)}}_i}$$

Where i is the farm in the survey, with going from 1 to N; N is the total number of farms surveyed.

Once the farm output value per hectare has been calculated for each farm, the second step of the calculation procedure implies calculating the farm output value per hectare corresponding to the 90th percentile of the related distribution.

Sub-indicator 2: Net farm income

Description: The sub-indicator captures whether a farm is profitable over a 3-year period. The focus of this sub-indicator is on income from farming operations as distinct from the total income of the farming household, which may include other sources of income.

Sustainability criteria: The following sustainability criteria have been defined to classify the agricultural area of the farm by sustainability status:

- Green (desirable): above zero for past 3 consecutive years
- Yellow (acceptable): above zero for at least 1 of the past 3 consecutive years
- Red (unsustainable): below zero for all of the past 3 consecutive years

Sub-indicator 3: Risk mitigation mechanisms

Description: This sub-indicator measures the incidence of the following mitigation mechanisms:

- Access to or availed credit.
- Access to or availed insurance.
- On-farm diversification (share of a single agricultural commodity not greater than 66% in the total value of production of the holding).

Access to credit and/or insurance is defined here as when a given service is available and the holder has enough means to obtain the service (required documents, collateral, positive credit history, etc.). Broadly, access to one or more the above 3 factors will allow the farm to prevent, resist, adapt and recover from external shocks such as, floods, droughts, market failure (e.g. price shock), climate shock and pest/animal diseases.

Sustainability criteria: The following sustainability criteria are defined to classify the agricultural area of the farm by sustainability status:

- Green (desirable): Access to or availed at least two of the above-listed mitigation mechanisms.
- Yellow (acceptable): Access to or availed at least one of the above-listed mitigation mechanisms.
- Red (unsustainable): No access to the listed mitigation mechanisms.

Calculation steps: the calculation procedure for this indicator is two-step:
Classify farms according to the sustainability criteria mentioned earlier.

The following data items are used to identify farms that meet at least one of the following mitigation mechanisms:

1. Agricultural holding access to credit, insurance or other financial instruments:
   - Credit (formal, informal)
   - Insurance
2. List of other on-farm activities apart from crops and livestock
3. Value of production for the listed on-farm commodities
4. Agricultural land area of the farm holding

Once the farms have been classified according to their sustainability status, the second and final step is to calculate the proportion of sustainable agricultural area. This is done by adding up the total agricultural area associated with farms classified as green, yellow or red in total agricultural area.

On-farm diversification. It captures the share of the value of production of one single agricultural commodity over total value of production of the agricultural holding. This variable is calculated according to the below formula:

$$\boldsymbol{On - farm\ diversification} = \frac{\boldsymbol{Value\ of\ production}_{i,c}}{\boldsymbol{Total\ value\ of\ production\ of\ the\ holding}_{i}} \quad [3]$$

Where is the value of production of the c-th agricultural commodity related to the i-th agricultural holding and is the total value of production of the i-th agricultural holding.

B. Environmental dimension

Sub-indicator 4: Prevalence of soil degradation (PSD)

Description: The sub- indicator measures the extent to which agriculture activities affects soil health and, therefore, represents a sustainability aspect. A review of the 10 threats to soil shows that all except one (soil sealing, which is the loss of natural soil to construction/urbanization) are potentially and primarily affected by inappropriate agricultural practices. Ideally, therefore, all soils under agricultural land area in a country should be the subject of periodic monitoring in order to assess the impact of agriculture on soils. This requires detailed surveys and sampling campaigns, associated with laboratory testing. In order to propose a manageable solution while capturing the main trends in the country in terms of soil health, the farm survey focuses on the four threats that combine the characteristics more widespread (for national monitoring, countries may choose to add any of the other areas indicated above, depending on relevance), and easier to assess through farm surveys:

1. Soil erosion
2. Reduction in soil fertility
3. Salinization of irrigated land
4. Waterlogging
5. Other -specify
6. None of the above

The farm survey captures farmer's knowledge about the situation of the agricultural holding in terms of soil degradation. Experience has shown that farmers are very much aware of the state of their soils, health and degradation level. Farmers may also be offered the opportunity to mention other threats than the above four.

Other data sources on soil health may either complement the information collected through the farm survey and offer opportunities for cross-checking farmers' responses; or be used as alternative sources of data. Prior to the farm survey, a desk study could collect all available information on soil health, including using national official statistics or statistics available from international agencies such as FAO. This typically includes maps, models, results from soil sampling, laboratory analysis and field surveys, and all existing report on soil and land degradation at national level. On the basis of this information, maps or tables (by administrative boundaries or other divisions of the country) can be established, showing the threats to soils according to the above 4 categories of threats.

Sustainability criteria: The following sustainability criteria have been defined to classify the agricultural area of the farm by sustainability status:

- Green (desirable): The combined area affected by any of the four selected threats to soil health is negligible (less than 10% of the total agriculture area of the farm).
- Yellow (acceptable): The combined area affected by any of the four selected threats to soil health is between 10% and 50% of the total agriculture area of the farm.
- Red (unsustainable): The combined area affected by any of the four selected threats to soil health is above 50% of the total agriculture area of the farm.

Calculation steps: the calculation procedure consists of two steps:

1. Information on the prevalence of soil degradation requires the computation of a number of primary variables that can be derived by inferring information from a survey related to: 1) whether or not the agricultural holding was affected by any of the above listed soil degradation threats; 2) the total agricultural area of the holding, as well as the agricultural area of the holding that was affected by these threats; and finally 3) the share of the combined area affected by any of the four selected threats.

Agricultural area affected. This variable measures the agricultural land areas of the farm which was affected by any of the above-listed soil degradation threats, in hectares of land.

$$\textbf{Share of agricultural area affected by any threat} = \frac{\boldsymbol{Agricultural\ area\ \ affected_i}}{\boldsymbol{Agricultural\ area\ of\ the\ holding_i}}$$

This variable measures the proportion of the total agricultural area of the holding that was affected by soil degradation threats.

2. The second step involves calculation of the agricultural area by sustainability status.

Sub-Indicator 5: Variation in water availability

Description: The sub-indicator captures the extent to which agriculture contributes to unsustainable patterns of water use. Ideally, the level of sustainability in water use is measured at the

scale of the river basin or groundwater aquifer, as it is the combined effect of all users sharing the same resource that impact water sustainability. The farm survey captures farmer's awareness and behavior in relation with water scarcity, and associates them with three levels of sustainability. This awareness and behavior are expressed in terms of:

- whether the farmer uses water to irrigate crops on at least 10% of the agriculture area of the farm and why, if the answer is negative (does not need, cannot afford);
- whether the farmer is aware about issues of water availability in the area of the farm and notices a reduction in water availability over time;
- whether there are organizations (water users organizations, others) in charge of allocating water among users and the extent to which these organizations are working effectively.

Other data sources may either complement the farm survey on water use and offer opportunities for cross-checking farmers' responses; or be used as alternative sources of data. Prior to the farm survey, a desk study should collect all available information on water balance, including national official statistics or statistics available from international agencies such as FAO. Information on water resources and use is usually collected by the entities in charge of water management or monitoring and are organized by hydrological entity (river basin or groundwater aquifer). They typically include hydrological records (river flow, groundwater levels), models and maps showing the extent of water use by hydrological entity.

Sustainability criteria: The following sustainability criteria have been defined to classify the agricultural area of the farm by sustainability status:

• Green (desirable): Water availability remains stable over the years, for farms irrigating crops on more than 10% of the agriculture area of the farm. Default result for farms irrigating less than 10% of their agricultural area.

• Yellow (acceptable): uses water to irrigate crops on at least 10% of the agriculture area of the farm, does not know whether water availability remains stable over the years, or experiences reduction on water availability over the years, but there is an organization that effectively allocates water among users.

• Red (unsustainable): in all other cases.

Calculation steps: the calculation procedure for this indicator envisages two steps:

1. Information on variation of water availability requires the computation of four main primary variables that can be derived by inferring information from a survey related to:

1) whether or not the agricultural holding irrigated its land;

2) the percentage of the area of the holding where water was used for irrigating crops;

$$\textbf{Percentage of total area irrigated} = \frac{\boldsymbol{Total\ area\ irrigated_i}}{\boldsymbol{Agricultural\ area\ of\ the\ holding_i}}$$

This variable measures the proportion of the total agricultural area of the holding where water was used for irrigating crops.

3) whether (or not) water remains stable over years; and, finally

4) if there are organizations that effectively allocate water among users.

2. The proportion of agricultural area by sustainability status is calculated by deriving the agricultural areas associated with farms under a given sustainability status.

Sub-indicator 6: Management of fertilizers

Description: The proposed approach is based on questions to farmers about their use of fertilizer, in particular mineral or synthetic fertilizers, their awareness about the environmental risks associated with fertilizers (including manure), and their behavior in terms of fertilizer and manure management. List of management measures that help reducing risk is as follows:

1. Follow protocols as per extension service or retail outlet recommendations or local regulations, not exceeding recommended doses
2. Use organic source of nutrients (including manure or composting residues) alone, or in combination with synthetic or mineral fertilizers
3. Use legumes as a cover crop, or component of a multi/crop system to reduce fertilizer inputs
4. Distribute synthetic or mineral fertilizer application over the growing period
5. Consider soil type and climate in deciding fertilizer application doses and frequencies
6. Use soil sampling at least every 5 years to perform nutrient budget calculations
7. Perform site-specific nutrient management or precision farming11
8. Use buffer strips along water courses.

Sustainability criteria: The following sustainability criteria have been adopted to classify the agricultural area of the farm by sustainability status:

• Green (desirable): The farm takes specific measures to mitigate environmental risks (at least four from the list above). Default result for farms not using fertilizers12

• Yellow (acceptable): the farm uses fertilizers and takes at least two measures from the above list to mitigate environmental risks

• Red (unsustainable): farmer uses fertilizer and does not take any of the above specific measures to mitigate environmental risks associated with their use.

Calculation steps: the calculation procedure envisages two steps:

1. Farms are classified by sustainability status as per above-identified criteria.

Information on variation on management of fertilizers requires exploring whether the agricultural holding 1) uses (or do not use) fertilizers and 2) in case of affirmative responses the number of specific measures adopted, if any, in order to mitigate environmental risks.

The sustainability status of agricultural holdings is determined depending on whether the agricultural holding uses fertilizers and on the total number of measures adopted by the holding to mitigate environmental-related risks.

2. Calculate the proportion of agricultural areas associated with farms classified green, yellow and red.

Sub-indicator 7: Management of pesticides

Description: The proposed sub-indicator is based on information on the use of pesticides on the farms, the type of pesticide used and the type of measure(s) taken to mitigate the associated risks. List of possible measures:

Health

1. Adherence to label recommendations for pesticide use
2. Use of personal protection equipment
3. Safe disposal of waste (cartons, bottles and bags)

Environment

1. Adherence to label directions for pesticide application
2. Adopt any of the above good agricultural practices (GAPs): adjust planting time, apply crop spacing, crop rotation, mixed cropping or inter-cropping
3. Perform biological pest control or use biopesticides
4. Adopt pasture rotation to suppress livestock pest population
5. Systematic removal of plant parts attacked by pests
6. Maintenance and cleansing of spray equipment after use
7. Use one pesticide no more than two times or in mixture in a season to avoid pesticide resistance.

Sustainability criteria: The following sustainability criteria have been developed to classify the agricultural area of the farm by sustainability status:

• Green (desirable): The farm uses only moderately or slightly hazardous15 pesticides (WHO Class II or III). In this case, it adheres to all three health-related measures and at least four of the environment-related measures. Default result for farms not using pesticides.

•Yellow (acceptable): The farm uses only moderately or slightly hazardous pesticides (WHO Class II or III) and takes some measures to mitigate environmental and health risks (at least two from each of the lists above)

• Red (unsustainable): The farm uses highly or extremely hazardous pesticides (WHO Class Ia or Ib), illegal pesticides16, or uses moderately or slightly hazardous pesticides without taking specific measures to mitigate environmental or health risks associated with their use (fewer than two from any of the two lists above).

Calculation steps: the calculation procedure for this indicator is two steps:

1. The sustainability status of agricultural holdings is determined depending on whether the agricultural holding uses pesticides, the type of pesticides used and on the total number of measures adopted by the holding to mitigate environmental and heath related risks.
2. Calculate the proportion of agricultural areas associated with farms classified green, yellow and red.

Sub-indicator 8: Use of biodiversity-supportive practices

Description: This sub-indicator measures the level of adoption of biodiversity-supportive practices by the farm at ecosystem, species and genetic levels. This indicator addresses both crops and livestock. The practices are broken down as follows:

- Leaves at least 10% of the holding area for natural or diverse vegetation. This can include natural pasture/grassland, maintaining wildflower strips, stone and wood heaps, trees or hedgerows, natural ponds or wetlands.
- Farm produces agricultural products that are organically certified, or its products are undergoing the certification process.

- Does not use synthetic pesticides, does not purchase more than 50% of the feed for livestock and does not use antimicrobials as growth promoters.
- At least two of the following contribute to the farm production: 1) temporary crops, 2) pasture, 3) permanent crops, 4) trees on farm, 5) livestock or animal products, and 6) aquaculture.
- Practices crop or crop/pasture rotation involving at least 3 crops on at least 80% of the farm area.
- Livestock includes locally adapted breeds.
- Areas larger than 2 hectares under a single commodity use at least two different varieties

Sustainability criteria: The following sustainability criteria have been defined to classify the agricultural area of the farm by sustainability status:

- Green (desirable): The agricultural holding meets at least three of the above criteria
- Yellow (acceptable): The agricultural holding meets between two and four of the above
- Red (unsustainable): The agricultural holding meets none of above criteria

Calculation steps: the calculation procedure for this indicator is two steps:

1. Farms are classified by sustainability status as per above-identified criteria.

This sub-indicator relies on the calculation of six main criteria, four of which must be met in order for the area of the agricultural holding to be sustainable in terms of bio-diversity.

1st criterion calculates the share of the total agricultural area of the holding which is under natural or diverse vegetation and check whether the computed share is greater or lower than the 10 % of the total agricultural area of the holding as per formula below.

2nd Criterion, check whether the agricultural holding that producing crops or livestock are organically certified or undergoing organic certification.

3rd Criterion, check whether the agricultural holding uses medically important antimicrobials as growth promoters.

4th Criterion, first, calculate if the following contribute to farm production 1) temporary crops, 2) pasture, 3) permanent crops, 4) trees on farm, 5) livestock or animal products, and 6) aquaculture, over total value of farm production. Then check if each of them represents at least 10% of the value of the holding's production.

Step 1. Calculate the total farm value of production.

The farm output value is calculated as the summation of the quantities () of each: crop, by-product crop, livestock, by-product livestock and on-farm commodities of the *i-th* agricultural holding multiplied by the corresponding farm gate prices. The measure is expressed in local currency unit (LCU).

Step 2. Calculate the total farm value of production from:

1) Value of output of crops and its by-products;
2) Value of output of tree products;
3) Value of output of livestock and animal products;
4) Value of output of aquaculture.

The calculation procedure is aligned with the total farm production calculated for sub-indicator 1 but it does not account for all of the commodities that are not listed among the four

above-mentioned (i.e. 1) crop/pasture, 2) trees or tree products (including permanent crops like orchards or vineyards), 3) livestock or animal products and 4) fish.

Step 3. Once both the total farm output value and the output value from 1) crop/pasture, 2) trees or tree products, 3) livestock or animal products and 4) fish/aquaculture has been calculated, the corresponding contribution is calculated as follows:

5th Criterion, calculate the percentage of the agricultural area on which crop rotation or crop/pasture rotation involving at least two different crops is practiced.

6th Criterion. In order to ascertain whether (or not) the agricultural holding meets the sixth bio-diversity criterion, the first step consists in identifying locally adapted breeds. The next step is to check if the number of livestock locally adopted breeds out of the total breeds (both local and foreign) is greater than 1.

The sustainability status of agricultural holdings is determined depending on how many of the six bio-diversity criteria are met by the agricultural holding.

2. The proportion of agricultural area by sustainability status is calculated by adding up total agricultural areas under a given sustainability status.

C. Social dimension

Sub-indicator 9: Wage rate in agriculture

Description: This sub-indicator measures the farm unskilled labour daily wage rate in the International Standard Classification of Occupation (ISCO-08 - code 92).

Sustainability criteria: The following sustainability criteria have been developed classify the agricultural area of the farm by sustainability status:

- Green (desirable): If the wage rate paid to unskilled labour is above the minimum national wage rate or minimum agricultural sector wage rate (if available). Default result for farms not hiring labour.
- Yellow (acceptable): if the wage rate paid to unskilled labour is equals to the minimum national wage rate or minimum agricultural sector wage rate (if available).
- Red (unsustainable): if the wage rate paid to unskilled labour is below the minimum national wage rate or minimum agricultural sector wage rate (if available).

Calculation Steps: The calculation procedure for this indicator is three steps:

1. For each farm, calculate the farm output value per hectare:

$$Daily\ wage\ rate\ of\ unskilled\ hired\ labor = \frac{\boldsymbol{Total\ annual\ compensation}}{\boldsymbol{Total\ annual\ hours\ worked}} * \mathbf{8}$$

To calculate the daily wage rate in agriculture, the following data items are required:

- **Unskilled workers hired on the agricultural holding (Yes/No).** Unskilled workers as defined according to the International Standard Classification of occupation

Unskilled workers are workers performing basic and routine tasks in the agricultural sector.

- Average pay in-cash and/or in-kind for a hired unskilled worker per day (of 8 hours)

- Minimum agricultural sector wage rate (if available) or minimum national wage rate

2. Once the daily wage is calculated, farms are classified by sustainability status by benchmarking the daily wage rate against the national or agricultural sector minimum wage.

• Farms are classified as green (desirable) if their daily wage rate paid to unskilled workers is greater than minimum national wage rate or minimum agricultural sector wage rate (if available).

• Farm are classified as yellow (acceptable) if their daily wage rate paid to unskilled workers is equal to the minimum national wage rate or minimum agricultural sector wage rate (if available).

• Farm are classified as yellow red (unsustainable) if their daily wage rate paid to unskilled workers is equal to the minimum national wage rate or minimum agricultural sector wage rate (if available).

2. The third and final step is aimed at calculating the proportion of sustainable agricultural area by sustainability status. This is done by adding up the total agricultural area associated with farms classified as having a given sustainability status (green, yellow or red) in total agricultural area. It is important to notice that the final sub-indicator only accounts for total agricultural area associated with farms employing paid labour.

Sub-indicator 10: Food Insecurity Experience Scale (FIES).

Description of the sub-indicator 10: Food Insecurity Experience Scale (FIES). The sub-indicator on Food Insecurity Experience Scale (FIES) is a measure of the severity of food insecurity experienced by individuals or households. The proportion of sustainable (non-sustainable) agricultural area by this indicator is calculated by accounting for the area associated with household farms that do not experience food insecurity.

Definition of the sustainability criteria: The following sustainability criteria have been adopted to classify the agricultural area of the household farm by sustainability status:

• Green (desirable): the household farm has mild food insecurity

• Yellow (acceptable): the household farm has moderate food insecurity

• Red (unsustainable): the household farm has severe food insecurity

Calculation steps:

Information on the severity of food insecurity experienced by agricultural households are gathered from household surveys containing the 8 standardized FIES questions.

The 8 FIES questions allows capturing a specific item, which is latter associated with a certain degree of severity of food insecurity.

Table. Items, domain and assumed severity of food insecurity

FIES order of items	Variables	Variable description	Domains of the food insecurity	Assumed severity of food insecurity
1	**Worried**	Felt anxiety about having enough food at any time during the previous 12 months	uncertainty and worry about food	Mild
2	**Healthy**	Not able to eat healthy and nutritious food because of lack of money or other resources to get food	inadequate food quality	Mild
3	**Fewfood**	Consumed a diet based on only few kinds of foods because of lack of money or other resources to get food	inadequate food quality	Mild
4	**Skipped**	Did not eat breakfast, lunch or dinner [or skipped a meal] because there was not enough money or other resources to get food	insufficient food quantity	Moderate
5	**Ateless**	Ate less than they thought they should because of lack of money or other resources to get food	insufficient food quantity	Moderate
6	**Runout**	Household ran out of food because of lack of money or other resources to get food	insufficient food quantity	Moderate
7	**Hungry**	Felt hungry but didn't eat because there was not enough money or other resources for food	insufficient food quantity	Severe
8	**Whlday**	Went without eating for a whole day	insufficient food quantity	Severe

The methodology to calculate SDG indicator 2.1.2 on the severity of food insecurity is used. SDG indicator 2.1.2 provides estimates of the proportion of household farms facing moderate or severe difficulties in accessing food. Specifically, the approach used to analyze FIES data comes from Item Response Theory (IRT), a branch of statistics that permits the measurement of unobservable traits through analysis of responses to surveys and tests.

The Rasch model provides a theoretical base and a set of statistical tools to 1) assess the suitability of a set of survey questions ("items") for constructing a measurement scale and to 2) compare a scale's performance across different populations and survey contexts.

The logic behind the Rasch model is that the likelihood of a respondent reporting an experience depends on the distance along the scale between the severity of that respondent and that of the item associated with that experience. The more severe a respondent's food insecurity

is, relative to that of the item, the more likely they are to answer "yes" (give an affirmative response). In other words, the higher the probability to say “yes” to a specific question, the more severe a respondent’s food insecurity is relative to that item, which means that the more severe the food insecurity of given respondent, the higher the probability will respond “Yes”. The Rasch model can be formalized as follows:

The relative severity associated with each of the experiences (the parameters β_i in the formula above) can be inferred from the frequency with which they are reported by a large sample of respondents, assuming that, all else being equal, more severe experiences are reported by fewer respondents. Once the severity of each experience is estimated, the severity of a respondent’s condition (the θ_h parameter) can be computed by noting how many of the items have been affirmed. The rationale for this is that, on average, it is expected that a respondent will answer affirmatively to all questions that refer to experiences that are less severe of their food insecurity situation, and negatively to questions that refer to situations that are more severe.

The Rasch model concerns estimates of the parameters of the raw score. The raw score is the number of affirmative responses given to the eight FIES questions. A respondent's raw score is the basis for calculating the respondent parameter.

Program R or Statistical Program such as SPSS (Statistical Package for the Social Science) can be used for parameters estimation of the Rasch model.

The probability of a respondent getting the item correct given their ability level will be calculated. For example, for item Fewfood, the estimator will show that a household has something like a ….% probability of getting to say “yes” (predicted).

The final step is aimed at calculating the proportion of sustainable agricultural area by sustainability status. This is done by adding up the total agricultural area associated with farms classified as having a given sustainability status (green, yellow or red) in total agricultural area. It is important to notice that the final sub-indicator only accounts for the agricultural area associated with household farms.

The same method as above was used to calculate the FIES for COVID19

Sub-indicator 11: Secure Tenure Rights to Land

Description: The sub-indicator measures ownership or secure rights over use of agricultural land areas using the following criteria:

- Formal document issued by the Land Registry/Cadastral Agency
- Name of the holder listed as owner/use right holder on legally recognized documents
- Rights to sell any of the parcel of the holding
- Rights to bequeath any of the parcel of the holding

Sustainability criteria: The following sustainability criteria have been adopted to classify the agricultural area of the household farm by sustainability status:

• Green (desirable): has a formal document with the name of the holder/holding on it, or has the right to sell any of the parcel of the holding, or has the right to bequeath any of the parcel of the holding

• Yellow (acceptable): has a formal document even if the name of the holder/holding is not on it

• Red (unsustainable): no positive responses to any of the 4 questions above

Calculation steps: the calculation procedure for these indicators is two-fold:

1. Classification of farms by sustainability status on the basis of the following criteria of the above-mentioned sustainability criteria.

2. Once farms have been classified according to their sustainability status (sustainable, acceptable and unsustainable), the proportion of agricultural area by sustainability status can be derived accordingly. This is done by adding up the total agricultural area associated with farms classified as having a given sustainability status (green, yellow or red) in total agricultural area.

Chapter 4. Pilot Survey Result

This chapter summarizes pilot survey information and analysis results associated with each sub- indicator of the SDG indicator 2.4.1. The pilot survey was conducted in 4 districts in Chachoengsao province namely Phanom Sarakham, Sanam Chai Khet, Ban Pho, and Mueang Chachoengsao districts during 24-29 December 2020 and 15-21 March 2021.

The sample of farms was selected from farmers registration database of Thailand called "Farmer One" in 2020. The target population for this study applied simple random sampling method and were selected in 2 stages which are 1) randomly selected 45 villages out of 66 villages in 4 districts 2) randomly selected 169 samples by proportionally to the total agricultural household in 45 villages.

4.1 Respondents Characteristics

Table 1 below illustrates the respondent's characteristics of 169 households which were randomly selected to answer the questionnaire from 4 districts in Chachoengsao province. The majority of respondents aged between 51 and 60 years old, have primary school education, and own agricultural land.

Looking at the information in greater detail, 87 respondents out of 169 total respondents are male (51.50 %). Most of the respondents aged between 51 – 60 years old (73 respondents or 43.20 %), followed by respondents with aged higher than 60 years old (41 respondents or 24.30 %), and aged between 41 – 50 years old (38 respondents or 22.50 %), respectively.

According to the education background of respondents, most of the respondents have primary school education level (110 respondents or 65.10 %), followed by respondents graduated from high school or had diploma/high vocational certificate (27 respondents or 16.00%) and respondents with secondary school degree or had vocational certificate (21 respondents or 12.40 %), respectively. Only 2 respondents (1.20 %) had master's degree or higher education backgrounds which were considered to be the smallest.

Turning to the figure of agricultural land holding role, the highest number of respondents is land holders (143 respondents or 84.60 %), 20 respondents are household members (11.8 %), and 6 respondents are co – holders (3.60 %).

In terms of legal status, 160 respondents are civil/natural persons which are considered as the majority (94.70 %). While the rest, 9 respondents, are a group of civil/natural persons (5.30 %).

To consider land tenure type, almost half of the respondents own and operate agricultural land (48.5 % or 82 respondents), 54 respondents (32.0 %) own and borrow agricultural land, and 26 respondents (15.40 %) rented agricultural land.

Table 1: Respondent's characteristics in Chachoengsao province

n = 169

Item	Number	Percent (%)
Gender		
Female	82	48.50
Male	87	51.50
Age		
Less than 41 years old	17	10.00
41 – 50 years old	38	22.50
51 – 60 years old	73	43.20
More than 60 years old	41	24.30
Education Background		
Primary School	110	65.10
Secondary School/ Vocational Certificate	21	12.40
High School/ Diploma/ High Vocational Certificate	27	16.00
Bachelor's degree	9	5.30
Master's degree or Higher	2	1.20
Agricultural Land Holding Role		
Holder	143	84.60
Co – holder	6	3.60
Household member	20	11.80
Legal Status of Holder		
Civil/natural person	160	94.70
Group of civil/natural persons	9	5.30
Land Tenure Type		
Owned and operated	82	48.50
Rented-in	26	15.40
Borrowed for free	5	3.00
Owned, and rented-in	54	32.00
Owned, and rented-out	1	0.60
Owned, rented-in, and rented-out	1	0.60

Table 2 below provides information regarding the respondents' behavior on internet usage. Most of the respondents use the internet in everyday life (119 respondents or 70.4 %). For other respondents, they claimed that they do not use the internet (50 respondents or 29.60 %).

We ask further questions regarding what application they used. As shown by table 2, Line (Messenger application), YouTube, and Facebook are top 3 applications that reported to be used by respondents. 115 out of 169 respondents (68.05 %) use Line which ranks the first place. Followed by YouTube (102 respondents or 60.36 %), and Facebook (90 respondents or 53.25 %), respectively.

Regarding applications implemented by the Ministry of Agricultural and Cooperatives, Thailand, DOAE's Farmbook application reported to be used the most (33 out of 46 respondents or 19.53 %), while the rest applications reported to be used surprisingly little (less than 10 respondents or less than 10.00 %).

Furthermore, there is additional question regarding the application that assists in agricultural activities. There are 7 applications that commonly use among Thai farmers, namely namely Ricult, Ling, SOAE's Farmbook, LLD Zoning, Smart Rice Farm (SRF) DOA – Research, DOA – GAP, QSDS – Silk Service, and DOF – Feed. It is noticeable that most of the respondents do not use applications for farming activities (85 out of 127 respondents or 66.93 %) followed by 19 respondents (14.96 %) who use Ling applications, and 16 respondents

(12.60 %) use DOAE's Farmbook applications to assist farming activities. While other applications were used less than 5 respondents (less than 5.00 %).

Table 2: Internet usage behavior of respondents

Item	Number	Percent (%)
Daily Internet Usage (n = 169)		
Yes	119	70.40
No	50	29.60
Applications Usage (n = 169)		
Search Engine	47	27.81
Facebook	90	53.25
Line	115	68.05
YouTube	102	60.36
Others (Lazada, Instagram, TikTok, Paotang, etc)	27	15.98
Does not use any application	6	3.55
MOAC's Applications Usage (Total respondents = 46)		
DOAE – Farmbook Application	33	71.7
OAE – Ag-Info	0	0.0
OAE – RCMO	6	13.0
LDD – Zoning	2	4.4
Smart Rice Farm (SRF)	1	2.2
DOA – Research	1	2.2
DOA – GAP	3	6.5
QSDS – Silk Service	0	0.0
DOF – Feed	0	0.0
Application assists with Agricultural Activities (total respondents = 127)		
Ricult	1	0.79
Ling	19	14.96
DOAE Farmbook Application	16	12.60
LLD - Zoning	1	0.79
DOA – Research	1	0.79
DOA – GAP	3	2.36
DOF – Feed	1	0.79
Does not use any application	85	66.93

4.2 SDG 2.4.1 Proportion of agricultural area under productive and sustainable agriculture

The proportion of agricultural area under productive and sustainable agriculture is measured using the extent of both land under productive and sustainable agriculture. This chapter reports sustainability results of 3 dimension consists of 11 themes and sub-indicators which collected during the pilot survey in Chachoengsao province in section a-c. The set of sub-indicators are presented in the form of a dashboard in section d.

Although, the total number of samples are 169 household, there are 34 household that have an aquaculture as a major production. As a result, only 135 households are in scope of the survey and will be used to calculate for each sub-indicators of SDG 2.4.1

Hence, this survey results do not represent in the provincial level as this study is estimate the results based on small samples (135 households).

a. Economics dimension

Economics dimension of the SDG indicator 2.4.1 consists of 3 themes: 1) land productivity, 2) profitability, and 3) resilience. The sub-indicator used for calculating these themes are farm output value per hectare, net farm income, and risk mitigation mechanism, respectively. The pilot survey results of each term and sub-indicator are reported as follows.

i) Land productivity

Land productivity theme is determined from the farm output value per hectare sub-indicator, which is calculated from the total value of production of each agricultural holding divided by agricultural land area.

The minimum farm output value per hectare of 135 respondents is reported to be 4,651.16 baht per hectare, while the maximum of this sub-indicator is 859,375 baht per hectare which is about 185 times higher than the minimum value. The 90th percentile value of 135 samples is 159,399 baht per hectare, thus the threshold of unsustainable status (less than 1/3 of the corresponding 90th percentile) is 53,133 baht per hectare and the threshold of desirable status (greater than or equal to 2/3 of the corresponding 90th percentile) is 106,266 baht per hectare.

For this theme, the farm category classification was not considered in the calculation due to the small sample size. The farm values per hectare results of Chachoengsao province shows that 38.26 ha (4.88 %) is classified as desirable, 101.34 ha (12.90 %) is classified as acceptable, and the rest (645.16 ha or 82.21 %) is classified as unsustainable as table 3 below.

Table 3 Sustainability status of economics dimension, land productivity theme

Sustainability status (sub-indicator #1)	Agricultural area (ha)	Proportion of agricultural area (%)
Desirable	38.26	4.88
Acceptable	101.34	12.91
Unsustainable	645.16	82.21
Total	**784.76**	**100.00**

However, analysis of the results showed that there was heterogeneity in the vegetable farmer categories. We therefore calculate the results according to the FAO manual (Guidelines on Data Analysis and Reporting) by categorized in 3 categories; 1; crops, 2) mixed and 3) livestock, but the results from the categorization of crops, livestock and mixed are not much different from the above results.

Therefore, we have categorized the 135 samples by five agricultural activities (table 4) based on the activity with the highest production value, in case there are farmers who have multiple agricultural activities

Table 4 Category of farm by highest production value

Major production	Crops	Vegetable	Fruits	Livestock	Perennial plant	Total
Number of Households	74	21	5	11	24	135

Table 5 below shows the result of the calculation using the category of farms classification of table 4. It shows that 193.28 ha (24.63 %) is classified as desirable, 476.26 ha (60.69 %) is classified as acceptable, and the rest (115.22 ha or 14.68 %) is classified as unsustainable

Table 5 Sustainability status of economics dimension, land productivity theme with farm category classification (Reference results)

Sustainability status (sub-indicator #1)	Agricultural area (ha)	Proportion of agricultural area (%)
Desirable	193.28	24.63
Acceptable	476.26	60.69
Unsustainable	115.22	14.68
Total	**784.76**	**100.00**

ii) Profitability

Profitability theme is determined from net farm income of 3 consecutive years. If respondents have net farm income above zero for the past 3 consecutive years, the desirable status will be assigned. If respondents have net farm income above zero for at least 1 of the past 3 consecutive years, the acceptable status will be assigned. On the other hand, the unsustainable status will be assigned, if the respondent does not have net farm income for all 3 years.

Results from the pilot survey show that 501.30 ha (63.88 %) of the agricultural area is classified as desirable. 206.10 ha (26.26 %) is classified as acceptable, and the rest (77.36 ha or 9.86 %) is classified as unsustainable. The results show sustainable area are high, because the farmgate price of rice, cassava, and natural rubber in last 2 years are satisfied, but there is no specific figure for how much profit they made.

Table 6 Sustainability status of economics dimension, Profitability theme

Sustainability status (sub-indicator #2)	Agricultural area (ha)	Proportion of agricultural area (%)
Desirable	501.30	63.88
Acceptable	206.10	26.26
Unsustainable	77.36	9.86
Total	**784.76**	**100.00**

iii) Resilience

Resilience theme is determined from risk mitigation mechanisms. In this theme, the respondents were asked whether they are practice or are able to access any of 3 factors related to risk mitigation mechanisms which are 1) credit accessibility, 2) insurance accessibility and 3) on-farm diversification of the household to protect against external shocks. The desirable status will be assigned if all 3 mechanisms are available or accessible by the respondent. In case, the respondent has access at least 1 mechanism, it will be considered as

acceptable. Otherwise, the unsustainable status will be assigned if they are not access any listed mitigation mechanisms.

According to a pilot survey, 381.42 ha of the agricultural area (48.60 %) is classified as desirable. 379.42 ha (48.35 %) is classified as acceptable, and the rest (23.92 ha or 3.05 %) is classified as unsustainable.

Table 7 Sustainability status of economics dimension, resilience theme

Sustainability status (sub-indicator #3)	Agricultural area (ha)	Proportion of agricultural area (%)
Desirable	381.42	48.60
Acceptable	379.42	48.35
Unsustainable	23.92	3.05
Total	**784.76**	**100.00**

b. Environmental dimension

Environmental dimension in the SDG indicator 2.4.1 consists of 5 themes: 1) soil health, 2) water use, 3) fertilizer risk, 4) pesticide risk, and 5) biodiversity. The sub-indicator used for calculating these themes are prevalence of soil degradation, variation in water availability, management of fertilizers, management of pesticides, and use of agro-biodiversity supportive practice, respectively. The pilot survey results of each term and sub-indicator are reported as follows.

i) Soil health

Prevalence of soil degradation sub-indicator will be used for soil health determination. There are 4 soil degradation threats; 1) soil erosion, 2) reduction in soil fertility, 3) salinization, and 4) waterlogging; were considered for this sub indicator which represent a sustainability issue. The threshold of this sub-indicator is determined from the area that is affected by the soil degradation threat. If one or more of these threats occur, the total agricultural area that is affected by these threats will be asked.

If less than 10 % of the total agricultural area is affected by the soil degradation threat, then the desirable status will be assigned. If the affected area is equal or higher than 10 % but not more than 50 % of the total agricultural area, the acceptable status will be assigned. In case, the area affected by any of 4 threats is over 50%, the unsustainable status will be assigned.

According to a pilot survey, the acid sulfate soil and fungal disease also been reported by the respondent as the soil degradation threat apart from 4 main threats in the questionnaire (soil erosion, reduction in soil fertility, salinization of irrigation land, and waterlogging).

Out of 135 respondents, 466 ha of the agricultural area (59.40 %) is classified as desirable. 241.50 ha (30.80 %) is classified as acceptable, and only 77.26 ha (9.80 %) is classified as unsustainable. For unsustainable area, most of them have a decline in soil fertility problem. Soil fertility decline occurs when the quantities of nutrients removed from the soil in harvested products exceed the quantities of nutrients being applied. In this situation, the nutrient requirements of the crop are met from soil reserves until these reserves cannot meet crop demands. This results in a reduction of plant growth and yield.

Table 8 Sustainability status of environmental dimension, soil health theme

Sustainability status (sub-indicator #4)	Agricultural area (ha)	Proportion of agricultural area (%)
Desirable	466.00	59.40
Acceptable	241.50	30.80
Unsustainable	77.26	9.80
Total	**784.76**	**100.0**

ii) Water use

In this theme, the variation of water availability will be considered for the water usage status of respondents.

The sustainability status will be estimated by the irrigated area and the stability of water level of the respondent's agricultural area including the availability of organizations that are responsible for water allocation in those area.

The desirable status will be assigned if the irrigated area is less than 10 % or the water availability remain stable over the years for the farm that have more than 10% of irrigated area. However, in case respondents experienced instability of water level over the years but there are organizations which are responsible for water allocation, the acceptable status will be assigned. Apart from those criteria, they will be considered as unsustain.

According to the pilot survey results, 619.44 ha of the total agricultural area (78.93%) has desirable status. 23.60 ha (3.01%) has acceptable status, and 141.72 ha (18.06%) has unsustainable status.

From the interview, most of agricultural area in Chachoengsao province does not use the irrigation system and some respondents said they does not know that there is regional irrigation office in the area as they only contact with water allocation group of the village. The chief of this group will be the one who contact with the officer directly.

Table 9 Sustainability status of environmental dimension, water use theme

Sustainability status (sub-indicator #5)	Agricultural area (ha)	Proportion of agricultural area (%)
Desirable	619.44	78.93
Acceptable	23.60	3.01
Unsustainable	141.72	18.06
Total	**784.76**	**100.0**

iii) Fertilizer risk

There are 8 measures regarding the respondent's behavior associated with fertilizer and manure applications, assigned by FAO in fertilizer pollution risk measurement. The desirable status will be assigned, If the farm adopted at least 4 measures. If at least 2 or 3 measures were adopted, the acceptable status will be assigned. On the contrary, the unsustainable

status will be assigned, if a famer applied fertilizer and does not take any measures to help reducing risk.

The result shows that 323.68 ha (41.25 %) of the agricultural area adopts at least 4 measures, which considered as desirable status. Followed by 401.64 ha (51.18%) of acceptable status which is considered as the majority. Only 59.44 ha or 7.57% of the total agricultural area are considered to be unsustainable as they adopts only one measure or does not take any measures.

Table 10 Sustainability status of environmental dimension, fertilizer risk theme

Sustainability status (sub-indicator #6)	Agricultural area (ha)	Proportion of agricultural area (%)
Desirable	323.68	41.25
Acceptable	401.64	51.18
Unsustainable	59.44	7.57
Total	**784.76**	**100.0**

iv) Pesticide risk

Pesticide management sub-indicator is considered by the adoption of 10 measurements consist of 3 health-related measures and 7 environment-related measurements. At first, types of pesticide will be considered to evaluate this sub indicator's sustainability status. In case farmers use highly or extremely hazardous pesticide, or use illegal pesticide, they will be assigned as unsustainable status straight away. For farmers who use moderately, or slightly hazardous pesticides and they adopted all 3 health-related measures and at least 4 or more of environment-related measures, the desirable status will be assigned to those particular farmers. In case, they adopted only 2 or 3 measures from health and environment-related measures, the acceptable status will be assigned. However, even if there are farmers who use moderately or slightly hazardous pesticides, but they adopted less than 2 measures of health and environment related measures, they will be considered as unsustainable status.

The result from the pilot survey surprisingly have almost the same percentage of each status.307.32 ha of the agricultural area (39.16%) has unsustainable status, which is the majority of the result. Followed by the desirable status at 243.52 ha (31.03%). The acceptable status has the least share at 233.92 ha (29.81%).

According to survey results, some farmers do not aware of the environmental risks associated with the use of pesticides as they still use highly or extremely hazardous pesticides, or illegal pesticides for their crop production.

Table 11 Sustainability status of environmental dimension, theme

Sustainability status (sub-indicator #7)	Agricultural area (ha)	Proportion of agricultural area (%)
Desirable	243.52	31.03
Acceptable	233.92	29.81
Unsustainable	307.32	39.16
Total	**784.76**	**100.0**

v) Biodiversity

Use of AGRO-biodiversity-supportive practices (UBSP) sub-indicator is used for biodiversity theme measurement. This sub-indicator is measures differently depending on whether (or not) the country has the applicability of the organic certification system. In Thailand, the organic certification is provided by the Organic Agriculture Certification Thailand (ACT). Hence, the threshold of sustainability criteria for countries with organic certificates will be used for sustainability status evaluation. Desirable status will be assigned if the agricultural holding meets at least 3 out of 6 criteria. Acceptable status will be assigned if the agricultural holding meets at least 2 of 6 criteria. However, the unsustainable status will be assigned if the agricultural holding meets none if 6 criteria. The majority of the pilot survey results have acceptable status which is 364.24 ha of the agricultural area (46.41 %). Followed by 252.30 ha with the unsustainable status and 168.22 ha with the desirable status (32.15 % and 21.44 %, respectively).

Table 12 Sustainability status of environmental dimension, biodiversity theme

Sustainability status (sub-indicator #8)	Agricultural area (ha)	Proportion of agricultural area (%)
Desirable	168.22	21.44
Acceptable	364.24	46.41
Unsustainable	252.30	32.15
Total	**784.76**	**100.00**

c. Social dimension

Social dimension of the SDG indicator 2.4.1 consists of 3 themes: 1) decent employment, 2) food security, and 3) land tenure. The sub-indicator used for calculating these themes are wage rate in agriculture, Food Insecurity Experience Scale (FIES), and secure tenure rights to land, respectively. The pilot survey results of each term and sub-indicator are reported as follows.

i) Decent employment

This theme investigates unskilled labour's economic risks in terms of remuneration received which measured the unskilled labour's daily wage in local currency unit to the national or agriculture sector minimum wage rate. In this survey, the minimum wage rate proposed by the National Wage Committee, Ministry of Labour, Thailand will be used for result evaluation. The minimum wage rate per day of Chachoengsao province is 330 baht, this will be set as a threshold for assigning sustainability status. If the wage rate of unskilled labour is higher than 330 baht, the desirable status will be assigned. If the wage rate is equals to 330 baht, the acceptable status will be assigned. However, if the wage rate is lower than 330 baht, it will be considered as unsustain.

According to the survey result, most of the respondents have the desirable status (538.40 ha of the agricultural area or 68.61%), the rest (246.369 ha or 31.39%) have an unsustainable status. For an acceptable status, no respondent falls under these criteria. The survey shows that most of household samples hire agricultural workers because of their aging. For the wage, agriculture jobs in Thailand pay wages lower than other sectors (e.g. industrial sector and

service jobs earn almost 50% higher than agriculture jobs) which is caused the labour shortage in agricultural sector due to wage difference. For this reason, Immigrant or foreign workers play role in filling labor demand to this sector and their daily wage is lower than Thai workers.

Table 13 Sustainability status of social dimension categorized by sub-indicators

Sustainability status (sub-indicator #9)	Agricultural area (ha)	Proportion of agricultural area (%)
Desirable	538.40	68.61
Acceptable	0.00	0.00
Unsustainable	246.36	31.39
Total	**784.76**	**100.00**

ii) Food security

The total agricultural area in the country under given sustainability status is computed alongside its corresponding proportion (over total agricultural area). According to the pilot survey, all 784.76 ha of the agricultural area has desirable status (100.00 %). No respondents were assigned with the acceptable status and unsustainable status.

Table 14 Sustainability status of social dimension categorized by sub-indicators

Sustainability status (sub-indicator #10)	Agricultural area (ha)	Proportion of agricultural area (%)
Desirable	784.76	100.00
Acceptable	0.00	0.00
Unsustainable	0.00	0.00
Total	**784.76**	**100.00**

However, due to the fact that the COVID-19 pandemic situation in Thailand is still active, the FIES sub-indicator questions are modified to reflect the food insecurity experience caused by the COVID-19 pandemic. The result of the pilot survey shows that, under the COVID-19 pandemic situation, 773.24 ha of the agricultural area has the desirable status (98.53 %). Followed by the acceptable status and the unsustainable status at 7.92 ha (1.01 %) and 3.60 ha (0.46 %), respectively.

Although the COVID-19 pandemic situation is still active, unsustainable percentage is very low because there was low impact on Covid19 during January to December 2020 (the period covered by the survey) and Thailand faced an uncontrolled outbreak since April 2021. From the interview, COVID-19 have affected farmer income and debt-paying ability due to the restriction of logistic and decreasing of non-agricultural income more than worrying that there is no food to consume as they still have food that they can produce by themselves.

Table 15 Sustainability status of social dimension, food security theme with COVID-19 pandemic situation modification

Sustainability status (sub-indicator #10(COVID-19))	Agricultural area (ha)	Proportion of agricultural area (%)
Desirable	773.24.	98.53
Acceptable	7.92.	1.01
Unsustainable	3.60.	0.46
Total	**784.76.**	**100.00**

iii) Land tenure

For this theme, the secure tenure rights to land sub-indicator will be considered for the sustainability status assignment. There are 4 criteria used for considering the level of security of land access; 1) formal document 2) name of the holder/holding on the document 3) right to sell any of parcel, and 4) right to bequeath any of parcel. If all 4 criteria are applied, the desirable status will be assigned. If famers have formal documents but other criteria do not apply, the acceptable status will be assigned. On the contrary, if there are no positive response to any of 4 criteria, the unsustainable status will be assigned.

According to the survey result, 655.66 ha of the agriculture land (84.80 %) is considered as the desirable status. For the acceptable status, only 72.54 ha (9.20 %) is reported, the rest (46.56 ha or 5.90 %) falls under the unsustainable status.

Table 16 Sustainability status of social dimension categorized by sub-indicators

Sustainability status (sub-indicator #11)	Agricultural area (ha)	Proportion of agricultural area (%)
Desirable	665.66	84.83
Acceptable	72.54	9.24
Unsustainable	46.56	5.93
Total	**784.76**	**100.00**

d. SDG 2.4.1 Dashboard

Using data from the pilot survey carried out in Chachoengsao province, it is unmistakable that the sub-indicator with the highest level of unsustainability is Farm Output Value per Hectare with at least 82.21 % of the agricultural area classified as unsustainable.

Table 16: The proportion of agricultural areas in total agricultural area that is desirable, acceptable, and unsustainable for each sub-indicator

Sustainability status of the holding	Area associated with											
	Farm output value per hectare	Net farm income	Risk mitigation mechanisms	Prevalence of soil degradation	Variation in water availability	Management of fertilizers	Management of pesticides	Use of biodiversity -supportive practices	Wage rate in agriculture	FIES	FIES (COVID-19)	Secure tenure rights to land
Desirable	4.88	63.88	48.60	59.38	78.93	41.25	31.03	21.44	68.61	100	98.53	84.82
Acceptable	12.91	26.26	48.35	30.77	3.01	51.18	29.81	46.41	0.00	0	1.01	9.24
Unsustainable	82.21	9.86	3.05	9.85	18.06	7.57	39.16	32.15	31.39	0	0.46	5.93

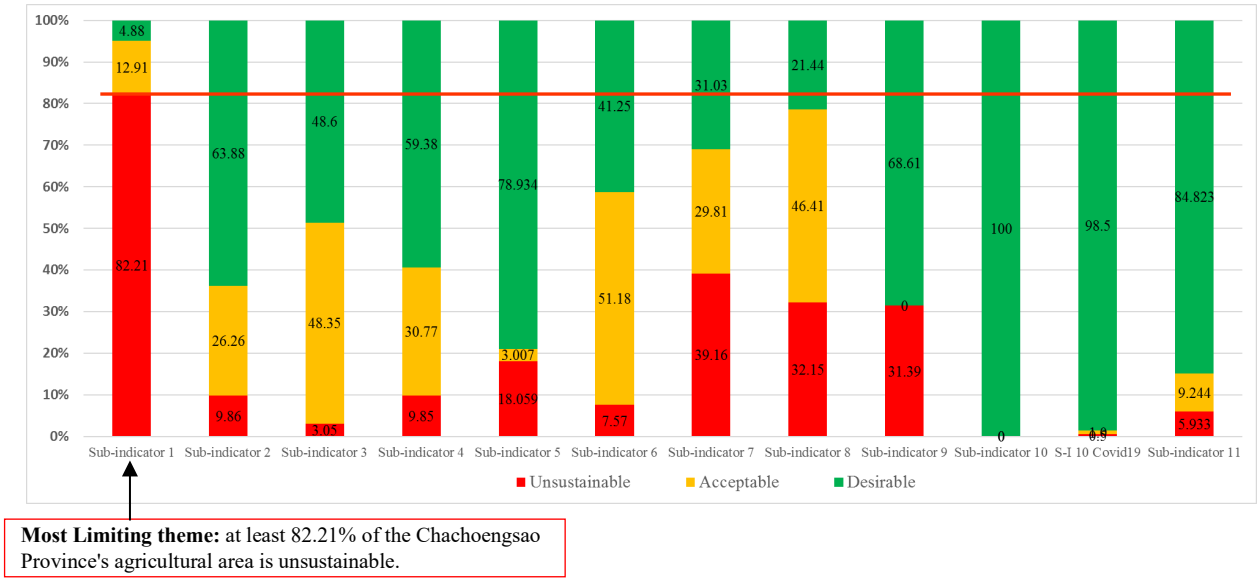

Figure 1: Final dashboard

For sub-indicator 1(Farm output value per hectare), the resulted found very few farmers meeting the "Desirable" and "Acceptable" criteria. This result was significantly influenced by the fact that there are several farmers, such as hydroponic farmers (farmer those who cultivate vegetables.), who have a high income due to their high productivity and these farmers do not have a large area of farmland. The 90th percentile was set at a high level, with correspondingly high 2/3 and 1/3 thresholds. Farmers with high FOVH held only a small area of agricultural land, which was not reflected in the area percentage of sustainability performance. Due to the heterogeneity in the vegetable farmer category, we have used the " category of farms " approach to calculate our own " vegetable category " as the charts shown below.

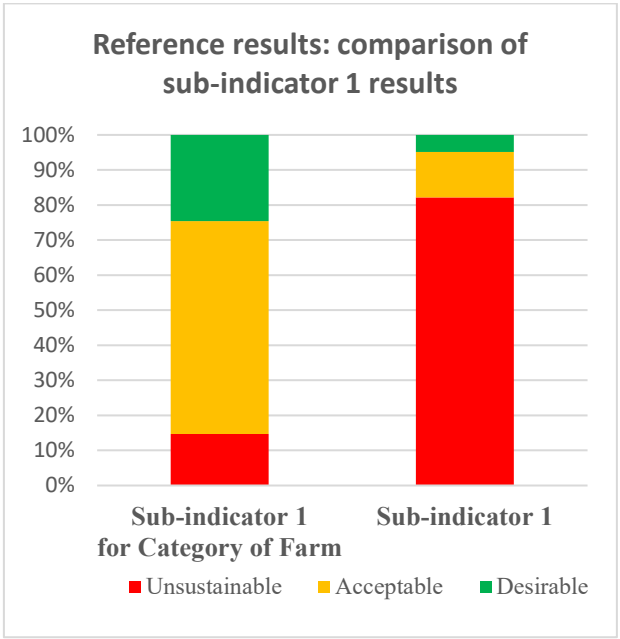

Figure 2: Comparison of Sub-indicator 1 results (table 4 and table 5 on page 37)

For sub-indicator 7 (Management of Pesticides), the unsustainable status accounted for 39.16%, which is considered as a large percentage. Since Thai farmers use pesticides and chemicals more than necessary and it does not increase the productivity as it should be, it is necessary to provide guidance to farmers and strengthen publicity through the local government officials to ensure that farmers are fully aware of the pesticide risks and also limit the impact on their health and on the environment.

Sub-indicator 8 (Use of agro-biodiversity-supportive practices) has unsustainable agricultural area at 32.15%, which is also considered as a large percentage. Based on the results, this may be due to a large farm size of the holding that have at least two different crops or pastures rotation which is more difficult in farm management than planting only one crop. In addition, there are limitation in adopting new technologies and increase productivity since most of farmers are elderly.

Chapter 5 Conclusion and recommendation

5.1 Conclusion

The information in this study points out some of the key results of agricultural sector in Thailand.

5.1.1 Characteristics of Respondents

The majority of respondents have become an aging society since the most of them aged higher than 50 years old. This is consistent with the report by World Bank (2016) that by 2040 the number of Thai people who aged 65 years or over is projected to reach 17 million people. Another key finding is that there is no gender discrimination basis since the percentage points of male and female are slightly different. Fortunately, the study has also found that all respondents are educated as most of them are granted basically primary and secondary/vocational certificates and there is no illiterate person reported. They also have legal possession and tenure rights in land as well as internet access.

5.1.2 Three multidimensional natures: economics, social, and environment

The empirical results suggested are as follows:

1) In order to ensure a sufficient level of income which is satisfactory to sustain a livelihood of the family farming for unforeseeable future, there is a significant necessity to vigorously improve land productivity, even though, the agricultural holdings can satisfy profitability and risk mitigation mechanisms. These implied that farm households can still sustain their livelihood income-generation mechanism and can be adjustable to market volatility and natural shocks.

2) The environment is another discrete aspect to be delineated as the result suggests that natural resources are weakening due to the unappropriated use of pesticides and ineffective management in biodiversity.

3) The social dimension is not deliberately to be concerned in terms of food security, food security under the spreading of COVID-19, and tenure rights, although, there are some possible risks for unskilled labours. New problems may arise in the future as increasing numbers of urban unemployed return to their hometowns to work in agriculture.

5.1.3 Sustainability policy

This paper primarily suggests that to achieve SDG 2.4.1 Percentage of agricultural area under sustainable agricultural practices, the improvement for numerators on some sub-indicators mentioned previously requires active policy to sustain life as well as ascertaining land degradation and productivity. In short, in accordance with the development plans of the country, Thailand should incessantly operationalize efficiency policy on sustainable agriculture practices.

5.2 Recommendations and Limitations

5.2.1 For every type of survey, the availability of an appropriate sampling frame is crucial for conducting validated surveys. Basically, because the sampling frame captures the relationship between the target population and the unit of observation. This pilot project although used existed sampling frame, ostensibly there is unavailable sample frame for the non-household sector. The variant of land productivity was not taken into consideration. Another aspect relevant to the land utilization is that the sample unit should be categorized by size of landholding. Indeed, in order to resolve this problem, the double sampling design should be used so crucial that the stratification can produce disaggregated statistics and valid survey.

5.2.2 This pilot survey was conducted in 5 districts (Phanom Sarakham, Sanam Chai Khet, Bang Nam Priao, Ban Pho, and Mueang Chachoengsao districts) in 1 province (Chachoengsao province). The sample size of 240 is yet too small to characterize the whole province. As Chachoengsao has diversified agricultural characteristics, the minute sample size was a constraint to capture the actual picture of the agricultural sector at the local level.

5.2.3 Due to the COVID-19 pandemic, it is almost impracticable to conduct data collection, for example, tighter policies, cross-border restrictions, and mobility restrictions. Additionally, the enumerators were not trained and questionnaire was not designed for remote data collection, consequently, the valid responses of 135 were not adequate to provide the reliable information. The desirable solution would be adaptive plans which could apply instantaneously on unforeseen occurrences.

5.3 Future research suggestions

1) The double sampling design suggested by FAO is essential for conducting the future farm survey. The stratification is additionally indispensable for the classification of diversified groups of agricultural holdings (farm household and non-farm household), low, medium, and high intensification of land productivity, and also diversification of landholding size.

2) For data collection, the sample size and distribution should be relatively sizeable to define the agricultural activities of the whole kingdom. Additionally, aggregate evidence in this study suggests that the data collection should be highlighted on important cash crops.

3) The data from farm survey can be supplemented with information from other sources, for example, the data, which has been obtained from agricultural census done by National Statistical Office, would probably accomplish sub-indicator 1 and 2.

4) Some key concepts and their specific definitions are uncommon in Thailand context. Enumerators and respondents have difficulties in comprehending those concepts. Another challenge is some questions in the survey create difficulty in recall, for example, the recollection of profitability in the last three consecutive years. The complicated contents in questionnaire creates respondent burden during the survey. The best practices would be 4.1) the multiple- choice questions would need to be adjusted to suit Thai circumstances,

4.2) the questionnaire should be simplified and comprehendible so that it will not be a burden for both enumerators and selected respondents

5) Essentially, the Thai authorities should discuss with FAO consultants whether aquaculture sector exclusively should be included in the future survey since the sector is one of the major contributions to the agriculture in Thailand.

References

Department of Fisheries. 2019 Fisheries Statistics of Thailand. 2021. https://www4.fisheries.go.th/local/index.php/main/view_activities/1408/85334

Food and Agriculture Organization of the United Nation (FAO). 2019. Guidelines on Data Analysis and Reporting. http://www.fao.org/3/cb0617en_P14-15_Category Painted.pdf

Food and Agriculture Organization of the United Nation (FAO). 2020a. SDG Indicator 2.4.1: Proportion of agricultural area under productive and sustainable agriculture. http://www.fao.org/3/ca5157en/ca5157en.pdf

Food and Agriculture Organization of the United Nation (FAO). 2020b. SDG Indicator 2.4.1: Methodological notes. http://www.fao.org/3/CA2639EN/ca2639en.pdf

National Statistical Office. 2020. The labor force survey whole kingdom. 21 July 2021. http://www.nso.go.th/sites/2014en/Survey/social/labour/LaborForce/2020/pocketbook2020.pdf

Office of Agricultural Economic, Agricultural Statistics of Thailand 2020. March 2021

Office of Agricultural Economic. 2020. Farmer One. 2021. http://farmerone.org:9502/analytics/saw.dll?Portal

Office of the National Economic and Social Development. 2021. Gross Domestic Product Chain Volume Measures. https://www.nesdc.go.th/nesdb_en/ewt_w3c/main.php?filename=national_account.

Office of the National Economic and Social Development Council. 2021. Gross Regional and Provincial Product Chain Volume Measure 2019 Edition. https://www.nesdc.go.th/nesdb_en/ewt_w3c/ewt_dl_link.php?nid=4317

Office of the Permanent Secretary for Ministry of Agriculture and Cooperatives. 2019. Agricultural Development Plan (Chachoengsao 2018-2022). https://www.opsmoac.go.th/chachoengsao-strategic-files-412791791816

Regional Office of Agricultural Economics 6. 2019 Agricultural Economic Outlook of Chachoengsao. May 2021. https://online.anyflip.com/lkjho/bxbm/mobile/index.html

World Bank. 2016. Thailand economic monitor: aging society and economy. https://documents1.worldbank.org/curated/en/830261469638312246/pdf/107267-WP-PUBLIC-Thailand-Economic-Monitor-2016.pdf

Annex: Application of Ministry of Agriculture and Cooperatives

DOAE Farmbook application allows agricultural household to identify/ revise their information on agricultural activities via smart phone including checking their registration information and their accessibility to the government supporting measures.

OAE Ag-Info is an application of information resources and news of agricultural economics to help farmers on decision making and farming planning. By using this application, the users will be able to track daily agricultural prices changes in the central market, farm gate prices, agricultural products calendar, monitor the situation of agricultural production, disaster alert as well as press releases and policies from the government.

OAE RCMO Application is an application to assist farmers in calculating agricultural production costs and comparing costs to make decisions for their investment. This application also provides market information and the suitability of the products in the area in order for farmers to make the right decision on investing in the products that are the most suitable for their area.

LDD Zoning is the application that provides the access to information for the officers of the Land Development Department of the Ministry Agriculture and Cooperatives as well as general users on Economics Crop Zoning of 13 agricultural commodities which classified into 4 levels according to soil properties; 1) high suitable area (S1), moderately suitable area (S2), slightly suitable area (S3) and unsuitable area (N). The information will be shown with administrative boundaries at the provincial, district, sub-district level, Digital Color Orthophoto and water resources of the Department of Land Development.

Smart Rice Farm – SRF is an application in cooperation of the Rice Department and Land Development Department of the Ministry Agriculture and Cooperatives, Thailand jointly develop for providing technology and knowledge on rice production improvement as well as using academic reference.

DOA Research application provides the opportunity for agricultural producers and general users to research academic references and published documents from the researchers of the Department of Agriculture, the Ministry Agriculture and Cooperatives, Thailand. The users can access to read full text papers from publishers.

DOA GAP assists farmers and general users by providing information on database of GAP farming area and organic farming area which users can search by using area numbers, certificate numbers, ID card numbers, farmer‘s name, crop name or located area (province, district, or sub-district).

QSDS Service is a system that provides services on promoting Thai silk production to reach the international standards.

Feed is a smart tool for smart farmer that assists farmers in shrimp farming guidance and increase shrimp productivity. By using this application, the program will guide the users to feed shrimp correctly and efficiently as many farmers are seeking for new tools for improving effective shrimp farming.