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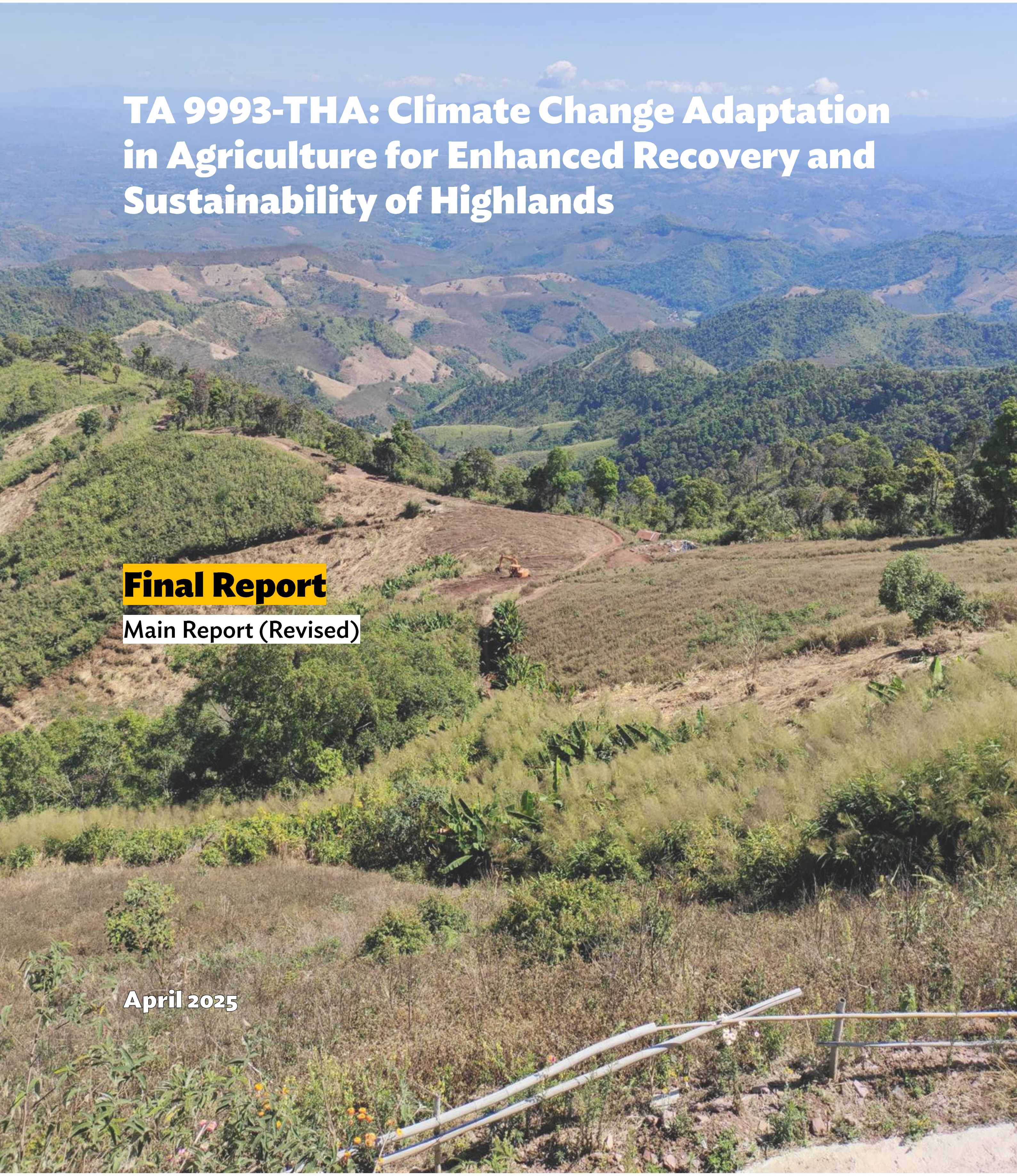

TA 9993-THA: Climate Change Adaptation in Agriculture for Enhanced Recovery and Sustainability of Highlands

Final Report

Main Report (Revised)

April 2025

AIT Asian Institute of Technology

NIPPON KOEI

TEAM GROUP

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Abbreviations

ADB	Asian Development Bank
AIT	Asian Institute of Technology
BAAC	Bank for Agriculture and Agricultural Cooperatives
BCG	Bio Circular Green
BCR	Benefit-Cost Ratio
CBA	Cost-Benefit Analysis
CDD	Community Development Department
CNA	Capacity Needs Assessment

COVID	Coronavirus Disease
CSA	Climate Smart Agriculture
CSR	Corporate Social Responsibility
DOAE	Department of Agricultural Extension
FDA	Food and Drug Administration
GAP	Good Agricultural Practices
GIS	Geographic information system
GMP	Good Manufacturing Practices
GMS	Greater Mekong Subregion
JFPR	Japan Fund for Prosperous and Resilient Asia and Pacific
MCA	Multicriteria Analysis
MOAC	Ministry of Agriculture and Cooperatives
NDVI	Normalized Difference Vegetation Index
NGO	Non-Government Organization
NIR	Near Infrared
NPV	Net Present Value
OAE	Office of Agricultural Economics
OTOP	One Tambon One Product
PCC	Participation, Communication and Capacity Building
PGS	Participatory Guarantee System
RMUTL	Rajamangala University of Technology Lanna
SAO	Subdistrict Administration Organization
SCALA	Scaling up Climate Ambition on Land Use and Agriculture through NDCs and National Adaptation Plans
SDG	Sustainable Development Goals
THA	Thailand
THB	Thai Baht
TNA	Training Needs Assessment
USA	United States of America
USD	United States Dollar

1. Introduction

1.1 Technical Assistance Overview

1. In June 2020, the Asian Development Bank (ADB) approved a Technical Assistance (TA) to Thailand entitled "Climate Change Adaptation in Agriculture for Enhanced Recovery and Sustainability of Highlands" with financial support from the Japan Fund for Prosperous and Resilient Asia and the Pacific (JFPR). The Ministry of Agriculture and Cooperatives (MOAC) is the executing agency, and the Office of Agricultural Economics (OAE) is the coordination and implementing agency.

2. The TA aims to reduce climate change vulnerability and enhance the adaptive capacity of highland communities and ecosystems to cope with current and projected climate change impacts; improve household livelihoods and food security; and boost rural employment and support Thailand's economic recovery after the coronavirus disease (COVID–19) pandemic. The TA's expected impact is improved agricultural competitiveness in the highlands. The expected outcome is an enhanced enabling environment for the adoption of climate-smart agriculture (CSA) in the project areas.

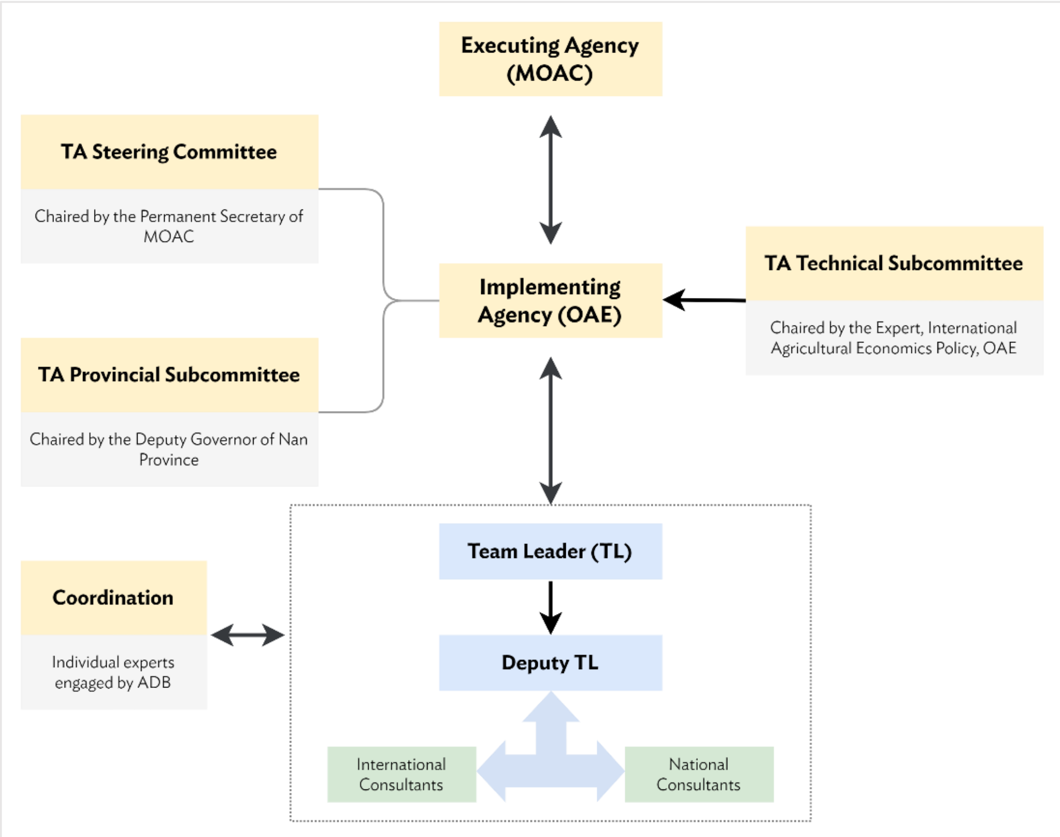
3. The TA has four outputs: (i) capacity to assess climate change vulnerability of highland agriculture evaluated; (ii) gender- and COVID-19-responsive CSA practices prioritized and analyzed; (iii) agricultural product quality, value addition, and market linkages assessed; and (iv) capacity of local governments and communities to address climate change strengthened. The TA has demonstrated several CSA practices in a highland province (Nan province) in Thailand, including (i) climate- smart water management (keyline technology and solar irrigation); (ii) climate-adaptive soil management (soil carbon sequestration through biochar application and participatory guarantee system for organic agriculture); (iii) bio-circular green (BCG) economy through sustainable management of agricultural residues; and (iv) a digital technology-based agri-food traceability solution.

Figure 1: TA impact and outcome.

1.2 TA Implementation Arrangements

4. Figure 2 was the implementation structure of the Technical Assistance.

Figure 2: TA implementation arrangements.



1.2.1 TA executing and implementing agencies

5. MOAC served as the executing agency, while the OAE was the implementing agency for the TA. MOAC established a TA steering committee, a TA provincial subcommittee, and a TA technical subcommittee to ensure the project proceeded as planned and achieved its objectives.

1.2.2 TA steering and technical committees

6. MOAC had appointed a TA steering committee (SC), chaired by the Permanent Secretary of MOAC. The committee included 18 members representing various departments, offices, and agencies under MOAC, along with other relevant national organizations. The Director of the International Agricultural Economics Division, OAE, served as the Secretary, and the Director of the 2nd Office of Agricultural Economics served as the Deputy Secretary of the SC. The TA Steering Committee was responsible for guiding the implementation of the project to ensure that its objectives were successfully achieved. It steered the project in alignment with relevant rules, regulations, and timelines, while also overseeing its financial aspects to ensure proper resource management. The Committee monitored progress and provided strategic and technical advice as needed throughout the implementation process. As appropriate, it established sub-committees and working groups or assigned designated officers to carry out specific tasks. The TA Steering Committee also undertook other related assignments necessary to support the effective execution of the project. The composition is provided in Table 1 below.

Table 1: TA Steering Committee composition.

1.	Permanent Secretary of Ministry of Agriculture and Cooperative	Chairperson
2.	Secretary General of Agricultural Economics	Vice Chairperson
3.	Director General of Royal Irrigation Department	Committee
4.	Director General of Department of Fisheries	Committee
5.	Director General of Department of Livestock Development	Committee

6.	Director General of Land Development Department	Committee
7.	Director General of Department of Agriculture	Committee
8.	Director General of Department of Agricultural Extension	Committee
9.	Director General of Cooperative Promotion Department	Committee
10.	Secretary General of Agricultural Land Reform Office	Committee
11.	Secretary General of National Bureau of Agricultural Commodity and Food Standards	Committee
12.	Director of Highland Research and Development Institute (Public Organization)	Committee
13.	Director of Bureau of Foreign Agricultural Affairs, Office of the Permanent Secretary	Committee
14.	Director of Agricultural technology and sustainable agriculture policy division, Office of the Permanent Secretary	Committee
15.	Nan Provincial Agriculture and Cooperatives, Office of the Permanent Secretary	Committee
16.	Representative of Asian Development Bank	Committee
17.	Director of International Agricultural Economics Division, Office of Agricultural Economics	Committee and Secretary
18.	Director of the 2^{nd} Office of Agricultural Economics	Committee and Deputy Secretary

7. The SC also appointed a TA Provincial Subcommittee consisting of 34 members, with the Governor acting as an Advisor and the Deputy Governor (with an economics-related function) of Nan Province as the Chair. The Provincial Subcommittee supported the implementation of the project at the local level to ensure that its objectives were successfully achieved. It steered the local-level implementation in accordance with relevant rules, regulations, and timelines. The Subcommittee monitored progress and provided advice as needed to facilitate effective implementation. It regularly reported on the project's progress, as well as any problems and obstacles encountered, to the TA Steering Committee. Where appropriate, it appointed working groups or assigned officers to carry out specific project activities. The Provincial Subcommittee also undertook other related assignments to support the overall success of the project. The composition is provided in Table 2 below.

Table 2: TA Provincial Subcommittee composition.

1.	Governor, Nan Province	Advisor
2.	Deputy Governor, Economics related function, Nan Province	Chairperson
3.	Chief District Officer of Na Noi District	Vice Chairperson
4.	Commander, Mobile Development Office 31, Royal Thai Armed Forces Headquarters	Sub-Committee
5.	Nan Provincial Social Development and Human Security Office	Sub-Committee
6.	Director, Nan Provincial office for Natural Resources and Environment	Sub-Committee
7.	Nan Provincial Public Health Medical Doctor	Sub-Committee
8.	Nan Provincial Office of Commercial Affairs	Sub-Committee
9.	Nan Provincial Community Development Office	Sub-Committee
10.	Nan Local Administrative Office	Sub-Committee
11.	Vice-Chancellor, Rajamangala University of Technology Lanna Nan	Sub-Committee
12.	Dean, School of Agricultural, Center of Learning Network for the Region, Chulalongkorn University, Nan Province	Sub-Committee
13.	Director, Nan Primary Educational Service Area Office 1	Sub-Committee
14.	Nan Provincial Energy Officer	Sub-Committee
15.	Nan Provincial Agricultural; Extension Officer	Sub-Committee
16.	Nan Provincial Livestock Officer	Sub-Committee
17.	Nan Provincial Fisheries Officer	Sub-Committee
18.	Director, Nan Irrigation Project	Sub-Committee
19.	Nan Provincial Cooperative Officer	Sub-Committee
20.	Agricultural Land Reform Officer	Sub-Committee
21.	Director, Nan Land Development Station	Sub-Committee
22.	Director, Nan Land Development Office 7, Land Development Department	Sub-Committee
23.	Head, Nan Cooperative Auditing Office	Sub-Committee
24.	Director, Nan Agricultural Research and Development Center	Sub-Committee

25.	Director, Bank for Agriculture and Agricultural Cooperatives, Nan Office	Sub-Committee
26.	President, Nan Chamber of Commerce	Sub-Committee
27.	Manager, Highland Development using the Royal Project Approach Project, Group 3, Nan Basin	Sub-Committee
28.	Director, Freshwater Aquaculture Research and Development Center, Nan	Sub-Committee
29.	Director, Nan Agricultural Occupation Promotion and Development Center	Sub-Committee
30.	Director, Irrigation Bureau 2 (Lampang Province)	Sub-Committee
31.	Director, Conservation Area Administration Office 13 (Phrae)	Sub-Committee
32.	Representative of the Agricultural Cooperatives Expansion Khun Sathan Royal Project, Ban Saensuk Co., Ltd., Na Noi District, Nan Province	Sub-Committee
33.	Nan Provincial Agriculture and Cooperatives Officer	Sub-committee and Secretary
34.	Director, Office of Agricultural Economics 2, Office of Agricultural Economics	Sub-committee and Deputy Secretary

8. Additionally, a Technical Subcommittee was appointed by the SC to provide technical guidance, advice, and monitoring of the TA implementation. The Technical Subcommittee provided suggestions, advice, and oversight for the implementation of the project. It addressed related challenges and coordinated closely with the Office of Agricultural Economics and the project advisor. The Subcommittee contributed input and recommendations on the project implementation plan and reported on the project's progress and deliverables. It also organized consultation meetings by inviting relevant agencies to ensure broad stakeholder engagement. Additionally, the Technical Subcommittee reported project implementation updates to the TA Steering Committee and undertook other related assignments to support the effective execution of the project. The composition is provided in Table 3 below.

Table 3: TA Technical Subcommittee composition.

1.	Deputy Secretary General, Office of Agricultural Economics	Chairperson
2.	Specialist, International Agricultural Economics Policy	Vice Chairperson
3.	Representative, Royal Irrigation Department	Sub-committee
4.	Representative, Department of Fisheries	Sub-committee
5.	Representative, Department of Livestock Development	Sub-committee
6.	Representative, Land Development Department	Sub-committee
7.	Representative, Department of Agriculture	Sub-committee
8.	Representative, Department of Agricultural Extension	Sub-committee
9.	Representative, Cooperative Promotion Department	Sub-committee
10.	Representative of Secretary General, Agricultural Land Reform Office	Sub-committee
11.	Representative of Secretary General, National Bureau of Agricultural Commodity and Food Standards	Sub-committee
12.	Representative, Highland Research and Development Institute (Public Organization)	Sub-committee
13.	Representative, Division of Agricultural Technology and Sustainable Agriculture Policy	Sub-committee
14.	Representative, International Agricultural Economics Division, Office of Agricultural Economics	Sub-committee and Secretary

1.2.3 TA Consultant team and staff from the Government

9. The Consultant's team, (Table 4) consisted of seven international and nine national experts contracted to deliver the assignment. Dr. Nathsuda and Mr. Danuwat were experts providing the required expertise in Climate-Smart Agriculture and Organic Farming. Dr. Nathsuda was designated as the team leader (with 16 person months allocation) and Danuwat P. as Organic farming specialist (with 8 person months allocation).

Table 4: TA consultant team.

Position/ Area of Expertise		Name of Expert
International		
1	Climate Smart Agriculture and Organic Farming Specialist/ Deputy Team Leader	John Ward
2	Agribusiness Value Chains Improvement Specialist	Vichelle Roaring Arunsuwannakorn[1]
3	Climate Change Vulnerability and Adaptation Specialist	S.V.R.K. Prabhakar
4	Climate Smart Soil and Water Management Specialist	B. Maheshwari
5	Food Safety and Quality Improvement Specialist	Sujitta Raungrusmee
6	Digital Agriculture Specialist	Kiyoshi Honda
7	Capacity Building and Knowledge Management Specialist	Mukand S. Babel
National		
1	Climate Smart Agriculture and Organic Farming Specialist/ Team Leader	Nathsuda Pumijumnong
		Danuwat Pengont
2	Agribusiness Value Chains Improvement Specialist	Takuji W. Tsusaka
3	Climate Change Vulnerability and Adaptation Specialist	Sangam Shrestha
4	Climate Smart Soil and Water Management Specialist	Avishek Datta
5	Food Safety and Quality Improvement Specialist	Anil K. Anal
6	Digital Agriculture Specialist	Rassarin Chinnachodteeranun
7	Gender and Social Development Specialist	Siriluck Sirisup
8	Capacity Building and Knowledge Management Specialist	Voravate Chonlasin

10. Mr. Shinichiro Sugimoto provided support, as required, for both International and National Agribusiness Value Chains Improvement Specialists, namely, Dr. A. B. Prakasam (initially and later to Vichelle Roaring-Arunsuwannakorn) and Dr. Takuji W. Tsusaka. Table 5 presents the list of staff at national and local levels facilitating and supporting the Consultant in the TA implementation.

Table 5: National and local level government staff[2] facilitating the TA implementation.

Staff	Position/Organization	Contact details
Ms. Pasinee Napombejra	Policy and Plan Analyst Senior Professional Level, OAE	+66-81-912-3713 pasinee23@gmail.com
Mr. Paiboon Techakampon-Sarakit	Policy and Plan Analyst Senior Professional Level, OAE	+66-85-8150883 paiboon.paik@gmail.com
Mr. Thitipong Srisombat	Policy and Plan Analyst Professional Level, OAE	+66-86-518-2732 thitipong.oae@gmail.com
Ms. Patitta Nantasit	Policy and Plan Analyst, Expert, Provincial Agriculture and Cooperatives Office, Nan Province	+66-63-585-9542
Ms. Yada Kawinkham	Policy and Plan Analyst, Bua Yai Subdistrict Administrative Organization (SAO)	+66-91-078-4515

[1] Replaced Dr. Anand Babu Prakasam.
[2] Officially not nominated by the OAE/MOAC.

1.3 TA Objectives

11. The TA supported efforts to: (1) strengthen technical and institutional capacities for assessing climate change vulnerabilities; (2) demonstrate Climate-Smart Agriculture (CSA) practices and digital technologies for traceability of agri-food products; and (3) assist local governments in integrating climate change considerations into agricultural planning. It also contributed to Thailand's broader goals to: (1) recover from the socio-economic impacts of the COVID-19 pandemic; (2) reduce poverty, income inequality, and climate vulnerability; and (3) enhance the resilience of highland communities and their ecosystems.

1.4 Final Performance Assessment Against the Design and Monitoring Framework

12. Table 6 shows the final performance assessment of this TA against the Design and Monitoring Framework.

Table 6: Final performance assessment of the TA against the design and monitoring framework.

Impact: Agricultural Competitiveness in Highlands Improved (Thailand's Master Plan on Agriculture under the National Strategy (2018-2037))

Results Chain	Performance Indicators with Targets and Baselines	Achievements
Outcome Enabling environment for adoption of CSA in project areas enhanced	a. At least 300 persons (at least 30% women) have improved capacity to implement CSA solutions	a. **Achieved (exceeded the target).** 911 persons (62% women, 6% youth, 19% government staff, 4% private sector representatives) had enhanced capacity to implement CSA solutions through the implementation of 8 capacity building workshops, 1 international knowledge sharing workshop, and 1 field visit to demonstration sites.
	b. At least five agribusinesses integrated female and male highland farmers in resource-efficient value chains	b. **Substantially Achieved**. Identified 5 agribusinesses for integration of CSA practices and highland farmers into resource-efficient value chains. **Additional Information**: • Support needed for the identified agribusinesses, target stakeholders, expected resources, and potential funding sources identified. • Localized strategies and interventions at Na Noi district level and Nan Province level identified for strengthening agribusiness investment, scaling up of CSA initiatives, strengthening market access, and promoting agro-tourism as a climate-smart economic diversification strategy
	c. At least two gender- and COVID-19-responsive and inclusive CSA action plans at the district and provincial levels developed	c. **Achieved**. 2 action plans at province and district levels developed.
Outputs 1. Capacity to assess climate change vulnerability of highland agriculture improved	1a. At least 30 local government staff (at least 30% women) have enhanced understanding and capacity on methods of conducting climate change vulnerability assessment	1a. **Achieved**. 120 total participants (59 onsite and 61 online) – 51 government officials (47 onsite and 4 online), 12 from academia, and 2 private sector representatives – with 47% women – enhanced their understanding and capacity on methods of conducting climate change vulnerability assessment through the capacity building event titled, "Climate Change Vulnerability Assessment in Highland Agriculture: Challenges and Opportunities."
	1b. At least two vulnerability and impact assessments of highland agriculture at	1b. **Achieved**. 4 agricultural crops (rice, maize, soybean, coffee) and their yields

Results Chain	Performance Indicators with Targets and Baselines	Achievements
	district and provincial levels for current and future climate scenarios conducted	assessed under current and future climate change scenarios. Knowledge product on Vulnerability of Highland Agriculture – Current and Future Climate Change Scenarios prepared.
	1c. A guidance manual on climate change vulnerability assessment in highlands prepared	1c. **Achieved**. Guidance manual on Climate Change Vulnerability Assessment in Highlands prepared.
2. Gender- responsive, CSA practices prioritized and demonstrated	2a. Cost-benefit analysis of at least three gender- responsive CSA practices conducted	2a. **Achieved**. Cost-benefit analysis of 3 CSA practices (keyline water management, solar irrigation system, biochar application) against traditional maize cultivation carried out. Furthermore, cost-benefit analysis of climate-adaptive organic farming with PGS at value chain level conducted.
	2b. At least two demonstrations on gender- and COVID-19-responsive CSA practices delivered	2b. **Achieved**. 6 demonstrations on keyline water management; solar irrigation system; climate-adaptive soil management using biochar; climate-adaptive organic farming through PGS; bio-circular green economy and sustainable waste management of maize residue; and digital-technology based farm-to-fork traceability solution for lemongrass oil implemented.
	2c. At least 150 farmers, youth, and local NGO and private sector representatives (at least 30% women and 25% youth) have enhanced knowledge and skills on CSA	2c. **Achieved (exceeded target)**. 132 participants (58% women, 10% youth, 11% government staff) – 83 farmers (49% women), 25 school students (100% youth, 52% women), and 24 government officials (58% women) – enhanced their knowledge through the capacity building workshop on Gender-Conscious Climate-Smart Agriculture in Highlands. Additionally, a field visit was organized for 173 farmers, students, and local government officials from 6 neighboring subdistricts, 4 districts, and 5 highland provinces to the pilot demonstration sites. 50% of the participants were women and 24% were youth.
	2d. At least two knowledge products on gender- and COVID-19 responsive CSA for highlands prepared	2d. **Achieved**. 2 knowledge products on **Gender-Conscious Climate Smart Agriculture for Highlands** and **Climate-Smart Agriculture Demonstration Process** prepared.
3. Agricultural product quality, value addition, and market linkages enhanced	3a. Knowledge and capacity of at least 50 persons (at least 30% women) on grower certification schemes, organic farming, good agricultural practices, agricultural product safety and quality improvement, and value addition enhanced	3a. **Achieved (exceeded target)**. Knowledge and capacity of 132 persons (52% women, 3% government officials, and 4% private sector representatives) on grower certification schemes, organic farming, good agricultural practices, agricultural product safety and quality improvement, and value addition enhanced

Results Chain	Performance Indicators with Targets and Baselines	Achievements
		through the following capacity building workshops: • Grower Certification Schemes, Organic Farming, and Good Agricultural Practices (70 participants – 65 farmers and 5 government officials – with 63% women) • Agricultural Product Quality and Safety Enhancement, Value Addition, and Market Linkages (49 farmers, 6 government officials, 7 private sector representatives – with 55% women)
	3b. At least two raw agricultural products and two processed agricultural products received certification for good quality and safety with market links established	3b. **Substantially Achieved**. Raw and processed pumpkin and cacao received certification for good quality and safety. **Additional Information:** **Pumpkin** • In 2013, Ms. Thikamporn Kongsorn launched the "One Rai of Bua Yai Organic Agriculture" project. Initially converting her own one-rai plot for diversified vegetable cultivation • Transitioning from a single annual maize crop, the community recognized native organic pumpkins—especially the indigenous 'Kai-Nao' variety—as a promising cash crop due to local expertise and superior taste, attracting interest from major businesses like Central Group Co., Ltd. • With FDA-certified products and a GAP-standard processing plant supported through technology transfer, fresh and processed pumpkins now penetrate major supermarket chains (Tops, Big C, Makro), reinforcing the region's economic stability. • Despite achieving participatory guarantee standards, local pumpkin cultivation has not secured Organic Thailand certification due to land ownership constraints.

Results Chain	Performance Indicators with Targets and Baselines	Achievements
		• In response, certified inspectors (under IFOAM and the Department of Internal Trade) have been engaged to evaluate operations, while targeted training sessions have been organized to bolster farmers' knowledge of national organic standards. **Cacao** • The Community Enterprise Group for Afforestation 3 Benefits 4, established on February 28, 2021, in Bua Yai sub-district, comprises 32 members managing 136 rai dedicated to cocoa cultivation. • Harvested cocoa fruits are transformed into high-value products such as cocoa powder, chocolate, and cocoa butter. • By-products like cocoa shells are repurposed into charcoal and compost, thereby reducing waste and boosting the overall economic value of cocoa production. This integrated approach fosters a circular agricultural system. • To address challenges pertaining to processing quality, an educational center has been established to train workers and stakeholders in best practices across all production phases—from harvesting and fermentation to drying and final processing. • This initiative supports continuous improvement and helps align the group's practices with internationally recognized standards (GHPs, Codex, HACCP).
	3c. At least one digital technology demonstration for traceability of agricultural products conducted	3c. **Achieved**. 1 demonstration for digital-technology based farm-to-fork traceability solution for lemongrass oil implemented.
	3d. At least two knowledge products on quality and safety, value addition, and grower certification schemes prepared	3d. **Achieved**. 2 knowledge products produced.

Results Chain	Performance Indicators with Targets and Baselines	Achievements
		• Grower Certification Schemes, Organic Farming, and Good Agricultural Practices • Agricultural Product Quality and Safety Enhancement, Value Addition, and Market Linkages
4. Capacity of local governments and communities to address climate change strengthened	4a. At least 30 government staff (at least 30% women) demonstrate enhanced understanding on ways to integrate climate change in local agricultural planning	4a. **Achieved**. 37 local government staff from 17 different agencies and 1 private sector representative – with 61% women – had enhanced understanding on ways to integrate climate change in local agricultural planning.
	4b. At least 100 farmers, youth, and local NGO and private sector representatives (at least 30% women and 25% youth) demonstrate increased knowledge on agricultural adaptation and alternative livelihood options for highlands	4b. **Achieved (exceeded target)**. 550 persons (71% women, 8% youth, 9% government staff, and 5% private sector representatives) had increased knowledge on agricultural adaptation and alternative livelihood options for highlands through capacity building workshops on: • Alternative Livelihood Options for Highlands[3]– 396 farmers (79% women, 9% youth) • International Workshop on CSA in Highlands – 135 participants (10% farmers, 33% government officials, 10% private sector representatives) comprising of 49% women • Private-Sector Engagement in CSA in Highlands – Challenges and Opportunities[4] (16 private sector representatives and 3 government officials - 56% women)
	4c. At least two field visits to CSA demonstration sites organized for at least 30 visitors (at least 30% women and 25% youth) from other districts and provinces	4c. **Achieved (exceeded target)**. 5 field visits for 173 farmers, students, and local government officials from 6 neighboring subdistricts, 4 districts, and 5 highland provinces to the pilot demonstration sites. 50% of the participants were women and 24% were youth.
	4d. At least two knowledge products, including a video, on CSA demonstrations and alternate livelihood options for highlands prepared	4d. **Achieved**. 2 knowledge products – Alternative Livelihood Options for Highland Communities and 7 videos (one overview; 6 related to the pilot demonstrations) – prepared.

[3] Additional activity after mid-term review.
[4] Additional activity after mid-term review.

Actual Key Activities with Milestones

Output 1: Capacity to assess climate change vulnerability of highland agriculture improved

1.1 Conduct consultations with stakeholders, including women and ethnic groups, to determine factors contributing to climate change vulnerability of highland agriculture (2021–2022)

- Mapped over 60 stakeholder institutions, classified by sector, level, and role in climate-smart highland agriculture (December 2021)
- Assigned stakeholder roles based on their Influence and Interest, using a 2×2 power-interest matrix (December 2021)
- Identified 36 government agencies at national and provincial levels to be "Managed Closely", including MOAC, OAE, and all Nan-based agricultural departments (December 2021)
- Identified 10 stakeholders with "Anticipate and Meet Needs" classification—high influence, low interest (e.g., Royal Thai Armed Forces HQ, Nan Public Health Office) (December 2021)
- Listed 8 private sector entities (e.g., Tops Supermarket, Big C, SC Agro Co.) as high-interest, high-influence actors for CSA market linkages (December 2021)
- Identified 4 academic institutions such as Rajamangala University of Technology Lanna and Chulalongkorn University-Nan campus, with moderate influence (December 2021)
- Identified 3 NGOs (e.g., Green Net, Hug Muang Nan Foundation) and multiple ethnic minority groups, emphasizing inclusive participation (December 2021)
- Identified the Bua Yai Subdistrict Administrative Organization and 8 village leaders as high-priority community-level actors (December 2021)
- Identified the Nan Sandbox and Organic Farming Group as integrated CSA-local innovation networks (December 2021)
- Developed and disseminated a structured questionnaire to assess perceptions of exposure, sensitivity, and adaptive capacity using 37 indicators (10 Exposure indicators, 15 Sensitivity indicators, and 12 Adaptive Capacity indicators) to determine factors contributing to climate change vulnerability of highland agriculture systems (February 2022)

1.2 Collect and analyze existing baseline data (sex-disaggregated) and identify capacity needs and gaps through literature, surveys, and interviews on vulnerability in different agriculture subsectors (2021–2024)

- Conducted a baseline livelihood survey with 320 households from 8 villages in Bua Yai Subdistrict (December 2021)
- Surveyed 1,051 individuals (498 males, 553 females); average household size: 3.3 members (December 2021)
- Recorded that 39% of households lost jobs due to COVID-19, revealing vulnerability to external shocks (December 2021)
- Identified yield gap in certain villages (e.g., B. Oi, B. Mai Mongkol) as high as 22% (December 2021)
- Identified lack of crop and livestock insurance (December 2021)
- Identified heavy reliance on external resources by local officials for climate change adaptation (December 2021)
- Outlined farmer-preferred adaptation measures, including: (1) solar irrigation, (2) climate-resilient crops, (3) storage, (4) crop insurance, and (5) market forecasting (December 2021)
- Identified gaps in weather and forest fire forecasting, extension services, and pest management (December 2021)
- Identified the need for localized solutions that consider significant biophysical (soil erosion, soil degradation, deforestation) and socioeconomic factors (landholding size, limited crop diversification, sustainable production practices, etc.) to target identified vulnerabilities in highland agriculture (December 2021 and June 2024)

1.3 Conduct workshops to strengthen the capacity of local government staff, including women, to collect data and assess climate change vulnerability (2022)

- Conducted a 2-day workshop from 4–5 July 2022 in Nan City, focused on vulnerability assessment and adaptation (July 2022)
- Engaged around 120 participants, with 59 actively participating (47% women), including 34 onsite and 25 online attendees (July 2022)
- Represented 21 agencies across national, regional, provincial, and local levels (July 2022)
- Delivered capacity-building on climate models, downscaling, and data selection, with emphasis on GCM-based projections, along with vulnerability assessment and Community-based Adaptation (CbA) (July 2022)
- Demonstrated bias correction and vulnerability index calculation using Microsoft Excel and R programming (July 2022)
- Introduced concepts of exposure, sensitivity, and adaptive capacity using indicator-based frameworks and applied stakeholder-driven feedback to validate indicator selection and weighting techniques (July 2022)

Actual Key Activities with Milestones

1.4 Assess impacts of climate change under current and future climate scenarios (2022–2023)

- Downscaled future climate data from 6 General Circulation Models (GCMs) under SSP245 and SSP585 scenarios using the ERA5 dataset from a 100km x 100km resolution to a 9km x 9km resolution (April 2022–September 2022)
- Applied AquaCrop to simulate yield changes under changing temperature and precipitation for rice, maize, coffee, and soybean (May 2022–September 2022)
- Calculated crop yield changes under future climate: (1) Rice: Yield decline of up to −5%, (2) Maize: Yield decline of up to −11%, (3) Soybean: Slight increase up to +3%, and (4) Coffee: Yield increase of +4% to +8% under SSP245 scenario (May 2022–September 2022)
- Simulated future precipitation increases of 12–18% during wet seasons and 5–8% in dry seasons (May 2022–September 2022)
- Evaluated vulnerability across 8 villages using a composite Vulnerability Index (VI) with percentile-based classes (May 2022–September 2022)
- Applied 19 indicators for exposure, sensitivity, and adaptive capacity to calculate VI (May 2022–September 2022)
- Identified exposure and sensitivity contributed >65% to overall vulnerability in most villages (May 2022–September 2022)
- Ranked Ban San Phayom and Ban Nakai as the most vulnerable villages based on VI scores (May 2022–September 2022)
- Proposed village-specific adaptation interventions such as water harvesting, slope stabilization, and CSA transition (May 2022–September 2022)
- Prepared priority actions and policy interventions for the 8 villages in Bua Yai Subdistrict in line with Thailand's National Strategy (2018-2037) (May 2022–September 2022)
- Prepared knowledge product on *Vulnerability of Highland Agriculture: Current and Future Climate Scenarios* (October 2022–November 2023)

1.5 Developed knowledge products, including a guidance manual, on assessing climate change vulnerability in highlands (2022–2023)

- Prepared a guidance manual on *Climate Change Vulnerability Assessment in Highlands* (October 2023–November 2023)
- Outlined an 11-step methodology to calculate the Vulnerability Index (VI), including normalization, weighting, and driver identification (October 2022–November 2023)
- Listed over 50 indicators categorized under exposure (10+), sensitivity (10+), and adaptive capacity (10+) for flexible use (October 2022–November 2023)
- Recommended downscaling GCM projections using empirical quantile mapping, implemented via R's "qmap" package (October 2022–November 2023)
- Created percentile-based vulnerability classes using thresholds: <20% = low, 21–40% = moderate, etc. (October 2022–November 2023)
- Highlighted the use of Community-Based Adaptation (CBA) through a 7-step participatory planning cycle (October 2022–November 2023)
- Prepared a glossary of over 60 climate and modeling terms, along with two R scripts (October 2022–November 2023)
- Recommended stakeholder mapping as a key step in the planning phase, linking interest and influence scores (October 2022–November 2023)

Output 2: Gender- and COVID–19-responsive, CSA practices prioritized and demonstrated

2.1 Prepared an inventory of gender- and COVID–19-responsive CSA practices for highlands and conduct a multi-criteria assessment with local stakeholders including farmers, civil society organizations, women, the private sector, and government staff to prioritize appropriate CSA practices (2022–2024)

- Conducted a thorough review of CSA practices and prepared an inventory of CSA practices applicable to highland agriculture systems (contributed to the knowledge product *Climate Smart Agriculture in Highlands: A Compendium of Practices for Sustainable Watershed Management*) (January 2022 and July 2024)
- Identified 7 CSA practices suitable for Nan highlands, linking them to productivity, adaptation, and mitigation: (1) solar-powered irrigation, (2) biochar, (3) keyline water management, (4) organic composting, (5) mulching, (6) drought-tolerant crops, and (7) agroforestry (January 2022)
- Conducted multi-criteria assessment of identified CSA practices with 51 farmers (55% female) based on 10 potential benefits of CSA practices, which included (1) input cost saving, (2) water saving, (3) labor saving, (4) soil improvement, (5) increased production, (6) increased income-profitability, (7) sustainability in the long-run, (8) prior knowledge, (9) adaptation potential, and (10) mitigation (GHG emissions) potential (January 2022)

Actual Key Activities with Milestones

- Prioritized 3 CSA practices (solar irrigation, keyline water management, and biochar) based on farmer feedback and site-specific requirements and constraints (February 2022)
- Conducted a capacity-building workshop for 132 participants on-site and 17 online (58% women) on CSA principles and identification of suitable sites for the implementation of selected CSA practices, and selection of alternative crops to maize monocropping through farmer consultations (February 2022)
- Engaged 83 villagers (63%), 25 officials (19%), and 24 youth (18%) across 8 villages, 3 schools, and 14 agencies (February 2022)
- Facilitated selection of 3 Keyline water management sites and 10 solar irrigation demonstration sites in consultation with participants (February 2022)
- Facilitated selection of 15 alternate crops, with 6 alternate crops identified for application alongside CSA practices (cacao, avocado, lemongrass, banana, pumpkin, peanut) (February 2022)
- Produced a knowledge product on *Gender-Conscious Climate-Smart Agriculture in Highlands* (September 2023)

2.2 Conducted a cost–benefit analysis of at least three priority CSA practices (2023–2024)

- Conducted cost-benefit analysis of cacao and avocado cultivation through keyline water management, solar irrigation systems, and biochar application as CSA practices against traditional maize cultivation (November 2023–July 2024)
- Calculated a benefit-cost ratio (BCR) of 1.14 for traditional maize cultivation in the highlands, indicating marginal profitability, but with negative environmental impacts (soil degradation and erosion) (November 2023–July 2024)
- Recorded BCRs for cacao cultivation (November 2023–July 2024):
  - » Without CSA: BCR 4.02, NPV THB 401,337.17
  - » Biochar: BCR 2.82, NPV THB 344,505.16
  - » Keyline: BCR 2.85, NPV THB 346,767.49
  - » Solar Irrigation: BCR 3.12, NPV THB 362,629.06
- Recorded BCRs for avocado cultivation (November 2023–July 2024):
  - » Without CSA: BCR 3.66, NPV THB 312,383.69
  - » Biochar: BCR 2.31, NPV THB 244,148.79
  - » Keyline: BCR 2.50, NPV THB 257,814.01
  - » Solar Irrigation: BCR 2.75, NPV THB 273,675.58
- Demonstrated that cacao had up to 252% higher BCR than maize, and avocado up to 221% higher (November 2023–July 2024)
- Attributed enhanced benefits to improved soil moisture, carbon sequestration, and reduced erosion from CSA use (November 2023–July 2024)
- Identified high economic feasibility of switching from maize to cacao/avocado under CSA for highland farmers (November 2023–July 2024)
- Recommended bundling CSA practices (solar, biochar, keyline) for greatest environmental co-benefits (November 2023–July 2024)

2.3 Demonstrated at least two most appropriate gender- and COVID–19-responsive CSA practices in the target area (2022–2024)

- Demonstrated 6 gender- and COVID-19-responsive CSA practices in Bua Yai Subdistrict
  - » 2 demonstrations on climate-smart water management: keyline water management and climate-smart solar irrigation[5] (November 2022 to December 2023)
  - » 3 demonstrations on climate-adaptive soil management and organic farming: climate-smart soil management using biochar, climate-adaptive organic agriculture with Participatory Guarantee System (PGS)[6], and climate-smart circular agriculture economy and sustainable waste management using maize residue (November 2022, February 2023 & July 2023, September 2024)
  - » 1 demonstration on digital technology-based farm-to-fork traceability solution of agricultural products (lemongrass oil) (October 2022 to March 2025)[7]

[5] A total of 2 solar irrigation units were installed in two villages – Ban Mai Mongkol and Ban Tabman. The demonstration of solar irrigation system in Ban Mai Mongkol was expanded through an additional solar irrigation unit after reaching consensus during the midterm review in June–July 2023

[6] Details presented in Output 3, Activity 3.2 (pilot demonstration was conducted as a capacity-building workshop)

[7] Details presented in Output 3, Activity 3.4

Actual Key Activities with Milestones

Climate-smart circular agriculture economy and sustainable waste management using maize residue (September 2024)

- Engaged 167 participants (60% women, 43% youth) in the pilot demonstration on sustainable waste management and Bio-Circular Green (BCG) Economy of maize residues, aligned with Thailand's BCG Economy strategies and Thailand's Waste Management and Public Health Acts for agricultural waste reuse (September 2024)
- Demonstrated maize waste upcycling over 3 days at Ban Aoi Community School, Bua Yai Subdistrict (September 2024)
- Engaged participants in all steps of maize pulp production: separation, crushing, boiling, washing, beating, drying (September 2024)
- Produced paper pulp and eco-products using maize husks (plant pots, containers, and molded eco-tableware) (September 2024)
- Highlighted value addition pathways using maize stalks, cobs, and husks such as (1) biochar, (2) biogas, (3) animal silage, (4) cellulosic ethanol, (5) biodegradable packaging, and (6) bio-based chemicals (September 2024)
- Linked product creation to reduction in open-air burning and increased farmer income potential (September 2024)

Monitoring & Evaluation of CSA Demonstrations (November 2023–July 2024)

- Established CSA demonstration plots with 7 farmers from 3 villages (Ban Mai Mongkol, Ban Tabman, Ban Nong Ha) ranging from 0.8 to 2 hectares (November 2023–July 2024)
- Implemented 15 distinct CSA treatment combinations between solar irrigation, biochar, keyline, and biofertilizer across 4 locations (November 2023– July 2024)
- Designed each experimental set with 5 replicates per CSA combination, ensuring data robustness (November 2023– July 2024)
- Collected data on soil moisture, plant height, diameter, and yield across multiple weeks (November 2023– July 2024)
- Reported significant increases in plant height and diameter under CSA treatments compared to controls (November 2023– July 2024)
- Observed improved soil moisture retention under solar irrigation and biochar plots (November 2023– July 2024)
- Recorded estimated fruit yield increase of 18–25% in cacao and avocado CSA plots (November 2023– July 2024)
- Monitored lemongrass plots with CSA showing enhanced herbage yield by 22–29% (November 2023– July 2024)

Benefit-Cost Analysis of Climate-Adaptive Organic Farming with Participatory Guarantee System (PGS) at Value Chain Level (November 2023–September 2024)

- Conducted a benefit-cost analysis of climate-adaptive organic farming with PGS at value chain level for avocado and cacao (November 2023–September 2024)
- Calculated internal rate of return (IRR) for CSA avocado at 6.5–8.0%, and for cacao at over 8.0%, exceeding benchmark discount rates (November 2023–September 2024)
- Compared CSA cacao with conventional methods, showing 50% higher returns for CSA-based practices (November 2023–September 2024)
- Recorded BCRs exceeding 4.0 for CSA cacao and 7.0 for CSA avocado, far above conventional systems (November 2023–September 2024)

2.4 Identified private sector companies promoting CSA practices (e.g., seed, fertilizer, irrigation, and machinery providers) that may benefit from ADB non-sovereign assistance and prepare a road map for inclusive climate-friendly agribusiness investment project for Nan Province (2022–2025)

- Identified 10 private sector companies across three value chain functions – production, processing, and retail – involved in 4 TA alternative crops: cacao, lemongrass, pumpkin, and peanut (December 2022)
- 8 private companies involved in production, 2 companies involved in all three value chain functions, and 3 companies involved in processing and marketing (multiple value chain functions included for 3 companies) (December 2022)
- Prepared a knowledge product entitled *Roadmap for Inclusive and Climate-Friendly Agribusiness Investments in Nan Province* that focuses on policy and investment priorities, including expansion of financial resources, strengthening agribusiness participation, and developing public-private partnership models for driving private-sector investment in agribusiness value chains (January 2025–March 2025)

Actual Key Activities with Milestones

2.5 Prepared knowledge products on CSA demonstration process and most appropriate CSA practices for highlands (2025)

- 2 knowledge products on *Climate-Smart Agriculture Demonstration Process* (January 2025) and *Climate Smart Agriculture in Highlands: A Compendium of Practices for Sustainable Watershed Management*[8] (March 2025) produced

Output 3: Agricultural product quality, value addition and market linkages enhanced

3.1 Assessed capacity needs and gaps and identify priority products for quality and safety improvement and value addition (e.g., processing, packaging, and branding) by the private sector (2022–2025)

- Conducted an 8-day assessment mission (13–20 Dec 2022) covering 8 input suppliers, 5 output buyers, and 20 farmers, focusing on CSA-aligned agribusiness value chains
- Identified six priority products for quality enhancement and value addition: cacao, lemongrass, pumpkin, peanut, herbal oils, and avocado (December 2022)
- Identified only 10–15% of farmers were certified under Good Agricultural Practices (GAP), PGS, or organic systems, indicating a major capacity gap in certification readiness (December 2022)
- Identified a lack of training among farmers in post-harvest handling, recordkeeping, and traceability protocols, limiting access to premium markets (December 2022)
- Reported significant infrastructure gaps for smallholders, including absence of fermentation units (cacao), drying and grading equipment (peanut/pumpkin), and essential oil distillation units (herbs) (December 2022)
- Identified a training gap in CSA-aligned post-harvest and processing techniques, with most farmers unaware of Good Manufacturing Practices (GMP), Hazard Analysis and Critical Control Points (HACCP), or QR traceability systems (December 2022)
- Found resistance among smallholders to GAP due to complex documentation, high audit costs, and perception of low returns from certification (December 2022)
- Recommended the establishment of a CSA Innovation Hub to address the observed capacity gaps through bundled support in training, certification, aggregation, and market access (December 2022)
- Prepared an implementation roadmap for developing sustainable climate-friendly agribusinesses (cross-cutting activity with Activity 2.4) (January 2025–March 2025)

3.2 Conducted workshops to build capacity of local communities, including women, on grower certification schemes, organic farming, and good agricultural practices (2023)

- Conducted capacity building workshops – in two phases – for local communities on grower certification schemes, organic farming, and good agricultural practices (February 2023 and July 2023)

Phase 1 (February 2023)

- Conducted a 3-day capacity-building workshop from 25–27 February 2023 in Bua Yai Subdistrict, Nan Province
- Trained 65 farmers from 5 villages, with a gender distribution of 39 women (60%) and 26 men (40%) (February 2023)
- Inspected a total of 49 agricultural plots (February 2023)
- Certified 39 plots in the first year under the SDG-PGS scheme, including 33 essential oil farmers covering 89.075 rai (February 2023)
- Issued SDG-PGS certification to 8 additional farmers during the first year and 2 in the second year (February 2023)
- Demonstrated biofertilizer composting and biopesticide production (February 2023)
- Demonstrated certification pathways including conditional and unconditional SDG-PGS approval and outlined a 4-year pathway for full organic certification after continuous inspections (February 2023)
- Introduced the Organic Agricultural Network (OAN) platform for digital registration and traceability (February 2023)
- Distributed biofertilizer expansion tanks and printed manuals to each participant at the end of the workshop (February 2023)

Phase 2 (July 2023)

- Conducted the second phase on 17 July 2023 in Bua Yai Subdistrict, with a focus on product processing and marketing
- Engaged 63 participants, including 58 farmers (70% women), the Na Noi District sheriff, manager of the Bank for Agriculture and Agricultural Cooperatives (BAAC) Na Noi, and 3 district agriculture officers (July 2023)

[8] Additional knowledge product

Actual Key Activities with Milestones

- Demonstrated (1) biofertilizer propagation, (2) cocoa processing, and (3) organic product marketing (July 2023)
- Conducted a food safety forum (July 2023)
- Opened an organic marketing event officiated by the Na Noi District Chief, featuring farm produce sales (July 2023)

3.3 Trained local communities and youth on opportunities for quality and safety improvement and value addition and identify private firms for value addition of agricultural products (through processing, packaging, branding, and marketing) (2024)

- Conducted a 3-day workshop from 18–20 September 2024 in Nan Province
- Trained 62 participants (55% women), including farmers, food processors, private firms, academics, and government officials (September 2024)
- Delivered 2 core activities: (1) GAP-aligned post-harvest training; (2) product quality, safety, and value addition training with a focus on 6 alternative crops: cocoa, pumpkin, banana, lemongrass, peanut, and avocado (September 2024)
- Conducted field visits to the Peanut House Co., Ltd., and Rajamangala University of Technology Lanna for demonstrating post-harvest technologies (September 2024)

3.4 Demonstrated application of digital technologies for traceability in linking good-quality products from highlands with domestic and international markets (2022–2025)

- Initiated a digital traceability pilot for lemongrass oil with a group of 37 Good Agricultural Practices (GAP)–certified organic farmers under the enterprise "EPS Essen Planters Na Noi" in Nan Province with a total land size of 80 hectares (October 2022–December 2023)
- Introduced a mobile application, GIS mapping, satellite imagery, drones, and soil nutrient sensors to digitize field operations (April 2023)
- Digitized 26 out of 37 farmer profiles, including farm boundaries, crop types, and soil management data (December 2023)
- Trained 12 farmers, 2 distillation staff, and 3 extension officers on the FarmAI platform (May 2024)
- Linked farm and post-harvest data to QR codes, enabling traceability for the essential oil and herb-based product (June 2024)
- Documented production data from farm to distillation via a web-based dashboard integrated with the mobile app (July 2024–August 2024)
- Enabled QR code access for consumers to view field management and processing histories (July 2024–August 2024)
- Highlighted an ROI of 30% and a benefit-to-cost ratio of 1.30 for lemongrass essential oil production (July 2024–August 2024)
- Prepared a knowledge product on *Digital Farm-to-Fork Traceability Solutions for Organic Agricultural Products in the Highlands* (January 2024–March 2025)

3.5 Prepared knowledge products on grower certification schemes, quality and safety enhancement, and value addition. (2025)

- Prepared 2 knowledge products in English and Thai on *Grower Certification Schemes and Good Agricultural Practices*[9]; and *Agricultural Product Quality & Safety Improvement and Market Linkages*[10] (February 2025)

Output 4: Capacity of local governments & communities to address climate change strengthened

4.1 Organized awareness-raising seminars for farmers, women's groups, youth, NGOs, and the private sector on CSA and alternate livelihood options for resilience (2022–2024)

- Organized 2 awareness raising seminars for farming communities on climate-adaptive agricultural practices and alternative livelihood options in highlands (July 2022[11] and June–July 2024[12, 13]) and 1 workshop on private-sector engagement in CSA in highland regions (December 2024[14])

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[9] Output of capacity-building workshop on Grower Certification Schemes and Good Agricultural Practices (February 2023 and July 2023)
[10] Output of capacity-building workshop on Agricultural Product Quality & Safety Improvement, Value Addition, and Market Linkages (September 2024)
[11] Workshop: Alternative Livelihood Options for Highland Communities (July 2022)
[12] Workshop: Alternative Livelihood Options for Highland Communities (June – July 2024)
[13] Additional activity after mid-term review in June–July 2023
[14] Workshop: Private-Sector Engagement in CSA in Highlands – Challenges and Opportunities (December 2024)

Actual Key Activities with Milestones

Alternative Livelihood Options in Highlands (July 2022)

- Conducted a 2-day capacity-building seminar from 6–7 July 2022 in Bua Yai Subdistrict, Nan Province
- Engaged 80 farmer participants (52.5% women) from 8 villages in Bua Yai Subdistrict (July 2022)
- Documented 32 gender-sensitive and livelihood-specific policy suggestions proposed by participants (July 2022)
- Focused on 4 key themes: gender in agriculture, COVID-19 response, alternate livelihood options, and supply chains (July 2022)
- Incorporated local success stories from Phayao Province, emphasizing women-led organic CSA models (July 2022)

Alternative Livelihood Options in Highlands (June–July 2024)

- Conducted 6 women-focused training workshops from 26 June to 22 July 2024 (13 workshop days) in Bua Yai Subdistrict, Nan Province on (i) preparation and preservation of Makwaen, mushroom, and banana; (ii) preparation and preservation of pumpkin and bamboo shoot; (iii) cacao and avocado processing; (iv) value addition of honey products; (v) furniture making and basketry; and (vi) traditional homestay practices
- Engaged 316 participants (>90 % women) from all 8 villages in Bua Yai Subdistrict (June–July 2024)
- Created one-day and two-day tour programs tailored to Bua Yai's community-based tourism potential (June–July 2024)
- Partnered with Rajamangala University of Technology Lanna Nan and Nan Community College as lead trainers for 5 workshops (June–July 2024)

Private-Sector Engagement in CSA in Highlands (December 2024)

- Conducted a 1-day workshop titled "Private Sector Engagement in CSA in Highlands: Challenges and Opportunities" on 2 December 2024
- Engaged 16 private sector representatives from 12 companies spanning the agri-food value chain (December 2024)
- Discussed 7 key challenge themes: policy barriers, market access, technical knowledge gaps, high investment costs, land tenure, aging farmers, and logistics (December 2024)
- Proposed a *Smart Sustainable Sandbox – Highland Value Chain* platform for multi-stakeholder collaboration and innovation (December 2024)

4.2 Trained local government staff on integrating climate concerns in local development plans and application of technologies (e.g., remote sensing, geographic information systems, and mobile phone-based applications) to improve resilience of communities and ecosystems (2023)

- Conducted a 3-day capacity-building program titled *Integrating Climate Change in Local Agricultural Planning* from 25–27 April 2023 in Nan Province
- Trained 38 government officials (60.5% women) from 17 agencies at the national, regional, provincial, district, and subdistrict level, along with one potential organic farmer, on integrating climate change in local agricultural planning and the application of technologies to improve resilience of communities and ecosystems (April 2023)
- Considered the *5-year Nan Provincial Development Plan* a suitable base for fulfilling climate change adaptation, in line with guidance from the *Climate Change Strategic Plan for the Agriculture Sector 2023–2027*, the *Master Plan for Climate Change 2015–2050*, and Thailand's Nationally Determined Contribution (NDC) (April 2023)
- Facilitated a value chain session discussing inputs, processors, and GMP-certified cacao and peanut buyers in Nan and encouraged collaboration across 15 line agencies with overlapping CSA and climate-related mandates in Nan
- Produced a working draft for integration of CSA in the *Revised Nan Provincial Development Plan* (April 2023)
- Organized a brief field visit to 3 demonstration sites (solar irrigation, biochar, and keyline plowing) for the 38 government officials (April 2023)

4.3 Conducted field visits to the demonstration sites (2024)

- Organized a 5-day field visit from 19–23 June 2024 for knowledge exchange on CSA demonstrations (solar irrigation; keyline water management; biochar application; Participatory Guarantee Systems; circular economy through maize residue management; and digital technology-based traceability for lemongrass oil)
- Engaged 173 participants from 5 provinces (Chiang Mai, Chiang Rai, Phrae, Uttaradit, Phayao), 4 districts (Muang, Mae Jarim, Wiang Sa, Na Mun), and 6 sub-districts (Sathan, Santha, Chiang Khong, Sisaket, Na Noi, Namtok) of northern Thailand (June 2024)
- Ensured a balanced gender participation with 49.71% male and 50.29% female attendees (June 2024)
- Included 36 participants (teachers and students) from 3 academic institutions (June 2024)

Actual Key Activities with Milestones
• Established a farmer–government–academic network for potential CSA replication in other highland areas (June 2024) **4.4 Prepared knowledge products on CSA and alternate livelihood options for adaptation to climate change in highlands (2023–2025)** • Prepared a knowledge product on Alternative Livelihood Options for Highland Communities in English and Thai (September 2023–August 2024) • Prepared the knowledge product through insights from the capacity building events on Alternative Livelihood Options (July 2022 and June–July 2024), existing alternative livelihood options in Bua Yai Subdistrict, and field visits to the Learning Centre for Living Following the Sufficiency Economy Approach and the Integrated Organic Farming Practiced by Mr. Jamnong Nackpradub in Phayao Province (January 2023) • Prepared a video on all six pilot demonstrations and one TA overview video (February 2025) **4.5 Organized an international workshop on CSA to share best practices from the TA (2023–2025)** • Disseminated a Call for Abstracts to over 3000 people (May 2024–June 2024) • Organized a two-day international workshop on Climate-Smart Agriculture (CSA) (October 2024) • Engaged 135 participants from 19 different nationalities across the Asia-Pacific region [51 from academia, 13 from development partners, 14 farmers involved in the pilot demonstrations, 44 government staff (central and provincial) and 13 from the private sector] (October 2024) • Featured 5 female farmers as presenters in the 3 special sessions focused on farmer experience sharing (October 2024) • Presented 5 thematic areas for CSA investment: carbon credit markets, blended finance, resilience metrics, market access, and farmer-led investment (October 2024) • Prepared a knowledge product entitled *Climate-Smart Agriculture in Highlands: Insights from Asia*, which synthesized lessons from CSA demonstrations in Nan Province, Thailand, and comparative CSA experiences from other Asian nations (February 2025)

2. The TA Study Area

2.1 Background

13. Agriculture is a key sector in Thailand's economy, with over 48% of population living in rural areas and over 30% employed in agriculture[15]. In northern Thailand, mono cropping (especially maize) has become the dominant economic activity following conversion of large tracts of forests into agricultural land. Unsustainable farming practices and over-exploitation of natural resources led to severe resource degradation, low productivity, negative health impacts, and unstable incomes. Key challenges facing the highland agriculture in provinces such as Nan include: (i) severe soil erosion due to crop cultivation on sloping areas without adequate soil conservation measures; (ii) soil degradation resulting from monoculture; (iii) soil and water pollution due to sloping topographies and over-use of fertilizers and pesticides; (iv) high sedimentation in water bodies, leading to low carrying capacity; (v) lack of secure land ownership or user rights; and (vi) limited collaboration and cooperation of local ethnic groups living in upstream areas with local government agencies.

14. Problems experienced in Nan province such as deforestation, drought, soil degradation and air pollution are strongly linked to the expansion of maize monoculture on sloping land, a practice considered a key part of upland farmers' livelihoods. The rapid expansion of maize cultivation in the highlands has also contributed to an increase in the use of agrochemicals, leading to contamination of local water sources. Such practices are common in northern Thailand, and especially in Nan province, where maize production has expanded rapidly in recent years, leading in turn to the degradation of natural resources[16]. A study in 2018 indicated that total forest loss in Nan Province during 2001–2016 was 66,072 ha (9.1% of the forest cover in 2000), and that most of this lost forest (92%) had been converted into crop (mainly maize) fields by 2017. Annual forest loss is significantly correlated with global maize price ($p < 0.01$), re-confirming agricultural expansion as a key driver of forest loss in Nan Province[17].

15. Climate variability and change, manifested through rising temperatures and a greater frequency of extreme weather events such as droughts and floods, is exacerbating the problems. The World Bank Climate Knowledge Portal shows that the mean annual temperature is projected to increase by 1.4 to 1.8°C by the 2060's, and 3.0 to 3.8°C by the 2090's. The projected rate of warming is similar in all seasons, but more rapid in the northern, interior regions of the country than in the southern, coastal regions. Rainfall projections vary between +28% to +74% by the 2090's but all models indicate an increase in rainfall. The no. of wet days will increase, with the maximum increase projected for November and the February to May season. According to an ensemble of models for the RCP8.5, annual precipitation will rise by 81.77mm (-270.38mm to 532.10mm) in 2040-2059. Annual maximum 5-day rainfall (25-yr RL) will rise by 32.89mm (-84.29mm to 597.74mm) in 2040-2059. Where soils are increasingly exposed on steep slopes due to deforestation and the cessation of swidden agriculture, these increases in rainfall presage massive increases in soil erosion and landslides. Farmers in highlands areas are directly and severely impacted by climate change. Addressing degradation of natural resources and impacts of climate change, in close cooperation with local farmers, nongovernmental organizations (NGOs) and governments, is critical to enhance recovery and sustainability of highland communities and ecosystems.

16. Demand for organic food outstrips supply in most of the Greater Mekong Sub-region (GMS)[18]. The challenge is to convince farmers to make the switch from agrochemical reliant production. Many farmers are heavily indebted due to low commodity prices and the high cost of fertilizer and pesticides. They lack the money, knowledge, and training to obtain third-party certification—typically from private sector providers—needed to label and market a product as officially organic. Moreover, the issues of natural water sources contamination and land rights are also major hindrances to farmers transitioning to organic farming practices. As a corollary, Thailand's MOAC, together with private food and hospitality enterprises such as Lemon Farm have partnered with the Asian Development Bank (ADB) and the Thai Organic Agriculture Foundation to develop a peer-to-peer system for farmers to test and certify each other's produce. The participatory guaranteed system, or PGS, is being piloted at 15 sites around Thailand, five of them funded under a $14 million technical assistance grant to implement the second phase of the ADB-supported GMS Core Agriculture Support Program[19].

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[15] https://www.statista.com

[16] Pampasit R and Pampasit S (2018). Socioeconomic condition and Land Use Transformation of farmers in Maize Farming: The case study of NAN province, THAILAND. PEOPLE: International Journal of Social Sciences; 4(3): 382-395

[17] Zeng, Z, Gower, DB, Wood, EF. Accelerating forest loss in Southeast Asian Massif in the 21st century: A case study in Nan Province, Thailand. Glob Change Biol. 2018; 24: 4682– 4695.

[18] Weaver, T. R. D., Ramachandran, P., & Adriano, L. S. (2019). Policies for high quality, safe, and sustainable food supply in the Greater Mekong Subregion. Asian Development Bank Institute.

[19] https://www.adb.org/results/helping-farmers-go-organic-thailand

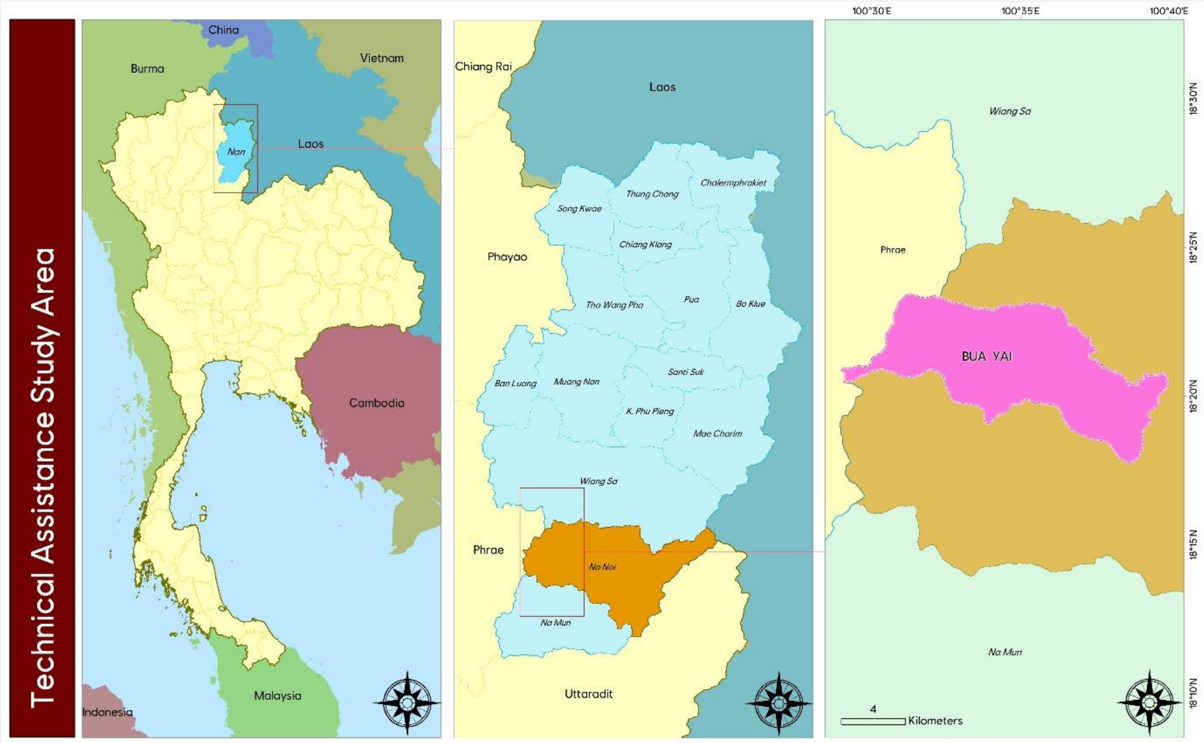
17. Thailand needs to transform the trajectory of its agriculture sector from resource-intensive, unsustainable farming practices to an agriculture sector that yields high quality, safe, climate-friendly, and gender responsive agriculture products that are market competitive both domestically and internationally.

2.2 Study Area

2.2.1 Demographics and Social Structure

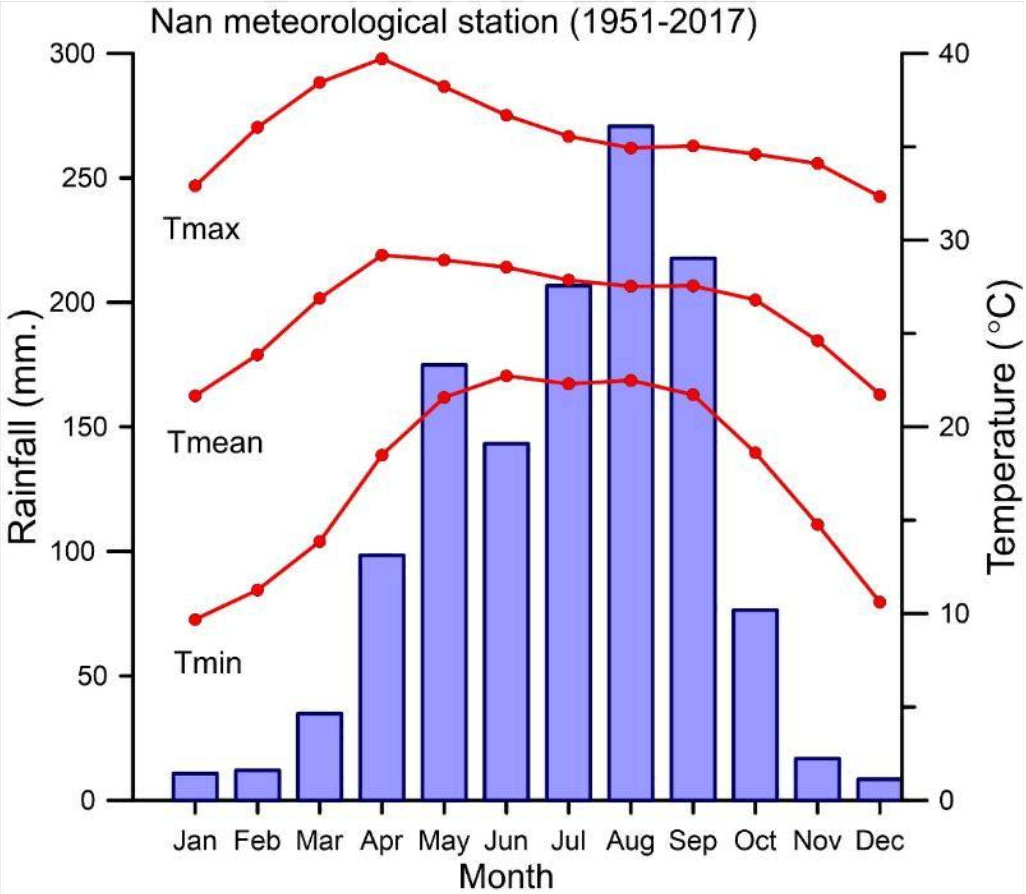
18. Bua Yai Subdistrict, situated within Na Noi District of Nan Province in northern Thailand, spans approximately 131.1 square kilometers (or 81,939 rai) and is characterized by its mountainous terrain, part of the Luang Prabang and Phi Pan Nam Mountain ranges. These ranges vary in elevation from 600 to 1,200 meters above mean sea level, with slopes often exceeding 30 degrees, making the landscape highly susceptible to erosion and difficult for traditional farming practices. The province, covering around 12,000 square kilometers, includes one-third of the Nan River Basin, which flows southward and ultimately joins the Chao Phraya River. This proximity to significant water bodies defines Bua Yai's hydrology and impacts the local ecology, especially under climate stressors that affect rainfall and water availability.

Figure 3: Map of the project area showing, (a) Location of Nan province in northern Thailand, (b) Location of Na Noi district, and (c) Bua Yai subdistrict and other in Na Noi district.



19. Nan Province experiences a tropical savanna climate, marked by distinct wet and dry seasons. The wet season, driven by the summer monsoon, typically runs from May to October, with an average monthly rainfall of 181 millimeters, peaking between 125 and 231 millimeters. The mean monthly temperature during this period ranges from 26.7 to 29.3°C. The dry season, spanning November to April, sees far less rainfall, averaging just 30 millimeters per month, with monthly mean temperatures between 23.0 and 26.2°C. Long-term climate models suggest a trend toward decreasing rainfall, a shorter wet season, and prolonged dry spells, along with increasing average temperatures. These changes have significant implications for Bua Yai's agriculture, affecting crop yields, water resources, and the overall resilience of highland communities reliant on consistent climate patterns for their farming activities.

Figure 4: Climate diagram of Nan Province during 1951-2017.



20. The demographic profile of Bua Yai reveals a population that is relatively small but dependent on agriculture. As of April 2019, the subdistrict had a total population of 3,973 people across 1,346 households, averaging three members per household (Table 7). The population is nearly evenly split by gender, with a gender ratio of 1.01 women to men. The subdistrict's low population density, at approximately 30 people per square kilometer, is consistent with other highland regions in Nan, where challenging topography limits large-scale settlement and infrastructure development. This sparse population density contrasts sharply with Thailand's national average of 130 people per square kilometer, underscoring Bua Yai's isolation and the challenges residents face in accessing markets, healthcare, and education facilities.

Table 7: Population characteristics of 8 villages of Bua Yai Subdistrict.

Village Name	Village No.	No. of Households	No. of males	No. of females	Total
Ban Oi	1	205	330	323	654
Ban Mai Mongkol	2	150	228	247	475
Ban Na Haen	3	214	302	293	595
Ban Tabman	4	186	272	276	548
Ban Nakai	5	199	293	293	586
Ban Tong Muang	6	83	114	129	243
Ban San Phayom	7	94	106	113	219
Ban Nong Ha	8	214	327	327	655
Total of all villages		**1,346**	**1,972**	**2,001**	**3,973**

Source: Registration Administration Office, Department of Provincial Administration, April 2019

21. Bua Yai's cultural and ethnic composition is predominantly Khon Maung, an ethnic group that constitutes over 97% of the population in Na Noi District, including Bua Yai Subdistrict. Nan Province, however, is ethnically diverse overall, with at least 13 recognized ethnic groups, among which the Maung, Lue, and Mui are the most prevalent. The Khon Maung people's traditions and practices are closely intertwined with the natural environment, shaping their agricultural methods and social structures. However, this connection to traditional methods also presents challenges, as modern sustainable practices such as climate-smart agriculture (CSA) require a shift from customary farming techniques to more resilient and sustainable approaches.

22. Economically, Bua Yai relies heavily on agricultural practices that are becoming increasingly unsustainable. Monoculture is widespread, particularly with maize and rubber as the primary crops. The region's total cropping area of 7,481 rai is dominated by rubber, which covers about 50% (3,741 rai) of the land, and maize, which occupies roughly 44% (3,259 rai). The prevalence of monoculture contributes to significant environmental strain, including soil erosion, chemical contamination, and deforestation, all exacerbated by the steep and erosion-prone topography. The reliance on these crops also ties the community's economic well-being to market volatility, as fluctuations in the prices of rubber and maize can substantially impact household incomes and drive farmers into cycles of debt.

23. The economic challenges of Bua Yai are underscored by a high poverty rate, which mirrors the broader economic issues in Nan Province. With 55% of households engaged in agriculture, the population's financial security is closely tied to their land and crop productivity. Nan Province has long struggled with poverty, with around 28.8% of the population living below the poverty line (USD 1,057 per person annually in 2015), significantly higher than the national poverty rate of 8.6%. Bua Yai, situated on steeper and more agriculturally challenging terrain, has a particularly high concentration of low-income households, which limits their capacity to invest in sustainable farming practices and technologies that could improve resilience to climate variability.

24. In terms of social structure, Bua Yai has a highly integrated community where gender roles are traditional yet fluid within certain aspects of decision-making. While men predominantly control decisions regarding crop types and land preparation, women are actively involved in household decisions and play essential roles in community-based organizations. In fact, the "Community Organic Agriculture Enterprise" in Bua Yai comprises 56% female members, indicating that women are increasingly engaging in community initiatives, particularly those related to sustainable practices. Additionally, women are actively organized into groups supported by the Department of Agricultural Extension (DOAE) and the Community Development Department (CDD), further emphasizing their role in the socio-economic development of the area (Table 8).

Table 8: Women groups in Bua Yai Subdistrict.

No.	Group	Village no.	No. of member
Women groups supported by DOAE			
1	Woman group, Ban Mai Mongkol	2	141
2	Woman group making hat, Ban Tabman	4	29
3	Woman group Ban Tong Muang	6	50
Women groups supported by CDD			
1	Woman development committee Tambon Bua Yai	1	16
2	Woman development committee at Ban Oi	1	15
3	Woman development committee at Ban Mai Mongkol	2	9
4	Woman development committee at Ban Tabman	4	13
5	Woman development committee at Ban San Phayom	7	2
Total of 8 groups		**1,2,4,6,7**	**275**

Source: Nan provincial office of DOAE and CDD.

25. The gender structure in Bua Yai is essential to understanding community dynamics, as women not only contribute significantly to agriculture but are also primary caregivers and decision-makers in household matters. However, disparities remain, with women having limited access to resources and decision-making power regarding larger economic and agricultural initiatives. This gap has implications for the project's success in promoting gender-responsive CSA practices and empowering women as key actors in agricultural adaptation and resilience-building.

2.2.2 Issues faced by Bua Yai farmers

26. Bua Yai, a primarily agricultural community located in the rugged mountainous terrain of Nan Province, relies heavily on maize and rubber cultivation. However, unsustainable practices have led to significant ecological strain, compounded by the impacts of climate change and socio-economic constraints, making this a key focus area for interventions.

27. The area's vulnerability is further magnified by the challenges associated with highland agriculture, where steep slopes are common, often exceeding 30 degrees. Such topography, combined with widespread monoculture practices, has led to extensive soil erosion and degradation, negatively affecting productivity. Due to the limited availability of flat arable land, agricultural expansion frequently encroaches upon forested areas, adding deforestation to the list of environmental pressures. As more land is converted, the local ecosystem's resilience decreases, leaving it less capable of withstanding environmental stressors like drought, increased temperature, and irregular rainfall patterns that have become more prevalent. These factors not only harm the natural landscape but also threaten the sustainability of farming activities, creating a cycle of environmental and economic decline.

28. In Bua Yai, where agriculture forms the economic backbone, maize production is widespread but problematic. As a crop, maize is heavily dependent on fertilizers and pesticides, which, when combined with steep and erosion-prone terrain, contribute to significant runoff and contamination of water sources. Consequently, the widespread use of agrochemicals has led to deteriorating water quality in the region, creating a public health issue that affects communities downstream. Soil degradation and fertility loss

have likewise emerged as pressing problems, placing farmers in a position where yields are declining, and production costs are rising. In response to these difficulties, many farmers have turned to expanding their farming areas into forests, perpetuating deforestation and environmental degradation.

29. Compounding the environmental challenges, farmers in Bua Yai are often financially insecure. Many are trapped in a cycle of debt due to the rising costs associated with crop production and the need to purchase chemical inputs annually. The debt-to-income ratio among highland farmers has steadily increased, creating an economic strain that limits farmers' capacity to adopt alternative, sustainable practices. This financial vulnerability hinders the local population's ability to invest in practices that could improve resilience to climate change, such as climate-smart agriculture (CSA). The limited resources also prevent these communities from adopting newer, eco-friendly technologies, and they tend to rely on traditional farming practices that may not be sustainable in the long term.

30. Gender dynamics play a significant role in Bua Yai's agricultural landscape. While men predominantly make decisions regarding crops and land preparation, women are active in household work, farming, and some community decisions. Women's roles are multifaceted—they contribute significantly to agricultural labor and are key players in household food security and community initiatives, such as the Community Organic Agriculture Enterprise. However, the highland communities still face gender disparities in decision-making, access to resources, and economic opportunities, which can hinder inclusive development. The project's emphasis on gender-responsive CSA practices reflect a recognition of these dynamics, aiming to empower women as crucial stakeholders in the adaptation process.

31. COVID-19 has added another layer of difficulty to the already challenging agricultural environment. Many households reported disruptions to their income sources, with approximately 39% of respondents stating that they either lost their jobs or were unable to find work due to pandemic restrictions. The impacts of the pandemic have strained local social support systems, with households primarily relying on family and neighbors for assistance. While the community has shown resilience, this dependence on local networks highlights the lack of formal support structures and the need for strengthened institutional capacities to buffer against such shocks in the future.

32. Income sources in Bua Yai are typically diversified across farm and off-farm activities, yet the agricultural sector remains dominant. Household income from farming is critical, but it is often insufficient to cover expenses, pushing families to seek additional income through off-farm work, which is particularly common among women. A skewed income distribution is apparent, with some households earning significantly more than others. This income disparity suggests that policy planning should focus on supporting lower-income households, particularly those who rely heavily on farming, to ensure that income inequality does not undermine the community's ability to transition towards sustainable agricultural practices.

33. Farmers in Bua Yai face practical challenges in adopting sustainable practices. Soil management, for instance, has proven difficult due to the community's limited knowledge of soil conservation and the expense associated with organic farming. Current practices for managing crop residues vary, with a substantial proportion of farmers either plowing residues back into the soil or burning them, which can further degrade soil quality and contribute to air pollution. Few farmers practice mulching or other conservation techniques that could help retain soil moisture and improve fertility. Organic farming faces further obstacles, with most farmers expressing uncertainty about its profitability and the logistical challenges of obtaining organic certification.

34. Digital technology, although gradually gaining traction in Bua Yai, remains underutilized. While about 40% of households use smartphones for financial transactions, few have adopted digital tools specifically for agriculture, such as applications for weather forecasting or crop management. The reluctance to adopt technology reflects a broader conservatism in the community towards experimenting with unfamiliar methods, as well as potential barriers like digital literacy and access to reliable internet. This hesitation may also stem from a lack of exposure to successful examples of CSA practices and their tangible benefits, suggesting a need for demonstrations and training to encourage wider adoption.

35. Finally, climate change has increasingly affected the livelihoods of Bua Yai's farmers. Rising temperatures, more frequent droughts, and unpredictable rainfall patterns are already impacting crop yields, and farmers report changes in the timing and intensity of the wet season. These climate impacts not only reduce agricultural productivity but also exacerbate existing environmental and economic vulnerabilities. Addressing these challenges requires building local capacity to assess and respond to climate risks, as well as creating an enabling environment for sustainable practices. By focusing on empowering local communities, enhancing agricultural resilience, and strengthening gender-responsive CSA practices, the TA aims to lay the foundation for a sustainable agricultural system in Bua Yai that can adapt to both current and future challenges.

3. Stakeholder Participation and Communication

3.1 Importance of Stakeholder Participation

36. Stakeholder participation was pivotal in the success of the Technical Assistance (TA), ensuring alignment of project activities with the needs and aspirations of rural communities and local government staff, including extension officers. The Consultant team emphasized two-way knowledge exchange, enabling communities and provincial agency staff to articulate challenges and opportunities. This participatory approach facilitated the co-design of field research and pilot demonstrations tailored to address stakeholder-identified issues, ensuring practical and impactful solutions. Active engagement strengthened trust and collaboration, fostering an enabling environment for sustainable agricultural practices and climate adaptation.

3.2 Communication Strategies Used During TA

37. The TA communication strategy focused on three key tasks to ensure successful TA results. Firstly, the Consultant ensured that the knowledge generated by the TA is derived from the TA outputs, particularly the demonstration sites. This ensures that the results are tangible and applicable to the target groups. Secondly, the Consultant strived to make this knowledge accessible, relevant, and understandable to the stakeholders. Clear and effective communication channels were established via interactive workshops and consultations to disseminate the information in a way that met their specific needs. Furthermore, TA Newsletters were disseminated every 6 months to inform the stakeholders of the progress being made in the TA. A final newsletter at the end of 2024 is expected to be disseminated which would include all major achievements of the TA and the International Workshop organized in October 2024. The Consultant has actively facilitated the involvement of stakeholders throughout the TA, fostering a sense of ownership and empowering them to contribute actively.

3.3 Integration of Participation, Communication, and Capacity Building (PCC)

38. The PCC strategy adopted during the TA maximized opportunities for integration and collaboration among stakeholders. Participation from diverse groups, clear and regular communication, and targeted capacity-building initiatives formed the triad of this strategy, ensuring that stakeholders remained informed, engaged, and empowered. Demonstration site visits and capacity-building events reinforced practical learning and skill development, fostering resilience in rural communities. This integrated approach not only addressed immediate agricultural challenges but also strengthened long-term stakeholder relationships, establishing a sustainable foundation for CSA practices.

3.3.1 Capacity Building Events

39. As part of the PCC strategy, the TA Consultant organized six capacity building (CB) events since commencing the TA activities. These events have been instrumental in empowering stakeholders and enhancing their understanding and skills. The completed CB events include:

Inception Workshop (CB0)

40. The virtual inception workshop, conducted virtually on 27 May 2021 due to COVID-19 restrictions, engaged key stakeholders across national and provincial levels to align on the project's objectives, activities, and implementation strategy. This workshop introduced participants to the planned outputs, including climate change vulnerability assessment, the prioritization of gender-responsive CSA practices, enhancement of agricultural product quality and market linkages, and capacity building for local governance and communities. The workshop sessions, led by experts and attended by representatives from MOAC, local leaders, and organizations across eight highland provinces, allowed for meaningful discussions and feedback on the project approach and desired outcomes.

41. Insights generated from the workshop highlighted the importance of adapting CSA practices to local needs and integrating sustainable approaches in all project components. Participants underscored the value of using localized data for vulnerability assessments, aligning demonstration sites with community needs, and including youth and ethnic groups in capacity-building activities. The need to consider additional crops suited to the highlands and include digital technology to add value along the agricultural value chain was also emphasized. The TA team committed to implementing these insights, intending to enhance both the resilience of highland farmers to climate change and the economic viability of their agricultural practices.

42. In conclusion, stakeholders recommended a continued emphasis on local engagement, practical communication strategies, and collaboration across government, private, and community sectors. Recognizing the logistical challenges posed by COVID-19, the TA team proposed adaptive strategies for effective information dissemination and fieldwork. Participants endorsed the project's

overarching goals and committed to supporting the TA's implementation in highland communities, signaling a strong foundational alignment for ongoing project activities.

Workshop - Gender-Conscious Climate-Smart Agriculture (CB1)

43. The Gender-Conscious Climate-Smart Agriculture workshop aimed to enhance participants' understanding of CSA principles and identify demonstration sites for implementing CSA practices. It brought together stakeholders from various sectors, including local villagers, officials from relevant agencies, and students from Bua Yai. Participants learned about sustainable practices such as Keyline water management, solar irrigation, and biochar production. By integrating gender-conscious approaches, the workshop ensured that women, who comprised the majority of attendees, actively participated in selecting and assessing demonstration sites for CSA practices.

44. The workshop identified specific demonstration areas for CSA technologies, using a multi-criteria analysis that included factors such as water availability, technical suitability, and local stakeholder readiness. Participants chose two sites for Keyline water management and two for solar irrigation, emphasizing climate resilience and cost-effectiveness. The workshop also facilitated the selection of alternative crops suited to local climate conditions, with avocado, cacao, lemongrass, pumpkin, banana, and peanut ranked as the top six choices based on criteria like water conservation, soil improvement, and market demand. The collaborative selection process enabled participants to evaluate options that would provide both ecological and economic benefits.

45. Feedback from participants indicated high satisfaction with the knowledge transfer and organizational structure of the workshop. The post-workshop assessments showed a substantial improvement in understanding climate change impacts, CSA methods, and the potential of alternative crops for enhancing resilience. Attendees expressed interest in further implementing the learned practices, particularly solar irrigation and Keyline management, to strengthen local agriculture. The workshop's success underscored the importance of integrating gender-sensitive and locally tailored approaches in climate adaptation strategies for highland communities.

46. The workshop report is listed in the list of supplementary documents at the end of the chapter.

Workshop - Climate Change Vulnerability Assessment in Highland Agriculture: Challenges and Opportunities (CB2)

47. The "Climate Change Vulnerability Assessment in Highland Agriculture: Challenges and Opportunities" workshop, held on 4–5 July 2022, aimed to strengthen local government and stakeholder capacity to integrate climate vulnerability into agricultural policy in Thailand's highland regions. This two-day event, held in Nan province, included 120 participants and featured five sessions on topics like vulnerability assessment techniques, climate adaptation strategies, and community-based approaches. Sessions combined presentations, discussions, and practical group exercises, offering attendees hands-on experience with tools like Microsoft Excel and R for vulnerability analysis, enriching their understanding of climate adaptation methodologies.

48. Insights from the workshop emphasized the importance of tailored, localized indicators for climate assessments, with specific feedback on improving the weighting and spatial resolution of indicators to meet local needs. Panelists and participants noted the necessity of incorporating extreme climate events, like droughts and floods, into the assessment framework. This feedback highlighted the need for community-level engagement to foster resilient agricultural practices, addressing challenges such as limited technical knowledge and the socio-economic dynamics that shape highland farming communities.

49. Evaluation results showed a marked improvement in participants' knowledge of climate change impacts and adaptation practices, with over 90% expressing satisfaction with the content and delivery. Participants recommended continued workshops to deepen practical knowledge, suggesting future events include simplified technical language and more robust, hands-on activities for building resilience in highland agriculture.

50. The workshop report is listed in the list of supplementary documents at the end of the chapter.

Seminar - Gender- and COVID-19 Responsive CSA Practices and Alternate Livelihood Options for Enhanced Resilience of Highlands (CB3)

51. The seminar on "Gender- and COVID-19-Responsive Climate-Smart Agriculture Practices and Alternate Livelihood Options for Enhanced Resilience of Highlands", held on 6–7 July 2022, aimed to empower highland farming communities in Nan province with sustainable agricultural practices and alternative livelihoods. Held over two days, the seminar focused on addressing gender roles, the impacts of COVID-19, and the potential of climate-smart agriculture (CSA) to enhance resilience. Participants, including 80 farmers from eight villages, shared insights into the challenges they face, such as water shortages, soil degradation, and limited market access. The event encouraged active dialogue between farmers and government officials, emphasizing collaborative problem-solving and capacity building.

52. Key outputs of the seminar included a shared understanding of the benefits of CSA practices, the identification of barriers to their adoption, and the co-development of a community roadmap for sustainable livelihoods. Group discussions revealed a strong interest in learning about new crops, technologies, and farm management techniques that could address local challenges.

Participants also highlighted the importance of improving women's roles in agriculture, particularly in decision-making and income generation, and called for enhanced support from public and private entities. Practical demonstrations and success stories further inspired farmers to explore innovative farming approaches.

53. The post-seminar evaluations showed a significant increase in participants' understanding of gender perspectives, COVID-19-responsive CSA practices, and supply chain development. Over 90% of attendees expressed satisfaction with the seminar, emphasizing its relevance and impact. Recommendations for future activities included ongoing engagement with farmers, practical training on organic farming, and pilot projects to showcase successful CSA practices. These insights reinforced the seminar's role in fostering resilience and sustainability in highland agriculture.

54. The workshop report is listed in the list of supplementary documents at the end of the chapter.

Workshop: Integrating Climate Change in Local Agricultural Planning (CB4)

55. The "Integrating Climate Change in Local Agricultural Planning" workshop, held on 25–27 April 2023, aimed to empower provincial and local government officials in Nan province to integrate climate adaptation strategies into agricultural development. The three-day event combined interactive indoor sessions with field visits to demonstration sites, engaging 38 participants from 15 agencies. Key topics included Climate-Smart Agriculture (CSA) practices, greenhouse gas mitigation, and strategies for embedding climate adaptation into local plans. Participants analyzed case studies from the Philippines and Indonesia, which provided valuable insights into decentralization and agroforestry practices, as well as tools for environmental assessment. Field visits to demonstration sites showcased CSA technologies, such as solar-powered irrigation, biochar production, and keyline plowing, highlighting their practical applications in highland agriculture.

56. The workshop fostered collaboration among agencies and identified gaps in existing climate adaptation efforts. Participants agreed on the need for a unified approach, proposing to use the Five-Year Nan Provincial Development Plan as a framework for integrating CSA practices and addressing climate vulnerabilities. Discussions revealed overlapping responsibilities among agencies, emphasizing the importance of coordinated planning. Priorities such as sustainable land use, organic farming, and alternative energy were identified as key focus areas. Additionally, the workshop encouraged active knowledge-sharing and highlighted the importance of aligning local efforts with national climate strategies.

57. Evaluations indicated significant knowledge gains among participants, particularly regarding CSA technologies and their role in climate resilience. Recommendations included organizing follow-up workshops to refine integrated plans, establishing clear roles for each agency, and securing financial and technical support. Participants expressed enthusiasm for the practical demonstrations and proposed scaling up these initiatives. The event concluded successfully, laying a foundation for a cohesive, climate-resilient agricultural strategy in Nan province.

58. The workshop report is listed in the list of supplementary documents at the end of the chapter.

Workshop: Agricultural Product Quality, Value Addition, and Market Linkages (CB5)

Aide Memoire Action Item 17: Completion of a training workshop for local communities and youth on agricultural product quality and safety improvement and value addition

59. The "Agricultural Product Quality, Value Addition, and Market Linkage" workshop, held on 18–20 September 2024, trained 62 participants, including farmers, food processors, and stakeholders, with women making up 55% of attendees. Held over three days, the event provided practical training on food safety, post-harvest technologies, and product development for six climate-resilient crops: cocoa, pumpkin, banana, lemongrass, peanut, and avocado. Highlights included sessions on good hygienic practices and advanced packaging techniques, and a field trip to processing facilities. This hands-on approach allowed participants to bridge theoretical concepts with practical applications, enhancing their understanding of sustainable farming and value chain development.

60. Workshop evaluations showed an increase in participants' knowledge, with post-workshop assessments revealing average scores of 4.4 to 4.6 out of 5 across critical areas such as GAP compliance, post-harvest safety, and packaging protocols—statistically significant improvements over pre-workshop scores. Field visits showcased technologies like freeze-drying and biochar application, while case studies emphasized market linkages. For example, Makro and other enterprises highlighted requirements for certification and product quality to access domestic and international markets.

61. Key insights included the potential for value addition to increase crop profitability, with recommendations for further investment in post-harvest technologies to reduce losses and maintain quality. For instance, post-harvest improvements for bananas and cocoa were shown to cut losses by up to 20%. Collaborative efforts, including partnerships with Agro Nan and other networks, were identified as essential for strengthening market linkages and enhancing competitiveness. Participants expressed high satisfaction, with over 90% rating the workshop as highly relevant and impactful, paving the way for expanded initiatives in climate-resilient agriculture.

62. The workshop report is listed in the list of supplementary documents at the end of the chapter.

International Workshop: Climate-Smart Agriculture in Highlands – Best Practices and Lessons Learned (CB6)

Aide Memoire Action Item 26: Organization of an international conference on climate smart agriculture in highlands

63. The International Workshop on Climate-Smart Agriculture in Highlands, held on 29–30 October 2024, brought together 135 participants from 19 nationalities, including experts, policymakers, farmers, and industry stakeholders. The event featured over 20 presentations, panel discussions, and experience-sharing sessions. It addressed key themes such as climate-smart technologies, gender-conscious adaptive strategies, agricultural value chains, and investment planning for highlands. The workshop highlighted pilot demonstrations in Nan province, showcasing practices like keyline water management, solar irrigation, and biochar application, which improved yields and reduced resource use. Practical insights emphasized the importance of integrating local knowledge with digital tools for scaling CSA practices.

64. The event underscored significant challenges in highland agriculture, including fragmented farmlands, socio-economic disparities, and vulnerability to extreme weather. Panelists and participants advocated for participatory frameworks, gender-inclusive approaches, and collaborative policies for adaptation. Recommendations included adopting agroecological principles like crop diversification and soil conservation, leveraging digital technologies for traceability, and ensuring equitable access to CSA innovations. Success stories, such as enhanced soil moisture retention and improved crop growth using biochar, illustrated the transformative potential of CSA when adapted to specific contexts.

65. Participants rated the workshop highly, with over 90% acknowledging improved understanding of CSA's role in enhancing resilience. The synthesis session emphasized multi-stakeholder collaboration, financial sustainability, and scalable CSA investments, including carbon credit systems and agroforestry models. Future directions highlighted fostering local capacities, designing bankable CSA projects, and balancing short- and long-term goals to ensure resilience and sustainability in highland agriculture.

66. The workshop report is listed in the list of supplementary documents at the end of the chapter.

Workshop: Grower Certification Schemes, Organic Farming, and Good Agricultural Practices (CB7-A and CB7-B)

67. The "Capacity Building Workshop on Grower Certification Schemes, Organic Farming, and Good Agricultural Practices (CB7)" was conducted in two phases and engaged a total of 70 participants, including farmers, local officials, and agricultural experts. Phase 1, attended by 65 farmers (63% women) from five villages in Nan province, focused on participatory guarantee systems (PGS), organic farming, and biological pest control. Inspectors assessed 49 agricultural plots, resulting in 39 achieving SDG-PGS certification within the first year. Phase 2, which included 63 participants (70% women), emphasized marketing, food safety, and cocoa processing. Practical demonstrations on biofertilizer composting and pest control were complemented by training in cocoa processing and organic product marketing.

68. Across both phases, participants demonstrated significant improvements in their understanding of sustainable agricultural practices. Phase 1 saw knowledge scores improve by 17.7% in pre- and post-workshop assessments, while Phase 2 reported 81% satisfaction with the food safety forum and 93% positive feedback on biofertilizer propagation. Notably, 87% of participants in Phase 2 found the cocoa processing sessions highly valuable, with many expressing interests in adopting these practices for income diversification. Both phases encouraged collaboration across villages, fostering strong networks among farmers to share knowledge and support the transition to organic farming.

69. Feedback from both phases underscored the need for continued support in simplifying certification processes, enhancing market linkages, and scaling up training on sustainable practices. Participants emphasized the importance of integrating hands-on, practical demonstrations with policy-level discussions to ensure relevance and applicability. Certified farmers are expected to serve as community role models, promoting the adoption of organic farming, improving agricultural sustainability, and increasing certified agricultural land in Nan province. Together, these efforts mark a significant step toward building a resilient, climate-smart agricultural system.

70. The workshop report is listed in the list of supplementary documents at the end of the chapter.

Workshop: Women-focused Alternative Livelihood Options for Highland Communities (CB8)

Aide Memoire Action Item 28: Organization of a women-focused training workshop on alternate livelihood options, including handicrafts, food preparation, processing, and preservation

71. The capacity-building event conducted in Bua Yai focused on equipping local women and farmers with skills in alternative livelihood options to strengthen their economic resilience and adaptive capacity to climate change. This training workshop, held over several weeks, featured six distinct sessions, including food processing, furniture-making, honey product value addition, and homestay management. Participation surpassed expectations, with 316 attendees from various backgrounds engaging actively in

the hands-on, practical sessions. The event leveraged local resources and traditional knowledge, aligning training content with community needs, particularly for income generation and reduced household costs during the off-season.

72. The workshops yielded valuable insights into the role of localized and gender-responsive training in sustainable agriculture. Many participants expressed appreciation for learning how to incorporate hygiene and nutritional standards into food preservation and saw potential market opportunities in producing goods like honey-based products, handmade furniture, and culturally relevant homestay experiences. A cost-and-return analysis integrated into each session encouraged participants to see the economic viability of their efforts, revealing a strong interest in applying these skills for home consumption and local sales. The training further strengthened community ties, as participants collaborated and shared ideas on utilizing local materials to develop products with cultural value.

73. Evaluations showed high participant satisfaction, with attendees noting the relevance of skills learned to their day-to-day lives and seasonal economic needs. The training successfully highlighted the importance of a community-based approach in adapting to climate impacts while ensuring food security and economic stability. Recommendations from participants included expanding these types of capacity-building activities to reach more people, focusing on practical knowledge transfer that meets local demands and draws on readily available resources.

74. The workshop report is listed in the list of supplementary documents at the end of the chapter.

Workshop: Private Sector Engagement in Climate-Smart Agriculture in Highlands – Challenges and Opportunities (CB9)

Aide Memoire Action Item 29: Organization of a women-focused training workshop on alternate livelihood options, including handicrafts, food preparation, processing, and preservation

75. The workshop on **Private Sector Engagement in Climate-Smart Agriculture in Highlands – Challenges and Opportunities** was held on 02 December 2024 at the ADB Thailand Resident Mission, Bangkok. The workshop brought together 30 participants, including 16 private sector representatives from key agri-food companies like Cargill Thailand and Charoen Pokphand Foods PCL, as well as government officials and ADB members. The primary objective was to foster collaboration and identify opportunities for the private sector to play a larger role in enhancing CSA adoption in highland regions.

76. The discussions identified several challenges hindering CSA adoption, including environmental risks, unclear land tenure, inadequate infrastructure (irrigation, logistics, energy), and social barriers such as an aging farmer population and labor shortages. Additionally, high initial investment costs and limited access to quality inputs were significant obstacles to improving agricultural productivity and sustainability. These challenges highlight the need for cohesive policy support, improved market access, and investments in infrastructure and capacity-building to enable the private sector to engage effectively in CSA.

77. To address these challenges, participants proposed several solutions, including innovative financing mechanisms like tax incentives, carbon credits, and green financing to offset the costs of CSA adoption. Public-private partnerships (PPPs) were emphasized, with a proposal for a “Smart Sustainable Sandbox” to promote collaboration and innovation. The workshop also highlighted the importance of technology, digitalization, and CSR initiatives for scaling CSA. Concluding the event, participants suggested creating a neutral umbrella organization for cross-border coordination, establishing climate metrics, and promoting waste management solutions to ensure long-term, inclusive, and climate-smart growth in highland agricultural value chains.

78. The workshop report is listed in the list of supplementary documents at the end of the chapter.

3.3.2 Knowledge Products

79. **Eleven Knowledge Products (KP)** have been prepared for use by relevant stakeholders. The KPs are presented in Table 9.

Table 9: Knowledge products prepared under the TA.

#	Knowledge Product Title	Document Link
KP1	Gender-Conscious Climate Smart Agriculture for Highlands	KP1
KP2	Vulnerability of Highland Agriculture: Current and Future Climate Change Scenarios	KP2
KP3	Climate Change Vulnerability Assessment in Highlands	KP3
KP4	Alternative Livelihood Options for Highland Communities	KP4
KP5	Roadmap for Inclusive and Climate-Friendly Agribusiness Investments in Nan Province	KP5
KP6	Documentation of Climate-Smart Agriculture Demonstration Process	KP6
KP7-A	Grower Certification Schemes, Organic Farming, and Good Agricultural Practices[20]	KP7-A
KP7-B	Agricultural Product Quality and Safety Enhancement, Value Addition, and Market Linkages	KP7-B
KP8	Digital Technology-based Farm-to-Fork Traceability Solutions for Organic Agricultural Products in the Highlands	KP8

[20] KP7 was separated into two: KP7-A, an output of CB7 and KP7-B, an output of CB5.

#	Knowledge Product Title	Document Link
KP9	Climate-Smart Agriculture in Highlands: Insights from Asia	KP9
KP10	Climate Smart Agriculture in Highlands: A Compendium of Practices for Sustainable Watershed Management	KP10

3.3.3 Newsletters

80. To date, **6 newsletters** incorporating TA updates and news related to CSA were disseminated to over 500 readers. The newsletters were prepared in English and Thai. The final newsletter was disseminated at the end of Q1 2025 (March 2025). The newsletters that have been disseminated are listed hereafter.

- Newsletter #1 (English • Thai)
- Newsletter #2 (English • Thai)
- Newsletter #3 (English • Thai)
- Newsletter #4 (English • Thai)
- Newsletter #5 (English • Thai)
- Newsletter #6 (**English** • **Thai**)

3.4 Visits to Demonstration Sites

81. Visits to demonstration sites have been instrumental in fostering stakeholder participation and understanding of the project's impact. By observing CSA practices in real-life settings, stakeholders gained valuable insights into the feasibility and benefits of the solutions being implemented. These visits also served as interactive platforms for engagement, where participants provided feedback, raised questions, and shared their perspectives. The firsthand experience of innovative practices helped build trust and commitment among stakeholders while showcasing the tangible results of the project's interventions.

82. Notably, these engagements were integrated into capacity-building workshops such as CB3 and CB4, ensuring that government stakeholders were directly involved in observing and assessing pilot demonstration activities. The Office of Agricultural Economics (OAE) and provincial government officials contributed significantly by facilitating discussions with farmers and identifying potential areas for policy alignment and support. Their involvement underscored the importance of multi-level collaboration in achieving sustainable outcomes.

83. Additionally, OAE and provincial government officials undertook a visit to the demonstration sites in February 2023. The OAE delegation, led by Secretary-General Mr. Chantanon Wannakejohn, included senior advisors, policy analysts, and regional representatives, ensuring high-level oversight and diverse expertise. They actively participated in presentations by the TA Consultant team, where progress and ongoing challenges were discussed. The delegation's visit to demonstration sites further strengthened their understanding of CSA practices and their practical application in highland agriculture. During the site visits, the OAE officials engaged in extensive discussions with farmers about their experiences and challenges in adopting CSA practices. They showed particular interest in the biochar production process, noting its potential for scalability and integration into a circular economy model. The Secretary General suggested increasing the size of the biochar kiln and expanding its use to other highland areas. Similarly, they appreciated the ongoing transition from maize to cacao cultivation, which aligns with Thailand's goal of reducing imports of high-value cacao products by boosting local production. Local government officials also played a key role by facilitating the field visit and ensuring smooth communication between the Consultant team and farmers. Their involvement was instrumental in identifying logistical needs, such as water accessibility for solar irrigation systems, and in supporting farmers with resources and guidance. The OAE and local officials expressed their gratitude for the project's efforts, emphasizing the importance of completing the remaining activities on time to establish a model for other highland regions. Their collaborative engagement underscored the critical role of governance in scaling up sustainable agricultural practices.

84. Furthermore, field visits to the demonstration sites were also organized in June 2024 for a diverse group of 173 individuals from the northern highlands of five provinces (Chiang Mai, Chiang Rai, Phrae, Uttaradit, and Phayao), four districts in Nan Province (Mueang, Mae Charim, Wiang Sa, and Na Muen), six subdistricts of Na Noi District, Nan Province (Sathan, Santha, Chiang Khong, Sisaket, Na Noi, and Namtok), and academic institutions (Rajamangala College Lanna, Nan; Ban Oi Community School; and Na Noi School). The group included farmers, subdistrict administrative officers, government officials, academics, and youths, with a balanced gender ratio and a significant youth presence. The visit emphasized peer-to-peer learning, with participants expressing high satisfaction (average approval ratings above 90%) across categories like innovation applicability, cost reduction potential, and information dissemination. Demonstrations such as biofertilizer and biochar production received the highest approval, showcasing their effectiveness in enhancing soil health and reducing chemical dependencies. However, challenges like initial costs of equipment for solar irrigation and keyline plowing were noted as barriers to adoption. Participants formed networks for collaborative learning and emphasized integrating these practices into broader agricultural policies. The visit also highlighted critical issues like water access, pest control, and market price stability. These observations provided actionable feedback for scaling CSA practices, including expanding technical support, improving market linkages, and addressing logistical constraints.

3.5 Continuous Engagement and Advocacy

85. Continuous engagement and advocacy have been central to the success of the Technical Assistance (TA) project, ensuring the sustained involvement of stakeholders and the effective application of project findings. From the inception of the project, efforts have focused on fostering relationships and promoting knowledge exchange through workshops, field visits, and consultations. These deliberate actions have created a platform for stakeholders to actively engage with the project, enhancing their capacity to adopt and integrate CSA practices into their communities and operations.

86. The project's advocacy efforts have emphasized the practical application of findings by targeted communities, aligning project outputs with their needs and realities. By maintaining open lines of communication and incorporating stakeholder feedback, the TA team has empowered participants to implement solutions tailored to local challenges. For instance, farmers and local officials who participated in field visits to demonstration sites have not only adopted CSA practices like biochar production and biofertilizers but also shared these innovations within their networks, amplifying the project's impact.

87. Continuous engagement has also strengthened the relationships built through the PCC strategy. Regular interactions with stakeholders, such as government agencies, development organizations, and private sector partners, have reinforced collaboration and trust. These connections have been pivotal in advocating for policy alignment and resource mobilization to support the adoption of CSA practices, ensuring that the project's benefits extend beyond its immediate timeline.

88. Moreover, the emphasis on advocacy has fostered a sense of ownership among stakeholders, ensuring the sustainability of the project's impact. By equipping participants with the tools, knowledge, and networks needed to implement CSA practices, the TA has created a ripple effect, encouraging the spread of these innovations across highland communities. As stakeholders continue to champion these practices, the project's legacy will be one of resilience, sustainability, and collaborative progress in addressing climate challenges in highland agriculture.

3.6 Lessons Learned

89. The TA demonstrated that early and continuous stakeholder engagement is critical for achieving successful outcomes in rural development initiatives. By involving central, provincial, and local stakeholders, including farmers, government officials, and private sector representatives, the project ensured that its activities were aligned with community needs and priorities. Field visits and workshops emphasized two-way knowledge exchange, which fostered trust, strengthened relationships, and allowed stakeholders to co-develop solutions for challenges like soil degradation, water access, and pest management. For example, the participatory guarantee systems (PGS) implemented during capacity-building sessions empowered local farmers to take ownership of sustainable farming practices.

90. Practical demonstrations at CSA pilot sites were particularly effective in transferring knowledge and showcasing real-world applications of CSA practices. During the five-day visit to Bua Yai, 173 participants from five northern provinces and districts within Nan Province observed six CSA innovations, including solar irrigation, keyline water management, and biochar production. Participants rated these innovations highly, with satisfaction levels exceeding 90%, particularly for biochar and biofertilizers, which were recognized for improving soil health and reducing reliance on chemical inputs. However, barriers such as the initial costs of equipment for solar irrigation and keyline plowing underscored the importance of addressing logistical and financial challenges to enable broader adoption.

91. A significant lesson was the need for solutions tailored to local contexts. The shift from maize to high-value crops like cacao, which was well-received by stakeholders including the OAE, highlighted the importance of aligning interventions with both ecological conditions and market opportunities. The Secretary General of the OAE recommended scaling up biochar production and expanding its integration into a circular economy model, illustrating how feedback from high-level officials can guide strategic scaling efforts. This recommendation was echoed by local government officials who played a vital role in identifying infrastructure needs and facilitating resources for farmers.

92. Another key takeaway was the importance of multi-level collaboration. The engagement of organizations like the OAE and academic institutions, alongside local farmers, created a robust network for knowledge sharing and policy alignment. For instance, during capacity-building workshops, participants from diverse backgrounds worked together to integrate CSA practices into agricultural policies, fostering cross-sectoral collaboration. The collaborative environment not only strengthened local capacities but also highlighted the critical role of governance in scaling sustainable agricultural practices.

93. Lastly, the TA underscored the value of inclusivity in capacity-building activities. With a balanced gender ratio and significant youth participation in field visits and workshops, the project ensured that diverse perspectives were incorporated into its activities. This inclusivity enriched discussions and broadened the reach of CSA adoption. Furthermore, advocacy and continuous engagement efforts strengthened the sustainability of project outcomes by empowering stakeholders to apply and champion CSA practices within their communities. These lessons provide a model for future initiatives, demonstrating how participatory approaches, practical learning, and multi-level collaboration can transform agricultural systems in highland regions.

3.7 JFPR Visibility

94. The JFPR logo was used in all reports and knowledge products produced as part of the TA. The former JFPR name (Japan Fund for Poverty Reduction) and logo was rebranded on 1 September 2021, following the approval from ADB's Board of Directors approval (Figure 5).

Figure 5: Former and current JFPR Logo.

Former Logo **Current Logo**

95. The current logo is featured in all documented works of the TA, including the Facebook page and the TA website. The Facebook page provided updates on field missions and capacity building events pertinent to this TA and also served as a platform to share relevant development news from other TAs in the region as well as works done by the ADB and other international organizations. The page has now been closed following project completion.

96. The TA website (https://bit.ly/ADB-TA) also served the same purpose as the Facebook page and contained news related to the TA activities. Additionally, the website contained links to completed reports, knowledge products, and articles compiled as part of this TAs outputs and served as a knowledge bank for the stakeholders. Furthermore, the website contained useful video links about CSA practices, which the stakeholders could learn from and apply to their farms as well. The website will be kept active until March 2026 to provide access to the knowledge products to interested readers.

97. All reports, knowledge products, and newsletters also contained the emblems of all organizations.

3.8 Relevant Documents for Chapter 3

98. The relevant reports for the sections presented in Chapter 3 are listed below and are populated with their respective links.

Section	Description
3.3.1	**Capacity Building Events**
1	Gender-Conscious Climate-Smart Agriculture (CB1)
2	Climate Change Vulnerability Assessment in Highland Agriculture: Challenges and Opportunities (CB2)
3	Gender- and COVID-19 Responsive CSA Practices and Alternate Livelihood Options for Enhanced Resilience of Highlands (CB3)
4	Integrating Climate Change in Local Agricultural Planning (CB4)
5	Agricultural Product Quality, Value Addition, and Market Linkages (CB5)
6	International Workshop: Climate-Smart Agriculture in Highlands – Best Practices and Lessons Learned (CB6)
7	Grower Certification Schemes, Organic Farming, and Good Agricultural Practices (CB7-A and CB7-B)
8	Women-focused Alternative Livelihood Options for Highland Communities (CB8)
9	Private Sector Engagement in Climate-Smart Agriculture in Highlands – Challenges and Opportunities (CB9)
3.4	**Visits to Demonstration Sites**
1	OAE Field Visit (February 2024)
2	Field Visit to Demonstration Sites

4. Achievements on TA Implementation

4.1 Output 1: Capacity to assess climate change vulnerability of highland agriculture improved

4.1.1 Activity 1.1: Conduct consultations with stakeholders, including women and ethnic groups, to determine factors contributing to climate change vulnerability of highland agriculture.

99. Stakeholder mapping was carried out based on the level of influence and level of interest for the capacity building workshop on Climate Change Vulnerability Assessment in Highlands (CB2). The results are presented in Table 10. A questionnaire to identify factors contributing to climate change vulnerability of highland agriculture was prepared and circulated to 80 stakeholders, which included provincial and local officers, and farmers. The questionnaire included multiple indicators for exposure, sensitivity, and adaptive capacity with options for additional indicators suggested by respondents. Despite regular follow-ups the response rate was low. To rectify this issue, government officials were presented with a list of indicators agreed upon by the experts in the Consultant team during the CB2 workshop. The officials and the Consultant agreed and finalized the factors contributing to climate change vulnerability for further assessment.

Table 10: Stakeholders and their levels of interest and influence.

Stakeholders	Interest	Influence	Mapping
Government Sector			
National Level			
MOAC	High	High	Manage Closely
OAE	High	High	Manage Closely
Provincial Level			
Nan Governor's Office	High	High	Manage Closely
Na Noi District Office	High	High	Manage Closely
Mobile Development Office 31, Royal Thai Armed Forces Headquarters	Low	High	Anticipate and Meet Needs
Nan Provincial Social Development and Human Security Office	Low	High	Anticipate and Meet Needs
Nan Provincial Office for Natural Resources and Environment	High	High	Manage Closely
Nan Provincial Public Health Office	Low	High	Anticipate and Meet Needs
Office of Commercial Affairs Nan	High	High	Manage Closely
Community Development Office Nan	High	High	Manage Closely
Nan Provincial Office for Local Administration	High	High	Manage Closely
Provincial Energy Office of Nan	Low	High	Anticipate and Meet Needs
Nan Provincial Agriculture Office	High	High	Manage Closely
Nan Provincial Livestock Office	High	High	Manage Closely
Nan Provincial Fisheries Office	High	High	Manage Closely
Nan Irrigation Project	High	High	Manage Closely
Nan Cooperatives Office	High	High	Manage Closely
Agricultural Land Reform Office	High	High	Manage Closely
Nan Land Development Station	High	High	Manage Closely
Nan Land Development Regional Office 7	High	High	Manage Closely
Nan Cooperatives Auditing Office	Low	High	Anticipate and Meet Needs
Nan Agricultural Research and Development Center	High	High	Manage Closely
Bank for Agriculture and Agricultural Cooperatives, Nan Office	High	Low	Keep Informed
Highland Development Project using the Royal Project System, Group 3, Nan Basin	High	High	Manage Closely
Freshwater Aquaculture Research and Development Center, Nan	High	High	Manage Closely

Stakeholders	Interest	Influence	Mapping
Nan Agricultural Occupation Promotion and Development Center	High	High	Manage Closely
Irrigation Office 2 (Lampang Province)	High	High	Manage Closely
Protected Area Regional Office 13 Phrae	High	High	Manage Closely
Agricultural Cooperatives Expansion Khun Sathan Royal Project, Ban Saensuk Co., Ltd., Na Noi District, Nan Province	High	High	Manage Closely
Nan Provincial Agriculture and Cooperatives Office	High	High	Manage Closely
Regional Office of Agricultural Economics 2	High	High	Manage Closely
Meteorological Station Nan	High	High	Manage Closely
Hydro Meteorological Station Tha Wang Pha	High	High	Manage Closely
Agricultural Meteorological Station Nan	High	High	Manage Closely
Bureau of Groundwater Resources Region 1 (Lampang)	High	High	Manage Closely
Private Sector			
Nan Chamber of Commerce	High	High	Manage Closely
Tops Supermarket	High	High	Manage Closely
TPP Foods Co., Ltd.	High	High	Manage Closely
SC and Agro Company Limited	High	High	Manage Closely
Lemon Farm	High	High	Manage Closely
Big C	High	High	Manage Closely
Academia			
Nan Community College	Low	Low	Monitor
Nan Rajabhat University	High	Low	Keep Informed
Rajamangala University of Technology Lanna Nan	High	Low	Keep Informed
School of Agriculture, Center of Learning Network for the Region, Chulalongkorn University, Nan Province	High	Low	Keep Informed
Nan Primary Educational Service Area Office 1	Low	Low	Monitor
Non-Governmental Organizations (NGOs)			
Green Net (www.greennet.or.th)	High	Low	Keep Informed
Thai Health Promotion Foundation (http://en.thaihealth.or.th)	Low	Low	Monitor
Hug Muang Nan Foundation	Low	Low	Monitor
Local Organizations/Communities			
Bua Yai Subdistrict Administrative Organization	High	High	Manage Closely
Village leaders and villagers/farmers in 8 villages in Bua Yai subdistrict	High	High	Manage Closely
Others			
Nan Sandbox	High	High	Manage Closely
Lemon Farm Organic Farming Group	High	High	Manage Closely
Nan Organic Agricultural Network	High	High	Manage Closely

Table 11: Stakeholder mapping matrix.

High level of influence	**Anticipate and meet needs**	**Manage closely**
Low level of influence	**Monitor**	**Keep informed**
Stakeholders	**Low level of interest**	**High level of interest**

4.1.2 Activity 1.2: Collect and analyze existing gender-disaggregated baseline data (sex-disaggregated) and identify capacity needs and gaps through literature, surveys, and interviews on vulnerability in different agriculture subsectors.

100. Bio-physical data such as elevation, land use, and soil were collected from secondary sources. Socio-economic data required to determine vulnerability index was complemented by the baseline survey data collected in December 2021, which also entailed the identification of local stakeholders, including farmers, local offices, and provincial offices (as shown in Table 7). A capacity and training needs assessment (CNA and TNA) was conducted through an online survey to identify knowledge gaps. The assessment highlighted that government officials have significant knowledge gaps in the relationship between highland agriculture and climate change vulnerability. Based on the survey results, capacity-building workshops were recommended to enhance their understanding and align with highland farmers' needs. Key findings indicated officers' **limited experience in highland agriculture**, **reliance on social media for climate change information**, and **unfamiliarity with vulnerability assessment techniques**. The assessment underscored the importance of addressing climate patterns, adaptation measures, and increasing awareness of climate change vulnerability in highland agriculture. The baseline survey report is presented **here**.

101. Furthermore, a field survey was undertaken in June 2024 to prepare a Briefing Note on Climate Change Vulnerability of Agriculture Subsectors in Nan Province, and Capacity Needs and Gaps for Vulnerability Assessment. It was found that to address the sustainable development goals and needs, the highlands need to be infused with localized solutions that target the identified vulnerabilities while taking into consideration the capacity factors discussed in this briefing note. Of the vulnerability factors, significant ones are factors related to biophysical (soil erosion, soil degradation, deforestation), and socioeconomic (including landholding size, limited crop diversification, sustainable production practices, etc.) attributes. The presence of a highly educated population with significant access to smartphones provides them with a capacity to address issues such as the infusion of advanced technologies, access to information, and access to markets and finance. The government and civil society organizations need to take these factors into consideration while engaging with the farmers and building their capacity for climate-smart and sustainable agriculture in the highlands in the future.

4.1.3 Activity 1.3: Conduct workshops to strengthen the capacity of local government staff, including women, to collect data and assess CC vulnerability. (CB2 and W2)

102. The workshop on "Climate Change Vulnerability Assessment in Highland Agriculture: Challenges and Opportunities" was organized to address critical capacity gaps among local government staff in assessing and responding to the impacts of climate change (CC) on agriculture. Highland regions in Thailand face heightened risks from changing climate patterns, including altered rainfall, increased temperatures, and more frequent extreme weather events. These changes threaten livelihoods, food security, and ecosystems. The workshop aimed to strengthen the ability of government officials to collect relevant data, analyze vulnerabilities, and design adaptive strategies that could be incorporated into decision-making processes. With a focus on building technical capacity and fostering gender inclusion, the event targeted provincial and local government staff, along with representatives from academia, NGOs, and international organizations.

Understanding of Climate Change Concepts

103. The workshop led to a substantial increase in participants' understanding of fundamental climate change concepts. Before the workshop, only 6% of participants strongly agreed that "climate and weather are different concepts," whereas this increased to 21% after the workshop. Similarly, agreement that climate change is affecting their area rose from 50% pre-workshop to 83% post-workshop (Figure 6).

104. The recognition of changing weather patterns as a sign of climate change grew from 53% agreement pre-workshop to 67% post-workshop, with a significant reduction in neutral or uncertain responses. Understanding of the impacts of climate change on livelihoods increased as well, with strong agreement rising from 53% pre-workshop to 75% post-workshop. However, despite these improvements, 13% of participants post-workshop disagreed that climate change affects cropping patterns, reflecting some lingering skepticism or diverse experiences among attendees (Figure 6).

Awareness of Climate Vulnerability

105. Participants' understanding of how climate change exacerbates agricultural vulnerability showed marked improvement. For instance, agreement that exposure to climate change increases vulnerability rose from 53% pre-workshop to 75% post-workshop. Similarly, the recognition that changes in rainfall and temperature increase vulnerability grew from 65% pre-workshop to 79% post-workshop (Figure 7).

106. Participants became more aware of specific strategies to mitigate vulnerability. Agreement that soil water conservation techniques reduce agricultural vulnerability rose from 41% pre-workshop to 75% post-workshop. Furthermore, belief in the role of crop diversity in reducing climate vulnerability increased from 44% pre-workshop to 75% post-workshop. Awareness of the link between climate change vulnerability and decreased crop yield also improved, with agreement increasing from 47% to 71% post-

workshop. However, a small proportion of participants (4%) remained uncertain about the accuracy or applicability of these assessments (Figure 7).

Comprehension of Climate Adaptation Practices

107. The workshop significantly enhanced participants' understanding of climate-smart agricultural practices. For instance, the perception that changing cropping patterns can increase crop yields saw strong agreement rise from 32% pre-workshop to 54% post-workshop. Agreement that changing crop types can improve agricultural production increased from 24% to 63%. Additionally, awareness of the importance of climate-smart agriculture rose from 56% pre-workshop to 75% post-workshop (Figure 8).

108. Participants also displayed a stronger grasp of water, crops, and farm management practices, with agreement increasing from 38% to 75% post-workshop. Understanding the role of supplementary irrigation water in boosting production improved, with 67% of participants agreeing post-workshop compared to 35% pre-workshop. However, some participants (8%) remained skeptical about the effectiveness of increasing fertilizer use as an adaptation strategy (Figure 8).

Figure 6: Change in respondents' perception about climate change before and after workshop.

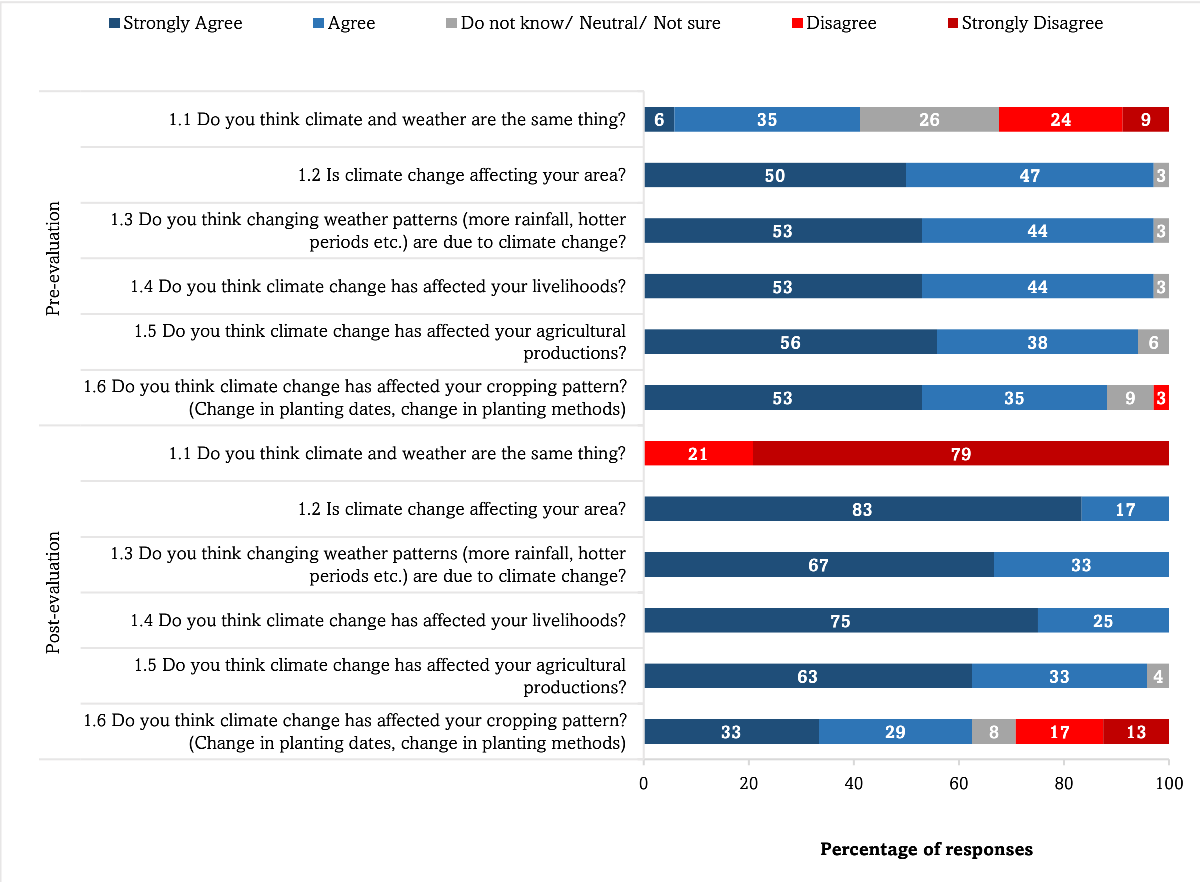
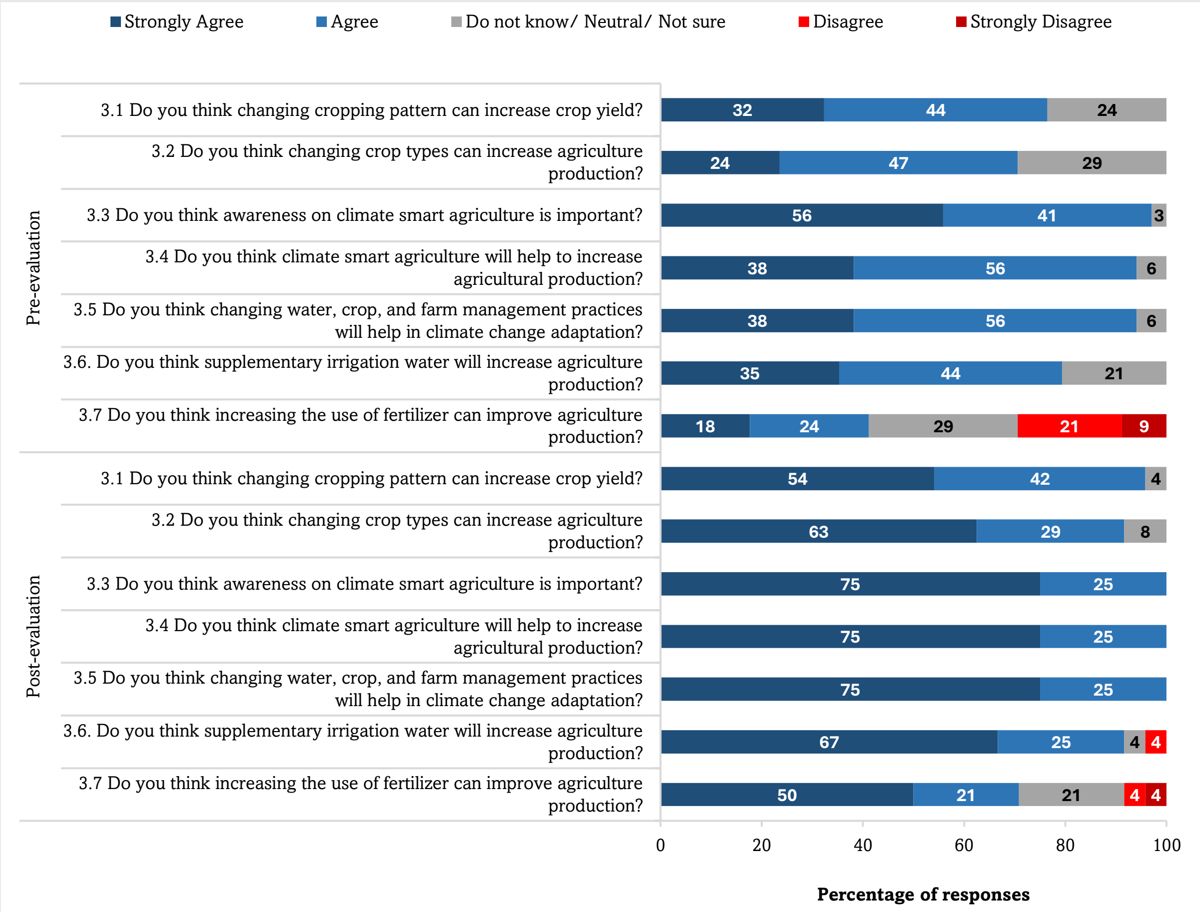


Figure 7: Change in respondents' perception about climate change vulnerability before and after workshop.

Figure 8: Change in respondents' perception about adaptation practices.

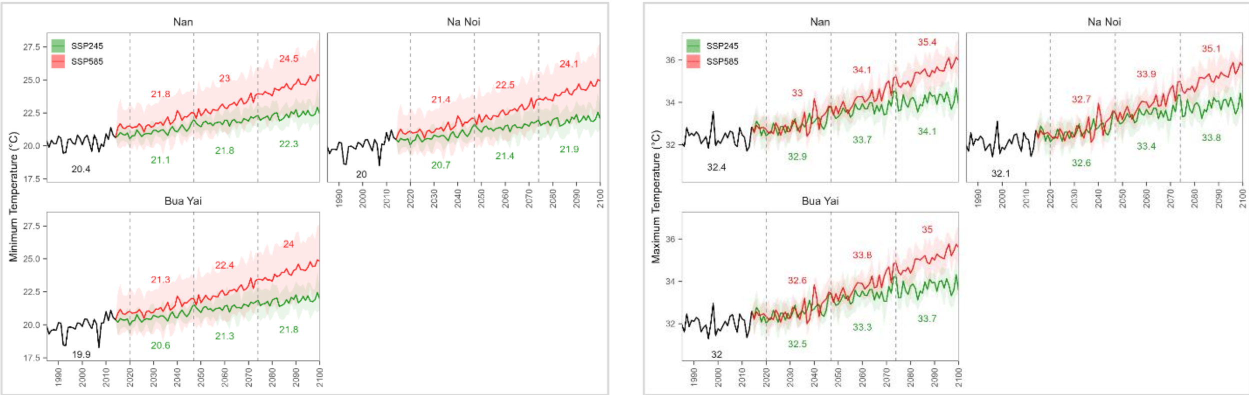


4.1.4 Activity 1.4: Assess impacts of climate change under current and future climate scenarios. (KP2)

Future Climate and Anticipated Impacts in Project Area

109. Future climate scenarios for Nan province indicate significant warming, with average annual temperatures projected to rise by 1.8°C to 3.6°C by the end of the 21st century. Minimum temperatures are expected to increase more sharply, up to 4.1°C, compared to a maximum temperature increase of 3.0°C, reducing the diurnal temperature range (Figure 9). Rainfall is anticipated to rise by 239 to 466 mm annually, with dry season rainfall increasing by 40–60% and wet season rainfall by 16–34%. Bua Yai and Na Noi are expected to experience less rainfall than the provincial average, highlighting the need for location-specific water management strategies.

Figure 9: Temporal change in minimum and maximum temperatures during 1985–2100

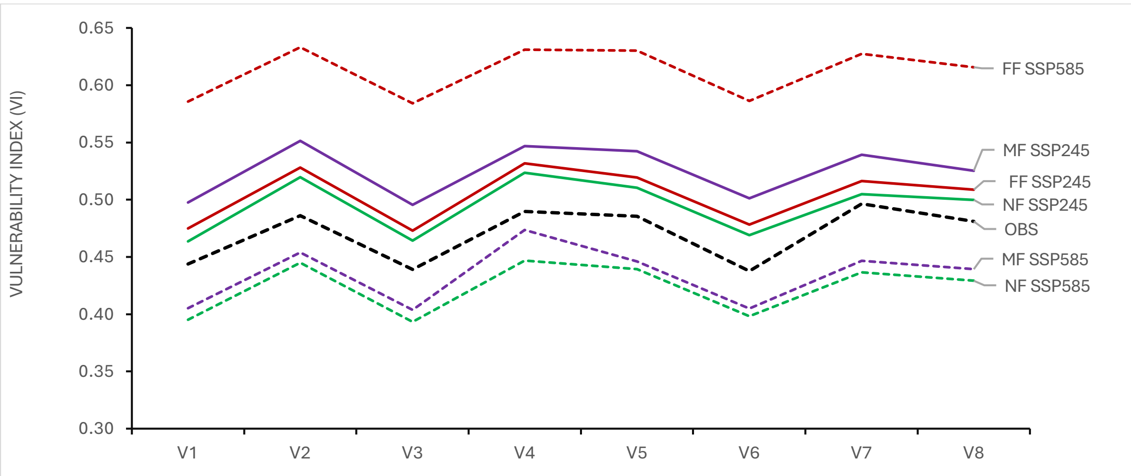


110. Projected climate changes will significantly impact crop yields. Rice yields may initially decline by up to 6% in the near future but could recover, increasing by 8–14% in mid and far-future periods. Maize and soybean yields are expected to increase by 15% and 35%, respectively, underscoring their resilience. In contrast, coffee yields are projected to decline by up to 32%, reflecting its sensitivity to temperature and rainfall variability. These findings emphasize the urgency of promoting crop diversification, adopting climate-resilient varieties, and implementing sustainable agricultural practices to ensure productivity under changing climatic conditions.

Vulnerability Profile of Highland Agriculture in Project Area

111. Highland agriculture in Bua Yai is projected to become increasingly vulnerable compared to the baseline period (1985–2014), with villages such as B. San Phayom (V7) and B. Tabman (V4) showing heightened risks (Figure 10). Village-level vulnerability variation is minimal compared to temporal variation, with near and mid-future periods under the SSP245 scenario seeing significant increases in vulnerability. SSP585, while initially projecting decreased vulnerability, aligns with SSP245 in forecasting heightened risks in the far future. Precipitation variability, a primary driver of vulnerability, contributes to uncertainty in these projections, emphasizing the need for robust adaptation planning to address potential extremes.

Figure 10: Variation in vulnerabilities across villages (units) and time periods [baseline (1985–2014), near future (2020–2046), mid future (2047–2073) and far future (2074–2100)] for different climate change scenarios (SSP245 and SSP585).

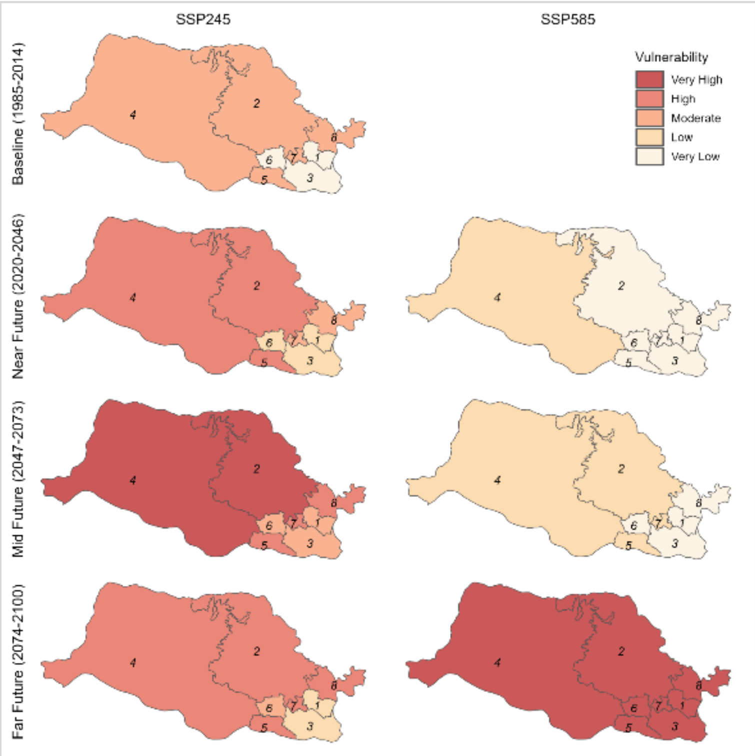


112. Vulnerability analysis highlights the role of three main components: exposure, sensitivity, and adaptive capacity. Villages like B. San Phayom (V7) and B. Nong Ha (V8) are among the most exposed due to climatic and environmental factors, including deforestation and steep terrains. Sensitivity is pronounced in areas heavily reliant on monoculture farming, such as B. Tabman (V4) and B. Mai Mongkol (V2), which also suffer from low soil fertility and limited income diversification. Adaptive capacity remains weakest in B. Nakai (V5), constrained by insecure land tenure and insufficient access to resources like credit and infrastructure.

113. Among the 29 indicators contributing to vulnerability, change in annual rainfall is the most significant driver, impacting six villages and accounting for approximately 7% of the overall vulnerability index. Other key indicators include landholding size, livestock density, and crop water use efficiency, reflecting the dependence of these villages on natural resources and fragile ecosystems. Indicators such as off-farm income and soil acidity also contribute significantly, underscoring the need for both environmental and socio-economic interventions tailored to local contexts.

114. Vulnerability mapping under SSP245 highlights that villages such as B. Mai Mongkol (V2), B. Tabman (V4), and B. Nakai (V5) transition from moderate to high vulnerability in the near future, while B. Oi (V1), B. Na Haen (V3), and B. Tong Muang (V6) move from very low to low vulnerability. These maps serve as critical tools for identifying high-risk areas and prioritizing interventions such as improved water management, crop diversification, and soil conservation. Stable villages, such as B. Nong Ha (V8), offer opportunities to replicate successful adaptation practices (Figure 11).

Figure 11: Vulnerability classes of different villages during baseline and future periods under SSP245 and SSP585 scenarios.



115. Effective adaptation strategies must focus on addressing precipitation variability through rainwater harvesting, small-scale irrigation, and increased crop water use efficiency. Promoting diversified cropping systems and agroforestry will reduce reliance on monocultures, while improving access to financial resources and securing land tenure will enhance adaptive capacity. Given the uncertainties in far-future projections, prioritizing actions for the near and mid-future periods under SSP245 provides a pragmatic approach to mitigating risks and building resilience in highland agriculture.

Policy and Operational Implications

116. Integrating climate vulnerability considerations into local agricultural development plans is essential for building resilience. Policies should prioritize interventions such as promoting crop diversification, developing water-smart technologies, and enhancing soil conservation practices. Vulnerability maps provide a robust tool for guiding resource allocation and identifying priority areas for adaptation measures, ensuring that interventions are targeted and effective.

Figure 12: Steps for designing local adaptation strategies.

117. Both community-based and ecosystem-based approaches are vital for enhancing resilience in highland agriculture. Community-based adaptation focuses on integrating local knowledge with modern agricultural practices, while ecosystem-based strategies, such as reforestation and agroforestry, address broader environmental challenges. Locally appropriate adaptation strategies, including terracing to prevent soil erosion and adopting drought-resistant crop varieties, are critical for sustaining agricultural productivity and livelihoods (Figure 12).

118. Clear priorities for action include expanding capacity-building programs for farmers, securing land rights to reduce socio-economic vulnerabilities, and investing in infrastructure such as irrigation and storage facilities. Collaborative efforts between government agencies, private investors, and local communities are necessary to ensure the successful implementation of these strategies. By addressing both immediate risks and long-term vulnerabilities, these measures can significantly enhance the resilience of highland agriculture in Nan province.

Knowledge Product

119. Information from these analyses has been presented in a KP, titled **Vulnerability of Highland Agriculture: Current and Future Climate Change Scenarios (KP2)**. KP2 can be read **here**.

Capacity needs and gaps on vulnerability in different agriculture subsectors (e.g., crops, livestock, forestry, inland fisheries)

120. In addition to the vulnerabilities faced by the arable crop subsector, other agricultural subsectors in Thailand's highlands, such as livestock, forestry, and inland fisheries, are also significantly affected by climate change and related environmental and socio-economic pressures.

121. **Livestock**. The livestock subsector in the highlands, while not as large as crop farming, still plays a critical role in the livelihoods of many highland families. However, this sector is facing considerable challenges. Livestock owners in the highlands primarily rear poultry, pigs, and cattle, but there has been a noticeable decline in animal husbandry over the years. In the surveyed villages, only 14% of households reported owning livestock, with the majority raising poultry (about one-third of households) and a smaller proportion raising pigs and cattle. This decline can be attributed to various factors, including socio-economic shifts such as the outmigration of younger generations who prefer education and urban employment over farming. Additionally, there are cultural shifts where younger generations are less willing to take on the responsibility of livestock care, which further reduces the number of households engaged in animal husbandry.

122. As a result of declining livestock production, highland communities are facing reduced income diversification, which in turn limits their ability to buffer against climate and market shocks. Livestock is also crucial for soil fertility, as manure can be used to improve soil quality. The reduction in animal husbandry has a cascading effect on agriculture, as it decreases the availability of organic fertilizer, which is especially important in maintaining soil health in highland areas with poor soil fertility.

123. Livestock also faces direct vulnerabilities due to climate change. Rising temperatures can lead to heat stress in animals, which can affect their health, reproduction, and overall productivity. Increased rainfall and humidity can contribute to the spread of diseases, such as foot-and-mouth disease and avian influenza, which can devastate livestock populations. Additionally, the scarcity of water, especially in drought-prone periods, poses a challenge for providing adequate drinking water for animals, further impacting livestock health and productivity.

124. **Forestry**. Forestry in Thailand's highlands is another crucial subsector, providing both ecological services and economic resources to local communities. The highlands have historically been home to rich, biodiverse forests that support a wide range of plant and animal species. However, over the past decades, deforestation has increased due to both legal and illegal logging, agricultural expansion, and urbanization. From 2002 to 2023, Nan province lost 2,700 hectares of humid primary forest, largely due to the expansion of rubber plantations and maize farming. Deforestation has led to a loss of biodiversity, reduced carbon sequestration capacity, and the disruption of local water cycles. This is particularly concerning given that forests in highland regions play a vital role in regulating water flow, preventing soil erosion, and providing habitat for wildlife.

125. The degradation of forests not only affects the environment but also the livelihoods of local communities. Many highland communities depend on forest resources for fuelwood, medicinal plants, and non-timber forest products. Forest degradation reduces the availability of these resources, impacting both household incomes and cultural practices. The loss of forest cover also contributes to increased soil erosion, which further degrades the land and reduces its agricultural potential. Climate change, which is expected to exacerbate the risks of forest fires and pests, further threatens the health and sustainability of these forests.

126. **Inland Fisheries**. Inland fisheries are another important agricultural subsector in the highlands, particularly in areas with access to rivers and ponds. However, this subsector is highly sensitive to changes in water availability and quality, both of which are being affected by climate change. Increased temperatures and altered precipitation patterns are leading to lower water levels in rivers and ponds, which in turn affect fish populations. The reduction in water volume leads to higher water temperatures, which can harm fish health, reduce oxygen levels in the water, and increase the risk of diseases.

127. Moreover, water contamination from agricultural runoff, including pesticides and fertilizers, is another threat to inland fisheries. These chemicals can lead to eutrophication, where the excessive growth of algae depletes oxygen in the water, suffocating fish and other aquatic life. In Nan province, where maize cultivation and the use of chemical inputs are widespread, water bodies are particularly vulnerable to such contamination. The decline in fish stocks reduces the availability of protein for local communities and undermines the economic value of inland fisheries, which are an important source of income and nutrition for many highland families.

128. **Sustainability Challenges Across Sub-Sectors**. Across all subsectors—agriculture, livestock, forestry, and fisheries—the challenges are compounded by the physical isolation of highland communities, which makes it difficult to access markets, technology, and knowledge. This isolation results in high marketing costs and limited market access, which are critical factors in the sustainability of these agricultural subsectors. For example, many farmers in the highlands rely on local markets with limited infrastructure and weak market linkages, reducing their ability to access fair prices for their products.

129. Climate change further complicates these challenges by introducing new risks that are often unpredictable. The vulnerability of these sectors is particularly high because they are all interconnected. For instance, the degradation of forest resources and the increasing reliance on monoculture farming put pressure on local water systems, which, in turn, affects both crop farming and fisheries. Similarly, the decline in livestock husbandry reduces the availability of manure for soil improvement, further exacerbating the challenges for crop production.

130. In conclusion, the agriculture, livestock, forestry, and fisheries subsectors in the highlands of Thailand are all facing significant vulnerabilities due to a combination of climate change, unsustainable land use practices, and socio-economic pressures. To build resilience across these subsectors, it is crucial to adopt integrated approaches that address the interconnected challenges and promote sustainable practices in all areas of highland agriculture. Capacity-building efforts, including better access to market information, financial resilience, and climate adaptation technologies, are essential for improving the adaptive capacity of these communities and ensuring the long-term sustainability of their livelihoods.

131. The detailed briefing note is presented **here**.

Vulnerability Assessment with a focus on Highland Communities

132. Climate change vulnerability in highland agricultural communities in Thailand is influenced by a variety of factors, including socio-economic conditions, cultural practices, and geographical location. Ethnic groups such as the Mien, Hmong, Thai Lue, Mlabri, H'tin, and Khamu face unique challenges shaped by these variables. Through consultations with farmers and local government officials, it has become clear that these communities experience climate change in different ways, highlighting the need for tailored adaptation strategies that consider local realities and strengths.

133. The impacts of climate change on agriculture vary significantly across different crops. While crops like coffee and rice are particularly vulnerable, showing decreased yields under changing climatic conditions, other crops like maize and soybean may benefit from warmer temperatures, leading to increased yields. This variability underscores the importance of not only addressing the exposure to climate risks but also understanding the adaptive capacity of the communities. Traditional farming methods, often tied to deep cultural practices, may not be well-suited to cope with these changes, making it crucial to integrate modern techniques while respecting indigenous knowledge.

134. Each ethnic group has its own set of strengths and vulnerabilities. The Hmong, for example, have shifted from opium cultivation to growing rice and corn, and their craft traditions, including textiles, have become a significant economic activity. Similarly, the Thai Lue, engaged in both agriculture and local tourism, have a rich cultural heritage that can be leveraged for sustainable development. However, many of these groups face common challenges, such as limited access to climate change education and modern farming practices. These gaps hinder their ability to adapt to changing environmental conditions and improve their resilience.

135. Gender disparities also play a key role in vulnerability. While both men and women contribute to farming, women often bear the brunt of household chores, which limits their time and energy for agricultural work. This unequal division of labor affects their well-being and economic contribution. Addressing these gender imbalances through targeted interventions would not only improve

household dynamics but also strengthen the community's overall resilience to climate change. Additionally, preserving and integrating traditional knowledge into climate adaptation strategies can enhance cultural identity and provide valuable tools for coping with climate risks.

136. To better equip these communities for climate resilience, efforts should focus on increasing local government engagement with ethnic groups and fostering collaboration across sectors. Capacity-building programs that introduce sustainable agricultural practices, alongside awareness campaigns on climate change, will help communities better understand and respond to climate risks. By promoting diverse livelihood opportunities such as agroforestry, agrotourism, and improved marketing strategies, communities can reduce their dependency on vulnerable agricultural practices and build a more sustainable future. Ultimately, empowering these highland communities to navigate climate change will enhance their ability to thrive in a rapidly changing world.

137. A detailed analysis is presented **here**.

4.1.5 Activity 1.5: Develop knowledge products, including a guidance manual, on assessing climate change vulnerability in highlands

138. The knowledge product, "Climate Change Vulnerability Assessment in Highlands: A Guidance Manual," was developed to provide a systematic framework for understanding and addressing the unique vulnerabilities of highland agriculture to climate change. Given the rapid changes in temperature, precipitation patterns, and environmental conditions in highland regions, this manual responds to the urgent need for localized tools and strategies to mitigate climate risks. The manual integrates scientific methodologies with participatory approaches to support stakeholders, including policymakers, researchers, and local communities, in identifying and addressing the factors driving vulnerability.

139. This product is built on rigorous data analysis and stakeholder engagement to deliver actionable insights. Using downscaled climate models under SSP245 (moderate) and SSP585 (extreme) scenarios, it analyzed projections of annual temperature increases ranging from 1.4°C–1.8°C by the 2060s to 3.0°C–3.8°C by the 2090s, alongside annual precipitation increases of 39–48 mm by 2050. These projections informed vulnerability assessments and adaptation planning to ensure they reflect the realities of highland regions.

Key Findings

140. The manual outlines a comprehensive vulnerability assessment framework, focusing on the key components of exposure, sensitivity, and adaptive capacity. Exposure was analyzed based on climatic hazards such as rising temperatures, erratic rainfall, and droughts, which were found to significantly impact villages like B. San Phayom (V7) and B. Nong Ha (V8). Sensitivity, driven by reliance on monoculture farming, low soil fertility, and socio-economic dependency on agriculture, was highest in villages such as B. Tabman (V4) and B. Mai Mongkol (V2). Adaptive capacity, measured through indicators like access to resources, infrastructure, and diversified livelihoods, was weakest in B. Nakai (V5).

141. To ensure actionable outcomes, vulnerability mapping was conducted at the village level. These maps revealed that under SSP245, vulnerability is projected to increase significantly by mid-century, with villages like B. Mai Mongkol (V2) and B. Nakai (V5) transitioning from moderate to high vulnerability. Conversely, villages such as B. Oi (V1) and B. Na Haen (V3) showed relatively stable trends but are expected to reach low vulnerability levels due to gradual improvements in adaptive capacity.

Quantitative Analysis and Drivers of Vulnerability

142. The work identified 29 indicators contributing to vulnerability, with change in annual rainfall emerging as the top driver, accounting for approximately 7% of the overall vulnerability index in six villages. Other key drivers included landholding size, livestock density, and crop water use efficiency, reflecting the dependence of highland livelihoods on natural resources. Indicators like soil acidity and the proportion of off-farm income also played significant roles in shaping vulnerability. These findings provide a granular understanding of the factors that exacerbate risks and highlight opportunities for targeted interventions.

143. Uncertainty in vulnerability assessments was also analyzed, particularly regarding rainfall trends under different scenarios. While SSP245 projects increasing rainfall variability, SSP585 shows an initial decrease in vulnerability before aligning with SSP245 in the far future. This duality underscores the importance of planning for multiple scenarios and focusing on the most likely pathway to address near-term vulnerabilities effectively.

Applications and Recommendations

144. This knowledge product provides a detailed roadmap for integrating vulnerability assessments into policy and planning processes. The vulnerability mapping exercises were designed to guide resource allocation and prioritize interventions in high-risk areas, such as B. Tabman (V4) and B. Mai Mongkol (V2). For example, water management practices like rainwater harvesting and small-scale irrigation were recommended to address variability in rainfall, while crop diversification and agroforestry were suggested to enhance resilience against monoculture dependencies.

145. Additionally, the manual emphasizes improving adaptive capacity through socio-economic measures, including securing land tenure, improving access to financial resources, and fostering diversified livelihoods. These strategies were tailored to address the specific challenges identified in highland villages, ensuring that interventions are contextually appropriate and equitable.

146. By consolidating scientific analysis and stakeholder insights, this knowledge product successfully delivers a comprehensive framework for assessing and mitigating climate vulnerabilities in highland agriculture. Its findings and recommendations offer a robust foundation for policymakers and practitioners to implement targeted adaptation strategies, ensuring sustainable agricultural practices and resilient livelihoods in highland regions. The manual not only serves as a critical tool for decision-making but also underscores the urgency of proactive measures to address the escalating challenges of climate change.

Knowledge Product

147. Information from these analyses has been presented in a KP, titled **Climate Change Vulnerability Assessment in Highlands: A Guidance Manual (KP3)**. KP3 can be accessed **here**.

4.1.6 List of Appendices for Output 1

- Baseline Survey Report
- CB2 Workshop Report
- KP2: Vulnerability of Highland Agriculture – Current and Future Climate Change Scenarios
- Briefing Note on Capacity needs and gaps on vulnerability in different agriculture subsectors (e.g., crops, livestock, forestry, inland fisheries) (Aide Memoire Action Item 5)
- Working Paper on bottom-up climate change vulnerability assessment, based on consultations with local stakeholders, especially farmers, including ethnic communities (Aide Memoire Action Item 6)
- KP3: Climate Change Vulnerability Assessment in Highlands – A Guidance Manual

4.2 Output 2: Gender– and COVID–19-Responsive CSA Practices Prioritized and Demonstrated

4.2.1 Activity 2.1: Prepare an inventory of gender- and COVID–19-responsive CSA practices for highlands and conduct a multi-criteria assessment with local stakeholders including farmers, civil society organizations, women, the private sector, and government staff to prioritize appropriate CSA practices. (CB1, W1 and KP1)

Inventory Analysis

148. A comprehensive study was conducted to identify and evaluate CSA practices for highland regions in Nan Province, Thailand, focusing on addressing the challenges posed by climate change. The investigation sought to enhance agricultural productivity, strengthen resilience to climatic variability, and mitigate greenhouse gas emissions. These objectives were framed within the context of transitioning from conventional agricultural practices, which are highly vulnerable to climate impacts, to more sustainable and adaptive systems.

149. The baseline assessment revealed that the region faced significant climatic challenges, including erratic rainfall, rising temperatures, and frequent extreme weather events such as droughts and floods. The agricultural systems were primarily rainfed and heavily dependent on maize monoculture, leading to severe water scarcity, soil degradation, and erosion. These issues were compounded by a lack of land ownership rights, which limited long-term investment in sustainable farming practices. These findings underscored the necessity of tailored CSA practices that could address these constraints while improving the sustainability of agricultural systems.

150. Among the identified practices, solar-powered irrigation systems were evaluated for their potential to address water scarcity. These systems demonstrated the ability to provide consistent water supply, increase crop yields, and enhance income stability. Furthermore, they offered significant mitigation benefits by replacing diesel-based pumps with renewable solar energy. However, the high initial investment costs presented a barrier to widespread adoption, necessitating the development of innovative financing mechanisms to ensure accessibility for small-scale farmers.

151. The use of biochar as a soil amendment was extensively analyzed. Biochar was found to improve soil fertility by increasing nutrient availability, enhancing water retention, and reducing nutrient leaching. Its application also contributed to significant carbon sequestration, making it a valuable tool for both productivity enhancement and climate mitigation. Field trials indicated that biochar could be particularly effective in improving yields in high-value crop systems such as vegetable production.

152. The Keyline approach was implemented to optimize water management and reduce soil compaction. This method involved strategic plowing along contour lines to slow and spread rainwater, promoting deeper infiltration and reducing runoff. The results demonstrated improved water retention and soil structure, which contributed to enhanced drought and flood resilience. This practice also supported groundwater recharge, providing a sustainable solution to long-term water management challenges.

153. Traditional organic composting practices were promoted as a sustainable waste management strategy. Organic composting converted agricultural and municipal organic waste into nutrient-rich fertilizer, improving soil structure and microbial diversity. The process reduced greenhouse gas emissions associated with unmanaged waste and enhanced the moisture-holding capacity of treated soils. Composting also offered a cost-effective and environmentally friendly alternative to synthetic fertilizers.

154. Mulching was introduced as a method to reduce water loss, control soil temperature, and prevent erosion. The practice involved covering soil with organic or inorganic materials, which minimized evapotranspiration, improved soil fertility, and reduced weed growth. Mulching proved to be a highly effective and affordable strategy, particularly for smallholder farmers, as it required minimal additional resources while providing substantial benefits to soil and crop health.

155. Stress-tolerant crop varieties, particularly drought-resistant maize hybrids, were deployed to address climate-induced yield instability. These varieties maintained productivity under adverse conditions such as drought and heat stress while reducing dependency on external inputs like fertilizers and irrigation. Field trials confirmed their suitability for the highland conditions, with consistent yields even in extreme climatic scenarios.

156. Agroforestry systems were integrated into the farming landscape to combine the benefits of agriculture and forestry. These systems contributed to biodiversity conservation, carbon sequestration, and soil stabilization. Agroforestry also diversified income streams for farmers by incorporating tree-based products such as fruits, timber, and fodder. The integration of trees with crops and livestock enhanced resilience to climatic variability and provided ecosystem services essential for long-term sustainability.

157. The study highlighted the complementary nature of the selected CSA practices. Each practice addressed specific challenges while collectively contributing to the overall goals of productivity, resilience, and mitigation. The findings emphasized the importance of adopting a multi-faceted approach to CSA implementation, supported by capacity-building initiatives, policy alignment, and financial incentives. Scaling these practices in the highlands of Nan Province and similar regions can significantly contribute to sustainable agricultural development and climate adaptation.

158. The inventory can be viewed **here**.

Multi-Criteria Analysis and Prioritization of CSA Practices

159. A multi-criteria analysis (MCA) was employed to evaluate and prioritize climate-smart agriculture (CSA) practices suitable for highlands in Nan Province, Thailand. The study aimed to identify the most impactful practices based on their ability to address critical agricultural challenges such as water scarcity, soil degradation, and climate variability. The assessment focused on a set of predefined CSA practices, including solar-powered irrigation systems, biochar, the Keyline approach, traditional organic composting, mulching and soil cover, stress-tolerant crop varieties, and agroforestry.

160. The analysis began with a structured questionnaire survey involving 51 farmers from eight villages in the Bua Yai Subdistrict. The farmers rated the potential benefits of each CSA practice on a scale from 0 (not sure) to 3 (high), across ten criteria:

(1) input cost saving
(2) water saving
(3) labor saving
(4) soil improvement
(5) increased production
(6) increased income
(7) long-term sustainability
(8) prior knowledge
(9) adaptation potential, and
(10) mitigation of greenhouse gas emissions.

161. This participatory approach ensured the evaluation reflected the practical needs and experiences of local farmers.

162. The socio-demographic profile of respondents revealed an average age of 54 years, indicating extensive farming experience. However, only 10% had university education, with the majority having primary or middle school education. Women constituted 55% of the sample. Rainfall was the primary water source for 65% of respondents, highlighting the region's reliance on rainfed agriculture and the vulnerability to water scarcity. These characteristics provided critical context for interpreting the preferences and priorities expressed by the farmers.

163. The MCA results showed that traditional organic composting was ranked highest by the farmers due to its clear benefits in soil improvement, input cost saving, and long-term sustainability. Agroforestry followed closely, valued for its contributions to water saving, soil stabilization, and diverse income generation opportunities. Solar-powered irrigation systems ranked third, with high scores for labor and water savings, increased income potential, and long-term sustainability, making them particularly appealing for addressing the region's water scarcity.

164. Biochar was noted for its soil enhancement properties, contributing to increased productivity and long-term sustainability. However, it ranked lower overall due to its relatively complex application process and limited prior knowledge among farmers. The Keyline approach, while recognized for its ability to conserve water and improve soil conditions, received lower scores, potentially due to the higher technical understanding required for its implementation.

165. Mulching and soil cover were highlighted for their affordability and effectiveness in conserving soil moisture, improving fertility, and reducing erosion. Stress-tolerant crop varieties also received moderate rankings, appreciated for their ability to ensure stable yields under adverse climatic conditions, although they required long-term research and development investment to optimize their potential.

166. The CSA practices were ranked using an aggregate scoring system derived from the survey data. Traditional organic composting achieved the highest overall score, followed by agroforestry and solar-powered irrigation systems. Despite this ranking, project interventions were selected based on their alignment with specific regional needs, such as water management and soil restoration. Consequently, solar-powered irrigation systems, the Keyline approach, and biochar were prioritized for implementation.

167. The findings emphasized the importance of tailoring CSA interventions to the specific socio-environmental context of the study area. The participatory nature of the analysis not only enhanced the relevance of the selected practices but also increased the likelihood of their adoption by local farmers. The study concluded that targeted policies and capacity-building efforts would be crucial to overcoming barriers and maximizing the impact of CSA practices in the region.

168. The analysis can be viewed **here**.

Capacity Building Workshop (CB1)

169. A workshop on gender-conscious climate-smart agriculture for highlands (CB1) was organized to address the challenges posed by climate change in highland agriculture. The primary objectives were to enhance understanding of CSA principles among stakeholders, identify demonstration sites for CSA practices, evaluate alternative crops, and integrate gender-sensitive

approaches in CSA strategies. The workshop utilized a participatory approach involving farmers, local agencies, civil society organizations, and youth from the Bua Yai Subdistrict.

170. The workshop activities included pre- and post-workshop evaluations to assess knowledge levels and changes among participants. It began with an introduction to CSA principles and their relevance to highland agriculture. Discussions were facilitated on specific CSA technologies, such as solar-powered irrigation systems, Keyline water management, and biochar application. The session also focused on identifying alternative crops that are climate-resilient and responsive to market demands.

171. Participants actively engaged in site selection for CSA demonstrations, using a multi-criteria evaluation framework that incorporated technical suitability, stakeholder involvement, CSA relevance, value chain competitiveness, and additional context-specific criteria. Ten sites were proposed for solar irrigation and three for Keyline water management. Criteria for selection included water availability, soil conditions, and community readiness. Solar irrigation demonstrations were prioritized for areas with consistent water sources, while Keyline areas were chosen based on their potential for water retention and soil improvement.

172. An assessment of alternative crops highlighted the importance of water-saving, climate resilience, and market demand as key factors in decision-making. Farmers and stakeholders evaluated 15 crop options, ultimately ranking banana, lemongrass, pumpkin, avocado, and peanuts as the top five choices. Benefit-cost analysis revealed these crops offered significant economic returns and adaptability to local conditions, making them viable replacements for maize monoculture.

173. The pre- and post-workshop evaluations indicated substantial improvement in participants' knowledge of CSA practices, climate change impacts, and alternative cropping systems. The workshop demonstrated substantial improvements in participants' knowledge and understanding across all evaluated themes: Climate Change, Keyline Agriculture, Solar Irrigation, Biochar Technology, and Alternative Crops. Pre-workshop assessments revealed limited knowledge in these areas, with **15% to 47%** of participants reporting low or no understanding across various topics. Post-workshop results highlighted a significant shift, with high knowledge scores increasing by **20% to 40%** on average across all themes.

174. For **climate change**, participants with high knowledge rose from **18.6%–33% pre-workshop** to **44.4%–66.7% post-workshop**. Similarly, **keyline water management** saw a dramatic improvement, with high knowledge increasing from **7.2%–19.6% to 37.5%–44.4%.** This indicates participants gained a much deeper understanding of soil-water conservation techniques and their practical applications.

175. **Solar irrigation** knowledge improved markedly as well, with high scores rising from **14.4%–23.7%** to **43.1%–55.6%,** reflecting increased awareness of the system's benefits in mitigating climate impacts. **Biochar technology** exhibited the most dramatic transformation; while only **8.2%–13.4%** of participants reported high knowledge before the workshop, this jumped to **25%–34.7%** post-workshop, demonstrating newfound confidence in its use for soil improvement.

176. Finally, knowledge of **alternative crops** saw significant gains, with high scores increasing from **12.4%–30.9%** to **37.5%–51.4%**. Participants showed a heightened understanding of the costs, benefits, and market potential of alternative crops, which reflects the workshop's success in promoting climate-resilient agricultural options.

177. Feedback from participants underscored the workshop's effectiveness in transferring knowledge and fostering collaboration among diverse stakeholders. Farmers expressed a strong interest in CSA practices like biochar and solar irrigation but highlighted the need for technical training and resources for successful adoption. Gender inclusivity was evident, with women making up a significant proportion of attendees and contributing actively to discussions and site selections.

178. The workshop facilitated the establishment of demonstration sites, laying the groundwork for scaling CSA practices in highland areas. It also emphasized the need for ongoing capacity-building efforts, particularly in biochar application and the development of value chains for alternative crops. The integration of youth and gender perspectives further enriched the discussions and broadened the scope of participation.

179. The workshop report can be accessed **here**.

Knowledge Product (KP1)

180. The "**Gender Conscious Climate-Smart Agriculture for Highlands**" knowledge product serves as a comprehensive resource aimed at addressing the intersection of gender dynamics and climate-smart agricultural practices in the highland regions of Thailand. The knowledge product is designed to inform policymakers, practitioners, and stakeholders about the critical role of gender in agricultural practices, particularly in the context of climate change, and to provide actionable insights for fostering gender equality in agricultural development.

181. The preparation of this knowledge product involved a multi-faceted approach that combined both qualitative and quantitative research methodologies. The research team conducted focus group discussions, interviews with key informants, and participatory workshops to gather empirical data on gender relations and agricultural practices in the Bua Yai sub-district. Additionally, a randomized household livelihood survey was implemented to collect gender-disaggregated data, which allowed for a nuanced understanding of the roles, responsibilities, and challenges faced by men and women in agriculture. This comprehensive data collection process was essential for developing a robust framework that accurately reflects the local context and informs effective interventions.

182. One of the major findings of the knowledge product is the identification of gender as a cross-cutting socio-cultural variable that significantly influences agricultural practices and decision-making processes. It emphasizes that gender relations manifest in various forms of inequality, including distributional, procedural, and recognitional equality. It highlights that women often face barriers to accessing resources, information, and decision-making power, which limits their ability to engage fully in climate-smart agricultural practices. The findings suggest that addressing these inequalities is crucial for promoting sustainable agricultural development and enhancing the resilience of highland communities to climate change.

183. Another significant insight is the importance of integrating gender considerations into climate-smart agriculture strategies. The knowledge product outlines a framework for gender-conscious CSA that includes understanding the social dynamics between men and women, evaluating gender equality across multiple dimensions, and identifying specific gender inequalities that hinder the adoption of CSA practices. By promoting a CSA enabling environment that systematically addresses these dimensions, the project aims to empower women and enhance their contributions to agricultural productivity and food security.

184. Furthermore, the necessity of tailored communication and extension services that consider the diverse needs of different genders and age groups within the community is underscored in the knowledge product. It advocates for the development of gender-sensitive training programs and resources that can facilitate the adoption of CSA practices among both men and women. The insights derived from the knowledge product not only contribute to the academic discourse on gender and agriculture but also provide practical recommendations for stakeholders involved in agricultural development, ensuring that gender equality is at the forefront of climate adaptation strategies in the highlands.

185. KP1 can be read **here**.

4.2.2 Activity 2.2: Conduct a cost–benefit analysis of at least three priority CSA practices

186. A comprehensive cost-benefit analysis (CBA) was conducted to evaluate the economic and environmental viability of maize, avocado, and cacao cultivation in Thailand's highlands, incorporating climate-smart agriculture (CSA) practices. The study aimed to assess baseline farming practices and compare them with alternatives integrated with CSA technologies, specifically biochar, keyline ploughing, and solar irrigation.

187. The baseline analysis focused on maize cultivation, which has historically dominated the highlands due to its high demand in the animal feed industry. The findings indicated a benefit-cost ratio (BCR) of 1.14, showing that maize cultivation is marginally profitable. However, significant environmental costs were associated with soil degradation, erosion, and pesticide use. These challenges highlighted the need for alternative crops with better economic returns and lower environmental impacts.

188. Cacao cultivation emerged as a highly profitable alternative, with a BCR of 4.02 and a net present value (NPV) of 401,337.17 THB under traditional practices. When CSA technologies were applied, cacao showed incremental benefits. For instance, biochar improved soil fertility and carbon sequestration, yielding a BCR of 2.82 and an NPV of 344,505.16 THB. Keyline ploughing further enhanced water retention and soil aeration, achieving a BCR of 2.85 and an NPV of 346,767.49 THB. Solar irrigation improved water use efficiency and reduced the carbon footprint, resulting in a BCR of 3.12 and an NPV of 362,629.06 THB.

189. Similarly, avocado cultivation demonstrated significant profitability and sustainability. Traditional avocado farming had a BCR of 3.66 and an NPV of 312,383.69 THB. The integration of biochar into avocado farming improved soil structure and nutrient availability but reduced the BCR to 2.31 due to the additional costs, although the NPV remained positive at 244,148.79 THB. Keyline ploughing for avocado cultivation increased the BCR to 2.50 and the NPV to 257,814.01 THB, while solar irrigation provided a BCR of 2.75 and an NPV of 273,675.58 THB, enhancing resilience against drought conditions.

Figure 13: Comparative analysis of profitability of maize, avocado, and cacao.

Crop	Treatment	BCR	NPV (THB)	Environmental Impact
Maize	Baseline	1.14	-	Soil degradation, pesticide use, erosion
Cacao	Without Treatment	4.02	401,337.17	Highest profitability, basic environmental impact of cacao cultivation
	With Biochar	2.82	344,505.16	Enhanced soil health and carbon sequestration
	With Keyline Ploughing	2.85	346,767.49	Improved water retention, soil aeration, and reduced erosion
	With Solar Irrigation	3.12	362,629.06	Increased water- use efficiency and reduced carbon footprint due to the use of renewable energy
Avocado	Without Treatment	3.66	312,383.69	Improved profitability, basic environmental impact of avocado cultivation
	With Biochar	2.31	244,148.79	Enhanced soil health and carbon sequestration
	With Keyline Ploughing	2.50	257,814.01	Improved water retention, soil aeration, and reduced erosion
	With Solar Irrigation	2.75	273,675.58	Increased water-use efficiency and reduced carbon footprint due to the use of renewable energy

190. The analysis underscored the significant environmental and economic advantages of transitioning from maize to cacao and avocado cultivation with CSA practices. Maize's environmental impacts, such as soil erosion and pesticide-related contamination, limit its sustainability compared to the other crops analyzed. The CSA technologies introduced for cacao and avocado not only provided substantial returns on investment but also contributed to long-term environmental benefits.

191. The financial analysis was structured using a 15-year projection with a discount rate of 6.975% to reflect the time value of money. This rigorous methodology ensured accurate comparisons of the economic feasibility of each crop under various scenarios. The study also incorporated primary and secondary data sources, including field surveys, interviews with agricultural experts, and market analysis.

192. The payback period for CSA-integrated cacao and avocado cultivation ranged from three to four years, making these practices attractive for smallholder farmers and stakeholders. Solar irrigation had the shortest payback period among CSA interventions, followed by keyline ploughing and biochar. These results highlighted the importance of selecting CSA practices based on local needs and resource availability.

193. The findings provide actionable recommendations for policymakers and practitioners. Transitioning to alternative crops supported by CSA practices can enhance income stability, reduce environmental degradation, and increase resilience to climate change in the highlands. These interventions align with broader goals of sustainable agriculture and climate adaptation while ensuring economic viability for farmers.

194. Overall, the CBA demonstrated that combining alternative crops with CSA practices creates a pathway for achieving sustainable and profitable agriculture in Thailand's highlands. The insights from this analysis can guide future investments and inform the design of policies promoting CSA adoption. The study concluded that strategic integration of these practices has the potential to transform agricultural systems in climate-sensitive regions.

195. The detailed report on the cost-benefit analysis can be viewed **here**.

4.2.3 Activity 2.3: Demonstrate at least two most appropriate gender- and COVID–19-responsive CSA practices in the target area

196. Six pilot demonstrations were implemented in Bua Yai Subdistrict through a participatory approach. Pilot demonstration sites were identified through consultations with farmers and local authorities at the Gender–Conscious Climate–Smart Agriculture workshop (4.2.1). A solar irrigation system and 4 biochar making units were added to the demonstration sites in Ban Mai Mongkol and Ban Tabman based on discussions with the farmers during the midterm review mission. The details of the demonstration sites are presented below:

No.	Pilot Demonstration	Location	Site Code	Farmer(s)
1	Keyline Water Management	Ban Mai Mongkol (Village 2)	2-1	Mrs. Kwanjai Khaeongriangkhwang and Mr. Amonthep Mamat
		Ban Tabman (Village 4)	4-2	Mr. Somsak Deepromkul
2	Solar Irrigation System	Ban Mai Mongkol (Village 2)	2-1	Mrs. Kwanjai Khaeongriangkhwang and Mr. Amonthep Mamat
			2-2	Mr. Weerasak Thapumin
		Ban Tabman (Village 4)	4-1	Mr. Niphatphol Phromphira
3	Biochar	Ban Mai Mongkol (Village 2)	2-1	Mrs. Kwanjai Khaeongriangkhwang and Mr. Amonthep Mamat
			2-2	Mr. Weerasak Thapumin
		Ban Tabman (Village 4)	4-1	Mr. Niphatphol Phromphira
			4-2	Mr. Somsak Deepromkul
4	Climate-Adaptive Organic Agriculture with Participatory Guarantee System (SDG–PGS)	Ban Oi (Village 1)	N/A	6 farmers (3 male and 3 female)
		Ban Mai Mongkol (Village 2)		45 farmers (18 male and 27 female)
		Ban Tabman (Village 4)		11 farmers (5 male and 6 female)
		Ban San Phayom (Village 7)		1 farmer (female)
		Ban Nong Ha (Village 8)		2 farmers (both female)
5	Bio-Circular Green (BCG) Economy for Agricultural Waste Management	Ban Mai Mongkol (Village 2)	N/A	Ms. Chotiros Saengthi
6	Digital Technology-Based Farm-To-Fork Traceability Solution	Ban Mai Mongkol (Village 2)	N/A	Mr. Weerasak Thapumin

Keyline Water Management, Solar Irrigation System, and Biochar

197. The monitoring and evaluation of CSA practices focused on three primary interventions: solar-powered irrigation, biochar application, and biofertilizer integration. Data points for keyline water management were insufficient for a comprehensive analysis. The investigation was carried out across demonstration plots for avocado, cacao, and lemongrass in distinct locations. These practices were evaluated for their impacts on soil moisture retention, crop growth, and productivity.

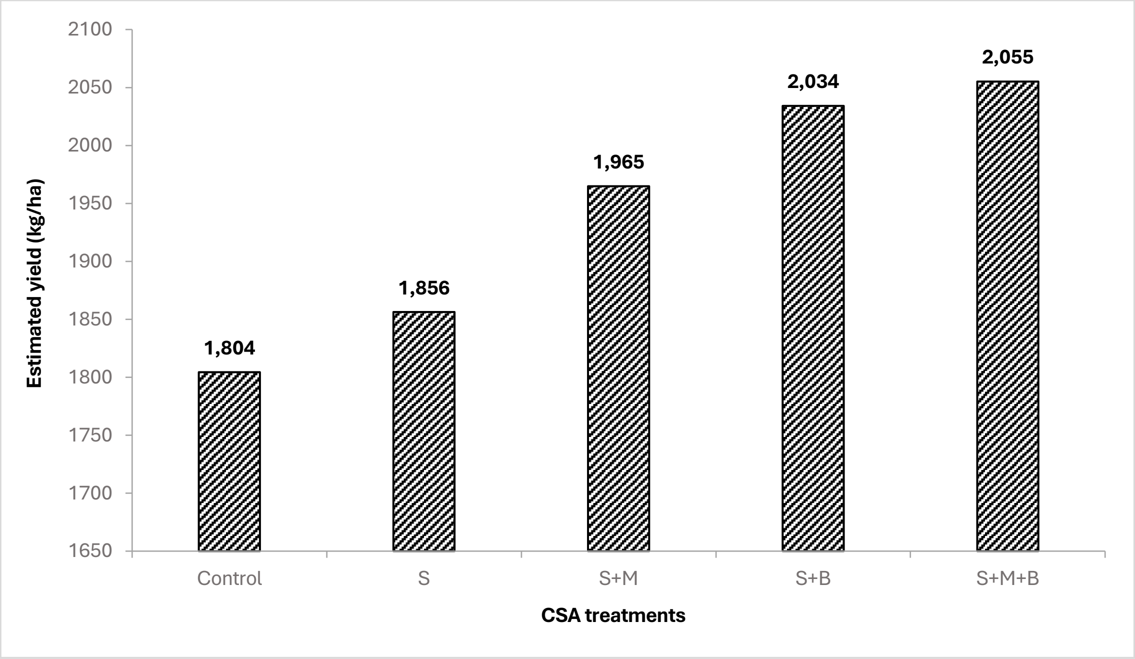
198. Data collection followed a rigorous methodology, with plots set up using randomized designs and treatments tailored to different CSA combinations. Solar irrigation consistently outperformed control plots in water retention, with soil moisture levels markedly higher in solar-irrigated plots. The addition of biochar and biofertilizer further enhanced moisture retention, demonstrating synergistic effects. Among these treatments, the combination of solar irrigation, biochar, and biofertilizer achieved the highest levels of soil moisture retention, underscoring the integrated benefits of these technologies.

199. Crop growth parameters, including plant height and diameter, were monitored at regular intervals. For avocado, solar irrigation resulted in improved growth metrics compared to the control. The combination of biochar and biofertilizer further amplified these effects, with the most significant gains observed in plots where all three CSA practices were applied. Similarly, cacao demonstrated enhanced growth, with the combination of biochar and biofertilizer yielding the most robust plant height and diameter metrics. Lemongrass, as a test crop, exhibited the greatest improvement in herbage yield when subjected to combined treatments, emphasizing the economic potential of integrating CSA practices.

200. The estimated yields reflected substantial economic benefits. For avocado, the yield in solar-irrigated plots with biochar and biofertilizer was approximately 2,055 kg/ha, significantly higher than the control yield of 1,804 kg/ha (Figure 14). Cacao yields

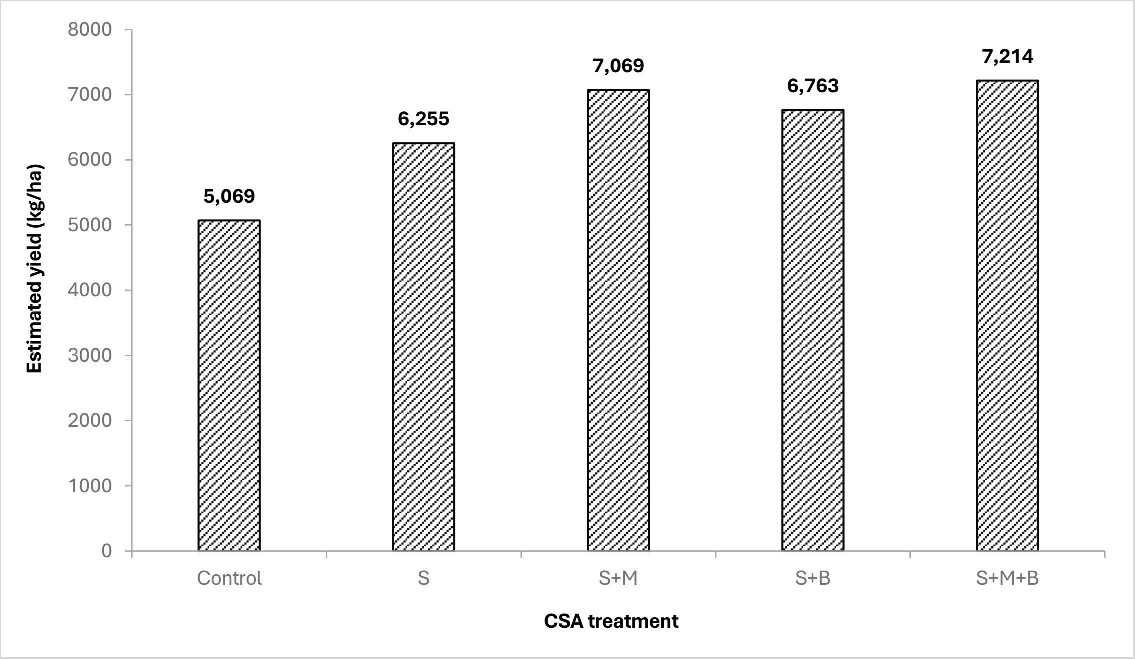
followed a similar trend, with combined treatments achieving 7,214 kg/ha compared to 5,069 kg/ha in control plots (Figure 15). For lemongrass, herbage yield under combined treatments reached 2,494 kg/ha, surpassing the control yield of 1,689 kg/ha (Figure 16). These results illustrate the financial viability and productivity improvements achievable through CSA integration.

Figure 14: Estimated fruit yield of avocado as influenced by different CSA treatments.



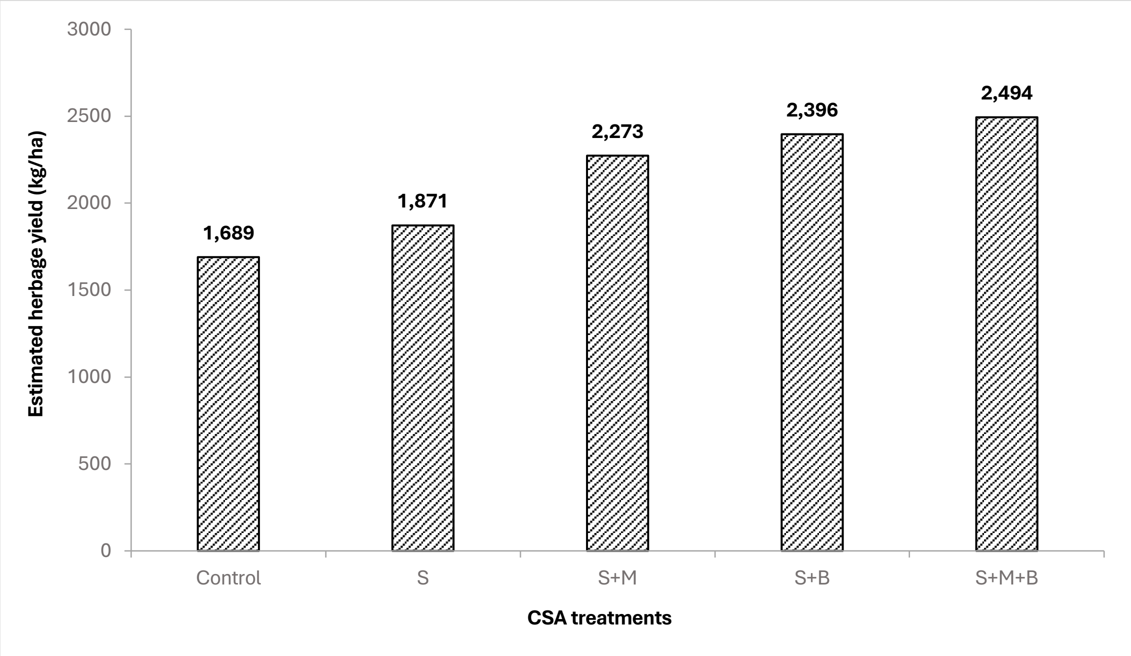
S: Solar Irrigation, M: Biofertilizer, B: Biochar

Figure 15: Estimated fruit yield of cacao as influenced by different CSA treatments.



S: Solar Irrigation, M: Biofertilizer, B: Biochar

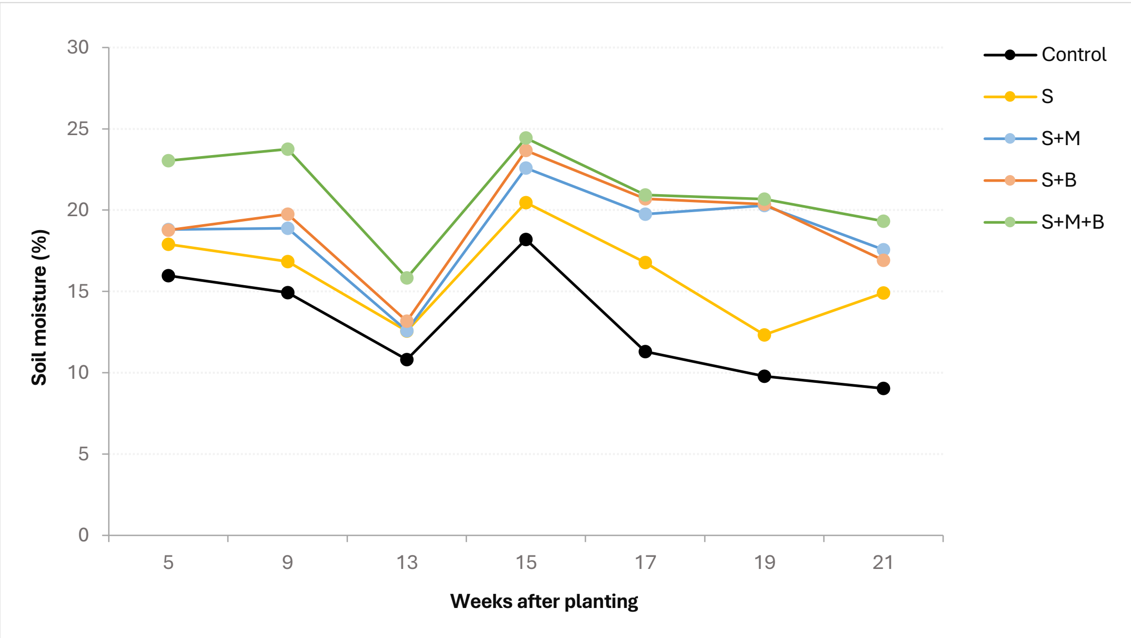
Figure 16: Estimated herbage yield of lemongrass as influenced by different CSA treatments in Ban Mai Mongkol Village.



S: Solar Irrigation, M: Biofertilizer, B: Biochar

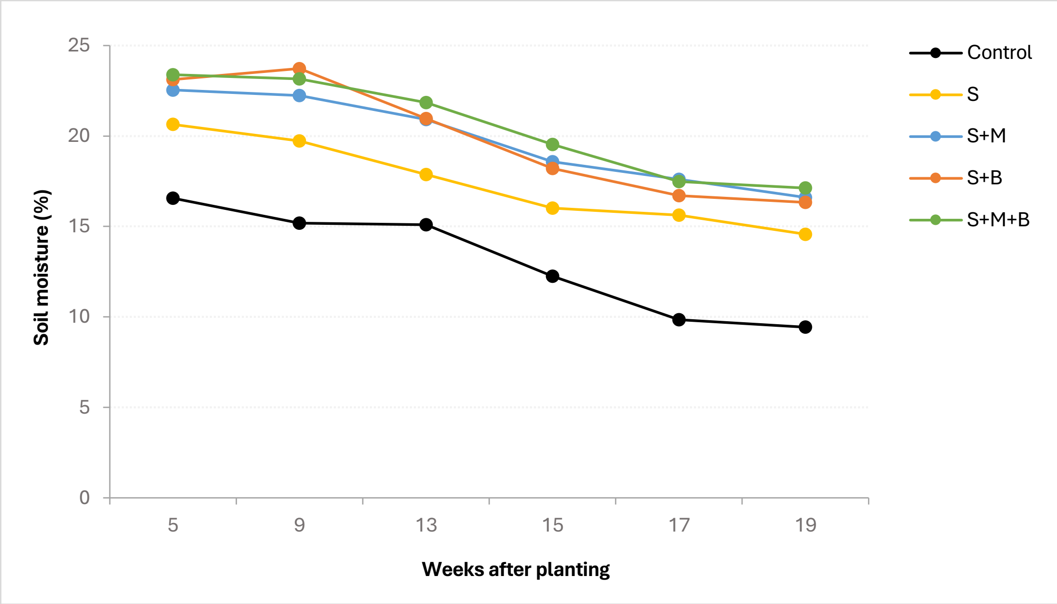
201. Soil moisture trends over time demonstrated the effectiveness of biochar and biofertilizer in enhancing water retention (Figure 17, Figure 18, Figure 19). Solar irrigation alone improved water availability, but the combined application of biochar and biofertilizer sustained higher moisture levels for longer durations. This finding is critical for highland areas prone to drought and erratic rainfall patterns, as it highlights the resilience offered by CSA practices.

Figure 17: Soil moisture trends over time in plots using avocado as a test crop as influenced by different CSA treatments.



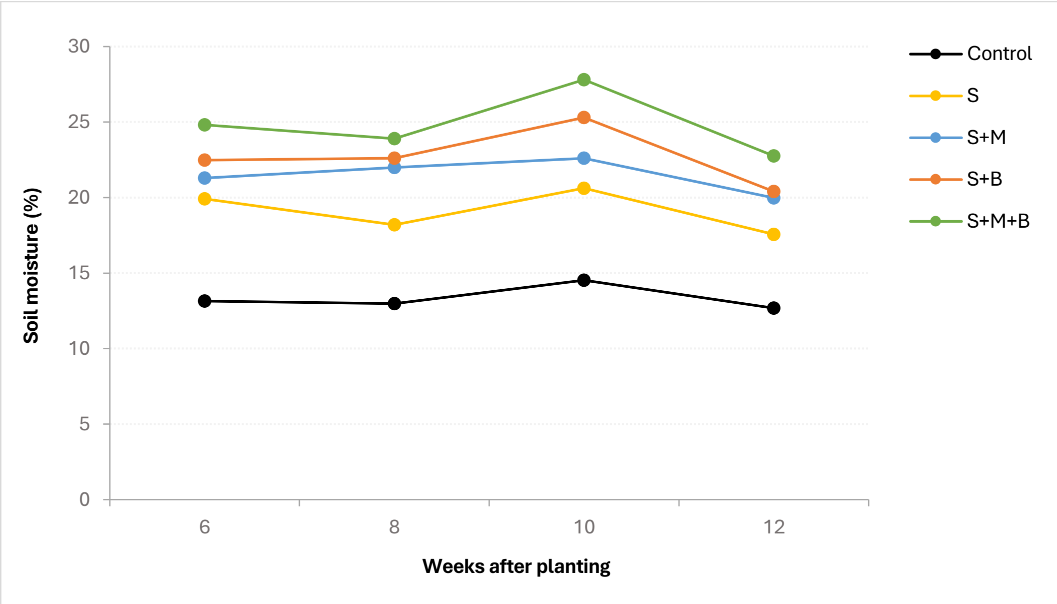
S: Solar Irrigation, M: Biofertilizer, B: Biochar

Figure 18: Soil moisture trends over time in plots using cacao as a test crop as influenced by different CSA treatments in Ban Tabman Village.



S: Solar Irrigation, M: Biofertilizer, B: Biochar

Figure 19: Soil moisture trends over time in plots using lemongrass as a test crop as influenced by different CSA treatments in Ban Mai Mongkol Village.



S: Solar Irrigation, M: Biofertilizer, B: Biochar

202. The environmental benefits were also significant. Biochar applications improved soil structure, porosity, and carbon content, contributing to reduced nutrient leaching and greenhouse gas emissions. Biofertilizers enhanced nutrient cycling and soil microbial activity, further supporting sustainable farming. These practices align with goals for climate adaptation and mitigation, offering scalable solutions for highland agriculture.

203. The monitoring process revealed challenges, including variability in implementation efficiency among participants and the need for tailored training to optimize CSA adoption. Data collection intervals and sample sizes in some plots were insufficient for comprehensive analysis, indicating the necessity of standardizing procedures for future studies. Additionally, the upfront costs of CSA technologies remain a barrier, requiring financial incentives or subsidies for widespread adoption.

204. The findings underscore the transformative potential of integrating CSA practices in highland agriculture. These practices not only improve crop productivity and resource efficiency but also contribute to long-term soil health and climate resilience. Policy measures, including subsidies, training programs, and public-private partnerships, are essential to scaling these interventions. The results from this monitoring and evaluation highlight a sustainable pathway for addressing the dual challenges of climate change and food security in highland regions.

205. The monitoring and evaluation report is presented **here**.

BCA at PGS Level

206. The analysis undertaken focused on evaluating the economic, environmental, and social benefits of adopting climate-smart agriculture (CSA) practices, particularly for cacao and avocado cultivation, in Nan Province, Thailand. The methodologies integrated financial metrics such as Net Present Value (NPV), Benefit-Cost Ratio (BCR), and Internal Rate of Return (IRR), comparing CSA-based organic farming with conventional agricultural methods.

207. Demonstration sites for cacao and avocado cultivation incorporated CSA components, including keyline plowing, biochar application, solar irrigation, and adherence to Participatory Guarantee System (PGS) standards. Costs and benefits were assessed over 20 years, factoring in labor, inputs, and environmental gains. The analysis utilized discount rates of 3.5%, 6.5%, and 8% to present findings across varying economic conditions. Data collection methods included farmer surveys, market price tracking, and consultation with agricultural extension agents.

208. Economic results for cacao showed substantial profitability under CSA practices, with BCRs ranging from 4.12 to 4.38 across discount rates. This indicated that for every 1 THB invested, returns ranged from 4.12 to 4.38 THB. The NPV was consistently positive, with values between 1.18 and 1.9 million THB, significantly outperforming conventional farming. The payback period was reduced to four years under CSA, compared to five years for traditional methods. The marked difference was attributed to higher market prices for organic cacao beans, which fetched 250–350 THB/kg compared to 40–60 THB/kg for conventional beans.

Table 12: Economic analysis comparison between CSA cacao and conventional cacao.

Items	Costs	Benefits	Net Profit	Profit/Year	IRR	BCR
CSA Cacao						
Discount Rate 3.5%	2,408,762.79	549,891.63	1,899,235.30	94,961.77	88.27%	4.38
Discount Rate 6.5%	1,767,614.93	419,965.91	1,376,206.89	68,810.34	82.41%	4.21
Discount Rate 8.0%	1,529,673.99	371,362.91	1,175,998.73	58,799.94	79.49%	4.12
Ratio between Cash costs and Non-cash costs = 10.86% : 89.14% (1:8.2)						
Payback Period = 4 years						
Conventional Cacao						
Discount Rate 3.5%	533,345.86	1,204,669.62	684,873.99	34,243.70	48.21%	2.26
Discount Rate 6.5%	399,131.12	868,015.81	475,978.16	23,798.91	43.60%	2.17
Discount Rate 8.0%	349,279.13	744,265.38	397,163.35	19,858.17	41.30%	2.13
Ratio between Cash costs and Non-cash costs = 38.76% : 61.24% (1:1.16)						
Payback Period = 5 years						

209. In avocado cultivation, the economic advantage of CSA practices was less pronounced but still significant. BCRs ranged from 7.68 to 8.26 for CSA avocados, reflecting returns of 7.68–8.26 THB per 1 THB invested. However, conventional avocado farming achieved slightly higher NPVs and IRRs due to lower input costs and market dynamics. The three-year payback period for both CSA and conventional methods highlighted the economic viability of avocado cultivation in general.

Table 13: Economic analysis comparison between CSA and conventional avocado.

Items	Costs	Benefits	Net Profit	Profit/Year	IRR	BCR
CSA Avocado						
Discount Rate 3.5%	215,150.08	1,776,722.70	1,595,901.68	78,078.63	118%	8.26
Discount Rate 6.5%	165,633.30	1,305,430.44	1,165,251.01	56,989.86	114%	7.88
Discount Rate 8.0%	147,113.57	1,130,511.12	480,473.82	49,169.88	114%	7.68
Ratio between Cash costs and Non-cash costs = 28.18%: 71.82% (1:2.6)						
Payback Period = 3 year						
Conventional Avocado						
Discount Rate 3.5%	173,037.72	1,484,852.88	1,340,785.49	67,039.27	133%	8.58
Discount Rate 6.5%	133,190.51	1,093,010.52	981,628.72	49,081.44	126%	8.21
Discount Rate 8.0%	118,270.04	947,447.02	843,920.07	42,196.00	122%	8.01
Ratio between Cash costs and Non-cash costs = 39.60%: 60.40% (1:1.5)						
Payback Period = 3 years						

210. Sensitivity analyses underscored the critical impact of market prices on profitability. Ensuring high-quality standards through organic certification or Good Agricultural Practices (GAP) emerged as a strategic recommendation to secure premium prices and stabilize revenues. The introduction of post-harvest value addition, such as cacao butter and chocolate production, was identified as a high-potential opportunity to further enhance economic outcomes for farmers.

211. Environmental benefits of CSA practices included significant carbon sequestration. Cacao and avocado plantations sequestered 2.28 tons and 9.9 tons of carbon per rai over 20 years, respectively. Biochar applications improved soil health by increasing nutrient retention and microbial activity, while solar irrigation reduced reliance on fossil fuels and optimized water use. Keyline plowing effectively mitigated soil erosion and improved water infiltration, enhancing land resilience against climate variability.

212. The PGS organic certification system promoted the elimination of chemical inputs, reducing environmental contamination and enhancing food safety. It also fostered community engagement, integrating farmers, consumers, and local authorities in collaborative governance. This system strengthened market access and supported the transition to sustainable agricultural practices in the region.

213. The full report can be accessed **here**.

Climate-Adaptive Organic Agriculture with Participatory Guarantee System (SDG–PGS)

214. The demonstration on Climate-Adaptive Organic Agriculture with Participatory Guarantee System (SDG–PGS) was carried out through the capacity-building workshop on Grower Certification Schemes, Organic Farming, and Good Agricultural Practices, which aimed to disseminate knowledge and share experiences regarding grower certification schemes, particularly the Participatory Guarantee System (PGS), organic farming, and good agricultural practices. emphasized participatory guarantee systems (PGS), biofertilizer composting, and food safety to support highland farmers in adapting to climate impacts, enhancing their livelihoods, and aligning with organic certification standards.

215. **Phase 1**: Building Certification Knowledge and Practices Phase 1, held in June 2023, focused on introducing farmers to grower certification schemes like the PGS, along with organic farming and GAP (Good Agricultural Practices). This introductory phase aimed to foster an understanding of certification's significance, disseminate organic farming knowledge, and train farmers in the fundamentals of soil improvement and biological pest control. Dr. Anurag Ruangrob emphasized the importance of SDG-PGS certification for organic farming in Thailand and its role in sustainable agricultural networks. A total of 65 farmers, predominantly women, attended, actively participating in discussions and practical training.

216. Farmers in Bua Yai village particularly engaged in plot inspections and, of the 49 inspected plots, 39 achieved SDG-PGS certifications by the first transition year. This initial certification success demonstrated the viability of community-led organic practices in highland settings. Farmers also showed enthusiasm for composting techniques and biological pesticides, reflecting their interest in reducing chemical inputs and improving sustainability.

217. **Phase 2**: Market Linkages, Product Processing, and Advanced Training Phase 2, conducted in July 2023, expanded on Phase 1 by integrating aspects of market readiness, product processing, and biofertilizer inoculation for safe farming. Participants engaged in a food safety dialogue and received demonstrations on cocoa processing–a promising alternative crop for highland farmers. The cocoa training covered every processing stage, from fermentation to producing cocoa butter and powder, providing farmers with practical skills to diversify their income through high-value products.

218. Biofertilizer composting was further demonstrated, with farmers learning specific formulations for plant growth, pest control, and disease prevention. They actively participated in the hands-on preparation of these formulations, enhancing their practical

understanding and commitment to applying these techniques on their farms. Farmers responded positively to the biofertilizer techniques, with high satisfaction rates reflecting a recognition of biofertilizers' environmental and economic benefits.

219. **Quantitative Impacts and Recommendations**: The workshops marked improvements in participants' knowledge. Pre- and post-assessments revealed an increase in understanding, with an average knowledge score rising from 4.8 to 5.65 in Phase 1. Similarly, participants in Phase 2 rated the demonstrations highly; 81.06% valued the food safety discussions, while 93.62% found the biofertilizer inoculation training beneficial, underscoring the workshops' effectiveness in knowledge dissemination.

220. To sustain this progress, farmers recommended continued support in certification, food safety education, and marketing initiatives. Practical, hands-on demonstrations were preferred over lecture-based sessions, aligning with farmers' feedback on the importance of active engagement for skill-building.

221. In conclusion, this two-phased workshop effectively advanced highland farmers' capabilities in organic certification and sustainable practices, enhancing their adaptive capacity against climate change while providing pathways to value-added production. The emphasis on PGS, biofertilizer composting, and cocoa processing serves as a replicable model for fostering climate-smart and economically viable agriculture in other highland regions.

Preparation of biofertilizer

SDG-PGS certification obtained by farmers

Sustainable Management and Bio-Circular Green (BCG) Economy of Maize Residues in Highlands

222. The demonstration on the "Sustainable Management and Bio-Circular Green (BCG) Economy of Maize Residues in Highlands" provided critical insights into transforming agricultural waste into value-added products. Conducted from 12–14 September 2024 in Nan Province, Thailand, this pilot project targeted highland maize farmers and focused on educating them about circular economy practices to mitigate waste, improve income, and reduce environmental pollution.

223. Thailand's highland maize production is dominated by monocropping, with the maize residues—stalks, husks, and cobs—typically burned, causing severe air pollution. Approximately 35% of maize residue undergoes open-air burning, releasing PM2.5 particulates, CO_2, and other pollutants. The demonstration aimed to promote the BCG economy by reusing maize waste, reducing air pollution, and creating alternative income streams for farmers. Additionally, Thailand's strategic BCG model emphasizes using agricultural residues to enhance sustainability and economic resilience.

224. The demonstration was divided into awareness-raising and hands-on workshops, with activities designed to help farmers create high-value products from maize waste.

(1) **Day One – Awareness Workshop**: Government officials, private sector representatives, and local farmers gathered for an introductory lecture on sustainable waste management. The discussion centered on alternative uses for maize residue, with emphasis on the environmental and economic benefits of reducing burning practices. Participants discussed the potential for using maize residues in biogas, cellulosic ethanol, animal feed, bio-based plastics, and handicrafts.

(2) **Day Two – Pulp and Paper Production Demonstration**: Participants, equipped with tools and materials, engaged in creating pulp from maize husks through a multi-step process:

- Husk cleaning and chopping,
- Boiling and beating to create fibers,
- *Drying and pressing the maize pulp into paper sheets*. This hands-on session allowed participants to produce eco-friendly paper from maize husks. A high satisfaction rate (85.2%) among participants reflected appreciation for learning practical skills that could lead to additional income.

(3) **Day Three – Product Design and Marketing**: Participants designed products such as plant pots and tableware using maize pulp, with a focus on adding marketable value to maize residues. Product design had the highest satisfaction rate

(87.56%), underscoring the practical and income-generating potential of these activities. The participants displayed enthusiasm for the hands-on experience, recognizing the products' marketability and potential for income diversification.

225. The demonstration yielded substantial quantitative findings on waste utilization. With 91,428 hectares of maize in Nan, producing an estimated 715,644 tons of stalks and 93,345 tons of corn cobs, the region presents a significant opportunity for value-added products. Replacing open-air burning with alternative uses of this residue could save an estimated 617,996 kg of CO_2 equivalent PM2.5 emissions annually. Participant feedback indicated that 84.59% felt more knowledgeable about agricultural waste management post-workshop, and 87.11% appreciated the demonstration's emphasis on waste value addition.

226. A total of 167 participants attended, including government officials, educators, students, and local farmers. Satisfaction with the activities ranged from 76.54% to over 90%, with the highest scores in product design, speaker competence, and waste management promotion. Participants recognized the workshop as highly beneficial, with many expressing plans to apply these practices on their farms.

227. This demonstration illustrates how circular economy principles can reduce pollution and create economic benefits for farmers. By turning maize residue into high-demand products, farmers can access new income streams and reduce reliance on environmentally harmful burning practices. The potential for using residues in biogas, bioplastics, and biodegradable products highlights the demonstration's alignment with Thailand's BCG strategy to foster economic resilience through sustainable practices.

228. The demonstration provided a replicable model for other regions aiming to implement BCG principles. The hands-on approach effectively engaged farmers, enhancing their skills and commitment to sustainable waste management. Expanding such demonstrations can promote alternative practices in other crop-heavy areas, boosting both economic resilience and environmental sustainability.

229. The pilot demonstration report can be accessed **here**.

Separation of corn cobs from corn husk

Forming paper from pulp

Digital Traceability for Agricultural Products

230. The details of the pilot demonstration of **Digital Technology-Based Farm-To-Fork Traceability Solution** are presented in Section 4.3.5.

4.2.4 Activity 2.4: Identify private sector companies promoting CSA practices (e.g., seed, fertilizer, irrigation, and machinery providers) that may benefit from ADB non-sovereign assistance and prepare a road map for inclusive climate-friendly agribusiness investment project for Nan Province

231. An extensive field visit was conducted from December 13 to 20, 2022, in the highlands of Nan Province, Thailand. The objective was to explore the roles and capacities of private sector input suppliers and output buyers within the context of the Climate Change Adaptation in Agriculture project. This mission also aimed to identify potential beneficiaries of CSA practices and quality improvement interventions promoted under the TA.

232. The investigation covered various stakeholders, including government agencies, community enterprises, input suppliers, and private companies engaged in value chains for strategic crops such as cacao, pumpkin, and essential oils. A participatory methodology was employed, comprising in-depth interviews, focus group discussions, and direct observations of farming practices and processing operations. **Eight input suppliers and five output processors** (including double counting) that are relevant to the TA interventions have been engaged as candidates for collaboration in TA activities and outputs.

Figure 20: Companies and their value chain functions.

Company/Enterprise	Value Chain Function			TA Crop
	Input Supply	Processing	Retail	
Community Enterprise Group of Forest Planting 3 types 4 benefits		✓		Cacao
Community Enterprise of Ban Mai Mongkol Medical Herbs Group for Essential Oil Extraction		✓		Lemongrass
Bua Yai Sub-district Organic Agriculture Community Enterprise (Nan Organic Agriculture Community Enterprise Network)	✓	✓		Pumpkin
Cocoa Valley Resort Company	✓	✓	✓	Cacao
Singuang Nan & Peanut House	✓	✓	✓	Peanut
Chok Por. Panit Shop	✓			
Keeratayamitkaset Shop	✓			
Sa Than Organic Farming Community Enterprise	✓			Pumpkin
Technology Lanna	✓			
Weerachon Solar Cell	✓			

233. The fieldwork revealed that community enterprises like the cacao production and processing group had taken initial steps toward sustainable practices. These included mixed cropping systems and organic methods, although challenges such as limited infrastructure and market price volatility hindered progress. The enterprise emphasized the importance of financial and technical support for scaling up operations and enhancing product value through better processing facilities.

234. In the pumpkin value chain, the Organic Agriculture Community Enterprise demonstrated a successful model for integrating smallholder farmers into high-value markets. This group supplied both fresh and processed organic pumpkins to major retailers, with a traceability system ensuring product quality. However, issues such as inadequate certification coverage and high processing costs highlighted the need for capacity-building initiatives and policy support to sustain their growth.

235. The herbal essential oil enterprise showcased potential for high-value niche markets. Its members produced essential oils from locally sourced herbs, meeting the demand for premium-grade products. Despite their success, the enterprise faced challenges in obtaining GMP certification due to financial constraints and the high cost of quality assurance testing, which limited market expansion.

236. Input suppliers like Chok Por. Panit and Keeratayamitkaset shops indicated limited engagement with CSA practices. Their focus remained on synthetic fertilizers and pesticides, although there was some interest in biochar and other sustainable inputs. The high upfront costs of CSA technologies, such as solar irrigation, were cited as barriers to adoption. These suppliers suggested that government subsidies and awareness campaigns could incentivize farmers to shift toward sustainable inputs.

237. Private companies like Cocoa Valley Resort and Peanut House illustrated successful examples of value addition and agrotourism integration. Cocoa Valley Resort, for instance, utilized local cacao supplies to produce chocolate and cosmetic products, which were marketed internationally. However, ensuring consistent supply quality from local farmers emerged as a key challenge, emphasizing the need for capacity building and better coordination.

238. The fieldwork identified significant gaps in farmer knowledge and practices related to food safety and agricultural certification. Many farmers expressed concerns about the practicality of implementing standards such as GAP and PGS, citing cumbersome documentation requirements and limited economic incentives. Additionally, contamination risks from neighboring conventional farms posed barriers to achieving organic certification.

239. Traceability emerged as a recurring theme, with several stakeholders recognizing its potential to enhance market access and product credibility. Enterprises like the Organic Agriculture Community employed QR code systems for farm-level traceability, while others highlighted the need for simplified digital tools to support broader adoption.

240. A critical finding was the disparity in support provided by government and private sector stakeholders. While some enterprises benefited from partnerships with private firms for market access and technical support, others reported limited engagement from government agencies. Strengthening institutional support mechanisms and fostering public-private collaboration were identified as priorities for scaling CSA practices.

241. The detailed field visit report is presented **here**.

Provision of support to at least five agribusinesses in Nan province to integrate female and male highland farmers in resource-efficient agribusiness value chains

242. The "Action Plan to Support Inclusive and Sustainable Agribusiness Value Chains in Nan Province" outlines a strategy for integrating climate-smart agriculture (CSA) practices and improving the economic sustainability of agribusinesses in Nan Province, Thailand. The goal is to enhance the resilience of highland farmers to climate change by promoting resource-efficient, sustainable practices and strengthening agribusiness value chains.

243. **Key Objectives**

244. The action plan targets the following key objectives:

(1) Assessing CSA opportunities and challenges in Nan Province, particularly addressing barriers like soil erosion, deforestation, and water scarcity.
(2) Identifying high-value crops with strong market potential for both domestic and international markets.
(3) Promoting private sector engagement and investment to improve value-added processing and expand market access.
(4) Strengthening agribusiness value chains through financial and technical support, infrastructure development, and integrating agritourism.
(5) Supporting multi-level interventions at district, provincial, and national levels to transform agribusinesses.
(6) Enhancing product quality and market competitiveness through food safety certifications and digital traceability.

245. **CSA Opportunities and Barriers**

246. CSA techniques such as agroforestry, crop diversification, water management, and soil conservation are emphasized as effective strategies to improve long-term agricultural productivity and climate resilience. However, barriers such as financial constraints, knowledge gaps, weak market linkages, and infrastructure limitations hinder widespread adoption of CSA practices. Expanding financing options, providing technical training, and enhancing market access are crucial to overcoming these challenges.

247. **Agribusiness Support**

248. Efforts to strengthen agribusiness value chains include:

(1) Expanding financial support for agribusinesses and CSA adoption through blended finance models, microfinance, and concessional loans.
(2) Strengthening public-private partnerships (PPP) to improve infrastructure, including storage facilities, processing units, and logistics networks.
(3) Developing agritourism initiatives to integrate local cultural heritage with sustainable agribusiness, attracting eco-conscious tourists and diversifying income for farmers.

249. **Market Opportunities and Digital Innovations**

250. Nan Province holds significant market potential for high-value crops such as cacao, lemongrass, and organic rice. Certification programs like GAP and PGS are essential for helping smallholder farmers access premium markets. Digital innovations such as blockchain-based traceability systems, precision farming tools, and e-commerce platforms will improve market access, supply chain efficiency, and the competitiveness of Nan's agribusiness sector.

251. Private Sector Investment and Support

252. Key agribusinesses in Nan, including those involved in cacao production, herbal essential oils, organic pumpkin processing, and peanut processing, are identified as playing a role in CSA adoption. These businesses face challenges in scaling operations and accessing new markets. Support is needed in the form of financial incentives, certification training, and infrastructure investment, particularly in processing facilities and cold storage.

253. **Localized Strategy for Sustainable Growth**

254. A localized strategy focuses on enhancing market competitiveness by leveraging trade agreements with neighboring countries like Laos, Vietnam, and China. Improving agribusiness infrastructure, promoting digital integration, and developing agro-tourism models that showcase Nan's agricultural practices are key to supporting sustainable growth.

255. **Implementation Roadmap**

256. The action plan outlines an implementation roadmap with specific actions:

(1) Provide targeted training for agribusinesses and cooperatives in CSA integration, quality control, financial literacy, and digital marketing.
(2) Promote gender-inclusive agribusiness development through capacity-building initiatives and access to financial resources.
(3) Strengthen product branding, digital marketing, and export readiness to increase market access.
(4) Enhance digital traceability and certification processes to ensure compliance with food safety regulations.
(5) Expand access to finance using blended finance models and encourage public-private collaboration to support agribusiness growth.

257. These efforts aim to create a resilient and competitive agribusiness sector in Nan Province, enabling farmers to adapt to climate challenges while improving their livelihoods.

258. The working document can be read **here**.

Knowledge Product (KP5) on Roadmap for Inclusive and Climate-Friendly Agribusiness Investments in Nan Province

259. The analysis presented above contributed to the development of the knowledge product **Roadmap for Inclusive and Climate-Friendly Agribusiness Investments in Nan Province**, which provides strategic guidance for sustainable agribusiness development. It synthesizes key findings from stakeholder engagements, market assessments, and policy reviews to facilitate CSA adoption and investment readiness in the region.

260. A comprehensive agribusiness situation analysis for Nan Province was conducted, highlighting emerging opportunities and challenges. Soil degradation, deforestation, and climate variability remain key threats to agricultural productivity and food security. However, promising CSA initiatives, such as alternative cropping systems, value chain integration, and financial mechanisms for agribusinesses, have been identified as critical solutions. A market demand assessment also revealed investment opportunities in high-value crops like cacao, lemongrass, and organic produce, which can strengthen climate resilience and rural livelihoods.

261. Key policy interventions and investment strategies were outlined, including leveraging public-private partnerships (PPPs) and regional cooperation mechanisms to enhance financial access for smallholder farmers. The roadmap proposes a multi-tiered investment approach that aligns with Thailand's Bio-Circular-Green (BCG) Economy Model and the 12th National Economic and Social Development Plan. Additionally, engagement with stakeholders through workshops, including the International Workshop on CSA (October 2024) and the Private Sector Workshop on CSA (December 2024), facilitated knowledge exchange and refined investment priorities.

262. Gender inclusivity and social equity were integral aspects of the CSA interventions. Women's participation in agribusiness remains constrained due to limited access to credit and land tenure. Gender-responsive policies, including tailored financial products and certification schemes for female-led agribusinesses, were recommended to promote equitable access to climate-resilient opportunities. Additionally, digital transformation prospects were explored, emphasizing the role of e-commerce and digital market integration in boosting CSA adoption.

263. The KP can be accessed **here**.

4.2.5 Activity 2.5: Prepare knowledge products on CSA demonstration process and most appropriate CSA practices for highlands

264. The knowledge product (KP) on **Documentation of Climate-Smart Agriculture (CSA) Demonstration Process** (KP6) presents an in-depth analysis of climate-smart agriculture (CSA) implementation in the highlands of Thailand, particularly in Bua Yai Subdistrict, Na Noi District, Nan Province. It outlines key challenges, CSA practices, demonstration site selection, training initiatives, and economic evaluations of CSA adoption. The KP addresses the impact of climate change on highland farming, emphasizing sustainable approaches such as solar irrigation, keyline plowing, and biochar application. It also highlights the role of CSA in mitigating greenhouse gas emissions, enhancing soil fertility, and improving water management. Farmers were engaged through participatory selection processes and training programs to ensure effective implementation.

265. The KP describes the site selection criteria used for the CSA demonstration plots. Three key CSA practices—solar irrigation, keyline plowing, and biochar production—were prioritized based on their ability to enhance productivity, reduce environmental degradation, and improve climate resilience. Workshops facilitated discussions with farmers on their land-use practices, and demonstration plots were established in selected locations based on factors such as land suitability, willingness to participate, and expected benefits. For solar irrigation, ten sites were identified, while keyline plowing was implemented in two locations. Biochar kilns were provided to selected farmers, supporting soil health improvements.

266. The implementation phase involved training sessions and capacity-building activities for farmers to adopt CSA practices effectively. Technical assistants and experts supervised the installation of solar irrigation systems, ensuring farmers understood their operation and maintenance. Keyline plowing required modifications to existing farming equipment to optimize water retention and prevent soil erosion. The biochar production process was demonstrated to farmers, emphasizing its role in enhancing soil fertility when fermented with organic matter before application. Additionally, alternative climate-resilient crops such as banana, lemongrass, and cacao were introduced to diversify income streams.

267. Monitoring and evaluation efforts assessed the effectiveness of CSA interventions. Solar irrigation significantly reduced greenhouse gas emissions compared to conventional energy sources. Soil moisture retention improved in plots with keyline plowing, particularly when combined with irrigation. Economic analyses indicated that CSA practices yielded a higher net present values (NPV) and internal rates of return (IRR) compared to conventional farming methods, reinforcing their financial viability. The benefit-cost ratio (BCR) of CSA cacao cultivation demonstrated that investments in CSA practices could generate substantial returns over time.

268. The KP concludes by discussing challenges faced by farmers and local authorities, including high initial investment costs, limited technical expertise, and coordination difficulties. Solutions such as financial support mechanisms, farmer training programs, and policy incentives are recommended to enhance CSA adoption. Opportunities for scaling up CSA practices include integrating CSA into national agricultural policies, facilitating access to credit, strengthening value chains, and promoting knowledge-sharing networks. It underscores the need for continuous stakeholder engagement, policy alignment, and investment in research to expand CSA adoption in Thailand's highland regions. The KP can be accessed **here**.

269. The KP on **Climate Smart Agriculture in Highlands: A Compendium of Practices for Sustainable Watershed Management (KP10)** identifies climate-smart agriculture as a comprehensive approach tailored to enhance agricultural productivity, resilience, and sustainability in highland ecosystems. These regions, characterized by fragile landscapes and climate vulnerability, necessitate innovative practices to address soil degradation, water scarcity, and changing climatic patterns. This KP consolidates evidence-backed practices that align with CSA objectives, including water management, soil conservation, crop diversification, and integration of digital tools.

270. The compendium also emphasized gender-responsive CSA strategies, recognizing the pivotal role of women in highland agriculture. Addressing gender disparities in access to resources and decision-making was found to enhance the overall effectiveness and sustainability of CSA interventions. Inclusive approaches promoted equitable benefits across communities, strengthening social resilience alongside environmental outcomes.

271. The KP is presented **here**.

4.2.6 List of Appendices for Output 2

- Inventory Analysis of CSA Practices
- Multi-Criteria Analysis of CSA Practices
- CB1 Workshop Report
- KP1: Gender-Conscious Climate-Smart Agriculture for Highlands
- Cost-Benefit Analysis Report (Aide Memoire Action Item 7)
- Monitoring and Evaluation of Pilot Demonstrations (Aide Memorie Action Item 13)
- Benefit-Cost Analysis at PGS Level (Aide Memorie Action Item 14)
- Pilot Demonstration Report on SDG-PGS (CB7A and CB7B)
- Pilot Demonstration Report on Bio-Circular Green Economy and Sustainable Waste Management of Maize Residue (Aide Memoire Action Item 8)
- Report: Identification of Private Sector Firms (Aide Memoire Action Item 9, Action Item 15, And Action Item 20)
- Working Document: Provision of support to at least five agribusinesses in Nan province to integrate female and male highland farmers in resource-efficient agribusiness value chains (Aide Memoire Action Item 19)
- KP5: Roadmap for Inclusive and Climate-Friendly Agribusiness Investments in Nan Province (Aide Memoire Action item 11)
- KP6: Documentation of Climate-Smart Agriculture (CSA) Demonstration Process (Aide Memoire Action Item 12)
- KP10: Climate Smart Agriculture in Highlands: A Compendium of Practices for Sustainable Watershed Management (Additional KP and Aide Memoire Action item 10)

4.3 Output 3: Assess Capacity Needs and Gaps and Identify Priority Products for Quality and Safety Improvement and Value Addition

4.3.1 Activity 3.1: Assess capacity needs and gaps and identify priority products for quality and safety improvement and value addition (e.g., processing, packaging, and branding) by the private sector

Capacity Needs and Gaps

272. A capacity needs and gaps assessment of smallholder farmers in Bua Yai sub-district, evaluating both food safety and product quality improvements as well as the acceptance of Climate-Smart Agriculture (CSA) practices was carried out. This activity is cross-cutting with Output 2, Activity 2.4, which identifies private sector firms that may benefit from TA intervention.

273. **Knowledge Gaps in Food Safety and Agricultural Practices.** The survey of 19 randomly selected farmers revealed significant gaps in food safety practices, particularly in areas such as water quality management, pesticide use, and record-keeping. The results highlighted misconceptions about the persistence of harmful microorganisms, with over 68% of farmers unaware that some microorganisms thrive in refrigerated temperatures. Moreover, there was a lack of awareness about contamination risks associated with irrigation systems, with only 21% of farmers adequately managing water quality on their farms. These knowledge gaps can be attributed to insufficient training (with 47% of farmers not having attended any formal agricultural training), as well as financial barriers that prevent farmers from adopting better food safety practices and technologies.

274. **Attitude Toward Food Safety**. The attitudes of farmers toward food safety were largely positive, with 94.7% of respondents acknowledging the importance of maintaining food safety on farms. However, despite recognizing its importance, 68.4% of farmers perceived food safety practices as expensive or difficult to implement. This disconnect between awareness and practice suggests that while farmers understand the value of food safety, economic constraints and the perceived difficulty of implementing best practices act as major barriers to adoption.

275. **Capacity Needs and CSA Adoption**. Regarding CSA, a structured survey of 120 farm households in eight villages assessed the acceptance of solar irrigation, keyline plowing, and biochar application. The results showed that farmers were generally willing to adopt CSA practices, but they faced barriers such as high upfront costs and a lack of technical expertise. For example, 60% of farmers indicated that the cost of biochar production and equipment would be a major obstacle, with some expressing concerns about the complexity of implementing solar irrigation systems. A significant portion of the farmers also pointed out the need for training and external support to overcome these barriers.

276. **Farmer Demographics and Training Needs**. The surveyed farmers tended to be older, with 42.1% aged 60 or older, and most had over 12 years of farming experience. Despite their extensive farming experience, formal education was lacking, with 53% of farmers having not completed primary education. This demographic profile underscores the need for targeted educational initiatives that focus on the younger generation and farmer leaders who can effectively disseminate knowledge. The lack of GAP certification among most farmers (88.2%) further highlights the need for accessible, affordable training programs that can help farmers meet food safety standards.

277. **Economic Constraints and Organic Farming**. A significant barrier to adopting organic farming practices was identified as technical difficulties (42%) and lack of knowledge (21%). Additionally, economic constraints, including insufficient capital to purchase organic inputs, were mentioned by 16% of farmers as key reasons for not transitioning to organic farming. This points to a need for financial support mechanisms, such as subsidies or low-interest loans, to enable farmers to transition to more sustainable and climate-resilient agricultural practices.

278. **Impact of Climate Change and Water Management**. The assessment also highlighted climate change impacts, with 63% of farmers observing increased drought and higher temperatures, leading to lower crop yields and uncertainty in annual income. Furthermore, 94.7% of farmers did not use any water-saving techniques, relying solely on rainfall for irrigation. This presents an urgent need to promote water-efficient irrigation technologies, such as drip irrigation or solar-powered irrigation systems, to improve water conservation and crop productivity in the face of changing climatic conditions.

279. In conclusion, the assessment reveals significant gaps in knowledge, attitudes, and practices that hinder the effective implementation of CSA and food safety standards. The key recommendations include improving education and training, enhancing financial support for technology adoption, and fostering the development of farmer leaders to drive peer-to-peer knowledge transfer. Addressing these gaps will require a holistic approach that combines policy support, capacity building, and financial incentives to enable farmers to adopt both CSA and food safety practices effectively.

280. The detailed report can be accessed **here**.

Value Chain Analysis and Market Demand Assessment

281. The value chain and market demand assessment present a comprehensive analysis of the value chain and market demand for the agri-food sector in Nan Province, Thailand, with a focus on CSA and sustainable agribusiness development. It examines key

agricultural challenges in the province, such as deforestation, soil degradation, climate variability, and weak market linkages, and suggests solutions to enhance the competitiveness and resilience of the agricultural sector.

282. Agriculture Value Chains and Key Considerations. Nan Province is transitioning from monoculture maize cultivation to diversified farming systems incorporating high-value crops like cacao, lemongrass, and essential oils. This shift aims to enhance soil health, improve economic stability, and reduce vulnerability to climate change. The report outlines the importance of sustainable practices like agroforestry and integrated farming to improve environmental resilience. Furthermore, the province's agricultural transformation is closely tied to agrotourism, leveraging local cultural heritage to create additional economic opportunities.

283. High-Value Crops and Market Potential. The province's push towards high-value crops such as cacao, lemongrass, and essential oils offers substantial economic opportunities, but challenges remain in processing, quality assurance, and market access. Cacao, for instance, has export potential, especially in the premium chocolate market, but it faces bottlenecks in post-harvest processing, certification, and consistent product quality. Lemongrass and essential oils are also gaining traction but struggle with high processing costs and fragmented supply chains, limiting their competitiveness.

284. Other alternative crops like pumpkins, bananas, and avocados are identified as viable options for diversification, providing farmers with greater economic stability while meeting domestic demand for healthy and sustainable food products. Expanding investments in these crops could significantly boost Nan's agribusiness sector, but processing infrastructure, market linkages, and certification programs must be enhanced.

285. Investment Landscape and Strategic Interventions. Nan Province faces significant investment gaps in critical areas such as processing facilities, certification programs, and market access. Public-private partnerships (PPPs) are seen as essential for improving agribusiness infrastructure, with investments needed in cold storage, value-added processing, and renewable energy technologies. Additionally, the lack of access to formal financial services and the limited use of modern farming techniques hinders farmers' ability to adopt CSA practices effectively.

286. Targeted interventions are proposed to bridge these gaps, including expanding access to financing, improving post-harvest infrastructure, and supporting certification programs like GAP and organic certifications. Key strategic interventions also include strengthening supply chain linkages, enhancing branding and traceability systems, and facilitating market access for premium, sustainably produced products.

287. Alternative Livelihoods and Ecotourism. The document also emphasizes the importance of diversifying livelihoods beyond traditional agriculture. It identifies honey production, food processing, and ecotourism as key areas with high potential for growth. For example, the Organic Pumpkin Processing Enterprise in Nan exemplifies how value-added processing can enhance income stability for farmers. Similarly, the growing demand for ecotourism, including agritourism and cultural tourism, offers Nan Province an opportunity to capitalize on its unique agricultural landscape while promoting sustainable land use practices.

288. Recommendations and Future Prospects. To unlock the full potential of Nan's agri-food sector, the report recommends scaling up CSA adoption, improving infrastructure, and enhancing market access through public-private collaboration. Specific strategies include promoting CSA certification, expanding digital marketing platforms for rural tourism, and developing regional food hubs to streamline food processing and distribution. Furthermore, fostering youth engagement in agriculture and providing intergenerational training programs are crucial for ensuring the sustainability and growth of the sector.

289. In conclusion, the value chain analysis and market demand assessment underscore Nan Province's significant agricultural potential but highlight the need for targeted investments, better infrastructure, and enhanced collaboration to drive sustainable growth and climate resilience in the province's agri-food sector.

290. The full report can be viewed **here**.

4.3.2 Activity 3.2: Conduct workshops to build capacity of local communities, including women, on grower certification schemes (e.g., participatory guarantee system), organic farming, and good agricultural practices

291. The "Capacity Building Workshop on Grower Certification Schemes, Organic Farming, and Good Agricultural Practices (CB7)" was conducted in two phases and engaged a total of 70 participants, including farmers, local officials, and agricultural experts. Phase 1, attended by 65 farmers (63% women) from five villages in Nan province, focused on participatory guarantee systems (PGS), organic farming, and biological pest control. Inspectors assessed 49 agricultural plots, resulting in 39 achieving SDG-PGS certification within the first year. Phase 2, which included 63 participants (70% women), emphasized marketing, food safety, and cocoa processing. Practical demonstrations on biofertilizer composting and pest control were complemented by training in cocoa processing and organic product marketing.

Phase 1

292. Pre- and post-training knowledge assessments were conducted with a total of 10 questions covering core concepts of sustainable agriculture, organic certification, and composting methods. Before the workshop, participants achieved an average score of 4.8 out of 10 (48%), reflecting moderate familiarity with the subject. Post-training scores improved to 5.65 (56.5%), indicating a 17% increase in knowledge levels. However, older participants demonstrated lower post-test improvements, suggesting a need for tailored educational approaches.

293. Plot inspections conducted during the workshops covered **49 agricultural plots**. Of these, 39 plots achieved initial certification under the Sustainable Development Goal Participatory Guarantee System (SDG-PGS) in their first year, while two more plots were certified in their second year. Certified plots collectively covered 89.075 rai (approximately 14.25 hectares). These inspections evaluated soil quality, water sources, pesticide usage, and evidence of chemical residues, ensuring alignment with SDG-PGS organic standards.

294. Farmers actively engaged in practical sessions, producing biofertilizers and bio-pesticides for use on their plots. Biofertilizer composting involved gathering agricultural waste and fermenting it with inoculum over four weeks. A total of four demonstration areas were established, benefiting key farmers in Villages 2, 4, and 8. This activity demonstrated cost-effective solutions for reducing chemical inputs and enhancing soil fertility.

TA Consultant Dr. Danuwat explaining farmers about organic farming practices

Organic pumpkins grown at Ms. Thikamporn Kongsorn's farm

295. The workshops also highlighted challenges in transitioning to organic practices. Participants identified complex certification requirements as a major obstacle. Despite these challenges, farmers expressed enthusiasm for reducing chemical pesticide usage and increasing reliance on biofertilizers. The percentage of farmers using bio-pesticides increased significantly after training sessions, contributing to sustainable pest control.

296. In terms of gender participation, the workshops achieved inclusivity, with women representing 62.86% of attendees. Female farmers actively participated in discussions, practical sessions, and plot inspections, showcasing the importance of gender-responsive capacity building. The workshops emphasized that empowering women in agriculture is essential for the adoption of sustainable practices.

297. Participants provided feedback on the workshops, with 90% expressing satisfaction with the training's practical components. Farmers noted that hands-on demonstrations and collaborative learning significantly enhanced their confidence in adopting new techniques. The workshops also encouraged collective efforts, as farmers shared resources and knowledge for producing biofertilizers and bio-pesticides.

298. Recommendations based on the analysis included simplifying certification processes, particularly for smallholder farmers, and providing continued technical support. Establishing model farms with certified plots was proposed to serve as reference points

for scaling organic farming practices. The need for ongoing market integration strategies, such as linking certified farmers to buyers seeking organic products, was also emphasized.

Phase 2

299. Phase 2 was held on July 17, 2023, and it emphasized marketing, food safety, and cocoa processing. Practical demonstrations on biofertilizer composting and pest control were complemented by training in cocoa processing and organic product marketing. A total of 63 participants attended, including 58 farmers, of whom 44 (69.84%) were women and 19 (30.16%) were men, highlighting a strong gender-inclusive approach.

300. The workshop featured panel discussions, demonstrations on cocoa processing, and training on biofertilizer inoculum expansion for fertilizer and herbicide production. The cocoa processing demonstration attracted 49 participants (80.33%), with 32 respondents rating it as highly useful. Participants showed significant interest in learning about cocoa's potential as a high-value alternative crop, with 87.07% of attendees expressing satisfaction with the session.

301. Biofertilizer inoculum training engaged 47 participants (77.05%), with 38 respondents finding it insightful and 40 expressing willingness to apply the knowledge on their farms. Farmers learned techniques for creating plant growth promotion formulas, pest prevention biopesticides, and pathogen control using Trichoderma fungi. This hands-on training was particularly appreciated for its practical applications, with 93.62% of respondents finding it useful.

302. The event also included a food safety forum, attended by 61 participants. Discussions emphasized the importance of producing clean and safe food for both local and international markets. The forum achieved an 81.06% approval rate, with farmers gaining actionable insights into integrating food safety practices into their farming systems.

303. Pre- and post-assessment evaluations highlighted significant knowledge gains among participants. While initial familiarity with biofertilizer propagation (Figure 21) and cocoa processing (Figure 22) was low, post-workshop feedback indicated improved understanding, with respondents reporting increased readiness to implement the demonstrated practices. Gender-disaggregated data revealed that 61.70% of female participants and 38.30% of male participants engaged actively in biofertilizer propagation training, demonstrating equitable participation.

Figure 21: Level of satisfaction of the respondents pertaining to the demonstration on biofertilizer propagation.

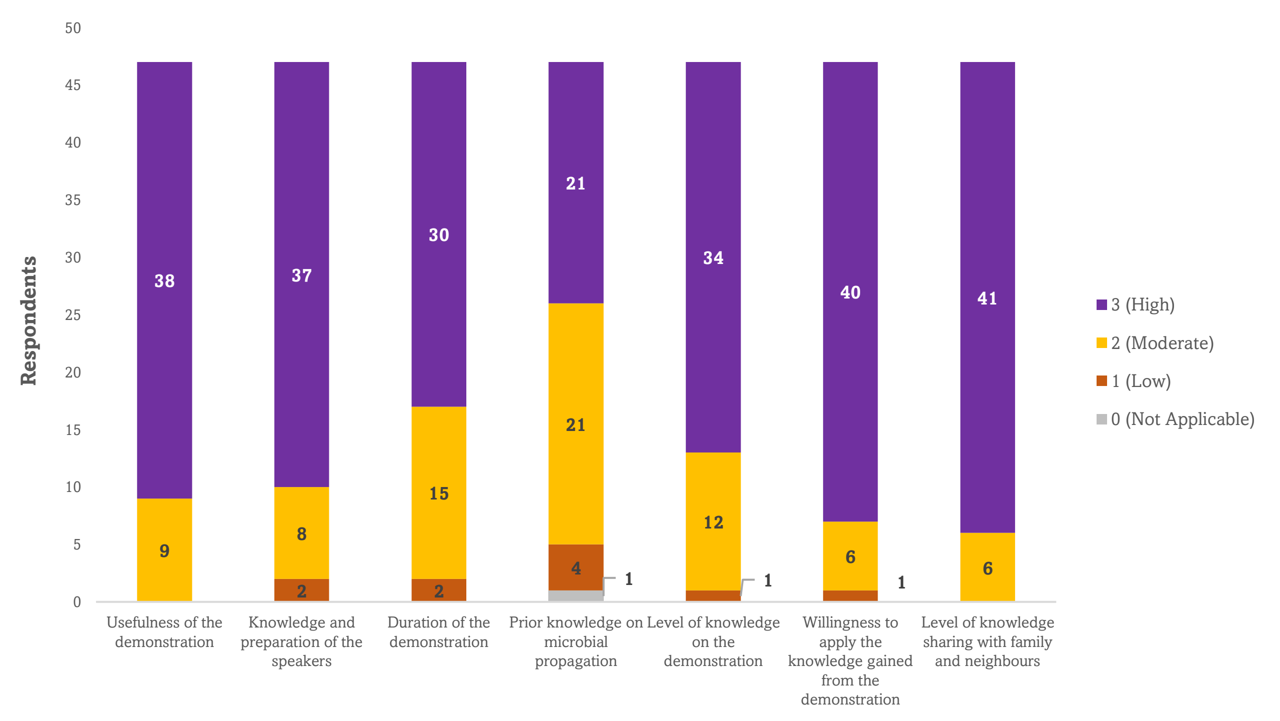
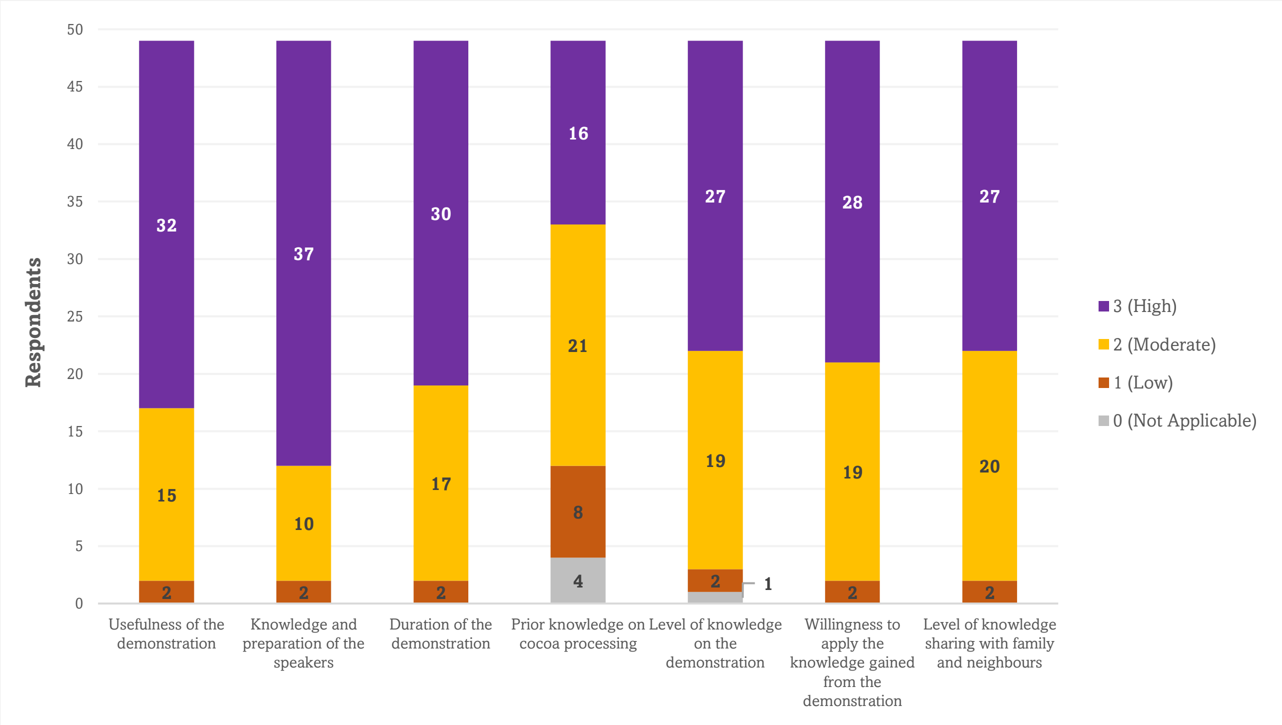


Figure 22: Level of satisfaction of the respondents pertaining to the demonstration on cocoa processing.



304. The workshop also facilitated market exposure by organizing an organic marketing event at the Bua Yai Subdistrict Administrative Organization. Farmers showcased and sold organic produce from their certified plots, fostering direct engagement with potential buyers and enhancing their understanding of market dynamics.

305. Key observations included high satisfaction with interactive and practical sessions compared to lecture-style activities. Farmers were particularly engaged during hands-on demonstrations, which enabled them to practice techniques directly. Recommendations emphasized the need for more such participatory activities in future workshops to sustain engagement and knowledge retention.

306. The workshop report is presented **here**.

4.3.3 Activity 3.3: Train local communities and youth on opportunities for quality and safety improvement and value addition and identify private firms improving the quality of agricultural products (through value added processing, packaging, branding, and marketing) that may benefit from ADB non-sovereign assistance

307. The "**Agricultural Product Quality, Value Addition, and Market Linkage**" workshop, held on **18–20 September 2024**, trained 62 participants, including farmers, food processors, and stakeholders, with women making up 55% of attendees. Held over three days, the event provided practical training on food safety, post-harvest technologies, and product development for six climate-resilient crops: cocoa, pumpkin, banana, lemongrass, peanut, and avocado.

308. The event focused on post-harvest techniques, value addition, and compliance with food safety standards, integrating diverse stakeholders, including farmers, private enterprises, government agencies, and academic institutions.

309. The first day highlighted government initiatives supporting sustainable and organic farming. The Ministry of Agriculture and Cooperatives emphasized strengthening certification processes and food safety standards to align with national and international market requirements. Post-harvest management techniques for the six target crops were introduced to reduce losses and improve quality. Collaboration between local farmer networks and organizations like Agro Nan Group underscored the importance of shared resources and expanded market access.

310. Day two focused on international food safety standards, including Codex Alimentarius and Good Manufacturing Practices (GMP), which are critical for both food and non-food products. Experts detailed the importance of packaging methods in preserving product quality and extending shelf life. Advanced processing techniques, such as freeze-drying and fermentation, were demonstrated, showcasing their role in enhancing product value and meeting market demands. Sessions also included discussions on innovative packaging solutions tailored to the specific needs of the identified crops.

311. The third day included field trips to agricultural research facilities and processing units. Visits to enterprises like Peanut House Co., Ltd. illustrated how advanced technologies could transform raw agricultural materials into high-value products. These demonstrations provided practical insights into applying workshop learnings to real-world scenarios, fostering sustainable development in highland agriculture.

Panel Discussion: Sustainability of food safety and quality improvement for alternative crop cultivation and post-harvest process

Panel Discussion: Experience sharing on value addition of food and non-food products

Field visit to the laboratory at Rajamangala University of Technology Lanna (RMUTL)

Evaluation of workshop and field visit

312. Key findings emphasized the consensus among stakeholders on advancing food safety and promoting organic farming through certification programs and sustainable practices. Investments in post-harvest technologies were identified as critical to reducing losses, maintaining quality, and improving marketability for crops like bananas and cocoa. The workshop also highlighted the importance of developing value chains for alternative crops, ensuring economic returns and environmental sustainability.

313. Collaborations between farmers and private enterprises emerged as pivotal in achieving quality standards and stable market access. Companies like Makro and Agro Nan Group provided technical support and ensured product competitiveness in global markets. Expansion of market networks and adherence to international trade standards were recommended to enhance the region's agricultural competitiveness.

314. Sustainable farming practices, including reducing chemical usage and integrating carbon credits, were emphasized as essential for preserving ecosystems and ensuring long-term productivity. Government programs, such as OTOP and FDA guidelines, were identified as critical enablers for supporting local product quality and facilitating access to domestic and international markets.

315. The adoption of advanced processing and packaging technologies was recommended to add value to agricultural products, extending shelf life and increasing consumer appeal. Public-private partnerships in Nan Province demonstrated the effectiveness of collaborative approaches in fostering sustainable agriculture, improving food quality, and ensuring technical resource access.

316. The workshop evaluation outcomes for 43 participants reveal a marked increase in knowledge across various domains of agricultural practice, quality, and safety. The workshop evaluation outcomes indicate that participants gained substantial knowledge across all assessed areas related to agricultural practices, quality control, and safety standards. With an average mean score around 4.4 to 4.6 on a 5-point scale, participants showed high levels of understanding in key topics such as Good Agricultural Practice (GAP) requirements, post-harvest quality control, safety legislation, and technology use for product quality enhancement.

317. All results showed statistical significance at the 1% level (***), indicating that the workshop had a meaningful impact on the participants' knowledge and readiness to apply these concepts in their practices. A detailed analysis is presented in the workshop report, linked **here**.

Table 14: Comparison of evaluation outcomes pre- and post-workshop (n = 43).

No.	Examination	Pre-test	Post-test	Mean difference	t – statistic
1.	Requirements for Good Agricultural Practice (GAP) or Organic Agriculture (e.g. Organic Thailand, PGS)	3.79	4.58	-0.79	-5.12***
2.	Post-harvest quality control of agricultural products	3.58	4.35	-0.77	-3.61***
3.	Control of agricultural product safety post-harvest	3.63	4.42	-0.79	-3.83***
4.	Utilizing technology to enhance the quality and safety of post-harvest agricultural products.	3.51	4.58	-1.07	-5.06***
5.	Quality and safety standards mandated by purchasers or importers of processed commodities.	3.51	4.47	-0.95	-4.14***
6.	Legislation on quality and safety of agricultural and processed commodities	3.44	4.58	-1.14	-5.19***
7.	Protocols for the formulation of processed goods	3.42	4.56	-1.14	-5.38***
8.	Guidelines for packaging development	3.35	4.40	-1.05	-4.54***
9.	Protocols for enhancing the market value of processed products	3.40	4.40	-1.00	-4.53***

Provision of support for at least two raw agricultural products and two processed agricultural products in receiving certification for good quality and safety and in establishing market linkages

318. The analysis focuses on two key agricultural products—pumpkins and cocoa—in Nan Province, Thailand. The implementation of food safety and quality standards to improve the safety, marketability, and economic viability of these products was studied. The case studies demonstrate the transition from conventional, chemical-intensive farming to sustainable, organic practices that align with Good Agricultural Practices (GAP), Good Hygienic Practices (GHP), Good Manufacturing Practices (GMP), and Participatory Guarantee Systems (PGS).

319. Nan Province, located in northern Thailand, has traditionally been an agricultural region with a reliance on monoculture crops like maize. However, challenges such as soil degradation, health risks from pesticide use, and economic instability led to the adoption of sustainable farming models, particularly organic agriculture. The document emphasizes the importance of food safety in agriculture and food processing, explaining how compliance with food safety standards is essential for safeguarding public health, improving product quality, and accessing both domestic and international markets.

320. **Pumpkin**. The pumpkin industry in Bua Yai Subdistrict represents a successful transition to organic farming. Led by Ms. Thikamporn Kongsorn, the Bua Yai Organic Agriculture Community Enterprise shifted from monoculture maize farming to diversified organic vegetable farming, including pumpkins. The pumpkins produced in the region, particularly the local "Kai-Nao" variety, gained attention for their high quality and taste, with businesses like Central Group Co., Ltd. expressing interest in selling them in supermarkets. The transition to organic farming led to improved environmental conditions, reduced reliance on chemical inputs, and increased economic stability for farmers. However, land ownership restrictions hindered the farm from obtaining

Organic Thailand certification. Despite this, the farmers were able to meet the standards of PGS certification and worked towards achieving national-level organic certification.

321. To enhance the value of pumpkins, a processing system was established to utilize pumpkins that did not meet fresh-sale standards. Processed products included pumpkin pastries, cookies, cakes, rice crackers, seed oil, and pumpkin powder, with some by-products, like pumpkin rind and pulp, repurposed as chicken feed. The community enterprise has gained FDA certification for several products and plans to expand its market reach. This case study demonstrates how value-added processing, and certification can help farmers enhance the profitability of their crops and contribute to the local economy.

322. **Cocoa**. The second case study focuses on cocoa cultivation by the Community Enterprise Group for Afforestation in Bua Yai Subdistrict. This group, dedicated to sustainable agriculture, adopted environmentally friendly practices like intercropping cocoa trees with lemongrass, which serves as a natural pest repellent and helps improve soil fertility. The group has achieved GAP certification for its cocoa plots, ensuring compliance with food safety standards and contributing to sustainable production.

323. Cocoa is processed into various products, including cocoa powder, chocolate, and cocoa butter. The fermentation and drying process is essential for developing the flavor and quality of the cocoa beans. However, challenges arose in the processing phase, particularly with the quality of cocoa beans. Despite these issues, the group has worked on improving quality through training, achieving certifications, and utilizing by-products such as cocoa shells for charcoal and compost.

324. **Conclusion and Recommendations**. The case studies on pumpkins and cocoa highlight the benefits of adopting food safety standards and sustainable farming practices. These efforts have not only improved food safety and product quality but have also enabled farmers to access higher-value markets. However, challenges such as land ownership issues and certification barriers remain. To further improve food safety and quality standards in Nan Province, the document recommends enhancing training and capacity building for farmers, expanding market access, investing in processing infrastructure, and encouraging sustainable farming practices. Additionally, policy and regulatory support should be provided to reduce certification costs and create a favorable environment for small-scale farmers. By implementing these recommendations, Nan Province can strengthen its position as a model for sustainable agriculture, ensuring long-term food safety, economic viability, and environmental resilience.

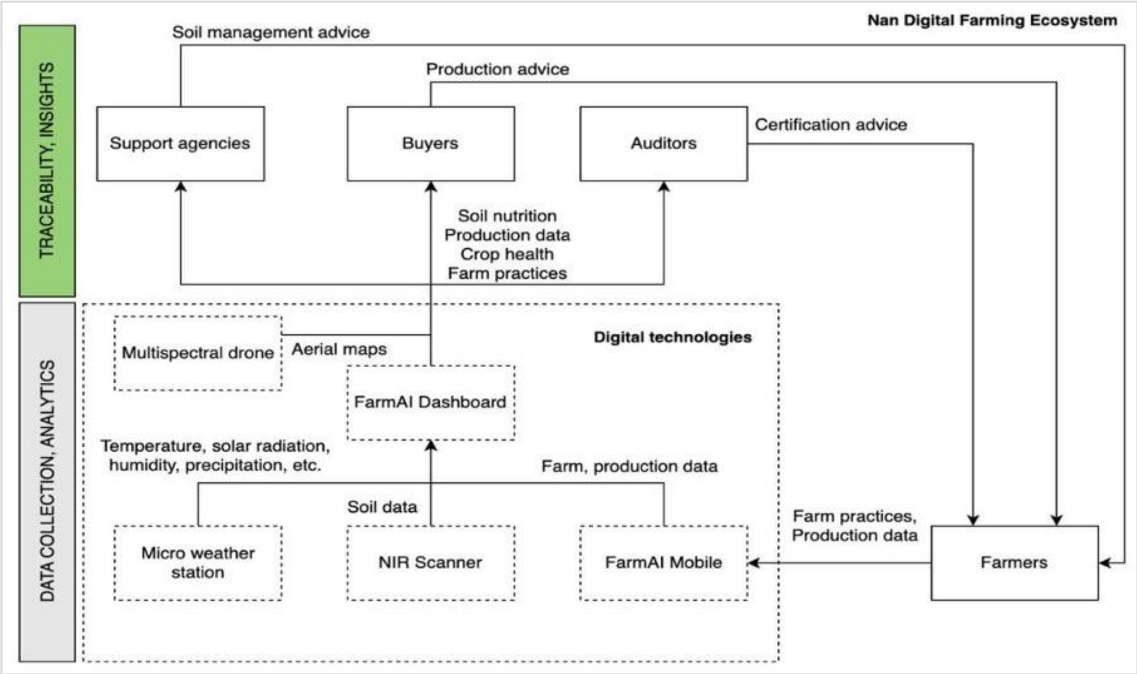
325. The analysis can be read **here**.

4.3.4 Activity 3.4: Demonstrate application of digital technologies for traceability in linking good-quality products from highlands with domestic and international markets

326. The "**Digital Technology-Based Farm-To-Fork Traceability Solution**" pilot highlights an extensive effort to integrate advanced digital technologies into highland agriculture in Nan Province. The pilot project focused on building a comprehensive farm-to-fork traceability system for organic farming, targeting crops with high market potential, such as lemongrass, citronella, and turmeric, which are processed into essential oils. This initiative was designed to address challenges in soil health management, market transparency, and compliance with organic certification requirements, while improving farmer incomes and agricultural sustainability.

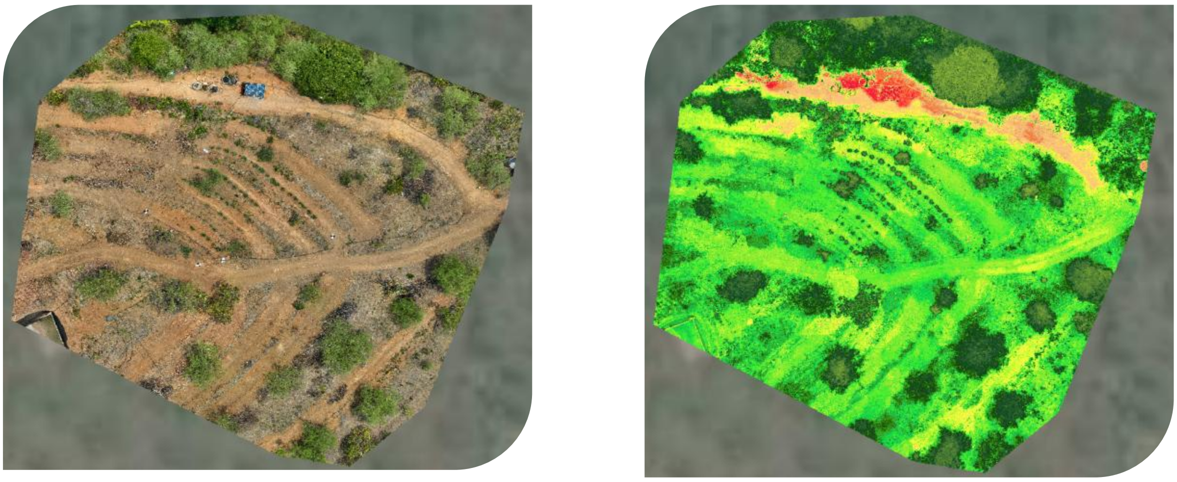
327. The project engaged **37 farmers across 80 hectares (500 rai)** of highland farms, part of the community enterprise called **EPS Essen Planters Na Noi**, specializing in essential oil production. Each farm was digitized using GIS-based mapping, with polygons delineating field boundaries and unique identifiers assigned to each farm. This mapping system provided critical spatial data, enabling real-time tracking of farming activities and integration with other digital tools. The traceability system linked each farm to its batch of essential oil through QR codes, which provided buyers and auditors access to comprehensive production data, including soil characteristics, farming practices, and distillation parameters.

Figure 23: Conceptual framework of the implementation of the community-based farm management system



328. Soil quality assessments were a cornerstone of the project, employing Near Infrared (NIR) soil scanners for rapid, on-site analysis of 13 critical soil properties, including organic matter, nitrogen, phosphorus, and potassium levels. Compared to traditional wet chemistry methods, which require up to two months for results, NIR technology delivered data in under 10 minutes per sample. Preliminary results from soil analysis revealed widespread deficiencies in organic matter, nitrogen, and phosphorus, which are essential for plant growth. Farms supplemented with biochar demonstrated improved soil structure and nutrient retention, indicating the potential of biochar as a sustainable soil amendment. Recommendations included applying compost, biochar, and organic fertilizers to enhance soil fertility and moisture retention.

329. Drone and satellite imagery were utilized to monitor crop health through Normalized Difference Vegetation Index (NDVI) analysis. Sentinel-2 satellite data provided broader coverage, while drone imaging delivered high-resolution insights into field variability. The NDVI values ranged from 0.22 to 0.66 across pilot plots, indicating stages of crop growth from early to mid-development. Drones were particularly effective in identifying nutrient deficiencies and pest infestations within small, irregular plots, although their operational costs and battery limitations were noted. Integrating satellite and drone data allowed for comprehensive crop monitoring, optimizing resource allocation and addressing challenges specific to highland farming.



Drone imaging demonstrated to the farmers

330. Hyperlocal weather stations were installed to address the limitations of regional meteorological data, which often failed to capture the microclimatic variations critical for highland agriculture. Data from these stations revealed significant discrepancies in temperature and precipitation compared to regional reports, highlighting the need for localized weather monitoring. Farmers used this hyperlocal data to better plan planting and harvesting schedules, reducing crop losses due to unexpected weather events.

331. Capacity-building workshops were integral to the project's success, providing farmers with hands-on training in digital tools and sustainable practices. Workshops covered the use of mobile applications for recording farm activities, interpreting drone and satellite imagery, and utilizing hyperlocal weather data for decision-making. Pre- and post-workshop assessments indicated substantial knowledge gains, with low pre-workshop familiarity with precision agriculture technologies (62%) increasing to high familiarity (59%) post-training. Farmers reported increased confidence in managing their plots digitally and understanding the benefits of traceability for market access.

Capacity building for the farmers

332. Economic evaluations highlighted the financial viability of the traceability system, though the high costs posed challenges for smallholder farmers. The annual cost of implementing the FarmAI platform was approximately **7,300 THB per farmer**, compared to the average annual production cost of **3,450 THB for two rai of lemongrass** (Table 15). The report recommended government subsidies to offset these costs, enabling broader adoption and ensuring the financial sustainability of the system. Subsidizing such initiatives would enhance farmer livelihoods, improve market competitiveness, and align with Thailand's Agricultural Technology 4.0 strategy.

Table 15: Estimated annual cost of lemongrass production of a farmer operating 2 rai of land.

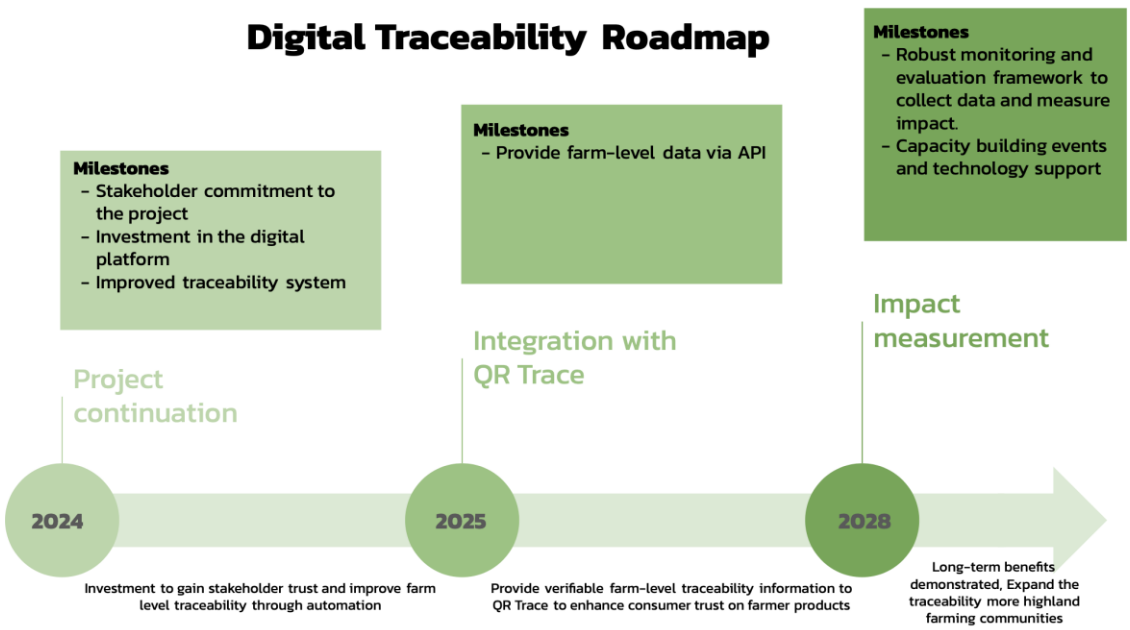
Cost item	Amount (THB)	Remarks
Seedlings	1,600.00	2 THB per seedling, 1,600 seedlings required per rai
Weed control	250.00	
Harvesting	600.00	
Other labor	1,000.00	Includes land preparation, planting, monitoring, transporting harvest to distillation facility
Total	**3,450.00**	

333. The traceability system also provided significant market benefits. The QR-code-enabled reporting system linked the final essential oil product to its source farm, allowing buyers to verify its origin, production conditions, and quality. This transparency fostered trust and enabled access to premium markets, where certified organic products command higher prices. Buyers reported improved confidence in the quality and authenticity of the products, further strengthening market linkages for the farmers.

334. The project's outputs extended beyond immediate technical and market benefits. By integrating advanced digital tools, the initiative promoted a shift towards climate-smart agriculture, optimizing resource use and reducing environmental impact. Recommendations for scaling the system included expanding the traceability framework to additional high-value crops, integrating government support, and continuing capacity-building efforts (Figure 24). The long-term vision involves demonstrating the economic, social, and environmental benefits of digital traceability, ensuring that it becomes a cornerstone of sustainable agricultural development in highland regions.

335. The full report is presented **here**.

Figure 24: Roadmap overview from 2024 to 2028.



Knowledge Product 8: Digital Technology-based Farm-to-Fork Traceability Solutions for Organic Agricultural Products in the Highlands

336. The knowledge product focuses on implementing digital technology-based solutions to improve farm-to-fork traceability for organic agricultural products in Thailand's highlands. The document highlights the potential of digital tools in enhancing the traceability, safety, and sustainability of organic farming practices. With climate change posing significant risks to highland agriculture, the adoption of digital traceability systems can help mitigate these challenges by ensuring greater operational efficiency, compliance with organic standards, and better market access for farmers.

337. The shift towards perennial crops, such as lemongrass, is identified as a potential livelihood alternative for highland farmers, given its resilience to climate extremes and lower labor requirements. Digital tools can support this transition by providing data on soil health, crop growth, and environmental conditions, thus allowing farmers to optimize their practices. The application of digital traceability systems ensures that the entire agricultural process— from farm management to product distribution—is transparent and traceable, which boosts consumer confidence and enhances market access. This is particularly important in the context of

organic certification, where strict standards of production and post-harvest handling must be adhered to in order to access premium markets.

338. One of the key strategies discussed is the implementation of group certifications, where farmers collaborate to meet organic certification standards. Digital traceability systems play a vital role in this process by documenting every stage of production, ensuring compliance, and improving operational efficiencies. For instance, mobile applications and IoT-based solutions can help farmers record data on inputs, soil conditions, crop management, and pest control, all of which are crucial for maintaining organic certification. These systems not only streamline the certification process but also provide the foundation for improved farm management practices that can lead to higher yields and reduced costs.

339. The success stories shared within the document, such as the initiatives of Khun Mantana and Khun Supatra in Sum Sung district, demonstrate the transformative potential of organic farming. These examples highlight the growing demand for organic products and the benefits of adopting sustainable agricultural practices, which are further supported by digital traceability tools. By using platforms like QR Trace and DGT Farm, farmers can increase their visibility in the supply chain, improve their product marketing, and connect directly with consumers, ultimately boosting their income and fostering community development.

340. Furthermore, the report discusses the key challenges to the adoption of digital traceability, including institutional barriers, lack of digital infrastructure, and the need for tailored solutions that cater to the unique needs of highland farmers. It proposes several recommendations, such as expanding broadband access, providing educational resources, and promoting public-private partnerships to support the integration of digital tools in highland agriculture. The long-term success of these initiatives depends on the continuous support of stakeholders, including government bodies, NGOs, and private sector players, to ensure that digital traceability becomes a widespread and sustainable practice in the region.

341. The KP is presented **here**.

4.3.5 Activity 3.5: Prepare knowledge products on grower certification schemes, quality and safety enhancement, and value addition

KP7-A: Grower Certification Schemes and Good Agricultural Practices

342. Good Agricultural Practices (GAP) serve as a standard for safe and high-quality food production, with a strong focus on food safety, environmental sustainability, and the health of workers. GAP certification under the Thai Agricultural Standard (TAS 9001-2013) ensures that food crops, such as vegetables, fruits, field crops, spices, and herbs, are produced safely. The standard covers water quality, soil health, pest control, fertilizer management, and post-harvest handling, and requires that production processes minimize hazardous substances. GAP aims to improve product quality, enhance food safety, and reduce environmental impacts, with specific procedural steps to maintain traceability and compliance throughout the production process.

343. Organic farming is described as a holistic agricultural management system that emphasizes the use of natural materials and avoids synthetic chemicals or genetically modified organisms (GMOs). Organic farming promotes biodiversity, soil fertility, and ecosystem health through practices such as crop rotation, the use of green manure, and the conservation of natural pest predators. Under Thai Organic Standard (TAS 9000), organic farming encourages sustainable practices but also presents challenges, such as high certification costs, limited international recognition, and complex administrative requirements. Organic certification involves a transition period for farmers to shift from conventional to organic farming practices, with rigorous standards for input materials, pest control, and product handling to maintain organic integrity.

344. The Participatory Guarantee System (PGS) offers a certification approach that engages farmers directly in the process, aligning with sustainable development goals (SDGs). PGS emphasizes community involvement, transparency, and organic farming principles. It provides a more accessible alternative to traditional certification schemes, helping farmers in Nan Province gain organic certification. While PGS has advantages such as fostering local networks and improving market access, it faces challenges, including the need for enhanced support and increased farmer participation. A case study from Nan Province illustrates the practical steps of certification, including agricultural plot inspections, data collection, and compliance with PGS standards.

345. International organic agriculture standards, including those set by IFOAM, the EU, NOP, and SDGs PGS, provide guidelines for organic farming practices globally. These standards include requirements for a minimum transition period for crops to become certified organic, with specifications for soil and water management, pest control, and the use of organic fertilizers. Traceability is emphasized to ensure product integrity and consumer confidence. The global standards align with organic principles such as the prevention of contamination from synthetic chemicals, the use of non-GMO seeds, and the maintenance of biodiversity within farming systems.

346. In Nan Province, the implementation of GAP and organic certification faces several challenges that require a multifaceted approach to overcome. These challenges include high certification fees, limited access to training, and bureaucratic barriers. To address these, recommendations include providing financial support, simplifying the certification process, and improving market access for organic products. Collaboration among stakeholders, including government agencies, NGOs, and the private sector, is essential to create a supportive environment for farmers to pursue certification. By improving education, offering incentives, and streamlining the certification process, farmers in Nan Province can be better supported in transitioning to organic and sustainable agricultural practices.

347. The KP can be viewed **here**.

KP7-B: Agricultural Product Quality and Safety Enhancement and Value Addition

348. KP7-B on " Agricultural Product Quality and Safety Enhancement and Value Addition" focuses on improving food safety and quality in small and medium-sized enterprises (SMEs) within the food processing industry, particularly in Thailand. This knowledge product emphasizes the importance of robust food safety systems, including HACCP (Hazard Analysis and Critical Control Points), Good Manufacturing Practices (GMP), and Good Agricultural Practices (GAP), which are essential for ensuring food safety, consumer confidence, and market access. The report also highlights the significant role of SMEs in driving innovation, economic development, and sustainability in the food sector, despite the challenges they face in maintaining high standards of food safety while balancing cost-efficiency.

349. A strong food safety culture is crucial for the success of SMEs. Leadership plays a key role in shaping this culture by demonstrating a commitment to food safety and promoting it throughout the organization. Establishing clear communication, defining roles and responsibilities, and fostering a sense of responsibility among all staff members are essential for maintaining safety standards. Beyond technical practices, the behaviors and attitudes of employees influence food safety outcomes, making training and management practices vital to ensuring that safety protocols are consistently followed.

350. Value addition presents a powerful opportunity for SMEs to diversify their offerings and enhance profitability. Transforming raw agricultural products into processed foods with higher value, such as through techniques like drying, frying, smoking, baking, pasteurization, and essential oil extraction, not only extends shelf life but also opens new markets. Additionally, non-thermal processes like fermentation, chilling, and freezing, along with packaging strategies that preserve product quality, are explored as essential methods to meet growing consumer demand for safe, nutritious, and sustainable food.

351. Regulatory frameworks play a critical role in maintaining food safety standards. In Thailand, the Ministry of Public Health, the Thai Food and Drug Administration (FDA), and the National Bureau of Agricultural Commodity and Food Standards (ACFS) are responsible for overseeing food safety regulations. These bodies ensure that food products meet both domestic and international safety requirements. The Food Safety Act of 2017, a key component of Thailand's regulatory framework, aims to enhance food safety management, including both domestic and imported products.

352. While food safety regulations are essential, SMEs often face significant challenges in implementing these standards. Limited financial resources, inadequate infrastructure, and a lack of technical expertise are common obstacles. To address these, it is crucial for government and private sectors to collaborate by providing financial assistance, training, and access to resources that will help SMEs overcome barriers and enhance their food safety practices. Public awareness campaigns, along with stronger inspection systems, are recommended to foster greater compliance and improve food safety outcomes.

353. Achieving high food safety standards requires ongoing commitment to improvement. Although frameworks like HACCP and GMP are effective in mitigating foodborne risks, continuous education and adherence to best practices are necessary to address emerging food safety concerns. Properly implemented food safety management systems ensure that food products are safe for consumption and can meet the demands of both local and international markets.

354. The KP can be viewed **here**.

4.3.6 List of Appendices for Output 3

- Capacity Needs and Gaps Assessment Report
- Value Chain Analysis and Market Demand Assessment (Aide Memoire Action Item 16)
- CB7 Workshop Report (SDG-PGS Pilot Demonstration)
- CB5 Workshop Report (Aide Memoire Action Item 17)
- Working Document: Provision of support for at least two raw agricultural products and two processed agricultural products in receiving certification for good quality and safety and in establishing market linkages (Aide Memoire Action item 21)
- Digital Traceability Demonstration Report (Aide Memoire Action Item 22)
- KP8: Digital Technology-based Farm-to-Fork Traceability Solutions for Organic Agricultural Products in the Highlands (Aide Memoire Action Item 22)
- KP7-A: Grower Certification Schemes and Good Agricultural Practices (Aide Memoire Action Item 18)
- KP7-B: Agricultural Product Quality and Safety Enhancement and Value Addition (Aide Memoire Action Item 18)

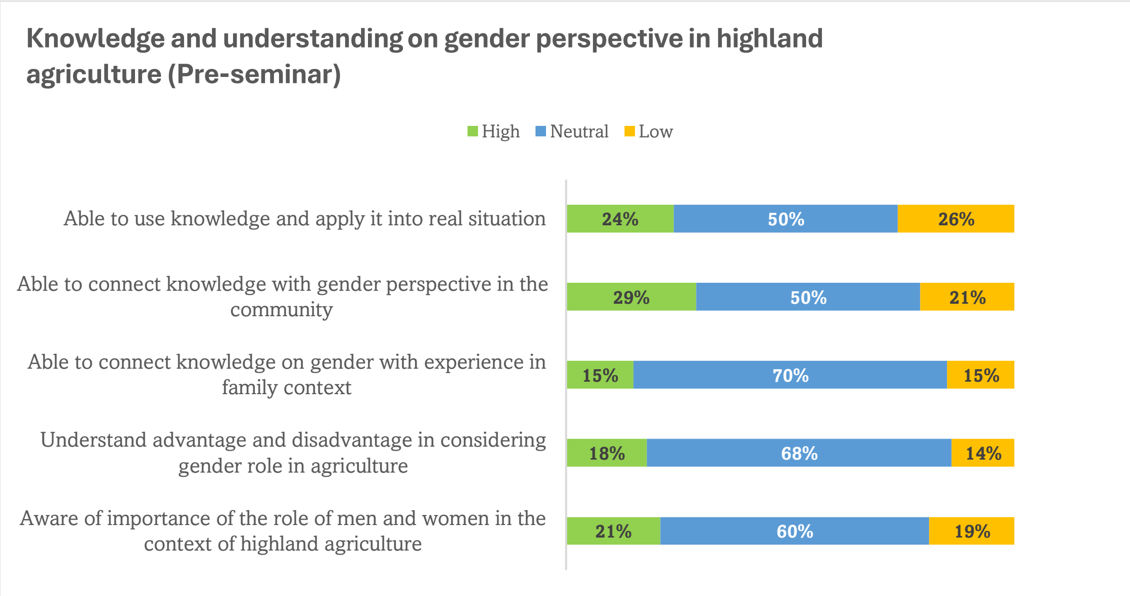
4.4 Output 4: Capacity of local governments and communities to address climate change strengthened

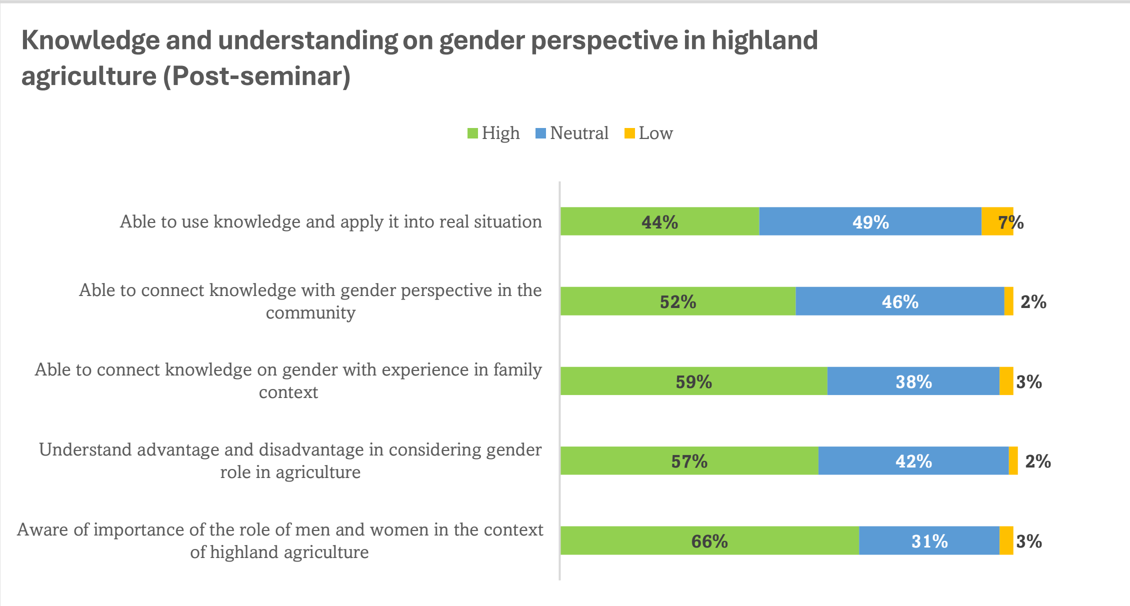
4.4.1 Activity 4.1: Organize awareness-raising seminars for farmers, women's groups, youth, NGOs, and the private sector on CSA and alternate livelihood options for resilience. (CB3 and W3)

355. The seminar on "Gender- and COVID-19 Responsive Climate-Smart Agriculture Practices and Alternate Livelihood Options for Enhanced Resilience of Highlands," conducted on July 6-7, 2022, in Bua Yai Subdistrict, Nan Province, involved 80 farmers, with women accounting for 52.5% and men 47.5% of participants. It aimed to raise awareness of climate-smart agricultural practices (CSA) and alternate livelihoods, focusing on building resilience among highland communities against climate change and socioeconomic challenges exacerbated by the COVID-19 pandemic.

356. Participants were drawn from eight villages, representing diverse backgrounds and farming systems. Pre-seminar assessments revealed that only 21% of participants were highly aware of the importance of gender roles in agriculture, while 60% reported low to neutral levels of understanding. Post-seminar evaluations showed significant improvement, with high awareness increasing to 66% and low awareness dropping to 3%. Similarly, knowledge of the adaptation of farming practices due to COVID-19 impacts rose from 44% to 60% in the high-awareness category (Figure 25).

Figure 25: Pre- and post-seminar knowledge and understanding on gender perspective in highland agriculture.

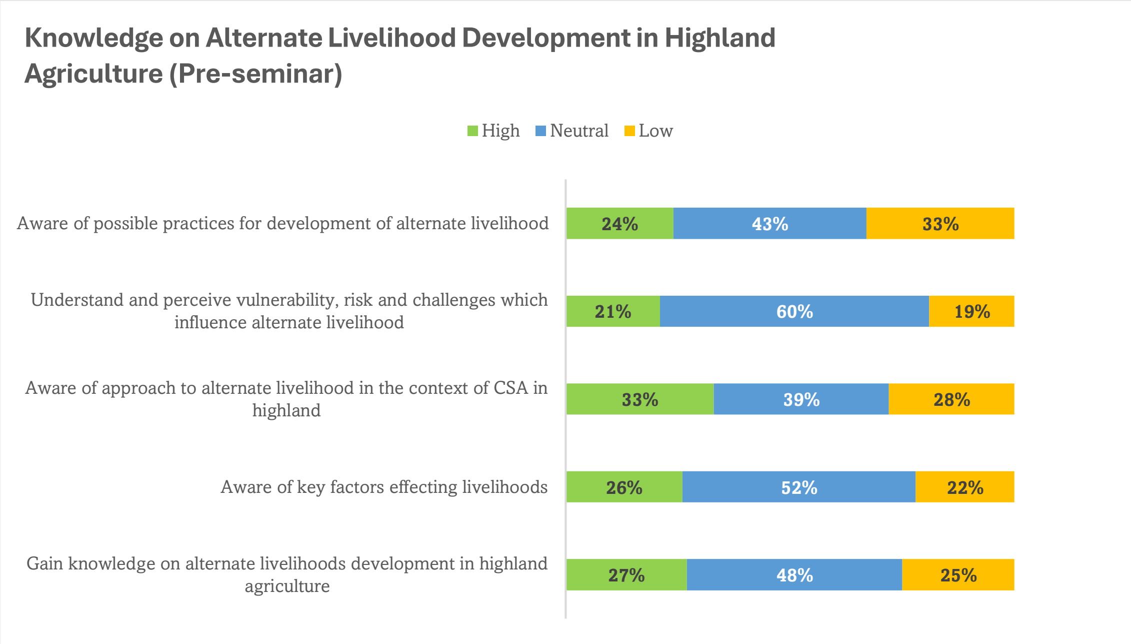


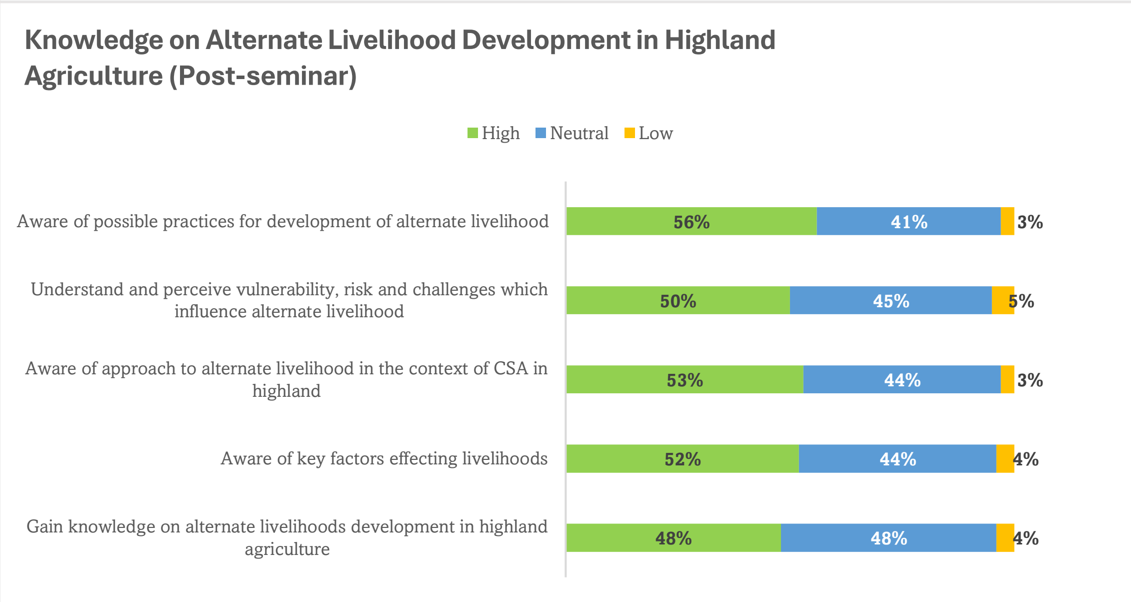


357. The seminar utilized a participatory approach, with sessions structured around presentations, panel discussions, and group activities. Day one began with a focus on gender-conscious CSA practices. Key presentations highlighted existing gender dynamics, where men predominantly handle physical labor, while women manage household and community roles, often balancing these with caregiving responsibilities. A notable case study from Phayao Province illustrated how women-led initiatives in organic farming contributed to economic stability and sustainable practices. Group discussions encouraged participants to identify challenges, such as the lack of technical support for women, and to propose strategies to strengthen their roles in agriculture.

358. Day two centered on alternate livelihood development and supply chain integration. A presentation on the multidimensional aspects of livelihood development emphasized the importance of market access, resource management, and knowledge capital. Farmers reported water shortages, soil degradation, and high input costs as their primary barriers. A subsequent session on value chain strategies introduced methods to enhance market connectivity, including contract farming, traceability systems, and collective bargaining. Pre-seminar data indicated that only 24% of participants had a high level of understanding of supply chain considerations; this increased to 47% post-seminar, while low awareness declined from 35% to 3%.

Figure 26: Pre- and post-seminar knowledge and understanding on alternate livelihood development in highland agriculture.





359. The seminar also facilitated interactive activities, such as group brainstorming sessions to co-develop a roadmap for sustainable livelihoods. Farmers identified the need for practical demonstrations of CSA practices, increased access to clean water resources, and government support for organic certification. Post-seminar evaluations showed that 59% of participants found the information presented entirely new, while 36% rated it partially new. Satisfaction with the seminar organization was high, with 47% strongly agreeing and 53% agreeing that the program was well-structured.

360. In terms of logistics and delivery, 53% of participants strongly agreed that the venue and schedule were convenient, and 41% were highly satisfied with the quality of meals provided. Speaker evaluations revealed that 56% found the presenters to be highly informative, while 53% agreed that the materials were clear and engaging. The hands-on and interactive nature of the sessions was particularly appreciated, as it allowed farmers to relate theoretical concepts to practical applications.

361. By the end of the seminar, 52% of participants demonstrated a high level of understanding of alternate livelihood options compared to 27% at the outset. Knowledge about CSA practices and their relevance to COVID-19 recovery also improved significantly, with 74% reporting a high level of awareness of the risks posed by COVID-19 to farm households, up from 52% pre-seminar. These results reflect the seminar's effectiveness in building capacity and addressing pressing agricultural and socioeconomic challenges faced by highland communities.

362. The seminar concluded with a commitment to continue capacity-building efforts and to ensure that farmers receive ongoing technical support and market integration assistance. Recommendations included expanding the demonstration of CSA practices to additional villages, simplifying organic certification processes, and leveraging public-private partnerships to address systemic challenges in the agricultural value chain. The seminar effectively laid the groundwork for enhancing resilience and sustainability among highland farming communities, supported by evidence of substantial knowledge gains and increased readiness to adopt climate-smart practices.

363. The seminar report is presented **here**.

Capacity building seminar on CSA practices and alternative livelihood options

Organization of a women-focused training workshop on alternate livelihood options, including handicrafts, food preparation, processing, and preservation - CB8

364. An additional training workshop on Women-Focused Alternative Livelihood Options was organized from 26 June to 22 July 2024. The Women-Focused Training Workshop on Alternate Livelihood Options, conducted from June 26 to July 22, 2024, in Bua Yai Subdistrict, Nan Province, trained 316 participants, surpassing the expected 280 attendees. Women constituted 85% of the participants, reflecting the program's emphasis on gender inclusivity. The workshops aimed to diversify incomes during the non-farming season (February to May) by introducing sustainable livelihood strategies aligned with local resources and skills. The program covered six key areas: food processing, cacao and avocado value addition, honey production, handicrafts, furniture making, and traditional homestay management.

365. The first workshop on food processing engaged 112 participants who learned techniques to produce Makwaen-based spice blends, banana chips, mushroom snacks, pumpkin preserves, and bamboo shoot pickles. Practical sessions demonstrated cost-return analysis, and post-training evaluations showed that 85% of participants could effectively calculate production costs and potential profits. Survey results indicated that 72% of attendees planned to commercialize at least one processed product, estimating a potential 15–20% increase in household income during the non-farming season.

366. The cacao and avocado value addition workshop attracted 94 participants, emphasizing high-value product development. Attendees produced items like brownies, lip balms, and lotions, with a 73% success rate in meeting product quality standards during practical assessments. Cost analysis revealed that producing 1 kilogram of cacao brownies incurred a cost of 145 THB, while market prices averaged 300 THB, indicating a profit margin of 107%. Similarly, avocado lotion production costs were calculated at 65 THB per unit, with a potential retail price of 120 THB, providing an 85% profit margin. Post-workshop surveys showed that 68% of participants intended to commercialize these products.

367. The honey production and value addition workshop engaged 76 participants, with 58% being existing beekeepers. Training included honey extraction, beeswax processing, and honey-based soap production. The average honey extraction efficiency improved by 24% after training, as measured by participant assessments. Participants produced 45 units of honey-based soap during the practical session, with an estimated production cost of 30 THB per unit and a market price of 80 THB. Survey responses indicated that 62% of participants planned to scale up honey-related ventures, targeting both local and tourist markets.

368. The handicraft and furniture-making workshop targeted elderly participants and attracted 61 attendees. Using bamboo, participants created 37 baskets, 19 brooms, and 12 pieces of furniture during the session. The cost of materials for a bamboo chair was estimated at 120 THB, while the selling price averaged 350 THB, offering a profit margin of 190%. While most attendees indicated they would use these skills for personal benefit, 41% expressed interest in small-scale commercialization to supplement household income.

369. The traditional homestay management workshop had 78 participants and focused on aligning homestay programs with the Thai Homestay Standard. Participants developed business plans that incorporated organic food, cultural practices, and eco-tourism. Practical exercises included field visits to successful homestays, where participants assessed operational strategies. Post-workshop evaluations showed a 29% increase in confidence among attendees in managing homestays, with 62% expressing intent to develop homestay businesses within their communities. Revenue projections for a three-room homestay, based on market data, indicated potential earnings of 8,000–10,000 THB per month during peak tourist seasons.

370. Overall, 86% of participants rated the workshops as highly satisfactory, citing the relevance of the skills to their livelihood needs. Post-workshop surveys revealed that 74% of attendees planned to implement at least one skill learned, with 53% aiming to collaborate in small groups for production and marketing. The workshops emphasized gender empowerment, with women taking the lead in planning and implementing alternative livelihood strategies, supported by technical training and practical demonstrations. Quantitative results highlight the potential of these initiatives to enhance economic resilience and resource efficiency in highland communities.

371. The full workshop report is presented **here**.

Organization of a private-sector focused training workshop on climate smart agribusinesses - CB9

372. The Private Sector Workshop on Climate-Smart Agriculture (CSA) was held on December 2, 2024, as part of the ADB TA-9993 initiative to promote CSA adoption in Thailand's highland regions. The workshop aimed to engage the private sector, government officials, and other stakeholders to address challenges and explore opportunities for scaling CSA technologies and practices in areas like Nan Province. It also served as a platform to share key insights from ongoing efforts under the technical assistance project.

373. The workshop featured 30 participants, including 16 private sector representatives from companies such as Cargill Thailand, Varuna (Thailand), and Charoen Pokphand Foods PCL, as well as ADB officials and the TA team. The participants came from various segments of the agri-food value chain, such as production, processing, distribution, and marketing. This broad

representation helped foster discussions on scaling up CSA in highland areas and identifying obstacles faced by the private sector, particularly in terms of market access, infrastructure, and financial investments.

374. During the workshop, discussions were organized into several sessions. In the first session, ADB officials presented the support provided to the private sector through programs like ADB Ventures and ADB Frontier, which assist enterprises in scaling climate-focused innovations. The second session identified the key challenges along the agrifood value chain in highlands, including climate risks, high initial investments, limited infrastructure, and issues around food safety, quality standards, and market access. Participants highlighted the need for coordinated policy support and investments to improve resilience in the agrifood sector.

375. In the third session, participants discussed opportunities and solutions to overcome these barriers, emphasizing the importance of public-private partnerships (PPPs) and innovative financing mechanisms, such as tax incentives, carbon credits, and green financing. The idea of a "Smart Sustainable Sandbox – Highland Value Chain" was proposed to bring together various stakeholders to share knowledge and foster innovation. Demonstration projects were also emphasized as crucial for building trust and showcasing the benefits of CSA. Lastly, capacity-building and farmer education were identified as essential strategies to ensure that CSA practices are adopted at scale.

376. The final session focused on synthesizing the workshop's key findings and exploring ways to drive long-term CSA growth in highland regions. It was suggested that a neutral umbrella organization be established to coordinate cross-border CSA efforts, alongside the development of climate metrics for measurable sustainability. Other key recommendations included promoting minimum-tillage practices, sustainable waste management, and expanding CSA solutions to other sectors like sustainable tourism and hydropower. The workshop concluded with a call for continued collaboration, emphasizing the need for inclusive stakeholder engagement to ensure the long-term resilience and growth of CSA in highland areas.

377. The workshop report can be accessed **here**.

4.4.2 Activity 4.2: Train local government staff on integrating climate concerns in local development plans and application of technologies (e.g., remote sensing, geographic information systems, and mobile phone-based applications) to improve resilience of communities and ecosystems. (CB4 and W4)

378. The two-part workshop on "Integrating Climate Change in Local Agricultural Planning" focused on capacity building for local government officials and stakeholders in Nan Province. It emphasized integrating climate-smart agriculture (CSA) practices and digital technologies into agricultural planning. The detailed findings and analysis are as follows:

379. The first section, CB 4-1, focused on integrating climate change adaptation into agricultural development plans. It involved 38 participants, predominantly from provincial and local government agencies, with women accounting for 60.5% of attendees. The sessions included theoretical discussions and visits to CSA demonstration sites. Participants reviewed existing plans and identified gaps in incorporating climate change adaptation. Knowledge assessments revealed significant improvements: pre-workshop, 57% had low knowledge of climate change impacts, which decreased to 21% post-workshop, with 79% reporting high knowledge levels.

380. Three demonstration sites in Bua Yai Subdistrict showcased practical CSA interventions. These included solar-powered irrigation systems, biochar production, and keyline ploughing. The solar-powered irrigation systems demonstrated significant potential for water conservation and crop resilience. The biochar production unit illustrated methods for soil improvement using agricultural waste. At the keyline ploughing site, participants observed techniques for water retention on sloped agricultural land. These demonstrations were highlighted as transformative for resource management.

381. Discussions during the working sessions revealed overlaps among 15 agencies' climate change-related activities. While efforts in water resource management, alternative energy, and sustainable agriculture were noted, a lack of inter-agency coordination was emphasized. Participants agreed on the necessity of an integrated approach, using the Nan Provincial Development Plan as a foundation. They proposed adapting the Five-Year Agricultural Development Plan with guidance from Thailand's Draft Climate Change Strategic Plan for Agriculture 2023-2027.

Central and provincial government officials

Field visit to one of the demonstration sites

382. In CB 4-2, the focus shifted to applying digital technologies to enhance resilience. Precision agriculture technologies, such as soil sensors, drones, and geographic information systems (GIS), were introduced to help monitor environmental changes and optimize resource use. Pre-workshop surveys showed 62% of participants had low knowledge of these technologies, which decreased to 10% post-workshop. Post-workshop, 59% of participants reported high knowledge levels of precision agriculture technologies.

383. Participants were trained in a digital ecosystem approach, emphasizing sustainability. A practical session introduced a mobile app enabling farmers to create digital field maps, track farming activities, and access weather forecasts. A field visit to an essential oil extraction plant demonstrated how digital solutions link highland products with markets. Farmers expressed enthusiasm for the app, citing user-friendliness and relevance to daily activities. Some challenges, such as mobile device compatibility, were noted.

384. The workshops yielded clear outcomes, including increased knowledge of CSA practices and the potential of digital technologies in agricultural planning. Officials developed an outline for the Nan Provincial Climate Change Adaptation Plan for Agriculture, focusing on integrating CSA practices and digital tools. Recommendations included fostering collaboration across agencies, securing funding for sustained implementation, and conducting follow-up workshops to refine the integrated plan.

385. The workshops were successful in strengthening technical capacities and building a collaborative framework for climate-resilient agriculture. The combination of theoretical sessions, practical demonstrations, and digital applications provided participants with

a holistic understanding of integrating CSA and digital solutions into agricultural planning, setting a robust foundation for long-term sustainability.

386. The workshop report is attached **here**.

Preparation of at least two CSA action plans at Na Noi district level and Nan province level

387. The Climate-Smart Agriculture (CSA) Action Plan focuses on integrating climate-smart agricultural practices into local development planning at the district and provincial levels in Nan Province, Thailand. The plan aligns with Thailand's national and provincial agricultural development strategies, emphasizing sustainable agricultural practices, economic growth, and environmental conservation.

388. **Agricultural Development Planning Framework**. Thailand's agricultural policies follow a structured framework guided by the 13th Five-Year National Economic and Social Development Plan and the 20-Year National Development Strategy. Nan Province's development strategies focus on four key areas: grassroots economic strengthening, infrastructure development, community empowerment, and government capacity building. The province has allocated significant financial resources, including a budget of THB 54.86 million for agricultural sector development. The provincial agricultural development goals prioritize increasing farmers' incomes, improving product quality, adopting advanced technology, and empowering farmer organizations. The province implements a five-year strategy (2023–2027) centered on food security, competitiveness, social equity, sustainable resource management, and inter-agency coordination. MOAC's Climate Change Action Plan (2023–2027) provides a framework for building climate resilience in agriculture through adaptation measures, greenhouse gas reduction, knowledge management, capacity building, and policy integration.

389. **Climate-Smart Agriculture Integration Strategy**. The plan identifies critical entry points for integrating CSA into local agricultural systems. Key CSA interventions include:

(1) **Solar Irrigation Systems**: Enhancing water use efficiency and improving soil moisture retention in high-value crop production such as cacao, lemongrass, and avocado.
(2) **Biochar Application**: Increasing soil fertility, improving water retention, and enhancing soil structure to support long-term productivity and carbon sequestration.
(3) **Biofertilizers**: Strengthening plant resilience and nutrient uptake while improving soil health and sustainability.

390. These strategies collectively enhance agricultural productivity, optimize resource use, and reduce climate-related risks. The document outlines proactive, corrective, preventive, and safeguarding strategies for CSA adoption, emphasizing innovation, environmental sustainability, and data-driven decision-making.

391. **Provincial and District-Level CSA Action Plans**. The Provincial CSA Action Plan aligns with Thailand's Bio-Circular-Green (BCG) Economy Model and includes:

(1) Strengthening agribusiness value chains to increase farmer incomes.
(2) Developing a digital platform for data-driven climate risk analysis and agricultural decision-making.
(3) Enhancing infrastructure for climate-smart agribusinesses through investment in green technologies and sustainable farming practices.
(4) Scaling high-value crop production with low-carbon, climate-resilient techniques.

392. At the district level, the Na Noi District CSA Action Plan focuses on:

(1) Capacity-building for local agencies in precision agriculture and digital farming applications.
(2) Scaling CSA technologies through pilot projects and sandbox initiatives.
(3) Developing value-added products and green agribusiness under the BCG model.
(4) Establishing partnerships with private-sector investors to expand CSA initiatives.

393. **Investment Plan and Implementation Framework**. The CSA investment framework leverages four funding sources: provincial budgets, local government allocations, private sector investment, and the Green Climate Fund. The plan proposes a five-year investment of THB 876.23 million, with 35% allocated to CSA initiatives. Key financial commitments include THB 16.5 million from the Green Climate Fund and THB 21.12 million from private investors. The operationalization strategy assigns implementation responsibilities to various government agencies, including the Ministry of Agriculture and Cooperatives (MOAC), the Department of Agricultural Extension, and the Nan Provincial Development Committees. Coordination across agencies, private sector partnerships, and capacity-building initiatives play a crucial role in ensuring effective CSA integration.

394. Recommendations for Future Action. The plan recommends securing financial support from provincial and national government sources, integrating CSA into the BCG policy framework, and leveraging climate finance mechanisms. Strengthening private sector involvement through co-financing arrangements, developing risk-mitigation financial instruments, and enhancing agricultural extension services are critical next steps for sustainable CSA implementation in Nan Province. This comprehensive strategy

establishes a scalable model for climate-smart agriculture integration, enhancing resilience, productivity, and sustainability in Thailand's highland agricultural sector. The CSA Action plan is presented **here**.

4.4.3 Activity 4.3: Conduct field visits to the demonstration sites.

395. From June 19 to 23, 2024, a diverse group of 173 individuals from the northern highlands of five provinces (Chiang Mai, Chiang Rai, Phrae, Uttaradit, and Phayao), four districts from Nan Province (Mueang, Mae Charim, Wiang Sa, and Na Muen), six subdistricts of Na Noi District, Nan Province (Sathan, Santha, Chiang Khong, Sisaket, Na Noi, and Namtok), and academic institutions (Rajamangala College Lanna, Nan; Ban Oi Community School; and Na Noi School) participated. The group included farmers, subdistrict administrative offices, government officers, academics, and youths, with a balanced gender ratio and a significant youth presence.

396. The visit facilitated firsthand observation, peer-to-peer learning, and interaction with host farmers to enhance knowledge on highland agriculture and promote the adoption of CSA practices. Special attention was given to involving women and youth to ensure long-term sustainability through future generations.

397. The field visit focused on enhancing farmers' understanding and application of innovative agricultural practices, particularly in the context of climate change adaptation. Participants visited demonstration sites showcasing various technologies, including solar-powered irrigation systems and keyline water management techniques. Feedback collected from participants indicated a high level of satisfaction, with overall approval ratings reaching 90.56% (Figure 27). Notably, innovations such as biofertilizers and biochar received the highest satisfaction scores, emphasizing their perceived benefits in improving soil health and crop yields. The hands-on experience allowed farmers to visualize the practical applications of these technologies, fostering a deeper understanding of their potential impact on agricultural productivity.

Farmers from neighboring provinces, districts, and subdistricts visiting the pilot demonstration sites in Bua Yai Subdistrict

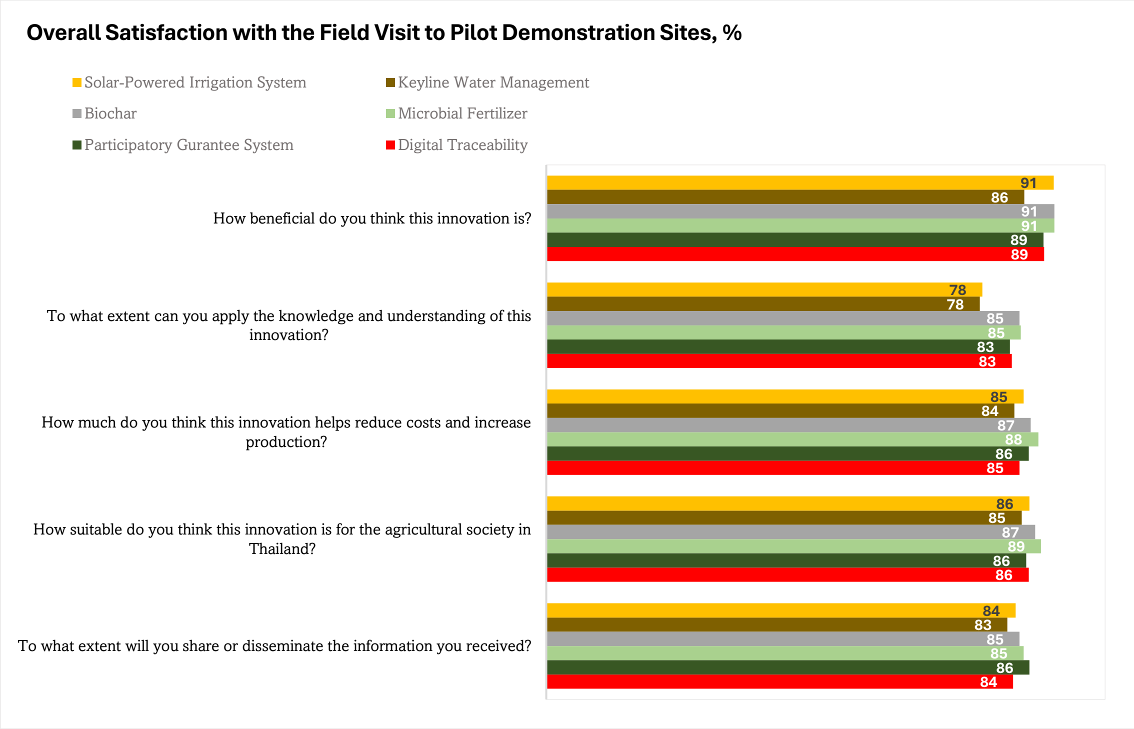
398. Technical discussions during the workshop highlighted the importance of integrating sustainable practices into traditional farming methods. Participants learned about the efficiency of solar irrigation systems, which not only reduce reliance on conventional energy sources but also lower operational costs. The workshop emphasized the need for farmers to adopt these technologies to mitigate the effects of water scarcity, a significant challenge faced in the region. Additionally, the keyline water management approach was presented as a viable solution for enhancing water retention and distribution across agricultural lands, thereby improving resilience against drought conditions. The technical training provided insights into the design and implementation of these systems, equipping farmers with the knowledge to adapt these innovations to their specific contexts.

399. In terms of recommendations, it is crucial to establish a continuous support network among participants to facilitate knowledge sharing and collaboration. The formation of farmer groups or cooperatives can enhance collective learning and resource sharing, enabling farmers to implement the demonstrated technologies more effectively. Furthermore, ongoing training sessions should be organized to cover advanced topics such as soil health management and pest control strategies, ensuring that farmers remain informed about the latest agricultural practices. The report suggests that local agricultural extension services play a vital role in providing this support, acting as a bridge between farmers and technical experts.

400. The field visit underscored the importance of disseminating the knowledge gained to a broader audience. Participants expressed a strong willingness to share information with their communities, indicating a potential multiplier effect in the adoption of sustainable practices. To facilitate this, the development of educational materials and workshops tailored to different audience segments, including youth and women in agriculture, is recommended. By empowering these groups with knowledge and resources, the initiative can foster a more inclusive approach to climate-smart agriculture, ultimately contributing to the sustainability and resilience of the agricultural sector in Thailand.

401. The field visit report can be accessed **here**.

Figure 27: Overall satisfaction percentages from the field visit to pilot demonstration sites, evaluating six innovations on their benefits, applicability, cost reduction, suitability for Thailand's agricultural society, and information dissemination.



4.4.4 Activity 4.4: Prepare knowledge products on CSA and alternate livelihood options for adaptation to climate change in highlands. (KP4)

402. The seminar report for CB3 was prepared and analyzed for extracting success stories pertaining to alternative livelihood options in highlands. Furthermore, a field trip to Phayao Province was undertaken by Gender and Social Development Specialist Dr. Siriluck Sirisup from 26-27 January 2023 to meet selective farmers and learn about factors influencing their decision-making to practice sustainable agriculture. This information supplemented the information obtained from the seminar.

403. The knowledge product titled "Alternative Livelihood Options for Highland Communities" provides practical examples of how Climate-Smart Agriculture (CSA) and alternative livelihood practices are transforming agriculture in northern Thailand's highland regions. It includes six case studies – two from Phayao Province and four from Bua Yai Subdistrict in Nan Province – that showcase the transition from traditional farming to sustainable, eco-friendly methods. These stories are designed to inspire policymakers and small-scale farmers to adopt CSA practices by illustrating the tangible benefits of adapting to climate change through innovative agricultural and livelihood approaches.

404. In Phayao Province, the two case studies reflect a shift from monocropping and heavy chemical dependence to sustainable practices inspired by King Rama IX's Sufficiency Economy Philosophy. This approach has enabled small-scale farmers to reduce their reliance on chemical inputs, significantly lower their farming costs, and lessen their environmental impact while increasing income and freeing themselves from cycles of debt. This transition proved particularly beneficial during the COVID-19 pandemic, as farmers who had adopted CSA could rely on home-grown organic produce, demonstrating the resilience that CSA practices can bring to rural communities in times of crisis.

405. The four case studies from Nan Province highlight various CSA practices and alternative livelihoods that are well-suited to the local climate and topography. Examples include drought-resistant crops like pumpkin and sesame, which thrive in the highlands and require minimal labor. Beekeeping has also emerged as a viable, low-input livelihood option, with more than 30 families in Bua Yai engaging in this sustainable activity. Additionally, traditional hand weaving among elderly women provides a valuable source of income, illustrating how indigenous knowledge can enhance livelihoods while promoting cultural sustainability.

406. The success of these case studies underscores the crucial role of technical and financial support in facilitating these transitions. Farmers in Phayao received training in organic farming, soil improvement, and bio-compost usage, while those in Nan benefited from marketing support that enabled them to sell organic products at premium prices. Partnerships with public and private sector stakeholders, including academic institutions, were instrumental in providing the necessary expertise and resources. This collaborative support has helped farmers not only improve their economic status but also protect the environment by reducing carbon emissions and preventing soil degradation.

407. The KP is presented in **here**.

408. **Seven stand-alone videos**, each with a duration of 3 minutes, have been prepared and offer a comprehensive and engaging overview that captures the essence and impact of the TA. This will be achieved through two key components: the content and the video clip.

409. The video covers the project's background, components of CSA, and the benefits of the demonstration activities. It also includes messages from local stakeholders, showcases best practices and lessons learned, and discusses potential strategies for replication and scaling up.

410. The video clips highlight key aspects of the TA, including the implementation process, interviews with essential local actors and stakeholder representatives, and key features of the demonstration sites. It emphasizes the benefits of the TA for highland agriculture in Thailand, its alignment with Sustainable Development Goals (SDGs), and climate risk mitigation. Additionally, it conveys persuasive messages to encourage broader adoption and scaling up of these practices.

411. The videos can be viewed **here**. The ADB's Department of Communications and Knowledge Management (DOCK) have reviewed the overview video, and the video was revised to incorporate the comments and be up to par with ADB DOCK guidelines.

4.4.5 Activity 4.5: Organize an international workshop on CSA to share best practices from the TA. (CB6 and W6) (KP9)

412. The International Workshop (IW) on Climate–Smart Agriculture in Highlands: Best Practices and Lessons Learned was organized from 29–-30 October 2024 at the AIT Conference Centre, Pathum Thani, Thailand.

413. The workshop addressed multifaceted aspects of climate-smart agriculture with an overall aim to provide a platform for exchanging innovative ideas, technologies, and methodologies, fostering stakeholder collaboration and networking, and catalyzing the adoption of climate-smart agriculture practices in highland regions. The workshop also focused on the experience gained from the implementation of the TA in Nan province of Thailand.

414. 135 participants attended the two-day workshop. The sectoral breakdown is provided in Table 16.

Table 16: Sectoral breakdown of workshop participants.

Sector Type	Participants
Academia/CSOs/NGOs	51
Development Partners	13
Farmers	14
Government Staff	44
Private Sector	13
Total	**135**

Dr. Kanjana Kwanmuang
Deputy Secretary-General, Office of Agricultural Economics (OAE), Thailand

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Principal Climate Change Specialist, Asian Development Bank (ADB)

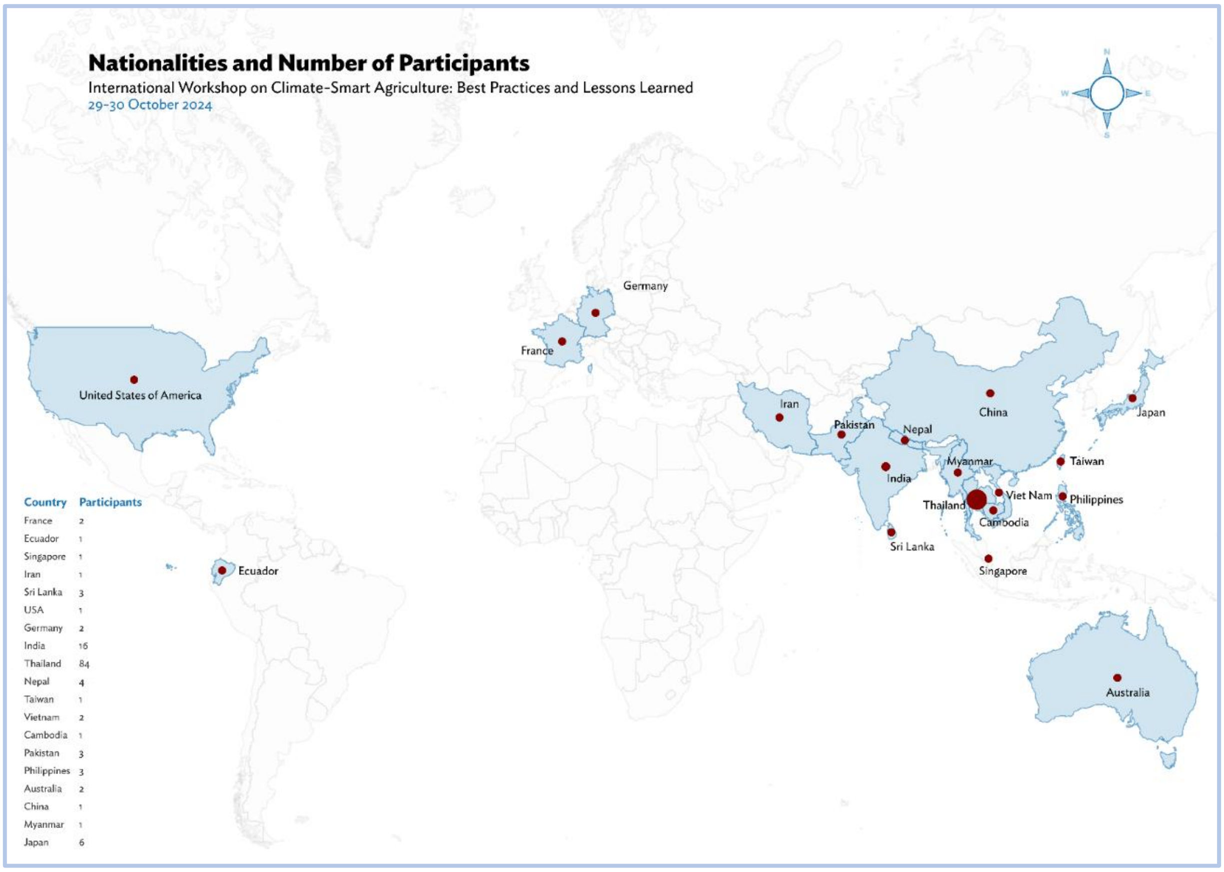
415. The 135 participants represented 19 different nationalities working in the Asia-Pacific region. The nationalities of the participants are presented in Table 17 and Figure 28.

Table 17: Nationalities of workshop participants.

Country	Participants
Australia	2
Cambodia	1
China	1
Ecuador	1
France	2
Germany	2
India	16
Iran	1
Japan	6
Myanmar	1
Nepal	4
Pakistan	3
Philippines	3
Singapore	1
Sri Lanka	3
Taiwan	1
Thailand	84

Country	Participants
USA	1
Vietnam	2
Total	**135**

Figure 28: Nationalities of participants at the workshop.



416. The workshop addressed major climate-related challenges affecting highland farming and explored tailored, sustainable solutions. Participants recognized that highland agriculture faces unique climate vulnerabilities, such as unpredictable weather patterns, soil erosion, and declining crop yields. To address these issues, it was recommended that CSA strategies be tailored to specific environmental and socio-economic conditions in highland areas. A strong emphasis was placed on community-driven and gender-sensitive practices—like agroforestry and crop diversification—as essential means for strengthening resilience and food security. Workshop experts advocated for integrating top-down climate modeling with community insights, facilitating a precise understanding of local vulnerabilities and adaptive needs.

417. Empowering local governments and communities emerged as a central recommendation for sustainable CSA adoption. Building local capacity through hands-on training, demonstration plots, and community-led workshops was identified as crucial for equipping communities to manage CSA practices independently. Insights from pilot projects in Nan province underscored this need: farmers who participated in these demonstrations reported increased soil moisture retention, improved crop health, and reduced water requirements through practices like keyline water management and biochar application. However, they also highlighted challenges, including the need for specialized equipment and technical support. To support broader CSA adoption, the workshop recommended investing in localized resources, equipment tailored to CSA methods, and skill development.

418. Digital innovations were identified as critical enablers of CSA in highland agriculture, especially through traceability systems, predictive analytics, and AI-driven tools. Presenters demonstrated that these technologies could improve crop quality monitoring, optimize water use, and support efficient market access. The success of digital traceability systems in the Thai durian industry was presented as a replicable model for other high-value crops. However, workshop participants emphasized that government support and incentives will be essential to encourage the broader adoption of these digital tools, which should be accompanied by appropriate training for local stakeholders.

419. The workshop further highlighted the role of innovative financing mechanisms, like carbon credits, in incentivizing sustainable practices. By collaborating with financial institutions and private sector partners, CSA investments could become more financially viable and accessible. Specific recommendations included establishing revenue-sharing models for carbon credits, introducing resilience metrics to evaluate CSA impact, and promoting farmer-led investment. With supportive policies and comprehensive financing structures, highland agriculture could effectively contribute to both local climate resilience and sustainable agricultural development.

420. The workshop report is presented **here**.

KP9: Climate-Smart Agriculture in Highlands – Insights from Asia

421. The knowledge product (KP9) on Climate-Smart Agriculture in Highlands: Insights from Asia is an output of this IW. CSA in Asia, particularly in highland regions, is emerging as a pivotal strategy to address the intertwined challenges of climate variability, unsustainable farming practices, and socio-economic vulnerabilities. The KP outlines how traditional agricultural systems are being reformed through a mix of modern technological solutions and community-based innovations that aim to enhance resilience, boost productivity, and promote sustainable land management. The case studies from all over Asia illustrate the adverse effects of unsustainable monocropping, deforestation, and chemical overuse, which are now being countered with integrated CSA approaches.

422. A significant portion of the KP is dedicated to understanding the diverse challenges faced by highland communities—from erratic weather patterns and soil degradation to limited market access and insecure land tenure. In response, a series of climate vulnerability assessments and adaptive capacity studies have been conducted, providing a granular look at local environmental and socio-economic conditions. These assessments not only highlight the need for tailored interventions but also form the evidence base for innovative solutions such as improved water management, diversified cropping systems, and digital technologies for enhanced agricultural traceability.

423. Prioritizing recommendations and policy aspects, the document stresses the importance of multi-stakeholder collaboration to ensure effective CSA adoption. Key policy recommendations include establishing robust data collection systems for high-resolution vulnerability assessments, strengthening capacity-building initiatives for local governments and extension services, and creating financial and technical incentives to encourage farmers to adopt sustainable practices. This KP underscores that secure land tenure and clear policy frameworks are critical for fostering long-term investments in sustainable agriculture. Moreover, field-based demonstration projects and targeted technical assistance are essential to translate innovative practices into scalable, community-driven solutions.

424. In conclusion, the KP advocates for an integrated policy approach that harmonizes traditional knowledge with scientific advancements. It calls for a coordinated effort among governments, NGOs, research institutions, and the private sector to create supportive environments that not only incentivize CSA adoption but also build local resilience against climate uncertainties. This comprehensive framework is envisioned to drive sustainable development in Asia's highland regions, ensuring that both the environment and the livelihoods of rural communities are safeguarded in an era of rapid climate change.

425. The KP is presented **here**.

4.4.6 List of Appendices for Output 4

- CB3 Workshop Report
- CB8 Workshop Report (Aide Memoire Action item 28)
- CB9 Workshop Report (Aide Memoire Action Item 29)
- CB4 Workshop Report
- CSA Action Plan at Na Noi District and Nan Province Level (Aide Memoire Action Item 24)
- Report: Field Visit to Demonstration Sites (Aide Memoire Action Item 23)
- KP4: Alternative Livelihood Options for Highland Communities (Aide Memoire Action Item 25)
- Videos on TA Overview and Demonstrations (Aide Memoire Action Item 25)
- International Workshop Report (Aide Memoire Action Item 26)
- KP9: Climate-Smart Agriculture in Highlands – Insights from Asia (Aide Memoire Action Item 26)

5. TA Assessment

Criterion	Assessment
Relevance	The TA was fully aligned with Thailand's Strategies, Plans, and Models such as The Twenty-Year National Strategy 2018-2037[21]; The Twelfth (2017-2022) and Thirteenth (2023-2027) National Economic and Social Development Plan[22]; Master Plan on Agriculture under The National Strategy (2018-2037)[23]; Action Plan of the Ministry of Agriculture and Cooperatives (2020-2022)[24]; Smart Agriculture Action Plan (2022-2023); Strategy on Climate Change on Agriculture, Ministry of Agriculture (2017 to 2021); Scaling up Climate Ambition on Land Use and Agriculture through NDCs and National Adaptation Plans (SCALA) program (2020-2025); The Bio-Circular-Green Economy (BCG) model; and the Sufficiency Economy Philosophy[25]. Furthermore, The TA was aligned with the Greater Mekong Subregion (GMS) Hanoi Action Plan, 2018–2022 and the strategy for promoting safe and environment-friendly agro-based value chains in the GMS. It is strongly aligned with six operational priorities of ADB's Strategy 2030: (i) promoting rural development and food security; (ii) addressing remaining poverty and reducing inequalities; (iii) tackling climate change, building climate and disaster resilience, and enhancing environmental sustainability; (iv) accelerating progress in gender equality; (v) strengthening governance and institutional capacity; and (vi) fostering regional cooperation and integration. The TA supported Thailand in its efforts to achieve the Sustainable Development Goals (SDGs), especially SDG 1, SDG 2, and SDG 13, and Thailand's nationally determined contributions under the Paris agreement on climate change.
Effectiveness	The TA completed project activities fully and satisfactorily. The TA conducted 10 capacity-building workshops that enhanced understanding of CSA practices, climate vulnerability assessment, alternative livelihood options, integration of climate concerns into local development planning, and organic farming certification. Capacity building followed a diversity-positive approach, engaging mid-career national, provincial, and local government officials, policymakers, farmers, community leaders, development partners, academia, private sector actors, and NGOs. This inclusive approach fostered productive knowledge exchange, encouraged institutional memory, and promoted changes in CSA-related attitudes and practices, contributing to long-term sustainability. The planning and implementation of pilot demonstration projects—including keyline water management, solar irrigation, biochar application, climate-adaptive organic agriculture with PGS, circular agriculture and sustainable waste management using maize residue, and digital farm-to-fork traceability solutions—further strengthened the capacity of farmers and local government staff to respond to climate change, build resilience to climate and disaster risks, and improve environmental sustainability. Networking among farmers, the private sector, academia, and local governments remained a central feature of all capacity-building and TA interventions. Eleven knowledge products were prepared in English to serve as practical guides for government officials and practitioners, and all products were translated into Thai to ensure accessibility and utility for central, provincial, and local users.
Efficiency	The TA was designed to be implemented for 3 years from 11 August 2020 to 30 August 2023. However, the TA faced significant delays due to the COVID-19 pandemic, which caused the inception workshop to be held a year later in May 2021. Travel restrictions due to the pandemic hampered field visits for baseline survey and organization of workshops. Such delays led to 2 extensions of the TA closing date. The first extension was conducted on 14 September 2023, which revised the closing date to 31 December 2024,

[21] Royal Thai Government. The Twenty-Year National Strategy 2018-2037
[22] Office of the National Economic and Social Development Council (NESDC). The Twelfth National Economic and Social Development Plan (2017-2022) and the Thirteenth National Economic and Social Development Plan (2023-2027)
[23] Master plan under the National Strategy on Agriculture (2018-2037), Ministry of Agriculture and Cooperatives.
[24] Action Plan of the Ministry of Agriculture and Cooperatives (2020-2022) for three-year period
[25] Bergsteiner, H., & Dharmapiya, P. (2016). Sufficiency economy philosophy process. In G.C. Avery & H. Bergsteiner (Eds.), Sufficiency Thinking: Thailand's gift to an unsustainable world (pp. 1023-1343). Sydney: Allen & Unwin.

Criterion	Assessment
	and the second extension was conducted on 20 December 2024, which led to a revised closing date on 31 March 2025. All TA activities were implemented within the approved budget. ADB protocols for the procurement of goods and services were strictly followed, including the solicitation of quotations and the selection of the most responsive lowest bidder. TA funds allocated under the Communications and Printing category were minimally utilized, while expenditures under all other budget categories remained within their respective allocations.
Sustainability	The TA, particularly through its pilot demonstrations, was expected to create a favorable environment for the scaling up and replicability of CSA practices in highland areas. The long-term sustainability of TA activities required the empowerment of local communities as sources of knowledge and innovation, alongside clearly defined responsibilities for local government agencies and the provision of supportive policies and adequate resources from the relevant ministries. The adoption of CSA practices among highland farmers was anticipated to expand significantly, especially as farmers observed increased income from the cultivation of alternative organic crops.

6. Conclusions and Recommendations

6.1 Conclusions including Lessons Learned

426. The workshops, capacity-building activities, field activities, and pilot demonstrations conducted under this TA provided a robust platform for advancing CSA practices, digital technologies, and resilient agricultural planning. These initiatives equipped stakeholders with critical knowledge, practical skills, and collaborative frameworks to address challenges posed by climate change, resource degradation, and socio-economic vulnerabilities in highland regions. The following sections synthesize the key lessons learned and propose policy measures to scale up these efforts effectively.

427. The workshops demonstrated that participatory and inclusive approaches significantly enhance the effectiveness of knowledge transfer and capacity building. The active engagement of farmers, local government officials, and private sector stakeholders fostered a sense of ownership and practical applicability of CSA practices. A notable achievement was the inclusion of women, who constituted over half of the participants in many sessions, underscoring the critical role of gender-responsive strategies in building community resilience. However, pre-workshop evaluations revealed substantial knowledge gaps in CSA practices, precision agriculture technologies, and digital tools, with baseline knowledge levels below 40 percent in most cases. Post-training assessments indicated marked improvement, but the initial gaps highlighted the need for sustained training and education.

428. The introduction of digital tools, such as mobile applications, GIS, soil sensors, and drones, showcased their transformative potential for enhancing resource management, traceability, and climate adaptation. While farmers expressed enthusiasm for these tools, challenges such as device compatibility, user interfaces, and limited digital literacy, particularly among older participants, need to be addressed. Field demonstrations bridged the gap between theory and practice, with interventions like solar-powered irrigation systems, biochar production, and keyline ploughing significantly enhancing participants' understanding and confidence. These hands-on experiences emerged as critical enablers for the adoption of new practices.

429. The workshops also revealed the necessity of interagency collaboration to maximize impact. Overlaps in activities across agencies highlighted inefficiencies that could be resolved through better coordination. Additionally, the cost-benefit analyses conducted during the sessions emphasized that financial incentives and clear economic benefits are key drivers for farmers' adoption of CSA practices. For example, interventions such as biochar application and solar irrigation showed high returns but required upfront investments, underscoring the importance of financial support mechanisms.

6.2 Recommendations for Policy Measures

430. To successfully scale up Climate-Smart Agriculture (CSA) practices in Thailand's highlands, a comprehensive, multifaceted approach is required that addresses both capacity gaps and systemic challenges. Several key policy measures and strategies are essential for creating a supportive environment for CSA adoption and ensuring long-term sustainability.

6.2.1 Capacity Building and Knowledge Dissemination

431. One of the primary recommendations is to institutionalize regular training programs on CSA practices, which should be accessible not only to farmers but also to government officials. Training must be designed to cater to a variety of audiences, ensuring that materials are tailored to different literacy levels, including gender-sensitive approaches to address the unique needs of women. Farmer leader development is also crucial. In the recommendation section, should include the development process of Farmer leaders for each knowledge. The development of Farmer leaders will be the main actor to drive and scale up knowledge from the project to other farmers, in an efficient and sustainable way. These leaders will be empowered with specialized expertise and become key actors in disseminating CSA knowledge efficiently and sustainably, driving the scaling-up process within their communities. By empowering these farmer leaders, knowledge transfer will be more effective, ensuring that the CSA practices are adopted widely across the farming community. The training programs should include topics such as soil management, water conservation, organic farming, and digital technologies. Furthermore, capacity-building efforts must include digital tools like farm management software and weather stations, which are essential to modernizing agriculture. These tools can facilitate better decision-making, improve productivity, and enhance market linkages. Investing in user-friendly digital platforms that integrate GIS mapping and farm management tools will help farmers access essential data on weather patterns and agricultural practices.

6.2.2 Financial Support and Incentives

432. For CSA practices to be adopted at scale, financial mechanisms must be enhanced. The government should introduce subsidies, tax incentives, and low-interest green financing options that support farmers in adopting CSA technologies. These financial tools can alleviate the financial burden on smallholder farmers, making the transition to more sustainable agricultural practices more feasible. Additionally, there should be incentives for organic certification and participatory guarantee systems that encourage farmers to adopt environmentally friendly practices. Establishing climate-smart investment funds could further support pilot projects, helping to scale successful initiatives and demonstrate CSA's economic and environmental benefits. Furthermore, government-backed financial support for demonstration projects should be prioritized, as these initiatives provide practical examples of CSA benefits, building trust and encouraging broader adoption across regions.

6.2.3 Strengthening Market Access and Value Chains

433. Improving market access and infrastructure is crucial to making Climate-Smart Agriculture (CSA) practices economically viable for farmers. Strengthening logistics—such as cold storage facilities and transportation networks—can significantly enhance farmers' ability to reach both domestic and international markets with CSA-certified products. Developing robust value chains for high-value crops like cacao, lemongrass, and avocado is equally important. In this context, public-private partnerships (PPPs) can play a pivotal role in connecting farmers to premium markets by providing critical resources, training, and market linkages. At the same time, developing local agro-processing industries can add value to CSA products, enhance their competitiveness, and generate new economic opportunities for rural communities. Expanding demonstration sites as practical learning hubs will further support farmers by offering technical guidance and fostering peer-to-peer knowledge exchange, ultimately reinforcing market linkages and showcasing the economic benefits of CSA.

434. In parallel, engaging the private sector through Corporate Social Responsibility (CSR) initiatives is essential for building a more sustainable food system. CSR reflects an organization's ethical commitment to social and environmental responsibility, both within and beyond its operations. By integrating CSR principles, companies can align their business goals with sustainability efforts, creating shared value for both enterprises and communities. These initiatives can also provide tangible incentives—such as tax benefits—that motivate greater private sector participation in sustainable development. Highlighting these benefits can help attract more investment and innovation, thereby accelerating the adoption and scaling of CSA practices across value chains.

6.2.4 Interagency Coordination and Institutional Support

435. Institutionalizing interagency coordination is critical to aligning efforts across various sectors such as agriculture, natural resource management, and climate change adaptation. The establishment of provincial-level task forces would facilitate the integration of CSA practices into both local and national agricultural development plans, ensuring that these plans reflect local priorities while benefiting from national and international policy frameworks. Enhanced data sharing across agencies will improve decision-making and policy formulation, enabling more effective and cohesive strategies for CSA scaling.

6.2.5 Gender and Youth Integration

436. It is essential that gender-sensitive approaches be integrated into all CSA and policy initiatives. Ensuring equitable access to resources, land, and decision-making roles for women farmers will enhance the sustainability and inclusivity of CSA efforts. Similarly, engaging youth in targeted programs that combine climate-smart technologies with livelihood opportunities will promote innovation and foster long-term resilience. By empowering these two key groups, CSA practices will be more widely adopted, and the agricultural sector will be better positioned for sustainable development.

6.2.6 Community-Level Development and Long-Term Sustainability

437. Fostering sustainable community development at the grassroots level is essential for the long-term success and scalability of Climate-Smart Agriculture (CSA). This begins with the establishment of strong coordination mechanisms that align community development plans with CSA outcomes, particularly in regions like Bua Yai Subdistrict in Nan Province. Drawing from insights shared during the International Conference, these strategies should be adapted to local contexts to ensure their relevance, ownership, and sustainability. Robust monitoring and evaluation frameworks—leveraging digital tools—are also critical for tracking CSA adoption, measuring impacts, and continuously refining approaches based on real-time data and feedback from the ground.

438. To extend the benefits of CSA beyond pilot sites, a structured framework for cross-district collaboration within Nan Province and adjacent regions is required. A detailed roadmap for climate-friendly agribusiness investments in Nan, as outlined in KP5, provides valuable guidance for scaling up successful models and strengthening value chains across the region. However, effective implementation hinges on proactive and sustained engagement with farmers—who often adhere to long-established practices and may be resistant to change. Building trust through ongoing dialogue,

demonstration, and capacity-building is crucial to help farmers recognize that CSA strategies not only safeguard natural resources and reduce environmental degradation but also enhance long-term productivity and resilience.

439. Local government bodies, which are deeply embedded in highland communities, must take an active role in facilitating this transition. As partners and coaches, they can offer consistent support, guide farmers through the process of adopting CSA practices, and ensure that interventions are inclusive, context-sensitive, and sustainable. Their leadership is vital in bridging the gap between policy and practice at the community level.

440. In summary, scaling up CSA in Thailand's highlands demands a comprehensive, multi-pronged approach that includes capacity-building, financial support, improved market access, interagency coordination, and the integration of gender and youth perspectives. Equally important is fostering community-driven development to create a sense of ownership and ensure long-term impact. By addressing these interconnected challenges through cohesive and strategic policy measures, Thailand can accelerate the widespread adoption of CSA and build more resilient, productive, and environmentally sustainable agricultural systems.

441. While each CSA practice has its own limitations, many can still be tailored and applied to other highland agricultural areas where appropriate. However, before scaling up implementation, it is critical to understand local farming cultures and conduct detailed assessments of each region's environment, topography, and the climate-related challenges farmers face. Only with this foundation can the most suitable CSA practices be identified and applied effectively, ensuring both local relevance and long-term viability.