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# Avocado Model: Toward Sustainable Economic Forest Development in Highland Areas

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**Abstract**

Avocado (Persea americana Mill.) is an increasingly significant economic crop in Thailand, cultivated on more than 50,000 rai[1] predominantly in highland areas of northern Thailand, yet domestic production remains insufficient to meet demand. Highland farming communities face structural challenges, including prolonged monoculture dependence, climate variability, and limited access to quality germplasm and production technology. This paper presents the outcomes of the project "Extension of Safe Avocado Production Technology toward Sustainability in Highland Areas," funded by the Agricultural Research Development Agency (ARDA) for fiscal years 2024-2025. Implemented by the Department of Agriculture and a multi-institutional network across six northern provinces (Phetchabun, Phitsanulok, Tak, Mae Hong Son, Nan, and Uttaradit), the project comprised five core activities: (1) technical plan development; (2) establishment of superior varieties collection plots; (3) production of quality planting material; (4) technology dissemination to farmers; and (5) monitoring and evaluation. Quantitative outcomes included the establishment of 6 learning centers (18 rai), collection plots of more than 30 varieties, production of 15,000 grafted seedlings and 1,500 disease-free rootstocks, and training of 2,700 farmers across six provinces, covering a total cultivation area of 52 rai, comprising six community cooperative orchards and 46 mixed-cropping plots, of which 40 plots received Good Agricultural Practice (GAP) certification. Qualitative outcomes demonstrated a yield increase from 114 to 250–7,500 kg/rai, a price increase from THB 15–30 to THB 50–120/kg, and a reduction in pest and disease incidence exceeding 50%. The project contributed to forest encroachment reduction, sustainable land use, and achievement of multiple Sustainable Development Goals (SDGs 12, 13, 15, and 17). Key challenges included climate variability, sociocultural diversity among highland ethnic groups, and market uncertainty. Recommendations include the formulation of a national avocado strategy, the establishment of the Thailand Highland Avocado Standard (THAS), and continued investment in research and network development.

**Introduction**

Avocado has been designated as "green gold" owing to its exceptional nutritional composition and substantial economic value. In 2022, the global avocado market was valued at approximately USD 15.83 billion, with projections indicating an increase to USD 26.04 billion by 2030, reflecting a compound annual growth rate (CAGR) of 7.4% for the period 2023-2030. Fresh avocado products accounted for the highest market share at 78.1% in 2022. The primary drivers of market expansion include growing consumer demand for health-promoting food products (Grand View Research, 2023). In Thailand, avocado is cultivated on more than 50,000 rai (approximately 8,000 hectares), predominantly in the northern and northeastern regions, producing no fewer than 10,000 metric tons valued at approximately THB 360 million. Nevertheless, domestic production remains insufficient to meet local demand, necessitating imports exceeding 50,000 metric tons valued at over THB 300 million. Thailand's avocado export volume remains modest at approximately THB 180,000 (Freshela, 2025). Thailand currently exports fresh, chilled, and frozen avocado to several countries, including Hungary, Macau, Bhutan, Romania, the United Arab Emirates, and Singapore. Avocado emerged as a prominent Thai export commodity in 2024, exhibiting high growth rates and export share (Department of International Trade Promotion, 2024).

As avocado has become a preferred fruit among health-conscious consumers and domestic supply consistently falls short of demand, the cultivated area has expanded by more than 100% in recent years. Its classification as a perennial evergreen tree, combined with its adaptability across diverse agro-ecological zones, genetic diversity among varieties suitable for specific highland or lowland environments, high yield potential and economic returns, variability in fruit size and flavor, and year-round production capability make avocado an ideal candidate for cultivation as an economic crop to replace monoculture systems. This is particularly relevant for highland areas in northern Thailand, which face structural challenges including prolonged dependence on monoculture farming. Climate change and price volatility have exposed farmers to substantial financial risk, with maize producers typically earning net incomes below THB 3,000 per rai. Under drought, flood, or pest outbreak conditions, net income may turn negative, driving further encroachment into forested areas to expand cultivated land. Moreover, post-harvest burning of crop residues during the dry season has been identified as a contributing factor to PM2.5 particulate matter pollution, which directly affects public health and inflicts incalculable economic damage on the tourism sector.

Despite its potential, avocado production in Thailand is constrained by genetic variability arising from seed propagation, resulting in non-standardized fruit quality. Farmers also face deficits in quality production knowledge, particularly regarding varieties selection appropriate to specific localities and seasonal market demands, limited access to superior germplasm, vegetative propagation techniques, disease and pest management, and pre- and post-harvest management. These challenges are compounded by the illicit import of substandard produce, which undermines consumer confidence and domestic price stability, as well as the lack of private sector linkages to absorb future market supply. Accelerating the dissemination of superior germplasm and quality production technology is therefore essential to enable farmers to produce market-grade avocado, enhance economic competitiveness, reduce imports, increase exports, and generate stable long-term income while contributing to economic forest creation, ecological balance, the Sustainable Development Goals (SDGs), disease and pest reduction, decreased agrochemical use, and soil and water conservation. To support community-level adoption, six community cooperative orchards were established in schools and temples across five provinces (excluding Uttaradit), alongside 46 mixed-cropping plots covering a total area of 52 rai across all six provinces, of which 40 plots achieved Good Agricultural Practice (GAP) certification for safe crop production quality.

In response, the Department of Agriculture, through the Office of Agricultural Research and Development Region 2 and its network partners - including the Tak Agricultural Research and Development Center, Phetchabun Agricultural Research and Development Center, Uttaradit Agricultural Research and Development Center, Nan Agricultural Research and Development Center, Mae Hong Son Agricultural Research and Development Center, Phetchabun Highland Agricultural Research Center (under the Institute of Horticultural Research), the Department of Agricultural Extension, the Highland Research and Development Institute (HRDI), Faculty of Agriculture at Kasetsart University (Kamphaeng Saen Campus), Thai Avocado Entrepreneur Association, Rakpasak Foundation, Phetchabun Farmers Council, Sub-district Administrative Organizations, community enterprises, and farmer networks - implemented the project "Extension of Safe Avocado Production Technology toward Sustainability in Highland

Areas." This project received research funding from the Agricultural Research Development Agency (Public Organization) (ARDA) under the Research Utilization (RU) Work Plan for Fiscal Years 2024-2025, conducted from 1 May 2024 to 30 April 2026.

This study therefore aimed to: (1) develop technical plans for superior varieties propagation, disease-free rootstock production, and integrated cropping systems appropriate to highland conditions; (2) establish superior avocado varieties collection plots as regional germplasm repositories; (3) produce and distribute quality grafted seedlings and disease-free rootstocks; (4) disseminate production technology to farmers and extension officers across six northern provinces through training, demonstration plots, community cooperative orchards, and market network linkages; and (5) monitor and evaluate project outcomes to assess the scalability and sustainability of the Avocado Model as a vehicle for highland economic forest development.

**Related Literature**

A growing body of literature examines avocado production sustainability, agricultural technology dissemination, and smallholder farmer adoption in both global and Thai contexts. Salazar-García et al. (2021) investigated the ecological and human dimensions of avocado expansion in Mexico, demonstrating that supply-chain sustainability requires coordinated governance across producer communities, markets, and regulatory systems - a finding directly applicable to Thailand's highland avocado development trajectory. On disease management, Ramírez-Gil et al. (2020) proposed an integrated approach to controlling root rot caused by Phytophthora cinnamomi in Hass avocado crops, confirming that multi-component management combining chemical, biological, and cultural methods significantly reduces disease incidence - a challenge equally critical in highland Thailand. Extending this work, Ramírez-Gil et al. (2022) validated technologies and evaluated the technological level in avocado production systems using a value-chain approach, emphasizing that systematic technology validation is essential for translating research outputs into farmer-adoptable practices.

On the relationship between avocado cultivation and rural livelihoods, Seid et al. (2024) demonstrated that homegarden-based improved avocado cultivation in highland Ethiopia contributed significantly to income diversification and household food security, providing empirical support for the Avocado Model's premise that avocado is an effective livelihood crop for smallholder highland communities. In the Thai context, Limpamont et al. (2024) examined agricultural technology adoption challenges in the agri-food industry, finding that innovation support structures, extension networks, and institutional linkages are critical determinants of successful technology uptake among smallholders.

Within the Thai academic literature, several studies address closely related themes. Nuangklin et al. (2024) investigated factors influencing avocado farmers' adoption of Good Agricultural Practice (GAP) standards in Phop Phra District, Tak Province - the same operational area as the present project - finding that training frequency, labor availability, and land tenure were the principal determinants of GAP adoption, underscoring the importance of targeted training programs. Hongboonmee and Bunsaoad (2023) developed a smartphone-based avocado species classification system using deep learning, demonstrating that digital tools can support accurate and accessible variety identification for highland farmers and extension workers in Thailand. Meechoovet and Siriwato (2023) examined the impacts of smart agriculture on Thai farmers, concluding that participatory training, demonstration sites, and farmer-to-farmer knowledge transfer are more effective than technology-only approaches in promoting sustainable agricultural transitions - a finding that validates the curriculum design of the present project. Kamondetdacha and Janhom (2022) analyzed the dynamics of participatory guarantee systems (PGS) in Nan Province agricultural communities, finding that university-community partnerships and inclusive governance structures significantly strengthen farmers' capacity to achieve quality certification - directly relevant to the project's GAP certification activities. Finally, Pradain et al. (2025) examined sustainable innovation in highland Arabica coffee communities in northern Thailand, demonstrating that community-based business model innovation combined with identity branding enhances both market competitiveness and ecological conservation - a parallel trajectory to the Avocado Highlands brand established under the present project.

**Theoretical Framework**

**1. Diffusion of Innovations Theory (Rogers, 2003)**

The Diffusion of Innovations Theory, developed by Everett M. Rogers (2003), provides the primary theoretical basis for this project. The theory explains how new ideas, practices, and technologies spread through social systems over

time via defined communication channels. Rogers identified five categories of adopters-innovators, early adopters, early majority, late majority, and laggards-each differing in their readiness to accept change. The theory emphasizes that successful technology transfer is not merely a matter of providing information, but requires attention to perceived relative advantage, compatibility with existing practices, complexity, trialability, and observability of the innovation. In the context of highland avocado production, this framework guided the project's strategy of training master trainers, establishing demonstration plots, and building farmer networks to accelerate the adoption of quality production technology across diverse communities.

**2. Sustainable Livelihoods Framework (DFID, 1999)**

The Sustainable Livelihoods Framework (SLF), developed by the UK Department for International Development (DFID, 1999), conceptualizes rural livelihoods as dependent on five categories of capital assets: human capital (skills and knowledge), social capital (networks and trust), natural capital (land, water, and biodiversity), physical capital (infrastructure and tools), and financial capital (income and savings). A livelihood is considered sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation without undermining the natural resource base. This framework is directly applicable to the highland avocado development context, where improving human capital through farmer training, strengthening social capital through network formation, and restoring natural capital through agroforestry practices collectively contribute to more resilient and sustainable agricultural livelihoods for highland communities.

**3. Agroforestry and Economic Forest Theory**

Agroforestry is defined as a land-use management system in which trees or shrubs are grown around or among crops or pastureland, creating a more diverse, productive, profitable, healthy, and sustainable land-use system (Nair, 1993). The economic forest concept extends this principle by selecting tree species that deliver dual benefits: ecological services (carbon sequestration, watershed protection, soil stabilization, and biodiversity conservation) alongside commercially viable yields. Avocado, as a perennial evergreen species with a deep root system and dense canopy, fulfills both criteria. Its cultivation in highland agroforestry systems replaces erosion-prone monoculture fields, reduces the incidence of harmful agricultural burning, and contributes to landscape-scale forest recovery-all while generating substantially higher net returns than conventional field crops such as maize. This dual functionality underpins the concept of the "Avocado Model" as a vehicle for sustainable highland economic forest development.

**4. Participatory Extension and Community-Based Development**

Participatory extension approaches recognize that sustainable agricultural development cannot be achieved through top-down technology transfer alone. Drawing from Freire's (1970) pedagogy of empowerment and Chambers' (1994) participatory rural appraisal methodology, this approach positions farmers as active knowledge co-producers rather than passive recipients. Community-based development theory further emphasizes that lasting behavioral change and resource management practices emerge when communities are meaningfully engaged in planning, implementation, and monitoring processes. In this project, these principles were operationalized through the training of farmer-to-farmer instructors, the establishment of community cooperative orchards, the co-creation of model farms, and multi-stakeholder roundtable discussions, ensuring that technology uptake is contextually appropriate, culturally sensitive, and locally owned.

**Conceptual Framework**

The conceptual framework of this study integrates the four theoretical perspectives described above into a logical input-process-output-outcome model tailored to the highland avocado development context (Figure 1). The framework consists of four interconnected components:

**Inputs:** Research funding (ARDA), institutional networks, superior germplasm, scientific knowledge, extension personnel, and community participation constitute the foundational resources that enable project implementation.

**Processes:** Technology development and validation, participatory training, demonstration plot establishment, germplasm production and distribution, market network formation, and quality certification processes-operationalized through the five project activities-constitute the core intervention mechanisms.

**Outputs:** Measurable deliverables including trained farmers and instructors, superior seedlings and rootstocks produced and distributed, learning centers and demonstration plots established, field day events organized, and marketing networks formed represent the direct products of project activities.

**Outcomes and Impacts:** Short-term outcomes include increased farmer knowledge and adoption of quality production technology; medium-term outcomes encompass yield improvement, price enhancement, and income growth; long-term impacts address forest encroachment reduction, ecological restoration, PM2.5 mitigation, and contribution to SDGs 12, 13, 15, and 17-representing the ultimate goal of sustainable highland economic forest development.

Underpinning all four components are two cross-cutting enabling conditions: (1) multi-stakeholder partnership and institutional collaboration, reflecting SDG 17; and (2) contextual adaptation to the sociocultural and agroecological diversity of highland communities. These enabling conditions are essential for ensuring that the innovation diffusion process (Rogers, 2003) is both technically sound and socially legitimate, and that livelihood improvements (DFID, 1999) are equitable and durable. The integrated logic of these components is illustrated in Figure 1.

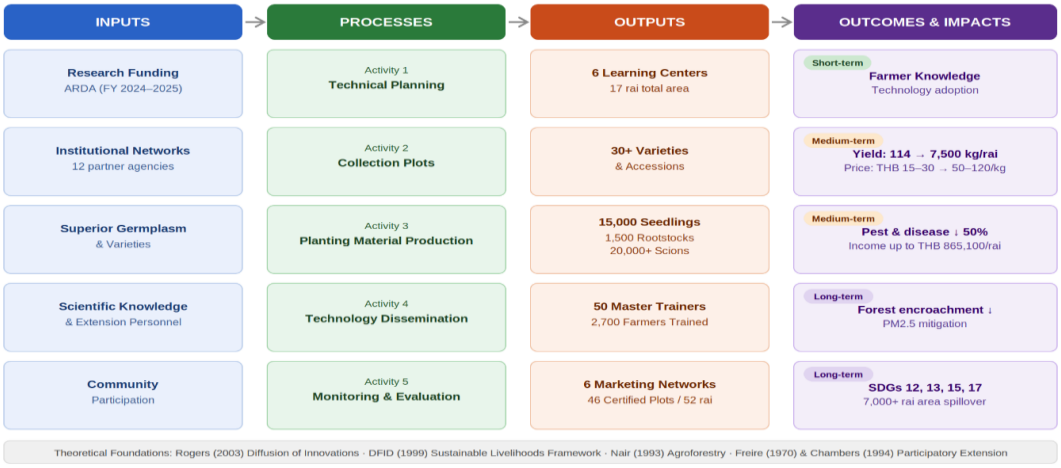


*Figure 1. Conceptual Framework: The Avovado Model for Sustainable Highland Economic Forest Development*

The project targeted highland farming communities across six provinces: (1) Khao Kho, Nam Nao, and Lom Kao districts, Phetchabun Province; (2) Chat Trakan, Nakhon Thai, and Noen Maprang districts, Phitsanulok Province; (3) Phop Phra, Mae Sot, Tha Song Yang, and Mae Ramat districts, Tak Province; (4) Pai, Khun Yuam, Pang Mapha, Mae Sariang, and Sop Moei districts, Mae Hong Son Province; (5) Pua, Mueang, Chiang Klang, and Mae Charim districts, Nan Province; and Tha Pla, Laplae, Fak Tha, and Nam Pat districts, Uttaradit Province. The project was structured under five core activities:

1. Development of technical plans encompassing: superior varieties propagation; volunteer standardization initiatives for disease-free rootstock production; crown rot control techniques; integrated cropping systems appropriate to highland conditions; and establishment of quality avocado production learning centers at research station sites.
2. Establishment of superior avocado varieties collection plots at the Tak Agricultural Research and Development Center and the Phetchabun Agricultural Research and Development Center.
3. Production of superior avocado planting material at the Tak Agricultural Research and Development Center (Phop Phra Horticultural Experiment Station unit) and production of disease-free rootstock at the tissue culture laboratory, Department of Horticulture, Kasetsart University (Kamphaeng Saen Campus).
4. Technology dissemination was carried out across six provinces through a series of interconnected activities. Master trainers and farmers received practical training in avocado orchard management, with the curriculum designed around 30% theory and 70% hands-on application. Integrated mixed-cropping systems with avocado as the primary crop were established in accordance with local conditions, while community cooperative orchards were set up in shared community spaces such as temples, schools, and public utility areas. Model plots and model farmers were designated within communities to serve as local reference points for quality production. Avocado Field Day events were organized to inspire and motivate farmers toward quality improvement, and participating farmers were supported in obtaining safe crop production certification and connecting to marketing networks.
5. Monitoring and Evaluation, conducted throughout the project period to assess progress

against targets and ensure quality of implementation. This activity encompassed field visits to all six provinces, data collection on farmer knowledge acquisition, technology adoption rates, yield and price outcomes, and incidence of pests and diseases. Findings were used to guide adaptive management decisions, address implementation challenges, and document best practices for future replication and scaling.

**Empirical Results**

The project established the institutional and biological infrastructure necessary to sustain highland avocado development beyond the immediate project period. Six quality production learning centers were created within research stations across all six target provinces, encompassing 18 rai of demonstration land, with the largest center located at the Tak Agricultural Research and Development Center (Phop Phra Horticultural Experiment Station) at 8 rai. Complementing these learning sites, superior varieties collection plots containing more than 30 avocado varieties and accessions were established at two locations in Tak Province and one in Phetchabun Province, collectively functioning as germplasm repositories, varieties verification centers, and continuous sources of quality planting material. From these foundations, the project produced 15,000 superior varieties grafted seedlings through commercial varieties top-working, 1,500 disease-free rootstock plants via tissue culture at Kasetsart University, and more than 20,000 superior budwood scions - inputs whose significance lies not merely in their quantity but in their role as the biological capital through which quality can be systematically reproduced across the region.

Technology dissemination reached its intended scale through a structured train-the-trainer approach. Fifty extension officers and model farmers completed the master trainer curriculum and became qualified local agricultural instructors, while 2,700 farmers across six provinces received practical training in top-working propagation, pruning, crown rot management, and pre- and post-harvest techniques. Field-level technology adoption was documented across more than 73 rai, with each trained farmer receiving material support in the form of superior seedlings, disease-free rootstocks, or budwood scions to enable immediate application. The curriculum design - allocating 30% to theory and 70% to practical application - reflects a deliberate alignment with the participatory extension principles of Freire (1970) and Chambers (1994), recognizing that procedural competence in tasks such as cleft grafting cannot be transmitted through lecture alone but must be acquired through guided, supervised practice. The practical, hands-on nature of this approach is illustrated in Figure 2.

*Figure 2. Project officer demonstrating cleft-grafting technique to highland students during a hands-on training session*

Beyond individual farmer training, the project pursued community-level integration through three complementary mechanisms. First, 46 integrated mixed-cropping plots totaling 52 rai were established across all six provinces, demonstrating avocado as a primary crop within diversified systems rather than as an additional monoculture. Second, six community cooperative orchards totaling 6 rai were co-located in community anchor institutions - schools, a church, and a Royal Forestry Department permitted-use plot - embedding the Avocado Model within existing structures of communal trust and daily life. Third, six community model

farms were designated across six provinces as research and learning sites for location-specific production technology, each serving simultaneously as a proof-of-concept visible to neighboring farmers and as a node in the broader knowledge network. Figure 3 illustrates one such community cooperative orchard established at a highland school in Tak Province.

*Figure 3. Students from Ruam Thai Pattana School, Ruam Thai Pattana Sub-district, Phop Phra District, Tak Province, visiting the learning center demonstration plot at Phop Phra Horticultural Experiment Station as part of the community cooperative orchard program.*

The dissemination infrastructure was brought to public attention through two major technology transfer events. The first, held at Robinson Lifestyle Shopping Center in Mae Sot, Tak Province (29-30 August 2024), drew 572 participants against a target of 500. The second, the Emerald Avocado of the Highland event at the Phetchabun Highland Agricultural Research Center (8-10 August 2025), attracted 1,075 participants - more than double the target - demonstrating the genuine market demand for quality highland avocado knowledge. Six marketing networks were established as direct outcomes of these events. Forty-six mixed-cropping farmer plots, with a total cultivation area of 52 rai, entered the safe crop production quality certification process, anchoring the Avocado Model's market proposition in verifiable standards rather than informal claims. At the regional level, the 1st ASEAN Avocado Seminar, convened in Mae Sot, and a multi-stakeholder roundtable at the World Horticultural Center in Chiang Mai collectively signaled the project's aspiration to position Thai highland avocado within an international quality landscape. The scale of public engagement achieved through these field events is depicted in Figure 4.


*Figure 4. Department of Agriculture exhibition booth at the Avocado Field Day, Khao Kho District, Phetchabun Province, August 2025*

At the farm level, outcomes were substantive across multiple dimensions. Farmer satisfaction with knowledge acquisition and practical benefit from project participation was reported as high to very high by 97.4% of respondents, with more than 80% indicating direct application of acquired techniques. Agronomically, the incidence of crown and root rot, thrips, and stem-boring caterpillars - historically among the most damaging constraints to highland avocado productivity - declined by more than 50%. Yield gains were commensurate with tree maturity: five-year-old trees reached 250 kg/rai compared to a baseline of 114 kg/rai, while ten-year-old orchards produced up to 7,500 kg/rai, demonstrating the long-term productivity trajectory that the Avocado Model promises to participating farmers. Market prices correspondingly improved from the pre-project range of THB 15-30/kg to THB 50-120/kg, reflecting both improved fruit quality and the strengthened market linkages fostered by the project. With production costs ranging from THB 6,690 to 8,450/rai/year, net returns at years five to ten ranged from THB 2,600 to 865,100/rai depending on price level, providing farmers with an economically meaningful alternative to maize income cycles that have historically offered little protection against climate or market shocks. The quality of fruit achieved under project-supported management is demonstrated in Figure 5.


*Figure 5. Opening ceremony of the Emerald Avocado of the Highland Festival (8–10 August 2025) at the Phetchabun Highland Agricultural Research Center, organized by the Department of Agriculture to showcase highland avocado quality and strengthen market networks.*

The project's impacts extended well beyond its direct participants. During 2024-2025, 750 farmers and extension officers visited the demonstration sites as study and technology transfer venues, while 5,700 superior seedlings and 15,000 superior scions were distributed to farmers and agencies outside the project perimeter. Community-level models emerged demonstrating reduced forest encroachment, decreased monoculture cultivation, improved soil and water conservation, and enhanced economic security through high-value avocado production - outcomes that collectively operationalize the ecological dimension of the Avocado Model. Spillover adoption resulted in avocado cultivation area expansion of more than 7,000 rai beyond direct project sites, representing a concrete, measurable transition toward sustainable agricultural production ecosystems. The institutional engagement behind these outcomes is captured in Figure 6. New occupational groups - including 65 superior seedling and rootstock producers, 38 scion and seed sellers, and 7 avocado product processors - emerged as evidence of value-chain deepening that extends the project's economic logic beyond the farm gate. The establishment of the "Avocado Highlands" (Avocado Maragot Haeng Khun Khao) brand, communicating the narrative of indigenous communities and forest conservation, offers a differentiation strategy that may command premium prices in domestic and export markets while advancing SDGs 12 (Responsible Consumption and Production), 13 (Climate Action), 15 (Life on Land), and 17 (Partnerships for the Goals).

*Figure 6. Multi-institutional project team conducting a site visit to the model farmer's mixed-cropping plot in Phetchabun Province, demonstrating inter-agency collaboration in supporting highland avocado development.*

**Challenges and Operational Complexity**

The implementation of the Avocado Model across the diverse agro-ecological and sociocultural landscape of six highland provinces exposed a set of structural challenges whose significance extends beyond operational inconvenience to fundamental questions about the model's scalability and resilience. The most acute challenge was climatic: rainfall fluctuation and natural disasters created unpredictable disruptions to crop development, forecasting, and logistics throughout the project period. Major flooding in late 2024, caused by Typhoons Yagi and Sulik, resulted in plant uprooting, weakening, slow recovery, and elevated incidence of root rot across multiple sites (GISTDA, 2024) - a stark reminder that agronomic excellence offers no protection against hydro-meteorological shocks that are increasing in frequency and intensity under climate change. Compounding this environmental vulnerability, individual avocado varieties have distinct climatic requirements that necessitate context-specific selection decisions rather than province-wide standardization. Disease and pest management was further complicated by monoculture crops surrounding demonstration plots, which elevated the risk of crown rot and other disease outbreaks, while the persistent practice of premature harvesting by some farmers damaged fruit quality and undermined the consumer confidence that quality certification is designed to build.

Market-related constraints present a different but equally fundamental challenge. Avocado requires three to five years to reach productive age, and this extended payback period creates liquidity constraints that can force farmers to abandon the transition before realizing returns - precisely the opposite of the behavioral change the project intended to catalyze. Market access remains heavily mediated by intermediaries, limiting farmers' price negotiation power and exposing them to the volatility that undermines the income security the Avocado Model promises. These market-side vulnerabilities intersect with technology adoption barriers rooted in farmers' rational risk aversion: transitioning from familiar crops to avocado requires accepting short-term uncertainty in exchange for medium-term returns and building the trust necessary to motivate that transition was identified by field teams as a critical and time-intensive success factor. Finally, the sociocultural diversity of highland areas - comprising distinct ethnic communities with different languages, belief systems, and traditional agricultural practices - required differentiated communication strategies that could not always be delivered within the standardized training frameworks that the project's scale demanded.

**Recommendations**

The evidence generated by this project points to three interconnected priorities that must be addressed if the Avocado Model is to fulfill its

potential as a vehicle for sustainable highland economic forest development. The most urgent is the formulation of a comprehensive national avocado development strategy that targets the expansion of highland avocado cultivation to 10,000 rai within five years and establishes the institutional architecture needed to support that expansion. This strategy should encompass a national disease-free rootstock program to secure the biological foundation of quality production; the establishment of the Thailand Highland Avocado Standard (THAS) to provide the quality certification framework through which market premiums can be consistently achieved; income support mechanisms for farmers during the critical pre-productive period when liquidity constraints are highest; investment in processing facilities and highland-specific market infrastructure to reduce dependence on intermediaries; expanded partnerships with financial institutions to improve smallholder access to agricultural credit; and the formation of large-scale avocado grower networks and associations that can sustain the collective knowledge and market coordination functions that individual farmers cannot achieve alone.

The second priority is sustained investment in research, human resource development, and inter-institutional collaboration. The technical knowledge generated by this project - on varieties performance, grafting protocols, disease management, and location-specific production systems - represents a public good whose value depreciates rapidly if it is not continuously renewed, refined, and disseminated. Systematic planning for model farmer development, combined with national and international academic engagement through avocado research conferences, would anchor Thailand's emerging highland avocado industry within the global knowledge ecosystem from which it can draw technical and market intelligence. The 1st ASEAN Avocado Seminar demonstrated the appetite for this kind of regional dialogue; building on it requires institutional commitment rather than episodic project funding.

The third priority is deliberate planning for post-project continuity. The most durable risk facing the Avocado Model is not agronomic or climatic but institutional: the tendency for well-designed development interventions to dissipate when the funding cycle ends, and the project team disperses. Continuity requires governance mechanisms - within community enterprises, farmer associations, and local administrative bodies - that can maintain the orchards, networks, and quality standards the project established. It requires expansion strategies that bring the model to neighboring areas and to provinces with demonstrable production potential, using the learning centers and model farms established by this project as diffusion nodes rather than endpoints. And it requires an evaluation framework capable of tracking not just output indicators but the resilience, equity, and adaptive capacity of the livelihood systems the project has helped build - the criteria by which the Sustainable Livelihoods Framework ultimately judges whether development has been achieved.

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