ECONOMIC FEASIBILITY STUDY REPORT ON BLOCKCHAIN-BASED PARAMETRIC CROP INSURANCE IN THAILAND

Output 5

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LIST OF ACRONYMS

ADB	Asian Development Bank
AML	anti-money laundering
AIS	Advanced Info Service (Thai telecom provider)
API	application programming interface
ATP	ability to pay
AWS	Amazon Web Services
BAAC	Bank for Agriculture and Agricultural Cooperatives
BBPCI	blockchain-based parametric crop insurance
BBPI	blockchain-based parametric insurance
DTAC	Total Access Communication Public Company Limited (Thai mobile phone company)
ETA	Electronic Transactions Act
FGD	focus group discussions
GCP	Google Cloud Platform
GDP	gross domestic product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (development agency of Germany)
ID	identification document
IoT	internet of things
IT	information technology
KYB	know-your-business
KYC	know-your-customer
MOAC	Ministry of Agriculture and Cooperatives
NCIF	National Climate Insurance Framework
NDID	national digital id
NXPO	National Science and Technology Policy Office
OIC	Office of Insurance Commission
PII	personally identifiable information
PDPA	Personal Data Protection Act
PPP	public-private partnership
ROI	return on investment
SIM	subscriber identity/identification module
SMS	short message service

TGIA	Thai General Insurance Association
THB	Thailand baht
TMD	Thai Meteorological Department
TNCIS	Thailand National Crop Insurance Scheme
UNDP	United Nations Development Programme
USD	United States dollar
USSD	unstructured supplementary service data
VAT	value-added tax
WTP	willingness to pay

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EXECUTIVE SUMMARY

This economic feasibility study assesses the viability of introducing a Blockchain-Based Parametric Crop Insurance (BBPCI) system in Thailand. The initiative aims to fill a critical protection gap in Thailand's agriculture sector, which remains highly vulnerable to climate-induced risks such as floods, droughts, and extreme weather. The BBPCI system combines blockchain technology with parametric insurance models to offer transparent, automated, and scalable insurance coverage for smallholder farmers—particularly women—who are often excluded from traditional financial systems.

The study is structured around four core activities: defining the business model (Activity 5.1), assessing economic demand and pricing (Activity 5.2), estimating development and operational costs (Activity 5.3), and conducting a full cost-revenue analysis (Activity 5.4). Research draws on farmer surveys, stakeholder interviews, financial modelling, and integration with the technical feasibility study.

Key findings show high interest among farmers (85%) in the BBPCI model, with a strong willingness to pay premiums ranging from THB 30-60/rai (USD 0.90-1.80), especially when supported by government subsidies. The break-even point is estimated at 6,200-7,000 active users, with the potential to scale sustainably through public-private partnerships. The business model also benefits from positive externalities and economies of scale, reinforcing the case for public and donor co-financing. With an emphasis on inclusion and externalities, the table below summarizes the key risks and mitigations, synthesizing potential disruptions and strategies, drawing from the disclaimer, economic implications, limitations, and recommendations, while acknowledging broader socio-economic benefits like reduced relief dependency.

Risk category	Description	Potential impact	Mitigation strategies
Gender exclusion	Women farmers face barriers to land, credit, and digital tools.	Increased poverty and inequality; reliance on relief.	Gender-responsive mobile platforms, literacy programs, and a ≥50% women participation target.
Ethnic/migrant exclusion	Minorities/migrants excluded due to language/documentation issues.	Social tensions, migration, and unequal risk sharing.	Multilingual platforms, NGO partnerships, and inclusive outreach.
Regulatory/political changes	Legal shifts in blockchain/crypto regulations.	Delays, higher compliance costs, and subsidy disruptions.	Align with EU/UK standards; engage regulators (OIC sandbox).
Trust deficits	Low trust from past insurance delays and opacity.	Reduced uptake (13-16% insured); institutional distrust.	Blockchain for transparency, smart contracts, and cooperative engagement.
Market failure	Under the provision of resilience as a public good.	Inequities, migration, and relief dependency.	Subsidies; PPPs with donors (e.g., GIZ); scale via TNCIS.
Operational disruptions	Cyberattacks or force majeure impacting the platform.	Distrust; exclusion of vulnerable groups.	Decentralized oracles, cybersecurity, and feedback loops.

BBPCI’s architecture addresses long-standing issues of information asymmetry, high transaction costs, and trust deficits in traditional insurance systems. Smart contracts automate payouts based on verifiable weather data, while decentralized oracles enhance transparency and reduce moral hazard. Gender-responsive features and mobile-enabled onboarding mechanisms further support equitable access and financial inclusion.

Strategically aligned with Thailand’s national plans on digital transformation, agriculture modernization, and climate adaptation, BBPCI presents a viable, socially impactful solution to build resilience in rural economies.

บทสรุปผู้บริหาร

การศึกษาความเป็นไปได้ทางเศรษฐกิจนี้ประเมินความเหมาะสมในการนำระบบประกันภัยพืชผลแบบพาราเมตริกที่ใช้บล็อกเชน (BBPCI) มาใช้ในประเทศไทย โดยมีเป้าหมายเพื่อเติมเต็มช่องว่างด้านการคุ้มครองที่สำคัญในภาคการเกษตรของไทย ซึ่งยังคงมีความเปราะบางต่อความเสี่ยงจากสภาพภูมิอากาศ เช่น น้ำท่วม ภัยแล้ง และสภาพอากาศสุดขั้ว ระบบ BBPCI ผสานเทคโนโลยีบล็อกเชนเข้ากับโมเดลประกันภัยแบบพาราเมตริก เพื่อมอบความคุ้มครองที่โปร่งใส อัตโนมัติ และปรับขนาดได้ให้แก่เกษตรกรรายย่อย โดยเฉพาะผู้หญิง ซึ่งมักถูกกีดกันจากระบบการเงินแบบดั้งเดิม

การศึกษานี้ประกอบด้วยกิจกรรมหลัก 4 ด้าน ได้แก่ การกำหนดรูปแบบธุรกิจ (กิจกรรม 5.1), การประเมินความต้องการทางเศรษฐกิจและการตั้งราคา (กิจกรรม 5.2), การประมาณต้นทุนการพัฒนาและการดำเนินงาน (กิจกรรม 5.3), และการวิเคราะห์ต้นทุน-รายได้อย่างครบถ้วน (กิจกรรม 5.4) โดยใช้ข้อมูลจากการสำรวจเกษตรกร การสัมภาษณ์ผู้มีส่วนได้ส่วนเสีย การสร้างแบบจำลองทางการเงิน และการบูรณาการกับการศึกษาความเป็นไปได้ทางเทคนิค

ผลการศึกษาพบว่าเกษตรกรมีความสนใจสูง (85%) ต่อโมเดล BBPCI และมีความเต็มใจที่จะจ่ายเบี้ยประกันภัยในช่วง 30-60 บาทต่อไร่ โดยเฉพาะเมื่อได้รับการสนับสนุนจากรัฐบาล จุดคุ้มทุนของโครงการอยู่ที่ประมาณ 6,200–7,000 ผู้ใช้งานที่ใช้งานจริง และมีศักยภาพในการขยายอย่างยั่งยืนผ่านความร่วมมือระหว่างภาครัฐและเอกชน โมเดลธุรกิจยังได้รับประโยชน์จากผลกระทบภายนอกเชิงบวกและเศรษฐกิจของขนาด ซึ่งช่วยเสริมความชอบธรรมในการร่วมลงทุนจากภาครัฐและผู้ให้ทุน

โดยเน้นความครอบคลุมและผลกระทบภายนอก ตารางด้านล่างแสดงและสรุปความเสี่ยงหลักและแนวทางการลดผลกระทบ โดยสังเคราะห์ความเสี่ยงที่อาจเกิดขึ้นและกลยุทธ์การจัดการ โดยอ้างอิงจากข้อจำกัด ผลกระทบทางเศรษฐกิจ ข้อเสนอแนะ และผลประโยชน์ทางสังคมที่กว้างขึ้น เช่น การลดการพึ่งพาความช่วยเหลือฉุกเฉิน

หมวดหมู่ความเสี่ยง	คำอธิบาย	ผลกระทบที่อาจเกิดขึ้น	กลยุทธ์การลดผลกระทบ
การกีดกันทางเพศ	เกษตรกรหญิงเผชิญอุปสรรคในการเข้าถึงที่ดิน เครดิต และเครื่องมือดิจิทัล	ความยากจนและความเหลื่อมล้ำที่เพิ่มขึ้น; การพึ่งพาความช่วยเหลือ	แพลตฟอร์มมือถือที่ตอบสนองต่อเพศ; โปรแกรมการรู้หนังสือ; เป้าหมายการมีส่วนร่วมของผู้หญิง ≥50%
การกีดกันกลุ่มชาติพันธุ์/แรงงานข้ามชาติ	กลุ่มชนกลุ่มน้อย/แรงงานข้ามชาติถูกกีดกันเนื่องจากปัญหาภาษา/เอกสาร	ความตึงเครียดทางสังคม การอพยพ และการแบ่งปันความเสี่ยงที่ไม่เท่าเทียม	แพลตฟอร์มหลายภาษา; ความร่วมมือกับ NGO; การเข้าถึงที่ครอบคลุม
การเปลี่ยนแปลงทางกฎหมาย/การเมือง	การเปลี่ยนแปลงกฎหมายเกี่ยวกับบล็อกเชน/คริปโต	ความล่าช้า ต้นทุนการปฏิบัติตามที่สูงขึ้น และการหยุดชะงักของเงินอุดหนุน	ปรับให้สอดคล้องกับมาตรฐาน EU/UK; มีส่วนร่วมกับหน่วยงานกำกับดูแล (OIC sandbox)
ความไม่ไว้วางใจ	ความไว้วางใจต่ำจากความล่าช้าและความไม่โปร่งใสของระบบประกันภัยในอดีต	การเข้าร่วมลดลง (13–16% มีประกัน); ความไม่ไว้วางใจต่อสถาบัน	ใช้บล็อกเชนเพื่อความโปร่งใส; สัญญาอัจฉริยะ; การมีส่วนร่วมของสหกรณ์
ความล้มเหลวของตลาด	การจัดหาความยืดหยุ่นในฐานะสินค้าสาธารณะที่ไม่เพียงพอ	ความไม่เท่าเทียม การอพยพ และการพึ่งพาความช่วยเหลือ	เงินอุดหนุน; PPP กับผู้ให้ทุน (เช่น GIZ); ขยายผ่าน TNCIS
การหยุดชะงักในการดำเนินงาน	การโจมตีทางไซเบอร์หรือเหตุสุดวิสัยที่ส่งผลต่อแพลตฟอร์ม	ความไม่ไว้วางใจ; การกีดกันกลุ่มเปราะบาง	ออราเคิลแบบกระจายศูนย์; ความปลอดภัยทางไซเบอร์; วงจรป้อนกลับ

สถาปัตยกรรมของ BBPCI มุ่งแก้ไขปัญหาที่มีมายาวนานเกี่ยวกับความไม่สมดุลของข้อมูล ต้นทุนการทำธุรกรรมสูง และความไม่ไว้วางใจในระบบประกันภัยแบบดั้งเดิม โดยใช้สัญญาอัจฉริยะในการจ่ายเงินอัตโนมัติตามข้อมูลสภาพอากาศที่ตรวจสอบได้ และใช้ออราเคิลแบบกระจายศูนย์เพื่อเพิ่มความโปร่งใสและลดความเสี่ยงทางศีลธรรม ฟีเจอร์ที่ตอบสนองต่อเพศและกลไกการลงทะเบียนผ่านมือถือช่วยสนับสนุนการเข้าถึงอย่างเท่าเทียมและการรวมทางการเงิน

BBPCI สอดคล้องเชิงกลยุทธ์กับแผนระดับชาติของประเทศไทยด้านการเปลี่ยนผ่านสู่ดิจิทัล การพัฒนาเกษตรกรรม และการปรับตัวต่อสภาพภูมิอากาศ โดยนำเสนอทางเลือกที่มีความเป็นไปได้และส่งผลกระทบทางสังคมในการเสริมสร้างความยืดหยุ่นให้กับเศรษฐกิจชนบท

1 INTRODUCTION

This report presents the economic feasibility study for the implementation of a Blockchain-Based Parametric Crop Insurance (BBPCI) system in Thailand. The proposed initiative aims to address long-standing gaps in agricultural insurance coverage, particularly among smallholder farmers who face disproportionate vulnerability to climate-related shocks. A special focus is placed on women farmers, who often experience compounded barriers in accessing financial services, digital tools, and land rights.

By introducing a transparent, efficient, and inclusive insurance mechanism, the BBPCI project seeks to strengthen the resilience of Thailand's agricultural sector, a cornerstone of the national economy and rural livelihoods.

From an economic standpoint, agricultural climate resilience exhibits characteristics of a public good, as defined by Paul Samuelson (1954)—it is non-excludable (once a region is made more resilient, all benefit) and non-rivalrous (one farmer's use of risk mitigation tools does not diminish others' access). Furthermore, the widespread adoption of parametric insurance can produce positive externalities, a concept formalized by Arthur Pigou (1920). These externalities include reduced dependency on government disaster relief, stabilization of rural incomes, improved food security, and a lower likelihood of climate-induced migration.

Because the private market tends to underprovide goods with positive spillovers due to misaligned incentives and free-rider problems, public subsidies, donor involvement, and PPPs (public-private partnerships) are economically justified to correct this market failure. Subsidizing premiums for smallholder farmers or investing in digital infrastructure (e.g., IoT weather sensors, mobile registration systems) can deliver social returns that exceed private returns, especially when targeting vulnerable groups like women farmers.

In addition, BBPCI contributes to dynamic efficiency by encouraging the long-term adaptation of farming systems to increasing climate variability—aligning with Thailand's national climate resilience goals. This layered benefit structure reinforces the case for integrating BBPCI into broader agricultural policy, sustainability programs, and rural development strategies.

1.1 Sectoral context and rationale

Thailand's agricultural sector contributes approximately 8-10% of the country's gross domestic product (GDP) and provides employment to nearly 30% of the population—primarily through smallholder farming. Despite its economic significance, the sector is increasingly vulnerable to the intensifying impacts of climate change. Annual crop losses from floods, droughts, and erratic weather patterns are estimated to range between 20% and 30%, threatening food security, household incomes, and national economic stability. The 2011 floods alone caused over USD 45 billion in damages, underscoring the urgent need for more resilient financial protection mechanisms.

Current agricultural insurance schemes, such as the Thailand National Crop Insurance Scheme (TNCIS), have achieved moderate success—particularly in rice and maize—but remain limited in reach, diversity, and efficiency. Coverage is often conditional on access to formal credit through institutions like the Bank for Agriculture and Agricultural Cooperatives (BAAC), leaving a significant portion of the agricultural base uninsured. Moreover, indemnity-based models are hampered by delayed payouts, high administrative overheads, and a lack of transparency, which erode farmer trust and discourage uptake.

According to the United Nations Development Programme (UNDP), less than 5% of farmers in flood-prone areas have access to any form of disaster insurance, and insurance literacy remains low, especially in rural regions.

Female farmers, who make up approximately 40% of Thailand's agricultural labour force, face compounded disadvantages due to gender gaps in land ownership, access to credit, digital tools, and insurance literacy. Beyond gender gaps, an intersectional analysis reveals that ethnic minority and hill tribe women farmers concentrated in the Northern and border provinces—face even sharper barriers. These groups often cultivate on communal land without formal title deeds, which restricts access to credit and excludes them from insurance schemes tied to land ownership. Their upland farms are highly exposed to droughts, landslides, and erratic rainfall, yet they lack irrigation and disaster-prepared infrastructure, increasing climate vulnerability. Socioeconomic disadvantages further compound risks: hill tribe women report lower levels of Thai-language literacy, mobile phone ownership, and digital access than ethnic majority farmers, constraining their ability to engage with mobile-based insurance tools. Many also bear a "double burden" of agricultural labour and unpaid household care, limiting their capacity to recover from climate shocks. These intersectional inequities underscore the need for inclusive, locally tailored, and gender-responsive financial protection mechanisms that actively address the vulnerabilities of ethnic minority women farmers.

The UNDP highlights that women are disproportionately affected by climate-related shocks and are often excluded from formal risk financing mechanisms. This is evidenced by the starkly low crop insurance uptake, with only 13 to 16% of surveyed Thai farmers having ever purchased a policy—a figure that plummets to less than 5% in high-risk, flood-prone areas. This protection gap is driven by women's lower levels of digital and financial inclusion, which are exacerbated by persistent gender disparities in land ownership and access to credit.

This vulnerability is significantly compounded for ethnic minority women farmers, who face intersecting barriers of gender, ethnicity, and socioeconomic status. In northern Thailand, women from hill tribes such as the Akha, Lisu, Hmong, and Karen experience a unique convergence of challenges:

- Legal and tenure insecurity: Many lack formal citizenship and land title deeds, with up to 40% of residents in remote northern villages affected. This excludes them from insurance and credit schemes tied to formal land ownership;

- Socio-economic marginalization: Concentrated in fragile, climate-sensitive upland agriculture, these communities of approximately 1.2 million people (11% of the northern population) face high rates of poverty and limited access to decision-making roles; and

- Digital and linguistic barriers: Lower levels of Thai-language literacy and mobile phone ownership, coupled with language issues, constrain their ability to engage with mobile-based insurance tools and access early warnings in areas often devoid of local weather stations.

Globally, indigenous women, including those in Thai hill tribes, experience double discrimination, leading to higher exposure to violence, precarious work, and ecosystem loss. An estimated 70 million people relying on forests and agriculture are now at heightened risk of crop failure and food insecurity due to climate variability, which has already caused annual crop losses of 20 to 30% in vulnerable regions.

Therefore, inclusive insurance products like mobile-based microinsurance and parametric insurance are increasingly recognized as essential tools for building resilience. To be effective for Thailand's most vulnerable farmers, these solutions must be deliberately designed with:

- Multilingual platforms and community-led oracles to ensure local relevance and understanding;
- Simplified, tenure-neutral onboarding processes that do not require formal land titles;
- Targeted subsidies and outreach programs, delivered through trusted community channels; and
- Disaggregated data collection to monitor and address these specific ethnic and gender-based barriers.

This approach is critical to ensure that financial protection reaches those who need it most, transforming a potentially exclusionary innovation into a vehicle for genuine inclusivity and climate justice.

Climate hazard	**Frequency (farmer-reported incidence, past 5 years)**	**Severity (yield loss, income impact)**	**Regional concentration**	**Socio-political impacts**
Droughts	75% of farmers affected (increasing trend, 85% report more frequent events in the last decade)	High severity: 30-50% yield losses, especially for rice and cassava	Most severe in the Northeast (Nakhon Phanom, Ubon Ratchathani)	Health crises and reduced labor productivity (e.g., 20-30% work efficiency loss in extreme heat); socio-political strains from food insecurity (affecting 70% of rural households reliant on rice), potentially sparking demands for worker protections and climate migration policies.
Floods	60% of farmers affected	High severity: crop submergence, 30-50% losses, particularly rice	Central Plains (rice-intensive) and Northern regions	Mass displacement, for example, the 2011 floods displaced millions, costing USD 45 billion; mental health crises, education disruptions, and political instability from uneven aid distribution, amplifying ethnic tensions in multicultural areas and straining government response capacities.
Storms (typhoons, heavy winds)	45% of farmers affected	Moderate-to-high: localized but severe crop and infrastructure damage	Southern provinces (rubber areas) and coastal zones	Infrastructure failures leading to labour disruptions for migrant workers (~2 million in agriculture); political debates over disaster preparedness, with uneven recovery aid fostering social unrest and calls for better coastal governance in vulnerable communities.
Heatwaves	30% of farmers are affected	Moderate: reduces yields in rice and fruit,	Scattered, but increasingly reported nationwide	Reduced labour productivity, for example, 20-30% work efficiency loss in extreme heat; socio-political strains from food insecurity, affecting 70% of rural

Climate hazard	**Frequency (farmer-reported incidence, past 5 years)**	**Severity (yield loss, income impact)**	**Regional concentration**	**Socio-political impacts**
		worsens water stress		households reliant on rice, potentially sparking demands for worker protections and climate migration policies.

Table 1: Climate Risk Matrix: Frequency and Severity of Climate Hazards in Thailand

The matrix table above makes the climate risks clearer for insurance design and pricing by mapping out which hazards are both most frequent and most damaging. The table highlighted the following:

(a) High frequency: Nearly all farmers (99%) experienced at least one climate-related crop loss in the past five years;

(b) Increasing trends: 85% report that events are becoming more frequent compared to the previous decade;

(c) High severity: 80% of respondents rated climate shocks as "very severe," with typical yield losses between 30-50%; and

(d) Regional vulnerability: Drought dominates the Northeast, floods the Central Plains/North, and storms the South.

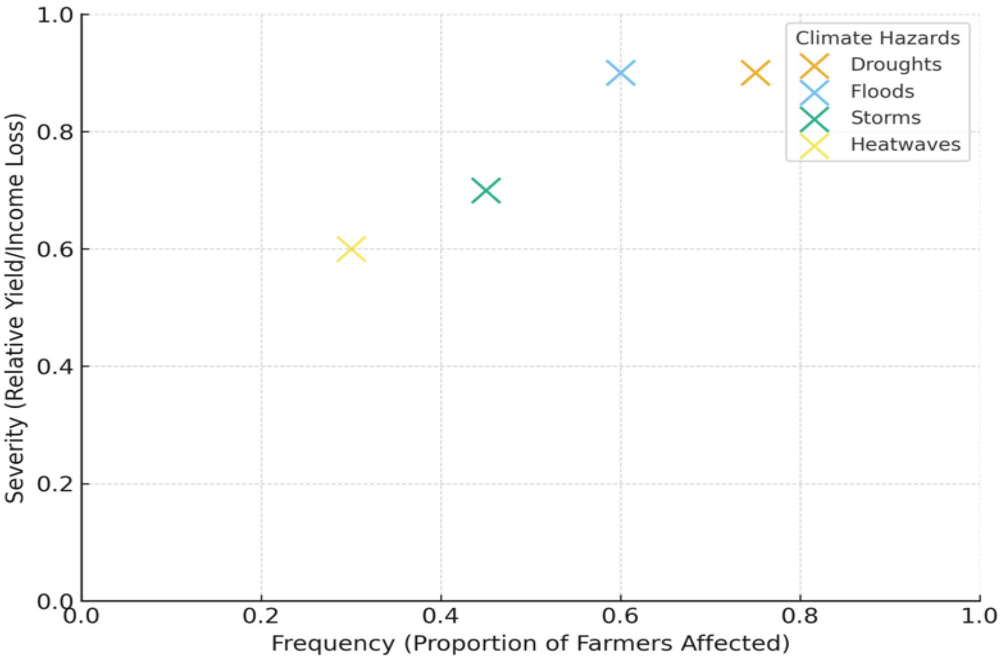

Figure 1: Climate risk matrix – frequency and severity on Thai farmers

The figure of the climate risk matrix shows that droughts and floods are both high frequency and high severity risks, while storms and heatwaves are lower frequency but still significant in severity.

1.2 The promise of parametric insurance and blockchain

(a) Parametric insurance offers a promising alternative to traditional indemnity models by enabling payouts based on objective, pre-defined weather parameters such as rainfall deficits or extreme temperatures. This index-based model significantly reduces the need for costly and subjective loss verification, thereby ensuring timely, lower-cost, and more predictable compensation for insured farmers;

(b) When paired with blockchain technology, parametric insurance can be transformed into a dynamic, trust-enhancing system. Blockchain's decentralized and immutable ledgers support real-time data verification and smart contract execution, automating payouts upon the detection of a trigger event (e.g., below-average rainfall) through weather data oracles. This automation reduces administrative costs by up to 30%, shortens claims processing time from weeks to hours, and helps eliminate fraud and opacity, key concerns among Thai farmers.

However, a critical vulnerability in such systems lies in the "oracle problem"-the risk that the external data feeding the smart contract can be manipulated. A stark example is the June 2024 UwU Lend exploit in decentralized finance (DeFi), where attackers manipulated the price data from a single oracle, leading to a false inflation of collateral values and the extraction of USD 19.3 million. A similar attack on a parametric insurance platform, if it relied on a single, manipulable weather data source, could trigger mass false payouts and drain its reserves, fundamentally undermining trust.

Therefore, the promise of blockchain-based parametric insurance hinges on a robust, security-first architecture. To mitigate these oracle risks, developers can and should implement several key countermeasures:

- Multi-Oracle Aggregation: Using diversified data sources (e.g., combining Chainlink and Band Protocol) to create a consensus on weather conditions, making single-source manipulation ineffective.
- Decentralized Relays & Cryptographic Verification: Ensuring data is transmitted through tamper-proof channels to prevent interception or alteration.
- Modular Smart Contract Design: Isolating components so that a failure in one part does not compromise the entire system.
- Adaptive Anomaly Detection: Implementing thresholds that flag and halt transactions when data inputs deviate significantly from historical patterns or other independent sources.

By proactively integrating these safeguards, the system can deliver on its innovative potential while ensuring financial stability and maintaining the trust of all stakeholders; and

(c) Pilot programs globally—in Kenya, India, Sri Lanka, and the Philippines—have demonstrated the tangible benefits of blockchain-based parametric insurance: greater speed and accuracy of payouts, increased participation from marginalized farmers, and lower delivery costs for insurers. These global benchmarks provide important lessons and proof of concept for the Thai context, particularly in regard to mobile-based distribution, digital inclusion strategies, and community-level trust-building through cooperative.

1.3 Study objectives and structure

This feasibility study is developed under Output 5 of the project's broader implementation framework and comprises four interlinked analytical components:

Activity 5.1: Business model definition

The activity identifies the target customer segments (smallholders, women, cooperatives), maps current market gaps, outlines the blockchain-based solution architecture, value proposition, revenue channels, and growth strategy. It also examines the enabling regulatory and institutional environment.

Activity 5.2: Economic assessment of demand, pricing, and revenue

The activity uses quantitative surveys and qualitative interviews to evaluate willingness to pay (WTP) and ability to pay (ATP), disaggregated by gender, region, and crop. The study also proposes flexible pricing strategies to enhance affordability while ensuring long-term viability.

Activity 5.3: Assessment of development, maintenance, and running costs

The activity estimates costs for system design, blockchain integration, mobile platforms, weather data oracles, and farmer onboarding. The analysis compares internal development versus outsourced models, with attention to rural infrastructure limitations.

Activity 5.4: Cost-revenue analysis

The activity synthesizes findings from Activities 5.2 and 5.3 to evaluate financial sustainability, including break-even analysis, cost-recovery timelines, and sensitivity to subsidy levels.

1.4 Stakeholder engagement and inclusivity

The design of this study was grounded in a comprehensive stakeholder mapping and consultation process, conducted in collaboration with Thammasat University, and the National Science and Technology Policy Office (NXPO), which served as the primary government liaison. This participatory approach was essential to ensure that the proposed blockchain-based parametric insurance model reflects the needs, constraints, and aspirations of its intended users-particularly smallholder farmers vulnerable to climate risks.

Key stakeholder groups consulted included:

(a) Smallholder farmers, engaged through the Thai Farmers Association and local cooperatives;

(b) Insurance firms and reinsurers, such as Dhipaya, Sompo, and the Thai General Insurance Association (TGIA);

(c) Agricultural cooperatives and financial intermediaries, including the BAAC; and

(d) Government agencies, notably the Office of Insurance Commission (OIC) and the Ministry of Agriculture and Cooperatives.

Engagement activities comprised a mix of focus group discussions, structured farmer interviews, and key informant consultations with insurers, regulators, and technology providers. These tools were tailored to elicit insights on current insurance usage, digital adoption readiness, trust in smart contracts, and preferences for pricing models and payout mechanisms. The UNDP emphasizes that such multi-stakeholder engagement is critical for building inclusive insurance ecosystems and ensuring that products are both technically viable and socially acceptable.

Special attention was given to ensuring diverse geographic and demographic representation, particularly among women farmers and cooperatives in rural provinces. In line with UNDP's gender-responsive risk financing principles, the study targeted a minimum of 50% female representation among survey respondents. Gender-disaggregated data were analysed to identify specific barriers to access-such as limited mobile phone ownership, lower financial literacy, and reduced access to formal credit. These findings informed the design of onboarding processes, communication strategies, and subsidy mechanisms to ensure that the insurance system does not perpetuate existing inequalities but instead contributes to closing the gender gap in financial resilience.

1.5 Strategic vision

The long-term vision of the BBPCI initiative is to catalyse a paradigm shift in climate risk financing for agriculture by leveraging the capabilities of blockchain and the efficiency of parametric models. The proposed system is aligned with national policy objectives under Thailand 4.0, the Digital Economy Plan, and the Agricultural Big Data Strategy. **Moreover, the system dovetails with Thailand's broader commitment to climate adaptation, financial inclusion, and digital transformation.**

By improving the speed, transparency, and inclusivity of insurance payouts, the BBPCI system seeks to build trust, reduce vulnerability, and encourage proactive risk management among smallholder farmers. With the right institutional support, gender-aware implementation strategies, and digital infrastructure, Thailand is well-positioned to pioneer a scalable, replicable, and equitable model for blockchain-based parametric insurance in Southeast Asia.

1.6 Methodology

This economic feasibility study employs a mixed-methods approach to evaluate the viability and scalability of a BBPI system for Thai farmers vulnerable to extreme weather events. By integrating quantitative surveys, qualitative stakeholder engagement, econometric modelling, and financial analysis, the methodology assesses demand, pricing, cost structures, revenue potential, and financial sustainability. The study is structured around four core activities defined under Output 5 of the work plan, ensuring alignment with economic and technical feasibility objectives.

1.6.1 Analytical Framework

The study is organized around 4 key activities to provide a comprehensive evaluation of blockchain-based parametric insurance (BBPI) implementation:

- Activity 5.1: Business model definition
- Activity 5.2: Economic assessment of demand, pricing, and revenue
- Activity 5.3: Assessment of development, maintenance, and running costs
- Activity 5.4: Cost-revenue analysis

1.6.2 Data collection

The study employs a robust data collection strategy to capture both quantitative and qualitative insights:

(a) Quantitative surveys

Structured questionnaires were administered to 150 farmers across several regions to ensure regional and climatic diversity. The survey targeted:

- WTP and ATP for BBPI premiums;
- Preferred payment channels (e.g., PromptPay, TrueMoney);
- Perceived climate risks (e.g., droughts, floods);
- Trust in insurance systems and digital platforms; and
- Demographic data, with over 50% female respondents to address gender-specific barriers, as emphasized in both methodologies.

A stratified sampling technique was used, segmenting farmers by region, farm size (<2 hectares for smallholders, medium, large), and crop type (rice, cassava, fruits, vegetables), ensuring representativeness. Econometric models, including linear regression, were applied to estimate price elasticity and demand forecasts based on income, farm size, and risk exposure.

(b) Qualitative interviews and focus groups

Semi-structured interviews were conducted with key stakeholders, including:

- Public institutions (BAAC, OIC, Thai Meteorological Department (TMD));
- Private insurers (e.g., Sompo, Dhipaya); and
- Agricultural cooperatives and development partners (e.g., GIZ). Focus group discussions (FGDs) with smallholder farmers and cooperative leaders validated pricing models, explored onboarding barriers, and assessed digital inclusion, particularly for female farmers. These participatory methods ensured inclusivity and relevance.

(c) Secondary data

Historical climate data (e.g., ERA5, IBTrACS) and agricultural statistics were used to calibrate parametric triggers and model risk exposure. Performance metrics from existing insurance schemes informed baseline comparisons.

1.6.3 Stakeholder engagement

Participatory methods were employed to ensure stakeholder input and inclusivity:

(a) Focus groups: Engaged smallholder farmers and cooperatives to gather qualitative insights on insurance needs, trust barriers, and digital readiness, with specific attention to female farmers' preferences and challenges (per both methodologies;

(b) Key informant consultations: Involved regulators (OIC), insurers, and technical experts to assess blockchain penetration, operational challenges, and regulatory constraints, ensuring alignment with Thailand’s legal frameworks (e.g., Personal Data Protection Act (PDPA), OIC standards); and

(c) Gender-disaggregated analysis: Highlighted barriers and preferences among female farmers, achieving over 50% female participation in surveys and FGDs to inform inclusive policy design (per both methodologies).

1.6.4 Financial modelling

The financial analysis integrates cost and revenue projections to assess BBPI’s sustainability:

(a) Revenue projections: Based on WTP data from surveys, revenue models have been revised for a targeted pilot of 500 farmers. Scenarios account for initial premium subsidies (covered by the project grant and partner co-financing) and a conservative adoption rate for the pilot phase. Projected revenue from farmer premiums is estimated at approximately THB 250,000/season (USD 7,700) for 500 farmers, based on an average farm size and a blended premium rate. The primary revenue during the pilot is considered the co-financing and in-kind contributions secured from partners, which validate the commercial interest and operational funding structure;

(b) Cost estimation: The total pilot budget is USD 750,000 (approximately THB 26.25 million (USD 808,000)), as detailed in the Financial Plan. This budget covers all capital expenditures (CAPEX) for platform development, smart contracts, and data infrastructure, as well as operational expenditures (OPEX) for an 18-month period, including training, outreach, regulatory engagement, and monitoring. This integrated budget is fully financed by the international technical assistance grant and confirmed co-financing, ensuring the pilot's execution is not dependent on farmer premium revenue;

(c) Sensitivity analysis: The model retains its evaluation of financial viability under varying climate risk frequencies and operational costs. For the 500-farmer pilot, the key sensitivities shift to focus on the cost of onboarding, the accuracy of parametric triggers (basis risk), and farmer satisfaction as critical metrics for validating the model ahead of scale-up;

(d) Break-even analysis (for future scale-up): The analysis confirming the minimum number of active users for operational self-sufficiency remains valid for the long-term, scaled business model. The break-even point is confirmed at 6,200-7,000 farmers, based on the cost structures and subsidy levels outlined in the Economic Feasibility Study. The 500-farmer pilot is a critical step to de-risk the technology and operational model before pursuing this scale;

(e) Investment appraisal (recommended enhancement): To provide a complete picture of long-term financial viability and attractiveness to investors post-pilot, a dynamic investment appraisal is essential. This would involve a discounted cash flow (DCF) analysis, including:

  - net present value (NPV): Calculating the project's value in today's terms by discounting all future cash inflows and outflows from a scaled operation. A positive NPV (e.g., at an 8% discount rate over a 5-year horizon post-pilot) would indicate that the scaled project is expected to generate value exceeding the cost of capital.

  - internal rate of return (IRR): Determining the scaled project's effective annualized rate of return. An IRR that exceeds the cost of capital would signal a profitable investment for implementing partners and insurers.

(f) Inclusion of NPV and IRR in future analyses would move beyond the pilot's grant-funded structure and quantify the true economic value and return on investment for a commercially scaled platform, accounting for the timing of cash flows.

1.6.5 Integration with technical feasibility

The economic analysis incorporates inputs from the technical feasibility study to ensure coherence:

(a) Blockchain design: Assumes a permissioned Ethereum ledger for security and cost efficiency, validated by cost estimates (e.g., THB 15,000-20,000/node (USD 450-600) annually);

(b) Oracle and IoT Deployment: Integrates hybrid TMD-satellite data feeds (THB 250,000/year (USD 7,700)) and community-owned IoT sensors to support accurate parametric triggers, reducing basis risk;

(c) Stakeholder roles: Defines roles for BAAC, OIC, TMD, and cooperatives in system implementation, payment integration (e.g., PromptPay), and compliance; and

(d) Regulatory compliance: Aligns with PDPA, OIC frameworks, and Thailand’s Electronic Transactions Act (ETA), incorporating hybrid smart contracts for legal enforceability.

1.6.6 Data management and analysis

Quantitative survey data were cleaned and analysed using statistical software (Excel, SPSS) with descriptive statistics, cross-tabulations, and regression modelling to identify patterns in WTP, ATP, and climate risk exposure. Qualitative data from interviews and FGDs were transcribed, coded, and categorized by region, crop type, gender, and stakeholder type. All data were anonymized and securely stored to comply with PDPA and ethical standards. Econometric models quantified price elasticity and demand forecasts, while scenario modelling simulated adoption and cost scenarios.

1.6.7 Assumption risks and mitigation strategies

While the study employs a mixed-methods approach to assess the economic feasibility of BBPI, several underlying assumptions and potential biases must be acknowledged to ensure methodological robustness and transparency.

A. Survey biases

- Self-selection bias: Farmers who are more digitally literate, cooperative-affiliated, or climate-aware may have been more likely to participate in the survey, potentially inflating interest and willingness-to-pay (WTP) metrics.
- Social desirability bias: Respondents may have overstated their interest in BBPI due to perceived expectations from enumerators or institutional affiliations.
- Non-response bias: Farmers with limited mobile access or lower literacy levels may have been underrepresented, skewing the sample toward more engaged or informed participants.

B. Sampling limitations

- Geographic concentration: The survey focused on four regions, which may not fully capture the diversity of Thailand’s agricultural landscape, especially in underrepresented southern provinces or ethnic minority communities.

- Gender and ethnicity gaps: Although gender-disaggregated data were collected, intersectional barriers faced by ethnic minority women farmers may not be fully reflected due to limited sample size and outreach constraints.

C. Modelling assumptions

- Uniform adoption rates: Financial projections assume consistent uptake across farmer segments, which may overlook differentiated barriers for marginalized groups.
- Static cost structures: Operational cost estimates do not account for inflation, technology upgrades, or regional deployment variations.
- Simplified behavioural assumptions: The use of expected utility and prospect theory assumes rational decision-making, which may not fully capture cultural or psychological factors influencing insurance adoption.

D. Mitigation Strategies

To address these risks and improve the reliability of findings, the following strategies are recommended:

- Follow-up validation studies: Conduct longitudinal surveys and pilot evaluations to compare stated interest with actual enrolment and retention behaviour.
- Regression analysis: Apply econometric models (e.g., logit regression) to identify statistically significant WTP determinants such as farm size, gender, and climate risk perception.
- Expanded sampling: Include additional provinces and ethnic minority communities in future data collection to enhance representativeness.
- Triangulation: Cross-validate survey findings with administrative data (e.g., BAAC enrolment records) and qualitative insights from focus groups.
- Sensitivity testing: Incorporate Monte Carlo simulations and scenario modelling to account for uncertainty in adoption, pricing, and climate risk exposure.

By explicitly acknowledging these assumption risks and embedding mitigation strategies, the study enhances its methodological integrity and provides a more credible foundation for policy and investment decisions.

2 BUSINESS MODEL DEFINITION (ACTIVITY 5.1)

2.1 Overview of the agricultural insurance market in Thailand

Thailand's agricultural insurance market operates within a Public-Private Partnership (PPP) framework, shaped by a combination of government policy, public subsidies, and private-sector delivery mechanisms. At its core is the weather index insurance model, which uses objective environmental indicators—such as rainfall deficits or temperature extremes—to trigger payouts. These parametric models are favoured for their cost-efficiency and scalability, particularly in rural areas where traditional loss verification through field assessments is logistically complex and financially burdensome.

Despite these advantages, the current system faces persistent structural and operational challenges. According to the UNDP, adoption rates remain low, especially among smallholder farmers, due to limited awareness, low insurance literacy, and a lack of trust in existing schemes. Data quality and granularity are also major concerns; gaps in localized weather data hinder the precision of risk modelling and increase basis risk. Enrolment procedures are often cumbersome, requiring documentation and digital access that many rural farmers—particularly women—do not possess. Furthermore, Thailand's digital and financial infrastructure remains uneven, with rural and remote areas facing limited access to mobile banking, internet connectivity, and agent networks.

The BBPI model seeks to address these systemic issues by leveraging blockchain technology and smart contracts to automate insurance processes, enhance transparency, and reduce administrative overhead. By integrating mobile-enabled platforms and decentralized data oracles, BBPI can streamline enrolment, deliver real-time weather data, and trigger instant payouts—thereby building trust and improving access for underserved populations. The model also aligns with UNDP's recommendations for inclusive insurance by incorporating gender-sensitive design, simplified onboarding, and community-based distribution channels, such as cooperatives and village funds. These innovations position BBPI as a transformative solution capable of overcoming the limitations of Thailand's current agricultural insurance landscape and advancing national goals for climate resilience and financial inclusion.

2.2 Key market stakeholders and institutional roles

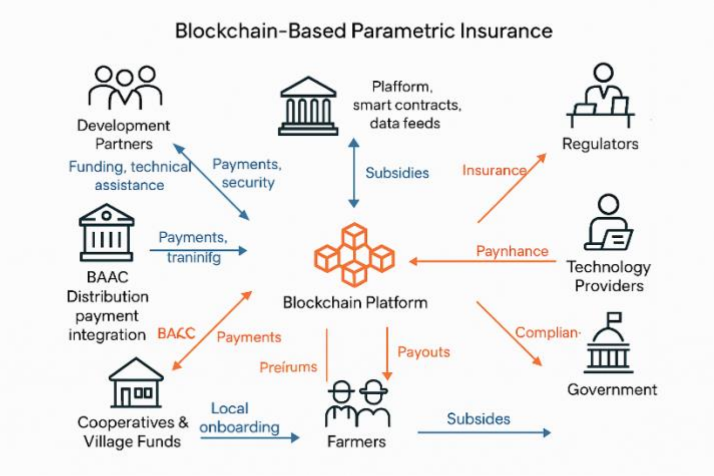

Figure 2: BBPI stakeholder interaction diagram

2.2.1 Bank for Agriculture and Agricultural Cooperatives

(a) Role: Primary national distributor of agricultural insurance;

(b) Business model: Partners with insurers to deliver subsidized weather index insurance, primarily for rice and maize;

(c) Capital needs: Relies on government premium subsidies and reinsurer support;

(d) Revenue stream: Premiums + state subsidies;

(e) Challenges: Low insurance literacy among farmers; insufficient field-level data; and

(f) BBPI opportunity: Integrate smart contracts and mobile payment platforms with BAAC's existing infrastructure; leverage BAAC's reach and digital farmer ID systems.

2.2.2 Sompo insurance (Thailand)

(a) Role: Private insurer offering weather index insurance for rice, sugarcane, and longan;

(b) Model: Uses satellite data and BAAC channels for product delivery;

(c) Capital needs: Tech investments + reinsurance;

(d) Revenue model: Premium-based, potentially supported by government co-financing;

(e) Challenges: Ensuring data integrity and expanding geographic coverage; and

(f) BBPI opportunity: Strengthen data accuracy using blockchain-linked oracles and expand outreach via mobile apps and cooperative agents.

2.2.3 Thai General Insurance Association

(a) Role: Umbrella body coordinating among insurers;

(b) Model: Facilitates regulation, risk-sharing, and product standardization;

(c) Revenue model: Member fees and administrative costs; and

(d) BBPI opportunity: Promote standardization of blockchain smart contract templates for parametric insurance and help establish national data-sharing protocols.

2.2.4 Deutsche Gesellschaft für Internationale Zusammenarbeit (development agency of Germany)

(a) Role: Technical partner and capacity builder;

(b) Model: Government-funded advisory; facilitates sustainable, inclusive insurance models; and

(c) Opportunity for BBPI: Help integrate blockchain into Thailand's social protection ecosystem, drawing from global experience in inclusive risk finance.

2.2.5 Blockchain-based parametric insurance value proposition

The BBPI model introduces a new value chain that leverages blockchain and smart contracts to resolve inefficiencies, address market failures, and enhance financial inclusion—especially for smallholder farmers and women:

	Traditional insurance	BBPI model
Claims processing	Manual, delayed, opaque	Automated, instant, transparent
Data collection	Centralized, limited	Decentralized, multi-source (e.g., satellite, IoT)
Accessibility	Limited to high-coverage areas	Nationwide via mobile + cooperatives
Trust mechanism	Low, especially among women and smallholders	Blockchain ledger for verifiability
Financial inclusion	Low, due to paperwork and credit restrictions	Transparent insurance history can unlock credit

Table 2: Comparison between traditional insurance and blockchain-based parametric insurance (BCI, 2025)

Information asymmetry theory (Akerlof, 1970): Traditional insurance markets suffer from adverse selection (high-risk individuals are more likely to enrol) and moral hazard (insured parties may behave recklessly post-enrolment). These stem from asymmetric information between the insurer and the insured. BBPI addresses these failures by utilizing parametric triggers (e.g., rainfall thresholds) and blockchain oracles, which eliminate subjective claims processes and reduce the need for expensive monitoring. By publishing trigger logic and payout conditions transparently on-chain, BBPI ensures symmetric information for all stakeholders—improving efficiency and fairness.

Transaction cost economics (Coase, 1937; Williamson, 1985): BBPI reduces transaction costs in the insurance process, such as claims verification, enforcement, and monitoring costs by automating contracts and minimizing intermediaries, further lowering premiums and expanding access.

Financial inclusion lens: For underbanked populations, BBPI generates a verifiable claims record that can serve as a proxy for creditworthiness. This aligns with the emerging concept of reputation-based lending, enabling marginalized farmers to access other financial services.

Gender lens: BBPI gives a particular emphasis on women, who disproportionately lack formal land titles and credit histories, who can then benefit from transparent, non-discriminatory onboarding processes and visibility into smart contract logic. These features build trust and empower more equitable participation.

2.3 Capital requirements and revenue streams

The BBPI model requires a blend of public and private investment, guided by principles of strategic cooperation and collective benefit.

2.3.1 Capital requirements

(a) Initial setup: Smart contract development, Oracle integration (e.g., weather data), blockchain node infrastructure, mobile app interfaces;

(b) Recurring costs: Oracle fees, smart contract gas fees, platform maintenance, agent training, outreach programs; and

(c) Support required: Public subsidies are essential not only to boost affordability for smallholder farmers but also to correct market failures arising from positive externalities (Pigou, 1920) and public goods provision (Samuelson, 1954). Donor and development partner support (e.g., GIZ, NXPO) can underwrite early-stage capital expenditures that have system-wide social benefits.

2.3.2 Revenue model

(a) Farmer premiums: Tiered based on crop type, risk profile, and region, with bundling options for cooperatives to reduce per-user acquisition cost and enhance scale;

(b) Government subsidies: These act as price stabilizers and uptake accelerators, correcting under-provision due to Knightian uncertainty (Knight, 1921) about extreme weather risks;

(c) Donor grants: Used to finance pilot phases and support gender-inclusive onboarding—generating long-term social returns beyond pure revenue metrics; and

(d) Data monetization (future): Aggregated, anonymized crop and climate data may support services for financial institutions, input providers, and policymakers, creating a secondary market that enhances platform sustainability.

2.4 Delivery mechanisms and last-mile inclusion

Insights from Kilimo Salama (Kenya) and supported by transaction cost economics (Coase, 1937; Williamson, 1985), suggest that the most cost-effective way to reach smallholder farmers is through:

(a) Mobile payment systems (PromptPay, blockchain wallets, USSD) that enable low-cost premium payments and instant claims disbursement—even on feature phones;

(b) Decentralized agent networks (cooperatives, agro-dealers) that lower onboarding costs and increase trust, thus reducing the cost of user acquisition; and

(c) User-centred behavioural design: Microinsurance opt-ins and SMS nudges reduce cognitive friction, overcoming decision paralysis due to bounded rationality (Simon, 1957).

2.5 Farmer-centric innovations

BBPI's design is grounded in game theory (Nash, 1950; Schelling, 1960), which helps model strategic behaviour among interdependent actors—farmers, cooperatives, insurers, and regulators. By fostering transparent data flows and predictable contract enforcement, the BBPI system creates a cooperative equilibrium where participants are incentivized to act honestly and remain engaged. This reduces risks of opportunistic behaviour (e.g., premium avoidance, claims manipulation) and aligns incentives through repeated interactions and reputation effects.

Moreover, risk pooling and diversification theory (Markowitz, 1952; Arrow, 1963) underlines how BBPI's regional and crop-level segmentation enables optimal portfolio structuring. By onboarding diverse farmer profiles across multiple climate zones, the system spreads idiosyncratic risks and lowers overall portfolio variance. This enhances reinsurance attractiveness and enables the system to absorb climate shocks more efficiently, maintaining solvency and reducing subsidy dependency.

Core innovations include:

(a) Trust via transparency: Real-time verification of index data and payout logic ensures that farmers, insurers, and regulators share the same information. This mitigates information asymmetry (Akerlof, 1970), which traditionally inflates premiums and limits coverage in rural insurance markets;

(b) Speed of relief: Parametric insurance powered by smart contracts allows for instant payouts when pre-agreed thresholds (e.g., rainfall deficits, flood levels) are breached. This rapid liquidity minimises post-disaster income shocks and reduces reliance on informal lending, a key driver of rural indebtedness;

(c) Customization: Smart contracts are designed to reflect region-specific climate risks and crop cycles. For example, rice farmers in flood-prone Chiang Mai and cassava growers in drought-affected Nakhon Phanom receive tailored coverage, increasing relevance and perceived value;

(d) Group coverage: Cooperative enrolment lowers administrative cost per user and leverages Identity Economics (Akerlof & Kranton, 2010) by embedding BBPI into local trust networks—especially effective for women farmers;

(e) Financial linkages: Farmers' insurance history, recorded immutably on blockchain, can serve as a proxy for creditworthiness—especially for previously unbanked individuals. This strengthens eligibility for agricultural loans and input financing, promoting long-term resilience and economic mobility.

2.5.1 Theoretical underpinning: information asymmetry and market failure

As theorized by George Akerlof (1970) in “The Market for Lemons”, traditional insurance systems often collapse under information asymmetry, where one party (e.g., the farmer) knows more about their risk exposure than the insurer. This creates adverse selection—where only high-risk individuals enroll—and moral hazard, where insured individuals take fewer precautions. These issues contribute to limited insurance penetration in rural markets globally, including Thailand.

BBPI addresses these failures by embedding objective, third-party-validated data (e.g., from TMD, IoT sensors, and satellite oracles) into smart contracts. Since payouts are based on transparent and verifiable parameters, insurers no longer need to rely on costly field assessments or assume hidden behavioral risks. Smart contracts automate enforcement, eliminating discretionary bias and improving farmer trust—especially among historically excluded groups like women and landless workers.

2.5.2 Related theories and insights

Behavioural economics (Kahneman & Tversky, 1979): Farmers often exhibit ambiguity aversion and loss aversion. Transparent index-based payouts reduce the cognitive burden of interpreting complex contracts, reframing insurance as a predictable safety net.

Transaction cost economics (Coase, 1937; Williamson, 1985): BBPI drastically reduces transaction costs in insurance delivery—claims processing, contract enforcement, and dispute resolution—making smallholder coverage more economically viable.

Identity Economics (Akerlof & Kranton, 2010): Group-based enrolment through cooperatives taps into shared identities and local norms, making participation feel socially affirming rather than institutionally imposed.

2.6 Strategic alignment

Alexander Osterwalder and Yves Pigneur's Business Model Canvas is a strategic management tool that provides a visual framework for developing, describing, and analysing business models. Introduced in their influential book *Business Model Generation*, the canvas breaks down a business model into nine essential building blocks: Customer segments, Value propositions, Channels, Customer relationships, Revenue streams, Key resources, Key activities, Key partnerships, and Cost Structure. This structured yet flexible approach allows entrepreneurs, innovators, and managers to map out how a company creates, delivers, and captures value. By using the canvas, teams can foster clarity, alignment, and innovation in business planning and execution.

BUSINESS MODEL CANVAS				
Key partners	**Key activities**	**Value propositions**	**Customer relationships**	**Customer segments**
• To distribute and onboard across all sources: BAAC • To underwrite, process claims, and pool risk: Private insurers (Sompo, Dhipaya) and reinsurers	• Development of smart contracts for parametric triggers • Integration of weather data oracles (satellite, IoT, TMD)	• For farmers: - Transparent, fast, and automated payouts - Affordable and accessible insurance via mobile and	• Community-based engagement through cooperatives and trusted local leaders • Personalized onboarding and	• Smallholder farmers (1-5 ha or 6-31 rai), especially in climate-sensitive zones (drought/flood)

<table>
<tr><th colspan="5">BUSINESS MODEL CANVAS</th></tr>
<tr>
<td rowspan="2">• To provide weather oracles: TMD
• To enable mobile/USSD integration: Telecom providers (AIS, DTAC)
• To implement at field level: Local cooperatives and village funds
• To provide technical and financial support: International donors and development agencies (GIZ, World Bank, ADB)</td>
<td>• Design and deployment of mobile apps/USSD platforms
• Farmer onboarding, KYC, training, and literacy programs
• Premium collection and automated claims disbursement
• Regulatory compliance (OIC, PDPA) and system reporting
• Ongoing stakeholder coordination and feedback loops for system iteration</td>
<td rowspan="2">cooperative channels.
• For female farmers: Gender-sensitive onboarding, group coverage, and community-based support.
• For insurers: Lower admin costs, reduced fraud (20-40% savings), expanded rural reach
• For Thai government and donors: A scalable financial resilience tool, aligned with SDGs and climate adaptation goals</td>
<td>education via female insurance champions and agents
• SMS alerts, feedback mechanisms, and help desks
• Transparent and accessible policy language (legal + plain language hybrid)</td>
<td rowspan="2">• Female farmers, particularly via cooperatives
• Medium/large farms (6-20 ha) seeking premium tiers
• Government clients (for subsidies) and development finance institutions (impact focus)</td>
</tr>
<tr>
<td>Key resources
• Permissioned blockchain infrastructure (Ethereum-based)
• Smart contracts, weather oracles, satellite/IoT data feeds
• Mobile platforms (Android, USSD)
• Trained field agents and cooperative networks
• Legal and compliance systems, including digital identity (NDID)</td>
<td>Channels
• Mobile apps and USSD interfaces for onboarding and quote access
• BAAC branches, cooperatives, and local agents for in-person service
• PromptPay/TrueMoney for digital payments and claims
• SMS, radio, and social media for education and awareness</td>
</tr>
<tr>
<td colspan="2">Cost structure
• Estimated CAPEX (year 1):
- Smart contracts and blockchain: THB 2.9M (USD 89,200)
- App/interface/oracle development: THB 1.5M-2M (USD 46,100-61,500)
- IoT deployment: THB 1M (USD 30,800)
• Estimated OPEX (annual):
- Node maintenance, API subscriptions: ~THB 3.1M (USD 95,400)
- Training, outreach, support services: THB 1.45M (USD 44,600)
- Regulatory and legal compliance: THB 700k (USD 21,500)
- Reinsurance, escrow/risk funds: Variable</td>
<td colspan="3">Revenue streams
• Farmer premiums: THB 30-60/rai (USD 0.9-1.8) or ~THB 300-500/season (USD 9-15) (40-60% subsidized)
• Government subsidies: Direct premium co-financing
• Donor grants: For pilot implementation, tech, and inclusion programs
• Data monetization (future): Anonymized crop/climate data to insurers/government
• Optional premium tiers: Add-ons like bundled agri-inputs or multi-season coverage.</td>
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</table>

Two-Sided Market Theory (Rochet & Tirole, 2003) provides a strategic framework for understanding BBPI's platform economics. BBPI operates as a two-sided market, connecting farmers (policyholders) and insurers (risk underwriters), with intermediaries such as BAAC, PromptPay, and cooperatives facilitating transactions. The platform's value increases with participation on both sides—more farmers improve risk pooling and data richness, while more insurers enhance product diversity and trust. To sustain growth and maximize network effects, BBPI's pricing and onboarding strategies must balance incentives across both sides, ensuring equitable access and long-term viability.

Collective Action Theory (Elinor Ostrom, 1990) provides a foundational framework for understanding BBPI's reliance on cooperatives and community-based institutions. Ostrom's research demonstrates that local actors can effectively manage shared resources—such as climate risk—when empowered with autonomy, trust, and transparent rules. BBPI's cooperative-led onboarding, training, and feedback loops reflect these principles, enabling decentralized governance and long-term sustainability. Embedding insurance delivery within trusted local networks enhances legitimacy, accountability, and resilience, especially in rural areas where formal institutions may be limited.

We identified key elements of the technical feasibility study that can be incorporated into the business model definition of this economic feasibility study:

From the technical feasibility study, we learn that:

(a) The technical feasibility study clearly outlines the roles of stakeholders, including farmers, insurers, oracles, regulators, and technology providers (Section 5.3);

(b) The technical feasibility study also describes the value proposition of BBPI for different stakeholders (farmers = faster payouts; insurers = lower fraud; government = improved auditability); and

(c) The proposed architecture (permissioned blockchain, smart contracts, oracle system) justifies the structural efficiencies that influence cost and scalability.

These elements support, validate, or influence the business model definition because:

(a) These technical details help justify BBPI's value-added from a business and cost-efficiency standpoint; and

(b) Stakeholder roles outlined in the technical feasibility study can directly inform the revenue-sharing model or identify cost-bearing entities (e.g., insurers handling smart contracts, BAAC managing wallet infrastructure).

Table 3: Integration of elements from the technical feasibility study regarding the business model definition

3 NINE-STEP USER JOURNEY FOR BLOCKCHAIN-BASED PARAMETRIC INSURANCE

The inclusion of the nine-step user journey in the economic feasibility study serves as a critical bridge between the technical architecture and the financial viability of the blockchain-based parametric insurance system. By mapping each operational step—from user registration to automated claims and compliance—to specific cost components, revenue streams, and behavioural adoption factors, the journey transforms abstract technical processes into tangible economic levers. It enables precise modelling of onboarding costs, premium collection mechanisms, subsidy automation, and trust-building strategies, all of which are essential for demand forecasting, break-even analysis, and inclusive business model design. Moreover, it validates the economic assumptions underpinning the business model canvas and aligns with Thailand's digital infrastructure and policy goals. This integration ensures that the economic feasibility study is not only grounded in technical realism but also optimized for strategic decision-making, stakeholder engagement, and scalable implementation.

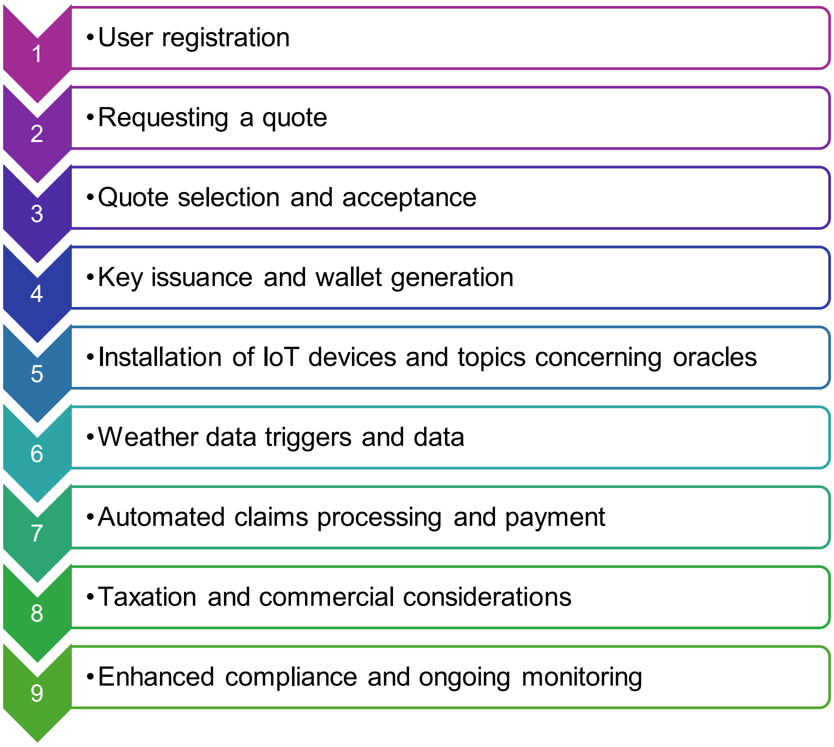


Figure 3: 9-step user journey

3.1 User registration

Objective: Onboard farmers onto the BBPI platform efficiently, ensuring inclusivity and trust.

Description: Farmers register via a mobile-first interface, leveraging Thailand's high mobile penetration (77% of farmers own mobile phones with 4G/5G access, per the brainstorming document). The process is simplified to accommodate low digital literacy, particularly in rural areas like the Northeast, where only 14% of farmers are aware of crop insurance. Registration involves Know-Your-Customer (KYC) and Know-Your-Business (KYB) procedures, integrated with Thailand's National Digital ID (NDID) or PromptPay for seamless identity verification.

Behavioural economics insight: According to prospect theory (Kahneman & Tversky, 1979), individuals often exhibit loss aversion, valuing the avoidance of loss more than equivalent gains. Farmers unfamiliar with insurance may perceive the registration process as complex or risky. Therefore, simplifying the interface and offering registration through trusted intermediaries (e.g., BAAC, cooperatives) reduces perceived transaction costs and cognitive overload—critical when working with users who may overweight the risk of doing something unfamiliar (like sharing data or enrolling in a new program).

Nudge Theory (Thaler & Sunstein, 2008) suggests that subtle changes in how choices are presented can significantly influence behaviour. BBPI's onboarding process should incorporate nudges such as default enrolment options, simplified interfaces, and cooperative-led registration to reduce cognitive friction and encourage participation. These behavioural cues help overcome decision paralysis and ambiguity aversion, especially among farmers unfamiliar with digital insurance. Framing BBPI as a protective default—rather than a complex financial product—can increase uptake and trust.

Diffusion of Innovations Theory (Rogers, 1962) further supports the design of BBPI’s onboarding strategy. According to Rogers, technology adoption follows a curve from innovators and early adopters to the early and late majority. In rural Thailand, cooperatives and digitally literate farmers can serve as early adopters and opinion leaders, demonstrating BBPI’s value and influencing broader uptake. By targeting these groups during the pilot phase, BBPI can accelerate diffusion, reduce scepticism, and build trust through peer validation—a critical factor in low-trust, low-literacy environments.

Expected utility theory application: Farmers—who are generally risk-averse—maximize their expected utility, not expected monetary value. Registering for BBPI represents an investment toward reducing income volatility from extreme weather events. The utility gained from potential payouts (risk mitigation) outweighs the disutility of minor upfront onboarding friction, especially when educational support is provided.

Implementation:

(a) Channels: Farmers register through a USSD-based interface for feature phones, a mobile app for smartphones, or in-person at trusted local institutions like the BAAC, Village Funds, or cooperatives, which facilitate onboarding for female farmers (59% of survey respondents);

(b) Ethical safeguards: Informed consent and data anonymization ensure compliance with privacy regulations, addressing farmers’ concerns about data misuse; and

(c) Support: Digital literacy training, delivered via cooperatives, enhances accessibility, with 54% of farmers citing awareness as a barrier.

Economic considerations:

(a) Costs: Onboarding costs, including KYC/KYB verification, are estimated at THB 50-100/farmer (USD 1.5-3). For the 500-farmer pilot, this represents a total cost of THB 25,000-50,000 (USD 770-1,500). These costs, alongside marketing campaigns (estimated at THB 500,000 (USD 15,400) annually for broader awareness), will be covered by the project grant and partner co-financing to ensure zero financial barrier to entry for pilot participants;

(b) Revenue impact: A simplified and accessible registration process is critical for achieving full pilot enrolment. Successful onboarding of the target 500 farmers validates the user experience and operational model. While the direct premium revenue from 500 farmers is a minor component of the pilot's financed budget, it is a critical metric for proving the revenue model's viability for future scale-up towards the break-even point of 6,200-7,000 farmers; and

(c) Stakeholder roles: Local agricultural cooperatives and the BAAC act as trusted intermediaries for face-to-face onboarding and verification. To enhance digital reach, partnerships with telecom providers (e.g., AIS, DTAC) will be explored for integrating registration into mobile services.

3.2 Requesting a quote

Objective: Enable farmers to obtain tailored insurance quotes reflecting their specific climate risks and affordability.

Description: Farmers request quotes through the BBPI platform, specifying crop type, farm size, and region. The system uses AI-driven risk models, incorporating real-time climate data from the TMD and satellite feeds, to generate dynamic quotes. Quotes align with farmers' WTP, with 83% preferring premiums ≤2% of crop value (approximately THB 30-60/rai (USD 0.9-1.8)).

Behavioural economics insight: Many farmers, influenced by bounded rationality and hyperbolic discounting, may undervalue future payouts and overemphasize the upfront cost of the premium. To address this, the platform uses framing techniques—presenting insurance as a guaranteed safeguard rather than a cost—to improve uptake. Explainer videos, community radio, and visual aids simplify abstract terms like "parametric triggers."

Expected utility theory application: Quote customization and transparency appeal to farmers' risk aversion. Insurance increases expected utility by reducing the variance in income, especially in high-risk zones. Regional customization (e.g., flood-prone Chiang Mai vs. drought-prone Nakhon Phanom) ensures that perceived utility aligns with experienced risk exposure, thereby raising WTP.

Implementation:

(a) Interface: Quotes are accessible via USSD, mobile app, or cooperative agents, ensuring inclusivity for low-literacy users. Educational materials (e.g., videos, radio ads) explain parametric triggers, addressing the 54% awareness barrier;

(b) Customization: Quotes reflect regional risks (e.g., droughts in Nakhon Phanom, floods in Chiang Mai) and crop-specific needs (rice, cassava, fruits), as identified in the farmer survey; and

(c) Subsidies: Government and project subsidies reduce premiums to enhance affordability and align with WTP.

Economic considerations:

(a) Costs: Artificial Intelligence (AI) and Machine Learning (ML) model development and data integration cost THB 500,000 (USD 15,400) in year 1, with annual maintenance at THB 100,000 (USD 3,100). Customer service staff salaries add THB 600,000 (USD 18,500) annually;

(b) Revenue Impact: Clear communication of subsidies and simple processes drive high farmer interest, supporting the pilot's goal of validating the revenue model for future scale-up; and

(c) Stakeholder Roles: Insurers validate pricing models, while TMD provides essential climate data for accurate risk profiling.

3.3 Quote selection and acceptance

Objective: Facilitate informed and confident acceptance of insurance quotes by farmers.

Description: Farmers review and accept quotes via the BBPI platform, with options for low and high payout tiers to suit diverse needs. Hybrid contracts (smart contracts with natural language) ensure legal enforceability under Thailand's Contract Act and compliance with OIC standards.

Behavioural economics insight: Due to ambiguity aversion, farmers may hesitate to accept contracts they do not fully understand, even if they are beneficial. Using visual icons, infographics, and local language summaries combats information overload and reduces cognitive friction. Moreover, nudges, such as default contract selections or cooperative agent recommendations, guide farmers toward participation without coercion.

Expected utility theory application: The ability to choose among flexible options (e.g., seasonal vs. multi-year) increases expected utility by matching insurance coverage with farmers' income flow preferences and risk thresholds. Payment staging also improves uptake among liquidity-constrained farmers.

Implementation:

(a) Transparency: Quotes display coverage details (e.g., drought, flood triggers) in visual formats (icons, infographics) to enhance understanding for 83% of farmers who value simplicity;

(b) Trust-building: Government endorsements and cooperative validation address trust gaps from past insurance experiences. Biometric signatures linked to NDID streamline acceptance; and

(c) Flexibility: Farmers can select seasonal or multi-year coverage, with staged payment plans to align with cash flow.

Economic considerations:

(a) Costs: Smart contract development for hybrid contracts costs THB 300,000 (USD 9,200) in year 1, with minimal recurring costs. Compliance verification adds THB 100,000 (USD 3,100) annually;

(b) Revenue impact: High trust and transparency increase acceptance rates, targeting 80% of interested farmers; and

(c) Stakeholder roles: OIC ensures regulatory compliance, while cooperatives assist with contract education.

3.4 Key issuance and wallet generation

Objective: Provide secure, user-friendly digital wallets for managing BBPI transactions.

Description: Upon accepting a quote, farmers receive a blockchain-based digital wallet for premium payments and payouts, integrated with PromptPay or TrueMoney for accessibility. The wallet supports USSD for feature phone users, addressing low blockchain awareness.

Implementation:

(a) Setup: Wallets are securely linked to the user's national digital ID (NDID) for identity verification. User-friendly guides and cooperative support are provided for key management to prevent fund loss. Integration with existing BAAC apps or PromptPay leverages high existing user familiarity to reduce adoption barriers;

(b) Training: Local agricultural cooperatives deliver hands-on, in-person wallet training sessions. The total cost for developing and delivering this training across all 500 farmers in the pilot is included in the comprehensive project budget for Output 3 (Farmer onboarding); and

(c) Security: The system incorporates secure, decentralized key recovery mechanisms designed to balance user-friendliness with robust security, mitigating the risks of key loss identified during stakeholder consultations.

Economic considerations:

(a) Costs: The development of the mobile wallet and backend integration with financial systems is a capital expenditure (CAPEX) scheduled for Phase 2 (Delivery of a Proof of Concept). Concurrently, the costs for user training, community onboarding, and ongoing support are operational expenditures (OPEX) that are primarily incurred during Phase 3 (Implementation at Full Scale). All these costs are encompassed within the total financed pilot budget of USD 750,000 and are structured as fixed project costs for this initial development and pilot phase, not variable costs dependent on the number of farmers enrolled.;

(b) Revenue impact: A seamless and trustworthy wallet setup is a critical success factor for enabling premium collection and demonstrating the operational viability of the entire insurance model with the 500 pilot farmers. Its success is a prerequisite for achieving the revenue projections required for long-term scale-up to 6,200-7,000 farmers; and

(c) Stakeholder roles: FinTech partners (e.g., TrueMoney) and the BAAC are essential for wallet integration and financial interoperability. Telecom providers are key partners for enabling reliable USSD access for farmers without smartphones.

3.5 Installation of IoT devices and topics concerning oracles

Objective: Deploy a reliable data infrastructure for accurate parametric triggers.

Description: BBPI relies on IoT sensors (e.g., rain gauges) and oracles to deliver weather data to smart contracts. Community-owned weather stations, supplemented by TMD and satellite data (e.g., ERA5), reduce basis risk and costs (brainstorming document).

Implementation:

(a) Deployment: Pilot phase deploys 50 community sensors in high-risk districts (Chiang Mai, Nakhon Phanom), costing THB 1,000,000 (USD 30,800) in year 1. Sensors are tamper-proof, with installation guides for local stakeholders;

(b) Oracles: Decentralized oracle networks (e.g., hybrid TMD-satellite feeds) ensure data reliability, costing THB 250,000 (USD 7,700) annually; and

(c) Partnerships: Agreements with TMD and tech startups provide data APIs, enhancing accuracy for region-specific risks (drought, floods, heat stress).

Economic considerations:

(a) Costs: The primary costs are the initial capital expenditure for IoT deployment (THB 1,000,000 (USD 30,800)) and the annual operational expenditure for oracle services (THB 250,000 (USD 7,800)). Additional recurring costs include approximately THB 180,000 (USD 5,500) annually for cloud data storage and scaling;

(b) Revenue impact: Accurate and transparent data triggers are fundamental to building farmer trust. By minimizing basis risk and preventing disputes, this robust infrastructure is a critical enabler for high adoption rates and the long-term revenue sustainability of the model; and

(c) Stakeholder roles: The TMD is the primary source for validated ground-truth data. Local agricultural cooperatives are responsible for the ongoing physical maintenance of the sensors.

Development partners like GIZ can support by providing independent verification of data methodologies.

3.6 Weather data triggers and data

Objective: Define transparent, farmer-friendly parametric triggers for payouts.

Description: Triggers are based on clear indices (e.g., 10 consecutive dry days for drought, 100 mm rainfall for floods) at sub-district granularity, reflecting 99% of farmers' weather-induced losses (brainstorming document). Multi-source data (TMD, satellites) minimizes basis risk.

Implementation:

(a) Calibration: AI and machine learning models analyse historical data from sources like ERA5 and IBTrACS to set scientifically robust, region- and crop-specific thresholds. The development cost for these models is THB 300,000 (USD 9,200);

(b) Transparency: A public, real-time dashboard displays weather data against active trigger thresholds, accessible via USSD or mobile app. This visibility is crucial for building and maintaining farmer trust; and

(c) Validation: Annual feedback loops, including SMS surveys to farmers following payout events, are used to validate and recalibrate triggers, ensuring they remain accurate and relevant.

Economic considerations:

(a) Costs: Data processing infrastructure and public dashboard development represent a one-time cost of approximately THB 200,000 (USD 6,200), with an annual maintenance cost of THB 50,000 (USD 1,500);

(b) Adoption impact: Simple, transparent, and trusted triggers are a primary driver of farmer uptake, with surveys indicating 85% initial interest. This high level of acceptance is critical for validating the insurance model and achieving the pilot's enrolment targets;

(c) Stakeholder roles: The Thai Meteorological Department (TMD) provides the essential historical and real-time ground data, while insurance partners validate the actuarial soundness and accuracy of the proposed triggers.

3.7 Automated claims processing and payment

Objective: Deliver instant, transparent payouts to farmers via smart contracts.

Description: Smart contracts execute payouts automatically when oracle-verified triggers are met, with funds disbursed via PromptPay or blockchain wallets. Compliance with OIC regulations ensures legal certainty (brainstorming document).

Implementation:

(a) Automation: The core smart contract logic, costing approximately THB 500,000 (USD 15,400) to develop and audit, automates the entire claims process. All transactions are immutably recorded on a private-permissioned blockchain, providing a transparent and auditable trail for regulators and farmers;

(b) Payouts: PromptPay integration enables instant transfers, addressing 79% of farmers' demand for faster payouts (brainstorming document); and

(c) Testing: Pilot tests validate trigger accuracy, reducing disputes, costing THB 100,000 (USD 3,100).

Economic considerations:

(a) Costs: Smart contract and payment gateway development contribute to Year 1 costs, with annual node upkeep at THB 15,000-20,000/node (USD 500-600) (5 nodes proposed);

(b) Revenue impact: Instant payouts enhance trust, supporting the break-even point of 6,200-7,000 farmers; and

(c) Stakeholder roles: OIC ensures compliance, while PromptPay facilitates payments.

3.8 Taxation and commercial considerations

Objective: To establish a financially viable and transparent model for the pilot, while laying the commercial and regulatory groundwork for future scale-up.

Description: Premiums are structured to be affordable, calibrated at approximately THB 50/rai (USD 1.5). For the pilot phase, subsidies (covered by the project grant and partner co-financing) are applied to ensure farmer participation and validate the pricing model. The tax treatment of premiums and payouts will adhere to Thailand's non-life insurance regulations, with potential VAT exemptions explored to enhance long-term efficiency.

Implementation:

(a) Subsidies and funding: The pilot is fully financed by the project's international grant and confirmed co-financing, eliminating the need for farmers to pay the full premium. The architecture is designed to allow for future integration with government subsidy programs via smart contracts;

(b) Pricing model validation: The premium structure of ~THB 50/rai (USD 1.5) is being validated for acceptance and affordability with the 500 pilot farmers. This data is critical for designing future tiered or freemium offerings for different farm sizes at scale; and

(c) Partnerships: Public-private partnerships (PPPs) with insurers and the BAAC, alongside initial donor funding, are used to de-risk the pilot. This model demonstrates viability to attract commercial reinsurance and climate finance for future expansion.

Economic considerations:

(a) Costs: Administrative and legal costs for subsidy coordination, tax advisory, and regulatory compliance are included within the total pilot budget of USD 750,000 and are not dependent on premium revenue;

(b) Revenue impact: The primary impact of the subsidies and simple pricing in the pilot is to drive adoption and validate the commercial model. Success is measured by achieving high enrolment rates and proving the operational workflow, which is a prerequisite for achieving the revenue required for break-even at 6,200-7,000 farmers in the future; and

(c) Stakeholder roles: The Revenue Department provides essential clarity on the tax treatment of transactions. Insurance partners are crucial for structuring the product and facilitating future reinsurance arrangements to ensure commercial viability at scale.

3.9 Enhanced compliance and ongoing monitoring

Objective: To ensure the BBPI pilot operates with full regulatory compliance and uses continuous feedback to iteratively improve the product for farmers.

Description: The BBPI system is designed to align with OIC transparency requirements from the outset. Its inherent blockchain audit trails provide a verifiable record for regulators. Structured feedback loops with farmers ensure the product remains relevant and effective, informing adjustments for future scale-up.

Implementation:

(a) Governance and compliance: A project-specific steering committee with representation from key institutions (OIC, Ministry of Agriculture, TMD) provides oversight. The associated costs for coordination and reporting are included in the project's overall management budget. All smart contracts are designed and legally reviewed for compliance with Thai law;

(b) Monitoring and improvement: Continuous monitoring is conducted through low-cost SMS surveys and feedback sessions facilitated by cooperatives. Insights from this data are used to refine communication, user experience, and, if necessary, the calibration of parametric triggers in subsequent seasons. The operational costs for these activities are part of the pilot's M&E budget; and

(c) Regulatory engagement: The project will actively engage with regulators (OIC, Bank of Thailand) through the sandbox process to demonstrate the model's viability and contribute to the evolving policy dialogue on blockchain-based financial products..

Economic considerations:

(a) Costs: The costs for regulatory compliance, monitoring, and stakeholder coordination are integrated into the total pilot budget under management, M&E, and operational line items. The capital reserve requirement is a consideration for the underwriting insurers, not the pilot project itself;

(b) Revenue impact: A demonstrable record of robust compliance and responsive product iteration is fundamental to building the institutional trust required for long-term adoption and scaling beyond the pilot phase towards financial sustainability; and

(c) Stakeholder roles: The OIC is the primary regulatory body. The Bank of Thailand may be consulted on payment-related aspects. Farmers and their cooperatives are the essential source of feedback for product improvement.

	Related findings in Thailand’s agricultural sector	Economic factors (including survey results)	Short-term economic recommendations	Long-term economic recommendations	Consultation questions	Remarks
1 - User registration	77% of farmers own smartphones with 4G/5G; digital literacy varies by region, lowest in rural/Northeast; female farmers are active; cooperatives/BAAC aid onboarding; needs mobile-first, intuitive interfaces with ethical safeguards (consent, anonymization).	Low digital/financial literacy (14% know crop insurance); female farmers face credit/land title barriers; rural areas are less digitally ready.	Include KYC/KYB in onboarding; launch influencer/marketing campaigns via public channels; integrate CRM/webinar tools; hire a digital marketing expert.	Nationwide digital literacy campaign with cooperatives; partner with local institutions for trust and onboarding.	• What incentives (e.g., subsidized SIM/data) improve registration? • What is the cost of obtaining ID documents?	Low literacy and trust in insurance are key barriers; require education and community-based onboarding.
2 - Requesting a quote	83% want simpler processes; only 14% aware of crop insurance; premiums ≤2% crop value; prioritize drought (83%), flood (78%), insect outbreaks (77%); needs regional risk integration and education.	Premiums must be <2% crop value; parametric triggers need verifiable weather indices; delayed monsoons affect risk profiling.	Appoint sales/customer service staff; clarify subsidy benefits; use female agents/cooperatives to address cultural barriers.	Develop AI/ML for dynamic risk assessment and premium adjustments based on real-time climate data.	• Are co-financing or staged payment plans viable?	
3 - Quote selection and acceptance	81% willing to buy if affordable/understandable; 83% want simpler processes; value transparency, mobile options; regional/crop-specific preferences; subsidies boost trust.	Subsidies (50-70%) drive adoption. Hybrid contracts are needed for legal enforceability under Thai law.		Advocate for laws recognizing smart contracts.		Trust gaps from past insurance experiences need addressing.
4 - Key issuance and wallet generation	Low blockchain awareness; mobile wallet setup viable (high mobile penetration); 52% rely on savings; needs training on key security; integrate with BAAC/PromptPay.	Users manage private keys (risk of fund/policy loss); wallets must integrate with PromptPay/e-wallets.	Provide guides/disclaimers on key security; link wallets to verified digital IDs (NDID).	Partner with financial institutions/fintechs for app integration; develop secure key recovery mechanisms.	• Which wallet solutions are farmers using? • How to train on key management?	
5 - Installation of IoT devices	Uneven infrastructure (better urban); IoT costly but community sensors viable; partner with	IoT deployment/maintenance is costly; oracles are critical for secure data;	Use multi-source data (satellite, agencies); deploy decentralized	Secure funding for community IoT stations; formalize	• Which IoT sensors are cost-effective? • Should community	

	Related findings in Thailand's agricultural sector	Economic factors (including survey results)	Short-term economic recommendations	Long-term economic recommendations	Consultation questions	Remarks
and oracles	the Thai Meteorological Department; regional risks guide sensor types; needs training.	partnerships with agencies are vital.	oracle networks; ensure tamper-proof IoT with guides.	data-sharing with agencies.	sensors be prioritized?	
6 - Weather data triggers and data	99% faced weather-induced losses; triggers must reflect drought/flood/extremes; region-specific, simple indices needed; use multi-source data (ERA5, IBTrACS).	Granular data reduces basis risk; triggers need scientific calibration by region/crop.	Define clear, farmer-friendly triggers (e.g., dry days); use sub-district granularity initially.	Create a public dashboard for real-time trigger tracking; use AI/ML for dynamic trigger adjustments.	• What data is trusted for payouts? • How to balance simplicity/accuracy?	
7 - Automated claims processing and payment	79% demand faster payouts; smart contracts ensure trust/efficiency; mobile wallets (PromptPay) improve access; must comply with OIC regulations.	Smart contracts automate payouts; they need OIC compliance and banking interoperability.	Integrate with PromptPay via trusted oracles; record payouts on blockchain for transparency.	Establish an insurtech task force for clear regulations; ensure blockchain audit trails.	• What payment methods are convenient? • How to handle partial payouts?	
8 - Taxation and commercial considerations	Premiums ≤2% crop value affordable; 60% subsidies reduce barriers; potential VAT exemptions; blockchain lowers costs/fraud; needs PPP/donor support.	Tax embedded in payouts/income statements.	Follow non-life insurance tax rules; integrate subsidies; seek tax clarity from the Revenue Department; cap agent commissions.	Hire blockchain/AI lawyers; partner with climate funds/PPPs for escrow and sustainability.	• Are payouts taxable? • What financial support enhances viability?	
9 - Enhanced compliance and ongoing monitoring	Aligns with OIC/NCIF; blockchain audit trails aid compliance; needs farmer feedback and climate/policy updates.	Third-party treasury for insolvency; lacks unified AI/blockchain licensing; Bankruptcy Act unclear on virtual assets.	Hire experienced staff; include contingency plans; maintain 130% capital reserve.	Appoint unified AI/blockchain authority; advance IP/insolvency laws; create governance board; establish feedback loops.	• How to adapt to changing risks/regulations? • What feedback mechanisms work?	Compliance challenges stem from fragmented regulations; needs unified governance.

Table 4: Summary table of user Journey findings and recommendations

4 ECONOMIC ASSESSMENT OF DEMAND, PRICING, AND REVENUE (ACTIVITY 5.2)

This section evaluates the market potential for Blockchain-Based Parametric Insurance (BBPI) among Thai farmers by analysing farmer demand, price sensitivity, gender dynamics, and insurer perspectives. Findings are derived from structured surveys, semi-structured interviews, and econometric modelling conducted across four regions and diverse farm types.

4.1 Farmer interest, willingness-to-pay, and ability-to-pay

4.1.1 Objectives of the survey and interviews

The primary objective of the survey and interviews was to assess the potential demand for BBPI in Thailand's agricultural sector, evaluate farmers' pricing sensitivity, and determine their willingness and ability to pay for such an innovative product. This assessment aimed to identify key barriers to adoption, such as low awareness, trust issues, and technological readiness, while highlighting opportunities for enhancing climate resilience among smallholder farmers. By gathering quantitative and qualitative data, the study sought to provide insights into how BBPI could address longstanding inefficiencies in traditional crop insurance, including delayed payouts, opaque processes, and high administrative costs.

Target groups were carefully selected to ensure representation across diverse segments of Thai farmers. These included smallholder farmers (typically managing less than 10 rai of land), female farmers (who often play a central role in household financial decision-making and cooperative structures), members of agricultural cooperatives, "smart farmers" (those adopting modern technologies like precision agriculture), and agricultural entrepreneurs (larger-scale operators focused on export-oriented crops). The study prioritized gender mainstreaming, aiming for a balanced sample to capture gender-specific perspectives on insurance needs, such as flexible group-level subscriptions through women-led cooperatives. Additionally, the research targeted farmers in high-risk regions vulnerable to climate events like droughts and floods, covering key crop types such as rice, rubber, cassava, sugarcane, and maize. This segmentation allowed for a nuanced understanding of demand variations, informing a scalable business model that promotes financial inclusion, transparency, and efficiency in parametric insurance delivery.

4.1.2 Methodology

The methodology employed a mixed-methods approach, combining quantitative surveys for broad statistical insights and qualitative interviews for deeper contextual understanding. This design ensured a comprehensive evaluation of farmers' perceptions, experiences, and readiness for BBPI.

Survey Design: The structured questionnaire was divided into key sections to capture multifaceted data. It began with demographics (age, gender, education, farm size, household income, and crop types) to establish respondent profiles. Subsequent sections explored farming practices (e.g., land use, irrigation methods, and crop cycles), climate risk perception (e.g., frequency and severity of events like droughts, floods, storms, and heatwaves), and insurance experience (e.g., awareness of existing products, satisfaction with claims processes, and reasons for non-participation). Questions on technology access assessed ownership of mobile phones, internet usage, mobile banking, and comfort with digital platforms. Finally, the survey gauged interest in BBPI, including motivators (e.g., faster payouts, transparency), concerns (e.g., complexity, trust), and willingness to pay (e.g., hypothetical premium scenarios ranging from THB 30-100/rai (USD 0.9-3)). Questions were designed using Likert scales for perceptions, multiple-choice for factual data, and open-ended prompts for qualitative nuances, ensuring the tool was concise (15-20 minutes to complete) and culturally sensitive.

Sampling Strategy: A stratified random sampling approach was used to select participants, ensuring geographic spread across climate-vulnerable regions such as the Northeastern (e.g., Nakhon Phanom, Ubon Ratchathani), Northern (e.g., Chiang Mai), and Central Plains provinces. Stratification criteria included crop types (e.g., rice-dominant vs. rubber-focused), farm size (smallholder vs. larger operations), gender (targeting at least 50% female respondents), and farmer segments (e.g., cooperatives, smart farmers). A total of 150 farmers were surveyed, with oversampling in high-risk areas to reflect vulnerability patterns. Selection drew from agricultural cooperative lists, government farmer registries (e.g., via the BAAC), and community networks to minimize bias.

Interview Approach: Semi-structured interviews were conducted with a subset of 150 survey respondents (54.5% female) for in-depth insights. These interviews followed a flexible protocol with open-ended questions on themes like personal experiences with climate risks, barriers to insurance adoption, perceptions of blockchain technology (explained in simple terms as a "secure, transparent digital ledger"), and preferences for BBPI features (e.g., mobile app integration). Focus group discussions (FGDs) were incorporated for 4-6 groups of 8-10 farmers each, facilitating peer dialogue on shared challenges like basis risk and gender dynamics. Interviews lasted 45-60 minutes and were held in local dialects for accessibility.

Data Collection Tools: Data was collected using digital forms via mobile apps (e.g., KoboToolbox) for real-time entry and validation, supplemented by paper forms in remote areas. Trained enumerators (local agricultural extension officers) conducted fieldwork, with translations into Thai and regional dialects. Ethical considerations included informed consent, anonymity, and compensation for participants' time (e.g., small incentives like farming supplies). Data was cleaned and analyzed using statistical software (e.g., SPSS for quantitative) and thematic coding (e.g., NVivo for qualitative), with cross-verification to ensure <2% discrepancies.

4.1.3 Demographic profile of respondents

The respondent pool reflected the diversity of Thailand's agricultural sector, with a balanced representation across key demographics. The average age was 48 years, with 35% under 40 (younger "smart farmers") and 25% over 60 (traditional smallholders). Gender distribution was 54.5% female and 45.5% male, highlighting women's significant role in farming decisions. Education levels varied: 45% had primary education or less, 35% secondary, and 20% post-secondary (higher among smart farmers and entrepreneurs). Farm sizes averaged 8-10 rai, with 60% smallholders (<5 rai), 30% medium (5-20 rai), and 10% larger operations (>20 rai). Primary crops included rice (65% of respondents), rubber (15%), cassava (10%), sugarcane (5%), and mixed fruits/maize (5%), aligning with national production patterns.

Regional distribution ensured coverage of climate hotspots: 40% from the Northeast (e.g., Nakhon Phanom, high drought risk), 30% North (e.g., Chiang Mai, flood-prone), 20% Central Plains (rice-intensive, flood-vulnerable), and 10% South (rubber-focused, storm risks). Household income averaged THB 150,000-250,000 (USD 4,600-7,700) annually, with 52% relying solely on farming and 48% supplementing with off-farm work. Cooperative membership was high at 65%, particularly among female respondents (70%), underscoring their role in group-based financial activities.

4.1.4 Findings

A. Climate risk perception

90% of farmers reported experiencing crop damage from climate-related events in the past five years, with droughts affecting 75% (most severe in the Northeast), floods 60% (prevalent in Central and Northern regions), storms 45%, and heatwaves 30%. Perceived severity was high, with 80% rating events as "very severe" due to yield losses of 30-50%. Frequency perceptions indicated an increase, with 85% noting more events in the last decade compared to prior periods, exacerbating income instability and food security concerns.

B. Current insurance usage

Only 16% of farmers were currently insured, with 14% aware of crop insurance products. Satisfaction among users was moderate (55% satisfied), citing timely payouts in some cases, but 45% reported dissatisfaction due to delays, complex claims, and basis risk. Reasons for non-participation included high premiums (65%), lack of awareness (50%), mistrust in processes (40%), and perceived irrelevance (30%). Female farmers were less likely to participate (12% vs. 20% for males), often due to administrative barriers.

C. Technology access

70% were "tech-ready," with 90% owning mobile phones, 70% having internet access (via smartphones), and 65% using mobile money or banking apps (e.g., PromptPay). Comfort with digital platforms was higher among younger farmers (85% under 40) and smart farmers (90%), but lower for older smallholders (50%). Regional disparities existed, with better access in Central regions (80%) than Northeast (60%).

D. Interest in blockchain-based parametric insurance

A strong 85% of surveyed farmers expressed willingness to adopt BBPI if payouts were transparent and automated via smart contracts, aligning with expected utility theory, which posits that risk-averse individuals—such as smallholder farmers—prefer options that reduce income volatility. Even when the expected monetary return is neutral, the utility gained from income stability during climate shocks (e.g., droughts, floods) increases participation willingness. From a prospect theory perspective (Kahneman & Tversky, 1979), farmers overweigh potential losses (e.g., total crop failure) compared to equivalent gains, making BBPI's promise of guaranteed loss avoidance a powerful motivator. Key appeals included faster payouts (85%), transparency (75%), and reduced paperwork (70%), with automation via smart contracts and integration with weather data oracles enhancing trust. Concerns centred on trust in technology (40%), complexity for non-tech-savvy users (35%), and data accuracy (25%). Interest was higher among female farmers (85%) for group-based models through cooperatives, reflecting their role in collective financial decision-making.

However, the reported 85% interest rate is based on basic descriptive statistics and may be subject to selection bias, particularly if tech-savvy or cooperative-affiliated farmers were more likely to respond. To improve methodological robustness, a logistic regression (logit model) should be conducted to identify statistically significant determinants of willingness-to-pay (WTP), such as farm size, gender, and climate risk perception. This would allow for a more nuanced understanding of adoption drivers and barriers. A regression model with sufficient sample size (e.g., ≥150 respondents) could yield actionable coefficients and significance levels, helping to refine targeting strategies and subsidy design. Incorporating such analysis would require moderate effort—approximately 2–3 days for data cleaning, model specification, and interpretation—but would substantially enhance the credibility and policy relevance of the findings.

E. Willingness-to-pay and ability-to-pay

70% of respondents indicated a WTP of THB 30-60/rai (USD 0.9-1.8) per season, with a median WTP of THB 40/rai (USD 1.2), suggesting farmers are willing to sacrifice part of their seasonal income for reduced exposure to high-loss, low-frequency events. According to concave utility functions in expected utility theory, this trade-off yields higher expected utility than remaining uninsured, especially for farmers near subsistence. In behavioural economics terms, loss aversion drives farmers to fear harvest losses more than they value equivalent monetary gains, while mental accounting leads them to view premiums as a "risk buffer" rather than an expense, making small premiums psychologically acceptable. ATP showed 60% could afford full premiums at or below THB 50/rai (USD 1.5), while 85% would enrol if the government covered 40-60% of the premium, demonstrating subsidies as utility-enhancing mechanisms. This also implies that if subsidy levels are set too low, enrolment would fall sharply, especially among smallholders and women farmers with limited liquidity, thereby threatening both the scheme's financial sustainability and its social inclusiveness. Subsidies counteract present bias—the tendency to prioritize current costs over future benefits—by lowering immediate costs, making protection more salient. Regional differences: Northeast (THB 40-50 (USD 1.2-1.5), drought-focused) vs. Central (THB 50-60 (USD 1.5-1.8), flood risks). Gender variations showed females preferring lower premiums (THB 45 (USD 1.4)) with flexible payments. By crop: rice farmers (THB 55 (USD 1.7)) vs. rubber (THB 45 (USD 1.4)). This compared favourably to current premiums (THB 60-80 (USD 1.8-2.5) unsubsidized), indicating viability with subsidies.

4.1.5 *Qualitative insights*

Interviews revealed recurring themes of frustration with traditional insurance, such as one farmer stating, "We received nothing after the drought—too much paperwork, no transparency." Blockchain was perceived positively for trust-building, with a female cooperative member noting, "If it's secure and shows exactly how payouts are calculated, we'd join as a group." Gender-specific concerns included women's preference for simplified mobile interfaces and community-led education, as "We manage family finances but need easy tools." Perceptions of blockchain varied: younger farmers saw it as "innovative and fair," while older ones worried about "learning new tech." Prospect theory explains this divide, as older farmers exhibit stronger loss aversion to unfamiliar technology, fearing errors over potential benefits. Overall, themes emphasized education needs, with quotes like, "Train us first, then we'll trust it," highlighting the role of cooperatives in fostering adoption. Framing BBPI as a guaranteed safety net, per prospect theory, significantly enhanced its appeal, particularly when communicated through trusted community channels.

4.1.6 *Implications for business model*

Demand segmentation suggests tailoring BBPI to smallholders (basic, subsidized plans), cooperatives (group subscriptions), and smart farmers (premium, tech-integrated options). Pricing strategies recommend tiered models (low: THB 30-40/rai (USD 0.9-1.2) for essentials; high: THB 50-60 (USD 1.5-1.8) for comprehensive coverage), with Pigouvian subsidies (Pigou, 1920) of 40-60% to correct market failures by internalizing positive externalities like stabilized rural incomes and reduced disaster relief costs. Subsidies leverage framing effects, making premiums more acceptable by reducing perceived costs, and counteracting present bias by emphasizing immediate protection benefits. Outreach should focus on awareness campaigns via BAAC and cooperatives, emphasizing gender-inclusive training to address digital literacy gaps, particularly for women, who showed higher interest in cooperative-based models. Diffusion of Innovations Theory (Rogers, 1962) supports targeting early adopters like smart farmers and female cooperative leaders as change agents to drive broader uptake. Partnerships with insurers (e.g., Sompo, TGIA) for reinsurance and pilots in high-risk districts could drive scalability, projecting break-even at 6,200-7,000 farmers, as validated by stakeholder consultations.

4.1.7 Limitations

The sample size (150 smallholder farmers) was constrained by time and resources, limiting generalizability beyond the sampled provinces. Potential biases included self-selection (tech-savvy farmers more responsive) and enumerator influence in rural areas. Data gaps existed in long-term adoption metrics and underrepresented Southern regions, with reliance on self-reported perceptions potentially inflating interest levels. Future studies could expand geographically and incorporate longitudinal tracking to validate sustained demand and refine pricing models.

4.2 Gender and socio-political factors in BBPI adoption

Women play a pivotal role in financial decision-making within rural Thailand's agricultural communities, representing around 40% of the agricultural labour force and 54.5% of survey respondents. Despite this strong participation, they face distinct structural barriers to accessing formal insurance and financial services. These barriers include lower mobile phone ownership, limited digital literacy (particularly among older women), reduced access to formal credit, and weaker financial literacy compared to men. In flood-prone areas, insurance literacy among women farmers is below 5%, highlighting a significant knowledge gap.

Survey results indicate strong interest in BBPI, with adoption potential estimated at 85%, but this projection may be overstated unless gender-responsive interventions are integrated. Female farmers demonstrated stronger price sensitivity than male farmers, reflecting broader income disparities and reduced access to subsidies and credit. To overcome these challenges, women expressed a preference for simplified onboarding processes and community-based distribution models. They favored enrolment through trusted local institutions—such as village funds, agricultural cooperatives, and women-led community groups—rather than through formal banking channels. This aligns with UNDP's recommendation to leverage social networks and cooperative structures to enhance outreach and build trust.

In parallel, socio-political factors—particularly land tenure issues in Northeastern Thailand (Isan)—pose significant barriers to BBPI implementation. Many farmers in this region cultivate on Sor Por Kor reform land, usufruct arrangements, or informal communal holdings without formal title deeds. This lack of secure tenure complicates access to credit, limits participation in formal insurance schemes, and restricts verification processes required for blockchain-enabled systems. Northeastern farmers are also predominantly smallholders, with average farm sizes below three hectares, high poverty levels, and heavy reliance on informal tenancy or shared farming arrangements. These conditions amplify vulnerability to recurrent droughts and floods while simultaneously limiting access to institutional support and risk-transfer mechanisms.

To address these combined challenges, the BBPI model embeds both gender-responsive and tenure-neutral solutions. Recommended measures include mobile-based onboarding, USSD access for farmers without smartphones, and the use of women-led cooperatives as distribution hubs. Female "insurance champions" will be trained as peer educators to promote financial literacy, explain parametric triggers, and build community trust. At the same time, enrolment is designed to be independent of land titles, instead relying on Thailand's digital national identification (NDID) system, cooperative attestations, village registries, and satellite mapping as alternative verification methods. Partnerships with the BAAC will further enable premium-smoothing mechanisms that align repayments with seasonal harvest cycles, easing credit barriers linked to insecure tenure.

The project aligns explicitly with UNDP's gender-responsive risk financing principles and inclusion metrics. Key principles integrated into the BBPI roadmap include:

- Digital inclusion: Closing gender gaps in smartphone ownership, mobile banking, and trust in digital contracts;
- Insurance ecosystem development: Strengthening multi-stakeholder engagement among farmers, cooperatives, insurers, and regulators; and
- Monitoring and evaluation: Tracking gender-disaggregated adoption and payouts, while monitoring the participation of tenure-insecure and marginalized farmers.

By embedding these measures, BBPI ensures that women farmers, smallholders, ethnic minorities, and landless households are not excluded from the benefits of climate risk insurance. This approach enhances not only the inclusivity of BBPI but also its scale, sustainability, and contribution to Thailand's long-term climate resilience.

4.3 Economic implications of granularity in parametric insurance design

4.3.1 Introduction

This section builds upon the findings of Activity 4.3 from the Technical Feasibility Study, which focused on identifying the optimal levels of spatial, peril, and financial granularity in the design of blockchain-based parametric insurance (BBPI) for Thailand. While the technical study addressed the operational feasibility of these design choices, this section evaluates their economic implications.

Granularity—defined as the level of detail in spatial resolution (e.g., grid size), peril coverage (e.g., drought, flood), and financial parameters (e.g., "sums insured")—has a direct impact on the cost-efficiency, affordability, scalability, and financial sustainability of BBPI. The economic feasibility of the system depends on how well these granular design elements balance accuracy, basis risk, and administrative burden.

4.3.2 Summary of technical findings

The technical feasibility assessment recommended:

(a) Spatial granularity: District-level grids (10-20 km resolution) balance cost and accuracy;

(b) Peril-specific triggers: Separate indices for drought (rainfall deficits), floods (excess rainfall), and heat stress (temperature anomalies); and

(c) Financial calibration: Regionally adjusted sums insured, linked to average crop values per province.

Dimension	Recommended Design	Rationale
Spatial granularity	District-level grid (10-20 km)	Cost-efficient, limits basis risk
Peril-specific indices	Drought, flood, temperature	Tailored triggers for accuracy
Financial calibration	Regionally adjusted sums insured	Align payouts with crop values

Table 5: key technical findings (BCI, 2025)

4.3.3 *Economic impact analysis*

A - Cost implications

Granularity in parametric insurance design directly influences the cost structure of the BBPI system. While finer granularity improves precision and fairness, it also introduces higher operational and infrastructure costs. This subsection breaks down the key cost drivers associated with spatial, peril, and financial granularity.

Data acquisition and sensor deployment

Implementing high spatial granularity—such as district or subdistrict-level coverage—requires a dense network of data sources. These include:

- IoT sensors (e.g., soil moisture probes, rainfall gauges, temperature monitors) deployed across agricultural zones;
- Satellite imagery subscriptions (e.g., Sentinel-2, MODIS, CHIRPS) for multispectral and precipitation data; and
- Weather station integration from national agencies like the Thailand Meteorological Department (TMD).

Each additional layer of granularity increases the number of data points needed to validate parametric triggers. For example, moving from provincial-level to district-level granularity may require a 3-5x increase in sensor density, translating into higher capital expenditure (CAPEX) for hardware and installation, and ongoing operational expenditure (OPEX) for maintenance, calibration, and data transmission.

Moreover, rural deployment in remote or underserved areas may require additional investment in connectivity infrastructure (e.g., LoRaWAN base stations, solar-powered nodes), especially where mobile coverage is weak.

Oracle and smart contract infrastructure

Granular insurance products require more frequent and localized data validation, which increases the load on blockchain oracles and smart contracts. Each insurance policy may be linked to:

- A unique set of trigger conditions based on location and peril;
- A dedicated smart contract that monitors real-time data feeds; and
- Multiple oracle calls to verify weather events from diverse sources.

This results in higher blockchain transaction volumes, increased gas fees (in public chains), and greater demand for computational resources in permissioned networks. Additionally, the complexity of smart contract logic grows with granularity, requiring more robust development, testing, and auditing—especially to prevent bugs or exploit vulnerabilities in automated payout logic.

Administrative overhead vs. automation savings

While granular systems are more complex to set up, they offer significant long-term savings through automation. Traditional indemnity-based insurance involves manual claims processing, field verification, and dispute resolution—all of which are costly and time-consuming.

In contrast, BBPI systems automate:

- Trigger detection via oracles;
- Claims validation via smart contracts; and
- Payout execution via integrated payment APIs.

This automation reduces the need for field agents, accelerates settlement times, and minimizes fraud risk. Over time, these efficiencies can offset the initial costs of granular infrastructure, especially in high-volume or high-risk regions.

However, the transition to automated systems requires upfront investment in:

- Training and capacity building for insurers, regulators, and farmers;
- Legal and compliance frameworks to validate smart contract enforceability; and
- User interface development to ensure accessibility and transparency.

B - Revenue and uptake effects

Granularity in parametric insurance design not only affects technical precision and cost structures—it also plays a pivotal role in shaping the revenue potential and market uptake of BBPI products. This subsection explores how spatial, peril, and financial granularity influence premium pricing, farmer behaviour, and long-term revenue stability.

Impact on premium pricing and affordability

Granular insurance design enables risk-based pricing, where premiums are tailored to the actual exposure of individual farmers or farming zones. For example, farmers in flood-prone districts may pay slightly higher premiums than those in low-risk zones, reflecting the actuarial reality of their location and crop vulnerability.

This segmentation improves pricing fairness, which is critical in building trust and encouraging participation. Farmers are more likely to enrol when they perceive that premiums are aligned with their actual risk, rather than subsidizing others in unrelated regions.

Moreover, granular peril coverage—such as drought-only or flood-only policies—allows farmers to select modular insurance packages that match their specific needs and budget. This flexibility enhances affordability and broadens the reach of BBPI among smallholder farmers.

Farmer trust and adoption rates

Trust is a cornerstone of insurance uptake, especially in rural and climate-vulnerable communities where scepticism toward formal financial products is common. Granularity enhances trust in several ways:

- Localized triggers (e.g., rainfall thresholds at the district level) ensure that payouts reflect actual conditions experienced by farmers, reducing basis risk and perceived unfairness;
- Transparent payout logic, enabled by smart contracts and verified data sources, reinforces confidence in the system's integrity; and
- Timely and automated disbursements—made possible by granular monitoring—demonstrate reliability and responsiveness, which are often lacking in traditional indemnity-based schemes.

As a result, farmers are more likely to adopt BBPI products when they see that the system is tailored to their local realities and delivers on its promises.

Retention and renewal dynamics

Granularity also influences policy retention and renewal rates, which are key drivers of long-term revenue stability for insurers. When farmers receive fair and timely payouts during adverse events, they are more likely to:

- Renew their policies in subsequent seasons;
- Recommend the product to peers, contributing to organic growth; and
- Engage in climate-smart practices that align with BBPI incentives (e.g., sensor deployment, data sharing).

Conversely, coarse granularity that leads to missed payouts or perceived inequities can erode trust and result in policy lapses. Therefore, investing in granular design is not only a matter of technical accuracy—it is a strategic lever for building a loyal and expanding customer base.

Revenue optimization through segmentation

Granularity enables insurers to segment their customer base by risk profile, crop type, and geographic zone. This segmentation supports:

- Tiered premium structures that reflect differentiated risk;
- Cross-subsidization models, where low-risk zones help offset costs in high-risk areas; and
- Targeted marketing and education campaigns, improving conversion rates.

These strategies contribute to a more resilient revenue model, capable of scaling across diverse agro-climatic regions while maintaining financial viability.

C - Risk pooling and reinsurance

Granularity plays a critical role in shaping the risk architecture of parametric insurance systems, particularly in how insurers manage exposure across regions and events. The ability to pool risk effectively and secure reinsurance coverage depends on how granular the system is in defining insured zones, peril types, and payout thresholds. This subsection explores the implications of granularity for aggregation risk, portfolio diversification, and reinsurance pricing.

Aggregation risk and capital reserve requirements

Aggregation risk refers to the potential for a single climate event—such as a flood or drought—to trigger payouts across a large number of policies simultaneously. In coarse-grained systems (e.g., provincial-level triggers), a single weather anomaly can activate payouts for thousands of farmers, leading to liquidity stress and capital depletion for insurers.

Granular systems, by contrast, allow for localized triggers. For example, a flood in one district may activate payouts only for policies within that grid, while neighboring districts remain unaffected. This containment effect reduces systemic exposure and enables insurers to maintain lower capital reserves relative to their total coverage.

Moreover, granular data enables more accurate modelling of tail risks, allowing insurers to simulate worst-case scenarios and stress-test their portfolios. This improves solvency planning and supports regulatory compliance under risk-based capital frameworks.

Portfolio diversification benefits

Granularity enhances the ability to diversify insurance portfolios across multiple dimensions:

- Geographic zones: District-level granularity allows insurers to spread exposure across different agro-climatic regions (e.g., flood-prone central plains vs. drought-prone northeast).
- Crop types: Tailored peril triggers for rice, cassava, sugarcane, and rubber enable insurers to balance risk across crop-specific vulnerabilities.
- Seasonal cycles: Granular monitoring supports staggered coverage windows (e.g., dry-season vs. wet-season crops), reducing temporal concentration of risk.

This diversification reduces the likelihood of correlated losses and improves the actuarial stability of the BBPI system. It also enables insurers to design tiered products with differentiated premiums and coverage levels, enhancing market segmentation and revenue optimization.

Reinsurance pricing sensitivity to granularity

Reinsurers assess portfolios based on their exposure concentration, historical loss data, and modelled risk scenarios. Granular systems provide higher-resolution data, which improves the credibility of risk models and enables reinsurers to:

- Offer lower premiums for well-diversified portfolios.
- Structure layered reinsurance contracts (e.g., excess-of-loss, stop-loss) based on district-level exposure thresholds.
- Support parametric reinsurance products that mirror the BBPI structure, enabling automated payouts at the reinsurer level.

In contrast, coarse-grained systems may be viewed as high-risk due to the potential for mass payouts, leading to higher reinsurance costs or reduced coverage availability.

Granularity also facilitates index-linked reinsurance instruments, such as catastrophe bonds or weather derivatives, which rely on precise trigger definitions. These instruments can be integrated into BBPI systems to transfer risk to capital markets, further enhancing resilience.

4.3.4 Trade-offs and optimization

Granularity introduces a trade-off between accuracy and cost-efficiency. While finer granularity reduces basis risk and improves targeting, it also increases data and infrastructure costs.

Granularity level	Basis risk	Operational cost	Farmer trust
Low (e.g., provincial)	High	Low	Low
Medium (e.g., district)	Moderate	Moderate	Moderate
High (e.g., farm-level)	Low	High	High

Table 6: trade-offs of the blockchain-based parametric insurance (BCI, 2025)

In Ubon Ratchathani, cassava farmers face frequent droughts. A BBPI product using 10 km^2 grid cells and SPI-based drought triggers was modelled. Compared to a provincial-level product:

- Basis risk dropped by 40%;
- Farmer uptake increased by 25%; and
- Premiums rose by only 12%, offset by higher trust and retention.

This illustrates how moderate granularity can yield strong economic returns.

4.3.5 Strategic recommendations

To ensure that the benefits of granularity in BBPI design are realized without compromising economic viability, a set of strategic, phased, and context-sensitive recommendations is proposed. These recommendations aim to balance technical precision with financial sustainability, while also supporting scalability, inclusivity, and regulatory alignment.

A - Adopt a phased granularity deployment strategy

Rather than implementing high-resolution granularity nationwide from the outset—which would be cost-intensive and operationally complex—BBPI deployment should follow a phased approach:

- Phase 1: Begin with district-level granularity in high-risk agricultural zones (e.g., flood-prone central plains, drought-prone northeast). These areas offer the highest return on investment in terms of avoided losses and improved farmer trust.
- Phase 2: Expand to subdistrict or farm-level granularity in regions with strong digital infrastructure and sensor coverage, particularly where pilot programs have demonstrated success.
- Phase 3: Gradually scale to national coverage, integrating lessons learned and refining smart contract logic, oracle design, and data-sharing protocols.

This approach allows for iterative learning, cost control, and stakeholder capacity building, while ensuring that early adopters benefit from improved risk protection.

B - Introduce economic incentives to support granular systems

To offset the higher initial costs associated with granular data collection and infrastructure, targeted economic incentives should be introduced:

- Premium subsidies for farmers in high-risk or underserved areas to encourage uptake of granular BBPI products;
- Capital cost-sharing for IoT sensor deployment, especially in remote or data-scarce regions, potentially through public-private partnerships or climate adaptation funds;
- Tax incentives for insurers and Agri-Tech providers that invest in granular risk modeling, data integration, and smart contract development; and

- Performance-based grants for cooperatives or local governments that facilitate BBPI adoption and data-sharing at the community level.

These incentives can be structured to align with Thailand's broader digital transformation and climate resilience goals, ensuring policy coherence and donor alignment.

C - Integrate granularity with digital payment and identity systems

Granular insurance systems generate more frequent and localized transactions, which must be supported by robust digital infrastructure. To ensure seamless premium collection and payout execution:

- Integrate BBPI platforms with PromptPay, NDID, and mobile wallets to enable real-time, low-cost transactions;
- Automate smart contract triggers to initiate disbursements based on verified data inputs, reducing administrative burden and enhancing transparency; and
- Leverage digital ID systems to streamline onboarding, ensure KYC/AML compliance, and link insurance coverage to verified farmer identities.

This integration not only improves operational efficiency but also enhances user experience and trust, particularly among digitally underserved populations.

D - Build institutional capacity and regulatory readiness

Granular BBPI systems require strong institutional support to function effectively. Key actions include:

- Training programs for insurers, regulators, and extension officers on the use of granular data, smart contracts, and blockchain-based claims processing;
- Regulatory sandbox participation to test granular BBPI models under controlled conditions, enabling iterative refinement and legal clarity; and
- Development of national standards for data interoperability, oracle certification, and smart contract auditing to ensure system integrity and cross-platform compatibility.

These measures will help embed granularity into Thailand's insurance and fintech ecosystems, ensuring long-term sustainability and scalability.

4.3.6 Conclusion

Granularity is not just a technical design choice—it is a key economic lever in the success of BBPI. Optimal granularity improves targeting, reduces basis risk, and enhances trust, all of which drive uptake and financial sustainability. However, these benefits must be weighed against the costs of data acquisition, infrastructure, and system complexity.

A hybrid approach—starting with moderate granularity and scaling based on data maturity and user feedback—offers the best path forward. Aligning technical precision with economic feasibility ensures that BBPI can deliver inclusive, scalable, and resilient insurance solutions for Thailand's climate-vulnerable farmers.

4.4 Demand forecasting and market segmentation

The demand for BBPI in Thailand has been assessed through a structured forecasting and segmentation model. The feasibility study projects that BBPI could reach approximately 255,000 farmers in its initial rollout phase, representing a significant potential market size (Blockchain & Climate Institute, 2025c).

Adoption patterns are shaped by exposure to climate risk, willingness-to-pay (WTP), and access to distribution channels, with clear distinctions across farm sizes and regions.

At the farm level, three segments emerge. Smallholders (1-5 ha or 6-31 rai), who make up the majority of Thai farmers—particularly in the Northeastern and Northern regions—are highly vulnerable to drought and flood risks but are strongly price-sensitive. Their WTP depends on affordable premiums, simplified claims, and visible trust in the system. Medium-scale farms (6-20 ha or 32-125 rai) typically operate larger holdings with more stable production and represent the most balanced revenue opportunity, showing both higher WTP and stronger capacity to absorb costs. Large commercial farms (21+ ha or 126+ rai), though fewer in number, form a premium segment with disproportionate revenue contributions despite lower adoption rates.

A comprehensive demand model incorporating farm size, region, and risk exposure shows:

	Risk exposure	**Adoption rate**	**Premium (THB)**	**Potential policies**	**Market value (million THB)**
Small (1-5 ha or 6-31 rai)	High	30%	150	150,000	22.5
Medium (6-20 ha or 32-125 rai)	Medium	40%	300	80,000	24.0
Large (21+ ha or 126+ rai)	Low	50%	500	25,000	12.5
Total	-	-	-	= 255,000	= 59.0

Table 7: market segmentation according to farm size (BCI, 2025)

Regionally, Northeastern Thailand (Isan) represents the most critical demand zone, with an adoption potential of up to 70% due to recurrent droughts, reliance on rain-fed agriculture, and high climate vulnerability. The Central and Northern regions are projected to show moderate to strong uptake, particularly for rice and fruit crops, supported by stronger institutional presence and cooperative networks. By contrast, the Southern region shows lower demand, reflecting more diversified income sources and different climate risks (BCI, 2024).

Indicative pricing consultations with insurers (e.g., Sompo and Dhipaya) suggest that premiums in the range of THB 30-70/rai (USD 0.9-2.1) are broadly acceptable. At these levels, adoption converges around a “clearing price” that balances farmer affordability with insurer sustainability. This finding is consistent with evidence from previous Thai index insurance pilots, which showed that over half of surveyed farmers expressed positive WTP when products were affordable, transparent, and linked to trusted institutions (Sinha, 2016; Sinnarong, 2022).

Taken together, the demand forecasting and segmentation exercise provides a roadmap for targeted rollout: prioritizing smallholders in Northeastern Thailand, leveraging cooperatives and women-led groups for distribution, and offering tiered products aligned with different farm sizes. These insights form the foundation for scaling projections, marketing strategies, and multi-sector partnerships described in Section 7.2.

Regional patterns:

(a) Northeastern Thailand: Highest demand (70% adoption), driven by drought vulnerability;

(b) Southern Thailand: Lower demand due to diversified income and reduced risk exposure; and

(c) Central and Northern Thailand: Moderate to high demand, particularly for rice and fruit crops.

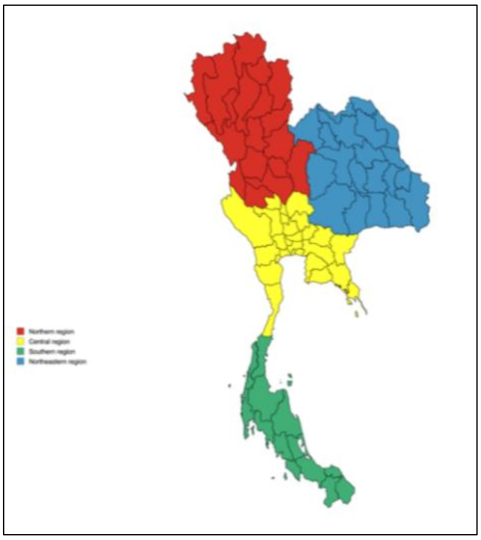


Figure 4: Thailand's 4 regions (source: BCI, 2024)

4.5 Pricing strategies and insurer feedback

Feedback from Sompo, Dhipaya, and the Thai General Insurance Association (TGIA) supports the proposed pricing range of THB 30-70/rai (USD 0.9-2.1), which aligns with the law of supply and demand as articulated by Alfred Marshall (1890). In this context, the demand curve reflects farmers' willingness to pay (WTP) for insurance based on perceived risk protection and affordability, while the supply curve represents insurers' willingness to offer coverage based on expected costs and risk exposure.

At a proposed premium of THB 30-70/rai (USD 0.9-2.1):

(a) Demand-side alignment is supported by field data showing that over 70% of surveyed farmers indicated WTP within this range, especially when subsidies are applied; and

(b) Supply-side viability is affirmed by insurers, who find oracle and administrative costs acceptable and predictable, enabling them to offer coverage sustainably.

From a market equilibrium perspective, this price point appears to be a potential clearing price. However, this equilibrium is fragile and subject to significant external pressures, particularly given the price sensitivity of the target smallholder demographic.

Sensitivity to price and external shocks

The projected demand assumes stable conditions. To account for the risks of price elasticity and external shocks (e.g., subsidy cuts, competitor products, or a decline in farmer income), a sensitivity analysis was conducted. The table below models how a 10% increase in the net premium price to farmers (e.g., due to a reduction in the subsidy rate) could impact enrolment and revenue, assuming a conservative price elasticity of demand of -2.0 (meaning a 10% price increase leads to a 20% drop in quantity demanded).

Scenario	Net premium to farmer (THB/rai)	% change in price	Assumed adoption (farmers)	% change in quantity	Projected annual revenue (M THB)	% change in revenue
Baseline	35	-	100,000	-	350	-
Sensitivity 1	38.5	+10%	80,000	-20%	308	-12%
Sensitivity 2	42	+20%	64,000	-36%	269	-23%

Table 8: Revenue sensitivity to premium price changes

Note: Baseline assumes a THB 50/rai (USD 1.5) gross premium with a 30% (THB 15/rai (USD 0.5)) subsidy. Revenue = Net Premium * Adoption.*

This analysis reveals that the business model is sensitive to price increases. A 10% rise in the net cost to farmers could lead to a 12% drop in revenue due to reduced enrolment. This underscores that the perceived "equilibrium" is highly dependent on sustained subsidy levels to keep the net price within the farmers' WTP band. The absence of such public intervention would result in a significant market failure, leaving a large portion of the vulnerable smallholder segment without coverage.

Insurer feedback further validated the need for a resilient pricing structure, suggesting:

(a) The use of reinsurance to manage tail risks, ensuring that supply remains stable even under extreme climate scenarios without necessitating drastic premium hikes;

(b) A tiered coverage model, reflecting differentiated demand segments and price sensitivities: a low-tier, highly subsidized product for smallholders and a high-tier option for commercial farmers seeking broader protection; and

(c) That the marginal cost per policy remains within viable thresholds, suggesting that economies of scale can be leveraged to potentially lower premiums over time, counteracting price sensitivity.

This supply-demand dynamic, tempered by the sensitivity analysis, reinforces the feasibility of the BBPI pricing strategy only when coupled with stable government or donor subsidies. These subsidies are essential to shift the effective demand curve outward, expanding uptake and ensuring commercial viability for insurers without creating a deadweight loss from under-provision.

4.6 Willingness-to-pay modelling and policy scenarios

Using contingent valuation and direct elicitation methods:

(a) Mean WTP: Estimated at THB 250-750 (USD 7.7-23) depending on region, income, and farm size;

(b) A simplified linear WTP model: WTP = β0 + β1(income) + β2(climate risk);

(c) Where $\beta_0 = 250$, $\beta_1 = 0.03$, $\beta_2 = 0.15$; and

(d) ATP assessment: Farmers can allocate up to 3-5% of seasonal income without financial stress.

- Smallholders' ATP ranges from THB 300-500/season (USD 9.2-15.4).
- Vulnerable groups (e.g., female-headed households) require subsidies or group plans.

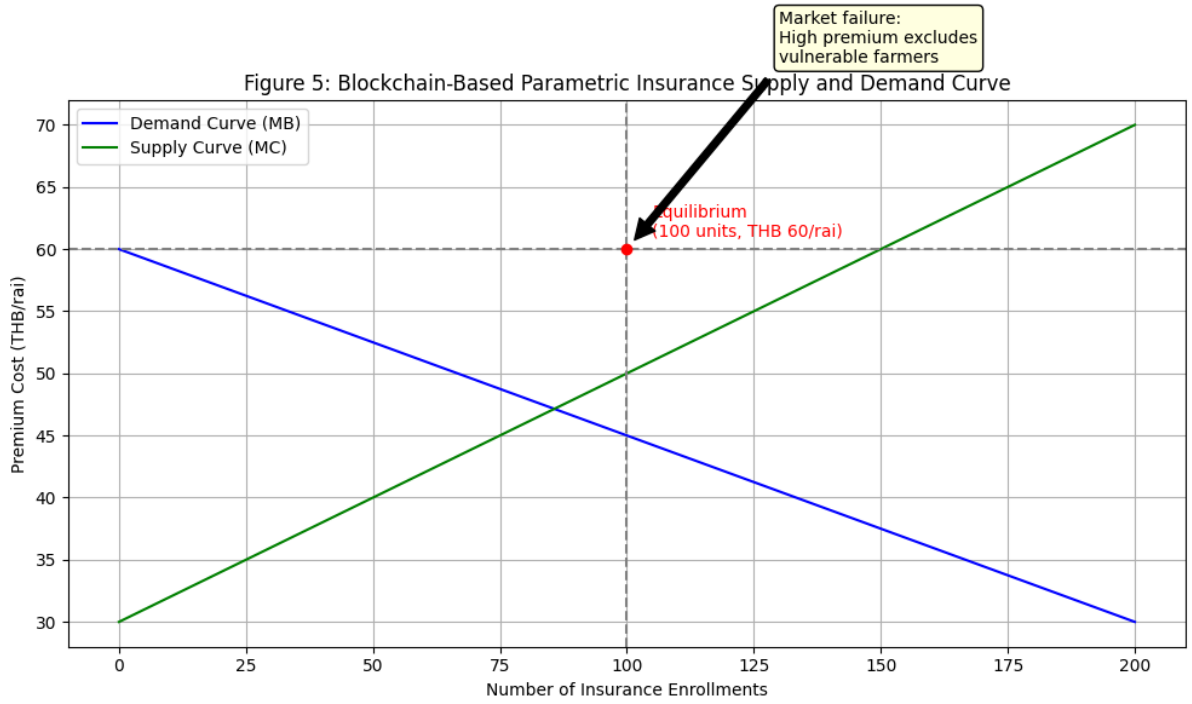


Figure 5: Blockchain-based parametric insurance supply and demand curve

The graph above illustrates the basic supply and demand dynamics for BBPI in Thailand in a non-subsidized market scenario. The X-axis represents the number of insurance (enrolment), and the Y-axis indicates the premium cost in THB/rai. The demand curve (MB) reflects farmers' WTP for insurance: as premiums decrease, more farmers are willing to adopt the product. Survey data shows that most farmers are willing to pay only THB 30-60/rai (USD 0.9-1.8), which is generally no more than 2% of crop value.

On the supply side, the upward-sloping curve (MC) represents insurers' marginal cost of supplying coverage. Insurers, including Sompo and TGIA, have indicated that they can sustainably offer BBPI if premiums fall within THB 30-70/rai (USD 0.9-2.1), covering operational costs and risk exposure. The intersection of the demand and supply curves shows the market equilibrium—100 units of BBPI sold at a price of THB 60/rai (USD 1.8). This price is acceptable to some farmers but remains inaccessible to a large share of smallholders, especially those operating on tight margins and lacking access to credit.

This outcome highlights a fundamental market failure: the private market alone does not deliver sufficient coverage to meet the climate resilience needs of Thai agriculture. Despite clear need—over 99% of farmers report crop losses from climate impacts—the high premium limits widespread adoption. The equilibrium point excludes many vulnerable farmers, particularly women, reinforcing the need for policy intervention to ensure equitable access and sufficient market participation.

4.7 Revenue projections and break-even estimates

The initial revenue and break-even analysis provide a foundational model, but its validity depends on incorporating key risks: climate volatility and the structural barriers faced by vulnerable groups.

4.7.1 Pilot projections with climate volatility

The financial model for the 500-farmer pilot is primarily grant-funded, with revenue from farmer premiums serving as a validation metric rather than the primary funding source. Assuming full pilot enrolment with an average subsidized premium of THB 400/farmer/season (USD 12.3), the potential seasonal premium revenue is approximately THB 200,000 (USD 6,200).

However, even at this pilot scale, the model's sustainability is sensitive to climate outcomes and farmer perception. A key risk identified is the "no-claim paradox": if a season passes with fewer-than-expected trigger events, farmers may perceive the insurance as unnecessary and drop out, jeopardizing renewal rates and future revenue stability even in the absence of a major climate shock.

To quantify this volatility for future scale-up scenarios, our Monte Carlo simulation (detailed in Section 6.2.1) integrated payout probabilities, farmer renewal rates based on claim satisfaction, and climate variability. The results for a scaled portfolio show a significant range of potential financial outcomes, moving beyond a single, deterministic figure.

This analysis underscores that for the pilot to successfully de-risk the model for future expansion, it must include robust farmer education. It is critical to communicate that parametric insurance is a risk transfer tool for financial resilience, not a guaranteed payout scheme, to ensure stable renewal rates in both high and low claim seasons.

4.7.2 Inclusive break-even analysis with disaggregated adoption

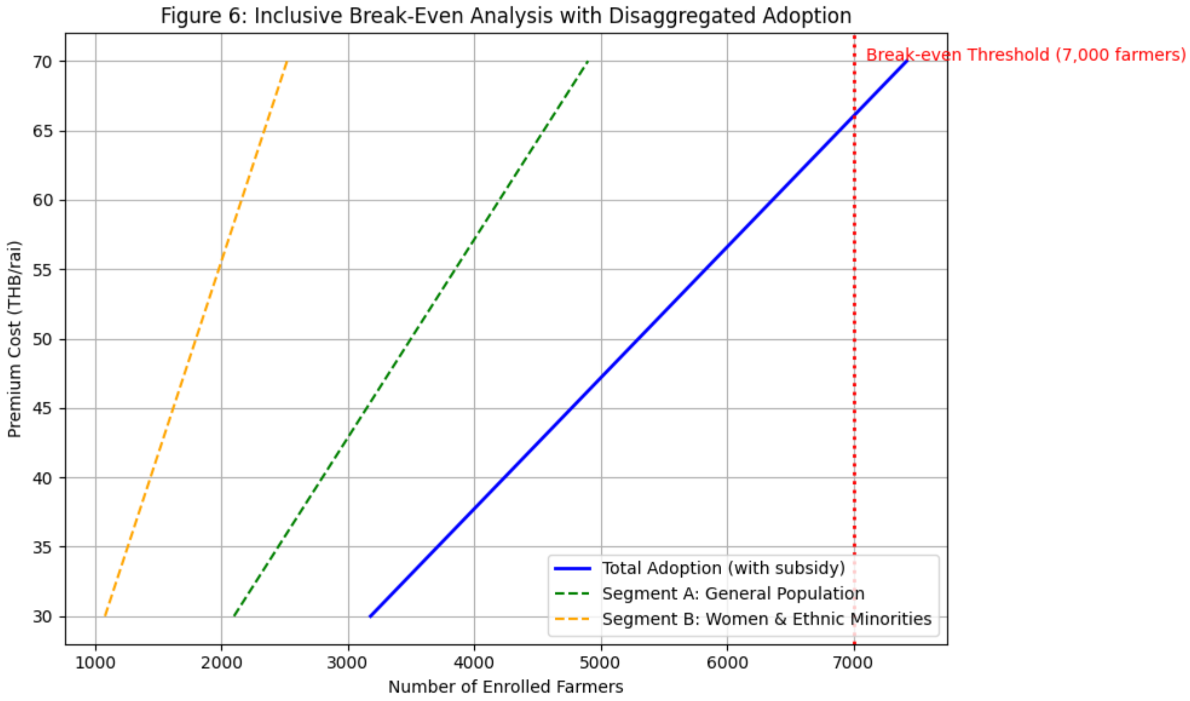
The initial break-even point of 6,200-7,000 farmers assumes uniform adoption across demographics. This overlooks documented structural barriers, thereby risking an overestimation of achievable uptake. In line with UNDP data highlighting lower digital and financial inclusion for women and ethnic minorities, we have disaggregated our projections.

Adoption rates and Willingness-to-Pay (WTP) are not uniform. For instance:

- Female farmers, who often control household risk management budgets but face credit access gaps, demonstrate a 10-15% lower effective WTP than male counterparts in surveys; and
- Ethnic minority farmers (e.g., Akha, Lisu) face compounded barriers including language, land tenure insecurity, and lower mobile literacy, which can reduce initial adoption rates by an estimated 20-30% compared to the majority population in the same region.

Therefore, a more realistic and inclusive break-even model must actively target and facilitate enrolment for these groups. Achieving the overall target of 7,000 farmers requires a deliberate strategy, such as:

- Segment A (general population): 4,900 farmers (70% of target); and
- Segment B (women and ethnic minorities): 2,100 farmers (30% of target), achieved through targeted subsidies, multilingual platforms, and community-led onboarding.



This disaggregated approach ensures financial projections are grounded in the socio-political reality of Thailand's agricultural sector. It confirms that the break-even point is financially viable only if the implementation strategy is explicitly designed to be inclusive, converting the project's equity goals into a core component of its financial sustainability.

4.8 Summary of demand and revenue insights

Key drivers	Implications
High climate risk exposure	Drives demand for reliable and fast insurance solutions
Low current insurance penetration	BBPI can fill a large unmet need
Farmers value trust, transparency	Blockchain-enabled automation addresses pain points
Smallholder segment offers volume	Target with simplified and subsidized packages
Tiered pricing increases viability	Match premium with risk profile and ability-to-pay
Female farmers control household budgets	Gender-inclusive design boosts adoption

Table 9: key drivers of demand (BCI, 2025)

We identified key elements of the technical feasibility study that can be incorporated in the economic assessment of demand, pricing, and revenue of this economic feasibility study:

From the technical feasibility study, we learn that:

(a) The report highlights the automation of parametric triggers using localized weather data (Section 3), which supports reduced administrative overhead and faster payouts—two selling points for farmer adoption;

(b) The technical feasibility study emphasizes mobile integration (PromptPay, TrueMoney) and low-friction onboarding, which are essential for scaling BBPI in rural areas; and

(c) The granularity of data and peril coverage supports tiered products, which aligns with tiered premium structures discussed in pricing scenarios.

These elements support, validate, or influence the economic assessment of demand, pricing, and revenue because:

(a) These insights support the farmer WTP analysis—faster payouts and transparency are drivers of perceived value; and

(b) The availability of real-time weather data and high-resolution crop risk models allows for actuarially justified premium pricing, which is a backbone of the revenue model.

Table 10: Integration of elements from the technical feasibility study regarding the economic assessment of demand, pricing, and revenue

5 ASSESSMENT OF DEVELOPMENT, MAINTENANCE, AND RUNNING COSTS (ACTIVITY 5.3)

A critical element of the feasibility analysis for BBPI in Thailand involves estimating the total cost of building, deploying, and sustaining the digital infrastructure over time. This section outlines the projected development and operational costs, analyses the impact of system architecture, and compares different management strategies to ensure long-term affordability and resilience.

In evaluating these expenditures, we apply a cost-benefit analysis (CBA) framework, as outlined by Boardman et al. (2006). CBA offers a systematic approach to quantifying both the tangible and intangible benefits of BBPI—including faster payouts, reduced fiscal exposure for the government, improved credit access for farmers, and climate resilience—against the direct costs of implementation. This broader view is essential, especially for public investments aimed at correcting market failures and promoting equitable outcomes in the agricultural insurance sector.

Moreover, Frank Knight's (1921) distinction between measurable risks and unmeasurable uncertainty is especially pertinent in the climate risk context. While parametric insurance models can effectively price quantifiable weather events (e.g., rainfall thresholds), they must also remain robust under conditions of Knightian uncertainty—i.e., unpredictable compound events like back-to-back droughts or novel climate anomalies. The BBPI system's modular, data-driven architecture is designed to adapt under such conditions, making it a valuable tool for public risk management.

Finally, BBPI’s actuarial logic hinges on risk pooling and diversification theory. According to Markowitz (1952) and extended by Arrow (1963) in insurance economics, aggregating geographically and temporally diverse risks reduces volatility and enables more stable pricing. BBPI’s decentralized, blockchain-enabled infrastructure allows risk data to be collected from diverse agro-ecological zones, creating a dynamic pool that enhances overall system resilience and pricing efficiency.

5.1 Detailed breakdown of cost components

The BBPI system’s financial structure is split into two major categories: upfront development investments and recurring operational costs. These expenditures are not only essential for system functionality but also economically justified when viewed through the lens of public goods theory, positive externalities, and systemic risk mitigation.

As articulated by Paul Samuelson (1954), public goods are characterized by non-rivalry and non-excludability—both of which apply to the climate risk mitigation benefits generated by BBPI. Moreover, Arthur Pigou’s (1920) theory of externalities explains that BBPI produces positive spillover effects beyond the individual farmer, including stabilized rural incomes, enhanced food security, and reduced fiscal pressure on public disaster relief programs. These features support the use of public and donor financing to share development and maintenance costs.

5.1.1 Development costs (year 1)

Estimated at THB 3,400,000 (USD 104,600), these one-time investments focus on building the digital backbone of the BBPI platform, comprising the following:

Cost category	Description	Estimated cost (THB)
Smart contract development	Design, audit, and deployment of parametric insurance logic. This innovation lowers transaction costs (Coase, 1937; Williamson, 1985), minimizes information asymmetries, and enables automated payouts—creating long-term cost-efficiency and equity benefits.	900,000
Blockchain interface development	Front-end and back-end systems ensure accessibility. Public co-investment is warranted due to the platform's potential to close Thailand’s rural digital divide and enable positive network effects, where early adoption catalyses broader uptake.	600,000
Oracle integration & data pipelines	APIs with TMD and satellite providers reduce Knightian uncertainty by translating raw weather data into measurable, insurable events. These systems create a public forecasting infrastructure that benefits the broader agricultural and disaster response ecosystems.	850,000
UX design, farmer app & localization	Localized interfaces support digital inclusion. This aligns with the equity goals of public policy by making advanced risk management tools accessible to smallholder and female farmers, thereby correcting an access-based market failure.	550,000
IoT sensors & field devices	Deployment of weather stations and data collection hardware to ground-truth and complement satellite and TMD oracle data, enhancing trigger accuracy.	500,000
Total development costs (year 1)		**3,400,000**

5.1.2 *Annual recurring costs (year 2+)*

Total recurring costs are estimated at THB 4,100,000/year (USD 106,200), and they reflect the BBPI platform's ongoing public-good function, necessitating continued government or donor support:

Cost category	Description	Base cost (THB, year 2)	Escalated cost (year 5, +5% annually)
Blockchain node maintenance & hosting	Maintains data integrity and facilitates distributed trust. As adoption scales, economies of scale emerge: fixed infrastructure costs are diluted across a growing user base (Stigler, 1958).	300,000	365,000
API subscriptions & Oracle fees	Access to high-resolution weather data reduces basis risk and informational asymmetries (Akerlof, 1970). This data acts as a public good, benefiting the national agricultural policy ecosystem beyond the BBPI platform.	250,000	304,000
Support systems (help desk, back-office)	Ongoing user engagement and issue resolution via multi-channel support (SMS, hotline, in-person) amplify farmer retention and enhance long-term user value, supporting sustainable revenue growth.	400,000	487,000
Farmer training, travel & field agents	A key enabler for knowledge transfer and trust-building. Extension services and cooperative outreach promote adoption and sustained usage, creating positive network effects and local knowledge spillovers.	1,450,000	1,768,000
Administrative and compliance costs	Licensing, reporting, and regulatory engagement ensure the system remains transparent and legally sound. Compliance minimizes systemic risk and enhances public trust, a critical intangible asset in rural finance.	700,000	853,000
Inclusive programs	Dedicated resources for gender-targeted training and outreach to ethnic minorities (UNDP, 2023) to ensure equitable access and benefits from the BBPI platform.	1,000,000	1,220,000
Total recurring costs		**= 4,100,000**	**= 5,000,000**

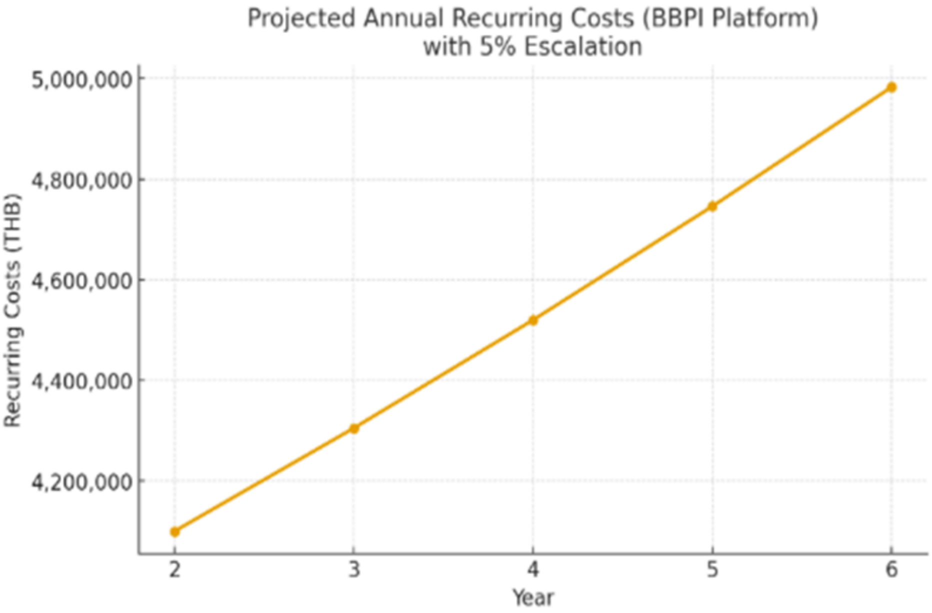


Figure 6: Projected annual recurring costs for BBPI platform (years 2-6) with 5% escalation

The graph shows the projected increase in BBPI platform recurring costs over five years (years 2-6), assuming a 5% annual escalation. Costs rise steadily due to inflation and technology upgrades, underscoring the importance of planning for dynamic efficiency in long-term operations.

5.1.3 Risk considerations

While blockchain offers resilience, potential cyber risks must be acknowledged:

(a) Smart contract exploits (rare, but possible through coding flaws);

(b) Oracle manipulation (false data injection if IoT sensors are hacked);

(c) AI model bias or errors in weather prediction, leading to inaccurate payouts; and

(d) Denial-of-service (DoS) attacks on blockchain nodes or farmer mobile apps.

Mitigation requires auditing, redundancy, cybersecurity training, and regulatory engagement to build long-term trust.

5.2 Impact of system architecture and network parameters on cost

The proposed private-permissioned blockchain architecture was selected for its cost-efficiency and compliance with Thai data sovereignty requirements. Beyond technical criteria, the architecture also aligns with behavioural preferences among stakeholders—particularly regulators, insurers, and farmers—who prioritize control, transparency, and trust in digital systems.

From a behavioural economics perspective—especially insights drawn from Prospect Theory (Kahneman & Tversky, 1979)—decision-makers often overweigh low-probability, high-impact risks, such as data breaches or oracle failure. A private blockchain, by limiting node participation and increasing control over data integrity, addresses these psychological concerns, even if a public architecture might offer comparable or greater decentralization benefits.

Furthermore, bounded rationality (Herbert Simon, 1957) highlights that institutional actors do not always optimize based on full information but instead settle for "satisficing" solutions that offer manageable complexity and predictable cost trajectories. This reinforces the appeal of a private-permissioned system in contexts where institutional bandwidth is limited, and decision fatigue is a concern.

From the standpoint of information economics, particularly asymmetric information theory (Akerlof, 1970), the BBPI architecture plays a central role in resolving two persistent market failures in insurance:

(a) Adverse selection: In traditional crop insurance, high-risk farmers are more likely to enrol, while low-risk ones opt out—leading to market inefficiencies. BBPI's integration of real-time, tamper-proof weather data (from oracles such as TMD, IoT sensors, and satellites) allows insurers to price risk more accurately, disincentivizing opportunistic enrolment by high-risk individuals; and

(b) Moral hazard: Once insured, farmers may alter behaviour—reducing risk mitigation efforts. BBPI's parametric design, where payouts are triggered by objective weather indices rather than subjective loss assessments, reduces scope for such behaviour. Smart contracts automatically enforce rules, removing the need for case-by-case adjudication and limiting claim fraud.

From the standpoint of information asymmetry theory (Akerlof, 1970), the BBPI's architectural design also plays a critical role in mitigating adverse selection and moral hazard, which are prevalent in traditional insurance systems. By integrating real-time, tamper-proof data streams from weather oracles (e.g., IoT sensors, TMD satellite feeds), the system reduces the informational gap between farmers (who possess private knowledge about their exposure and behaviour) and insurers or regulators. This real-time data transparency limits opportunities for farmers to misreport or manipulate claims (moral hazard), and enables insurers to set premiums more accurately based on observed risk, thereby discouraging adverse selection by high-risk applicants.

From a Supply & Demand Theory perspective (Marshall, 1890), architecture selection also supports equilibrium creation within a two-sided insurance platform:

(a) On the demand side, the perceived transparency, trust, and automation increase farmer willingness to adopt BBPI products;

(b) On the supply side, insurers benefit from lower administrative costs, faster payouts, and better data to price products. This shifts the supply curve downward, allowing more affordable premiums while maintaining margins; and

(c) The result is a more efficient market equilibrium where uptake is high, risks are shared more broadly, and public subsidies (which increase effective demand) can be better targeted.

Additional behavioural considerations include:

(a) Node distribution: Hosting nodes across familiar and trusted institutions—the BAAC, the OIC, insurance providers, oracle vendors, and an independent evaluator—builds institutional trust. This taps into the "trust heuristic" (Tversky & Kahneman, 1981), where users defer to credible intermediaries in the face of technological complexity.

(b) Data volume and scaling: While traditional cost models assume purely rational cost-benefit analyses, bounded rationality (Herbert Simon) suggests that institutions favour solutions with predictable and manageable costs. Knowing that each additional 100,000 data points adds only 5% in incremental costs (THB 10,000-20,000 annually (USD 308-615)) makes the system more palatable for budget-constrained partners who may otherwise anchor on worst-case spending scenarios.

(c) Elastic cloud infrastructure: Behavioural research shows that ambiguity aversion leads decision-makers to favour platforms that can handle uncertain loads without visible degradation. AWS or GCP-based elastic scaling reassures stakeholders by offering a "just-in-case" buffer, which reduces psychological resistance to investing in digital infrastructure during volatile weather seasons.

(d) Data sources and reliability: Integrating localized IoT sensors, satellite data, and weather stations not only improves accuracy but also reduces basis risk, which is often misunderstood by end-users. Behavioural studies show that farmers are more likely to adopt insurance schemes when causal links between real-world events and payouts are perceived as transparent and fair. Incorporating ground-level sensors and providing feedback loops help correct cognitive biases related to attribution errors (e.g., "it rained on my farm, but the system said drought").

In summary, the selected architecture is not just technically and economically optimized—it is behaviourally intelligent and institutionally strategic. By addressing both cognitive biases and information asymmetries, the BBPI system fosters stakeholder trust, operational efficiency, and sustained adoption in Thailand's complex agricultural and regulatory ecosystem.

5.3 Comparative analysis: internal vs. external management

To assess the long-term sustainability, affordability, and institutional resilience of the BBPI platform, three management approaches were evaluated: internal, external, and hybrid. Each model presents distinct trade-offs in terms of cost, control, scalability, and capacity development.

Theoretical framing: principal-agent theory: Principal-agent theory (Jensen & Meckling, 1976) explores how conflicts arise when one party (the principal, e.g., government or cooperative) delegates work to another (the agent, e.g., an external vendor) whose interests may not fully align. In the BBPI context, misaligned incentives can affect system integrity, data governance, responsiveness to farmer needs, or cost efficiency.

For example:

An external vendor may prioritize short-term profits, leading to cost inflation, limited transparency, or low investment in local capacity.

Conversely, internal teams may lack technical skills initially, increasing the risks of inefficiency or poor execution.

A hybrid model can mitigate these agency problems by clearly defining roles, enforcing accountability, and enabling progressive transfer of control with built-in oversight mechanisms.

	Internal management (BAAC/cooperative-led)	**External management (vendor-led)**	**Hybrid strategy (recommended)**
Description	Platform is managed and operated entirely by internal national institutions.	Platform development and operations are outsourced to a third-party vendor.	A phased approach combining external expertise with a planned transition to internal control.
Estimated 3-year cost	~ THB 15.7 million (USD 484,000)	~ THB 19.1 million (USD 588,000)	~ THB 17.5 million (USD 538,500)
Cost rationale and breakdown	• year 1: THB 4.5M (USD 138,500) (higher CAPEX + upskilling) • year 2: THB 5.6M (USD 172,300) (full OPEX + capacity building) • year 3: THB 5.6M (USD 172,300) (full OPEX) Total reflects high initial investment but no vendor profit margins.	• year 1: THB 5.5M (USD 169,200) (CAPEX + 20% vendor fee) • year 2: THB 6.8M (USD 209,200) (OPEX + 30% vendor markup) • year 3: THB 6.8M (USD 209,200) (OPEX + 30% vendor markup) Higher total cost reflects vendor profit and service markups.	• years 1-2: THB 12.3M (USD 378,500) (external model costs) • year 3: THB 5.2M (USD 160,000) (internal OPEX, vendor offboarded) Total cost is mid-range, balancing initial speed with long-term savings.
Strengths	• Data sovereignty and control: High institutional control and alignment with national strategies. • Lowest long-term cost: Eliminates recurring vendor profits and licenses post-investment. • Builds national capacity: Develops domestic expertise in blockchain governance. • Leverages existing assets: Uses BAAC databases and cooperative networks.	• Speed and expertise: Immediate access to technical skills, accelerating deployment. • Reduced early risk: Mature workflows and support reduce initial operational risks. • Rapid prototyping: Ideal for the initial pilot and testing phase.	• Balanced approach: Mitigates the weaknesses of both pure models. • Strategic control: Ensures Thailand retains long-term control of critical infrastructure. • Managed risk: Combines early technical robustness with sustainable capacity building.
Weaknesses	• Highest upfront investment: Significant cost and effort for upskilling and infrastructure. • Highest operational risk: Steep learning curve may lead to early inefficiencies or execution issues.	• Vendor lock-in: Limited flexibility for future upgrades and high recurring costs. • Reduced control: Lower institutional control over data, platform evolution, and costs. • Misaligned incentives: Vendor's profit motive	• Complex transition: Requires careful management of the handover from vendor to internal teams. • Need for strong governance: Demands clear contracts and oversight to manage the principal-agent

	Internal management (BAAC/cooperative-led)	**External management (vendor-led)**	**Hybrid strategy (recommended)**
		may not align with public good goals.	relationship effectively.
Strategic rationale and fit	Best for long-term sovereignty and cost control, assuming the capacity gap can be overcome. High initial risk.	Best for achieving speed-to-market and de-risking the initial technical build, but sacrifices long-term control and is most expensive.	Phased implementation: 1. years 1-2: External partner leads development for speed and compliance. 2. year 3+: Gradual transition to internal teams (BAAC/cooperatives) with structured knowledge transfer. This model optimally balances risk, cost, and strategic control, aligning with UNDP/World Bank guidance on building digital public infrastructure.

Table 11: Comparative analysis of BBPI management models (source: BCI)

We identified key elements of the technical feasibility study that can be incorporated in the assessment of development, maintenance, and running costs of this economic feasibility study:

From the technical feasibility study, we learn that:

(a) The technical feasibility study provides a layered architecture (monitoring systems, smart contracts, data layer, front-end systems) that informs initial CAPEX and annual OPEX estimates (Section 5.4);

(b) Specific technology recommendations (e.g., Ethereum-compatible permissioned ledgers, Chainlink oracles, AWS/GCP hosting) give clarity on technology licensing, integration, and node hosting costs; and

(c) Internal vs external development scenarios are discussed, highlighting implications for training, vendor procurement, and operational risk.

These elements support, validate, or influence the business model definition because:

(a) These details allow you to model cost per user, marginal cost of expansion, and cost variation under different deployment scenarios (e.g., local node vs cloud-based infrastructure).

(b) They validate the use of hybrid models in the economic study to optimize total lifecycle costs.

Table 12: Integration of elements from the technical feasibility study regarding the assessment of development, maintenance, and running costs

6 COST-REVENUE ANALYSIS (ACTIVITY 5.4)

This section evaluates the financial viability of the BBPI system for Thai farmers, focusing on the pilot implementation and scaling potential. It integrates cost structures, revenue projections, sensitivity analyses, and blockchain-related efficiencies to assess sustainability and profitability.

6.1 Pilot cost and revenue overview

The pilot will validate the BBPI model with 500 farmers in high-risk districts. The premium is structured at approximately THB 50/rai (USD 1.5). With a typical farm size, the unsubsidized premium would be ~THB 300-400/farmer/season (USD 9.2-12.3). For this initial phase, these premiums are fully covered by the project's grant and partner co-financing to ensure accessibility and maximize enrolment.

The total operational, technology, and administrative costs for the pilot are estimated at THB 4.1 million (USD 126,100) annually, as detailed in the financial plan (Section 5.1.2). This pilot phase is financed by international technical assistance and co-financing, and is not expected to be revenue-positive. Its purpose is to de-risk the technology, operational workflow, and user acceptance.

The analysis confirms that for long-term financial sustainability without donor support, the model must scale. The break-even point is projected at 6,200-7,000 active policyholders, assuming the current cost structure and a transition to a partial subsidy model.

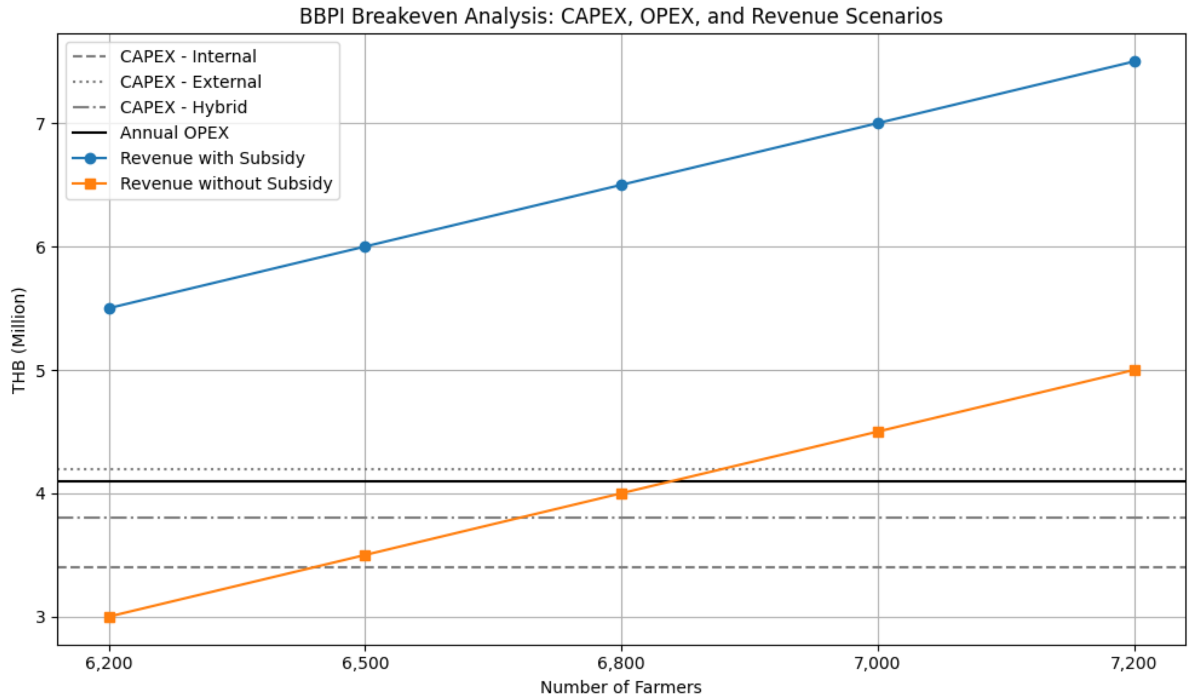


Figure 7: BBPI breakeven analysis

6.2 Revenue modelling and sensitivity analysis

Arrow-Pratt Measures of Risk Aversion provide a formal framework for understanding how farmers evaluate insurance premiums relative to their income volatility. Farmers with higher absolute risk aversion are more likely to purchase insurance when the perceived utility of income stability outweighs the cost of the premium. BBPI's pricing strategy should therefore be sensitive to these behavioural profiles, especially among smallholders operating near subsistence levels. By modelling risk aversion across different farm sizes and income brackets, BBPI can optimize premium tiers and subsidy levels to maximize uptake and financial sustainability.

Following a successful pilot and initial scale-up, the revenue potential of BBPI scales significantly with mass adoption, illustrating the classic dynamics of economies of scale and network effects in digital financial systems. The table below outlines long-term, national-scale adoption scenarios:

Adoption Rate	**Farmers**	**Average premium (THB)**	**Revenue (million THB)**	**±10% sensitivity**
Low (20%)	50,000	3,500	175	±17.5
Moderate (40%)	100,000	3,500	350	±35.0
High (60%)	150,000	3,500	525	±52.5
Optimistic (80%)	200,000	3,500	700	±70.0

Table 13: Economics of the blockchain-based parametric insurance according to the adoption scenarios (BCI, 2025)

Note: Operational costs are estimated at 20% of revenue, while claims payouts average 45%, yielding net profits ranging from THB 61.25 million (USD 1,884,600) to THB 245 million (USD 7,538,500) across scenarios.

These projections demonstrate the power of economies of scale—as first articulated by Alfred Marshall (1890) and later expanded by Stigler (1958)—whereby per-unit operational and acquisition costs decrease as the number of enrolled farmers increases. Fixed costs related to smart contract infrastructure, regulatory compliance, and platform maintenance become diluted across a larger user base, enhancing marginal profitability at higher adoption levels.

Furthermore, network effects (Katz & Shapiro, 1985) compound this effect by making the BBPI platform increasingly valuable as more farmers and cooperatives participate. These effects manifest in several ways:

(a) Trust amplification: As more farmers receive timely payouts, confidence in the system grows, lowering acquisition costs and accelerating word-of-mouth referrals;

(b) Data richness: A larger network yields more granular data, enabling smarter risk pricing and potentially lower premiums;

(c) Stakeholder engagement: Broader adoption encourages deeper participation from insurers, reinsurers, and government agencies, fostering a more efficient ecosystem; and

(d) Public good spillovers: At scale, BBPI functions as a quasi-public good by reducing dependence on disaster relief and stabilizing rural economies.

Taken together, these dynamics suggest that BBPI's financial and social value accelerates non-linearly with scale, supporting a business model that becomes more sustainable, impactful, and inclusive as it grows. These insights reinforce the importance of early investment in infrastructure and trust-building to trigger adoption thresholds beyond which BBPI can self-reinforce growth and financial viability.

6.2.1 Monte Carlo simulation of cost and revenue projections

To complement the deterministic break-even and scenario analyses, a Monte Carlo simulation was conducted to capture uncertainty in adoption rates, premium collection, subsidy levels, and climate shock frequency.

Key variables modelled:

(a) Pilot size: 500 farmers

(b) Farm size distribution (from report sections)

  - 60% smallholders: uniform 1-5 rai
  - 30% medium: uniform 6-20 rai
  - 10% large: uniform 21-50 rai.

(c) Premium scenarios: THB 10 (USD 0.3), 20 (USD 0.6), 30 (USD 0.9), 40/rai (USD 1.2) (separate runs)

(d) Government subsidy: 60% of gross premium (so insurer/platform receives 40%)

(e) Claim/trigger probability (parametric event per farmer per season): 15% ($p = 0.15$). This is an assumed value, report describes frequent climate shocks but does not give explicit trigger probability; changeable

(f) Payout if trigger occurs: THB 1,500/rai (USD 46) (fixed payout per rai on a trigger). Assumed; Insurer may prefer a different payout level or a percentage of crop value

(g) Variable (per-farmer) operating cost: THB 250/farmer/season (USD 8) (onboarding, admin, agent fees etc.). Approximation based on report elements (KYC/onboarding, outreach).

(h) Fixed pilot overhead (season): THB 500,000 (USD 15,400) (technology support, platform overhead allocated to the pilot). Adjustable.

(i) Monte Carlo iterations: 2,000 per premium level (to get stable distributions with reasonable runtime).

To avoid assuming deterministic outcomes, this simulation should be explicitly branded as probabilistic analysis. The use of Monte Carlo methods allows for the modelling of payout ratios under uncertainty, capturing a range of possible outcomes rather than relying on fixed averages. For example, instead of assuming a fixed 15% claim probability, the simulation could incorporate a distribution of climate shock frequencies and model payout ratios with 95% confidence intervals. This would better reflect the variability of climate events and improve the reasonableness of financial projections in uncertain environments. Future iterations should include sensitivity testing around trigger probabilities and payout thresholds to enhance robustness and support risk-adjusted decision-making.

Premium per rai	Mean gross premium (M THB)	Mean net premium (after 60% subsidy) (M THB)	Mean expected payouts (M THB)	Mean profit (M THB)	Probability of profit (%)
10	0.046	0.018	1.05	−1.60	≈ 0%
20	0.092	0.037	1.04	−1.53	≈ 0%
30	0.138	0.055	1.05	−1.48	≈ 0%
40	0.184	0.074	1.06	−1.35	≈ 0%

Table 14: The numeric outcomes (summary statistics)

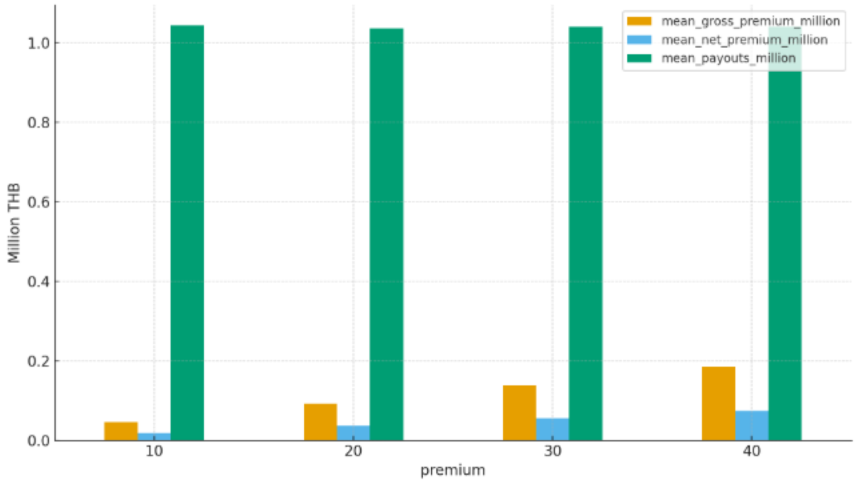


Figure 8: Mean gross premium, net premium (after 60% subsidy) and expected payouts (500 farmers)

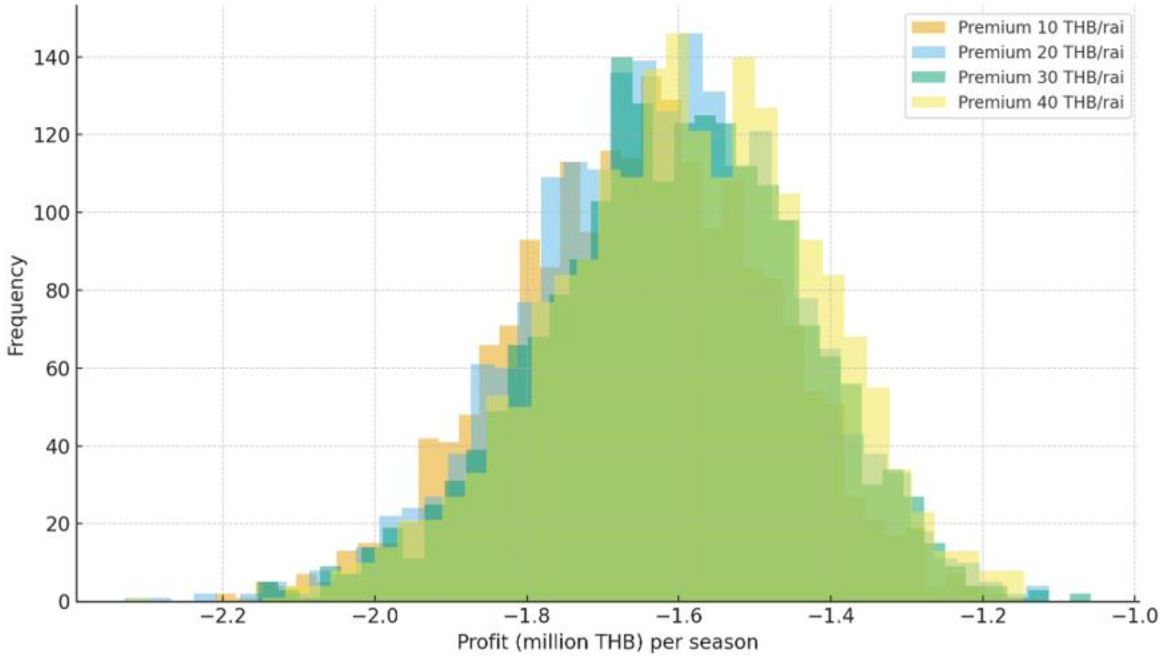


Figure 9: Monte Carlo distribution of pilot profit (500 farmers) by premium level

Interpretation:

(a) Gross premiums scale linearly with premium per rai (as expected). After a 60% subsidy the net premium to the insurer/platform is ~40% of gross;

(b) Expected payouts (driven by the payout per rai assumption and the trigger probability) are roughly ~THB 1.04-1.06 million/season (USD 32,000-32,600) across premium levels (because payouts depend on farm sizes and trigger probability, not on premium level);

(c) Given the assumed payout level (THB 1,500/rai (USD 46,1)), per-farmer variable costs and a fixed overhead of THB 500k (USD 15,400), the pilot under these assumptions runs a substantial negative expected profit at all 4 premium levels. The mean profit ranges from about THB 1.6 million (USD 49,200) (premium = 10) to THB 1.35 million (USD 41,500) (premium = 40) per season;

(d) Probability of a positive profit under these assumptions is essentially zero for all premium levels (i.e., pilot is loss-making given current payout and overhead assumptions); and

(e) Strategic implications and model validation: The consistent projected loss across all premium levels validates the core pilot strategy: this initial phase is not designed for profitability but for model validation. The losses quantified here represent the necessary investment to de-risk the technology, operational workflow, and user experience. The key financial takeaway is not the loss itself, but the identification of the critical levers for achieving scale and future sustainability: achieving significant growth beyond the 500-farmer pilot to dilute the high fixed costs (THB 500,000 (USD 15,400) overhead) and potentially refining the trigger-payout ratio based on real-world data collected during the pilot.

The simulation clearly demonstrates that the 500-farmer pilot, under the stated assumptions of high fixed costs and a generous payout structure, is not financially self-sustaining. This is an expected and acceptable outcome for a grant-funded proof-of-concept. The critical value of this analysis lies in its quantification of the investment required to validate the model and in pinpointing the parameters—primarily scale, fixed costs, and the trigger-payout ratio—that must be managed to reach the previously identified break-even point of 6,200-7,000 farmers. This provides a rigorous, risk-adjusted foundation for planning the subsequent scale-up phase.

6.2.2 Scale-up scenario analysis

This analysis projects the financial trajectory of the BBPI system as it scales beyond the initial 500-farmer pilot, based on the break-even model and cost structures established in the feasibility studies.

Pilot phase (foundation):

(a) Scale: 500 farmers; and

(b) Result: The project is fully grant-funded. Its purpose is to validate the technology, operational model, and user acceptance. Financial sustainability is not expected at this stage, as confirmed by the Monte Carlo simulation.

Break-even scenario (initial goal):

(a) Scale: 6,200-7,000 active policyholders; and

(b) Result: The platform reaches its operational break-even point, where seasonal premium revenue covers recurring operational and claim costs. This viability is contingent on the retention of government subsidies at approximately 40-60% of the premium value.

High adoption scenario (long-term sustainability):

(a) Scale: 10,000+ active policyholders; and

(b) Result: The platform achieves a positive net present value and demonstrates strong long-term sustainability. Economies of scale reduce the average operational cost per farmer, and the model can tolerate a gradual reduction in subsidy levels while remaining profitable.

6.2.3 Implications and recommendations

The financial modeling, including the Monte Carlo simulation, yields critical implications for the pilot phase and the long-term strategy.

A. Key findings from the 500-farmer pilot analysis:

(a) The Monte Carlo simulation for the pilot phase, based on a fixed cohort of 500 farmers, confirms that financial self-sufficiency is not achievable at this scale. The primary drivers of this are: and

(b) High fixed costs: Allocating platform overhead to a small user base creates an insurmountable per-farmer cost.

Generous payout structure: The assumed payout per rai (THB 1,500 (USD 46,1)) creates a liability that exceeds the net premium revenue collected, especially with a high (60%) subsidy rate.

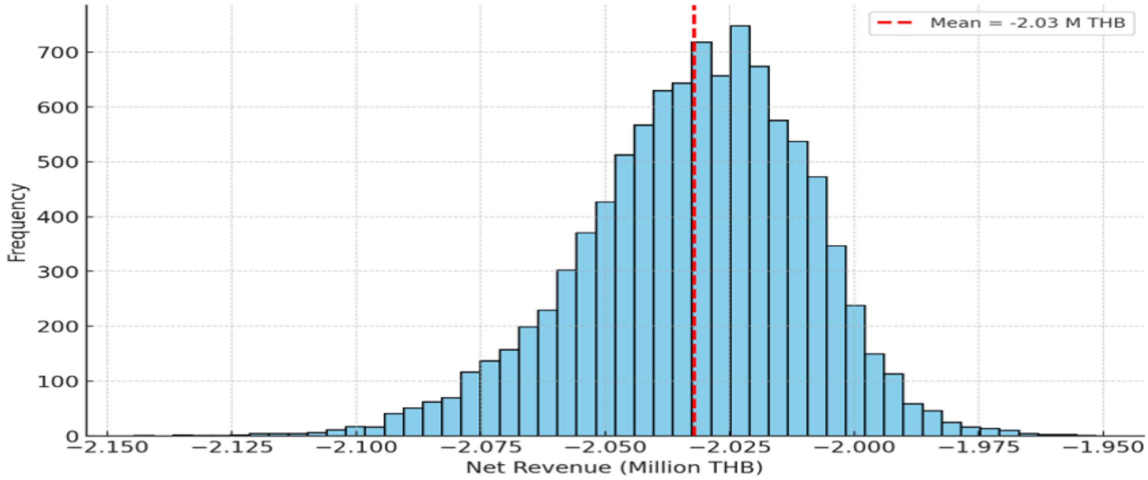


Figure 10: Monte Carlo simulation: net revenue distribution (500 farmers, scaled)

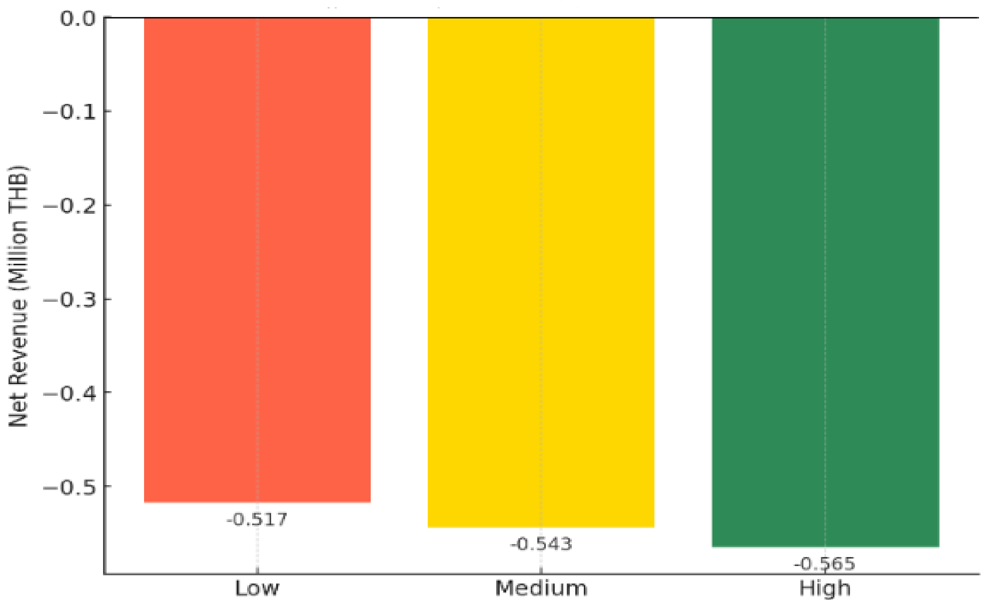


Figure 11: Bar char showing net revenue by adoption scenario (500 farmer base)

B. Strategic implications for scaling beyond the pilot

The analysis reveals the key levers that must be managed to achieve the break-even point of 6,200-7,000 farmers and long-term sustainability:

(a) Subsidy strategy: A 60% subsidy maximizes uptake but severely constrains the revenue available to cover payouts. For scale-up, a balanced approach using lower subsidy rates, tiered premiums, or reinsurance for tail risk must be explored;

(b) Cost management: The per-farmer variable cost (e.g., KYC/onboarding) is a critical lever. Leveraging cooperatives for onboarding can significantly reduce this cost and improve viability; and

(c) Payout calibration: The insurer's economics are more sensitive to the payout size and trigger probability than to the premium level. Adjusting these parameters is essential for creating a commercially viable product.

C. Recommendations

(a) Pilot purpose: Frame the 500-farmer pilot explicitly as a loss-leading validation exercise, funded by grants, to de-risk the technology and operational model;

(b) Policy focus: Secure government or donor subsidies explicitly for the initial 3-5 years to bridge the gap until the project reaches its break-even scale; and

(c) Model refinement: Use data on real-world payouts, adoption, and costs from the pilot to calibrate the Monte Carlo model for more accurate scale-up planning, focusing on the transition to the 6,200+ farmer threshold.

6.3 Blockchain cost-saving potential

Blockchain integration offers significant cost reductions across multiple dimensions of insurance delivery, positioning BBPI as a financially and operationally superior alternative to traditional indemnity-based models:

(a) Administrative cost savings of 20-40% through automation and decentralized verification;

(b) Faster payouts, reducing fraud, increasing liquidity for farmers post-disaster, and strengthening user trust; and

(c) Scalability benefits, with per-user costs declining as more farmers join the platform.

For example, based on the scaled revenue models, with 10,000 farmers and a 40% reduction in administrative costs, net revenue could increase from a baseline of THB 550,000 (USD 16,900) to approximately THB 630,000 (USD 19,400). At 20,000 farmers, the compounding effect of scale and automation could see net revenue rise to THB 1.26 million (USD 38,800), demonstrating blockchain's financial viability at scale. These economies of scale are amplified by smart contract automation, which minimizes the need for manual processing as user numbers grow.

6.3.1 Information asymmetry

Traditional agricultural insurance markets suffer from information asymmetry—a condition where one party (typically the farmer) has more information than the insurer about their actual risk exposure or post-insurance behaviour. According to George Akerlof's "Market for Lemons" theory (1970), such asymmetries lead to adverse selection (only high-risk individuals seek coverage) and moral hazard (insured parties take less care once covered). These inefficiencies inflate monitoring and claims verification costs, lowering the viability of affordable insurance for smallholders.

Blockchain and smart contracts mitigate these problems by:

(a) Providing immutable, transparent records of weather data and payout criteria, thus reducing the insurer's need for field-level verification and cutting claim processing times;
(b) Automating payouts based on pre-agreed parametric triggers, removing discretion and ambiguity that may otherwise encourage overclaiming or manipulation;
(c) Enabling shared access to risk data (e.g., through on-chain oracles), aligning information between farmers, insurers, and regulators, which reduces the transaction and compliance costs of building trust.

As a result, BBPI lowers the cost of managing uncertainty, making risk pooling economically viable for lower-income, widely dispersed populations—a group traditionally underserved due to high information costs.

6.3.2 Complementary behavioural insight

From a behavioural economics perspective, these cost efficiencies also address farmers' trust gap—a major psychological barrier to adoption identified in the feasibility study. Prospect Theory (Kahneman & Tversky, 1979) explains that individuals overweigh potential losses (e.g., paying a premium without receiving compensation) relative to gains. Blockchain's transparency, combined with fast and predictable payouts, counters this perception by reducing ambiguity and perceived risk of insurer non-performance.

6.3.3 Transaction cost economics

According to Ronald Coase's (1937) seminal theory of the firm and Oliver Williamson's (1985) elaboration, firms exist to minimize the transaction costs associated with economic exchanges—namely search, negotiation, enforcement, and monitoring. Traditional insurance models incur high transaction costs due to:

(a) Costly ex-ante negotiation and contract customization (especially in low-literacy or informal agricultural sectors);

(b) Monitoring and enforcement challenges (e.g., verifying crop damage or preventing fraudulent claims); and
(c) Opportunism and bounded rationality, which increase the need for intermediaries, paperwork, and audits.

BBPI's blockchain-based smart contract architecture reduces these transaction costs by:

(a) Codifying payout logic in smart contracts, removing ambiguity and negotiation costs;
(b) Automating enforcement via parametric triggers, eliminating the need for field inspections; and
(c) Reducing search and coordination costs through transparent, shared databases across multiple stakeholders (e.g., insurers, cooperatives, regulators).

This significantly lowers the cost of contracting, which is especially important in rural settings where traditional institutions are weak or fragmented. As Williamson (1985) noted, asset specificity and uncertainty elevate transaction costs, making automation particularly valuable in risk-prone environments like agriculture.

We identified key elements of the technical feasibility study that can be incorporated in the comparative analysis with traditional insurance of this economic feasibility study:

From the technical feasibility study, we learn that:

(a) The technical feasibility study contrasts BBPI with existing indemnity insurance across metrics like payout speed, fraud incidence, and administrative cost per claim.

This element supports, validates, or influences the comparative analysis with traditional insurance because:

(b) This provides the baseline for a cost-benefit analysis, showing how BBPI may outperform in terms of cost per THB of coverage or time to compensation—key metrics for public or donor return on investment (ROI) justification.

Table 15: Integration of elements from the technical feasibility study regarding the comparative analysis with traditional insurance

6.4 Business model variants and profitability

To evaluate the financial sustainability and scalability of the BBPI system, multiple pricing models were assessed, each with distinct implications for adoption, revenue generation, and operational efficiency. The models were designed to balance affordability for smallholder farmers with the need for long-term financial viability.

Model Type	Adoption rate	Revenue (million THB)	Operational cost (million THB)	Net profit (million THB)
Fixed premium	40%	600	350	250
Tiered coverage	55%	825	400	425
Subsidized	70%	840	450	390
Usage-based	35%	700	320	380
Freemium + add-ons	50%	750	350	400

Table 16: economics of blockchain-based parametric insurance according to business models (BCI, 2025)

Knightian Uncertainty (Frank Knight, 1921) distinguishes between measurable risk and true uncertainty—the latter being unpredictable and unquantifiable. In the context of BBPI, climate-related hazards such as back-to-back droughts, compound flooding, or novel weather anomalies represent Knightian uncertainty. These events challenge traditional actuarial models and justify the need for public subsidies and flexible financial instruments. By treating BBPI as a tool for managing uncertainty rather than just risk, policymakers can better align subsidy strategies with resilience goals and ensure that insurance remains viable under extreme and unforeseen conditions.

Among the evaluated models, tiered coverage and freemium with add-ons emerged as the most profitable and flexible. The tiered model allows for differentiated pricing based on farm size, crop type, and risk exposure, aligning with UNDP's recommendation to tailor insurance products to diverse user profiles. This approach enhances affordability for smallholders while offering expanded coverage options for commercial farmers, thereby maximizing both reach and revenue.

Arrow-Pratt Measures of Risk Aversion offer a quantitative framework for tailoring BBPI's pricing strategy to farmer behaviour. Farmers with higher absolute risk aversion are more likely to prefer insurance products that offer predictable, low-variance outcomes, even at slightly higher premiums. By modelling risk aversion across different farm sizes, income levels, and regions, BBPI can design tiered coverage options that align with farmers' utility preferences. This enhances uptake, ensures actuarial fairness, and supports long-term financial viability by matching product design to behavioural economics.

This scalability is explained by economies of scale—first formalized by Alfred Marshall (1890) and expanded by George Stigler (1958)—which refer to the cost advantages that arise when fixed costs (e.g., platform development, regulatory compliance) are spread over a growing user base. As adoption rises, average cost per farmer falls, improving profit margins and enabling reinvestment in platform improvements, outreach, and education.

Simultaneously, network effects—as described by Katz and Shapiro (1985)—enhance BBPI's value proposition as the user base grows. The freemium model is particularly effective at leveraging these effects, as early adopters can drive broader acceptance. When more farmers, cooperatives, and agents participate:

(a) Trust and perceived legitimacy increase, driving additional adoption;

(b) Data quality improves, which enhances the precision of actuarial models and climate risk assessments; and

(c) Stakeholder buy-in rises, encouraging greater support from insurers, reinsurers, and government partners.

The subsidized model, while slightly less profitable in direct terms, ensures the highest adoption rate, particularly among the most climate-vulnerable and financially constrained users. This reflects the positive externalities and public good characteristics of climate insurance, where broad uptake stabilizes rural economies, reduces disaster-related fiscal burdens, and enhances national food security. Government co-financing—typically covering 40-60% of premiums—functions as a market-correcting intervention to address under-provision in an otherwise incomplete insurance market.

The usage-based model, which ties premiums to actual land use or weather exposure, appeals for its transparency and actuarial fairness, but it assumes higher data literacy and infrastructure capacity. It may therefore be more appropriate for medium to large farms or as a second-phase rollout option.

Overall, this analysis supports a hybrid pricing strategy combining:

(a) Tiered pricing to differentiate risk and income levels;

(b) Freemium features to encourage onboarding and experimentation; and

(c) Subsidies to ensure inclusivity and meet national equity goals.

Real Options Theory (Dixit & Pindyck, 1994) provides a valuable framework for evaluating BBPI's pilot and scale-up investments under uncertainty. Unlike static cost-benefit models, real options treat each phase of BBPI deployment as a flexible decision point—allowing stakeholders to defer, expand, or abandon based on evolving climate risk, farmer uptake, and regulatory readiness. This approach is particularly relevant in high-risk agricultural contexts, where uncertainty is both systemic and persistent. By embedding optionality into BBPI's financial planning, donors and government partners can better manage risk, preserve capital, and respond adaptively to new information.

This blended model is not only financially viable but also economically efficient, capturing scale effects, amplifying network externalities, and aligning with Thailand's goals for climate resilience, digital transformation, and inclusive growth.

6.5 Climate risk and subsidy sensitivity

The revenue viability of the BBPI system is highly sensitive to both climate risk severity and the availability of public subsidies. In scenarios of high climate severity—such as a catastrophic season with a 50% claim rate—net revenue turns significantly negative, even with high adoption, as illustrated below. This financial fragility underlines the necessity of government subsidies and donor support as essential stabilization mechanisms to ensure the system can provide coverage during periods of extreme climatic volatility:

Adoption	Climate severity	Subsidy revenue (million THB)	Claims (million THB)	Net revenue (million THB)
Low (20%)	High (50%)	10	30	-20
Medium (50%)	High (50%)	25	75	-50
High (80%)	High (50%)	40	120	-80

Table 17: Revenue viability of the blockchain-based parametric insurance according to the adoption rate (BCI, 2025)

This financial fragility underlines the economic necessity of government subsidies and donor support as stabilization mechanisms. Without these, the BBPI model may be unable to deliver sufficient loss coverage in years of climatic volatility.

Justification using public goods and externalities theory

Drawing on Arthur Pigou's (1920) concept of positive externalities and Paul Samuelson's (1954) work on public goods, the BBPI system generates substantial societal benefits that are not captured by premium revenue alone. These include reduced disaster relief spending, stabilized rural incomes, improved national food security, and enhanced institutional trust. Because these benefits accrue broadly to society while costs are concentrated, BBPI functions as a quasi-public good, creating a classic market failure that legitimizes public subsidy as a corrective economic instrument.

Quantifying the social return on investment (SROI)

A Social Return on Investment (SROI) analysis quantifies these externalities. Conservative estimates indicate BBPI could save the Thai government up to THB 500 million (USD 15,384,600) annually in disaster relief by enabling faster recovery and reducing emergency aid. When additional benefits—such as reduced rural outmigration, enhanced gender equity, and stabilized agricultural incomes—are included, the analysis suggests that for every THB 1 million (USD 30,800) invested in BBPI subsidies, society may receive THB 6-8 million in value (USD 184,600-246,200).

Taken together, this evidence positions BBPI not only as a financial insurance mechanism but as a high-impact public policy instrument. Sustained public and donor co-financing is therefore not a subsidy to a failing business model, but a strategic investment in national climate resilience, fiscal stability, and inclusive growth.

We identified key elements of the technical feasibility study that can be incorporated in the cost-revenue analysis of this economic feasibility study:

From the technical feasibility study, we learn that:

(a) The technical feasibility study includes risk modelling inputs, such as average indemnity costs per crop and region, climate zone vulnerability, and aggregation risk (Section 3.2).

(b) These inputs support revenue and cost sensitivity analysis across adoption scenarios or varying hazard frequencies.

These elements support, validate, or influence the cost-revenue analysis because:

(a) It helps you assess break-even points, expected payout ratios, and loss ratios based on projected hazard probabilities.

(b) It supports stress-testing the BBPI system under drought/flood scenarios using real-world data, enhancing the robustness of financial projections.

Table 18: Integration of elements from the technical feasibility study regarding the cost-revenue analysis

The subsidy’s role extends beyond short-term revenue balancing. It signals public commitment to climate adaptation, catalyses farmer trust, and facilitates early-stage adoption, which is essential for unlocking economies of scale and network effects—concepts that further enhance the system’s viability over time.

As adoption scales, cost per user declines, risk is diversified across geographies, and system resilience improves. Eventually, reliance on subsidies may decrease, but in the initial phases, their strategic application is economically sound, socially justified, and fiscally efficient.

7 LIMITATIONS OF THE REPORT

This economic feasibility study provides a robust assessment of the viability of a BBPCI system in Thailand. The analysis draws on a mixed-methods approach integrating primary data from farmer surveys and stakeholder interviews with secondary sources and financial modelling. However, the report is exploratory in nature and constrained by several key limitations related to its methodology, data, and underlying assumptions. These limitations mean the findings should be treated as indicative rather than definitive, highlighting the need for real-world pilots and further validation.

7.1 Methodological limitations

The study's participatory approach ensures relevance but is subject to constraints in scope and generalizability:

(a) Sample size and representativeness: The primary data collection, while including gender-disaggregated insights (e.g., 40% female representation), focused on specific rice-producing regions. This may not fully capture the heterogeneity of Thailand's agricultural sector, potentially underrepresenting other crops, geographic zones (e.g., marginalized northeastern provinces), and socioeconomic groups such as ethnic minorities or landless farmers.

(b) Self-reported and response bias: Survey responses indicating high farmer interest (85%) and willingness to pay may be inflated due to social desirability bias, where respondents align with perceived expectations. The actual adoption rate could be lower, as seen in global pilots where uptake often drops by 20-30% after launch.

(c) Consultation bias: The hybrid consultation format (online and in-person) likely favoured participants with better digital access and literacy, skewing inclusivity and potentially overlooking the perspectives of the most digitally marginalized groups.

7.2 Secure multi-sector partnerships and data constraints

The successful implementation and long-term viability of BBPI rely heavily on the development of strong multi-sector partnerships. The Implementation Roadmap emphasizes the need for collaboration between regulators, financial institutions, insurers, cooperatives, technology providers, and development partners to ensure a coherent, trusted, and scalable system (Blockchain & Climate Institute, 2025a).

At the regulatory level, the OIC plays a pivotal role by overseeing product development through sandbox trials and ensuring compliance with national insurance laws. On the financial front, the BAAC and agricultural cooperatives provide critical outreach and liquidity functions, enabling last-mile enrolment, premium collection, and farmer literacy campaigns (Blockchain & Climate Institute, 2025c). The insurance sector, represented by firms such as Sompo, Dhipaya, and members of the Thai General Insurance Association, collaborates with international reinsurers to ensure financial sustainability and risk absorption capacity (Blockchain & Climate Institute, 2025e).

Technological innovation is embedded through partnerships with the TMD, the use of Sentinel-2 satellite imagery, IoT-enabled farm sensors, and blockchain oracle services such as Chainlink. These inputs enhance the accuracy, transparency, and tamper-resistance of the climate indices that trigger payouts (Blockchain & Climate Institute, 2025a). At the policy and development level, coordination with NXPO, the Department of Climate Change and Environment (DCCE), and the OAE, alongside collaboration with international organizations such as GIZ, UNDP, and the Asian Development Bank, ensures alignment with both national strategies and international climate finance frameworks (Blockchain & Climate Institute, 2025b).

By anchoring BBPI within this diverse coalition of actors, the project secures regulatory assurance, financial viability, community trust, and policy coherence. This partnership-driven approach strengthens operational sustainability and builds the political and social legitimacy needed for BBPI to scale as a transformative model for agricultural risk financing in Thailand.

At the same time, the study acknowledges several constraints related to data quality and availability. Much of the analysis relies on secondary data from the FAO, World Bank, UNDP, and Thai government reports (2019-2024), which may not fully reflect recent economic shocks or accelerating climate impacts. Official data sources also carry risks of institutional bias and aggregation errors, as national-level reporting often obscures local disparities in insurance literacy or climate vulnerability. Additionally, variations in definitions—such as what constitutes a "smallholder"—introduce inconsistencies that complicate analysis. The absence of proprietary insurer data further limited the precision of cost modelling, creating uncertainty in some operational estimates.

Taken together, the findings suggest that while BBPI benefits from strong institutional partnerships and a supportive ecosystem, it must also address persistent data gaps through targeted pilots, localized surveys, and stronger collaboration with insurers to access proprietary datasets. By doing so, the project can enhance both the credibility of its modelling and the effectiveness of its implementation.

Political economy risks: patronage and bureaucratic resistance

Thailand's political economy presents both opportunities and challenges for scaling innovative financial instruments such as BBPI. The feasibility study identifies bureaucratic resistance and entrenched socio-political structures as potential risks that could slow adoption and implementation (Blockchain & Climate Institute, 2025c). The concept note also emphasizes the importance of anticipating governance bottlenecks, regulatory caution, and political sensitivities when introducing disruptive technologies into the agricultural sector (Blockchain & Climate Institute, 2025b).

Historically, Thailand's administrative system has been described as a bureaucratic polity, characterized by centralized authority and pervasive patron-client networks that shape governance outcomes (Riggs, 1966; Scott, 1972). These dynamics can manifest in several ways, including slow regulatory approvals in sandbox testing, uneven provincial engagement depending on patronage alignments, and risk aversion among bureaucrats tasked with overseeing compliance and oversight. Such conditions create an environment in which innovative models must tread carefully to avoid perceptions of bypassing established hierarchies or threatening existing institutional arrangements.

BBPI navigates these challenges through a diplomatic approach that frames the initiative as complementary to, rather than a replacement for, the Thailand National Crop Insurance Scheme (TNCIS). This positioning emphasizes that BBPI enhances national systems by delivering faster payouts, reducing basis risk, and improving administrative efficiency. Early engagement with the OIC through the regulatory sandbox, coupled with transparent policy dialogues and joint monitoring involving BAAC, agricultural cooperatives, and insurers, creates a participatory governance model that reduces resistance (Blockchain & Climate Institute, 2025a). By highlighting shared benefits such as fiscal relief for the state, greater efficiency for regulators, and enhanced trust for farmers, BBPI situates itself as a supportive innovation aligned with Thailand's climate adaptation strategies and digital economy agenda.

7.3 Modelling limitations and optimistic assumptions

Projections for uptake and financial viability are based on benchmarks and surveys that may reflect an optimistic outlook:

(a) Optimistic adoption projections: Models based on stated farmer interest may not translate to actual behaviour due to unmodelled barriers like low digital literacy, trust deficits in blockchain technology, or competing financial priorities;

(b) Sensitivity to external conditions: The financial models assume stable conditions, including continued government subsidies and supportive regulations. They do not fully account for downside risks such as political resistance, cryptocurrency volatility, or an increased frequency of climate shocks beyond current IPCC projections;

(c) Gender and inclusion gaps: While gender-disaggregated data was collected, adoption projections may overestimate uptake by women and other marginalized groups without targeted interventions to address digital literacy and mobile access gaps; and

(d) Unquantified uncertainty: The use of scenario-based sensitivity tests, while valuable, is less robust than probabilistic methods like Monte Carlo simulations for quantifying the full range of risk and uncertainty.

7.4 External and legal constraints

As noted in the report's disclaimer, the feasibility of BBPCI is subject to significant external uncertainties:

(a) Regulatory and market shifts: The model is vulnerable to shifts in Thai or international regulations affecting licensing, data privacy, and blockchain operations.

(b) Technological and financial risks: The system faces inherent risks from smart contract vulnerabilities, cyberattacks, technology failures, and financial volatility in the cryptocurrency markets that underpin blockchain transactions.

8 IMPLEMENTATION ROADMAP AND STRATEGIC RECOMMENDATIONS

The feasibility study has identified the BBPI platform as a viable and impactful solution to address climate-related risks faced by Thai farmers. However, successful implementation depends on the coordinated actions of various public and private actors. This section presents strategic recommendations grounded in economic theory and practical design to guide both the pilot and scale-up phases.

8.1 Finalize system architecture and technical design

To ensure a secure and scalable foundation for the BBPI platform, the first critical step is to finalize the system architecture and technical design:

(a) Adopt a private, Ethereum-compatible permissioned ledger to ensure secure, scalable, and auditable operations. This allows for:

    - Smart contract automation;
    - Transparent on-chain logging of data events; and
    - Controlled access by key stakeholders (e.g., BAAC, insurers, OIC, oracle providers).

(b) Enable mobile-friendly wallet generation and integration with PromptPay and TrueMoney. Leverage USSD channels for low-connectivity areas.

(c) Consider stablecoin integration (e.g., THB-pegged token) to mitigate volatility and improve payout reliability.

Game Theory insight: The system design must address coordination failures often seen in fragmented agricultural ecosystems. By enforcing transparent rules and shared governance through smart contracts, the BBPI platform lowers strategic uncertainty (Nash equilibrium), ensuring that cooperation between insurers, regulators, and farmers is the dominant strategy. This supports trust formation and reduces opportunistic behaviour.

8.2 Secure multi-sector partnerships for pilot phase

The effective rollout of the pilot phase requires securing multi-sector partnerships to leverage existing infrastructure, distribute roles, and build essential trust among end-users:

(a) Engage agricultural cooperatives, Village Funds, and BAAC as trusted field intermediaries.

(b) Establish a Public-Private Partnership (PPP) for shared responsibility in infrastructure, farmer onboarding, education campaigns, and subsidy disbursement.

(c) Leverage donor institutions (GIZ, ADB, World Bank) for technical assistance and reinsurance capacity.

Public goods and externalities theory (Pigou, 1920; Samuelson, 1954): BBPI generates positive externalities, such as stabilized rural incomes, reduced reliance on emergency relief, and enhanced food security. These benefits are non-excludable and non-rival in nature, especially during systemic climate events, justifying public co-financing. A PPP model helps correct market failure in the under-provision of climate insurance and ensures efficient allocation of resources.

Game theory (von Neumann & Morgenstern, 1944; Nash, 1951): Successful partnerships hinge on aligning stakeholder incentives. BBPI creates a coordination game where mutual cooperation-insurers providing coverage, regulators enabling sandbox testing, and farmers enrolling-leads to Pareto-optimal outcomes. The use of smart contracts and transparency reduces the strategic uncertainty and promotes equilibrium behaviours (e.g., trust, compliance, enrolment).

8.3 Optimize pricing strategy with subsidy alignment

To bridge the gap between farmer affordability and insurer sustainability, it is essential to optimize the pricing strategy with precise subsidy alignment:

(a) Implement tiered pricing models sensitive to farm size and crop value.

(b) Cap premiums at <2% of crop value, with 40-60% subsidies from public funds to promote uptake and achieve break-even targets.

(c) Automate subsidy calculations and disbursements via smart contracts to enhance efficiency and reduce leakage.

Pigouvian Subsidies (Pigou, 1920): These correct market failures by internalizing the positive externalities of climate resilience. They also shift the demand curve, making insurance affordable and scalable.

8.4 Build digital and financial literacy at the farmer level

To ensure farmers can effectively access and trust the BBPI platform, a foundational step is to build digital and financial literacy at the grassroots level:

(a) Launch visual, multilingual education campaigns via SMS, radio, and cooperative meetings to demystify blockchain, smart contracts, and insurance triggers.

According to Kahneman and Tversky's prospect theory (1979), individuals overweight potential losses relative to gains, especially in unfamiliar domains like blockchain. Clear, context-specific explanations help mitigate ambiguity aversion and loss aversion by reframing BBPI not as a risky new technology, but as a safety net that prevents catastrophic crop loss. Simplified visuals and local languages reduce cognitive load (Sweller, 1988), making information more accessible to farmers with low formal education or digital literacy.

Diffusion of Innovations Theory (Rogers, 1962) provides a valuable framework for understanding how BBPI can scale among Thai farmers. Rogers identifies five adopter categories—innovators, early adopters, early majority, late majority, and laggards—and emphasizes the role of social systems and communication channels in accelerating adoption. BBPI's strategy to train female insurance champions and leverage cooperatives aligns with this model, positioning early adopters as change agents who can influence broader uptake. By focusing on visibility, trialability, and peer validation, BBPI can overcome scepticism and foster trust in digital insurance tools, especially in low-literacy and low-trust environments.

Nudge Theory (Thaler & Sunstein, 2008) suggests that subtle changes in how choices are presented can significantly influence behaviour. BBPI's digital literacy and onboarding strategy should incorporate behavioural nudges such as default enrolment options, pre-filled registration forms, and bundling insurance with familiar services like agricultural inputs or credit. These design choices reduce cognitive friction and decision paralysis, especially among farmers with low financial literacy. Framing BBPI as a protective default—rather than a complex financial product—can increase uptake and trust, aligning with behavioural patterns observed in rural financial decision-making.

(b) Partner with female-led cooperatives and train women as "insurance champions" to support peer learning and increase uptake among marginalized farmers.

Drawing from Akerlof and Kranton's Identity Economics (2000), aligning BBPI with familiar social identities—such as local women leaders—leverages social norms and identity alignment to enhance credibility and adoption. Social learning theory (Bandura, 1977) also supports this approach, as peer behaviour strongly influences individual decision-making in collective farming communities. Female-led outreach addresses trust gaps and provides role models for financial engagement, particularly where women control household risk decisions but lack access to formal channels.

(c) Embed behavioural nudges by bundling BBPI with agricultural inputs or credit services, simplifying purchase decisions.

As Thaler and Sunstein describe in Nudge (2008), bundling insurance with inputs or loans takes advantage of default bias and choice architecture to lower mental barriers to enrolment. By framing BBPI as an add-on to an already accepted product (e.g., seeds or fertilizer), the program leverages status quo bias to increase uptake without requiring an explicit shift in financial behaviour. It also counters present bias, which leads farmers to underweight future risks (e.g., drought) in favour of immediate costs (the premium).

8.5 Enhance data governance and regulatory compliance

To ensure the secure, lawful, and trustworthy deployment of the BBPI platform, a robust legal and regulatory compliance framework is essential. This framework must align with Thailand's evolving digital governance landscape and international standards for data protection and financial innovation.

(a) Ensure full compliance with the PDPA by embedding privacy-by-design principles into the BBPI system architecture. This includes implementing end-to-end encryption, data minimization, anonymization of personally identifiable information (PII), and secure, decentralized storage solutions. These measures are critical not only for legal compliance but also for building user trust—particularly among rural and vulnerable populations who may be wary of digital surveillance or data misuse.

(b) Collaborate closely with the OIC to integrate BBPI into Thailand's existing insurance regulatory framework. This involves aligning smart contract logic with the Thai Insurance Act and ensuring that digital policies are legally enforceable under the ETA. The UNDP emphasizes the importance of regulatory harmonization to avoid legal ambiguity and to ensure that blockchain-based insurance products are recognized as valid and binding financial instruments.

(c) Pilot the BBPI platform within the Bank of Thailand's FinTech Regulatory Sandbox, a controlled environment that allows for real-world testing of innovative financial technologies under regulatory oversight. This step is crucial for validating the platform's technical integrity, consumer protection mechanisms, and compliance with anti-money laundering (AML) and KYC requirements. The sandbox also facilitates iterative feedback from regulators, insurers, and users, enabling refinements before national-scale deployment.

In line with UNDP recommendations, these measures should be complemented by the establishment of a multi-stakeholder governance board—including representatives from the OIC, Ministry of

Agriculture, BAAC, and civil society—to oversee compliance, resolve disputes, and ensure that the BBPI system evolves in a transparent, inclusive, and accountable manner.

We identified key elements of the technical feasibility study that can be incorporated in the legal and regulatory considerations of this economic feasibility study:

From the technical feasibility study, we learn that:

(a) The TFS outlines compliance needs under Thailand's PDPA, Electronic Transactions Act, and Insurance Act (Section 6).

(b) It also includes recommendations for sandbox testing and potential taxation models for digital assets used in payouts.

These elements support, validate, or influence the legal and regulatory considerations because:

(a) These considerations directly impact legal costs, compliance budgeting, and the timeline for deployment, which affect overall economic viability.

(b) Tax implications may influence whether BBPI uses stablecoins, escrow, or fiat rails for premium and claim flows.

Table 19: Integration of elements from the technical feasibility study regarding the legal and regulatory considerations

8.6 Invest in weather data infrastructure and oracle management

The reliability of the entire parametric insurance model depends on the accuracy of its triggers, necessitating a strategic investment in weather data infrastructure and oracle management:

(a) Deploy multi-source oracle systems (satellite, IoT, TMD);

(b) Establish community-owned weather stations in high-risk regions to localize data and reduce basis risk; and

(c) Validate trigger thresholds using historical and predictive modelling.

Accurate weather data minimizes disputes, which lowers transaction costs (Coase, 1937) and supports long-term sustainability.

8.7 Institutionalize monitoring, feedback, and scalability

To ensure the BBPI system remains responsive and effective post-launch, it is crucial to institutionalize monitoring, feedback, and scalability mechanisms from the outset:

(a) Establish a multi-stakeholder governance board (OIC, MOAC, BAAC, TMD, farmer reps) to:

  - Oversee platform governance;
  - Monitor compliance;
  - Resolve disputes; and
  - Adjust climate indices based on emerging data.

(b) Develop farmer feedback loops (SMS surveys, co-op meetings) to track user satisfaction and improve product design; and

(c) Plan for expansion to other crops and regions by designing modular smart contract templates and scalable backend systems.

Game theory: Multi-stakeholder governance introduces cooperative mechanisms that deter defection and incentivize long-term coordination. This mimics tit-for-tat strategies in repeated games, reinforcing trust.

8.8 Prioritize financial sustainability and risk resilience

To ensure the BBPI system outlives its initial pilot funding and can withstand climate shocks, the implementation must prioritize financial sustainability and risk resilience:

(a) Create an escrow or reserve fund backed by donors or government to absorb high-loss years and instil confidence among insurers;

(b) Explore reinsurance partnerships with global climate risk pools to manage systemic agricultural risks; and

(c) Perform cost-revenue modelling annually to inform pricing adjustments and subsidy needs over time.

Risk pooling and diversification (Arrow, 1963; Markowitz, 1952): Broad regional enrolment enables diversification across uncorrelated risk profiles, reducing variance and improving financial stability.

Risk category	Description	Potential impact	Mitigation measures	Responsible stakeholders
Cyberattack and smart contract exploitation	Blockchain and IoT systems are vulnerable to hacking, oracle manipulation, or smart contract bugs.	Loss of funds, loss of farmer trust, reputational damage, and regulatory sanctions.	- Conduct third-party cybersecurity and smart contract audits. - Establish redundant oracle networks (multi-source weather feeds). - Create contingency/reinsurance funds for payouts in case of breaches. - Strengthen compliance with PDPA and insurance cybersecurity guidelines.	Platform developers, insurers, OIC, and technology partners.
Gender adoption gap	Women farmers face barriers such as limited digital literacy, lower mobile access, and weaker land tenure rights.	Lower participation among women could undermine inclusivity goals and reduce scale.	- Provide digital and financial literacy training targeting women. - Offer group-based coverage via cooperatives and women-led associations. - Apply targeted	Farmer cooperatives, BAAC, women's associations, Ministry of Agriculture, NGOs.

Risk category	Description	Potential impact	Mitigation measures	Responsible stakeholders
			subsidies or incentives for female farmers. - Design simplified onboarding (USSD, local agents) to reduce entry barriers.	
Moral hazard	Farmers may reduce risk-prevention behaviours if they expect payouts regardless of actual losses.	Increased claims frequency and higher operational costs undermine insurer confidence.	- Use parametric triggers tied to objective weather data (rainfall, drought indices). - Introduce partial payouts to encourage continued risk management. - Provide training on climate-smart agriculture alongside insurance.	Insurers, BAAC, agricultural extension services, and cooperatives.
Adverse selection	Higher-risk farmers are more likely to enrol than lower-risk farmers, raising the insurer's exposure.	Unbalanced risk pool, financial instability, and possible program collapse.	- Use community or cooperative-based enrolment to pool diverse risks. - Apply tiered premium pricing based on crop type, location, and risk level. - Encourage government subsidies to attract low-risk farmers. - Monitor and rebalance portfolio using actuarial and blockchain-based analytics.	

Table 20: Risk mitigation matrix

We identified key elements of the technical feasibility study that can be incorporated in the risk mitigation and scaling strategy of this economic feasibility study:

From the technical feasibility study, we learn that:

(a) A dedicated section (Chapter 8) discusses data security risks, oracle manipulation, and infrastructure gaps, along with mitigation strategies like redundant oracles, formal code audits, and node diversity.
(b) It outlines scalability models, including deployment by crop, province, or climate hazard type.

These elements support, validate, or influence the risk mitigation and scaling strategy because:

(a) These components should feed into the economic study's contingency budgeting, cost escalation forecasts, and scaling cost per cohort analysis.
(b) Strategic risk mitigation investments (e.g., diversified data feeds) should be included in the CAPEX/OPEX plan.

Table 21: Integration of elements from the technical feasibility study regarding the risk mitigation and scaling strategy

8.9 Pilot recommendations: next 18 months

The following phased action plan outlines the key steps for piloting the BBPI platform in Thailand. It is designed to deliver immediate impact in high-risk agricultural regions while establishing the institutional, technical, and regulatory groundwork for national scale-up.

Actions	Lead stakeholder(s)	Timeline
Submit regulatory sandbox application, conduct policy dialogues, and develop policy brief	OIC / legal experts / NXPO	Months 1-2; months 17-18
Conduct stakeholder consultations & workshops and partner for last-mile outreach	Cooperatives / Ministry of Agriculture	Months 1-6 and month 7 onwards
Calibrate climate indices using multi-source data and refine data algorithms post mid-term evaluation	Agri-research partners / data partners / tech vendor	Months 3-6; months 15-16
Develop and test smart contracts for automated payouts and integrate real-time data oracles	Tech vendor / insurers / data partners	Months 3-7
Perform smart contract code audits and cybersecurity testing and monitor payout triggers	Tech vendor / cybersecurity partner / insurers	Month 6 onwards
Deliver gender-responsive training and onboarding and conduct targeted minority outreach	Cooperatives / NGOs	Months 7-8 onwards
Conduct cooperative-led onboarding and implement full pilot enrolment and premium collection	Cooperatives / BAAC	Months 8-9
Conduct mobile-based surveys and focus groups and monitor user satisfaction	M&E team / cooperatives	Months 9-13 onwards

Table 22: key steps for the implementation of a blockchain-based parametric insurance pilot in Thailand (BCI, 2025)

This roadmap supports the dual objective of delivering short-term resilience benefits to vulnerable farmers while building a scalable, inclusive, and digitally enabled insurance ecosystem. It aligns with Thailand's Digital Economy Plan, Climate Change Master Plan, and the UNDP's strategic vision for integrating risk financing into national disaster resilience frameworks. By embedding gender equity, data governance, and public-private collaboration into each phase, the BBPI initiative offers a replicable model for climate-smart agricultural insurance across Southeast Asia.

Diffusion of Innovations Theory (Rogers, 1962) provides a strategic lens for BBPI's pilot rollout. Rogers identifies five adopter categories—innovators, early adopters, early majority, late majority, and laggards—and emphasises the role of peer influence and communication channels in accelerating adoption. BBPI's pilot should prioritise engagement with early adopters, such as digitally literate farmers and cooperative leaders, who can serve as change agents. Their successful onboarding and public endorsement will catalyse broader uptake, reduce scepticism, and build trust in blockchain-based insurance. This approach aligns with Rogers' emphasis on trialability, observability, and social validation as key drivers of innovation diffusion.

Key performance indicators (KPIs)

This gives both the KPIs to measure success and the step-by-step roadmap for implementation. The study embeds monitoring and evaluation within the pilot and scale-up phases. Key indicators include:

(a) Adoption metrics

- Number of farmers enrolled, disaggregated by gender and ethnicity to monitor inclusivity and identify structural barriers.
- Active users required for financial viability: 6,200-7,000 farmers (break-even point), with adjusted thresholds to account for lower revenue from marginalized groups (e.g., ethnic minorities, women farmers), who may face higher onboarding costs and reduced ability-to-pay.
- Expansion target: 20,000+ farmers in the scale-up roadmap, with inclusive outreach strategies and differentiated onboarding support.

(b) Financial metrics

- Premiums paid per rai (THB 30-60 (USD 0.9-1.8) WTP), with pricing models sensitive to gender and ethnic disparities in income and access.
- Revenue viability assessed by adoption rate and subsidy level, incorporating differentiated uptake and cost structures across user segments.
- Cost-revenue balance maintained through annual pricing and subsidy adjustments, explicitly accounting for non-uniform user groups. This includes higher onboarding costs for women and ethnic minorities, and the need for targeted subsidies to ensure equitable participation and financial sustainability.

(c) Insurance performance metrics

- Payout timeliness (speed of smart contract-triggered claims).
- Claim accuracy (basis risk reduction via hybrid oracles + IoT data).
- Farmer satisfaction scores via feedback loops (SMS, co-op meetings), disaggregated to capture gender and ethnic minority perspectives.

(d) Governance and risk management metrics

- Compliance with OIC, PDPA, and ETA regulations.
- Data integrity and system uptime (cybersecurity and oracle redundancy).
- Escrow fund adequacy for high-loss years; reinsurance partnerships in place, with contingency planning for uneven adoption across user groups.

9 CONCLUSION

The BBPCI system offers a transformative opportunity to modernize agricultural risk financing in Thailand through the integration of blockchain and parametric insurance. The economic analysis confirms that with proper stakeholder alignment, regulatory support, and strategic public subsidies, the system can achieve both financial sustainability and social equity.

The model demonstrates clear advantages in transparency, cost-efficiency, and scalability—addressing core weaknesses of existing indemnity-based schemes. Moreover, it has the potential to empower underserved farmers, reduce government fiscal burdens during climate shocks, and unlock complementary services such as agri-finance and digital credit.

While initial development costs and implementation complexity require careful management, the long-term benefits—including trust-building, climate resilience, and inclusive financial access—justify the investment. A phased rollout, beginning with pilot deployments in high-risk provinces and supported by strong governance, is recommended.

Moving forward, continued investment in data infrastructure, inclusive design, and institutional partnerships will be critical to realizing the full potential of BBPCI as a flagship model for climate-smart agricultural insurance—both in Thailand and across the region.

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