TECHNICAL FEASIBILITY STUDY REPORT ON BLOCKCHAIN-BASED CROP RISK PARAMETRIC INSURANCE SYSTEM FOR THAILAND

Abridged version

Output 4

Contract No. UNEP/2024/288 (Umoja No. 4700028629)

Emerging Technology Division

Research Division III

May 2025

DISCLAIMER

1. The “Technical Feasibility Study for Blockchain-based Parametric Insurance System in Thailand” document (hereinafter referred to as the “Report”) is intended for informational, illustrative, educational and quality assurance purposes to introduce the risk assessment by the Contractor (hereinafter referred to as the “Blockchain & Climate Institute” or the “BCI”), and to safeguard maintenance of the Platform (hereinafter referred to as the “Platform”) for issuing and managing real-time climate risk parametric insurance product and the Platform’s successful introduction to the market of the Kingdom of Thailand.

   The Platform is designed to provide insurance products leveraging technologies such as the Blockchain, the Artificial Intelligence (hereinafter referred to as the “AI”), the Distributed Ledger Technology (hereinafter referred to as the “DLT”), the Internet of Things (hereinafter referred to as the “IoT”) components responsible for the Remote Sensing (hereinafter referred to as the “Remote Sensing”) and other technological innovations (collectively referred to as the “Technologies”).

2. The Report document does not constitute an annex to the “Contract”, No. UNEP/2022/274, document or a prospectus, offering memorandum, solicitation, or offering to sell or acquire securities and/or tokens.

3. The information provided herein is based on publicly available sources and the Blockchain & Climate Institute’s *know-how,* deemed reliable at the time of drafting. Opinions and estimates are provided for informational, illustrative, educational, and quality assurance purposes.

   The historical performance of any product, service, strategy, or investment does not constitute a dependable predictor of its current or future outcomes. Markets concerning the Technologies are highly volatile.

4. The Blockchain & Climate Institute is responsible for the information provided in the Report document and ensures that the Report document is accurate, complete, and compliant with common practice.

   The Report document has been prepared in compliance with the requirements of industry standards concerning markets in crypto assets and Artificial Intelligence, which are compliant with the laws of the European Union, the United Kingdom, and the ISO standards.

5. The Blockchain & Climate Institute acknowledges the possibility that the intended use of the Platform may encounter challenges or disruptions arising from unforeseen events or circumstances, including, but not limited to:

   Alterations of the Kingdom of Thailand’s or international legal regulations might affect operations and/or costs associated with introducing the Platform to the Kingdom of Thailand’s market, licenses to deploy the Technologies, transaction fees, altering business models, and other external factors may impact the cost structure and revenue projections.

Financial performance and projections might differ due to unforeseen operational costs, changes in currency rates, unexpected expenses, budget reallocation to critical operations, or shifts in market conditions. The aforementioned components might affect the Project's financial projections and timelines. Blockchain-based real-time climate risk parametric insurance products involving crypto assets are subject to significant market volatility.

Differences in commercial performance upon the Blockchain & Climate Institute's delivery of the Project in matters such as processes in regard to the Platform maintenance, financial performance, compliance, human resources, corporate governance, shareholder and/or stakeholder relations, customer/user acquisition, customer conversion, sales, sales training, campaign performance, email marketing, digital marketing performance and/or organic marketing performance.

Loss of data and/or functionality of the Platform caused by third parties, cyberattacks, hacking, manipulations, exploitation of smart contracts, inaccuracies, unauthorised accesses, *force majeure* events, misuses, failures of the Technology, and/or frauds.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

This technical feasibility study assesses the viability of a Blockchain-Based Parametric Insurance (BBPI) system to protect Thailand's smallholder farmers from climate risks. The Thai agricultural sector, a cornerstone of the economy, is highly vulnerable to increasing floods, droughts, and storms. Traditional indemnity-based insurance has proven inadequate due to high costs, slow claims processing, and low uptake.

The proposed BBPI system offers a transformative solution by combining two innovative approaches:

1. Parametric insurance: Payouts are triggered automatically by objective, pre-defined indices (e.g., rainfall levels, temperature thresholds) rather than assessed losses. This eliminates lengthy on-field assessments, reduces administrative costs, and enables rapid disbursement of funds.
2. Blockchain technology: A secure, transparent, and distributed ledger automates the entire process via smart contracts. This ensures tamper-proof record-keeping, builds trust among stakeholders, and minimizes fraud by automatically verifying trigger data and executing payouts without manual intervention.

The study concludes that implementing a BBPI system in Thailand is technically feasible. The country possesses a strong foundation, including a robust digital payment ecosystem (e.g., PromptPay), relevant climate data from national agencies, and a regulatory environment supportive of fintech innovation through regulatory sandboxes.

Key findings and recommendations include:

- Technical architecture: A phased pilot implementation is recommended, starting in high-risk regions for specific crops, utilizing a permissioned blockchain, decentralized oracles for reliable data, and user-friendly mobile interfaces;

- Risk Mitigation: Strategies are outlined to address key challenges, including data quality, basis risk (mismatch between payout and actual loss), cybersecurity, and user digital literacy;

- Affordability and sustainability: A public subsidy of 40-60% is critical for initial farmer adoption. A tiered pricing model and group policies via cooperatives are recommended to ensure long-term commercial viability and inclusivity; and

- Governance: The establishment of a multi-stakeholder consortium (the Thailand Agri-Digital Insurance Consortium - TAIDIC) is proposed to oversee the platform, ensuring balanced governance among government, insurers, farmers, and technology providers.

In conclusion, the BBPI system presents a paradigm shift from a cumbersome, paper-based process to an efficient, transparent, and accessible digital solution. With careful implementation and sustained collaboration between public and private sectors, this system can significantly enhance the climate resilience of Thailand's farmers, promote financial inclusion, and position the country as a leader in digital agricultural innovation.

บทสรุปผู้บริหาร

การศึกษาเชิงเทคนิคฉบับนี้ประเมินความสามารถในการนำระบบประกันภัยพารามิเตอร์บนฐานบล็อกเชน (BBPI) ไปใช้เพื่อปกป้องเกษตรกรรายย่อยของประเทศไทยจากความเสี่ยงด้านสภาพอากาศได้จริงหรือไม่ ภาคการเกษตรไทย ซึ่งเป็นเสาหลักของเศรษฐกิจ มีความเปราะบางสูงต่ออุทกภัย ภัยแล้ง และพายุที่ทวีความรุนแรงและความถี่มากขึ้น ระบบประกันภัยแบบเดิมที่จ่ายค่าชดเชยตามความเสียหายจริง (Indemnity-based) กลับมีข้อจำกัดเนื่องจากมีต้นทุนสูง กระบวนการเรียกร้องค่าชดเชยที่ล่าช้า และอัตราการเข้าถึงที่ต่ำ

ระบบ BBPI ที่นำเสนอเป็นแนวทางแก้ปัญหาที่จะพลิกโฉมวงการประกันภัยโดยการผสมผสานนวัตกรรมสองอย่างเข้าด้วยกัน:

1. **ประกันภัยพารามิเตอร์:** การจ่ายค่าชดเชยจะถูก activate โดยอัตโนมัติเมื่อดัชนีวัตถุวิสัยที่กำหนดไว้ล่วงหน้า (เช่น ระดับปริมาณน้ำฝน อุณหภูมิ) ตกอยู่ในเกณฑ์ที่กำหนด แทนที่การประเมินความเสียหายจริงในพื้นที่ วิธีนี้ช่วยลดขั้นตอนการประเมิน損失ที่ยาวนาน ลดต้นทุนการบริหารจัดการ และทำให้สามารถจ่ายเงินช่วยเหลือได้อย่างรวดเร็ว
2. **เทคโนโลยีบล็อกเชน:** บัญชีแยกประเภทแบบกระจายศูนย์ที่ปลอดภัยและโปร่งใส จะช่วยให้ระบบทำงานอัตโนมัติผ่านสัญญาอัจฉริยะ (Smart Contracts) ซึ่งช่วยบันทึกข้อมูลที่ปลอมแปลงได้ยาก สร้างความไว้วางใจระหว่างผู้มีส่วนได้ส่วนเสีย และลดการทุจริตโดยการยืนยันข้อมูลที่ activate การจ่ายเงินและดำเนินการจ่ายค่าชดเชยโดยอัตโนมัติโดยไม่ต้องมีการแทรกแซงจากมนุษย์

ผลการศึกษาสรุปว่า การนำระบบ BBPI มาใช้ในประเทศไทย **มีความเป็นไปได้ในทางเทคนิค** ประเทศไทยมีพื้นฐานที่แข็งแกร่งอยู่แล้ว 包括 ระบบนิเวศการชำระเงินดิจิทัลที่ก้าวหน้า (เช่น พร้อมเพย์) ข้อมูลสภาพอากาศที่เกี่ยวข้องจากหน่วยงานภาครัฐ และสภาพแวดล้อมทางกฎหมายที่สนับสนุนนวัตกรรมฟินเทคผ่าน Regulatory Sandbox

ข้อค้นพบและข้อเสนอแนะที่สำคัญ包括:

- **โครงสร้างทางเทคนิค:** แนะนำให้ดำเนินการนำร่องเป็นระยะ โดยเริ่มในพื้นที่เสี่ยงสูงสำหรับพืชบางชนิด ใช้บล็อกเชนแบบได้รับอนุญาต (Permissioned Blockchain) ระบบ Oracle ที่กระจายศูนย์เพื่อความน่าเชื่อถือของข้อมูล และอินเทอร์เฟซบนมือถือที่ใช้ง่าย
- **การลดความเสี่ยง:** มีการวางกลยุทธ์เพื่อจัดการกับความท้าทายหลัก 包括คุณภาพข้อมูล ความเสี่ยงพื้นฐาน (Basis Risk - การไม่ตรงกันระหว่างการจ่ายค่าชดเชยและความเสียหายจริง) ความปลอดภัยทางไซเบอร์ และการรู้เท่าทันดิจิทัลของผู้ใช้
- **ความสามารถในการจ่ายและความยั่งยืน:** การอุดหนุนภาครัฐ 40-60% เป็นสิ่งสำคัญสำหรับการรับเข้าของเกษตรกรในระยะเริ่มต้น แนะนำให้ใช้แบบจำลองการกำหนดราคาเป็นระดับและนโยบายกลุ่มผ่านสหกรณ์การเกษตร เพื่อให้มั่นใจถึงความยั่งยืนทางการค้าในระยะยาวและความครอบคลุม
- **การกำกับดูแล:** มีข้อเสนอให้จัดตั้งコンソอร์เซียมระหว่างผู้มีส่วนได้ส่วนเสีย (ชื่อที่เสนอ: Thailand Agri-Digital Insurance Consortium - TAIDIC) เพื่อกำกับดูแลแพลตฟอร์ม ซึ่งจะรับประกันการกำกับดูแลที่สมดุลระหว่างภาครัฐ บริษัทประกันภัย เกษตรกร และผู้ให้บริการเทคโนโลยี

โดยสรุป ระบบ BBPI เป็นการเปลี่ยนผ่านจากกระบวนการที่ยุ่งยาก based on กระดาษ ไปสู่โซลูชันดิจิทัลที่มีประสิทธิภาพ โปร่งใส และเข้าถึงได้ ด้วยการดำเนินการอย่างรอบคอบและความร่วมมืออย่างต่อเนื่องระหว่างภาครัฐและเอกชน ระบบนี้จะสามารถยกระดับความสามารถในการฟื้นตัวจากสภาพอากาศของเกษตรกรไทย ส่งเสริมการเข้าถึงบริการทางการเงิน และวางตำแหน่งให้ประเทศไทยเป็นผู้นำด้านนวัตกรรมการเกษตรดิจิทัลในภูมิภาค

1 INTRODUCTION

1.1 Background and rationale

Agriculture is a cornerstone of Thailand's economy, providing livelihoods for a significant portion of the population and contributing substantially to the country's GDP. However, the sector is highly vulnerable to a range of climate-related risks, including floods, droughts, and storms. These risks have been exacerbated in recent years by the increasing frequency and severity of extreme weather events, a trend widely attributed to climate change. As a result, Thai farmers face growing uncertainty and financial instability, which can undermine food security, rural development, and overall economic resilience.

Traditional agricultural insurance schemes in Thailand have struggled to provide adequate protection for farmers. Conventional indemnity-based insurance products are often hampered by high administrative costs, lengthy claims processes, and challenges in accurately assessing losses. These limitations have contributed to low insurance penetration rates among smallholder farmers, leaving many exposed to the devastating impacts of climate shocks.

In response to these challenges, there is a pressing need for innovative risk financing mechanisms that can offer timely, efficient, and accessible protection for farmers. One promising approach is parametric insurance, which pays out benefits based on the occurrence of predefined events or thresholds—such as a certain amount of rainfall or temperature—rather than on actual losses. This model can significantly reduce administrative burdens and speed up payouts, making it particularly well-suited for smallholder farmers in developing countries.

1.2 Climate risk in Thailand's agriculture

Thailand's agricultural sector is characterized by its diversity, with crops ranging from rice and maize to sugarcane, cassava, and a variety of fruits and vegetables. The country's geography and climate make it both highly productive and highly vulnerable. Seasonal monsoons, riverine flooding, and periodic droughts are recurring features of the Thai landscape, shaping agricultural cycles and influencing yields.

In recent decades, the impacts of climate change have become increasingly apparent. Data from the Thai Meteorological Department and international agencies indicate a rise in average temperatures, shifts in rainfall patterns, and an increase in the frequency of extreme weather events. These changes have led to more frequent crop failures, reduced productivity, and increased volatility in farm incomes.

Smallholder farmers, who make up the majority of Thailand's agricultural workforce, are particularly at risk. Many operate on thin profit margins and lack the financial resources to recover from major shocks. The consequences of climate risk are not limited to individual farmers; they ripple through rural communities, affecting food supply chains, local economies, and national food security.

1.3 The need for innovative risk financing

Given the scale and complexity of climate risks facing Thai agriculture, traditional risk management strategies—such as savings, informal lending, and government disaster relief—are often insufficient. These approaches can provide some short-term relief but do not offer sustainable, long-term solutions for building resilience.

Insurance is widely recognized as a critical tool for managing agricultural risk. However, as noted earlier, conventional insurance models have struggled to gain traction in Thailand. The reasons are manifold: high transaction costs, moral hazard, adverse selection, and the logistical challenges of assessing losses in remote or dispersed farming communities.

Parametric insurance offers a compelling alternative. By linking payouts to objective, independently verifiable indices—such as rainfall measurements from weather stations or satellite data—parametric products can streamline the claims process and reduce opportunities for fraud. This approach also enables insurers to offer coverage at a lower cost, making it more accessible to smallholder farmers.

Despite its potential, the adoption of parametric insurance in Thailand has been limited. Barriers include a lack of awareness among farmers, limited availability of suitable products, and challenges in data collection and index design. Addressing these barriers requires coordinated efforts from government agencies, insurers, technology providers, and development partners.

1.4 Parametric insurance: concept and benefits

Parametric insurance, sometimes referred to as index-based insurance, represents a paradigm shift in the way agricultural risks are managed. Unlike traditional insurance, which compensates policyholders for actual losses incurred, parametric insurance pays out when a specific parameter or index exceeds a predetermined threshold. For example, if rainfall during a critical growing period falls below a certain level, the policyholder receives a payout, regardless of the actual damage to crops.

This model offers several advantages. First, it eliminates the need for costly and time-consuming loss assessments, enabling faster payouts and reducing administrative overhead. Second, it provides greater transparency and predictability, as both insurers and policyholders know in advance the conditions that will trigger a payout. Third, parametric insurance can be tailored to a wide range of risks and crops, making it highly adaptable to local conditions.

However, parametric insurance also presents challenges. The most significant is basis risk—the possibility that a farmer experiences a loss but does not receive a payout because the index was not triggered, or vice versa. Designing effective indices that closely correlate with actual losses is therefore critical to the success of parametric products.

In Thailand, pilot projects and feasibility studies have demonstrated the potential of parametric insurance to enhance resilience among smallholder farmers. These initiatives have highlighted the importance of robust data infrastructure, farmer education, and supportive policy frameworks in scaling up adoption.

1.5 Blockchain technology in insurance

Blockchain technology has emerged as a transformative force across a range of industries, including finance, supply chain management, and insurance. At its core, blockchain is a decentralized, distributed ledger that enables secure, transparent, and tamper-proof record-keeping. In the context of insurance, blockchain can address many of the challenges that have hindered the effectiveness of traditional and parametric products.

One of the key benefits of blockchain is its ability to automate complex processes through smart contracts—self-executing agreements that are triggered when predefined conditions are met. In a parametric insurance scheme, smart contracts can be programmed to automatically verify index data (such as rainfall or temperature readings) and initiate payouts to policyholders without the need for manual intervention. This automation reduces administrative costs, minimizes the risk of human error or fraud, and ensures that farmers receive timely compensation.

Blockchain also enhances transparency and trust. All transactions and data entries are recorded on the ledger, which is accessible to all authorized participants. This openness can help build confidence among farmers, insurers, and regulators, fostering greater participation in insurance schemes.

In Thailand, the integration of blockchain technology into parametric insurance is still in its early stages. However, pilot projects and feasibility studies suggest that blockchain-based solutions could play a pivotal role in overcoming existing barriers to adoption, particularly in areas such as claims processing, data management, and stakeholder coordination.

1.6 Objectives of the feasibility study

This technical feasibility study aims to assess the potential for implementing a Blockchain-Based Parametric Insurance (BBPI) system in Thailand's agricultural sector. The study is guided by several key objectives:

- To analyse the current landscape of agricultural risk and insurance in Thailand, with a focus on climate-related hazards and the needs of smallholder farmers;
- To evaluate the suitability of parametric insurance models for addressing these risks, including an assessment of existing pilot projects and international best practices;
- To explore the potential of blockchain technology to enhance the efficiency, transparency, and scalability of parametric insurance schemes;
- To identify the technical, regulatory, and operational requirements for developing and deploying a BBPI system in Thailand; and
- To provide actionable recommendations for policymakers, insurers, technology providers, and other stakeholders interested in advancing climate risk financing solutions.

The study draws on a combination of literature review, stakeholder consultations, data analysis, and case studies to provide a comprehensive assessment of the opportunities and challenges associated with BBPI in Thailand.

1.7 Structure of the report

The remainder of this report is organized as follows:

- **Chapter 2** provides an overview of the agricultural sector in Thailand, including key crops, production systems, and the socio-economic context of smallholder farmers.
- **Chapter 3** examines the nature and impacts of climate risk in Thai agriculture, drawing on recent data and case studies.
- **Chapter 4** reviews the current state of agricultural insurance in Thailand, highlighting gaps and opportunities for innovation.
- **Chapter 5** introduces the concept of parametric insurance, with a focus on its application in agriculture and lessons from international experience.
- **Chapter 6** provides the consideration of regulatory, legal, and commercial aspects of the proposed solution in thailand's context.
- **Chapter 7** presents the findings of the feasibility assessment, including technical, regulatory, and operational considerations for implementing a BBPI system.
- **Chapter 8** offers conclusions and recommendations for next steps.

2 METHODOLOGY

The development of a blockchain-based parametric insurance solution for Thailand's agricultural sector required a rigorous, multi-disciplinary methodology. The approach combined qualitative and quantitative research, stakeholder engagement, and iterative design to ensure that the proposed system would be technically feasible, contextually appropriate, and responsive to the needs of smallholder farmers, insurers, and regulators.

The study began with an extensive review of existing literature and best practices in parametric insurance, blockchain technology, and digital financial services. Academic articles, industry reports, and case studies from both Thailand and comparable international contexts were analysed to identify key success factors, common pitfalls, and lessons learned. This desk research provided a foundation for understanding the unique challenges and opportunities present in Thailand's agricultural landscape, including the diversity of crops, climate risks, and the structure of rural communities.

Building on this foundation, the research team conducted a series of stakeholder consultations. Interviews and focus group discussions were held with smallholder farmers, cooperative leaders, insurance providers, government officials, technology experts, and representatives from non-governmental organizations. These engagements were critical for capturing local knowledge, understanding user needs and pain points, and identifying barriers to adoption. Special attention was paid to the perspectives of women, youth, and marginalized groups, ensuring that the solution would be inclusive and equitable.

Quantitative data collection focused on climate risk assessment and insurance product design. Historical weather data, crop yield records, and disaster loss statistics were gathered from national agencies such as the Thailand Meteorological Department and the Ministry of Agriculture. Geospatial analysis and statistical modelling were used to map risk hotspots, estimate potential losses, and calibrate parametric triggers. The team also reviewed the availability and quality of digital infrastructure, including mobile network coverage, digital payment systems, and data privacy frameworks.

A key component of the methodology was the iterative design and prototyping of the insurance platform. Drawing on user-centred design principles, the team developed wireframes and mock-ups of the digital interfaces, which were tested with farmers and other stakeholders in pilot regions. Feedback from these sessions informed refinements to the user journey, language options, and accessibility features. The technical architecture—including the blockchain network, smart contracts, and data oracles—was developed in parallel, with a focus on modularity, scalability, and compliance with Thai regulations.

To validate the feasibility and effectiveness of the proposed solution, the team conducted scenario analysis and pilot simulations. These exercises tested the system's ability to process enrolments, collect premiums, trigger payouts, and handle data from multiple sources under real-world conditions. Performance metrics such as transaction speed, data accuracy, and user satisfaction were monitored and analysed. The results provided valuable insights into operational challenges, risk mitigation needs, and areas for further improvement.

Throughout the study, continuous engagement with policymakers and industry leaders ensured alignment with national strategies for financial inclusion, digital transformation, and climate resilience. Regular workshops and presentations facilitated knowledge sharing and built consensus around the project's goals and design choices.

In summary, the methodology combined desk research, stakeholder engagement, quantitative analysis, user-centred design, technical prototyping, and pilot testing. This comprehensive approach ensured that the blockchain-based parametric insurance solution was grounded in evidence, tailored to the Thai context, and positioned for successful implementation and scaling.

3 AUTOMATING THE DETECTION AND MONITORING OF EXTREME WEATHER EVENTS USING LOCAL DATA CHANNELS

3.2 Introduction

Thailand's agricultural sector, the backbone of rural livelihoods and a key contributor to national food security, faces mounting threats from extreme weather events. The increasing frequency and intensity of floods, droughts, tropical storms, and heatwaves—driven by climate change—have exposed the limitations of traditional risk management and insurance mechanisms. Smallholder farmers, who constitute the majority of agricultural producers, are particularly vulnerable, as they often lack the resources to recover from major losses and have limited access to timely, fair compensation. In this context, parametric insurance, which bases payouts on objective, pre-defined indices such as rainfall or temperature thresholds, has emerged as a promising alternative. However, the effectiveness of such schemes depends fundamentally on the ability to detect and monitor extreme weather events accurately, reliably, and in real time. This chapter provides an in-depth exploration of the technical, operational, and institutional aspects of automating the detection and monitoring of extreme weather events in Thailand, with a focus on their integration into a blockchain-based parametric insurance system.

3.3 Historical analysis of extreme weather events in Thailand

Understanding the historical patterns and impacts of extreme weather events is essential for designing effective parametric insurance products. Thailand's diverse geography, ranging from mountainous regions in the north to fertile plains in the central basin and coastal areas in the south, exposes its agricultural sector to a variety of climate hazards. The country's monsoon climate brings seasonal rainfall, but also periodic droughts and floods. These hazards are not distributed evenly; their impacts vary by region, crop type, and farming system.

Floods are a recurrent hazard, particularly in central and northeastern Thailand, where riverine and flash floods can submerge fields for weeks, destroy crops, erode topsoil, and damage rural infrastructure. The devastating floods of 2011, for example, affected over 1.6 million hectares of farmland and caused billions of baht in losses, highlighting the scale of the challenge. Droughts, on the other hand, are most common in the northeast, known as Isan, and can be prolonged and severe, especially during El Niño years. Water scarcity during these periods reduces yields and can lead to total crop failure in rainfed areas, as seen during the 2015-2016 drought, which led to a 20% drop in rice production in some provinces. Tropical storms and cyclones, while less frequent than in neighbouring countries, occasionally make landfall, bringing intense rainfall and high winds that flatten crops, uproot trees, and disrupt supply chains. Extreme temperatures, including both heatwaves and cold spells, can stress crops, reduce yields, and increase the risk of pest and disease outbreaks, as illustrated by the cold snap in 2014 that damaged fruit crops in the north.

To analyse these hazards, a range of data sources is employed. The Thailand Meteorological Department (TMD) operates over 100 weather stations nationwide, providing long-term records of rainfall, temperature, humidity, and wind speed. These data are critical for identifying trends and patterns in extreme weather events. Satellite-based datasets, such as MODIS, CHIRPS, and IMERG, offer high-resolution, spatially continuous information on precipitation, temperature, and vegetation health, which is especially valuable for areas with sparse ground-based observations. Remote sensing technologies, including radar and multispectral imaging, enable the monitoring of large and inaccessible areas, providing valuable data for early warning systems and post-event assessment. Crop yield records, collected by the Ministry of Agriculture and Cooperatives, are analysed alongside weather data to assess the impacts of extreme events on agricultural productivity. National and international disaster databases, such as EM-DAT, provide records of major weather-related disasters, including their impacts on agriculture.

The analytical approach combines time series analysis, spatial mapping, and regression models to correlate weather events with crop yield data. Time series analysis examines trends and cycles in weather and yield data over multiple decades, identifying periods of increased risk. Spatial analysis uses GIS tools to map the distribution of hazards and impacts, revealing regional patterns and hotspots. Correlation and regression techniques quantify the relationship between weather variables and crop yields, informing the selection of indices for insurance triggers. For example, a regression analysis might reveal that rice yields in a particular province are highly sensitive to rainfall deficits during the critical growing period, suggesting that a rainfall-based trigger would be appropriate for parametric insurance in that region.

3.4 Localized climate data and their availability

The success of parametric insurance depends on the availability, accuracy, and granularity of localized climate data. While Thailand's data collection infrastructure is anchored by the Thailand Meteorological Department (TMD) and its network of weather stations, coverage remains uneven, particularly in remote and high-risk agricultural zones. Expanding this network and ensuring regular maintenance are critical for comprehensive coverage.

To address these gaps, the BBPI framework leverages multiple complementary data sources:

- National agencies:
  - Royal Irrigation Department (RID) – water flow and irrigation data
  - Department of Agricultural Extension (DOAE) – crop calendars and field-level observations
  - Geo-Informatics and Space Technology Development Agency (GISTDA) – satellite imagery and NDVI for drought and flood monitoring
- International and global datasets:
  - ERA5 (ECMWF) – high-resolution reanalysis data for rainfall, temperature, and wind
  - CHIRPS – blended satellite and station-based rainfall estimates for drought detection
  - IBTrACS – tropical cyclone tracks and intensity data
  - NASA POWER and NOAA – solar radiation and climate indicators for validation
- Community-based monitoring: Local weather observers equipped with standardized instruments provide ground-truth data in underserved areas, enhancing coverage and fostering trust.
- IoT and edge devices: Low-cost sensors deployed at the farm level measure rainfall, temperature, and soil moisture, transmitting data via mobile or satellite networks. These devices enable real-time data collection, essential for timely insurance payouts.

To ensure data quality and reliability, the system employs:

- Regular calibration and maintenance of sensors;
- Automated anomaly detection (e.g., flagging zero rainfall during a storm); and
- Redundancy through multi-source validation (e.g., cross-checking IoT data with satellite imagery).

Finally, data accessibility and interoperability are key enablers. Open data platforms, standardized APIs, and data-sharing agreements allow seamless integration of diverse datasets into the BBPI platform. This interoperability ensures automated information flow and accurate triggering of smart contracts for insurance payouts.

3.5 Automating the monitoring and detection of extreme weather events

Automation is at the heart of efficient and reliable parametric insurance systems. By automating the detection and monitoring of extreme weather events, the system can trigger payouts rapidly and objectively, reducing administrative costs and minimizing disputes. The design of parametric triggers must account for the spatial variability of weather events. High-resolution data allows for location-specific triggers, reducing basis risk—the risk that payouts do not match actual losses. For example, a rainfall trigger based on data from a station 50 kilometres away may not accurately reflect conditions on a farmer's field. Therefore, the integration of multiple data sources, including ground-based sensors, satellite data, and community observations, is essential for capturing local conditions.

Oracles play a critical role in this process. Oracles are trusted data feeds that transmit external data, such as weather indices, to the blockchain. Multi-layered oracle designs, involving multiple independent data sources, enhance reliability and reduce the risk of manipulation or error. To ensure the integrity of trigger events, multiple oracles and consensus mechanisms are used. For example, a payout may be triggered only if at least three independent data sources confirm that rainfall has fallen below a specified threshold. This approach not only increases the robustness of the system but also builds trust among stakeholders.

The integration of IoT and satellite technologies further enhances the system's capabilities. IoT devices provide hyper-local, real-time data on weather conditions, soil moisture, and crop health. These devices can be deployed in fields, on irrigation systems, or attached to farm equipment, transmitting data via mobile networks or satellite links. Satellite imagery is used for large-scale monitoring, drought assessment, and flood mapping. For example, the Normalized Difference Vegetation Index (NDVI) derived from satellite data can indicate crop stress due to drought or flooding. Data fusion algorithms integrate multiple data streams, weighting them according to reliability and relevance, to improve the accuracy and reliability of event detection.

Designing effective oracle models for Thailand requires a deep understanding of the local context. Oracle models must be tailored to Thailand's agro-climatic zones, accounting for regional differences in weather patterns, crop types, and farming practices. For example, triggers for rice insurance in the central plains may differ from those for maize in the northeast. Transparency and auditability are also crucial. All oracle transactions are recorded on the blockchain, ensuring transparency and enabling audits. Farmers, insurers, and regulators can verify the data and logic used to trigger payouts, which is essential for building trust in the system. Security is another key consideration. Oracles must be secured against cyber threats and unauthorized access through encryption, authentication protocols, and regular security audits.

Artificial intelligence (AI) and machine learning (ML) are increasingly being used to enhance event detection. AI algorithms can detect anomalies in weather data, such as sudden drops in rainfall or temperature spikes, which may indicate extreme events. For example, a machine learning model can be trained to recognize the signature of a developing drought based on historical data. Predictive analytics, powered by ML, can forecast the likelihood of extreme weather events, enabling proactive risk management. For instance, a model might predict the probability of a flood in a given region based on rainfall forecasts, river levels, and soil moisture data. These models are continuously updated with new data to improve accuracy and adapt to changing climate patterns. Feedback loops allow the system to learn from past events and refine its predictions, making the system more resilient over time.

3.6 Case studies and pilot implementations

Several pilot projects in Thailand have demonstrated the feasibility and benefits of automated weather event detection and parametric insurance. In the flood-prone Chao Phraya Basin, a pilot project deployed a network of weather stations, IoT sensors, and satellite data feeds to monitor rainfall and river levels. The system was integrated with a blockchain-based insurance platform, enabling automated payouts to farmers when flood thresholds were exceeded. This pilot not only reduced the time required for claims processing but also increased transparency and trust among farmers.

In the drought-prone northeast, another pilot project combined remote sensing data, ground-based sensors, and community observations to monitor soil moisture and rainfall. Early warnings were issued to farmers, and insurance payouts were triggered automatically when drought conditions were confirmed. These pilots highlighted the importance of comprehensive data coverage and the challenges of maintaining sensor networks in remote areas. In some cases, data gaps led to delays or disputes over payouts, underscoring the need for redundancy and robust maintenance protocols.

Stakeholder engagement was a key factor in the success of these pilots. Close collaboration with local communities, government agencies, and technology providers ensured that the system was tailored to local needs and that farmers understood how it worked. Training and capacity building were essential for building trust and ensuring the effective use of the system. Lessons from these pilots have informed the scaling of automated monitoring systems to other regions and crops. Standardized protocols and modular system designs have facilitated replication and adaptation, making it possible to extend the benefits of automated parametric insurance to a wider range of farmers.

3.7 Challenges and mitigation strategies

Despite the progress made, several challenges remain in automating the detection and monitoring of extreme weather events. Ensuring data quality and reliability is a constant challenge, particularly in remote or underserved areas. Regular maintenance schedules and remote diagnostics are essential for reducing downtime and data gaps. Sensors can be equipped with self-diagnostic features that alert operators to potential issues, while backup sensors and data sources ensure continuity in the event of equipment failure. For instance, if a ground-based sensor fails, satellite data can be used as a fallback.

Basis risk—the risk that payouts do not match actual losses—remains a concern. Careful design of parametric triggers, using multiple indices or adjusting thresholds based on historical data, can help minimize this risk. Triggers must be regularly calibrated using both historical and real-time data to ensure that they remain relevant and accurate. Infrastructure and connectivity are also critical issues. Investments in mobile and internet infrastructure are needed to improve data transmission in rural areas, while partnerships with telecom providers can help extend coverage to underserved regions. Systems must be designed to operate in low-connectivity environments, with data uploaded when connectivity is restored. For example, IoT devices can store data locally and transmit it when a network connection becomes available.

Cybersecurity is another major concern. All data transmissions must be encrypted to prevent unauthorized access, and strict access controls and authentication protocols must be in place to protect sensitive data. Only authorized users should be able to access or modify system settings, and regular security audits are necessary to identify and address potential vulnerabilities.

3.8 Integration with the BBPI platform

The integration of automated detection and monitoring systems with the BBPI platform is essential for delivering timely, transparent, and reliable insurance solutions. Data flows seamlessly from sensors and satellites to the BBPI platform, where it is used to trigger smart contracts and automate payouts. For example, when rainfall falls below a specified threshold, the system automatically verifies the data, triggers the smart contract, and disburses funds to the insured farmer's account. All data and transactions are recorded on the blockchain, providing an immutable audit trail for regulators and stakeholders. This transparency builds trust and facilitates regulatory oversight.

User interfaces are designed to be accessible and user-friendly. Farmer dashboards provide real-time information on weather conditions, insurance coverage, and claim status. Visualizations and alerts help farmers understand their risk exposure and take proactive measures. Insurer portals provide access to data analytics and system performance metrics, supporting risk assessment, product design, and claims management. These tools are essential for ensuring that all stakeholders can effectively use and benefit from the system.

3.9 Policy and institutional considerations

The successful implementation of automated detection and monitoring systems requires supportive policy and institutional frameworks. Compliance with Thailand's Personal Data Protection Act (PDPA) and other relevant regulations is essential to protect the privacy and security of farmers' data. Data sharing agreements must specify how data can be used, stored, and shared, while the BBPI platform must operate within the framework of Thai insurance laws and guidelines. Regulatory sandboxes may be used to test new products and technologies in a controlled environment, allowing for innovation while managing risks.

Government agencies, such as the TMD and the Ministry of Agriculture, play key roles in data provision, system oversight, and policy support. Their involvement ensures that the system aligns with national priorities and standards. The private sector, including technology providers, insurers, and financial institutions, is also essential for developing and maintaining the automated monitoring system. Public-private partnerships are critical for scaling and sustainability, leveraging the resources and expertise of multiple stakeholders.

3.10 Future directions and recommendations

Looking ahead, continued investment in technological advancements will be essential for enhancing the capabilities and resilience of automated detection and monitoring systems. The integration of AI and machine learning will further improve predictive capabilities, enabling the system to forecast the likelihood of extreme events weeks in advance and support proactive risk management. The deployment of edge computing devices will improve real-time data processing and reduce latency, allowing data to be processed locally and reducing the need for constant connectivity.

Scaling and replication of the system to other regions and countries will require regional cooperation and harmonization of standards. Partnerships between government, private sector, and international organizations will be essential for leveraging resources and expertise. Capacity-building initiatives for farmers, local officials, and system operators will ensure effective use and maintenance of the system, while public awareness campaigns will promote understanding and trust in automated parametric insurance solutions. Communication strategies should use multiple channels, including radio, social media, and community meetings, to reach diverse audiences.

3.11 Summary

Automating the detection and monitoring of extreme weather events in Thailand is feasible with existing data infrastructure, though enhancements are required for full reliability. The country already benefits from TMD's network of over 100 weather stations, complemented by satellite datasets (e.g., GISTDA, CHIRPS, ERA5) and pilot deployments of IoT sensors in high-risk regions. These resources enable the BBPI platform to integrate multi-source data through oracles, ensuring accurate and timely triggers for insurance payouts. However, scaling IoT coverage, enforcing sensor calibration, and strengthening data-sharing protocols remain critical for reducing basis risk and sustaining system performance. Continued investment in these areas, combined with stakeholder engagement, will ensure that the system is both technically viable and resilient to evolving climate risks.

4 MANAGING THE INSURANCE PRODUCTS AND CLAIMS ON LOSS/DAMAGE UPON CLIMATE RISK EVENTS

4.1 Introduction

The management of insurance products and the processing of claims in response to climate risk events are central to the effectiveness and credibility of any agricultural insurance system. In Thailand, where smallholder farmers are highly exposed to the vagaries of weather, the need for timely, transparent, and fair insurance solutions is particularly acute. Traditional indemnity-based insurance models have long struggled with high administrative costs, slow claims processing, and disputes over loss assessment. The advent of parametric insurance, especially when combined with blockchain technology, offers a transformative approach to managing climate risk in agriculture. This chapter explores the design, administration, and claims management of insurance products tailored to climate risks, with a focus on the integration of data-driven methodologies, automation, and digital infrastructure.

4.2 Theoretical loss exposure and risk profiling

A foundational step in managing climate risk insurance products is the assessment of theoretical loss exposure for key crops and regions. This study conducted a data-driven analysis using Thai datasets to quantify potential losses from extreme weather events. Historical climate and yield data from the Thailand Meteorological Department (TMD), Department of Agricultural Extension (DOAE), and Office of Agricultural Economics (OAE) were combined with international datasets (e.g., CHIRPS, ERA5) to model risk for major crops: rice, cassava, sugarcane, and rubber.

Data and methodology

The following key elements summarize the data sources and analytical methods applied in this study:

- Historical datasets (2010–2020): Weather station records, crop yield statistics, and disaster reports;
- Simulation models: DSSAT and AquaCrop calibrated for Thai agro-ecological zones; and
- Analytical techniques: Time-series analysis, GIS-based spatial mapping, and regression models to correlate weather anomalies with yield losses.

Key findings

The analysis produced the following key insights on crop-specific vulnerabilities and loss patterns in Thailand:

- Rice: Highly sensitive to floods and droughts; historical events show 20-40% yield loss from floods and 50–70% from severe droughts;
- Cassava: Drought-tolerant but vulnerable to prolonged dry spells; losses up to 60% during multi-month droughts;
- Sugarcane: Floods and cyclones cause 20-50% yield reduction, while heat stress reduces sucrose content; and
- Rubber: Flooding and typhoons disrupt tapping and reduce latex yield by up to 25%.

Risk profiling

Risk scores were mapped at district and subdistrict levels using GIS, revealing high-risk zones in:

- Central Plains: Flood-prone rice and sugarcane areas;
- Northeast: Drought-sensitive cassava regions; and
- Southern Peninsula: Rubber plantations exposed to cyclones.

These insights inform the design of parametric insurance triggers (e.g., rainfall thresholds, drought indices) and premium pricing, reducing basis risk and improving fairness.

4.3 Product design: parametric triggers and coverage

The core innovation of parametric insurance lies in its use of objective, pre-defined triggers to determine payouts. Unlike traditional insurance, which requires on-site loss assessment, parametric products pay out when a specific index—such as rainfall, temperature, or wind speed—crosses a predetermined threshold. This approach greatly reduces administrative costs and enables rapid compensation, which is critical for farmers facing immediate recovery needs.

Designing effective parametric triggers requires careful selection of indices that are both highly correlated with actual losses and reliably measurable. In Thailand, rainfall is a common trigger for rice insurance, while temperature and soil moisture indices may be more relevant for other crops. The spatial and temporal granularity of the trigger is also important; triggers must be localized enough to reflect conditions on individual farms, but broad enough to be practical and cost-effective.

The calibration of parametric products involves extensive analysis of historical data to set appropriate thresholds and payout structures. For example, a rainfall index might be set to trigger a payout if cumulative rainfall during the planting season falls below a certain percentile of the historical average. The payout amount is typically structured to cover a portion of the expected loss, balancing affordability for farmers with the financial sustainability of the insurance pool.

To address the issue of basis risk—the risk that the index does not perfectly match actual losses—insurers may use multiple indices or blended triggers. For instance, a product might combine rainfall and soil moisture data, or use satellite-derived vegetation indices to validate ground-based measurements. Ongoing calibration and validation are essential to ensure that the triggers remain relevant as climate patterns evolve.

4.4 Premium setting and affordability

Premium pricing is a critical determinant of both the uptake and long-term sustainability of climate risk insurance. The challenge lies in balancing affordability for smallholder farmers, who often operate on thin margins, with actuarial soundness to ensure insurer solvency and system resilience.

Recommended premium structure

Based on farmer surveys, insurer consultations, and financial modelling, the recommended premium range for BBPI in Thailand is:

- Indicative range: THB 30-70/rai (≈ USD 0.9-2.1), aligning with both farmer willingness-to-pay (WTP) and insurer viability;
- Median WTP: Approximately THB 40/rai (≈ USD 1.2), with most farmers comfortable at THB 30-60 per rai when subsidies are applied; and
- Pilot pricing: ≈ THB 50/rai (≈ USD 1.5), fully subsidized during the pilot phase to validate the model and encourage adoption.

Subsidy alignment

To achieve widespread adoption and correct market failures associated with positive externalities (e.g., reduced disaster relief costs, improved food security), public subsidies of 40-60% of the gross premium are recommended. Sensitivity analysis shows that even a 10% increase in net premium could reduce enrolment by 20%, underscoring the importance of subsidy stability.

Tiered and inclusive pricing

A tiered pricing strategy is advised to reflect differences in farm size, crop type, and risk exposure:

- Smallholders: Lower-tier premiums with higher subsidy support;
- Medium and large farms: Higher-tier premiums with optional add-ons (e.g., multi-season coverage, bundled agri-inputs); and
- Group policies: Cooperative-based enrolment to reduce per-user acquisition costs and enhance affordability.

Innovative payment mechanisms

Digital payment solutions such as PromptPay, mobile wallets, and USSD channels will facilitate premium collection and instant payouts, even for farmers without smartphones. Blockchain integration ensures transparency in premium flows and subsidy disbursement, reducing fraud and administrative overhead.

4.5 Policy issuance and customer onboarding

The process of policy issuance and customer onboarding is a critical touchpoint for building trust and ensuring the effective delivery of insurance products. Digital platforms, including mobile apps and web portals, have streamlined the process, allowing farmers to enroll, select coverage options, and pay premiums with minimal paperwork. User-friendly interfaces, available in local languages, are essential for reaching farmers with varying levels of digital literacy.

Verification of customer information is facilitated by integration with national digital ID systems and geolocation data. Farmers can register their land parcels using GPS coordinates, upload photos of their fields, and provide basic information about their crops and farming practices. This data not only supports risk assessment and product customization but also enables targeted outreach and education campaigns.

Onboarding processes often include training sessions and informational materials to help farmers understand how parametric insurance works, what is covered, and how claims are triggered. Partnerships with local cooperatives, extension agents, and NGOs can enhance outreach and support, ensuring that even the most marginalized farmers are able to participate.

4.6 Claims management: automation and transparency

One of the most significant advantages of blockchain-based parametric insurance is the automation of claims management. When a trigger event is detected—such as rainfall falling below a specified threshold—smart contracts on the blockchain automatically verify the data, calculate the payout, and initiate the transfer of funds to the insured farmer's account. This end-to-end automation eliminates the need for manual claims submission, loss assessment, and approval, dramatically reducing the time and cost associated with traditional claims processing.

Transparency is further enhanced by the immutable nature of blockchain records. All transactions, from premium payments to claims payouts, are recorded on the distributed ledger, providing a verifiable audit trail for regulators, insurers, and policyholders. Farmers can track the status of their coverage and claims in real time through digital dashboards, while insurers and regulators can monitor system performance and compliance.

To ensure fairness and accuracy, the claims process incorporates multiple layers of data validation. Oracles—trusted data feeds—aggregate information from weather stations, satellites, and IoT sensors, cross-checking data to confirm that trigger conditions have been met. In cases where data discrepancies arise, predefined dispute resolution mechanisms are activated, allowing for independent review and adjudication. This multi-source validation reduces the risk of erroneous payouts and builds confidence in the system.

4.7 Addressing basis risk and product calibration

Despite the advantages of parametric insurance, basis risk remains a key challenge. Basis risk arises when the index used to trigger payouts does not perfectly align with the actual losses experienced by farmers. This can occur due to spatial variability in weather events, measurement errors, or the use of indices that are not fully representative of local conditions.

To mitigate basis risk, insurers employ a range of strategies. The use of high-resolution, localized data—such as farm-level IoT sensors and satellite imagery—improves the accuracy of indices and reduces the likelihood of mismatches. Blended indices, which combine multiple data sources, provide a more comprehensive picture of risk and enhance the robustness of triggers. Regular calibration of products, informed by ongoing analysis of claims data and farmer feedback, ensures that indices remain relevant and responsive to changing climate patterns.

Engagement with farmers is also critical. By involving farmers in the design and calibration of products, insurers can better understand local risk perceptions and preferences, leading to more acceptable and effective solutions. Educational initiatives help farmers interpret index data and understand the rationale behind payouts, reducing the potential for disputes and dissatisfaction.

4.8 Capacity building, outreach, and farmer engagement

Building the capacity of farmers, insurers, and local institutions is critical for the long-term success of parametric insurance. Training programs, delivered through extension services, cooperatives, and digital platforms, equip farmers with the knowledge and skills needed to understand and utilize insurance products. Topics include the principles of parametric insurance, the interpretation of index data, and the use of digital tools for enrolment and claims tracking.

Outreach campaigns, using radio, social media, and community meetings, raise awareness of insurance options and encourage participation. Special efforts are made to reach women, youth, and marginalized groups, who may face additional barriers to access. Feedback mechanisms, such as hotlines and user surveys, provide channels for farmers to express concerns, report problems, and suggest improvements.

Engagement with local leaders and trusted intermediaries enhances credibility and trust. By involving community organizations, religious leaders, and respected farmers in outreach and education, insurers can build social capital and foster a sense of ownership among participants.

4.9 Monitoring, evaluation, and continuous improvement

Effective management of insurance products and claims requires robust monitoring and evaluation systems. Key performance indicators include the speed and accuracy of claims processing, the uptake and retention of insurance products, and the satisfaction of policyholders. Data analytics and reporting tools provide real-time insights into system performance, enabling insurers and regulators to identify trends, detect anomalies, and respond to emerging challenges.

Continuous improvement is achieved through regular review of claims data, farmer feedback, and market developments. Lessons learned from pilot projects and early deployments inform the refinement of products, processes, and technologies. Adaptive management ensures that the insurance system remains responsive to changing climate risks, evolving farmer needs, and advances in data and digital infrastructure.

4.10 Conclusion

The management of insurance products and claims in response to climate risk events is a complex but critical component of agricultural resilience in Thailand. The integration of parametric insurance with blockchain technology, advanced data analytics, and digital infrastructure offers a powerful solution to the challenges of traditional insurance models. By leveraging objective indices, automating claims processing, and enhancing transparency, blockchain-based parametric insurance can deliver timely, fair, and accessible protection to smallholder farmers. Success depends on the careful design and calibration of products, robust digital and regulatory infrastructure, and sustained engagement with farmers and stakeholders. As climate risks continue to evolve, ongoing investment in innovation, capacity building, and institutional collaboration will be essential to ensure that insurance systems remain effective, inclusive, and resilient.

5 EVALUATION OF THE EXISTING DIGITAL INFRASTRUCTURE FOR DISBURSING PAYMENTS

5.1 Introduction

The effectiveness of a blockchain-based parametric insurance system for Thailand's agricultural sector depends not only on the accuracy of climate data and the automation of claims but also on the robustness and inclusivity of the digital infrastructure that supports payment disbursement. As insurance payouts must reach smallholder farmers quickly and securely, the underlying digital payment ecosystem becomes a critical enabler of financial resilience. This chapter evaluates the current state of Thailand's digital infrastructure for disbursing payments, examining its strengths, limitations, and readiness to support scalable, transparent, and efficient insurance solutions.

5.2 Overview of Thailand's digital payment ecosystem

Over the past decade, Thailand has made significant strides in building a modern, inclusive digital payment ecosystem. The country's financial sector has embraced digital transformation, with the Bank of Thailand and other regulatory bodies actively promoting cashless transactions, financial inclusion, and fintech innovation. The introduction of PromptPay, a national real-time payment system, has been a game-changer, enabling instant, low-cost transfers between individuals, businesses, and government agencies. PromptPay's integration with national ID numbers, mobile phone numbers, and business tax IDs has made it accessible to a broad segment of the population, including those in rural areas.

Mobile banking and e-wallet adoption have surged, driven by the proliferation of smartphones and the expansion of mobile internet coverage. Major banks and fintech companies offer user-friendly apps that allow customers to send and receive money, pay bills, and access a range of financial services. The government's digital ID initiative, NDID (National Digital ID), further streamlines onboarding and verification processes, reducing barriers to entry for unbanked and underbanked populations. These developments have laid a strong foundation for the integration of digital payments into insurance platforms, making it possible to deliver payouts directly to farmers' bank accounts or mobile wallets with minimal delay.

5.3 Integration with insurance platforms

The integration of digital payment systems with insurance platforms is essential for the seamless disbursement of parametric insurance payouts. Blockchain technology enhances this process by providing a secure, transparent, and tamper-proof record of transactions. When a trigger event occurs—such as a drought or flood—smart contracts on the blockchain automatically verify the data, calculate the payout, and initiate the transfer of funds to the insured farmer's digital account. This automation eliminates manual intervention, reduces the risk of errors or fraud, and ensures that payments are made promptly.

Insurance platforms are designed to interface with existing payment rails, such as PromptPay and mobile banking APIs, allowing for real-time transfers regardless of the recipient's bank or location. Farmers can register their preferred payment method during the onboarding process, choosing between bank accounts, e-wallets, or even cash-out agents in areas with limited banking infrastructure. The use of QR codes and biometric authentication further simplifies transactions and enhances security, particularly for users with limited digital literacy.

To ensure inclusivity, insurance platforms also support offline and low-connectivity environments. SMS-based notifications and USSD codes enable farmers without smartphones to receive payment alerts and check their account balances. In remote areas, partnerships with local cooperatives, agricultural extension offices, and mobile money agents facilitate cash-out services and provide support for users who may be unfamiliar with digital payments.

5.4 Security, compliance, and user trust

The security and integrity of digital payment systems are paramount, especially when dealing with vulnerable populations and large-scale disbursements. Thailand's regulatory framework, including the Payment Systems Act and the Personal Data Protection Act (PDPA), sets stringent standards for data privacy, cybersecurity, and consumer protection. Financial institutions and fintech providers are required to implement robust encryption, multi-factor authentication, and real-time monitoring to detect and prevent unauthorized transactions.

Blockchain technology adds an additional layer of security by creating an immutable ledger of all transactions, which can be audited by regulators, insurers, and policyholders. Smart contracts are programmed to execute only when predefined conditions are met, reducing the risk of human error or manipulation. Regular security audits, penetration testing, and compliance checks are conducted to identify and address potential vulnerabilities.

Building user trust is equally important. Transparent communication about how payments are processed, what data is collected, and how it is protected helps alleviate concerns and encourages adoption. Training and support services, delivered through local partners and digital channels, empower farmers to use digital payment tools confidently and safely. Feedback mechanisms, such as hotlines and in-app reporting, provide channels for users to report issues and seek assistance.

5.5 Challenges and opportunities

Despite the progress made, several challenges remain in ensuring that digital payment infrastructure fully supports the needs of a blockchain-based parametric insurance system. Digital literacy and access to technology vary widely across regions and demographic groups. While smartphone penetration is high in urban areas, some rural communities still rely on basic mobile phones or have limited internet connectivity. Addressing these gaps requires ongoing investment in digital infrastructure, targeted outreach, and the development of user-friendly interfaces that accommodate different levels of technological proficiency.

Interoperability between different payment systems and financial institutions is another area for improvement. While PromptPay has achieved broad adoption, some farmers may still be excluded due to lack of bank accounts or documentation. Expanding partnerships with e-wallet providers, microfinance institutions, and community-based organizations can help bridge these gaps and ensure that all eligible farmers can receive payouts.

The risk of cyberattacks, fraud, and data breaches is an ever-present concern. As digital payment volumes grow, so does the attractiveness of these systems to malicious actors. Continuous investment in cybersecurity, staff training, and public awareness campaigns is essential to safeguard the integrity of the payment ecosystem.

On the opportunity side, the digital payment infrastructure offers a platform for delivering a range of complementary services to farmers. Beyond insurance payouts, digital wallets can be used for savings, credit, input purchases, and access to government subsidies. The data generated through digital transactions can support credit scoring, financial planning, and the development of new financial products tailored to the needs of smallholder farmers.

5.6 Future directions and recommendations

Looking ahead, the continued evolution of Thailand's digital payment infrastructure will play a pivotal role in scaling blockchain-based parametric insurance and other financial innovations. Policymakers and industry leaders should prioritize investments in rural connectivity, digital literacy, and interoperability to ensure that no farmer is left behind. Regulatory frameworks must remain agile, balancing the need for innovation with robust consumer protection and risk management.

The integration of emerging technologies, such as artificial intelligence, biometrics, and decentralized finance (DeFi), holds promise for further enhancing the efficiency, security, and inclusivity of digital payments. Pilot projects and regulatory sandboxes can provide valuable insights into the practical challenges and benefits of these innovations, informing the development of best practices and standards.

Collaboration between government agencies, financial institutions, technology providers, and farmer organizations will be essential for building a resilient and inclusive digital payment ecosystem. By leveraging the strengths of each stakeholder, Thailand can ensure that its digital infrastructure not only supports the immediate needs of parametric insurance but also lays the foundation for broader financial inclusion and rural development.

5.7 Conclusion

In conclusion, Thailand's digital payment infrastructure is well-positioned to support the disbursement of blockchain-based parametric insurance payouts to smallholder farmers. The widespread adoption of real-time payment systems, mobile banking, and digital ID has created a robust foundation for efficient, transparent, and secure financial transactions. While challenges remain in terms of digital literacy, connectivity, and interoperability, ongoing investments and collaborative efforts are addressing these gaps. As the digital ecosystem continues to evolve, it will play an increasingly important role in enhancing the resilience of Thailand's agricultural sector and empowering farmers to manage climate risks more effectively.

6 THE CONSIDERATION OF REGULATORY, LEGAL, AND COMMERCIAL ASPECTS OF THE PROPOSED SOLUTION IN THAILAND'S CONTEXT

6.1 Introduction

The successful implementation of a blockchain-based parametric insurance system in Thailand's agricultural sector hinges not only on technological innovation and data infrastructure but also on the careful navigation of regulatory, legal, and commercial landscapes. As the country seeks to modernize its approach to climate risk management, it must address a complex web of statutes, guidelines, and market realities that shape the development, deployment, and scaling of digital insurance solutions. This chapter provides a comprehensive analysis of the regulatory, legal, and commercial considerations relevant to the proposed solution, examining the current environment, identifying gaps and challenges, and offering recommendations for harmonizing innovation with compliance and market sustainability.

6.2 The regulatory landscape for insurance and digital innovation

Thailand's insurance sector is governed by a robust regulatory framework, with the Office of Insurance Commission (OIC) serving as the primary supervisory authority. The OIC is responsible for licensing insurers, approving products, monitoring solvency, and protecting consumer interests. The Insurance Act, together with a suite of subordinate regulations, sets out the requirements for product design, claims management, capital adequacy, and reporting. In recent years, the OIC has demonstrated a willingness to embrace digital innovation, launching regulatory sandboxes and issuing guidelines for insurtech and fintech products.

The regulatory environment for digital payments and data management is equally dynamic. The Bank of Thailand oversees payment systems, while the Electronic Transactions Development Agency (ETDA) sets standards for digital signatures, electronic contracts, and cybersecurity. The Personal Data Protection Act (PDPA), modeled on the European Union's GDPR, establishes strict requirements for data collection, processing, and sharing, with significant implications for insurance platforms that handle sensitive personal and financial information.

The emergence of blockchain technology and smart contracts presents both opportunities and challenges for regulators. On one hand, blockchain's transparency, immutability, and automation can enhance trust, reduce fraud, and streamline compliance. On the other, the decentralized and programmable nature of blockchain raises questions about legal enforceability, liability, and oversight. Regulators must balance the need to protect consumers and maintain market stability with the imperative to foster innovation and competitiveness.

6.3 Legal recognition of smart contracts and digital transactions

A central feature of the proposed parametric insurance solution is the use of smart contracts—self-executing agreements coded on the blockchain that automatically trigger payouts when predefined conditions are met. The legal recognition of such contracts is a prerequisite for their enforceability and acceptance in the Thai market.

Thailand's Electronic Transactions Act provides a foundation for the legal validity of digital contracts, electronic signatures, and automated processes. The Act stipulates that contracts formed electronically are as binding as those executed on paper, provided that the parties' intent and consent are clear and that the system used is reliable. This legal framework may support the use of smart contracts in insurance, but there remain legal questions as to the recognition of smart contracts existing purely in code as legally binding and enforceable and practical questions regarding dispute resolution, error correction, and the allocation of liability in the event of system failures or data inaccuracies.

The legal enforceability of smart contracts as legally binding contracts depends on their alignment with the substantive requirements of contract law, including mutual intention of the parties, evidenced through offer and acceptance. The Electronic Transactions Act (ETA) provides that the validity of a contract cannot be denied merely because it was formed through automated systems. In other words, automation alone does not render an agreement invalid. However, for a smart contract to be legally enforceable under Thai law, it must still meet the substantive requirements of the Civil and Commercial Code (CCC). Whether the execution of code alone can amount to an implied or express declaration of intent remains legally uncertain and subject to judicial interpretation, particularly given the technical complexity of smart contracts and the difficulty of ensuring clarity and specificity.

While simple parametric insurance agreements—such as those based on rainfall indices—can be readily codified, more complex arrangements may require hybrid models that combine automated execution with human oversight. The OIC and other regulators are actively exploring these issues, with pilot projects and regulatory sandboxes providing valuable insights into best practices and potential pitfalls.

6.4 Data privacy, security, and consumer protection

The handling of personal and financial data is a critical concern in the design and operation of digital insurance platforms. The PDPA imposes strict obligations on data controllers and processors, including requirements for informed consent, data minimization, purpose limitation, and the right to access, correct, or delete personal information. Insurance providers must implement robust data governance frameworks, with clear policies for data collection, storage, sharing, and breach notification.

Blockchain technology offers inherent advantages in data security, with cryptographic techniques ensuring the integrity and confidentiality of transactions. However, the immutability of blockchain records can create challenges for compliance with data erasure and correction rights. Solutions such as off-chain storage, data anonymization, and permissioned blockchains are being explored to reconcile these tensions.

Consumer protection extends beyond data privacy to encompass transparency, fairness, and recourse. Insurance products must be clearly explained, with terms and conditions accessible in plain language and local language. Automated claims processes must include mechanisms for dispute resolution, appeals, and human intervention as may be appropriate. Regulators are increasingly focused on the ethical dimensions of digital insurance, including the prevention of algorithmic bias, the protection of vulnerable groups, and the promotion of financial literacy.

6.5 Regulatory sandboxes and innovation pathways

To facilitate the responsible introduction of new technologies, the OIC and other agencies have established regulatory sandboxes—controlled environments in which innovative products and services can be tested under relaxed regulatory conditions. These sandboxes allow insurers, technology providers, and regulators to collaborate in real time, identifying risks, refining processes, and building evidence for broader adoption.

The sandbox approach has proven effective in accelerating the development of parametric insurance products, digital payment solutions, and blockchain applications. Participants benefit from regulatory guidance, access to data, and opportunities for stakeholder engagement. Successful pilots can inform the revision of regulations, the issuance of new guidelines, and the scaling of proven models. However, the transition from sandbox to full market deployment requires careful planning, with attention to interoperability, scalability, and the integration of lessons learned.

6.6 Licensing, supervision, and market entry

The entry of new insurance products and providers into the Thai market is subject to rigorous licensing and supervision. The OIC evaluates applicants' financial strength, governance structures, risk management capabilities, and compliance with prudential standards. For digital and blockchain-based solutions, additional scrutiny is applied to technology architecture, cybersecurity, and data management.

Foreign insurers and technology partners may face additional requirements, including joint ventures with local firms, localization of data and operations, and adherence to Thai language and cultural norms. The licensing process is designed to ensure that only reputable, well-capitalized, and competent entities are permitted to operate, protecting consumers and maintaining market stability.

Ongoing supervision includes regular reporting, audits, and inspections. The OIC has developed specialized teams to monitor digital insurance platforms, assess emerging risks, and respond to incidents. Collaboration with other regulators, such as the Bank of Thailand and the ETDA, ensures a coordinated approach to oversight.

6.7 Taxation, accounting, and financial reporting

The taxation of insurance premiums, claims payouts, and investment income is governed by the Revenue Code and related regulations. Premiums are generally subject to value-added tax (VAT), while claims payments are treated as non-taxable compensation. Insurers must maintain detailed records of transactions, comply with accounting standards, and submit regular financial reports to the OIC and tax authorities.

Blockchain technology can enhance the transparency and accuracy of financial reporting, with automated reconciliation of premiums, claims, and reserves. Smart contracts can be programmed to generate digital receipts, track fund flows, and facilitate audits. However, the adoption of new technologies may require updates to accounting standards, tax guidance, and regulatory reporting templates.

6.8 Anti-Money Laundering (AML) and Counter-Terrorism Financing (CFT)

The insurance sector is subject to stringent AML and CFT requirements, including customer due diligence, transaction monitoring, and suspicious activity reporting. Digital platforms must implement robust identity verification, risk assessment, and record-keeping processes. The use of digital ID systems, biometric authentication, and blockchain analytics can enhance compliance and reduce the risk of illicit activity.

Regulators are increasingly focused on the risks and opportunities associated with cryptocurrencies, stablecoins, and decentralized finance (DeFi) platforms. While blockchain can improve traceability and auditability, it also introduces new vectors for money laundering and fraud. Ongoing collaboration between insurers, regulators, and law enforcement is essential to maintain the integrity of the financial system.

6.9 Commercial considerations: market readiness and adoption

The commercial viability of blockchain-based parametric insurance depends on a range of market factors, including demand, affordability, distribution channels, and stakeholder engagement. Thailand's agricultural sector is characterized by a large, diverse, and geographically dispersed population of smallholder farmers, many of whom have limited experience with formal insurance or digital financial services.

Market research indicates a growing awareness of climate risks and a willingness to adopt innovative risk management tools, particularly when supported by government subsidies, donor programs, or trusted intermediaries. The success of pilot projects and early deployments has demonstrated the potential for rapid scaling, provided that products are tailored to local needs, priced affordably, and delivered through accessible channels.

Distribution strategies must account for the realities of rural life, including limited connectivity, variable digital literacy, and the importance of social networks. Partnerships with cooperatives, extension services, microfinance institutions, and agri-tech platforms can enhance outreach and support. Training, education, and capacity-building initiatives are critical for building trust and ensuring effective use.

6.10 Product design, customization, and innovation

The flexibility of blockchain and smart contracts enables the development of a wide range of insurance products, from simple weather-indexed policies to more complex, multi-peril solutions. Customization is key to meeting the diverse needs of Thai farmers, who face different risks depending on their location, crop, and farming system.

Product innovation is driven by advances in data analytics, remote sensing, and IoT integration. High-resolution weather data, satellite imagery, and farm-level sensors enable the creation of localized indices and tailored coverage options. Blended triggers, multi-crop policies, and group insurance schemes can further enhance value and reduce basis risk.

The iterative process of product development involves close collaboration with farmers, insurers, regulators, and technology providers. Feedback loops, pilot testing, and adaptive management ensure that products remain relevant, effective, and responsive to changing conditions.

6.11 Claims management, dispute resolution, and redress

Automated claims management is a hallmark of parametric insurance, with smart contracts executing payouts based on objective data. However, the system must also accommodate exceptions, disputes, and appeals. Transparent processes, clear communication, and accessible recourse mechanisms are essential for maintaining trust and satisfaction.

Dispute resolution may involve independent review panels, mediation, or arbitration, depending on the nature and complexity of the issue. Regulators play a key role in overseeing claims processes, investigating complaints, and enforcing standards. The integration of digital tools, such as chatbots, hotlines, and online portals, can enhance accessibility and efficiency.

6.12 Interoperability, standards, and ecosystem development

The long-term success of blockchain-based insurance depends on the development of interoperable systems, common standards, and a vibrant ecosystem of stakeholders. Interoperability enables data sharing, cross-platform integration, and the scaling of solutions across regions and sectors. Standards for data formats, APIs, security protocols, and performance metrics facilitate collaboration and reduce fragmentation.

Ecosystem development involves the cultivation of partnerships, networks, and communities of practice. Government agencies, industry associations, research institutions, and international organizations all have roles to play in fostering innovation, sharing knowledge, and building capacity.

6.13 International experience and lessons learned

Thailand can draw valuable lessons from international experience with blockchain-based and parametric insurance. Countries such as Kenya, India, and Mexico have implemented index-based insurance schemes, leveraging mobile technology, satellite data, and public-private partnerships. These experiences highlight the importance of regulatory flexibility, stakeholder engagement, and continuous learning.

Global standards and best practices, such as those developed by the International Association of Insurance Supervisors (IAIS) and the World Bank, provide guidance on product design, consumer protection, and risk management. Participation in regional and international forums can enhance Thailand’s capacity to innovate and adapt.

6.14 Risks, challenges, and mitigation strategies

The implementation of blockchain-based parametric insurance is not without risks. Technical challenges include data quality, system reliability, and cybersecurity. Legal and regulatory uncertainties may create barriers to adoption or expose stakeholders to liability. Market risks include low uptake, adverse selection, and moral hazard.

Mitigation strategies include robust risk assessment, scenario planning, and contingency measures. Regular audits, stress testing, and incident response protocols enhance resilience. Ongoing dialogue with stakeholders, adaptive regulation, and investment in research and development support continuous improvement.

6.15 Roadmap for implementation and policy recommendations

A phased approach to implementation is recommended, beginning with pilot projects in high-risk regions, followed by scaling and integration with national systems. Key policy recommendations include the harmonization of regulations, the promotion of digital literacy, the strengthening of data infrastructure, and the encouragement of public-private partnerships.

Regulators should continue to support innovation through sandboxes, guidance, and capacity building. Insurers and technology providers should prioritize transparency, consumer protection, and inclusivity. Farmers and communities should be engaged as active partners in the design, deployment, and evaluation of solutions.

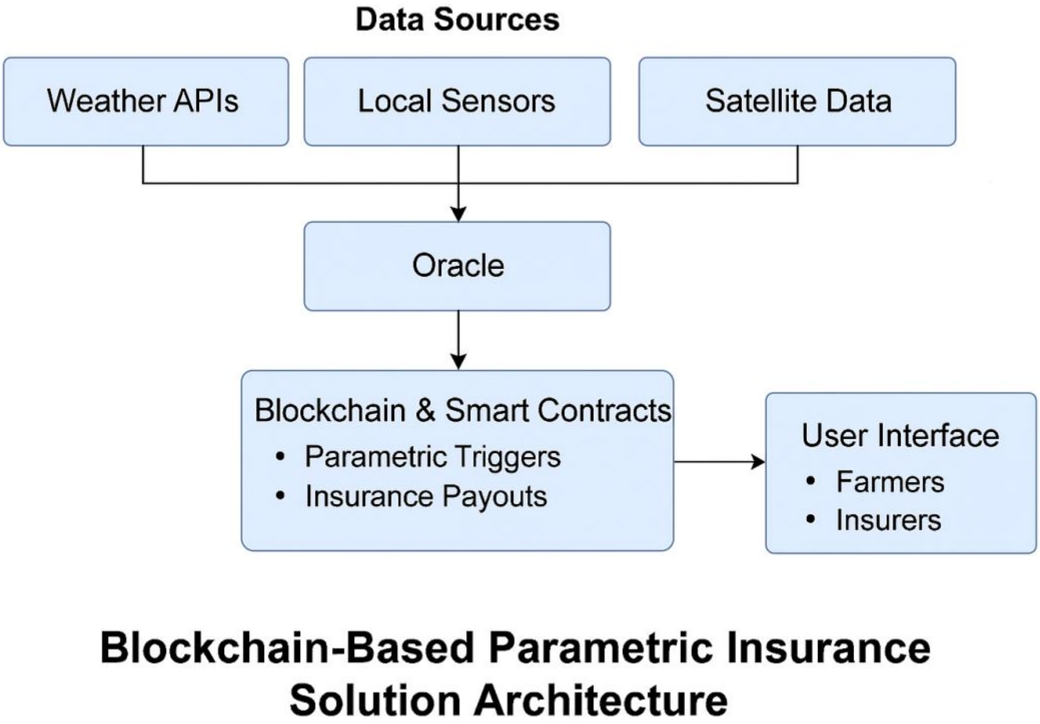
6.16 Conclusion

The consideration of regulatory, legal, and commercial aspects is central to the success of blockchain-based parametric insurance in Thailand. By aligning innovation with compliance, fostering collaboration, and addressing the needs of all stakeholders, Thailand can build a resilient, inclusive, and sustainable insurance system that empowers farmers to manage climate risks and secure their livelihoods in an uncertain future.

7 PROPOSED BLOCKCHAIN-BASED PARAMETRIC INSURANCE SOLUTION ARCHITECTURE AND DESIGN

7.1 Introduction

The agricultural sector in Thailand is the lifeblood of rural communities and a cornerstone of national food security. Yet, it is increasingly vulnerable to the impacts of climate change, with extreme weather events such as droughts, floods, and storms threatening the livelihoods of millions of smallholder farmers. Traditional insurance models, while providing some measure of protection, have often fallen short in delivering timely, transparent, and scalable solutions. The convergence of blockchain technology, parametric insurance, and digital infrastructure offers a transformative opportunity to address these challenges. This chapter presents a comprehensive, deeply elaborated architecture and design for a blockchain-based parametric insurance solution tailored to the Thai context, integrating technical, operational, and user-centric considerations to ensure effectiveness, scalability, and sustainability.



Proposed blockchain-based parametric insurance solution architecture (source: BCI, 2025)

7.2 Design principles and objectives

The architecture of the proposed solution is guided by several core principles: transparency, automation, scalability, security, interoperability, and inclusivity. Transparency is achieved through the use of blockchain's immutable ledger, which records all transactions and events in a manner accessible to authorized stakeholders, including farmers, insurers, regulators, and auditors. This transparency is not only technical but also procedural, with clear documentation, open standards, and regular reporting.

Automation is realized through smart contracts, which execute insurance agreements and claims without manual intervention, reducing administrative costs and delays. These smart contracts are designed to be modular, upgradable, and auditable, allowing for continuous improvement and adaptation to changing regulatory or market conditions.

Scalability is built into the system's modular design, allowing for expansion across regions, crops, and insurance products. The architecture supports horizontal scaling—adding more nodes, data sources, and users—as well as vertical scaling, with the ability to handle increasing transaction volumes and data complexity.

Security is ensured through robust encryption, authentication, and consensus mechanisms, protecting sensitive data and financial assets. The system employs multi-layered security protocols, including role-based access control, multi-factor authentication, and regular security audits.

Interoperability is prioritized by adhering to open standards, APIs, and data formats, enabling seamless integration with external systems such as government databases, weather services, and financial institutions. This ensures that the solution can evolve alongside Thailand's broader digital ecosystem.

Inclusivity is a guiding value, with interfaces and processes designed to accommodate the diverse needs and capabilities of Thai farmers, insurers, and regulators. Special attention is given to language, literacy, accessibility, and cultural relevance, ensuring that even the most marginalized communities can participate fully.

The overarching objective is to create a system that not only delivers timely and fair compensation to farmers affected by climate risks but also fosters trust, efficiency, and innovation across the insurance value chain. The architecture must support the integration of multiple data sources, the customization of insurance products, and the seamless flow of information and funds among stakeholders.

7.3 System overview and stakeholder roles

At its core, the proposed solution consists of a permissioned blockchain network, a suite of smart contracts, a set of data oracles, and a range of user interfaces tailored to different stakeholders. A comprehensive mapping of these stakeholders and their roles is provided in ANNEX 1. The permissioned blockchain, built on a platform such as R3 Corda or Hyperledger Fabric, ensures that only authorized participants—insurers, regulators, data providers, and farmer organizations—can access and validate transactions. This approach balances the need for transparency with the requirements of privacy and regulatory compliance.

Smart contracts encode the terms of insurance agreements, including coverage parameters, premium payments, and claims triggers. These contracts are deployed on the blockchain and interact with external data sources via oracles. Oracles serve as trusted bridges between the blockchain and the outside world, delivering real-time weather, crop, and payment data to the system. User interfaces, including web portals, mobile apps, and SMS gateways, provide access points for farmers, insurers, regulators, and other stakeholders, enabling enrolment, policy management, claims submission, and monitoring.

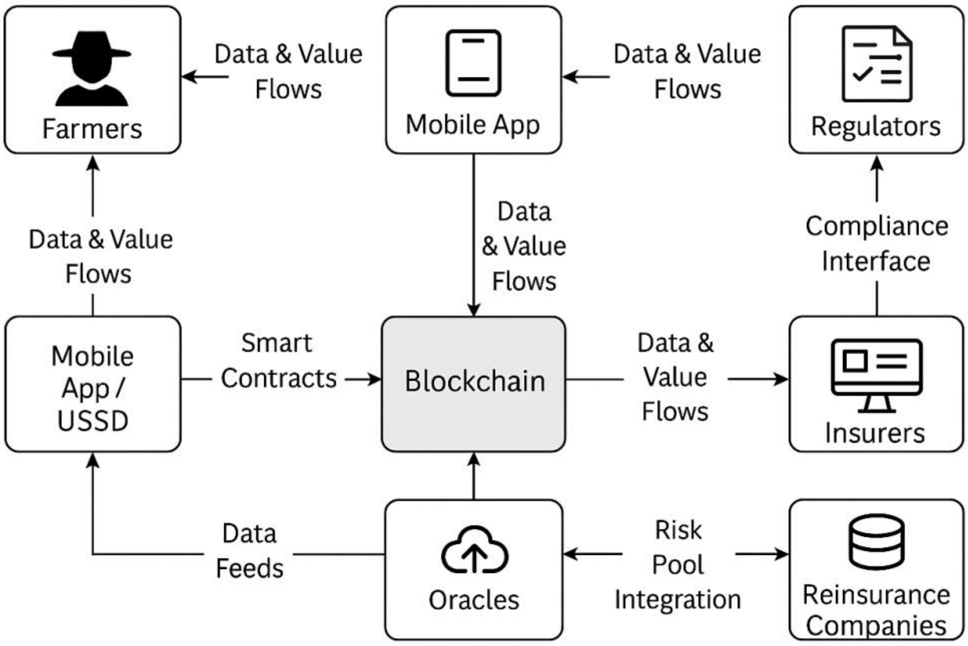
Farmers engage with the system primarily through mobile devices, registering their land, selecting insurance products, and receiving payouts. The user experience is designed to be intuitive, with step-by-step guidance, visual aids, and support for local languages and dialects. Farmers can also access educational resources, weather forecasts, and advisory services through the platform.

Insurers manage product offerings, risk assessment, and fund management through dedicated dashboards. These dashboards provide real-time analytics, portfolio management tools, and compliance monitoring features. Insurers can design new products, adjust pricing, and monitor claims activity, all within a secure and auditable environment.

Regulators oversee compliance, monitor system performance, and access audit trails. The platform provides regulators with real-time access to transaction records, policy data, and system performance metrics. This enables proactive supervision, rapid response to incidents, and evidence-based policy development.

Data providers, such as the Thailand Meteorological Department, satellite operators, and IoT device manufacturers, supply the indices that underpin parametric triggers. These providers are integrated into the Oracle network, with clear protocols for data submission, validation, and compensation.

Other stakeholders, including reinsurance companies, development agencies, and technology partners, can participate in the ecosystem through defined roles and interfaces. The architecture supports collaboration, innovation, and the creation of value-added services.



Stakeholder interaction diagram (source: BCI, 2025)

7.4 Data architecture and integration

A robust data architecture is essential for the reliability and accuracy of parametric insurance. The system integrates multiple sources of environmental, agricultural, and financial data, ensuring that triggers are based on objective, verifiable information. Weather data is collected from a network of ground stations, satellites, and IoT sensors, providing high-resolution coverage across Thailand's diverse agro-ecological zones. Crop data, including planting dates, varieties, and yields, is gathered through farmer self-reporting, extension services, and remote sensing.

The data architecture is designed for flexibility, scalability, and resilience. Data flows into the blockchain system via standardized APIs, which validate, format, and timestamp incoming information. Oracles aggregate and cross-verify data from multiple sources, reducing the risk of manipulation or error. The system supports both real-time and batch data processing, accommodating the varying latency and reliability of different data streams.

Data privacy and security are maintained through encryption, access controls, and compliance with the Personal Data Protection Act (PDPA). Sensitive information is stored off-chain where necessary, with cryptographic hashes recorded on the blockchain to ensure integrity and auditability. Data retention policies are aligned with regulatory requirements and user preferences.

The architecture also supports data analytics, machine learning, and artificial intelligence applications. Historical and real-time data are used to calibrate insurance products, forecast risks, and optimize system performance. The platform provides tools for data visualization, reporting, and decision support, enabling stakeholders to make informed choices.

7.5 Smart contract design and automation

Smart contracts are the engine of automation in the proposed solution. Each insurance product is represented by a set of smart contracts that define eligibility criteria, coverage terms, premium schedules, and claims logic. When a farmer enrols in a policy, a unique contract instance is created, recording the details of the agreement and linking it to the relevant data sources.

Premium payments are tracked and verified by the smart contract, which updates the policy status and triggers reminders or penalties for missed payments. When a trigger event—such as a rainfall deficit or temperature spike—is detected by the oracles, the smart contract automatically calculates the payout amount and initiates the transfer of funds to the farmer's digital wallet or bank account. All actions are recorded on the blockchain, creating an immutable audit trail.

The design of smart contracts emphasizes modularity and upgradability. Core functions, such as data validation, payout calculation, and dispute resolution, are implemented as separate modules that can be updated or replaced as needed. This approach allows the system to adapt to changing regulations, new data sources, and evolving user needs without requiring a complete overhaul.

Smart contracts are also designed to be transparent and auditable. The logic, parameters, and execution history of each contract are accessible to authorized stakeholders, enabling independent verification and oversight. This transparency builds trust and accountability, reducing the risk of disputes and fraud.

7.6 Oracle network and data validation

The reliability of parametric insurance depends on the accuracy and integrity of the data used to trigger claims. The Oracle network is designed to aggregate, validate, and deliver data from multiple independent sources, minimizing the risk of false positives or negatives. Oracles are operated by trusted entities, including government agencies, research institutions, and private data providers, each subject to rigorous vetting and oversight.

Data validation involves cross-checking inputs from different sources, applying statistical filters, and flagging anomalies for review. For example, if a ground station reports zero rainfall during a period when satellite data indicates heavy precipitation, the system can trigger a manual review or use additional data to resolve the discrepancy. Oracles also timestamp and sign data submissions, ensuring traceability and accountability.

The oracle network is governed by a set of protocols that define data formats, submission intervals, and consensus mechanisms. In the event of conflicting data, the system can apply majority voting, weighted averages, or other algorithms to determine the most reliable value. The architecture supports the addition of new oracles and data types as technology and user needs evolve.

The system also supports the integration of advanced analytics and machine learning models into the oracle network. These models can detect patterns, forecast risks, and enhance the accuracy of trigger events. For example, a machine learning model might analyse historical weather data, crop yields, and remote sensing imagery to predict the likelihood of a drought or flood, informing both insurance product design and real-time claims processing.

7.7 User experience and accessibility

A key goal of the proposed solution is to make insurance accessible and user-friendly for all stakeholders, particularly smallholder farmers with limited digital literacy. The user interface is designed with simplicity, clarity, and local relevance in mind. Farmers can enroll in insurance products through mobile apps, SMS, or in-person assistance from extension agents. The enrollment process guides users through the selection of coverage options, entry of farm details, and payment of premiums.

Visual dashboards provide real-time updates on policy status, weather conditions, and claims eligibility. Alerts and notifications are delivered via SMS or app push messages, ensuring that farmers are informed of trigger events and payouts. The system supports multiple languages and dialects, with icons and graphics to aid comprehension.

For insurers and regulators, the platform offers advanced analytics, reporting tools, and compliance dashboards. These features enable efficient risk assessment, product management, and oversight, reducing administrative burdens and enhancing transparency.

The user experience is continuously refined through user feedback, usability testing, and community engagement. Training programs, help desks, and peer support networks are established to assist users in navigating the system and resolving issues.

7.8 Payment systems and financial integration

The disbursement of insurance payouts is facilitated by integration with Thailand's digital payment infrastructure, including PromptPay, mobile banking, and e-wallets. When a claim is triggered, the smart contract initiates a payment transaction, which is processed through the selected channel and credited to the farmer's account. The system supports both instant and scheduled payments, accommodating the preferences and needs of different users.

Premium collection is similarly automated, with options for one-time or recurring payments. Farmers can pay premiums via bank transfer, mobile money, or cash-in agents, with receipts and confirmations recorded on the blockchain. The platform reconciles all financial transactions, generating reports for insurers, regulators, and auditors.

Security and compliance are maintained through encryption, multi-factor authentication, and adherence to anti-money laundering (AML) and counter-terrorism financing (CFT) regulations. The system monitors transactions for suspicious activity and provides tools for reporting and investigation.

The financial integration also supports interoperability with other financial services, such as savings, credit, and input financing. Farmers can use the platform to access a range of financial products, enhancing their resilience and economic opportunities.

7.9 Security, privacy, and compliance

The architecture incorporates multiple layers of security to protect data, assets, and user privacy. Access to the blockchain network is restricted to authorized participants, with role-based permissions and audit logs. All data transmissions are encrypted, and sensitive information is stored off-chain with secure references on the blockchain.

Compliance with the PDPA and other relevant regulations is ensured through data minimization, user consent, and transparent privacy policies. Users have the right to access, correct, or delete their personal data, subject to legal and operational constraints. Regular security audits, penetration testing, and incident response protocols are implemented to identify and address vulnerabilities.

The system is designed to support regulatory reporting and oversight, with real-time access to transaction records, policy data, and system performance metrics. Regulators can monitor compliance, investigate incidents, and enforce standards through dedicated dashboards and tools.

7.10 Scalability, interoperability, and future-proofing

Scalability is a core requirement for the proposed solution, given the diversity and size of Thailand's agricultural sector. The modular architecture allows for the addition of new regions, crops, insurance products, and data sources without disrupting existing operations. The use of standardized APIs and data formats facilitates integration with external systems, including government databases, weather services, and financial institutions.

Interoperability is supported through adherence to industry standards and participation in ecosystem initiatives. The platform can exchange data and transactions with other blockchain networks, enabling cross-border insurance, reinsurance, and risk pooling. The architecture is designed to accommodate future technologies, such as artificial intelligence, machine learning, and decentralized finance (DeFi), ensuring long-term relevance and adaptability.

The system is also designed for resilience, with redundancy, failover mechanisms, and disaster recovery protocols. Regular stress testing, scenario analysis, and capacity planning ensure that the platform can handle peak loads and recover from disruptions.

7.11 Governance and ecosystem development

A robust and clearly defined governance model is essential for the long-term sustainability, trust, and scalability of the BBPI platform. The proposed model is designed to balance the interests of all stakeholders while ensuring decisive leadership, operational efficiency, and alignment with national strategic goals.

Proposed governance model: the Thailand Agri-Digital Insurance Consortium (TAIDIC)

The governance will be structured as a consortium model, the TAIDIC, a legally established entity responsible for overseeing the BBPI platform. This model ensures that no single entity has unilateral control, fostering trust and collaboration among a diverse group of stakeholders.

Consortium leadership and membership

The TAIDIC will be led by a Steering Committee composed of senior representatives from the following core stakeholder groups to ensure balanced leadership:

- Chair: A representative from the Ministry of Agriculture and Cooperatives or the Office of Insurance Commission (OIC). This public-sector leadership is proposed to ensure the platform prioritizes farmer welfare, public policy objectives, and financial inclusion, rather than purely commercial interests;

- Vice-Chair (technical): A representative from the Digital Government Development Agency (DGA) or a leading Thai technology university to provide oversight on the blockchain architecture, data security, and interoperability.

- Core members:

  - Insurers and reinsurers: Both public (e.g., Thai Reinsurance) and private companies providing capital and risk underwriting
  - Financial institutions: Representatives from the Bank of Thailand and major Thai banks (e.g., for PromptPay integration)
  - Data providers: The Thailand Meteorological Department and the Geo-Informatics and Space Technology Development Agency (GISTDA)
  - Farmer associations: Representatives from major agricultural cooperatives to ensure the farmer's voice is central to all decisions
  - Technology partners: The core developers and maintainers of the platform (e.g., the Blockchain & Climate Institute consortium)

Roles, responsibilities, and decision-making

The TAIDIC Steering Committee will have the following key responsibilities:

1. Strategic direction and policy setting: Establishing the platform's strategic roadmap, approving new insurance products, and setting data privacy and security policies.
2. Membership management: Vetting and onboarding new insurers, technology providers, or data partners into the ecosystem.
3. Technical oversight and upgrades: Approving major upgrades to the blockchain protocol, smart contract standards, and oracle networks.
4. Financial governance: Overseeing the consortium's budget, fee structures, and the financial integrity of the shared platform infrastructure.
5. Dispute resolution: Serving as the final arbiter for technical or contractual disputes between participants that cannot be resolved at an operational level.

Decision-making will be based on a super-majority vote (e.g., 2/3 majority) to prevent deadlocks while protecting minority interests.

Ecosystem development and innovation

To foster a vibrant ecosystem, the TAIDIC will actively promote:

- Open APIs and developer tools: Providing well-documented APIs to allow fintechs, agri-tech companies, and researchers to build complementary services (e.g., advanced analytics dashboards, financial planning tools for farmers) on top of the BBPI platform;
- Funding and grant mechanisms: Establishing a fund, potentially supported by initial project funding and a small percentage of transaction fees, to grant to innovators building applications that enhance platform utility for farmers; and
- Capacity building and knowledge sharing: Organizing regular workshops and training programs for insurers on product design, for farmers on digital literacy, and for government officials on regulating the new technology. This ensures all parties can participate effectively.

This proposed governance framework ensures the BBPI system is not just a technological solution but a sustainable, multi-stakeholder institution that is accountable, responsive, and poised for long-term growth.

7.12 Pilot implementation and scaling strategy

A carefully structured, phased implementation is critical for de-risking the technology, validating the business model, and building stakeholder confidence. This strategy moves from a controlled proof-of-concept to a full-scale national rollout, contingent on achieving specific, measurable milestones.

Phase 1: Proof-of-concept pilot (months 1-13) – budget: USD 325,000

The initial pilot is designed as a live laboratory to test all system components under real-world conditions and generate the empirical evidence needed for a scale-up decision:

- Pilot region and farmer selection:
  - Target regions: The pilot will be deployed in three high-risk agro-ecological zones identified through climate hazard mapping: Chiang Mai Province (drought for high-value horticulture), Nakhon Phanom Province (floods for rice), and Ubon Ratchathani Province (mixed flood/drought for maize/cassava).
  - Target farmers: A controlled pilot group of 200-300 smallholder farmers will be enrolled, with a focus on members of existing agricultural cooperatives to leverage trust and communication channels. A minimum of 50% participation from women farmers is a key target.
- Pilot scope and insurance products:
  - Product A (flood): Payout triggered when 72-hour cumulative rainfall from Thai Meteorological Department (TMD) stations exceeds a predefined threshold and river water levels surpass a danger mark.
  - Product B (drought): Payout triggered when the 30-day cumulative rainfall index (blending TMD ground data and CHIRPS satellite data) falls below a calibrated threshold during a critical growing period.
- Technology and integration:
  - The pilot will utilize a permissioned blockchain (e.g., Hyperledger Fabric) for the core ledger.
  - Decentralized oracles (e.g., Chainlink) will be configured to pull and verify data from the TMD API and satellite feeds.

- Payouts will be automated to farmers' PromptPay-enabled bank accounts or mobile wallets, integrated via the Bank for Agriculture and Agricultural Cooperatives (BAAC).

- Key success metrics for go/no-go decision:
  - Technical: >99% platform uptime; processing payouts within 7 days of a trigger event.
  - User experience: >80% farmer satisfaction rate post-pilot; >90% of users able to navigate the mobile enrolment app with minimal assistance.
  - Financial and risk: Completion of a basis risk assessment quantifying the correlation between payouts and actual losses; validation of the actuarial model.
  - Regulatory: Successful completion of a regulatory sandbox trial with the Office of Insurance Commission (OIC) and a positive legal review on smart contract enforceability.

Phase 2: Full-scale implementation and national integration (months 14-24) – budget: USD 425,000

This phase is conditional on a successful "go" decision based on the Phase 1 validation report. It focuses on achieving national impact and financial sustainability.

- Scaling targets:
  - Geographic expansion: Scale the platform to cover all major agricultural regions in Thailand.
  - Farmer onboarding: Launch mass enrolment campaigns to onboard over 20,000 farmers.
  - Product diversification: Introduce insurance for additional high-value crops (e.g., sugarcane, durian) and multi-peril coverage.

- Core scaling activities:
  - Large-scale resource mobilization: Secure co-financing from private insurers (USD 150,000) and public subsidies (USD 100,000) to transition from a grant-dependent to a commercially viable model.
  - Platform scaling: Scale the platform architecture to handle the increased transaction volume and user base.
  - National integration: Formalize the integration of the BBPCI model into the Thailand National Crop Insurance Scheme (TNCIS) via a signed Memorandum of Understanding (MoU) with the relevant ministries.

- Enabling strategy for scaling:
  - Regulatory pathway: Phase 1 secures operational legitimacy via the sandbox. Phase 2 will advocate for formal regulatory guidance from the OIC to enable widespread insurer adoption.
  - Financial sustainability: The model transitions from donor grants to a co-financed structure, with insurers progressively taking on more risk. The target is to demonstrate a clear path to operational breakeven with the 20,000+ farmer base.
  - Capacity building and replication: Develop standardized training modules and a "replicability toolkit"—including the technical architecture, legal pathway document, and implementation guide—to facilitate adaptation in other ASEAN countries.

7.13 Monitoring, evaluation, and continuous improvement

The performance of the solution is monitored through a comprehensive set of indicators, including enrolment rates, claims processing times, payout accuracy, user satisfaction, and system reliability. Data analytics and reporting tools provide real-time insights, enabling proactive management and continuous improvement.

Regular evaluations, including independent audits and impact assessments, inform strategic decisions and policy recommendations. The system is designed to evolve in response to changing needs, technological advances, and regulatory developments.

Continuous improvement is supported by a culture of learning, innovation, and collaboration. Stakeholders are encouraged to share feedback, propose enhancements, and participate in the co-creation of new features and services.

7.14 Risks, challenges, and mitigation strategies

The implementation of a blockchain-based parametric insurance solution entails a range of risks and challenges, including technical complexity, data quality, user adoption, and regulatory uncertainty. Mitigation strategies include robust risk assessment, scenario planning, stakeholder engagement, and adaptive management.

Technical risks are addressed through rigorous testing, redundancy, and failover mechanisms. Data quality is ensured through validation, cross-verification, and continuous calibration. User adoption is supported by training, outreach, and user-centred design. Regulatory risks are managed through ongoing dialogue with authorities, participation in sandboxes, and compliance with evolving standards.

The system also incorporates contingency plans for cyberattacks, data breaches, and operational disruptions. Regular drills, incident response protocols, and insurance coverage for cyber risks enhance resilience and preparedness.

7.15 Policy implications and recommendations

The successful deployment of the proposed solution has significant policy implications for Thailand's agricultural, financial, and digital sectors. Policymakers are encouraged to support innovation through enabling regulations, investment in digital infrastructure, and the promotion of public-private partnerships. The harmonization of standards, the protection of consumer rights, and the fostering of digital literacy are critical for maximizing the benefits of blockchain-based insurance.

Recommendations include the establishment of a national task force on digital insurance, the development of guidelines for smart contracts and data oracles, and the integration of insurance platforms with government databases and payment systems. Ongoing research, pilot projects, and international collaboration will further strengthen Thailand's capacity to lead in digital risk management.

7.16 International experience and lessons learned

Thailand can draw valuable lessons from international experience with blockchain-based and parametric insurance. Countries such as Kenya, India, and Mexico have implemented index-based insurance schemes, leveraging mobile technology, satellite data, and public-private partnerships. These experiences highlight the importance of regulatory flexibility, stakeholder engagement, and continuous learning.

Global standards and best practices, such as those developed by the International Association of Insurance Supervisors (IAIS) and the World Bank, provide guidance on product design, consumer protection, and risk management. Participation in regional and international forums can enhance Thailand's capacity to innovate and adapt.

7.17 Future directions and research opportunities

Looking ahead, the integration of emerging technologies such as artificial intelligence, machine learning, and decentralized finance (DeFi) holds promise for further enhancing the efficiency, security, and inclusivity of digital insurance. Research opportunities abound in areas such as predictive analytics, behavioural economics, and climate modelling.

Collaboration between academia, industry, and government will be essential for advancing knowledge, developing new solutions, and building capacity. Pilot projects, regulatory sandboxes, and innovation hubs can serve as testbeds for experimentation and learning.

7.18 Conclusion

The proposed blockchain-based parametric insurance solution represents a paradigm shift in the management of climate risk for Thailand's agricultural sector. By leveraging the strengths of blockchain technology, smart contracts, and digital infrastructure, the system delivers timely, transparent, and scalable protection to farmers, while enhancing efficiency, trust, and innovation across the insurance value chain. The architecture and design presented in this chapter provide a roadmap for implementation, adaptation, and continuous improvement, positioning Thailand as a leader in digital agricultural resilience.

8 TRADE-OFFS OF THE PROPOSED BLOCKCHAIN-BASED PARAMETRIC INSURANCE SYSTEM AGAINST THE EXISTING BUSINESS-AS-USUAL SCENARIO

8.1 Introduction

The transition from traditional, indemnity-based agricultural insurance to a blockchain-based parametric insurance system represents a significant shift in how climate risk is managed for Thailand's smallholder farmers. While the proposed solution promises greater efficiency, transparency, and inclusivity, it also introduces new complexities and trade-offs. This chapter explores these trade-offs in depth, comparing the user experience, operational realities, and systemic impacts of the new system against the established business-as-usual (BAU) approach.

8.2 User experience: from paperwork to automation

In the BAU scenario, a typical farmer seeking insurance must navigate a complex web of paperwork, in-person visits to insurance offices, and lengthy verification processes. Policy enrollment often requires multiple forms, supporting documents, and sometimes even collateral. When a climate event occurs, the claims process is equally cumbersome: the farmer must submit a claim, wait for an assessor to visit the farm, and then endure weeks or months of uncertainty before a payout is approved—if it is approved at all. Many farmers, discouraged by these hurdles, either forgo insurance altogether or lose trust in the system.

By contrast, the blockchain-based parametric insurance system streamlines the entire user journey. Enrolment is digital, accessible via mobile phone or through local agents, and requires only basic information and geolocation data. The farmer's policy is instantly recorded on the blockchain, and all subsequent interactions—premium payments, policy status checks, and claims—are managed through a simple app or SMS interface. When a trigger event such as drought or flood is detected by the system's oracles, the smart contract automatically calculates and disburses the payout, often within hours. The farmer receives a notification and can access funds immediately, without the need for manual claims submission or field assessment. This automation not only reduces stress and uncertainty but also builds trust and encourages broader participation.

8.3 Operational efficiency and transparency

For insurers, the BAU model is labour-intensive and costly. Manual data entry, field assessments, and paper-based recordkeeping create opportunities for error, fraud, and delay. Disputes over claims are common, and the lack of real-time data makes it difficult to assess risk accurately or design responsive products. Regulators, meanwhile, face challenges in monitoring compliance, detecting malfeasance, and ensuring consumer protection.

The blockchain-based system addresses these inefficiencies through automation, data integration, and immutable recordkeeping. Smart contracts eliminate the need for manual claims processing, while oracles provide real-time, objective data for risk assessment and product calibration. All transactions are recorded on the blockchain, creating a transparent, auditable trail that regulators can access at any time. This transparency reduces the risk of fraud, accelerates regulatory oversight, and supports evidence-based policy development. Insurers benefit from lower administrative costs, faster product development cycles, and improved risk management, while regulators gain new tools for market supervision and consumer protection.

8.4 Inclusivity, accessibility, and trust

One of the most significant trade-offs concerns inclusivity and accessibility. The BAU system, with its reliance on physical offices, paperwork, and in-person verification, often excludes the most vulnerable farmers—those in remote areas, with limited literacy, or without formal land titles. Language barriers, travel costs, and lack of awareness further limit participation, reinforcing cycles of vulnerability and exclusion.

The proposed digital system is designed to overcome these barriers. Mobile-based enrolment, local language support, and visual interfaces make insurance accessible to a wider range of users. Farmers can register their land using GPS, receive policy information via SMS, and access support through local agents or hotlines. The system's transparency and automation build trust, as farmers see clear rules, timely payouts, and a reduction in disputes. However, digital literacy and access to technology remain challenges, and ongoing investment in training, outreach, and infrastructure is essential to ensure that no one is left behind.

8.5 Data, privacy, and security

The shift to a blockchain-based system introduces new considerations around data privacy and security. While the BAU model relies on paper records and siloed databases, the digital system collects, processes, and stores large volumes of personal, financial, and geospatial data. Blockchain's cryptographic security and immutable ledger offer strong protections against tampering and unauthorized access, but they also raise questions about data ownership, consent, and the right to be forgotten. Compliance with Thailand's Personal Data Protection Act (PDPA) is built into the system's design, with clear policies for data minimization, user consent, and access controls. Farmers have greater visibility and control over their data, but must also trust that the system's operators and partners adhere to best practices in cybersecurity and privacy.

8.6 Flexibility, customization, and basis risk

Traditional insurance products are often rigid, with limited options for customization or adaptation to local conditions. The BAU approach struggles to account for the diversity of Thailand's agro-ecological zones, crop types, and risk profiles. Basis risk—the mismatch between actual losses and insurance payouts—is a persistent problem, leading to dissatisfaction and underinsurance.

The blockchain-based parametric system offers greater flexibility and customization. Insurers can design products tailored to specific crops, regions, and risk factors, using real-time data to calibrate triggers and payouts. Farmers can choose from a menu of options, adjust coverage as their needs change, and receive clear explanations of how payouts are determined. While basis risk cannot be eliminated entirely, the use of multiple data sources, blended indices, and ongoing calibration helps to minimize it. The system's transparency and auditability also make it easier to identify and address issues as they arise.

8.7 Costs, sustainability, and systemic impact

Implementing a blockchain-based insurance system requires significant upfront investment in technology, training, and outreach. The BAU model, while less efficient, relies on existing infrastructure and established practices. However, the long-term costs of manual processing, fraud, and low participation can outweigh the initial savings. The digital system, once established, offers lower operating costs, faster scaling, and the potential for integration with other financial services—such as credit, savings, and input financing.

From a systemic perspective, the proposed solution supports broader goals of financial inclusion, rural development, and climate resilience. By making insurance more accessible, transparent, and responsive, it empowers farmers to manage risk, invest in productivity, and recover more quickly from shocks. Insurers and regulators benefit from better data, improved oversight, and new opportunities for innovation. The trade-off is a shift from familiar, paper-based processes to a more complex, technology-driven model—one that requires ongoing investment, capacity building, and stakeholder engagement to realize its full potential.

8.8 Conclusion

The transition to a blockchain-based parametric insurance system offers clear advantages in efficiency, transparency, and inclusivity, but it also introduces new challenges in technology adoption, data management, and user support. For the typical Thai farmer, the journey becomes simpler, faster, and more predictable, with fewer barriers and greater trust. For insurers and regulators, the system provides powerful tools for risk management, compliance, and innovation. The trade-offs are real, but with thoughtful design, investment, and collaboration, the benefits can far outweigh the costs—paving the way for a more resilient and equitable future for Thailand's agricultural sector.

9 RISK MITIGATION STRATEGIES FOR BLOCKCHAIN-BASED PARAMETRIC INSURANCE

9.1 Introduction

The adoption of a blockchain-based parametric insurance system in Thailand's agricultural sector promises significant improvements in efficiency, transparency, and inclusivity. However, as with any complex digital innovation, it introduces a new set of risks that must be proactively managed. These risks span technical, operational, regulatory, and user-related domains. This chapter explores the key risks associated with the proposed system and outlines practical strategies for their mitigation, ensuring that the solution remains robust, trustworthy, and sustainable for all stakeholders—especially smallholder farmers.

9.2 Technical risks and mitigation

The technical foundation of the system—blockchain infrastructure, smart contracts, and data oracles—must be resilient against failures, cyberattacks, and data integrity issues. System downtime, software bugs, or compromised nodes could disrupt policy management or claims processing, undermining user trust.

To mitigate these risks, the architecture incorporates redundancy at multiple levels. The blockchain network is distributed across several nodes, ensuring that no single point of failure can halt operations. Regular software updates, code audits, and penetration testing are conducted to identify and patch vulnerabilities. Smart contracts are developed using industry best practices, with extensive testing in sandbox environments before deployment. Automated monitoring tools track system health and performance, triggering alerts and failover protocols in the event of anomalies.

Data oracles, which feed weather and crop data into the system, are diversified and cross-validated. Multiple independent sources—such as ground stations, satellites, and IoT sensors—are used to reduce reliance on any single provider. Consensus mechanisms and statistical filters detect and flag outliers or suspicious data, prompting manual review when necessary. This layered approach ensures that technical failures or attacks do not compromise the integrity or availability of the insurance platform.

9.3 Data quality, privacy, and security

The reliability of parametric insurance depends on the accuracy and security of the underlying data. Inaccurate, delayed, or manipulated data can lead to inappropriate payouts or denied claims, eroding confidence in the system. At the same time, the collection and processing of personal, financial, and geospatial data raise important privacy and security concerns.

To address data quality risks, the system employs rigorous validation protocols. Data from different sources is cross-checked, and machine learning models are used to detect inconsistencies or anomalies. Historical data is used to calibrate indices and triggers, while real-time data streams are continuously monitored for accuracy. Farmers and local agents are trained to report issues and provide ground-truth verification when needed.

Privacy and security are safeguarded through encryption, access controls, and compliance with Thailand's Personal Data Protection Act (PDPA). Sensitive information is stored off-chain, with only cryptographic references on the blockchain. Users have control over their data, with clear consent mechanisms and the ability to review or correct their information. Regular security audits and incident response plans ensure that breaches are detected and contained quickly, minimizing potential harm.

9.4 Regulatory and compliance risks

The regulatory environment for digital insurance and blockchain technology is evolving. Uncertainty around legal recognition, licensing, and compliance requirements can create barriers to adoption or expose stakeholders to legal liabilities. Changes in data protection laws, insurance regulations, or financial standards may require system updates or operational changes.

To mitigate regulatory risks, the project team maintains ongoing dialogue with relevant authorities, including the Office of Insurance Commission (OIC), the Bank of Thailand, and the Electronic Transactions Development Agency (ETDA). Participation in regulatory sandboxes allows for controlled testing and feedback, helping to align the solution with current and emerging requirements. Legal counsel is engaged to review contracts, policies, and system architecture, ensuring compliance at every stage.

The system is designed for flexibility, with modular smart contracts and configurable parameters that can be updated as regulations evolve. Comprehensive documentation, audit trails, and reporting tools support transparency and facilitate regulatory oversight. By building strong relationships with regulators and demonstrating a commitment to compliance, the project reduces the risk of legal or operational disruptions.

9.5 User adoption, literacy, and trust

Even the most advanced technical solution will fail if users do not understand, trust, or adopt it. Digital literacy, access to technology, and cultural acceptance are critical factors in the success of the blockchain-based insurance system. Farmers may be wary of new processes, concerned about data privacy, or unfamiliar with mobile apps and digital payments.

To mitigate these risks, the user journey is designed to be as simple and supportive as possible. Enrolment, policy management, and claims are accessible via mobile app, SMS, or through local agents. Visual aids, local language support, and voice prompts help bridge literacy gaps. Training programs, community workshops, and peer support networks build confidence and skills among users.

Trust is further reinforced by transparency and responsiveness. Farmers can see clear rules for payouts, track their policy status, and receive timely notifications. Feedback mechanisms—such as hotlines, surveys, and in-person consultations—allow users to report problems, ask questions, and suggest improvements. The involvement of trusted local organizations, cooperatives, and extension agents helps build credibility and social acceptance.

9.6 Financial and operational sustainability

The long-term sustainability of the system depends on sound financial management and operational resilience. Risks include insufficient premium collection, liquidity shortfalls, or misalignment between payouts and actual losses (basis risk). Operational risks such as staff turnover, supply chain disruptions, or partner failures can also impact service delivery.

To address financial risks, actuarial models are used to set premiums and reserves based on historical data and risk profiles. Reinsurance arrangements and contingency funds provide additional buffers against catastrophic losses. Automated financial reconciliation and reporting tools ensure transparency and accountability in fund management.

Operational sustainability is supported by clear governance structures, defined roles and responsibilities, and robust partner agreements. Regular training, performance monitoring, and contingency planning help maintain service quality and continuity. The system is designed to scale gradually, with pilot phases and incremental expansion informed by ongoing evaluation and learning.

9.7 Conclusion

The implementation of a blockchain-based parametric insurance system in Thailand offers significant benefits, but it also introduces new risks that must be carefully managed. By adopting a comprehensive, multi-layered approach to risk mitigation—spanning technical, data, regulatory, user, and financial domains—the project can build a resilient, trustworthy, and sustainable platform. The ultimate goal is to empower farmers with reliable protection against climate risks, while supporting insurers, regulators, and the broader ecosystem in delivering effective, inclusive, and innovative insurance solutions.

10 CONCLUSION

The journey toward a resilient, inclusive, and efficient agricultural insurance system in Thailand has reached a pivotal moment. As climate change intensifies the frequency and severity of extreme weather events, the vulnerabilities of smallholder farmers—who form the backbone of the nation's food security—have become ever more apparent. Traditional insurance models, while offering some protection, have struggled to deliver timely, transparent, and accessible solutions. The exploration and design of a blockchain-based parametric insurance system, as detailed in this report, represent a bold and necessary step forward.

The proposed solution is not merely a technological upgrade; it is a reimagining of how risk is managed, how trust is built, and how value is delivered to all stakeholders. By leveraging blockchain's transparency and automation, parametric insurance's objectivity, and Thailand's growing digital infrastructure, the system addresses many of the shortcomings of the business-as-usual approach. Farmers, who once faced daunting paperwork, long waits, and uncertain payouts, can now enroll in insurance with a few taps on a mobile phone, receive real-time updates, and access rapid, data-driven compensation when disaster strikes. Insurers benefit from streamlined operations, reduced fraud, and the ability to design products that are more closely aligned with actual risk. Regulators gain powerful tools for oversight, compliance, and market development, all while maintaining robust consumer protections.

Throughout the report, the user journey has been central. From the initial enrollment—where a farmer registers her land and selects a product tailored to her needs—to the moment a payout is triggered by a verified weather event, the system is designed to be intuitive, fair, and empowering. The integration of local language support, visual aids, and community-based outreach ensures that even the most marginalized farmers are not left behind. The use of oracles and smart contracts guarantees that payouts are based on objective, tamper-proof data, reducing disputes and building confidence in the system.

Yet, the transition to a blockchain-based parametric insurance model is not without challenges. Technical risks, data quality concerns, regulatory uncertainties, and the need for ongoing user education all require careful management. The report has outlined comprehensive risk mitigation strategies, emphasizing redundancy, cross-validation, compliance, and continuous improvement. The importance of partnerships—between government, private sector, civil society, and international organizations—cannot be overstated. Only through collaboration and shared commitment can the system achieve its full potential.

Looking ahead, the proposed solution offers a foundation for broader financial inclusion and rural development. Its modular, scalable architecture allows for the integration of additional services, such as credit, savings, and advisory tools, further enhancing the resilience and prosperity of Thailand's rural communities. The lessons learned and best practices developed here can serve as a model for other countries facing similar challenges.

In conclusion, the blockchain-based parametric insurance system represents a transformative opportunity for Thailand. It aligns technological innovation with the real needs of farmers, insurers, and regulators, paving the way for a more secure, equitable, and sustainable agricultural future. The next steps—pilot implementation, scaling, and continuous refinement will require vision, investment, and unwavering focus on the user experience. With these elements in place, Thailand can lead the region in digital agricultural resilience, ensuring that its farmers are not only protected from the risks of today but are also empowered to seize the opportunities of tomorrow.

ANNEX 1

	Examples / entities mentioned	Role in BBPI context
Farmers and cooperatives	Smallholder farmers; agricultural cooperatives; village-level digital agents	Primary beneficiaries; provided local knowledge; pilot testing
Government agencies	Ministry of Agriculture and Cooperatives (MOAC); Office of Insurance Commission (OIC); Bank of Thailand (BOT); Royal Irrigation Department (RID); Thailand Meteorological Department (TMD); Local governments	Regulation, data provision, policy alignment, oversight
International organizations and donors	Green Climate Fund (GCF); United Nations Development Programme (UNDP); Climate Investment Funds (CIF); CTCN (Climate Technology Centre & Network)	Funding, technical assistance, climate resilience programs
Insurance sector	Local insurance companies; reinsurers; risk pool managers	Product design, underwriting, claims automation
Financial institutions	Banks (e.g., BAAC – Bank for Agriculture and Agricultural Cooperatives); Mobile money providers (PromptPay, TrueMoney)	Premium collection, payout disbursement
Technology providers	Blockchain developers; Oracle providers (e.g., Chainlink); IoT sensor vendors; Cloud service providers (Google Cloud, Microsoft Azure)	Platform development, data integration, automation
NGOs and development partners	Local NGOs; Farmer support organizations; Extension services	Outreach, capacity building, farmer engagement
Academia and research	Thammasat university	Risk modelling, AI/ML integration, feasibility validation

Stakeholders consulted or referenced in the BBPI feasibility study