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Suitability and Eligibility of Climate Change Parametric Insurance for Rice Farmers

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ABSTRACT

This study examined whether parametric insurance aligns with the risk profiles of rice farmers and is suitable as an instrument for mitigating climate change-related risks, particularly within the institutional framework of Perusahaan Umum Badan Urusan Logistik (Perum BULOG). The study adopted an agricultural and institutional risk management perspective, emphasizing risk protection as an institutional mechanism for reducing farmers' economic uncertainty. A mixed-methods approach with a comparative research design was employed in Indramayu Regency and East Lombok Regency, Indonesia. Primary data were collected through questionnaires administered to 60 respondents and analyzed using descriptive statistics, the Mann–Whitney U test, chi-square tests, Spearman's rank correlation, Cronbach's alpha, and ordinary least squares (OLS) regression to examine willingness to pay (WTP). The analysis also considered regional climate risk profiles, farmers' trust in Perum BULOG, interest in parametric insurance products, willingness and ability to pay premiums, and the alignment between estimated premiums and farmers' WTP. The findings revealed distinct regional risk characteristics, with flooding being more prevalent in Indramayu and drought and excessive rainfall posing significant risks in East Lombok. Farmers demonstrated relatively favorable levels of trust in Perum BULOG; however, the median WTP was only IDR 37,500 per hectare per growing season, substantially below the estimated insurance premium range of IDR 152,000–608,000 per hectare per growing season. These findings suggest that parametric insurance has potential technical and institutional suitability, although its financial feasibility remains conditional on affordability and institutional support. Successful implementation would require tiered premium subsidies, improved insurance literacy, reliable climate data infrastructure, and the development of locally calibrated insurance indices and payout triggers that reflect regional climate risk characteristics.

INTRODUCTION

Climate change has become a significant structural factor contributing to uncertainty in the agricultural sector, particularly rice production in Indonesia (Bon et al., 2025). Shifting rainfall patterns, the increasing frequency of droughts and floods, and extreme weather events during critical crop growth stages can reduce agricultural productivity and increase the risk of crop failure (Castaing & Gazeaud, 2025). These conditions not only affect farmers' incomes and the sustainability of agricultural operations but also threaten food supply stability and

national food security (Pan, 2026). Consequently, effective risk mitigation instruments are needed to provide timely, measurable protection against climate-related losses while accommodating the specific characteristics of agricultural risks (Chen et al., 2025).

One instrument developed to address these challenges is climate index-based parametric insurance (Carter et al., 2016; Cecchi et al., 2024). Unlike conventional indemnity-based insurance, which generally requires an assessment of actual losses, parametric insurance relies on predefined, objectively measurable parameters or indices, such as rainfall, temperature, or drought indicators, to determine payout eligibility. This mechanism can reduce uncertainty in claims processing and accelerate payouts when predetermined thresholds are reached (Adelesi et al., 2024). Therefore, parametric insurance warrants further investigation as an alternative mechanism for protecting rice farmers against climate-related production risks amid increasing exposure to climate change (Mao et al., 2025).

Previous studies have indicated that the effectiveness of agricultural insurance depends substantially on the alignment between insurance product design and local risk characteristics, farmers' capacity to afford premiums, their understanding of insurance mechanisms, and their trust in implementing institutions (Nee & Brinton, 2003). In parametric insurance, selecting appropriate indices and payout triggers is particularly important because compensation is determined by predefined parameters rather than farmers' actual losses. Consequently, basis risk may arise when the selected indices or payout triggers do not adequately correspond to the losses experienced by insured farmers (Klerkx et al., 2012). This limitation highlights the importance of evaluating the technical, economic, social, and institutional dimensions of parametric insurance feasibility within an integrated analytical framework.

Theoretically, this study draws on agricultural risk management and institutional theory to examine how risk protection mechanisms can be established through institutions with existing relationships with farmers (Jensen & Barrett, 2017). From an institutional perspective, organizations function not merely as administrative entities but also as mechanisms that shape rules, incentives, trust, and coordination among stakeholders. Within this framework, Perusahaan Umum Badan Urusan Logistik (Perum BULOG), Indonesia's state-owned food logistics enterprise, occupies a potentially strategic position because of its established institutional networks, including its role as an agricultural produce buyer (offtaker), its Social and Environmental Responsibility (Tanggung Jawab Sosial dan Lingkungan [TJSL]) program, and its agricultural partnership arrangements through Mitra Tani. These institutional relationships could provide a foundation for integrating climate risk mitigation instruments into existing economic interactions between Perum BULOG and rice farmers (Nordmeyer et al., 2023; Hossain et al., 2022).

Empirically, the need for climate risk mitigation instruments must be examined in relation to variations in regional risk characteristics. Indramayu Regency and East Lombok Regency exhibit different agroecological conditions and experiences of climate-related hazards, potentially resulting in differences in farmers' protection needs and responses to parametric insurance products. Accordingly, product suitability cannot be determined solely by the presence of climate-related risks but must also account for local risk profiles,

institutional trust, product acceptance, and farmers' ability and willingness to pay insurance premiums. This study builds on the preliminary report prepared by PT Tritama Lestari in July 2026 by incorporating additional analyses of respondent-level raw data that were unavailable during the preparation of the initial report.

(Shahin & Pradhan, 2026) The novelty of this study lies in its integrated assessment of parametric insurance suitability and feasibility, combining climate risk profiling, institutional trust, willingness-to-pay (WTP) analysis, and premium design evaluation within a unified analytical framework. Rather than examining these dimensions independently, the study investigates their interrelationships to provide a comprehensive understanding of how regional climate risks, institutional readiness, and financial affordability influence the potential implementation of parametric insurance (Bergsvik & Kloppenburg, 2024). Furthermore, the research contributes to the literature on agricultural climate risk management in developing countries by examining the potential role of state-owned enterprises as institutional intermediaries in insurance distribution and implementation. The comparative analysis of two regions with distinct agroecological characteristics also provides an opportunity to identify contextual factors that may influence insurance suitability and feasibility across different agricultural environments.

Against this background, the central research problem concerns whether climate index-based parametric insurance is appropriately designed to address the actual climate risks experienced by rice farmers in Indramayu Regency and East Lombok Regency and whether such insurance is technically, economically, and institutionally feasible within the Perum BULOG institutional ecosystem. This assessment considers the relationships among regional climate risk profiles, institutional acceptance, farmers' willingness to pay premiums, insurance index selection, payout trigger design, and the availability and reliability of supporting climate data (Joseph et al., 2026). Accordingly, this study aims to evaluate the extent to which parametric insurance can function as a technically appropriate, financially accessible, and institutionally viable risk mitigation instrument for rice farmers within Perum BULOG's existing agricultural partnership framework.

This study is expected to provide both theoretical and practical contributions. Theoretically, it extends the literature on agricultural risk management, institutional economics, and climate change adaptation by providing empirical evidence on factors associated with the suitability and feasibility of parametric insurance in Indonesia. Practically, the findings are intended to inform Perum BULOG, policymakers, and insurance providers in developing appropriate premium subsidy mechanisms, strengthening farmers' insurance literacy, and designing climate indices and payout triggers that reflect local agricultural risk characteristics. The study also identifies relevant data limitations and methodological considerations that may guide future research and insurance product development. Ultimately, the research seeks to support the development of more accessible and contextually appropriate agricultural risk protection mechanisms, thereby contributing to the resilience of Indonesia's rice farming sector and broader national food security objectives.

METHOD

Research Design

This study employed a mixed-methods, cross-sectional, comparative case study design across two locations. Primary quantitative data were collected through questionnaires administered to 60 farmers and stakeholders, comprising 28 respondents from Indramayu Regency and 32 from East Lombok Regency. Secondary data were obtained from official publications issued by Perum BULOG, the Ministry of Agriculture, the Indonesian Agency for Meteorology, Climatology, and Geophysics (BMKG), and the Financial Services Authority (OJK). Additional technical data on insurance payout triggers and premium estimates were derived from Chapter 11 of the preliminary report, which used BMKG climate data covering Java rather than farm-level data specific to Indramayu and East Lombok.

Audit Data (Output 1)

Data Structure

The dataset consists of 60 rows × 37 columns. Variables include: demographics (4 variables), climate risk profile B1-B6 (6 variables), institutional relations of BULOG C1-C6 (6 variables), WTP/interest D1-D6 (6 variables), social acceptance E1-E6 (6 variables), and open-ended questions F1-F3 (3 variables).

Critical Data Quality Findings

- No duplicate IDs or combinations of name+village were found.
- *Missingness* varies per variable: core items (blocks B-E) have 5-13 blank values (8-22%); open-ended questions (F1-F3) have very high *missingness* (35-42%).
- 7 out of 60 respondents (12%) had questionnaires that were almost entirely blank in the core block (only 1-10 out of 26 items were filled) — 5 in East Lombok, 2 in Indramayu. This row was not removed from the dataset (following the audit rule: do not delete data carelessly), but was automatically excluded from the composite index calculation because the average function ignores the blank value, so the effective N of the composite index is 52-53 instead of 60. This is explicitly expressed in each results table.
- No *extreme numerical outliers* were found in the age variables (range 18-75 years, demographically reasonable) or *WTP brackets* (as per the questionnaire design). There was no indication of obvious input errors.
- Variables B3 (type of climate risk) and E2 (adaptive strategy) are multi-select (separated by semicolons) and are analyzed by breaking (*explode*) per category, rather than being calculated as a single combined category, so that the frequency distribution is not biased.

Concise Data Dictionary

The seven key variables are shown as follows; The full dictionary data of 37 variables is presented in Appendix A.

Table 1. Key Variables and Their Analytical Functions in the Study

Variabel	Meaning	Type/Scale	Use of Analysis
B2 Crop Failure	Historical frequency of crop failure	Ordinal, 4 level	Risk exposure, PFI
B3 Types of Climate	Dominant types of climate risk	Nominal multi-select, 5 categories	Product fit, regional comparison
B4 Disadvantages	Estimated crop loss percentage	Ordinal, 5 level	Risk severity
C1/C3/C4/C6	Know, be satisfied, trust, know the BULOG program	Ordinal, 4 level/butir	Trust Index (α=0.51)
D2/D3	Conditional interest and willingness to premium	Ordinal, 4-5 level	Feasibility Index (α=0,42)
D4	Maximum premium willing to be paid	Ordinal interval-coded, 6 bracket	WTP (Rupiah, midpoint bracket)
E1/E3/E4/E6	Worries, traditional beliefs, cultural barriers, collective willingness	Ordinal, 4-5 level/butir	Social Acceptance Index (α=0.20)

Research Design Correction

The initial research framework (KAK) mentions four national study areas. The final research analyzed in this report only covers two areas for which empirical data are available: Indramayu Regency and East Lombok Regency, as a two-site comparative case study. Data from Jambi and Bali are not used because they are not available.

Data & Methodology Reconciliation Table

In accordance with research rules that require transparency when there are conflicts between data sources (Initial Report, questionnaire, Excel, digital analysis), the following table presents an explicit reconciliation.

Table 2. Reconciliation of Data and Methodological Discrepancies Across Research Sources

Conflict	Evidence	Verdict	Rationale
The dashboard reported *a very low Feasibility Index* (6.4-6.9/100), while a reconstruction of the D2+D3 raw grain yielded ~53-54/100	The formula/weight of the dashboard is not documented on any of the files received; cannot be reproduced or audited	Use the index of transparent reconstruction results (this report) as the official number; the dashboard numbers are included only as a secondary reference	Research guidelines prohibit unexplained/arbitrary weights
Dashboard Trust Index (54.0-56.7) vs reconstruction (65.9-69.3)	Possibility of dashboards inserting additional items/different weights that are not documented	Use the reconstruction of this report; the direction of the findings (Indramayu > East Lombok) is consistent in both sources	Directional consistency strengthens the qualitative validity of findings despite different magnitudes

Conflict	Evidence	Verdict	Rationale
The Preliminary Report states that the climate risk hypothesis of Indramayu (multi-type: flood/flood/rob) vs East Lombok (drought-dominant) as the initial hypothesis, has not been tested	B3 raw data is now available and confirms this hypothesis directly	The hypothesis was upgraded to FACT, supported by direct primary data	As per the rule of "do not equate *inference* with *fact*" — there is now direct evidence
The reliability of the composite index is low (α 0.20-0.51) but the dashboard displays a score as if it were high precision (1 decimal)	Cronbach's Alpha calculation on raw data	This report reports indices with explicit reliability disclaimers in each table	The rule of "do not overclaim" — *FACT vs INFERENCE* must be distinctively distinguished

Statistical Methods Used

Table 3. Statistical Methods Used in the Analysis and Their Justification

Method	Used For	Justification
Descriptive statistics	All variables	Basic respondent profile
Mann-Whitney U	Differences in index/WTP between regions	Ordinal/skewed data, not assuming normality
Chi-square	Area associations × risk/experience categories	Nominal variable
Spearman Correlation	Inter-indices, indices vs WTP	Ordinal data, abnormal distribution
Cronbach's Alpha	Internal reliability of 3 composite indexes	n is adequate (41-53), but the items per index are few (2-4) so α tend to be structurally low — reported as they are
OLS Regression	Determinants of WTP (Rupiah)	n=41 after *listwise deletion*; results marked exploratory, abnormal residual (Jarque-Bera p<0.001)—reported with explicit methodological caveats
KMO/Bartlett, EFA, SEM-PLS	Not done	The number of grains per construct (2-4) is too small for a meaningful EFA; n borderline for multi-construct SEM-PLS

The index formula used is consistent throughout the report:

```
TrustIndex = mean(C1_kenal, C3_puas, C4_percaya, C6_TJSL)  [skala 0-100 per butir]

FeasibilityIndex = mean(D2_interest, D3_kesediaan_bersyarat)  [skala 0-100 per butir]

SocialAcceptanceIndex = mean(E1_khawatir, E3_percaya_tradisional_rev,
                E4_hambatan_budaya_rev, E6_kolektif)
```

Equal *weighting* between items in a single index was chosen because there was no documented *expert-judgement* justification for different weights; this was explicitly stated as a methodological limitation, not concealed.

RESULTS AND DISCUSSION

Demographic and Agroclimatic Profile

Table 4. Demographic and Agroclimatic Characteristics of Respondents by Region

Features	Indramayu (n=28)	East Lombok (n=32)
Average age	≈48 years old	≈48 years (48.2 years combined, n valid=56)
Education is dominant	High School/Equivalent (12), Elementary (5)	High School/Equivalent (11), Diploma/Bachelor (9)
Dominant land area	0.5-1 ha (10), 1-2 ha (9)	0.5-1 ha (9), >2 ha (6), <0.5 ha (7)
Dominant respondent status	Chairman of Farmer Group/Gapoktan, Farmer Owner	Mixture, including 5 PPL
Dominant types of climate risk	Flood (17/28 = 61%)	Drought (15/32 = 47%), Excess rainfall (12/32 = 38%)
Crop failure "never"	12/28 (43%)	2/32 (6%)
An Introduction to the Concept of Self-Discovery ("Self-Discovery")	16/28 (57%)	2/32 (6%)

Types of Climate Risks by Region

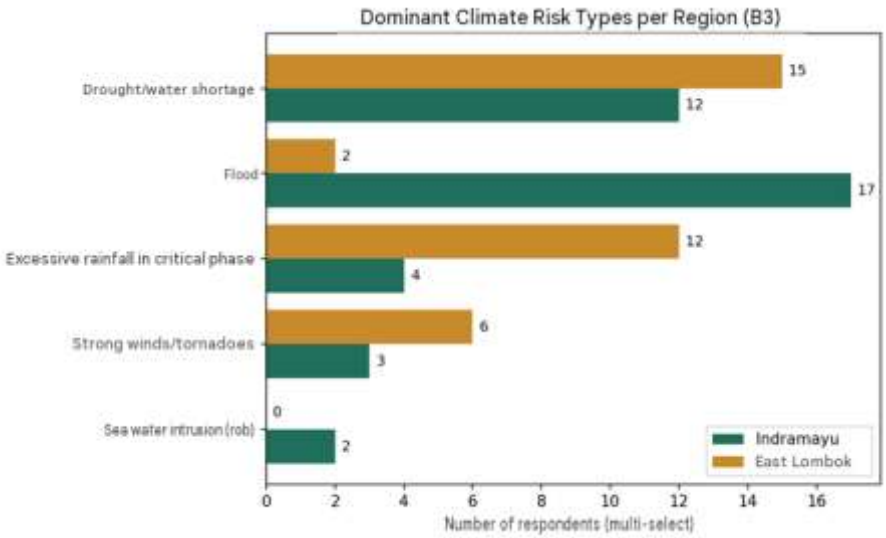

Figure 1. Dominant types of climate risk per region (variable B3, multi-select)

The graph above directly confirms that it is no longer a hypothesis as in the Preliminary Report that Indramayu is a flood/inundation risk area while East Lombok is an

area at risk of drought and excessive rainfall in the critical phase of growth. This difference is the key to the interpretation of the entire next chapter, especially the design of the trigger index in Chapter V.

Frequency of Crop Failure

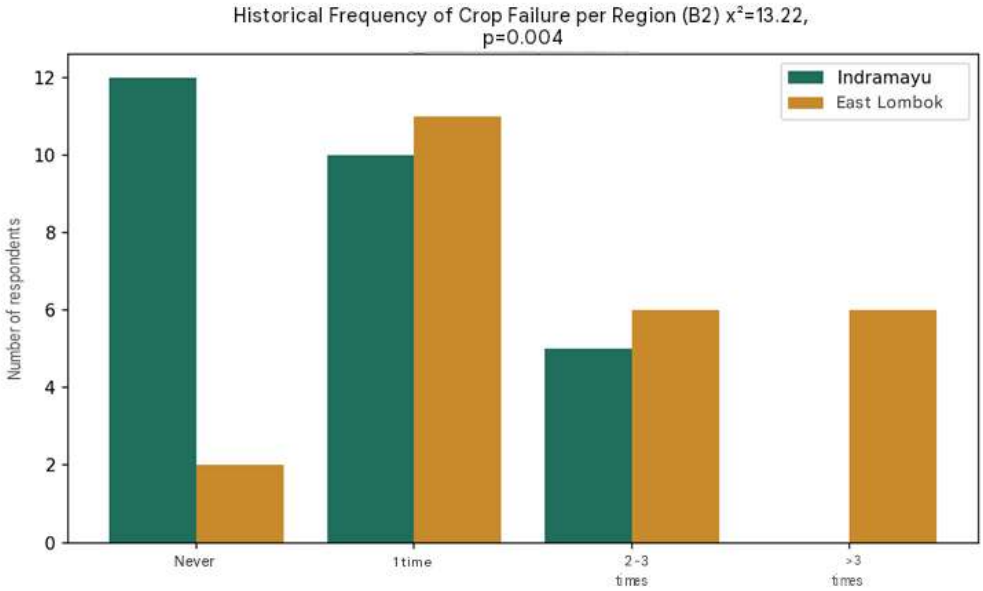

Figure 2. Historical frequency of crop failure per region (variable B2). Chi-square test: χ^2=13.22, p=0.004 (significant)

East Lombok showed a much higher exposure to production risks than Indramayu: only 6% of East Lombok respondents stated that they had never experienced crop failure, compared to 43% in Indramayu. This difference was statistically significant (p=0.004).

Previous Insurance Experience

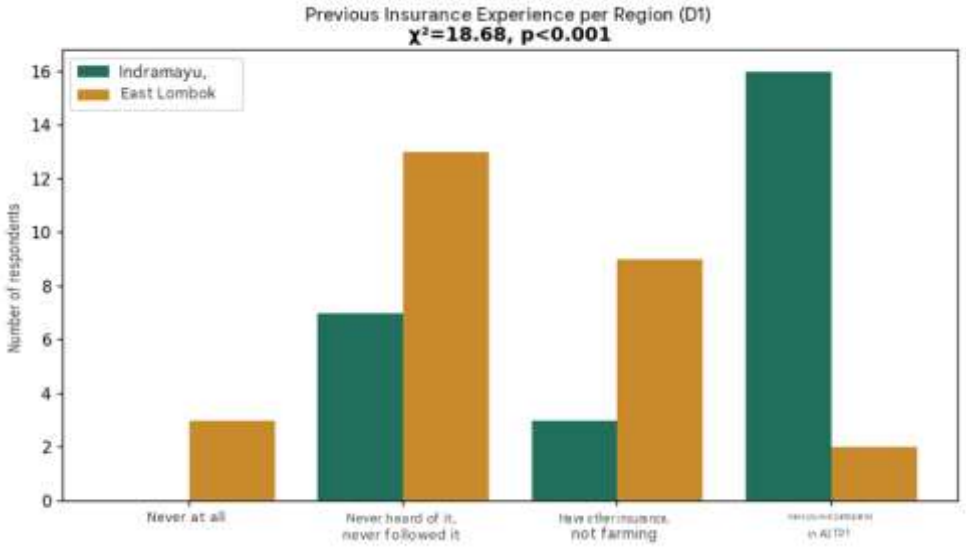

Figure 3. Previous agricultural insurance experience per region (variable D1). Chi-square test: χ^2=18.68, p<0.001 (very significant)

The gap in insurance literacy between regions is very sharp: 57% of Indramayu respondents have participated in Rice Farmers Business Insurance (AUTP), compared to only 6% in East Lombok. This fact is one of the main explanations for why the Trust Index and the level of institutional readiness are relatively more mature in Indramayu (see Chapter VI), and have direct implications for educational strategies that must differ from region to region.

Analisis Willingness to Pay (CVM)

Level WTP

Table 5. Comparison of Farmers' Willingness to Pay for Parametric Insurance by Region

Statistics	Indramayu	East Lombok	Combinations
n valid	26	27	53
Red (Rp/ha/season)	72.596	45.833	58.962
Median (Rp/ha/season)	37.500	37.500	37.500
Std. Deviation	67.270	67.671	—

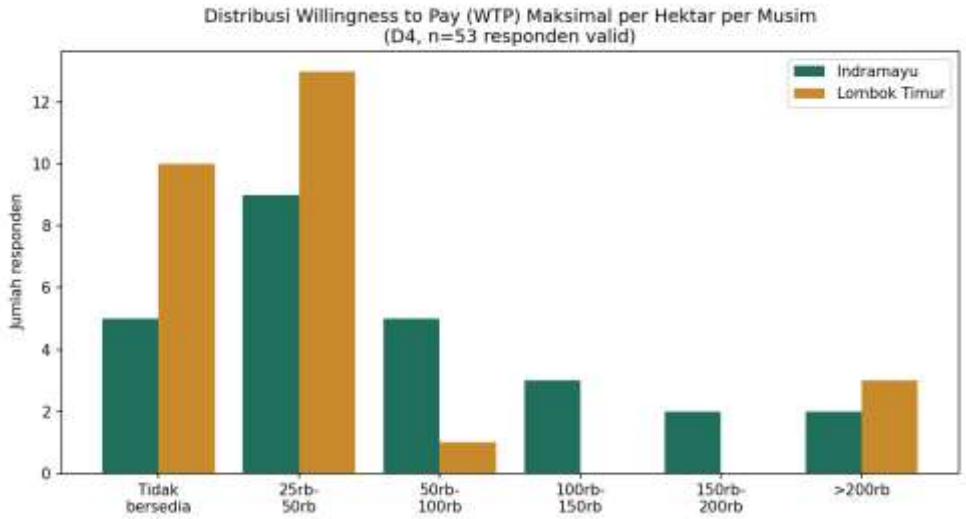

Figure 6. Maximum WTP distribution per hectare per season (variable D4), per region

The distribution was very *right-skewed* (some respondents with high WTP pulled the average upwards; the median was much more representative of the median of the population). *The Mann-Whitney test* on the average showed a difference (p=0.039), but *the median* was identical in both regions so the conclusion "Indramayu WTP is higher" must be read carefully: true for the average (driven by a small percentage of respondents with high WTP in Indramayu), but typical farmers (median) in both regions are willing to pay the same amount.

WTP vs Actuarial Premium

Referring to Chapter 11 of the Preliminary Report (Tier 1 parametric premium, land of 0.25 ha = Rp152,000/ha/season, to Tier 4 = Rp608,000/ha/season):

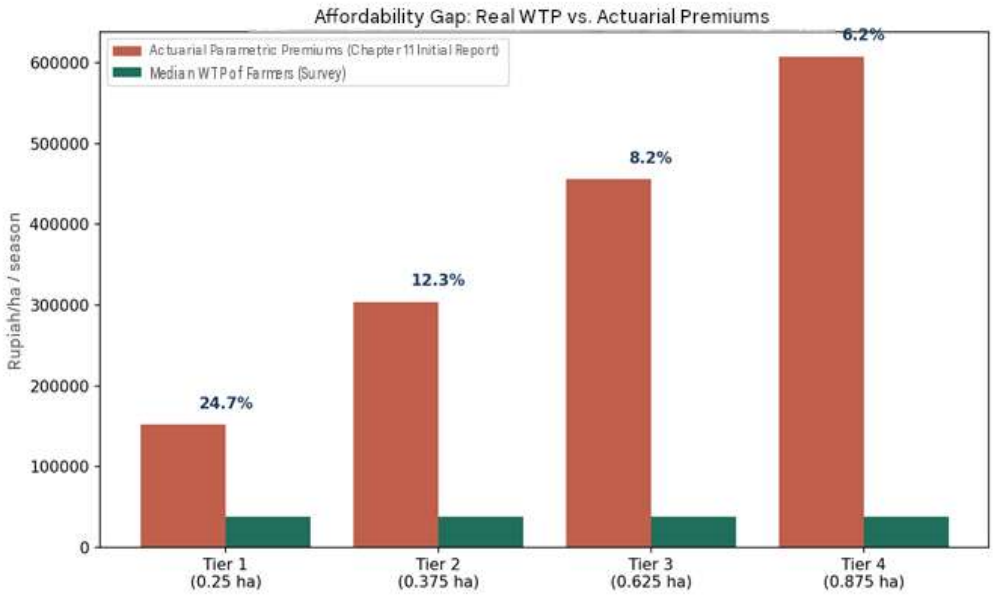

Figure 7. Affordability gap: median farmer WTP vs actuarial premium per land tier

Table 6. Comparison of Actuarial Premiums and Median Willingness to Pay by Land Tier

Tier Lahan	Parametrik Premiums (Rp/ha)	Median WTP (Rp/ha)	Rasio WTP/Awards
Tier 1 (0,25 ha)	152.000	37.500	24,7%
Tier 2 (0,375 ha)	304.000	37.500	12,3%
Tier 3 (0,625 ha)	456.000	37.500	8,2%
Tier 4 (0,875 ha)	608.000	37.500	6,2%

Finding: The *affordability gap* is enormous across all tiers—the median WTP only covers 6-25% of the actuarial premiums calculated in the Preliminary Report.
Interpretation: subsidies are required at least 75-94% to get close to the willingness to pay farmers' real wages.
Product implication: large subsidy schemes are not worth launching.
Institutional implication: BULOG needs financing partners (local/central governments) to close this gap, rather than relying on premium deductions from the offtake value alone.

Determine WTP (Regresi OLS, n=41)

Model: WTP (Rupiah) ~ *Trust Index* + *Social Acceptance Index* + Age + Land Area + Education + Region.

Table 7. OLS Regression Results for Determinants of Farmers' Willingness to Pay

Predictor	Coeficin	p-value	Interpretasi
Konstanta	58.970	0,458	—
Trust Index	-358	0,414	Insignificant
Social Acceptance Index	+661	0,165	Insignificant, positive direction (reasonable)
Age	-345	0,743	Insignificant
Land area (ha)	-22.190	0,068	Marginal — larger land tends to lower WTP/ha
Education	+15.930	0,139	Insignificant, positive direction
Region (East Lombok)	-39.600	0,024	Significant — WTP in East Lombok ~Rp39,600/ha lower than Indramayu, ceteris paribus

The overall model was insignificant (F-test $p=0.105$; $R^2=0.25$, Adj-$R^2=0.12$) and residual was not normally distributed (Jarque-Bera $p<0.001$) due to skewness of the WTP and small n data.

FACT: region is the only significant predictor in this model. INFERENCE: trust and literacy may contribute but are not detected significantly at n=41, most likely due to underpowered samples, not evidence of the absence of a relationship. HYPOTHESIS for follow-up testing with a larger sample: WTP determinants are more influenced by region-structural factors (local grain prices, access to credit, actual loss history in Rupiah) than individual attitudes as measured by current composite indices.

Payment Preference and Important Factors

The most preferred payment scheme: early season cash payment (17/50 valid = 34%), deducted from the proceeds of grain sales to BULOG (9/50 = 18%), paid via farmer group (10/50 = 20%). The most important factors for farmers: quick and easy claim process (13 respondents) and affordable premiums (12 respondents) exceed the "amount of compensation" (5 respondents), indicating that speed and simplicity of the process are more important than the amount of payout for the majority of farmers finding relevant to the operational design of index-based automated claims.

Premium Scenario Matrix

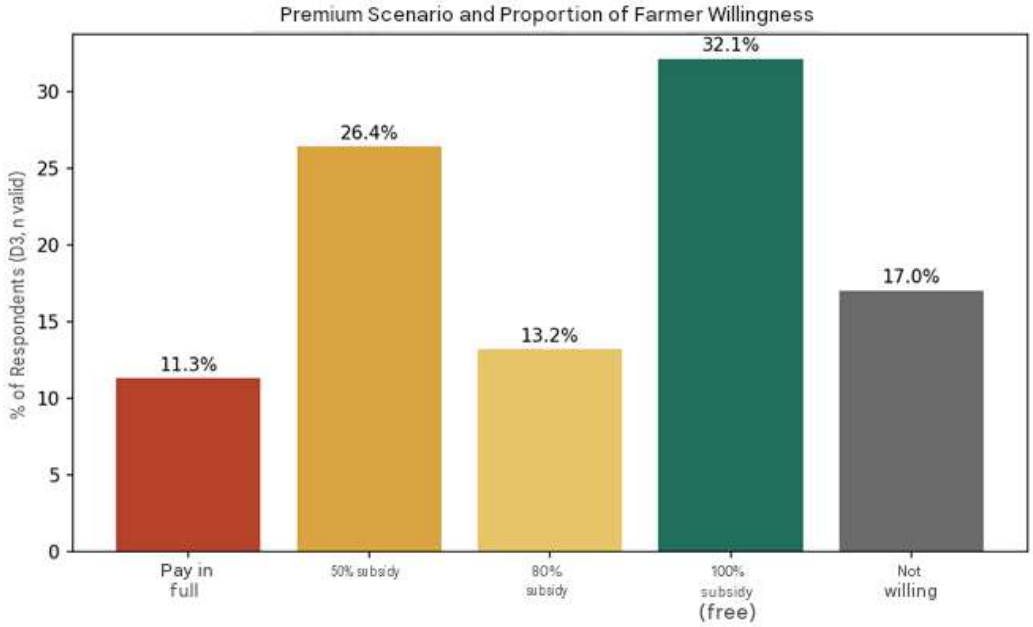

Figure 8. Premium scenario and proportion of farmers' willingness (indicative, based on item D3)

Table 8. Premium Subsidy Scenarios and Farmers' Willingness to Participate

Skenario	Award (Subsidy)	% of Respondents Willing (D3)	Segmen Target	Subsidy Needs
Full price	Pay in full	11,3%	*High-trust*, large land	0%
50% subsidy	≈ IDR 200,000	26,4%	*Medium-high* trust	50%
80% subsidy	≈ IDR 80,000	13,2%	Medium majority	80%
100% subsidy	Free	32,1%	*Risk-exposed, low-feasibility*	100%
Unprepared	—	17,0%	Need education/redesign before being offered a price	—

Note: this figure is based on stated preference, not actual purchasing behavior consistent with the inherent limitations of the CVM method that must be stated (potential hypothetical bias).

Institutional Linkage (Victor NEE)
Level Micro

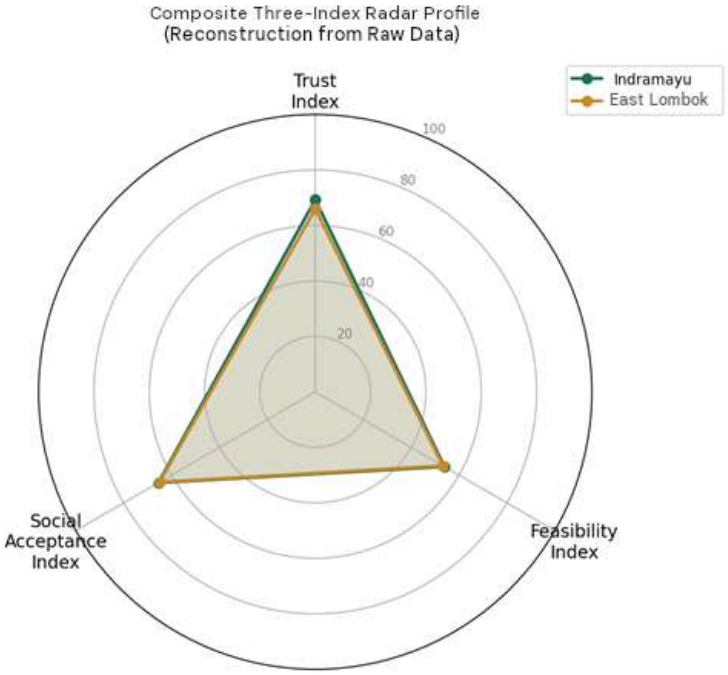

Figure 9. Radar profile of three composite indexes of raw data reconstruction, per region of the Trust Index reconstruction

Indramayu 69.3 vs East Lombok 65.9 (scale 0-100; median 73.0 vs 66.7), did not differ statistically significantly (Mann-Whitney p=0.47) although the previous dashboard implied a sharper difference. Conclusion: moderate-high institutional trust capital is available in both regions, not only in Indramayu.

The correlation *of the Trust Index* with the *Feasibility Index* was positive (Spearman r=0.32, p=0.021, n=52) higher confidence was associated with higher interest/willingness to pay conditionally, although it did not correlate with the level of WTP in Rupiah (r=0.00, p=0.98). This means that trust drives interest, but not the real financial ability to pay higher premiums.

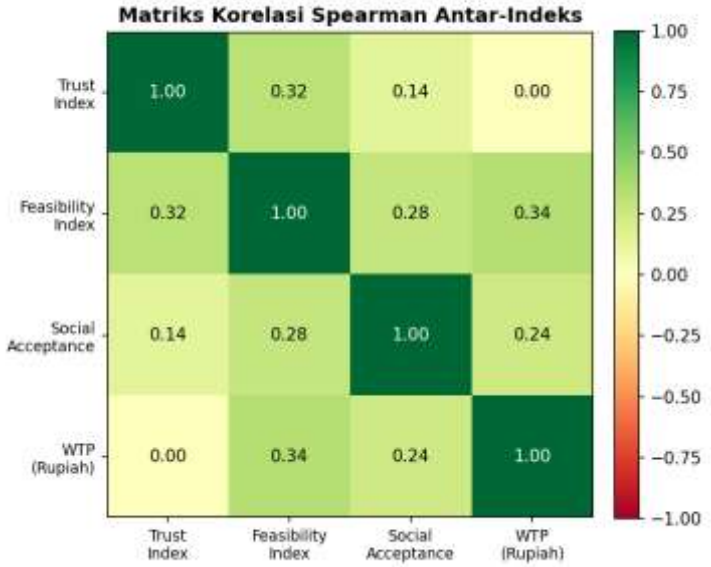

Figure 10. Spearman correlation matrix between composite index and WTP

Level Meso

The structure of farmer groups is strong in both regions: 37 out of 52 valid respondents (71%) stated that they are "very active" in a solid meso farmer group/social capital gapoktan for product distribution channels. However, BULOG's TJSL program is only known-and-never-followed by a minority (10/52 = 19%; majority state "know but have never participated" or "have heard but are not clear") a *communication/participation* gap at the meso level.

Level Macro

According to the Initial Report: the regulation of food SOE-based parametric insurance does not yet have its own legal framework (*stand-alone*) — it is still under Law No. 40/2014 on Insurance supervised by the Financial Services Authority (OJK); the parameters of Rice Farmer Business Insurance (AUTP) are determined by the Ministry of Agriculture and the Ministry of Finance. *This governance gap* has not changed at this stage of the report because there is no new data related to regulations.

CONCLUSION

The analysis of primary data confirmed distinct regional climate risk profiles, with flooding representing the predominant threat in Indramayu and drought posing a greater risk in East Lombok. Institutional trust in Perum BULOG was relatively favorable and showed no statistically significant difference between the two regions, indicating that both locations possessed a foundation of institutional trust that could support program implementation (Chaulagain et al., 2026; Adelesi et al., 2026). However, the primary barrier to adopting parametric insurance was financial affordability rather than institutional trust or social acceptance, as farmers' willingness to pay (WTP) covered only 6–25% of the estimated actuarially determined premiums (Yu et al., 2026; Kalthof et al., 2026). This challenge was

particularly pronounced in East Lombok, where higher climate risk exposure was accompanied by lower insurance literacy, highlighting the importance of providing insurance education before introducing insurance products. Methodologically, the questionnaire's composite indices demonstrated low to moderate internal consistency, indicating the need for further instrument refinement through additional measurement items and clearer differentiation between overlapping constructs, particularly social acceptance. Furthermore, the unavailability of agricultural extension officer (Penyuluh Pertanian Lapangan [PPL]) data, observations from Jambi and Bali, and farm-level climate and production data limited the national generalizability of the findings and prevented a robust quantitative assessment of basis risk.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest, either financial or non-financial, that could influence the conduct of the research, data analysis, interpretation of results, or the preparation and publication of this article.

AUTHOR CONTRIBUTIONS

The first author contributed to data processing and analysis as well as interpretation of the research results. The second author contributed to the drafting, writing, and editing of the journal manuscript. The third author contributed to data collection, coordination of field research activities, and provision of research data. All authors contributed to the discussion of the research results, reviewed and revised the manuscript, and approved the final version of the article for publication.

GENERATIVE AI STATEMENT

In the process of preparing this manuscript, the author uses the help of Artificial Intelligence (AI) on a limited basis, which is solely for the purpose of grammar examination and language refinement. AI is not used in the process of data collection, substantive analysis, or drawing research conclusions.

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