ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26oct1095

Beyond Rainfall: A Conceptual Framework for Multi-Hazard Weather-Based Insurance Adoption Among Small-Scale Tobacco Farmers in Zimbabwe

Takawira Chirume[1]; Dr. Tapiwa Joel Furusa[2]

[1]Durban University of Technology, South Africa
[2](PhD); Binary University

Publication Date: 2026/10/28

Abstract: Smallholder tobacco farmers in Mashonaland West Province, Zimbabwe, face increasing exposure to multi-hazard climate catastrophes, including drought, excessive rainfall, hail, and windstorms. Although weather-based crop insurance is promoted as a climate risk-financing tool, most products rely on single rainfall indices that poorly capture localized perils, creating basis risk and low renewal rates. This conceptual paper develops an integrated adoption framework that moves beyond rainfall. Combining Protection Motivation Theory [PMT] and Diffusion of Innovations Theory [DOI], the paper explains adoption intention as a function of threat appraisal, coping appraisal, innovation attributes, affordability, and institutional trust. To bridge the gap between adoption and actual resilience, the paper proposes the original Climate Catastrophe Agricultural Insurance and Resilience [CCAIR] Model with six pillars: Catastrophe intelligence, Contract matching, Affordable financing, Information integrity, Rapid recovery, and Resilience learning. The model specifies hazard-specific product design, inclusive premium financing, and measurable post-event recovery outcomes. A sequential mixed-methods validation protocol is outlined for Mashonaland West, comprising documentary review, farmer surveys, key informant interviews, and historical index-loss back-testing. The paper does not report primary data; all relationships are propositional and await empirical testing.

Keywords: *Weather-Index Insurance; Multi-Hazard; Basis Risk; Protection Motivation Theory; Diffusion of Innovations; CCAIR Model; Smallholder Tobacco; Zimbabwe.*

How to Cite: Takawira Chirume; Dr. Tapiwa Joel Furusa (2026) Beyond Rainfall: A Conceptual Framework for Multi-Hazard Weather-Based Insurance Adoption Among Small-Scale Tobacco Farmers in Zimbabwe. *International Journal of Innovative Science and Research Technology*, 11(10), 2032-2036. https://doi.org/10.38124/ijisrt/26oct1095

I. INTRODUCTION

Tobacco is a cornerstone of Zimbabwe's agricultural economy, and Mashonaland West - comprising Hurungwe, Makonde, Zvimba, and Karoi districts - accounts for the largest share of smallholder tobacco production. Smallholder production is predominantly rain-fed and vulnerable to climate variability. The 2023/24 El Niño-induced drought and recurrent localized hailstorms demonstrated how covariate and idiosyncratic events undermine yields, leaf quality, income stability, and loan repayment capacity. Traditional indemnity crop insurance requires individual loss verification, which is costly for geographically dispersed farms. Parametric, weather-index insurance offers an alternative, with payouts triggered by independently measured weather indicators rather than field assessments. Its advantages include lower administrative costs, faster settlement, and reduced moral hazard. Its central weakness is basis risk - the imperfect correlation between an index trigger and actual farm loss (Morsink, Clarke & Mapfumo, 2016; World Bank, 2025).

Zimbabwe's institutional architecture for index insurance is taking shape. The Insurance and Pensions Commission [IPEC] reported ongoing work on agricultural index insurance frameworks, while the Insurance Council of Zimbabwe [ICZ] announced the formation of an agro-insurance pool and a planned pilot for the 2023/24 season. These developments signal regulatory intent; they do not confirm that affordable, multi-peril cover is currently accessible to smallholder tobacco farmers (IPEC, 2023; Insurance Council of Zimbabwe, 2025).

The core problem is both conceptual and practical: increasing insurance enrollment without ensuring that contracts align with dominant local hazards, that triggers are transparent, and that payouts support recovery, risks creating nominal insurance with limited resilience value. This paper

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therefore moves beyond a rainfall-only conception of risk to develop a multi-hazard adoption framework.

A. Problem Statement

Smallholder tobacco farmers in Zimbabwe experience multi-peril exposure but have limited access to credible hazard intelligence, affordable formal insurance and clear product information. Even when insurance is offered, premiums that exceed willingness to pay or contracts that exclude hail or wind leave farmers exposed. Furthermore, single-index products may generate false negatives - severe farm loss without payout - and false positives - payout without loss - undermining trust and renewal.

Three specific research gaps are addressed: First, behavioral studies of insurance demand in Zimbabwe have been small-scale and qualitative, limiting the ability to estimate provincial adoption rates. Second, international studies highlight that basis risk, affordability, and delivery costs constrain index insurance demand (Smith, 2016; World Bank, 2025), yet these insights have not been integrated into a tobacco-specific, multi-hazard model. Third, no existing framework in Zimbabwe links catastrophe exposure, adoption psychology, hazard-specific underwriting, financing architecture, and post-disaster livelihood recovery in smallholder tobacco systems (Maireva, 2023).

B. Objectives, Questions and Propositions

➢ *General Objective:*

To develop and specify a conceptual framework for assessing the determinants of adoption and proposed effectiveness of multi-hazard weather-based crop insurance among smallholder tobacco farmers in Zimbabwe.

➢ *Specific Objectives:*

- To determine the principal perceived climate catastrophes and associated crop, income and debt exposures in Mashonaland West.
- To evaluate farmers' awareness, risk perceptions, trust, willingness to pay and adoption intention.
- To assess the suitability of single-index, multi-index and hybrid products for different perils.
- To develop the CCAIR Model linking adoption, payout reliability and agricultural financial resilience.
- To identify institutional, regulatory and financing conditions for an equitable pilot.

➢ *Research Questions (RQ):*

- RQ1: Which catastrophic risks most affect production and income security?
- RQ2: How do PMT constructs and DOI attributes influence adoption intention?
- RQ3: How well do proposed weather indicators predict documented farm losses?
- RQ4: Which partnerships and premium-support options produce a viable and fair pilot?

➢ *Testable Propositions (P):*

- P1: Higher perceived threat is positively associated with adoption intention where response efficacy is high.
- P2: Premium affordability and institutional trust strengthen adoption intention.
- P3: Transparent triggers and higher index-loss correlation reduce perceived basis risk and improve renewal intention.
- P4: Timely and adequate payouts are positively associated with liquidity preservation and replanting capacity.
- P5: Targeted subsidies or blended finance moderate the relationship between vulnerability and adoption.

II. LITERATURE SYNTHESIS AND CRITICAL EMPIRICAL EVIDENCE

Maireva (2023) used phenomenological interviews with 13 purposively selected smallholder tobacco farmers across Mashonaland provinces. The study revealed that risk experience and coping behaviour shaped perceptions of microinsurance. While valuable for depth, the sample cannot estimate uptake rates.

Morsink, Clarke and Mapfumo (2016) provide the critical actuarial insight for this paper: index contracts can diverge substantially from individual losses. They advocate directly measuring basis risk through historical comparisons of triggers and outcomes. Smith (2016) argues that without subsidy and efficient delivery, commercial index insurance may remain unattractive to smallholders due to basis risk and competing coping strategies. Recent IPEC and ICZ reports confirm market-building activity in Zimbabwe but should not be interpreted as evidence of established coverage. The synthesis indicates that a framework for tobacco must be multi-hazard, behaviorally grounded and performance-monitored, not merely sales-oriented.

The empirical evidence therefore justifies evaluating a tailored product, rather than treating insurance as a proven panacea.

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Table 1 Emperical Evidence and Implications

Evidence source	Setting and approach	Finding relevant to this study	Limitation or design implication
Maireva (2023)	Zimbabwe Mashonaland tobacco farmers; qualitative interviews, n=13	Perceptions of microinsurance are shaped by risk experience and coping responses	Do not infer provincial adoption prevalence from a small purposive sample
Morsink, Clarke & Mapfumo (2016)	International index-insurance methodological analysis	Payout triggers can diverge from actual individual losses	Back-test index-loss matching; provide basis-risk safeguards
Smith (2016)	Review of smallholder insurance options	Demand and affordability constrained by delivery costs and imperfect coverage	Evaluate premium support and group distribution
IPEC (2023)	Zimbabwe regulatory annual report	Documents institutional work toward agricultural index insurance	Confirm contemporary market products and legal status before pilot
Insurance Council of Zimbabwe (2025)	Industry account of index-insurance development	Describes an agro-insurance pool and plans for a pilot	Do not equate pilot plans with verified national coverage
World Bank (2025)	International evidence discussion	Identifies benefits and challenges of index products	Measure coverage reliability, not simply policy sales

➢ *Theoretical Foundations*

- *Protection Motivation Theory [PMT]*

PMT (Rogers, 1975; Maddux & Rogers, 1983) posits that protection motivation results from threat appraisal (perceived severity and susceptibility) and coping appraisal (response efficacy, self-efficacy and response costs). A tobacco farmer may perceive drought as severe yet decline insurance if response efficacy is low – that is, if payouts are seen as unreliable - or response costs are high.

- *Diffusion of Innovations Theory (DOI)*

DOI explains uptake through five perceived attributes: relative advantage, compatibility, complexity, trialability and observability. In weather-based insurance, clear contract language, mobile payouts, farmer group endorsements and demonstration of payouts in both payout and non-payout years support diffusion (Rogers, 2003). The theory adds a product-design and social-learning dimension not fully specified in PMT.

- *Integrated Theoretical Logic*

This paper integrates PMT and DOI and adds a third pathway: Contract Performance. Adoption intention is necessary but insufficient. Contract performance (hazard-index fit, trigger transparency, and settlement speed) mediates the relationship between adoption and financial resilience. Moderators include affordability, household vulnerability, gender, geography, and contractor arrangements. Feedback loops are explicit: claim experience influences trust and renewal.

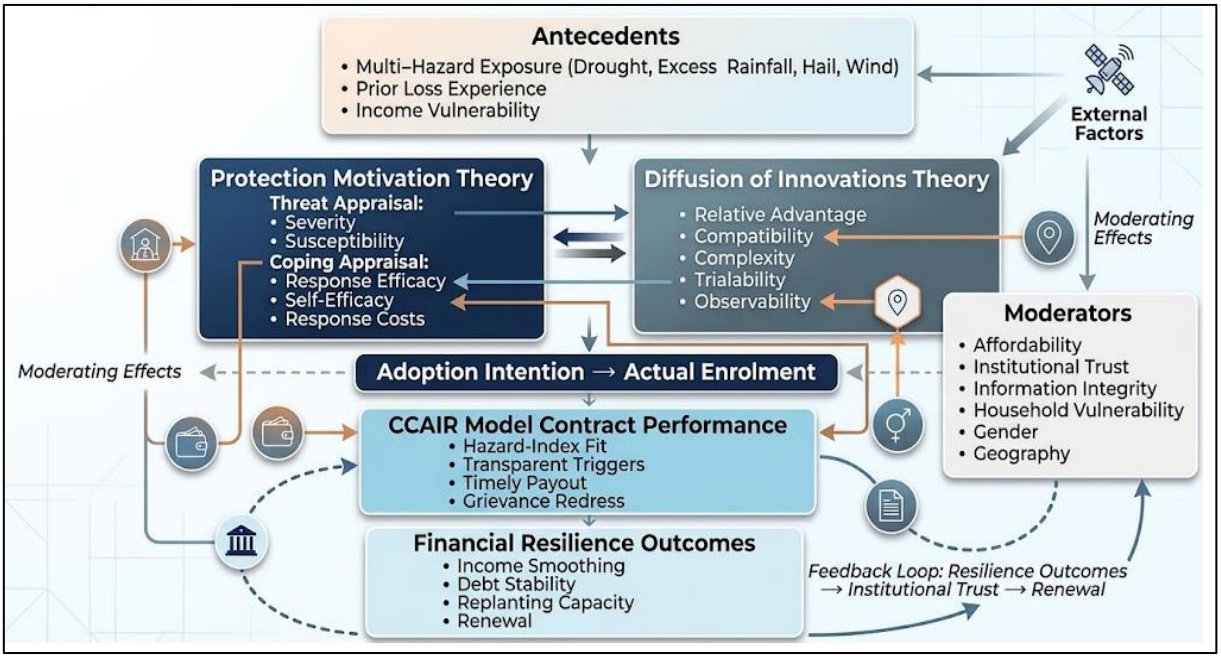


Fig 1 Multi-Hazard Weather-Based Insurance Adoption Framework
Source: Author's Synthesis (2026)

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26oct1095

The framework distinguishes adoption intention from contract performance and resilience.

- *Proposed Climate Catastrophe Agricultural Insurance and Resilience (CCAIR) Model*

The CCAIR Model is an original proposal in this paper, not an existing tested scheme. It is designed around six sequential but mutually reinforcing functions. First, household and farm registration should capture location, insured area, planting dates, basic production history, relevant vulnerability characteristics and existing contract arrangements, with informed consent and data safeguards. Second, multi-hazard intelligence should combine reliable weather-station records, remotely sensed measures, crop calendars and independently verified event reports. Third, policies should match the peril: drought and excessive rainfall may suit objective rainfall or soil-moisture indices; broad-area wind events may suit independently validated wind thresholds; isolated hail events may need radar-derived hail indicators plus an area-based or rapid-loss-assessment endorsement.

Fourth, premiums should be structured using actuarial expected losses, administrative costs, reinsurance and transparent distribution charges, with targeted subsidies considered for the most vulnerable. Fifth, payouts must be made promptly when validated triggers occur; a defined correction or appeal mechanism is needed when severe crop loss occurs without a trigger. Sixth, farmer recovery should be measured beyond payment itself, including debt arrears, access to inputs, ability to replant and continuity in the next season. Funding of the scheme may involve insurers, reinsurers, aggregators, farmer associations and public climate-risk instruments, subject to statutory and prudential requirements.

Table 2 CCAIRR Model

CCAIR pillar	Operational mechanism	Accountable actors	Performance indicator
C — Catastrophe mapping	Geo-tagged, crop-stage-specific exposure profiling	Meteorological services; agronomists; farmers	Verified hazard and loss dataset completeness
C — Contract matching	Peril-specific parametric cover plus hybrid loss endorsement	Insurers; actuaries; regulator	Index-loss correlation; false-negative trigger rate
A — Affordable financing	Tiered premiums; transparent subsidy; group enrolment	Insurers; contractors; financiers; public sector	Premium-to-expected-income ratio; inclusion rate
I — Information integrity	Independent weather data and public trigger rules	Data providers; independent auditors	Data availability; trigger disputes
R — Rapid recovery	Timely mobile/bank payout and grievance process	Insurers; payment providers; farmer associations	Time to settlement; payout adequacy
R — Resilience learning	Season-end back-testing and redesign	Researchers; regulator; farmer organisations	Renewal, next-season planting and debt outcomes

A practical pilot could offer three layers: (i) affordable core cover for widespread drought and excess rainfall through prespecified indices; (ii) optional catastrophe endorsements for severe wind, hail or flooding where scientifically credible triggers or independent assessment can be supported; and (iii) exceptional-loss review for clearly documented losses not reflected in the relevant index. Not every peril should automatically be labelled weather-index insurable. Disease, fire and post-harvest storage losses require separate product definitions and may fall outside weather-triggered contracts.

An illustrative drought-trigger formula is $P = S \times \min[1, \max(0, (T - R)/(T - E))]$, where P is the payout, S the sum insured, R the observed rainfall measure, T the entry threshold and E the exhaustion threshold, with T greater than E. This illustration assumes an index where lower rainfall represents more severe drought. Thresholds, measurement windows and insured sums are not estimated here; they must be calibrated to observed tobacco crop stages and loss records. Excess-rainfall cover would require a separate direction of trigger. Where highly localised hail has weak correlation with available weather indicators, an indemnity or hybrid assessment remains more defensible.

A pilot must pre-register policy terms: insured event definitions, exclusions, trigger data owner, observation periods, premiums, coverage limits, settlement currency, dispute handling, data access and payout schedule. Independent back-testing should report false positives, false negatives, average shortfalls and farmer-level distributional impacts, rather than presenting a single headline payout percentage.

III. METHODOLOGY FOR EMPIRICAL VALIDATION

A pragmatic sequential mixed-methods design is proposed.

- Phase 1 Documentary: Review of IPEC regulations, ICZ pool design, tobacco contract farming agreements, 10-year climate records, TIMB yield data.
- Phase 2 Quantitative Survey: Population: registered smallholder tobacco farmers in Hurungwe, Makonde, Zvimba. Sampling will be stratified multistage. The sample size will be calculated from verified sampling frame [anticipated 350-400]. The instruments to be used are the PMT scale, DOI scale, insurance literacy, trust, willingness-to-pay discrete choice experiment. Analysis will involve the use of Confirmatory Factor Analysis (CFA) and Structural Equation Modelling (SEM) for theory-derived constructs. Back-testing will involve comparing candidate indices against farm loss records.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26oct1095

- Phase 3 Qualitative: There will be 15-20 key informant interviews with IPEC, ICZ, insurers, reinsurers, MSD, Agritex, ZITSA, tobacco contractors. Thematic analysis with triangulation. Ethical safeguards will involve voluntary enrolment, informed consent in Shona/English, separation of insurance from input debt, transparent premium deduction disclosure, data privacy for geolocation, an independent grievance mechanism, and avoidance of promising full compensation. We will seek approval from local authorities.

IV. POLICY AND PRACTICAL IMPLICATIONS

- For regulator: Mandate plain-language disclosure of triggers, exclusions, basis risk and claims process. The regulator must further require annual publication of index performance.
- For insurers: Invest in multi-peril actuarial capacity, reinsurance for catastrophe accumulation, and low-cost mobile distribution.
- For farmer organizations: Emphasize peer demonstration and literacy.
- For contractors/lenders: Prohibit automatic set-off of insurance payouts against input debt without explicit farmer consent.

The success criteria for pilot must go beyond policies sold to include fairness of coverage, trigger reliability, complaint rates, speed of settlement and subsequent recovery.

V. CONCLUSION

Weather-based insurance can be a component of climate risk financing for smallholder tobacco farmers, but only if it moves beyond rainfall. Its viability depends on hazard-specific design, affordability, data credibility and institutional trust. The CCAIR Model provides a testable, operational framework that distinguishes adoption from effective protection. Future research must validate constructs, quantify basis risk for each peril in Mashonaland West, and test whether insurance materially improves recovery compared to alternative adaptation strategies.

- Research setting: Mashonaland West Province, Zimbabwe.

- Manuscript type: Conceptual synthesis and empirical research protocol.

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