

FACTORS INFLUENCING ADAPTATION PRACTICES AMONG SMALLHOLDER FARMERS IN MULTI-HAZARD REGIONS: EVIDENCE FROM BALI, INDONESIA



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BACKGROUND

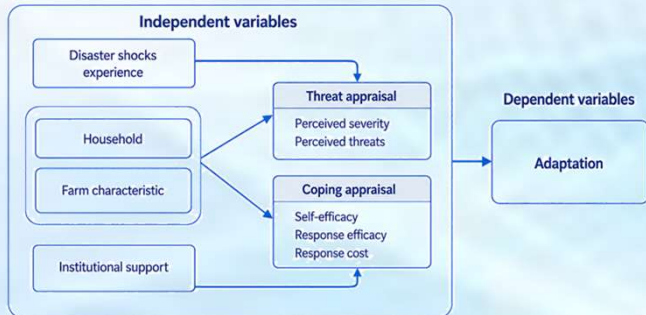
Smallholder farmers increasingly experience multiple and recurrent hazards, but adaptation research often examines single hazards or treats adaptation as a binary adopt/non-adopt decision (UNDRR & ISC, 2025; White et al., 2025). Farmers' responses are heterogeneous: different combinations of practices may reflect distinct adaptation pathways rather than simply different levels of adoption (Bartkowski et al., 2022; Han & Niles, 2023). Protection Motivation Theory (PMT) proposes that protective behaviour is shaped by threat appraisal and coping appraisal; however, high perceived risk alone does not necessarily result in protective action (Rogers, 1975; Grothmann & Patt, 2005; Bubeck et al., 2012). Bali provides a relevant multi-hazard setting where hydrometeorological and geophysical hazards intersect with smallholder agriculture and locally embedded resource-management systems. Risk perception may motivate protective behaviour, but actual responses also depend on capacity, resources and feasibility (Rogers, 1975; Grothmann & Patt, 2005; Bubeck et al., 2012).

OBJECTIVES

Objective: Identify farmers' adaptation pathways under multi-hazard exposure and examine factors associated with pathway membership.

RQ1. What distinct combinations of adaptation practices are used by farming households?

RQ2. How are household resources, farm characteristics, multi-hazard experience, institutional access and PMT-related appraisals associated with the pathways?



Sources: Rogers (1975); Floyd et al. (2000); Grothmann & Patt (2005).

METHODOLOGY

Study area: Jembrana, Buleleng and Karangasem, Bali, Indonesia

Data: 367 farming households, surveyed June–August 2025

Sampling: Multi-stage site selection followed by household-level snowball sampling

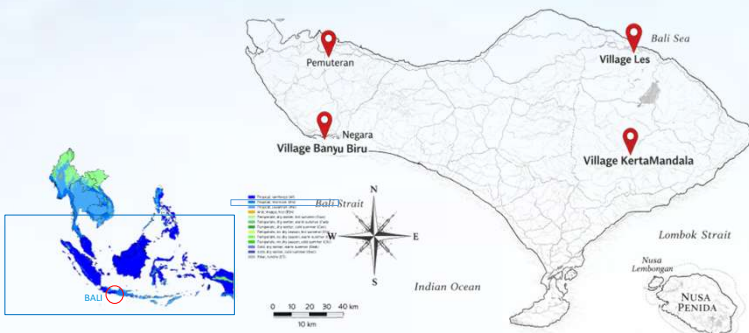


Figure 1. Map of Bali

STEP 1 — LATENT CLASS ANALYSIS

R / polCA; 1–10 class solutions compared. A three-class model was selected using minimum BIC.

STEP 2 — MULTINOMIAL LOGIT REGRESSION

Reference: Non-adopters. Predictors covered household and farm characteristics, hazard exposure, institutional access and PMT appraisals.

VIF = 1.09–1.55. Robustness was checked with average marginal effects and binary logit models.

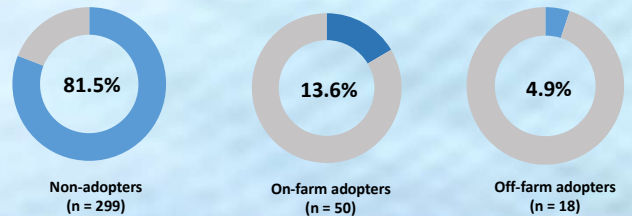
ACKNOWLEDGEMENTS

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SELECTED REFERENCES: Bartkowski, B., Schüller, C., & Müller, B. (2022). Typologies of European farmers: approaches, methods and research gaps. *Regional Environmental Change*, 22. Bubeck, P., Botzen, W.J.W., & Aerts, J.C.J.H. (2012). A review of risk perceptions and other factors that influence flood mitigation behavior. *Risk Analysis*, 32(9), 1481–1495. Grothmann, T., & Patt, A. (2005). Adaptive capacity and human cognition: the process of individual adaptation to climate change. *Global Environmental Change*. Han, G., & Niles, M.T. (2023). An adoption spectrum for sustainable agriculture practices: a new framework applied to cover crop adoption. *Agricultural Systems*, 212, 103771. Rogers, R.W. (1975). A Protection Motivation Theory of Fear Appeals and Attitude Change. *The Journal of Psychology*, 91(1), 93–114. UNDRR. (2015). Sendai Framework for Disaster Risk Reduction 2015–2030. United Nations Office for Disaster Risk Reduction. UNDRR & ISC. (2025). Hazard Definition and Classification Review: Technical Report. White, C.J. et al. (2025). Towards multi-hazard and multi-risk indicators: a review and recommendations for development and implementation. *Natural Hazards and Earth System Sciences*, 25, 4263–4281.

RESULTS

Non-adopters showed near-zero probability of using the eight identified practices. **On-farm adopters** emphasised planting-calendar adjustment, disaster-resilient plants and seed saving. **Off-farm adopters** combined water management, local inputs, work on other farms and non-farm activities.



WHAT DIFFERENTIATES THE PATHWAYS?

Predictor	Off-farm vs Non-adopters	On-farm vs Non-adopters
Household size	↓ *	ns
Education	↑ **	↓ **
Income	↑ **	↑ ***
Farming experience	ns	↑ **
Farm size	ns	↑ *
Multi-hazard experience	ns	↑ ***
Credit access	ns	ns
Threat appraisal	ns	ns
Coping appraisal	ns	↓ ***

Note: arrow shows coeff +/-, *** p < 0.01; ** p < 0.05; * p < 0.10; ns = not significant.

Higher exposure to multi hazard tends to adopt **on-farm activities**

Higher education may lead farmers to **more adaptation** options

Higher coping capacity was associated with a lower likelihood of on-farm adaptation

CONCLUSION & RECOMMENDATIONS

Farmers exposed to multi-hazard conditions do not follow a uniform adaptation pathway. Hazard experience, resources, education, and coping capacity differentiate whether households remain non-adopters or move towards On-farm or Off-farm adaptation.

“One risk – one intervention” solutions should move towards pathway-specific agricultural DRR that reflects household resources, livelihood options, and local hazard conditions (UNDRR, 2015; UNDRR & ISC, 2025).

Policy recommendations:

- Integrate agricultural extension and DRR.** Indonesia's Ministry of Agriculture could strengthen coordination between agricultural extension officers (PPL), BPBD, and village disaster groups that hazard information is translated to practical farm-level risk-reduction options
- Match support to adaptation pathways.** On-farm adaptation requires locally suitable resilient planting materials, seed-saving support, water-management options, regular extension service support, and risk-reduction financing
- Prioritise constrained non-adopters.** The dominance of non-adopters (81.5 %) suggests that policy should identify barriers to feasible action, increase capacity building and knowledge transfers for farmers
- Recognise livelihood diversification as risk management.** Off-farm activities may provide an important household buffer against recurrent agricultural shocks, integrating tourism with risk-reduction on-farm practices could provide alternative solutions to reduce impact of these shocks