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Behavioural Determinants of Adaptation and Maladaptation in Coastal Farming: Evidence from Indonesia

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Abstract

Smallholder farmers' behavioural responses to climate stress play a crucial role in determining the resilience of agri-food systems. In coastal Indonesia, rising salinity and recurrent flooding pose a significant threat to rice yields, rural livelihoods, and food security. Yet, limited research has explored how farmers actually adapt – or fail to adapt – to these climatic pressures. This study examines the social and psychological mechanisms that underline both adaptation and maladaptation, explaining why similar environmental threats elicit divergent behavioural responses. A dual-pathway behavioural model was developed by integrating four conceptual frameworks: the Theory of Planned Behaviour, Protection Motivation Theory, the Risk-Coping-Social Appraisal model, and the Model of Private Proactive Adaptation to Climate Change. Using survey data from 150 coastal rice farmers in Central Java, the study employed Partial Least Squares Structural Equation Modeling (PLS-SEM) to analyze relationships among attitudes, perceived social norms, adaptive efficacy, perceived vulnerability, and avoidant coping. The results indicate that subjective norms, positive attitudes,

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perceived vulnerability, and adaptive efficacy strongly shape adaptation intentions. Economic constraints and perceived risk severity play less significant roles. Perceived vulnerability increases adaptation when efficacy is high but contributes to disengagement when institutional support is weak. This study enhances our understanding of how farmers adapt their behaviour and suggests that group expectations and local support systems influence coping strategies. The study provides practical guidance for climate adaptation plans, emphasizing the importance of strengthening extension services, building farmers' confidence, and enhancing food system resilience.

Dual-pathway model
Subjective norms
Smallholder farmers

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Introduction

Communities in coastal agricultural regions are at the forefront of climate change. For millions of smallholder farmers, rising sea levels and increasing salinity are not distant threats, but rather daily realities that erode land, livelihoods, and food security (J. Chen *et al.*, 2022; Hasan & Kumar, 2020). In low- and middle-income countries, the sustainability of resource-based livelihoods is increasingly undermined by saltwater intrusion, land degradation, and socio-economic vulnerability (Aryal *et al.*, 2020; Gopalakrishnan *et al.*, 2019; Santeramo *et al.*, 2021). In Indonesia, this phenomenon presents a significant threat to smallholder rice farming, as salinisation reduces arable land and diminishes productivity (Oelviani, Adiyoga, *et al.*, 2024; Oelviani *et al.*, 2023). While agronomic solutions, such as salt-tolerant rice, offer partial relief, they are insufficient to address the complex and multifaceted threats confronting coastal agriculture (Dam *et al.*, 2019; Hopmans *et al.*, 2021; Surendhar *et al.*, 2021).

Emerging research indicates that farmers' responses to climate risks are shaped by factors beyond technical and economic considerations. Cognitive, emotional, and social influences also inform their decision-making (Faisal *et al.*, 2020; Grothmann & Patt, 2005; Truelove *et al.*, 2015). For instance, risk perceptions, efficacy, social norms, and fatalism may take precedence over objective conditions (van Valkengoed *et al.*, 2024; Zobeidi *et al.*, 2022). Although climate services and policies can facilitate adaptation, persistent barriers remain. Economic insecurity and psychological disengagement often lead to inaction or maladaptive coping strategies (Gifford, 2011; Vieira *et al.*, 2023). Understanding both the behavioural determinants and constraints of adaptation is therefore essential (Fisichelli *et al.*, 2016; Rahman & Hickey, 2019).

Behavioural models provide insight but often address partial processes operating at different analytical levels, leading to fragmented explanations.

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The Theory of Planned Behaviour (TPB) frames intentions in terms of attitudes, norms, and control, but does not explicitly incorporate risk perceptions as a core construct (Ajzen, 1985, 1991). Protection Motivation Theory (PMT) encompasses threat and coping appraisals, such as vulnerability and confidence, but gives limited and indirect attention to social and institutional contexts (Luu *et al.*, 2019; Rogers, 1983).

The Risk, Coping, and Social Appraisal (RCSA) model includes social influence but provides a more limited treatment of avoidant and disengagement behaviours. The Model of Private Proactive Adaptation to Climate Change (MPPACC) considers withdrawal and fatalism (D. Chen *et al.*, 2024; Schwaller *et al.*, 2020). However, no single framework fully captures why some adapt while others avoid (Gifford, 2011; Grothmann & Patt, 2005).

This study addresses a theoretical gap by introducing and testing a dual-pathway behavioural model. The model defines two main responses to climate stress: proactive adaptation and avoidant maladaptation. It combines key cognitive, emotional, and social factors from TPB, PMT, RCSA, and MPPACC. Proactive adaptation involves deliberate, positive changes. Avoidant maladaptation is a separate pathway shaped by perceived risk, low confidence, social norms, and structural barriers (D. Chen *et al.*, 2024; Rahman & Hickey, 2019; Zhang *et al.*, 2020).

In summary, this research provides both theoretical and practical contributions. It contributes to environmental behavioural theory by integrating parallel adaptation pathways, while helping to clarify how cognitive, emotional, and social mechanisms interact with climate-induced stressors at multiple levels. This study specifically links the behavioural responses of farmers – both adaptive and maladaptive – to institutional and policy frameworks. In Indonesia, agricultural adaptation occurs within a decentralized governance system, where national initiatives provide overarching strategic direction, while local agrarian offices translate these policies into local implementation (Ministry of Environment and Forestry, 2017; Ministry of National Development Planning, 2014). This multi-level coordination directly shapes farmers' access to information, resources, and institutional support. Therefore, analysing behavioural adaptation within these nested policy contexts is essential for understanding how psychological responses contribute to agri-food resilience.

1. Theoretical Background and Research Gap

Before detailing the specific behavioural models, it is essential to establish the core premise of this study for a broader interdisciplinary audience: farmers do not merely react to climate threats based solely on objective

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weather data or economic costs. Instead, their decisions are profoundly filtered through psychological and social lenses. For instance, a farmer might face severe flooding but choose not to adapt if they feel powerless to change the situation (low efficacy) or if their community peers are similarly inactive (social norms). To systematically unpack these complex human elements, this study integrates four established frameworks, each capturing a distinct dimension of the decision-making process.

Farmers' responses to climate risks have been analysed through several behavioural frameworks, yet each elucidates only a portion of the decision-making process. The TPB links attitudes, subjective norms, and perceived behavioural control to intentions, but does not explicitly incorporate emotions and risk perceptions as core constructs (Ajzen, 1985, 1991). PMT encompasses threat and coping appraisals – such as vulnerability, severity, and efficacy – treating adaptation primarily as an individual process and giving limited and indirect attention to social and institutional contexts (Luu *et al.*, 2019; Rogers, 1983). The RCSA model foregrounds collective efficacy and shared norms, yet it tends to emphasise rational and constructive responses (Schwaller *et al.*, 2020). In contrast, the MPPACC emphasises maladaptive responses, such as denial and fatalism, while placing less emphasis on enabling social and structural conditions (D. Chen *et al.*, 2024).

Empirical findings generally support this fragmented view. Self-efficacy and response efficacy consistently encourage the adoption of new practices. High perceived costs act as barriers (Riccioli *et al.*, 2023; van Valkengoed *et al.*, 2024; Yang *et al.*, 2024). In collectivist farming communities, subjective norms have a strong influence on intentions. Psychological distress, fatalism, and disengagement often lead to maladaptation (Gifford, 2011; Vieira *et al.*, 2023). Cross-national studies demonstrate that norms and efficacy are robust predictors across various contexts. However, the interaction between these factors and vulnerability to produce maladaptive outcomes remains poorly understood (Fisichelli *et al.*, 2016; Li *et al.*, 2021; Mitter *et al.*, 2019).

In sum, previous research addresses partial processes operating at different analytical levels. While some models account for heterogeneity in responses, they often provide incomplete or partial explanations as to why similar risks prompt some farmers to adapt while leading others to disengage. Furthermore, in many instances within existing models, maladaptation is not explicitly addressed at all, rather than being conceptualised as a coexisting outcome alongside adaptation. This reveals a research gap: there is limited integration across frameworks to explain both adaptive and maladaptive pathways in climate-vulnerable farming systems.

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Conceptual Model Overview

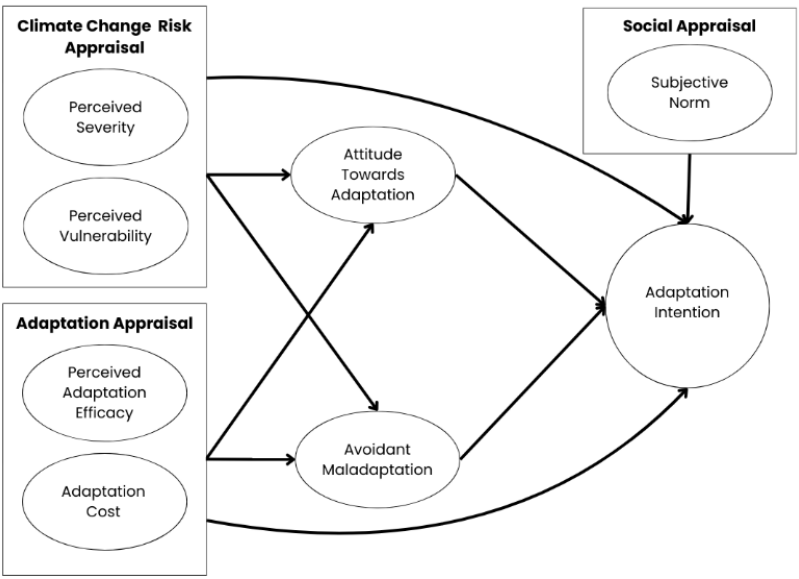
To address these gaps, this study creates a dual-pathway behavioural framework. It combines ideas from the TPB, PMT, the RCSA model, and the MPPACC. The model brings these perspectives into three main domains (Ajzen, 1985; D. Chen *et al.*, 2024; Rogers, 1983; Schwaller *et al.*, 2020). Climate risk appraisal encompasses perceived severity and vulnerability, which can motivate adaptation or, if overwhelming, lead to withdrawal (D. Chen *et al.*, 2024; van Valkengoed *et al.*, 2024). Adaptation appraisal considers efficacy and costs. Confidence in one's coping ability encourages action, while a high perceived cost discourages it. Social appraisal examines subjective norms (Etse & Adu-Aboagye, 2025; Williams *et al.*, 2020; Yang *et al.*, 2024). This domain is critical in collectivist farming communities, where adaptation decisions are made within peer and leadership networks (Wang *et al.*, 2023; Zobeidi *et al.*, 2022).

These domains shape intentions in two main ways. Positive attitudes, efficacy, and supportive norms drive proactive adaptation (van Valkengoed *et al.*, 2024; Zhang *et al.*, 2020). Avoidant maladaptation manifests as disengagement, denial, or persistence in ineffective practices (Gifford, 2011; Vieira *et al.*, 2023). The model views maladaptation as a distinct pathway, rather than simply the absence of adaptation. This approach provides a conceptual refinement of behavioural theory. It helps explain how vulnerability, low efficacy, and contextual conditions may lead to defensive responses (Fisichelli *et al.*, 2016; Rahman & Hickey, 2019).

This dual-pathway framework suggests that both constructive and maladaptive processes can coincide. It offers a more comprehensive perspective on climate-related decision-making. It may inform interventions aimed at enhancing efficacy, leveraging community norms, and mitigating psychological barriers. The relationships between constructs are illustrated in Figure 1.

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Figure 1 - Conceptual Model of Adaptation Intention



Hypotheses Development

This study develops hypotheses based on a model with two pathways: behavioural determinants of adaptation and barriers to farmers' intentions. Key enablers are adaptation efficacy, subjective norms, and attitudes. Constraints include maladaptive tendencies and perceived costs. Presenting these as opposing paths clarifies what motivates adaptation and what leads to withdrawal.

Subjective norms are expected to increase adaptation intention, reflecting collective decision-making in agricultural communities. Peer groups, leadership, and cooperatives shape individual responses to climate threats (Ajzen, 1991; Hounnou *et al*., 2024; Zobeidi *et al*., 2022).

- H1: Subjective Norms positively influence Adaptation Intention.

Similarly, an individual's attitude toward adaptation predicts intention and is shown in the perceived desirability of adaptive practices. Positive attitudes consistently correlate with a greater willingness to act (Arya & Kumar, 2023; Chang *et al*., 2022).

- H2: Attitude towards Adaptation positively influences Adaptation Intention.

Avoidant maladaptation refers to psychological disengagement or passive coping strategies in response to climate risk. Fatalism, uncertainty, or emotional fatigue can cause inaction despite recognition of threats (Magnan, 2022; Valois *et al*., 2020).

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- H3: Avoidant Maladaptation negatively influences Adaptation Intention.

Perceived severity reflects individuals' beliefs about the seriousness of climate threats. Moderate severity motivates adaptation (Hale *et al.*, 2024; Yiridomoh *et al.*, 2022). Extremely high severity, however, may lead to fear-based paralysis. Severity thus affects both adaptive and maladaptive responses.

- H4: Perceived Severity positively influences Adaptation Intention.
- H5: Perceived Severity positively influences Attitude towards Adaptation.
- H6: Perceived Severity positively influences Avoidant Maladaptation.

Perceived vulnerability refers to a sense of exposure to climate-related hazards. Greater exposure can increase adaptation intentions and positive attitudes (Dang *et al.*, 2017; Nelson *et al.*, 2023; Valois *et al.*, 2020). However, with low efficacy or high constraints, vulnerability may lead to avoidance (Fisichelli *et al.*, 2016; Grothmann & Patt, 2005; Werg *et al.*, 2020).

- H7: Perceived Vulnerability positively influences Adaptation Intention.
- H8: Perceived Vulnerability positively influences Attitude towards Adaptation.
- H9: Perceived Vulnerability positively influences Avoidant Maladaptation.

Perceived adaptation efficacy is confidence in one's ability to respond. High efficacy drives action and reduces avoidance (Attems *et al.*, 2020; Shi *et al.*, 2019; Truelove *et al.*, 2015; van Valkengoed *et al.*, 2024).

- H10: Perceived Adaptation Efficacy positively influences Adaptation Intention.
- H11: Perceived Adaptation Efficacy positively influences Attitude towards Adaptation.
- H12: Perceived Adaptation Efficacy negatively influences Avoidant Maladaptation.

Perceived adaptation cost includes financial, cognitive, and social factors. Some see these as investments, while others view them as barriers that can lead to disengagement (Ehsan *et al.*, 2022; Riccioli *et al.*, 2023; Yazdanpanah *et al.*, 2024).

- H13: Perceived Adaptation Cost positively influences Adaptation Intention.
- H14: Perceived Adaptation Cost positively influences Attitude towards Adaptation.
- H15: Perceived Adaptation Cost positively influences Avoidant Maladaptation.

These hypotheses show that climate adaptation behaviour is complex. They help study how psychosocial, cognitive, and contextual factors support adaptation or lead to avoidant maladaptation.

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2. Materials and methods

This study examines smallholder rice farmers in Pemalang and Kendal, two coastal districts in Central Java, exposed to climate-related vulnerabilities. Both regions face recurrent tidal flooding, saltwater intrusion, coastal erosion, and seasonal droughts. These hazards pose a threat to food security and livelihoods. In Pemalang, over 7,000 hectares are regularly inundated. Kendal has lost more than 190 hectares of shoreline in the past decade. Salinity intrusion now affects nearly 10% of Kendal's farmland (Oelviani, Adiyoga, *et al.*, 2024; Oelviani, Susilowati, *et al.*, 2024).

Farmers rely on a traditional rice-rice-fallow system. The adoption of improved or salt-tolerant varieties remains limited due to restricted access and poor suitability under stressed conditions. Many households depend on informal networks for adaptation knowledge. These constraints compound ecological pressures, intensifying both economic and psychological stress.

Pemalang and Kendal are hotspots of ecological stress and behavioural constraints in Southeast Asia's coastal farming systems. Their dual vulnerability makes them suitable for testing a behavioural framework that integrates adaptive and maladaptive responses. This has broader implications for climate-vulnerable communities in the Global South.

Conceptual Model Overview

This study examined eight latent variables reflecting both adaptive and maladaptive responses to climate change (Ajzen, 1991; Grothmann & Patt, 2005; Luu *et al.*, 2019). Subjective norms, attitudes, and adaptation intentions were derived from the TPB. Protection Motivation Theory (PMT) and the MPPACC informed perceptions of severity, vulnerability, efficacy, and adaptation costs (D. Chen *et al.*, 2024; Rogers, 1983). Avoidant maladaptation was assessed through indicators of psychological disengagement, fatalism, and passive coping, highlighting strategies especially pertinent in climate-vulnerable contexts (Gifford, 2011; Vieira *et al.*, 2023).

A total of 36 validated items from established scales were adapted to the study context, with each indicator mapped to its respective theoretical construct. Measures of severity, vulnerability, efficacy, and cost were sourced from established PMT and MPPACC scales (Grothmann & Patt, 2005; van Valkengoed *et al.*, 2024). Subjective norms and adaptation intentions were adapted from Ajzen (1991) and recent climate adaptation studies (Faisal *et al.*, 2020). All items employed a five-point Likert scale (1 = strongly disagree to 5 = strongly agree), thereby facilitating systematic assessment of cognitive, affective, and social factors. It is important to clarify that these

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Likert-scale items are designed to measure self-reported perceptions and behavioural orientations (i.e., intentions), rather than actual observed adaptive or maladaptive behaviours in the field. Instrument development adhered to established validation procedures to ensure both content relevance and cultural appropriateness. Minor refinements were introduced following a pilot assessment, thereby enhancing clarity and strengthening the robustness of subsequent data collection. The operationalisation of these constructs and their references is summarised in Table 1.

Table 1 - Constructs, Indicators, and Supporting References for the Theoretical Framework

Constructs	**Indicators**	**References**
Perceived severity (PSV)	• PSV1 • PSV2 • PSV3 • PSV4 • PSV5	Yiridomoh *et al.* (2022), Manh *et al.* (2023), Begum *et al.* (2022), Hale *et al.* (2024)
Perceived vulnerability (PVL)	• PVL1 • PVL2 • PVL3 • PVL4	Dang *et al.* (2017), Demski *et al.* (2017), Lane *et al.* (2018), Nelson *et al.* (2023), Mugisho & Nfuamba (2023)
Perceived adaptation efficacy (PAE)	• PAE1 • PAE2 • PAE3 • PAE4	Attems *et al.* (2020), Bourret Soto & Guillon (2024), Truelove *et al.* (2015), Van Valkengoed *et al.* (2024), Niles *et al.* (2016)
Perceived adaptation cost (PAC)	• PAC1 • PAC2 • PAC3 • PAC4 • PAC5	Ehsan *et al.* (2022), Yazdanpanah *et al.* (2024), Nabara *et al.* (2020), Riccioli *et al.* (2023)
Avoidant maladaptation (AVM)	• AVM1 • AVM2 • AVM3 • AVM4	Chi *et al.* (2021), Magnan (2022) Rahman & Hickey (2019), Ghanian *et al.* (2020) Naufal *et al.* (2023)
Attitude (ATT)	• ATT1 • ATT2 • ATT3 • ATT4 • ATT5	Ajzen (1991), Tanyanyiwa & Muhwati (2021), Singh *et al.* (2020), Arya & Kumar (2023), Chang *et al.* (2022)

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Constructs	Indicators	References
Subjective norm (SBN)	• SBN1 • SBN2 • SBN3 • SBN4 • SBN5	Ajzen (1991), Schwaller *et al.* (2020), Zobeidi *et al.* (2022), Hounnou *et al.* (2024)
Adaptation intention (ADI)	• ADI1 • ADI2 • ADI3 • ADI4	Ajzen (1991), Mitter *et al.* (2019), Manh *et al.* (2023), Niles *et al.* (2016)

Sample, Data Collection, and Analysis

A survey was conducted involving 150 smallholder rice farmers in Kendal and Pemalang, two coastal districts in Central Java, exposed to salinity intrusion, tidal flooding, and drought. Respondents were purposively selected to represent those most affected: active rice farmers cultivating land within a five-kilometre radius of the coastline, each with a minimum of ten years' farming experience. Eligible villages were identified in collaboration with local agricultural offices and farmer groups, ensuring variation in landholding and resource access despite the non-random sampling design.

The sample was predominantly male (91%) and comprised individuals over 50 years of age (72%), with low educational attainment (43% had not completed primary school) and modest incomes (65% earned less than IDR 5 million per month). More than half had over 25 years of farming experience, consistent with regional patterns of smallholder agriculture in South and Southeast Asia (Aryal *et al.*, 2020; Irungu *et al.*, 2024).

Although modest in size, the sample exceeded PLS-SEM requirements. With twelve predictors for the most complex construct, the minimum threshold was 120, and 150 respondents provided sufficient statistical power (Hair *et al.*, 2021). Data were collected using structured questionnaires, with assistance provided to those with limited literacy. Responses were screened for completeness and normality before analysis. PLS-SEM was conducted in SmartPLS 4.0, with the reliability and validity of the measurement model assessed before subsequently testing structural linkages. Discriminant validity was confirmed using the Fornell-Larcker criterion and HTMT ratios (< 0.90).

To complement the survey, informal discussions with farmers provided contextual insights into adaptation costs and the influence of social norms. While the sample is skewed towards older male farmers with limited

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education, this reflects the demographic profile of coastal rice-farming households in Central Java. This limitation is acknowledged, underscoring the need for broader demographic inclusion in future research. The socio-demographic characteristics of respondents are detailed in Table 2.

Table 2 - Respondent's Profile n = 150

Profile	**Criteria**	**Frequency**	**Percentage**
Gender	Man (Male)	137	91.33
	Women (Female)	13	8.67
Age	< 30	1	0.67
	31-40	7	4.67
	41-50	23	15.33
	51-60	62	41.33
	61-70	46	30.67
	> 70	11	7.33
Last education level	No Formal Education	31	20.67
	Incomplete Primary Education	34	22.67
	SD	30	20
	SMP	20	13.33
	SMA	28	18.67
	D4/S1	7	4.67
Family size	< 2	31	20.67
	2-5	106	70.67
	> 5	13	8.67
Monthly income	IDR 1,000,000-2,500,000	39	26
	IDR 3,000,000-500,000,000	59	39.33
	IDR 6,000,000-10,000,000	38	25.33
	IDR > 10,000,000	11	7.33
Farming experience	< 5	3	2
	5-10	7	4.67
	11-15	10	6.67
	16-20	19	10.67
	21-25	34	22.67
	> 25	77	51.33

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Agricultural Policy and Local Governance Context

Indonesian agricultural policy strikes a balance between national food security and climate resilience. The Ministry of Agriculture maintains rice self-sufficiency with subsidies, irrigation, and productivity programmes. The National Action Plan for Climate Change Adaptation, climate-smart practices, and Climate Village Programme (ProKlim) guides sectors such as agriculture, focusing on salt-tolerant rice and improved water management (Ministry of Agriculture, 2024; Ministry of National Development Planning, 2014; Ministry of Public Works and Housing (PUPR) *et al.*, 2020). Provincial and district agencies implement these frameworks at the local level.

At the local level, agricultural extension services act as technical advisors by introducing new technologies and providing guidance. Farmer groups (Kelompok Tani-Poktan) function as facilitators of collective action, enabling resource sharing and fostering social learning among members. Both institutions disseminate policy and support adaptation practices. However, limited staffing and operational constraints, especially in coastal districts, often reduce their reach and effectiveness.

Within this policy landscape, farmers' decision-making is shaped by both formal government programmes, led by state agencies, and informal community mechanisms, steered by local leaders and networks. National frameworks, designed by policymakers, offer strategic direction. However, inconsistent institutional support means that adaptation often depends on local norms, peer networks, and community leadership. This study situates behavioural responses within a socio-political context, where collective processes and social expectations, reinforced by both officials and community actors, play a significant role in shaping adaptation outcomes.

3. Results

Measurement and Structural Model Assessment

The measurement model assessment demonstrates robust internal consistency, as well as both convergent and discriminant validity. Specifically, Cronbach's alpha values range from 0.864 to 0.963, which is well above the recommended threshold of 0.70 by Hair *et al.* (2021), indicating excellent reliability. Additionally, Composite Reliability (CR) values are above 0.70 for all constructs, which further confirms internal consistency. However, it is acknowledged that the exceptionally high reliability values for Attitude and Subjective Norm may indicate a degree of item redundancy, suggesting a relatively narrow operationalisation of these specific constructs in the current study.

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Average Variance Extracted (AVE) values for all constructs surpass the 0.50 benchmark. For example, Perceived Severity attains an AVE of 0.684. This indicates adequate convergent validity throughout the model. One item within the *Perceived Severity* construct – PSV4 – shows a relatively low outer loading of 0.311, but it is retained on theoretical grounds. This item reflects a dimension of long-term psychological perception of climate risks. It aligns with broader frameworks on climate threat appraisal in vulnerable communities (Hale *et al.*, 2024; Yiridomoh *et al.*, 2022). Empirically, the overall reliability remains strong (Cronbach's $\alpha = 0.864$; CR = 0.908), and the AVE exceeds the required threshold. According to Fornell and Larcker (1981), such indicators may be retained when they enhance construct depth and the overall measurement stays robust. Detailed indicator loadings, reliability, and AVE values are presented in Table 3.

Table 3 - Model Constructs Reliability and Convergent Validity Testing

Variables	**Indicators**	**Outer loading**	**Cronbach's alpha**	**Composite reliability**	**AVE**
Perceived severity	PSV1	0.914	0.864	0.908	0.684
	PSV2	0.924			
	PSV3	0.910			
	PSV4	0.311			
	PSV5	0.898			
Perceived vulnerability	PVL1	0.898	0.864	0.908	0.684
	PVL2	0.953			
	PVL3	0.928			
	PVL4	0.912			
Perceived adaptation efficacy	PAE1	0.771	0.861	0.904	0.702
	PAE2	0.870			
	PAE3	0.825			
	PAE4	0.882			
Adaptation cost	PAC1	0.895	0.911	0.934	0.739
	PAC2	0.884			
	PAC3	0.908			
	PAC4	0.875			
	PAC5	0.721			

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Variables	Indicators	Outer loading	Cronbach's alpha	Composite reliability	AVE
Avoidant maladaptation	AVM1	0.821	0.904	0.933	0.777
	AVM2	0.913			
	AVM3	0.898			
	AVM4	0.891			
Attitude	ATT1	0.879	0.961	0.970	0.867
	ATT2	0.943			
	ATT3	0.959			
	ATT4	0.945			
	ATT5	0.927			
Subjective norm	SBN1	0.924	0.963	0.972	0.872
	SBN2	0.931			
	SBN3	0.956			
	SBN4	0.935			
	SBN5	0.924			
Adaptation intention	ADI1	0.908	0.905	0.934	0.780
	ADI2	0.923			
	ADI3	0.806			
	ADI4	0.892			

Discriminant validity was checked using two methods: the Fornell-Larcker criterion and the Heterotrait-Monotrait Ratio (HTMT). For each variable, the square root of the average variance extracted (AVE) is greater than the correlations between variables, meeting the Fornell-Larcker requirement. All HTMT values are less than 0.90, supporting discriminant validity (Henseler *et al*., 2015). Results of discriminant validity are shown in Table 4 and Table 5, respectively.

Overall, the measurement model demonstrates satisfactory reliability and validity and is suitable for studying climate adaptation behaviour among smallholder farmers in vulnerable areas.

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Table 4 - Discriminant Validity - Fornell-Larcker criterion

Variables	PAC	ADI	ATT	AVM	PAE	PVL	PSV	SBN
PAC	0.859							
ADI	0.164	0.883						
ATT	0.268	0.690	0.931					
AVM	0.139	–0.059	–0.104	0.881				
PAE	–0.233	0.249	0.061	0.186	0.838			
PSV	0.403	0.447	0.601	0.207	0.038	0.827		
PVL	0.319	0.407	0.446	0.263	–0.008	0.721	0.923	
SBN	0.124	0.639	0.576	–0.158	0.329	0.295	0.129	0.934

Table 5 - Discriminant Validity - Heterotrait-monotrait ratio (HTMT)

Variables	PAC	ADI	ATT	AVM	PAE	PVL	PSV	SBN
PAC								
ADI	0.167							
ATT	0.278	0.738						
AVM	0.163	0.078	0.113					
PAE	0.291	0.300	0.124	0.209				
PSV	0.458	0.507	0.640	0.233	0.102			
PVL	0.349	0.441	0.466	0.284	0.045	0.785		
SBN	0.127	0.683	0.597	0.170	0.370	0.332	0.134	

The structural model exhibited strong explanatory power, accounting for 60.3% of the variance in Adaptation Intention ($R^2 = 0.603$). With a Standardised Root Mean Square Residual (SRMR) of 0.068 (Table 4), the model achieved a satisfactory fit. This value is below the recommended threshold of 0.08 (Hair *et al.*, 2021), indicating an acceptable level of model fit in a PLS-SEM context. However, while the reported R^2 and SRMR values indicate acceptable explanatory power and approximate model fit within a PLS-SEM context, it is important to note that SRMR should not be interpreted as absolute evidence of overall model adequacy in a strict confirmatory sense. Model fit and explanatory power are further summarised in Table 6.

Additionally, the model identified significant predictors of adaptation intention: Subjective Norm ($\beta = 0.334$, $p < 0.001$), Attitude towards Adaptation ($\beta = 0.415$, $p < 0.001$), Perceived Vulnerability ($\beta = 0.240$, $p < 0.01$), and

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Perceived Adaptation Efficacy ($\beta = 0.143$, $p < 0.05$), supporting H1, H2, H7, and H10. Furthermore, Perceived Severity significantly and positively influenced Attitude towards Adaptation ($\beta = 0.553$, $p < 0.001$), supporting H5.

In contrast to the above, the only significant predictor of maladaptation was Perceived Vulnerability ($\beta = 0.249$, $p < 0.01$), supporting H9.

Several relationships were non-significant: Perceived Severity on Adaptation Intention ($\beta = -0.071$, $p = 0.478$) and Avoidant Maladaptation ($\beta = -0.030$, $p = 0.789$), leading to the rejection of H4 and H6. Similarly, Avoidant Maladaptation did not significantly influence Adaptation Intention ($\beta = -0.035$, $p = 0.560$), which led to the rejection of H3. Additionally, Perceived Vulnerability did not significantly affect Attitude towards Adaptation ($\beta = 0.030$, $p = 0.786$), rejecting H8.

Perceived Adaptation Cost also showed no significant effects on Adaptation Intention ($\beta = 0.004$, $p = 0.956$), Attitude ($\beta = 0.059$, $p = 0.540$), or Maladaptation ($\beta = 0.118$, $p = 0.311$), leading to the rejection of H13-H15.

The results are summarised in Table 7, while Figure 2 visualises the validated structural paths and their corresponding t-statistics derived from the bootstrapping procedure.

Table 6 - Model Fit and Explained Variance

Indicator	Value	Interpretation
SRMR	0.068	Good fit (< 0.08 threshold)
R^2(Adaptation Intention)	0.603	Substantial; the model explains 60.3% of the variance in adaptation intention.

Note: SRMR = Standardized Root Mean Square Residual; R^2 = coefficient of determination.

These results suggest that the structural model meets established criteria for both overall fit and explanatory strength, providing a solid foundation for subsequent hypothesis testing and policy implications (Hair *et al.*, 2021).

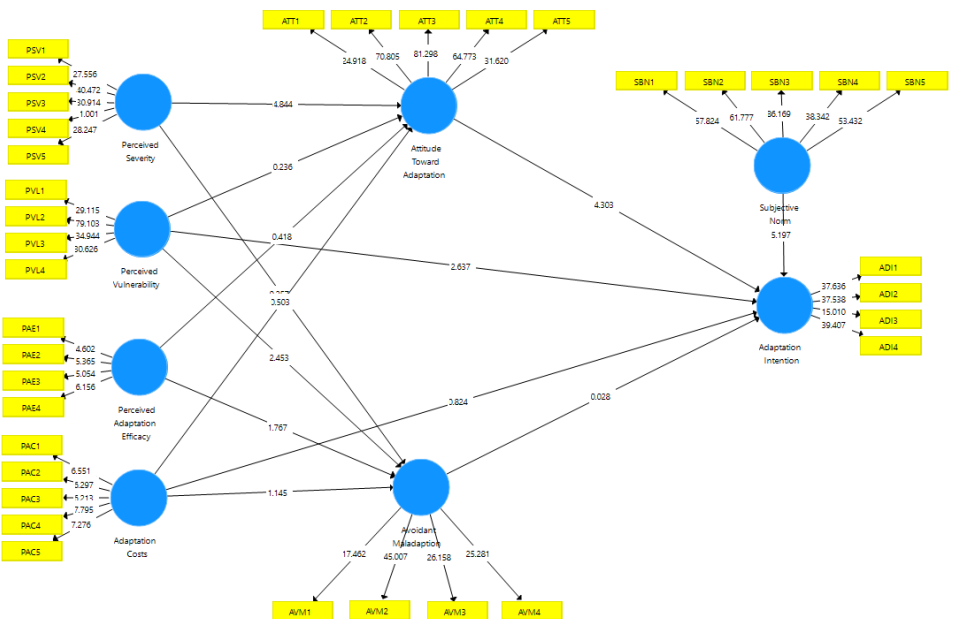
Table 7 - Summary of Hypothesis Testing

Hypothesis	Path	β-value	t-statistics	p-value	Decisions
H1	SBN → ADI	0.334	4.646	0.000	Accepted
H2	ATT → ADI	0.415	4.922	0.000	Accepted
H3	AVM → ADI	–0.035	0.583	0.560	Rejected
H4	PSV → ADI	–0.071	0.711	0.478	Rejected

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Hypothesis	Path	β-value	t-statistics	p-value	Decisions
H5	PSV → ATT	0.553	4.995	0.000	Accepted
H6	PSV → AVM	–0.030	0.268	0.789	Rejected
H7	PVL → ADI	0.240	2.870	0.004	Accepted
H8	PVL → ATT	0.030	0.272	0.786	Rejected
H9	PVL → AVM	0.249	2.645	0.008	Accepted
H10	PAE → ADI	0.143	2.316	0.021	Accepted
H11	PAE → ATT	0.095	1.150	0.251	Rejected
H12	PAE → AVM	0.193	1.697	0.090	Rejected
H13	PAC → ADI	0.004	0.055	0.956	Rejected
H14	PAC → ATT	0.059	0.613	0.540	Rejected
H15	PAC → AVM	0.118	1.014	0.311	Rejected

Figure 2 - Structural Model Assessment (t-statistics)



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4. Discussion

Adaptation as a Socially Embedded Process

For coastal farmers in Central Java, adaptation is a social process, not just a reaction to environmental threats. This study suggests that adaptation decisions are more strongly shaped by what the community accepts, expects, and values than by risk or cost. Attitudes and subjective norms are the strongest predictors of adaptation intention, aligning with the Theory of Planned Behaviour. Farmers rarely make decisions alone; they often negotiate with peers, local leaders, and support networks.

Social appraisal – the community's interpretation of risk – shapes collective farming responses (Selje *et al.*, 2024; Truelove *et al.*, 2015; Vargas *et al.*, 2023). Practices such as *gotong royong* (communal labour) and farmer cooperatives demonstrate how adaptation decisions are influenced by local norms. Both a strategy's practical effectiveness and its alignment with a sense of "what people like us do" are equally influential (de la Poterie *et al.*, 2018; Wang *et al.*, 2023).

Economic factors, particularly input costs, had a minimal influence on adaptation decisions. In subsistence systems, seeds, water, and labour are seen as necessities, not discretionary expenses. Their essential role in survival may explain why adaptation is seen less as an economic burden and more as a social obligation, particularly with community support. This contrasts with models that focus on cost as the main barrier.

Perceived vulnerability showed a stronger and more consistent link to adaptive behaviour. Farmers directly affected by salinisation were more likely to act if they also felt able to respond (Dang *et al.*, 2017; Nelson *et al.*, 2023). Yet, awareness alone was not enough. Without a sense of efficacy or support, high vulnerability often led to psychological disengagement or resignation. This supports the dual-process model proposed by Grothmann and Patt (2005) and aligns with recent evidence from Southeast Asia and Sub-Saharan Africa (Fisichelli *et al.*, 2016; Lane *et al.*, 2018; Werg *et al.*, 2020). Exposure to chronic stressors, such as flooding or salinity, has become routine, making threats seem less urgent unless practical solutions are in place.

Overall, these findings suggest that adaptation intention is primarily influenced by social factors, including belonging, obligation, and conformity to norms. Social meaning and trust drive collective, value-driven responses, often outweighing economic or risk-based motives.

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Avoidant Maladaptation as a Parallel Psychological Pathway

Avoidant maladaptation constitutes a distinct behavioural response to climate stress, rather than simply the absence of adaptation. Farmers frequently undertake practical adaptive actions – such as cultivating salt-tolerant crops – whilst simultaneously disengaging from broader adaptation planning. These findings corroborate the argument that adaptation and avoidance can operate in parallel (Grothmann *et al.*, 2017; Grothmann & Patt, 2005).

Perceived vulnerability plays a dual role: it encourages adaptation when joined with efficacy, but leads to avoidance without confidence or support (Etana *et al.*, 2020; Nelson *et al.*, 2023). In this context, avoidance becomes a rational self-protection against chronic stress and institutional limits (Fisichelli *et al.*, 2016; Magnan, 2022).

Contrary to expectations, perceived severity did not predict maladaptive behaviour. Emotional and structural constraints, rather than abstract threat awareness, were more decisive (Hale *et al.*, 2024; Yiridomoh *et al.*, 2022). This finding provides nuance to models that emphasise risk perception and suggests that action gaps stem from reduced coping resources, rather than a lack of knowledge (Gifford, 2011).

Overall, these findings indicate that addressing maladaptation necessitates more than just information. It demands restoring confidence, boosting efficacy, and enlarging institutional space for agency (Attems *et al.*, 2020; Lenhard *et al.*, 2024).

While the proposed dual-pathway framework offers a conceptual distinction between adaptation and maladaptation, it is important to candidly acknowledge that the maladaptation pathway received limited empirical support in our structural model. Given that maladaptation represents a central component of the framework, this limited support warrants cautious interpretation. In contrast to adaptation intention, which was robustly influenced by multiple cognitive and social factors, avoidant maladaptation was primarily predicted by perceived vulnerability alone. Other hypothesised predictors, including perceived severity and adaptation costs, did not show significant effects.

This partial mismatch between the theoretical framework and empirical findings suggests that maladaptive responses in this coastal context may be less complexly determined than proactive adaptive actions. It also indicates that the current specification of the maladaptation pathway may be incomplete, particularly in capturing emotional, institutional, or contextual determinants beyond perceived vulnerability. Avoidance appears to be triggered when farmers experience heightened vulnerability, regardless of the severity of abstract threats or financial costs.

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Future research should incorporate constructs such as emotional coping (e.g., fear, anxiety), institutional trust, and perceived controllability to better capture the range of determinants shaping maladaptive behaviour in climate-vulnerable contexts.

Theoretical Contributions and Dialogue with Existing Literature

This study introduces a dual-pathway model, conceptualising adaptation and avoidant maladaptation as parallel responses to climate risk, shaped by intersecting cognitive, emotional, and social factors. In contrast to conventional models that treat these outcomes as discrete, this framework synthesises four principal theories: the Theory of Planned Behaviour (Ajzen, 1991), Protection Motivation Theory (Rogers, 1983), the Risk-Coping-Social Appraisal model (Truelove *et al*., 2015), and the Model of Private Proactive Adaptation to Climate Change (D. Chen *et al*., 2024).

Three main contributions stand out. First, perceived severity has a minimal influence on action, challenging the Protection Motivation Theory's assumption that threat intensity is decisive. Second, perceived vulnerability operates as a dual trigger, prompting either adaptation or avoidance based on efficacy and support (Etana *et al*., 2020; Grothmann & Patt, 2005). Third, adaptation costs do not affect intention – supporting findings that, in subsistence systems, such costs are absorbed into survival strategies, not regarded as barriers (Riccioli *et al*., 2023).

This study provides insights from a collectivist, agrarian context, which is often overlooked in Global North literature. Here, perceived efficacy takes on a diminished role. This is not due to cognitive limitations, but rather stems from structural constraints, including limited institutional trust and restricted access to extension services (Truelove *et al*., 2015).

Maladaptation is not viewed as a failure, but rather as a rational response to chronic constraint. Evidence from Sub-Saharan Africa and Pacific Island states supports this view (Hale *et al*., 2024; Magnan, 2022). This aligns with the IPCC AR6 suggestion to move from technical solutions to socio-psychological models, which recognise emotion, fatigue, and social norms as key to adaptive capacity.

In summary, this model shows that adaptation and maladaptation should not be seen as opposites. They are interconnected behaviours, shaped by agency, context, and subjective meaning. However, these findings should be interpreted with an understanding of the data's nature. While the construct reliability and validity of the measurement model are statistically satisfactory, the findings rely entirely on self-reported Likert measures. These measures capture farmers' perceptions and behavioural orientations (i.e., intentions)

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rather than their directly observed adaptation or maladaptation behaviours in the field. Future research could benefit from integrating observational data to validate these self-reported intentions**.**

5. Practical and Policy Implications

This study identifies five principal strategies to enhance climate resilience among smallholder farmers. First, address economic constraints through inclusive financial mechanisms such as subsidies and low-interest loans (Ehsan *et al*., 2022; Williams *et al*., 2020). Second, integrate psychological and social mechanisms shaping behaviour into adaptation programming, recognising the importance of efficacy, norms, and emotional fatigue (Grothmann & Patt, 2005; Vieira *et al*., 2023). Third, strengthen social capital through peer-based learning networks, as these foster trust and knowledge exchange (Arya & Kumar, 2023; Zobeidi *et al*., 2022). Fourth, embed confidence-building elements within adaptation support structures (van Valkengoed *et al*., 2024). Fifth, tailor institutional support to local contexts by prioritising subjective norms, attitudes, vulnerability, and efficacy (Dang *et al*., 2017; Mitter *et al*., 2019).

At farm and community levels, interventions should: (1) Foster collective decision-making and peer knowledge exchange (Selje *et al*., 2024; Zobeidi *et al*., 2022) ; (2) Use farmer-to-farmer networks, supported by cooperatives and extension services, to spread climate-smart practices (Arya & Kumar, 2023; Riccioli *et al*., 2023); (3) Prioritise visual aids, practical demonstrations, and accessible language in training (Begum *et al*., 2022); and (4) Ensure women and young people are included for sustained, inclusive resilience (Nelson *et al*., 2023; Yiridomoh *et al*., 2022).

Policymakers should: (1) Leverage social cohesion to ease economic barriers (Hounnou *et al*., 2024; Schwaller *et al*., 2020); (2) Pair financial supports – subsidised inputs, insurance, and loans – with psychosocial assistance (Hale *et al*., 2024; Rahman & Hickey, 2019);(3) Align land-use, water, and ecosystem policies for coherence (Oelviani *et al*., 2023); (4) Apply Integrated Coastal Zone Management and Ecosystem-Based Adaptation to bridge community participation with resilience goals (DasGupta *et al*., 2018; Selje *et al*., 2024).

Development programmes and NGOs should: (1) Strengthen community-based organisations as intermediaries between local practices and policy; and (2) Prioritise support for coastal agricultural systems facing salinity stress and limited institutional trust and adaptive capacity (J. Chen *et al*., 2022; Mudekhere *et al*., 2023; Oelviani *et al*., 2023).

Maladaptation is a parallel psychological pathway – not just the absence of adaptation. Farmers may adopt new technologies while still showing avoidant

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behaviour. Key recommendations: (1) Anticipate emotional fatigue and risk resignation (Vieira *et al*., 2023); (2) Use behavioural interventions like participatory dialogues, reframing, and collective incentives for proactive adaptation (Grothmann & Patt, 2005); (3) Anchor these tools locally to genuinely lower vulnerability (Fisichelli *et al*., 2016; Rahman & Hickey, 2019). Insights have broader relevance: adaptation across the Global South must prioritise social norms, efficacy, and perceived vulnerability, not just cost or technology-based approaches (Arya & Kumar, 2023; van Valkengoed *et al*., 2024).

These findings support Indonesia's policies to enhance agricultural resilience. Integrating behavioural insights into the National Action Plan for Climate Change Adaptation, climate-smart practices, and the Climate Village Programme can enhance adaptation effectiveness (Ministry of National Development Planning, 2014). Local extension systems and farmer groups, coordinated by Balai Penyuluh Pertanian, are strategic points for applying these insights. Empowering farmers' efficacy and promoting positive social norms through peer learning will accelerate the adoption of adaptive practices and reduce maladaptive coping strategies. Recognising local governance limitations – particularly in coastal, high-salinity areas – is essential for tailored, effective interventions. Aligning behavioural, institutional, and economic incentives will support both household adaptation and long-term resilience in Indonesia's agricultural and food systems.

Conclusion

This study examined the factors shaping climate adaptation and maladaptation among smallholder rice farmers in coastal Central Java, Indonesia. The results indicate that adaptation intentions are primarily influenced by socio-psychological factors, including subjective norms, positive attitudes, perceived vulnerability, and adaptive efficacy. Economic factors, such as adaptation costs and general risk awareness, play a minor role. In this collectivist, agrarian context, community values and expectations have a greater impact on adaptive behaviour than individual financial or risk calculations.

A key contribution of this research is a dual-pathway behavioural model that the study developed and tested. By combining four theoretical frameworks, the study conceptualises maladaptation as a distinct psychological process shaped by disengagement, fatalism, and structural constraints, rather than merely as a lack of adaptation. This framework helps explain how cognitive, emotional, and social factors interact under climate stress, illustrating why farmers facing similar threats often exhibit different behaviours.

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However, given that maladaptation is a central component of the proposed dual-pathway framework, the limited empirical support observed here warrants cautious interpretation and underscores the need to refine this pathway in future research.

These findings have relevant implications for Indonesia's agricultural policy. The study suggests that investing in social capital may be a more cost-effective and sustainable approach to enhancing the resilience of the agri-food system than relying solely on financial incentives. Policymakers could utilise these insights by incorporating behavioural factors into national programs, such as the National Action Plan for Climate Change Adaptation (RAN-API), climate-smart practices, and the Climate Village Programme (ProKlim). In particular, improving local extension systems (Balai Penyuluh Pertanian) and farmer networks can enhance efficacy and reinforce positive social norms. This approach could help increase the adoption of adaptive practices and support the long-term sustainability of rural livelihoods.

While this study offers important insights, its conclusions are specific to the context it examines. Future research should test and refine the dual-pathway model across other agro-ecological regions. Researchers can also consider adding variables such as institutional trust and market dynamics. Explicit comparisons between behavioural interventions and traditional economic incentives can further enhance our understanding of how behavioural factors contribute to building climate resilience in agri-food systems.

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