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Impact of Climate Change on Farmers' Adaptive Strategies in the Upper Brahmaputra Valley Zone: An Integration of Protection Motivation Theory and Theory of Planned Behaviour

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ABSTRACT

This study examines how climate change shapes farmers' adaptive strategies in the Upper Brahmaputra Valley Zone by integrating Protection Motivation Theory (PMT) and the Theory of Planned Behaviour (TPB) into a single behavioural framework. The model operationalizes threat appraisal (perceived severity, perceived vulnerability, fear) and coping appraisal (response efficacy, self-efficacy) alongside TPB predictors (attitude, subjective norms, perceived behavioural control) to explain adaptive intention and adaptive strategies. Using survey-based construct measures, the instrument demonstrates satisfactory internal consistency and strong factorability. Confirmatory factor analysis supports measurement validity with standardized factor loadings largely above accepted thresholds (≥ 0.50) and acceptable model fit. The validated integrated model provides a defensible basis for explaining how perceived climate threats and efficacy beliefs translate into intention and, ultimately, farm-level adaptation actions such as crop diversification, improved varieties, and climate-resilient practices.

1. Introduction

Agriculture is the most vulnerable sector to climate change due to its huge size and sensitivity to weather parameters, causing huge economic impacts (Mendelsohn, 2009). The changes in climatic events such as temperature and rainfall significantly affect the yield of crops. The effect of rising temperatures, precipitation variation, and CO2 fertilization varies according to the crop, location, and magnitude of change in the parameters. The temperature increase is found to reduce the yield, while the precipitation increase is likely to offset or reduce the impact of increasing temperature (Adams, *et al.*, 1988). Recent study also indicates that change in climate is increasingly impacting agriculture, forest, fisheries and food systems thereby causing crisis in food security (IPCC, 2022)

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Plants' response to climate change varies according to the plant species and developmental stage of the plant. There are species-specific thresholds for different plants, and their responses, such as elongation of roots, disturbance in growth angle of roots, and reduction in yield, vary among different species of plants (Gray, 2016). Climate change affects food security in four dimensions, food availability, food accessibility, food utilization, and food system stability. It will also have an impact on human health, livelihood assets, and food production and distribution channels (FAO, 2008). In context to this, a climate-smart agriculture focuses on enhancing productivity and income, building resilience to changing climate and reducing greenhouse gas emission (FAO, 2023).

The Indian crop sector is one of the most sensitive and exposed areas to climate change due to its less adaptive capacity to cope with it (Birthal *et al.*, 2014). The assessment of climate change effects on crop productivity in India is highly important where a substantial share of the population depends on farming for their livelihood and sustenance (Pattanayak & Kumar, 2014).Recent studies on absence of adaptation measures in India showed a decline of 20% in rice yield by 2050, 47% by 2080, while a decline of 19.35 by 2050 and 40% by 2080 in wheat yield (GOI, 2023). Therefore, farmers need to adopt suitable adaptive strategies like crop diversification, improve crop varieties, climate-resistance cropping practices, soil and water conservation practices to reduce significant risks in the future.

The present study aims to contribute to the body of knowledge on behavioural adoption in the context of agricultural production by integrating two widely used behaviour al change frameworks, PMT and TPB, when explaining climate change mitigation and adaptation behaviour in agricultural production. PMT is relevant because it explains how farmers respond to climate threats, while TPB explains how a farmer's attitude, subjective norms and perceived behavioural control influence adaptive intention and adaptive strategies.

2. Conceptual Framework And Hypotheses Development

2.1. Protection Motivation Theory

The Protection Motivation Theory guided research on protective health risk behaviour, nuclear war, water conservation, and marketing communication (Floyd et al, 2000; Cismaru, 2008). More recently PMT appeared in research on environmental risks, natural hazards, and climate change (Grothmann, 2005; Osberghaus, 2010; and Dang, 2014). PMT addresses four core elements of the cognitive mediating processes: threat appraisal, coping appraisal, maladaptive coping, and protection motivation (Milne, 2000) (Figure 2). Regarding climate change, these elements are climate change risk appraisal, adaptation appraisal, avoidant maladaptation (Grothmann, 2005), risk perception of climate change, adaptation assessment, mal-adaptation, and adaptation intention. Other concepts, such as belief in climate change, adaptation incentives/disincentives, habits, and subjective norms, are hypothesized to affect the adaptation intention of farmers in response to climate change (Dang, 2012).

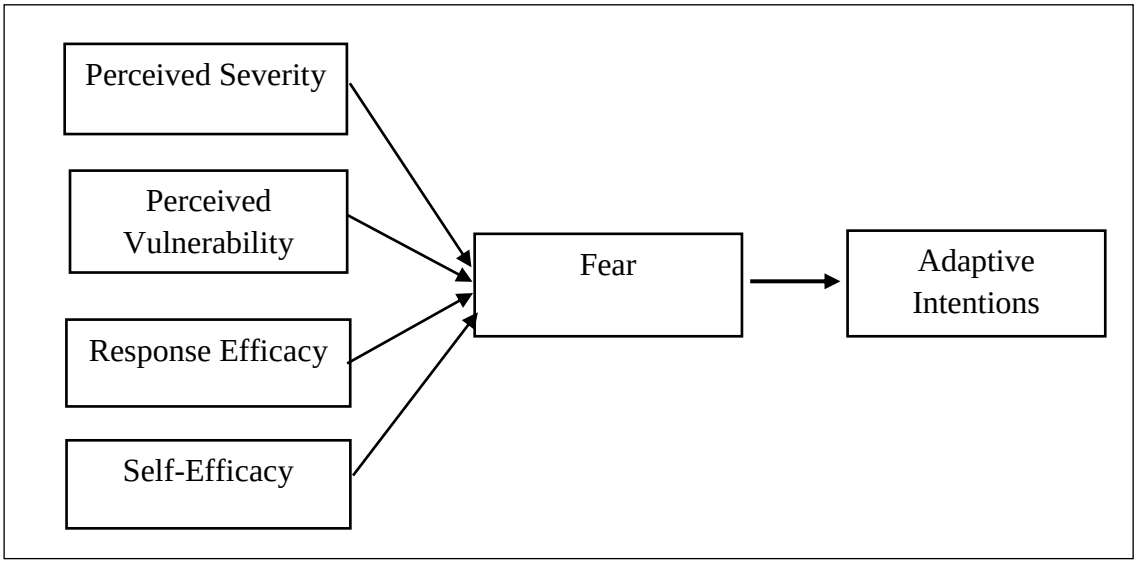


Figure 1: Protection Motivation Theory

Source: Literature Review

2.2. Theory of Planned Behaviour

The theory of planned behaviour suggests that consumer attitudes, subjective norms, and perceived behaviour al control constitute behaviour al intention, which is further employed to directly predict behaviour (Ajzen, 1985 and Ajzen, 1991). The theoretical model of the TPB is applied to explain a wide range of intentions and behaviour s across research fields (Masud, *et al.* 2015; Yadav and Pathak, 2017), including studies related to the environment and climate change (Wang, 2019; Chen, 2016 and Niles, 2016).

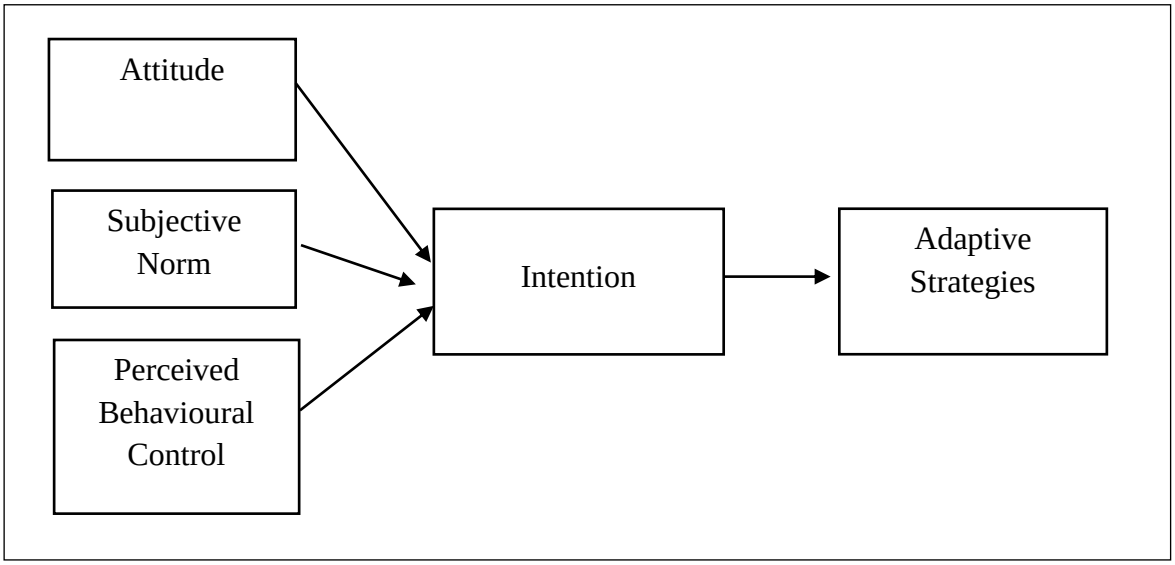


Figure 2: Theory of Planned Behaviour

Source: Literature Review

2.3. Conceptual Framework

Table 1: PMT and TPB Constructs and their Latent Variables

Constructs	Items defining constructs	Measurement Scale
Perceived Severity	1. Climate change affects the total production of agriculture. 2. Climate change affects the total productivity of agriculture. 3. Climate Change affects the quality of output produced.	5=Strongly Agree 1=Strongly Disagree
Perceived Vulnerability	1.Climate Change may affect the indigenous crop varieties 2. Climate Change may lead to soil infertility 3. Climate Change may increase crop diseases	5=Strongly Agree 1=Strongly Disagree
Response Efficacy	1. I believe adaptation to climate change will help me in reducing production losses 2. I believe adaptation to climate change will aid in eliminating crop failures 3. I believe adaptation to climate change will reduce vulnerability to climate-related agricultural risks and shocks.	5=Strongly Agree 1=Strongly Disagree
Self-Efficacy	1.I have the necessary knowledge to adapt to climate friendly strategies 2. I have the time and skills to apply climate-adaptive strategies 3.I have the economic capacity to apply adaptive strategies	5=Strongly Agree 1=Strongly Disagree
Fear	1. The decline in income from traditional agricultural activities and its impacts have made farming households vulnerable 2. I am afraid of a gradual decline in production due to not using climate-resistant agricultural practices 3. I am afraid of crop damage due to a lack of proper adaption to climate change	5= Strongly Agree 1= Strongly Disagree
Attitude	1. I believe climate change has compelled me to adopt various survival strategies. 2. I believe the impact of climate change has compelled me to choose new varieties for production. 3.I believe the sooner I adapt to climate-resistance farming, the higher the benefit	5=Strongly Agree 1=Strongly Disagree
Subjective Norm	1.I believe my loved ones will support my decision to cultivate climate-resistant crops 2. If I cultivate a new variety of rice due to the changing climate and sell it in the market, my loved ones will support my actions. 3. My family and friends believe that adapting to climate-resistance farming is a good survival strategy in today's agriculture.	5= Strongly Agree 1=Strongly Disagree
Perceived Behavioural	1.I perceive that I can make effective decisions and earn a good income if I adapt effectively to	5=Strongly Agree 1=Strongly Disagree

Control	climate change 2.I perceive that I have adequate knowledge to adapt to climate-smart agriculture. 3. I perceive that I have sufficient capital to adapt to climate change by changing the selection of crops and farming techniques	
Adaptive Intention	1. I intend to adapt climate resistance cropping practices 2. I intend to adopt improved crop varieties. 3. I intend to adopt crop diversification. 4. I intend to adopts oil and water conservation strategies.	5=Strongly Agree 1=Strongly Disagree
Adaptive Strategies	1.Crop Diversification 2. Improved crop variety 3.Climate-resilient cropping practices	5=Strongly Agree 1=Strongly Disagree

Source: Author's compilation

2.4. Hypotheses Development

The hypotheses developed for the study are as follows:

H1: Perceived Severity is significantly associated with the fear of farmers.

H2: Perceived Vulnerability is significantly associated with the fear of farmers.

H3: Response efficacy is significantly associated with the fear of farmers.

H4: Self-efficacy is significantly associated with the fear of farmers

H5: Fear is significantly associated with the adaptive strategies of farmers

H6: Attitude toward climate change is significantly associated with the adaptive intention of farmers.

H7: Subjective Norms toward climate change are significantly associated with the adaptive intention of farmers.

H8: Perceived Behavioural Control toward climate change is significantly associated with the adaptive intention of farmers.

H9: Adaptive Intention is significantly associated with the adaptive strategies of farmers.

3. Materials And Methods

3.1. Study Design

This research used a cross-sectional, quantitative survey design to examine farmers' climate-adaptation behaviour through an integrated Protection Motivation Theory (PMT) and Theory of Planned Behaviour (TPB) framework. PMT explains how threat appraisal and coping appraisal shape protection motivation (Rogers, 1975). TPB explains how attitude, subjective norms, and perceived behaviour al control shape intention, which then predicts behaviour (Ajzen, 1991).

3.2. Study Area and Population

The study was conducted in the Upper Brahmaputra Valley Zone (India) agro-climatic zone comprising Tinsukia, Dibrugarh, Sivasagar, Jorhat and Golaghat targeted farmers actively involved in farming

decisions. The population included farming households exposed to climate variability and related production risks, making the zone appropriate for examining behaviour al drivers of adaptation strategies.

3.3. Sampling and Data

Respondents were selected from the study area using field-based sampling at village/community level (as operationally feasible). A total of 280 farmers were selected for the study. Data were collected through a structured questionnaire administered directly to farmers to ensure clarity of questions and reduce non-response and misunderstanding common in rural survey contexts. Participation was voluntary, and responses were recorded anonymously to protect confidentiality.

3.4. Research Instrument and Measures

The questionnaire measured latent constructs from PMT and TPB using multi-item Likert-type scales. PMT constructs included Perceived Severity (PS), Perceived Vulnerability (PV), Response Efficacy (RE), Self-Efficacy (SE) and Fear (F), while TPB constructs included Attitude (AT), Subjective Norm (SN), Perceived Behaviour al Control (PBC), leading to Adaptive Intention (AI) and Adaptive Strategies (AS). The combined framework is consistent with the original PMT proposition (Rogers, 1975) and TPB's intention-based mechanism (Ajzen, 1991).

3.5. Reliability and Validity Assessment

Internal consistency was assessed using Cronbach's alpha for each construct. To confirm that the dataset was appropriate for factor-based modelling, the study used Kaiser–Meyer–Olkin (KMO) and Bartlett's Test of Sphericity, which are standard checks for sample adequacy and factorability prior to confirmatory analysis.

3.6. Measurement Model

A Confirmatory Factor Analysis (CFA) was conducted to validate the measurement model (items → constructs). The study retained indicators with acceptable standardized loadings (commonly ≥ 0.50, and ideally higher), consistent with widely used CFA reporting guidance. Model fit was evaluated using multiple indices rather than a single statistic, following established guidance that a two-index strategy and cut-offs such as CFI/TLI near 0.95 and RMSEA near 0.06 provide evidence of good fit (Hu & Bentler, 1999).

After establishing acceptable measurement validity, the study tested the structural paths linking PMT and TPB constructs. The analysis followed the recommended two-step SEM approach: first validate the measurement model using CFA, then test the structural relationships among latent variables (Anderson & Gerbing, 1988). Hypotheses were evaluated using standardized path estimates and statistical significance.

4. Results

4.1. Reliability Analysis

The factors namely perceived usefulness, perceived ease of use, subjective norms, and perceived behaviour control are composed of three variables, and the factors attitude, intention, and behaviour have four variables. The greater the value of alpha, the better the internal consistency of the variables is determined. Table 2 indicates that the Cronbach alpha ranges from 0.607 to 0.828 indicating a satisfactory internal consistency.

Table 2: Results of Reliability Analysis

Factor name	Variables/items	Cronbach Alpha	Mean
Perceived Severity	3	.607	4.328
Perceived Vulnerability	3	.774	4.120
Response-Efficacy	3	.701	4.010
Self-Efficacy	3	.651	4.410
Attitude	3	.797	4.102
Subjective Norms	3	.828	3.706
Perceived behaviour al control	3	.777	4.208
Adaptive Intention	4	.877	4.266
Adaptive Strategies	3	.824	3.906

Source: Author's compilation

4.2. Suitability analysis

The Variance in the Variable is determined by KMO measures of Sample Adequacy. The test showed a result of 0.914 (> 0.50), indicating that the data is eligible for factor analysis and is significant at 1%.

Table 3: Suitability Test

KMO		0.914
Bartlett's Test of Sphericity	Approx. Chi-Square	11941.212
	Df	276
	Sig.	0.000

Source: Author's compilation

4.3. Confirmatory Factor Analysis

CFA measures the quality of all latent constructs employed in the development of a structural equation model. The factor loadings of the latent variable are given in table 4 below:

Table 4: Factor Loadings of the Latent Variable

Constructs	Code	Items defining constructs	Factor loadings
Perceived Severity	PS1	Climate change affects the total production of agriculture.	0.75
	PS2	Climate change affects the total productivity of agriculture.	0.72

	PS3	Climate Change affects the quality of output produced.	0.68
Perceived Vulnerability	PV1	Climate Change may affect the indigenous crop varieties	0.78
	PV2	2. Climate Change may lead to soil infertility	0.74
	PV3	3. Climate Change may increase crop diseases	0.75
Response Efficacy	RE1	I believe adaptation to climate change will help me in reducing production losses	0.82
	RE2	I believe adaptation to climate change will aid in eliminating crop failures	0.77
	RE3	I believe adaptation to climate change will reduce vulnerability to climate-related agricultural risks and shocks.	0.80
Self-Efficacy	SE1	I have the necessary knowledge to adapt to climate-friendly strategies	0.84
	SE2	I have the time and skills to apply climate-adaptive strategies	0.79
	SE3	I have the economic capacity to apply adaptive strategies	0.76
Fear	F1	The decline in income from traditional agricultural activities and its impacts have made farming households vulnerable	0.72
	F2	I am afraid of a gradual decline in production due to not using climate-resistant agricultural practices	0.77
	F3	I am afraid of crop damage due to a lack of proper adaption to climate change	0.74
Attitude	AT1	I believe climate change has compelled me to adopt various survival strategies.	0.81
	AT2	I believe the impact of climate change has compelled me to choose new varieties for production.	0.78
	AT3	I believe the sooner I adapt to climate-resistance farming, the higher the benefit	0.76
Subjective Norm	SN1	I believe my loved ones will support my decision to cultivate climate-resistant crops	0.79
	SN2	If I cultivate a new variety of rice due to the changing climate and sell it in the market, my loved ones will support my actions.	0.75
	SN3	My family and friends believe that adapting to climate-resistance farming is a good survival strategy in today's agriculture.	0.77
Perceived Behavioural Control	PBC1	I perceive that I can make effective decisions and earn a good income if I adapt effectively to climate change	0.82
	PBC2	I perceive that I have adequate knowledge to adapt to climate-smart agriculture.	0.78
	PBC3	I perceive that I have sufficient capital to adapt to climate change by changing the selection of crops and farming techniques	0.74
Adaptive Intention	AI1	I intend to adapt climate resistance cropping practices	0.86
		I intend to adopt improved crop varieties.	
	AI2	I intend to adopt soil and water conservation strategies	0.83
	AI3		0.81

Adaptive Strategies	AS1	Crop Diversification	0.80
	AS2	Improved crop variety	0.78
	AS3	Climate-resilient cropping practices	0.82

Source: Author's compilation

It is observed that the factor loadings of observed items are acceptable, ranging between 0.70 and 0.90. The observed variable's factor loadings or regression estimations should be greater than 0.50. This indicates that each construct satisfies further analysis.

4.4. Model Conformity Fit

Table 4 depicts that all model fit statistics show a satisfactory fit and as a result, the model is accepted to predict the objectives of the study.

Table 5: Model Conformity Fit Indices

Indices of fit	Value
Chi-square	0.0652
GFI	0.972
RMSEA	0.036
CFI	0.951
TLI	0.921

Source: Author's compilation

4.5. Application of PMT and TPB

Table 6: Structural (path) relationships in the integrated PMT–TPB model

Path ID	From (Latent)	→	To (Latent)	Hypothesis	Expected Sign
P1	Perceived Severity (PS)	→	Attitude (AT)	H1	+
P2	Perceived Vulnerability (PV)	→	Attitude (AT)	H2	+
P3	Response Efficacy (RE)	→	Attitude (AT)	H3	+
P4	Self-Efficacy (SE)	→	Attitude (AT)	H4	+
P5	Self-Efficacy (SE)	→	PBC	H5	+
P6	Attitude (AT)	→	Adaptive Intention (AI)	H6	+
P7	Subjective Norm (SN)	→	Adaptive Intention (AI)	H7	+
P8	PBC	→	Adaptive Intention (AI)	H8	+
P9	Adaptive Intention (AI)	→	Adaptive Strategies (AS)	H9	+

Source: Author's compilation

Table 6 summarizes the structural (path) relationships in the integrated PMT–TPB model and indicates the expected direction of influence among the latent constructs. The first block of paths (P1–P5) captures how PMT appraisals shape the key TPB antecedents: higher perceived severity (PS) and perceived vulnerability (PV) are expected to strengthen attitude (AT) toward adopting adaptation actions because individuals who

view the threat as serious and personally relevant are more likely to evaluate protective behaviour favorably. Similarly, stronger coping appraisal through response efficacy (RE) and self-efficacy (SE) is expected to increase positive attitude and perceived control over adaptation. This aligns with PMT's central logic that protection motivation increases when threat appraisal and coping appraisal are high. The second block (P6–P10) follows the TPB mechanism, where attitude, subjective norm (SN), and perceived behaviour al control (PBC) jointly predict adaptive intention (AI), and intention predicts adaptive strategies/behaviour (AS); TPB also allows PBC to directly influence behaviour when real-world constraints exist.

5. Discussion

The present study highlights farmers' adaptive strategies are influenced by both climate risk perception and behavioural intention. Farmers' perception of climate change as a threat to production, productivity, crop quality indigenous varieties, crop yield, soil fertility highlights the importance of perceived severity and perceived vulnerability in adaptation behaviour. These findings are similar to prior studies which observed that an adaptation decision is influenced by risk perception and perceived capacity to adapt (Grothmann & Patt, 2005; Dang *et al.*, 2014). Recent studies further support these findings by demonstrating perceived climate risk, knowledge, time, skill and confidence in adaptation measures influences a farmers' positive intention to adapt (Lamichhane *et al.*, 2022; Purwanti *et al.*, 2023). The present study is found to be similar to findings that report farmers' intention and adoption to climate adaptive strategies are influenced by behaviour and farm level factors, ultimately supporting The Theory of Planned Behaviour (Niles *et al.* 2016) and Protection Motivation Theory (Huang *et al.*, 2024; Song *et al.*, 2025). Thus, the present study is an effort to show that, farmers' climate adaptive intentions and strategies is not only a technical response but a behavioural process explained through the integrated PMT-TPB framework.

6. Conclusion and Future Scope

The study demonstrates that an integrated PMT–TPB framework is suitable for explaining farmers' climate adaptation behaviour in the Upper Brahmaputra Valley Zone. Measurement results confirm that the constructs used to represent threat appraisal, intention formation, and adaptive strategies are reliable and valid: Cronbach's alpha values are largely acceptable, the dataset is highly suitable for factor analysis (KMO = 0.914), CFA loadings are above minimum thresholds, and global fit indices indicate a satisfactory model fit. These findings support the practical conclusion that adaptation behaviour is best promoted through a combined strategy: improving farmers' perception of climate risks (severity and vulnerability), strengthening beliefs that adaptation actions are effective (response efficacy), increasing farmers' capacity and confidence to act (self-efficacy and perceived control), and reinforcing supportive social norms.

The study also emphasises on future scope for further research like instead of collecting data only once, researchers can track the same farmers across two or more cropping seasons to check whether intention really turns into actual adaptation behaviour over time. Second, the model can include response cost (money,

labor, time, input availability) because PMT highlights that even when farmers feel at risk and believe adaptation works, high costs can still stop adoption. Third, future studies can run multi-group analysis (e.g., small vs. large farmers, male vs. female, high vs. low exposure areas) to see whether the same pathways work equally for different groups, which helps make policies more targeted.

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