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The Adaptation Behaviour of Marine Fishermen towards Climate Change and Food Security: An Application of the Theory of Planned Behaviour and Health Belief Model

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Abstract: Key food production sectors, such as fisheries, are predicted to be severely impacted by climate change, which threatens food security. Owing to the direct influence of climate change on the lives and means of livelihood of marine fishing communities, effective adaptation methods are required to ensure the well-being of coastal communities. Thus, the goal of this study is to examine the various factors that impact the adaptation behaviour of marine fishermen towards climate change. To this end, data were collected from 312 Bangladeshi fishermen using survey questionnaires and subsequently analysed by employing partial least square structural equation modelling (PLS-SEM). Our findings reveal a significant and positive association between all components (perceived severity, perceived benefit and perceived barrier) of the Health Belief Model (HBM) and marine fishermen's adaptation behaviour. However, the perceived susceptibility component of the HBM had no effect on the climate change adaption behaviour of marine fishermen. Likewise, the findings indicate that awareness influences attitude, which in turn impacts the adaption behaviour of marine fishermen. Furthermore, the study results establish the indirect mediating role of awareness and attitude with respect to the adaptation behaviour of marine fishers. The findings of this study can be adopted by policymakers to develop adaptation strategies to aid marine fishermen in adapting to climatic effects. Furthermore, the various responses of marine fishermen to climate change will also serve as a useful source of information for the government. In summary, the information generated from this research can serve as a practical basis to foster adaptation behaviour among marine fishers and advance adaptation policies at the national level, not only in Bangladesh but also for other coastal communities that are at risk as a result of climate change.

Keywords: climate change; food security; adaptation behaviour; marine fishermen; Bangladesh

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1. Introduction

Fisheries and associated industries play important roles in the social and economic development of a country. In particular, they provide employment to many people and contribute to food security, as well as the well-being of marine and inland ecosystems [1,2]. Fishery products are crucial to the survival of coastal populations, especially in the tropical region, where people rely on them for food, subsistence, cultural development and economic growth [3–5]. However, the fishery sector is influenced by climate change [6–9], as well as its accompanying weather consequences, thus threatening the livelihoods of

fishing communities [10]. The significant and varied impact of the changing climate has forced communities, particularly marine fishermen, to undertake significant adaptation strategies [11]. However, communities of small-scale marine fishermen in South Asia are especially vulnerable, owing to their limited ability to adjust to the adverse effects of climate change [12]. Climate change adaptation remains one of the most serious challenges confronting coastal communities [13]. Generally, individual beliefs, social norms, attitudes and cognitive preferences influence adaptation behaviour of individuals [14]. Consequently, there are distinct risks of climate change, irrespective of countries, regions or groups, as a result of the varied backgrounds of physical geography and human geography [15]. Thus, adaptation behaviour varies according to the situation and changes over time between geographies and within communities [16,17].

Climate change is a scientific and social concern [18] warranting the deployment of effective adaptation strategies. Numerous studies have been undertaken to identify the various factors influencing adaptation behaviour in different parts of the world. Most of these studies have focused on climate change adaptation among farmers on global and local scales [19–25]. Only a few researchers [26–28] have examined the various factors affecting the individual adaptation of fishermen to climate change. However, a quantitative investigation of the critical components influencing adaptive behaviour in response to climatically associated threats is still required to gain a holistic and thorough understanding of the various determinants of adaptation behaviour [29], particularly in the context of a developing economy, such as that of Bangladesh, which lacks sufficient research data in this area. A review of the available empirical literature on adaptation towards climate change in Bangladesh revealed that most studies conducted to date [30–39] have concentrated on agriculture, agricultural farmers and coastal shrimp farmers. Moreover, the bulk of empirical research [40–53] has examined the perception, barriers and social components of the adaptation of marine fishermen and coastal communities in Bangladesh. However, a few thorough empirical studies have been conducted on how families of marine fishermen perceive climatic variability and change, how their perceptions relate to their awareness and attitudes and how these factors eventually affect the manner in which they act in terms of adaptation. Therefore, the aim of the current study is to bridge this research gap by investigating the factors that influence the adaptation behaviour of marine fishermen in Bangladesh with response to climate change.

2. Literature Review and Hypothesis Development

Several conceptual models have been developed by social and behavioural researchers to help explain the variables that impact the environmental decision-making process of individuals [54]. Ajzen established the theory of planned behaviour (TPB), which asserts that attitudes, subjective norms and perceived behavioural controls affect behavioural intentions [55]. Therefore, researchers may incorporate this theory into their investigations to predict and promote human behaviour with favourable outcomes [56,57]. Many researchers [58–63] have indicated that the attitude of farmers is favourably related to their intentions, suggesting that the TPB may also be used to study the adaptation behaviour of marine fishermen. According to El-Deeb et al. [64], under the effect of environmental changes, people's behaviour may reflect an intent to adapt to their environment or a desire to change it. The stages of changes, TPB, the health belief model (HBM) and the health action process approach (HAPA) are just a few of the theoretical frameworks and concepts that have been established and applied in recent years to help explain the various factors influencing the attitudes and behaviours of individuals. Existing literature indicates that the HBM has long been used to explore a wide range of farmers' intentions and behaviours. To the best of our knowledge, no study has utilized the HBM model to analyse the factors impacting the adaptation behaviour of marine fishermen in Bangladesh. With the current study, we intend to bridge this gap by examining the factors influencing the climate-change-related adaptation behaviour of Bangladeshi marine fishermen using the TPB and HBM.

2.1. Perceived Susceptibility and Adaptation Behaviour

Perceived susceptibility, as a component of HBM, is defined as an individual's subjective perception of the possibility of becoming involved in a negative situation as a consequence of engaging in a specific behaviour [65]. Generally, an individual's impression of their vulnerability to certain conditions, e.g., climate change, is regarded as their perception of susceptibility [66]. Sea level rise, changes in the frequency and severity of natural disasters, such as storms and cyclones, increases in sea surface temperature and many other factors have an impact on coastal communities as a consequence of climate change, exposing them to increased risk [67]. For example, strong weather discourages fishermen from venturing out to sea, whereas extreme winds and massive waves endanger islanders and the entire coastal population [68]. Additionally, it has been discovered that an individual's perception of risk significantly affects their likelihood to exhibit certain pro-environmental behaviours [69], leading to the proposition of the following hypothesis:

H1. *Perceived susceptibility significantly influences adaptation behaviour.*

2.2. Perceived Severity and Adaptation Behaviour

"Perceived severity" refers to the extent to which an individual feels that the consequences of their actions will affect their welfare, such as health [70,71]. Generally, perceived severity is a theoretical belief about the extent of an individual's loss associated with a given behaviour, i.e., how much threat is involved in the adoption of a particular behaviour [71]. Ever-changing climatic conditions are expected to be consequential to islanders who rely on the fishing and tourism sectors for their means of livelihood [68]. For instance, winds and waves could cause damage to homes and public infrastructure in coastal areas and make fishing difficult [26]. As a result, the following hypothesis was proposed:

H2. *Perceived severity significantly influences adaptation behaviour.*

2.3. Perceived Benefit and Adaptation Behaviour

A person's perception that a given action might lessen their likelihood of suffering from the unfavourable effects of threats is referred to as "perceived benefits" [70]. An individual's ability to engage in behaviours that result in adaptation depends on incentives, their cognitive and behavioural preferences and the extent to which they perceive threats from changing environmental situations [72]. When an individual feels that a given behaviour will make them less susceptible to a negative outcome, they are more likely to persist in that behaviour [73]. Therefore, stakeholders are anticipated to endorse and abide by policies that are beneficial to the community and geographically suitable [74,75]. Moreover, various stakeholder groups, such as fishermen, managers and travel industry workers, have differing opinions regarding the benefits and expenses of various adaptation practices [76,77]. Consequently, the following hypothesis was postulated:

H3. *Perceived benefit significantly influences adaptation behaviour*.

2.4. Perceived Barriers and Adaptation Behaviour

The term "perceived barriers" is defined as the manner in which an individual perceives the difficulties they could experience as a result of their engagement in a given behaviour [65]. Barriers vary depending on context and normative judgments [78], implying that an individual may confront a range of barriers, including financial and societal constraints, when they work to improve their environment [79]. Barriers unquestionably diminish the effectiveness of adaptation techniques and complicate the development and implementation adaptation mechanisms [80], leading to the postulation of our fourth hypothesis as follows:

H4. *Perceived barriers significantly negatively influence adaptation behaviour*.

2.5. Awareness and Attitudes

Awareness is a significant variable that affects the degree of environmental commitment. Extreme weather conditions make it difficult for fishermen to execute their daily operations, forcing them to struggle with the deteriorating quality and quantity of ocean resources accompanying temperature increases [81,82]. Capacity for adaptation provides a coping mechanism for the marine fishing community in response to an unpredictable future by curbing the negative effects of climate change [83]. To help households and communities deal with the various effects of climate change, it is essential to increase awareness of the phenomenon [84]. People who are aware of the severe implications of climate change are more willing to personally support governmental initiatives, even if it involves making sacrifices [85]. In addition, it was discovered that farmers who were aware of how climate change might affect agriculture had a more favourable attitude towards adaptive management techniques [86]. Furthermore, household awareness promotes the development and adaptation of alternative strategies, which can lead to decreased susceptibility and improved livelihood opportunities [87–89]. Moreover, awareness is a vital component of problem diagnosis, which fosters the development of acceptable environmental attitudes [90]; through an understanding of the problem, a positive attitude towards climate change can be encouraged [79]. Effective adaptation enables marine fishing communities to prepare reactively and proactively in response to the expected consequences of a changing climate [10]. Therefore, it is possible to infer that awareness, perception and attitudes towards behaviours can contribute to adaptation behaviour [79]. Based on the abovementioned literature, the following hypothesis was developed:

H5. *Awareness of climate change significantly influences attitudes towards climate change.*

2.6. The Mediating Effects of Awareness and Attitude towards Adaptation Behaviour

The views of fishers on the impact of and vulnerability to climate change are critical in making fishery-related decisions that promote resilience or social adaptation capacity against climate change [41,91,92]. Perceived threat, a potential driver of pro-environmental behaviour [93], is an outcome of the perception of severity and susceptibility [70,71]. Studies have shown that larger shifts in attitudes are related to increased anxiety and the perceived intensity of threat to an individual's means of livelihood [94–96]. Consequently, climate change awareness, knowledge and risk perception influence the development of favourable attitudes with respect to climatic change [97]. Therefore, fishermen must be properly enlightened and informed about climate change, given its potential negative effects on their socioeconomic operations [98]. Fishermen's awareness of the severe consequences of climate change drives them to appreciate their environment and propel their leadership in the conservation of natural resources [99]. Environmental attitudes are positively and significantly influenced by awareness of the threats caused environmental problems [97,100]. According to the theory of planned behaviour, attitude is a significant predictor of behaviour. Bayard and Jolly [66] highlighted that awareness and attitudes towards environmental challenges are influenced by awareness of susceptibility and that a stronger perception of farmers' vulnerability to soil degradation affects their awareness and attitudes towards the environment. Researchers [66,79,101] have reported the mediation effects of awareness and attitude on the relationship between perception and adaptation behaviours. Consequently, the following hypothesis was postulated:

H6. *Awareness plays a significant mediating role in the relationship between perceived susceptibility and adaptation behaviour.*

H7. *Awareness plays a significant mediating role in the relationship between perceived severity and adaptation behaviour.*

H8. *Awareness plays a significant mediating role in the relationship between perceived benefit and adaptation behaviour.*

H9. *Awareness plays a significant mediating role in the relationship between perceived barriers and adaptation behaviour.*

H10. *Attitude plays a significant mediating role in the relationship between perceived susceptibility and adaptation behaviour.*

H11. *Attitude plays a significant mediating role in the relationship between perceived severity and adaptation behaviour.*

H12. *Attitude plays a significant mediating role in the relationship between perceived benefit and adaptation behaviour.*

H13. *Attitude plays a significant mediating role in the relationship between perceived barriers and adaptation behaviour.*

2.7. Research Framework

Based on the comprehensive literature review highlighted above, we developed the proposed research model shown in Figure 1, which demonstrates the impact of perceived severity, susceptibility, benefits and barriers on awareness, attitudes and adaptation behaviour. The proposed model was developed based on the HBM and TPB to help explore the various factors influencing the adaptation behaviour of marine fishermen across two fishing villages in Bangladesh.

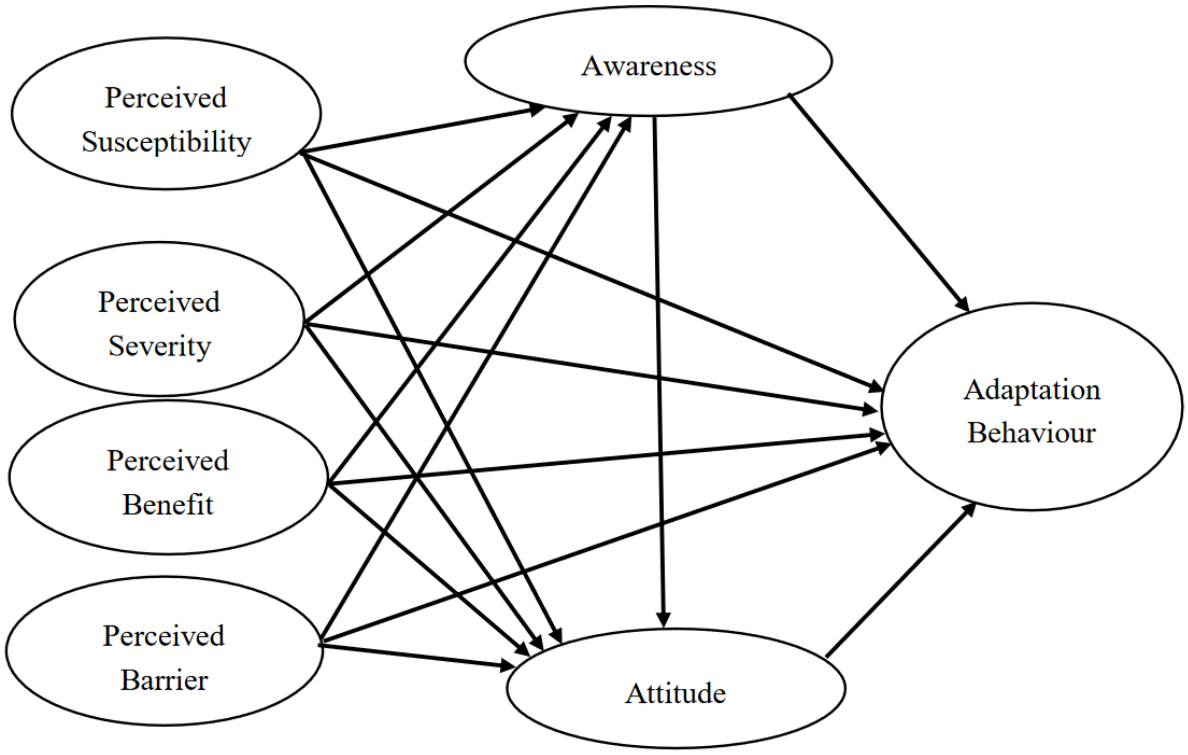

Figure 1. Proposed research model.

3. Research Methods

3.1. Questionnaire Design

The research was conducted at the Gabura (Dumuria village) and Jahajmara (Jahajmara village) Unions of the Shyamnagar and Hatiya Upazilas of the Shatkhira and Noakhali Districts, respectively (See Figure 2). These two Unions are islands off Bangladesh's southeast and southwest coasts, respectively. As a survey is the only effective method to reach large population sizes and to allow for collection of data with high representativeness, in this study, we employed a quantitative research approach using a questionnaire survey.

Given the respondents' literacy level, language variables and the remoteness of the survey locations, a face-to-face survey was deemed appropriate for the acquisition of data in this study [41]. The survey questionnaire was developed based on previously conducted studies and consisted of two parts; part one comprised the demographic information of respondents and factors relating to the vulnerability with respect to their means of livelihood, and the second part included HBM components, marine fishermen's awareness, attitudes and adaptation behaviours. Because a Likert scale of 5 or 7 points was sufficient to provide a statistically valid measurement [102], the constructs for this study were graded using 5-point Likert scales, ranging from 1 (strongly disagree) to 5 (strongly agree).

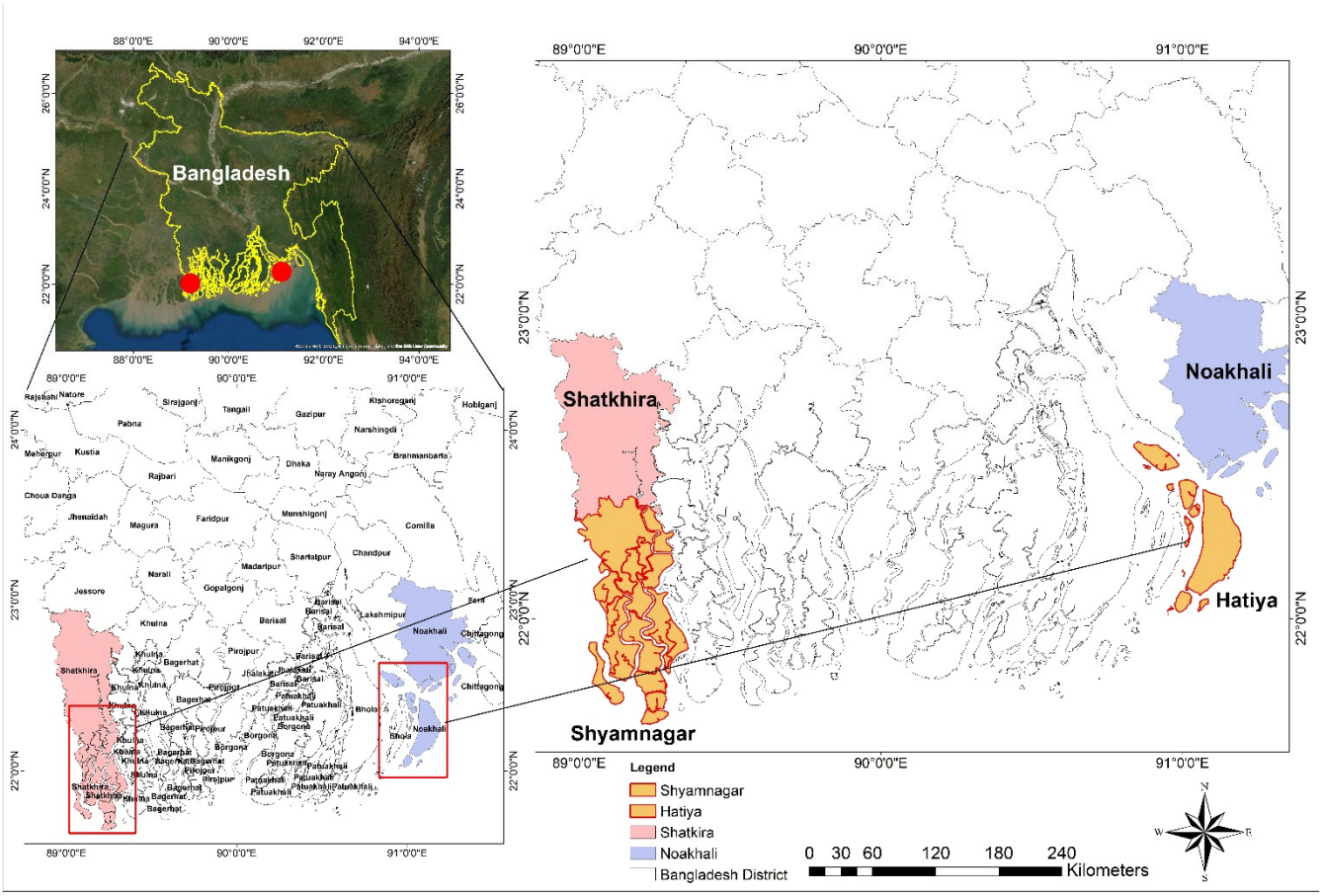

Figure 2. Location of the study areas.

3.2. Sample Size, Sampling Technique and Data Collection

The target respondents of this research were coastal and/or brackish water fishermen, with lists of prospective respondents obtained from concerned fisheries officers. A sample size of 312 was calculated, in line with the study conducted by Krejcie and Morgan [103]. In this survey, respondents were stratified by two coastal villages and selected at random. Before the formal survey was conducted, a presurvey and pilot test was undertaken to confirm the sufficiency of the information, as well as comprehensibility of the questions. To enhance the validity and reliability of the research, several inappropriate questions were removed, and the language and meanings of the questionnaire were modified or amended based on the responses of the interviewees. Following the finalization of the survey questionnaires in 2021, fieldwork research was conducted over a five-month period (April to August). The fieldwork research took longer than expected owing to the country's partial lockdown in response to the COVID-19 pandemic, as well as adverse weather conditions. Personal interviews and distributed questionnaires were deployed to gather

data, and respondents of interest were the heads of households who engaged in marine fishing. The data collected in this research were abnormally distributed, and the sample size was small. However, Hair et al. [104] noted that the PLS-SEM is a better approach for non-normal data and small sample sizes. Therefore, the PLS-SEM, a multidimensional statistical approach for estimation and analysis of the causal relationships between variables in a model, was used to evaluate the research hypotheses (Figure 3).

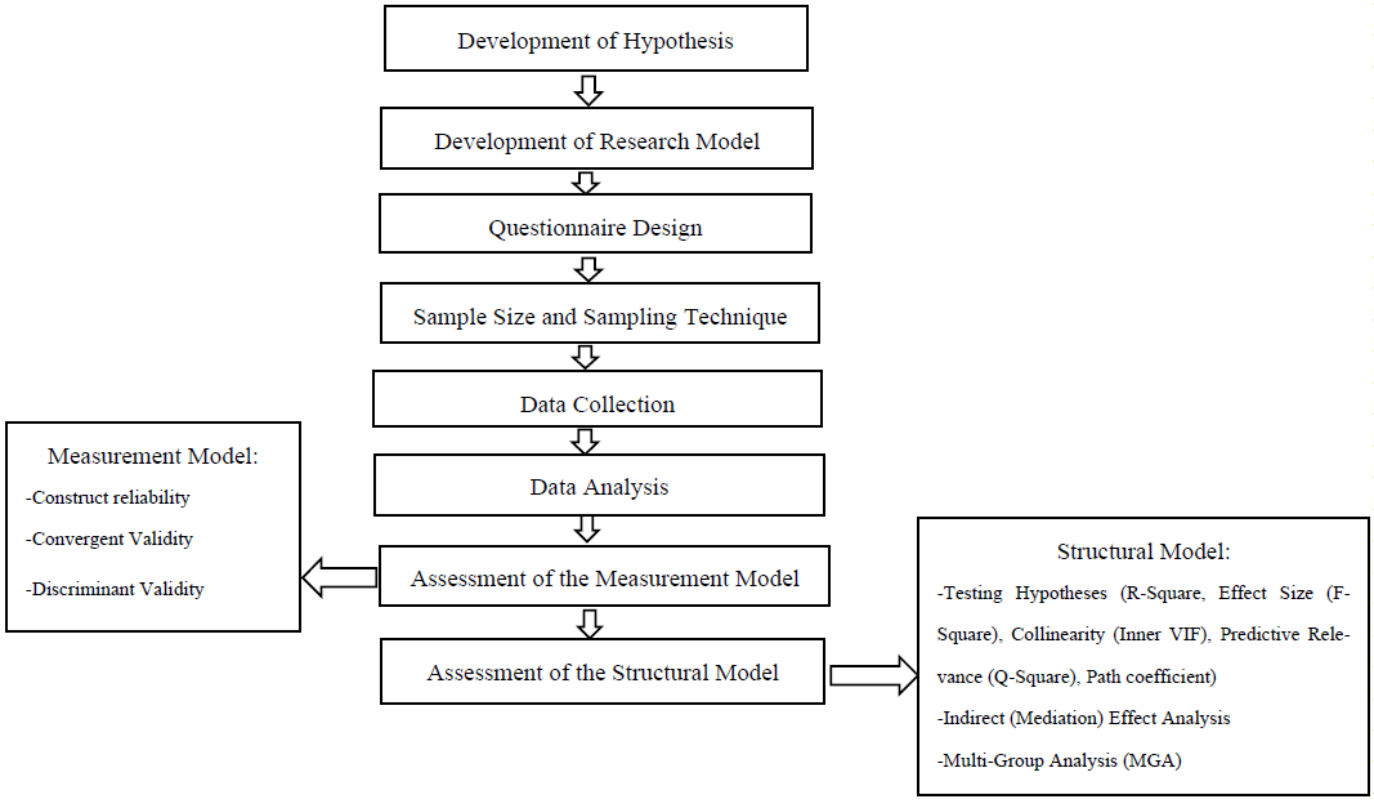

Figure 3. Flow chart of the research methodology.

4. Results

4.1. Demographic Characteristics of Marine Fishermen

The descriptive findings of this study revealed that sample consisted of 302 household-head fishermen (96.5%) and 10 household-head fisherwomen (3.2%). Of the respondents, 269 (85.9%) and 43 (13.3%) were full-time and part-time fishermen, respectively, and the majority (82.7%) of the participants had at least 10 years of fishing experience. Most of the fishermen (74.8%) were younger than 50 years of age. In terms of education level, a large percent of the respondents (70.3%) had no formal education, 18.8% had elementary education, 8.9% had secondary education, 1.0% had a higher secondary degree and 0.6% had a bachelor's degree. As displayed in Table 1, 86.9% of the surveyed fishermen had no technical skills, such as driving, mechanics or other trades, apart from fishing that may be used to augment their income during the off season.

Table 1. Demographic profile of the respondents.

Variable	Frequency	%
Gender		
Male	302	96.5
Female	10	3.2
Full-time/Part-time		
Full-time fishers	269	85.9
Part-time fishers	43	13.7
Marital Status		
Married	301	96.2
Unmarried	7	2.2
Others	4	1.3
Fishing experience (years)		
1–10	53	16.9
11–20	143	45.7
21–30	79	25.2
31–40	26	8.3
41–50	10	3.2
51–60	1	0.3
Household head is <50 years old		
Yes	234	74.8
No	77	24.6
Education Level		
No formal education	220	70.3
Primary	59	18.8
Secondary	3	1.0
Higher secondary	28	8.9
Bachelor's degree	2	0.6
Technical Skills		
Yes	40	12.8
No	272	86.9

4.2. Assessment of the Measurement Model

The PLS-SEM technique involves two steps, the first being the measurement model. To determine the internal consistency of the measurement items, factor loadings were computed in this study. Table 2 demonstrates that all item loadings, except item 39, attained the suggested value of 0.70 [104].

Table 2. Outer loadings of the measurement model.

Item	Measurement Item	Outer Loading
	Adaptation Behaviour/Strategies	
1	I change fishing gear and use more nets frequently	0.815
2	I change target species and do not catch smaller fish	0.796
3	I shift fishing time and fishing for a longer period (even during cyclones)	0.789
4	I change fishing grounds very often through navigation	0.815
5	I am keen to explore new areas to increase my catch	0.793
6	I like to use fisheries technology, as it significantly helps my fishing activities	0.790
7	I am increasing aquaculture farming	0.754
8	I support migration to other places away from my villages for better work opportunities	0.724
	Attitude towards climate change	
9	I am willing to know about the climate change issue	0.812
10	Climate change adaptation is important to me	0.749
11	Climate change affects fishermen's livelihoods	0.814
12	Climate change hampers coastal and marine fish production	0.728
13	Preservation of the coastal and marine environment is important to me	0.834
	Awareness about climate change	

Table 2. *Cont.*

Item	Measurement Item	Outer Loading
14	Climate change is happening	0.806
15	The rainfall pattern is changing	0.739
16	Temperature is changing	0.802
17	I am aware that climate change is a major threat to coastal and marine fish	0.790
18	I am aware that climate change affects the coastal and marine fisheries sector	0.785
	Perceived susceptibility to climate change	
19	The frequency and intensity of typhoon and cyclone is increasing	0.788
20	Fish catches are reducing	0.778
21	Fish size is decreasing	0.757
22	Water quality is dropping	0.823
23	Fish landing sites are being damaged	0.825
24	Spending more time to find commercially important fish species owing to the movement of fishing ground	0.716
25	Decrease in the number of fishing days due to extreme weather conditions	0.803
26	Increase job uncertainties due to climate change effects	0.749
27	Increased number of bycatch (non-target species)	0.848
28	Decrease income level from fisheries	0.805
	Perceived severity of climate change	
29	The coastal and marine fisheries sector is mostly affected by climate change	0.793
30	Climate change can cause coastal and marine water pollution	0.841
31	I believe that climate change is extremely dangerous and can seriously put fishermen's health at risk	0.830
32	There is no early-warning system for extreme weather conditions	0.764
33	There is no weather information station in fishing harbours	0.815
	Perceived benefits of adaptation	
34	Good adaptation practices can lead to an increase in fish production	0.805
35	The living standard of fishermen will improve	0.779
36	Adaptation will reduce the adverse effect of climate change on coastal and marine fisheries sectors	0.800
37	Preparation for climate change can save our lives	0.808
38	Fishermen may receive special financial benefits and incentives	0.772
	Perceived Barrier	
39	Absence of radio signal and inaccurate cyclone forecast	0.638
40	Lack of safety equipment and navigational instruments	0.808
41	Poor quality boats and engines	0.799
42	Low incomes and lack of access to credit	0.752
43	Lack of skills and livelihood alternatives	0.826
44	Unpredictable weather	0.804
45	Limited access to fisheries extension officers	0.761
46	A high cost of adaptation measures	0.744

The reflective measurement model takes two factors (convergent validity and discriminant validity) into account to determine the extent to which items are represented in the constructs [105]. A set of observed variables that precisely represents the underlying theoretical notion is known as convergent validity [106]. The average variance extracted (AVE), a popular approach, was employed in this research to calculate the convergent validity [106–108]. The AVE value of each latent variable is presented in Table 3, exceeding an average of 0.5 (50%), indicating that each construct is capable of accounting for more than half of the variance in its measuring items [105]. Table 3 also highlights the Cronbach's alpha as being greater than 0.7 [109] and the composite reliability as being greater than 0.70 [110], establishing the reliability and validity of the constructs.

Table 3. Construct validity and reliability results.

Variable	Cronbach's Alpha	Composite Reliability	AVE
Adaptation behaviour	0.911	0.928	0.616
Attitude	0.847	0.891	0.622
Awareness	0.844	0.889	0.616
Perceived barriers	0.902	0.920	0.591
Perceived benefit	0.852	0.894	0.629
Perceived severity	0.868	0.905	0.655
Perceived susceptibility	0.933	0.943	0.624

Notes: AVE: average variance extracted; CR: composite reliability; CA: Cronbach's alpha.

Discriminant validity defines the extent to which a construct differs from the other constructs. In this research, we employed three methods to determine the discriminant validity, with Fornell and Larcker [105] being the first criteria. In accordance with the Fornell and Larcker criteria, the values of the square root of the AVE of one construct must exceed the value of the intercorrelations between the constructs. As shown in Table 4, the square roots of the AVE values of all variables exceed their corresponding intercorrelation values.

Table 4. Discriminant validity: Fornell and Larcker criteria.

Construct	Adaptation Behaviour	Attitude	Awareness	Barriers	Benefit	Severity	Susceptibility
Adaptation Behaviour	0.785						
Attitude	0.454	0.810					
Awareness	0.514	0.492	0.785				
Perceived barriers	−0.078	−0.063	0.093	0.769			
Perceived benefit	0.577	0.126	0.478	0.123	0.793		
Perceived severity	0.190	0.057	0.212	0.069	0.132	0.809	
Perceived susceptibility	0.272	0.264	0.342	−0.123	0.241	−0.050	0.790

Notes: The diagonal is the square root of AVE values, and the off-diagonal values are the correlations between latent variables.

The second approach deployed for the assessment of the discriminant validity is the cross-loading matrix. According to this approach, cross loadings with other constructs must be lower than item loadings with their own construct to confirm discriminant validity [104]. The findings of the current research (as shown in Table 5) confirm the discriminant validity.

Table 5. Outer/factor loading with cross loadings.

Items	Adaptation Behaviour	Attitude	Awareness	Barriers	Benefit	Severity	Susceptivility
Adaptation Behaviour 1	0.818	0.427	0.445	−0.070	0.496	0.129	0.241
Adaptation Behaviour 2	0.795	0.339	0.389	−0.083	0.480	0.163	0.213
Adaptation Behaviour 3	0.787	0.345	0.402	−0.085	0.457	0.204	0.226
Adaptation Behaviour 4	0.818	0.425	0.417	−0.064	0.483	0.126	0.235
Adaptation Behaviour 5	0.793	0.348	0.417	−0.081	0.484	0.188	0.222
Adaptation Behaviour 6	0.788	0.284	0.364	−0.032	0.443	0.132	0.188
Adaptation Behaviour 7	0.753	0.345	0.413	0.022	0.396	0.112	0.195
Adaptation Behaviour 8	0.722	0.316	0.373	−0.083	0.365	0.135	0.174
Attitude1	0.303	0.827	0.441	−0.040	0.105	0.022	0.209
Attitude2	0.321	0.770	0.409	−0.055	0.129	0.072	0.195
Attitude3	0.392	0.828	0.389	−0.038	0.090	0.080	0.279
Attitude4	0.384	0.779	0.335	−0.058	0.100	0.016	0.206
Attitude5	0.430	0.845	0.417	−0.064	0.089	0.041	0.183
Awareness1	0.373	0.455	0.808	0.067	0.360	0.151	0.282
Awareness2	0.382	0.364	0.739	0.016	0.408	0.204	0.267
Awareness3	0.430	0.380	0.802	0.140	0.385	0.141	0.308
Awareness4	0.398	0.340	0.789	0.106	0.352	0.189	0.245
Awareness5	0.431	0.386	0.783	0.034	0.369	0.149	0.238
Perceived barriers1	0.005	0.059	0.122	0.667	0.059	−0.013	−0.053
Perceived barriers2	−0.034	−0.051	0.050	0.785	0.091	0.036	−0.108
Perceived barriers3	−0.083	−0.077	0.075	0.802	0.121	0.033	−0.065
Perceived barriers4	−0.071	−0.058	0.073	0.778	0.070	0.044	−0.105
Perceived barriers5	−0.049	−0.072	0.033	0.801	0.087	0.081	−0.141
Perceived barriers6	−0.102	−0.032	0.065	0.803	0.091	0.045	−0.099
Perceived barriers7	−0.081	−0.090	0.049	0.755	0.062	0.131	−0.167
Perceived barriers8	−0.002	−0.001	0.131	0.754	0.175	0.034	−0.001
Perceived benefit1	0.484	0.123	0.380	0.071	0.803	0.068	0.188
Perceived Benefit2	0.480	0.071	0.359	0.055	0.780	0.117	0.153
Perceived benefit3	0.447	0.100	0.380	0.148	0.800	0.136	0.182
Perceived benefit4	0.461	0.128	0.395	0.132	0.808	0.086	0.207
Perceived benefit5	0.415	0.074	0.381	0.082	0.772	0.121	0.226
Perceived severity1	0.154	0.084	0.189	0.078	0.103	0.800	−0.007
Perceived severity2	0.184	0.048	0.165	0.012	0.089	0.845	0.007
Perceived severity3	0.180	0.041	0.130	0.053	0.087	0.827	−0.055
Perceived severity4	0.076	−0.024	0.169	0.189	0.071	0.748	−0.118
Perceived severity5	0.155	0.059	0.199	−0.006	0.169	0.819	−0.059
Perceived suscept1	0.166	0.148	0.286	−0.092	0.301	−0.030	0.784
Perceived suscept10	0.204	0.264	0.273	−0.132	0.088	−0.026	0.780
Perceived suscept2	0.167	0.204	0.267	−0.067	0.215	−0.005	0.761
Perceived suscept3	0.321	0.271	0.312	−0.092	0.214	−0.053	0.825
Perceived suscept4	0.210	0.254	0.258	−0.091	0.124	−0.047	0.827
Perceived suscept5	0.168	0.138	0.194	−0.146	0.105	−0.104	0.711
Perceived suscept6	0.183	0.195	0.292	−0.091	0.260	−0.022	0.804
Perceived suscept7	0.142	0.182	0.237	−0.064	0.193	0.012	0.752
Perceived suscept8	0.311	0.231	0.318	−0.109	0.219	−0.048	0.847
Perceived suscept9	0.193	0.140	0.226	−0.097	0.178	−0.086	0.800

The third criterion employed in the assessment of the discriminant validity is the HTMT designed by Henseler et al. [111]. For this approach, all values must lie below the

HTMT cut-off value of 0.90 [111,112]; according to the study findings, the discriminant validity was verified (Table 6). Furthermore, the HTMT results revealed that the confidence interval for all constructs is exclusive of one [113], further validating the discriminant validity.

Table 6. Heterotrait–monotrait (HTMT) ratio results.

Construct	Adaptation Behaviour	Attitude	Awareness	Barriers	Benefit	Severity	Susceptibility
Adaptation Behaviour							
Attitude	0.505						
Awareness	0.585	0.573					
Perceived barriers	0.094	0.090	0.125				
Perceived benefit	0.651	0.148	0.564	0.146			
Perceived severity	0.208	0.077	0.247	0.105	0.151		
Perceived susceptibility	0.281	0.285	0.379	0.135	0.270	0.083	

4.3. Assessment of the Structural Model

Evaluation of the structural model is the second step in the PLS-SEM method after assessing the measurement model and determining its fit. It is critical to confirm the existence of collinearity issues when analysing the structural model. According to Yoo et al. [114], multicollinearity occurs when similar indicators exist across many constructs, as evidenced by a total variance inflation factor (VIF) value of more than 5 [115] or 3.3 in a rigorous context [116]. The results of this research (Table 7) revealed the VIF values ranged from 1.030 to 1.751 suggesting the non-existence of multicollinearity problems.

According to Klarner and Raisch [117], the coefficient of determination (R^2) is the most important parameter for evaluation of structural models. According to Cohen [118], R^2 values ranging from 0.02 to 0.12 suggest weak coefficients of determination, values of 0.13 to 0.25 indicate a moderate coefficient of determination and R^2 values exceeding 0.25 imply a substantial coefficient of determination. As indicated in Table 7, the R^2 value of adaptation behaviour is 0.516, which is greater than 0.25, indicating a large acceptable prediction level in empirical research [119]. Awareness also has a substantial coefficient (0.317) of determination exceeding the 0.25 threshold. On the other hand, attitude exhibited a moderate predictive relevance, with a value of 0.239, which falls between 0.12 and 0.25.

The effect size is represented by F^2; F^2 values ranging from 0.02 to 0.15 suggest a small influence, 0.15 to 0.35 imply a medium effect and F^2 values above 0.35 indicate a substantial impact [120]. Table 7 reveals that the influence of perceived barriers and perceived severity on attitude is small, whereas the influence of awareness is medium. Likewise, the perceived severity and perceived susceptibility have a minor impact on awareness, whereas perceived benefit has a medium effect. However, both awareness and perceived barriers have a minimal influence on adaption behaviour, whereas perceived benefit has a medium effect on adaptation behaviour. Finally, a blindfolding test was performed to calculate the model's Q2 value. A Q2 value exceeding zero implies that the model has adequate predictive relevance [121,122]. According to the results presented in Table 7, the Q2 values exceed zero, confirming the good fit and strong predictive relevance of the entire model.

Table 7. Results of the structural model.

R-Square	Endogenous Variable	R Square		R Square Adjusted	0.25: Substantial, 0.12: Moderate, 0.02: Weak [119]
	Adaptation Behaviour	0.516		0.269	
	Attitude	0.239		0.227	
	Awareness	0.317		0.308	
Effect Size (F-Square)	Exogenous Variables	Adaptation Behaviour	Attitude	Awareness	0.35: Large, 0.15: Medium effect, 0.02: Small effect [119]
	Adaptation behaviour				
	Attitude	0.018			
	Awareness	0.054	0.198		
	Perceived barriers	0.033	0.029	0.005	
	Perceived benefit	0.267	0.002	0.194	
	Perceived severity	0.018	0.028	0.042	
	Perceived susceptibility	0.003	0.004	0.094	
Collinearity (Inner VIF)	Exogenous Variables	Adaptation Behaviour	Attitude	Awareness	VIF <= 5.0 [123]
	Adaptation behaviour	1.314			
	Attitude	1.751	1.462		
	Awareness	1.081	1.051	1.046	
	Perceived barriers	1.329	1.326	1.113	
	Perceived benefit	1.101	1.071	1.030	
	Perceived severity	1.207	1.202	1.099	
Predictive Relevance (Q-Square)	Endogenous Variables	CCR		CCC	Value larger than 0 indicates predictive relevance [123]
	Adaptation behaviour	0.270		0.495	
	Attitude	0.143		0.433	
	Awareness	0.190		0.419	

Notes: CCR = construct cross-validated redundancy; CCC = construct cross-validated communality.

The structural model was subjected to a bootstrapping technique to reveal the inner-path findings and assess the significance of the relationships. The distinct hypothetical path within the research framework was also observed using the regression coefficient (β). To verify the outcomes of the proposed hypotheses in the structural model, the value of β was investigated. Of the five hypotheses, four were validated, as shown in Table 8 and Figure 4 of the path coefficient evaluation. At the least level of 0.05, the supported hypotheses were observed to be significant. The three direct correlations shown in Table 8 are significant, as their *p* values are lower than 0.05 and their t-values exceed 1.96. The highest significant path was found in this study between perceived benefit and adaptive behaviours (t = 6.947, β = 0.442 or 44%), followed by awareness and attitude (t = 4.872, β = 0.469), perceived barriers and adaptation behaviour (t = 2.317, β = −0.139) and, lastly, between perceived severity and adaptive behaviour (t = 2.072, β = 0.104 or 10%).

Table 8. Path coefficient results.

Hypothesis	OS/Beta	SM	SD	T	*p*	Decision
H1: Perceived susceptibility -> adaptation behaviour	0.047	0.045	0.055	0.877	0.394	Not significant
H2: Perceived severity -> adaptation behaviour	0.104	0.110	0.052	2.072	0.038	Significant
H3: Perceived benefit -> adaptation behaviour	0.442	0.443	0.065	6.947	0.000	Significant
H4: Perceived barriers -> adaptation behaviour	−0.139	−0.135	0.057	2.317	0.014	Significant
H5: Awareness -> attitude	0.469	0.474	0.099	4.872	0.000	Significant

Notes: significant = $p < 0.05$; OS = beta of original sample; SM = sample mean; SD = standard deviation.

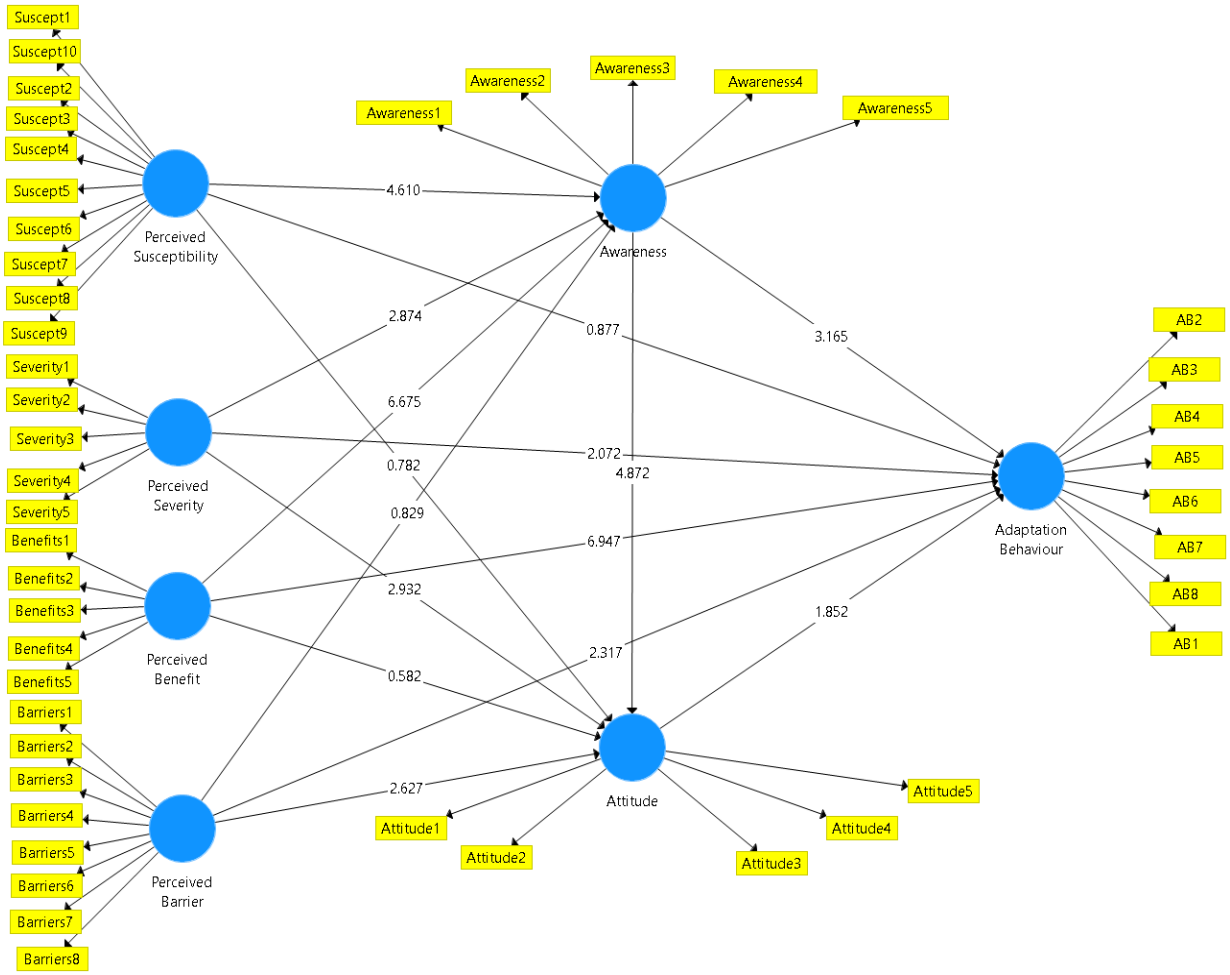

Figure 4. Structural model with t-values (bootstrapping result).

4.4. Indirect (Mediation) Effect Analysis

The bootstrapping approach, which was recommended by Hair et al. [124], was employed in the mediating analysis in this study. Table 9 shows the findings of the mediation analysis, revealing that five of the eight mediating hypotheses were validated. Specifically, the first mediating path (susceptibility -> awareness -> adaption behaviour) was statistically significant (t = 2.469, β = 0.061, p = 0.014). Similarly, the second mediating path (severity -> awareness -> adaptation behaviour) was observed to be statistically significant (t = 2.191, β = 0.039, p = 0.029), and the third path (benefit -> awareness -> adaptation behaviour) was statistically significant (t= 2.887, β = 0.088, p = 0.004). Likewise, the sixth path (severity -> attitude -> adaptation behaviour) and the eighth path (barriers -> attitude -> adaptation behaviour) were observed to be statistically significant ($p < 0.05$), with LL (lower-level) and UL (upper-level) values being either positive or negative, respectively, confirming a significant mediating role. Furthermore, all the significant paths were observed to exhibit partial mediation, except for the first path between susceptibility and adaptation behaviour, which exhibited full mediation. However, the mediating routes of barriers -> awareness -> adaptation behaviour, susceptibility -> attitude -> adaptation behaviour and benefit -> attitude -> adaptation behaviour, were shown to be statistically insignificant ($p < 0.05$).

Table 9. Hypothesis testing of the mediation paths.

Hypothesis	Beta/OS	95% Confidence Interval Bias Corrected		T	P	Decision	Mediation
		LL	UL				
H6: Susceptibility -> awareness -> adaptation behaviour	0.061	0.021	0.111	2.469	0.014	Significant	Full
H7: Severity -> awareness -> adaptation behaviour	0.039	0.013	0.089	2.191	0.029	Significant	Partial
H8: Benefit -> awareness -> adaptation behaviour	0.088	0.038	0.156	2.887	0.004	Significant	Partial
H9: Barriers -> awareness -> adaptation behaviour	0.014	−0.017	0.053	0.770	0.442	Not Significant	No
H10: Susceptibility -> attitude -> adaptation behaviour	0.007	−0.007	0.035	0.645	0.519	Not Significant	No
H11: Severity -> attitude -> adaptation behaviour	−0.077	−0.043	−0.001	2.142	0.027	Significant	Partial
H12: Benefit -> Attitude -> adaptation behaviour	−0.005	−0.033	0.009	0.499	0.618	Not Significant	No
H13: Barriers -> attitude -> adaptation behaviour	−0.067	−0.043	−0.001	1.991	0.048	Significant	Partial

Notes: Significant = $p < 0.05$; LL = lower level; UL = upper level.

4.5. Multigroup Analysis (MGA)

To investigate the differences in adaption behaviour between Dumuria and Jahajmara villages, the subsequent hypothesis was developed: The intensity of the association among HBM components, awareness, attitude and adaptation behaviour will vary between the two villages. The findings presented in Table 10 highlight the comparison between the two villages in terms of adaptation behaviour and indicate that four of the thirteen individual pathways were supported, whereas the remaining nine pathways were unsupported due to a lack of difference in the outcomes of the two villages. This implies that a considerable difference exists between the two communities, particularly in terms of the relationship between susceptibility, severity, barriers, attitude and adaptation behaviour. The impact of susceptibility, severity and barriers on adaptation behaviour was significant in Dumuria village but not in Jahajmara village, probably due to the prevalence of fishermen who were least enlightened about the adverse effects of climate change in the area.

Table 10. Comparison between Dumuria and Jahajmara Villages.

Hypothesis	Beta (Dumuria)	Beta (Jahajmara)	SD (D)	SD (J)	*p*-Value (Dumuria)	*p*-Value (Jahajmara)	Decision
Perceived susceptibility -> adaptation behaviour	−0.191	0.038	0.059	0.096	0.001	0.690	Supported
Perceived severity -> adaptation behaviour	0.197	0.075	0.069	0.099	0.005	0.449	Supported
Perceived benefit -> adaptation behaviour	0.443	0.505	0.084	0.084	0.000	0.000	Not supported
Perceived barriers -> adaptation behaviour	−0.313	0.107	0.075	0.070	0.000	0.127	Supported
Awareness -> attitude	0.469	0.820	0.100	0.188	0.000	0.000	Not supported
Perceived susceptibility -> awareness -> adaptation behaviour	−0.006	0.120	0.019	0.070	0.749	0.085	Not supported

Table 10. *Cont.*

Hypothesis	Beta (Dumuria)	Beta (Jahajmara)	SD (D)	SD (J)	*p*-Value (Dumuria)	*p*-Value (Jahajmara)	Decision
Perceived severity -> awareness -> adaptation behaviour	−0.007	0.136	0.019	0.079	0.728	0.087	Not supported
Perceived benefit -> awareness -> adaptation behaviour	0.077	0.024	0.040	0.021	0.055	0.264	Not supported
Perceived barriers -> awareness -> adaptation behaviour	0.049	−0.028	0.030	0.020	0.096	0.166	Not supported
Perceived susceptibility -> attitude -> adaptation behaviour	0.055	0.005	0.040	0.022	0.174	0.822	Not supported
Perceived severity -> attitude -> adaptation behaviour	0.018	0.015	0.031	0.046	0.547	0.752	Not supported
Perceived benefit -> attitude -> adaptation behaviour	0.069	0.005	0.037	0.021	0.061	0.804	Not supported
Perceived barriers -> attitude -> adaptation behaviour	−0.123	0.001	0.042	0.012	0.004	0.933	Supported

5. Discussion

In this research, we explored the variables influencing the adaption behaviour of Bangladeshi marine fishermen towards climate change. The first hypothesis of the study states that perceived susceptibility significantly influences adaptation behaviour. The findings indicate that perceived susceptibility does not significantly influence the adaption behaviour of marine fishermen. The results of this research are consistent with the results of investigations conducted by Hanson and Benedict [125], Lubran [126], Rezaei and Mianaji, [127], Simsekoglu and Lajunen [128] and Vassallo et al. [129]. This finding might be attributed to the failure of marine fishermen to evaluate the possible risk components of climate change when considering adaptation options. Otherwise, fishermen who are uninterested in participating in adaptation efforts may assume that climate variability and change only represent a minor issue.

According to the second hypothesis, perceived severity significantly influences adaptation behaviour. This outcome concurs with the findings of Akhtar et al. [79], Clayton et al. [130], Orji et al. [71], Rezaei and Mianaji [127] and Schafer et al. [131]. Bayard and Jolly [66] confirmed that farmers are more inclined to take actions to improve the environment when they perceive the problem as severe. With respect to third hypothesis, the findings demonstrate that perceived benefit, one of the crucial elements of the HBM, had a favourable and substantial influence on the adaptation behaviour of marine fishermen. Studies conducted by Rezaei and Mianaji [127], Akhtar et al. [79], Carpenter [132], Orji et al. [71], Vassallo et al. [129] and Riggins [133] revealed similar results. This result can be attributed fishermen's decision to exhibit adaptive behaviour because they felt it would benefit them and their community. These benefits could further motivate fishermen to engage in such behaviours. Additionally, many adaptation measures, including risk spreading and sharing, early warning systems, climate services and catastrophic risk management, are available throughout sectors and could provide considerable advantages when coupled with other available adaptation choices [134]. Thus, marine fishermen will

only accept new adaptation behaviours if they perceive added advantages associated with their adoption.

The fourth hypothesis claims that perceived barriers significantly negatively influence adaptation behaviour. This hypothesis was supported by the study results, consistent with the findings of previous studies [79,127–130,132,133,135]. When an individual perceives severe hurdles in their path, they become reluctant to engage in adaptive behaviour [65]. Therefore, fishermen who perceive barriers to applying an adaptive behaviour are less likely to adopt such behaviours.

The fifth hypothesis states that awareness of climate change significantly influences attitudes towards climate change. These findings are congruent with those of Akhtar et al. [79], Bayard and Jolly [66], and Vaske and Kobrin [136]. The findings imply that awareness of susceptibility to and severity of environmental constraints among fishermen may influence their attitudes, resulting in adoption of adaptation behaviour. Increased awareness of climate change is associated with increased fishing revenue (Sereenonchai and Arunrat. [137], Vulturius et al. [138]). This implies that awareness of climate change may encourage fishermen to continue fishing, even in the face of adverse climate change effects [51]. Previous studies [139,140] revealed that a change in an individual's attitude was necessary to help them adapt to changing climate and earn a better living. Additionally, a positive attitude shift is required to ensure readiness and preparation with respect to climate change adaptation [141]. Hasan and Nursey-Bray [41] examined the perception of Bangladeshi fishermen towards climate change and discovered that a few significant characteristics, such as geographical location and experiences with various disasters, influence the climate change attitudes of fishermen. More importantly, the first stage in disaster preparedness is awareness of the environmental shifts that may occur [142,143].

In this research, we also investigated and confirmed the mediating effects of awareness and attitudes towards climate change on the association between HBM components and adaptation behaviour. Hypotheses six to nine state that awareness plays a significant mediating role in the relationship between perceived susceptibility, perceived severity, perceived benefit, perceived barriers and adaptation behaviour. Furthermore, hypotheses ten to thirteen propose that attitude plays a significant mediating role in the relationship between perceived susceptibility, perceived severity, perceived benefit, perceived barriers and adaptation behaviour. Similar findings have been reported in previous studies [66,79,101,144,145], in which the awareness and attitude of respondents were observed to mediate the relationship between perception and adaptation behaviour towards changing climate. Such findings are justifiable, as climate change awareness, one of the resilience components [146], implies the ability of a community to develop reactive and proactive measures in response to the incidence of climatic change [147]. However, accurate perceptions can have a considerable impact on awareness [79]. Research performed by Le Dang et al. [148] revealed a relationship between farmers' perception of climate change and their resulting adaptation behaviour, implying that individuals will worry about their means of livelihood when they perceive that they are being impacted by a natural calamity, such as environmental deterioration. As a result, awareness might influence attitudes towards behaving a certain way [149] and making certain decisions [150]. Bayard and Jolly [66] conducted a study on Haitian farmers and discovered that the more the susceptibility experienced by farmers, the better their awareness of the severity of environmental deterioration and the stronger their adoption of a constructive attitude against the crisis.

Multigroup analysis revealed a considerable difference between the two communities investigated in the present study. The two villages differ in terms of relationships between susceptibility, severity, barriers, attitudes and adaptation behaviour. The effects of susceptibility, severity and barriers on adaptation behaviour were significant in Dumuria village but insignificant in Jahajmara village, probably due to a lower level of climate change awareness among fishermen in Jahajmara village compared to those in Dumuria village [147]. Long-term engagement of fishermen in fishing activities rendered them insensitive to such shifts, diminishing their awareness of climatic change [151]. Increased adaptation to the

consequences of climate change is critical in promoting awareness, learning and acquiring broader experience [83]. Nursey-Bray [152] emphasised the need for related stakeholders to supply meteorological data, develop conservation programmes and ban behaviours that are harmful to the environment to help improve the positive attitudes and environmental awareness of villagers.

Limitations of the Study and Future Research Directions

This research is subject to a number of limitations. First, only two villages from two districts on Bangladesh's east and west coasts were chosen as the study area. Consequently, caution should be exercised in extrapolating results of this research to fishermen residing in other coastal locations around the country, as adaptation strategies differ from place to place. Therefore, we recommend that researchers replicate this study by including inhabitants and fishermen from other coastal regions to compare the results with our findings and to improve the generalizability of the findings. Furthermore, in this study, we only examined the impact of six constructs on adaptation behaviour; other variables, such as cues of action, health motivation, general beliefs, perceived significance, self-identity, health value, perceived self-efficacy, subjective norms, perceived behavioural control, sociodemographic traits and intention, may have a significant influence on the adaptation behaviour of marine fishermen.

6. Conclusions and Policy Implications

Regarding adaptation to climate change, the findings of this study have several implications for marine fishermen in Bangladesh. First, the study contributes to the growing domain of research on how marine fishermen adapt to adverse weather conditions, as well as the factors that determine their behaviours in response to climate change. Second, policymakers and fisheries experts can use the results of this study to help marine fishermen deal with the consequences of a changing climate. Third, these research findings bridge the existing policy gap. The Bangladesh Climate Change Strategy and Action Plan (BCCSAP) [153] and the National Adaptation Programme of Action (NAPA) [154] are the two primary policy instruments in Bangladesh that provide thorough policy and action strategies to deal with the effects of climate change. These documents feature medium and long-term adaptation strategies and action plans for coastal and marine fisheries sectors but do not include the perceptions, awareness, attitudes and adaptation behaviour of marine fishers towards climate change. Thus, the outcomes of this research may be useful in this regard.

The following recommendations are put forth considering the empirical findings of the present study. First, most respondents in the present study were younger than 50 years old and lacked other technical skills. The Bangladeshi government should offer increased compensation packages to younger people to encourage their participation in the marine fisheries sector, including provision of professional training to local youth to equip them with fundamental fishing skills and expertise that will help them to manage new technologies and improve their technical abilities. Generally, fishermen with greater motivations are more likely to alter their behaviour to cope with climate change. Second, there is a definite prerequisite for an effective marine fishermen education and awareness campaign. Owing to the frequency of severe weather events, such as coastal floods and storms, Bangladesh's marine fisheries sector is particularly sensitive to climate change. As a result, government entities should strive to establish awareness-raising programs to promote climate change adaptation attitudes among marine fishermen. Third, through a variety of programs, universities in coastal regions can provide fishing communities with vital knowledge about climate change, along with adaptation strategies to sensitize and influence their attitudes toward adaptation behaviour. Finally, the government and non-governmental organizations should work together to develop small rural businesses based on easily available fishing items to integrate local youth into the workforce. As

a result of these alternative offerings, more young people may become motivated and attracted to seek jobs in the marine fisheries industry.

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