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RESEARCH ARTICLE

MEASURING THE DETERMINANTS OF ADAPTIVE CAPACITY TO UNDERSTAND THE VULNERABILITY RISK AMONG THE RIVERBANK EROSION AFFECTED HOUSEHOLDS IN BANGLADESH: A STRUCTURAL EQUATION MODELING (SEM) APPROACH

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Abstract

Bangladesh is one of the most disaster-prone countries in the world. In particular, its riverine dwellers face continuous riverbank erosion, frequent flooding, and other adverse effects of climate change which makes the life of people more vulnerable. In order to assess adaptive capacity, understanding of how different households' comprehend climate change is crucial. This paper aims to measure the determinants of adaptive capacityto understand the vulnerability risk among the riverbank erosion affected households. An integrated model was proposed with the constructs derived from Awareness-Ability-Action (AAA) and Socioeconomic-Sociopolitical and Institutional-Socioecological (SSS) model. A structured questionnaire survey was used to collect data from 300 participants who were affected by natural disaster specifically river erosion. The proposed research model was tested using the partial least-squares (PLS) method, a statistical analysis technique based upon structural equation modeling (SEM).The results show that the loss of farming land and all levels of riparian households impacted severely by riverbank erosion and forced into a low livelihood status, strong adaptive capacity would reduce vulnerability risk in the affected areas, community-level vulnerability measurement enhances communities understandings, build capacity, make aware, and allow them to identify appropriate locally adaptation strategies, and local level adaptation strategies may reduce the impact of such hazards on all sorts of vulnerability risk among rural households. The nature of this study may restrict its generalizability to other research settings. Future research may be necessary to validate the findings by applying this model in the vulnerability context in other developing countries. This research method and results would generate new insights with respect to planning the sustainable development goal and provide a reference for decision-making.

Introduction:-

Over the last few decades, Climate change is an inevitable and urgent global challenge with long-term implications for the sustainable development of all countries. A study by Eckstein et al. (2018) reported that more than 526,000 people died worldwide and there were losses of $3.47 trillion as a result of more than 11,500 extreme weather events

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between 1998 and 2017.The severity of the impact of climate change event is projected to be felt more in the global context (FitzRoy and Papyrakis, 2010, Field et al., 2014). A study by Kundzewicz et al. (2014) projected that 800 million people worldwide or 11% of the world population are currently exposed to natural disasters each year, and about 70 million or 1% of the global population are living at riparian community in the coastal areas. In recent years, the frequency of occurrence of natural disasters, and the extent of their devastating impact on both economic and humankind shown exponential growth (Harrison and Williams, 2016, Cerè et al., 2017). In a new global index, a country is highly vulnerable due to the unique geographical positions to suffer irregular and several climatic hazards such as floods, tropical cyclones, storm surges, landslides, droughts, the rising sea levels, soil salinity and river erosion.

On the other hand, Bangladesh is one of the most vulnerable countries in the world due to climate change and natural disasters particularly in the country's coastal areas. According to Global Climate Risk Index 2019, we found that Bangladesh is a hot spot natural disasters risk prone country, and ranked 9th with the score of 17.38 among 173 nations in the world by extreme weather events in 20 years since 1998 (David Eckstein et al., 2019). A research by Dasgupta and Susmita (2010) specified Bangladesh are badly exposed to the vulnerability to storm, surge and riverbank erosion-related inundation due to proximity of ocean. Bangladesh's flat topography, low-lying and climatic features, combined with its population density and socio-economic environment, make it highly susceptible to many natural hazards, including floods, river erosion, droughts, cyclones and earthquakes. More than 80 percent of the population is potentially exposed to floods, river erosion, earthquakes and droughts, and more than 70 percent to cyclones. On average, the country experiences severe tropical cyclone every three years, and about 25 percent of the land mass is inundated with flood waters every year. Severe flooding occurs every 4-5 years and covers 60 percent of the land mass (WB, 2018). The country also suffered an economic loss of about $2826.68 million (Star, 2018). Moreover, Bangladeshi poor people are facing hell-like sufferings (Roy and Sultana, 2010) for extreme climatic induced hazard such as storm surges, floods, river erosion and drought pose major risks to the livelihood of the rural population (Mollah and Ferdaush, 2015, GOB, 2018). One of the projected adverse impact of climate change is river bank erosion due to heavy rainfall and floods (Field et al., 2014).

Riverbank erosion has now become a common phenomenon and one of the major natural calamities of Bangladesh, and is considered to be the most damaging hazards in terms of economic loss of riverine areas (Alam, 2017). Riverbank erosion has severe effects on the livelihoods of the affected people. In the coastal areas of Bangladesh, riverbank erosion has been creating a wide array of socio-economic problems extensively. Due to riverbank erosion, most of the affected people are suffering a lot of problems, i.e., people loss their homestead area and house, facing economic problems, shifting their occupation also and migrated from one place to another place and a very large number of people are unable to get back to their homestead or even any new places (Iva et al., 2017). The riverine and coastal districts in Bangladesh are Shatkhira, Bagerhat, Khulna, Manikganj, Netrokona, Kurigram, Sherpur, Gaibandha, Mymensingh, Tangail, Sirajganj, Rajshahi, Pabna, Kushtia, Comilla, Barisal, Noakhali, Patuakhali, Pirojpur, Bhola, Coax's Bazar are certainly vulnerable to riverbank erosion, and affected by this disaster several times which contribute to the loss of lands and other natural resources resulting in an increased vulnerability (IFAD, 2013, Lein, 2010, Khan et al., 2018).

On the other hand, CEGIS (2018) also reported that Bangladesh is projected to lose around 8700 hectares of homestead and farming land this year due to riverbank erosion which displaces 200,000 people annually pushes into them vulnerable conditions (Huq and Rabbani, 2011) along the estimated 150,000 km of riverbank annually (Ahmed, 2015). Furthermore, Gravgaard and Wheeler (2009) stated that damage from riverbank erosion occurs gradually and has long term impacts that are naturally irrecoverable. A study by Allison and Al (2005) reported that, one of the groups most vulnerable to climate related change is riparian communities. There are several indicators which suggest that riparian households are more vulnerable to climatic hazards (Alam, 2016, Alam et al., 2017b, Ahmed, 2015). Riverine households are also likely to be affected by other climatic hazards such as flooding and water logging due to their proximity to the river (Alam, 2017). Scholars revealed that riverbank erosion has impacted on physical, economic, social and political conditions, resulting in catastrophic impacts on the lives and livelihoods of the riverine households in Bangladesh (Alam, 2016, Ahmed, 2015, Lein, 2010, Zaman, 1989, Hutton and Haque, 2003, Haque, 1997, Hossain, 1993, Elahi and Rogge, 1990, Rogge and Haque, 1987, Romanowski, 1987). To address this and related concerns, determinants of adaptive capacity of theHouseholds is required to measure that can help understanding the vulnerability risk.

Adaptive capacity itself, defined as the ability of the system to reduce the vulnerability and risk to impacts and take advantage of the changes, has been of interest too many researchers within the last decade (Juhola and Kruse, 2015). Weis et al. (2016) demonstrates that "adaptive capacity" covers a multitude of factors and there is no universal consensus as to what these factors should be. Communities have inherent capacities to adapt to climate change. These capacities are bound up in the ability of societies to act collectively. Decisions on adaptation are made by individuals, groups, organizations and governments on behalf of the community (Jones et al., 2010). (Adger et al., 2005) asserted that the capacity of individuals to adapt to climate change is a function of their access to resources, their ability to act collectively (denoted as social capital) in the face of the threats posed by climate change, the institutions for resource management and their effectiveness, efficiency and legitimacy. Hence, a study by (Cruz et al., 2007) has placed local knowledge of the adaptation at the center of the discussions to formulate adaptation strategies.By implementing adaption policy, vulnerability, which is the degree of susceptibility to an adverse effect of climate change, can be reduced (Adger, 2006).Thus, a research by Shah et al. (2013) have opined that policy interventions would do little affect poverty dynamics unless the vulnerability context is properly understated. Hence, countries around the world are already beginning to incorporate issues of vulnerability, adaptation and resilience into their nationally determined contributions towards climate change. Therefore, significant mobilization is necessary from the government of Bangladesh, nongovernmental organizations, researchers, and farmers to develop successful adaptation strategies (Sadik et al., 2018).

However, critical information on the degree of livelihood vulnerability determinants is not available, this information is crucial for the development of appropriate social, economic and environmental policies. Some of studies focused on knowledge of local level adaptation for resilience in the face of hazards and for coping with climate change and variability based developing countries. Notwithstanding, the considerable importance devoted to investigating the determinants of adaptive capacity to climate change around the world, the available empirical evidence on determinants of adaptive capacity and vulnerability context among the riverbank erosion affected households in Bangladesh has so far been on large scale and extremely disintegrated. To ensure a better understanding of riverbank erosion affected households' vulnerability and adaptive capacity to climate change necessitate detail assessment of the factors that determines their adaptive capacity to climate change.

This study, using survey data from the most riverbank erosion-prone district that aims to provide new insights on measuring the determinants of household adaptive capacity at the local-level and provide a comprehensive understanding of the extent of vulnerability of riparian community. As per above literature, the objective of this study was to attempt to fill the above identified gaps by assessing dimensions and determinants of adaptive capacity to understand vulnerability risk in a developing country context like Bangladesh and hence the following specific research questions was formulated; 'What are the causal relationship between adaptive capacity and vulnerability along with measuring the key determinants of adaptive capacity influencing vulnerability?' The significance of this study is that its findings will assist in targeting appropriate district-specific climate change adaptive capacities to ameliorate the vulnerability of riverbank erosion affected households to climate change risks at large. This would help to provide improved guidance on appropriate interventions to enhance the resilience of riparian households and communities.

Theoretical Framework and Hypothesis

The concepts of adaptation, adaptive capacity, vulnerability, resilience, exposure and sensitivity are interrelated and have wide application to global change science. The proposed model is derived from Acosta et al. (2013), McClanahan et al. (2009)&Cinner et al. (2010) who have developed their concept based on many previous studies. Acosta et al. (2013) conceptualized adaptive capacity according to three human dimensions – awareness, ability and action, which has been classified as Awareness-Ability-Action framework for adaptive capacity. This paper builds on this framework in measuring human adaptive behavior. We identified determinants for each dimension, i.e., knowledge and awareness, knowledge and experience, social learning for awareness, individual competence, access to infrastructural resources, access to infrastructural resources, institutions, intended adaptation, and performed adaptation for action (Figure 1). McClanahan et al. (2009) and Cinner et al. (2010) developed a composite measure, an index of adaptive capacity, which makes the concept of adaptive capacity operative. The adaptive capacity comprises three dimensions: socioeconomic, socio-political/institutional and social-ecological, which attempt to capture comprehensively the determinants of adaptive capacity. This model is able to measure adaptive capacity according to dimensions. The proposed theoretical model was developed to provide a comprehensive understanding of the determinants that affect adaptive capacity of vulnerable people in river erosion prone areas. Awareness, ability, and action, socioeconomic, socio-political/institutional, and social-ecological are interrelated dimensions of

adaptive capacity. The following section discusses a number of empirically testable hypotheses from the proposed model. These hypotheses describe the relationships between adaptive capacity and vulnerability risk.

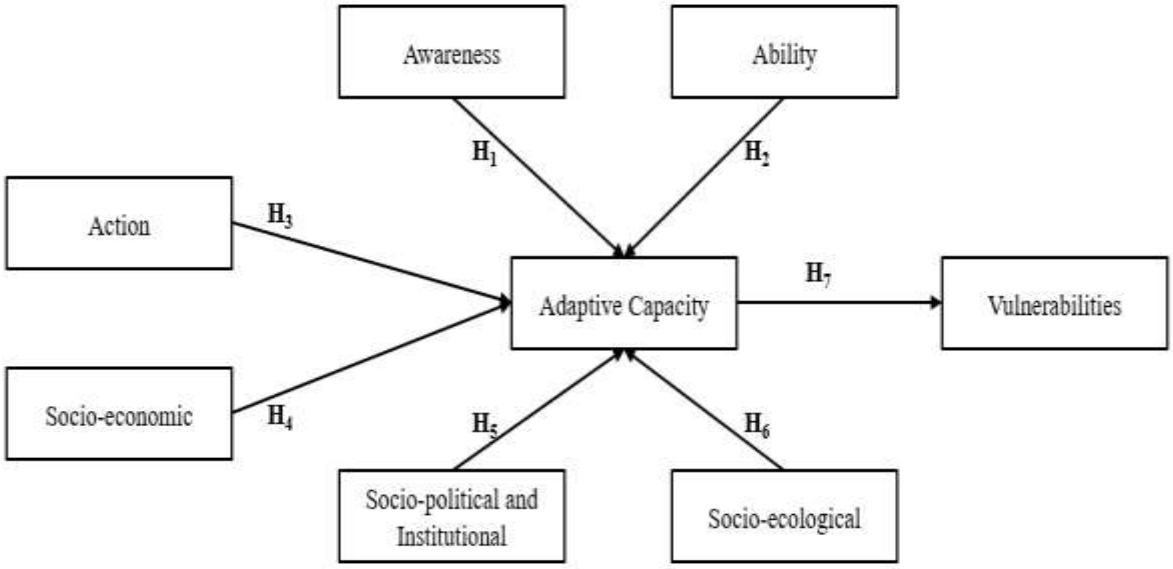

Figure 1:- Proposed Research Model.

Awareness provides knowledge that creates an individual's ability to plan an adaptation action. Any action actually performed provides an experience, which then adds up to the knowledge that may lead to an increased, or even changed, awareness of an individual. A study by Hill (2010) argued that one of the most crucial aspects of awareness is the changes it undergoes, which have countless important consequences for knowledge and action. Regions with a high problem awareness concerning adaptive capacity impacts in their own region have a lower vulnerability (Greiving et al., 2011). But, a higher level of awareness leads to higher level of an adaptive capacity among vulnerable people in riverbank erosion areas. Thus, based on the prior studies, we hypothesized that:
H_1: There is a positive association between Awarenessand Adaptive Capacity.

Ability refers to the capacities that underlie the society's ability, i.e. infrastructure and technology, to adapt. At the same time, the current methodologies for assessing adaptive capacity and their ability to provide reliable and sound information (Hinkel, 2011, Malone and Engle, 2011). For example, Park et al. (2012)&S Park (2012) develop a standardized, non-contextualized index approach that analysis shows how rankings of relative vulnerability are dependent on the assessment tool that is being used. Ability removes cognitive barriers and thus enables adaptive behavior. The study by Kuruppu and Liverman (2011) demonstrated that unless cognitive barriers are addressed, a high level of adaptive capacity of individuals will not automatically facilitate adaptive behavior. Extending prior research on this study, ability is considered as distinct proximal determinants of adaptive capacity, this study hypothesized that:
H_2: There is a positive association between Abilityand Adaptive Capacity.

Action refers to the capacities that are necessary to take action, i.e. political institutions.Transforming the results into action is one of the key challenges associated with assessments of adaptive capacity (Preston et al., 2011), since results often do not include a ready-to-use set of measures that can easily be put into practice by decision makers.To what extent intended adaptations were to be translated into performed adaptations depends on several reasons, for example:1. similitude of expectations to the actual climatic stimuli or their effects;2. reliability of available resources when disaster actually occurs three extents of loss and damage is not beyond adaptation. A study by Webb and Sheeran (2006)&Kuruppu and Liverman (2011) mentioned that intention is a more likely behavior performed for infrequent unstable condition like drought, but not for frequently recurring condition like dry weather. Finally, performed adaptations create new knowledge or experience that improves thecompetence of an individual in performing future adaptations. This study hypothesized that
H_3: There is a positive association between Action and Adaptive Capacity

The socioeconomic dimension (SN) incorporates social and economic characteristics of households and communities, which shape their relationship with the natural environment and confers on them the ability to face disturbances (McClanahan et al., 2008). It comprises the following indicators: poverty level, public infrastructure, and occupational characteristics. To estimate this indicator, a set of 10 public infrastructure items, which were evaluated in terms of their presence in the community like health center, hospital, elementary school, high school, roads, piped drinking water, sewerage, public electricity, solid waste collection and disposal, and natural gas (Cinner et al., 2010, POLLNAC et al., 2001). With this view, we hypothesized:
H_4: There is a positive association between socioeconomic dimension and Adaptive Capacity.

Socio-political and institutional dimension (SI) reflects formal and informal rules and norms that govern relationships among individuals, and between them and external institutions for controlling access to and use of resources and natural capital upon which they depend. Given that social capital involves several dimensions and variables, and that the ability of a community to adapt to external institutions is favored by the legitimacy of those institutions, we included three sub indicators at the socio-political and institutional dimension of IAC: structural social capital, cognitive social capital and for measuring external institutions' legitimacy thus conferring adaptive capacity (Jentoft, 2000, Folke et al., 2005, Grafton, 2005, Armitage et al., 2010, Berkes, 2007, Sekhar, 2007). Thus we hypothesized:
H_5: There is a positive association between Sociopolitical & Institutional dimension and Adaptive Capacity.

Social–ecological resilience refers to the ability of a social–ecological system (or the components of that system) to be robust to disturbance and capable of responding to change resilience (Olsson et al., 2004).The social-ecological dimension is made up of three indicators: resource use dependence, awareness about ecological processes and functions, and ability to anticipate disturbances. This dimension includes some of the indicators proposed previously by McClanahan et al. (2008), McClanahan et al. (2009), Cinner et al. (2010), (Cinner et al., 2009a)&(Cinner et al., 2009b). Literature suggests that the capacity to both learn from previous experiences, observations, social interactions, or by doing, and to use acquired knowledge, either scientific or traditional, for responding to disturbances, is a key component of any adaptive process (Armitage et al., 2007, Berkes, 2007, Cinner et al., 2009a). With this view, we hypothesized that:
H_6: There is a positive association between Socio-ecological dimension and Adaptive Capacity.

Institutional research definition of adaptive capacity is the inherent characteristics of institutions that empower social actors to respond to short and long-term impacts either through planned measures or through allowing and encouraging creative responses from society both ex ante and ex post (Gupta et al., 2010). This is the set of capabilities, resources and institutions of a country, etc. that allows is to implement effective measures to adapt to climate change. Practical initiatives that tangibly address and improve societal adaptive capacity, thereby reducing vulnerability, are commonly expected to be evident at the community scale (Kates, 2000, Kelly and Adger, 2000, Ford and Smit, 2004). Adaptive capacity is context-specific and varies from country to country, from community to community, among social groups and individuals, and over time. It varies not only in terms of its value but also according to its nature. The scales of adaptive capacity are not independent or separate: the capacity of a household to cope with climate risks depends to some degree on the enabling environment of the community, and the adaptive capacity of the community is reflective of the resources and processes of the region (Smit and Pilifosova, 2003, Yohe and Tol, 2002).
H_7: There is a positive association between Adaptive Capacityand Vulnerability.

Methodology:-

Research Instruments

All of the measures for latent constructs within the proposed model were developed from prior studies modified according to the adaptive capacity and vulnerabilities items shown in table1.

Table 1:- Research Instruments.

Constructs	Items		Sources
Awareness	AW-1	Knowledge and Awareness (KNA)	(Acosta et al., 2013, Hill, 2010)
	AW-2	Knowledge and Experience (KNE)	
	AW-3	Social Learning (SOL)	
Ability	AB-1	Individual Competence (INC)	

	AB-2	Access to Infrastructural Resource (AIR)	(Smith and Hancock, 1995, Acosta et al., 2013)
	AB-3	Access to Technological Resource (ATR)	
Action	ACN-1	Institutions (INS)	(Acosta et al., 2013, Kuruppu and Liverman, 2011)
	ACN-2	Intended Adaptation (INA)	
	ACN-3	Performed Adaptation (PEA)	
Socio-economic	SE-1	Poverty (POV)	(Pollnac and Crawford, 2000, McClanahan et al., 2008, Cinner et al., 2010, Marshall and Marshall, 2007)
	SE-2	Infrastructure (INF)	
	SE-3	Occupational Characteristics (OCC)	
Socio-political & Institutional	SPI-1	Structural Social Capital (SSC)	(Olsson et al., 2004, Pretty and Smith, 2004, Ostrom, 2005, Uphoff, 2000, Pretty, 2003)
	SPI-2	Cognitive Social Capital (CSC)	
	SPI-3	Perception about MPAs (PAP)	
Socio-ecological	SEL-1	Resource Use Dependence (RUD)	(Plummer and Armitage, 2010)
	SEL-2	Awareness about Ecological Process and Functions (AEP)	
	SEL-3	Ability to Anticipate Disturbances (AAD)	
Vulnerability	VUL-1	Sensitivity (SEN)	(Smit and Pilifosova, 2003, Yohe and Tol, 2002)
	VUL-2	Exposure (EXP)	

Questionnaire design and data collection

A pretest with a convenience sample of 20 was undertaken to ensure that (a) the question content, wording, sequence, format and layout, (b) the question difficulty, instructions and (c) the range of the scale (5-point vs. 7 point) were appropriate. Based on responses from the pretest, we made context-specific adjustments to refine the final version of the questionnaire. Initially, an English questionnaire was developed and later translated into Bengali by a skilled professional translator in order to get the accurate opinions from participants. A standard 5 point Likert scales were stretched from strongly agree (5) to strongly disagree (1). A well-trained interviewer consists of six members who were recruited for collecting the data.A structured questionnaire is divided into two sections. The firstsection measured demographic characteristics of respondents and the second section contains the construct items proposed in the model. The population was defined who had experience of natural disaster or riverbank erosion event. In order to obtain a probability-based sample, simple random sampling was applied so that each sample unit/element had an equal chance of being selected. Data were collected from January 25, 2021 to April 30, 2021, from 300 participants who were affected by natural disaster specifically riverbank erosion area at Patuakhali district in Bangladesh. All respondents were given consent forms and information sheets, which explained the purpose of the study. In addition, informed written consent was obtained from participants and the confidentiality and anonymity were ensured in this study. About 380 questionnaires were randomly distributed and 320 were returned, resulting in an 85 percent response rate. Out of 320, ten were incomplete, which were not included for the analysis. However, after omitting the missing fields, 300 valid questionnaires were selected for further analysis.

Data Analysis Technique

The analysis involved different phases, phase one was frequency analysis of the background data todetermine the sample characteristics and profiles of the respondents interviewed. The second section of the questionnaire measured themain study variables that constructed the models tested here.In phase two, the focuswas on measurement and structural model of the independent and dependent variables. This assisted in makingconclusions on the identified hypotheses. Data were analyzed using smart PLS 2 based on Structural Equation Modeling (SEM) to investigate the degree of relationship between thevariables in the study.

Results:-

Demographic Characteristics of Sample

The detailed demographic attributes of the respondents are shown in Table-2. Out of 300 respondents, 70% were male and 30% were female who participated in the study. The distribution of the respondents by age, with 11.67% were less than 20 years old, from 20 to 30 were 35%, 31 to 39 years 34%, and more than 40 years 19.33%. Approximately 80 per cent of respondents have under-graduate education and among them 88.33% had engaged in non-government service, and most of them were married.

Table 2:- Demographics Profile.

Variable	Description (Coding)	Frequency	Percentage (%)
Gender	Male	210	70.00
	Female	90	30.00
Age	Less than 20 years	35	11.67
	20-30 Years	105	35.00
	31-39 Years	102	34.00
	More than 40 years	58	19.33
Marital Status	Single	85	28.33
	Married	215	71.67
Qualification	Primary	20	6.67
	SSC	80	26.67
	HSC	140	46.67
	Others	60	20.00
Occupation	Government	98	11.67
	Non-government	202	88.33

Source: Author's calculation, 2021; Data: Primary; Tools: SPSS 23

Measurement Model

Table-3 shows the summary of measurement model of this study. It shows the corresponding factor structure and the loading items and their scores. The items used to measure awareness, ability, action, socioeconomic, sociopolitical and institutional, and socio-ecological dimensions are listed in table together with the results of confirmatory factor analysis (CFA), reliability test, and Average Variance Explained (AVE). Confirmatory factor analysis tests the validity and reliability of all constructs that is conceived as a one-dimensional, precise, and consistent indicator in measuring its latent variables (Jöreskog and Sörbom, 1993). The cut of value for the construct reliability is recommended to be > 0.7, while the cut of the value of average variance extracted is recommended to be > 0.5, and the recommended loading factor is 0.6 or more (Hair Jr et al., 2016).

Table 3:- Convergent Validity and Internal Reliability.

Constructs	Items	Loadings	AVE	CR	R^2	Cronbach's alpha (α)
Awareness	AW1	0.8792	0.8422	0.9411		0.8816
	AW2	0.9033				
	AW3	0.9684				
Ability	AB1	0.8285	0.8193	0.9311		0.8786
	AB2	0.9998				
	AB3	0.8757				
Action	AC1	0.8083	0.8154	0.9295		0.8825
	AC2	0.9687				
	AC3	0.9243				
Socioeconomic	SE1	0.7769	0.7541	0.9013		0.8707
	SE2	0.8617				
	SE3	0.9572				
Sociopolitical & Institutional	SPI1	0.9035	0.9711	0.9901		0.894
	SPI2	0.9640				
	SPI3	0.9988				
Social ecological	SEL1	0.7441	0.5046	0.7527		0.8238
	SEL2	0.6451				
	SEL3	0.7376				
Adaptive Capacity	AC1	0.9257	0.7822	0.9556	0.8936	0.9335
	AC2	0.8248				
	AC3	0.9136				
	AC4	0.9129				

	AC5	0.8263				
	AC6	0.8973				
Vulnerabilities	VUL1	0.9887	0.9457	0.9721	0.7582	0.9048
	VUL2	0.9560				

Source: Author's calculation, 2021; Data: Primary; Tools: Smart PLS 2

The loadings, AVE, composite reliability and Cronbach's alpha (α) are presented in Table-3. It can be seen from the Table-3 that the calculated Cronbach's alpha (α) values ranged from 0.8816 to 0.9335 and composite reliability values ranged from 0.7527 to 0.9901, which supports strong internal reliability. Table-3 also shows that the estimated constructs loading ranged from 0.6451 to 0.9988 and AVE ranged from 0.5046 to 0.9711 are greater than the recommended levels. Therefore, the conditions for convergent validity are satisfied in this study.

Correlation matrix and square root of the AVE

Discriminant validity shows the extent to which one construct is distinct from another construct. To determine the discriminant validity of the construct's used in this research, we followed the criteria suggested by Fornell and Larcker (1981) They suggested that the value of the square root of the AVE for each construct should exceed that of correlations between constructs. As can be seen in Table-4, the square root values of the AVE for each construct are higher in comparison with the AVEs.

Table 4:- Correlation matrix and square root of the AVE.

	AW	**AB**	**ACN**	**SE**	**SPI**	**SEL**	**AC**	**VUL**
AW	**0.905**							
AB	0.802	**0.902**						
ACN	0.810	0.801	**0.884**					
SE	0.821	0.845	0.821	**0.918**				
SPI	0.318	0.268	0.282	0.324	**0.710**			
SEL	0.793	0.847	0.847	0.777	0.259	**0.868**		
AC	0.607	0.593	0.673	0.652	0.275	0.556	**0.9854**	
VUL	0.798	0.794	0.871	0.801	0.244	0.742	0.667	**0.9724**

Source: Author's calculation, 2021; Data: Primary; Tools: Smart PLS 2

Structural Model

The data was analyzed using structural equation. Table 5 shows a path analysis summary which would have been processed by Smart PLS, so as to result in a standardized path coefficient as shown in relative table. Table-5 is used as the base in the testing of the seven hypotheses proposed in the research. The relationships are tested using the path coefficients and the level of significance. From Table-5, it shows that the hypotheses test, in determining the significance of each path coefficient, and critical ratio for regression weight were used. Structural equation modeling analysis is conducted to determine the relationship of several variables in the research model. Hence, awareness has a significant positive and direct impact on adaptive capacity (t = 2.111; β =.2146; p = 0.03558) or H_1 is supported. Ability has a significant positive and direct impact on adaptive capacity (t = 2.162; β =0.2229; p = 0.03140) or H_2 is supported. Action has a significant positive and direct impact on adaptive capacity (t = 2.826; β =0.3157; p = 0.00503) or H_3 is supported. Socioeconomic factor has a significant positive and direct impact on adaptive capacity (t = 2.319; β =0.1755; p = 0.02105) or H_4 is supported. Sociopolitical and institutional factor has a significant positive and direct impact on adaptive capacity (t = 2.417; β =0.1186; p = 0.01623) or H_5 is supported. Socio-ecological factor does not have significant impact on adaptive capacity (t = 0.5658; β =-0.0206; p = 0.57195) or H_6 is not supported. Adaptive Capacity has a significant positive and direct impact on vulnerability (t = 28.4916; β =0.8707, p = 0.0000**) or H_7 is supported.

Table 5:- Result of the Hypotheses Testing.

Hypothesis	**Path**	**β**	**t-Statistics**	**P-value**	**Comments**
H_1	AW-> AC	0.2146	2.111	0.03558	Accepted
H_2	AB -> AC	0.2229	2.162	0.03140	Accepted

H_3	ACN -> AC	0.3157	2.826	0.00503	Accepted
H_4	SE -> AC	0.1755	2.319	0.02105	Accepted
H_5	SPI -> AC	0.1186	2.417	0.01623	Accepted
H_6	SEL -> AC	-0.0206	0.5658	0.57195	Rejected
H_7	AC -> VUL	0.8707	28.4916	0.00000	Accepted

Source: Author's calculation, 2021; Data: Primary; Tools: Smart PLS 2

Goodness of Fit (GoF)

Goodness of Fit (GoF) was measured to consider the overall fit of the research model. GoF is an index which validates the predictive power of the model as a whole, based on both measurement and structure model's performance. Unlike AMOS, PLS does not provide the overall fit statistics. To address this issue, Tenenhaus et al. (2004) introduced an alternative way to assess the goodness of model fit. The global GoF of our model were calculated in the followings;

Goodness of Fit = $\sqrt{}$ [(average communality) x (average R^2)]

= $\sqrt{}$ (0.8043x 0.8259)

= 0.8150

The result of the GoF indicates that our research model has a GoF value of 0.8150, which exceeded the cut-off value of 0.36 recommended by previous researchers.

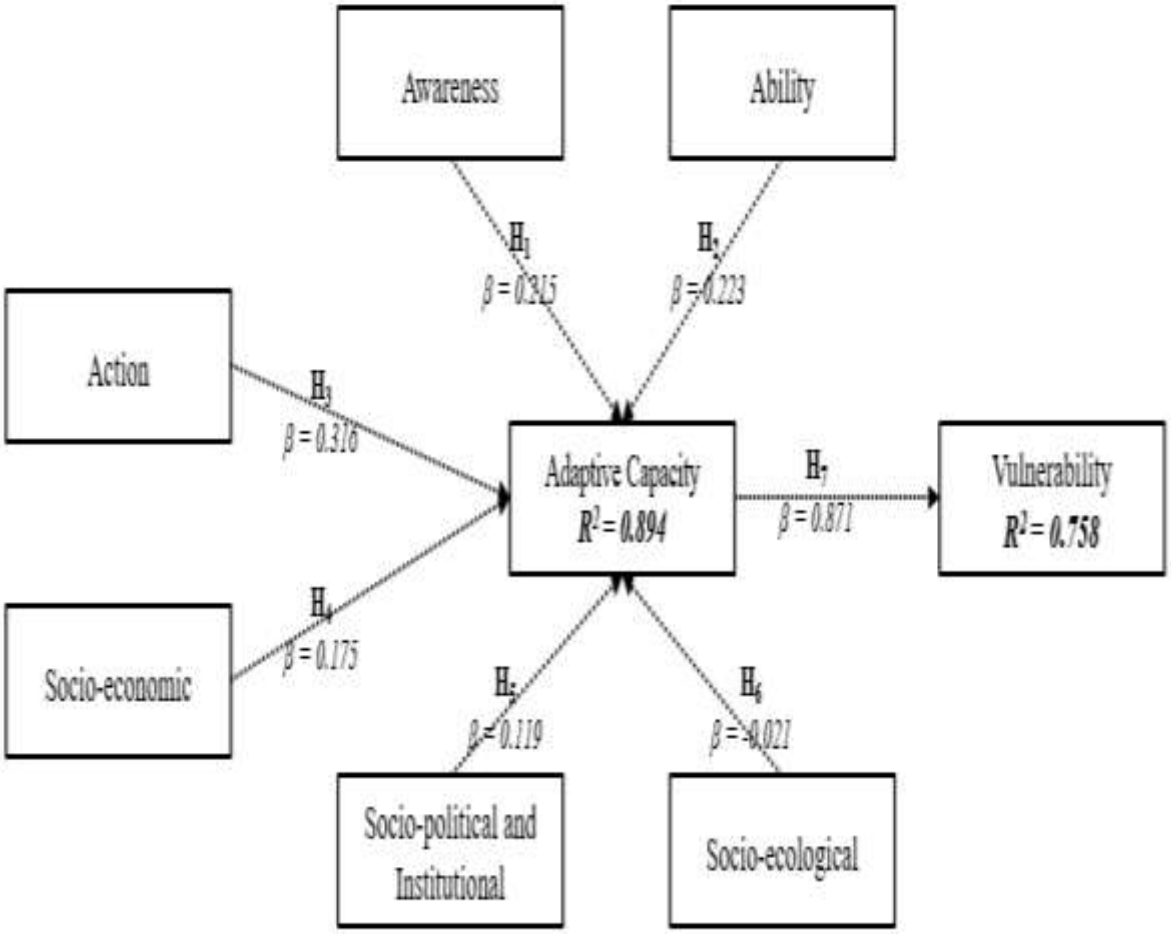

Figure 2:- Results of the Structural Model with Loading Values**.**

Discussion:-

Drawing upon prior research from the adaptive capacity to vulnerability context, we proposed integrated model, and empirically examined a set of individual factors that might influence the adaptive capacity in riverbank erosions areas. In general, the results provide support for the capability of the integrated model to measure the individual factors towards vulnerability. Furthermore, we discovered evidence of the influence of the awareness, ability, action,

socioeconomic, sociopolitical and institutional, and socio-ecological dimensions' impact on the vulnerability. Similar to the natural disaster context, where the awareness, ability and action are expected to have a positive effect on vulnerabilities to take action, these key beliefs directly affected by the adaptive capacity. The findings of this study suggest that the effect of the adaptive capacity towards vulnerability is positive and significant. The results of this study are consistent with the previous studies in the disaster prone area (Alam, 2017, Alam et al., 2017a)and show that if the adaptive capacity are high, the probability to vulnerability risk would be lower. This study revealed that AW, AB, ACN, SE and SPI have a strong influence on adaptive capacity to vulnerability.

Surprisingly, the study found an insignificant co-relationship between SEL and AC. As elaborated in the previous section, this finding may be unexpected but could be reflective of the current socioeconomic context (Alam et al., 2016). The findings is consistent with previous studies which have reported similar results that education, farming experience, land size, and training have positively influenced households' adaptive capacity (Islam and Hasan, 2016, Stojanov et al., 2016). Previous studies, however, failed to recognize these factors as a significant determinant of adaptive capacity to vulnerability such as resources, technology, government policies and institutional support from government agencies and NGOs, which influence, to a large extent, the adaptation or mal-adaptation of households to climate variability.

Conclusions and Policy Implications:-

Conclusions:-

This paper identified the attributes and indicators of the dimensions of vulnerability for understanding vulnerability risk and their related adaptive capacity in the riparian community. The results indicate that;

1. Loss of farming land and all levels of riparian households impacted severely by riverbank erosion and forced into a low livelihood status;
2. Strong adaptive capacity would reduce vulnerability risk in the affected areas;
3. Community-level vulnerability measurement enhances community's understandings, build capacity, make aware, and allow them to identify appropriate locally adaptation strategies;
4. Local level adaptation strategies may reduce the impact of such hazards on all sorts of vulnerability risk among rural households.

Thus, this study has been provided a comprehensive understanding of the extent of vulnerability and adaptive capacity of households to riverbank erosion affected areas. In these areas, droughts and floods have resulted in land degradation, soil erosion, soil infertility, and reduced seeding area with serious consequences, including reduced access to livelihoods insecurity. So, in attempting to support households' adaptation strategies to natural disaster, considerable attention should be paid to understanding socio-economic factors to develop sustainable strategies that will be culturally accepted by households and communities.

Policy Implications

This paper presents a conceptual framework for measuring adaptive capacity to vulnerability based on a review of both theoretical and empirical literature in relating to vulnerability risk. This study provides new information that might be useful in understanding the risk of vulnerable people and having strong adaptive capacity to reduce the relative vulnerability risk among the riparian households. These considerations thus led to the following practical implications;

1. It is expected that this study will assist policy makers to facilitate and provide guidance to take action regarding strong adaptive capacity.
2. Before providing guidance, the policy makers should consider the attractiveness of such knowledge and awareness, knowledge and experience, competence and social learning irrespective of individuals in riparian community.
3. The policy makers can demonstrate the systems to create confidence among community people where the possibility of natural disaster specifically riverbank erosion happening event is more.
4. The policy makers should provide a special program such as workshops or seminars to encourage community people to make them aware about adoption strategies to reduce vulnerability risk during climatic hazards like river erosion.

Limitations and Future Research

The nature of this study may restrict its generalizability to other research settings. The important lessons relate to the further research needs within this field. Future research may be necessary to validate the findings of this study by applying this integrated model in other developing countries vulnerability context. The result of this study is needed to develop methodologies for adaptive capacity measurement and understand how to integrate qualitative and quantitative methodology in a mixed methods approach.

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