Role of shifting environmental conditions and livelihood capitals in differential adoption of Climate Smart Agricultural Practices: Insights from Coastal Bangladesh

Dr. Md. Mamun-ur-Rashid
Professor
Department of Agricultural Extension and Rural Development
Patuakhali Science and Technology University
E-mail: murashid@pstu.ac.bd

1. Introduction

According to latest climate risk index, (2020) Bangladesh is positioned 7th globally in terms of losses inflicted by weather events during 1998 to 2018.The aggregated losses experienced during this time period is 0.41% of GDP loss equivalent to 1 686.33 million USD (PPP) (Eckstein et al,, 2019). The adverse effect of climate change is manifested in the country in the form of increased frequency of floods, flash floods, cyclone, storm surges, salinity intrusion, extreme temperature and droughts, riverbank and coastal erosion, erratic rainfall, etc. The coastal region of the country, covers almost 29,000 km^2 or about 20% of the country and 30% of the cultivable land, is more susceptible to climate change impacts than rest of the country (Haque, 2006) The highly vulnerable southern belt of coastal Bangladesh suffers from salinity, sea level rise, erosion, cyclone, and storm surges (Tabrig et al., 2013). Future projections of climate change impacts show that climate stresses will be way higher in future. The expected impacts by 2100 are 1) increase in temperature ranging from 3 to 3.5℃, 2) increase in inter-annual and intra-seasonal variability of rainfall coupled with 3) an increase in frequency of above-normal monsoon rainfall and years with extremely deficit rainfall, 4) penetration of cyclones to further inland with increased wind velocity and storm surge height, 5) a 10% intensification of the current 1-in-100 year storm surge combined with 6) 1 m sea level rise (SLR) which is supposed to affect 23% of the coastal area with increased salinity intrusion are expected SLR (WHO, 2015; World Bank, 2013; Tanner et al., 2007).

Agriculture sector is one of the most vulnerable sectors for the climate stresses that results in reduction of production and income, increasing risk and disrupting markets (Lipper et al., 2014). Food security at global, national and regional level is very likely to be affected by climate change, as projected change in temperatures, precipitation patterns, reduction of water availability, extreme events may all contribute to reduced agricultural productivity. Interestingly, agriculture is not only the sufferer of climate change but also this sector is a prime contributor to planetary warming, which shares 19-29 % of global anthropogenic greenhouse gas emissions (Vermeulen et al., 2012). Hence, to avoid the risk of a transition to a vulnerable agricultural system incapable for supporting food security while contributing to increased GHG concentrations that leads to further feedback loops , a pathway to resilient, productive and low emission agricultural system is required. In this context, Climate Smart Agriculture (CSA) can be a decisive approach through integrating climate resilience thinking into the planning and implementation of sustainable agricultural strategies (Lipper et al., 2014). CSA is an integrated approach to managing landscapes- crop land, livestock, forests and fisheries that address the intertwined challenges of food security and climate change. CSA endeavors to simultaneously achieve three outcomes such as increase productivity, enhanced resilience and reduced greenhouse gas emission (World Bank, 2019).

Adoption of CSA largely depends upon livelihood capitals of households (Olsson et al., 2014). Livelihood capitals is a widely used concept in literature closely linked to vulnerability, poverty and rural development. As defined by Chambers and Conway (1992) "a livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the short and long term" (p. 6). Capabilities, as explained in this definition, are options one possesses to pursue various activities to generate income necessary for the survival and to realize its potential as a human being. Capabilities are shaped by the portfolio of assets one possess, relying on which one takes decisions to produce outcomes necessary for sustenance and well-being (Žurovec and Vedeld, 2019). Eventually, the ability to pursue adaptive strategies make households resilient is linked to their tangible and non-tangible assets labeled as five 'capitals' namely physical, natural, human, social and financial which has been confirmed by various studies (Žurovec and Vedeld, 2019; Mutabazi et al., 2015; Pagliacci et al., 2020) conducted in varied geographical location considering diversified households. In this work we identify additional capitals such as "information" and "market" capitals. In this regard, a pertinent question is, given the socioeconomic context, how strongly the livelihood capitals are linked to the household ability to pursue strategies that strengthen resilience, particularly to climate change context in coastal Bangladesh.

1.1 Conceptual Framework

Rising consumption of fossil fuels, agricultural activities and changes in land use are continuing to emit greenhouse gases, such as carbon dioxide (CO_2), methane (CH_4), nitrogen dioxide (NO_2), etc., in the atmosphere. These gases trap the heat in the Earth's atmosphere that would have normally been radiated back in the space. This accumulation of heat has led to greenhouse effect resulting climate change, which is mainly characterized by rise in average global temperature, changes in cloud cover and precipitation particularly over land, melting of ice caps and glaciers along with reduced snow cover and increase in ocean temperature and ocean acidity (UNFCC, 2007, p.8). This research considers manifestations of global climate change as the change in temperature, rainfall, occurrence of cyclones, and rise in salinity level in the coastal Bangladesh

Studies focusing Bangladesh showed that increase in temperature will decrease productivity of Aman rice (Islam et al., 2008), wheat and potato (Karim, 1993); increase in rainfall will decrease Aman rice production (IbId), salinity decrease and germination rate of some crop plants (Rashid et al., 2004; Ashraf et al., 2002), flood reduce agricultural production up to 45% (Karim, 1996), and cyclone cause massive damage to crop production (FAO/GIEWS Global Watch, 2007). From these studies it is clear that environmental factors such as temperature, rainfall, salinity, exceeding thresholds may cause severe impact on crop production in Bangladesh in addition to extreme events such as flood and cyclones. Hence, transition to CSA capable of accommodating changes in climatic factors is a felt need in the country.

Adaptation efforts by people are also affected by people's perception regarding climate change. A study in South Africa found that perception of the effect of climate change significantly influence adoption of CSA practices for both small and medium farmers (Abegunde et al., 2019). Perception here means an understanding of the climate stress levels generated from available information (Shaven in Johnson, 1994. P.476). Žurovec and Vedeld (2019) in their study in Bosnia Herzegovina found that people's perception of climate has a positive correlation with the observed change in climatic factors such as temperature, rainfall, etc. In a study in Bangladesh Alam et al. (2017) also found that household's perception of change in climatic factors like precipitation, temperature, etc., is in line with actual climate change data. However, the nexus between climate change acts on farmer's perception on climate change and its influence on CSA adoption in coastal Bangladesh is largely unknown, although understanding this nexus may contribute to climate change adaptation planning and designing.

Extreme climatic events and other perturbations such change in national and international economic trends, political systems, incidence of illness and death, conflict, etc., can influence people's livelihood (DFID, 1999). For instance, due to recent COVID-19 pandemic, the government of Bangladesh taken various measures to control the spread of the pandemic which affected agriculture as well through various pathways (Amjath-babu et al., 2020) . Endorsing these facts sustainable livelihoods framework (SLF) recognizes that the development of livelihood capital enhances livelihood outcomes including reduced vulnerability (DFID, 2000). However, livelihood capitals include natural, physical, human, social, financial and information resources that are critical to the survival of people in response to stresses and shocks while not compromising the natural resource base (Ansoms and McKay, 2010; Mutenje et al., 2010; Scoones, 1998; Odero, 2006). Hence, it is suggested that improvement of livelihood capitals might help to adapt to the risks of climate change and other shocks as well as enhance the resilience of households. Here, resilience is the ability of countries, communities and households to manage change, by maintaining or transforming living standards in the face of shocks or stresses – such as earthquakes, drought or violent conflict – without compromising their long-term prospects (DFID, 2011).

To adapt changes in environmental thresholds due to global climate change, people adopt various strategies. Mubtazi et al. (2015) in their study in Morogoro region of Tanzania grouped adaptation strategies as extensification (bringing additional land parcels into cultivation), intensification (more inputs such as labor, water and nutrients to farms), diversification (e.g. agroforestry, crop diversification), and migration (remittances from migrants), and alteration (changing planting time and date, introduction of stress-resistant varieties, etc.). Based on this grouping, adaptation strategies revealed by a study of Alam et al. (2017) in Bangladesh are related to intensification, diversification, and migration. Aryal et al. (2020) also traced alteration as a strategy to adapt climate change in Bangladesh. However, Bangladesh is a very densely populated small country, where 80% of farmers are either marginal or small farmer hence extensification may not be a possible strategy to adapt climate change and other perturbations. Rather, coastal farmers shift their farming from crop to fisheries or livestock or forestry and followed different mitigating strategies such as zero tillage, mulching, etc., to address the causes of climate change. Hence, this research considered two other sets of strategies namely transformation and mitigation.

As discussed earlier, transition to climate smart agriculture is largely shaped by livelihood assets, shifting environmental thresholds and people perception of climate change. The environment stress considered in this work is increasing salinity level due to sea level rise in coastal Bangladesh. External disruptive events such as COVID-19 pandemic can also affect CSA pathways in short and long time scales. Thus understanding this complex nexus can help us to address the impediments of CSA practices adoption and assist us to device appropriate policies to continue precise CSA strategies during the time of crisis.

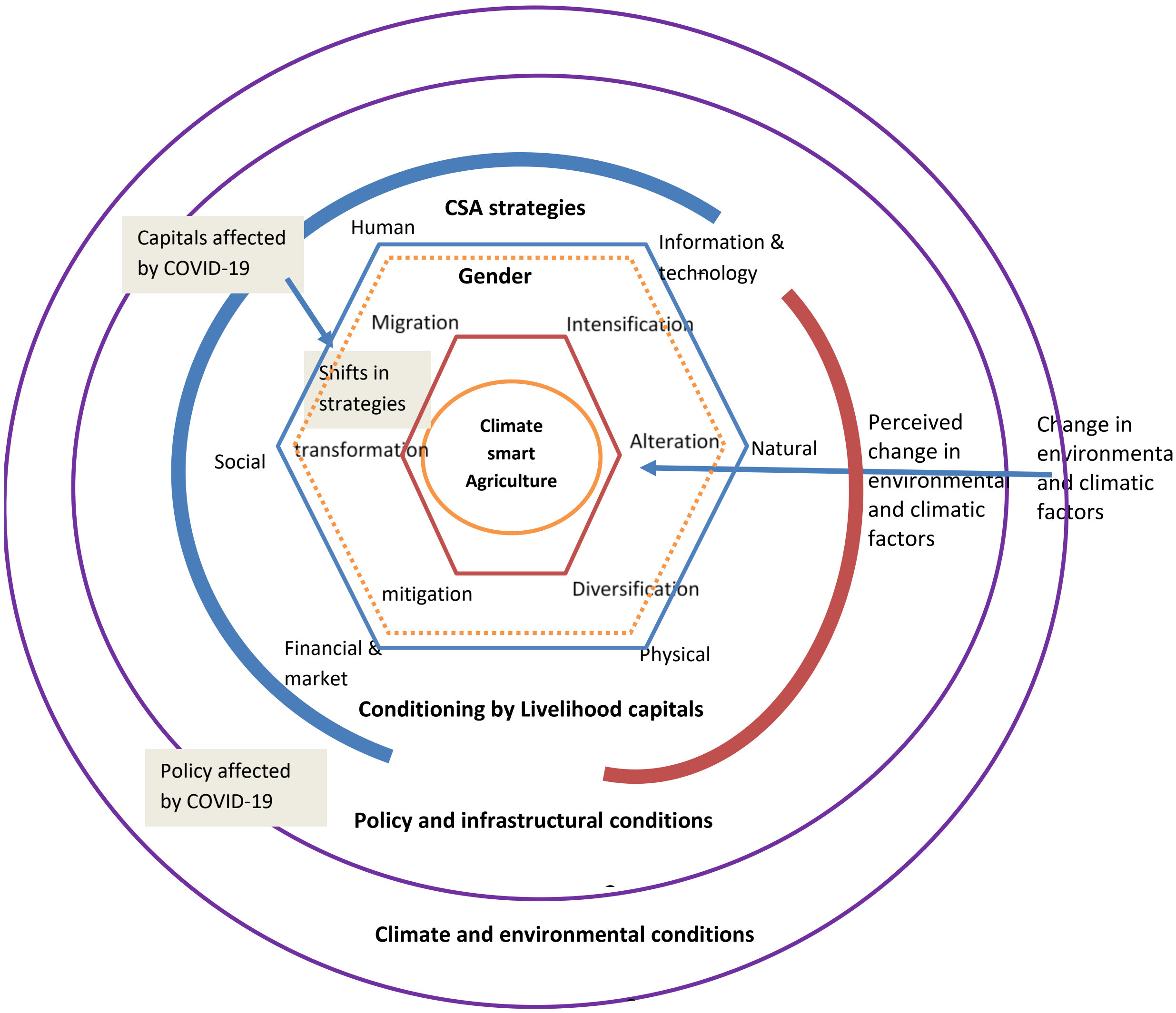

Fig. Conceptual framework of the study

1.3 Research questions

In the light of above discussion, it is essential to find out the answers of the following research questions.

1. Does change in climatic and salinity thresholds effect adoption of CSA?
2. Does people's perception of climate change has any effect on the adoption of CSA?
3. How livelihood capitals driving resilience enhancing actions such as adoption of CSA?
4. Does changes in livelihood capitals due to COVID-19 is changing adoption of CSA practices?

1.4 Research objectives

The general objective of this research is to evaluate how environmental thresholds and livelihood capital affect the adoption of various climate smart agricultural actions. In addition, it explores how COVID-19 pandemic effect adoption strategies of CSA by shifting the livelihood capitals. However, the specific objectives encompass:

1. To reveal the effect of climatic and salinity thresholds on the adoption of CSA.
2. To explore how people perceive climate change and how their perception effect adoption of CSA.
3. To understand how livelihood resources drive CSA adoption among the farmers of Costal Bangladesh?
4. To analyze the interaction of environmental thresholds and shift in livelihood resources with CSA adoption in coastal Bangladesh.

2. Methodology

2.1 Study location: Barishal division will be the location of this study. Three sub districts will be selected based on salinity level, such as strongly saline, moderately saline and slightly saline based on available latest soil salinity map.

2.2 Study approach: This study will adopt quantitative approach to reach its objectives. However, during development of the data collecting instrument qualitative methods such as focus group discussion and informal interviews may be deployed.

2.3 Data collecting instrument: A structured interview schedule will be developed following available literature.

2.4 Population and sampling: All the farmers suffer climatic hazards and COVID-19 pandemic shocks in the study area will constitute the population of the study. The sample for this study will be selected randomly and the sample size will be determined using Yamane's formula. However, the tentative sample size of this study might be 400 farmers.

2.5 Statistical analysis: A composite index of resilience building adaptive strategies (REBAS) of farm households will be developed based on a set of selected indicators. The construct indicators encompass the adaptive strategies, such as intensification, diversification, alteration, transformation, mitigation and migration. The REBAS will be constructed as a weighted index that merges the sub-indices of all identified strategies of resilience building **(e.g.** intensification, diversification, alteration, transformation, mitigation and migration, etc.) in a single composite indicator as follows:

$$C_{jk} = \sum_{l} a_k^l \left(X_j^l\right)$$

$$REBAS_j = \sum_{k} v_k \left(C_{jk}\right)$$

Where, $REBAS_j$ is the composite score of resilience-building livelihood strategies of *j*th household; C_{jk} is kth principal component of *j*th farmer where a_k^l is the loading of *k*th component for *l*th variable; v_k variance accounted by the kth principal component. X_j^i are *j*th household's binary code value (1 or 0) for *i*th construct variable.

To ascertain the linkage between livelihood assets such as natural, human, physical, social, financial and information and the use of CSA index it is hypothesized that the ability to take REBAS depend on the aforesaid assets. Hence, a multiple regression model will be use as follows:

$$REBAS_j = \sum \beta_i Z_j^i + u_i$$

I= 1,2,…,m j=1,2,3….j

Where, Z_j^i stands for the variables representing the four capitals and β_i denote respective coefficients. The variables considered as determinants of the composite index of resilience.

The COVID-19 pandemic could have affected the CSA activities reported in the Aman season 2020. The data for CSA strategies employed last crop seasons will be used to understand these shifts The methodology for the assessment is understanding the shifts in REBASj scores and the underlying changes in strategies.

3. Expected outcomes

The findings of this study will provide quantitative evidence to the linkages and shed light on the need of enhancing livelihood resources to upscale the ability to undertake CSA strategies that enhance the ability to withstand stresses and shocks due to climate change and other drivers. This research also helps us to guide actions to improve livelihood capitals in order to assist resilience to the farming systems against the changing climate and other perturbations such as COVID-19 pandemic. It is important to note that the findings of this study will be published in SCI/SSCI/SCOPUS indexed journals and present in international conference.

4. Outreach to local farmers and other stakeholders

The adaptation strategies used by the farmers in the study will be shared with the farmers and farmers groups in the coastal areas to encourage CSA practices in general. Moreover, the findings of this study will be shared with GOs and NGOs working on the adaptation to climate change in the coastal areas of Bangladesh. In addition, the findings of this study will be shared with international stakeholders via publication in journals and presenting results in international conference.

5. Research time frame

Activity	**Time**									
	2020			**2021**						
	Oct	Nov	Dec	Jan	Feb	March	Apr	May	June	July
Reviewing literature and consulting experts										
Preparation of interview schedule										
Pretest and finalization of interview schedule										
Field visit, data collection										
Data processing and analysis										
Report writing										

6. Research Budget

Activities	**Rate**	**Euro**
Preparation of questionnaire (Pre-test + Main survey)	0.20 €/Questionnaire,430X0.20	86
Research Assistant	@150 €/month/10 months	1500
Data Collection Charge including food and lodging	@25 €/day /90 days	2225

Books, Journals and other relevant materials	Consolidated	100
Travelling and lodging	Consolidated	400
Office Stationary (pen, pencil, paper, printer tonner, etc.)	Consolidated	50
Data entry and tabulation	0.40 €@430	172
Data analysis,	Consolidated	100
Report preparation and printing	Consolidated	100
Conference participation and publication	Consolidated	1500
Total (Six thousand two hundred thirty three Euro only)		= 6233/=

7. References

Abegunde, Victor O., Sibanda, M. and Obi, A. (2019). Determinants of the adoption of climate-smartagricultural practices by small-scale farminghouseholds in king cetshwayo district municipality,South Africa. Sustainability, 12, 195; doi:10.3390/su12010195

Alam, G.M.M., Alam, K., Mushtaq, S. (2017). Climate change perceptions and local adaptation strategies of hazard-prone rural households in Bangladesh. Climate Risk Management, 17:52-63

Amjath-Babu, T.S., Krupnik, T.J., Thilsted, S.H. et al. Key indicators for monitoring food system disruptions caused by the COVID-19 pandemic: Insights from Bangladesh towards effective response. Food Sec. 12, 761–768 (2020). https://doi.org/10.1007/s12571-020-01083-2

Ansoms, A. and McKay, A. (2010). A quantitative analysis of poverty and livelihood profiles: The case of rural Rwanda. Food Policy, 35(6), 584-598

Aryal, J.P., Sapkota, T.B., Rahut, D.B. et al. (2020). Major Climate risks and Adaptation Strategies of Smallholder Farmers in Coastal Bangladesh. Environmental Management 66, 105–120. Doi: https://doi.org/10.1007/s00267-020-01291-8

Ashraf, M.Y., Sarwar, G., Ashraf, M., Afaf, R. and Sattar, A. (2002). Salinity induced changes in α-anylase activity during germination and early cotton seedling growth, Biologia Plantarum pp.589-91.

Chambers, R. and Conway, G. (1992). Sustainable rural livelihoods: Practical concepts for the 21st century.IDS Discuss Paper,296, 1–29.

DFID. (2000). Sustainable livelihoods guidance sheets. London, UK: Department for International Development

DFID. (2011). Defining disaster resilience: A DFID approach paper. Available at: https://www.fsnnetwork.org/sites/default/files/dfid_defining_disaster_resilience.pdf

DFID.(1999). Sustainable Livelihoods Guidance Sheets. London, UK: Department for International Development

Eckstein, D., Künzel, V., Schäfer, L., and Winges, M. (2019). GLOBAL CLIMATE RISK INDEX 2020 Who Suffers Most from Extreme Weather Events? Weather-Related Loss Events in 2018 and 1999 to 2018. Briefing paper. GERMANWATCH. Available at: https://www.germanwatch.org/en/17307

FAO/GIEWS Global Watch. (2007). Livelihood of over 8.9 million people adversely affected by Cyclone Sidr in Bangladesh. Available at: http://www.fao.org/giews/english/shortnews/bangladesh071221.htm

Haque, S.A. (2006). Salinity problems and crop production in coastal regions of Bangladesh. Pakistan Journal of Botany, 38(5):1359-1365

Islam, M. N., Baten, M. A., Hossain, M. S. and Islam, M. T. (2008). Impact of few important Climatic Parameters on Aman Rice Production in MymensinghDistrict. J. Environ. Sci. & Natural Resources. 1(2): 49-54.

Johnson, N. A. (1994). The pervasive, persuasive power of perceptions. The Alberta Journal of Educational Research, XL(4):475±497.

Karim Z. (1993). Preliminary Agricultural Vulnerability Assessment: Drought Impacts due to Climate Change in Bangladesh. IPCC Eastern Hemisphere Workshop on Vulnerability Assessment to Sea-Level Rise and Coastal Zone Management, 3-6 August 1993, Tsukuba, Japan

Karim, Z., Hussain, S.G. and Ahmed, M. (1996). Assessing impacts of climate variations on foodgrain production in Bangladesh. Water, Air, and Soil Pollution, 92:53-62.

Linda Liebenberg, Natacha Joubert, & Marie-Lynne Foucault. (2017). Understanding Core Resilience Elements and Indicators: A Comprehensive Review of the Literature. Available at: https://bettercarenetwork.org/library/strengthening-family-care/psychosocial-support/understanding-core-resilience-elements-and-indicators-a-comprehensive-review-of-the-literature

Lipper, L., Thornton, P., Campbell, B. *et al.* (2014).Climate-smart agriculture for food security. *Nature Clim Change* 4**,** 1068–1072 . Doi: https://doi.org/10.1038/nclimate2437S.

Mutabazi, Khamaldin D. Amjath-Babu, T. S. and Sieber, Stefan. (2015). Influence of livelihood resources on adaptive strategies to enhanceclimatic resilience of farm households in Morogoro, Tanzania:an indicator-based analysis. Environ Change, 15(7), Doi: 10.1007/s10113-015-0800-7

Mutenje, M.J., Ortmann, G.F., Ferrer, S.R.D. and Darroch, M.A.G. (2010) Rural livelihood diversity to manage economic shocks: Evidence from south-east Zimbabwe, Agrekon, 49:3, 338-357, DOI: 10.1080/03031853.2010.503381

Odero, K.K. (2006). Information capital: 6th asset of sustainable livelihood framework. Discovery and Innovation, 18(2) 2006: 83-91

Olsson, L., Opondo, M., Tschakert, P., Agrawal, A., and Eriksen, S.E. (2014). Livelihoods and poverty. In Climate Change2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working GroupII to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change; Field, C.B., Barros, V.R.,Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C.,Eds.; Cambridge University Press: Cambridge, UK; New York, NY, USA, 2014; pp. 793–832.

Olsson, L.; Opondo, M.; Tschakert, P.; Agrawal, A.; Eriksen, S.E. Livelihoods and poverty. In Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change; Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Eds.; Cambridge University Press: Cambridge, UK; New York, NY, USA, 2014; pp. 793–832.

Pagliacci, F., Defrancesco, E., Mozzato, D., Bortolini, L., Pezzuolo, A., Pirotti, F., .. et al. (2020). Drivers of farmers' adoption and continuation of climate-smart agricultural practices. A study from northeastern Italy.Science of The Total Environment, 710:136345

Rashid, M.M., Hoque, A.K.F. and Iftekhar, M.S. (2004). Salt Tolerances of Some Multipurpose Tree Species as Determined by Seed Germination. Journal of Biological Sciences, 4 (3): 288-292

Scoones, I. (1998). Sustainable Rural Livelihoods: A Framework for Analysis; IDS Working Paper 72; Institute of Development Studies: Brighton, UK

Tabrig, M.S.U., Shamim, A.H.M., Rahman, M.A., Islam, K.M.M. and Akae, T. (2013). Impacts of salinity problems on livelihood in Bangladesh: a case study. Int. J. Expt. Agric., 3(1):13-21

Tanner, T.M., Hassan, A., Islam, K.M.N., Conway, D., Mechler, R., Ahmed, A.U., and Alam, M. (2007). Piloting Climate Risk Screening in DFID Bangladesh. Detailed Research Report. Institute of Development Studies, University of Sussex, UK.

UNFCC. (2007). Impacts, Vulnerabilitiesand Adaptationin Developing Countries. Climate Change Secretariat (UNFCCC), Bonn, Germany. Available at: https://unfccc.int/resource/docs/publications/impacts.pdf

Vermeulen, J. , Campbell, B.M. and Ingram, J.S.I. (2012). Climate change and food systems. Annu Rev Environ Resour, 37 (2012): 195

Vermeulen, Sonja J., Campbell, Bruce M. and Ingram, John, S.I. (2012). Climate Change and Food Systems. Annual Review of Environment and Resources, 37:195-222.Doi: https://doi.org/10.1146/annurev-environ-020411-130608

WHO. (2015). Vulnerability and Adaptation to Climate Change in Coastal and Drought Prone Areas of Bangladesh: Healthand WASH. ENVIRONMENTAL HEALTH UNIT, WHO: Bangladesh. Available at: https://www.who.int/globalchange/resources/wash-toolkit/vulnerability-and-adaptation-to-climate-change-in-coastal-and-drought-prone-areas-of-bangladesh.pdf?ua=1

World Bank, (2013). Turn down the heat: Climate extremes, regional impacts, and the case for resilience. A report for the World Bank by the Potsdam Institute for Climate Impact Research and Climate Analytics. Washington, DC:World Bank.

World Bank. (2019). Climate Smart Agriculture Overview. Available at: https://www.worldbank.org/en/topic/climate-smart-agriculture

World Bank. (2019). Climate Smart Agriculture. Available at: https://www.worldbank.org/en/topic/climate-smart-agriculture

Žurovec, O. and Vedeld, P.O. (2019). Rural Livelihoods and Climate Change Adaptation inLaggard Transitional Economies: A Case from Bosniaand Herzegovina. Sustainability, 11. 6079; doi:10.3390/su11216079