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Community Based Risk Assessment of Agriculture Sector in Sreerampur Union of Bangladesh

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Abstract Community based risk assessment (CBRA) is process for assessing local hazards, vulnerabilities, risks; coping capacity and finally identified risk mitigations options are the ultimate outcome of CBRA. Selected study area was Sreerampur sub-sub district in Dumki sub district of Patuakhali district in Bangladesh aiming to gather information on local hazards; to assess community vulnerabilities, capacity, risks and existing adaptation measures adopted by agriculture farmers. Focus-group-discussions, key-informant-interviews, extensive physical visit and exploration of secondary data sources were followed to collect primary and secondary data. Result revealed that in Sreerampur no innovative adaptations options were practiced. Only alternative options are adopting to reduce risks which results higher production costs in agriculture and environmental degradation. Due to the changing trend in risk profiles; increasing its persistence time and frequency and intensity, farmer's adaptation capacities and sustainability are more exposed to vulnerability. They are increasingly depending on the non-agricultural livelihood activities and migrating from nature based traditional on-farm livelihood to nonfarm livelihood as alternative options, not as innovative sustainable options. Therefore need community based hazard specific more research in agriculture to understand characteristics of hazard events, mode of impact and community based appropriate adaptive measures if we want community resilience in the country.

Keywords: *adaptation, agriculture, community, farmers, risk assessment*

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1. Introduction

Hazard is a dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage [1]. Hazard means an abnormal event which has the potential to cause colossal loss to human life and livelihood and which can be either natural, human induced, biological or technological in nature.

Risk results from the interaction of physically defined hazards with the properties of the exposed systems, i.e. sensitivity or vulnerability. In risk assessment, the focus is on individuals and social groups and understanding the probabilistic of the triggering event [2]. These interactions mean that different people are exposed in different ways to stresses and threats. Or more simply, who is vulnerable? To what? Risk equals the probability of climate hazard multiplied by a given system's vulnerability. Although measurement of risk is clearly important, quantification does not always tell the whole story, and not all risks are quantifiable [3]. According to UNISDR, **risk** is the combination of the probability of a hazardous event and its consequences which result from interaction(s) between natural or man-made hazard(s), vulnerability, exposure and capacity [1]. It is important to consider the social contexts in which risks occur and that people therefore do not necessarily share the same perceptions of risk and their underlying risk factors. **Risk assessment** is an approach to determine the nature and extent of risk by analyzing potential hazards and evaluating existing conditions of vulnerability. ISO 31000 defines risk assessment as a process made up of processes: risk identification, risk analysis, and risk evaluation. **Risk identification** is process that is used to find, recognize, and describe the risks that could affect the achievement of objectives [1]. Over the last two decades there has been a growing realization that disaster management is most effective at the community level where specific local needs, resources, and capacities are met [4,5]. In risk assessment, the focus is on individuals and social groups and understanding the probabilistic of the triggering event [2,6]. Several studies have been revealed the positive outcomes of community based approaches for disaster management worldwide [7,8,9]. This present study focused on farmer's Hazards, vulnerability, capacity and risk analysis by understanding, planning for and adapting to a changing climate that individual agriculture farmer can take advantage of opportunities to reduce risks associated with climate-induced stresses [10]. The UNDP [11] define risk by the equation: Risk = Hazard X Vulnerability. [R= (HXV)], Scientists [12,13,14,15] adds manageability or capacity to the equation and propose: Risk = (Hazard x Vulnerability) /Manageability or Capacity.

According to the report of working group II of the IPCC [16], definition of **vulnerability** of climate change is, "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. **Vulnerability** is "a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity". Poverty and its common consequences such as malnutrition, homelessness, poor housing and destitution – is a major contributor to vulnerability. Scientists [17] categorize vulnerabilities into three areas: ***Physical/Material Vulnerability:*** For example, poor people who have few physical and material resources usually suffer more from disasters than rich people. People who are poor often live on marginal lands; they don't have any savings or insurance; they are in poor health. These factors make them more vulnerable to disasters and mean that they have harder time surviving and recovering from a calamity than people who are better off economically. ***Social/organizational Vulnerability:*** People who have been marginalized in social, economic or political terms are vulnerable to suffering from disasters whereas groups, which are well organized and have high commitment to their members, suffer less during disasters. Weakness in social and organizational areas may also cause disasters. ***Attitudinal/Motivational Vulnerability:*** People who have low confidence in their ability to affect change or who have "lost heart" and feel defeated by events they cannot control, are harder hit by disasters than those who have a sense of their ability to bring the changes they desire.

According to the UNISDR **Capacity** is the combination of all the strengths, attributes and resources available within a community, society or organization that can be used to achieve agreed goals. **Coping capacity** is the ability of people, organizations and systems, using available skills and resources, to face and manage adverse conditions, emergencies or disasters. The capacity to cope requires continuing awareness, resources and good management, both in normal times as well as during crises or adverse conditions. Coping capacities contribute to the reduction of disaster risks [1]. **Adaptive capacity** is the capacity of a system to adapt in order to be less vulnerable, is a dynamic notion. It is shaped by the interaction of environmental, social, cultural, political and economic forces that determine vulnerability through exposures and sensitivities, and the way the system's components are internally reacting to shocks. In fact, it has two dimensions: adaptive capacity to shocks (coping ability) and adaptive capacity to change. The first dimension is related to the coping ability (absorption of the shock), the second dimension is related to time (adaptability, management capacity). Adaptations are manifestations of adaptive capacity [18].

Over the last two decades there has been a growing realization that disaster management is most effective at the community level where specific local needs, resources, and capacities are met [4,19]. Reason for implementing community-based approaches is that communities are knowledgeable about the hazards occurring in their environment and are able to anticipate them in some cases. They may not be scientific but the richness of experience and indigenous knowledge is a resource to be recognized [4]. In risk assessment, the focus is on individuals and social groups and understanding the probabilistic of the triggering event [2]. Several studies have been revealed the positive outcomes of community based approaches for disaster management worldwide [7,8,9,20].

As the dominant economic activity in Bangladesh, role of agriculture is vital in enhancing productivity, profitability and employment in the rural areas for improving the livelihood security status of the poor [21,22,23]. As the largest private enterprise, agriculture (crops, livestock, fisheries and forestry) contributes about 21% of the GDP, sustains the livelihood of about 52% of the labor force [24], and remains a major supplier of raw materials for agro-based industries. Agriculture is also a social sector concerned with issues like food and nutritional security, income generation and poverty reduction [25,26]. Agricultural activities are by nature prone to risks and uncertainties of various nature, biophysical, abiotic, climatic, environmental, biotic (pests, diseases) and economic. Many of these risks have a climatic component and most of them will be affected by climate change, either in intensity, scope or frequency [27]. Agriculture sector is one of the threatened sectors due to the continuous threat of natural and manmade disasters and climate change and this sector will be remarkably affected due to climate change impacts resulting different climatic hazards/ disasters [28].

The common natural disasters in this region are cyclones, storm surges, floods, water logging, drought, pest and diseases epidemic etc. that resulted severe impacts on agriculture sector. The risk of crop losses from pest and disease are an important vulnerability for agricultural producers. Recently intensity and frequency of pest and disease attack has been increased-resulting the crops and vegetables are damaged drastically [29,30]. As a result, the livelihoods of the community are under threats. Therefore, it is very important to identify and analyze the underlying factors that increase the risk for this study area in terms of agriculture and to explore some options that can make their livelihoods more secured. To do so, it is necessary to assess the hazards potentiality to cause damage, the community's risk and vulnerability. For these reasons, this study focuses on exploring the agriculture farmer's risk profile through Sreerampur union's community participation. The main objectives of the research are:

- to gather all available information on identified local hazards to assess the community vulnerabilities, its capacity and risks related to agriculture sector;
- to develop a community based disaster risk management framework in agriculture sector by analyzing the copping strategies towards these hazards in agriculture sector engaging the community approach.

2. Materials and Methods

2.1. Description of the Study Area

Selected study area is the southern coastal Sreerampur union of Dumki upazila under Patuakhali district of Bangladesh (Figure 1). The area of this union is 92.46 sq km, located in between 22°23' and 22°30' north latitudes and in between 90°17' and 90°27' east longitudes. Its total population and households are 7,470 and 1,442, respectively. It is bounded by Bakerganj upazila on the north, Patuakhali sadar and Bauphal upazilas on the south, Bauphal upazila on the east, Mirjagonj upazila on the west. Selected area is highly prone to natural disaster that has already been experienced with the devastating impact of cyclone SIDR in 2007 and AILA in 2009. Other disasters like hail storm, thunderstorm, drought also hit every year. Pest and diseases epidemics are also regular hazard for this area affected agriculture production every year [26].

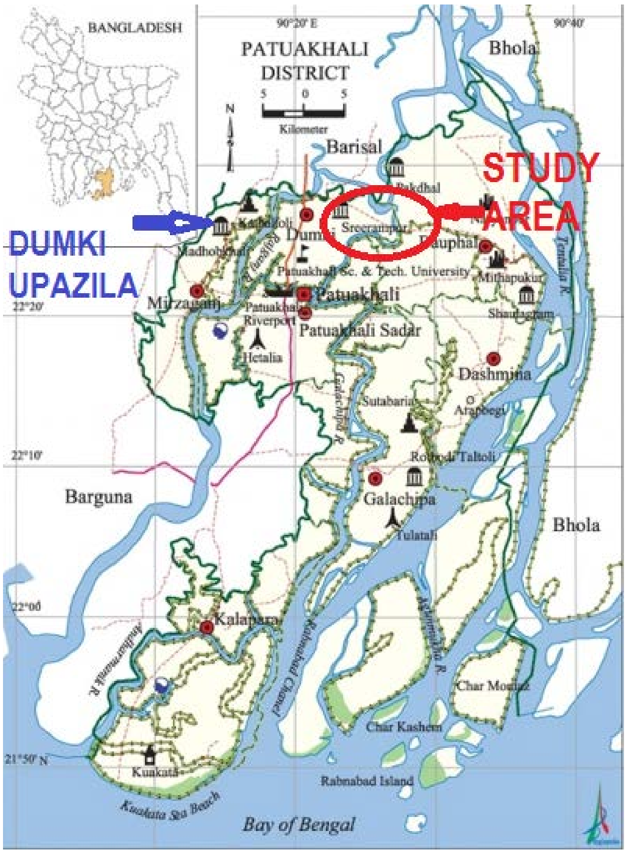

Figure 1. Sreerampur union (circled) of Dumki upazila (Blue colored) under Patuakhali district of Bangladesh [31]

2.2. Research Methods and Data Collection

This study was conducted from January 2015 to May 2015. Data was collected carefully to ensure that the people who participated volunteered and were not forced to be interviewed. The methods of data collection included completion of the Focus Group Discussion (FGD)- semi-structured farmer's interviews (questionnaire survey) with the community members, direct field observation and Key Informant Interviews (KII). A total of 22 FGD sessions was conducted. Additional information as secondary data was pertaining to the study was attained by accessing the relevant information from media such as journal articles, research thesis, recorded data, data from different local government administrative offices-Union and Upazila Parishad. A total of 03 key informant interviews were done with school teachers, agriculture extension officer of Dumki Upazila and assistant agriculture officer of Sreerampur Union. During data collection the following questions were focused to get the information—i) existing hazards for agricultural sector, vulnerability and capacity of this community in the study area ii) risk factors related the agriculture and impact of all risk factors on local community based agriculture production and iii) existing best adopted adaptations strategies.

2.3. Data Processing Method, Statistical Tools and Techniques

After the completion of data collection, tabulation work including editing, coding and tabulation manually. Data computation and analysis was done using Microsoft Office Excel program.

The UNDP [11], define risk by the equation: Risk = Hazard X Vulnerability. [R= (HXV)]. Scientists [12,13,14,15] adds manageability or capacity to the equation and propose: Risk = (Hazard X Vulnerability) /Manageability or Capacity [R = (HxV)/C]. Therefore risk assessment and computation was done following the equation (1) (Here, R= Risk; H= hazard; V= Vulnerability and C= capacity).

Correlation (CORREL) between different dependent and independent variables was determined and ANOVA was performed to determine the significance or insignificance at 5% level of probability. Different secondary data are analyzed and integrated with primary data.

3. Results and Discussions

3.1. Socio-demographic Condition

We conducted this research in a diversified aged group of people in where the highest number of respondents (37%) was under 50 years to above, while 32 % was 18-35, and 31% was 36-50 years. Results revealed that education helps a farmer to take challenge the risk and adoption of new technology to cope with. The educated farmers differentiated themselves from non-educated ones with respect to the acceptance of recommended farm practices. Education helps a farmer to go to extension workers for solving any problem regarding crop production [32]. In the study area the highest proportion (59%) of the farmers belonged to the primary level of education, while about 35% and 6% of them belonged to secondary and above secondary levels of education, respectively. Analysis showed that 38% farmers are holding 1-50 decimal land, 35% having 60-100 decimal and above 100 decimal is only 27% farmer. Most of the farmers cultivate their land by shearing with other farmers or in case of financial crises they borrowing money from others and vice-versa. Survey revealed that only 26% farmers have above 30 years farming experience and rest 74% have up to 30 years farming experiences. Researchers reported that the ability of farming households to cope with disasters is also significantly impacted by family members' experiences and their economic context at the village level [20]. From other scientist's [33] research it was concluded that Bangladesh is a land scarce country where per capita cultivated land is only 12.5 decimals. On average landless farmers owned up to 0.22 acre land where family size is 4.8; marginal farmers owned 0.47 acres where family size is 5.1, small 1.63 acres where family size is 4.9 and medium 3.42 acres where family size is 5.7. The net amount of area in crop farming of the country was found declining because of land-loss from river and coastal erosions and agricultural land being used for urbanization [34] concluded by other researcher

3.2. Identification of Elements at Risk

Scientists [35] commented on the analysis of elements at risk that rice, vegetable, livestock and poultry production are faced flood, flash flood, drought and heavy rainfall hazards as well. In the study area elements at risk were identified considering the potential existing hazards phenomena. Different elements of Sreerampur union are at risk and are susceptible to being affected by different hazard events like pest and disease epidemic, cyclone, seasonal drought, hail storm, storm wind, thunderstorm, flood and salinization etc are interpreted below-

-Population: 7,470 inhabitants and 1,442 households at the area of Sreerampur union of Dumki Upazila of Patuakhali district.

-Households: 1,442 households of Sreerampur union of Dumki Upazila of Patuakhali district. Population density at the study area is per sq km is 356.

-Buildings- primary school 4, madrasa 3 (Islamic Institution), mosque 10.

-Sources of income: Agriculture 30.10%, fishing 26.45%, non-agricultural labor 3.3%, business 15.62%, construction 8.20%, rickshaw pulling -auto bike or motorcycle driving 16.03, religious service 0.30% (average of Dumki upazila) and

-Others: Agriculture crop and pulse etc; Hat 3 and 3 bazar; Communication facilities are pucca road and mud road; Access to electricity: all rural electrification area; Sources of drinking water: Tube-well, pond; Sanitation: all rural sanitation of the dwelling households.

3.3. Livelihood Diversifications

Due to limited scope of employments (off-farming economic sector), the livelihood diversification in the study areas has become one of the major challenges [36]. Non agriculture activities and employment opportunities are limited in the study area. People of Sreerampur union lead their livelihood mainly by agriculture farming (86%). Besides agriculture farming other small scale activities (14%) exist with regard to spinning, fishing, rickshaw-van pulling, day laborer, primary school teaching, rearing livestock, aquaculture, fishing, tailoring, retail shopping, Rickshaw workshops, motorbike-taxi driving and servicing, fishing net making and repairing, maids/servants for extreme poor women; bamboo materials (chatai, fishing equipments, mora etc.) are major nonfarm income generating activities in these regions. Approximately 50% household's rear indigenous poultry and livestock (mainly cow, goat and buffalo) in their homestead as their source of income which helps them during crisis as cash support. Traditionally women and girls take care for feeding and other rearing activities. Rich farmer in the village have cattle and buffalo but poor farmer have poultry, duck and goat. However during rainy season it is difficult to kept them diseases free and supply of available feed. Farmers are better aware and more attentive about milking cow rearing and duck rearing but not enough about goat and poultry rearing and their management, because these species are less adapted in the study area. Rural farmer rear their livestock following traditional practices. A good numbers of farmers (26%) are depended on fishing in open water bodies (mainly rivers and cannels) for the whole year. Pond fish culture has been increasing with rearing of exotic fish varieties for the last couple of years. There are ponds, ditches in each and every homestead but those are not well managed for getting highest yield. Previous researcher [37] suggested on risk mitigation techniques in agriculture and presented that the most commonly applied risk management strategy is diversification and risk-averse farmers particularly diversify their crop, livestock of nonfarm livelihood productions. By doing so, loss in one sector is relatively covered by productivity of the other sectors. From the previous research it was found [38] that farmer's generally rare livestock and poultry in their house for the cash income and generally they sell these in order to meet household financial needs during disaster and when they have no income. Previous researcher [36] commented that farmer's are increasingly changing their livelihoods as alternative options -not as appropriate innovative options and which results no sustainable change in agriculture but almost compensation based adaptation practice. Innovative adaptation practices are almost absent in locality. Poor farmers get about 50% percent [39] of their food and cash from homestead-based food production system likely to growing vegetables and fruits, rearing livestock, poultry and fishes and rising different varieties of trees and plants around the household that provide major share of livelihood especially for the poor farmers.

3.4. Agricultural Production Related Information and Risks Faced

Agriculture is the main source of livelihood for 1.3 billion smallholder farmers worldwide [40] and is highly vulnerable to climate change, particularly in the Tropics [41]. Sreerampur union of Dumki Upazila of Patuakhali district is one of the examples of sufferings and vulnerable area for agriculture. Farmer's works in the field all day long to produce crops and vegetables such as rice, pulse, potato, pumpkin, tomato, brinjal, ladies finger, bean, lentil, mung, felon pulse, soybean etc. Producing the crops they face many seasonal problems. In the month of February to April they suffer most lack of irrigation water due to the inactive sluice gate. Lake of surface water in the pond, canal and other sources make the crops and fishes are damaged. There is a need to reconstruct sluice gate to reserve surface water for draught period. Due to the river and canal bed siltation, the capacity to catch the surface water has been decreased. Also lack of water and high temperature and humidity increased pest epidemics and damaged field crops, vegetables etc. On the other hand during wet season all crops and crop land inundated and submerged and results high damage of crops. During FGD many farmers commented that hail storm also creating damages for water melon and other crops. From the above discussion it can be concluded that the farmers are exposed in vulnerable condition and expressed to have appropriate measures to reduce the vulnerabilities. Above results reinforced by earlier studies [42] and they reported that the inherent problems in the agricultural sector are lack of finances, poor irrigation infrastructure; high cost of fertilizer, quality seed, lack of credit, insect and disease problem etc. CDMP reported that the south-west region of Bangladesh about 10-15% of the land is used to grow petty cash crops like potato, sweet potato, mustard, sesame, pulses, watermelon and other types of vegetables [43].

Farmers who are living on agriculture and fish production they suffer a lot during dry season as drought, wet season flood, cyclone, inundation, flash flood is observed which destroyed livestock, cattle, paddy, trees and crops, and flood water swept away many crops [44]. Researchers commented that higher or lower than optimum temperature situations, crops tend to respond negatively, resulting in a drop in yield. Excessive rain fall may cause damage younger plants and yield declines due to water logging and increased pest infestations. Draught, inundation can also hinder field operations and increase the yield gap. The extent of crop damage depends on the duration of precipitation and flooding, crop developmental stage, and air and soil temperatures [45]. CDMP reported that the south-west region of Bangladesh farmers build seasonal dams across the local canals towards the end of the Kharif-II season to preserve fresh water for subsequent irrigation for the Rabi crops [43]. Early flood, hailstorm and drought are the main constraints to grow modern boro rice [46]. Researcher [39] stated that lack of irrigation facility had been identified by the respondent of the selected area as a severe constraint to the progress of homestead-based agriculture production system. Damage by pest and disease and traditional methods of farming are the two most perceived sources of production risk [30]. FAO [47] suggested and emphasis on appropriate crop variety selection, good quality seed, timely planting or sowing, line sowing, appropriate fertilizer management, irrigation and drainage, weeding and IPM as the examples of technologies, practices and approaches as important good agronomic practices for building resilient livelihoods for the farmer's community. Researcher also commented that timely planting, timely irrigation, timely weeding and timely harvesting constituting non-monetary good agronomic practices essential to adapt to increase the productivity, yield and profit suggested by other researcher [48,49].

Table 1. Disasters, years, losses and affected sectors

Disaster and rank	Years	Losses (medium/high) and Affected sectors
Pest and disease epidemic	2004, 2005, 2006, 2008, 2009, 2010, 2011, 2013, 2014, 2015	High: Agriculture resources, medical care and Medium: Livestock and poultry
Seasonal drought	2004, 2005, 2006, 2008, 2009, 2010, 2011, 2013, 2014, 2015	High: Agriculture production and Medium: Livestock and poultry
Hail storm	2004, 2005, 2006, 2008, 2009, 2010, 2011, 2013, 2014, 2015	High: Human. Agriculture resources, medical care and Medium: beef cattle.
Thunderstorm	2004, 2005, 2006, 2008, 2009, 2010, 2011, 2013, 2014, 2015	High: Human. Agriculture resources, medical care and Medium: beef cattle.
Storm surge	2006, 2007, 2008, 2009, 2011, 2013	High: Fisheries, health sector, infrastructure and Medium: Agriculture resources, livestock, communication.
Cyclone	2004, 2005, 2006, 2008, 2009, 2010, 2011, 2013	High: Agriculture resources, medical care and Medium: Fisheries, beef cattle.
Storm wind	2004, 2005, 2006, 2008, 2009, 2010, 2011, 2013, 2014, 2015	High: Agriculture, human resources, infrastructure and Medium: Fisheries, Livestock, communication.
Tidal flood	1986,1987,1988, 1995, 1998, 2004, 2009	High: Agriculture, human resources, infrastructure and Medium: Fisheries, Livestock, communication.
Salinization	2006, 2007, 2008, 2009, 2011, 2013	High: Fisheries, health sector, infrastructure and Medium: Agriculture resources, livestock

Table 1 elucidates the disaster rank, damage, intensity of losses and affected area of the Sreerampur union and revealed that because of these hazards crop-livestock-fisheries production, human health sectors, local level critical facilities, education, infrastructure development and biodiversity is seriously damaged. An analysis of the history of the disaster in the year of 1988-1991; 2003; 2004; 2007; 2009 and 2013 of Sreerampur union indicate that SIDR in 2007, AILA in 2009 and MOHASEN in 2013, the storms cyclones caused widespread damage and increasing vulnerability to hazards. CDMP, 2009 concluded in the report of 'Situation Assessment Report in South West Coastal Region of Bangladesh' that every year due to sever climatic disasters phenomena damaged farmer's livelihood, human health sectors, critical facilities, education systems, infrastructure development and biodiversity.

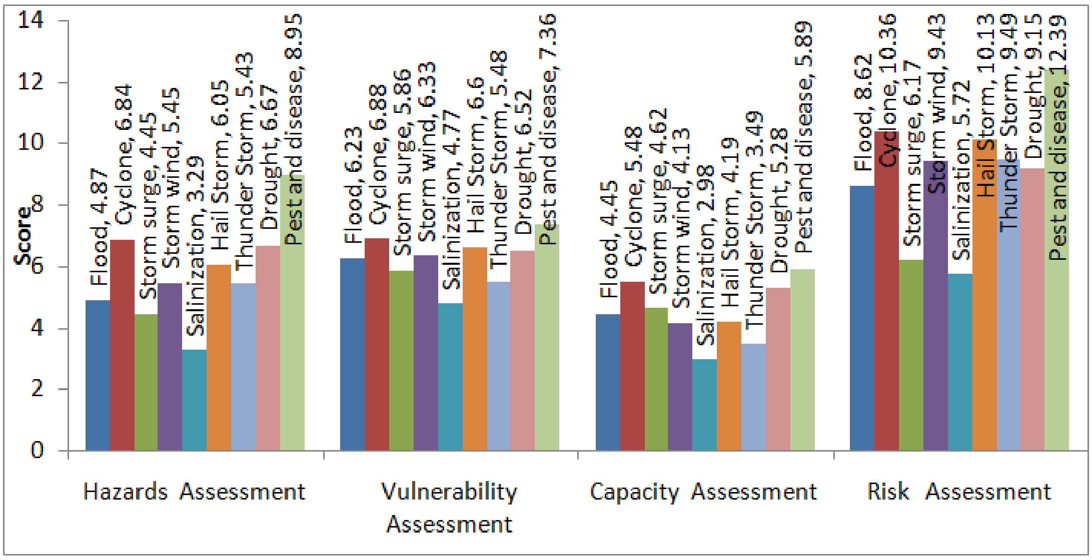

Figure 2. Hazard, vulnerability, capacity and risk Assessment in Sreerampur union

3.5. Hazard, Vulnerability, Capacity and Risk Assessment

Impact of different hazards, their vulnerability on agriculture production, farmer's capacity to cope with hazards and cumulative effect on raising risks at community level was calculated and shown in the Figure 2.

3.5.1. Hazards Assessment

Field studies and investigations among the local farmer's community allowed the identification of the types of potential hazards present in the studied region. Results were analyzed and the potential natural and human induced hazards were identified according to their intensity and frequency. Results indicate that among the hazards, pest and disease epidemic has the highest potentiality occupying highest score is 8.95 whereas salinization has the lowest having score is 3.29. The cyclone, seasonal drought and hail storm have more or less same potentiality score ranging from 6 to 7 (Figure 2) to make vulnerability in the study area. From the above result it can be concluded that on the basis of farmers community perceptions pest and disease attack got the highest priority and salinization have lowest priority hazard occurring in this area in agriculture sector. These types of regular phenomena are damaging crop, livelihood, homes, roads and property whole year round with severity in the periods of April to May and September to November. This area often accompanied by pest and diseases epidemic, storm wind, hail storm, drought etc. These caused every year a great damage of livelihood; crop-livestock-fisheries production; change in lifestyles; disruption of immobile infrastructure, communication and livelihood system and loss of life. Causes of pest and diseases epidemic in this area are adverse weather condition, high moisture, mild winter, irregular rainfall etc. Cause of cyclone, seasonal drought, hail storm, storm wind, thunderstorm, flood, storm surge and salinization are due to nor'wester, monsoon and monsoon downpour, irregular or heavy rainfall, drainage congestion due to river bed siltation, synchronization of water level peaks, riverbed aggradations and due to tillage practice etc. During the peak flow season (July - September) the Payra, Lohalia and Laukathi rivers abnormally overflow their banks onto the low-lying surrounding flat land, which lead to the soil drainage congestion and storm-tidal surges that induce high-magnitude flooding and water logging that inundates large cropping areas, and causes widespread damage to crops and property. However, occasionally normal flooding conditions lead to providing vital moisture and fertility to the soil.

Table 2. Seasonal hazards and livelihood activities calendar

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
On farm livelihood activities												
Aman Rice												
Aus Rice												
Winter Crop												
Homestead Vegetables												
Hazard event												
Flood												
Cyclone												
Drought												
Nor'easter												
Hail Storm												
Thunder Storm												
Pest and Disease epidemics												

According to the respondent's experience of occurring adverse impact of hazards at different time extent a seasonal hazard and crop calendar was prepared by the farmer's community for Sreerampur union has been shown in the Table 2. The Color Codes of each calendar are used for understanding the risk or probability of occurrence of particular hazards at different agriculture production of the year. The year round frequency of different hazards made the agriculture production of the Sreerampur union vulnerable. Occasionally these hazards organized in one month and make the situation worse than the other months to the farmer's community. The study reveals that the farmer's communities experienced of common risks around the year are mostly related to hydro-meteorological hazards. The community's expressed that the main risks persevering are that of the irregular and changing of period of occurrences of different hazards events round the year and simultaneously increasing or decreasing by length. This means communities are facing variable risk events for longer and unusual time which is ultimately threatening their adaptation capacities. The concepts of risk events suggest that, most of the threats are posed by pest and diseases epidemic, cyclone, seasonal drought, hail storm, storm wind etc as the consequence of high humidity and temperature. Table 2 shows that in rainy season farmers prefer to produce Aman rice but in this time flood occurs due to excessive rainfall and improper drainage system as the sluice gate are not managed properly and not constructed in the right place. Cyclone or storm wind may occur any time from April to November, damaging standing crops like rice or vegetables. Seasonal drought, lack of rainfall, foggy weather and sometimes nor'easter damages the winter crops (locally known as DHULAT). In dry season Rabi crops damaged by seasonal drought, irregular and insufficient rainfall, pest and disease epidemic, nor'easter and sometimes hail and thunder storms. Before onset of wet season hailstorm, thunderstorm and nor'easter occur and damage the standing crops and vegetables. Basically hailstorm occurs more than two to three times in a year but its impact on standing crop especially watermelon, homestead vegetables and other horticulture crops is very high according to the respondent's perception. Due to the climate change farmers face new types of pests and diseases attack every year and increase the gap of yield, mortality and morbidity of poultry and livestock. Research showed that almost every woman use their homestead area for vegetables and fruit gardening-are vulnerable to pest and disease epidemic, hail storm, nor'easter or others type of minor hazards, decrease the economic return.

The distribution and proliferation of pests are determined to a large extent by climate. Pests are any organism or microorganism- weeds, insects, and pathogens that harm or kill crops and reduce the value of crops before and after harvest. Most analyses concur that in a changing climate, pests may become even more active than they are currently, thus posing the threat of greater economic losses to farmers [45]. Adoptions of management practices are the most appropriate strategies to reduce these risks for growing crops were suggested by researchers [50]. Other researcher [51] commented that a combination of pest and insects control techniques in a particular cropping system includes cultural practices, crop rotation, use of resistant varieties and chemical treatment only when there is a real need. The problems in homestead agriculture production identified and including lack of impute -money and knowledge [52]. Research [46] commented that insect pest is one of the major causes for low production of those crops in Bangladesh and suggested to develop and use of eco-friendly, sustainable, socio-economic acceptable Integrated Pest Management packages and other good agronomic practices, which not only boost up the production of fruits, vegetables and flowers in Bangladesh but also ensure the quality of those crops [45,46,53].

3.5.2. Vulnerability Assessment

Risk results from the interaction of physically defined hazards with the properties of the exposed systems, i.e. sensitivity or vulnerability [2]. Literature review confirmed that risk is the combination of the probability of a hazardous event and its consequences which result from interaction(s) between natural or man-made hazard(s), vulnerability, exposure and capacity [1]. Hence it is important to consider the farmers contexts in which vulnerability increased and their underlying risk factors to increased vulnerability. This study was determined the nature and extent of risk and evaluated existing conditions of vulnerability. Judging from the findings of the community based vulnerability assessment; the Sreerampur union farmer's community is experiencing a high level of vulnerability in Agriculture sector. Figure 2 shows each hazard gets a unique vulnerability score that helps to prioritize them and the final result indicates that pest and disease epidemic have highest score and it is 7.36, then cyclone occupying score 6.87; hail storm having score 6.54; then seasonal drought score is 6.51; fifth position goes to storm wind having score 6.33, then flood due to excessive rainfall and lack of proper drainage having score 6.23; then storm surge's score is 5.86, then thunderstorm is 5.47 and then salinization score is 4.78. The risk of crop losses from pest and disease; natural hazards like drought, cyclone, flood, excessive rain fall etc are the important vulnerability for agricultural producers [29,30]. Researchers [45] commented that higher or lower than optimum temperature situations resulting in a drop in yield. Excessive rain fall causes water logging; increased pest infestations and inundation hinder the field operations and increase the yield gap. The increasing in damage and loss depends on the extend duration of rainfall and flooding, crop developmental stage, and air and soil temperatures.

3.5.3. Capacity Assessment

The current system of disaster prevention and disaster response has focused heavily on the building of the government's disaster management capacity [54], while the disaster response capacity of households has been largely neglected. Capacity to cope is increasingly seen as a key component of a household's or community's level of vulnerability [55]. Success or failure of a society's response to disasters depends to a large extent on individuals' capability to cope with adverse situations. Therefore increasing households' disaster preparedness may be crucial to saving lives and mitigating damages. At the end of the 1990s, researchers [17] stressed the need to identify the capacities that already exist in societies when designing disaster-related development interventions. Since then this positive aspect has been further explored. Figure 2 depicts the community level capacity to cope with different disasters in agriculture sectors in the Sreerampur union. Result shows that the highest capacity to cope with pest and disease epidemic and the score is 5.89; then cyclone occupying score 5.47; then seasonal drought having score 5.28; then storm surge having score is 4.62 and then flood-4.45, hail storm-4.19; storm wind-4.12, thunderstorm-3.49 and salinization-2.98. It is because community people do not have control on natural disasters. On the contrary, they can manage diseases and pests to some extent by adopting cultural, mechanical, chemical etc. methods.

3.5.4. Risk Assessment

After calculating, hazards potentiality, vulnerability and capacity, assessment of risk from the Hazard (H), Vulnerability (V) and Capacity (C) score following the equation number --1 was done and showed in the Figure 2 and indicates that the highest risk faced by the agriculture farmers is pest and disease epidemic having the score is 11.18; second the hail storm occupying score 9.44; then the cyclone risk having the score 8.60; then thunder storm having score 8.51; then storm wind 8.38, then seasonal drought 8.22; flood 6.81, then storm surge 5.65 and last is salinization 5.28.

3.6 Farmer's Perceptions on Impact of all Hazards on Capacity, Vulnerability and Risk in Agricultural Activities

Figure 3 shows the farmer's perceptions on impact of all hazards on capacity, vulnerability and risk in agriculture. Perception revealed that farmer's vulnerability to all hazards impact on agriculture production is higher than the capacity to cope but lower than the risks faced in agriculture production, because risk is equal hazards multiplied by vulnerability and divided by the capacity to cope with disaster. That means the farmers communities are facing variable risk events for longer and unusual time (shown in the Table 2- seasonal hazards and livelihood activities calendar) which is ultimately threaten and lower their adaptation and mitigation capacities. This situations result increasing vulnerabilities and aroused dynamic pressure of the fragile vulnerable conditions. When these fragile conditions are threatened the agriculture production ecosystem frequently and intensely the catastrophic disaster happened.

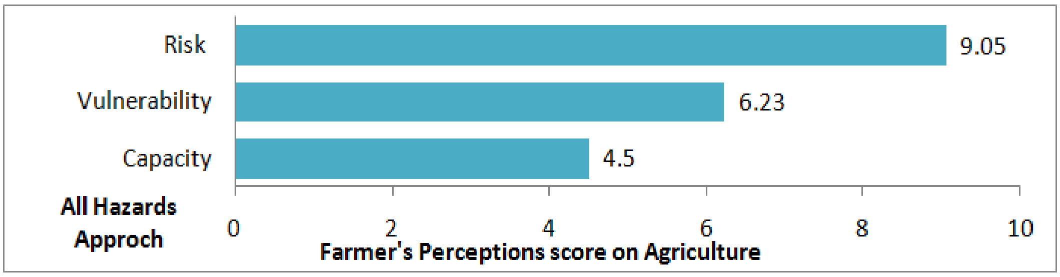

Figure 3. Farmer's perceptions on impact of all hazards on capacity, vulnerability and risk in Agricultural activities

Regarding farmer's capacity to cope with agriculture sector disaster Figure 3 showed that farmer's capacity is lower than the impact of vulnerability to disasters and the risks faced in agriculture production, because risk is equal to hazards multiplied by vulnerability and divided by the capacity to cope with disaster. That means the farmers communities are in vulnerable conditions and facing variable risk events which is ultimately damaged their agro-ecosystem. When the farmer's agro-ecosystem was damaged frequently and recurrently every year, their capacity to adopt mitigation and adaptation measures weekend. In these circumstances farmers are increasingly depend on nonfarm livelihood activities because of higher cost and low production. The more adaptive capacity the farmer's community has, the greater is the probability that the community farmers are able to adapt and thus is less vulnerable to climate change and variability. Regarding farmer's faced risks in agriculture sector, Figure 3 showed that impact of risks faced by farmer's are higher than the impact of vulnerability and farmer's capacity to cope with risks/disasters. Because risk is equal to hazards multiplied by vulnerability and divided by the capacity to cope with disaster. That means the farmers communities are in very much risky situation and facing lack in capacity and higher in vulnerability which is ultimately damaged their on-farm agricultural livelihood. Scientists [3,18] discussed that the vulnerability, its three components -exposure, sensitivity, adaptive capacity, as well as their determinants are specific to place and system and they can vary over time (i.e. they are dynamic), by type and by climatic stimuli (e.g. increasing temperature, droughts, etc.). Thus, vulnerability is context-specific, and the factors that make the farmers vulnerable to the effects of climate change depend on the nature of the system and the type of effect [56]. Lower levels of adaptive capacity in developing countries are very often associated with poverty [16,57]. In these circumstances researchers commentated with question-What happens to smallholder farmers in the future – as the climate changes – will therefore have significant social, economic and environmental consequences globally. Most smallholder farmers, especially in developing countries, have limited capacity to adapt to climate change, given their low education levels, low income, limited land areas, and poor access to technical assistance, market and credits, and often chronic dependence on external support [58,59].

3.7. Determination of Correlation among the Different Parameters and Risk Factors

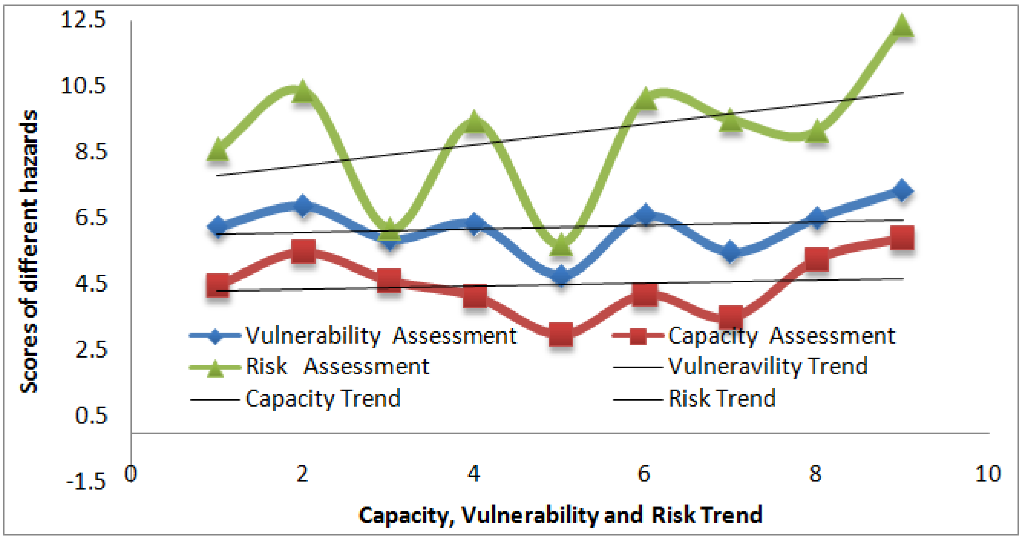

Figure 4. Analysis of correlation and their trends depend on the parameters-vulnerability, capacity and risk at all hazards level

Statistical analysis has been performed to understand the relationship between different natural and anthropogenic hazards, their created vulnerability, community coping capacity and probability of their combined effect on local level agriculture production of farmer's community. Thus, regarding the significance combined impact of risk and vulnerability; and risk and capacity on the agriculture production were analyzed. Figure 4 shows the good relation of three variables -vulnerability and risk; and capacity and risk created due to the impact of all hazards existing in the study area. This figure proved that when vulnerability is increased simultaneously risk also increased because of the lack of capacity and threatening hazard event. Again in some cases risk decreased because of the community coping capacity is increased and vice-versa.

3.8. Analysis of Correlation of Vulnerability, Capacity and Risk at All Hazards Level and Significance of r^2 Value

Regression analysis was done to understand the RSQ (r^2) between vulnerability to different natural and anthropogenic hazards, farmer's coping capacity, aroused risks and provability of their combined effect on local level agriculture production of farmer's community. Thus, regarding the significance combined impact of risk and vulnerability; and risk and capacity on the agriculture production were analyzed for specific hazards (Table 3). The best significant correlations (5% level of probability) are achieved by storm wind (r^2=0.38), salinization (r^2=0.47), hail storm (r^2=0.20), thunder storm (r^2=0.30), drought (r^2=0.44) and pest & disease epidemic (r^2=0.23) and impact of these hazards are positively correlated to the respondent's risk and vulnerability situations aroused. On the other hand the best significant correlations (5% level of probability) are achieved by flood (r^2=0.63), cyclone (r^2=0.53), storm wind (r^2=0.63), salinization (r^2=0.34), hail storm (r^2=0.43), thunder storm (r^2=0.40), drought (r^2=0.29) and pest & disease epidemic (r^2=0.67) and impact of these hazards are negatively correlated to the respondent's risk and coping capacity (Table 4) situations aroused.

Table 3. Analysis of correlation, r^2 value and provability of significance between different parameters of hazard at farmer's community level (*significant at 5% level of probability)

Hazard	Risk x Vulnerability			Risk x Capacity		
	Correlation	r^2 value	Probability (5% level)	Correlation	r^2 value	Probability (5% level)
Flood	0.320	0.102	0.146	(0.790)	0.625	0.000*
Cyclone	0.300	0.091	0.170	(0.730)	0.530	0.000*
Storm surge	0.370	0.139	0.087	(0.810)	0.625	0.000*
Storm wind	0.620	0.380	0.002*	(0.790)	0.629	0.000*
Salinization	0.680	0.466	0.000*	(0.630)	0.329	0.001*
Hail storm	0.450	0.201	0.035*	(0.680)	0.458	0.000*
Thunder storm	0.550	0.298	0.008*	(0.630)	0.401	0.001*
Drought	0.660	0.435	0.000*	(0.540)	0.292	0.009*
Pest and disease	0.480	0.233	0.022*	(0.820)	0.670	0.000*

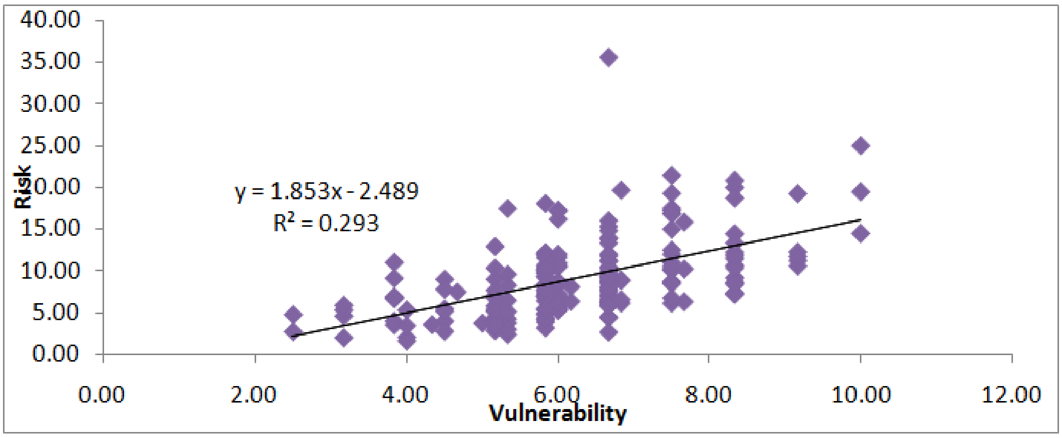

Figure 5. Correlation between vulnerability and risk for all hazards

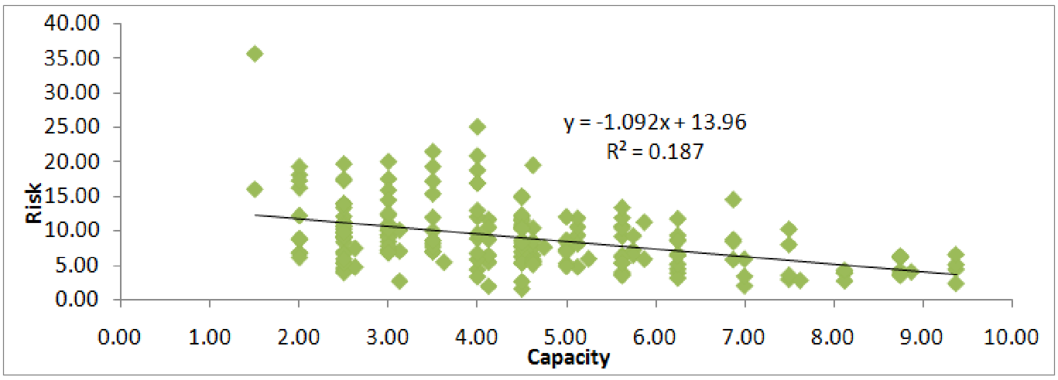

Figure 6. Correlation between capacity and risk for all hazards

Thus, regarding the significance cumulative effect of risk and vulnerability; and risk and capacity on the agriculture production was analyzed for all hazards combined. The best significant correlations (5% level of probability) are achieved by all hazards combined (r^2=0.29) (Figure 5) and cumulative impact of all hazards are positively correlated to the respondent's risk and vulnerability situations aroused. On the other hand the best significant correlations (5% level of probability) are achieved by all hazards combined (r^2=0.19) (Figure 6) and cumulative impact of all hazards are negatively correlated to the respondent's risk and coping capacity situations aroused. From the above discussion on correlation of different hazards and community level risk-vulnerability-capacity are valuable parameters that can be followed in future community based risk assessment in agricultural research and development.

3.9. Farmer's Adopted Strategy to Reduce Agricultural Vulnerability and Risk

There were distinct changes of frequency and intensity of climate change induced disasters which might have combined effect on cropping environment in the study area. To reduce the impact of these changes, government as well as local farmer's community has undertaken some adaptation measures. Based on the findings of the FGDs, field visits and discussion with farmers and review of the available literatures, some existing adaptation or innovative farming practices have been identified and documented. Identification of the innovative practices was considered based on the investigation of hazard, vulnerability, capacity and risk, sustainability of the crops and practices to meet farmer's needs. A number of adaptation option or practices were being used by the local farmer's community. Among the different adaptation practices against climate induced vulnerabilities, farmers were adopted with cultivating year round new types of vegetables, fruits on raised beds, creeper vegetables on bed edges, homestead gardening and cultivation of fishes on ditches during wet months in the water logged areas, introduction of submerged tolerant rice varieties, utilization fellow land in cultivating seasonal vegetables, fruits, compost making, and use of compost in homestead gardening. On the other hand trends of livelihoods sustainability and change in frequency and intensity of hazard events show that dependency of the community's on crop production, fishery and livestock has been reduced in the last decades and the climate change might have imposed farmers to changes their livelihoods pattern in this region. Recently the people are migrating into nonfarm activities like small business, handicraft, tailoring, stationary shops, motor cycle or auto bike driving, energy driven rickshaw puller, and in many case day labor as their alternative livelihood and the rate of these changes have gained new dimension in the recent years as an adaptation mechanism in climate change situations. An immediate and direct way to help smallholder farmers ensure their farm-based livelihoods in the face of the increasing stresses posed by climate variability is to focus on helping them use farm management practices based on agro-biodiversity and ecosystem services that provide adaptation benefits [60].

Previous researchers also research also reinforced the farmers adopted measures and recommended to adopt modern adaptation measures to reduce risk and suggested that as the important examples of technologies, practices and approaches to build resilient livelihoods for the farmer's community need to emphasis on appropriate crop variety selection, good quality seed, timely planting or sowing, line sowing, appropriate fertilizer management, irrigation and drainage, weeding and integrated pest management [47,49]; emphasis on non-monetary good agronomic practices [48]; providing credit facilities with soft loan [61]; establishment of 'Field school' as demonstration plot and center for crop seed or seedling; extensive promotion work for farmers to adopt [49]; location specific packages of technologies moving towards "prescription farming" [62] could be helpful to promote the adaptation of good agronomic practices to increase the productivity, yield and profit.

4. Conclusion and Recommendations

Community based risk assessment, as a tool for assess the risks of a community, the focus is always on individuals and vulnerable groups of the community and understanding the probability of the triggering event that back the individuals and communities resilience. This is a participatory process for assessing local hazards, vulnerabilities, risks; ability to cope with and finally explore appropriate options to reduce potential risks to be adopted by the communities at risk and identified options is the ultimate outcome of community based risk assessment used in developing risk reduction action plan. Communities are increasingly depending on the non-agricultural livelihood activities. People are migrating from their nature based traditional on farm livelihood to nonfarm livelihood as their alternative options, not as innovative sustainable option. And in such cases, local adaptation or innovative adaptation practices are almost absent in Sreerampur. Only alternatives options are applying to reduce risk and vulnerability which results higher costs of production in agriculture sector. In this situation need community based hazard specific more research in agriculture sector to understand roots and nature of hazards and appropriate measures of community adaptation if we want community resilience in the country.

Statement of Competing Interests

The authors have no competing interests.

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