

An Overview of Drought Hazards and Prospective Mitigation Approach in Bangladesh

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Authors' contributions

This work was carried out in collaboration between all authors. Author MAR designed the study, wrote the protocol, and wrote the first draft of the manuscript. Authors ME, MSA and MBH managed the literature searches and took part in the statistical analysis and, MAR& MBH prepared the final version of the manuscript. All authors read and approved the final manuscript.

ABSTRACT

Climate change context is now consider to be a vital cause of worsen condition of different environmental sphere. The interference of outsider factor may tends to change optimal condition of the natural environment. Climatic variables shows some anomalies in terms of compositional variation and greater context of instability. Long term instability of temperature and rainfall pattern leads to regional and local drought hazards. Consequently, it has been showed that, productive sector failure, worsen socio-economic status. Particularly agricultural activities appeared as a more vulnerable sector owing to unexpected drought events especially in Bangladesh. The lower production rate has been created social crisis like as groundwater scarcity, food insecurity and livelihood change. Regarding with the literature and observational feature, uncertainty of the rainfall pattern indirectly make emphasis on over extraction of groundwater for the irrigation purpose. As an agro-economy based country, it is very important to count and take initiatives to mitigate the situational and regional climatic hazards. On the basis of pragmatic extent, combined approach as categorical and sub-categorical aspects may ensure sustainability at the agricultural sector. At the local scale drought management, sustainable water and land management could be a follower guideline to bring sustainability in the agricultural activities against with adverse environmental hazards.

Keywords: Drought Hazards, Temperature & Rainfall, Agricultural Activities, Social Crisis, Mitigation Measure & Sustainable Development

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1. INTRODUCTION

In Bangladesh, droughts have appeared as a recurrent phenomenon and devastating nature, its scientific acceptance less than cyclones or flood [1, 2]. Every year different natural disasters hit our country like flood, drought, cyclone, river bank erosion, earthquake etc. [3]. Drought is one of the most formidable disaster which is frequently occurred in different regions in Bangladesh. Drought is a natural slow onset hazard and has non-structural damage. It is appeared by an unnoticed way and develop cumulative impacts and also its impacts not instantly visible [4], and thus directly obstruct to life and properties. Long period dryness condition and unavailable water supply is called drought. It refers to the water shortage problem in different sectors like as domestic uses, agricultural and industrial purposes. Drought can be defined by atmospheric or Meteorological, hydrological and agricultural condition. These conditions are closely related to each other. Meteorological condition leads to other conditions. Sometimes, drought hazards directly or indirectly accelerate to other social crisis like malnutrition, famine, social conflict and so on. The density and distribution of population are also influenced by drought [5]. Drought prone areas, people don't make their settlement because of shortage of facilities.

Natural hazards turn into a formidable situation for climate change. Agricultural sector is closely related with two natural disasters- flood and drought. Drought and untimed flood are enhanced by climate change. Regarding with [6] special report on climate change and its probable effects on rainfall pattern and warmer climate in Bangladesh, it may increase 5-6% rainfall by 2050 owing to snow melting which would be attributed to more intense monsoon, frequent and big flood, and prolonged flood as well as outside of the monsoon drought could be increased. However, vast areas of South Asia including central Pakistan, southern Pakistan, and western India is severe drought affected from onward early 2000. Many regions of the South Asia have been found to be perennially drought-prone area in the world. In the past five decades, Sri Lanka, Pakistan, India and Afghanistan is recorded to be drought prone country at least one time in every three year period. While drought is frequently occurring in Bangladesh and Nepal [7]. Within a total number of 19 drought events, some of like 1973, 1978, 1979, 1981, 1982, 1992, 1994, 1995, 2000 and 2006 worth mentioning drought severely hits to Bangladesh [8]. From 1949-1991, almost 24 drought events occurred in Bangladesh but severely hit to the country in 1989, 1984, 1982, 1981, 1975, 1972, 1961, 1958, 1957 and 1951 while 53% population and 47% area were typically affected owing to long term cumulative impacts [9]. Bangladesh also has foremost experienced on some high magnitude drought in 1995, 1994, 1992, 1989, 1982, 1981, 1979, 1978 and 1973 [9, 10]. A different of regions of Africa, Asia, Europe, America and Australia got longer experiences of intense drought hazards from 1950 [11]. Climate variability can also cause of global warming and sea level rise for increasing temperature. Global warming can bring about other disasters which may also hamper on crops. Cyclone is one of the most important disaster in the coastal region which is influenced by climate variability [12]. However, Bangladesh is more vulnerable country for the climate change. Bangladesh is also more vulnerable owing to frequently occurring different natural disasters as flood, drought and cyclone. Nevertheless, climate change refers to the long term variation of climatic parameters- temperature, precipitation, humidity, wind direction and pressure. It is one of the most important country whereas drought is frequently occurred in a year. The mean temperature in Bangladesh has been recorded ranges from 26.9 to 31.1° C during summer and 17 to 20.6° C during winter. In the climatic point of view, drought can be categorized into three distinct types, (i) from November to February (during winter season), (ii) March to May (during pre-monsoon hot summer season) and (iii) from June to October (during rainy season) [13]. Drought and its severity have been drawn some social insecurities. Regarding with the scientist concern about the changing pattern of precipitation in Bangladesh, it is necessary to evaluate some important factors or implementing mitigation approach to reduce

drought impacts like as risk and vulnerability assessment [14]. At the present time, along with high population growth and food demands does not support to the existing trends of the crop production trends. The crop production rate has been decreased due to the long term anomalies of climatic variables. This changing pattern and its severity might be turn into colossal damage at the local and large scales.

Every year drought hazards is commonly occurred in the northern part of Bangladesh. It is negatively attributed to the social security, food security and overall socioeconomic growth of the affected areas. Several papers have been reported on the impacts of droughts on land degradation [15-17], food production [18, 19], agriculture [20-24], society [19, 25] and economy [19, 26]. The land use change is one of the major cause to frequent occurrence of drought hazards in Bangladesh, in comparison with neighboring country [27]. However, sustainable agriculture would be a key factor to ensure individual food demand among the local communities but drought intensity directly inhibit to the local food supply by the malfunctioning of agricultural system. Rahman and Biswas [28] reported that, crop production decreased 60-70% due to drought. Paul [29] reported that, most of the households (e.g. who are belonging to lower socio-economic group) in the northern part of Bangladesh severely drought affected. In 1982, 52,896 metric tons rice production was lost due to drought hazards [30] while 41% of the total loss was caused by different types of environmental crisis. In 1978-1979, estimated 2 million tons rice production was reduced owing to drought [2]. It has been directly affected 44% of the total population and 42% of the total cultivated land [19]. At the time of drought events, its consequence directly attributed to the normal distribution of the water supply and probable demand. It has negative impacts on the regional economic growth in the northern districts of Bangladesh. This paper aims to investigate the problematic site of the drought events with special reference to agricultural aspects and it also deals with mitigation approach through making interconnection among the drought events accelerating factors.

2. ANALYZE THE CAUSES AND IMPACTS OF DROUGHT HAZARD IN BANGLADESH

Bangladesh is located between 20°34' and 26°38' north latitude and 88°01' and 99°41' east Longitude. In terms of climatology, Bangladesh is positioned at the sub-tropical region. The mean precipitation in Bangladesh varies from 1,329 mm (In the northwest) to 4,338 mm (In the northeast) [31]. The average rainfall at the western part of Bangladesh approximately 2,044 mm, which is much lower than others parts of the country [14]. Disaster, natural hazards and risk is considered to be geographically in nature [32, 33]. Every year drought visits in some parts of Bangladesh mostly northwestern part including Rangpur and Rajshahi divisions. In Bangladesh, seasonal and contingent drought is frequently occurred but there is no permanent drought-prone area. Bangladesh is densely populated, high level of poverty, lower economic growth and agro-economy based country while reverse monsoon weather is predominant but depending on some factors, temperature gradually increasing. Temperature raising is a common phenomenon to initiate some regional hazards like water shortage, soil dry up, monsoon rainfall variability and evaporation rate raise up. However, Himalayan Mountain is situated in the north side of Bangladesh. As a result, heavy rainfall occurs during monsoon. Sometimes, it get plenty of water in rainy season and also inundate the low lying areas that means flood. If the climate change occur in the regular pattern it will affect to the both high and low lands through emerging with the flooding hazards and also it may extent through water holding capacity with time and place [34]. The causes of drought are closely related to climatic variability. Climate variability is inversely related to vegetation. Continuous changing pattern of climatic variables may leads to drought hazard. Most of the river is going to dry owing to the long term impacts of flowing water body, results of rainfall uncertainty and artificial barrage at the upstream. In addition, the South Asian least develop countries

(LDCs) always experience all types of high frequency drought hazards like meteorological, agricultural, socio-economic and hydrological. These countries facing some threats for rainfall uncertainty including inter-regionally, intra-annually and intra seasonally. Nevertheless, monsoon rainfall sometimes delay until 20 to 30 days while it's impact directly inhibit to crops and livelihoods [35]. Nevertheless, South Asian least developed countries have some similar effect on nature of drought and poor, population growth and most vulnerabilities [36, 37].

The lower rates of the river discharge in the dry season is negatively impacted to the ecosystem, river morphology and aquatic ecosystem in the western part of Bangladesh [14]. In Bangladesh, Brahmaputra River is more vulnerable to flow of water, and it consider to be threaten for the food security of an estimated 26 million peoples [38]. On the other hand, Ganges-Brahmaputra river basin is consider to be susceptible at the time of extreme flooding and monsoon rainfall [39, 40]. The water discharges of the Ganges River has significantly decreased (around 57%) compare with the before stage to after Farakka Barrage at the upstream [41]. Teesta is the main river in the northern part of Bangladesh. Teesta River enters into Bangladesh through the Nilpharmary and Lalmonirhat districts. Government of Bangladesh has constructed a barrage on Teesta River at Dalia in Lalmonirhat district, is a major source of water irrigation in northern part of Bangladesh. The neighbor country of Bangladesh including India has also constructed an embankment on Teesta River in its side of the territory at Gazoldoba in jolpaiguri [42, 43]. During monsoon season open the all doors of Gazoldoba barrage in India results flood in the low areas of the northern part of Bangladesh. On the other hand, during dry season only few doors open for normally water flow result drought. Afroz and Rahman [44] reported that 80% water has been reduced owing to Teesta and Farakka barrage. The meteorological drought indicate to the unstable condition of climatic parameters such as rainfall uncertainty, temperature variation, high evaporation rate [45], lower humidity, cloud formation uncertainty and the dryness condition of the atmospheric environment. Meteorological drought brings about hydrological and agricultural drought [Fig.1(c),1(d)]. At the time drought hazards, the lower rate of river discharge and simultaneously over extraction of groundwater in the dry season accelerate to falling groundwater table and it helps to make water shortage problem each and every sector at the local scale [Fig.1(a),1(b)]. In the growing fields of development sector like as economic development, urbanization, industrialization and population growth demands for more water at the time of deficit rainfall rate, then drought impacts appear as a local level disaster in the severity scale [14].

2.1 Deforestation and Hydrological Cycle

Vegetation would be a most important issue that can contribute to climatic factors-temperature, precipitation and also carbon sequestration. Deforestation means cutting and clearing of vegetation. It occurs due to cut down of trees and vegetation to be used or sold as fuel, while cleared land is used as agricultural land, plantations of commodities and settlements. The intensity of deforestation increases with the increasing number of population. Densely populated region in the northern parts of Bangladesh have low percentage of vegetation. Deforestation can cause of damaged to habitat, loss of biodiversity, river bank erosion which brings about drought. It can also cause of extreme temperature, low and high precipitation. Literature revealed that average temperature is increasing day by day due to shortage of vegetation and increasing greenhouse gases. A greenhouse gas as carbon di oxide is a good absorber of temperature. It contains more temperature warm up gradually atmosphere its broad term Global warming. But deforestation and greenhouse gases are inversely related to each other. A total amount of anthropogenic greenhouse gases (GHGs) emission, 10-12% emit from farming activities in 2005. Less emission of N₂O and CH₄, small amount biomass burning as fuel, increasing C

sequestering and technical options may apply to reduce emission [46]. Owing to industrialization and agricultural practices, greenhouse gases emission are increasing day by day. In future, it could be a priority basis first threatening component for the living organism with special to human being to survive in the universe. But, if agricultural expansion continuing through deforestation then it would be intensified 10% of the total greenhouse gases which were reduced at the period of 2015-2020, and it could be helps to stored approximately 500 Mt CO₂-eq [47]. Changing pattern of agricultural system may reduce to climate change at the local and global scale.

The climate change and its variables variability leads to alter hydrological cycle and crop production rate [48] and land degradation [49]. Hydrological that means water cycle is also affected by deforestation. Trees extract groundwater through their roots and release it into the atmosphere through transpiration. Deforestation reduces the content of water in the soil and groundwater as well as atmospheric moisture. Trees help to form cloud and occurring precipitation. Deforestation affects the water cycle significantly as trees roots create macro pores – large conduits – in the soil that increase infiltration of water. Vegetation contributes to evaporation and reduces soil moisture via transpiration. Trees litter and other organic residue change soil properties that affect the capacity of soil to store water and litter stems. At last deforestation can cause of increasing temperature, loss of soil properties and water holding capacity, death of beneficial organism of soil.

2.2 Temperature and Agricultural Activities

Extreme temperature hamper to the agricultural crops and soil characteristics. Sometimes, high temperature act as a key factor to evolve new pest and/or diseases in the croplands. Agriculture and food security incorporated with the climatic effects, if the global temperature increase 2C (low-end) predictions by 2100 then its major implications will influence to rural poverty and urban food security [50]. Climatic impacts is negatively attributed to food production, patterns of crop productivity, fishery and livestock system, food distribution and market access [51, 52]. Climatic impacts may impair of crop physiological structure along with quality, in the developing world most of which countries is located at the tropical line [53]. Consequently, different kinds of bacteria, algae and virus borne diseases can be increased. As a result, it decreases the expected result of crop production that means the economic loss of a region or whole country. Soil quality is also affected by the increasing rates of temperature. A number of authors has been reported that, for the reducing of climatic rise should be control some important factors like as livelihood system and miscellany crop yields, soil and water resource management and plant protection initiatives to control crop production [54, 55]. Soil temperature is a one of the most important factor for the crop production. If the soil temperature will increase crops production ultimately reduce by affecting diseases. Different beneficial organisms in the soil for crops production cannot survive in high temperature. Frog is a most important beneficial organism in the soil. Frog decreases the harmful pest and insects within the crops by eating the harmful organisms. It cannot tolerates high temperature. On the hand farmers utilize different chemicals pesticides and fertilizers for good crops production when crops are affected by climate change. For the use of chemical pesticides and fertilizers, beneficial organisms are died by harmful organisms and create water pollution. In addition, climate change may affect to the crop production and growing period and farmers need to change their crop varieties, crop densities, fertilization levels and sowing dates when planting crops [56]. Sometimes water borne diseases may affect in the cropland due to water pollution.

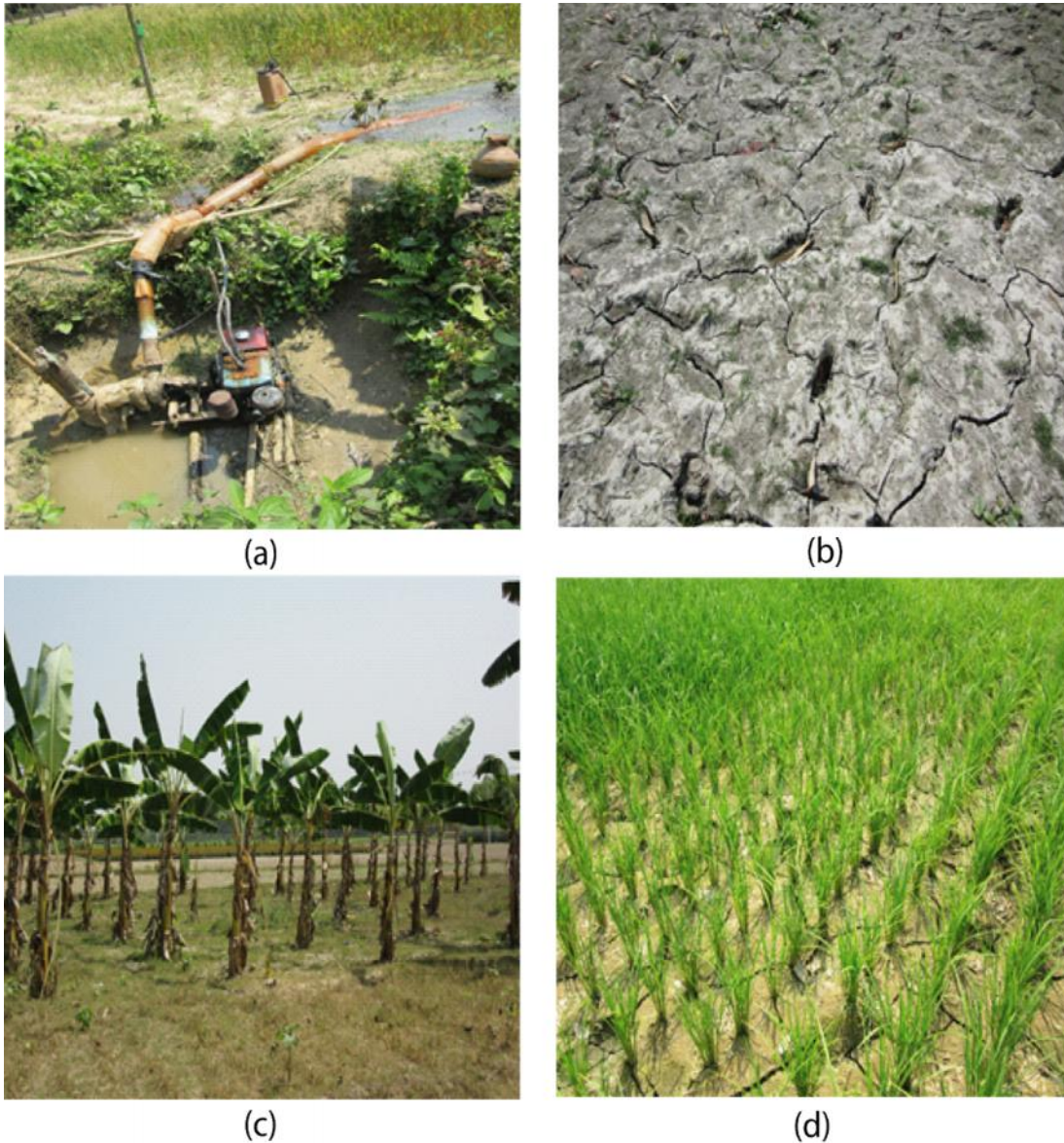


Fig. 1. Shows some drought severity impacts scenario (a. deepening shallow tube-well water [STW] extraction system for the irrigation purpose. However, it is reflected that the over extraction of groundwater for the irrigation purpose at the summer season, water table gradually tends to move downward; b. dry agricultural land, owing to the long term rainfall uncertainty it has been gone to dry; c. agricultural crops [banana] at the distressed position due to lack of water and scorching hot; d. rice field it has been fractured for the shortage of water)

2.3 Precipitation and Apparent Impact

We often think about drought in relation to precipitation applying to the degree of dryness and the duration of the dry period. It is known as a meteorological drought which is highly specific to a region as average precipitation may vary considerably spatially. Low precipitation effects apparently visible in the stream flow, soil moisture, reservoirs and lakes

water levels, and ground water recharge. Nevertheless, lower precipitation rate always influence to drought severity in the northern part of Bangladesh. Most of the natural hazards and disaster follow global context owing global warming, and number of climatic model has been projected that, normal precipitation rate decreases in dry season and increase at the time of monsoon in south Asia [57]. It could be observed unfavorable condition of cloud formation due to the main causes of climate change. If the condition remains long time it will bring about drought over the country. If precipitation is absence in a region, temperature will increase in the atmosphere [58]. As a result, the soil moisture will decrease slowly that means rising evaporation and transpiration by plants. Ground water level [59], also decrease by lower precipitation and lower infiltration rate of surface water. Agricultural production rate directly related to the soil properties but sometimes it has been fallen due to the long term dryness condition of soil components. Farmers should aware about the problems which can cause of drought and another hazards as decreasing ground water level, low crops production and economic growth. People should be alert about water harvesting, water supply programs, excavation and awareness building programs. The depth of the rivers, ponds, canals, channels are reduced in the northern areas for the continuous river bank erosion and siltation process. About 80% rainfall [45] occurs during monsoon naturally but we cannot sustainable manage the amount water and River water flow. We are failure to conserve the adequate water for our later usages. Most of people are blamed on their destiny that they were settled in the famine and drought prone areas. They cannot try to change their destiny through technically. They are upset to show the problems but cannot find out the solutions.

2.4 Water Crisis and Agricultural Activities

The northern part of Bangladesh is known as a major source of national food production. Most of the people of these area are directly dependent on agriculture. Landless labor and farmers depends on rainfed agriculture but now it is appeared as a vulnerable sector owing to rainfall and seasonal variability [50]. In the past, the main crops in the northern parts of Bangladesh were cultivated aman and boro rice. Now-a-days, farmers are encouraged to cultivate new varieties of high yielding crops but they are not fully aware about agro-technology and cultivation system [5]. Generally, the overall agricultural productivity in the Northern region is very low mainly due to unavailability of irrigation facilities, inadequate rainfall in dry season and less water flow in the rivers. Drought events and it impacts is more severe than flood damage in Bangladesh [14]. Then, drought hazards indicate to more rice production loss compare to flooding impacts to aggregate production between 1969-1970 and 1983-1984 respectively [41]. The famers of northern area, aush rice cultivates to be late by 2 months, to August-September instead of June-July. As a result, the physiological structure of the crops damaged because the rains end at development stage of the crop. Farmer extracts more ground water through deep and shallow tube-well for the purposes of agricultural and domestic usage. The amount of ground water extraction increases with the increasing number of deep and shallow tube well. Ground water level is decreasing day by day due to extraction water exceeds the amount of infiltration water in the ground as well as aquifers [60]. More extensively groundwater are using in household and irrigation purpose but rainfall (during monsoon season) is the main source of groundwater recharge, owing to lack of rainfall and its uncertainty during monsoon cannot revitalize the groundwater level. Over extraction of groundwater for the irrigation purpose, groundwater level has been depleted at the different region of Bangladesh. Ministry of Environment and forest of Bangladesh (MOEF) [61] has been reported that, aquifer level goes down 8.95 to 18.5 m in some area of the north-western part of Bangladesh.

Table 1 show that some historical data of drought hazards, agricultural and social crisis in different region of Bangladesh. However, Long term dryness condition of agricultural soil

may accelerate to damage function of the soil properties. Overall production rate of some agricultural crops has been decreased due to unwanted change of natural climate which tends to occur drought effects like as wheat, jute, corn, sugarcane, potatoes, several types of pulse and oil seed and, vegetables [62]. Farmers cultivate their crops through inappropriate cropping patterns, and changing Patterns of land use. In the agricultural land farmers use more chemical fertilizer in cultivated lands which reduce soil properties and water holding capacity. However, Agricultural production rate can be augmented with the application of irrigation and precipitation during the crop growth, meanwhile precipitation is more important for crop growth than temperature. Water holding capacity of soil could be supportive to reduce the frequency of drought and advance the crop yields [63]. Due to the climate change effects, water availability is a big question at the global scale while overall precipitation rate gradually decreasing in some region of the world. Along with the uncertainties of the climatic variables and socio-economic environmental effects suggest to efficient use of limited water and develop some new water resources [64]. If we meet up our water crisis by the snowmelt process or snow aggregation, then water system would be more vulnerable to climate change [65].

2.5 Drought Hazards and Social Crisis

Drought may create social impacts include life style, health, recreational, social programs, social conflict between people when occur scarcity of water. Different health problems find out during and after drought. In Bangladesh, a number of factors responsible to make more vulnerable to disaster poor infrastructure, inadequate financial resources, poor institutional capacity, high incidence of poverty and social inequity, high population density, high spatial and temporal climatic variability and extreme weather events [66]. Statistically showed that most vulnerable districts in the north Bangladesh – Kishorganj, Badarganj and Kurigram. Health problems occur during and after drought include malaria, cholera, dysentery, fever, typhoid, and most important diseases diarrhea [59]. Drought can also be cause of public safety from increasing number of fire and health problems. Climate shocks (e.g. drought, heat wave and flooding) leads to loss of life by the impairment of health, loss of properties and, changing livelihood pattern with productivity loss and infrastructure destruction [67, 68]. Different social programs as marriage, birthday party, festival ceremonies, and cultural functions are affected by drought. If a family loses own property due to drought marriage and another function will not celebrate easily. The patterns of cultural functions may be changed for drought. People suffer from anxiety or depression about economic losses caused by drought.

Climate change and its driving force leads to acute food insecurity who spend maximum portion of their income to consume food. Some peoples of the affected area frequently bought their daily food by selling their household goods, lands and livestock at low prices [69]. Using climate based food production technology would be helpful to make balance in the market approach to food producers and consumers [70]. Regarding with the FAO's information, the number of people has been identified who are suffering from chronic hunger from under 800 million (1996) to over a billion [71] whereas most of the hungry countries belong to south Asia and sub-Saharan Africa. In the growing world, water demands may appear as a common and fundamental crisis in the community. In the northwestern part of Bangladesh, social peoples engaged to water related conflict due to the shortage of water at the dry season [72]. The Government and non-government organization has been made some efforts to reduce drought risk through creating employment opportunity, financial aids, free food supply, medicine, relief goods and cloths [7].

Table 1. Historical data of drought hazard in Bangladesh.
Source: CEGIS Report [73, 7] _ (Modified from Banglapedia, 2006)

Description of Casualties	Affected area	Year
Crop Suffered greatly in most cases	Dhaka, Bogra and Sundarbans	1865, 1866, 1872, 1874
Substantially reduced rice production	Severe drought in north-west Bangladesh	1951
Resulted 1974 famine	Northern Bangladesh	1973
Affected more than 50% population	47% area of the country	1975
Reduced rice production by about 2 million tons, directly, affected about 42% of the cultivated land and 44% of the population	Wide spread	1978, 1979
Severe drought adversely affected crop production		1981
Drought caused a loss of rice production of about 53,000 t		1982
Drought dried up most of the rivers	Naogaon, Nawabganj, Nilpahamari and Thakurgaon	1989
Immense crop damage, specially to rice, jute and bamboo dumps		1994, 1995, 1996

2.6 Drought Mitigation Approach

In Asian region, frequent experiences loss of rice production about 23 million hectares owing to drought [74]. To meet up global Food security to the whole population is one of the major challenge for 21 century while total number of population augmenting, but it is threatened by climate change and stressed environment [75]. A number of peoples has been victimized due to the long term anomalies of drought intensity, magnitude and frequency. Drought hazards coping mechanism differ from local (e.g. local people try to cope with drought hazards using indigenous technique) to nationally and internationally [7]. Significantly increasing the studies on climatic impacts and adaptation strategy as a major scientific concerning issues at the present world e.g. productivity loss of framing crops such as wheat, maize and rice [76-82], forest [83], industry [84], water resource of the catchment area [85-88] and landscape [89, 90]. People try to adopt with drought hazards using two types of mitigation approach which is agricultural and non-agricultural [7]. Whereas, agricultural approach denoted some potential aspects of the crop production and agricultural adjustment like as increase crop yield, application of irrigation water, re-sowing of crops and compensate for crop loss [2]. Climate variables and even high technology of the agriculture area is considered to be potential factors to influence the crop productivity year to year [56]. In addition, Crop breeding is a substantial way to overcome climatic effects on crop productivity through increasing food production [91], it arguable mitigating climatic effects on agricultural sectors [92]. However, biological potentiality is one most important factor to increase crop yields through biotechnology and conventional crop breeding [93]. Consequently it has been developed with the consideration of thinking about climate change adapting farming system like as drought, heat, pest persistence and water logging [50].

Sustainable mitigation measure may ensure sustainability in the agricultural sector through taking mash networking initiatives. It is better reasonable approach from problem initiation to

ultimate taking action to mitigate. Whereas, each and every step of MAR drought mitigation approach (MAR[®]DMA) would be able to guide for the next step, which process could be suitable for the forthcoming step? However, MAR[®]DMA is a composite process which consist of several steps to follow consecutive way to reduce climatic stress such as soil management, crop management, tree plantation, reservoir renovation and new reservoir develop, rain water harvesting, local reservoir management, river basin management and groundwater management (Fig. 2). Each of the step contains specific point of interest which may indicate to its importance to combat desertification from a specific site. Soil management it deals with several aspects of the soil characteristics like heat protective organic biomass production, texture analysis and mix up with clay, water holding capacity buildup and earth worm culture whereas its standard feature might be fulfill the agricultural demand for the optimum production rate. Then, crop management is one of the vital aspects to fight against with global warming along with its adverse environmental crisis on crop through introducing new objects like short duration and high yield variety production rate, evaporation control by genetic engineering and seedling age (e.g. advance). In addition, tree plantation could be helpful to reduce greenhouse gases and make shadow surrounding the agricultural land it might be helpful to enhance soil properties like as soil moisture increase and water holding capacity buildup through biomass production. Rain water harvesting and proper management approach would be a suitable way (e.g. local reservoir management, river basin management, make up new reservoir, not waste water through unwanted discharging from local water body and given interval to groundwater discharge) to reduce the degree of agricultural hazards. Bangladesh is one of the most important agro-economic based country. It is clear that socioeconomic condition depends on agricultural produced crops. If agricultural production rate follow the upward trends then it would be possible to fight against with food scarcity problem at the northern part of Bangladesh. This thematic guideline would ensure sustainable agricultural system through shearing drought mitigation strategy and social development.

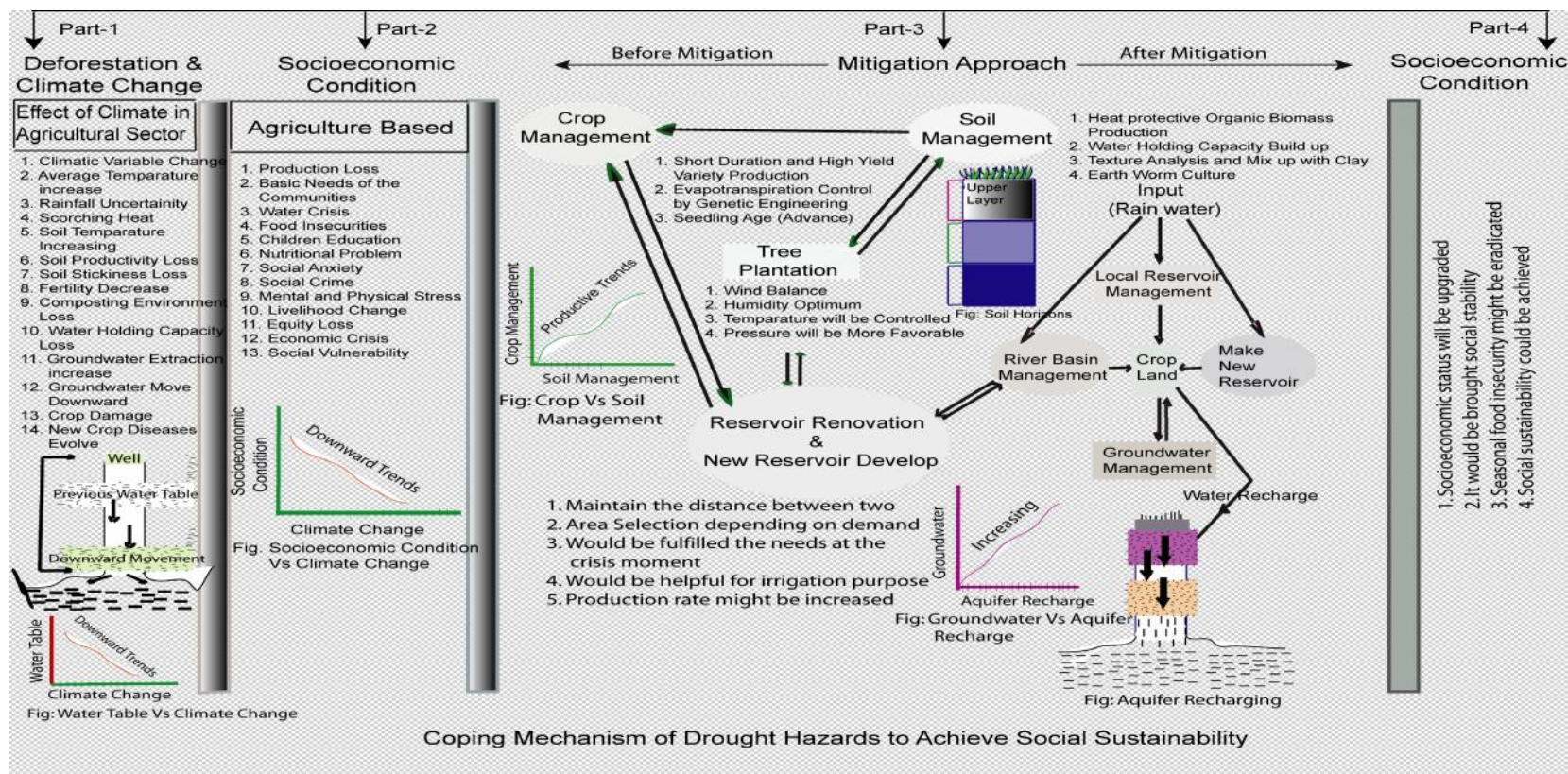


Fig. 2. Shows the prospective mitigation measures of drought hazards for the agricultural sector at the local scale. It has been divided into four parts like part-1, part-2, part-3 and part-4 while it is indicated deforestation & climate change, socioeconomic condition (before mitigation), mitigation approach and socioeconomic condition (after mitigation) respectively. This coping technique tried to accumulate cause and probable solution of agricultural drought. What are the main climatic effects in agricultural sector? What are the socioeconomic crisis on agriculture based? What could be the mitigation measures? What would be the possible outcomes after the mitigation measures? In the aspects of mitigation approach, soil management, crop management and water management is consider to be important element to ensure sustainability in the agricultural sectors. Sustainable agricultural practices may accelerate the socioeconomic development trends among the local communities.

2.7 Sustainability and sustainable Development

Agricultural livelihood system has already been vulnerable and face immediate risk to food insecurity, crop production failure, loss of livestock, lack of appropriate planting materials and seeds, new pattern of pest and diseases [94]. Drought is one of the principal cause famine, death and mass migration and its act as limiting factor to achieve sustainability of a region or country. For sustainable living, peoples are trying to adjust with the changing environment applying indigenous knowledge and practices [7].

However, Sustainability act as a key parameter to measure sustainable development in the society. Sustainable development depends on several sustainable factor whereas it might be act as key path finder to achieve sustainability against adverse environmental or situational case. A number of factors identified as more critical issues which could be lead to complex way of development one each other. At the point of initial step it might be make a linkage among the development factors and its presence helps to get sustainable socioeconomic structure. In the aspects of development strategy against with climatic hazards, sustainable society leads to ensure demand basis three important factors like sustainable agriculture, sustainable water management and sustainable land use (Fig. 3). Each of the factor, deals with sub-categorical factors which would be triggered to development trends in the way to sustainability. Firstly, sustainable agriculture embodied with different three factors such sustainable crop management, sustainable soil management, sustainable utility of require fertilizer and conditioner. Secondly, sustainable land use indicate to another three important factor like adjusting suitable crops depending on time and place, tree plantation depending on multi-agricultural approach and chemical fertilizer use depending on soil properties and characteristics. Thirdly, sustainable water management refers to the three crucial aspects of the probable factor like new reservoir development and old renovation, rain water harvesting and sustainable use of water (e.g. ground and surface water).

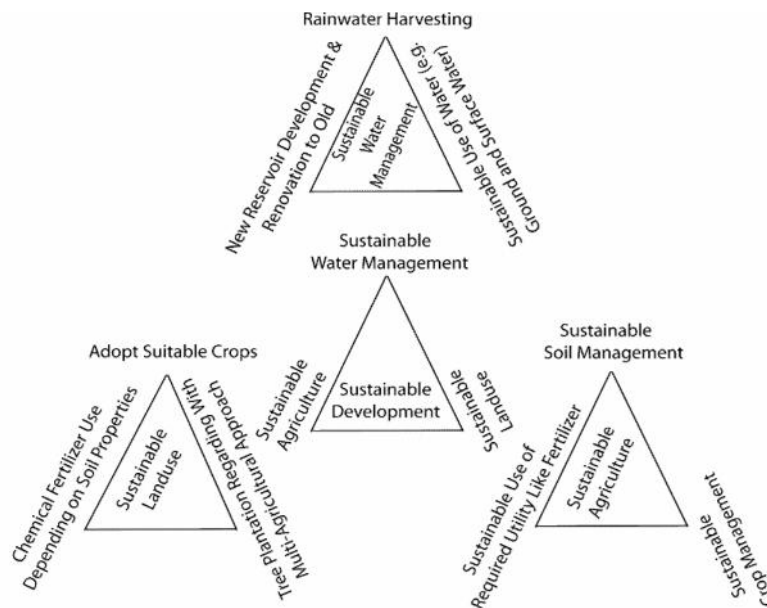


Fig.3. shows sustainable development approach to ensure sustainability in the agricultural component like as sustainable water management, sustainable land use and sustainable agriculture. Each of the key points embodied with a number of

strategic factor that has been drawn some crucial fact to deal with social security to achieve sustainability in the community.

3. CONCLUSION

Drought hazards is an ultimate consequences of climate change which has been evolved through unevenly change of climatic variables. Its pervasiveness are not same like as intensity and magnitude. However, severity of the climatic hazard depends on direct and indirect factors that is always inducing change and augmenting negative derivatives of climate change. Its discontinuation and anomalies changing pattern indicate to long term instability of climatic controlling variables like temperature. It might be brought global change whereas anthropogenic input always added into the atmosphere, it would be enough to induce any devastating disaster. In Bangladesh, drought is frequently occurred at the regional scale or extensively depending on cause and time. Whereas, a major part of the national economy rely on agricultural sector but now it shows downward trends due to continuous losses of production rate. Simultaneously, water and land use pattern identified as a vulnerable component to gear up social status with the creasing rate socioeconomic growth, for instance it has been turned into backward trends. So, its negative consequences tends to expedite temperature and rainfall uncertainty, agricultural damage, worsen socioeconomic condition, social and food insecurity. To make balance among the social components it is very important to take some initiative at the national and international level to accelerate the existing way of development. Regarding with the observational status, it is possible to make some efforts for the mitigation purpose at the local scale to keep in balance production rate for the fulfillment of the local demands. In the combined approach, it is needed to maintain water and land use management for the sustainability of the agricultural sector to achieve sustainable development. It is important to meet up sub-categorical aspects of the three key elements to fit drought mitigation model to achieve sustainable development. It would be helpful to ensure sustainability in the agricultural sector against with drought events.

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COMPETING INTERESTS

All authors have declared that no competing interest exist

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