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Droughts in Asian Least Developed Countries: Vulnerability and sustainability

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ABSTRACT

Droughts occur both in developed and developing countries with significant impacts and are exacerbating in frequency, severity and duration. Over exploitation of water resources, weather variability and climate change are mostly responsible for such exacerbation. The impacts of droughts encompass the global ecosystem as a whole but vary from region to region. Least developed countries (LDCs) are becoming the worst sufferer of the impacts due to physical, social and economic as well as knowledge and skills differences. The increasing biophysical vulnerability contexts and intensity in the Asian LDCs causing adverse effects on food security, human health, biodiversity, water resources, hydroelectric power generation, streams, perennial springs, and livelihood. Drought is also responsible for increasing pollution, pests and diseases and forced migration and famine. Information indicates monsoon has become erratic contributing to up-scaling of droughts. South and Southeast Asian LDCs like Bangladesh, Nepal, Bhutan, Cambodia and Lao PDR under the monsoon climatic zone have also been suffering from increasing droughts arising out of delayed and changing distribution patterns of precipitation. Prolong dry spells increase the frequencies of wildfire in grasslands, forests, and range-lands. The rain-fed crops of the plains are facing challenges from soil-moisture stress with projected droughts. Droughts causing migration of fishes, and marine anadromus species are having adverse impacts on spawning habitats. Reduction in annual surface runoff is decreasing the ground and surface water with negative effect on agriculture and water supply for industrial and domestic sectors. As droughts are exacerbating the consequences are accelerating. However, traditionally people are adapting with the changing situations applying indigenous knowledge and practices for sustainable living. This paper reflects on prevalence and impacts of droughts, existing coping mechanisms, initiatives to combat impacts and further doubles in the context of Asian LDCs.

1. Introduction

Drought is the slow onset natural disaster that starts unnoticed and develops cumulatively and its impacts are not immediately observable (ARCS, 2007) and thus hampers lives and properties seriously. Various definitions of drought have the common elements of dryness in atmospheric condition and shortage of water; cause moisture deficit with adverse effects on vegetation, animals, and human over a sizeable area (Warwick, 1975). The National Drought Mitigation Centre (NDMC) USA, classified drought in three types, namely meteorological, agricultural and hydrological, while the US Geological Survey added with it the socio-economic category which is really a consequence of weather-related shortfall of water.

Meteorological drought causes serious hydrological imbalance in the affected area (Huschke, 1959) and results in deficiencies of precipitation while agricultural droughts adversely affect crop production (Rosenberg, 1979) i.e. food production and farming and impacts of hydrological drought (Vujica et al., 1977) include low precipitation and supply of water. Regardless of the types, droughts have adverse economic, social, environmental, and developmental consequences.

Since 1970s, there is a drying trend, globally and in many regions, especially in high northern latitudes (Trenberth et al., 2007). At the same time, a widespread increase in droughts and spatially coherent shifts in drought regimes are expected with changing global circulation pattern (Dai, 2011). Since 1950, many regions of Asia, Africa, Australia, Europe, and America have experienced longer and intense droughts (IPCC Special Report, 2012). Regional climate simulations and high resolution global atmospheric model simulations over Europe indicated that the Mediterranean region is prone to severe droughts.

The China drought from 1876 to 1878 affected 83 million people; the America drought started in 1579 and spread over the southwestern region and lasted for more than twenty years. The African Sahel was one of the worst droughts in history, started in 1968 lasted till 1988, forced to starve about 150 million people

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across the Sahel -from Senegal through Mauritania, Mali, Burkina Faso, Niger, Nigeria and Sudan to Ethiopia. Australian drought of 2002–2003 affected 19 million and led to devastating wildfire and Niger drought affected 3.6 million people during 2004–2006. Serious droughts happen again and again in China, India, Australia, Chile, Bolivia, Ethiopia, and the Philippines (Woods and Woods, 2007).

From early 2000 onwards severe droughts affected vast areas of South Asia, including Western India, Southern and Central Pakistan. The South Asian regions have been among the perennially drought-prone regions of the world. Afghanistan, India, Pakistan and Sri Lanka have reported droughts at least once in every three year period in the past five decades, while Bangladesh and Nepal also suffer from drought frequently. In 2012, Pakistan declared emergency in Tharpakrakar and Mirpur Khas districts due to severe drought and many people had to be resettled (Tareq, 2012). In Cambodia, severe drought affected the late season and longer-duration genotypes (Tsubo et al., 2009).

The current understanding of climate change in the monsoon regions remains one of the important uncertainties with respect to circulation and precipitation (Hargel et al., 2007); while the Asian monsoon regions feed nearly half of the world's population, and when the monsoon rainfalls fail to come, people face severe droughts and famine (Science Daily, 2010). Asia has a long history of droughts, which has been linked with other climate extremes–having severe impacts on the LDCs.

There are 49 LDCs in the world which are spread over Asia and Africa. Most LDCs (34) are in Africa while Asia-Pacific has 14 and one in America. Asian LDCs mainly includes Bangladesh, Nepal, Bhutan, Myanmar, Afghanistan, Yemen, Cambodia, and Lao PDR which have been subjected to investigation in this paper. Small Island Developing Countries (SIDs) belonging to the Asia-Pacific region can be looked at separately due to their special characteristics and there are 52 numbers of SIDs in the world (Wikipedia). Global locations of the LDCs can be seen as below (Fig. 1).

Most of the climate models project a decrease in precipitation in dry season and an increase during the monsoon in South Asia (Christensen et al., 2007). This causes extreme droughts in this region; along with other disasters Bangladesh and Nepal have already shown an increased frequency of droughts in recent years (NDMC, 2006).

Ever-increasing exploitation of water resources and consequent water scarcity responsible for future climate change will exacerbate the frequency, severity, and duration of drought events and associated impacts (Wilhite, 2005). Global and regional studies project a higher likelihood of hydrological drought by the end of this century in North and South America, South and Central Asia, west and central Australia, and central Eurasia. There are still further sources of uncertainties affecting the projections of trends in meteorological drought for the coming century.

The uncertainties in the development of the ocean circulation and feed-backs between land surface and atmospheric process are related to the effects of drought on vegetation physiology and dynamics. Soil moisture stress and evapotranspiration affects the transpiration, growth and water use efficiency and on the hydrological cycle (Betts et al., 2007).

Spatially varied trends have been observed during the second half of the twentieth century, with increasing dryness particularly in East and Southeast Asia, adversely affecting socio-economic, agricultural and environmental conditions like extreme dryness and wildfire (IPCC Special Report, 2012). About 23 million hectares of Asian rice producing areas experience frequent yield loss due to drought (Widawasky and O'Toole 1990). There has been a drastic reduction in lowland rain-fed rice production in the Mekong region of Cambodia and Lao PDR due to droughts.

Drought is intimately related with food and nutrient security; therefore, its diagnosis and monitoring are essential. The diagnosis of drought is also important for the utilization of drought projection using climate modeling facilities for the stakeholders and planners of a country. People who are already vulnerable and food insecure are likely to be affected first. Agriculture-based livelihood systems that are already vulnerable to food insecurity face immediate risk of increased crop failure, new patterns of pests and diseases, lack of appropriate seeds and planting material, and loss of livestock (FAO, 2008). Droughts often cause mass migration, famine and death, and critically affect the sustainability of a country or a region.

It is the most cosmopolitan disaster among the Asian LDCs. Since droughts start unnoticed and develop cumulatively hampering lives and properties, it is very difficult to cope up with the situation by the poor nations. Most of the LDCs are dependent on agriculture: farming, herding and fishing, the impact vary from region to region and the sufferings, although substantive are hardly noticed cumulatively.

Drought is, thus, one of the most complex natural phenomena, that is hard to quantify and manage, and has multiple severe social and economic impacts, especially in the Asian LDCs. The magnitude of these impacts is determined by the level of development,

Fig. 1. Map of the World LDCs; Source Wikipedia (Wikipedia).

population density and structure, demands on water and other natural resources, government policies and institutional capacity, technology, and the political system (Eriyagama et al., 2009).

Droughts continue to have significant impacts in both developed and developing countries but the latter suffer the most. This paper seeks to synthesize the relevant information about droughts, its impact, coping behavior of the people as well as use of knowledge paradigms to manage drought situations for sustainable development in Asian LDCs especially in Bangladesh, Nepal, Bhutan, Myanmar, Afghanistan, Yemen, Cambodia, and Lao PDR. Since drought is a global phenomenon, it is useful to understand the pattern of various drought-related characteristics and impacts worldwide from a global development perspective.

2. Methodology

The methods of research employed in developing this paper includes desk study of relevant literature, articles, essays, conference proceedings and the like materials available in published form in books, peer reviewed materials, journals, magazines, newspapers, printing and electronic media and blogs. Besides, information was also gathered through organization of workshops and seminars as well as participation in different national and regional workshops and conferences which provided the additional opportunity of interaction with researchers and policy makers concerned with environmental changes, disaster mitigation, climate change, etc. Some information was also collected through visitation to research institutions, data bureaus, meteorological stations, rural and urban administrative bodies, Non-Government Organizations (NGOs) as well as meetings, interactions and consultations with experts particularly in Bangladesh, Nepal, Cambodia and Lao PDR- through field visits. Some information was also gathered through direct interaction with limited number of stakeholders viz. inhabitants of rural and urban areas, farming communities as well as women and youths. The impacts and vulnerabilities of droughts have been examined for each LDC and documented with their intensities and losses to assess the sufferings, reflect on the coping behavior and pulled together for cross-scale assimilation.

3. Prevalence of droughts

Drought is pervasive to all continents of the world. According to the Global Drought Information System (GDIS, Global Drought Information System, 2013), short-term global droughts remained relatively constant across the world in August 2013 affecting 44 million people while drought conditions, which eased in North America, Africa and Europe, remained intensive in Australia, constant in South America, and intensified in Asia. The global drought mapped by the University College of London shows 258 million people affected globally by exceptional drought in last 36 months (Fig. 2).

Drought in Russia in 2010 led to restrictions on agricultural exports, causing the price of staple grains to rise across North Africa and the Middle East. The resulting food shortages and price rises aggravated the tensions that led to the Arab Spring. Some studies suggest that water scarcity could reduce grain production by as much as 30% (Global Risk Report, 2014). The historic 2011 drought in the Horn of Africa affected 13 million people, caused huge displacement and humanitarian crisis as well as increased malnourishment to 50% of the children in camps and malnourished 30% of the drought affected people (IFRC, 2011) while around 80% of the African people were affected by droughts between 1970 and 2008 (ISDR, 2012). Severe droughts are taking place almost every year in Europe affecting more than 800,000 km² of the EU territory (37%) and 100 million inhabitants (20%) in 1989, 1990, 1991, and 2003 (European Commission, 2007). By 2020s, a large part of Asia is projected to experience increased risk of severe

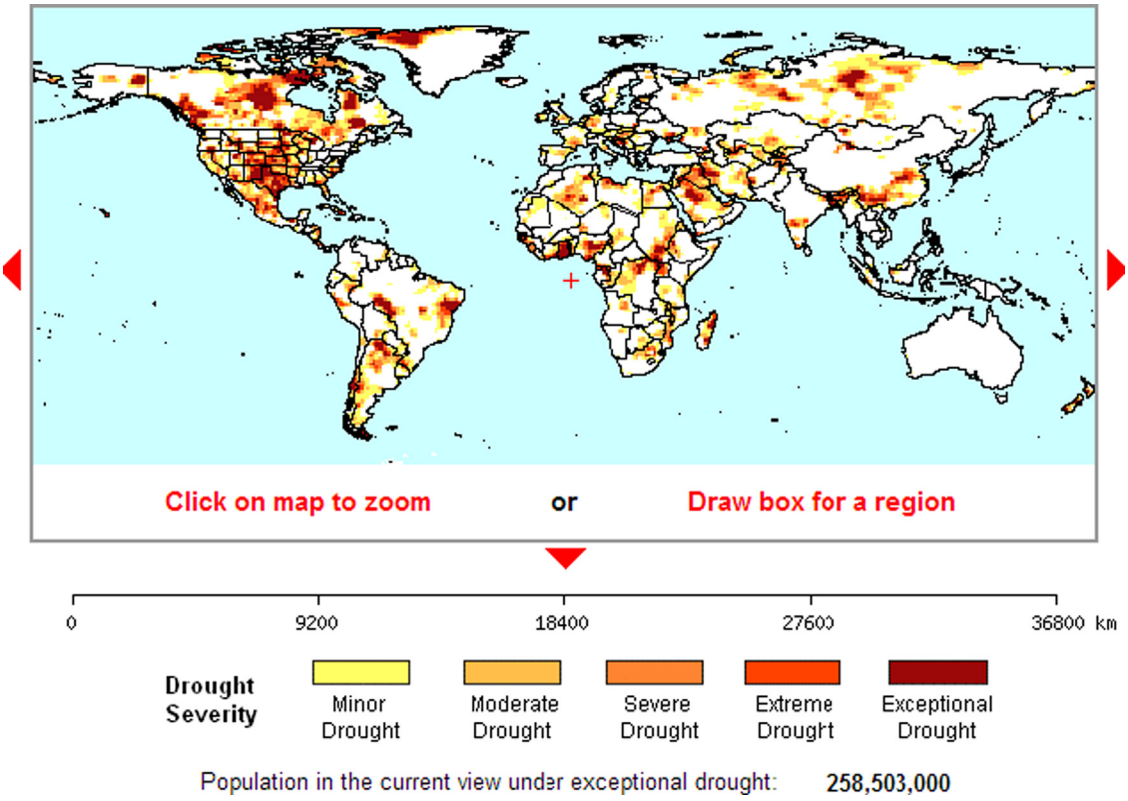

Fig. 2. Population in the current view under exceptional drought. Source: University College London.

droughts with multiple impacts (Centre for Low Carbon Future, 2012). In Summer 2012, around half of the continental United States experienced moderate to severe drought with arecord of high area coverage since 1895 (Benjamin et al., 2012) while studies founds that Australia is affected by droughts almost every year and severe drought affects some part of Australia on average once every 18 years (BoM, 2013).

Mega-droughts of Southern China and Northern Europe until 2010 was a decade long one. The North Atlantic region experiences strengthened wind pattern velocity as atmospheric circulation becomes more zonal in summertime causing more dryness in the region. Northern Europe cools as a pattern of colder weather lengthens the time that sea ice is present over the northern North Atlantic Ocean, creating a further cooling influence and extending the period of wintertime surface air temperatures (Schwartz et al., 2003).

Winds pick up as the atmosphere tries to deal with the stronger pole-to-equator temperature gradient. Cold air blowing across the European continent causes harsh conditions especially for agriculture. The combination of wind and dryness causes widespread dust storms and soil loss. Signs of incremental warming appear in the southern most areas along the Atlantic Ocean, but the dryness does not let up. By the end of the decade, Europe's climate is more like Siberia's (Schwartz and Randall, 2003). Severe drought incidents have afflicted wildlife in southern Africa. Their impacts have been variable, but certainly harmful. Kanvazina (1981) reported that the drought of 1980 resulted in poor regeneration of vegetation and nyala Tragelaphus an-gasi Gray mortality in Lengwe National Park, Malawi. Similar effects of the drought occurred in wildlife conservation areas in Botswana and South Africa (Walker et al., 1987) and in Zimbabwe (Magadza, 1994).

4. Prevalence of droughts in Asian LDCs

Among the 14 LDCs in the Asia-Pacific region (Wikipedia), 9 LDCs are located in Asia while other five are in the Pacific region. Of the 9 Asian LDCs, Afghanistan, Bhutan, Bangladesh, and Nepal are located in South Asia, Cambodia, East Timor, Myanmar, and Laos PDR are in the Southeast Asia while Yemen is located in the Middle Eastern region. Except Bhutan that experiences fewer droughts, all other Asian LDCs experience frequent moderate to severe droughts of all types and all possible impacts of droughts. The prevalence and devastation of droughts in these Asian LDCs are briefed in the South Asia, Southeast Asia and Middle Eastern LDC sections of this paper.

4.1. Prevalence of droughts in South Asian LDCs

As mentioned earlier, Afghanistan, Bangladesh, Bhutan, and Nepal are the South Asian LDCs and these countries experience all the meteorological, agricultural, hydrological, and socio-economic type of droughts with high frequency. The distribution of monsoon rainfall varies intra-seasonally, intra-annually, and inter-regionally. Such variation of rainfall causes meteorological hazards like drought. Study reveals that the monsoon has been delayed by 20 to 30 days affecting crops and livelihoods (Krishnamurthy and James, 2002). During drought, severe water scarcity results from insufficient precipitation, high evapotranspiration and over exploitation of water resources (Bhuiyan et al., 2006).

The worst record drought of 2011 in Afghanistan afflicted 14 out of 34 provinces of the country affecting 2.6 million people (Huffington Post, 2011; News, 2011). In Afghanistan, localized and wide-range droughts are recurrent features in the recent decades. According to an analysis of climate and drought records of Asian Development Bank, localized droughts have a periodicity of three to five years, and droughts covering large areas recur every 9–11 years. South and central areas are affected more from July through September. Afghanistan began experiencing unusual droughts beginning in 1995. It continued until heavy snow began falling in the 2002–2003 winter season (Oxfam, 2011). Drought combined with conflict has created internally displaced populations that are living in extremely poor conditions (Figs. 3 and 4).

Every year, Bangladesh experiences drought for six to seven months, from November to May, when rainfall is normally low. During the 1998–1999 dry seasons, there has been no rainfall at all for several months in some areas of the North-west, the South-west and central zones. Droughts have been more frequent in the past few decades. Between 1949 and 1991, droughts occurred 24 times in Bangladesh while very severe droughts hit the country in 1951, 1957, 1958, 1961, 1972, 1975, 1981, 1982, 1984, and 1989 and past droughts have typically affected about 47% area of the country and 53% of the population (Adnan, 1993). Bangladesh also experienced droughts of high magnitude in 1973, 1978, 1979, 1981, 1982, 1989, 1992, 1994, and 1995 (Adnan, 1993; Hossain, 1990). The droughts of 1973, 1979, and 1994–1995 (Figs. 5, 6 and 7) were the worst in recent history (Murshid, 1987; Rahman, 1995).

Drought condition was analyzed using Standardized Precipitation Index (SPI) from the rainfall data during 1961–1990 (Rafiuddin et al., 2011) and the results (Table 1) confirm the historical record for the duration of droughts (3–6 months) with some exceptions.

Decision Support System for Agrotechnology Transfer (DSSAT) Cropping System Model that is used to simulate future yield of the years 2030 and 2050 for BR11, BR14 and BRRI Dhan29 in the hotspots suggests an overall decrease in yield ranging from less than 10% to greater than 40% from present yield condition in vulnerable hotspots for both A2 and B1 in the year 2030 as well as BR 11 and BT 14 in 2050. In case of BR 29, the reduction in yield from base period in year 2030 and 2050 for both the scenarios ranges from less than 10% yield reduction to 30–40% yield reduction (CEGIS Study Report, 2013).

Using average rainfall data of East and West Nepal SPI was calculated for the period 1981–2007 and detected extreme drought during March and April in 1991(SMRC Report, 2009).

Bhutan has been experiencing extreme variations in its climate and weather patterns. Although evidential data and information is limited, there are cases where individual municipalities or agencies have made observations on selected sites. The winter of 2005 and 2006 experienced unusually dry winter with no rain and snow (NDRMF, 2006).

Nepal experienced droughts in 1972, 1977, 1982, and 1992. Since 2002, the country has been experiencing frequent dry spells and during the years 2002, 2004, 2005, and 2006 the country faced dry spells in both dry and wet monsoon. Sometimes these droughts have been followed by the floods and heavy rainfall (WeAdapt, 2008).

The 2008–2009 winter drought in Nepal was the worst on record (Figs. 8 and 9); according to the Department of Hydrology and Meteorology, the country received less than 50% of average precipitation during the period November 2008 to February 2009 (Joint Assessment Report, 2009).

4.2. Prevalence of droughts in Southeast Asian LDCs

Cambodia, Myanmar, and Laos PDR are the three Southeast Asian LDCs. This paper reports findings of investigations on representative areas like Cambodia, Laos and Mekong Basin to evaluate the drought condition of the region Fig. 10.

Cambodia experiences frequent droughts, and widespread droughts occurred throughout the country in 1986–87, 1994, 1997–98, 2002, and 2005 (Ministry of Environment, Cambodia,

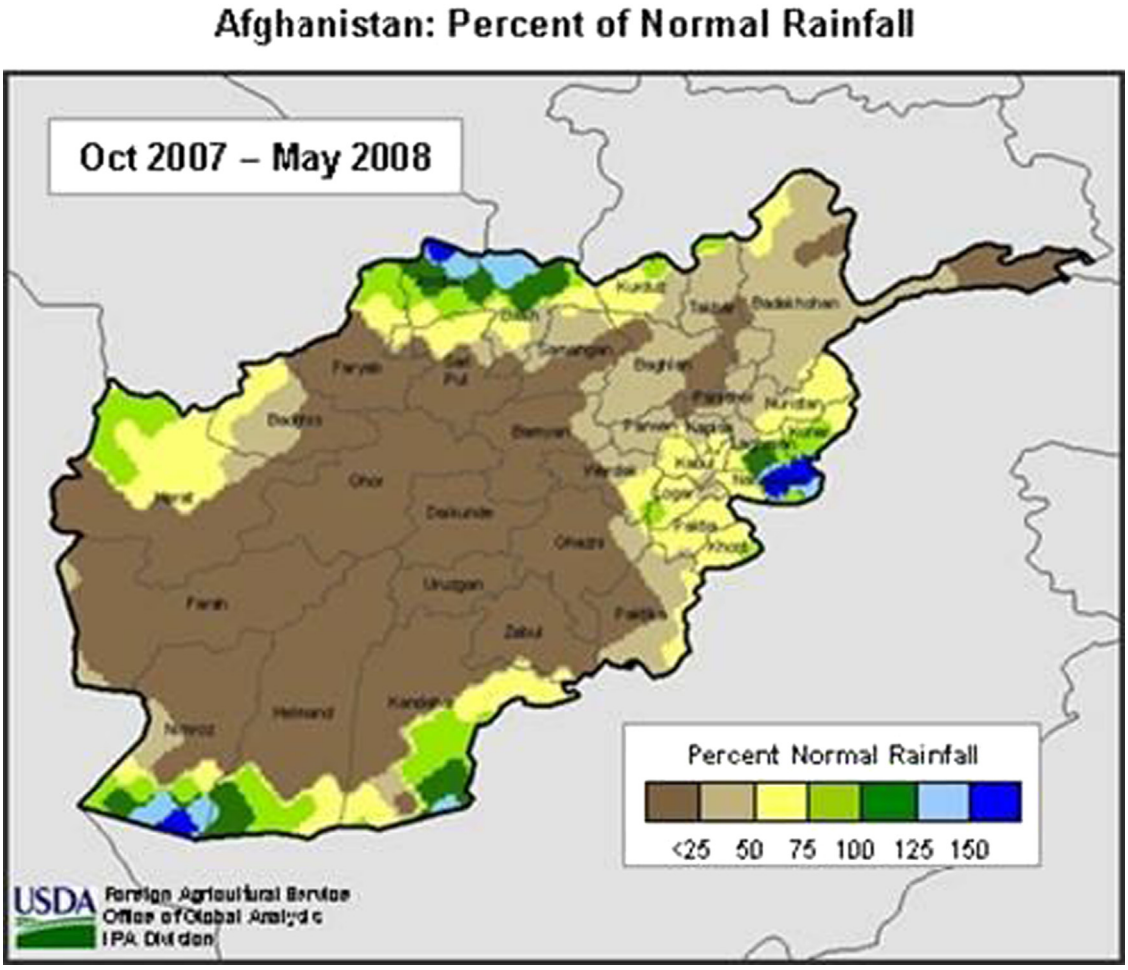

Fig. 3. Distribution of normal rainfall in Afghanistan.

Fig. 4. Afghanistan and drought impacted fields.

2002). According to phnompenhpost.com, droughts devastated 9,990 ha of paddy field and affected 122,297 ha across the Cambodia in 2012 (Figs. 11 and 12). According to Cambodia Disaster Statistics, historical droughts of 1994, 2002, and 2005 have seriously affected 5.0, 0.65 and 0.6 million people respectively and the total economic loss was 138 million US dollars.

Droughts being the most severe climatic hazards in 17 out of 20 provinces of Cambodia, the intensity and frequency have increased since 2000 while the following graph (Fig. 10) represents perverseness of droughts to all provinces of Cambodia measuring 11 provinces as quite vulnerable, two provinces as vulnerable, and one province as very vulnerable (NAPA, 2006).

Laos PDR experienced moderate to severe droughts in the years 1961, 1966, 1971, 1978, 1984, 1994, 1995, 1996, and 2009 that caused damage to lives and properties. Droughts are considered one of the most frequent and damaging disasters in Laos (Figs. 13 and 14). Historical data recorded from 1966 to 2009 shows that Laos experiences an average of 1.5 severe droughts every year (GFDRR, 2011).

Southeast Asian countries are identified as climate change hotspots and about 105 million people are experiencing water stress in Greater Mekong. Severe droughts caused rainfalls lower than average since September, assessed by Mekong River Commission (MRC). It declines rainfall to dry season even drier than normal. This is a regional problem and the MRC consisting of Vietnam, Cambodia, Laos PDR and Thailand is working on a common approach to water sharing and minimize drought effect in the region.

4.3. Prevalence of droughts in Middle Eastern LDCs

Yemen is the only LDC in the Middle East. It is one of the poorest countries and about 22 million people have been struck by severe droughts and depleted water supplies in recent years (Kenyon, 2008).

Yemen was seriously affected by severe droughts from 2007 to 2009 (Figs. 15 and 16) (⟨www.irinnews.org⟩) and it has become a

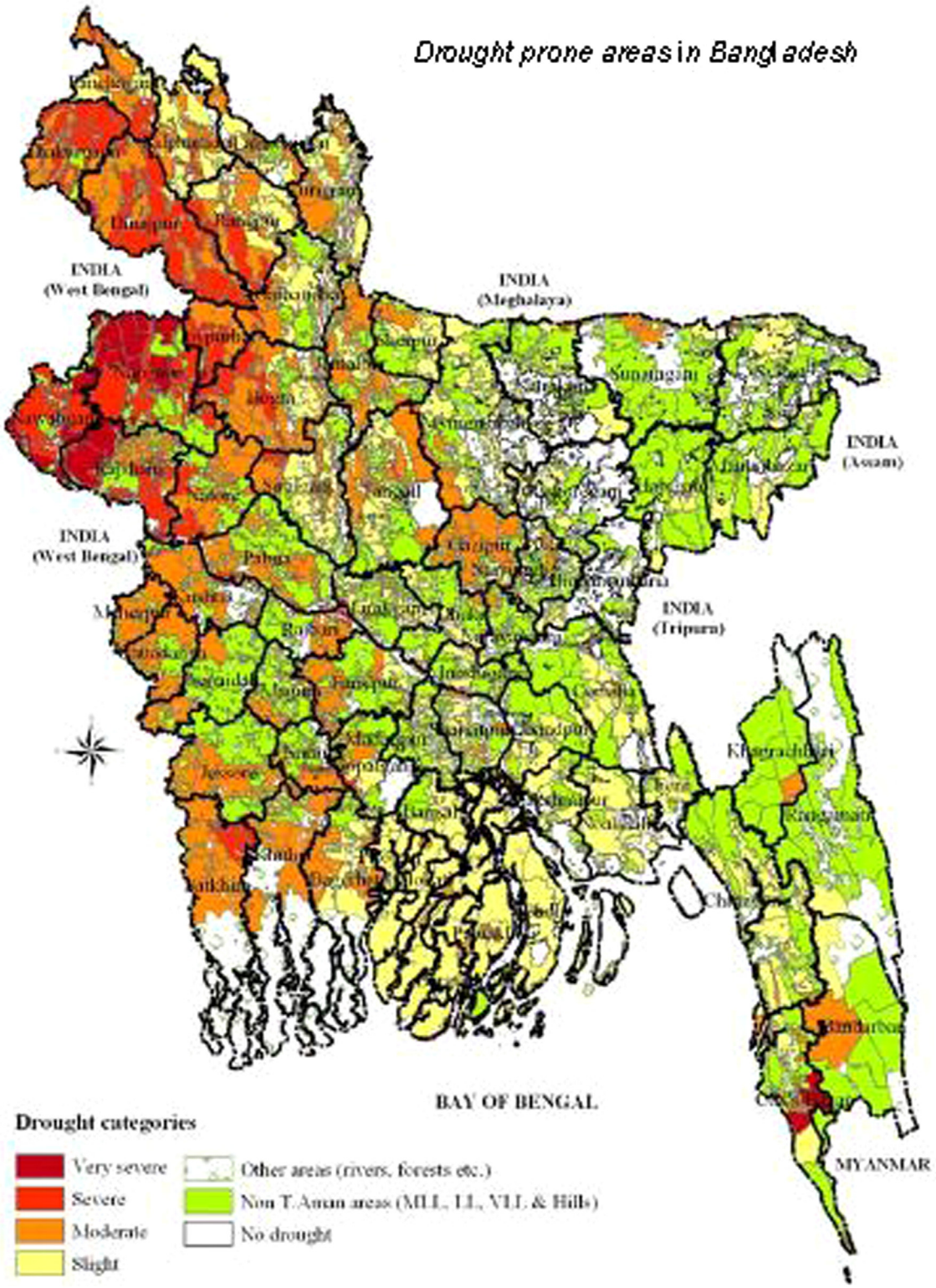

Fig. 5. Drought prone areas of Bangladesh and drought affected paddy.

looming catastrophe in the country. Yemenis receiving less than 200 m^3 of water per person a year, well below the international water poverty line of 1000 m^3 clarifies the severity of droughts and water crisis of the country (⟨www.theguardian.com⟩). In Yemen, drought has caused displacement of thousands of people from mountainous villages in al-Mahwit Governorate in 2008 (IRIN, 2008).

5. Impacts of droughts in Asian LDCs

The Asian LDCs are facing serious socio-economic problems due to increasing droughts. This section deals with the materials arising out of the synthesis work to integrate the information on impacts of droughts in Asian LDCs. Most of the LDCs are densely populated and vulnerable to droughts but have very limited

facilities and financial capacity to overcome the consequent impacts.

Current extreme weather events are already taking their toll on these developing countries' economies, leading to loss of human and economic capital. The climate extremes especially drought against which these LDCs have limited adaptive capacity and will further obstruct their development prospects due to additional loss of life, private assets, reduced productivity of important economic sectors, and destruction of infrastructure (OECD, 2003). Diverse biophysical conditions of Asian LDCs result in varied nature of climate change impacts. However, South Asian LDCs have some similar nature of drought effects and are densely populated, poor, and most vulnerable (UN-OHRLLS, 2009; IPCC, 2001). Droughts are recurrent features in Bangladesh and affect plant growth, loss of crop production, food shortages, and starvation. Drought affected households of the northern part of Bangladesh are severely affected; households belonging to the lower socio-economic group suffered the most (Paul, 1995). The total loss of rice production due to drought in 1982 was 52,896 metric tons (BBS, 1986) which is accounted for about 41% of the total damage caused by all types of environmental hazards. Brammer (1987) claimed that the 1978–1979 drought reduced rice production by an estimated two million tons. It directly affected about 42% of the cultivated land and 44% of the population (Erickson et al., 1993).

Fig. 6. Drought affected paddy field in Bangladesh.

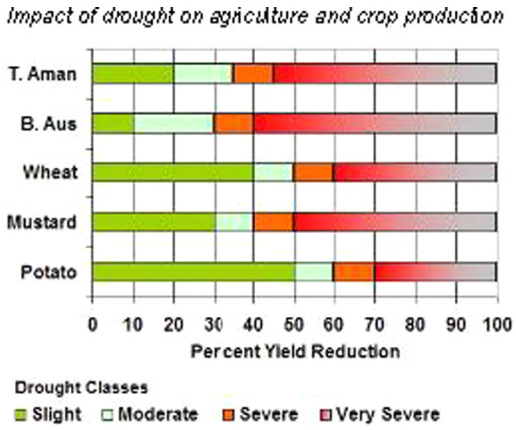

Fig. 7. Impact of drought on agriculture; Source: Climate Change Cell, Bangladesh 2006 (Climate Change Cell, Govt. 2006).

Bangladesh, being a lower riparian country, does not have any control on the flow of these rivers. Upstream withdrawal of water by India especially during the dry monsoon from the main GBM river system caused serious water crisis and drying up of rivers and wet bodies. Studies revealed that more than 80% water reduced from the Ganges and Tista rivers due to Farakka and Tista barrage (Afroz and Rahman, 2013). This water crisis caused severe stress to both crops and fruit trees particularly in areas where water cannot be pumped out from the rivers, wet bodies and shallow aquifers. In the coastal zone, due to drop-down of water the salinity increased affecting agriculture and livelihoods. Due to drying up of surface water bodies, the dependency of groundwater has been increased tremendously. However, the increasing withdrawal of groundwater for domestic, farming and industrials purposes subsides understanding about the severity of drought (Rahman, 2011; Miyan, 2012).

Bangladesh may face similar drought effects like Yemen due to continuous withdrawal of ground water. Dry season agriculture has become the main source of increased food production over the past 20 years (BBS 1994). But withdrawal of ground water is forcing the water-table to go down and is creating further crisis of water and increasing vulnerability of earthquake, especially in the cities where water-table is going down by more than one meter every year. More than 5 million people of the Barind Tract are under a great threat due to severe impact of drought forcing use of arsenic contaminated ground water. Throughout Bangladesh, about 2 million small farmers and 2.4 million rural wage laborers are vulnerable to very severe drought. In the hills, more than 90% perennial streams have lost their flow in the dry monsoon resulting in serious water crisis for hill people who in turn resulted in outbreak of diarrhea, dysentery and cholera etc. (Rahman, 2011).

High spatial and temporal climatic variability, extreme weather events, high population density, high incidence of poverty and social inequity, poor institutional capacity, inadequate financial resources, and poor infrastructure have made Bangladesh highly vulnerable to disaster (Shahid and Behrawan, 2008; Ali, 1996; Ahmed, 2004). During the last 50 years, Bangladesh suffered from 20 extreme drought conditions. Despite the recurrent and devastating nature of droughts in Bangladesh, it has attracted far less scientific attention than floods or cyclones (Alexander, 1995; Brammer, 1987). However, losses from drought are likely to be more severe than from floods in Bangladesh (Shahid and Behrawan, 2008). The impact of drought is of the same magnitude or even higher compared to the impact of floods and procedures set in place for flood management cannot be transferred directly for drought management. Drought assessment and alleviation is

Table 1
Frequency of drought in Bangladesh for different short-month-length using SPI calculated from the regional average.
Source: (Choudhury et al., 2003).

Sub-regions	Month 1		Month 3		Month 6	
	Moderate drought	Severe Drought	Moderate drought	Severe Drought	Moderate drought	Severe Drought
Central	52	3	49	10	58	8
Northern	32	4	50	4	58	1
Eastern	35	1	45	3	39	2
Southwestern	44	2	49	4	62	3
Bangladesh	163	10	193	21	217	14

Fig. 8. Map of Nepal.


Nepali women collect water in Patan, south of Kathmandu March 12, 2009. There is a shortage of w
Kathmandu valley due to a long drought.(Xinhua Photo)

Fig. 9. Water crisis in Katmundu in March 2009.

far more complex than flooding. Drought is a trans-boundary and basin-wide issue. These clarify the impacts of droughts and its adversity (Terink et al., 2011).

A number of studies have been carried out on the impact of droughts on agriculture (Jabbar et al., 1982; Karim et al., 1990; Saleh et al., 2000; Mazid et al., 2005), food production (Ahmed and Bernard, 1989; Erickson et al., 1993), land degradation (Rasheed, 1998; Karim and Iqbal, 2001), economy (Erickson et al., 1993; World Bank Bangladesh, 2000), and society (Erickson et al., 1993; Paul, 1998). WARPO-EGIC (1996) prepared maps of winter and pre-monsoon drought prone areas of Bangladesh using the agro-ecological zones database and land resources inventory map. However, in Bangladesh drought is an ongoing silent disaster. Effects of a few historical droughts are mentioned in Table 2.

Ahmed and Bernard (1989) and Hossain (1990), found that during the 1973–1987 period, about 2.18 million tons of rice was damaged due to drought. In the 1960s and the 1970s and towards the end of 1990s the tea industry experienced prolonged drought which affected tea production. Prolonged drought for five months in 2006 affected the tea industry seriously (BDNews, 2006). Due to drought the jute crop has also been affected due to shortage of water. A large number of crops were damaged because the drought period corresponds with 1995 sowing period of Aus, Aman, and Boro rice, jute, and summer chilies; 1994 sowing period of winter crops: e.g., vegetables, potatoes, pulses, sesame, Foxtail millet, onion, garlic, chilies, and wheat; 1994 harvesting period of Aman rice; and 1995 harvesting period of Boro rice, and winter crops including wheat.

Although Nepal is known as a water-rich country, holding second position after Brazil, the people of western Terai in the plain belt have been suffering consequences of droughts. Drought has reduced the water level in the well to the extent that residents are forced to drink poor quality water and collection of pure water has become difficult due to lack for source. In the dry monsoon (October – May), the western parts of the country remain dry affecting the agriculture and livelihoods. This makes life particularly difficult for those who have to collect the water. The existence of wide range of climatic conditions in Nepal is due to rapid changes in the altitude (Nayava, 1974). Domroes (1979) reported that there are east–west variations in mean annual as well as monthly precipitation at some stations in Nepal. The 2008–2009 winter season droughts impacted on crop loss and household food security, malnutrition, fresh water crisis, induced forest-fires e.g. fires detected with the Moderate Resolution Imaging Spectro-radiometer (MODIS) satellite data by the International Centre for Integrated Mountain Development (ICIMOD) revealed a large increase in the number of forest-fires in March 2009 compared to the same month last year–1500 fire locations compared to just 100 in March 2008 (Joint Assessment Report, 2009).

Droughts cause considerable economic loss as well as social and environmental impacts which are increasingly affecting the human systems in Cambodia. It was found that, 20% loss in rice production was experienced due to droughts in five years (1998–2002) which is projected to increase in the future (Ministry of Environment, Cambodia, 2002; NAPA, 2006).

In Cambodia, the drought of 2002 affected eight provinces and over two million people (Figs. 17 and 18). According to a study by World Food Programme (WFP) and the National Committee for Disaster Management (NCDM), around 270 communes out of total

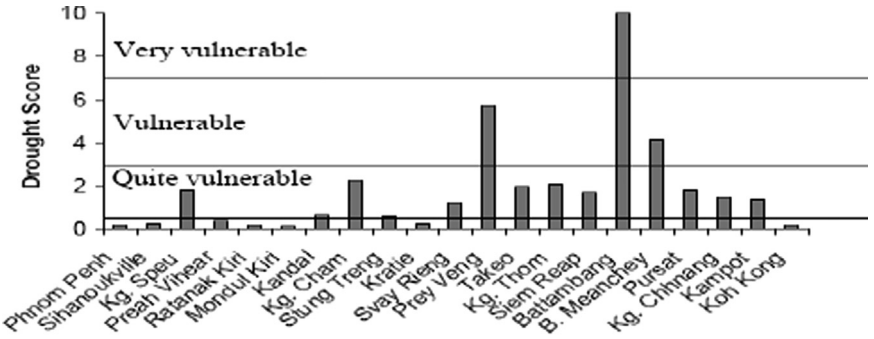

Fig. 10. Drought vulnerability in the Cambodian provinces (NAPA 2006).

Fig. 11. Map of Cambodia.

1621 in Cambodia are prone to drought. Provinces such as Prey Veng may be hit by both floods and drought in the same year. However, only about 40,000 out of 310,000 ha of the cultivated land in Prey Veng are estimated to have irrigation systems, meaning that over 80% of cultivation depends completely on seasonal rainfall and weather. Therefore, most farming households bear the full brunt droughts.

In Mekong, droughts force farmers to plant crops that require less water and refrained from planting a second rice crop. Subsistence farmers have to seek new off-farm job and change their way of life because crops (rice, coffee, sugar etc.) were damaged and stressed (Orn–uma Polpanich, Drought in Southeast Asia, 2010). Drought of 2010 in the Mekong Basin hampered Southeast Asian economy by excreting impacts on agriculture, tourism and other industries (The Bangkok Post, 2010). The IPCC concluded in their latest Assessment Report that low rainfall and higher temperatures will intensify drought in the Mekong Region substantially (Terink et al., 2011).

In Laos, there is a decline in rainfall, subjecting the area to drought. If rains stop falling, within a few years the area can become arid with the strong tropical sun baking down on the scrub-land and become more prone to devastating forest-fire (Butler, 2012). According to WFP (2010) many parts of the country reported drought conditions which delayed the planting of rice. These natural disasters represent shocks that can lead to a rapid deterioration in the nutrition situation.

A Cambodian in a paddy field in Kampong Speu province. Drought has hit Cambodia during its rainy season destroying more than 100,000 hectares of crops across the country— PHOTO: Reuters

Fig. 12. Cambodia and drought impacted paddy field.

A boy stands on a drought-hit rice field near Vientiane, March 27, 2010. The drought in Laos is expected to be worse this year.

Fig. 14. Laos and drought impacted paddy field.

Fig. 13. Map of Lao PDR.

The majority of Bhutan's population depends on subsistence farming for which timely precipitation is necessary. Bhutanese communities especially the rural population is highly vulnerable to impacts of droughts. Increased temperature and drought intensify incidences of forest fire. Climate scenarios prepared using Providing Regional Climates for Impacts Studies (PRECIS) model under the Second National Communication from Bhutan to UNFCCC indicate that winters in Bhutan will be drier and warmer in the future and this finding is consistent with other regional and global models (NAPA, 2012).

In Dagana dzongkhag, there was no rainfall for four months in 2012 which seriously affected vegetables and all other cereal crops. Consequent to the prolonged dry spell, crops are scalded, some to the extent of no rejuvenation (The Bhutanese, 2012). The rain become scarce in most part of Bhutan and farmers suffered severe dry spells (Lhakapa, 2012) and farmers started converting paddy fields into dry farming (Palden, 2011)

Inadequate rains and snowfall during 2008–2010 in parts of Afghanistan caused significant failure of the rain-fed crops in six provinces (UPI, 2011). These led to severe drought affecting the northern parts of Afghanistan with consequences of dried pasture lands, reduced water sources and caused death of thousands of animals. In Samangan, about 1,400,000 animals have been sold at low prices, while about 30% perished due to drought (IRIN, 2008). Nearly three million people have been facing severe food shortages as a result of drought in 14 out of Afghanistan's 34 provinces. Eighty percent of the non-irrigated wheat crop has been lost (IRIN, 2011).

In Afghanistan, the impacts of droughts are multidisciplinary starting from agriculture, herding, drying up of pasture, acute water crisis, food security and malnutrition, and domestic water shortage resulting in epidemics (OCHA, 2011). It has been further

Fig. 15. Map of Yemen.


The current drought in Southern Yemen has caused a wide spread live stock deaths, causing a large source of people's livelihoods and income to decrease in rural Yemen. 19th November 2011

Fig. 16. Yemen and drought affected livestock.

Fig. 17. Migration of and impact on fish species due to droughts.

Fig. 18. Droughts leading to harvesting paddy as fodder.

Table 2
Historical details of different droughts that occurred in Bangladesh.
Source: Modified from Banglapedia, 2006 extract from CEGIS Report 2013.

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

reported that drought caused serious shortfall of food production especially the rain-fed wheat up to 80% and the situation affected the most vulnerable populations in terms of access to food and water with health and nutritional consequences (UPI, 2011).

Yemen is one of the oldest irrigation civilizations in the world. Yemen is now facing a water crisis unprecedented in its history. Presently, Yemen is one of the world's ten most water-scarce countries. Excessive withdrawal of ground water for years has caused drying up of the aquifers; threatening agriculture and leaving major cities without adequate safe drinking water. Sana could be the first capital city in the world to run dry. Even today, many wells have to be drilled to depths of 2600–3900 feet, extremely deep by world standards. In Yemen, droughts contribute to and speed up overgrazing in the Highlands as a result of high stocking rate (Alabsi, 2001).

Extreme weather conditions and environmental changes are confusing farmers and threatening livelihoods, further aggravating Yemen's already fragile food security. Due to lack of research, there are no numbers that accurately describe how drought is affecting Yemenis. However, one thing is clear; Yemeni farmers' attitudes towards planting have changed. Yemen is getting hotter by the year towards climate extremes. According to the National Council for Climate, there has been an increase in average temperatures in the capital Sana'a over the last 20 years, though they do not have an exact figure due to a lack of research (MERIP, 2013). Agriculture takes the lion's share of Yemen's water resources, sucking up almost 90%. Until the early 1970s, traditional practices ensured a balance between supply and demand. Then, the introduction of deep tube wells led to a drastic expansion of land under cultivation. In the period from 1970 to 2004, the irrigated area increased tenfold, from 37,000 to 407,000 ha, 40% of which was supplied by deep groundwater aquifers. Thousands of Yemenis working abroad often invest their remittances in irrigation. Other incentives to expand farmland came in the form of agricultural and fuel subsidies. Farmers began growing less of the local, drought-resistant varieties of wheat and more water-intensive cash crops such as citrus and bananas.

It is estimated that qat production now accounts for 37% of all water used in irrigation. In the water-stressed highland basins of Sana, Sa'da, 'Amran and Dhammar, qat fields now occupy half of the total irrigated area. Groundwater levels in these highlands have fallen so precipitously that only the lucrative returns from qat justify the cost of operating and maintaining a well. A total of 13,500 wells have been inventoried in the basin. The vast majority of them serve farmers, but the water is disappearing. In the mid-1990s, extraction in the catchment area exceeded recharge from rainfall by over 400%. Available data give the Sanaa aquifer two decades of life, after which irrigated agriculture in the basin will end.

Yemen is under "serious water stress" according to a report by the UN Economic and Social Commission for Western Asia (UN-ESCWA). Climate change during the last few years and especially in 2009 is a real concern for Yemen, particularly if the frequency of precipitation events continues to diminish, putting agriculture in peril and potentially leading to a catastrophic drought as the rainfall patterns are changing. The rainy season in Yemen is usually from March to May and July to September, but rains are now starting in August.

Like the rest of the region Yemen is facing droughts and desertification on the one hand and torrential downpours on the other, rains that are useless because they are not harvested or channeled in any way.

Geographical location in an arid area makes it especially difficult for Yemen. It rains four months in a year, the rest of the year is dry. The population increase, especially in the mountainous area where up to 90% of the population density distribution is located, further aggravates the water crisis. Most of the population is also concentrated in the major cities. This puts pressure on ground water and an annual drop of four to six meters in most of the groundwater resources (The Yemen Times, 2009).

6. Coping with droughts

Some LDCs have their own ways of coping behavior to overcome the climate induced droughts. Decreased food production, abnormal increases in food grain prices, and non-availability of jobs reduce the food entitlement of rural people, especially the small farmers and landless laborers. At this stage, drought victims often are compelled to buy food by selling their lands, household goods, and livestock at distressed prices (Reardon et al., 1988). People start to consume wild plants, tubers, and leaves not normally eaten (Jallow, 1995). This provides an "early warning" of famine. In this stage government and NGOs need to mobilize additional food from different sources and distribute it free of cost or at subsidized price to the affected people and provide additional employment opportunities or financial aids to the drought victims. Failing such responses famine becomes unavoidable.

People adapt various strategies to cope with the effects of drought. At the household level, people intend to reduce the effects of drought hazard by using two types of drought-mitigating techniques. These techniques are referred to as agricultural and non-agricultural adjustments. People usually practice agricultural adjustments to compensate for crop loss. Without such adjustments, people will get lower than expected food production, which can threaten their food security. People practice some agricultural adjustments, such as re-sowing of crops, in order to compensate for the reduction in the crop area, and others, such as application of irrigation water, to increase crop yield (Brammer, 1987). Due to high prices of food-grains during the drought period, people need additional cash to buy food crops for consumption. For this reason, they generally practice non-agricultural adjustments. The need for cash is further aggravated due to remarkable decrease in demand for agricultural wage laborer. As a result, people either sell and/or mortgage their land and livestock, and sell their belongings to acquire additional cash.

The community in which the drought victims live also helps in coping with the negative impact of the hazard. All members of the affected community are not equally vulnerable to drought. At the community level, friends, neighbors, relatives, and affluent members of the society may help the drought victims by providing cash, loans, food, and clothes (Paul, 1995). Beyond the community level, the national government as well as friends and relatives of the drought victims who live outside the victims' community can play key roles by providing financial and other support to overcome the hardships of the drought victims as well as to halt the occurrence of famine. Distribution of free food, clothes, medicine, and other relief goods is the appropriate public response to drought hazard. The government can also minimize hardships by creating employment opportunities for the drought victims and providing financial assistance to them.

NGOs may also extend their support to the drought victims to cope with losses. Indeed, the impact of the drought can be reduced significantly if all parties respond to the hazard adequately in appropriate time. Otherwise drought victims face hardship in coping with the hazard. The government's interventions are particularly needed to avert famine and minimize the hardship of the drought victims. People used to follow some special techniques like fish, meat and fruit preservation; surface and rain water storage in large reservoirs like Ramsagar (Fig. 19) and Sagar Dighi in Bangladesh, which are the manmade practices to cope up with the adverse condition.

Fig. 19. Ramsagor Dinajpur: A manmade pond 1,079 m × 1,926 m, excavated in 1750s, funded by Raja Ram Nath, using about. 1.5 million laborers in northern drought prone Bangladesh http://en.wikipedia.org/wiki/Ramsagar.

Fig. 20. Indigenous traditional mechanism for preserving/harvesting water from mud-hole during droughts.

Fig. 21. Indigenous traditional mechanism for transferring/harvesting mountain water through tree-shell during droughts.

Researches on drought resistant crops are in progress; however, traditionally people used to adjust their crops with the climate. But with the increasing hybridization for HYV crops without respecting adaptation period in order to achieve high yield and to increase cropping intensity the demand for water has increased manifold. Moreover, crops are losing their immunity and become more prone to disease and climate adversity. Some LDCs including Bangladesh have started growing food tree crops which are much less susceptible to drought effects and thus reducing food and nutrient crises. During tree crop production, trees get water and nutrients from deep soil and also mitigate droughts by transpiration.

Traditional climatic manipulation techniques, use of sun, shade and partial shade loving crops of diverse species and their management techniques are the options for mitigation of adverse impacts of climate change leading to droughts.

Sustainable landscape management involving traditional floodplain management is necessary to find a solution for the recharging of ground water to solve acute water crisis (Figs. 20 and 21).

6.1. Governments' initiatives

For the adaptation measures including traditional coping behavior NAPA and Standing Orders for Disasters (SOD) have been developed by many LDCs for awareness and capacity building. Changing habits, lifestyle and cropping patterns are part of different projects. Bangladesh Climate Change Resilience Fund (BCCRF) has approved $153 million projects to fight adverse impacts of climate change that may lead to subsiding of droughts. Moreover, emphasis has been placed on dissemination of information on enhanced disaster and health risks due to climate change. Though fallacy in adapting with droughts is prevalent among some 24% of the people of around 17% households have reduced water consumption by limiting bathing in a week in Cambodia (NAPA, 2006). Few countries e.g. Laos and Cambodia have adopted drought monitoring, drought risk mapping and quantification of drought risks (Terink et al., 2011). The SAARC Meteorological Research Centre (SMRC) has initiated a drought research project for Bangladesh and Nepal considering the growing uncertainty of monsoon precipitation; to calibrate regional climate model baseline data sets with observed values. Such study could be extended to other countries and regions.

In Bangladesh, negotiation for prevention of unplanned transboundary withdrawal of water is in progress through joint discussion with different neighboring countries. Afforestation and tree plantation is an important measure to restore the hydrological cycle and keeping humid atmosphere and the government has taken massive plantation program on the hills, along the roads and highways, riverbanks and also in the coastal zone under public private partnership (PPP) viz. social forestry; NGOs and private sector initiatives are also important on extension of forestry.

To enhance capacity and resilience and to respond to disaster risks and climate change, the Government of Nepal formulated the National Strategy for Disaster Risk Management (NSDRM) in 2008 which directly contributes to the national commitment on the Hyogo Framework of Action and to the work of the Nepal Risk Reduction Consortium (NRRC), launched by the Government in 2009. Stronger engagement of the ministries at national and subnational levels has been emphasized for integrating comprehensive disaster risk management into annual development plans. To strengthen capacity and systems for disaster preparedness and emergency response in line with National Guidelines for Disaster Preparedness and Response Planning, the UNICEF and the Government of Nepal has budgeted US$ 5.225 million for DRR and emergency preparedness for the hazard prone areas for the period 2013–2017 (UNICEF Report, 2013).

The Ministry of Water and Environment Resources of Yemen has taken strategies for biodiversity and for climate change but not for combating desertification. There are drought mitigation plan and drought management actions on project basis. Yemen needs help in the following areas: drought projection, national drought strategy and action plan, adoption of standard approach, drought monitoring and early warning systems, preparedness and mitigation action, emergency response and recovery measures and impact assessment (DESA and ESCWA Report, 2013). Since the concept of Integrated Water Resources Management (IWRM) is still new to Yemen and needs to be applied by the water sector in order to strike a balance between water replenishment and usage.

7. Way forward to reduce vulnerability

For the most part, previous responses to drought in all parts of the world have been reactive, reflecting what is commonly referred to as the crisis management approach. This approach has been ineffective, poorly coordinated and untimely; more

importantly, it has done little to reduce the risks associated with drought. In fact, the economic, social and environmental impacts of drought have increased significantly in recent decades (National Drought Management Policy Guidelines, 2014). The Integrated Drought Management Policy (IDMP) of WMO has prepared the guidelines and emphasized for continuous evaluation of the nation's changing exposure and vulnerabilities and the ways in which governments and stakeholders can work in partnership to lessen risk.

Most of the economic impacts of drought are associated with agriculture and the income generated from crops. In some places field crops are being replaced with tree crops like, timber, fuel wood and fruit trees. Some drought resistant crop verities viz. BRRI dhan56 and BRRI dhan57 are also developed to reduce the vulnerability of droughts. Permaculture, mulching, and traditional harrowing followed by powdering the soil to protect evaporation etc. are being practiced in some areas. These options could be promoted throughout the Asian LDCs to reduce vulnerability to droughts.

Since many of the wet-bodies have been dried up, the fishermen are now started to close-water fish culture by excavating ponds using irrigated groundwater. Integrated culture with rice, duck, oyster, crabs and turtles etc. are being practiced and these are replicable across Asian LDCs.

Women and children are very vulnerable to drought effects, however, they practice the very conservative methods for water use and takes juicy foods during the scarcity of fresh water and save themselves from diseases and malnutrition. Plantation of long rooted juicy food plants should get priority in the drought prone areas toll get easy access to juicy foods, and is this a way forward for all LDCs.

Traditional methods of drought monitoring are limited in the LDCs. The most difficulty is relevance of conducting near real time ground data e.g. soil moisture condition, rainfall and humidity etc. Education, training and research in the field of remote sensing/geographical information system (RS/GIS) are needed to integrate drought monitoring study and information sharing. RS can provide large amounts of data quickly and inexpensively by means of collection. Also it allows integrating vast amounts of information from a wide variety of sources to make applicable in emergency situations. Moreover, drought is considered as regional phenomenon, therefore, RS can provide more accessible information though less ground information available (Polpanich, 2010). Technical assistance and consulting services are needed for advanced drought monitoring and assessment study and even move further to establish early warning system for drought. Therefore, education, research, training and technology as well as innovation of software applications to monitor and forecast droughts could be an investment option for LDCs to fight droughts and reduce vulnerability.

Drought awareness and knowledge management are to be promoted by the governments of LDCs to educate the local government, communities and households to cope with droughts.

Simple toolkits or methods can be developed to assist the community or local government to monitor drought severity.

Some institutes and NGOs are providing training to the youth and women bodies for sustainable uses of water resources, recycling and reuse of grey water, traditional rain water harvesting and purification. The reasons and consequences of droughts could be integrated into such curriculums for building awareness and help communities cope with droughts that could reduce vulnerability.

Knowledge Based Area Development (KBAD) or area based initiatives for capacity building through training and education in the drought prone regions could be a unique way forward to reduce drought related vulnerabilities (102).

The Cambodia's Initial National Communication under the UN Framework Convention on Climate Change of the Ministry of Environment, Cambodia offers some proactive ways forward for reducing drought vulnerability viz. (i) development of new high yielding drought resistant varieties, (ii) improvement of crop management and cultural practices, (iii) development of capacity for better adaptation like development of early warning system, development of maps showing rice growing areas prone to drought, (iv) development of irrigation facilities for low lying areas, (v) increasing planting index in suitable areas, and (vi) diversification of food. Cambodia has also incorporated climate change awareness education into the secondary education curriculum, established forum and trust to reduce vulnerability (⟨http://www.camclimate.org.kh⟩).

8. Conclusions

Drought is one of the most looming natural and climate induced disasters, which affects millions almost every year in the densely populated Asian LDCs. Climate change is the major cause of droughts worldwide. However, from the meteorological studies through satellite information and from the historical climate information early awareness can reduce the impacts of drought. With proper awareness, the drought victims can practice an array of adjustments to cope with the drought where public responses are essential. From historical data, in the South Asian and lower Mekong River countries some indexes are under implementation viz. Palmer Drought Severity Index PDSI), the Crop Moisture Index (CMI), SPI, Surface Water Supply Index (SWSI) and Dry Index etc. but drought forecasting and early warning are still underway. More study is required on complex nature of Asian LDCs which plays a significant role in Asian countries.

Diffusion and adoption of the existing practices and future initiatives presented in the Way Forward and Coping sections could help Asian LDCs achieve reasonable resilience against droughts. However, a conceptual framework needs to be developed to study drought mitigating techniques adopted by drought victims and the support they received from various levels which can provide important insights into different levels of vulnerability to droughts and help design response accordingly. Since drought initiation and persistence is not limited to a country like climate change, so the LDCs need is to acquire more capacity to monitor and predict all kinds of droughts and climate related hazards in all scales and times for taking proper adaptation and mitigation measures.

In the virtual absence of empirical research on drought in LDCs like Bangladesh, the present paper provides useful information on the survival strategies used to combat drought at the individual and community levels. This information is crucial for planners, administrators, extension officials, and NGOs to improve responses to future drought occurrences and thus help to minimize droughts induced consequences.

A serious gap has been observed in research and knowledge generation related to drought hazard and it is imperative to initiate country level studies in Asian LDCs on this phenomenon to combat the disastrous consequences and long-term affect of drought on vulnerable people especially the children and women. LDCs also need to analyze their individual vulnerabilities; traditional and long term coping up practices and these should be incorporated in the national IDMPs.

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