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Impact of Climate Change on Water and Health

Gaaloul Noureddine[1], Saeid Eslamian[2], Rim Katlane[3], Meriam Gaaloul[4]

[1] University of Carthage, National Research Institute of Rural Engineering, Water and Forestry, LR 16INRGREF02, LR Valorization of Unconventional Waters, 17 rue Hédi Karray, BP no. 10 Ariana 2080, Tunisia
[2] Department of Water Engineering, Isfahan University of Technology, Iran
[3] GEOMAG (LR19ES07)/PRODIG (UMR 8586), University of Mannouba-Tunis Campus Universities B.P.95 2010 Manouba, Tunisia;
[4]. Faculty of Architecture La Cambre Horta - ULB (Université Libre de Bruxelles)

Abstract

Detection and measurement of health effects of climate change are necessary to provide evidence on which to base national and international policies relating to control and mitigation measures.
Unequivocal evidence of health effects, and accurate measurements of their size, can come only from hard data. However, climate varies naturally as well as through human influences and in turn is only one of many determinants of health. There must be careful consideration of how best to collect and analyse information that will provide secure evidence of climate change impacts.
In this paper, we consider how monitoring may help provide evidence of early health impacts, examining the principles on which monitoring should be based, potential sources of monitoring data, and discussing issues in the analysis and interpretation of such data. There is a complex relationship between climatechange and health. Detecting and quantifying impacts on health will be gained only through broad scientific effort rather than individual monitoring studies.

Key Words*:* Water, Heatlth, Climate Change,

Impact du changement climatique sur l'eau et la santé

Résumé

La détection et la mesure des effets du changement climatique sur la santé sont nécessaires pour fournir des preuves sur lesquelles fonder les politiques nationales et internationales relatives aux mesures de contrôle et d'atténuation.
Des preuves sans équivoque des effets sur la santé et des mesures précises de leur ampleur ne peuvent provenir que de données concrètes. Cependant, le climat varie naturellement ainsi que par les influences humaines et, à son tour, n'est qu'un des nombreux déterminants de la santé. Il faut examiner attentivement la meilleure façon de collecter et d'analyser les informations qui fourniront des preuves sûres des impacts du changement climatique.
Dans cet article, nous examinons comment la surveillance peut aider à fournir des preuves d'impacts précoces sur la santé, en examinant les principes sur lesquels la surveillance devrait être basée, les sources potentielles de données de surveillance et en discutant des problèmes d'analyse et d'interprétation de ces données. Il existe une relation complexe entre le changement climatique et la santé. La détection et la quantification des impacts sur la santé ne seront obtenues que par un effort scientifique général plutôt que par des études de suivi individuelles.

Mots clés : Eau, Santé, Changement Climatique, .

[1] Corresponding author: gaaloul.noureddine@iresa.agrinet.tn

INTRODUCTION

Climate change is now accepted as a reality and is being recognised as a serious environmental threat by international organizations, some governments, the policy makers and scientists. Scientists have improved their understanding of climate system and present us with evidence of creditable threat about such a change. Mathematical models have been used and these models have performed well in reproducing historical trends of the past, which creates confi dence in future projections in response to greenhouse gas emissions and concentrations. However, these climate projections on their own do not defi ne the potential risks of climate change. These risks are manifested through the exposure and tolerance of natural and human systems and their capacity to adapt to the change. One of the aims is book is to examine the impacts of climate change, to enable us to be better prepared to adapt to these changes.

Climate change impacts every aspect of human life, including economic (because of changes in natural systems and resources availability), long term prosperity. While climate change variability and disasters associated with it are an additional burden to sustainable development, particularly in developing countries. We also know that impact of climate change is regional based. Africa will be the worst hit continent, where the increase in temperature is expected to be more than global average inspite of the fact that their contribution of greenhouse gases is minimal.

Change in climate also has an impact on health and trends. This might change or prolong the pollen season impacting people with allergies, indoor environment due to more heating or cooling will have an impact on the health of the people, there might be change in UV radiations impacting health of people etc. Climate change will also have an impact on vector borne diseases as well as water and food borne diseases. With increase in temperature, mosquitoes and ticks are creeping up on latitude (i.e. spreading in geographical areas where they did not exist before thus expanding the map for say West Nile and Dengue into North America and other places), change in precipitation is also changing the map of Malaria spread (in some cases with persistent drought breeding grounds for parasite has disappeared while Malaria has spread to newer places), also seasonal variation infl uences presence of pathogens such as Salmonella (i.e. higher temperatures provide ideal ground for growth of pathogens) leading to increased incidences of water and food borne diseases. Change in precipitation patterns will also link into agriculture, food security and availability of nutritious food (Based on Vardoulakis and Heaviside 2012).

Global warming has accelerated in the recent years; while the past 100 years saw an increase of about 0.75°C, the rate of increase of temperature in the past 25 years has been over 0.18°C per decade. The warming has been observed more over land than oceans. This rise in temperature is leading to sea-levels rise, glaciers melt and changes in precipitation patterns (for example from 1900 to 2005, precipitation has increased in eastern parts of North America, northern Europe, northern and central Asia and southern Europe while it has declined in southern Africa, parts of southern Asia, the Sahel, and the Mediterranean). In general, extreme weather events are increasing in terms of their frequency and intensity.

Impact of climate change is on both freshwater resources and also on oceans in terms of acidifi cation, coral reef bleaching. A change in ocean acidity is likely to reduce the ocean's capacity to absorb CO_2 from the atmosphere, thus compounding the effects of climate change, and will affect the entire marine food chain. Also, large-scale, irreversible system disruption and the destabilization of the Antarctic ice sheets are serious risks: changes to polar ice, glaciers and rainfall regimes have already occurred.

Climate change causes significant effects on water resources availability and management. It also causes significant effects on groundwater recharge and storage. Since groundwater is a key element in the global hydrologic cycle, more attention should be paid to the effects of climate change on recharge. Furthermore, climate change affects the physico-chemical quality of water resources (surface waters and groundwaters). Climate change affects the quality of water resources through various ways such as bio-chemical processes, acidification, salinization, etc. Generally, it is expected that climate change will reduce the physico-chemical quality of water resources. Development of a tool to assess the global change effects on water resources (based mainly on climate models) would greatly help decision makers and water resources companies in their long-term planning and in the development of adaptation strategies. (Haj-Amor and Bouri, 2020).

IMPACT OF CLIMATE CHANGE

Since climate change is severely affecting the availability of water and its quality, it also poses a direct challenge to health: water-borne, water wash and vector related diseases are spreading to wider geographical areas posing challenges to both the existing health system and safe water supply. Southern countries and vulnerable people, but also poor people in industrialized countries have been the main victims and suffering the most from both climate-induced physical impacts (temperature and sea-level rise, precipitation change, increase in the number and intensity of natural hazards such as drought, heat waves, storms and fl oods and societal effects (famine, food protests, diseases, migration) (UNESCOWWAP,2009).

It can be seen in Fig. 1 that as the temperature rises, the impact gets more severe. For example, in case of food: a slight or one degree rise might raise yield in some places at higher altitudes, while any further rise will affect in developing countries.

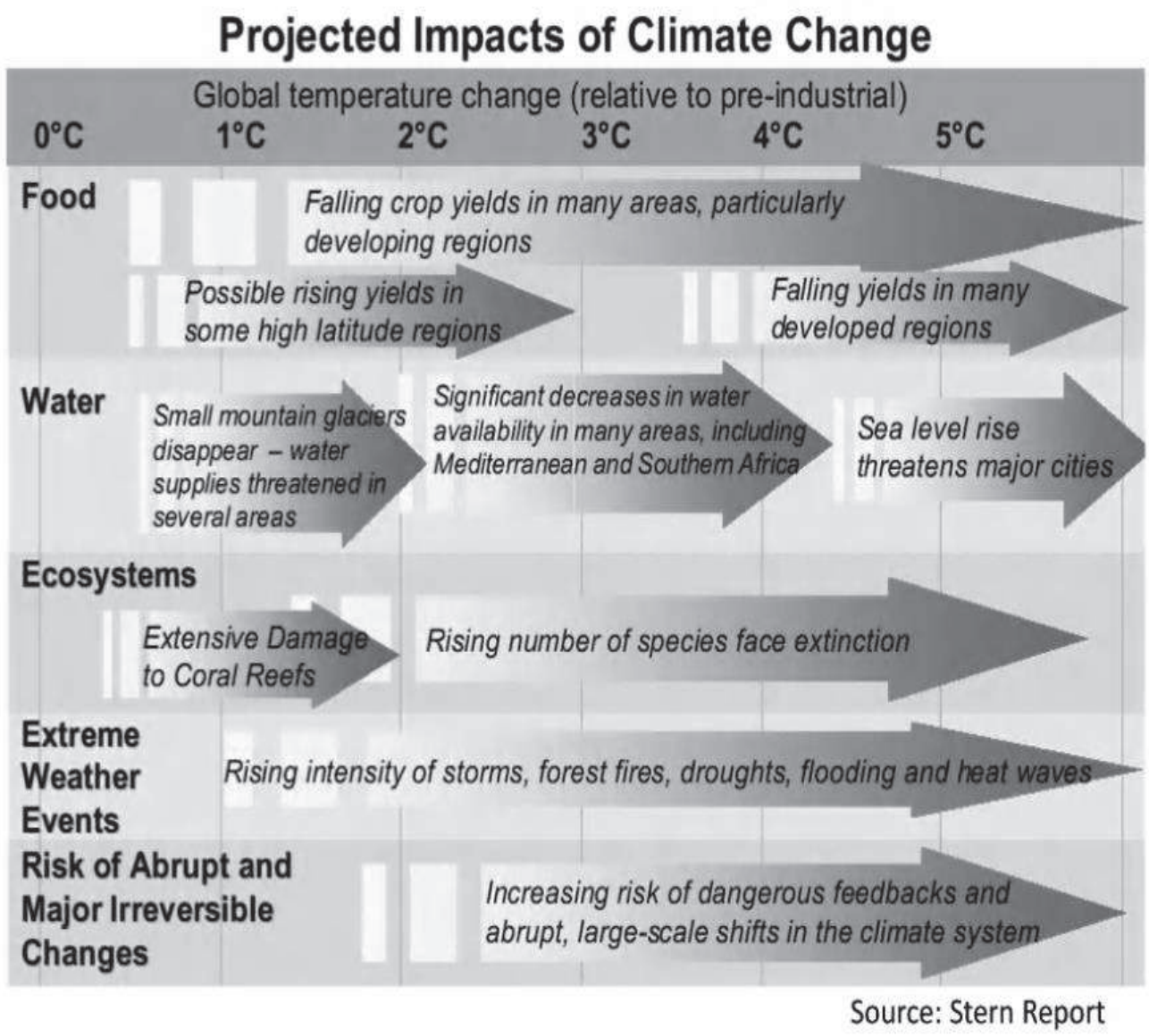

Figure 1. Projected impacts of climate change. Source: Stern Report

Usually, predictions of temperature rise are a global average; essentially temperature will increase in some parts more than the others. Even one degree temperature rise will have an impact on water systems, small glaciers, ecosystems and crops (affecting food security).

Regional impacts of climate change at places will be more than global average. For example, models of climate change predict that in the U.S. annual-mean temperatures might rise by 2°C to 3°C over the next 100 years, however northern regions will experience a greater increase of up to 5°C and some places such as northern Alaska might also see an increase of up to 10°C. Related to this increase in temperature other changes are also expected, such as in the U.S. precipitation, is predicted to continue to increase overall. Some GCMs predict a 20 percent increase for northern North America, a 15 percent increase in winter precipitation for northwestern regions, and a general increase in winter precipitation for central and eastern regions. Models predict a 20 percent decrease in summer precipitation, especially for southwestern regions, and a general decrease in summer precipitation is projected for southern areas. Although, there are predictions that precipitation will increase in most regions, yet there will be net decreases in water availability in those areas due to offsetting increases in evaporation (Adams and Peck, 2008).

Besides impact on climate and health, climate change will also impact movement of people (increasing climate change refugees, also discussed by Santa-Barbara in her chapter), agriculture (food security), energy and industries (because of variation in availability of water). The direct supplyside effects of climate change outlined previously, including increased water scarcity, fl ooding, accelerated glacial melting and rising sea levels, have the potential to accelerate human migration.

Agriculture is by far the largest consumer of freshwater. Globally, about 70 percent of freshwater is used in irrigated farming, and far greater volumes of water are used in rainfed agriculture. Although average temperatures are predicted to increase more dramatically in the northern hemisphere, the changes in temperature- dependent agriculture will be felt more signifi cantly in developing regions because of their heavy reliance on small-scale farming, dependence on rainfed agriculture, a fragile infrastructure and limited capacity to respond to emergencies. Many African communities will be at risk, particularly subsistence farmers with low incomes in sub-saharan Africa. This will essentially impact income of these small farmers, as increased droughts may exacerbate poverty levels and increase vulnerability of these people. The United Nations scientists warned in 2005 that one in six countries are facing food shortages because of severe droughts that could become semi-permanent.

National communications report that climate change will cause a general decline in many subsistence crops, for example sorghum in Sudan, Ethiopia, Eritrea and Zambia; maize in Ghana; millet in Sudan; and groundnuts in Gambia. Africa already accounts for a large proportion of the total additional people at risk of hunger as a result of climate change; by the 2080s it may account for the majority. Also, changing temperature, precipitation, humidity, rainfall and extreme weather-related incidents will make food security more complex. For example, studies in countries such as Mali and Nepal suggest that by 2050, 72 percent of the population could face serious food shortages. (Accenture, 2011).

Current climate variabilities already present serious challenges for food security in many developing countries. Rural based populations in countries that rely on rainfed-agriculture and primarily depend on subsistence farming systems are especially vulnerable. In general, water scarcity can limit food production and supply, putting pressure on food prices and increasing countries' dependence on food imports.

CLIMATE CHANGE AND WATER SECURITY

Water security and climate change are only two of the major problems humankind is facing at present, and they will continue to be so for decades to come. However, important as they are, there are many other critical problems the world will have to confront for the rest of the 21st century. Most of these problems are now known, but there may be some black swan incidents, such as Covid-19, which are unexpected and may occur in the coming decades. If so, these could make the global situations even more complex than anticipated at present.

Climate, increased temperature, and water contamination have been found to be associated with many previous global outbreaks (Harvell et al., 2002; Daszak et al. 2000; Epstein, 1999). An example is the Rift Valley fever outbreaks in East Africa during the years 1950–1998. The rift valley fever is a viral disease, common in domesticated animals in sub-Saharan Africa. The origin of the outbreak was in sub-Saharan Africa, and in 1977, it spread in Egypt through infected livestock trade. Rift Valley fever can also pose potential health risks to humans. The direct and indirect contact with infected animals was the main reason for transmission from livestock to humans (WHO, 2018). Multiple studies have been conducted to understand the potential linkages between climate and outbreaks, and in this case, the relationship between temperature and outbreaks was noticeable (Epstein, 1999). During warm seasonal weather increased cased of the fever were observed. This pattern of increased fever cases and warm weather continued for many decades.

An important global issue for many decades has been the steady increase in the global population. The current global population of some 7.95 billion is expected to rise to 9.7 billion by 2050 and to 11 billion by 2100 (UN Population Division, 2019a). Additionally, in 2020, 56.15% of the global population lived in urban areas. This is estimated to increase to 68% by 2050, and to 85% by 2100 (UN Population Division, 2019b). It will mean that, increasingly, larger percentages of the global population will be concentrated in and around urban areas. This will undoubtedly put growing and serious strains on reliable and affordable supplies of food, energy, water and all other natural resources, as well as on the environment. In addition, ready availability of public health and all other forms of social services, including housing, education and transportation, for the rest of this century, will continue to be important challenges which all countries will have to face.

According to the IPCC's Fourth Assessment Report, Africa's warming trend will be 1.5 times the global mean (Eriksen et al., 2008). Climate models project an increase in global temperatures of between 1.4 and 5.8ºC by 2100 and between 3 and 4ºC for Africa (IPCC, 2007). Evidence of Africa's changing climate already exists: during the last century, the continent as a whole warmed by 0.7ºC and the maximum temperature experienced in some regions increased by as much as 3.5ºC (Magrath, 2006). Temperature increases can also be seen through melting glaciers (Perkins, 2009) and shifting ecosystems.

For Africa, the IPCC (2007) predicts that northern Sahara, Mediterranean Africa, and southern Africa will experience a decrease in rainfall, whereas East Africa is likely to have an increase. The global models do not consider vegetation and dust aerosol feedbacks, and El Nino Southern Oscillation (ENSO), one of the key controlling factors for rainfall in Africa, is also not adequately represented (Hulme et al. 2001). These discrepancies create a level of uncertainty.

The models of the Sahel, the Guinean coast and southern Sahara have produced particularly confl icting results. Climatic changes are not uniform and are strongly infl uenced by localized variables, climatic zones and elevation across the continent.

Overall, the impact of climate change on freshwater resources across Africa is expected to be negative. More areas will be under water stress due to net reductions in rainfall and higher temperatures causing melting glaciers and increased evaporation of surface water. By the 2020s and 2050s, an additional 75–250 million and 350–600 million Africans, respectively, are expected to live in areas of water stress (Arnell 2004 as quoted in Bates et al. 2008). Even areas experiencing increased rainfall will contend with higher evaporation rates, more intense events, and an increased variability in the timing of onset and distribution of rains. The drier ground and high evaporation means that less runoff will reach rivers and surface water will have little time to replenish aquifers.

In southern Africa, climate models predict a 30 percent reduction in runoff for a 2ºC increase in global temperatures and 40–50 percent reduction for a 4ºC increase (Stern 2007). At the same time, warmer ocean temperatures will result in more intense rainfall events. In areas where soil becomes quickly saturated, runoff will

create fl ash fl oods. While the net increase would likely improve water security in developed countries, most African countries lack the necessary infrastructure to harvest and store water from these events for use during the dry periods.

Warmer temperatures, changing rainfall patterns, and more frequent extreme events will take a toll on the lives and livelihoods of the African population. Infectious diseases are likely to spread at higher rates and to new areas, while water-wash and water-borne diseases will increase with both higher and lower than normal water availability. Severe malnutrition will likely worsen and water scarcity will affect all aspects of health

The impacts of climate change in Africa will certainly place additional pressure on existing vulnerabilities. However, the complex relationships between social, economic, political and environmental factors in Africa means that equating increasingly poor health solely on climate change is irresponsible and inaccurate. Population growth, political instability, international trade standards are just some examples of factors placing the African population at risk.

It is estimated that by 2025, 21 countries in Africa will be subject to water stress or scarcity (Bates et al. 2008). This will increase the number of people without access to potable water, which currently affects two thirds of the rural population and one quarter of the urban population in Africa (Magrath 2006). Access to adequate potable water means that individuals should have reliable access to a supply of 20L water per day from a source less than 1 km away (WHO 2011). Lasage et al. (2008) note that in dry periods women and children can walk up to 20 km in search of water. Time spent fetching water impacts health by limiting time for other activities, such as farming, income generation and domestic duties. In addition, the long distances and heavy loads are often responsible for burning up to 85 percent of a women's daily calorie intake (UNDP, n.d).

The human development report (Watkins 2006) describes poor access to water and sanitation as "a polite euphemism for a form of deprivation that threatens life, destroys opportunity and undermines human dignity." Water is not only essential for survival but as discussed above there is considerable evidence that changes in the distribution and abundance of water will increase the transmission of both water-borne and vector-borne disease and have a considerable infl uence on food security. Approximately 3,900 children die every day as a result of contaminated water sources. Other diseases such as trachoma and scabies, albeit inconclusively, have also been associated with lack of water and associated impacts on proper hygiene (Pruss et al. 2002)

Incidences of extreme events are not limited to the increased frequency of fl oods and droughts, sea level rises will be accompanied by increased storm surges, saltwater intrusion, coastal erosion and fl ooding (Dasgupta et al. 2009). The IPCC (2007) predicts that storms and cyclones will change their paths and become more intense with higher wind speed and heavier rainfall. Coastal ecosystems, such as coral reefs and mangroves, which are vital for coastal protection and fi sheries, are being impacted by saltwater intrusion, sedimentation and increased wave action. The IPCC (1998) estimated that 60 percent of mangrove areas in Senegal have been lost due to a combination of factors including increased water and soil salinity.

According to the Stern Report (2007) inundation and coastal erosion is expected to place millions at risk around the African coastline. Changes in temperature and precipitation will threaten existing biomes and biodiversity. Shifts of 25–35 km have been noted in the Sahel, Sudan and Guinean ecological zones due to declining rainfall, and half of sub-humid and semi-arid southern Africa is at risk of desertifi cation (Bates et al. 2008). In addition to ecosystem shifts, diminishing ecosystem function will threaten water quality, waste assimilation and carrying capacity. The majority of Africans depend directly on the environment for their livelihoods and food intake, meaning that ecosystem shifts and other likely impacts of climate change are predicted to severely impact population health (Fig. 2).

Figure 2. Climate change vulnerability in Africa. Source: UNEP, 2002 as soucred from Simms and Reid, 2005

CLIMATE CHANGE AND HEALTH

The greatest health impact of climate change will be borne by the poor (mainly in developing countries, but also in developed countries) who are already facing a host of health- related problems due to socio-economic conditions. Kofi Annan (President, Global Humanitarian Forum) introduced the Human Impact Report Anatomy of a Silent Crisis noting that, "the fi rst hit and worst affected by climate change are the world's poorest groups. Ninety-nine percent of all casualties occur in developing countries. A stark contrast to the one percent of global emissions attributable to some 50 of the least developed nations".

As shown in the Fig. 3, climate change will impact us in different ways: by changing regional weathers and extreme weather conditions i.e. too much or too little rainfall, higher temperatures leading to heat waves causing illnesses and death, especially of vulnerable people, worsening air quality due to smog, increasing water and food-borne diseases etc.

The IPCC report shows that the impact of climate change on health issues will be mainly negative (Fig. 4). For example, in case of malaria, it will spread to more regions including higher altitudes because of favourable conditions due to change in climate (also shown in Fig. 5).

With the change in temperature and precipitation pattern spread of malaria will vary (since the spread of disease is directly related to the amount of precipitation and temperature for mosquitoes to thrive): in some areas the geographical range of the disease will contract while in the other areas it will expand and even the season when it is transmitted might change. There is a direct co-relation between higher minimum temperatures and incidences of malaria outbreaks, which has been shown in case of Ethiopia. Countries such as Senegal, for example, has seen a 60 percent drop in malaria cases in the past 30 yr because of reduced precipitation. However, in areas where temperatures are rising in the traditionally cool climates and higher latitudes, these areas will become more suitable reproductive habitats for the mosquitoes spreading malaria. In other places already warm zones may also see an increase in mosquito populations. Although, countries such as Senegal have seen a decrease in malaria incidences, it has returned to some places such as central and northern South America, most of Asia, some Mediterranean countries and much of the former USSR. Study estimates show that by 2080, approximately 260–320 million more people are likely to be affected by malaria.

The IPCC report (Parry et al. 2007) also predicts that malnutrition will be negatively impacted by the change in climate (Fig. 2), which is expected if agriculture will be impacted by change in precipitation threatening food security. Even today malnutrition is one of the most serious global health problems (FAO and WHO), about 178 million children globally are stunted and 1.5 million die annually from wasting, both important indicators of malnutrition. According to the IPCC report (Parry et al. 2007) there is an 80 percent cent chance that climate change will increase malnutrition and consequent disorders (Accenture, 2011).

Climate change will also have an impact on air quality, especially in cities, which will exacerbate the urban heat-island effect and increase the number of smog days and issues related to smog. Poor air quality is also known to cause respiratory health problems. The IPCC report (Parry et al. 2007) and other studies have shown that there will be an increase in cardio-respiratory morbidity and mortality associated with ground-level ozone (Accenture, 2011).

The IPCC reports (Parry et al. 2007) predict that there will be an 80 percent chance of increase in mortality and morbidity due to climate change related Extreme Weather Events (EWEs). In 2007, 95 percent of the 16,000 global fatalities from EWEs could be directly attributed to climate change. Because of the change in temperature and precipitation patterns, EWEs have changed in frequency and intensity.

As discussed in the IPCC report (Parry et al. 2007), impact of climate change on health will include spread of endemic and epidemic infectious diseases, water-borne diseases and vector-borne diseases. As temperatures change mosquitoes spreading diseases will move to higher latitudes where they did not exist before. For example, West Nile and dengue have crept up in North American provinces.

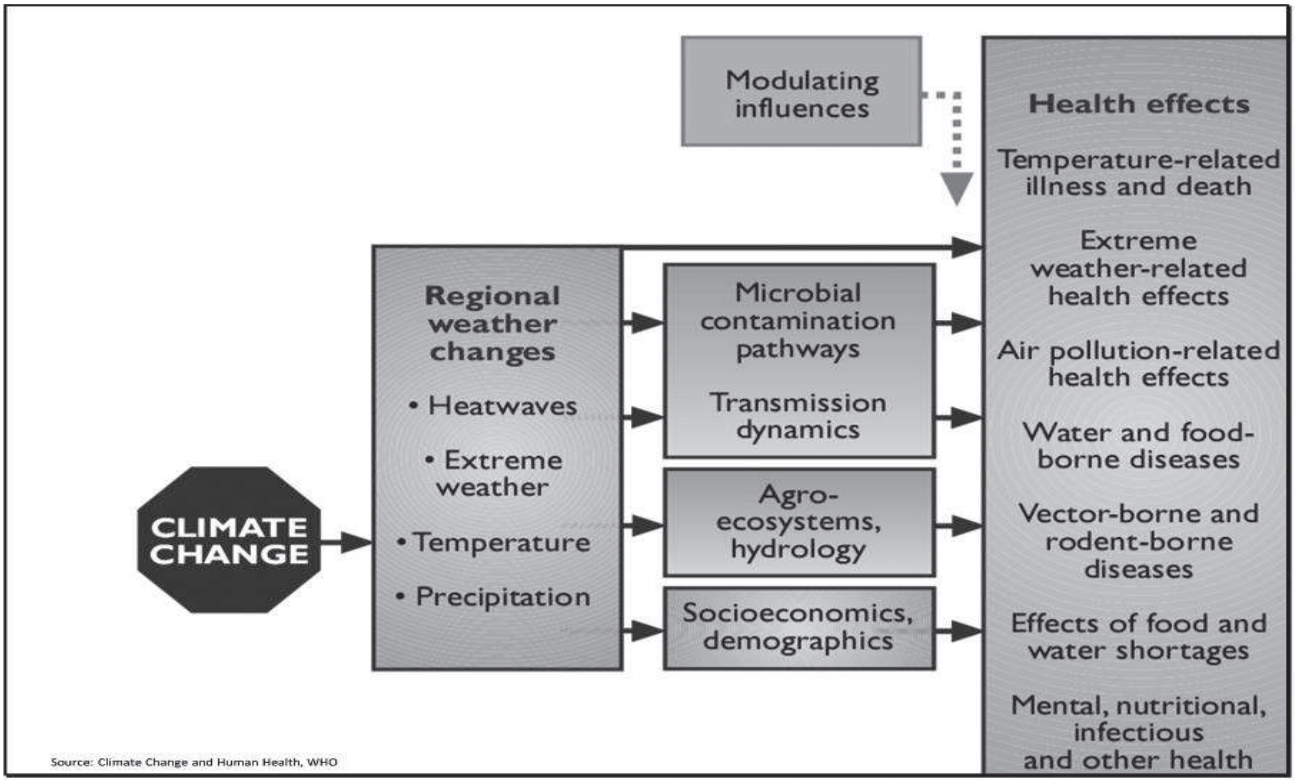

Figure 3. Impacts on climate change on health. Source: McMichael 2003

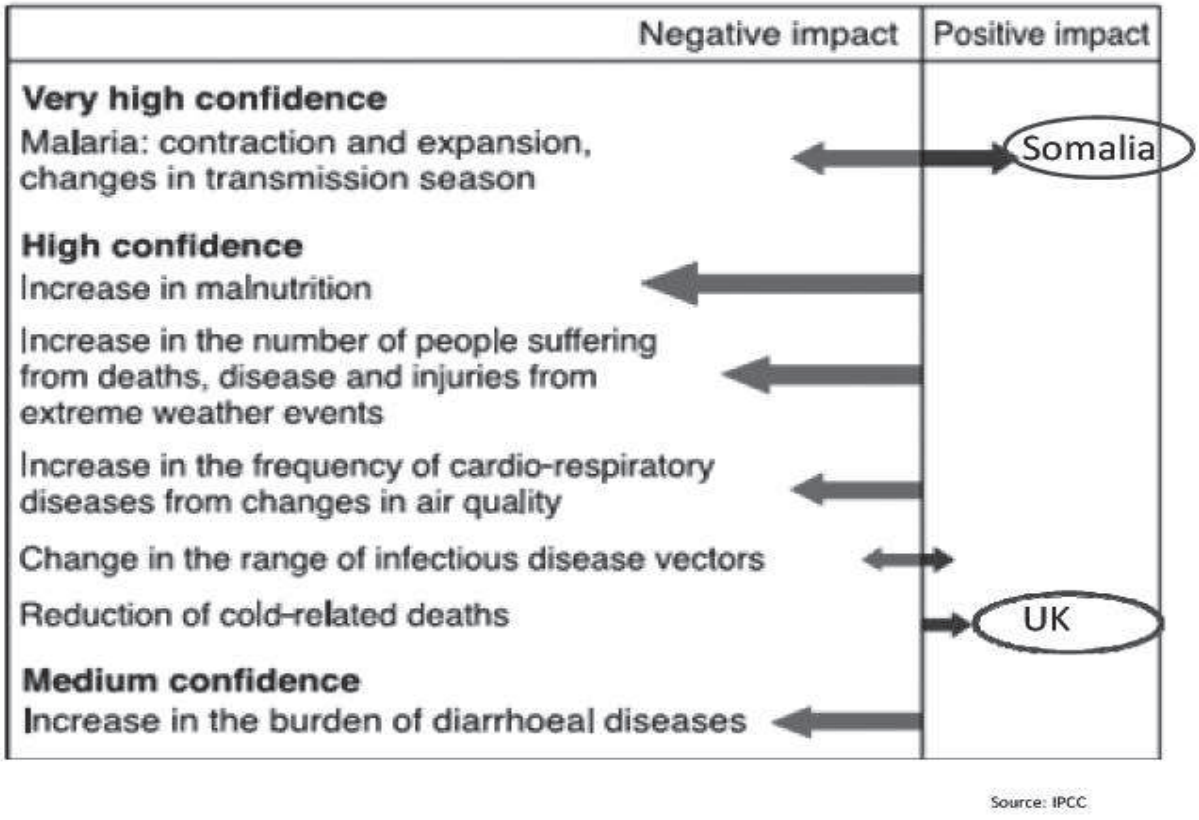

Figure 4. Direction and Magnitude of Change of Selected Health Impacts of Climate Change. Source: Parry et al. 2007

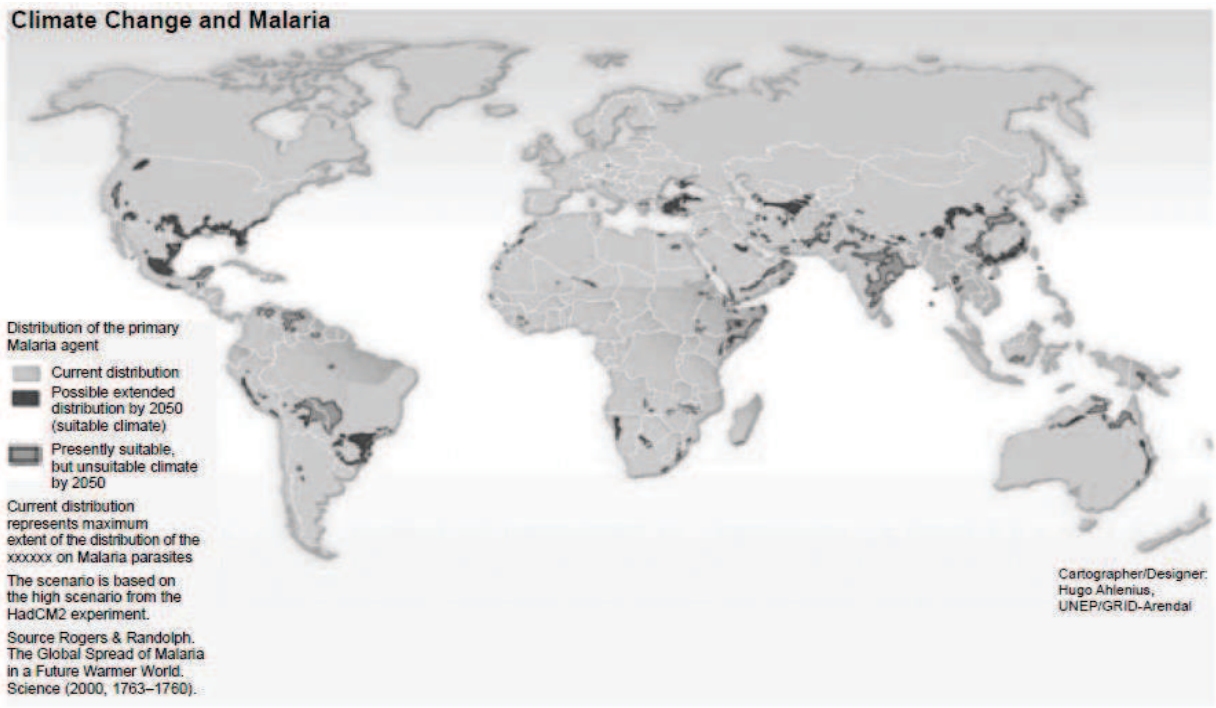

Figure 5 Climate Change and Malaria. Source: Accenture 2011

Fig. 6 below shows the global spread of dengue with change in climate (and temperature). As discussed earlier, change in temperatures will have an impact on water availability, timing and precipitation patterns. Disasters resulting from such changes will cause both droughts and fl oods, including loss of water availability from glaciers. The resultant impacts on health will also be highly signifi cant, and these impacts are also among the more reliable paths for assessing potential risks

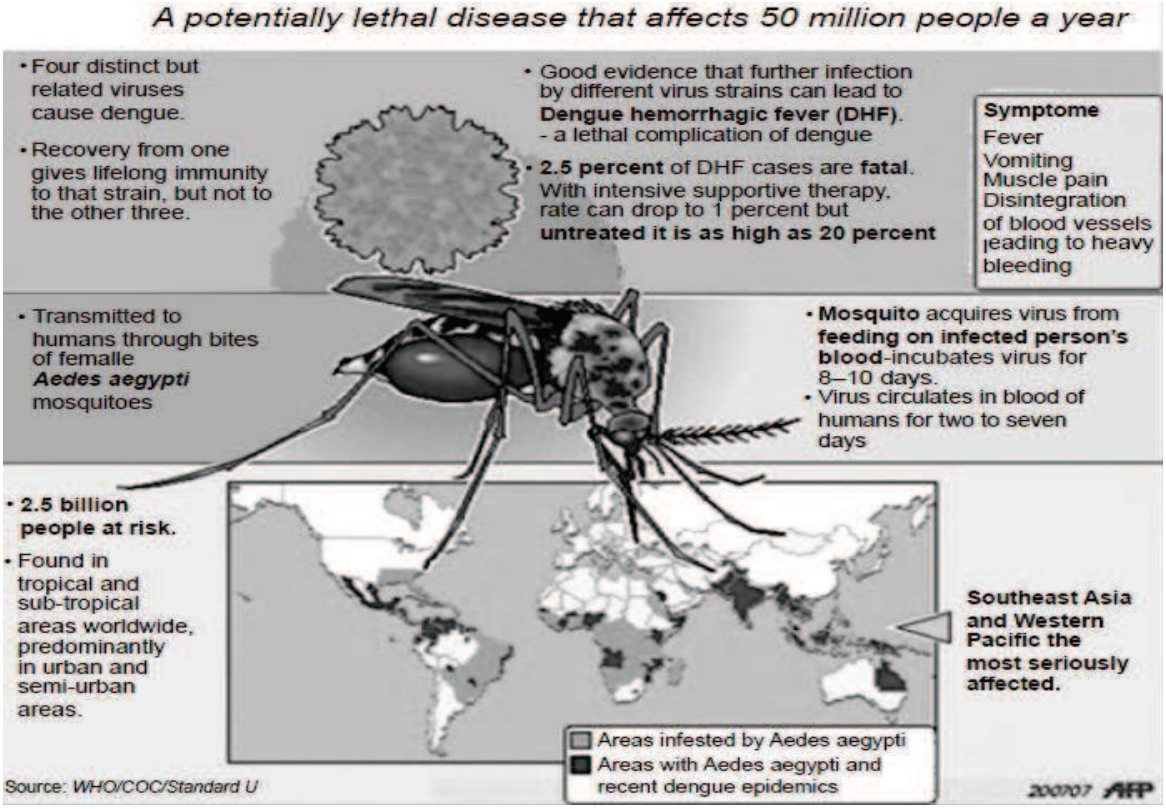

Figure 6. Global Spread of Dengue Fever

CONCLUSION

Climate change has exacerbated, and will continue to exacerbate, diseases and ill health amongst all the people of the world – but particularly the poor and the vulnerable. The health sector is known to be one of the major contributors towards the greenhouse gas emissions causing the climate crisis, the greatest health threat of the 21st century. The advent of COVID-19 has thrown a glaring light on the interconnectedness of health and environment, bringing into stark relief the urgency needed for stringent climate action. While climate change does impact everyone, the impacts will not be borne equally or fairly. The most vulnerable, including low-income communities, women, indigenous peoples, the elderly and children, will bear the brunt of climate impacts.

For the first time in history, the United Nation's 2030 Agenda for Sustainable Development (Sustainable Development Goals; SDGs) now legally acknowledges commitment to a sustainable future for all countries. This commitment puts agricultural systems under pressure—the twin challenge is to provide an ever-growing human population with sufficient and nutritious food, while facing environmental limits and climate change. With the escalating degradation of freshwater resources, a sustainable transformation of global farming is unattainable without a revolution in agricultural water use. To explore pathways towards sustainable food and water security in the "Anthropocene" of the 21st century, this special issue invites original contributions related to the fields of food system resilience, agriculture and climate change, on-farm water management, irrigation transitions, water resources sustainability, eradication of hunger and attainment of nutrition security, agricultural sector climate change adaptation and mitigation, and related topics.

Climate change is happening; no one is debating that fact anymore even though the reasons for change in climate (i.e. natural or anthropogenic) might be still debatable! Natural hazards are increasing as can be observed from fl oods, famine and intensity and number of hurricanes in the U.S., increased famine in Africa. This is not only causing loss of property, but is also increasing diseases (in the affected areas) and adding to the economic burden.

Availability of fresh water has always been an important factor impacting human population and civilizations. However, with the growth of population and economy, the pollution from anthropogenic activities is degrading the quality of water. The degradation in water quality is affecting the health of mankind and ecosystem. It is benign to understand the water quality parameters impacting the human health for judicious management of water quality

Climate change directly impacts the health of patients and communities. The interdependence between climate change and healthcare represents a unique opportunity for the healthcare sector to reduce climate change as well as combat it. The healthcare sector can be an example to other sectors by aggressively embracing climate-smart strategies, and using its collective voice for climate action at the policy level. The path taken by the healthcare facility affects the wellbeing of a community at large. Healthcare workers need to be sensitised about climate change and its associated impacts through the appropriate capacity-building interventions, so that they in turn can educate the community. When it comes to carbon-neutrality, going green and adopting climateresilient strategies, the leadership level of a healthcare facility needs to lead from the front.

Climate change leads to significant challenges for the health sector as it brings additional health concerns, demanding a concrete response from the sector. Climate change impacts health systems in various ways – infrastructural damage due to extreme flooding and precipitation, the rising burden of diseases, and disrupted supply chains leading to shortages of drugs and other medical commodities, to name a few. Health systems must be robust in order to meet increasing demands, and resilient so that they may survive the impacts of climate change. As healthcare providers and healthcare facilities are on the frontline, they need to be appropriately strengthened. In poorer countries, the already weak human resource structures and inadequate financing for health could stretch the health system to breaking point unless they undergo preparation to become climate-resilient.

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