Climate change and its impact on public health – A review of the global environment

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Abstract: Climate change is a product of human actions. The extreme events such as flash floods, droughts, heat waves, earthquakes, volcano eruptions and tsunamis seen in the world today are the result of indiscriminate human intrusion into the environment. Vulnerable countries and populations are the most affected by these climatic events. This places a burden on the resources of these countries. The Kyoto Protocol is a milestone in environmental management and the impetus created by it must be maintained by carrying out the much needed research into appropriate mitigating measures that will alleviate the climate change impact globally. A paradigm shift is needed in addressing the associated risks on human health to assess socioeconomic determinants and the related impacts on disease burden. Some wealthy nations emphasize economic benefits and downplay sustainability goals, health and equality. However the rising cost of energy is beginning to influence their outlook towards this issue. The implications on economics, human health and wellbeing are implicit. In order to strike a balance between disadvantaged and privileged nations, many international agencies are spearheading various research agenda to improve adaptation programmes on effects of changing climatic conditions on health. Malaysia too has such programmes initiated under its 5-year development plans.

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1. Popular Perceptions of Climate Change

In the popular press, climate change is portrayed in these terms: Human actions are contributing to drastic changes in the global environment. All around the world, flash floods, droughts, heat waves, earthquakes, volcano eruptions and tsunamis are causing undue stress on the global population, livestock and the ecosystem at large. This is resulting in a wide range of impacts on public health.

These natural disasters are attributed to the significant changes in the global climate. This is deemed to increase:

- Vector borne diseases
- Nutritional diseases due to food insufficiency
- Diarrhoea due to poor sanitation
- Inadequate clean potable water
- Heat waves
- Strokes
- Air pollution
- Respiratory effects

Due to poor economic conditions vulnerable countries continue to suffer the brunt of the impact. However, other developed countries are also not spared from these natural climatic changes and related disasters. Climate change is important globally. There must be appropriate adaptations and mitigation processes in place to address it without delay. News stories carry many reports globally: In poor countries many lives are lost because of natural disasters. In 2009 alone, 6 of the countries that reported high loses due to natural disasters were in Asia.

The effects of climate change are made worse due to rapid urbanization in many of these countries. In fact the frequency of such disasters has increased many-fold over the last 20 years. Many cities in Asia are prone to natural disasters. The question is 'What needs to be done, how and when?' The World Health Organization responds in these terms: Firstly there must be concerted actions to strengthen important areas of the health systems. Then there must be promotion of appropriate options for healthy development that can improve public health and defend against burdens of disease triggered by future climate change. A World Bank Report[1] has identified some cities in Asia: Guangzhou, Shanghai, Ho Chee Minh, Mumbai, Kolkata, Osaka and Bangladesh as prone to these disasters. This report suggests that specific community development programmes could mitigate the impacts of climate change in poverty stricken squatter areas. It is highlighted

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that in the absence of cyclone mitigating measures for flood control in Bangladesh, the cost of damage will exceed $9 billion dollars by 2015.

2. Climate Change in the Asia Pacific

Developing countries in the Asia Pacific Region are vulnerable to climate change. The resultant effects are amplified due to reduced economic growth, poverty, political rigidity, dependency on external help and isolation.[2] The ability of these countries to address or lessen the effects on public health due to climate change is impeded. Rapid population growth, new settlements and the indiscriminate use of natural resources all play a part. Disadvantaged populations in countries that are geographically isolated are affected by diseases resulting from climate change. Movement of people and goods, is an effect attributed to the influence of aid funds originating from developed countries[2]. This unintended consequence adds a further level of complexity for policy makers.

The global effect of climate change on public health will be long term. Policy makers must be vigilant and continue to implement policies to reduce future impacts for the benefit of the population.

The Kyoto Protocol of 1997 was a milestone in reference to climate change management as it set a limit to CO_2 emissions for all countries. However, CO_2 emissions from China and India continues to show an increasing trend due to their economic progress. This issue of ever increasing CO_2 emissions should be addressed with appropriate incentives for industries. They need to switch to non-polluting sources of renewable energy with advanced energy efficient production methods. The impact of fossil fuel on good health is well known. Mitigation of this effect can be achieved by improved designs in housing, developing parks in the city and appropriate management of coastal inundation due to sea level rise. Coastal inundation is particularly important as it impacts on vector breeding habitats resulting in increased vector and water borne diseases.[3]

Regulation of monitoring and surveillance systems, within countries, needs global commitment for collaborative research to be undertaken by intergovernmental agencies. This approach will need the participation of health professionals to data mine and develop appropriate strategies for the control of health effecting greenhouse gas emissions.[3]

3. Rich Versus Poor Countries

Rich and developed nations release more greenhouse gases and poor countries face the consequences. Technological advances in transportation have facilitated the easy movement of people between countries. Improved trade has also exposed people from developed countries to the vagaries of climate change on health.[4] Therefore, addressing issues such as burden of disease and loss in biodiversity should be a global priority. All countries need research into appropriate mitigating measures that will alleviate the climate change impact but balance will be hard to find.[4]

The population of the United States is about 5% of the global population. Yet it emits about 25% of estimated greenhouse gases produced globally. With its advanced technology, the US is able to manage well the adverse impacts on health. But the poor nations with their inadequate facilities experience the direct impact. All nations must be able to manage this imbalance better and they need development pathways that are energy efficient.[4]

Severe weather conditions have a direct effect on disease emergence, especially vector borne diseases. Other infectious diseases are also increasing and the reasons attributed for the emergence and re-emergence of these diseases are intricate.[5] Therefore mitigating and control measures need careful planning for a successful and effective programme to be put in place. Evidence shows that many disease agents are affected by factors such as deforestation, resistance to drugs and chemicals, emergence of dams and existing health policies within the country. Therefore we cannot take for granted that disease outbreak is always due to climate change.[5]

Appropriate modeling should be carried out with epidemiological and meteorological data. All countries need improved mechanisms to understand their disease variability. But we must also keep our feet on the ground in both rich and poor countries. No matter how we address climate change and disease outbreaks, public health practices and lifestyle will be the main factors for alleviating disease outbreaks.[5]

4. Climate Change 1970 to 2000 – Kyoto protocol

The 10,000 year Holocene age, which came after the receding of the ice caps from temperate zones, is now challenged by the increases in greenhouse gas concentrations and land-use patterns. The indiscriminate cutting of forests has impacted on the global climate and this combination has resulted in increase and spread of various diseases.[6] Climate change is not new. It is dynamic. There will always be interactions between prevailing environmental conditions. Some will give rise to new outbreaks. Yet increase in temperature may have positive effects on health by reducing vector habitats. Snails are one example – an intermediate host for schistosomiasis. Another and unrelated positive effect may be the reduction in number of deaths during the cold weather in the Northern Hemisphere from diseases of the respiratory tract. However, the significance of temperature increase and the related variations in the weather pattern is expected to eclipse possible advantages to health.[6]

Air pollution from fossil fuels and the precipitous removal of forests in the tropics now combine in a persistent disrupting effect on the current global heat budget. Observation of the life cycle of fossil fuels used in mining, refining and transport sectors shows many types of damage. These contribute to air pollution and acid rain which result in direct and significant health consequences.[6]

The effects of climate change between 1970 and 2000 may not seem severe. But the estimated annual loss due to its effect on health is. Two measures: mortality (150,000) and disability-adjusted life years (550,000) are considered significant to population wellbeing.[7] This impact of greenhouse gases due to anthropogenic activities on the burden of health must be addressed immediately. Otherwise it is forecasted that the impact will double by 2020, resulting in significant increase in diarrhoeal diseases and malnutrition in under-developed countries.[7]

To address this issue appropriately, policies on climate change must be linked to externally funded development programmes in developing countries. Therefore relevant adaptation policies must be put in place to reduce the disease load that may increase due to inconsistent climate patterns.[7] These approaches must show positive results immediately as well in the future. In this respect, the Kyoto Protocol of 1997 has set the stage for developing appropriate accords to tackle global climate change problems.[7]

Doubts surrounding the effects of climate change on health will always be present. The consequences of these effects will fall on the disadvantaged people from developing and under developed countries even though they contribute less to greenhouse gas emissions[7]. Countries which are advantaged and have used fossil fuels all along should now contribute to finding new ways. All must cut down on consumption and reduce dependence by finding alternative fuel sources.[7]

5. Temperate Oceanic Countries

In 2005 it was reported that heavy rainfall and increase in temperature over a 30 years period resulted in an estimated loss of 150,000 lives annually.[8] Due to lack of reliable and quality data on the cause of such mortality, the WHO says that there is uncertainty in such an assumption. Yet we know, anecdotally, that human diseases are linked to changes in the climatic patterns.[8]

The diseases linked to changes in climatic patterns are deemed to be:

- Cardiovascular;
- Respiratory infections;
- Malnutrition in nature.

However attributing the emergence or re-emergence of these diseases due to climate change remains an uncertainty. This is due to lack of factors such as good quality data, suitable socio-economic conditions, prevailing immune status and resistance due to drugs.[8]

The temperate regions, Pacific and Indian Ocean countries, are considered vulnerable to extreme events. The effects of global warming will be disproportionate over this area. There is growing evidence on the warming trend and associated public health problems in the future due to climatic changes. The increase in temperature over the years has resulted in the increase in the number of deaths as well as morbidity in different parts of the world.[8] Researchers need new tools with which to measure cause and effect. One Example: In Cuba the disease such as dengue which is influenced by climatic conditions is of primary concern. Researchers are observing the possible effects of climatic conditions and its impact on the general health of the people. Appropriate adaptation measures and climate predictions are being put in place to prevent outbreaks of disease. Tools capable of assessing the economic potential for cost reduction are being used. These may yield appropriate adaptive options, linked to climate variability and associated with climate change.[9]

6. So… What are the Risk Factors?

Assessing the risk factors for the incidence of disease such as cumulative disease burden needs validated methods. The World Health Organization has applied various methods including new models to assess the current and future trends in disease burden.

In order to formulate area specific intervention plans, they have standardized comparative risk assessment approaches for disease due to climatic variations. This approach is similar to epidemiological surveillance. It shows that small changes in disease pattern such as diarrhoea and malnutrition may ultimately lead to a large disease burden. The data from these assessments can be the building blocks for an information system. Such a system would narrow the gap in knowledge regarding climatic conditions and related disease outbreaks. This would be a very complex exercise. Data must be comprehensive to link epidemiology to climatic conditions and also relate exposure to long-term effects on the biotic systems.[10]

In the United States, 5 categories of health outcomes based on climate variability have been observed. These factors are:

- Temperature;
- Extreme weather events (e.g., storms and floods);
- Air pollution;
- Water and food-borne diseases; and
- Vector- and rodent-borne diseases[11]

Across such risk factors, researchers concluded that morbidity and mortality resulting from several health issues related to climate change will increase. Extreme heat exposure and air pollution impact were the governing factors.[11] Though the USA has good plans to mitigate, there are still gaps in knowledge regarding climate and health. Filling such gaps will help introduce better adaptations for effective resilience.[11]

Diseases such as cardiovascular, respiratory, diarrhoeal, malaria, dengue fever and schistosomiasis can be influenced by variation in climatic conditions. This health impact on morbidity and mortality will in turn apply pressure on the economic conditions and productivity of a country. Due to insufficient data there is usually an underestimate of the true losses of wellbeing among the population studies.[12]

Human health is inevitably influenced by climate change resulting from the emission of greenhouse

gases. Anthropogenic emissions are the main source of pollution that affect human health. Studies focus on thermal stress, extreme weather events, infectious diseases, food yield and hunger prevalence. In order to have a preemptive approach for dealing with such issues, there is need for efficient policy formulation. It must be based on broader criteria such as risks due to social issues, demography and economics.[13] Climate change influences health in many different ways such as heat waves, extreme cold, floods and droughts, vectors and related disease distribution. These effects are balanced between developed and developing countries as evidenced by available data.[13]

Improved surveillance is essential to mitigate these impacts. There must be alternatives to fossil fuels such as introduction of renewable energy technologies. Low income countries due to their economic weakness may face challenges regarding implementation of policies. Therefore options such as adaptation strategies, vulnerabilities, health cost must be assessed for early planning and for improved health.[14]

7. What steps are Countries and Organizations taking?

The United Kingdom has taken positive steps by introducing legislation to reduce greenhouse gas emissions by 60% by the year 2050. The European Union also has a similar target. There is an Emission Trading Scheme (ETS) in the EU, that is currently undergoing review for adaptation to a global market. The aim of the ETS is to provide a broad global approach to achieving the set goals.[15]

The onus is on governments to take the necessary collective action to reduce greenhouse gas (GHGs) emissions. Research, investment and collaboration in efficient energy utilization will be important. A low carbon economy must be promoted through stable long-term regulation and appropriate tax incentives for businesses. There should be no delay in implementing such measures as emerging economic powers such as China and India are influencing GHG emissions. Action must be prompt to stabilize GHGs at safe levels.[15] A study shows that the World Health Organisation, like many other organisations contributes to the increase in GHGs emissions. In fact we all contribute to this emission when we travel by air. It is said that a return air trip from Europe to Asia for a person, emits GHG exceeding a notional quota for that person for a whole year.[16] WHO could achieve a lot by reducing air travel. Awareness must be created among the population that these reductions are good for health. Options such as changing to renewable energy sources, sustainable urban planning and improved transport systems should be implemented.[16]

Malaysia in its 5-year development programmes over the last 5 decades has seen rapid economic, social and environmental change. The natural environment has been affected but emerging environmental concerns have been adequately addressed by the evolving policy response by the government. However many challengers still remain today and much emphasis is still placed on sustainable development.[17] In this aspect the government encourages foreign support for the introduction of cleaner and environmentally sound technology. They also encourage institutional, professional, public and private sector involvement in these programmes to keep abreast with global activities relating to improvement of the quality of the environment.[18]

Studies on global environmental change and impacts on health have for many years remained outside the scope of public health. This is mainly due to the fact that it needs a multi-disciplinary approach. Only world renowned research centres such as: Harvard, Johns Hopkins and London School of Tropical Medicine and Hygiene have groups dedicated to such research. The publication of these studies in high impact journals has drawn attention to health consequences resulting from changes in climate. Such findings need to influence mainstream public health research.[19]

Groups of people who are most vulnerable to disease that are caused by environmental changes are usually not

the ones who are responsible for causing the problem. High GHGs emissions are attributed to developed countries such as the United States of America, Australia, Canada, Japan and Western European Countries [WHO].[20] There is a method to quantify the imbalance caused by effects of climate change on groups of people. The method assesses the cumulative depleted CO_2 emissions per capita of the population in each country. By using this index known as 'natural debt' it is known that the relative responsibility of the US doubles that of China and India. According to this index, the highest per capita emissions of carbon come from the United States and Australia.[20]

Based on this index, precautionary measures should be taken to protect disadvantaged populations bearing full brunt of the climate change impact on their wellbeing[20]. At the same time, there must be equitable solutions with caution. Mitigation approaches may also produce negative side effects on disadvantaged populations. As an example, biofuels, though beneficial for climate may cause competition for food. Both the developed and developing nations should have stewardship of the planet's future.[20]

The Inter-governmental Panel on Climate Change (IPCC, 2001 quoted in Reference no. 21) says that some 20-30% of animal species may face extinction if the temperatures worldwide continue to rise. The impact of rising temperature can be manifold. Examples include:

- Melting glaciers in the Himalayas affect river runoff;
- Warm water temperature in lakes in Africa kills fishes;
- Droughts and fires destroy croplands and forests in Australia;
- Intrusion of salt water affects crops in South America;
- Fauna and flora ecology is upset by temperature rise in small islands.[21]

8. Key Vulnerabilities to Climate Change

Extreme climate will always affect vulnerable populations. Example: Russian cities showed increase in mortality (4,000 to 29,000 cases) through 1998 to 2002 due to heat waves. 'Risk specialists' think that increased warming will cause greater mortality in Russia. This projects a significant economic loss (cost of average statistical life is 30 to 40 million Rubles) to the country. Adequate preventive measures are required to mitigate this impact.[22]

In France due to poor interaction between various public sectors, the heat wave of 2003 caused very fatal consequences. From that experience France has now developed an action plan which addresses many issues. These include:

- Information sharing;
- Rules of conduct;
- Emergency management for disadvantaged groups; and
- Appropriately equipped nursing and health care centres.[22]

France now has both a National Action Plan and Local Action Plans to address extreme health consequences. After France, other European nations, including Russia, have formulated similar action plans.[22]

Poor nations contribute less to GHGs emissions than their rich counterparts. Not withstanding this, their efforts to combat health impacts has improved significantly. This, even though they lack relevant and up-to-date scientific data, can show links between practice and strategies regarding global health programmes.[23]

However, there are attempts in these countries to:

- Increase awareness among health practitioners;
- Improve data bases;
- Improve policy planning for management of climate change health effects;

- Get groups interested in global health and climate change to be involved; and
- Advocate climate change mitigation in their own countries.[23]

GHGs are anthropogenically derived and they are known to impact climate with related health consequences. GHGs in the ocean and fresh water systems will increase temperature, lower pH and cause change in the weather patterns.[24] There is much work needed to comprehend the consequences of changing climate patterns on fauna and flora of the ocean. For example, algal blooms are harmful but there is lack of information on their potential effects on human health. Research needs a multidisciplinary approach including: climatology, oceanography, biology, epidemiology and other related disciplines.[24]

Some wealthy nations emphasize economic benefits and downplay sustainability goals, health and equality. This denies health consequences due to changes in the climate. However the rising cost of energy is beginning to influence their outlook. They are now looking at health dividend, enhanced well-being, controlled consumption and increased equality. There is now a need for:

- Change in mindset;
- Improved interaction;
- Development of appropriate methodology; and
- Definite tasks to be achieved.[25]

9. Medical Gaps in Climate Change Research

The relationship between climate change and infectious disease is still not clearly understood. Modeling and other approaches have not really established the relationship and in some instances are conflicting.[26]

There is a need to assess socioeconomic determinants and their impact on human disease. This includes the socioeconomic factors with link to disease systems, such as:

- The establishment and spread of parasites and other pathogens;
- Also serious geophysical limitations, transport propects and biotic needs.

A better understanding of these variables will be useful to develop a predictive system to understand the link between disease systems and the consequences of changes in the climatic patterns.[26]

A paradigm shift is needed to envisage the changing climatic patterns and the type of risk it will have on human health. The health sector must reflect on ways to develop future health systems. These must address emerging health concerns such as planning and programming for adaption measures to avoid severe impacts due to GHGs.[27]

9.1 Early Detection

Early detection systems for climate change associated infectious diseases must be developed. These must track issues such as food and water-borne outbreaks due bacteria, virus and parasites.[28] Some associated important pathogens are *Giardia lamblia*, *Cryptosporidium* sp. *Vibrio parahemolyticus*, West Nile virus, Pumula virus, *Borrelia* spp. *Brucella* spp. *Echinococcus* spp., *Toxoplasma* spp. and other protozoa. There is also a need to establish the baseline prevalence potential of these pathogens to guide early detection and intervention strategies for good control initiatives.[28]

Based on projected temperature change over this century, climate change scenarios will depend on the choices (based on GHGs emissions) selected over the next few years.[29] Fossil fuel usage based on demographic, economic and technological changes will be of importance in determining human choices. These will relate to energy efficiency and investments in technology. The climatic system is in a very dynamic stage and the choices made in next few years will set the future for our children and grandchildren.[29]

9.2 Complex Interactions

The consequences of the changing climatic patterns in relation to health is complex and is receiving worldwide recognition. The implications on economics, human health and wellbeing are implicit (30). Many diseases such as cancers, diseases of respiratory origin, cardiovascular, vector, water and food borne diseases are important and complex. Social wellbeing, nutrition, trauma and vulnerable demographic sectors must also feature[30].

Countries in Southeast Asia and Africa will experience the greatest impact on its vulnerable groups such as the elderly, the young and those in poverty. In some of these countries the prevailing state of the environment is poor, the health system is inadequately developed and disease burden is high.[30]

In Africa there is a lack of empirical evidence relating health and climate change. Malaria incidence is influenced significantly by ecological conditions and changing weather patterns. This has to be addressed in all socio-economically disadvantaged nations. Climatic effects on health will be more profound in these countries, due to lack of clean water and adequate food.[31]

Many international agencies are helping such nations to improve their adaptation programmes by planning and financing through their national governments. The National Institutes of Health in USA is spearheading the research agenda on effects of changing climatic conditions on health. Currently the understanding of the subject is rather poor and needs strengthening. In some cases the impacts will vary by location, therefore the strategic planning for health must be regional to be relevant.[32]

9.3 The Economics of Climate Induced Disease

Health cost in managing diseases such as malaria and diarrhoeal diseases is set to increase in developing countries. Studies show a lack of data on the economics relating to adaptations to climate change and overall health expenditure. A review of methodologies has helped to identify research weaknesses and gaps which are essential for addressing these issues.[33]

Heat waves have been a major cause for health concerns due to climate change. In Western Europe it has been the cause of some 35,000 deaths in 2003. The efficiency and response of the public health services reduced the mortality and morbidity significantly and much was learnt from this experience.[34] However, there is little information in Europe on housing and the indoor environment. This is much needed for intervention studies to reduce impacts on health. Policy decisions are being hampered due to lack of evidence on public health issues.[34]

Any modeling on climate change and its impact on health will depend on risk management and economic assessment. These must be based on empirical evidence such as:

- Socio-economic status;
- Exposure-response function;
- Effects and policy measures.

New research needs to address the gaps seen in the IPCC Fifth Assessment Report.[34]

9.4 Raising Awareness

Climate change has a significant health impact on children and the responsibility of reducing this impact lies in the hands of clinicians and health care givers. The United States has guidelines in place to address the issues by encouraging the public health sector to raise public awareness on climate change.[35] Buildings should be energy efficient and a best practice guide should be in place to maintain sustainability of such practices. The impact on children (whether it be for the present or for the future) should be addressed. This might be done through education, appropriate strategies, policies and measures, as well as by personal contribution.[35]

Improved practices for the reduction of greenhouse gasses should also be continuously advocated. It is envisaged that these interventions will help reduce

health outcomes such as morbidity and mortality related to climate change.[35] Therefore the role of health care personnel at local, state and national levels is important to ensure success of these programmes. Clinicians and paediatricians have an important role by assisting in disaster preparedness and response planning for the good of the children's welfare.[35]

9.5 Pertinent Questions

Some pertinent questions regarding the health consequences due to changing climatic conditions have been addressed by a survey conducted in the United States, Canada and Malta between 2008 and 2009.[36] These researchers set out to assess the public's perception on climate change and its relationship to health risks.

The USA, Canadian and Maltese research addressed three questions:

- Are there health risks associated with climate change?
- If there are risks are they current or in the future?
- In what ways can such risks affect public health?

The survey found that:

- The public considered the risks to be significant and the harm was already taking place;
- The Canadians and the Maltese were concerned about their own vulnerable populations;
- In contrast the Americans felt that the people in developing countries were at greater risk.

The diseases of concern nominated by respondents to the survey were: respiratory problems, heat-related problems, cancer, infectious diseases, sunburns, allergies and injuries from extreme weather events.

However the study also showed that respondents did not consider the problem to need urgent attention. The study concluded that there is need for public health initiatives to improve the public perception of the climate change and health problems.[36]

In Malaysia we need to reflect on the issues raised by this study in Canada, Malta and the United States. We can see that there are two distinct views expressed. Taking this into consideration we Malaysians should analyse the situation in Malaysia and the Region:

- Are we Malaysians only interested in the wellbeing of our population? OR
- Are we also interested in the welfare of our neighbours?
- Are our neighbours affected by the consequences of climate change as well?

There is much need in Malaysia and the region to assess the consequences of climate on our populations. We see severe weather events such as hurricanes, flash floods, landslides and earthquakes. The questions we need to address are:

- What are the economic consequences of these natural disasters?
- What mitigating measures have been taken within the country and the region?
- What improvements are there in early warning systems?
- How effective are the early warning systems that we do have?
- What measures have been taken to protect disadvantaged populations?

We should also address the issues of man-made disasters due to indiscriminate destruction of the rainforests in the region. These are the many issues that researchers in Malaysia can address.

The challenge is – how can we provide the support and the much needed information for national programmes to mitigate consequences of climate change?

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