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Climate Change and Population Health: Possible Future Scenarios

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1. Introduction

There is little doubt the earth's climate is changing and will continue to change over time. Predictions suggest higher temperatures, and more frequent heat waves, heavy rains, floods, droughts and severe storms. Among the consequences may be detrimental health effects, to the extent that climate change has been termed the "biggest global health threat of the 21st century" (Costello et al., 2009). Primary health effects may include changing patterns in temperature- and weather-related morbidity and mortality, whereas secondary effects may result from water and food insecurity, mental stresses and changes in transmission patterns of certain infectious diseases.

Disparities will be apparent in the vulnerability of individuals and populations around the globe, and despite contributing little to the cause of climate change, populations in poorer countries will be particularly vulnerable (World Health Organization, 2008). Currently various human societies are implementing various adaptation strategies. Such strategies are informed by the socio-political and religious institutions of societies. While the developed world emphasises the virtues of technology and sound socio-political systems in promoting future adaptation strategies to climate change, many countries in the developing world utilise grass-roots based social action. The use of a multi-faceted approach offers novel ways for dealing with future climate change scenarios and its potential impacts on human population health.

2. Human health and environmental temperature

Population health can be directly affected by ambient temperature. In most parts of the world the association between temperature and mortality follows a U- shaped relationship (McMichael et al., 2008). Generally mortality is lowest at moderate temperatures and increases with extreme cold in winter or extreme heat in summer. The effect of climate change on this pattern and temperature-related deaths in general is unclear, but it is likely the warming of global temperatures will result in a reduction in cold-related mortality. Whilst some believe overall mortality rates will therefore decline and effects could be beneficial (Keatinge and Donaldson, 2004) others doubt there will be decreases in cold-related mortality (Medina-Ramon and Schwartz, 2007) and the health benefits will likely be exceeded by an eventual increase in heat-related mortality (Bambrick et al., 2008). However, net impacts as yet remain uncertain (Ebi et al., 2006).

The harmful health effects of hot weather can be partly explained by the body's physiological response to the surrounding thermal environment. Core body temperature is maintained between 36.1 and 37.8°C, and upon detecting an increase of about 1°C, receptors on the skin or within the body trigger signals that send messages to the brain where the hypothalamus (the body's temperature regulatory centre) initiates processes to cool the body (Matthies et al., 2008). In response to a rise in core temperature, heat dissipation involves an increase in cardiac output and blood flow to the skin where heat is distributed to the environment in one of four ways – conduction, convection, radiation, or via the evaporation of sweat (Matthies et al., 2008). Whilst less efficient in environments with high humidity, the evaporation of sweat is the only mechanism which is effective when air temperature exceeds skin temperature (Matthies et al., 2008). An awareness of being in an uncomfortably hot environment prompts behavioural reactions such as moving to a cooler place, decreasing activity, and drinking fluids. These actions are an important part of behavioural thermoregulation which in some individuals can be impaired for physical or cognitive reasons (Faunt et al., 1995; Kalkstein and Sheridan, 2007).

High temperatures and heat waves can also affect concentrations of air pollutants such as ground level ozone and particulate matter (Matthies et al., 2008), both of which can be detrimental to health. Ozone is formed by the action of sunlight on nitrogen oxides and volatile organic compounds, and concentrations increase with higher temperatures (Kinney, 2008). Windblown dust in arid regions and smoke from heat-associated bushfires can also elevate airborne concentrations of particulate matter. Whilst much remains unknown about the health effects of climate change, it is thought that levels of aeroallergens such as pollens and moulds will be affected with consequences for allergic disease sufferers (Kinney, 2008), and that the combined effects of warmer temperatures and altered concentrations of air pollutants on human health may be additive or synergistic (Luber and McGeehin, 2008; Matthies et al., 2008).

2.1 Heat-related illnesses

Exposure to extreme heat, strenuous physical exercise or a combination of the two, can overwhelm the body's ability to adequately dissipate heat, leading to hyperthermia and possibly heat-related illness, particularly if the individual is dehydrated (Simon, 1993). The continuum of heat-related illnesses range from mild to life-threatening and include heat rash, heat oedema, heat cramps, heat stress, heat syncope, and heat exhaustion (Matthies et al., 2008). Heat stroke is the most serious heat-related illness characterised by hyperthermia and central nervous system dysfunction. Due to subsequent multiorgan dysfunction, heat stroke is often fatal, and survivors can have ongoing health consequences or permanent neurological damage (Bouchama and Knochel, 2002). 'Classic heat stroke' usually affects the aged, whereas 'exertional heat stroke' is often seen in younger people as a result of exercising or working in the heat.

2.2 The epidemiology of heat waves

The Intergovernmental Panel on Climate Change predicts heat waves will increase in frequency, intensity and duration as a result of climate change (IPCC, 2007) and in the absence of adaptation or interventions, the consequences for population health may be considerable. Whilst there is no universal definition of a heat wave (Tong et al., 2010), generally city- or area-specific conditions determine local definitions of unusually high and prolonged temperatures. Studies in Adelaide, Australia have defined a heat wave as being three or more consecutive days of maximum temperatures of 35°C or above (Hansen et al., 2008a; Hansen et al., 2008b; Nitschke et al., 2007) whereas other studies have experimented with a range of definitions (Tong et al., 2010).

In recent decades intense and deadly heat waves have occurred around the world, with dire consequences for population health. The most serious heat wave occurred in Europe in August 2003 encompassing several countries, the worst affected being France where approximately 15,000 excess deaths occurred (Fouillet et al., 2006). Prior serious heat waves occurred in Athens, Greece in 1987 (Katsouyanni et al., 1988), Chicago, United States in 1995 (Semenza et al., 1996) and India in 1998 (Kumar, 1998). More recently deadly heat waves have occurred in California in 2006 (Ostro et al., 2009), Australia in 2009 (Victorian Chief Health Officer, 2009), and Russia in 2010 (Osborn, 2010). Often people in cities are worst affected during heat waves as a result of the urban heat island effect whereby the high thermal mass of concrete and bitumen surfaces in cities causes heat to be retained, resulting in higher temperatures during the day and night (Luber and McGeehin, 2008).

Numerous epidemiological studies investigating these heat waves have assisted in the identification of patterns of morbidity, mortality and heat-susceptibility within populations. As the process of maintaining heat balance can place physiological strain on the body in vulnerable individuals, adverse health events can be triggered, particularly in those with underlying chronic conditions, and generally cardiovascular, respiratory and cerebrovascular diseases are the main causes of deaths during heat waves (Basu and Samet, 2002). Additionally, studies have found that the instances of renal disease and acute renal failure increase during heat waves (Hansen et al., 2008b; Knowlton et al., 2009; Semenza, 1999), a likely indication of electrolyte imbalances and dehydration on the renal system. During the French heat wave of 2003, apart from deaths directly related to heat and dehydration, an increase in mortality due to cardiovascular, respiratory and nervous system diseases, mental disorders, infectious diseases, genitourinary diseases and ill-defined disorders was reported (Fouillet et al., 2006). As well as mortalities, ambulance callouts, emergency department presentations and hospital admissions tend to increase during heat waves (Fouillet et al., 2006; Knowlton et al., 2009; Nitschke et al., 2007; Semenza et al., 1999; Semenza et al., 1996), indicating the broad impact extreme heat can have on population health.

Those at the extremes of age are amongst the most vulnerable to the effects of heat due to underdeveloped or impaired thermoregulatory systems respectively. The elderly are particularly vulnerable for several reasons relating to poor fitness and physical and mental health, multiple co-morbidities that often accompany ageing, reduced social contacts and some medications that can affect heat dissipation (Luber and McGeehin, 2008; Matthies et al., 2008). Global warming and the demographic shift to an older population is a combination that will provide a challenge to public health in years to come (Saniotis and Bi, 2009).

Having an underlying chronic health condition can increase an individual’s susceptibility to heat and persons with mental health conditions are vulnerable for a number of reasons (Bark, 1998; Hansen et al., 2008a; Semenza et al., 1996). Deficits in cognition affect the ability to adjust one’s response to the thermal environment and the awareness of the need to modify behaviour, clothing, or fluid intake; certain psychiatric illnesses such as schizophrenia are thought to involve neurotransmitters in the brain that are also involved in temperature regulation; and antipsychotic medications can impair thermoregulation (Bark, 1998). Climate change may impact on mental health as communities struggle to cope with, and recover from, the social, emotional and economic consequences of weather related disasters such as heat waves, droughts, bushfires, storms, extreme rainfall events and floods (Berry et al., 2010).

Many outdoor workers in industries such as agriculture, construction, and mining are particularly vulnerable to heat stress and this risk will be increased with the higher ambient temperatures and extreme heat events associated with climate change scenarios. These conditions can produce an unsafe thermal working environment and affect productivity, particularly for workers in low and middle-income tropical countries (Kjellstrom et al., 2009). Other climate–related hazards facing these workers include extreme weather, air pollution, ultraviolet exposure, and vector-borne diseases (Schulte and Chun, 2009).

3. Adaptation and acclimatisation in a warming climate

The degree to which the health of a population will be affected by a warming climate will be tempered by its ability to acclimatise and adapt. Acclimatisation, the ability to adapt to commonly experienced climate patterns (Basu and Samet, 2002), is a physiological process whereby the body adjusts over time to the thermal environment via regulation of the cardiac, renal and pulmonary systems (Ramphal, 2000). Although more rapid in the young (Faunt et al., 1995) an average person can take up to two weeks to adapt to extreme temperatures (Ramphal, 2000).

Adaptation strategies that focus on preparedness and an increase in community-based resilience to weather-related disasters will be required to reduce the burden of climate change related health outcomes (Keim, 2008). As heat-related illnesses are preventable, the importance of adaptive behaviours and preventive measures during heat waves has been realised in recent years. Preventive measures may include rescheduling activities during the heat, increasing non-alcoholic fluid intake, wearing appropriate clothing and avoiding direct sunlight, and where practicable, locating to an air conditioned environment (Luber and McGeehin, 2008).

Heat wave watch/warning systems are a form of adaptation that has been introduced in many cities following major and deadly heat waves. The multi-level warning systems are triggered when oppressive conditions that could negatively affect health, are forecast for upcoming days (Kalkstein et al., 1996). These heat-health alerts use the general principles of emergency response to describe the hazard and when it will occur, and provide information and advice to the public and local authorities about appropriate adaptive behaviours (Kalkstein and Sheridan, 2007; Matthies et al., 2008).

A study in Perth, Australia, predicts that by 2070 there will be 15-26 days per year (compared to one day per year at present) when manual labour will be dangerous to perform for even acclimatised people (Maloney and Forbes, 2011). Adaptive strategies in the workplace may include information to workers about the risks of heat stress, recognition of symptoms and methods of prevention (Matthies et al., 2008), increased shading at worksites, or adjustment of working hours to avoid the hottest part of the day, the latter being more suited to indoor than outdoor workers (Kjellstrom et al., 2009).

Although populations will undergo some adaptation, those in low and middle-income countries will be particularly vulnerable to the effects of climate change (McMichael et al., 2008) whereas countries like the Unites States will have a greater capacity to implement effective adaptation measures and limit impacts on health (Ebi et al., 2006). Nevertheless in most situations, adaptation will be enhanced by education, early warning systems, responsive government, and an adequate health care sector able to respond to local climate-sensitive health problems (Woodward, 2011).

4. Infectious diseases and human population health

Climate conditions affect the transmission of vector/rodent-borne diseases in three ways: altering the distribution of vector species and their reproductive cycles; influencing the reproduction of the pathogens within the vector organism; and affecting human behaviours and activity. Malaria, dengue fever, Ross River virus (RRV) infection and Haemorrhagic Fever with Renal Syndrome (HFRS) are the most commonly investigated climate-related vector/rodent-borne diseases.

Many studies across the world indicate that increases in the incidences of malaria and dengue fever are strongly associated with higher temperatures and increased rainfall. Increasing temperatures with climate change will bring about more malaria and dengue fever cases in the future (Zhang et al, 2010; Tanser et al, 2003; Bi et al, 2003; Bi et al, 2001). Furthermore climate modelling shows that global warming will enlarge the potential range of the vector for malaria for example, which by 2030, could extend to a location 800 km south of its present limit in Australia (Bryan et al, 1996). This will bring about a serious public health issue to this current malaria-free country. Similarly, a slight increase in temperatures could result in epidemics of dengue in the world. In Australia, by 2100, if no effective policy and public health measures have been developed, the zone of potential transmission of dengue fever may expand 1,800 kilometres south, as far as Sydney. In contrast, by markedly constraining greenhouse gas emissions immediately, this southward extension could be limited to 600 km (Woodruff et al, 2006).

In terms of the relationship between RRV infections and climate variability, studies found that variations in rainfall, temperature and tides have been positively associated with the incidence of RRV infections (Harley et al, 2001; Tong et al, 2002). In addition, climate variability might be a contributor to the spatial change of the disease in Queensland, Australia over the past years (Tong et al, 2001). Examination of the relationship between rainfall and the incidence of HFRS in a low-lying region of eastern China showed a significant inverse association between the amount of precipitation and the incidence of HFRS when the density of rodents and the opportunities for human contact were considered, suggesting heavy rainfall in these low-lying areas could reduce the density of mice and thus the incidence of the disease (Bi et al, 1998; Bi et al, 2002). However, rainfall, land surface temperature, relative humidity and ENSO with lags of 3–5 months were positively associated with HFRS in northeastern China (Zhang et al, 2010).

Temperature and relative humidity may impact on the rate of replication of the pathogens and the survival of enteroviruses in the environment, animal reservoirs and host behaviours. It may affect eating habits, the type of food prepared in households and the meat industry. Rainfall, especially heavy rainfall events, may affect the frequency and level of contamination of drinking water. Moreover, climate change may influence water resources and sanitation so that water supply is effectively reduced. Such water scarcity may necessitate using sources of fresh water of poorer quality, such as rivers, which are often contaminated. All these factors may result in an increased incidence of food-borne and water-borne diseases.

The relationship between enteric infections and environmental temperature has been studied in Europe (Kovats et al, 2004, 2005; Tam et al, 2006; Bentham and Langford, 2001), Australia (D'Souza et al, 2004; Bi et al, 2008; Zhang et al, 2010), the USA (Curriero et al, 2001), Canada (Fleury et al, 2006), and Asia (Zhang et al, 2008). Most of these studies indicated that there was a positive association between temperature and enteric infections such as *Salmonella* infections and *Campylobacter* infections as well as Bacillary Dysentery. Studies have shown that a 1°C increase in temperature is associated with a 5%-15% increase in the risk of severe diarrhoea (Zhang et al, 2008; Kovats et al, 2004).

Emerging and re-emerging of vector-borne, rodent-borne, food-borne as well as water-borne diseases due to climate change will create huge health challenges for both developed and developing countries, especially for vulnerable populations such as the elderly, Indigenous communities, lower socioeconomic status groups and homeless people. It will particularly challenge the population health in developing countries such as China, India, Indonesia, and African countries etc, given their already overloaded and inadequate healthcare systems, high population density, inadequate infrastructure, lower level of health literacy, etc. For instance, the summer diarrheal diseases in Bangladesh due to flood and summer rainfall have made significantly negative impacts on the population health there, especially among children. Further climate change with more irregular extreme weather events will lead to more health issues for both developed and developing countries including more cases of relevant infectious diseases.

Therefore, relevant public health adaptation measurements should be taken immediately to reduce the negative impact of climate change on population health including infectious diseases. These should include:

1. To conduct health education and promotion among communities to build community resilience capacities to deal with the health challenge due to climate change, which include self-protection measures for infectious diseases among communities;
2. To improve infectious disease surveillance system, especially in developing countries so more accurate and updated communicable diseases intelligence could be obtained in a timely manner for decision-makers to take relevant actions;
3. To establish an early warning system to prevent infectious disease outbreaks due to climate change, requiring multidisciplinary collaborations;
4. To strengthen infectious disease control including the provision of vaccines for vulnerable groups and vector control before and during the epidemic seasons; and
5. To promote medical services, especially the roles of primary health care services, i.e., using General Practitioners to play an important role in the battle against the infectious diseases due to climate change. These may include health education, vaccination and effective diagnosis and treatment.

5. Asia and Africa: Climate change, human population health and adaptation responses

Populations vary in their vulnerability to climate change and this section will discuss the predicted impact on population health in Asia and Africa. It will also propose adaptation strategies to climate change in Asian and African countries. Due to its large population and widespread environmental degradation much of the Asian region will be particularly vulnerable to future climate change and global warming. From 1999, China contained 21% of the world's population and India contained 16% (Levy, 1999). A report by the

International Energy Agency (IEA) predicts that global CO_2 emissions will rise by between 30 and 42% by 2010, with China and India accounting for an "increase larger than all OECD countries combined" (Fu et al., 1998). Greenhouse emissions in Asian cities will also continually escalate due to increasing populations. Some 13 out of 21 Asian cities now exceed 10 million in population putting increasing demands on fuel food and water resources (Fu et al., 1998).

According to climate change projections there will be general warming over Asia and South-East Asia. Climate modelling of the Asian region predicts temperature rises from 0.5–2°C by 2030 and 1–7°C by 2070. Predicted temperature rises for Africa by 2100 range from 3 to 6^0C (APF, 2007). Such temperature rises for Asia and Africa will lead to adverse population health effects including increases in vector borne diseases.

Climate projections for Asia and Africa predict a variety of adverse weather patterns which will burden population health. These will include increasing cyclonic activity and flood severity in low-lying countries in Asia and South-East Asia, such as Bangladesh, China, Philippines and Thailand. Central parts may have diminished precipitation causing severe water stress which may lead to desert expansion and depletion of arable land. This may cause diminished agricultural output in many Asian and African countries which may have adverse social consequences such as and increase in food prices leading to famine and widespread hunger. Sea level rises in low-lying countries may have a tremendous impact on population health due to environmental refugees and increasing spread of communicable diseases due to unsanitary conditions.

5.1 Schistosomiasis transmission in China

In China, climate change may lead to higher transmission of schistosomiasis, which is caused by the parasite *Schistosoma japonicum* (Zhou et al., 2008). Research into schistosomiasis revealed the correlation between temperature rise and changes to the parasite's life cycles. Zhou et al used predictive models in order to simulate the spread of schistosomiasis by 2050. They found that average temperature increases for China will be in the range of 0.9°C by 2030 and by 1.6°C by 2050, predicting that schistosomiasis will cover an additional 8.1% of the Chinese mainland, and with the intensity increasing in areas which currently have schistosomiasis (Zhou et al., 2008).

Approximately 12 million people are at risk particularly in the Jiangsu province. It was found that even a temperature rise of one or two degrees can increase flooding in the Yangtze River, aiding in the transmission of disease-carrying snails. These snails then carry the disease to other areas. Adaptation strategies to mitigate the spread of schistosomiasis have included the creation of more efficient sanitation systems, the supplanting of water buffalo for machines, and the use of sensitive diagnostic tools (Zhou et al., 2008). The Chinese have also been using United States inspired technology in order to monitor the movements of snails via maps and a geographic information system (GIS) which predicts areas of predicted snail infestation.

Water supply, sanitation and contamination are on-going issues in many parts of China. Major river systems have been transformed in order to supply power to China's rapidly growing urban centres. In rural centres, there is a self reliance for people to manage water resources. However, rural people cannot finance larger water sanitation programs. What is needed is greater support by local and provincial governments to finance water resources which would also control the spread of schistosomiasis. In this way, adaptation strategies would take the form of much better co-ordination between local and provincial governments and rural people for controlling water resources.

5.2 Water and disease: population health

Climate change predictions have noted that many regions in Asia and Africa will suffer from water shortages and large water abundance due to flooding will cause adverse health problems. For example, flooding in Asian and African countries may result in soil run off and sewerage system overflows causing the spread of Cholera and diarrhoeal disease (Ahern et al., 2005). Low lying countries such as Bangladesh which is already prone to heavy flooding will bear a greater burden of diseases due to water abundance. Already, Bangladesh has had Cholera outbreaks along its coastal areas which have been linked to plankton and sea surface temperatures which are ideal reservoirs for the Cholera pathogen (Nerlander, 2009; IPCC, 2007). Much of Africa is also prone to flooding, particularly in the south, central and eastern Africa where approximately 14 African countries are prone to flooding. Flooding has had adverse social and economic impacts in recent floods in Algeria, Kenya and Mozambique. In Mozambique, the 2000 flood affected 2 million people and displaced over three hundred thousand. It also destroyed crop production (Urama & Ozor, 2010).

Alternately, water scarcity is currently being experienced in many Asian and African countries being affected by water stress. For example, approximately 75% of African countries and many central Asian countries are zones with minimal precipitation. It has been estimated that up to 250 million people will be exposed to water stress due to climate change (APF, 2007). Acute water shortages are being experienced in North African countries which have high populations (APF, 2007). Use of underground water reserves has also depleted the water tablelands in many countries. Lack of water availability increases the incidence of diarrhoeal disease and diseases linked to poor hygiene (Nerlander, 2009). Moreover, lack of water is a reason for population shifts which may cause overpopulation in areas of water availability.

Currently, there has been little done in creating efficient adaptation strategies for allocating water resources. One reason for this is due to the difficulty in controlling areas in flood prone areas. While this is not impossible, it would need considerable infrastructural measures. According to Nerlander (2009), long term infrastructural investments to infrastructures such as water sanitation plants are needed are needed in urban areas. In addition, city planners need to co-operate with water managers in order to ensure water availability throughout the year (Nerlander, 2009). In relation to extreme weather events, early warning systems need to be implemented in order to "enable the health sectors to preposition stocks enabling water purification" (Nerlander, 2009).

Another adaptation strategy would be to monitor ground water in order to ensure that water supplies are no longer compromised. Currently, there needs to be much more control of ground water resources. Local people will need to be at the forefront in monitoring ground water systems. Important progress can be achieved by regional governments improving policy and implementing various kinds of incentive frameworks and programs. The use of fiscal reforms may be instrumental in more efficient use of water, land and energy resources. Such reforms would also enable public funds to be freed up and invested in vulnerable groups (The World Bank, 2011). The maintenance of water inventories would be an important adaptation strategy for assessing the quantity and quality of groundwater resources. This would include:

1. Identification of different water sources.
2. Monitoring of water needs of users.
3. Water supply assessments for surface and ground water in relation to use by agriculture and industry.

4. Benchmarking water monitoring consistent with international standards (Urama & Ozor, 2010).

It is imperative that disaster management becomes an "integral part of adaptation and development process" (Urama & Ozor, 2010). This can include implementing proper infrastructure in order to reduce impacts, and "mitigating the problem among poor community and spreading it more widely through market mechanisms such as global insurance and capital markets" (Urama & Ozor, 2010). This would enable poorer communities to protect vital water resources.

5.3 Vector-borne diseases

Climate change research has shown that malaria and dengue disease vectors are especially affected by temperature increases. Changes in precipitation patterns affect breeding sites of vectors. This is particular the case with flooding which increases the prevalence of malaria. Malaria is prevalent in the sub-Saharan Africa, with over 90% of malaria cases originating from Africa, accounting for more than 40% of public health expenditure. Presently, almost 20 African countries are implementing efficient anti-malarial strategies such as reducing or eliminating taxes and tariffs on insecticide-treated nets (ITNs), to make them affordable to poor people. ITNs are being promoted as an effective anti-malarial adaptation strategy and improved vector control. While ITNs provide effective vector control African countries need to adopt other vector strategies due to on-going climate change. Such strategies include mitigating the rate of deforestation which increases vector borne diseases such as malaria and African trypanosomiasis (sleeping sickness). Ecological maintenance will ensure that the transmission of vectors can be controlled. However, this is a difficult proposition due to high populations in sub-Saharan Africa.

Efficient adaptation strategies to climate change will depend on health infrastructure of vulnerable countries. Many African countries are particularly susceptible to a diversity of vectors. This has the potential to precipitate multiple disease epidemics (Githeko et al., 2000). The onset of flooding which leads to population movement and displacement may also aid in the transmission of vectors and diseases caused by lack of sanitation. Far more infrastructural investment is needed in Africa in order to control vectors.

5.4 Heat wave events and population health

The occurrence of heat wave events in Asian and African regions may be a concomitant symptom of climate change. Many Asian and African countries suffer from lengthy heat wave events. For example, many Asian countries were affected by a heat wave event which occurred in May and June of 2007. In North India temperatures exceeded 40 degrees Celsius. In 2010 China experienced a heat wave during which temperatures in parts of Hebei and Shandong provinces reached 40 degrees Celsius. Research on heat waves in the Chinese city of Shanghai indicates a relationship between mortality and duration of heat wave events. In the two heat wave events pollution may also have contributed to human mortality (Tan et al., 2007).

In 2003 Shanghai experienced its hottest summer in 50 years and a heat wave impacted on people with co-morbidities such as cardiovascular disease and respiratory illness (Huang et al., 2010). The elderly (>65 years old) were especially affected by the heat wave. The 2003 heat wave was exacerbated by China's rapid urbanisation which is affecting local climate in ways which include increasing the heat island effect in urban areas, and affecting urban infrastructure and housing quality (Huang et al., 2010). There has been a dearth in studies researching on the heat island effect in Asian cities and this is an area where public health programs can be initiated.

Future adaptation strategies may include the extended use of air conditioners and fans during hot weather, housing changes to better accommodate for hot weather, increased urban green spaces, larger living areas, and higher levels of heat awareness (Tan et al., 2007). Initiating such changes will be problematic due to the already large influx of rural people in Asia's urban centres.

6. Conclusion

Climate change affects not only the environment, it is a major issue that can affect environmental health on a worldwide population basis (Costello et al., 2009). Whilst not all impacts will be detrimental, it is believed overall the negative effects on health will outweigh the benefits (World Health Organization, 2008). Changing patterns of temperature related morbidity and mortality, water and air quality, food supplies and infectious diseases transmission are the likely consequences of global warming that impact on human health and wellbeing in the developed and developing world. Furthermore, Asian cultures have been able to implement various culturally based adaptation strategies in order to combat climate change and biodiversity loss. Adaptation is a culturally based strategy which incorporates many levels of learning. While the rhetoric of climate change is relatively new this does not mean that adaptation strategies are in their nascent stages. What is evident is that different societies have the capacity for implementing novel and significant kinds of adaptation responses to climate change. This will continue to be the case in the future with predicted global warming and environmental degradation.

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