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The potential impacts of climate change on water supply in Johannesburg

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3 CLIMATE CHANGE AND WATER SUPPLY

"We're the modern weather-makers
and we're threatening the future of life as we know it"
(Joubert, 2008, 76).

Climate change has become a worldwide phenomenon that has resulted in diverse changes in weather and climate. These events are capable of having global repercussions; therefore every country will be affected. Water is a valuable commodity, and its supply is influenced by a wide range of factors closely related to climate and weather. This chapter describes the fundamentals of climate change and water supply. The section forms a vital component of the report in that it introduces, examines and provides a broad overview of two principal elements. Firstly, climate change and its depiction, theories, views and debates are presented. Secondly, accepted notions surrounding water supply are stated – from both a local and an international point of view. Thirdly, water supply problems in Africa and South Africa in particular, are put forward. These problems include existing barriers pertaining to water supply. Lastly, a conclusion to this chapter is presented. The rationale for this section is based on providing background and overall knowledge on the two main elements that provide the foundation of the rest of the report.

3.1 A DESCRIPTION OF CLIMATE CHANGE

Climate change is the result of an intensification of the greenhouse effect. As the level of atmospheric greenhouse gases increases, more heat is trapped in the atmosphere, that increases energy, which in turn drives the global climate and consequently intensifies climate systems worldwide, thereby altering the earth's temperature (Joubert, 2008).

"We know that climate change is happening, and we know that carbon dioxide (CO_2) and other greenhouse gases that we emit are the cause" – Ban Ki-moon (Kirby, 2008, 6). "Global climate change is possibly the greatest environmental challenge facing the world this century"(DEAT, 2004, 3).

Climate change is sometimes labelled 'global warming', but global climate change refers to the disarray in the world's climate and weather patterns (DEAT, 2004). Therefore, a more accurate explanation would be to say that climate change arises out of global warming, or as Keeney and McDaniels (2001) declare, global warming brings about climate change. Global warming occurs due to an increase in the level of greenhouse gases in the atmosphere that trap heat and consequently warm the earth in an unnatural way. This unnatural warming leads to a worldwide change in the earth, climate and weather worldwide, which explains why climate change is a global phenomenon.

Rowlands (1998) emphasises that three key environmental outcomes can be related to climate change:

1. Rising sea levels;
2. A shift of climatic zones; and
3. An increase in the number of severe events occurring.

Another aspect that is influenced by climate change and will affect climate change is the notion of carbon sinks. Given that carbon sinks have a tendency to be affected by climate change, there is a high probability that they will deteriorate in the future, due to terrestrial (land) and oceanic (ocean) changes, which are caused by climatic changes. This, in turn, will result in more carbon dioxide remaining in the atmosphere, which will bring about further changes in the earth's climate (Alcamo et al., 2009).

It is important to emphasise that climate change, as a consequence of global warming, is a continuous process with present as well as future impacts. The present impact, namely a rise in global temperatures, is a consequence of past fossil fuel emissions, dating back millennia (Johansen, 2006). Future impacts on earth will be as a direct outcome of present changes that humans are making to the climate (Alcamo et al., 2009). In truth, sea levels globally will keep rising for

centuries to come, even if the concentrations of greenhouse gases are somehow stabilised (Bates et al., 2008). It is predicted that the "global average surface temperature will hardly drop in the first thousand years after greenhouse gas emissions are cut to zero" (Alcamo et al., 2009, 10).

Chapter two has demonstrated that climate change and planning are linked, thus the impact that climate change will have on planning is that any future urban plans and designs will be changed by and will have to make allowances for the phenomenon – as a city expands and develops, any proposed future developments will have to make provision for climate change. The location, size and function of any new human settlement will be based on and driven by climate change considerations. Firstly, each new human settlement will have to take into consideration physical variability in both climate and weather. Secondly, the function of any human settlement determines how much carbon dioxide will be produced. Thirdly, in relation to location, the distance to work for employees will establish any additional carbon dioxide produced. Hence, the greater the number of employees, and the distance travelled, the greater the levels of carbon dioxide. Lastly, the size of the development will have to be taken into account. Planning mediates and verifies the factors of location, size and function of urban developments, and accordingly the consequences of climate change. Planning will have to incorporate and allow for engineering and geographical factors in any future plans and designs. All professionals will have to think outside the box, and take into account possible scenarios and likely alternatives.

By the 1960s scientists had begun warning that global warming, due to human activity, was emerging as a real threat (Leroux, 2005). In the 1970s environmental awareness really began taking a hold. Since then, scientists have been questioning, evaluating and analysing not only the possible effect of climate change on the world, but also the role that we humans play in contributing to or exacerbating the problem (Leroux, 2005; Spence, 2005; Joubert, 2006).

In 1995, scientists were in agreement that humankind was responsible for warming the earth (Rowlands, 1998; Johansen, 2006). Spence (2005) focuses on the reality that, after decades of research, scientists and experts have collectively agreed on the existence of the phenomenon of global warming, on the fact that

climate change is still occurring, and on the possibility that the warming of the past 50 years may have been caused by human activity (through the burning of fossil fuels; petrol, oil and coal). According to Joubert (2008), climate change became a highly publicised topic in 2006/2007, leading to greater public awareness and an acceptance of climate change globally. This gave rise to research documents, films on the topic and documentaries, and saw conferences being held on the subject. Houghton (2004), Godrej (2006), McCaffrey (2006), Jarman (2007), Joubert (2008) and Alcamo et al. (2009) confirm that worldwide, the notion of climate change has been accepted, and collectively they established that humans are accountable for global climate change and for – in effect – affecting the future of the entire world.

The concept of climate change (and its consequences) has, in the past been questioned (and is still being questioned to a certain extent). In this respect, Godrej (2006) emphasises that 'denial' is one of the main responses to climate change problems and the essential changes that the phenomenon requires. This aspect may also be connected to the theory that will be presented below, namely of certain individuals writing off climate change as essentially being a phase (hot or cold) that the earth is going through.

Jarman (2007) and Alcamo et al. (2009) stress that one of the existing problems related to climate change is a lack of public knowledge and awareness on the topic. Jarman (2007) argues that the concept of climate change is not publicised sufficiently or presented clearly enough to the average person. In addition, climate change has long-term consequences, and therefore the man in the street tends not to be concerned with 'possible' future scenarios, because he is more concerned with everyday, present problems (Jarman, 2007).

In addition to the above, other professions (in addition to planning) also find themselves at a disadvantage when it comes to knowledge on climate change. Scientists, politicians, climatologists, geographers and others in the field acquire the necessary, first-hand information on climate change. Therefore, planners are not usually the initial primary researchers on the subject, but are the secondary recipients of information. Consequently, the data, knowledge and research available to planners on the topic will be limited in both quantity and quality.

Parks and Roberts (2007) highlight the dilemma of developing countries', with limited knowledge of climate change and fewer scientists. As a result, Third World nations are less geared to execute their responsibilities regarding climate change; they produce fewer reports on the topic and participate less frequently in global functions due to a lack of money and resources. Joubert (2006) reiterates that the southern hemisphere lacks information, research and data on the impacts of climate change and lags behind research being done in the northern hemisphere. "The developing world faces greater challenges than the developed world, both in terms of the impacts of climate change and the capacity to respond to it" (DEAT, 2004, 3).

Another significant problem with regards to climate change is the issue of disproportion and inequality between the developed and developing countries'. The developed countries' are demanding a decrease in emissions on the part of developing countries, yet the problem is that developing countries are reluctant to curb their economic development, and hence cut back on their output of carbon dioxide. Developing countries' want to be allowed to develop and grow economically in the same way that the developed countries' have, in the past. Consequently, this causes friction in attempts to resolve the problem of climate change (Parks and Roberts, 2007).

The dilemma is that it is impossible for a country to develop economically while trying to limit its carbon dioxide outputs. The reality is that developing countries' are at a disadvantage in trying to develop economically while the world bears the burden of the effects of climate change.

The Intergovernmental Panel on Climate Change (IPCC) states that one of the main reasons for worldwide scepticism on climate change is the fact that the definition of 'climate' is often confused with that of 'weather' (Joubert, 2008). The IPCC states that another aspect, which confuses people, is related to the warming and the cooling of the earth. The earth goes through phases of hot and cold periods, but climate change will affect and exacerbate these phases (Rowlands, 1998; Joubert, 2008). "Due to natural climate variability, it is entirely possible to have a period as long as a decade or two of 'cooling' superimposed on the longer-term warming trend due to anthropogenic greenhouse gas forcing"

(Easterling and Wehner, 2009, 1). However, it is important to differentiate between the foreseen potential outcome of climate change and the regular periods of climatic unevenness that produce severe weather patterns (Lawson, 2008).

In recent years, according to Joubert (2008), the existing problem has not been the acknowledgment (or denial) of climate change, but the quality of research that has been published and presented globally on the subject. Jarman (2007) and Joubert (2008) state that politicians influenced the most recent IPCC predictions report of 2007. “The scientists received so much pressure from politicians that they were forced to tone down the severity of their findings” (Joubert, 2008, 151). Lawson (2008, 12) suggests that the IPCC “has mutated in the minds of most of those who head it, into something more like a politically correct alarmist pressure group”.

Nonetheless, the IPCC continues to be a highly prominent and respected group that puts forward reports presenting worldwide accepted knowledge on the most predominant global warming issues (Lawson, 2008).

Lawson (2008) insists that the science of global warming has yet to be finalised. While he argues that certain scientific facts have been settled, a number still remain unresolved. In addition Lawson (2008) draws attention to the reality that the science of global warming is a fairly new field, it is complicated and based on many uncertainties.

The empirical facts that have been confirmed, include:

1. The levels of carbon dioxide in the atmosphere have increased due to man-made emissions;
2. The increase in carbon dioxide in the atmosphere has primarily played a role in warming the earth and increasing temperatures (Lawson, 2008).

The following empirical facts (recognised by Lawson 2008), ought to be carefully examined and resolved:

1. Because plants require carbon dioxide to stay alive, will increased carbon dioxide levels result in improved plant growth? (Derr, 2004; Lawson, 2008);
2. How great has the increase of carbon dioxide been?
    a. Lawson questions future predictions of temperature variations;
    b. What price will present generations pay, and how effective will preventative methods be in reducing global warming; and
    c. The danger of forced action (Derr, 2004; Lawson, 2008);
3. The media tend to attribute every unusual weather event to global warming (Derr, 2004; Lawson, 2008) – even events which may have been caused locally, or which are unrelated to global warming.

To conclude this section of the chapter, the approach used (as pointed out in the introduction) is that this report is based on the reality that humans have contributed to global warming and consequently to climate change. The consequences of human contributions have resulted in an increase in the level of carbon dioxide in the atmosphere and a concurrent increase in global temperatures.

Climate change is a significant current issue. It is important to understand the origin, effect and future consequences of the phenomenon. While it has been stated that climate and weather change over time because of regular terrestrial hot and cold phases, not every weather and climate variation can be attributed to climate change. Nonetheless, it is necessary to be aware of climate change, of its consequences and of how we, as humans, contribute to it. Climate change and global warming can disrupt the regular cycles of the earth, causing increasingly brutal and unpredictable weather patterns.

Climate change influences and affects the supply of water, because changes in the earth's climate and weather alter the availability of usable water. The following sections will introduce the importance of and current problems associated with water supply.

3.2 AN ANALYSIS OF WATER SUPPLY

Water, as emphasised by Bates et al. (2008, 7), is “indispensable for all forms of life and is needed, in large quantities, in almost all human activities.” It is an irreplaceable commodity that is essential for the development of any human habitation, and as a vital necessity it determines the continued existence of man (Flinn and Grant, 1992). “In fact, without water, life as we know it could not exist” (Miller, 1996, 453).

“Water is never finally consumed: it changes its location, its form and its degree of purity but it does not leave the global system” (Barclays Bank, 1971, 11). Water repeatedly converts from one form to another, because it is a renewable resource: from evaporation to rainfall, to runoff and storage, to evaporation, before the cycle begins again (Hirji et al., 2002). There will never be global water scarcity; the problem lies with the adequate preservation and allocation of water (Barclays Bank, 1971).

“Global supply is fresh water lying on the surface of the earth stored in rivers, lakes and streams or temporarily frozen as ice and snow” (Barclays Bank, 1971, 11). The supply of water is affected by a wide range of factors:

1. Regular rainfall brings a fixed supply of water, which in turn seeps into the ground;
2. Increased water supply due to heavy rainfall or flooding will only occur if there is adequate storage capacity;
3. Heavy rainfall that occurs in short surges may not necessarily be a positive aspect, because due to the vast amounts of rainfall a great deal of water may be wasted, and there may be a scarcity of water between storms (Jarman, 2007).

Water shortages might produce a range of outcomes, including undesirable health-related implications (e.g. diseases from water contamination and parasites); affected food supply and agriculture; and a change in biodiversity and ecosystems (Bates et al., 2008). Increases in population and urbanisation may

possibly cause additional stress and competition for this limited resource (Hirji et al., 2002).

In reference to climate change, the effect that climate change has or is going to have on water supply will be guided by changes in temperature and precipitation, and consequently its effect on drought, floods and water availability. However, Bates et al. (2008, 7) believe that “so far, water resource issues have not been adequately addressed in climate change analyses and climate policy formulations”. This point demonstrates that exact and specific changes from climate change are difficult to state, but nevertheless Houghton (2004) and Bates et al. (2008) concluded that that freshwater resources have a high probability of being influenced by climate change. Bates et al. (2008) state that this will have extensive consequences for both ecosystems and humans. Additionally, Bates et al. (2008) stress that due to climate change the environment and humanity will experience the greatest stress in water availability and quality.

Climate change causes unpredictable climate and weather changes that lead to severe natural hazards and unpredictable rainfall patterns. Therefore climate change is going to influence water supply by conditional changes in precipitation, temperature, drought and floods. Changes and increases in variability of these factors are going to lead to changes in the availability of water, the demand for water and may cause water stress. “Climate change because of global warming will result in large changes in water supplies in many places” (Houghton, 2004, 164). Houghton (2004) demonstrates that due to increased and unpredictable rainfall and higher temperatures, this will bring about more powerful and larger number of floods and droughts. Hence, this will lead to changes in the supply of water and the demand for water.

Consequently, this links back to the points in chapter two, of demonstrating the link between planning and climate change; planning performs a significant role, as it shapes the development and growth of a city and contemplates the quantity of water that needs to be supplied. The actual existing and potential impacts from climate change on the supply of water are presented and expanded in chapter four.

Lawson (2008) identifies an interesting theory in relation to the predicted shortage of water supply in the future. He states that the envisaged water shortages may not necessarily be attributed to climate change, but believes our dilemma is related to the massive increase in the earth's population. Lawson argues that this will greatly increase the demand for water, whereas the supply of water will remain constant (Lawson, 2008). This point indicates and reiterates that the future of water supply is going to be affected by a variety of aspects that will include climate change.

3.3 WATER SUPPLY PROBLEMS IN SOUTH AFRICA

In Africa, water is an important existing and potential issue (Bates et al., 2008). Africa suffers the following water-related problems: inconsistency of rivers; fast runoff on arid land after intense rainfall; excessive transpiration and evaporation; greater water needs owing to extreme heat; and unpredictable seasonal rainfalls (Barclays Bank, 1971). "Of the 19 countries in the world that are classified as water-stressed, more are in Africa than any other continent" (Brunner et al., 2005, 176).

In southern Africa, water is a threatened resource, because the sub-Saharan region has been prone to droughts since the 1960s (Bates et al., 2008). This is mainly exacerbated by the following:

1. Transboundary waters create uncertainty in water supply due to complicated water rights;
2. Severe climatic unpredictability and rising temperatures;
3. Overuse of water, the loss of wetlands, water pollution and degradation of the watershed result in the increased deterioration of the water supply (Hirji et al., 2002).

Climate change may place extra stresses on water accessibility and availability (Bates et al., 2008). Hirji et al. (2002, 41) emphasise that "climate variability has

always been a fact of life in southern Africa, and the emerging challenge is the expected increase in variability due to global climate change."

Murewi and Sithole (2009) emphasise that Africa, as a developing continent, has been categorised as the most susceptible to climate change and variability. Ironically, for a continent that is so hard hit, Africa "produces the smallest amount of the greenhouse gases blamed for climate change" (Baldauf, 2006, 1).

Since South Africa lies within a semi-arid region, its water resources are limited and sparse. The availability of water nationwide is unequal on account of irregular spatial coverage, seasonality and the unpredictability of rainfall. Furthermore, evaporation outweighs rainfall. Generally, urban areas are located far away from big rivers, but South Africa is susceptible to both droughts and flooding (DWAF, 2004).

Surface water is the predominant means of accessing water in South Africa. In places where surface water is inadequate, for example in arid and rural areas, groundwater is used. Notably, 66% of the normal river flow remains in the rivers, therefore this water can be used further down the river and in neighbouring countries' (DEAT, 2007b).

According to DWAF (2004), the use of water in South Africa is divided into:

1. Irrigation – 62%;
2. Urban and domestic use – 27%;
3. Power generation, mining and industries – 8%; and
4. Forest plantations – less than 3%.

The South African Department of Environmental Affairs and Tourism (DEAT) (DEAT, 2007a) identified a number of factors that have an effect on the availability of water in South Africa. These include:

1. Human activities and urbanisation influence the level and speed of water, and limit the quantity of water that filters into the groundwater;
2. Unwise agricultural practices cause land erosion, leading to valuable topsoil being washed away into rivers;
3. Climate change;

4. Foreign vegetation uses more water; and
5. Human migration patterns place undue stresses on urban water supply.

While looking at the water supply problem in South Africa, Barclays Bank (1971, 47) noted that “few countries in the world have so formidable a basic problem in respect of water supplies as South Africa”. The warning that there would be water supply problems in South Africa by the year 2000 was already presented in 1971 (Barclays Bank, 1971).

In the most recent studies and projected demographics on water supply in the Southern African Development Community (SADC) region, South Africa is at present in the ‘water stress’ stage and will probably move into the ‘water shortage’ stage by 2025 (Hirji et al., 2002). Hirji et al. (2002, 5) point out that “in southern Africa, water is not only an essential resource, but also a limited and fragile resource”, because local water supply is under great stress.

According to Hirji et al. (2002), South Africa withdraws the most water in the whole SADC region. The researchers also noted that the South African population makes up 25% of the total population in the region, but its withdrawal of annual freshwater represents 63% of that of the entire SADC region. Consequently, ”the spectre of water scarcity in the region is now a reality and it is likely to seriously undermine food production, environmental conservation and economic development” (Hirji et al., 2002, 33).

South Africa, as has been revealed, is a water-stressed nation, but Du Plessis et al. (2003) draw attention to the fact that as the country grows and develops in order to offer a sufficient quality of life for all its people, the demand for water may exceed the supply. “Based on a population growth rate of 0.5%, domestic demand for water is expected to grow at 219% between 1996 and 2030” (Du Plessis et al., 2003, 241).

In summary, climate change arises out of global warming that has been induced by human activity. Climate change produces three main outcomes that will affect the design and function of future cities. It is a continuous process that will have future impacts caused by present carbon dioxide levels. The notion of climate

change arose in the 1960s, and since the 1970s the phenomenon has continued to be investigated on the one hand, and questioned on the other. In 1995 it was established that climate change came about as a result of human-induced carbon dioxide production. Problems relating to perceptions about climate change include issues such as denial, a lack of knowledge, discrimination between the countries' of the north and the south, general misunderstanding, and the notion that it is a fairly recent development in science. This report supports the notion that climate change is a result of man-made carbon dioxide emissions, and agrees that the future impacts and consequences of climate change need to be examined.

Water is an important product that is required by all species. Water supply is a renewable, cyclical process that is altered by rainfall and severe natural events. Climate change, which causes unpredictable climate and weather changes, affects the levels of water supply available for use and for general consumption. Planning controls the way in which urban areas develop, and could help to determine whether the necessary water will be available to us, in the future.

Problems relating to water supply in Africa and southern Africa include: the unpredictability of rainfall; the seasonality of rain; drought; high evaporation and the misuse of water. In addition, climate change will severely impact on Africa, even though the continent makes the smallest contribution to carbon dioxide emissions. As South Africa is a semi-arid country, which also has problems with the unpredictability and seasonality of rainfall, water shortages are expected to occur here by the year 2025.

The importance of this chapter in relation to the rest of the report is that it presents and examines two main, fundamental issues. The rest of the report refers to and is based on these two main issues. The exact impacts of climate change on water supply are presented and described in Chapter four. Chapter five provides a more detailed explanation of the context and climate of South Africa and Johannesburg in particular, the availability of water, and the effect which climate change has on water resources. Without the necessary knowledge contained in this chapter, the information presented in the rest of the report would be useless.