International Scholars Journals

African Journal of Environmental Economics and Management ISSN 2375-0707 Vol. 6 (1), pp. 384-393, January, 2018. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Review

An assessment of the effectiveness of water management in South Africa

***Candice Barnard, Justin Shuttleworth and Mark C. Verwoerd**

Civil and Chemical Engineering Department, University of South Africa – UNISA, Corner Christian de Wet Road and Pioneer Avenue, Florida, Private Bag X6, 1710, Florida Campus, Johannesburg, South Africa.

Accepted 12 October, 2017

In South Africa, there are many challenges regarding water management. Inadequate rainfall, may contribute to mismanagement, hence political breakdowns and racial groups do also contribute to the problem. To list some of the major challenges for effective management are: limited physical resources, a long cycle of inadequate rainfall, a rapid growing population, and stagnant economies. Water resource management is crucial for human security. In South Africa, almost everyone is affected by mismanagement of water resource, hence those living in poor area are the most affected as they do not have access to potable water and proper sanitation. Many policy-makers, researchers, and water managers advocate that water must be managed at the level of river basins, based on the argument that river basins are a ''natural'' unit and thus the logical unit for water management. Although stakeholder participation in water management is advocated, actually including the poor and achieving substantive stakeholder representation has proven elusive in practice. More often than not, participation is little more than token consultation, with no decision-making power in the hands of the people concerned? Too often, the participation discourse draws attention away from the very real social and economic differences between people and the need for the redistribution of resources, entitlements, and opportunities. This is typified by the definition of stakeholders as water.

Key words: Water, management, resources, stakeholder, population, economy.

INTRODUCTION

Water may be everywhere, but its use has always been constrained in terms of availability, quantity and quality (Biswas, 2004). The scarcity of water globally has lead to intense political pressures, often referred as "water stress". Furthermore, water problems not only involve political boundaries but, it also evades institutional classification and eludes legal generalization (Wolf, 1999). Many challenges regarding water management continue to face the world. Some of the primary difficulties may include: limited physical resources, a long cycle of inadequate rainfall, a rapid growing population, and stagnant economies. Complex challenges such as these dictate a critical need to manage and conserve water resources properly (Christopher, 1988).

In order to adapt to water shortages, some changes are needed that will maintain or improve the ability of a system such as the municipal water supply to continue to serve its function (Ivey et al., 2004). Hence, problems relating to water are neither homogenous, nor constant or consistent over time. They often vary from one region to another, even within a single country, from one season to another, and also from one year to another (Biswas, 2004).

Solutions to water problems depend not only on water availability, but also on many other factors such as: the processes through which water is managed; competence and capacities of the institutions (private and government) that manage them; prevailing socio-political conditions that dictate water planning; development and management processes and practices (Ivey et al., 2004; Biswas, 2004); supply management (Ivey et al., 2004) appropriateness and implementation status of the existing legal frameworks; availability of investment

*Corresponding author. E-mail: barnard.cad@yahoo.co.uk

funds; social and environmental conditions of the countries concerned; levels of available and usable technology; national, regional and international perceptions; modes of governance including issues like political interferences, transparency, corruption, etc.; educational and development conditions and status; quality and relevance of research that are being conducted on the national**,** sub national and local water problems (Biswas, 2004).

The current trends indicate that water problems will continue become more and more complex conflicting or interfering with other developmental sectors such as energy, agriculture, mining, transportation and communications and with social sectors including education, environment, health, rural and regional development (Biswas, 2004). In addition, water demands are increasingly due to population growth, groundwater levels are dropping down, surface water supplies are increasingly contaminated and becoming threats to living beings, delivery and treatment infrastructures are aging (Wolf, 1999). According to the World Bank, it was estimated that it would take about $600 million dollars to repair and improve the world's existing water delivery systems.

IMPACT OF CLIMATE CHANCE ON WATER AVAILABILITY

Access to potable water, sanitation and water for irrigation is already a serious problem in developing countries and is expected to even become more as population growth and climate change exacerbates existing inadequate delivery systems and dysfunctional management institutions. It stands to reason based on the predictions that water resources will be among the most affected sectors by change in the climate. When coupled with population growth and serious economic circumstances, climate change is an additional, highly uncertain and variable factor that exacerbates the difficulties in developing nations (Stachiv and Pietrowsky, 2009).

Climate change has many uncertainties, but generally, climate change can cause temperature increases, intensity of precipitation, storms, droughts and extreme events, change in average precipitation are less certain but will become more erratic and shifting season (Heath et al., 2010).

Studies have shown that greenhouse warming will have major impacts on water resources and a s a results water scarcity is expected to become an ever-increasing problem in the future for various reasons. First, the distribution of precipitation in space and time is very uneven, leading to tremendous variability in water resources worldwide (Oki et al., 2006). For example, the driest place on earth, the Atacama Desert in Chile receives very slight annual quantities of rainfall each year while on the other hand; Mawsynram, Assam, India receives over 450 inches of rainfall annually. If all the freshwater on the planet were divided equally among the global population, there would be 5,000 to 6,000 m^3 of water available for everyone, every year (Vorosmarty, 2000). Second, the rate of evaporation varies depending on the temperature and relative humidity, which impact the amount of water available to replenish groundwater supplies. The combination of shorter duration but more intense rainfall combined with increased evapotranspiration and increased irrigation is expected to lead to groundwater depletion (Konikow and Kendy, 2005). Possible impacts that may affect water planning and project evaluation include; change in precipitations and runoff patterns, sea level rise and land use and population shift may follow from the effects, warmer temperature will accelerate hydrologic cycles altering precipitation, the magnitude and timing of runoff, and the intensity and frequency of flood and droughts. Higher temperature will also increase the evapotranspiration rates and alter soil moisture and infiltration rates (Frederick and Major, 1997; Sullivan and Huntingford, 2009).

Climate change will impact water quality by:

1) Increasing extreme precipitation and flooding, which will increase erosion rates and washing soil based pollutants and toxins into waterways.
2) Contaminating coastal surface and groundwater resources due to sea level rise, resulting in saltwater intrusion into rivers, deltas, and aquifers.
3) Increasing water temperatures, leading to more algal and bacterial blooms that further contaminate water supplies.
4) Contributing to environmental health risks associated with water. For instance, changes in precipitation patterns are likely to increase flooding, and as a result mobilize more pathogens and contaminants (Pacific Institute and United Nation Global Impact, 2009).

WATER MANAGEMENT IN SOUTH AFRICA

Since 1994, the South African Government has undertaken important reforms aiming to address rural poverty and inequalities inherited from the past apartheid regime. Amongst other programs, it has adopted a new water legislation that promotes equity, sustainability, representatively and efficiency through water management decentralization, new local and regional institutions, water users' registration and licensing, and the emergence of water rights' markets (Perret, 2002).

The progressive South African water law (RSA, 1998) is expected to bring about fundamental changes in the way in which water is used and shared among different users. A major aim is to ensure a better balance between efficiency, sustainability and equity needs in water allocations (Levite et al., 2003). Water must be guaranteed for all, especially to meet the basic human

Table 1. Water access and usage among racial groups.

Groups	Poverty rate of individuals (%)	Percentage shares of	
		Population	Poor individuals
Blacks	54.8	80.1	93.3
Coloured	34.2	8.7	6.3
Indians	7.1	2.5	0.4
Whites	0.4	8.6	0.1
All	47.1	100.0	100.0

needs of poor people in rural areas who have been disadvantaged for so long. Furthermore, water cannot be simply allocated to meet the increased demand from agriculture, industry and other productive sectors but must also satisfy the requirements of aquatic ecosystems and the ecological reserve. Finally, responsibility for decision-making in respect of water allocations will be decentralized to the level of the future catchment management agencies (CMAs). A system of authorizations for water abstractions is foreseen with compulsory licensing when the basin is water stressed (Levite et al., 2003).

RURAL POVERTY - THE LEGACY OF DISCRIMINATION POLICIES

South Africa is a lower middle-income country in which agriculture accounts for a particularly low share of GDP compared to most other countries of its category. Although it has a well-performing commercial sector, agriculture represents less than 4% of GDP and 14% of the labor force (Perret, 2002). Moreover, irrigated agriculture and stock watering use about 52% of total water usage (Table 1). The rural population of South Africa is composed of approximately 1.5 million households living on commercial farms (mainly white) and 2.3 million households living in the former homelands. Approximately half the country's population lives in rural areas, and poverty rates are higher there than elsewhere. Poverty is race-related (Table 1). Three out of five children in South Africa live in poor households. Households headed by women are more likely to live in poverty than households headed by men (Perret, 2002).

These persistent traits have several causes of which some are directly derives from the past apartheid policy. It excluded black people from owning or renting land outside the country that was delineated as reserves. Moreover, today, land still remains mostly state-owned, and is granted to users through traditional authorities and regulations. These areas are typically poor rural areas, where many people live under conditions of deprivation as harsh as elsewhere in poorer African countries. Apartheid involved incentives, laws and institutions that favored large farms and discriminated against smaller, labor intensive farming systems (Perret, 2002). Apartheid also gave large white farms privileged access to natural resources, financial and agribusiness facilities, and rural infrastructures.

WATER RESOURCE - SCARCE AND UNEVENLY DISTRIBUTED

South Africa is a water scarce country, due to its low average annual precipitation, and the unevenness of surface and groundwater distribution which is a result of climate and geography and only 8.6% of rainfall converts to useable runoff, the lowest proportion in the world. About 14 million rural and suburban black South Africans still do not have access to running water in their homes. Rural women have to walk long distances to collect domestic water from rivers or water points.

Water resource management is crucial for food and ecological security. Despite the importance water assumes in overall human development, it is among them most mismanaged resources, especially in the context of developing countries including South Africa. Neglect of this important resource has resulted in severe food security problems at the household level and environmental degradation of enormous proportions (Reddy, 2002). The recent national water policy document lacks substances, direction and seriousness in addressing the real issues pertaining to water. It is a sad reflection of the status of water resources in the country. It narrates only the issues or problem areas, which are widely known and acknowledged. But it is silent on the more important aspects of how to go about tackling the problems. Moreover, it does not provide any new insights or approaches (Reddy, 2002).

ROLE OF INSTITUTIONS AND POLICY MAKING ON WATER RESOURCE MANAGEMENT IN SOUTH AFRICA

Resource management practice indicates a great diversity of ways in which individual choices and action are coordinated to balance needs and interests of users with the capacity of the resource system (Maarleveld and Dangb´egnon, 1999; Veeman and Politylo, 2002).

Institutional arrangements (government and private sectors) governing the water sector are undergoing remarkable changes and improving the current state of water management in South Africa (Saleth and Dinar, 2000; Veeman and Politylo, 2002; Wostl et al., 2007). Strengthening institutions and policy makers for the use and management of natural capital such as water is vital in enhancing economic development and alleviating poverty in South Africa (Veeman and Politylo, 2002; Wohlwend, 2007).

WATER LEGISLATION IN SOUTH AFRICA

In South Africa, water legislation draws on old standing traditions (water tribal), local customs and rules of conduct. Water legislation is not an end in itself but it is one of the various instruments (enforcement on water use, policy making, and water regulation) of giving effect to the water policies which it should reflect (Saleth and Dinar, 2000). Accordingly, legislation which is not preceded by, or does not explicitly involve the adoption of certain policies, is unlikely to be effective and non functional (Le Moigne et al., 1997). The policies may be adopted before the legislation and may even originate with another governmental body. To these two factors, namely, policies and legislation, a third policy should be added which can be: A water development plant for each country, and if necessary, specific planning for some river basins or ground water aquifers should also be included (Le Moigne et al., 1997). In South Africa water legislation have been reviewed based on certain hazards, community conflicts or specific uses through the following stages:

1) Legislation oriented towards certain hazards deriving from the existence use of water or water run-off (regulations on flood control, natural run-off of rain-water, and construction of wells.
2) Legislation oriented towards particular uses of water (laws on the supply of potable water, irrigation, river navigation, energy, industry, fish breeding)
3) Legislation oriented towards multiple uses of water and conservation of water as a resource, such legislation being concerned primarily with water and the coordination of its uses and secondarily with the particular uses themselves;
4) Legislation oriented towards the joint management of various natural resources, which takes into account and regulates the interdependence of water and other natural resources (soils, forest, etc)
5) Legislation oriented towards the environment and dealing with water and other natural resources.

The Department of Water Affairs has a division known as the National Water Resource Strategy and its aim is to:

1) Facilitate the proper management of the nation's water resources; provide a framework for the protection, use, development, conservation, management and control of water resources for the country as a whole
2) Provide a framework within which water will be managed at regional or catchment level in defined water management areas and
3) Provide information about all aspects of water resource management,
4) Identify water-related development opportunities and constraints (DWA, 1998; Seward et al., 2006).

Table 1 indicates water accessibility and usage among radial group, advantage and disadvantage groups. The table shows that blacks are the leading group with high rate of poor individuals (54.8%) and is the most leading group in terms of population (93%). White individuals are the least group affected by poverty with only percentage of 0.4%. Indian individuals are the less populated group in South Africa with percentage of 2.5%.

In Figure 1, it can be shown that most of African countries are water stress. Looking at South Africa specifically, in 1990, water availability per human capita was about between 1000 and 2000 m^3 which shows that already South Africa is in water stress situation. According to this figure, it is predicated that in 2025, almost all African countries will be vulnerable in terms of water availability. There are some many factors affecting water availability and these factors are different depending on the countries. Population influx, agriculture, developments are the major factors relating to water scarcity. Another factor that cannot be predicated and controlled and may negatively affect water availability is climate change.

Figure 2 indicates the allocation of water use in South Africa. In this figure, 52% of water allocation is used for agricultural activities while only 10% is allocated for domestic use. This huge imbalance in terms of water allocation and use indicates that, here are no proper legislations on water resource management in South Africa. It seems as if agricultural activities are being considered seriously than human activities. Well, this may be due to economic benefit; hence it looks inappropriate as human lives should be the main concern.

Figure 3 indicates water usage in high income suburbs of South Africa. As previously, it looks inappropriate to use more water on gardening and less for human consumption. When looking at the figure 50% of water is used for gardening and only 2% is used for drinking and cooking. This is inappropriate. South Africa has serious problems when it comes to policy making on water resource management. There is a lot that need to be done in terms of implementation of new legislation on integrated water resources management. Individuals living poor lives wish to have just a cup of clean water while other are using more that of that clean water to decorate their houses. Is there any fairness in this? Well,

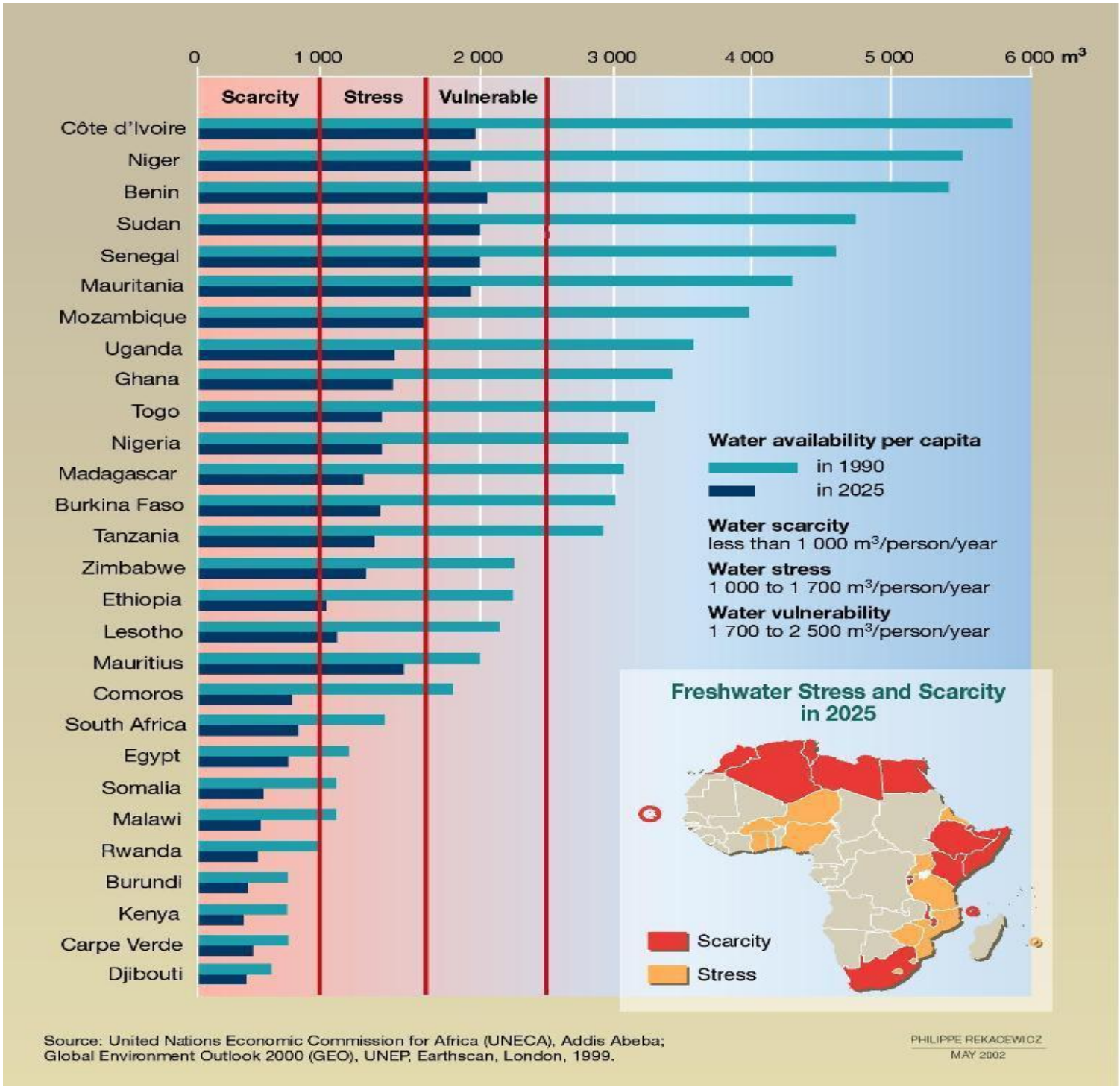

Figure 1. Water situations in Africa including South Africa (Fischer and Heilig 1997).

the answers lie in the hand of policy makers and politics.

In Figure 4, it can be seen that most of African countries are water stress. South Africa is already in water scarcity (less that 1000m3 per capita per year). There are some many factors affecting water availability and these factors are different depending on the countries. In South Africa, population influx, agriculture, developments (mining, industries) are the major factors relating to water scarcity. Another factor that cannot be predicated and controlled and may negatively affect water availability is climate change.

WATER USE AMONG RACIAL GROUPS

Water scarcity is becoming an increasing problem

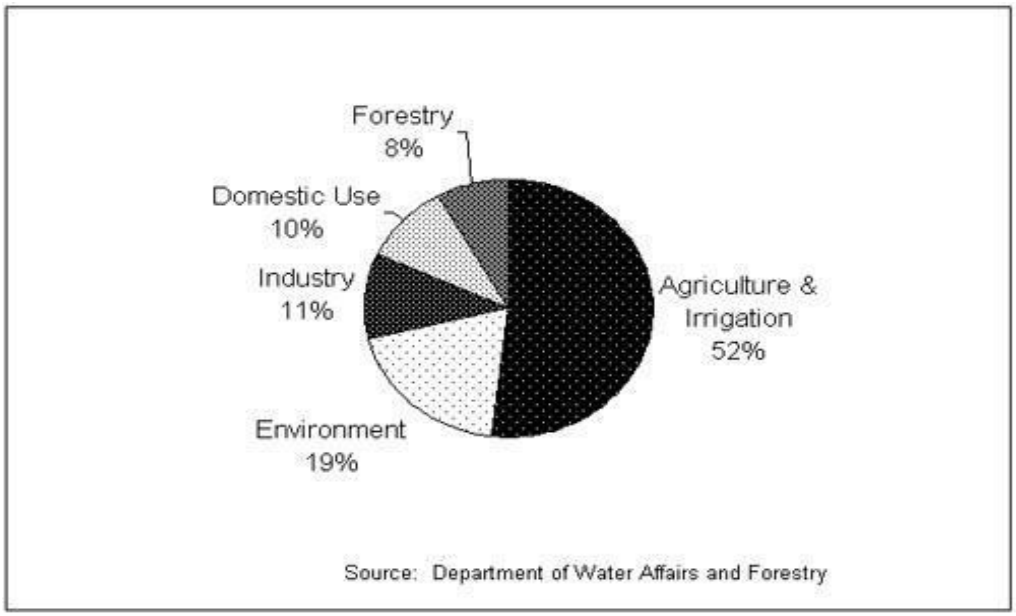

Figure 2. Water allocation and usage in South Africa (Jacobson, 2003)

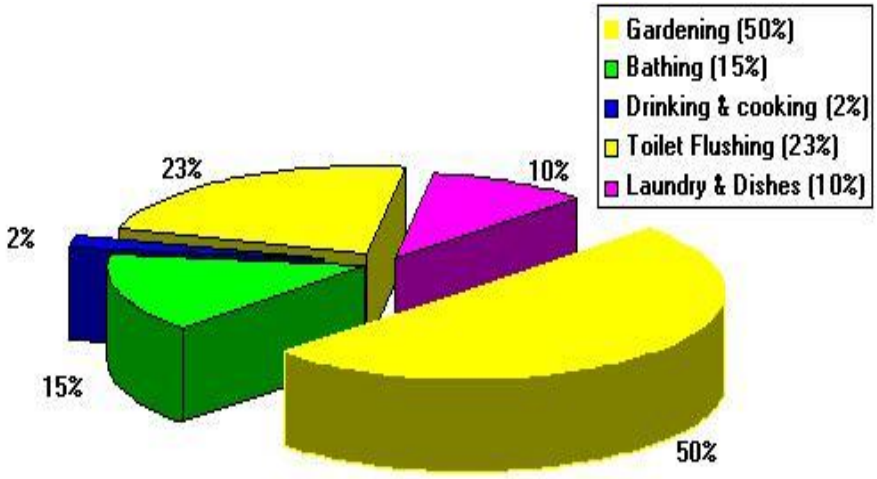

Figure 3. Domestic water usage in high income suburbs of South Africa (www.capetown.gov.za).

worldwide. Over the next few years, an increasing population demand and increasing water use demand will put more pressure on global water resources. By 2025, million of people living in South Africa (SA) will live in country with absolute water scarcity (Figures 1 and 4). This means that they will not have sufficient water resources to maintain their current level of per capita for domestic purposes. This seems to be a global problem especially in African countries. It has been estimated that a population of nearly 200 million people is facing serious water shortages by the 2025 (Figure 4). Nearly 230 million Africans including South Africans will be facing water scarcity, and 460 million will live in water-stressed countries as indicated in Figure 1.

In South Africa there is an imbalance in terms of water allocations and use among different racial groups. Table 1 gives an overview on how water is used amongst racial groups, advantaged and disadvantaged people. Looking at Table 1 blacks are dominant populated group in South Africa, having percentage of 80.1% while Indians being the least populated (2.5%). In this 80; 54.8% of black individuals are faced with poverty and with no access to potable drinking water. White individuals are the least affected with only 0.4% are affected with poverty and have access to potable water. Then, when it comes to percentage share of population and poor individuals; black individuals still lead the groups, having the highest percentage of 93% of poor individuals while white

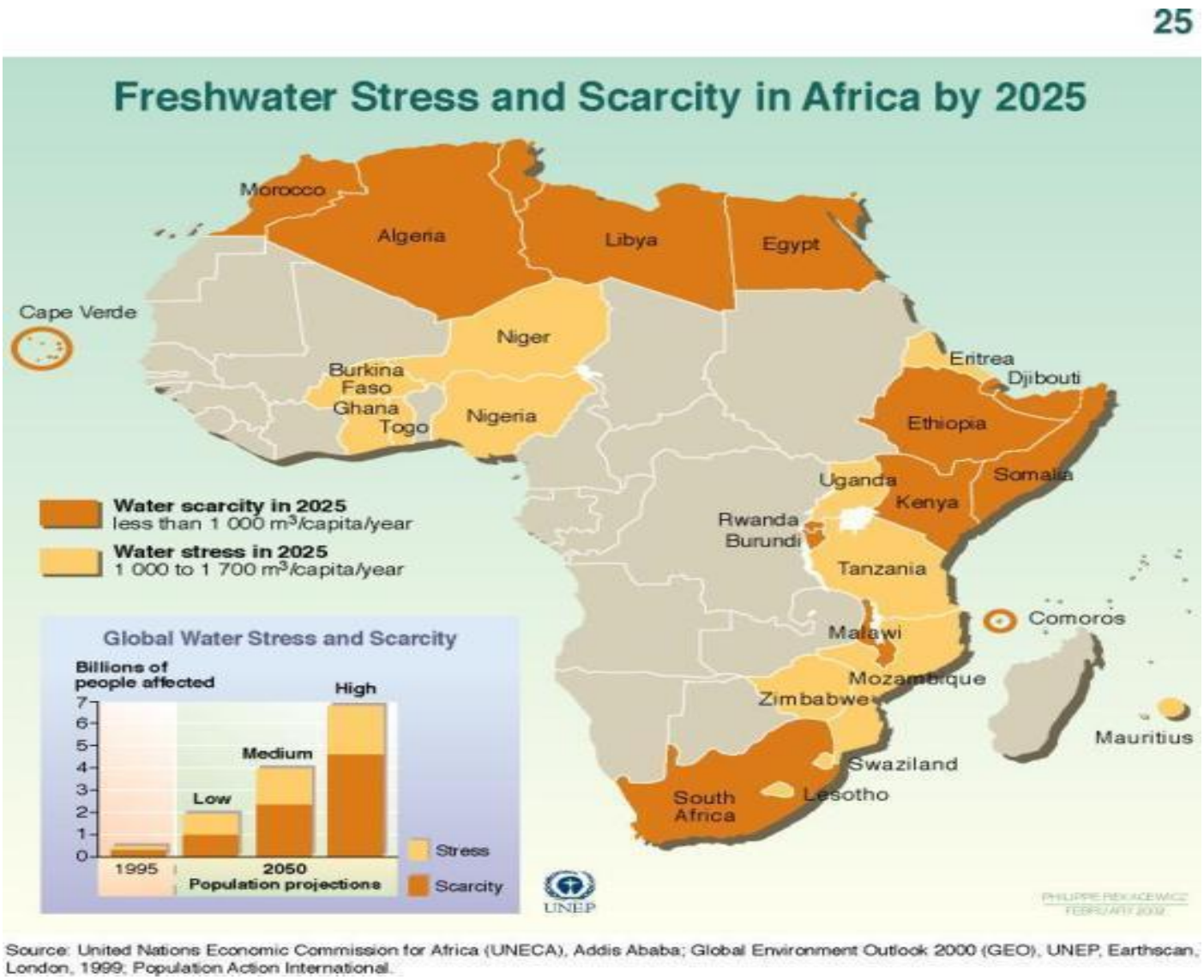

Figure 4. Water stress and scarcity in Africa including South Africa by 2025 (Fischer and Heilig 1997).

individuals only have 0.1% followed by Indian group with percentage of 0.4% (Table 1).

WATER ALLOCATION AND USAGE IN SOUTH AFRICA

The percentage of water usage for agriculture and irrigation is 52% and only 10% is used for domestic use in South Africa (Figure 2). Additionally, the water usage for gardening is 50% and only 2% is used for drinking and cooking in high income suburbs of South Africa and those are the cities where many white individuals live (Figure 3). With all these results in terms of water allocation and use in South Africa; one could ask: Why is there such a huge imbalance in terms of access to natural capitals such as water between racial, advantaged and disadvantaged groups in South Africa? The answer lies within the political powers; the poorer you are, the lesser you get and the easier you are forgotten, but the richer and powerful you are the more you get and have access to good living. South Africa still has a lot to do in term of implementation of new strategies on water resources management.

Implementation of new strategies to improve water resources management in South Africa

Water scarcity has become a significant threat to human well-being; a danger of the water scarcity narrative is that, it obscures issues concerning unequal access to and control over water (Mehta, 2000). While freshwater

supplies are clearly limited, for most people water scarcity is caused by competition between water uses and by political, technological and economic barriers that limit their access to water (Falkenmark and Lundqvist, 1998).

The serious inequality in access to and control over water and the conflicts between the different uses and users of water lie at the heart of the need for new approaches to water management. This need is widely recognized as is the belief that existing institutional arrangements for water management are inappropriate and a major constraint for achieving sustainable water management. To make the transition to more sustainable water management, most analysts recommend managing water based on river basins and increasing stakeholder participation in water management (Wester et al, 2003).

In South Africa, poor people are typically deprived of the benefits of water. They are the only people who suffer from life-threatening water-scarcity. Poor people are also more vulnerable for the adversities. Poverty, defined as a state and process of multi-dimensional deprivation affecting economic, health-related, psychological, socio-cultural, legal, and political facets of wellbeing (World Bank, 2000/2001) is manifest in society development and management of water resources in at least three ways: First, poor people lack the technological assets to access water. The lack of efficient access to available water resources have lead them to drink water of low quality against excessive labor or cash costs, especially during periods of drought. The same holds true for productive water use, for example for cropping.

Ineffective water policies and inefficient water infrastructures seriously disrupt societies as well as the environment. For effective and adequately management of natural capitals in South Africa, the following policies or legislations need to be revised:

1) Legislation oriented towards particular uses of water (laws on the supply of potable water, irrigation, river navigation, energy, industry, and fish breeding).
2) Legislation oriented towards multiple uses of water and conservation of water as a resource, such legislation being concerned primarily with water and the coordination of its uses and secondarily with the particular uses themselves;
3) Legislation oriented towards the joint management (public, private, stakeholders) of water use and allocation. This is a serious problem in South Africa as it has been seen in Figures 2 and 3 that agriculture and gardening seem to be the priority with high demand of water use as opposes to human activities. Legislation oriented towards the environment and dealing with water and other natural resources;
4) The involvement of communities during policy making can assist in understanding the demands (especially the basics) that the communities require. In addition empowering the communities on conservation management can aid in lessening mismanagement or misuse of natural resources (water).

IMPORTANCE OF FINANCIAL MANAGEMENT ON ADEQUATE WATER RESOURCE MANAGEMENT

Politics play major role during the implementation of policy making in South Africa. Hence, this affects the proper management of water resources due to debates on water allocation to South African individuals. It is the fact that the poor individuals do not benefit much in terms of access to natural resources such as water due to political activities. There is a subsidiary group called water allocation monitoring index in South Africa assigned by the Department of water affairs. The main role of this group is to ensure that every South African has access to potable water. However, this group seems not in existence, since some if not most South Africans “mostly the poorer” still do not have access to potable water. Is this group discriminating or could the inefficient operation of this group have to do with politics and money?

The interaction between economics and the environment through institutions is important to resource and environmental economics because, in presiding over the establishment of economic institutions, governments or other responsible agencies implicitly direct behavior with respect to resource use (Saleth and Dinar, 2000; Adler, 2005). Thus, any discussion of sustainable development and the conservation of natural capital should provide explicit treatment of economic institutions and their role in creating the necessary incentives to achieve these objectives (Wolf, 1999; Veeman and Politylo, 2002). The design and functioning of institutions will therefore determine the manner in which resources are allocated and how the income derived through resource management is distributed. The opportunity and transactions costs of institutional changes are not static but change continuously due to the effects of institutional inter-linkages as well as the impact of changes both in the endogenous (politics, racial groups, economy, population growth) and exogenous factors (impact of climate change on water availability) (Wolf, 1999). Since the magnitude of net benefits from institutional changes is a direct function of water scarcity, the economic urge for institutional change increases with each increase in water scarcity. Thus, as water scarcity becomes acute due to economic development or population growth, the real economic costs of inappropriate water institutions tend to rise (Saleth and Dinar, 2000).

Self empowerment of poor individuals on water availability

There is a saying that says “the poorer you are, the easily

you are forgotten but the richer you are the most important you are in your community" This seems true, in South Africa, the most populated individuals are blacks and are the highest in terms of poverty rating. Most of this people have no proper housing, proper sanitation, no access to portable water; yes they are still sustaining themselves to live. They do not just sit back and say we are forgotten, they try hard to keep themselves alive, they even voice out to the government to remind them that they are forgotten. On the other hand, some sustain themselves by practicing indigenous knowledge when conditions are harsh for them. However, government and stakeholders in South Africa should be willing and in a position to assist poor individuals in improving the quality of their lives by supplying relevant and useful resources or tools that will aid them improve their lives.

IMPACT OF CLIMATE CHANGE TO WATER AVAILABILITY: A WORLD PROBLEM

Climate change is a major problem affecting water availability and other natural capitals. This is a global problem and difficult to handle as it's not predictable. Extensive research on the impact of climate change on natural capitals including water is ongoing. With the help of new technologies and satellites that give signals on change in climate, it is promising that climate change can be controlled. But till then, people should be taught on control measures during harsh conditions. Hence, the questions are: are those who know on the impact of climate change on natural capitals send important information to those who do not know especially those in rural areas. Do richer and poorer individuals work together on control measures during unfavorable conditions (water scarcity), or are poor individuals being discriminated, does the government makes sure that every individual in South Africa?

CONCLUSION

Water is the commodity of life, without water many lives are being threatened. There are many challenges regarding water management in South Africa. This is mainly due to inadequate rainfall, hence mismanagement of water resources due to political breakdowns and racial groups also contribute to the problem. Some of the other challenges may include: limited physical resources, a rapid growing population, and stagnant economies. Complex challenges such as these, dictate a critical need to manage and conserve water resources properly. A lot still need to be done in terms of implementation of new strategies to combat some of the challenges negatively affecting proper water resources management in South Africa. In addition, legislations on water access and use need to be revised adequately to accommodate every South African irrespective of race, poor or richer, educated or illiterate. The water allocation monitoring index in South Africa could play a vital role by promoting programs that will ensure all South African get access to domestic and drinking water. However, this group sees not functioning accordingly; this may be due to financial instability and political activities.

Other institutions such as policy makers, legal boards should also strongly involve themselves during the implementation of strategies on integrated water resource management and adequately revising the existing policies on water usage and allocation in South Africa. Growth development and population increase are the major factors resulting in ineffective strategies on integrated water resource management. Therefore, existing policies should be revised consistently based on population growth and developments. Additionally, widespread poverty is the greatest barrier to systematic and proper adaptation. On the other hand, the impact of climate change may also the major factor affecting natural capitals such as water availability.

ACKNOWLEDGEMENT

Authors thank Mr. Pramod Sinha, Department of Civil and Chemical Engineering, University of South Africa, for his drive and contributions throughout the writing of this paper and for his good quality mentorship.

REFERENCES

Adler RW (2005). The law at the water's edge: Limits to "ownership" of aquatic ecosystems. In Arnold, C.A., ed. Wet Growth: Should Water Law Control Land Use? Washington, D.C, Environmental Law Institute.

Biswas AK (2004). Integrated Water Resources Management: A Reassessment A Water Forum Contribution. Int. Water Res. Assoc., 29(2): 248–256.

Christopher G (1988). Freshwater Ecosystems in West Africa: Problems and Overlooked Potentials. Symposium Proceedings. Emerg. Water Manage., Issues.

Department of Water Affairs (DWA) (1998). A guide to the National Water Act No. 36. South Africa.

Falkenmark M, Lundqvist J (1998). Towards water security: Political determination and human adaptation crucial. Nat. Res. Forum, 21: 37–51.

Fischer G, Heilig GK (1997). Population Momentum and the Demand on Land and Water Resources. Phil. Trans. Royal Soc. London, 352: 869-889.

Frederick K, Major DC (1997). Climate change and water resources. Climate Change, 37: 7-23.

Heath T, Parker A, Weatherhead K (2010). How to climate proof water and sanitation serviced for the urban poor. Water and sanitation for the urban poor in collaboration with Cranfield University, pp. 1-9.

Ivey JL, Smithers J, de Loe RC, Kreutzwiser RD (2004). Community Capacity for Adaptation to Climate- Induced Water Shortages: Linking Institutional Complexity and Local Actors. Environ. Manage., 33(1): 36–47.

Jacobson M (2003). Water Policy and Pricing Timber Plantations in South Africa: Implications for Sustainable forestry. World Forestry Congress. Québec City, Canada.

Konikow LF, Kendy E (2005). Groundwater depletion: A global problem. J. Hydrogeol., 13: 317-320.
Le Moigne G, Dinar A, Sandra G (1997). Principles and examples for the allocation of scarce water resources among economic sector. Agriculture and Natural Resources Department, World Bank.
Levite H, Sally H, Cour J (2003). Testing water demand management scenarios in a water-stressed basin in South Africa: Application of the WEAP mode. Phy. Chem. Earth, 28: 779–786.
Maarleveld M, Dangb´egnon C (1999). Managing natural resources: A social learning perspective. Agric. Hum. Values, 16: 267–280.
Mehta L (2000). Water for the twenty-first century: Challenges and misconceptions. Brighton, UK: Institute of Development Studies.
Perret SR (2002). Water policies and smallholding irrigation schemes in South Africa: A history and new institutional challenges. Water Policy, 4(3): 283-300.
Reddy VR (2002). Water security and management: Lessons from South Africa. Econ. Polit. Wkly, 37(28): 2878-2881.
Republic of South Africa (RSA) (1998). National Water Act. Government Gazette, 26th August, 398: 19182. Cape Town.
Saleth RM, Dinar A (2000). Institutional changes in global water sector: Trends, patterns, and implications. Water Pol., 2: 175-199.
Seward P, Xu Y, Brendonck L (2006). Sustainable groundwater use, the capture principle, and adaptive management. Water Res. Commission, 32(4): 474-482.
Stakhiv EZ, Pietrowsky RA (2009). Adapting to climate change in water resources and water services. Institute for Water Resources, U.S. Army Corps of Engineers, 7701, Alexandria, Virginia, 22315-3868.
Sullivan CA, Huntingford C (2009). Water resources, climate change and human vulnerability. 18th World IMACS / MODSIM Congress, Cairns, Australia 13-17 July, 2009. http://mssanz.org.au/modsim09.
Veeman TS, Politylo J (2002). The role of institutions and policy in enhancing sustainable development and conserving natural capital. Environ. Dev. Sustain., 5: 317–332.
Vorosmarty CJ, Green P, Salisbury J, Lammers RB (2000). Global Water Resources: Vulnerability from Climate Change and Population Growth. Sci., 289: 284-288.
Wester P, Merrey DJ, de Lange M (2003). Boundaries of Consent: Stakeholder Representation in River Basin Management in Mexico and South Africa. World Dev., 31(5): 797–812.
Wohlwend BJ (2007). Legal and institutional means to implement integrated water resources management. (http://www.bjwconsult.com).
Wolf AT (1999). Water and human security. Issue No. 3. Department of Geosciences, Oregon State University.
World Bank - World Resources Institute (2000 – 2001). A guide to world resources: People and ecosystems.
Wostl CP, Craps M, Art-Dewulf A, Mostert E, Tabara D, Taillieu T (2007). Social Learning and Water Resources Management. Ecol. Soc., 12(2): 5.