RAINWATER HARVESTING: A SUSTAINABLE PRACTICE FOR LOW- INCOME HOUSING IN SOUTH AFRICA

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Master of the Built Environment in Housing

2013

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A Research Report submitted to the Faculty of Engineering and the Built Environment, University of Witwatersrand, Johannesburg, in partial fulfilment of the requirements of the degree of Master of the Built Environment in Housing.

Johannesburg, 2013

DECLARATION

I, Josephine Peace Enninful, declare that this Research Report is my own unaided work being submitted for the degree of Master of the Built Environment in Housing in Housing at the University of Witwatersrand, Johannesburg, South Africa. I have not previously in its entirety or in part, submitted it at any university for a degree.

Signed:

19th September 2013

ABSTRACT

This report gives an overview on issues surrounding sustainable water management practices, specifically, rainwater harvesting (RWH), for low income households in South Africa. The agenda for sustainable development in South Africa has over time, downplayed the importance of Rainwater Harvesting. However, the South African Region is already a water scarce area, experiencing environmental and other threats to its limited water resources such as rapidly increasing demand for water from a growing population and economic sectors.

A purely qualitative research method was used to conduct this Research Report which demonstrated that Rainwater Harvesting across the world can bring immense socio-economic and environmental benefits such as increased food security, improved sanitation and quality of the natural environment. A key question of this Research Report was to establish whether Rainwater Harvesting could be feasible for use in Low-income households in South Africa. This research revealed that the DoH and DWAF can constitute projects for Rainwater Harvesting for Low-income households in their programmes.

DEDICATION

My God, my strength and provider.

I dedicate this work to Dr. Ato Essuman (Chief), a father I always prayed for.

ACKNOWLEDGEMENTS

My foremost gratitude goes to my mother, Mrs Regina Mintah, who has always been a huge pillar in my life, supporting and encouraging me all the way.

My greatest gratitude goes to my course conveyor, Prof. Marie Huchzermeyer, who was always available to provide invaluable advice, support and direction. She worked earnestly to ensure that I was not left out of any class activity and for me to successfully complete this course.

My supervisor, Dr. Brian Boshoff constantly engaged me and ensured that I remained focused on the subject. He helped to shape my knowledge in other aspects of this Research Report. I am therefore deeply indebted to him. Also, I wish to acknowledge the support of Dr. Harry Quainoo, of the school of Construction and Economics was also very instrumental in providing the necessary direction and advice when needed.

Additionally, my course mates in the 2012 MBE Housing class contributed to enrich my knowledge in housing from different parts of the world. I say thank you. Last, but not least, I wish to express gratitude to my friends, Gladys Anaman, Myra Quarm, Pumla Bafo who ensured that things were 'in order' whilst I was away from campus and to my uncles Raymond Nii Armah and Uncle Kojo who ensured that I was safe and comfortable all through my stay away from home.

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LIST OF ACRONYMS AND ABBREVIATIONS

AIDS	Acquired Immune Deficiency Syndrome
ARE	Swiss Federal Office for Spatial Development
BNG	Breaking New Ground
CEE	Centre for Environment Education
COHRE	Centre on Housing Rights and Evictions,
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
EPA	Environmental Protection Agency
GRR	Global Risk Report
HIV	Human Immuno Virus
ICESR	International Covenant on Economic, Social and Cultural Rights
IRD	Institute of Research Development
ISSD	International Institute for Sustainable Development
IWRM	Integrated Water Resources Management
MONET	Monitoring Sustainable Development
NASA	National Aeronautics and Space Administration
NDoH	National Department of Housing
NWRS	National Water Resource Strategy
RDP	Reconstruction and Development Programme
RWH	Rainwater Harvesting
SAEFL	Swiss Agency for the Environment, Forests and Landscape
SDC	Sustainable Development Commission
SFSO	Swiss Federal Statistical Office
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environmental Programme
UDHR	Universal Declaration of Human Rights
UN	United Nations
UNICEF	United Nations Children's Fund
UNHCR	United Nations High Commissioner for Human Rights
WBG	World Bank Group
WEF	World Economic Forum's
WHO	World Health Organisation

WMO	World Meteorological Organization
WSSCC	Water Supply and Sanitation Collaborative Council
WWF	World Wildlife Fund

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Considering the acute problems of water scarcity that many are likely to face in the near future, it would seem prudent not to ignore the direct exploitation of nature's simplest and most fundamental source of renewable freshwater - rain (Gould & Nissen-Petersen, 1999).

Keywords: Rainwater Harvesting; Sustainable; Low income Housing; South Africa

CHAPTER 1: INTRODUCTION

Water, sometimes called 'Blue Gold', is undeniably an essential resource for the sustenance of human life (Guardian News b, 2012: unpaginated). Throughout history, human settlements have been developed close to water sources and people depend on it for domestic, social, economic, religious and a myriad other purposes (The Economist, 2010; Pandey, Gupta and Anderson; 2003). Due to its nature, this resource is constantly under threat from human activities and the environment, notably industrial activities and global climate change (*ibid.*). Rapid population growth, industrialization, intense irrigation coupled with global climate change is increasingly putting pressure on available water sources (The Economist, 2010). This occurrence makes it difficult for adequate quality water to be accessible to most people, especially the poor and people in water scarce regions.

Currently, water supply in most countries is provided through a bulk centralized system for supply, such as dams, groundwater development and piped distribution systems. This system has proved to be unreliable, typically in cases of droughts, water mismanagement, earthquakes, landslides and or accidents (Roebuck, 2007). As a result of unreliable modern systems of water supply and global climate change, Rainwater Harvesting (RWH) is increasingly becoming an alternative system for about 100,000,000 people globally (Gould & Nissen-Peterson, 1999; Heggen, 2000). There is therefore increasing advocacy among stakeholders and professionals for the practice of RWH as an alternative source of water supply. Lack of this precious resource has the potential to bring about difficulties such as deepening of poverty, disease, famine and even conflicts between countries. (*ibid*.; Gould, 2012; Moriarty, 2010; Roebuck, 2007; Heggen, 2000; Gould & Nissen-Peterson, 1999).

Various governments and world organizations recognize the importance of affordable consistent water supply for all, especially the poor and vulnerable. This is evident in the laws and policies in place to ensure adequate water for all. For instance, Article 25 of the Universal Declaration of Human Rights, 'The Declaration' of 1948 and Article 11 of International Covenant on Economic, Social and Cultural Rights (ICESR), 'The Covenant' of 1966, are International Rights to adequate housing for all which is

linked to access to potable water (UDHR, 2012; UNHCR, 2012, COHRE, 2005). The Universal Declaration of Human Rights of 1948, also known as 'The Declaration' of 1948, states the right of all persons to basic human needs which includes water. 'The Covenant' of 1966 generally calls on governments to recognize and create the conducive atmosphere to make the rights stated in 'The declaration' possible. Therefore, governments are urged to facilitate the provision of basic services such as water for all citizens, especially vulnerable.

This need to ensure access to adequate water supply is also reflected in South Africa's post-apartheid housing and other policies, especially those pertaining to the poor. Section 27 (1) of the South African Constitution states the right of every individual to have access to sufficient water, while Section 153 (a) of the Constitution requires municipalities to provide basic services, which includes the provision of water. Key legislation such as the Water Services Act No. 108 of 1997 has the objective of providing for the rights of access to basic water supply and basic sanitation by setting national standards and norms (Department of Water Affairs, 2009). In support of this legislation, there are a number of RWH harvesting projects in the country – Botlhabela Village Project in Alexendria, Johannesburg, the Cato Manor green initiative at Durban, the AWARD and SSP's projects in Craigieburn and Thlakalahle Villages and Mahasheshe School all in Limpopo province, as well as the Shaster Foundation's initiative at the Indlovu Centre, Cape Town (AWARD, 2013; Botes, 2012; Naidoo, 2011; Becker, Fitzell and Royer, 2007).

There are additional plans to protect available water sources and encourage sustainable water use for all South Africans (Department of Water Affairs, 2004). The *Integrated Resource Planning* process is a framework which is adapted to implement sustainable water use (*ibid.*). It applies a 'holistic way of analysing the change in demand and operation of water institutions that evaluates a variety of supply and demand side management measures to determine the optimal way of providing water services' (*ibid.*; 36). The approach is termed 'integrated' as it considers how financial, energy and environmental resources can be harnessed to achieve efficiency in the management of water resources (*ibid.*). Further analysis and discussions in this research report will show how the aforementioned efforts of the government and other organisations to ensure adequate water provision are still inadequate.

Additionally, research conducted in 2010 on a rights based perspective to access to urban services in South Africa, revealed that 10.7% of the total South African population did not have access to potable water (Tissington, 2012; Stats SA GHS 2010). The issue of availability of water therefore becomes an

essential component in ensuring adequate living standards for all citizens. This report discusses and critiques the potential of RWH to significantly supplement available water sources for the low income housing group in South Africa, particularly in the Gauteng Province. This has become vital since formal piped water systems have become increasingly unreliable, making the economic and social lives of the poor more difficult.

1.2. Background on Global Water Scarcity

There is a growing concern around the world regarding water scarcity (UN-HABITAT, 2012; WWF South Africa, 2012). Much of this problem is related to issues such as global climate change, geographical location of some regions and overpopulation (Global Footprint Network and WWF, 2008). It is a scientific fact that water availability in every part of the world is determined by the weather patterns, therefore some areas have long rainy seasons whilst other parts have shorter seasons with very little rain (Minerva Union, 2013; Lu, Reichler, Vecchi, 2008).

In regions with shorter rainy seasons, the global climate change and rapid population growth has increased pressure on scarce water sources. Next to the financial meltdown, water shortage is listed as the second key risk by the World Economic Forum's (WEF) Global Risk Report of 2012 (WWF South Africa, 2012). According to the United Nations (2000), in the year 2000 1.1 billion people lacked access to safe water and 2.4 billion people lacked adequate sanitation. This number has grown rapidly over the last 12 years, making water an even scarcer resource over time (WHO; UNICEF; WSSCC, 2000). Campaigns have begun for measures to protect available water resources for the future; however, there is a need to emphasize immediate water management practices (Mariorty, 2002).

1.2.1. Water Scarcity in Gauteng Province, South Africa

South Africa generally lies in a region which is about to reach 'physical water scarcity' (Guardian News b, 2012: unpaginated; WWF South Africa, 2012). Gauteng province, the most populous and smallest Province in the country, has a population of about 11,191,700 as at 2010 (Stats SA, 2012). It lies in the heart of South Africa's Highveld and is home to 2 major cities: Johannesburg and Pretoria. Gauteng is considered the economic hub of the country, the Southern Africa sub region and the continent (*ibid.*). After 2000 when the Province was deemed as the location for the 2010 world cup, Gauteng has undergone many developmental projects (Social Housing

Foundation, 2010). The Province also lies in this water stressed area and often falls short in terms of water supply, especially affecting the low income housing sector (*ibid.*). This means that the geographical location of the province puts it in a more difficult position in terms of management of water resources for supply to its large population.

Fig. 1. Location Map of the Gauteng Province. Source: Tourism Maps, 2011.

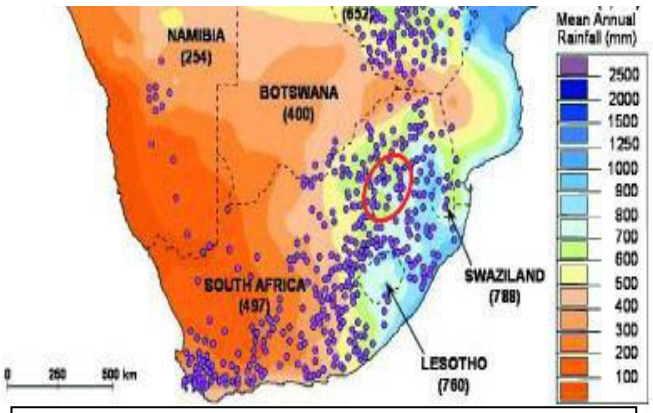


Fig. 2. Map of the Southern Africa region showing the rainfall pattern with Gauteng marked in red. Source: Tourism Maps, 2011.

Government policies such as the Free Basic Sanitation Implementation Strategy and Free Basic Water policy are insufficient for ensuring water accessibility, especially in the case of people with HIV/AIDS (Tissington, 2012). Alternate sources of water management practice are uncommon in households partly due to the design of their houses, lack of education about the viability of RWH to support their socio-economic lives and lack of technical knowhow to install affordable systems on their own (Moolla, Kotze and Block, 2011). Also, the country's key policies and strategies such as the *Breaking New Ground* (BNG) set up by the National Department of Housing (NDoH), do not place enough emphasis on sustainable water management practices, specifically, RWH harvesting for domestic use in water scarce regions such as the Gauteng Province. However, these policies are focused on developing 'integrated development and sustainable human settlements' (Tissington, 2011: 64; NDoH, 2008). The core issues in their campaigns for sustainability centre on the efficient use of energy thus neglecting the sustainable water management practice of RWH as a means of achieving sustainable development.

1.3. Problem Statement and Rationale

In the light of rapid global climate change, rapid population growth and pressure on available water sources, it is expedient to consider sustainable water management, especially for vulnerable groups such as low income groups (WWF South Africa, 2012; Stats SA, 2011; Cloete, 2008; NWRS, 2004; Otieno and Ochieng 2004). Although government policies and laws advocate sustainable water management, there is not enough consideration for RWH. This situation economically puts a strain low income households, since they end up spending a considerable proportion of their disposable income on water (Moolla *et al.*, 2011; Govender *et al*., 2011; Ramashamole, 2010; Tomlinson, 2006).

Additionally, low income houses provided by the South African government's Reconstruction and Development Programme (RDP) are not designed to make use of alternative water sources/sustainable water management, although the RDP programme generally emphasizes sustainability (Moolla *et al*., 2011; Govender *et. al.*, 2011; Ramashamole, 2010). Lastly, sustainable water management comes with an additional cost of installing RWH systems and this may not be affordable to the low income housing sector, making it a requirement for more financial assistance from government for effective implementation (Water AID, 2012; Kahinda, Taigbenu and Boroto, 2007). Low income groups considered in this report represent those earning between R1500 – R3500 as they mostly have some form of shelter and can take advantage of the RWH practice. This group also form a part of those who benefit from government subsidized housing.

1.4. Aims and Objectives

This report gives an overview of the various sustainable water management practice issues, specifically, RWH, for low income households in South Africa. It firstly aims at discussing RWH and whether it could be a viable practice in terms of the agenda of socio-economic sustainability for low income households in South Africa. Secondly, the Report looks at how the system has been used to supplement water provision in various parts of the world and in Africa. Other socio-economic and environmental benefits which the practice of efficient water management has brought to communities are also presented. The relationship between the government policies, programmes and laws concerning water management, conservation and RWH in the country is then critically analysed. This is done in order to contribute to finding practical means for introducing RWH to low income households and consequently sustainable

housing. Some sustainable technical approaches for installation of RWH systems in low income housing are identified, as well as policies and laws that can be instituted to encourage the practice in poor households for in South Africa.

RWH could ultimately become a viable practice in Africa and on other continents. It presently supplements available water sources and contributes positively to the socio-economic activities of low income housing groups. This Research Report is based on the premise that introducing RWH as part of government's sustainability policies and laws has the potential to significantly reduce pressure on incomes of the poor and improve on their socio-economic lives. The practice will also ease stress on the environment as the demand on the few water resources will be reduced. Furthermore, it is surmised that safe and affordable RWH systems can be adapted for use in low income households in South Africa. In this light, the research questions are as follows:

1.5. Research Questions

1. What is RWH and could it be a viable sustainable socio-economic practice for low income households in South Africa?

a. What is the relationship between the laws, policies and programmes on water sustainability and RWH for low income housing in South Africa?

b. What are some of the sustainable technical interventions that can be adopted to make RWH beneficial to the socio-economic lives of low income households in South Africa?

1.6. Research Methods

This study is conducted in order to highlight issues surrounding sustainable water management in South Africa and the economic and socio-economic importance of RWH for the formal low income housing group. The study is descriptive, exploratory and analytical. A purely qualitative approach is used, consisting of document analysis and literature review which Mouton (1996) describes as an analysis of known facts and information from trusted sources. The research report 'represents' the low income housing group (Cresswell, 2009: 176).

Issues on housing, water conservation, policies and practices are therefore discussed and critiqued. It also involves a literature review of international and local issues on sustainable water management.

Data from various organizations and institutions related to water sustainability are reviewed and analysed to establish key issues concerning water and its use in formal low income households.

In this regard, the efforts of Institutions such as the NDoH, DWAF, UNECE and UNEP to ensure easy access to water resources for communities and protect the environment are discussed. An approach such as the IWRM is reviewed to investigate how water availability influences the activities of households, notably the daily lives of women and children in poor households in developing countries. Reviews of the DWA's approaches to sustainable water management show that South Africa has adopted the IWRM approach.

As access to water is linked with housing provision, issues surrounding housing in South Africa, post-apartheid are discussed among with the new approaches to water management. The housing White paper on which the NDoH and DWAF draw some of their policies and programmes, exhibit an awareness on the need to harness environmental, human, institutional and infrastructural factors efforts to provide of water. It is on the basis of this document that policies such as the Free Basic Water policy came into existence. A critical look at the work of the NDoH and the RDP housing programme show that the challenges being experienced in the programme are linked with reversing the socio-economic, environmental and physical impacts of apartheid on the country. It also brings to light some factors that led to failure of the department to judiciously see to its mandate of implementing the mass housing project (RDP).

The main sources of data for the study are secondary, drawing information from books, academic journals, archives, policy documents and the articles from the internet. The comparative research approach is applied when analysing the information gathered on sustainable water management (RWH) from different countries around the world and then related to the South African approach to the practice of RWH (May, 2001). The policies, strategies, legislation and campaigns on water use in South Africa are compared to see how they co-relate and the influence they have on existing and upcoming campaigns on RWH. Lastly, techniques and materials for installing RWH systems in households are discussed in order to make suggestions on possible means the practice can be introduced for use in communities as well as affordable materials which are available in the country that can be used for.

In addition to comparing the issues above, they are also evaluated (Sarantakos, 2005) in order to assess the performance of programmes such as the Free Basic Water and National Water Resource Strategy

(NWRS) and whether they have impacted the socio-economic lives of the formal low income housing groups and whether they are sufficient for domestic use. I have been as objective as possible in order to help determine the actual facts and implications that the data analysis has brought to bear (Sarantakos, 2005).

1.6.1. Research Structure

This research work consists of eight chapters. The first chapter gives an overview of what the research report entails, drawing in on the key issues that call for the practice of RWH. Factors that cause water scarcity are introduced as well as the key challenges with introducing the practice of RWH to low income households in South Africa. The aims and objectives; research questions and research methods; structure, conceptual framework, limitations and ethical considerations of this research report are then discussed. The second chapter introduces the concept of Sustainable Development, different issues that necessitated the concept and how developed and developing countries have so far managed to apply it to various forms of developmental agendas. Other issues that affect Water Scarcity such as global climate change, rapid population growth and geographical location are explained to show how they are directly or indirectly linked to the subject of RWH. The practice of RWH is also introduced in this chapter, its historical uses; the importance of managing water resources as well as examples of how the practice of RWH has been used across the world and in Africa as a supplement to water supply.

The third chapter opens up discussions on low-income housing in South Africa, the policy formation process since 1994 and how the housing sector has been shaped by these policies and institutional set-up. Chapter four includes an overview of how the government institutional setup is harnessing efforts to achieve sustainable water management for low income households. Chapter five lays bare how sustainable water management has actually been realised in low income households, drawing mainly on the work of government institutions and policy framework tailored in that regard. The sixth chapter outlines some socio-economic and technical issues related to water management in low income households in South Africa. It firstly looks at some of the socio-economic challenges and some known communal and technical interventions for RWH that can be applied to salvage the problems. Chapter seven analyses issues discussed in chapters one through to six looking at how they inform the need and means for RWH in low income households on South Africa. Findings are then drawn mainly looking at how best to introduce the practice of RWH to low income households. Chapter eight draws conclusions on the overall Research Report.

1.7. Conceptual Framework

The literature review consists of a review of issues surrounding sustainability and water scarcity globally and the various determinants of this occurrence. The discussion on sustainability is then related to the global agenda for maintenance of water resources to further determine how Sustainable Development is related to the South African context. The local context will consist of review and critical analysis of government strategies for sustainable water management and especially the sustainable technical measures that can be adapted for use in low income households as well as how safe and feasible this measure will be. A framework for the main components of the literature is shown below.

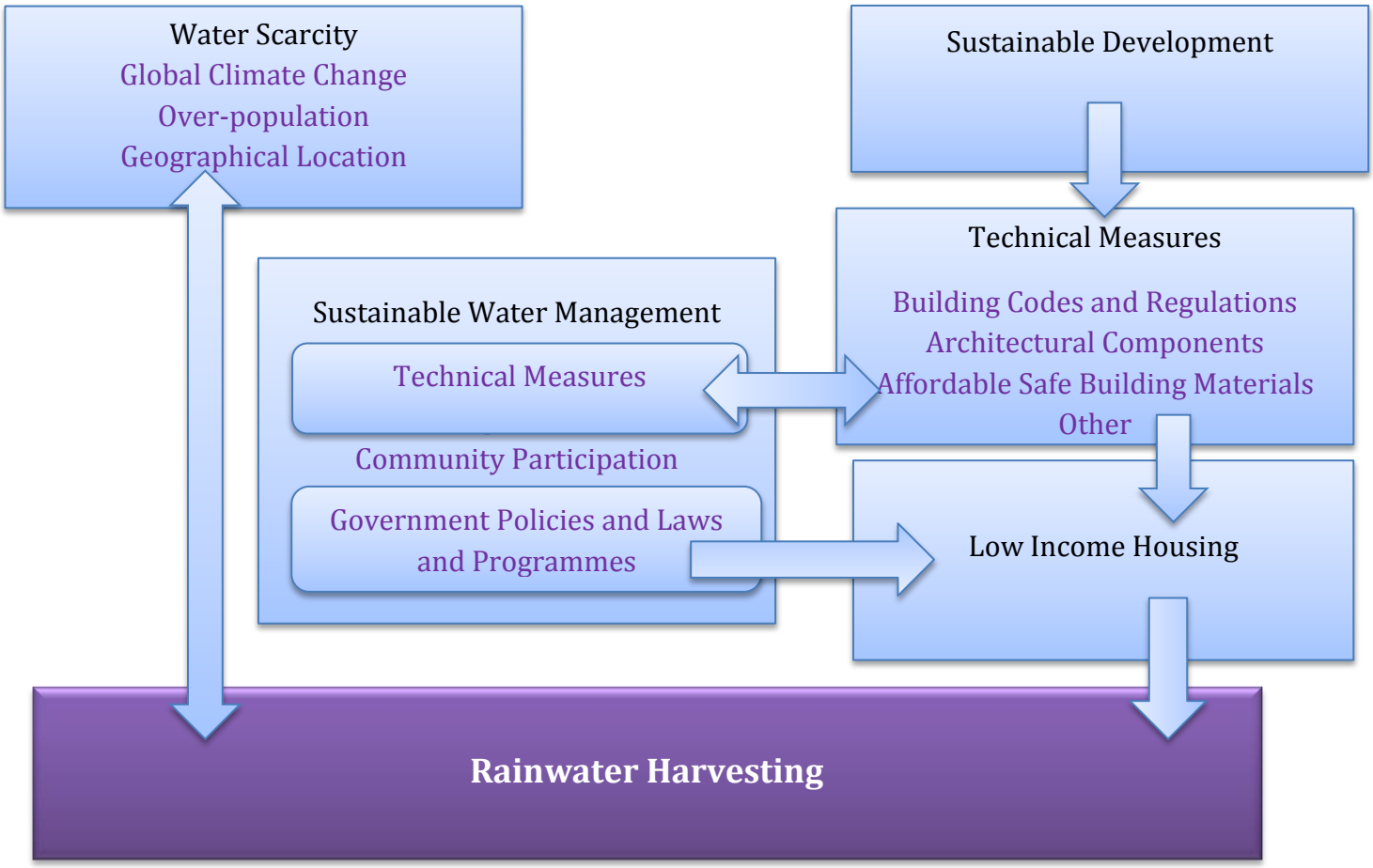


Fig. 3. Conceptual Framework Diagram.

1.8. Limitations and Ethical Considerations

Although I have made every effort to ensure that the varied literature compiled and analysed for this research is factual and from reliable sources, it is difficult to determine how accurate some information used may be. Time and funding constraints led me to choose desktop study and to focus on Gauteng Province as the region under study. The study could have developed richer analyses and findings, though, if the research was a mixture of other primary sources of information such as case studies.

The use of a sole method of desktop study therefore presents considerable limitations, especially as this study has some technical housing implications which may have been better analysed from primary sources. It would have been more prudent for instance, if I could conduct some field studies to find out available items and materials that could be acquired or recycled for use as water storage tanks or as part of the RWH system. Also, an investigation to find out whether low income households in South Africa are willing to accept the use of the RWH systems in their houses would have made the study more substantive.

1.9. Ethical Considerations and Limitations

The ethical issues I had to consider as a researcher were the likelihood of my perceptions and experiences influencing the analysis of theories on socio-economic and cultural issues on the vulnerabilities of the poor. This vulnerability may be compounded by the fact that this study is a desktop review, thus limiting the chance of exploring issues from a practical stance.

As a foreign student, having lived in South Africa for only about a year and over and having grown up in an urban setting, my background certainly has an influence on my analysis on the socio-cultural and health issues pertaining to water accessibility and RWH in the Gauteng province. This situation presented me with considerable limitations. Additionally, time constraints prevented me from verifying some of the issues discussed in other literature which I have cited in my research. This would have given a more substantive picture of how water accessibility affects the daily lives of the poor. For instance, on the case of women being left with the sole responsibility of providing water for homes and how availability of water affects the spread of HIV/ AIDS from mothers to children, although this research has brought these issues to bear, it would have been more substantive to have done some first-hand investigations to ascertain these facts and to find out how water accessibility can be made easier to deal with such issues.

CHAPTER 2: LITERATURE REVIEW OF ISSUES SURROUNDING RAINWATER HARVESTING

Over time, RWH proves as a practice that has helped to curb and cope with challenges of poverty, threats on food security, environmental degradation and even conflicts among nations. Some key factors contribute to these: rapid population growth; geographical location; the need for developments that are sustainable. Over many millennia, humans have used RWH to support water provision from land and cope with such problems. These discussions prove that RWH has continues to be used by various society to deal with the social, economic and environmental problems. Studies and investigations in countries such as the United States, China, India Brazil as well as Ethiopia, Kenya, Ghana and Namibia have realized the need to adopt the use of this practice in households especially those that are economically challenged. These efforts however need to come with the right methods and financial support.

2.1. Sustainable Development

Over time, several world organizations have attempted to create a pathway for development of social, economic, environmental agenda which will benefit future generations. One such concept is Sustainable development (United Nations Economic Commission for Europe [UNECE], 2012; ISSD, 2012; Sustainable Development Commission, 2011; World Meteorological Organization [WMO], 2012; The World Bank Group, 2001; Centre for Environment Education, 2007; Mebratu, 1998). Sustainable development was introduced as a result of an approach to international agenda and international community's outlook on economic, social and environmental development (UNECE, 2012). According to the UNECE, it was promoted in the Brundtland Commission's Report, published in 1987 (*ibid.;* World Commission on Environment and Development, 1987). 'Sustainable Development' was defined as 'development which meets the needs of current generations without compromising the ability of future generations to meet their own needs' and is described to be one of the most successful approaches to be introduced on the international agenda (*ibid.*: unpaginated; Sustainable Development Commission, 2011; The World Bank Group, 2001; World Commission on Environment and Development, 1987). Another definition of Sustainable Development was given in 1991 by the World Conservation Union – '[T]o improve the quality of life while living within the carrying capacity of ecosystems' (Centre for Environment Education, 2007: unpaginated). Also, a programme to which aims at closely guiding Sustainable Developmental projects in Switzerland, broadly defines the concept as a

> '…means [of] ensuring dignified living conditions with regard to human rights by creating and maintaining the widest possible range of options for freely defining life plans… therefore, 'The principle of fairness among and between present and future generations should be taken into account in the use of environmental, economic and social resources. Putting these needs into practice entails comprehensive protection of bio-diversity in terms of ecosystem, species and genetic diversity, all of which are the vital foundations of life' (MONET, SAEFL, SFSO, and ARE, 2004: unpaginated).

These ideas indicate the concerns of stakeholders in environmental sector, international community and world leaders regarding the need to protect the environment for environmental, economic and social development. This strategy is meant to ensure the continued survival of the physical environment for an overall improvement in the quality of human living, present and in future.

Irurah and Boshoff (2003), in a discussion on how sustainable development can be interpreted in terms of urban sustainability for affordable housing in South Africa, argue that the concept can be perceived as the merging of two paradigms that developed from two conflicting developments - economic growth and development, which was aimed at increasing the GDP (gross domestic product) as well as improving living standards of citizens to the detriment of the natural environment. Therefore the need for growth and satisfaction was pursued without much regard for its impact on the environment. This practice went on from the late 1900 until about 1950s to 1970s when environmental movements expressed grave concerns on issues of environmental exploitation and degradation that have ensued as a result of rapid population growth, increased levels of production and overconsumption (*ibid.*). It therefore became imperative to come up with ways in which these developments can occur simultaneously without harming the environment and satisfying human needs. It was at this point that ideas for Sustainable Development came to the forefront of world agendas such as those discussed above by Mebratu (1998) and Daly (1996).

The IISD (International Institute for Sustainable Development) (2012; unpaginated) explains that Sustainable Development makes the 'needs', especially those of the poor, a priority. '[L]imitations' are also obligations which can be instituted by governments and social organizations to reduce pressure on the environment to meet the present and future 'needs' (*ibid.*; OSEM, 1989). There is a focus on seeing the world a as 'system', where the actions or developments taken at a particular place in the world results in a negative or positive effect on another side of the planet (*ibid*.). Research by the IISD

therefore shows a relation of this occurrence to a time where the actions and decisions taken by humans will reflect on challenges or opportunities future generations will come across. The quality of life is similarly seen as a 'system' where the good state of human life such as good health, wealth, freedom, is related to the negative state of his environment such as droughts, air or water pollution and the effect these circumstances have on human life (Centre for Environment Education, 2007). This means that needs of humans and other living organisms form a closely linked system which needs to be well managed for improved quality of life. The responsibility lies with humans to ensure this form of development for the present, future generations and the environment.

Sustainable development as mentioned earlier, involves strong economic and social development, especially for the poor as their living standards and quality are usually low and they form a larger proportion of the human population (UNECE, 2012). In addition, the importance of protecting the natural resource base and the environment is highlighted and therefore concludes that economic and social well-being cannot be improved with measures that destroy the environment. It calls for cohesion and accountability between present and future generations towards the fulfilment of any advancement in development for posterity (*ibid.*).

As a way forward, the United Nations initiated and organized the Earth Summit in Rio de Janeiro in 1992 and ten years later, the World Summit for Sustainable Development (WSSD) in Johannesburg in 2002 (UN, 1992). World stakeholders in environment - practitioners, academics, and environmentalists - made commitments to ensure sustainable development in various sectors and on all levels and classes of society (Sustainable Development Commission, 2011). This enhanced both international and local action as National agencies for Sustainable Development were established with increased political involvement in several countries.

The 2012 conference on sustainable development was organized again in Rio, dubbed 'Rio+20' with the aim to bring in various international stakeholders to agree on 'a range of smart measures that can reduce poverty while promoting decent jobs, clean energy and a more sustainable and fair use of resources' (Guardian News a, 2012; UN, 2012: unpaginated). Current issues that influenced discussion were the following: the rapid increase in the world's population, expected to reach 9 billion by 2050; 1.5 billion of this number currently lives on $1.25 or less a day; about 1.5 billion have no access to electricity; 2.5 billion people have no access to decent sanitation; almost a billion people do not have

food supply; greenhouse emissions is increasing and if not controlled, about a third of 'all known' species could become extinct (UN, 2012: unpaginated). The main issues raised at the conference centred on 2 key themes: development of a green economy for sustainable development, in order to bring an end to poverty, and how international integration could be improved for sustainable development.

The main idea behind the development strategy is for advanced countries to eventually stabilize their economies and move away from 'over-production and overconsumption' to a 'redistribution of resources to the poor within these countries' (Irurah and Boshoff, 2003: 245). Poor countries on the other hand have to deal with the challenge of maintaining or slowing down population growth and working more on developments that will meet the basic needs of the majority poor and to stabilize overconsumption by the elite (*ibid.*). These conflicting requirements have become a source of many intense debates and negotiations at both the Earth summit in Rio de Janeiro and the WSSD in Johannesburg. For instance, no fixed objectives were agreed on concerning overproduction and overconsumption in developing countries.

A 10 year plan was instead put in place to formulate programmes on the ground. One key activity that gained much interest are the programmes that brought about 'redistribution of resources' from developed to developing countries during the WSSD (*ibid.:* 246). Resources were channelled into areas such as water and sanitation, energy, health, agriculture and biodiversity (*ibid.*). The development programmes were made possible as a result of partnerships between countries (*ibid*.; Globe Southern Africa, 2012). Voluntary collaborations were formed and targets set for developing countries. Developed countries agreed for resources from private and public sector to be invested into developmental projects in the developing countries (*ibid.*).

The sustainable development agenda has however, had a number of challenges. The UNECE (2012) and Mebratu (1998) point out that many varied interpretations have emerged nationally and internationally for the practical interpretations. Although actors from the some social sectors realized that they could capture opportunities to use this new concept, it is considered too broad and vague and its content could be given different interpretations. Whilst implementation of policies had started in countries, a deliberation of the concept continued, particularly the notion that 'sustainable development' could mean 'all things to all people' (UNECE, 2012) and the difficulties in implementation was evident when some advocates even branded the concept as 'an oxymoron' (Tryzna, 1995). Also, Holmberg (1994) reiterates this challenge where he explains that the concept of sustainable development became

eventually undervalued to a level where it was a mere 'cliché'. The environmental community accused governments and corporate business of 'cosmetic environmentalism' shrouded in the concept, whilst others sensed that the term was as an escape for proper intensive action (UNECE, 2012; unpaginated).

Other key concerns are the refusal of the United States of America to sign the Kyoto Protocol, the inability for member countries to set targets for renewable energy and the continued overproduction and overconsumption, the dominance of environmentalists in the agenda (Irurah and Boshoff, 2003). The UNECE (2012) calls for more emphasis on the economic and social fundamentals and aspects of the concept. The social aspect is perceived as only adaptable if it responds to social difficulties in independent countries whilst the economic factor is being called to be integrated into the whole concept and not regarded as an isolated element (*ibid*.). Ecological and physical dimensions of these concepts mainly concentrate on the development of compact landscapes, reduced and recycle of waste so that a lesser ecological footprint will be left (Irurah and Boshoff, 2003). Special efforts are made to encourage the use of renewable resources such as energy and water in order to reduce waste output into the environment.

A decade of implementing sustainable development in both developing and developed countries has resulted in the success of municipalities promoting sustainable development with maximum significance, increasing awareness and improved performance. However, problems noted such as the lack of understanding of the concept in administrations, insufficient political support, limited resources at different levels for proactive initiatives, inadequate involvement of civil society, lack of involvement of education systems, are still present (*ibid.*). Conversely, there are successes such as the development of social housing policies that promote social inclusion and equity, increase economic development, mobility and productivity.

In addition, there is reduced urban transportation which results in less pollution, less environmental and health related complications, reduced congestion of cities and fewer accidents. Sustainable development therefore is a process and not an end, as the UNECE (2012) concludes. Boshoff and Irurah (2003: 247) also conclude that 'articulation of a new development paradigm for human civilisation in the 20th century has meant a re-examination of all facets of human views towards re-alignment for sustainability'. With renewed recognition and commitment to make this concept to achieve substantial

impacts, stakeholders of sustainable development need to organise further annual deliberations to account for outcomes of these efforts.

2.2. Viability of Sustainable Water Management

As the issue of water scarcity around the world is of major concern for governments and stakeholders, many approaches are used to tackle this challenge. This has led to the formation of various strategies and approach to researching and addressing a means to achieve efficient and effective water management practices especially in third world countries. One such approach is Integrated Water Resources Management (IWRM), conceptualized at a UN water conference at Mar del Plata in Argentina, 1977 (Moriarty, 2010). Another programme is the IRC International which has the sole objective to facilitate sustainable access to water and sanitation for poor women and children in developing countries. In line with this objective, Matthews (2005) outlines the key reasons why it is important to promote access to safe water and sanitation:

i. The health of individuals is threatened when they do not have access to safe water and sanitation. Health hazards such as morbidity in particularly in children results in stunted growth, reduced life expectancy, epidemics and generally susceptibility to diseases. An estimation by WHO/ UNICEF (2000) cited by Matthews (2005), shows that 4 billion cases of diarrhoea are recorded every year which come about as a result of lack of water, unsafe water use, inadequate sanitation and poor hygiene. These cases result in the deaths of about 2 million children below the age of five. Rice *et. al.* (2000) highlight the fact that in developing countries, half the cause of death in children are associated with constant bouts of diarrhoea which weakens them whilst Curtis (1986) also discusses the concerns on the physical bodily injuries and chronic diseases caused by the burden of carrying water.

ii. Immense amount of family resources and energies are invested into time to collect water. This burden usually lies on women and children as a daily chore, taking long hours daily. This precious time could otherwise be invested into economically productive activities to the benefit of the whole family. Girls are particularly known to lose days in school as they use that time to assist mothers in search of water. Time taken look nurse family members who get sick as a result of lack of water also puts pressure on family time (WSSCC, 2004).

iii. For women, lack of adequate private sanitation leads to low self-esteem, and dignity, further deepening the levels of poverty (WSSCC, 2004).

The issues discussed by the IRC international clearly indicate the influence of access to water on the lives and health of women and children in households. It is also clear the key roles women and children, notably, girls play in the sustenance of households. If these important but vulnerable groups in households suffer and are not protected, it has a negative impact on the socio-economic lives of households. Sustainable water management such as RWH therefore goes to ultimately improve on all aspects of families.

The IWRM is formed with the role of developing a 'new philosophical framework' into how water resources are developed and managed in relation to land and other resources (Moriarty, 2010: 80, 82). It seeks to achieve this through education and regulation. IWRM recognizes that the need for water across various regions on the globe exceeds supply which makes it a unique resource in relation to land and other minerals, since they (land and minerals) 'represent finite quantities of a given resource located at some fixed place in space and time' (*ibid*., 80). However, '[W]ater, by contrast, is a flux, constantly recycled through the hydrological cycle and biological processes in humans, animals and plants' (*ibid*.). This firstly underlines the need for proper management of water (*ibid*.). The main principles of the IWRM centre on the four key factors (the Dublin Principles of IWRM):

1. Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment. Due to the key importance of water for the sustenance of human life, a holistic approach that links social and economic development with protection of natural ecosystems must be adopted for effective control. Management of fresh water must therefore be linked with an awareness of the characteristics of overall water and land or ground water aquifer.

2. Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels. To achieve effectiveness in participatory approaches, policymakers and citizens must be made more aware of the importance of water. This approach must therefore encourage decision making from the grassroots level with 'full consultation and involvement of users in planning and implementation of projects on water'.

3. Women play a central part in the provision, management and safeguarding of water (*ibid.*, Matthew, 2005). This principle calls for recognition of women's role as providers and guardians of water and the living environment. Institutional plans should reflect this approach in development and management of water resources. To fully accept and implement this principle, policies that are favourable and positive towards addressing women's specific needs must be considered. This gesture will equip and empower women to participate in water resource programmes at all levels. Women should also be allowed to create and implement policies and decisions that most suits them.

4. Water has an economic value in all its competing uses and should be recognized as an economic good. This principle firstly acknowledges the basic right of every individual to access to clean water and sanitation at an affordable price. Previous failure to recognise the economic value of water has led to waste of the resource which also damaged the environment. To achieve efficient and equitable use of water, it must be managed as an economic good, encouraging conservation and protection. (*ibid*.: 83, 84).

The IWRM also sets out six principles to guide policy makers to put in place more practical systems and projects to ensure adequate accessibility to water and sanitation for communities. The first 2 principles tackle 'resource availability, the third with maximising the impact of water in the livelihood of people, fourth and fifth address 'social' aspects of implementing IWRM, touching on stakeholders, gender and key users whilst the sixth tackles economic principles (*ibid.*: 89). Attention is drawn on the fact that any community water and sanitation project can take off successfully if there is enough water in adequate frequencies and of good quality.

In practical sense, when implementing a drinking water sanitation project, a thorough assessment of the current and likely future domestic water demand for the community must be carried out. This includes the needs of small scale productive users. Then an assessment on how best this demand can be reduced through proper management of demand to ensure the long term availability and accessibility of the water resource to the community.

Catchment management and source protection are essential to ensuring sustainability of supply. In taking off to ensure sustainable water supply the following questions must be asked:

a. Are sources adequate for both current and projected domestic use (including small scale productive uses)?
b. Are they reliable throughout the year and over the years? Many sources suffer from seasonal or periodic failure.
c. Is ownership of the source controlled by the community? Are there competing claims to it by other users or uses? (*ibid.:* 90)

With the required information, if any of the answers to these questions is a yes, then action will have to be taken to ensure an adequate supply of the resource. Actions to either increase water supply or reduce demand must be undertaken. These could include 'watershed management' and 'groundwater recharge'. Also, tree planting and regulating or banning farming activities within the water catchment area are important practices. Community must be involved in these activities, especially when they are small scale as this will be beneficial in educating them on sustainable water management practices. In some Latin American countries, an important aspect of this approach involves acquiring the water resource and the surrounding catchment area. Another crucial point is to ensure effective monitoring of the water source by the community. This will help them to be aware of how much water is available, the associated seasonal changes and so on. Some uses that may be seen as wasteful have to be ceased to prevent reserves from being eaten into.

1. Water use efficiency and demand management must be addressed to minimize the need for new source development. This principle builds on the monitoring of the resource for efficient use. It involves a need for 'local level management between competing resources and effective demand management of all water uses'. It stresses on restricting some activities and uses which may help reduce demand for water through rationing or banning and notes that this effort will be more efficient when it involves communities in monitoring and regulation.

   The approach can start by identifying all the uses to which water can be applied and all the potential actions that can limit consumption of excess water among these options. Improved efficiency in irrigation systems, for instance can go a long way to positively affect

the livelihood of the community. For such an activity, specialised institutions and personnel such as the local agricultural specialists need to be involved.

Water reuse is noted as a key element in demand management of the resource. For instance, using wastewater for irrigation, fish production and domestic water supply can help to reduce pressure on freshwater.

2. Multiple uses of water in differing social strata should be acknowledged. This principle discusses the need to reassess the role of the community in the water supply project itself. Normally, water is needed for drinking, cooking, washing and farming. However, most communities are unaware of the other needs of this resource. In areas where water is scarce, it represents a 'vital productive resource'; it is in demand for other essential activities than drinking. Even in urban areas, about 60% of water is used for food production, market gardening, domestic livestock production, laundry services and micro-industry. All these are potential productive uses that usually compete for water resources (Lovell, 2000; FAO, 2000). To address this competition for water resources means 'designing supplies with multiple uses in mind, and also identifying potential alternative sources [RWH, wastewater reuse...]'.

   When people understand that their livelihoods are based on water supply, they are able to achieve great impact on their well-being which is a factor in line with IWRM principles. This situation presents a starting point for an analysis of the various ways in which water supply system can be designed to meet these needs as suitable. The new water supply and use system should include domestic and non-domestic activities such as irrigation as it is a productive activity in water use and management. A livelihoods-based approach 'not only greatly increases the impact of water on people's well- being but also, by directly linking water supply to economic activity, greatly increases willingness and ability to pay for water and maintain water supply systems. (James, Verhagen, Wijk van, Nanavaty, Parikh, and Bhatt, 2002; Waughray, Lovell, and Mazhangara, 1998).

3. All stakeholders should be involved in decision making, but particular emphasis should be put on the active participation of users. The key concept of this principle is to encourage community stakeholders in the decision-making for the project. These must be also end

users of the Water and Sanitation Service (WSS) Project. This approach however, to deeply involve these members, should not be confused for control of the decision –making at the community level. The activity should be made of a 'representation of a water committee on water management bodies' at the local, regional or catchment levels. A key issue to be addressed at this level is to negotiate a right to water and methods that will ensure ample supply for the planned system. Here, the voices of women and the poorest are given due consideration to in order to achieve a requirement for equitable share of the available water resource. On the international level, catchment management is gaining popularity as a model which helps to achieve a more equitable and fairer method of managing water. This is typical in South Africa and Zimbabwe where domestic water supply initiatives require active involvement of stakeholders and end-users for this objective to be achieved.

In cases where there is no national framework for the IWRM achieving affair distribution of scarce water resources is a challenge. This is because the project may have to develop new institutions to run the management of water. This consists of setting up water resources management committees, or integrating domestic water supply concerns into existing bodies. A typical example of such an effort is the watershed management committees of India. Committee members will have to assist and train for monitoring and decision-making on issues such as water allocation rights, demand management, and source protection, as well as using monitoring as a tool to ensure the maintenance and protection of a domestic reserve. The decisions arrived at for the project must be assessed to ensure that they are tailored 'realistically' to meet the needs of the community.

4. Gender and equity issues must be addressed throughout the project cycle. This principle emphasises the concept of 'broadening' the 'interest' of gender issues from the Dublin declaration discussed above. It focuses on the role and various needs of women, which are considered different from men and particularly the poor are analysed and catered for. There is emphasis on the factors that burden and favour men and women are brought to the table and shared to help achieve a fairer distribution of roles and to enable women to claim their rights in decision making. This is because on the household level, men and women have different uses for water. For instance, women are responsible for domestic water. However, on farms where irrigation systems are used for subsistence vegetable farming, women are

left responsible until the farm gets to a level with 'cash-raising potential' where men become more involved. This scenario shows that although both men and women have common interests in water resources, women's efforts are mostly disregarded and taken advantage of.

Achieving socio-economic equity between men and women in the allocation of resources is of fundamental importance to professionals involved in community water projects. The voices of the poor tend to be side lined as they usually lack the political strength to express their views in official water allocation deliberations. Whether the poor use water for menial activities such as only drinking, cooking or other activity, an adequate and fair concept that includes their right to water in community water supply programmes must be considered.

5. Water provision should be priced so as to discourage wasteful use, while ensuring the right to access of a necessary minimum for all for domestic and small scale productive uses by the whole family. This last principle discusses pricing of water to ensure minimum waste and encourage an effective use of the limited resource. It is important to acknowledge the fact that reasonable pricing of water mostly for domestic purposes will help maintain the basic supply system. A problem with the use of user charges to reduce wasting of water is that the extra charges do not necessarily encourage service providers to improve efficiency of the system.

In the light of the fact that domestic purposes do not consume much water, it is not fair to include domestic water sector pricing in the economic measures used to limit water consumption. Instead, the domestic water sector can be used to ensure that non-domestic purposes such as irrigation are charged realistic rates.

Also, in cases where the private sector is involved in water provision, charging 'high bulk purchase prices for Water Rights', will make it easy to reduce charges for individual households This can 'provide a powerful incentive' to adequately maintain supply systems. This same concept can be used to charge community on two levels: as a community for its water right and secondly as individual households. (*ibid.*: 91, 95; Moriarty et al., 2000).

The authors conclude that the six principles outlined for community water and sanitation project was developed from experience on projects carried out by IRC International (Matthew, 2005) and partners in six countries across Africa, Asia and Latin America (Visscher, Bury, Gould and Moriarty, 1999; Moriarty, 2010). The experiences produced relatively different guiding factors to which specific questions which are relevant to the area were developed (Moriarty, 2010). The principles discussed here are therefore proposed practical measure and implications which can be applied in any community water supply programme and particular attention should be taken to learn from these principles and develop specific systems tailored to meet the needs of specific communities. The principles can also be used as a basis to assess the performance of water and sanitation projects. The IWRM approach will achieve most efficiency if it works in partnership with other sectors: irrigation or agricultural sector, industry and mining.

This shows how possible it is to adopt measures and principles to institute water and sanitation projects that are sustainable for different communities in South Africa. This approach if well managed will bring socio-economic improvement on the lives of individuals, households and communities at large. RWH therefore can be made a part of any IWRM project as a supplement to water supply for communities looking to increase efficiency in water use. As South Africa has adopted this approach, RWH must certainly be included in sustainable water management advocacy programmes.

2.3. Factors that Influence the Need to Harvest Rainwater

2.3.1. Global Climate Change

A key factor that informs and generates this topic is the extreme change of weather patterns, temperatures and natural disasters such as drought and floods that are rampant in most parts of the world lately and has resulted in unpredictable seasons especially the rains (EPA, 2012; WMO, 2012). The WMO (World Meteorological Organisation) (2012) is set to use its services, knowledge and products regarding the weather system to assist the realisation of the Millennium Development Goals. The World 2011 Meteorological Congress focused on the development of a framework which will support sustainable development in this respect as the impact of human activity on the climate was acknowledged. The strategy adopted is to create partnerships across geographical, political and disciplinary sectors to facilitate effective discussion of climatic challenges faced by different regions.

Results from these partnerships are hoped to serve as opportunities and leverages which can be used for the benefit of nations. Objectives to be implemented are: effective risk management from extreme weather conditions; an improvement and optimal use of water resources to provide sustainable access to potable fresh water; irrigation and household use.

RWH as a means of ensuring sustainable access to freshwater is pointed out by Deep, Gupta and Anderson (2003). In agreement with the WMO (2012), they explain that climate change is having a profound influence on human life: displacement of populations, cultural separation, abandonment of settlements which all mostly occurs as a result of people's need for water for food production and survival. In reality, climate patterns and water supply influence decisions on access to new water supply sources, plans for infrastructural expansion projects, as well as economic plans on agriculture, industry, tourism and major sporting activities (WMO, 2012). It is highlighted that climate change can interact with socio-cultural activities without disturbance and that a simple practice such as RWH can help prevent migration of people due to droughts (Deep, *et. al.*, 2003).

People can modify their dwellings and environments to ensure availability of water during droughts. Research studies reveal that climate change has caused 'mega-droughts' in certain continents in historical periods (from about 4500 BC to present) and occurred in India and other continents such as Arabian Peninsula, South America and North America (*ibid*., 52). This historical evidence shows that nations did not easily yield to the changing weather until they have exhausted all other options for survival. In all these continents there was evidence of groundwater wells, reservoirs, dams - some centrally located, residential and margin storage systems.

For modern times Deep, *et. al.* (*ibid*.) highlight that RWH is essential for the following reasons: rapid population growth resulting in increased pressure on water resources; over a billion of the world's population currently do not have access to potable water and 3 billion people without sanitation; intensification of earth's hydrological cycle influencing quality of water. The concluding remarks are that RWH in reaction to climate change augments human resilience to bear sudden extreme changes and affords humans the opportunity to learn and develop. There is a further call for in-depth historical information to be carried out on regional and local climate change to enable countries to be better informed about future changes in weather and prepare accordingly through a viable means such as RWH.

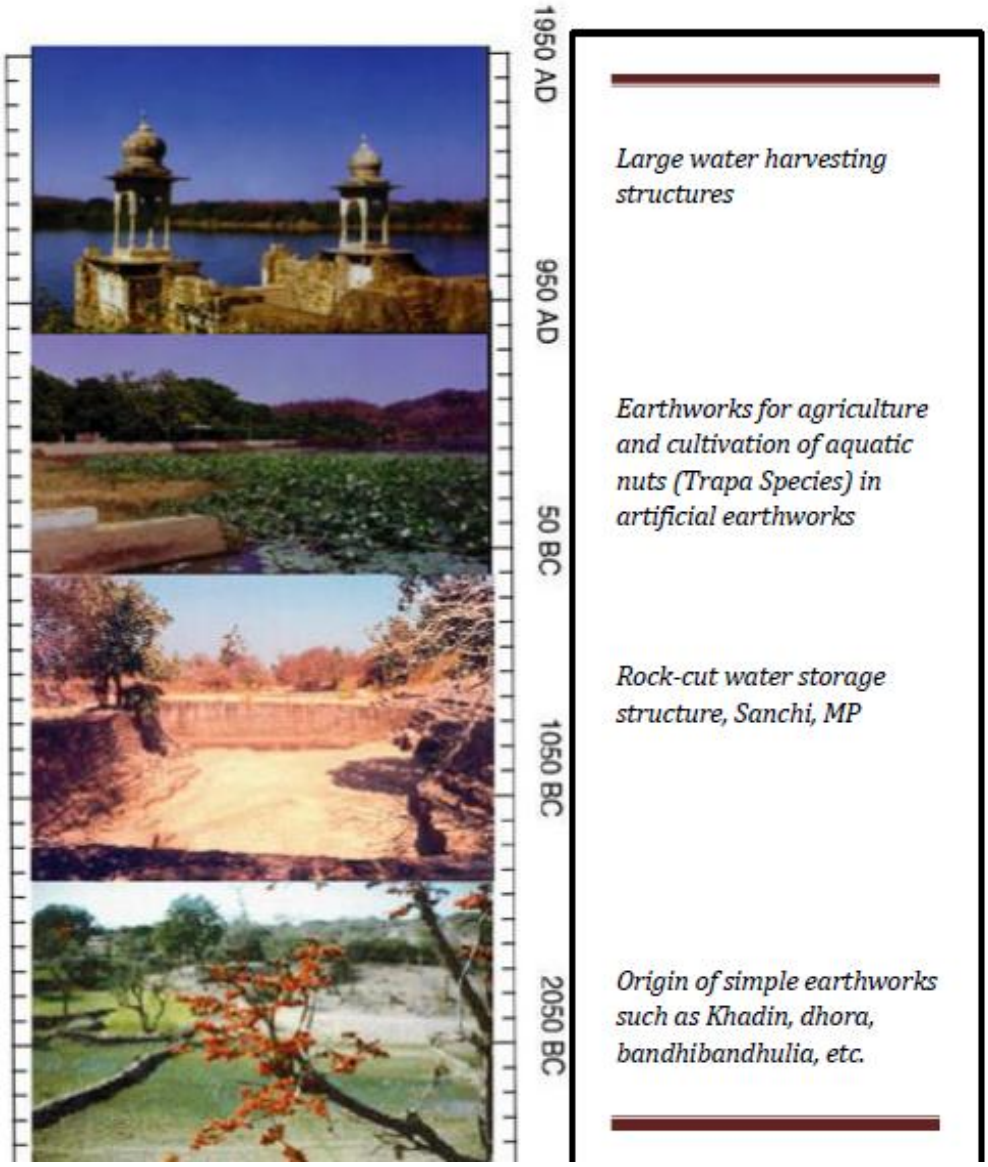


Fig. 4. Schematic representation of increasing complexity of RWH in India as an adaptation to climate change. Source: Pandey, Gupta, and Anderson, 2003.

Brown, Hammil and Robert (2007), regard climate change as a security threat to Africa. They reiterate the fact that earlier in the 1970s and 1980s when climate became an issue of concern to researchers, the problem was regarded as an issue to be dealt with only by environmentalists and not policymakers. By the 1990s the effect of the phenomenon was so evident that policy-makers begun looking for ways to reduce greenhouse gas (GHG) emissions. Given the fact that strategies that deal with climate change present a need to 'drastic'[ally] reduce amount of fossil fuel consumption, the subject became a top economic and energy issue (*ibid*., 1141). However, in recent times, the phenomenon is seen as a threat

to international peace and security, with Africa being the region most likely to suffer the worst. Notable in the discussion is the fact that climate change has brought uncertainties in the 'allocation of resources, [threats] to coastal populations, water and food security, increased forced migration, raised tensions and triggered conflicts' (*ibid*.). Security organizations are therefore called to prioritize this issue as clear examples such as the Dafur war (mainly caused by drought and misunderstanding on allocation of resources) present the probable catastrophes in security which global climate change have triggered (UNEP, 2007).

Contrary to these concerns, recent literature by Gartzke (2012), provide some evidence contrary to this accepted occurrence that climate change contributes to create conflicts. His arguments present research findings that prove that there are actually 'countervailing' facts to show that global warming has detrimental impacts on world peace. This evidence especially applies to the second half of the 20th century in which the world has experienced much of the phenomenon (*ibid*., 178; Nordås & Gleditsch, 2007; Buhaug, Gleditsch & Theisen, 2010; Buhaug, 2010). Gartzke (2012: 178) argues that burning fossil fuels - which produce greenhouse gases lead to global warming but 'propel economic and political systems'. There is a further argument that, 'industrialization leads to economic development and democracy, each of which has been associated with peace' (*ibid.*). This argument however is not substantive as it disregards the environmental component which is important for any positive developmental agenda especially Sustainable Development.

Other factors which disprove such arguments are seen in observations made by UNEP (2009) which brings to bare facts and discussions that the Global Climate Change phenomenon has brought about water conflicts in some regions. As a response it presents RWH as an alternative method that should be adopted by governments to supplement their water resources, as is the case for ground and surface water. It also underlines factors on how RWH can be used to achieve improvement in the ecosystem and to human well-being, helping to revive plant life the ecology; availability of low cost methods and technologies making it easy to be adapted for household and community use and its potential to increase food production by about 100% (*ibid*.).

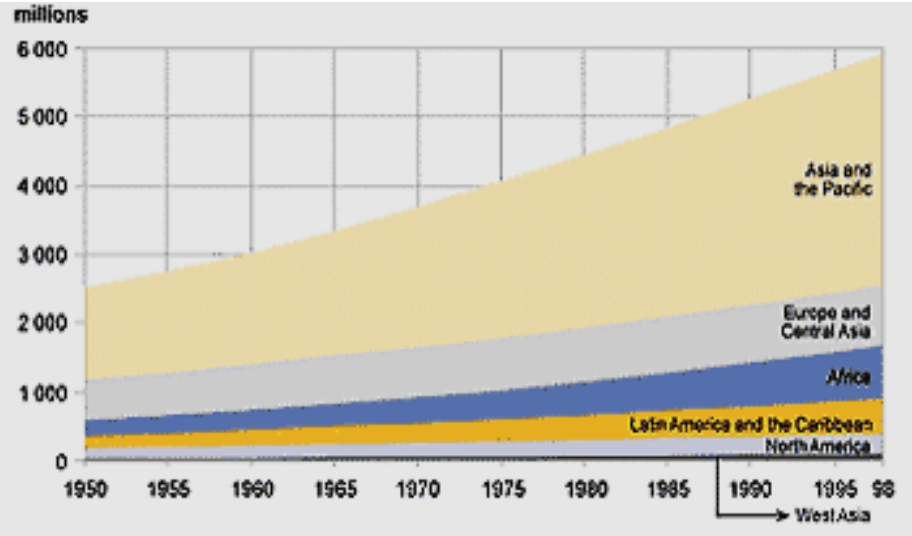
This discussion generally shows that global climate change is creating concerns for most stakeholders particularly in the area of food security, environmental protection and peace among nations. In addition,

RWH is clearly a practice that can be used to salvage these challenges as it serves as a sustainable water management practice that curbs the harsh effects of the phenomenon on human living.

2.3.2. Rapid Population Growth

Another key factor that threatens to reduce water resources and their quality is the high number of people who depending on it. The Economist (2010) and UNEP (undated) both outline global rapid population growth globally as the key reasons why sustainable water management and RWH should be promoted and practised. Both the Economist (2010) and UNEP (undated) agree that the population of the world has more than doubled since 1950, reaching 6 billion in between 1999 and 2000. According to UNEP (undated), the estimated growth rate at medium fertility is likely to reach maximum of 8.9 billion in 2050 after which the world's population is expected to stop growing (The Economist, 2010). Therefore, given that natural resources - water, soil, forests and fish stocks - are being exploited daily over their limit, substantial efforts need to be made towards meeting the needs of the extra 3 million people in the next 50 years (UNEP, undated). This is because currently, about 20 per cent of the population currently do not have access to potable water whilst 50% lack access to decent sanitation.

Table. 1. World population reached 6 billion in 1999



Source: UNEP, undated.

In addition, the world supply of freshwater keeps dwindling due to 'falling water tables' which lead to water shortages and 'salt intrusion' into coastal areas (*ibid.,* unpaginated). The main importance of water to the growing population is for growing food and this situation has become dire due to the high

number of people who rely on irrigation systems of farming. The Economist (2010) indicates that currently, the area under irrigation for the growing population of the world has doubled, an increase which has tripled the amount of water being drawn for farming. A typical example is presented that the proportion of people chronically short of water has increased from 8% (500 million) at the turn of the century to an estimated 45% (4 billion by 2050). Meanwhile, at least 1 billion people starve everyday partly due to lack of water to grow food (*ibid.*). In addition to the farmer's increasing demand for water, there is increased demand for better tasting and more interesting food and different foods need different quantities of water to grow.

Also, people's demand for water increases as their social status is elevated, therefore, with 2 billion people around the world entering the middle class, higher demand on water is expected even with dormancy in the population figures (*ibid.*). This fact is substantiated by Barron's (2009) submission that RWH can be a lifeline to human well-being. There is emphasis on the potential that the practice (RWH) has to assist countries with high urban populations such as China, Brazil, India and Brazil to achieve sustainable urban water management.

A system of managing water in urban areas is presented: 'artificial ecosystems where controlled flows of water and energy provide a habitat for the urban population', which means that water can effectively be provided to the growing populations if RWH is adopted and managed carefully (*ibid.*, unpaginated). The Economist (2010) explains that as more people move to the middle class, they adopt more sophisticated lifestyles which rely mostly on industry to produce processed food, electrical gadgets, cars and other items that make life easier. This takes about 22% of the world's 'withdrawals' (*ibid.*; 2), putting more pressure on the available water supplies. Industrial demand with domestic activities for instance, takes 8% of water resources and quadrupled in the 2nd half of the 20th century, growing twice as fast as that of farming and estimated not to slow down.

Other noted challenges to global water supply are contamination of drinking water, pollution of rivers, lakes and reservoirs with nitrate and heavy metal (UNEP, undated) which are a result of increase in the activities of industrial plants. The increasing number of people who depend on limited supplies of freshwater which are in turn becoming more polluted, makes water security a major national and regional priority in many parts of the world (*ibid*.).

From the review above it is clear that rapid population growth which leads to agricultural and water intensification lifestyles, urbanization, are some of the factors that contribute to global water shortages. Barron's (2012) proposals on how governments can partner with communities need to be adopted by countries looking to improve on water management. Also, plans which enable sustainable water management policies and legislation; cost-sharing and subsidies for RWH projects need to be promoted.

2.3.3. Geographical Location

As this study covers issues surrounding RWH, it is important to properly understand how location, geography and weather patterns affect water availability and its use as well as to establish the need to harvest rainwater even in areas where the quantity may be negligible. An overview of water availability and other sources of water in different regions across the world are discussed below.

People in various regions around the world have different means of acquiring water and as most of these sources are being depleted or overused, additional sources which are sustainable such as RWH need to be adopted as a supplement to water sources, regardless of location. Water availability across different parts of the world, according to scientists, is determined by weather patterns which are in turn determined by the 'Hadley Cells'- a global circulation pattern found on the equator (Minerva Union, 2013: unpaginated; Lu, *et. al.*, 2008; Fierson, Lu, Chen, 2007; Yale, undated). As a result of this weather activity, the driest regions of the world are mostly located between the Equator whilst the wetter regions are on the zones further south and up north on the globe (*ibid.*).

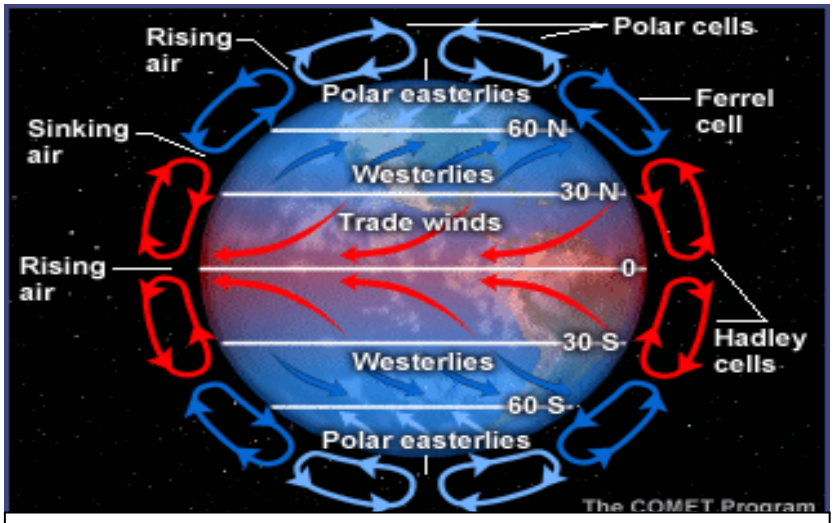


Fig. 5: The Hadley Cells around the equator which scientists believe controls weather patterns, making some regions dry. Source: Minerva Union, 2012.

Most European countries in the temperate regions therefore underestimate the need and importance of water for farming and other activities as The Economist (2010) agrees. Water sources on the planet Earth are unevenly distributed, as explained by the Economist that in arid regions such as the deserts, underground water is found very valuable as most surface water bodies have become used up.

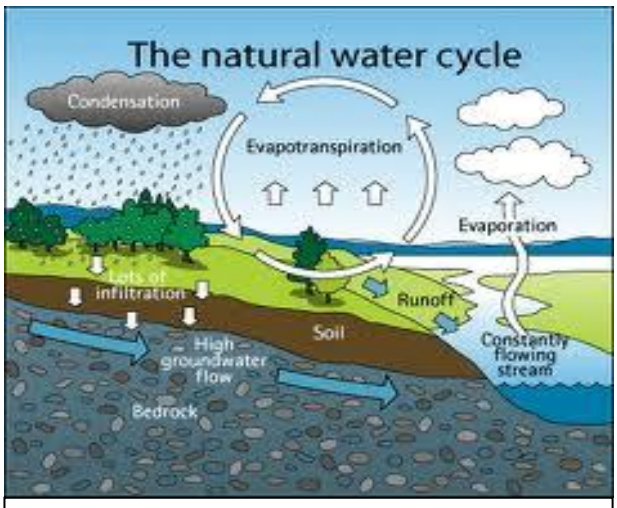


Fig. 6. The natural water cycle and water distribution on land and other water bodies. Source: www.sperchemical.com, 2012.

In some areas water used up is easily replaced, whilst in other places it takes longer to be replaced, all depending on the weather pattern and geography of the particular place (Economist, 2010). As a result, the planet is sometimes described as a 'miserly distributer of freshwater' since most water resources are saline, making them 'useless for humanity' (Guardian News b, 2012: unpaginated). Water security – the availability of fresh water in a specific place and how efficient it is used – has always been an issue of concern to most world leaders and various stakeholders in water provision. As fresh water is unevenly distributed across the earth and the levels of consumption around the regions vary, the percentages of use and particular purposes differ. For instance, in Britain, only 3% of water withdrawn is used for farming whilst it is 41% in the United States where the water is used for mostly irrigation agricultural practices (Economist, 2010; Guardian News b, 2012).

Countries located in regions with high populations and pressure on renewable resources also face the danger of easily depleting their available water resources (Guardian News b, 2012). This means that in

places where there are less renewable resources available, there is more pressure on the use of water resources. Typical in this case is the Middle East and North Africa where Bahrain uses about 220% of its available water resources, Saudi Arabia: 943% and a staggering percentage for Kuwait: 2465% (*ibid.*). The interesting case here is that the 'excess' water is used by desalination plants instead of being drawn from non-renewable ground water (*ibid.:* unpaginated). Also, as a result of overuse for irrigation, Lake Chad has already lost 90% of its surface area. The lake's area dwindled within a period of 30 years, affecting about 20 million people (IRD, 2013; NASA GSFC, 2013; One World UK, 2012).

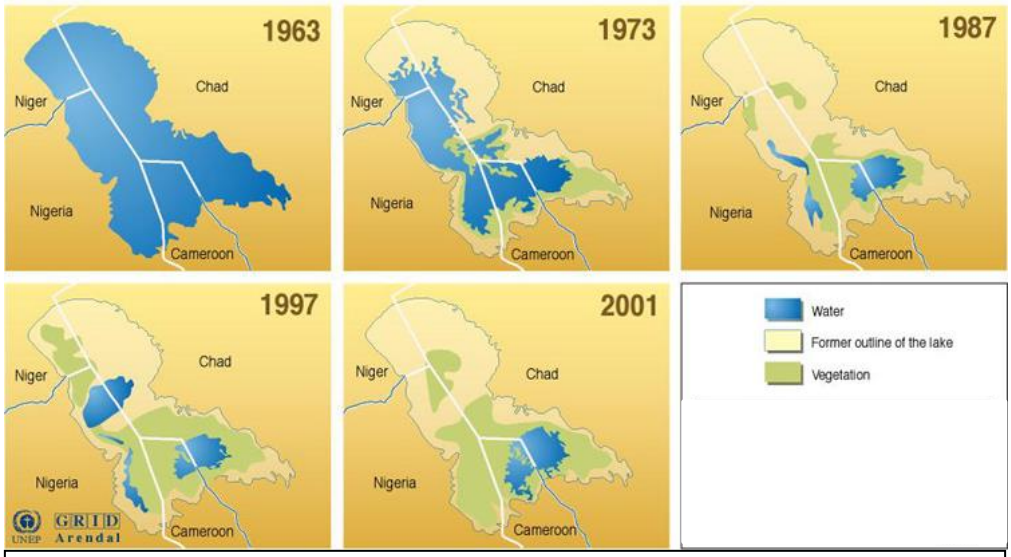


Fig. 7. The disappearance of Lake Chad. Source: NASA GSFC, 2002.

The geographical locations of these countries therefore determine the quantity of water being drawn and the purpose for which water resources are used (Guardian News b, 2012). Figure 3 below describes water distribution across the world, zoning in on the situation in the Middle East and then the wider world. The deeper the shade of colour the more water stressed the region. It covers 180 countries.

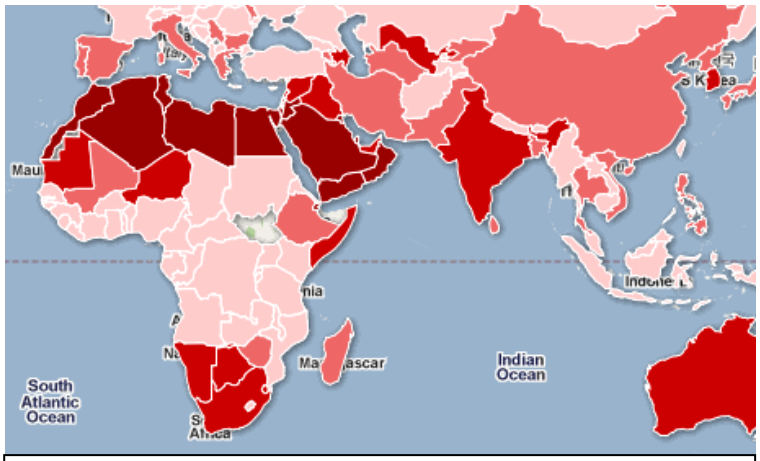


Fig. 8. Water Stressed Regions of the world, focusing mainly in the Middle East. Source: Guardian News b, 2012.

Uneven distribution of water affects food security in certain regions, notably, in the Horn of Africa where lack of water has caused droughts (One World UK, 2012). This situation has resulted in other conflicts, affecting over 2 million people whilst the UN has declared the area as one stricken with famine. However, the situation in Sub Saharan Africa is not an issue of unavailability but inefficient management as the region captures only 4% of rainwater for agricultural purposes. This great potential, if tapped into, could easily help the region to feed its rapidly growing population. A higher percentage is needed for agricultural activities in China where nearly 70% is used and a much higher percentage of 90% for India (The Economist, 2010; Guardian News b, 2012). Overall, it is indicated that the world uses about 70% of water resources for agricultural purposes (The Economist, 2010).

Some countries have reached the point of overusing their water sources, especially aquifers. In the north-eastern part if India for instance, the average rainfall is almost 110 times that of the deserts. In most parts of the country, rainy seasons tend to be a challenge as there is almost always flooding. However, droughts are common during the dry seasons (The Economist, 2010). In arid regions of the world such as the deserts in Arabia, underground water becomes very valuable as surface water resources dwindle.

There are environmental consequences with overdrawing aquifers: water sources may become compromised, sometimes causing cities to sink. In coastal belts, when aquifers run out, it could result in increased saline in aquifers. Rivers and lakes, if overdrawn, dammed for too long restrict flow of water, causing them to get dried up (*ibid.*). The Yellow River in China and the Murray-Darling in Australia presently stand the risk of losing their ecosystems if due attention is not given to how they are being managed. In countries such as India and China, the amount of water being withdrawn exceeds the amount available. This is a risky issue as water availability may be a challenge when the sources run out (The Economist, 2010).

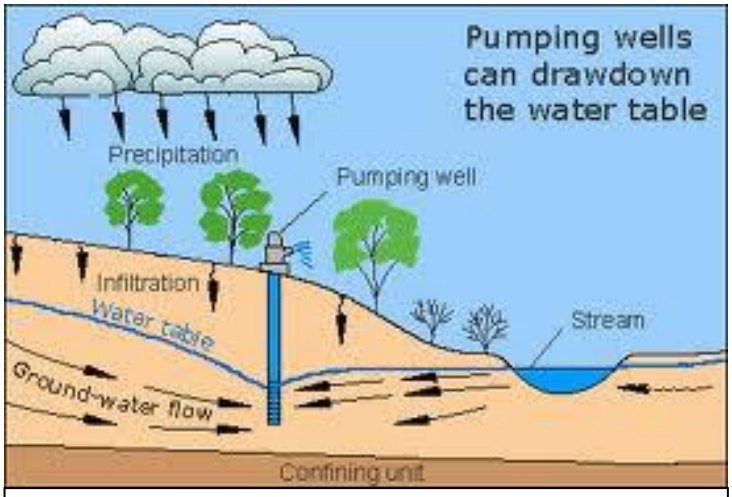


Fig. 9. Schematic illustration of an aquifer and how overdrawing can affect the water table. Source: Perlham, 2013

The situation in New Mexico and its surrounding area also present another example where about 70% of the population depend on water from aquifers, estimated to run out within the next 200 years at the current rate of 'extraction' (The Economist, 2010; 3). In Jakarta and Buenos Aires, getting access to water means that aquifers be drawn and this practice has resulted in pollution, contamination and massive depletion of the water aquifers. Similarly, The Economist presents the situation of the Hai River, China, where water has been exploited to the point of depletion as the water table has been pushed down about 90m below. Other regions known to be water stressed are Australia, South Africa, Spain and Hong Kong.

Due to location of countries, ownership of water bodies is a sensitive issue and has resulted in tense relations between neighbouring states. Cases in point are the River Jordan which serves Israel,

Palestinian territories, Jordan and Syria. All these countries claim some rights to River Jordan (One World UK, 2012). Similarly is the River Nile, where over 9 countries share the resources of the water body. The 2 major users, Egypt and Sudan have actually refused to sign 'The Entebbe Agreement' – a regulation which may modify their rights and consequently, their access to the river (*ibid.*: unpaginated). These claims are part of the contentions in North Africa which have brought about endless conflicts. As such, major water bodies that are shared by different states need to be carefully managed to prevent conflict among countries.

RWH as a supplement for water use is one of a key measure known to deal with water scarcity especially in the above regions where the resource is scarce. Rainwater can also be harvested to replenish depleted aquifers and other dwindling water bodies as well. Other measures are 'drip irrigation' technology for farming which reduces water use to about 50% and increases profits by about the same percentage; educating of farmers on sustainable agricultural practices which involve choosing high yielding 'drought tolerant' crops and techniques to conserve moisture and structure of the soil (One World UK, 2012: unpaginated). Also, to effectively manage 'water wars', there must be careful planning of 'mega-dam' construction projects and clear agreements must also be taken between states upstream and downstream.

As clearly seen above, geographical location of countries which determine fresh water availability and further influences food security may cause environmental hazards and even conflicts among nations. These challenges can be addressed by promoting efficient use of water especially RWH in countries in dry regions. An awareness of changing weather patterns will also help countries plan for floods or droughts before they occur.

2.4. Rainwater Harvesting

2.4.1. Historical Uses

RWH basically involves the collection, storage and continuous use of captured rainwater as either the main or alternative source of water (Roebuck, 2007). The Economist (2010) discusses the importance of the resource to human life on various levels – household, community, national, regional, continent and global.

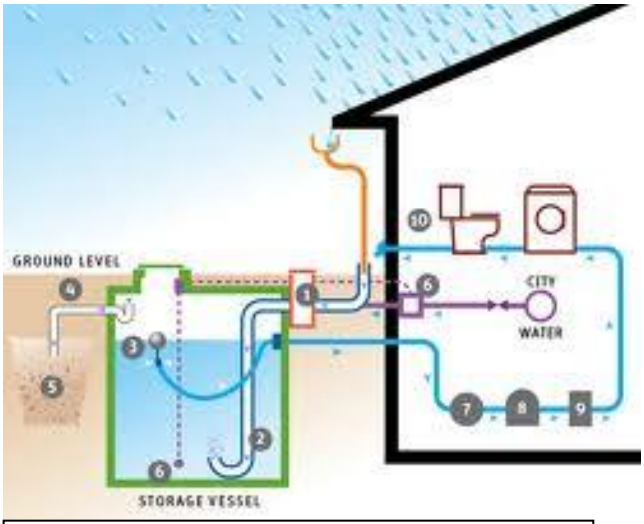


Fig. 10. Schematic Diagram showing how captured rainwater can be used in homes. Source: starkenenvironment.com, 2012.

The Guardian News b (2012: unpaginated) admits that nature is 'unkind' in distributing rainwater as almost 80% falls over the saline sea. Of this percentage, only 40% of rainwater that falls over land turns into 'blue water', trickling into aquifers, rivers and lakes, only accessible by those in proximity or water plants that can tap into the sources and supply (*ibid.*). This makes it only logical that other source of freshwater such as RWH are taken advantage of as a supplement to these sources from land. The discussions below give a brief overview of how RWH has been used over the centuries for purposes including agricultural, domestic use and human consumption.

In primitive times, crude methods used for harvesting rainwater could involve digging cisterns to act as receptacles on the ground or using broad leaves to channel water into a receptacle such as coconut (Rain Barrel, 2005). An illustrated example is seen below in the Sahel region of Africa with a technique called 'Zai' – use of shallow pits from uprooted tree cultivation to collect rainwater (IRHA, 2007: unpaginated)

Fig. 11. An illustration of how rainwater was harvested using holes in the ground. Source: IRHA, 2007.

Although the exact origin of RWH (RWH) cannot be found, the earliest known systems are from the early civilizations of the Middle East and Asia, dating back several thousand years (Gould & Nissen-Peterson, 1999). The Great Constantinople is known to have built the biggest known ancient structures for RWH (Rain Barrel, 2005). Hasse (1989) gives an overview on the history of RWH in some ancient civilisations, starting with how ancient Egyptian armies used rainwater to their advantage. Soldiers dug out secret storage cisterns out of solid rock, which enabled them to survive in secret places on the desert with no fear of intimidation (*ibid.*).

Also, in Roman history, notable parts of their architecture related to RWH are the atrium and reservoirs constructed to collect rainwater into cisterns. RWH is known to have been developed in Rome with influence from Knossos, a magnificent palace in ancient Crete (Ancient-Greece, 2013). Hasse (1989: unpaginated) adds to this history, describing how buildings were designed with a small room called a 'vestibulum' - a closed internal court with an atrium and a pool in the centre into which rainwater flows from the roof. The pool has sloping sides and is finished with ceramics. Water from the pools was used 'improve the microclimates' of rooms and also for domestic purposes (*ibid.*).

Fig. 12: An atrium at the House of Vettii, Rome, showing the area used for rainwater harvesting. Source: Study blue, 2012

This technology was popular in Rome and influenced the development of rainwater storage facilities in neighbouring lands, namely, the Islands of Capri, Malta, Spain and Turkey where water sources were scarce. The practice was popular for a while until the early 16 century AD when Augustus Caesar became emperor. In 850 BC, King Mesha of Moab in Jordan is documented to have ordered that cisterns be dug out for all households in the city of Qerkhah. In Malta between the 15th and 16th centuries, rainwater harvesting systems were used to sustain the country's large population. The first known water supply system was built in A.D. 1610 to improve supply water and stretched from the countryside to the seaports (*ibid.*).

Hasse's (*ibid.:* unpaginated) documentation also describes a RWH structure considered as an architectural icon, the 'Yerebatan Sarayi' (Sunken Palace) in Istanbul. It was used to collect rainwater from upstream of the city into the underground 'Palace' (*ibid.*). The vault was built by Caesar Justinian (A. D. 527-565), with an area of 140 by 70 metres and has a capacity of about 80,000m^3 of water.

Fig. 13: An interior view of the 'Sunken Palace' showing the massive extent of the storage area. Source: theguideistanbul.com, 2011.

Fig. 14: The 'Sunken Palace' showing water beautifully reflecting the columns and a central point. Source: theguideistanbul.com, 2011.

The 'Yerebatan Sarayi' was a typical example of a cheaper system of RWH for a whole city. However, it is no longer used for drinking as it became prone to contamination from the parts of the city upstream (Rain Barrel, 2005; Hasse, 1989). The storage facility is currently being used as a tourist site where tourists ride in boats through arrays of columns. In Malta, centralized water supply and plumbing developed over time as there was a need to improve hygiene, therefore traditional systems for RWH became less useful. This is part of the reason for current emphasis on water treatment before consumption. In Afghanistan, for instance, there are pockets of water scattered in deserts on the countryside but need to be treated before consumption as they tend to be poisonous (Rain Barrel, 2005; Todrerich and Tsukatani, 2005).

Technological advancements which declined during the dark ages in Europe gave way to cheaper methods to be developed especially during the peak of industrialisation (Rain Barrel, 2005). With growing social civilizations, centralized systems of water collection have become common. Hasse (1989) warns of the dangers of allowing the growing populations and economies to rely on centralized water supply, stating that these systems come with disadvantages: in cases of natural disasters such as earthquakes, acts of war or environmental pollution from chemicals, there is a risk of 'total cut-off' in water supply (*ibid*., unpaginated). Also, as developing economies are mostly based on expansion, there are huge demands on centralized water supply systems with no expectation that water resources can dwindle and therefore need to be managed with care. These weaknesses in 'modern centralized water

supply' can therefore be curbed by encouraging the use of other sources of water supply, RWH being the best option.

It is clear that over time, RWH systems prove to highly beneficial to any social and governmental setting that adopts its use, small or large scale. It has been used over the millennia and centuries to fulfil various human needs: domestic purposes, to support military defence systems as is or was the case of Egypt; construction of iconic architectural structures of authority as in the case of Knossos; for air conditioning interiors for comfort in Rome; to construct structures that now serve as a tourist attraction in Istanbul, bringing in revenue for the nation.

These purposes are being fulfilled as a result of efforts to manage water efficiently through the use of RWH. Although RWH became less popular over time, it needs to be adopted in modern times to supplement purposes such as construction projects in water scarce areas instead of using treated water, and the use of atriums in modern day buildings for air conditioning instead of machines for air conditioning.

2.4.2. Rainwater Harvesting Globally

In practice, many systems are employed by policymakers and users in different countries to deal with water scarcity. China and Brazil have taken the lead in using rainwater harvested from rooftops to provide water for almost all domestic use including drinking, irrigation, livestock farming, and re-filling and rejuvenating groundwater levels (Gould, 2012; UNEP, 2009; Nogueira, 2008). Discussions below show how RWH has been used in different countries across the world for various purposes and to champion various developmental agendas.

Brazil

The Semi-Arid regions of Brazil are characterized by unpredictable seasonal rainfall patterns with annual rainfall between 200mm-1000mm (UNEP, 2009; Nogueira, 2008). Irregular rainfall throughout the region causes seasonal droughts leaving the area generally underdeveloped and the majority of the people mostly without potable water and food. Indigenes have traditional techniques of collecting rain water by digging out rock catchments and river bedrock catchments. However, these techniques are not adequate. As a solution to this problem, civil society groups, NGOs - Articulação do Semi-Árido (ASA), churches, local and regional

organisations have therefore partnered with government to develop sustainable methods for potable water for households (*ibid*.).

The 'One Million RWH Programme' (P1MC) targeted female headed households without safe drinking water close to their home (Nogueira, 2008: unpaginated). The main objective of the policy is to construct 1 million RWH systems for a total of about 5 million people. By December 2007, the programme had organised 288, 541 households, constructed 221,514 RWH systems and trained 5,848 masons mainly from the families organised, making it one of the largest RWH programmes in the world (*ibid*.). Households were encouraged to participate in policy implementation. Some members are also trained to construct RWH tanks and to use water efficiently. Beneficiaries are analysed in community meetings under the following criteria: 1) female headed households; 2) families with children up to the age of 6 years; 3) families with children and adolescents of school age; 4) families with adults aged 65 years or older; 5) families which include disabled people (*ibid*.).

The RWH system is a 'semi-underground' tank, with a capacity of 16000 litres which collects rainwater from the roof of the house (Nogueira, 2008: unpaginated). It provides enough potable water for about eight months, the average drought period in the region. A cheap traditional method of using a breed of fish that eats larvae is used to keep the water safe for drinking. Households contribute to the programme by assisting to dig the hole for the tank, providing food and lodging for the masons during the generally 5 days of construction. Also, a family member is usually trained to manage and maintain the system. Women are the usually chosen and assigned this responsibility.

The selection criteria made female headed households a priority as they were recognised as the more vulnerable group. Also, from experience, it is more sustainable for females to be made responsible for the project. A typical example is seen where it is common to find men selling properties after construction of the RWH system since the value of properties went up unlike women, who kept their properties. Also, the system reduces women's daily work of fetching water although there is not always rainwater to fill the tank and water from trucks is used at these periods. In addition, the construction of the RWH system enables households to earn

more income as women could start cultivating vegetables, fruits or animal breeding. Those who have acquired skills from masonry training could also use their skills to fetch extra income. (*ibid*.)

Fig. 15. A Brazilian woman using her masonry skills to construct a tank for income. Photo: GWA, 2008. Source: Nogueira, 2008

This effort to provide sustainable water for people through RWH has gone a long way to improve their socio-economic lives and physical environment. Prioritising the female headed households by training and giving them management responsibilities is empowering and ceases their helplessness over the living environment. It also enables them have control on their lives and environment. By acquiring a RWH system, there is income, food for families, and people are more responsible towards their living environment. Farming activities employed will rejuvenate the soil and plant life in the region, creating a healthier environment. This approach is a clear case where the benefits of RWH have been judiciously exploited for people and the environment.

Fig. 16. A RWH tank made of pre-cast concrete plates. Source: UNEP, 2009

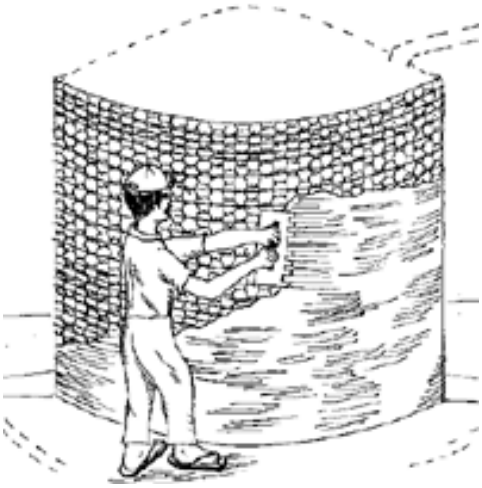


Fig. 17. RWH tank made of wire mesh concrete. Source: UNEP, 2009

China

Currently, the other biggest RWH project known worldwide is found in Gansu province in China (UNEP, 2009). The Gansu Province is one of the driest provinces in China with annual rainfall of about 300mm and average humidity at 1500-2000mm (*ibid*.). People mostly rely on groundwater from rain is the main water source used to support agricultural practices. A traditional method of excavating 20 m^3 of clay to line underground cisterns is a common practice for catching and storing surface runoff water. However, this practice is not dependable as dry seasons are dire with no surface water to be collected for seasons on end. This creates a difficult life for indigenes as they have to travel long distance to rivers and other water sources before they can have access to drinking water (*ibid*.).

Research, experiments and pilot projects carried out from 1988 led the Gansu Provincial Government to institute the '121' Rainwater Catchment Project in between 1995-1996 (*ibid*.; Centre for Science and Environment, 2012). Individual families were provided with tiled roof catchment area, two upgraded cement water cellars and plastic sheeting to concentrate rainwater runoff onto a field. The existing clay lined water cellars – 'shuijiao' – were upgraded by lining them with concrete and cement, and small metal pumps attached to them (*ibid*.). Trenches were then dug around the cemented courtyards and used to harvest vegetable

gardens close by ((*ibid*.). The affordable and sustainable methods used have assisted over 200,000 families, secured water and food for about 1 million people. About 2,183,000 RWH tanks had been constructed by 2000 with capacity of 73.1 million m^3 in the Gansu Province alone. This amount supplied potable water to 1.97 million people and supplemented irrigation of 234,400 hectares of farmland (*ibid*.).

Fig. 18. Agricultural Irrigation made effective with Rainwater Storage Cellar. Source: UNEP, 2004

The success of this project shows that there is always potential in communities to improve access to drinking water using RWH systems. The traditional methods used by the people can be upgraded using modern scientific methods which are tried and tested such as the use of cement to line the catchment are for water instead of clay. These upgrades are sustainable as they are cheaper and more familiar with the people, making them easy to manage.

United States

In the United States, before 2009, the state of Colorado legislature had instituted laws that strictly controlled and almost prevented RWH (Colorado Division of Water Resources, 2009). Colorado produces and exports water and so takes its water policies and laws very seriously. The 'Water Rights' stems from the Colorado 'Law of the River' where the upper Basin states - Utah, Mexico and Wyoming and Colorado - raised concerns about the water developments, projects and damming activities being a disadvantage to water users in the lower basin - Nevada, Arizona and California (South Western Water Conservation District, 2012).

A treaty signed in 1922 sealed this law which sought to deal with contentious issues on the use of the Colorado river such as suitable environmental legislations, water quality, Water Rights for

Indians, interstate conflicts and endangered species (*ibid.*). Before the law was amended, 'Water Rights' were entitled solely to particular owners. It gave these holders rights to 'all moisture in the atmosphere that falls within its borders to the state of Colorado. The constitution of the state explicitly spelt out that the 'said moisture is declared to be the property of the people of this[e] state, dedicated to their use'.

This implies that water was to be used according to 'priority of appropriation', which meant that it was a crime to divert and use water which fell on one's property unless the user had 'Water Rights' or only during periods when water bodies/ rivers overflowed their banks (Colorado Water Conservation Board, 2010: unpaginated). The law was commonly found in most urban, suburban and rural parts of the state. The system was adopted to protect the 'owners of senior Water Rights' especially in cases where there was not enough of the water resource (*ibid.*).

The close control and restriction on access to water was recently revised in July 2009 and limited to only those who met certain criteria to apply for a permit to install a 'rooftop precipitation collection system' (*ibid.*). The new 'Water Rights' law, allowed property owners some level of freedom to collect rainwater or precipitation. A strict criterion was drawn up for applicants who wanted to collect rain/groundwater:

1. The property on which the collection takes place must be a residential property; and
2. The landowner must use a well, or legally entitled to a well, for the water supply; and
3. The well must be permitted for domestic uses according to a section of the stipulated regulations and
4. There must be no water supply available in the area from a municipality or water district; and
5. The rainwater must be collected only from the roof of a building that is used primarily as a residence; and
6. The water must be used only for those uses that are allowed by, and identified on, the well permit. (*ibid.*)

Property owners were obliged to conform to all these laws and restrictions before they could get approval to collect rain/groundwater. In addition to the above requirements, other restrictions accompanied the law:

- Property owners must apply for and acquire a well permit before applying for the rights to collect water
- If property owners gained rights to collect rain/groundwater, they were not to use it to water gardens and landscapes within or outside their properties
- The law only applies to homes without access to a central water supply system, such as running water from the local department of water
- Individual owners are not permitted to develop on their own, 'large scale projects to collect precipitation from impervious surfaces' particularly where the area has a central water system

Also, the Colorado law currently does not allow drilling of water wells until the property covers at least 35 acres. (*ibid*.).

Fig. 19. Sterling Ranch, the first RWH site in Colorado. Source: www.lid.okstate.edu.com

Fig. 20. A storage tank made of pre-cast concrete being advertised for use in Colorado. Source: www.westerngardeners.com

Although it is important that local laws guide the developments that occur in their jurisdiction, the original Water Rights law which restricted RWH may need to be abandoned. Although this new law is an improvement in the previous one that existed before 2009, it is still extreme, unsustainable and does not to allow residents to use affordable alternatives available in their environment to manage water. It is also not environmentally friendly to restrict residences found within an area with central water supply to only depend on treated water for all domestic purposes. It is more economical for residents and the water supply services to use rainwater or

groundwater for other non-potable uses such as watering gardens and sanitary purposes, not to mention the environmental benefits.

Generally, it will be more beneficial and advantageous for the whole state of Colorado if this law is abolished so residents are permitted to exploit all the alternatives available for collecting precipitation on their own. However, the state is encouraged to continue with guidance on this new practice to enable the development of appropriate systems.

Bermuda

Unlike Colorado, other states use judicious means to employ RWH either as a key source or supplement to water. Bermuda, the US Virgin Islands and New Mexico law requires all new construction to include RWH in new buildings which will be adequate for the residents (Solomon, 2006; City of Albuquerque, 2005).

The Island of Bermuda which is a self-governing dependency located East of the North American coast with a total land area of 53.1 km^2 and has been using rainwater supply system for over 400 years (UNEP, 2012; Colorado Water Conservation Board, 2010:). The land mass is elevated less than 30 metres above the sea level with the land surface rising not more than 100 metres high; the soil is made of porous limestone which absorbs water easily and there is no river or freshwater body on the island (*ibid.*) . This feature of the land makes it difficult to collect water on a large-scale for distribution into households. The early settlers who were highly skilled in construction developed the rainwater catchment system. Over the years, it has been adapted and used, it is therefore common to find roofs, 'wedge – shaped limestone glides' laid to form sloping gutters which collect rainwater into storage tanks (UNEP, 2012).

Fig. 21. White roofs, a common sight in Bermuda Source: sites.securemgr.com.

Fig. 22. A close up view of the horizontal grids on roofs that slows down speed of water flow Source: internationalchristianfictionwriters. blogspot.com.

The law for every house-owner is to have a minimum of 80% of the total roof as a catchment area for rainwater (Bermuda Environmental Alliance, 2012; unpaginated). Roofs are designed such that rainwater falls and flows gently into collecting ducts without spilling and wasting away (*ibid.*). Wire mesh is placed at the edge of collecting ducts to prevent debris from entering the tank. The roof is then finished with a white paint called 'lime wash' which makes it wind, water and bacterial resistant (*ibid.*).

The majority of the RWH systems have their storage tanks built under buildings and connected with electric pumps to pump water into taps inside homes. The tanks floors, walls and roofs are built with reinforced concrete. The local Public health authority instituted the regulation for storage tanks to be painted with 'white latex paint', free from metals that may be absorbed into the collected water (UNEP, 2012). Tanks are cleaned and chlorinated every 5 years. Residents who also install RWH systems are advised to frequently maintain the tanks, gutters, pipes, vents and screens of their storage tanks. Roofs must be repainted, at minimum, bi-annually and storage tanks at least once every six years (Bermuda Environmental Alliance, 2012; unpaginated; UNEP, 2012). This system collects about 350,000 litres of water per house annually (*ibid.*).

The developments on the Island of Bermuda show that although the geography of an area can present challenges to water supply. Architecture can be adapted over time to take advantage of rainwater as a source of water supply. Due to the limited land area to collect water for individual homes, roofs are made the primary surface for water collection whilst tanks constructed underground the houses save space. The use of limestone from is also sustainable as it is readily available in the environment, making it affordable and a convenient material. However, the use of concrete for the underground storage tanks is expensive and cannot be applied where projects intend to save money.

The residents of Bermuda continue to adapt this water supply system as it has proved useful over the years. Local authorities can therefore always step in to advise communities on how traditional methods of water supply can be improved. This system enables residents to achieve

long-term means of water supply whilst they have control and total responsibility over their water management practices.

United Kingdom

In the United Kingdom, there is a 'code for sustainable homes' which is spells out the 'national standard for sustainable design and construction of new homes' (Department for Communities and Local Government, 2010; unpaginated). It applies in England, Northern Ireland and Wales. Homeowners are encouraged to apply it to new homes and therefore the code is voluntary. It covers nine categories of which water and 'surface water run-off' are included (*ibid*.). In the code, new homeowners are encouraged to save money and water resources by installing RWH systems to collect water for flushing toilets, washing clothes, watering the garden, and washing cars (*ibid*.).

This contributes a reduction of about 50% the volume of water used in the house (*ibid*.). It is also typical to find 'water butts' in domestic gardens for rainwater collection which is used to water gardens (*ibid*.). This requirement therefore encourages homeowners to acquire systems for RWH and made aware of the benefits they will derive from this directive: saving them money from extra charges they would have incurred if they solely rely on the local water supply.

RWH across the world therefore has become widely accepted as it presents a cheaper, more convenient means of accessing water supply. It is evident that that homes and environments can always be modified to harvest rainwater. New policies and laws can always be instituted and amended to achieve successful projects for RWH in communities and households. When communities are deeply involved in such projects and policies which are gender sensitive also applied, households stand to benefit more socially and economically.

2.5. RWH in Africa

Sustainable water management is not a new practice in Africa. Provision for RWH is part of the architecture of traditional buildings in Sub-Saharan African countries like Ghana, Burkina Faso, Senegal and Guinea Bissau (Pachpute, 2010; Pachpute, Tumbo, Sally and Mull 2009). There is proof that people in arid regions on the continent can also find cheaper methods of accessing water supply through RWH and this has been conducted in Ethiopia and Kenya. The following

discussion will show how RWH systems have helped households, communities and states improve all aspects their living standards on the continent.

Kenya and Ethiopia

In Kenya and Ethiopia, a research conducted by the Regional Land Management Unit (RELMA) and Swedish International Development Cooperation Agency (SIDA) helps determine the best methods farmers can use to store rainwater for domestic use (Nega and Kimeu, 2002). The need for this research arose when it became evident that there was a lack of adequate quality water for domestic use; the location of water sources which are far from homes also puts a strain on women's domestic activities as well as concerns about most girls being removed from school in order to assist with collection of water. East Africa is a region that is generally arid and water scarce, making Kenya and Ethiopia good options for this project experimentation.

For Kenya, water challenges are common, as people generally spend a large proportion of their time, resources and income on water. Water supplies are also not potable, making water borne diseases common. Government and other local authorities' efforts have not had much impact as funding is not available to embark on new water supply projects or maintain existing ones. In the meantime, people sacrifice a lot to get water, especially female children as most of them are known to be withdrawn from school to help fetch water (Nega and Kimeu, 2002). Similarly, Ethiopia also struggles with provision of water for the growing population. Only an estimated 3-4% of rural populations have access to safe water supply. Water borne diseases are therefore a major threat due to poor sanitation and lack of hygiene in homes. The situation in long dry seasons are so serious that people travel as far as 10-15 km to look for water in the much drier parts of the country, making water accessibility an issue which drains families in every aspect of their lives. As a result, the poor communities use cheap materials and resources known for transporting water such as clay pots and gourds; however, plastic jerrycans, tyre tubes, skin bags and barrels have recently become common as they are lighter and easier to manage. Clay pots also have the advantage of being cheaper and keeping water cool (*ibid.*).

The findings showed that local materials and cheap labour can be solicited to construct large vessels underground tanks for either individual homes or community use. Construction and

maintenance of storage tanks was an expensive venture, therefore, training community members and using collectively cheap labour from them was found most appropriate (*ibid*.; Thomas, 1998). Cheaper systems of RWH for domestic need simple materials such as iron corrugated roofing sheets or clay tiles, pipes and gutters for transporting water into storage tanks which could also be moulded from the iron sheets. It was also established that installation of underground tanks is cheaper and need to be closer to households; however, the installation comes with maintenance cost (Nega and Kimeu, 2002).

Availability of local materials and technical know-how is clearly are key factors that will be helpful in assisting communities install RWH systems for either communal or individual household use. Corrugated iron sheets will be an appropriate material for the case of South Africa if it is to embark on projects for poor communities as the material is readily available and commonly used in the country. As storage structures are the most expensive items for a RWH system, financial assistance could be given in acquiring them. Also, training community groups to become independent in installing and maintenance of RWH systems empowers communities socially and economically.

Ghana

Ghana is a third world economy in Sub-saharan Africa faced with the typical economic pressures of most African countries: high levels of poverty estimated at 26% as at 2012 (Ghanaweb, 2012), but it enjoys a fairly peaceful political and tribal environment compared to the rest of its neighbours in the region. It is estimated that by 2025, about 50% of the population will be affected by water shortages (NEPAD, 2002 cited in Malley et al. 2008 and Opare, 2011). Currently, food security in most rural communities in the country is at high risk as a result of water shortages and communities deprived of water mostly get aid from foreign donor programmes (Opare, 2011). These shortages are brought about by dry climate, droughts, rapid population growth and lack of funds to build and maintain dams, water storage reservoirs, dams and centralized water supply systems (Agyemang, 2011). In collaboration with neighbouring country Burkina Faso, Ghana has embarked on a programme to encourage the use of rainwater to supplement water supply especially for rural communities (Al-Hajj, 2012; Millward, 2011). The goal of this policy is to increase agricultural production which has seen many challenges as a result of unpredictable weather patterns and to supplement water supply for other uses.

In line with helping to curb water scarcity, stakeholders in Ghana are advocating for laws which oblige property owners to install RWH facilities in public and commercial buildings to be instituted (Asare, 2011; Al-Hajj, 2013). The Minister for Water Resources, Works and Housing expressed his views on a National Rainwater Harvesting policy being instituted, stating that '[W]ith a law backing rainwater harvesting, the government or stakeholders can go to court if people are not going by it' (Asare, 2011: unpaginated). This comment is related to current concerns on shortfalls in standards and codes in the country. The building and construction sector particularly, has issues with law enforcement by public authorities. It is further pointed out that the first President of Ghana, Dr. Kwame Nkrumah, one of the most dynamic leaders the country has had, started projects that incorporated RWH systems in some public buildings in Tarkwa, a mining town in the Western Region of the country. However, sustainable projects of this kind were not undertaken by successive governments.

The directive for sustainable water supply for the country therefore was outlined in June 2010, by the Minister for Water Resources, Works and Housing at a meeting to discuss major policies concerning Ghana's water sector. He stated that '… sometimes, the key to unlocking our water problems simply falls from the blue skies…', and that RWH has a great potential to enhance water availability in homes, farms, schools and offices all year round (Business Guide, 2011: unpaginated; Smith Asante, 2010: unpaginated). The Ghanaian market has water purifying equipment which the minister encouraged people to invest in to make harvested water safe for use. The Ministry has adopted a slogan: 'For every bucket of pipe water we use, we should endeavour to capture one from the heavens' which simply aims to prove how feasible it is to use rainwater as a supplement to other water sources (Asare, 2011; Al-Hajj, 2013). Long term plans for RWH are to be introduced through metropolitan, municipal and district assemblies who will be tasked to enforce the practice. In practice, builders will be required to build rain gutters to harvest rainwater which can be directed into open/ underground wells, small ponds and percolation chambers constructed strictly for water storage. In additional forms of rainwater harvesting, there is a 'flush' system attached to the system to divert the first batch of water which contains roof debris and a 'filter unit' to remove contaminants before storage (Alhajj, 2013: unpaginated).

Currently, projects being undertaken in the country are for basic schools and other educational institutions (Asare, 2011; Opare, 2011). Al-Hajj (2012) believes that RWH can be introduced in peri-urban communities where centralized water supply is clearly a failure and residents can be easily motivated to adopt their own strategies to obtain water.

As a third world country with great potential to easily improve the lives of citizens through its rich democracy, new discovery of oil and abundance of other minerals, Ghana can conveniently provide adequate water supply to most of its households. As observed earlier by One World Uk (2012), Ghana lies in a region of Sub Saharan Africa with adequate rainwater but uses only about 4% of harvested rainwater for agricultural purposes. The move to encourage the use of other sources of water through policies and law is in therefore in the right direction as it encourages citizens to take advantage of this potential and to support other sources of water. If well enforced and implemented, this policy will eventually increase food production. Ghana can take a cue from the experiences of a state such as Bermuda if these plans are to be taken seriously through passing of a bill and its enforcement. Poor households stand to gain immensely from this practice especially those in deprived parts of the country.

Namibia

The RWH project in Namibia was one of the first attempts at merging research methods with participatory approach to develop a collective system which will support water provision for poor communities. Namibia is the driest country in Sub-Saharan Africa with the shortest rainy season (Heyns, 2005). As a result, water demand has been a challenge coupled with high demand and unsuccessful government efforts to tackle the scarcity. This is attributed to the fact that a highly centralized supply system exists in the country which makes it difficult to provide water for the varied sections of the population: highly urbanized, sub-urban and informal housing sector (Baker, Grygorcewicz, Opperman, Ward, 2007).

A government policy was instituted which involved users accessing water via communal pipes. The water was only accessed using a prepaid charge card as payment. This policy was been criticised as it was expensive for the poor, especially those in the informal settlements (Baker *et al.*, 2007). The project by Baker *et. al.* (2007) therefore sought to assist informal settlements in Windhoek develop affordable means of accessing water on their own through RWH. The

participatory aspect of the project was intended to stimulate interest in rainwater harvesting by engaging the community in the process, from planning to implementation (*ibid.*). A RWH system was designed and constructed using recycled materials and items: a 200L drum discarded from a scrapyard, lined with plastic bag to prevent from leakage and used as a storage tank; a down pipe made from scrap metals joined together and the funnel from a plastic 5L container. To prevent mosquitoes from entering the tank, a wire mesh is placed inside the funnel.

Fig. 23. 200L Drum. Source: Baker, *et. al.*, 2007.

Fig. 24. A down pipe and funnel. Source: Baker, *et. al.*, 2007.

Fig. 25. The completed storage tank. Source: Baker, *et. al.*, 2007.

Figure 23 above shows a sample of the completed storage tank. This system is appropriate as the materials used were readily available in their environment as well making it cheap and easy to construct. The research proved that amount of rainwater harvested by the new catchment system 'could significantly offset municipal water usage' (*ibid.*, 44). The most appropriate RWH system for poor communities therefore was one that used recycled materials from the community.

The success of this project proves that even in the most extremely deprived circumstances in the most arid regions of the world, RWH can still be used to supplement and at most, be used as the main source of water supply. Engaging communities in all stages of the project; incorporating cheap and readily available materials found in their environment also facilitates adaptation of the system by the community.

RWH in Africa will be an integral part of water provision if the right approaches are adopted to introduce them into poor communities and households. For a start, policymakers and stakeholders in the water sector need to embark on more campaigns to make the practice accepted as either a law or a necessary requirement for cheap, adequate water supply. Cheap materials are available in the environment which can be recycled and inexpensive labour that can be sourced from training households and community members to either individually construct RWH systems on their own or communally construct storage systems, which are the most expensive phase of the system.

For South Africa, these initiatives can be easily adopted as it is an African country with more control on physical developments especially in the housing sector. There are presently many dynamics in the housing industry of South Africa which serves as a good potential for introducing RHW into low income households. Discussions below touch on some of these programs and systems, how they have shaped housing currently and initiatives that can be undertaken to introduce RWH into low income households in the country.

2.5.1. Rainwater Harvesting In South Africa

As a country which is water stressed, South Africa also has a number of projects for sustainable water management. These projects mainly stem from the constitutional requirement and legislations such as the Water Services Act) to provide access to basic water supply (Department of Water Affairs, 2009). Most of these RWH projects are part of other Green initiatives or community development programmes all aimed at achieving sustainable quality living for the poor.

The Bothlabela village, developed by Community Residential Unit (CRU) programme offers decent and affordable housing which is a key necessity in the Alexandria, Johannesburg. Located on the Far East bank of Alexandria, the housing development comprises 520 units fitted with RWH systems (SHF, 2010). As the buildings were purposed to be sustainable and energy efficient, they are also fitted with grey water recycling system, solar heating for hot water, cheaper public lighting, landscaping made to assist with storm water management and permaculture for food gardens (*ibid.*).

The Cato Manor project was undertaken as part of the GBCSA and the World Green Council's participation in the UN COP17 climate change summit (Naidoo, 2011). It sought to improve the lives of poor communities and at the same time reduce the impact of their livelihood activities on the

environment. Green retrofits were installed in 27 low cost houses and RWH, water storage tanks were installed to provide water in times of droughts for irrigation and for domestic activities such as laundry (Botes, 2012; Urban Earth, 2012; Naidoo, 2011). As a job creation initiative, residents received training on how to install RWH retrofits into homes (*ibid.*).

Fig. 26. : RWH tanks retroffited into a home provides water for backyard gardens in Cator Manor.

Another RWH project in Cape Town at the Indlovu Centre, Khayelitsa is aimed at developing sustainable communities through easy access to water resources. Undertaken by the Shaster Foundation, the initiative aims to tackle issues linked with poverty, disease, malnutrition and unemployment (Becker, Fitzell and Royer, 2007; Alex, Cusack, Mills and Sosa, 2007). Among other interventions, RWH and irrigation systems were constructed to support a laundry station in this project. This facility makes it possible for residents to use the laundry without the use of the municipal water which they have to pay for. Assistance for water provision in this from therefore presents an affordable and sustainable living for residents of these poor communities.

The AWARD and SSP's projects are an example of a programme aimed at promoting sustainable water management and also to improve the livelihoods of rural communities. Under the project scheme, different options for RWH are presented: the use of the ferro-cement tank, underground water storage and Jojo tanks (plastic) (AWARD a; AWARD b; 2013). Among these options, the Jojo tank is the best choice as it is readily available, cheaper to install and easier to maintain.

Collectively, these projects contribute to supplement water supply and management in poor communities as well as improve their quality of life. The training given to community members to install and maintain RWH systems is one key factor that makes significant impact as it tackles issues of unemployment, a major social problem.

CHAPTER 3: SUSTAINABLE WATER MANAGEMENT POLICIES SOUTH AFRICA

3.1. Integrated Water Resources Management

As noted earlier, in line with South Africa's vision to achieve a healthy and dignified lifestyle for its citizens through easy access to water, policies such as the National Water Policy (1997) and National Water Act (1998) have been instituted. The National Water Resource Strategy (IWRM) is therefore in place to give practical factors for efficiency in water use. The IWRM also outlines support and assistance put in place to achieve sustainable practice for water use. The strategy also considers affordability of water, especially for the poor and disadvantaged, but at the same time, emphasises its economic value. The integrated approach to water resources management is noted in the National Water Policy where water is recognised as a resource which occurs in 'many different forms which are all part of a unitary, inter-dependent cycle' and that it is important to inclusively manage it (Department of Water Affairs and Forestry, 2004: 10).

The document defines IWRM as 'process which promotes … co-ordinated development and management of water, land and related resources … to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems' (Department of Water Affairs and Forestry, 2004: 10). The key objective if IWRM as projected therefore is to create a synergy between using resources to support occupations and conserving for future generations, promoting social equity, environmental sustainability and economic efficiency. Since water resources cannot be managed without considering the users, it is important to apply appropriate technological and social systems to achieve integrated management (*ibid.*).

The IWRM document explains that fresh water in the form of groundwater, surface water and their quality and quantity are all connected to a continuous hydrological cycle of rainfall, runoff from the land and infiltrated into the ground as well as evaporated back into the atmosphere. Each process therefore influences the other and therefore must be managed by considering these interrelationships. The impact of human activities such as waste disposal, air pollution, on the quantity and quality of water available for human use, whilst the process of absorbing, storing and discharging waste into water resources all affect

the nature. These connections of water resources to the environment and human activity must therefore be noted by professionals dealing with water resource management. Generally, there is also the social and economic importance of the resource.

The IWRM presents a picture of the country's water sources. South Africa's water comes from four main river basins which collectively cover about 60% of the land area which account for 40% of the total surface runoff, with neighbouring countries (*ibid.*). High priority is therefore accorded to achieve constant cordial relations with these neighbours.

3.2. Institutional Arrangements for water resource management in South Africa

In terms of institutional arrangements to manage water resources in South Africa, the IWRM admits that the involvement of a large number of institutions, both domestic and international, present many complications to the strategy. The Department of Water Affairs and Forestry has the obligation to oversee the accordance of water resource programmes with government policy and in coordination also with significant programmes of other national departments. Conversely, other departmental programmes also have to function with due consideration for the water situation in the country. For the success of any project that relies on water, planning developments need to factor in the water situation of the country. The NWRS therefore has the responsibility to provide adequate information about water resources to facilitate comprehensible and complete planning and to create a workable framework for well-informed collaborations between water resource managers and development planners in other divisions. In accordance with the Water Act (1997) and NWRS, the Department of Water and Forestry seeks to successfully create 19 'catchment agencies' which will operate in a specific area in water management at the regional level (*ibid.*: 11).

This discussion shows the efforts of the South African government to effectively implement programs and projects which are in accordance with the precepts and concepts for water provision (National Water Act, 1997) in the country. The frameworks presented also seek not to make any development in isolation but to actively involve other related agencies in order to ensure effective and sustainable outcomes for NWRS projects across board.

However, there is not much recognition given to RWH, instead, the approach concentrates mainly on protection of available water resource and efficiency in its management. It will be very useful if the Department of Water and Forestry establishes policies and campaigns on RWH through the NWRS. This will help promote the practice in homes, reduce pressure on the available water resources and eventually contribute to its protection.

3.3. Integrated Water Resources Management as a Tool to Addressing Poverty and Gender Issues

The challenge of addressing abject poverty and gender inequality is of utmost priority for South Africa. Any approach, therefore adopted by the country, must be in tune with assisting to address this issue. The document on NWRS substantiates this fact by presenting international, local principles and models on which these plans are formed (Department of Water Affairs and Forestry, 2004). An integrated approach to managing water resources is regarded as a key approach to ensuring human survival, productivity and health (*ibid.*). Recent global meetings such as the United Nations Millennium Summit of September 2000 and the World Summit on Sustainable Development of August 2002 both reiterated the fact that human survival must be made the main core of sustainable development and water resource management strategies. Also discussed at these meetings are resolutions, plans and goals on poverty, gender inequality issues and the significance of water in addressing these matters as well as for water management approaches to be considered in all categories of implementation. The African context reflects these policy objectives for the Southern African Vision for Water, Life and the Environment in the 21st Century and the New African Partnership for Development.

Some of the water related objectives are:

Millennium Development Goals for 2015, using 1990 as a benchmark

- Halve the proportion of people living in extreme poverty and hunger
- Halve the proportion of people without access to safe drinking water (with sanitation added at the World Summit on Sustainable Development, 2002)
- Empower women and promote equity between women and men. (Department of Water Affairs and Forestry, 2004).

At a world summit on Sustainable Development, a plan was adopted - Johannesburg Plan of implementation (JPoI) – to help streamline implementation plans which are in line with the Millennium Development Goals for water in support to the approach to develop integrated water resources management and water efficiency plans by 2005. The plan seeks to:

- Develop and implement national/regional strategies, plans and programmes with regard to integrated river basin, watershed and groundwater management, and introduce measures to improve the efficiency of water infrastructure to reduce losses and increase recycling of water.
- Improve the efficient use of water resources and promote their allocation among competing uses in a way that gives priority to the satisfaction of basic human needs and balances the requirement of preserving or restoring ecosystems and their functions. (Department of Water Affairs and Forestry, 2004).

NEPAD Water and Sanitation Sector Policy Objectives:

- Ensure sustainable access to safe and adequate clean water supply and sanitation, especially for the poor
- Plan and manage water resources to become a basis for national and regional co-operation and development
- Systematically address and sustain ecosystems, biodiversity and wildlife Co-operate on shared rivers among member states
- Effectively address the threat of climate change
- Ensure enhanced irrigation and rain-fed agriculture to improve agricultural production and food security.

These objectives holistically recognise some of the issues discussed in Chapter 1 as contributing to water scarcity or its availability. It is commendable that South Africa regards these policy objectives in its plans to ensure easy access to water for its citizens, however, it is meaningless for such plans to only be on paper and not well implemented.

3.4. Southern African Vision for Water, Life and the Environment in the 21st Century

As water is considered for its social, environmental and economic advantages in South Africa as in other regions of the continent, it is important for policies to effectively improve on quality of life of individuals, especially the poor. Pressure on the available water resources as a result of some of the issues discussed in Chapter 1 of this report, there continues to be threat in maintenance of existing ecosystems. This situation also calls for efforts to ensure that policies created to address water provision constitute plans that allow the voices of the poor to be heard. Also, to successfully address gender equality, various legislations, policies, programmes and implementation strategies, must give fair grounds for participation of both sexes in water resources management.

From local and international experience, the involvement of women in all levels of water resources management enriches poverty eradication initiatives. The role, perspectives and viewpoints of men and women on water management are different; for instance, the authority of men in the social African setting is mostly regarded than that of women. This makes it easy for women to be solely left with the responsible for ensuring access to water in homes even in cases when men can clearly assist. These differences must be brought to the fore in participatory strategies and decision making deliberations. Poor black women and also, those in low income households are the most likely group in South Africa who experience such situations. There must therefore be deliberate efforts to meet the needs of this group in water management in households. Special emphasis must be made in the IWRM approach on participation of women in water resources management especially for RWH.

It is agreeable to use effective water resources management to address poverty and gender inequality in South Africa by especially involving women. However, the needs of children particularly in poor communities have been ignored in the IWRM approach. Children from poor rural communities are actively involved in water management to the point that sometimes their education is compromised as a result. When education for children and the youth as a whole is compromised, it goes a long way to deepen poverty. It is therefore

important that the needs of children are factored in policies and plans for efficient water management, from collection to use notably in campaigns for RWH. The IWRM for South Africa has to take note of this situation as the document discussed above agrees that an integrated approach to water management does not function in isolation. Appropriate measures which will achieve the best result in line with forming a society that is free from poverty and discrimination must therefore be adopted. The next chapter outlines some of approaches the country has adopted to achieve sustainable development through water accessibility and the whether goals have been met.

CHAPTER 4: SUSTAINABLE DEVELOPMENT AND WATER ACCESSIBILITY IN SOUTH AFRICA

As the South African government has chosen to achieve Sustainable Development at all levels of government there is an awareness of its benefits especially, in the long term. Various discussions have been made on the policies, plans and institutions put in place to achieve development especially those that relate to water accessibility. Some of these debates support and prove that there are social, physical, technological, economic and ecological gains with adapting developments which considers the needs of both present and future generations. Assurance for adequate resources for posterity is one key factor that drives these developments. This subchapter discusses sustainable development, some of the programmes and policies instituted to achieve it and how they relate to water accessibility, especially RWH in South African homes.

4.1. Sustainable Ecological Built Environment

Swilling (2006) discusses the need for South Africa to consider ecological sustainability issues in urban infrastructure, plans and other investments. Currently, he does not believe the country gives due attention to ecological issues and matters that deal with climate change. He (*ibid.*) implores stakeholders to consider prudent measures in resource use and be aware that available resources run out in time. Fresh water, fossil fuels and food are key resources which are likely to run out and become expensive, leaving low income groups to suffer with the high costs. It is expedient therefore, for sustainable methods to be adopted for infrastructural development as well as energy, water and food supply (*ibid.*; Baumann, 2003; Leckie, S., 2003). Methods for these resources need to be applied in all stages possible – processing, supply and use.

Swilling's (2006) discussion makes a clear example with the city of Cape Town, which relies heavily on water for irrigation and domestic purposes whilst it is water constrained. This situation needs to be given immediate attention by promoting a sustainable water accessibility mode such as RWH to supplement this demand. Also, ecologically sensitive housing provisions for the low income groups need to be designed such that they leave a 'low carbon footprint' (Global Footprint Network and WWF, 2008: 3). This development approach and the design of 'more compact', 'conventional housing' therefore will result in lower costs to the poor as cost of water, transportation, and electricity will reduce as well and eventually contribute to a lower carbon footprint (Behrens and Wilkinson, 2003; Swilling, 2006: 23). In addition to these

practices, common spaces and land resources such as wetlands, forests and parks which are especially close to housing developments must be managed better as they are closely linked to water accessibility.

4.2. Socio-economic Sustainability

For urban parts of the country, the government has an important objective to strategically attain social and economic development through increased investments in urban infrastructure. This is with the concept that investing in public infrastructure will have a positive impact on economic growth as it initiates and increases private sector investments, reduces poverty and brings about eventual social change (Department of Provincial and Local Government, 2004). The Municipal Infrastructure Grant (MIG) programme is planned to assist in the investment of over R15 billion for the development of municipal infrastructure for a period of about three years (initiated in 2004) (*ibid.*). In order to ensure adequate implementation of the funds spatially, the office of the President instituted the National Spatial Development Perspective (NSDP) policy framework (Office of the Presidency, 2006). Eventually, this policy is intended to help stimulate economic and social growth by investing the funds for infrastructural growth in areas where there is a high potential for growth and social needs are most needed (Department of Provincial and Local Government, 2004; Swilling, 2006).

Although Swilling (2006) points out some shortfalls on how state led investments are concentrated in urban areas whilst well established rural settings where low income households are based, are increasingly being neglected. This approach needs to be turned around for investments to be targeted in rural parts and poor neighbourhoods in certain settlements close to cities such as Soweto where most low income households are also found. There is therefore a call to concentrate on high growth areas in particular 'non-core parts of metropolitan areas' and centres of other 'secondary cities' (*ibid.*, 31). This is critical as in South Africa, most of these areas, especially those black communities and informal settlements, lack decent infrastructure, notably, water.

Some programmes being funded by the MIG mostly contribute to the sustainable development agenda: the increased assistance towards small scale industries and major enterprises, formation of new plans to support community based developments such as those in the housing sector. Some of these funds can therefore be invested into RWH programmes that can be promoted by private institutions, NGOs and Public-Private initiatives.

On its part, the Department of Water Affairs (DWAF, 2008) aims to use the MIG programme subsidize the capital cost of the basic infrastructure for the poor. Appropriate financial models are therefore used to assist infrastructural development for small scale economic activities especially for under privileged communities (mostly made up of low income households). For this purpose, the department calls for a revision of the MIG policy to direct it towards achieving these goals. In addition to investments for assurance of water supply, the department also plans to support water conservation and water demand management as it is aware of the eventual benefits and 'return on investment through water loss control and water use efficiency measures than supply side interventions' (*ibid.*, i). As funds from the MIG programme are available to be used in infrastructural developments, notably, housing developments; water and conservation, it is possible for such funds to be channelled for acquisition of installations for RWH systems. Other systems that make water accessible to poor communities can also be added to these programmes.

4.3. Implementation of Policies and Laws for Sustainable Housing

Generally, South Africa needs to intensify efforts at Sustainable Housing, especially in water provision. An analysis by du Plessis, Irurah and Scholes (2003), show that the country has taken steps to implement a number of policies and instituted laws but has not made serious commitments towards realizing concrete results. In addition, there are other opposing initiatives being undertaken which slows down the process of achieving sustainable development. Efforts to deal with climate change and sustainable development have therefore not had much impact due to the fact that South Africa uses resources and technologies that exploit the environment and does not take advantage of existing conditions. These factors lead to more difficulties in access to water.

A notable hindrance to access to water and environmental improvement is the lack of proper control of water resources. This situation is further exacerbated by the high consumption patterns by the middle to high income groups who use about 50% of the water they consume for their gardens, swimming pools and exotic gardens (du Plessis, Irurah and Scholes, 2003). Recent improvements in the service levels such as on-site access to municipal water, water borne sanitation and improved standard of living for less privileged areas also contributes to increase in water resource demand. Location of industrial and metropolitan developments around mineral deposits and harbours, for instance, adds to increased water scarcity as they are situated far from major water sources (Basson *et al*., 1997). Previous laws and policies therefore that gave way for certain directions in development make implementation of new laws that a difficult task.

Recent housing settlements and industrial developments such as those found in Gauteng and Cape metropolitan are located in areas where access to water is limited (Charlton and Kihato, 2006; COHRE, 2005; du Plessis, Irurah and Scholes, 2003 ; Irurah and Boshoff, 2003). Changing the location of already established industries, factories and plants are challenging as it would be an expensive endeavour to undertake, affecting economic, social and environmental sectors of the local area they are situated and eventually the larger environment.

In addition, policies and programmes that will work towards developing housing and employment opportunities in areas with available resources, particularly water for poor communities have proved difficult to be practically implemented. One such policy which seeks to directly address access to water is the Water Act of 1998 and Water Services Act of 1997 (Tissington, 2012; *ibid.*, 2011; Department of Water Affairs and Forestry, 2004: 10; du Plessis, Irurah and Scholes, 2003). The ultimate goals of these policies are to protect the environment and available water resources, ensure access to water for impoverished communities and achieve efficiency in water management.

In terms of health and living environment, access to water is one key factor that affects informality and HIV/ AIDS in South Africa, deepening poverty levels and consequently, efforts at sustainable development. This situation is so as residents of informal settlements

pay more for water of worse quality in smaller quantities, creating more difficult living conditions for them. Studies show that housing services, particularly water, can be used to control the spread of HIV/ AIDs and other infectious diseases (IRIN, 2013; WSSCC, 2012; Tomlinson, 2006; Natrass, 2004; Van Rensburg *et. al.*, 2002). For HIV/ AIDS, Wilson *et. al.* (2002) explain that where clean water is not easily accessible; children run a higher risk of contracting the disease from their mothers if other infectious diseases such as diarrhoea set in. An environment that has no adequate provision of water therefore is not adequate and highly risky for the vulnerable, a large majority in South Africa.

Unfortunately, the directive in the constitution to protect the environment for the benefit of future generations has not had much impact as only one response has been made to deal with environmental challenges and climate change. According to du Plessis, Irurah and Scholes (2003) a committee for climate change was charged with the responsibility of preparing a paper that commented on climate change; policy initiatives that arose from this paper have been ignored by government. The only national sector which is making significant strides towards achieving sustainable development is the Housing Department. With the task of developing human settlements aimed at reducing the housing backlog for low-income group, the Department has undertaken successful projects on 'Environmentally Efficient Housing' which provide 'non obligatory environmental norms and standards for low income housing' (du Plessis, Irurah and Scholes, 2003: 249).

Most notable among the programmes implemented are those directed at developing energy efficient housing (Tissington, 2011: 64; Ramashamole, 2010; NDoH, 2008). Many research studies have been commissioned on energy efficiency for low-income housing as well as the development of a 'residential eco-system' – a collective form of defining the relationship between the wildlife and human living environment of an area (du Plessis, Irurah and Scholes, 2003: 249; American Society of Landscape Architects, 2013; Cooper, Dickenson, Philips, Bonney, 2013) but not much in the water sector, especially RHW. As mentioned earlier, although most of these policies include plans to make water easily accessible to predominantly poor communities, they have been slow to realise impacts in most poor communities.

Key challenges that face the department of Housing in its bid to achieve sustainable housing are the inability of beneficiaries to pay for retrofits such as insulations, solar water heaters, fluorescent bulbs and other modifications to homes (Ramashamole, 2010). Also, local contractors do not benefit from sustainable housing projects as the profit margins are usually low, making it further difficult to meet requirements and standards for the housing projects. Beneficiaries are faced with the problem of raising funds through loans or personal savings to top up the subsidized amount provided by government and donor agencies. du Plessis, Irurah and Scholes (2003) propose measures that can help curb this problem such as increased subsidies for development projects and for government to encourage the development of 'medium density housing' - housing with 'greater mix' and 'higher density' (Onatu, 2010; CSIR, 2009) - which will make adequate housing accessible to the various under privileged groups in the country. Collaborations with international donor agencies such as the World Bank make it possible to give assistance in cases where government policies are not able to meet certain aspects of the intended objectives.

A critical point that stands out in this discussion is the fact that stakeholders of the built environment in South Africa do not give due consideration for climatically responsive designs to be adapted for the built environment. This shortfall is evident in the municipal development plans, building regulations, training programs for professionals, and additionally financiers and developers give little attention and investments to sustainable and climatically responsive designs. There must be more involvement and investments at the municipal sectors if practice of RWH is to be well established as these local authorities can promote measures that will best suit the local environment.

In retrospect, it is evident that numerous policies, programmes and campaigns have been undertaken by the government, supported by the World Bank, and other private bodies. These efforts all come with the concept of attaining sustainable development, notably, accessibility to water for the largely poor marginalized communities. Plans are therefore underway but have so far seen little results as they are not synchronized: most institutions involved are not privy to how communities will react to new policies that aim to reverse the effects of the apartheid era, the problem of corruption and lack of proper monitoring of policy implementation programmes especially in the new housing developments.

Implementing policies for RWH therefore seem farfetched as the high cost of embarking on housing projects do not make it possible to consider additional systems and installations as the sole aim initially was to provide basic living quarters for households which will be incrementally developed. The DWA is grappling with the seemingly impossible task of providing adequate water for millions of poor South Africans who cannot afford the minimum water unit. It is therefore only wise to add a system that will make communities independent in terms of water provision such as RWH. This reduces pressure on the scarce water resources. These issues show that it is of utmost importance that poor households have easily accessible water supply no matter where they are situated in the country.

CHAPTER 5: LOW INCOME HOUSING IN SOUTH AFRICA

Current concepts, policies and laws on housing in South Africa are influenced by a need to address the negative effects of decades of apartheid system and at the same time, respond to regional and international laws and standards on development, notably, sustainable development (Department of Housing, 1994; Bond, 2000; Huchzermeyer, 2001; Huchzermeyer, 2003; Khan and Thring, 2003; Leckie, 2003; Pottie, 2003; Baumann, 2003; Department of Housing, 2004; Charlton and Kihato, 2006). The right to housing is reflected in sections 26 (1) and (2) of the South African constitution which basically outlines the basic rights of all citizens as well as the responsibility of the state to ensure that these laws are adhered to through legislations, measures and policies formed according to available resources. These are rights to: a. legal security of tenure; b. availability of services, materials, facilities and infrastructure; c. location; d. habitability; e. affordability; f. accessibility and g. cultural adequacy (Leckie, 2003: 9, 10; COHRE, 2005: 24, 25).

The government has set out to fulfil the minimum core obligations which highlight foremost assistance for people in desperate situations and the vulnerable. It therefore gives a mandate to at least provide shelter for women, children, the old and the disabled. The housing programs set in this regard were formed by public, private sectors and non-governmental organizations. The White Paper (1994) on Housing which forms the key basis for most of the housing legislature and laws was first drafted by the NHF (National Housing Forum), and has since been adapted in instituting policies and programs such as National Housing Code (2000), Breaking New Ground (2004), Inclusionary Housing Policy (2007) and the Housing Act (1997). These programmes are aimed to bring into law the implementation strategies for housing and to set up the various governmental agencies that are to act on them. Low cost housing provision is achieved through a policy such as the National Housing Subsidy Scheme (NHSS) where subsidies are provided for low income households, the People's Housing Process (PHP) where communities benefiting from housing programmes take part in the decision making and implementation level and the Institutional Housing Subsidy private where entities are involved in the housing process in the form of social housing (COHRE, 2005). The involvement of beneficiaries in a program notably, the People's housing Process is also an attempt to refine the housing process through the end users.

Although efforts discussed above have been made towards fulfilling the minimum core obligations in order to ensure provision of shelter for all, huge inadequacies still exist as a broad section of the population - mostly black - have not had improvements in their housing situation. Even with the ANC

government producing a record of 1 million subsidised houses through its RDP housing project in 6 years, millions of South Africans still live in the worst living conditions. Notable among these is inadequate water supply. With subsidized housing, the few beneficiaries have had to grapple with many setbacks, particularly, the low quality of some of the houses (Moolla et al., 2011; Govender et al, 2011; Ramashamole, 2010; COHRE, 2005). Other key problems are the location of these new developments which are on the peripheries of the cities - far from jobs, infrastructure, social amenities and other opportunities.

Charlton and Kihato (SERI, 2011: 57) argue that these inadequacies are brought about as a result of 'political pressure' or 'departmental politics' and not as a genuine response to the need to bring improvements in the lives of the poor. However, many consider the attempts of the government plausible and actually the most successful in the world as a result of this record number of houses produced (Gardner, 2008). Omalley (2012) clarifies the fact that that South Africa has per capita gross national product (GNP) of more than R8, 500 and is regarded as an upper middle income country. With its resources, the country can provide enough food, housing, education healthcare for all its citizens.

There is therefore a need for more political commitment towards adequate housing provision. With more support from government, it will be possible to financially assist households and communities on campaigns for water sustainable practices such as RWH. This contributes to the provision of adequate housing outlined in the constitution. The next discussion discusses some of the policies, schemes and programmes that have been implemented so far and how they have been received or whether they impacted on the lives of the masses.

5.1. Some Housing Processes and Legislations Since 1990s

The White Paper on Housing – 1994

This is a very significant document as it discusses the new housing policy strategy to counteract the apartheid approach and reach out to improve living standards of the poor and marginalised. Gardner (2003: 7) describes it as the 'new deal for housing' in South Africa as its visions and target was unlike any other ever experienced in the history of the country. The vision for the strategy was to 'create viable, socially and economically integrated settlements where households could access opportunities, infrastructure and services, within which all South Africa's people will have access on a progressive basis to:

- A permanent residential structure with secure tenure, ensuring privacy and providing adequate protection against the elements; and
- Potable water, adequate sanitary facilities including waste disposal and domestic electricity supply' (NDoH, 1994).

Known as the RDP, the principal policy programme on housing and development, through the National Housing Subsidy Scheme (NHSS) was able to deliver over 1 million houses but has not achieved much of the economic empowerment and social integration it sought to attain.

The key challenges faced in this housing approach show that it is important for realistic goals to be set up by South Africa in its quest to provide housing for the masses. Although the programme seeks to empower the poor socio-economically, the right structures need to be placed at the right institutional set-up within realistic timeframe. The effects of these failed policies are still felt among the poor, with lack of access to water and sanitation, being of key concern.

The Housing White Paper – Vision for Water Provision and Issues that Affect this Vision

This document contains policies that continue to shape the development of the RDP programme. The Housing policy outlines a vision for Adequate Water Provision and touches on various levels as it explains the housing strategy. The first admission of inadequate water for the poor and low income households is made where it discusses the housing context in the country (NDoH, 1994), stating that in rural housing, both formal and informal housing is available but both housing types lack '…access to potable water and sanitation…' (*ibid.*: 3.1.3.e).

On access to basic services, it is stated that 'approximately one quarter of all functionally urban households in South Africa do not have access to a piped potable water supply' (*ibid.*). There is therefore a need to create policies towards potable water provision for all citizens as stated above as a key part of adequate housing. Therefore plans for infrastructure service standards and tariff setting recognises the fact that this non-cohesive management approach at the national level, an 'absence of authorities at the provincial level' and weak management

initiatives at the local government level must be dealt with. Institutional reform as well as structures for 'appropriate management systems, preferably catchment- based', water and sanitation services must be 'devolved to the lowest institutional level where adequate competence and capacity exists'. (*ibid.*, 5.8.1). Unfavourable land appropriation and planning policies are stated as part of the challenges that hamper integrated housing development and actually creates a crisis in efficient and affordable water resource utilization.

Also, appropriate national environmental standards on water resources are set in order for human activities to be controlled for effective management of water and sanitation services. In this respect, the following existing legislations have guided the new laws formed towards achieving the appropriate standards for water supply:

- SABS 241 (1984) Water for Domestic Supply: for water quality standards
- Water Act (Act 54 of 1956) as amended: for sewerage effluent quality for discharge into water courses
- Health Act (Act 63 of 1977) for the maintenance of public health; and
- Environment and Conservation Act (Act 73 of 1989) as amended for solid waste. (*ibid.*, 5.8.2a)

The cost of water and sanitation is set to be borne by households and communities to cater for operational and maintenance costs. In the case of the poor and destitute, however, the state and provincial authorities are urged to provide some subsidy packages in policies set out to guide this service provision. Such policies must identify a means of recovering the cost of the cost of the subsidies through appropriate financial measures such as loans. In order to make water supply available to the poor who form a majority of the population, a 'life-line or social tariff which is transparently subsidized' is allocated for them (*ibid.*, 5.8.4). Other users who are economically capable will be 'cross-subsidized' to cover some of the cost. The structure of the cost recovery process will therefore be such that it 'rises with increased consumption and includes a subsidy portion'. This structure, however, still needs input from the provincial and national sectors due to its high 'magnitude' in terms of subsidy allocations for a large number of people.

The housing strategy outlined in the White Paper therefore shows awareness towards effective water resource management and utilization. It makes environmental, human, institutional and

infrastructural provisions to cater for adequate water supply for all South Africans. There is also sensitivity towards cost of water management and responsibility is given to various government sectors (national, provincial and local levels) to set appropriate policies to handle these provisions.

The National Norms and Standards, 2007

As part of defining a clear path for the development sustainable human settlements, the Minister for Housing introduced these standards stemming for sections 3 (2) (a) of the Housing Act. The National Standards and Norms of 2007 was reviewed and included in the 2009 Housing Code specifying the regulations especially for houses to be built by government assisted programmes.). In terms of water standards, a single standpipe must be provided for each house and the water must be metered (National Housing Code, 2009). General further guidance for planning settlements and housing construction is given in a book published by the CSIR known as 'The Red Book'. These standards have become necessary as a result of the concerns about the low quality of government assisted housing provisions, typically, the RDP. It is hoped that with time, government will be more rigorous in enforcing these laws as failure to do so will result in a waste of resources and efforts put into the developments for sustainable housing.

5.2. Housing Policy Implementation

Breaking New Ground (BNG) and the RDP Programme

The BNG policy seeks to effectively refine the development of Sustainable Human Settlements through correction of the previous approach for the RDP programme (NDoH, 2008). It is the first document which bears an 'amendment or refinement' of the Housing White Paper (NDoH, 2008). It was introduced in 2004 when it became obvious that the government's housing programme was not achieving much of is intended goals and objectives (NDoH, 2005, Tomlinson, 2006; Onatu, 2010; Tissington, 2011). Problems noted to be tackled included 'peripheral residential development; poor quality products and settlements; the lack of community participation; the limited secondary low income housing market; corruption and maladministration; a slowdown in delivery; underspent budgets; limited or decreasing public sector participation; the increasing housing backlog; and the continued growth of informal settlements' (NDoH, 2008; Tissington, 2011).

Another important reason is the need to update the programme with the new ideas, knowledge and approached that have up over the past decade to be applied for the next decade. However, there is on-going debate on the clear direction that the BNG is steering towards as it has been criticised to be 'confusing and disappointing' with regards to the 'extensive research and consultation process that took place before the introduction of the programme (Charlton and Kihato, 2006 255; Tissington, 2011: 65). They (*ibid.*) highlight that the final document for the policy 'reflected little of the review process and lacked the involvement of key officials who drove the process in 2002 and 2003'.

In the review, the BNG places the local government closer to the housing programme as it envisions the municipals to be better able to understand the people and their social, financial and economic needs. There is also emphasis on upgrading of informal settlements instead of eradication as well as the housing developments in the urban areas since it recognizes it to be more socially integrating and sustainable.

The unique situation of South Africa is that it is working to reverse the negative socio-economic and environmental impacts of apartheid and at the same time, move towards a new concept of developing sustainable housing. Most of the challenges described above show how difficult this task has been. However, government needs to be aware of the seriousness of the situation and deal with it accordingly as the issue of sustainability is also time bound. A situation such as existence of large informal settlements on the peripheries of major urban centres is a case in point. If the government continues does not form sensitive policies to tackle informal settlements, it eventually continues to perpetuate environmental degradation and most importantly inappropriate housing option majority of the population.

Upgrading of Informal settlements Programme (UISP)

The issue of informal settlement upgrading has attracted much attention from local and international stakeholders, academics and professionals. Much of the discourses centre on how it should be handled: whether to upgrade or 'eradicate' (Huchzermeyer, 2008: 98; Misselhorn, 2008). Informal settlement issues are pertinent in South Africa as they affect about 25% of the population (HSRC, 2011). South Africa ascribes to apply measures to achieve the UN MDG 7,

Target 11 which speaks towards slum improvement and comes with the slogan 'cities without slums'. This target is to improve the lives of 100 million people living in slums by 2020 and has two divergent approaches: to improve the lives of the aforementioned number of slum dwellers and at the same time 'slum free cities' (UN, 2000; Huchzermeyer, 2008: 98).

Although slum 'eradication' issue, is absent in the Housing White Paper of 1994, was conceived as a result of housing backlog.

However, instead of promoting policies to upgrade slums, South Africa has rather instituted laws which are focused on relocation of slum dwellers into formal housing, transit camps which was a common practice during the apartheid era. This action also does not conform to international standards that the country ascribes to.

According to Huchzermeyer (2008: 94), there are clearly misconceptions on the issue of slum upgrading as the plans of the government to 'eradicate' or 'eliminate' informal settlements by 2014 are slightly misrepresented. This practise however still exists in South Africa and needs to be done away with. The political directive of the ministry of Housing needs to change the drive to eliminate slums by destroying them.

The above discourse clearly shows that with the many issues associated with improving the lives of the poor and people living in dire housing situations, access to water forms a key entry point to which their lives can be made better on a basic level. Although South Africa has not been directly successful with its free housing and upgrading programmes it is hoped that with time, the government will come to understand the advantages that come with it. Also, placing local government closer to housing programmes such as the BNG, is however only effective with adequate capacity and increased effort financially.

In the meantime, provisions should be made towards improving the lives of these people through provisions for affordable water supply. Slum upgrading programmes should involve encouragement of sustainable water practices such as RWH in households. The next chapter discusses how the socio-economic situation in South Africa can be harnessed for successful projects in RWH for low income housing.

CHAPTER 6: SOCIO-ECONOMIC ISSUES AND TECHNICAL STRATEGIES FOR RWH IN LOW-INCOME HOUSEHOLDS IN SOUTH AFRICA

In the socio-economic context the country has a middle-income economy with adequately developed modern infrastructure. The repercussions of apartheid are still felt in the country despite the government's numerous efforts to eradicate the inequalities of the system since 1994 (du Plessis, Irurah and Scholes, 2003). As at 2000, it was noted that the most deprived group which is about 10% of the total population received just about 1.4% of the total income whilst the richest 10% obtains 47.3% of the total income (CIA, 2000).

As a country which is water stressed, South Africa has a growing demand for water which is expected to rise beyond supply if not well monitored. With a population growth rate of 0.5%, local demand for water is expected to increase by 219% between 1996 and 2030. Urban water demand represented 10.8% and is expected to increase to 22.8% by 2030 (Ashton and Haasbroek, 2002). With the awareness of the direct relationship between the socio-economic and political development and environmental and physical development of the country, it has become apparent for government and civil society to closely monitor and control the direction of these developments towards more sustainable advancement. Issues discussed below show some of the means by which new and existing developments can be harnessed to achieve sustainable development especially projects on RWH for low income communities and households .

6.1. Sustainable Neighbourhoods for Socio - Economic Inclusion

Sustainable development options aimed at building 'sustainable neighbourhoods' are outlined as the 'building blocks for a sustainable urban future' (Swilling, 2006: 45). This concept of building is hoped to reduce the ecological footprint of communities by minimizing systems, practices and industries that over-consume resources without basically interfering with the livelihood of the people. It also involves investing in housing and infrastructure designed to eventually attain better living conditions for the poor. Key areas to be tackled in this regard include economic and ecological challenges faced by the poor. These will bring improvement in households by increasing quality of life and reducing cost of living for middle and lower income households.

To counteract the precepts of apartheid which encouraged social and economic exclusion as well as disempowerment of majority of blacks who formed a higher percentage of the total population, mixed income housing developments will be encouraged. Other policies aimed at forming creative planning and zoning laws, judicious use of space will also be applied to creating investments that could generate returns for poorer households.

If these practices are combined with efficient management of the eco-system, a careful stimulation of savings and credit system, increased income which will result in increased investment levels in communities. Efficient management of the eco-system will result in cheaper food costs, hence healthier eating habits. Sustainable neighbourhood development is not only limited to developing new communities at either lower or higher income property markets, but introducing the new developments in existing communities, be it in any of the housing developments mentioned above in the housing market. Provision of incentives and education to encourage the use of '…rainwater tanks, …on-site or neighbourhood-based sewerage treatment systems, water-conserving irrigation systems,…' are some of the policies and approaches to be used (Swilling, 2006: 47). Sustainable water use and reuse of treated sewerage can be adopted by communities through interventions which ensure that water supply by local retailers use water saving devices in the form of low flush systems, aerated tap nozzles and RWH systems (*ibid.*).

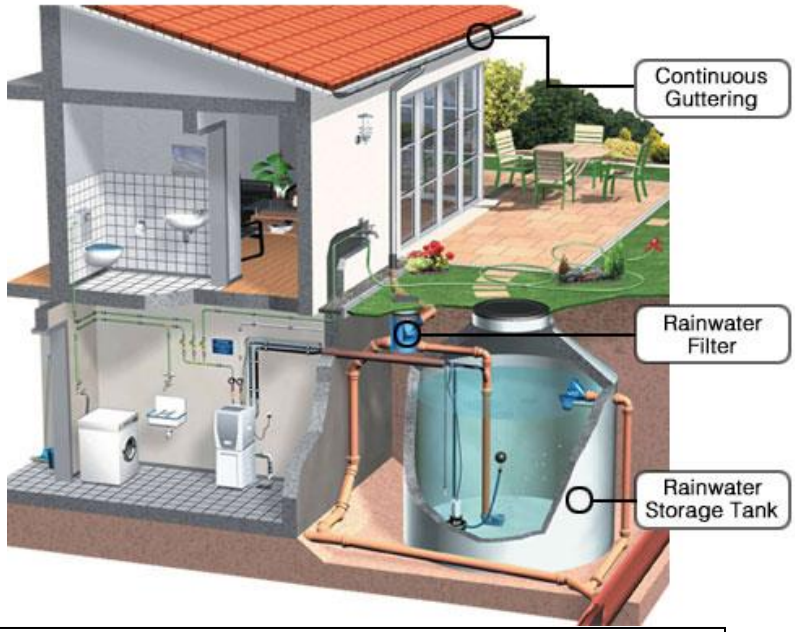


Fig. 27. A section through a typical house in a middle income area in South Africa and how rainwater harvesting can be used to supplement central water supply. Source: www.bluegranola.com/, 2012

Other long term priorities that can be considered are adequate management of water leakage in homes and sustainable management of aquifers. Construction developments for dams are being discouraged as they sometimes lead to flooding and destruction of vegetation and wildlife.

RWH systems, whether on small or large scale, could be made part of such project concepts for Sustainable Neighbourhoods. It will consist of a collection of systems which, when retrofitted into new and existing urban infrastructure, can achieve an overall reduction on the pressure on scarce water resources and the environment. This could be introduced on a small scale in neighbourhoods and communities and expanded to other communities until it eventually reaches the municipal, metropolitan, regional and national levels.

6.2. Sustainable Technical Strategies for RWH

Building Codes and Regulations

Previous discussions in this report have shown how various states have used or applied varied systems, methods, and appropriate materials to successfully harvest rainwater for use in communities and homes (Bermuda Environmental Alliance, 2012; Al-Hajj, 2012; Millward, 2011; Department for Communities and Local Government, 2010; Pachpute, 2010; Colorado Division of Water Resources, 2009; Pachpute, Tumbo, Sally and Mull 2009; UNEP, 2009; Nogueira, 2008; Baker, Grygorcewicz, Opperman, Ward, 2007; Solomon, 2006; City of Albuquerque, 2005; Nega and Kimeu, 2002). These plans all form a wider regional, continental, state and local effort to improve access to water to communities and households in these countries.

For South Africa, factors that can facilitate the use of RWH in low income homes are: approved government building codes, regulations, policies and programmes to educate people on the need and advantages of practicing RWH; training programmes such as those discussed for Brazil (Nogueira, 2008), Namibia (Baker, Grygorcewicz, Opperman and Ward, 2007) and China (Centre for Science and Environment, 2012), will be very beneficial to any programme South Africa embarks on.

Bermuda has already taken the lead in using local materials to develop a system and instituted the practice into law and requirement for all buildings and is reaping many socio-economic and environmental benefits. China, Brazil have adopted it for use in some poor communities whilst the state of Colorado have also begun amending laws to encourage the use of rainwater to supplement water supply. Ghana also aims to make the practice a law in order to ensure access to water supply for all homes in the country.

South Africa accordingly needs to begin campaigns which will eventually make RWH a law. There are validations that RWH can be adopted for use in South Africa, articles and discussions have been expressed on how RWH can be adopted for use in the country (Afreds, 2012; WWF South Africa, 2012; Muller *et. al.,* 2009; Department of Water Affairs and Forestry, 2008; Kahinda, Taigbenu, and Boroto, 2007; Otieno and Ochieng, 2004; Ashton and Haasbroek, 2004; Department of Water Affairs and Forestry, 2004). The key point here is that the government is aware of the socio-economic and environmental benefits of the practice especially for use in homes. The policies adopted will therefore be more effective and appropriate if applied at the local municipal levels.

These must be accompanied by trained personnel to help educate people on how they can acquire local materials and techniques to install the systems in their homes. As the target group here are the low-income housing group, affordable systems and materials must be used. The ensuing discussion touches on the building components and some basic affordable systems that can be adopted for use in homes.

Affordable Building Components of RWH System

Rainwater harvesting systems are usually very simple. They generally comprises of collection, filtration and distribution of rainwater from the roof of a building in to a storage receptacle or tank (Sustainable Buildings, 2007). Three main components make up the system as shown in Figure 24 below, consisting of catchment area (roof); conveyance system (pipes) and collection device (storage tank) (Gould and Nissen-Peterson, 1999).

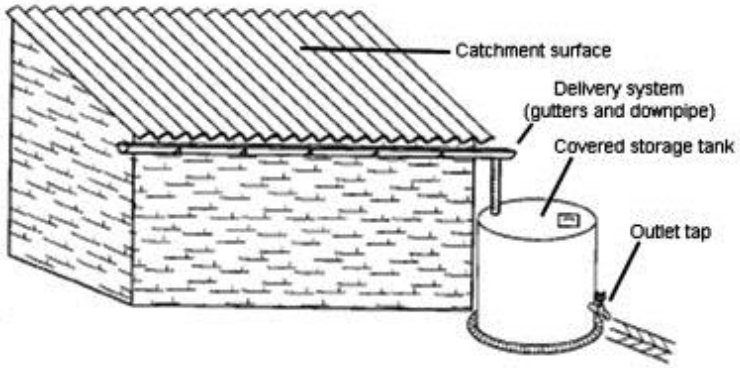


Fig. 25. Schematic illustration of the basic components for RWH from roof. Source:Gould and Nissen-Peterson, 1999.

Hermanus (2012) describes how the practice can be implemented in South African homes, giving a brief picture of the traditional method: placing a water tank/ storage receptacle under a 'down pipe' to carry collected rainwater (*ibid.:* unpaginated). The water is then fetched with buckets into the house for use. Modern methods are much easier as it is possible to connect the tank or storage receptacle to the main water supply of the house to feed outlets inside the house. The amount of water harvested depends on area of roof and type of material (whether metal/tile) as well as size of tank (Hermanus, 2012). The convenient aspect of this system is that the connection can be removed if rainwater is not needed in the house and re-fixed as needed. Water tanks can also be hidden in gardens or behind the house or placed wherever convenient (*ibid.*).

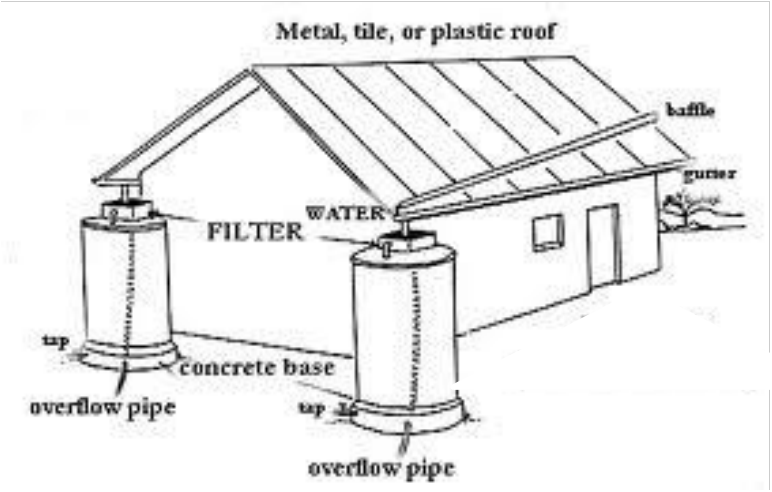


Fig. 28. An illustration of affordable materials and simplest system for RWH. Source: Global Permaculture Solutions, 2013.

Some critical technical factors however apply for construction of the system: roofing material used must be impermeable, typically, iron sheets, tiles (*ibid.*, Worm and Hattum, 2006; Gould, 1992); the availability of a minimum area of $1m^2$ for storage within proximity of the house; the number of people and types of uses to determine the storage capacity required; availability of trained or skilled personnel and materials in or close to the site of the house to assist in construction (Worm and Hattum, 2006; Centre for Science and Environment, 2012). Recommended materials for roofing include galvanised, corrugated iron sheets, corrugated plastic or tiles. Gutters can be made of local materials such as metal, aluminium, ceramic, bamboo or PVC whilst storage tanks can be made from plastic, bricks and cement, plain cement concrete or reinforced concrete. Downpipes made of local materials can also be used – metal, aluminium, ceramic or PVC (*ibid.*, Srinivas, 2012). For supply into the home, a tapping device is needed.

In order for the water to be potable, the right materials need to be used to construct the harvesting system. It is important that these materials are simple, affordable and easy to acquire. Most of the materials discussed above are affordable, appropriate and safe for use in any low income house in South Africa and discussions below describe some of the means through which these materials can be used and maintained in order for the harvested rainwater to be easy to use in homes.

Affordable, Safe Building Materials and Maintenance of Domestic RWH System

Modern technologies for harvesting rainwater have had very few cases of diseases and illnesses indicating the effectiveness of these technologies for household use. Srinivas (2012) advises that it is important for harvested rainwater to be at least filtered, especially if it is for domestic use and drinking. Other purposes such as watering gardens, cars and cleaning however do not need treated or filtered water. Besides filtering to make rainwater potable, it helps make the catchment system last longer. A course mesh or fine mesh must be placed at intermediary connections to filter the collected water before it reaches the storage area, keeping the finer ones close to the end of the storage area.

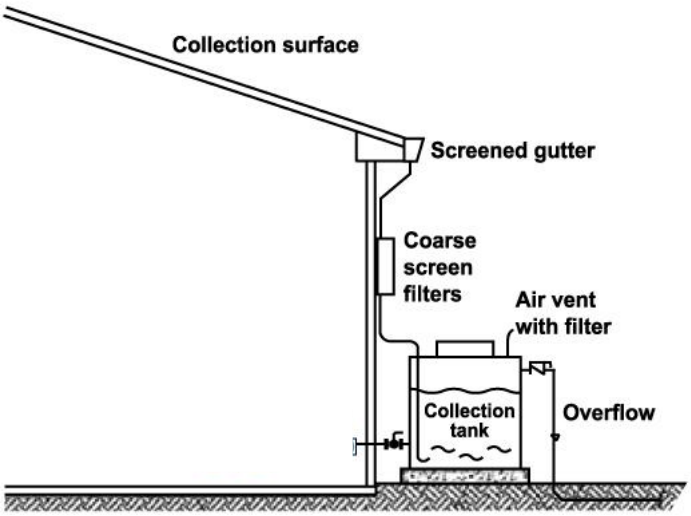


Fig. 27. A section through a house showing simple filtration system for rainwater. Source: Sweetwater LLC, 2011.

From time to time, depending on the intensity and amount of rainwater collected, the meshes must be replaced or cleaned to prevent them from clogging up (Rainwater Connection, 2010). The roof gutters and conduits used to connect the roofing area and storage area also need to be protected with a replaceable cover. This can be made of the same aluminium or PVC material used to construct the gutter. Filters such as charcoal water filter, sand and stone filters can also be used for filtering the water before it drains into the storage area (Centre for Science and Environment, 2012). If there are affordable filtering devices are available on the market, they can be purchased for this purpose. Srinivas (2012), advices that pipes connecting water into houses or taps supplying collected rainwater must be placed at least 10 cm above the base of the tank to allow for debris which could not be filtered out to settle on the bottom. This will ensure more quality stored water so long as the tap and tank are not disturbed.

For an effective RWH system, appropriate materials must be used and most importantly, a good filtering system. Types of filters used depend on the purpose for collecting the water: more intensive systems are used when water is to be used for domestic purposes and drinking whilst simpler systems are used for water to be used for other purposes outside the house such as cleaning and watering gardens. Overall, the collected water can be used for any purpose but care must be taken to filter it before use. The collection system also needs routine maintenance

to ensure its longevity. These techniques and practices clearly show how feasible it is to adopt RWH in low income households in South Africa. The main findings for this research are presented in the next chapter.

CHAPTER 7: RESEARCH ANALYSIS AND FINDINGS

7.1. Rainwater Harvesting as a means to Sustainable Development

Key precepts of sustainable development which involves the present generation taking responsibility for their environment begins in small ways such as RWH in poor households, contributing to a bigger cause to ease pressure on the environment and consequently improve the quality of human living. It is therefore of absolute necessity that water, like other natural resources on the earth, is managed with maximum discretion. The importance of water to human existence, influencing socio-economic and environmental development is clearly established in this Research Report and also other authors (UNECE, 2012; ISSD, 2012; Sustainable Development Commission, 2011; World Meteorological Organization [WMO], 2012; The World Bank Group, 2001; Centre for Environment Education, 2007). International and local policies and laws that address issues on water therefore can only be effective if made practical.

As the concept of Sustainable Development firstly emphasizes responsibility towards immediate environment, it is in the right direction to focus on protection of natural resources such as water. However, these efforts cannot yield much result if they are not emphasised at the grassroots level and made more practical for use in low income households. Environmental protection has however been a challenge to rapid population growth, resulting in pressure on the natural resources that are already dwindling. Water bodies and forests are increasingly being threatened by human activities that seek to establish improved and developed world class environments for modern living.

Climate change effects are also contributing to environmental changes and efforts to counteract these occurrences are underway. Programmes on development of 'green cities' in South Africa has had many campaigns and attention by government but has seen only few cases and pilot projects scattered around few urban and rural parts of the country (World Green Building Council, 2012; UNEP, 2011; Department of Economic Development; Environmental Affairs; Science and Technology and Trade & Industry, 2010). Implementation of sustainable housing and urban projects of this nature therefore, need to be intensified especially in poor communities.

Sustainable water management is a key factor in implementing sustainable development. As rapid population growth and the changing lifestyles of modern generation are having direct impacts on the water accessibility to the poor and vulnerable in human society and the environment, current infrastructural and housing projects need to emphasise sustainable water use. For South Africa, there must be a change in the water-intensive lifestyles of the urban and sub-urban class. Although they form a small percentage of the population, they use about 10.8% of water which is expected to increase by 219% by the year 2030 (Ashton and Haasbroek, 2002). Most of this water demand is used for watering gardens, swimming pools and exotic gardens which can be utilized sustainably.

Money and resources go into water treatment for drinking and therefore, if it is to be used for other household purposes such as cleaning, it is wasteful to treat spend resources to treat it. Proper and stricter laws therefore need to be applied for management of urban water resources. For effectiveness and efficiency in water use which will have direct impacts on protecting the environment and eco-system; new housing developments embarked on such as the BNG projects, need to introduce the use of RWH as a supplement to water supply.

The advantage with RWH is that it can be 'retrofitted' to existing houses. If the typical home in South Africa has a RWH system, it will significantly reduce the pressure on municipal water supply, making it easier to feed factories and industries that rely on water for production. There are already serious concerns on future water availability for the growing population as water provision for the province is expected to run out by 2013 (Hermanus, 2012).

For sustainable development to be effective, broad-based approaches need to be integrated for South Africa: a more compact physical infrastructural development which is sensitive to the environment, considering the inter-relation between transportation, housing, energy and industrial sectors and how they influence human living. Over time, especially after apartheid, many concerns have been raised on the need for the country to direct new policies and programmes towards this form of development but have not yielded much impact as few projects have been undertaken in this regard as discussed above. Notable

challenges to this is the varied social setting and the deeply rooted effects of the Apartheid system which had precepts that worked total contrary to sustainable development in many aspects (Charlton and Kihato, 2006; Irurah and Boshoff, 2003). Government policies should therefore be streamlined to be more practical and sensitive to these challenges.

7.2. RWH as a means to Counteract Water Scarcity

In spite of the many varied challenges with water availability across the world, there are ways out of each difficulty. RWH clearly stands out as one of the means through which water scarcity can be dealt with either to counteract effects of climate change, rapid population growth or geographical location. Other strategies such as the use of groundwater from aquifers, lakes and rivers may be available but are not sustainable as overuse may attract other environmental problems such as those at Lake Chad, North Africa and the Yellow River in China (IRD, 2013; NASA GSFC, 2013). Observations made by environmentalists that climate change threatens plant and animal life such that it causes major migration and in some cases, extinction are serious implications that need to be well noted and emphasised at environmental forums (Deep, Gupta and Anderson, 2003). Human populations are also displaced as a result of dramatic changes in environment especially with loss of water which provides a lifeline to human survival. When humans migrate, cultures and social links are lost, settlements are abandoned breaking social ties and causing homelessness as in the case of the people of Chad, which affected over 2 million people (IRD, 2013). The actions of the present generation therefore need to be more sensitive towards water use as this situation has affected a number of other nations across the world, notably, some areas in North and East Africa and other parts of the Middle East. Water scarcity influences the development of other problems such as conflicts among nations, especially in Africa and needs to be taken very seriously on the continent.

Arid parts of countries such as China and India with very high populations have adopted the practice of RWH as a means of water supply fully or partially. These strategies counteract any ideas of abandonment of settlements or migration for greener pastures or misunderstandings on ownership of water sources on land. As a result, there is no interference in their livelihoods or socio-economic lives. It is possible for environments to be modified to counteract the effects of climate change and water scarcity. The argument that

geographical location may determine or pose challenges is therefore, are not substantive as the situation does not place complete hindrance to water accessibility. Most countries discussed in this Research Report: India, Namibia, Brazil and China, are found in areas which are geographically dry and experience water scarcity in most seasons but manage to derive water supply through simple systems for RWH especially for poor communities.

With rapid population growth and more people moving up the social ladder, there is an estimated fast increase in water demand in most parts of the developing world. This influences available water for agricultural production, food supply and maintenance of the eco-system (Global Footprint Network and WWF, 2008). This situation is dire as population of the world is expected to reach 8.9 million by 2050 and already, about 2 million people have entered the middle class social group. Examples from India and China with their high population show however, that RWH can be used for irrigation purposes to grow food in mass quantities and for other domestic uses in poor communities. These strategies are in the right direction as they prove that it is possible to apply sustainable water management in any part of a country so long as the willingness and knowledge of its benefits are clear.
Mankind has over the millennia, adopted a cocktail of measures to support many challenges faced in his environment. Therefore, problems such as pressure on available resources, notably water, geographic location and climate change cannot present unsolvable challenges. For water scarcity, it is clear that the environment can be modified by installing systems to harvest rainwater which can be made wholesome by treatment. It is important in this light to be aware of the changing weather patterns to adequately prepare for the seasons and most importantly, for the environment (eco-system) to be protected by protection of plant, animal life and water bodies in order to ensure availability of rain.

7.3. South African Policies and Laws on Water Management and its Influence on RWH

Sustainable Water Management in South Africa needs to be pragmatic order to make any significant impact. There are many inadequacies and disconnections in policy and practice of sustainable water management plans which need to be synchronized. There is some disconnect between policy and practice as for instance, there are no directions on how to utilize funds meant to be invested in development of sustainability of the eco-system

services – the MIG and NSDP. The DWA can source for funds from this source and besides using it to support centralized water supply, conduct educational programmes on RWH or acquire materials and equipment and install them in low income households and poor communities that are yet to be connected to the national water grid.

Sustainable water management will start from an effectiveness of sustainable housing as planned by the NDOH 2004 and Housing White Paper (1994). This interrelation makes it imperative for the country to take housing provision for the poor more seriously as a neglect of the situation contributes to a perpetuation of environmental degradation and low living standards for the masses. The BNG's RDP programme for instance, needs to adopt measures to develop more rounded sustainable settlements, therefore not concentrate only on energy but water provision measures such as RWH. New mixed income housing developments such as those in Cosmo City also need to be encouraged to use RWH as supplement to municipal water supply.

Another key observation this research has brought to light are the challenges with reversing the apartheid policies and its effects on present development agenda. It is clear that most poor people who benefit from government housing programmes cannot even afford to pay for minimum water unit of 6 Kilolitres per month introduced by the DWA. Typical are some recent housing settlements and industrial developments in Gauteng and the Cape Metropolitan which are located in areas where access to water is limited as highlighted by Charlton and Kihato (2006) Irurah and Boshoff (2003). Households in such communities can therefore be assisted with training and materials to start harvesting Rainwater. Institutions such as the DWAF also need to be more connected with communities in their work. Most of the projects discussed above were conducted in collaboration with communities and therefore a relationship with them is a key factor for achieving successful water management projects on RWH. Developing a relationship with communities and households will also create opportunities to understand their real concerns and needs on water provision.

7.4. RWH as a Viable Sustainable Socio-economic Practice for Low Income Households in South Africa

There are many benefits to adopting the practice of RWH in low-income homes in South Africa. Rainwater harvesting basically involves the collection of rainwater for use in homes or other purposes. The practice has been in existence for thousands of years and it is not surprising to find many societies still relying on it for water provision. In modern times, it serves as a convenient alternative to centralized water supply as it is evident that large populations relying on only one source of water supply is not sustainable. The practice is easier when there is an existing housing with a roof which can 'catch' the rain and direct it through gutters into a storage tank. Other methods of collection exist such as collecting the water on large plain surfaces on the ground and allowing it to gather at a specific lower point of the land. This technique is usually used on farms where irrigation is used to feed plant crops.

However, this research report presents facts on how the practice can be used in homes either as a main source of water supply or supplement. It mainly hopes to encourage the use of this practice in areas of South Africa where water is scarce and households cannot afford to pay for water supply from the main municipal water agency.

Adopting the system requires simple installation of roof gutters to edges of roof of house and connecting it to a storage tank. The water harvested can be filtered for use depending on the purpose. RWH systems require constant maintenance to ensure their longevity and to keep harvested water fresh. Materials for constructing the system range from simple aluminium or PVC for gutters, plastic or concrete storage tanks.

In average low income or poor communities in South Africa, most women are the caretakers of the home therefore are responsible for domestic chores. As a result, they are in charge of ensuring that there is constant supply of water in the home for domestic purposes. Lack of water in homes therefore puts a strain on the activities of these women and their households. If the average low income home has a RWH system which provides water in times when central water supply cannot supply or when there are droughts, women and children will have less strain on their daily lives. This will afford them more time to attend to

other productive activities such as trading or farming and schooling for children. In addition, money saved from paying water bills can be used to other family needs.

Water availability in homes also reduces the threat of common diseases such as diarrhoea especially in infants and their mother. It also helps reduce the spread of HIV/ AIDS which is common in South Africa. When families have time and energy to engage in trading, farming and schooling especially in the case of female children, they are able to improve their social status and also support themselves. Availability of water also aids in the supply of food to homes. Female children mostly stand to gain when there is constant water supply in homes as they can fully attend school without much need for them to be home to help mothers find water. RWH therefore will contribute significantly to improving the socio-economic lives of low income households who form a large majority of the population in the country. As a result, households can save their income for food, clothing and better quality living environment.

Water Sustainability Strategies for RWH in Low income Housing in South Africa

Looking at the broad picture, there exists an almost perfect setting for RWH to be adopted for use in households in South Africa: the DWAF's plans for sustainable water management and campaigns should include the use of RWH in homes as it reduces long term costs to households; the DoH's human settlements development programme can include RWH systems as part of subsidised houses constructed. However, the DWAF and DoH need to liaise together to source for funds to finance RWH projects. Financing the cost of storage tanks will be an important part of RWH projects and this Research Report has shown that it is the most expensive item needed for the system to be complete. Also, institutions need to work more closely with communities as training programmes are necessary for efficiency in the use of the system in homes. These factors can all be harnessed together to encourage the use of RWH in the country.

Sustainable Technical Interventions for RWH in South Africa

Fortunately, there are many technical interventions that can be adopted for use as RWH systems in low income households: an important material such as corrugated aluminium roofing sheets is cheap and readily available on the South African market. It is also a safe material for harvesting rainwater. Gutters for the water collection can also be constructed

using the same aluminium material. It is fixed around the roof of any house to channel water into the storage tank. A simple plastic drum can be purchased with financial assistance from institutions such as the DWA. Also, recycled tanks can be used in cases when there may be no financial assistance. A plastic lining needs to be used in the tank to prevent it from rusting and contaminating the water. To make the water safe for drinking and consumption, it needs to be filtered using fine wire mesh, then boiled and allowed to cool. These simple methods exist and it only takes education and training of users who should mainly be adults, especially women in the home. The importance of this simple practice of RWH, if introduced in South Africa, will go a long way to improve the living standards of low income households in the country.

CHAPTER 8: RECOMMENDATIONS AND CONCLUSIONS

8.1. Conclusions

This research report sought to investigate the viability of using RWH as a means of improving the socio-economic lives of low-income households and it has become clear that the practice is one of the best methods for achieving this objective in the Gauteng Province and largely, South Africa. The development of the Gauteng Province is critical to as it is noted to be the business and economic hub of the country. RHW projects, when encouraged for use in this Province will ease financial and environmental pressure on municipalities with this area.

RWH comes with many benefits such as enabling households to save money which otherwise would have been used to pay for water supply from municipal agents; time and resources which otherwise would have been used to search for water for domestic use are also diverted to other productive use such as farming, trading and schooling especially for female children; a reduction in the onset and spread of certain diseases, notably, HIV/AIDS. This therefore means RWH also helps to promote the health and wellbeing of households.

As noted in earlier chapters, one key advantage of RWH is that it can easily be 'retrofitted' into existing homes and this advantage makes it easier to be encouraged for use in South Africa as the government has plans to enable average citizens own their own homes through programmes such as the BNG. There are environmental benefits that come with the practice - part of the reason for the government's development agenda on sustainable housing and sustainable water management. Currently, many factors influence constant water availability in South Africa, notably: the geographical location in a semi-arid region; global climate change which makes weather and seasonal patterns unpredictable. This makes it difficult to determine how water will be managed in a specific time. However, if the average house in South Africa has a RWH system, there will be a significant reduction in the pressure on municipal and provincial water supply which will in turn make it easier for water to be managed across the country and put less stress on the scarce water bodies. It is therefore only logical to harvest and keep in homes in expectation of uncertainties in supply.

Many countries across the world such as Brazil, China, India, Namibia, Ghana and Kenya have undertaken projects in this regard. Laws have been instituted in some countries to ensure that people

use the practice as a means of water supply as it has become evident that centralized water supply cannot be relied on at all times. These projects are conducted with participation of communities as it presents opportunities to empower, educate and allow these groups to express their needs according to the project on hand.

Installing a RWH system, however, may come with a few challenges such as affordability, as storage tanks and their installation tend to be expensive; loss of revenue to municipal water supply agencies; problem of acceptability of the practice on the part of users; the need to maintain the filtering system constantly, which involves extra training and some long term costs.

8.1. Recommendations

As a way forward, advocacy for the use of RWH systems in South Africa will begin with instituting laws, policies and building regulations that require homeowners to harvest rainwater and to educate people on its need and importance. As mentioned in earlier chapters, this has to begin with campaigns which will eventually make RWH a law, accompanied by increased education and training programmes on affordable materials and means of installing the system in homes. Additionally, the BNG's RDP programme needs to emphasise more on sustainable water management and introduce RWH as a means of achieving constant water supply almost all year round. New mixed income housing such as Cosmo city need to be encouraged to use RWH to supplement municipal water supply.

Setting up a RWH system in homes is a simple installation with materials such as Jojo tanks and aluminium or PVC pipes which are easily available in the South African market but needs to be financially supported with funding from institutions such as the DWAF and DoH. Part of these funds could be used for training programmes on how to install the system in low income homes and poor communities that are yet to be connected to the main national grid. On the other hand, materials can be recycled from the environment and used. Finally, discussions in previous chapters of this Report show that for successful community projects for RWH, it is important to actively engage and develop relationships with residents in order to understand their real concerns on water use and its provision. RWH therefore can be used to support the efforts of the South African government's objective of improving the living environment and quality of citizens, especially the large majority low income group and needs to be promoted in the country. Future areas for research in this regard may look into finding

out whether low income households in South Africa are willing to accept the use of the RWH systems in their houses.

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