RAINWATER HARVESTING, STORAGE AND TREATMENT FOR DOMESTIC PURPOSES IN MINNA, NIGER STATE

BY

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MATRIC No.: 2005/21549EA

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DECEMBER, 2010.

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BEING A FINAL YEAR PROJECT REPORT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG) DEGREE IN AGRICULTURAL AND BIORESOURCES ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA NIGER STATE

DECEMBER, 2010.

DECLARATION

I hereby declare that this project work is a record of a research work that was undertaken and written by me. It has not been presented before for any degree or diploma or certificate at any other University or Institution. Information derived from personal communications, published and unpublished work were duly referenced in the text.

Ehiomogue, Okhunkpamwunyi Precious

06-12-2010.

Date

CERTIFICATION

This is to certify that "Rainwater Harvesting, Storage and Treatment for Domestic Purposes in Minna, Niger State" by Ehiomogue, Okhunkpamwunyi Precious meets the regulations governing the award of the degree of Bachelor of Engineering (B.Eng.) of the Federal University of Technology, Minna, and it is approved for its contribution to scientific knowledge and literary presentation.

Mr. M.A. Sadeeq
(Supervisor)

10TH DECEMBER, 2010.
Date

Engr. Dr. A.A. Balami
Head of Department

13/12/2010
Date

External Examiner

8|12|2010
Date

DEDICATION

I dedicate this project work to God Almighty and to my parents.

ACKNOWLEDGEMENTS

I give thanks and Glory to God Almighty for the gift of life, he has offered unto me to his service and humanity. His grace has enabled me to complete this project work, which also marks the end of my first degree academic programme.

My foremost primary indebtedness goes to my project supervisor Engr. M.A. Sadeeq for his scholarly contribution and un-relented efforts in perusal and editing of this research work from its conceptual stage to realization.

My sincere thanks go to all the Staff of Agricultural and Bioresources Engineering Department, Federal University of Technology, Minna who in good faith and patience imparted knowledge into me.

I wish to commend the following persons in Agricultural and Bioresources Engineering Department, the H.O.D Engr. Dr. A.A. Balami, the project coordinator, Dr. O.Chukwu, Dr. M.Y. Otache, Mrs B. Orhevba and Engr. (Mrs) Mustapha for their support and immense encouragement.

To my parents, Mr. and Mrs. Ehiomogue, for their support and prayers, my sincere appreciation all goes to my siblings Lucky and Efe Ehiomogue.

Finally, to my friends among whom are Mudama Kenneth, Ajayi A. Stanley, Obalisa Paul Mayowa, Afe Olusegun, Abolarin Reuben just to mention a few.

ABSTRACT

The scarcity of natural water resources and the increasing growing gap between demand and supply of potable water in most part of Minna led into this research with a view to provide an alternative source of water supply for domestic purposes in order to mitigate water supply challenges. A total of 250 questionnaires were distributed to enable the researchers examine the level of awareness and adoption of rainwater harvesting techniques within the geographic location under consideration. This study describes the magnitude of rainwater harvesting in Minna obtained from a house-to-house survey, their methods of rainwater collection, practices, storage and usage. The result of the questionnaires using descriptive statistical method shows that the level of awareness is 99.5% but the adoption of these noble techniques is poor as people of Minna harvest rainwater but the quantity could not serve the family into the dry season. As they ran out of water even within few days after rainfall, in a bit to improve on this lapses, this project therefore recommend the following; the design of suitable rainwater harvesting structures in theses locality, establishing regional water plans, creating competition in water supply, increasing water supply options for both short and long terms, and other advanced water related technologies of which rainwater harvesting technology belong, and reducing the current waste in water use. Some specific programs to implement policies would enable and ensure water conservation becomes a duty for all users and sect.

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CHAPTER ONE

1. INTRODUCTION

1.1 Background to the study

Water is life. Yet millions of people throughout the world lack enough of this basic commodity for their hygiene and/or have no good quality water for drinking and preparing food. In many families both women and men also need water for animals, vegetables, crops and trees. Where groundwater and surface water sources are in short supply, rainwater may be a sustainable alternative or supplement. Roof harvesting of rain water is the most common but also other hard surface areas are used (Agarwal and Narain, 1997).

Rainwater collection is one of the oldest means of collecting water for domestic purposes. In India, simple stone-rubble structures for impounding rainwater date back to the third millennium BC (Agarwal and Narain, 1997). It was also a common technique throughout the Mediterranean and Middle East. Water collected from roofs and other hard surfaces was stored in underground reservoirs (cisterns) with masonry domes. In Western Europe, the Americas and Australia, rainwater was often the primary water source for drinking water. In all parts of the continents it continues to be an important water source for isolated homesteads and farms. Collection and storage for agricultural use has equally been widely practiced for thousands of years (Agarwal and Narain, 1997).

Water has a dual claim to be regarded as a unique and very remarkable product of nature in that firstly; it is the only inorganic which occurs in appreciable quantities and secondly it is the only substance found in three states of matter (solid, liquid and gas). Water is also universal solvent and can be use for domestic, agricultural and industrial purposes. (Nasir, 1989).

In considering the issue of water supply in this country Nigeria there are at least two systems of water supply which are referred to as the traditional system and modern system. The traditional system is the oldest and practiced by vast majority of Nigerians. It involves direct collection of rain water in containers and extractions from springs, streams, pond and hand dug wells. Although generally viewed as primitive, this system has its good points, especially in the multi-source and self reliant aspect. All the available local sources are used depending on the people's perception of quality, seasonal availability and technological knowledge. It is the most common system in use and it serves about 70% of a country's population (Faniran, 1988).

In contrast, the modern system started with the colonial administration. Unlike the traditional system which at best is community based and at worst individual owned e.g a well, the modern water supply scheme is a public sector affair undertaken and maintained by government at public expense. However, it is obvious that less than 30% of Nigerian had access to improved or modern water supply, leaving over 70% deprived. Several settlements which are supposed to be served did not have water several years after the commissioning of their water supply scheme. While several taps especially in the outskirts of rural centres remain dry for months. (Faniran, 1988)

To the unparalleled importance of water Jackson (1979), summed by concluding that from the dawn of civilization, ever since there has been an association of men which could be called "society" a resource, in the form of rainfall or snow, in the stream and lakes in the ocean and in aquifers have shaped the development of people and nations.

Archaeological discoveries and later documentary evidence have shown the significant part played by the location and magnitude of water supplies in human lives.

Clean water is needed to be supplied for proper health and well-being. In Nigeria today more than 75% of the population live in the rural areas, where provision of improved water supplies is particularly difficult and partially expensive and are of low quality. Also the living conditions of people in rural areas are largely characterized by low quality residential units, unsanitary environments and lack of basic social facilities such as community water supply, road, health and recreational centres and electricity. The local inhabitants usually spend time and much effort to obtain water from sources which are often inaccessible and very far from their abode. (Jackson, 1979)

In recognition of the need to enhance the quality of life of her people through the provision of portable water, successive Nigeria governments have put in place several facilities to improve the coverage and quality of water supplies. Despite the efforts of governments and various agencies several studies revealed that there is still a great reliance on polluted sources of water in rural areas, particularly, which make the inhabitants vulnerable to diseases and epidemics. The political interference in the distribution of water points which either leads to the prevalence of abandoned water projects by the government in the localities of high placed government officials that are in good books of incumbent governments, while others are neglected. For example, Oyun (Kwara state) having surplus provision of water projects while many villages are in deficit.

The supply of clean and available rural water systems is one essential factor necessary, not only for good health, welfare and productivity of rural population, but also for the entire economic growth and development of states in Nigeria. Its development is still at a low level, especially in the rural areas. The coverage of portable water in the rural community was 20% in 1985 and 30% in 1991. Presently, the service level in some rural areas in the country is about 10 litres as against the recommended standard of 60 litres per capital per day (Federal Government of Nigeria, 1992).

Various governments and non governmental organizations (NGOs) have enunciated various programme towards achieving this target, lack of portable water in Nigeria rural areas has been noted to result to different problems such as cases of water borne and water wash diseases including cholera, dysentery, diarrhea, typhoid, paratyphoid, river blindness, guinea worm (UNICEF, 1995).

Rainwater harvesting can be categorized according to the type of catchments surface used, and by implication the scale of activity.

Rainwater harvesting is the accumulating and storing, of rainwater. It has been used to provide drinking water, water for livestock, water for irrigation or to refill aquifers in a process called groundwater recharge. Rainwater collected from the roofs of houses, tents and local institutions can make an important contribution to the availability of drinking water. Water collected from the ground, sometimes from areas which are specially prepared for this purpose, is called storm water harvesting. In some cases, rainwater may be the only available, or economical, water source. Rainwater harvesting systems can be simple to construct from inexpensive local materials, and are potentially successful in most habitable locations. Roof rainwater can be of good quality and may not require treatment before consumption. Although some rooftop materials may produce rainwater that is harmful to human health, it can be useful in flushing toilets, washing clothes, watering the garden and washing cars; these uses alone halve the amount of water used by a typical home. Household rainfall catchments systems are appropriate in areas with an average rainfall greater than 200 mm (7.9 in) per year, and no other accessible water sources (Skinner and Cotton, 1992).

There are a number of types of systems to harvest rainwater ranging from very simple to the complex industrial systems. The rate at which water can be collected from either system is dependent on the plan area of the system, its efficiency, and the intensity of rainfall (i.e annual precipitation (mm per annum) x square meter of catchment area = litres per annum yield). A 200m2 are meter roof catchments catching 1,000mm PA yields 200 kLPA (Skinner and Cotton, 1992).

Rainwater harvesting systems channel rainwater that falls on to a roof into storage via a system of gutters and pipes. The first flush of rainwater after a dry season should be allowed to run to waste as it will be contaminated with dust, bird droppings etc. Roof gutters should have sufficient incline to avoid standing water. They must be strong enough, and large enough to carry peak flows. Storage tanks should be covered to prevent mosquito breeding and to reduce evaporation losses, contamination and algal growth. Rainwater harvesting systems require regular maintenance and cleaning to keep the system hygienic.

Rainwater can be used for groundwater recharge, where the runoff on the ground is collected and allowed to be absorbed, adding to the groundwater. In the US, rooftop rainwater is collected and stored in sump. In India this includes Bawdis and johads, or ponds which collect the run-off from small streams in wide area. In India, reservoirs called tankas were used to store water; typically they were shallow with mud walls. Ancient tankas still exist in some places.

Rainwater harvesting can:

(a) Assure an independent water supply during water restrictions, that is though somewhat dependent on end use and maintenance,

(b) Usually of acceptable quality for household needs and

(c) Renewable at acceptable volumes despite forecast climate change. It produces beneficial externalities by reducing peak storm water run off and processing costs. RH systems are simple to install and operate. Running costs are negligible, and they provide water at the point of consumption. We are consuming this water for our basic needs.

Rainwater harvesting can be adopted in cities to supplement the city's other water supplies, to increase soil moisture levels for urban greenery, to raise the water table through artificial recharge, to mitigate urban flooding and to improve the quality of groundwater. In urban areas of the developed world, at a household level, non-potable uses of harvested rainwater include bathroom (i.e. shower/bath/basin), flushing toilets and washing laundry. Indeed in hard water areas it is superior to municipal water for laundry because of its compatibility with detergents and soaps. Rainwater may require treatment prior to use for drinking, depending on anthropogenic (e.g. vehicle exhaust) and natural (e.g. Coal.) contaminants (Fewkes, 2006).

In New Zealand, many houses away from the larger towns and cities routinely rely on rainwater collected from roofs as the only source of water for all household activities. This is almost inevitably the case for many holiday homes (Skinner and Cotton, 1992).

As rainwater may be contaminated, it is often not considered suitable for drinking without treatment. However, there are many examples of rainwater being used for all purposes — including drinking — following suitable treatment.

Rainwater harvested from roofs can contain animal and bird faeces, mosses and lichens, windblown dust, particulates from urban pollution, pesticides, and inorganic ions from the sea (Ca, Mg, Na, K, Cl, SO_4), and dissolved gases (CO_2, NO_x, SO_x). High levels of pesticide have been found in rainwater in Europe with the highest concentrations occurring in the first rain immediately after a dry spell; the concentration of these and other contaminants are reduced significantly by diverting the initial flow of water to waste as described above. The water may need to be analyzed properly, and used in a way appropriate to its safety. In the Gansu province for example, harvested rainwater is boiled in parabolic solar cookers before being used for drinking. In Brazil alum and chlorine is added to disinfect water before consumption o-called "appropriate technology" methods, such as solar water disinfection, provide low-cost disinfection options for treatment of stored rainwater for drinking.

In the last two decades, interest in rainwater harvesting has grown. Its utilization is now an option along with more 'traditional' water supply technologies, particularly in rural areas. It is of particular importance and relevance for arid and semi-arid lands, small coral and volcanic islands, remote and scattered human settlements. The increased interest has been facilitated by a number of external factors, including:

1. the shift towards more community-based approaches and technologies which emphasize participation, ownership and sustainability;
2. the increased use of small-scale water supply for productive and economic purposes (livelihoods approach);
3. the decrease in the quality and quantity of ground- and surface water;
4. the failure of many piped water supply systems due to poor sanitary condition.
5. the flexibility and adaptability of rainwater harvesting technology;
6. the replacement of traditional roofing (thatch) with impervious materials (e.g. tiles and corrugated iron);
7. the increased availability of low-cost tanks (e.g. made of ferro-cement or plastics).

1.2 Objective of the Study

i. to determine the level of awareness and adoption of rain water harvesting techniques in Minna, Niger State

ii. to recommend possible ways of improving rain water harvesting technology to improve quality and quantity

iii. to device methods of improving both quality and quantity of the harvested rainwater

1.3 Statement of the Problem

The scarcity of natural water resources and the growing gap between demand and available supply of potable water in Minna is posing serious challenges for the populace. Maintaining economic prosperity with limited water supply, finding enough capital to increase supply, mastering advanced water technologies, securing supplies under all conditions, reducing negative impact to the environment, and coordinating the efforts of existing water institutions are only some of the challenges facing water requirements for domestic purposes.

1.4 Justification

Rain water harvesting has become a world wide practice to meet the increasing demand for fresh water. In Nigeria it is widely practiced mostly in the southern part as the rainfall is widespread for over 8 months in a year with mean intensity of 180 to 225 cm. Rain water harvesting is practiced at individual level, household level, community level and occasionally at Local or State government level to augment the dwindling water supplies to urban center.

The work is expected to contribute to the development of rainwater harvesting technology as a way of mitigating water scarcity which as become perennial problem over the years, which will eventually reduce the over dependence on ground water resource that is not readily available.

1.5 Scope of the Study

The scope of this project will be limited to rainwater harvesting, storage and treatment for domestic purposes.

CHAPTER TWO

2. LITERATURE REVIEW

Rainwater harvesting (RWH) primarily consists of the collection, storage and subsequent use of captured rainwater as either the principal or as a supplementary source of water. Both potable and non-potable applications are possible (Fewkes, 2006). Examples exist of systems that provide water for domestic, commercial, institutional and industrial purposes as well as agriculture, livestock, groundwater recharge, flood control, process water and as an emergency supply for fire fighting (Gould & Nissen-Peterson,1999);. The concept of RWH is both simple and ancient and systems can vary from small and basic, such as the attachment of a water butt to a rainwater downspout, to large and complex, such as those that collect water from many hectares and serve large numbers of people (Leggett *et al*, 2001). Before the latter half of the twentieth century, RWH systems were used predominantly in areas lacking alternative forms of water supply, such as coral islands and remote, arid locations lacking suitable surface or groundwater resources (Perrens, 1975).

The fundamental processes involved in rainwater harvesting are as follows:

1. Water use
2. Rainfall event(s)
3. Water storage in reservoir

All rainwater harvesting systems share a number of common components (Gould & Nissen-Peterson, 1999):

1. A catchment surface from which runoff is collected, e.g. a roof surface.

2. A system for transporting water from the catchment surface to a storage reservoir.

3. A reservoir where water is stored until needed.

4. A device for extracting water from the reservoir.

Fewkes (2006) identifies the main uses for harvested rainwater as:

1. The main source of potable (drinking) water,

2. A supplementary source of potable water, or

3. A supplementary source of non-potable water, e.g. for WC flushing.

In developing countries the main use of harvested water is for potable supply whilst in developed countries examples of all three uses exist, with potable supplies being more common in rural locations and non-potable supplies in urban areas.

Gould & Nissen-Peterson (1999) provide a detailed history of rainwater harvesting systems. The authors state that, whilst the exact origin of RWH has not been determined, the oldest known examples date back several thousand years and are associated with the early civilizations of the Middle East and Asia. In India, evidence has been found of simple stone-rubble structures for impounding water that date back to the third millennium BC (Agarwal & Narain, 1997). In the Negev desert in Israel, runoff from hillsides has been collected and stored in cisterns to be used for agricultural and domestic purposes since before 2000 BC (Evenari, 1961).

There is evidence in the Mediterranean region of a sophisticated rainwater collection and storage system at the Palace of Knossos which is believed to have been in use as early as 1700 BC (Hasse, 1989). In Sardinia, from the 6th century BC onwards, many settlements collected and used roof runoff as their main source of water (Crasta *et al*, 1982). Many Roman villages and cities are known to have used rainwater as the primary source of drinking water and for domestic purposes (Kovacs, 1979). There is evidence of the past utilization of harvested rainwater in many areas around the world, including North Africa, Turkey, East and Southeast Asia, Japan, China, the Indian sub-continent, Pakistan and much of the Islamic world, sub-Saharan Africa, Western Europe, North and South America, Australia and the South Pacific (Marjoram, 1987).

During the twentieth century the use of rainwater harvesting techniques declined around the world, partly due to the provision of large, centralized water supply schemes such as dam building projects, groundwater development. However, in the last few decades there has been an increasing interest in the use of harvested water (Gould & Nissen-Peterson, 1999) with an estimated 100,000,000 people worldwide currently utilizing a rainwater system of some description (Heggen, 2000). In the developed world, the use of RWH to supply potable water is mostly limited to rural locations, mainly because piping supplies from centralized water treatment facilities to areas with low population densities is often uneconomic. The development of appropriate groundwater resources can likewise be impractical for cost reasons (Fewkes, 2006). Perrens (1982) estimates that in Australia approximately one million people rely on rainwater as their primary source of supply. The total number of Australians in both rural and urban regions that rely on rainwater stored in tanks is believed to be about three million (ABS, 1994). In the USA it is thought that there are over 200,000 rainwater cisterns in existence that provide supplies to small communities and individual households (Lye, 1992). Harvesting rainwater for potable use also occurs in rural areas of Canada and Bermuda (Fewkes, 2006).

The use of RWH systems to supply non-potable water to buildings in urban areas has increased in popularity in the last 15-20 years (Fewkes, 2006). Examples of non-potable end uses include WC flushing, urinal flushing, laundry cleaning (washing machines), hot water systems, garden/landscape irrigation (Weiner, 2003, car washing and fire-fighting (Gould & Nissen-Peterson, 1999). Systems have been installed in a wide range of building types including domestic properties, high rise buildings, schools, offices, sports stadiums; Environment, garden centre, airports and exhibition centre such as the Millennium Dome in London (Hills *et al*, 1999);

The number of RWH systems installed varies from country to country. For instance, in Germany during the 1990"s the market leader alone installed over 100,000 systems, providing a total storage volume in excess of 600,000m3 (Herman and Schimda, 1999). It has been estimated that between 50,000 and 100,000 professionally designed systems are currently installed in Germany each year and the total number of built systems is believed to be approximately 600,000. By comparison, France has few installed systems. Those that do exist are often simple, inefficient and used mainly for garden irrigation, with the domestic utilizations of rainwater for flushing toilets and washing machines being virtually non-existent. This low uptake is attributed primarily to the organization of the French water supply system which is essentially a set of regional monopolies that have no incentive to introduce rainwater harvesting techniques since it would reduce their profits (Konig, 2001).

In urban locations, rainwater catchment surfaces tend to be restricted to roofs (Hassell, 2005; Fewkes, 2006) although runoff can also be collected from other impermeable areas such as pavements, roads and car parks. Runoff from these areas can be more polluted than that from roof surfaces and may require a higher degree of treatment to achieve an acceptable level of water quality (Leggett *et al*, 2001). Water storage and distribution elements generally consist of standardized pre-manufactured components that can range from a simple water butt with a tap at the base to more complicated systems that can consist of underground storage tanks, filters, pumps and automated controls. Where the latter type of arrangement is concerned, the use of package (proprietary) systems dominates the UK market and it is possible to purchase a complete system from a single supplier. One supplier stated that the overwhelming majority of their domestic sales were of the proprietary type as were most of those for commercial, institutional and industrial applications, though bespoke systems could be designed if required (Nick Bentley, 2005).

Konig (2001) states that in the past components such as tanks, pumps and filters were often supplied in kit form and had to be assembled on site, necessitating the use of skilled staff and leading to increases in both installation times and costs. Modern systems tend to be „modularised" and consist of standardized mass-produced components, usually of high quality. Components such as tanks, pumps and filters are delivered to site as complete units (no assembly required), are easier to install and commission than the older types of system and offer a greater degree of design flexibility.

Storage tanks with integrated filters, pump and electronic controls in what is essentially a complete system that only requires connecting to the relevant on-site pipe work and power points. With regards to water storage, the most common approach is to use underground tanks (Hassell, 2005) although storage in other structures is also possible, e.g. in the gravel sub-base of permeable driveways and pavements as well as above-ground tanks and ponds (Woods-Ballard *et al*, 2007).

The average per capita consumption for households (both metered and unmetered) in England and Wales is currently around 150 litres per person per day (Ofwat, 2006).In Australia rainwater harvesting is typically used to supplement the reticulated mains supply. In south east Queensland, households that harvested rainwater doubled each year from 2005 to 2008, reaching 40% penetration at that time (White, 2009).In the pre-Independence period, provision of domestic water supply was largely through individual and community efforts. The regional governments later got involved with the main concern of developing schemes to urban and semi-urban areas to the neglect of the rural communities. Water Boards or Corporations were established for this purpose by the regional governments to provide the services. The drought of the early seventies prompted the intervention of the Federal Government to take a number of actions. This resulted in the establishment of some Federal Agencies. These Agencies include the Federal Ministry of Water resources (1976), National Water Resources Institute (1977) and the River Basin Development Authorities (RBDAs, 1976). While the Ministry has the responsibility to formulate polices and give advice, the Institute is charged with the responsibility of Manpower training and research while the RBDAs are executing agencies providing irrigation water, and domestic water supply to the communities (Ofwat, 2006).

The tempo of water supply was raised in 1980 with the preparation for and campaign in favour of the United Nation's International Drinking Water Supply and Sanitation Decade (1981 – 1990). The goal of this programme is to provide water for all by the year 1990, 120 litres/day of water (WHO standard) for domestic use. However, just before the commencement of this programme, only 22% of the rural and 55% of urban population enjoyed potable water. These figures have increased only marginally. In absolute terms, by 1986 each rural dweller had access to 25 litres of potable water per day while his urban counterpart had access to 60 litres/day (Ofwat, 2006).

2.1 Constraints to Growth and Development

2.1.1 Lack of Basic Planning Data

One of the major constraints to water resources development in this country is the lack of basic planning data. The role of data collection has regrettably either been underplayed or ignored. It is therefore always very difficult to assemble reliable and adequate technical and socio-economic data capable of assisting in the assessment, planning, design, construction and maintenance of various development projects. Many projects have failed because of the unreliable and inadequate data on which analysis planning and management are based. The recent failure of some dams such on the Bagauda Dam and Ogumpa Food Disaster and other hydraulic structures are living testimonies. Flow pattern in space and time in rivers have largely been neglected and at best of time sporadic measurements are taken. The same holds true for groundwater. It is for this reason that Nigeria's neighbours with whom we share common waters or aquifers at the share of the river flow in the case of surface waters. Experiences on the Niger and Benue systems as well as the Lake Chad and Kalmalo Lake waters are still fresh in our memories. All these affect downstream development. Within the borders, the situation is not different either, hence Nigeria experiences persistent drought, flood and erosion without any long term solution (Hassell, 2005).

2.1.2 Flood and Erosion

The effect of flood has particularly been very devastating in the coastal areas of the country. This has sometimes led to severe erosion and consequent loss of agricultural soils and lands and damage to engineering structures including those for water resources development. Under this circumstance, a lot of sediment is transported which culminates in siltation and clogging up of reservoirs, river channels, etc and reduce their potentials for water storage. With a little more commitment and adequate manpower, the situation can be improved and the water harnessed for more productive activity and economic uses (Ofwat, 2006).

2.1.3 Manpower Shortage

The proper planning, implementation and management of water resources programmes and projects depend principally on the availability of competent personnel. It is common knowledge that in Nigeria, there has been a marked shortage of manpower in water resources particularly at professional and sub-professional levels. This paucity of trained personnel in the middle technical and management levels has been limiting the scale of success of various developments. The professional and sub-professionals are very few in number and some of them inexperienced. The few available ones have been spread too thingly on the design, construction, operation and maintenance of the existing projects. In order to cope with the challenges in the next decade, there is need to step up manpower training (Hassell, 2005).

2.1.4 Funds Shortages and Generation.

The non-availability of funds has always posed a major problem to the development of water resources programmes and projects. Most of the developments in this sector are government-financed. The dwindling of resources at the government disposal has also adversely affected successive allocations of money to water resources projects. The Federal Government allocations have declined, while States Government releases only 20 – 30% of their budgeted expenses to water supply. Most projects therefore remain uncompleted and those whose systems have broken down are financially stunted and cannot be easily rehabilitated all over the country (Ofwat, 2006).

The uncompleted head works and irrigation infrastructures have reduced and potentials for attaining self-sufficiency in water supplies, food production and consequent losses in revenue. In the case of irrigated agriculture, the 470,000ha of land yet to be completed is capable of producing 2,800 metric tones of rice at two cropping per season. The construction cost of these projects has been a major concern to policy makers. For example, the cost of irrigation development in Nigeria (about US $7,000 per ha or over ₦50, 000) is considered one of the highest in the world. This high cost has largely inhibited rate of irrigation development (Hassell, 2005).

A lot of fund has similarly been invested on the national borehole programme – a programme designed to assist the states in bringing potable water to the rural areas of the country. Despite the huge investment, the programme is yet to be completed. Only 330 of the 851 productive boreholes drilled have been commissioned to date. There has been no sufficient fund to procure the foreign input of pumps, generators and tank materials (Hassell, 2005).

Those projects that are completed that could have been yielding a lot of revenue could not do so because the beneficiaries enjoy a lot of subsidies. Irrigation water, domestic and industrial water supply, electricity consumption carry nominal charges to consumers until of recent when some of the tariff was slightly raised. Irrigation water initially costing between ₦100-150/ha was only recently raised to ₦500/ha irrespective of water consumption pattern of crops. Electricity consumption was also slightly raised for domestic consumers but significantly (about 600% in some cases) raised for industrial establishments. Charges on Water supply consumption remain unchanged. The recent rise notwithstanding, the charges are still below the operation and maintenance cost. Revenue which would have accrued to the Agencies concerned, and re-invested in other projects, is lost. Coupled with this, is the inefficient manner in the billing and revenue collection system of the concerned Agencies. Considerable amount of revenue is lost in the process (Hassell, 2005).

Loan assistance to farmers particularly on irrigated agriculture would have increased the level of production. Unfortunately, there are no coherent Institutional Credit facilities to small scale farmers. The existing credit facilities make seemingly impossible demands (collateral, security, title to land, etc.) on farmers. It is only recently that the People's Bank was established by the Federal Government and the impact of this Bank on farmers is yet to be ascertained

(Ofwat, 2006).

2.2 Strategies for Improving Water Supply Level in the 1990s'

In order to meet the nation's water demands for increased food crop production through irrigation, and demands for domestic and industrial water supply hydropower generation, navigation, recreation etc. Some of the constraints discussed above need to be removed. Before any meaningful strategy could be adopted, the issue of ownership of water has to be settled through legislation (Hassell, 2005).

2.3 Enactment of Water Legislation

The nagging question has always been "who owns the water?" It is the government (Federal, State or Local), its agencies or the individuals who have title to the land that also has the water which flows through or past his land? In addressing this issue, one should take note of the fact that water does not respect any sectional or political boundaries. This issue of water should therefore be tackled as a common problem and looked at on a global basis. Unlike the existing land use Decree, the ownership of water should be vested in the Federal Government. Potential water users can then apply to the Federal Government for licenses to develop the water as a part of the national resource. This measure will ensure a controlled use of water resources – surface water or groundwater. Drafted water resources legislation, along the line discussed above is already being worked upon by the Federal Ministry of Justice. The sooner this legislation is enacted the safer the protection and the surer the development and management of the nation's water resources (Hassell, 2005).

2.4 Completion of on-Going Projects

A lot of fund has been invested on a number of projects, which are temporarily abandoned for lack of fund. The investment should not be allowed to go down the drain; rather, the projects should be salvaged by completing them. It is only then that the full benefits of these projects can be realized, example, the on-going irrigation projects is capable of bringing 470,000ha of irrigated land. The revenue to accrue to the economy is considerable and the issue of completing existing projects should be a priority (Ofwat, 2006).

2.5 Procurement of Equipments and Spare Parts through Establishment of Fundies

In order to facilitate the completion of on-going projects and maintain existing ones, there is the urgent need to procure essential equipments and spare parts. Most of these equipments are imported, apart from the time delay, the foreign exchange for their procurement is very scarce. The establishment of foundries to fabricate some of our materials will be a welcome solution. Already, a laudable step has been taken by the federal department of Water Resources. In a joint effort with the Defence Industries Corporation (DIC), Kaduna, the Ruwatsan hand pump designed to our taste has been fabricated and will go into full production in due course. The production of similar water resources equipments and spare parts will no doubt speed up the pace of our developments (Ofwat, 2006).

2.5.1 Quantification of Groundwater Reserve

One has been able to have a rough estimate of our surface water (224 billion m3), but the quantity of groundwater remains unknown. There is therefore the need to direct attention on this issue through identification of various aquifers their geometry, other aquifer characteristics and the water availability. When the groundwater reserve is quantified, their judicious exploitation can be planned to meet their multipurpose uses (Ofwat, 2006).

2.5.2 Provision of Fund and Trained Manpower.

The demand for water resources is dynamic. Management should not be stagnant hence there is bound to be changes in management. There should therefore be sufficient and adequately trained personnel to cope with the changing demands and technologies. This calls for the need for various resources governments (federal, state and local) to increase their annual allocation to water resources projects. In addition, Institutionalized credit facilities similar to People's Bank should be established to take care of our small-scale farmers and water related industrialists (Ofwat, 2006).

It is a fact of life that no man is an island. While the country's resources are limited, the people's demands are infinite. This therefore calls for a pooling of the various resources for the benefit of the people. In the past, there have been noticeable but unavoidable overlaps in the activities of Water Resources Agencies that have never been harnessed. This is a wasteful exercise that should be discouraged. The on-going cooperation of Water Resources Agencies and Institutions in respect of the Operational Hydrological Program (OHP) is a welcome idea that should be extended to other areas to enhance the provision of basic need for the people. Nigerians need good and sufficient food, potable water, uninterrupted water supply of make all systems work, and cheaper transportation link between the coast and hinterland. The common denominator to all these is water. Let all Nigerians therefore jointly reserve the next decade (1989 – 1999) to its common development and proper management. The nation and her people shall be much better for it (Ofwat, 2006).

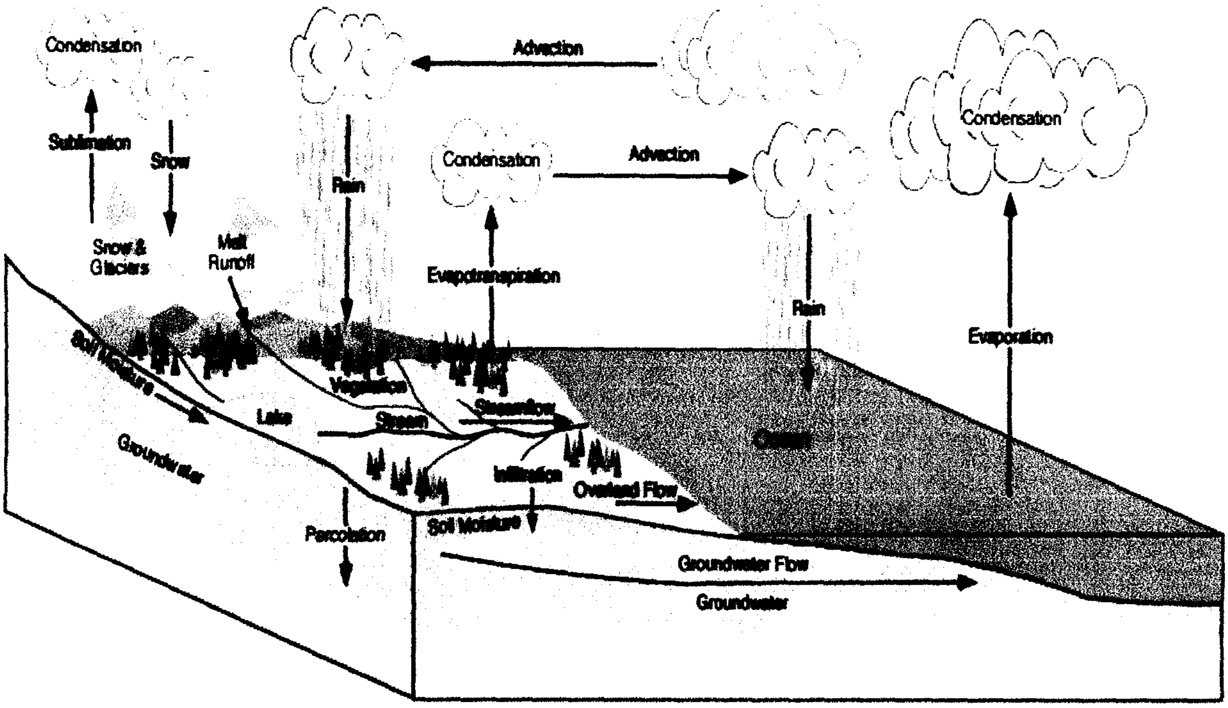

Figure 2.1 Hydrologic circle

Source: Wikipedia, 2010

The figure above shows the hydrologic cycle which is a conceptual model that describes the storage and movement of water between the biosphere, atmosphere, lithosphere, and the hydrosphere. Water on this planet can be stored in any one of the following reservoirs: atmosphere, oceans, lakes, rivers, soils, glaciers, snowfields, and groundwater. (Wikipedia, 2010)

2.6 Rain Water Harvesting Techniques

Rain water harvesting is a technology use for collecting and storing rain water from roof tops, the land surface or rock catchment using simple techniques such as jars and pot as well as more complex techniques such as underground check dams. The techniques usually found in Asia and Africa arises from practices employed by ancients civilization within these regions and still serve as a major source of drinking water supply in rural areas. Commonly used systems are constructed of three principal components; namely, the catchment's area, the collection device, and the conveyance system.

2.6.1 Catchment's Areas

2.6.1.1 **Rooftop catchments**: In the most basic form of this technology, rainwater is collected in simple vessels at the edge of the roof. Variations on this basic approach include collection of rainwater in gutters which drain to the collection vessel through down-pipes constructed for this purpose, and/or the diversion of rainwater from the gutters to containers for settling particulates before being conveyed to the storage container for the domestic use. As the rooftop is the main catchment area, the amount and quality of rainwater collected depends on the area and type of roofing material. Reasonably pure rainwater can be collected from roofs constructed with galvanized corrugated iron, aluminium or asbestos cement sheets, tiles and slates, although thatched roofs tied with bamboo gutters and laid in proper slopes can produce almost the same amount of runoff less expensively (Gould, 1992). However, the bamboo roofs are least suitable because of possible health hazards. Similarly, roofs with metallic paint or other coatings are not recommended as they may impart tastes or colour to the collected water. Roof catchments should also be cleaned regularly to remove dust, leaves and bird droppings so as to maintain the quality of the product water.

2.6.1.2 **Land surface catchments**: Rainwater harvesting using ground or land surface catchment areas is less complex way of collecting rainwater. It involves improving runoff capacity of the land surface through various techniques including collection of runoff with drain pipes and storage of collected water. Compared to rooftop catchment techniques, ground catchment techniques provide more opportunity for collecting water from a larger surface area. By retaining the flows (including flood flows) of small creeks and streams in small storage reservoirs (on surface or underground) created by low cost (e.g., earthen) dams, this technology can meet water demands during dry periods. There is a possibility of high rates of water loss due to infiltration into the ground, and, because of the often marginal quality of the water collected, this technique is mainly suitable for storing water for agricultural purposes. Various techniques available for increasing the runoff within ground catchment areas involve:

i) Clearing or altering vegetation cover,

ii) Increasing the land slope with artificial ground cover, and

iii) Reducing soil permeability by the soil compaction and application of chemicals.

2.6.1.3 **Clearing or altering vegetation cover**: Clearing vegetation from the ground can increase surface runoff but also can induce more soil erosion. Use of dense vegetation cover such as grass is usually suggested as it helps to both maintain an high rate of runoff and minimize soil erosion.

2.6.1.4 **Increasing slope**: Steeper slopes can allow rapid runoff of rainfall to the collector. However, the rate of runoff has to be controlled to minimize soil erosion from the catchment field. Use of plastic sheets, asphalt or tiles along with slope can further increase efficiency by reducing both evaporative losses and soil erosion. The use of flat sheets of galvanized iron with timber frames to prevent corrosion was recommended and constructed in the State of Victoria, Australia, about 65 years ago (Kenyon, 1929; cited in UNEP, 1982).

2.6.1.5 **Soil compaction by physical means**: This involves smoothing and compacting of soil surface using equipment such as graders and rollers. To increase the surface runoff and minimize soil erosion rates, conservation bench terraces are constructed along a slope perpendicular to runoff flow. The bench terraces are separated by the sloping collectors and provision is made for distributing the runoff evenly across the field strips as sheet flow. Excess flows are routed to a lower collector and stored (UNEP, 1982).

2.6.1.6 **Soil compaction by chemical treatments**: In addition to clearing, shaping and compacting a catchment area, chemical applications with such soil treatments as sodium can significantly reduce the soil permeability. Use of aqueous solutions of a silicone-water repellent is another technique for enhancing soil compaction technologies. Though soil permeability can be reduced through chemical treatments, soil compaction can induce greater rates of soil erosion and may be expensive. Use of sodium-based chemicals may increase the salt content in the collected water, which may not be suitable both for drinking and irrigation purposes.

2.6.2 Collection Devices

2.6.2.1 **Storage tanks**: Storage tanks for collecting rainwater harvested using guttering may be either above or below the ground. Precautions required in the use of storage tanks include provision of an adequate enclosure to minimize contamination from human, animal or other environmental contaminants, and a tight cover to prevent algal growth and the breeding of mosquitoes. Open containers are not recommended for collecting water for drinking purposes. Various types of rainwater storage facilities can be found in practice. Among them are cylindrical Ferro cement tanks and mortar jars. The Ferro cement tank consists of a lightly reinforced concrete base on which is erected a circular vertical cylinder with a 10 mm steel base. This cylinder is further wrapped in two layers of light wire mesh to form the frame of the tank. Mortar jars are large jar shaped vessels constructed from wire reinforced mortar. The storage capacity needed should be calculated to take into consideration the length of any dry spells, the amount of rainfall, and the per capita water consumption rate. In most of the Asian countries, the winter months are dry, sometimes for weeks on end, and the annual average rainfall can occur within just a few days. In such circumstances, the storage capacity should be large enough to cover the demands of two to three weeks. For example, a three person household should have a minimum capacity of 3 (Persons) x 90 (l) x 20 (days) = 5 400 l.

2.6.2.2 **Rainfall water containers**: As an alternative to storage tanks, battery tanks (i.e., interconnected tanks) made of pottery, Ferro cement, or polyethylene may be suitable. The polyethylene tanks are compact but have a large storage capacity (ca. 1 000 to 2 000 l), are easy to clean and have many openings which can be fitted with fittings for connecting pipes. In Asia, jars made of earthen materials or Ferro cement tanks are commonly used. During the 1980s, the use of rainwater catchment technologies, especially roof catchment systems, expanded rapidly in a number of regions, including Thailand where more than ten million 2 m3 Ferro cement rainwater jars were built and many tens of thousands of larger Ferro cement tanks were constructed between 1991 and 1993. Early problems with the jar design were quickly addressed by including a metal cover using readily available, standard brass fixtures. The immense success of the jar programme springs from the fact that the technology met a real need, was affordable, and invited community participation. The programme also captured the imagination and support of not only the citizens, but also of government at both local and national levels as well as community based organizations, small-scale enterprises and donor agencies. The introduction and rapid promotion of Bamboo reinforced tanks, however, was less successful because the bamboo was attacked by termites, bacteria and fungus. More than 50 000 tanks were built between 1986 and 1993 (mainly in Thailand and Indonesia) before a number started to fail, and, by the late 1980s, the bamboo reinforced tank design, which had promised to provide an excellent low-cost alternative to Ferro cement tanks, had to be abandoned.

2.6.2.3 ConveyanceSystems

Conveyance systems are required to transfer the rainwater collected on the rooftops to the storage tanks. This is usually accomplished by making connections to one or more down-pipes connected to the rooftop gutters. When selecting a conveyance system, consideration should be given to the fact that, when it first starts to rain, dirt and debris from the rooftop and gutters will be washed into the down-pipe. Thus, the relatively clean water will only be available some time later in the storm. There are several possible choices to selectively collect clean water for the storage tanks. The most common is the down-pipe flap. With this flap it is possible to direct the first flush of water flow through the down-pipe, while later rainfall is diverted into a storage tank. When it starts to rain, the flap is left in the closed position, directing water to the down-pipe, and, later, opened when relatively clean water can be collected. A great disadvantage of using this type of conveyance control system is the necessity to observe the runoff quality and manually operate the flap. An alternative approach would be to automate the opening of the flap as described below.

A funnel-shaped insert is integrated into the down-pipe system. Because the upper edge of the funnel is not in direct contact with the sides of the down-pipe, and a small gap exists between the down-pipe walls and the funnel, water is free to flow both around the funnel and through the funnel. When it first starts to rain, the volume of water passing down the pipe is small, and the dirty water runs down the walls of the pipe, around the funnel and is discharged to the ground as is normally the case with rainwater guttering. However, as the rainfall continues, the volume of water increases and clean water fills the down-pipe. At this higher volume, the funnel collects the clean water and redirects it to a storage tank. The pipes used for the collection of rainwater, wherever possible, should be made of plastic, PVC or other inert substance, as the pH of rainwater can be low (acidic) and could cause corrosion, and mobilization of metals, in metal pipes.

In order to safely fill a rainwater storage tank, it is necessary to make sure that excess water can overflow, and that blockages in the pipes or dirt in the water do not cause damage or contamination of the water supply. The design of the funnel system, with the drain-pipe being larger than the rainwater tank feed-pipe, helps to ensure that the water supply is protected by allowing excess water to bypass the storage tank. . In this system, it is possible to fill the tank from a municipal drinking water source, so that even during a prolonged drought the tank can be kept full. Care should be taken, however, to ensure that rainwater does not enter the drinking water distribution system.

The history of rainwater harvesting in Asia can be traced back to about the 9th or 10th Century and the small-scale collection of rainwater from roofs and simple brush dam constructions in the rural areas of South and South-east Asia. Rainwater collection from the eaves of roofs or via simple gutters into traditional jars and pots has been traced back almost 2 000 years in Thailand (Prempridi and Chatuthasry, 1982). Rainwater harvesting has long been used in the Loess Plateau regions of China. More recently, however, about 40 000 well storage tanks, in a variety of different forms, were constructed between 1970 and 1974 using a technology which stores rainwater and stormwater runoff in ponds of various sizes. A thin layer of red clay is generally laid on the bottom of the ponds to minimize seepage losses. Trees, planted at the edges of the ponds, help to minimize evaporative losses from the ponds (UNEP, 1982).

Various levels of governmental and community involvement in the development of rainwater harvesting technologies in different parts of Asia were noted. In Thailand and the Philippines, both governmental and household-based initiatives played key roles in expanding the use of this technology, especially in water scarce areas such as northeast Thailand.

Rainwater harvesting is an accepted freshwater augmentation technology in Asia. While the bacteriological quality of rainwater collected from ground catchments is poor, that from properly maintained rooftop catchment systems, equipped with storage tanks having good covers and taps, is generally suitable for drinking, and frequently meets WHO drinking water standards. Notwithstanding, such water generally is of higher quality than most traditional, and many of improved, water sources found in the developing world. Contrary to popular beliefs, rather than becoming stale with extended storage, rainwater quality often improves as bacteria and pathogens gradually die off (Wirojanagud et al., 1989). Rooftop catchment, rainwater storage tanks can provide good quality water, clean enough for drinking, as long as the rooftop is clean, impervious, and made from non-toxic materials (lead paints and asbestos roofing materials should be avoided), and located away from over-hanging trees since birds and animals in the trees may defecate on the roof.

Maintenance is generally limited to the annual cleaning of the tank and regular inspection of the gutters and down-pipes. Maintenance typically consists of the removal of dirt, leaves and other accumulated materials. Such cleaning should take place annually before the start of the major rainfall season. However, cracks in the storage tanks can create major problems and should be repaired immediately. In the case of ground and rock catchments, additional care is required to avoid damage and contamination by people and animals, and proper fencing is required.

Rainwater harvesting technologies are simple to install and operate. Local people can be easily trained to implement such technologies, and construction materials are also readily available. Rainwater harvesting is convenient in the sense that it provides water at the point of consumption, and family members have full control of their own systems, which greatly reduces operation and maintenance problems. Running costs, also, are almost negligible. Water collected from roof catchments usually is of acceptable quality for domestic purposes. As it is collected using existing structures not specially constructed for the purpose, rainwater harvesting has few negative environmental impacts compared to other water supply project technologies. Although regional or other local factors can modify the local climatic conditions, rainwater can be a continuous source of water supply for both the rural and poor. Depending upon household capacity and needs, both the water collection and storage capacity may be increased as needed within the available catchment area.

Disadvantages of rainwater harvesting technologies are mainly due to the limited supply and uncertainty of rainfall. Adoption of this technology requires a *bottom up* approach rather than the more usual *top down* approach employed in other water resources development projects. This may make rainwater harvesting less attractive to some governmental agencies tasked with providing water supplies in developing countries, but the mobilization of local government and NGO resources can serve the same basic role in the development of rainwater-based schemes as water resources development agencies in the larger, more traditional public water supply schemes. The augmentation of municipal water supplies with harvested rainwater is suited to both urban and rural areas. The construction of cement jars or provision of gutters does not require very highly skilled manpower.

The capital cost of rainwater harvesting systems is highly dependent on the type of catchments, conveyance and storage tank materials used. However, the cost of harvested rainwater in Asia, which varies from $0.17 to $0.37 per cubic metre of water storage, is relatively low compared to many countries in Africa (Lee and Vissher, 1990).

Compared to deep and shallow tube wells, rainwater collection systems are more cost effective, especially if the initial investment does not include the cost of roofing materials. The initial per unit cost of rainwater storage tanks (jars) in Northeast Thailand is estimated to be about $1/l, and each tank can last for more than ten years. The reported operation and maintenance costs are negligible.

The feasibility of rainwater harvesting in a particular locality is highly dependent upon the amount and intensity of rainfall. Other variables, such as catchments area and type of catchments surface, usually can be adjusted according to household needs. As rainfall is usually unevenly distributed throughout the year, rainwater collection methods can serve as only supplementary sources of household water. The viability of rainwater harvesting systems is also a function of: the quantity and quality of water available from other sources; household size and per capita water requirements; and budget available. The decision maker has to balance the total cost of the project against the available budget, including the economic benefit of conserving water supplied from other sources. Likewise, the cost of physical and environmental degradation associated with the development of available alternative sources should also be calculated and added to the economic analysis.

Assuming that rainwater harvesting has been determined to be feasible, two kinds of techniques--statistical and graphical methods--have been developed to aid in determining the size of the storage tanks. These methods are applicable for rooftop catchment systems only, and detail guidelines for design of these storage tanks can be found in Gould (1991) and Pacey and Cullis (1986, 1989).

Accounts of serious illness linked to rainwater supplies are few, suggesting that rainwater harvesting technologies are effective sources of water supply for many household purposes. It would appear that the potential for slight contamination of roof runoff from occasional bird droppings does not represent a major health risk; nevertheless, placing taps at least 10 cm above the base of the rainwater storage tanks allows any debris entering the tank to settle on the bottom, where it will not affect the quality of the stored water, provided it remains undisturbed. Ideally, storage tanks should cleaned annually, and sieves should fitted to the gutters and down-pipes to further minimize particulate contamination. A coarse sieve should be fitted in the gutter where the down-pipe is located. Such sieves are available made of plastic coated steel-wire or plastic, and may be wedged on top and/or inside gutter and near the down-pipe. It is also possible to fit a fine sieve within the down-pipe itself, but this must be removable for cleaning. A fine filter should also be fitted over the outlet of the down-pipe as the coarser sieves situated higher in the system may pass small particulates such as leaf fragments, etc. A simple and very inexpensive method is to use a small, fabric sack, which may be secured over the feed-pipe where it enters the storage tank.

If rainwater is used to supply household appliances such as the washing machine, even the tiniest particles of dirt may cause damage to the machine and the washing. To minimize the occurrence of such damage, it is advisable to install a fine filter of a type which is used in drinking water systems in the supply line upstream of the appliances. For use in wash basins or bath tubs, it is advisable to sterilize the water using a chlorine dosage pump.

Rainwater harvesting appears to be one of the most promising alternatives for supplying freshwater in the face of increasing water scarcity and escalating demand. The pressures on rural water supplies, greater environmental impacts associated with new projects, and increased opposition from NGOs to the development of new surface water sources, as well as deteriorating water quality in surface reservoirs already constructed, constrain the ability of communities to meet the demand for freshwater from traditional sources, and present an opportunity for augmentation of water supplies using this technology.

CHAPTER THREE

3. MATERIALS AND METHODS

3.1 Description of the Study Area

Minna town, the state capital of Niger state lies on latitude 9°3′N and longitude 6°3′E. The average temperature is 27.25C (81.05F). 19.00C (66.20F) is the lowest monthly average low temperature (occurring in December) while 37.00C (98.60F) is the highest monthly average high temperature which occurs in March. Thus the average temperature range is 5.50C (41.90F). Wet weather in Minna adds up to a total average rainfall of 1338.00mm (51.65in) per annum. That is equivalent to an average monthly rainfall of 109.33mm (4.30in). September is the month with the highest quantity of precipitation when 296mm (11.65in) of rain falls over a period of 21 days while in January only 2mm (0.08in) of rain falls over less than 1 day. Minna's climate is furnished with 101 days per year with greater than 0.1mm (0.004in) of rainfall. Relative humidity at Minna, Nigeria averages 48.91666667 percent over the year. 21percent is the lowest average monthly relative humidity which occurs in February and 73percent is the highest average monthly relative humidity which occurs in August. Minna, Nigeria's climate is furnished with 2672 hours of sunshine per year. That is an average of 7.32 hours per day. Daily hours of sunshine range from between 3.6 per day in August to 9.2 per day in November (Ija, 2007).

3.2 Types of Data Required

The main aim of this study is to examine the level of awareness and adoption of rainwater harvesting in Minna, Niger state, and the type of data used is mainly based on primary data.

3.2.1 Types and Source of Data

Both primary and secondary sources of data were use in this study. The variables that were used as a means of obtaining information to achieve the objectives of the study include:

a) Demographic characteristic such as sex, age and marital status.

b) Socio-economic characteristic of respondents such as educational level, occupation level, level of income.

c) Water situation in the study area, such as source of water, distance to source, accessibility, amount of water use per day.

d) Problems of rural water supply such as political, human/effort and environmental.

3.3 Method of Data Collection

The questionnaire method was adopted to gather data in the following sequence. First, a reconnaissance source of this study area was carried out and it was discovered that the study area was made up of many localities, this brought about the adoption of systematic random sampling which entails selecting five (5) district headquarters in the study area.

3.3.1 Field Observation

This is one of the primary source of obtaining information which was been carried out to analyze and to observe the socio-economic characteristics of the people and it relationship between water supply in the study area.

3.3.2 Questionnaire Administration

This is a set schedule question already written to generate information on specific issues from the people in the study area about the sources of water supply, distribution, accessibility and problems of water supply in the area, awareness of rainwater harvesting, and adoption of this rainwater harvesting, quantity harvested and stored. Twenty five questionnaires each were administered to the selected study area. Total sum of two hundred and fifty questionnaires were administered all together.

3.3.3 Sampling Framework

The sampling technique was subsequently employed where by individuals from each area have equal chances of being selected. The questionnaires were administered to civil servants, traders, farmers and indigenes in the area.

The method used in this study was drawn from brief survey of the entire Bosso local government area.

A sample of twenty five household respondents was selected from each area to make a total of two hundred and fifty (250) respondents for individual questionnaire in other to enhance the collection of representative information; respondents were selected from household in the study area.

CHAPTER FOUR

4. RESULTS AND DISCUSSION

During the process of collecting data for this research work on the rainwater harvesting, storage and treatment for domestic purposes in Minna, Niger state there are many factors that inhibit the unbiasness of the respondents and these are:

i) **Illiteracy**: As a result of illiteracy of some people in rural area or people who are academically illiterate, effective communication is difficult, especially in the case where these respondents can not read or write in English language so effort have to be made in translating the question to him/her.

ii) **Suspicious from the side of the respondents**: There is always a question from the respondent that why are we asking such questions and this can eventually lead to wrong information such as thinking that we are from the government that it might have some thing to do with tax increment.

iii) **Secrecy**: There are prejudices against certain questions that are often faced by researchers because people feel that their privacy are intruded into e.g. the number of children.

iv) Some respondents falsify information in other not to be looked down upon because they are seeing those administering the questionnaire as people from cities so by giving the right information they will think they are socially inferior.

The field quantitative data were interpreted with the use of the descriptive statistics e.g. chi-square, percentage, bar and pie charts to show the relationship between the quantity of water consumed per household, rainwater harvesting, and socio-economic variables such as family sizes, income, education and occupation and further to test the effect of education on the people's perception of rainwater harvesting, water quality, and conservation of household water.

Using the chi square formula below to test the three (3) hypotheses

$$\therefore X^2 = \Sigma \frac{(Fo - Fe)^2}{Fe}$$

Where fo = Frequency observed.

Fe = Expected frequency

For x^2 the degree of freedom is written as

d.f = (e-1) (r-1)

d = 0.05 level of confidence.

4.1 Demographic Characteristics of Respondents

4.1.1 Age of the Respondents

Table.4.1: shows the age distribution of the respondents.

Table 4.1: Age Distribution

Age	Frequency	Percentage (%)
Below 20 years	-	-
21-30 years	107	42.8
31-40 years	98	39.2
41-50 years	35	14
50 years and above	10	4
Total	250	100

Source: Field work (2010)

Table 1 above depicts the different various ranges of the age brackets, respondents below the age of 20 years accounts for zero (0) percent of the respondents, however respondents between the age bracket of 21 and 30 years accounts for 42.8% which implies that the age range has the highest number of respondents in the research work and this is closely followed by 39.2% ascribed to respondents between 31 and 40 years of age respondents between the age of 41 and 50 recorded 14%, the respondents above 50 years of age accounted for only 4% of the total respondents.

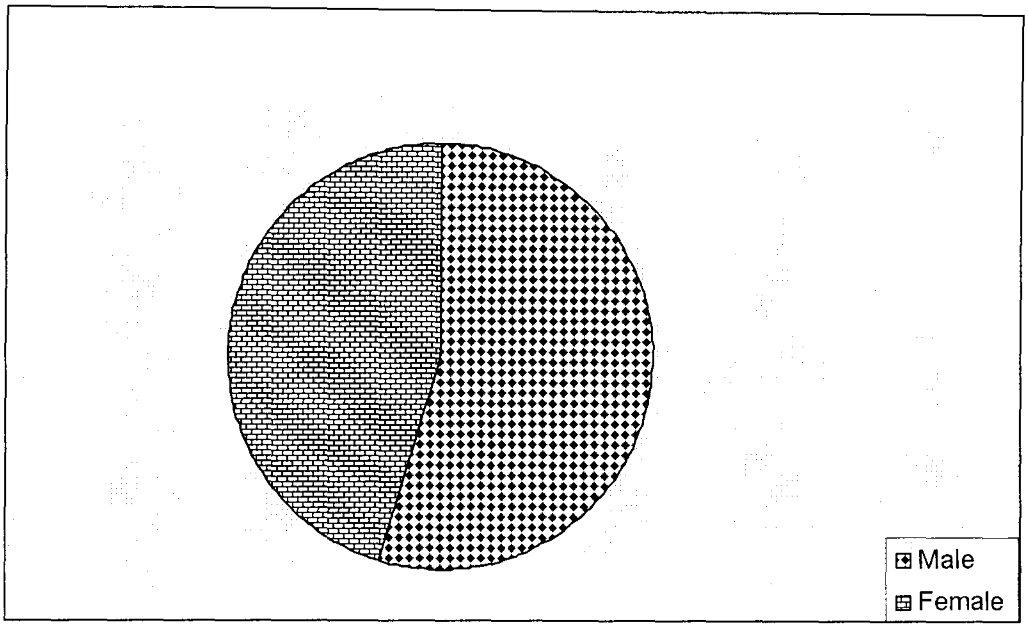

Figure 4.1: Pie Chart showing the sex of respondent in the study area

Source: Field work (2010)

From the chart above, it could be deduced that the male gender of the respondents was 54.7% while their female counterparts constitutes the remaining number of 45.3%.

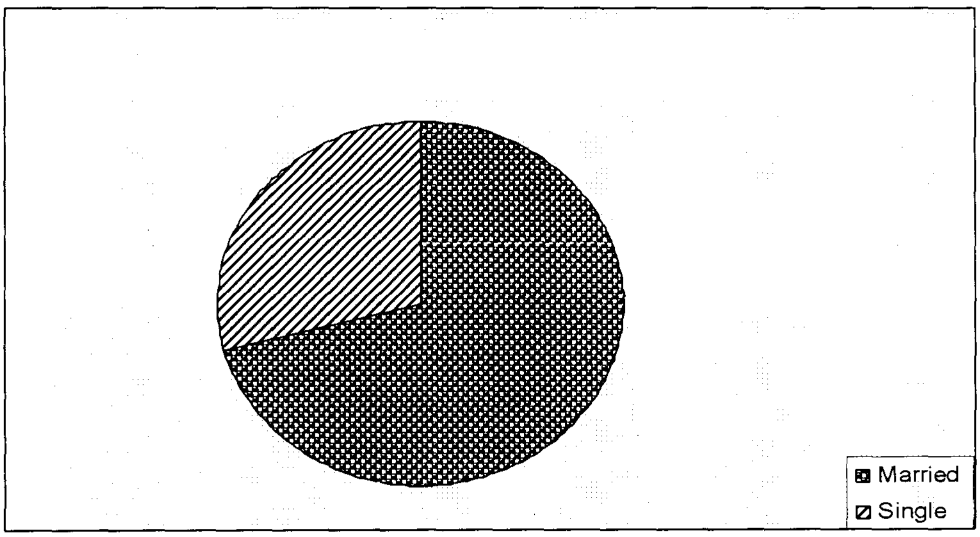

Figure 4.2: Pie Chart showing the Marital Status of Respondent

Source: Field work (2010)

It could be seen from the chart above and the pie chart that the married respondents in the study area is made of 70.7% which is the bulk of total number while the singles on the other hand constitutes 27.3% of the total number.

4.1.2 Number of Respondents per Household

Table 4.2: **Structure of household size**

No. of persons	Frequency	Percentage (%)
1	70	28
2	30	12
3	15	6
4	35	14
5	100	40
Total	250	100

Source: Field work (2010)

From the table 2, above the number of persons in a household; no doubt will have an effect on the total quantity of water consumed. The number of persons in the household ranges from 1 to 5 and above; and 40% of respondents account for five (5) persons and above hence the class emerge as the bulk of the respondents: this is followed by 14% which consists of four (4) persons in a household: 28% of the respondents lives alone 6% consist of three (3) persons, while 12% accounts for household that consists of two persons.

4.2 SOCIO-ECONOMIC CHARACTERISTICS OF RESPONDENTS

4.2.1 Educational Level of the Respondents

Table 4.3: Educational level of respondents

Level	Frequency	Percentage (%)
Primary	20	8
Secondary	50	20
University	60	24
NCE/Diploma	105	42
Quaranic only	15	6
Total	250	100

Source: Field work (2010)

Most of the respondents in the study area attained one level of education or the other and this include primary, secondary, university, Higher National Diploma (HND), National Certificate in Education (NCE) and diploma these levels of education have implications on water quality perception of the population.

It can be depicted from the table that respondents with Nation Certificate in Education (NCE) and Diploma Education level accounted from 42% which is the highest proportion followed by university degree holder and high national degree holder which accounted for 24%, 20% attained secondary education level while 8% accounts for respondents with primary education and the least proportion of the respondents goes to the respondents with no formal education but quanranic education only and they accounted for just 6% of the total respondents.

4.2.2 Occupation of the Respondents

Table 4.4: Occupational structure of the respondents.

Occupation	Frequency	Percentage (%)
Civil servant	80	32
Trader	78	31.2
Carpenter	21	8.4
Farmer	30	12
Others	41	16.4
Total	250	100

Source: Field work (2010)

From the above, it can be deducted that respondents whose occupation are civil servants e.g. local government workers, teachers are accounted for 32% dominating the number of the respondents and this is followed by traders with 31.2% of the whole respondents, farmer accounts for 12% of the respondents while others comprised of occupation like fashion designers, craft-man, clergy closely followed 16.4% and carpenters cast figure accounting for 8.4% of the study area.

Hence, the kind of occupation people engaged in is an important factor that determines the standards of living and water supplied. For instance, civil servants in the area are able to afford big reservoirs which can serve their household water storage for days.

4.3 Water Situation in the Study Area

4.3.1 Sources of Water in the Study Area

Table 4.5: Major sources of water

Source	Frequency	Percentage (%)
Stream/river	22	8.8
Rain water	50	20
Well	125	50
Spring	5	2
Pipe borne	48	19.2
Total	250	100

Source: Field work (2010)

The table above revealed that the inhabitants of the communities depends solely on well water where 50% of the respondents get their water from wells located within their compounds or very close to their abode. 19.2% get their water from pipe borne i.e. taps and boreholes, 8.8% obtain their water from streams and river, 2% obtain water from spring while the respondents who obtain their water from rain accounts for only 20% of the total respondents.

4.3.2 Distance to Source of Water

Table 4.6: Distance from the various source of water

Distance	Frequency	Percentage (%)
Less than 1km	180	72
1-2km	50	20
2-3km	10	4
3-4km	5	2
4 and above	5	2
Total	250	100

Source: Field work (2010)

Location theory apart from providing the theoretical framework for analyzing the location of water sources. It will also provide understanding for water uses. It will be expected that the closer one is to the water source, the more the use of water".

The table shows the distance trekked to water sources and it ranges from less than one (1) kilometer to over four (4) kilometer, it is deduced from the table that 72% of the respondents trekked less than one (1) kilometer reflecting the highest percentage of distance trekked. 20% treks between 1 and 2 kilometers to obtain water, 4% follows in descending order and is ascribed to the respondents that trek between 2 and 3 kilometer, 2% trek between 3km and 4km while only 2% of the respondents cover a distance of over 4km to obtain water for their various needs and uses.

4.3.3 Accessibility to Water Sources

The table above shows that the respondents have more accessibility to water sources this is because 79.3% of the respondents have easy accessibility to water sources due to the closeness to the source, while only 20.7% do not have easy access to water sources.

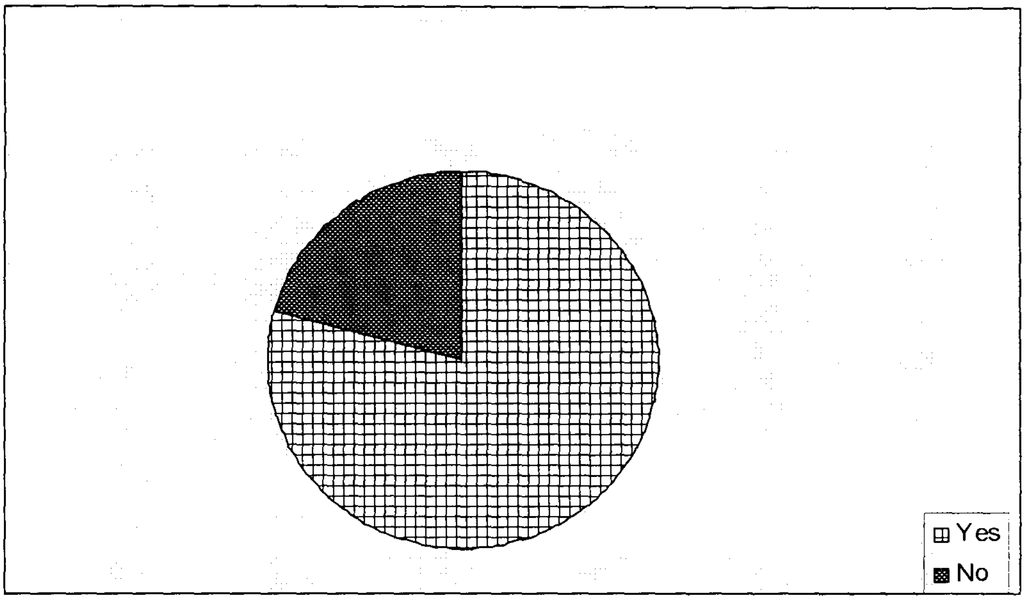

Figure 4.4: Pie Chart Showing the Accessibility of Water Sources

Source: Field work (2010)

4.3.4 Amount of Water Used Per Day

Table 4.7: The table below depicts the amount of water consumed per day by the respondents.

Amount in litres	Frequency	Percentage (%)
Less than 100	150	60
100-110 litres	100	40
110-150 litres	-	-
150-200 litres	-	-
200 and above	-	-
Total	250	100

Source: Field work (September, 2010)

From the table above it could be ascribed that 54% of the respondents use less than 100 litres of water per day while 32% uses 100-110 litres per day 4.7% on the other hand consumed between 110-150 litres per day more over 5.3% used up between 130 litres and 200 litres per day. Thus, we can see the need for adequate supply of water.

4.3.5 Problems of Rural Water Supply

Potable water supply is one of the most essential amenities in rural development processes not only is it vital for healthy living. It is also essential for domestic usage such as cooking, bathing, washing clothes, dishes, and cars, the important of pipe borne water can be better appreciated, it is realized that the traditional sources of water such as rain water, well water, streams and rivers are highly susceptible to incidents of pollution this is however so where there are sewage disposal as in the rural settings, poor toilet habits which is the unhygienic passing of fieces which are washed down to the streams and rivers therefore water from streams and rivers could be veritable source of diseases and infection .

Portable water supply is usually regarded as one of the basic infrastructural facilities and the problems that hinder the rural water supply which are;

(a) Political interference and administrative problems.

(b) Human problems

4.3.6 Political Interference and Administrative Problems

The political interference in the distribution of water points which either leads to the prevalence of abandoned water projects by the contractors or government agencies. The projects of water supply require a huge financial cost but the rural areas are not strong enough to make the project cost recovering. Hence this is why the government is responsive in providing such facilities.

4.3.7 Human Problems

The human factors that hinders the supply of potable water and distribution to the rural areas is the fact that perception of the inhabitants of rural areas to water supply they see it as a resources that government should supply free of charge, thereby do not want to pay for water charges. Even the charges paid on water consumption are by no means low to the amount of water consumed.

4.3.8 Efforts of the Communities towards Developmental Plans

Figure.4.5 shows the efforts of the communities towards development plan

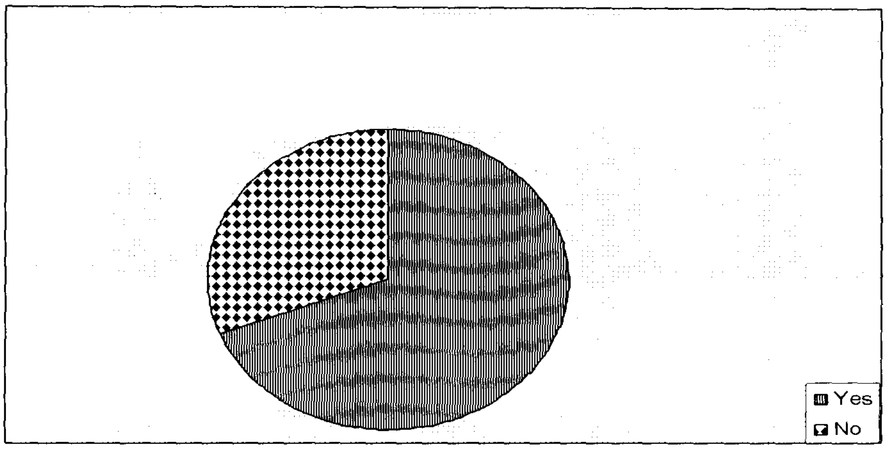

Figure 4.5: Pie Chart showing the effort of the community towards development plan
Source: Field work (2010)

From the table and pie chart above, it can be deducted that various wards are aware of the importance of potable and hygienic/safe water; they do not leave themselves to the mercy of the various governments (e.g. Federal, State and Local). They are now rising to be task of rural water development plan. 69.3% of the respondents that agrees to the community development plan while just 30.7% of the total respondents is ascribed to the respondents that did not agree to any development play by the community.

CHAPTER FIVE

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The research exercise was carried out on rainwater harvesting in Minna, and this was done by examining the level of awareness and adoption of rainwater harvesting techniques. Data was collected mainly through questionnaire survey and subjected to statistical analysis and explanations.

It was discovered that the level of awareness was 99.5% but techniques of adoption was poor as they ran out water few days after rainfall. 19.2% of the inhabitants depend on borehole and tap water; while 50% depend on well water while 8.8% depended on stream/river and spring water and just only 20% depends on rain water and all these are of less quality compared to tap and borehole water.

The concerned authority should improve the accessibility of these areas to water supply, by adopting modern rainwater harvesting techniques in terms of quantity and quality, hence putting an end to water shortage occurrences and water borne diseases and valuable time loss in the search for water. Most of the boreholes that were sunk are no longer functioning while some did not function since it was sunk. There is also a need for provision of storage facilities and people should be enlightened on rain water harvesting and how to store it properly, underground reservoirs should be utilized to combat the problem of scarcity.

The problem of inadequacy and irregular supply of water are not the only problem but the problem of unhygienic and low quality source of water e.g. streams, rivers, and ponds available to the residents of Bosso local government. This has posed health hazards like typhoid, dysentery and guinea worm which should be addressed. Other problems associated with these towns is that some inhabitants defecate carelessly in the bushes near the water sources most especially streams and rivers where excreta with it harmful bacteria organisms get washed into the stream after it rained, location of abattoir without proper waste treatment in the area before disposal of these waste. Other inhabitants have their bath and do their laundry. Obtain their drinking water or even obtain for various domestic uses at home.

5.2 RECOMMENDATIONS

The above enumerated problems can be reduced or solved long term solution to the shortage of water required if modern rainwater harvesting techniques are adopted which is more than reservoirs, dams and adhoc schemed.

i. Rain water harvesting must be studied and dealt with by teams of professionals comprised of physical scientists like geomorphologies, climatologists, hydrologists, biological scientist like biologists, and social scientist like sociologist.

ii. This study must be based on a thorough understanding of the interrelationship of natural force and a detail knowledge of the water cycle and where and how best to direct it for man's use. All concerned with the conservation and supply of water must appreciate the unity of the many natural features.

iii. Provision or more boreholes in and around these towns should be encouraged and those already sunk that are non-functional should be reactivated so each family would have easy access to water for their domestic needs.

iv. The provision will further enhance the standard of living of the people and incidence of water-borne disease reduced. It is hoped that the productivity of the people would increase.

v. Government should disburse funds to the various terms for solving and implementing these noble techniques of rainwater harvesting so as to mitigate the peculiar water problems.

vi. They should also encourage these terms to be self dependent, awareness programmes and enlightenment campaigns for the people should be created since most of them are ignorant of health and economic hazards that consumption or usage of unhygienic water can cause.

vii. Wells should be sunk and well covered by the local authority to further supplement water gotten from borehole, if these boreholes are very expensive to dig and it should be evenly distributed so that everybody will have an easy access to them.

viii. Good storage facilities should be provided like reservoirs that can contain litres of treated water to serve more than half of the population conveniently during periods of water shortage. Construction of (water) network of pipelines to serve reservoirs serving the local government should be done on the other hand small streams can be dammed and water in the rainy seasons are spread to areas of demand.

ix. Efforts should be made by the water corporation on to replace damaged or burst pipes. Contingency arrangement must be put in place by the water corporation for improved water supply during dry season.

x. Maintenance of water development scheme should be given priority consideration with faulty equipments being replaced and booster's station to boost the supply to town like Minna which is located on the basement rock to ensure maximum efficiency.

In tune with this project, it has thrown light into areas of rainwater harvesting techniques where future research work on rainwater harvesting could be profitably resourced for.

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