
Rainwater Harvesting Strategies for Sustainable Landscape Development of School of Management in Ramat Polytechnic Maiduguri, Nigeria

Sadiq Mohammed Mala, Hadiza MOHAMMED Lere, BULAMA Kyari, Babagana HALIL
Department of Architectural Technology, Ramat Polytechnic Maiduguri
E-mail: m90.sadique@yahoo.com

Abstract: Sustainability is the concept mostly put forward to ensure the planet’s future wellbeing for coming generations. The landscape surrounding the school is expected, along with the architecture of the building to reinforce an experience of escape from daily life. Often this is done through the creation of a “Garden”, using plants. Water is a resource that is becoming increasingly scarce and needs to be sustained, globally and locally. Maiduguri is one of the states that face this challenge. The need therefore arises to address the issue of how to manage our water resource in a sustainable way. This project is aimed at creating sustainable landscape using a garden concept in Ramat Polytechnic Maiduguri, Borno state. The research design for the study was case study using qualitative base approach which includes visual survey and structured interview. Results indicate that a substantial amount of rainwater can be captured and use for landscape purposes in the study area. This is achieved by designing efficient waste water recycling system for irrigation of the garden in the school. The design strategy proposes implementation of a garden in the school. A set of sustainable water management strategies is selected for three main areas: buildings, streets, and parking lots with respect to their distinct zone.

Key words: Sustainability, Landscape, Plants, & Rainwater

BACKGROUND OF STUDY

1.1 Introduction

Sustainability was the concept mostly put forward to ensure the planet’s future wellbeing for coming generations. (Bruntland, 2000). According to Liu, (2003) sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The landscape surrounding the hospital is expected, along with the architecture of the building to reinforce an experience of escape from daily life. Often this is done through the creation of a “therapeutics garden” (Mitrakis, 2008), using, therapeutic plants, meticulously maintained grounds, and expanses of turf grass, all of which require water. According to Kasim, (2007) hospitals in particular consume large amounts of water for leisure purposes such pools, spas, fountain, ornamental water feature and landscape irrigation.

Throughout history, many civilizations flourished in modern- day region where water is extremely limited. (Kasim 2007). According to the united nations human development report on African countries, the rainfall distribution is highly variable and in some countries, around 52% of the regions receive an average rainfall of less than 100mm, 15% receives 100-300mm, and 18% receives more than 300mm. Based on this report, there are some countries such as Syria and

Lebanon that receive a maximum rainfall of 1500mm/year. However a large amount of rainfall is lost due to surface runoff and evaporation (Mitrakis, 2008).

This scenario is prevalent in arid and semi-arid environments particularly that of third world countries where poverty and low level of technology combine to hinder development (Bohdanowicz 2005). This problem is compounded by the rapid population growth in these countries and hence increase in water demand. Maiduguri the Borno State capital fits into the scenario described above, hence the necessity for obtaining and securing quality water for both landscape and domestic use and consumption dominates political and economic discourse of both the people and the government(s). Water continues to be a development challenge in the city as the two main supply sources (Ground water and surface water) could not guarantee steady supply. As the water crisis becomes more critical, there is need for new sustainable solutions and strategies to meet the current and increasing human needs in order to not only recover the damaged environment, but also sustain it for the future.. Such alternative can be sourced from rain water harvesting from roof top as the case in many areas with similar water crisis (Bukar 2005).

Rainwater harvesting simply refers to the direct interception of rainfall for human use. In its broadest sense, UNEP (2000), defines it as the technology used for collecting and storing rain water for human use from roof tops, land surface, or rock catchment using simple and relatively affordable materials such as coarse mesh, gutters, conducts, filters, and storage tanks.

Overview of the study

This is to study and review the modern practices/concepts of waste water recycling and storm water management for various uses, particularly for the long dry season irrigation of various gardens and also to explore storm water harvesting technique to be used in therapeutics garden. In Maiduguri, underground water and surface water sources are the two major supplies for domestic needs. Underground water is mainly exploited through the various boreholes spreads in the area. The only exploited surface water for domestic uses is the dam at alau along the channels of river Ngadda. Alau dam supplies water to substantial's parts of Maiduguri and environs (Waziri 2001). At maximum operation hours, the boreholes yield 622,360 liters per day, while the current maximum yield from the Alau treatment plant is 25,000 m³ (25, 000, 000 liter per day), thus giving the combined supply from the two sources as 25.6 million liters daily. The analysis of domestic water demand in Maiduguri shows that the daily water need (domestic and Landscape) of the city is 31.16 million liters (Bukar 2006). This clearly indicates that there is a domestic water deficit of 5.56 million liters daily. Therefore, there is need for focusing on harvesting rain water for use in landscape design in order to avoid over consumption of the already scarce fresh drinking water in the environment.(Waziri 2001).

Sustainable development was the concept mostly put forward to ensure the planet's future wellbeing for coming generations. The often quoted Bruntland report defines sustainable development as: the development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Liu, 2003).

Definitions for RWH vary considerably depending on the source consulted. Mbilinyi *et al*, (2005) define RHW as the process of concentrating, collecting, and storing rainwater for different uses at a later time in the same area where the rain falls or in another area during the same or later time. The Texas Water Development Board (TWDB) (2005) stated that RWH in its essence is the collection, conveyance, and storage of rainwater. In all these definitions, there is no doubt that rain water harvesting is physical system that at least collects, conveys, and stores water.

METHODOLOGY

3.1 Qualitative Base Approach

Basically, qualitative research method will be used in the case study, which includes the following methods:

Visual Survey: Take a visit of the hospitals and careful observation of its features. This survey must be guided by critical literature review guidelines. Eg checklist. Visual survey can be documented through tabulation, sketches, plates, figures; written reports etc. in this particular case, plate will be used.

Structured interview: To interview of administrative and technical staff on several aspects of the hospital to get detailed and precise information on the functionality of the area.

3.2 Data collection

Case studies in landscape begin with a documentation of the case, and for theoretical research they may require the use of general methods of data collection (Oluigbo 2010). However, the methods of data collection adopted for this study is observations, visual survey, and structured interview.

3.3 Procedures for data collection.

The procedures for data collection for the local case study involved visits to the case study sites, and taking visual analysis of their landscape elements, as the reflects harmony with nature.

RESULTS AND DISCUSSION

4.1 Introduction

Results of the case studies selected for this work were assessed under the following background, site planning and landscaping, and rainwater harvesting, storm water and sewage recycling.

4.2 Case Study One: University of Maiduguri Teaching Hospital, Maiduguri.

4.2.1 Background

University of Maiduguri Teaching Hospital UMTH is located along Bama road in Maiduguri, Borno State, North eastern Nigeria. The city lies between latitude $10^{\circ} 50' N$ and longitude $13^{\circ} 09' E$ It has an area of approximately 69,435 km², having a physical setting which arises from the amalgamation of factors relating to geology, climate as well as intensity of solar radiation in the area. It a semi-arid Sahel savannah and has scattered mostly neem (*Adzadirica Indica*) trees. Maiduguri has one of the best-equipped universities and hospitals in Nigeria. The University of Maiduguri attracts foreign students from neighboring countries especially Cameroun and Niger

Republic. The College of medical sciences is amongst the top 5 best medical schools in Nigeria (Wikipedia).

4.1.3 Landscape feature

4.1.3.1 Planting

Luscious array of both mesophyte and xerophytes plants, grouped according to their water requirement in distinct areas and rows for each plant. Grouping plants with similar water requirements into separate areas simplifies the system by applying the desired amount of water needed by each plant. The plants managed to create a scheme that was brave and bold by using different plant varieties.

4.1.3.2 Irrigation system:

The irrigation system consists of a rubber hose and sprinkler connected to the tap, Water flows through the hose and seeps slowly to water the plants and grasses. These practice invariably result in too much water being used on plants that really do not require it.

4.1.4 Rainwater harvesting system

The roof outlets are connected with pipes that drop to the ground level and into the underground drainage system, where the water is release into the river. There is no form rain water harvesting system at the hospital.

4.1.5 Storm water system

The drainage systems have been engineered to quickly collect SW into the constructed underground drain, and discharge into larger and deeper collector drains and finally to the river. This design philosophy treats rainfall runoff as a waste, while sustainable SW design treats runoff as a valuable resource that can be used.

4.1.6 Sewage System

Sewage treatment system is one that treats wastewater and discharges effluent into the ground onsite. No form of recycling

Table 4.1 checklist for the assessment of sustainable water management practices at hospital

VARIABLES	BMPS	LEVEL OF APPLICATION				REMARK
		HIGH	Moderate	LOW	ABSENT	
Roof rain water	Rainwater tank/ reuse scheme				✓	No rainwater harvesting system
Storm water						

Filtration	Gravel filter			✓		Moderate use Of gravel and low vegetative Filters
	Vegetated filters				✓	
Conveyance	Bio swale					No use of bio swale and planter
	Planter					
Detention	Detention pond					No detention pond and dry swale.
	Dry swale					
Retention	Retention pond					Absent of retention pond, constructed wetland and under ground storage tanks
	Constructed wetland					
	Underground tanks					
Infiltration	Infiltration trench					Absent of infiltration trench, permeable paving and rain garden.
	Permeable paving					
	Rain garden					
Sewage water	Sewage recycling					✓ No sewage treatment plant

4.2 Case Study Two: Jos University Teaching Hospital

4.2.1 Background

It was located at the Murtala Muhammad way Jos, until in the year 2007, most medical activities relocated to the permanent site at Lamingo, Gwafan District of Jos north local Government council, Plateau State.

Jos university teaching hospital lies on latitude 9° 5'N 8° 53'E/9.9330N 8.8830E. It receives an annual rainfall range of 1,400mm, with temperature of 21°C to 25°C. It covers an area of about 5000 hectares of land.

4.2.2 Site Description

Considering its planning, the notion of JUTH staff parking spaces is separated from the public parking space. This would check security situation, and to accommodate more cars. The car parking space is located at about 500 meters away from the hospital, this affords both patients and staff the opportunity to walk on foot thereby, them the opportunity to do some exercise.

4.2 Landscape feature

4.2.3.1 Planting

From the gate there is formal planting of *Ixora coccinea hedges* in a straight column to the building and Large expanse of lawn at the back of the hospital, both native and exotic plants were used on the site.

Plants are planted in a formal way that merged by subtle degrees into a naturalistic background with a definite and precise structure to its distinct areas and row for each plant.

4.2.3.2 Irrigation system

The irrigation system in JUTH is unique in the sense that its source of irrigation water is pumped from the river into the constructed storage tank. From the storage, water flows to the sprinklers. In the sprinkler method of irrigation, water is sprayed into the air and allowed to fall on the ground surface somewhat resembling rainfall. The spray is developed by the flow of water under pressure through small orifices or nozzles. The pressure is usually obtained by pumping.

4.2.4 Rainwater harvesting system

There is no form of active rainwater harvesting system at the hospital. Rainwater pipe discharged runoff from the roof into the underground drainage system.

4.2.5 Storm water system

Storm water is discharged into the constructed underground drainage system within the paved area and channeled into a constructed wetland. Where it is pumped into a storage tank and used for irrigation.

4.2.6 Sewage system

Sewage treatment system is one that treats wastewater and discharges effluent into the ground onsite. No form of recycling

Table 4.2 checklist for the assessment of sustainable water management practices at Jos University teaching hospital

VARIABLES	BMPS	LEVEL OF APPLICATION				REMARK
		HIGH	MODERATE	LOW	ABSENT	
Roof rain water	Rainwater tank/ reuse scheme				√	No rainwater harvesting system
Storm water						
Filtration	Gravel filter		√			Moderate use Of

						gravel and low vegetative Filters
	Vegetated filters		✓			
Conveyance	Bio swale			✓		low use of bio swale and planter
	Planter			✓		
Detention	Detention pond					No detention pond and dry swale.
	Dry swale					
Retention	Retention pond					Absent of retention pond and underground storage tanks. High use of constructed wetland.
	Constructed wetland	✓				
	Underground tanks					
Infiltration	Infiltration trench					Absent of infiltration trench, permeable paving and rain garden.
	Permeable paving					
	Rain garden					
Sewage water	Sewage recycling					No sewage treatment plant

4.4 Findings from Interviews

Interview with the various hospital staffs at the three study areas was carried out using written notes and a recorder. Question that formed the interview will however be attached in the appendix.

4.4.1 Rainwater Harvesting

All three respondents were familiar with rainwater harvesting; this was not surprising given that rainwater harvesting is a common practice at household level in Nigeria. All the three respondents also viewed rainwater harvesting as appropriate for landscape use in hospital facility. However one landscape maintenance manager sees the cost of installation of storage tank as the biggest barrier to rainwater harvesting.

4.4.2 Therapeutics Garden

The respondents from the hospitals were familiar with the therapeutic garden and their respective institutions provided an area for the patients in the hospitals to visit as a healing environment

4.4.3 Storm water Management

Two respondents were not familiar with storm water management techniques. This could be attributed to the fact that storm water management is a not common practice in Nigeria. Upon

explanation all respondents viewed storm water management techniques as appropriate for use in a hospital

4.4.4 Sewage recycling

All of the three respondents were immediately familiar with sewage recycling. Upon hearing the definition, all respondents thought that sewage water recycling is appropriate for landscape use in hospitals properties, though concerns were expressed about public health and water quality. Two of the three respondents mention cost as a barrier to sewage recycling.

4.5 Summary findings from case studies

Checklist was used to determine the level of reflection of factor based on a scale of absent, low, moderate and high.

4.5.1 Rainwater Under rainwater harvesting an absent scale was reflected in all the three case studies. This was not shocking given that rainwater is not a common practice at commercial facilities level in Nigeria.

4.5.2 Therapeutics Garden

Under the therapeutics garden, most of the therapeutics plants were absents in the two hospitals due to the shortage of water in that area and also two of the hospitals has no pacific therapeutic garden but has an area that serve as healing area for the patients

4.5.3 Storm water

Four variables were assessed under storm water management, which include filtration, conveyance, detention and infiltration.

Filtration

Under filtration two sub variable were assessed; medium use of gravel filter was reflected at University of Maiduguri teaching hospital and high was reflected at Jos university teaching hospital and vegetative filter reflected high at the hospitals.

Conveyance

The case studies reflected low use of bio swale at university of Maiduguri teaching hospital and absent at both University of Maiduguri teaching hospital and . Planter reflected absent at all the hospitals.

Detention

These were assessed under two sub variable detention pond and dry swale, all the three hospitals reflected absent on the usage of planter as detention for storm.

Retention

All the three reflected absent on the use of retention pond, constructed wetland, and underground tanks, with the exception of university of Maiduguri teaching hospital were there was a constructed wetland.

Infiltration

Under infiltration three sub variable were analyzed; infiltration trench, permeable paving and

rain garden. All the three reflected absent expect case study 3 hospital were the use of permeable paving reflected as moderate.

4.5.3 Sewage recycling

The three case studies reflected absent of sewage recycling. This is not surprising given that sewage recycling is not a common practice in Nigeria.

4.6 conclusions

Rainwater harvesting, storm water management and sewage recycling in Nigeria hospitals is not yet a common practice. Most of the hospital discharges their waste water directly into municipal drainage system and rivers causing bad odor and erosion. By contrast, contemporary management of the water regards rain water, storm water, and sewage water as a resource that can be reused. These approaches to water management gives greater emphasis to on-site collection, treatment and utilization of water flows as part of an integrated treatment train, whereby providing the opportunity for sustainability. Water management in university of Maiduguri teaching hospitals is unique in the sense that its source of water for plant irrigation is pump from a constructed wet land into the constructed storage tank. From the storage, water is flows to the sprinklers.

One major concern of all landscape maintenance managers is the complexity and cost involved in implementing sustainable water resource practice, the fear that the change towards more sustainable practices is expensive. Therefore, it is also conceivable to assume that lack of knowledge and cost are two major challenges that thwart sustainable water management practices.

References

- Adamson, .S. & Aberg, .H. (2003). Future landscape and the future landscape ecology. *Landscape and Urban Planning* 37, pp1-9
- Adeleke, A. (2005), *Urban Forestry Grants available*. http://www.aces.edu/dept/extcom/news_papers/june_7aol.html. Accessed 11/07/2005
- Adeyemi, G.J. (2005), *Predicts Scenic Quality for the Urban forest using vegetation Measurement*, *Forest Science*, 30, 70-82.
- Aggrawal, V. & Narrain, N (1996). *Dying wisdom: Rise, fall and potentials of Indians traditional water harvesting system*. Center for science and environment (CES) New Delhi
- Alexander, V.R (2000). *Human Landscape*. Wiley, New York
- Ali, Z.K. (2008). *Assesment of Rural Water Supply (RWS) schemes in Maiduguri of Borno State*. M.sc Dissertation, Department of Geography, Federal University of Technology, Yola, Adamawa State. PP 70
- Benedict, M. and MacMahon, E. (2000). *Green Infrastructure: Smart Conservation for the 21st Century*. Washington, D.C.: *Sprawl Watch Clearinghouse Monograph Series*. <http://www.sprawlwatch.org/greeninfrastructure.pdf> (accessed April 16, 2014).
- Bohdanowic B. (2005). *Middle East Economic Digest*, Jeddah Modernizes Sewerage System 56(51), 32-33.
- Bukar, M W (2011). "The Viability and Sustainability of Rainwater Harvesting in Maiduguri Metropolis. Unpublished M.sc Dissertation, University of Maiduguri.

- Buttler, W.A (2002) Rural development in Africa connecting Theory Practice, and possibilities in, international journal of tourism research 6, pp 151-164.
- Chinke, C. (2010). Green Infrastructure and Public Health in the Florida Communities. Florid: Trust Public Land Acquisition Program
- Fewkes, H (1997). *Innovation Inspired by Nature*. New York, USA: William Morrow & Company, Inc.
- Gbadegesin, U. & Olorunfemi, A. (2009) Predicts Scenic Quality for the Urban forest using vegetation Measurement, Forest Science, 30, 70-82.
- Godron, H (2005) *Landscape Ecology*. Wiley, in New York Retrieved from www.tourism.enzinemark.com/tourism-as-fast-growing-service-sector Accessed on 11/09/94
- Hoyer et al (2011). *Landscape Impacts and Support for Portland, Oregon, USA in Ha Long Bay*, Hiwassaki, J.O (2003). Environmental Aesthetics ideas, Politics and Planning. Rontledge, London
- Hurbert W. A, (2009). Landscape ecology direction and approaches special publ. No 2 III history Survey. Champaign
- James, G. (2000), Urban Tourism, the visitor economy and the growth of large cities (2nd ed) continuum. Nigeria.
- Kasim, A. (2007). Landscape ecology direction and approaches special publ. No 2 III Natural history Survey. Champaign
- Liu, T. (2003) *Sustainable Development*. <http://www.lboro.ac.uk/research/susdesign/LTSN/Blocks/Block%204/Block%204.htm> . Retrieved December 22, 2008, from www.lboro.ac.uk
- Maiduguri. "Geographical Location and Climate." Last modified 2014. <http://www.Maiduguri.gov.sa/English/City/Geographical.php> (accessed April 6, 2014).
- Mikratis, G. (2000), Urban Landscape, the visitor economy and the growth of large cities (2nd ed) continuum. Nigeria.
- Oguz Etal (2010). Tourism and Sustainability: Development and Globalization in the Third World. UK: Taylor and Francis.
- Oluigbo, S.N (2010). Context and Application of Case Studies in Architectural Research. Department of Architecture, Ahmadu Bello University, Zaria, Nigeria: Unpublished Ph.D. Dissertation.
- Uji T.A, (2000). Valuation of Urban parks Landscape and Planning. 58 Kings Road, Reading, England 15, pp139-152
- Vietnam U. (2002). *An Examination of Residents Perceptions*. Asian Social Sciences. 8(8), pp28-29.
- Waziri, Y. (2011). "Management strategies of Rainwater Harvesting in Maiduguri Metropolis". Unpublished M.sc Dissertation, University of Maiduguri
- Zanna, M. (2001) *Environmental issues in Maiduguri Metroplis: Planning, Design and Refurbishment*. Unimaid Press, Maiduguri.