NATIONAL INNOVATION AND RESEARCH ACADEMIA
International Journal of Sustainable Development
ISSN: 2713-4683. Volume 6, Issue 4. Pages 62-77. November, 2021
Double Blind Peer Reviewed International Research Journal
editornirajournals@gmail.com

Sustainable Strategies for Urban Water Management in Maiduguri City, Borno State. Nigeria

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Abstract: *With the global concern of climate change, particularly the water shortage and degradation of the urban environment in Africa, there is a need for sustainable strategies to overcome these problems. This paper studies the traditional and modern practices of rainwater harvesting and storm water management to provide sustainable strategies for urban water management in arid regions, using Maiduguri City as a case study. The research methods and results are established with quantitative and qualitative data.). Rainwater collection and harvesting is a strategy that can address both conditions of excess. A model that relies on three metrics is include measuring the potential rainwater harvesting volume, the water requirement for a landscape area, and the volume of rooftop rainwater available for capture in the city of Maiduguri. Results indicate that a substantial amount of preserved rainwater can be captured and used for landscape purposes in the study area. The design strategy is proposes implementation of strategy to collect rainwater from rooftops in the historical area and to store it in neighborhood storage tanks located in selected public spaces, in addition to a green network plan to manage the storm water runoff. The second phase focuses on an urban transect that intended to analyze the urban fabric for the historical and the modern Maiduguri City*

Key words: *Landscape, Sustainability, Plant, and Water*

BACKROUND OF STUDY

Today, Climate Change holds unprecedented challenges for the entire Planet's Ecosystem. (Agrawal 2008). Water is an essential resource for our lives. Throughout history, many civilizations flourished in modern- day region where water is extremely limited. (Kasim 2007).

This scenario is prevailing in arid and semi-arid environments particularly that of third world countries were 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).

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.

Today, Maiduguri City needs solutions to address its current water and environmental problems. One of the areas in Maiduguri City that requires urgent solutions is its historical core. This paper proposes that a sustainable water management strategy can be developed for urban areas in Maiduguri City using both traditional knowledge as well as the modern practice of rainwater harvesting.

Over View

This provides a historical overview of the development of rainwater harvesting techniques and practices in Maiduguri City. The research explain that the cultural heritage value of rainwater harvesting and its importance in developing Maiduguri City.(Waziri 2002)

According to Design for Water by Heather Kinkade Levario, rainwater harvesting (RWH) can refer to any type of methods that captures, moves, and stores the runoff from various sources and for unlimited purposes.(Bukar 2000).

Generally, the RWH system has four main components: a catchment area, conveyance, storage, and distribution system. Rainwater is ideal for landscape use because it can reduce the salt accumulation in the soil (a common problem in irrigation systems) and flush it away from the root zone area, allowing for a healthy root growth. As previously mentioned, Maiduguri receives an average of 53.5mm amount of rainwater annually and this is enough for rainwater harvesting to potentially bring similar benefits to Maiduguri City.

According to Design for Water, the RWH system can be categorized into two types – passive and active (see Figure 11). Passive RWH systems collect the rainwater from any low infiltration surface area and move it to a landscape area for direct, immediate use on site. Examples of a passive system include rain gardens, bio swales, constructed wetlands, tree boxes, and green streets. Active RWH systems collect the runoff from the catchment area and store it in cisterns for future use. (Peter 2003).

These two rainwater harvesting systems are the basis of the modern green practices that manage storm water by using ecological and natural process to create healthier urban environments. Rainwater can be captured from any impervious surface. Typically, a rooftop catchment surface is the most common, simple, clean, and cost effective method for potable and non-potable use. In contrast, ground-level catchment areas—such as parking lots, streets and channeled gullies—are mostly used for non-potable use because of the higher risk of pollution.. For centuries, people in Maiduguri City have practiced this kind of a system, using their rooftops to capture rainwater and storing it in underground cisterns. We know that water quality was a continuous concern in Maiduguri City. The solutions can easily be retrofitted to current RWH systems in Maiduguri and also should be included in new ones.

The storage system is typically the most expensive component of a rainwater harvesting system. It is available in three types: surface storage, underground storage, and integral storage built into a property. However, whether or not rainwater can be conveyed by natural gravity or by pumping depends on its location; rooftop cisterns can use gravity, but basement cisterns require pumps to raise the water to where it will be used.(Agrawal 2005)

METHODOLOGY

This research deals with one of the fundamental areas in any project work. It elaborates on the ways in which data were collected, the methods used, the sampling frame selected if necessary and the methods used for analyzing data.

Visual Survey: Take a visit of the area 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 some of the areas on several aspects of the case study site to get detailed and precise information on the functionality of the area

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 roof top, run off water and landscape elements, as the reflects harmony with nature.

Variable of study

The case studies were assessed based on the following dependent variable; Background, Site planning and Landscaping, Rainwater harvesting, Storm water management technique.

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.

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.

PlateXXX1: Runoff Drainage pipes at 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.

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 4.2 checklist for the assessment of sustainable water management practices in some areas

VARIABLES	BMPS	LEVEL OFAPPLICATION				REMARK
		HIGH	MODERAT E	LOW	AABSENT	
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 pondand 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

Summary findings from case studies

4.5.1 Rainwater

Under rain water harvesting an absent scale was reflected in all the case study . This was not shocking given that rainwater is not a common practice at commercial facilities level in Nigeria.

Retention

All the three case study reflected absent on the use of retention pond, constructed wetland, and underground tanks.

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 suspiring given that sewage recycling is not a common practice in Nigeria.

DESIGN BRIEF

6.2 planning Concept

The plan evaluates the feasibility of various principle that, when fully implemented, will create a network of decentralized source controls to detain or capture more water on site that can be use for various non-potable uses. The concept chosen for the design is base on micro spaces.

6.3 Landscape Features Character

Considerations were given to the planning and landscaping of the city to enhance it patient experience. paving material of low reflectivity, colourful and plants, water features circulations form are display to provide the sensory and physical demands of the mentally and physically challenge and psychological ailments.

6.4 Design Considerations

The design attempts to promote sustainability by using some of the principle below.

6.4.1 Rain Water.

Rainwater harvesting requires that tanks be installed, to collects the runoff from the roof in other to provide water between rainfall events. Roof water from the main hotel building and the chalet will be harvested into a surface storage tanks as seen in the figure below.

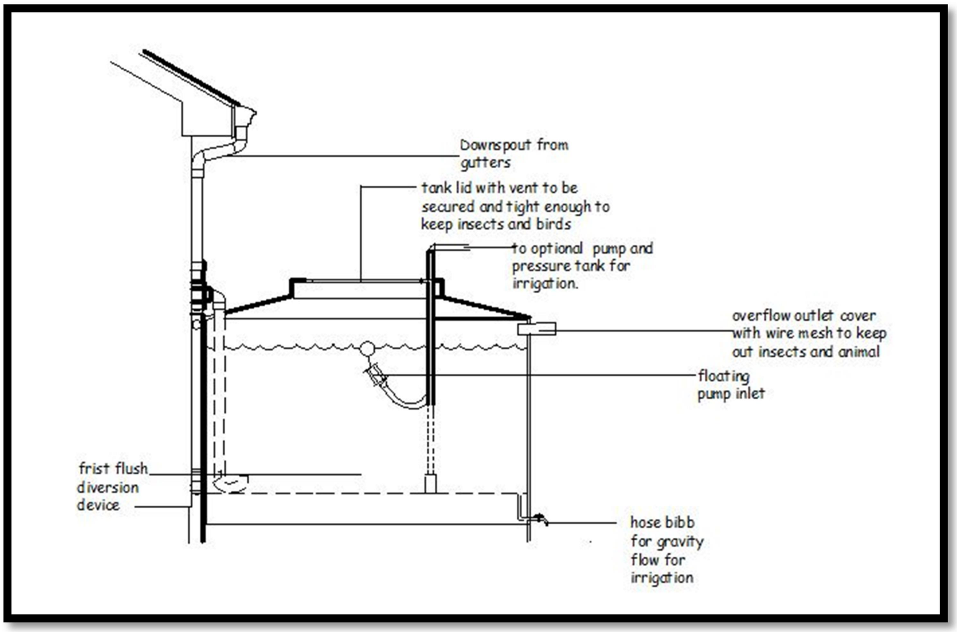

Figure 6.1: Section cutting through a tank from the roof.
Source: Researchers' compilation 2017

Harvesting rainwater can reduce the use of potable water for landscape feature. Additionally, Rainwater is available free of charge and puts no added strain on the municipal supply or private wells. Rain water will be harvested in tanks and be used for landscape features.

6.4.2 Storm water.

Sustainable storm water management aims at reducing runoff by using technologies for storm water utilization or storage and to increase infiltration. For these design some of the technique use are;

6.4.2.1 Underground storage.

Runoff from the parking lots will be directed into an underground storage and will be use to irrigate the plant as seen in the figure below.

6.4.2.2 Bio Swale

Swale is a linear vegetated drainage features that store or convey SW. for the design the open gutters were retrofitted into swales that has a perforated pipes at the base as seen in the figure below. As SW runoff flows through a vegetated swale, it is filtered by the vegetation in the swale and infiltrated into the underlying pipe and finally to the underground storage.

6.4.2.4 Rain Garden

The Rain garden were design to retain storm water thereby reducing runoff and also allow for infiltration to recharge the underground aquifer.

5.2 Site Characteristics

5.2.1 Topography

The entire site may be described as undulating, variation in the elevation and steepness of land surface give rise to the to the construction of retaining wall that provide the underlying form of a landscape.

5.2.2 Surface drainage.

The drainage systems have been engineered to quickly collect runoff in the constructed open drain which carries it from site into the river. This design philosophy treats rainfall runoff as a waste, further more causing erosion and increasing to flood. Sustainable SM design treats rainfall runoff as a valuable resource.

5.2.4 Vegetation

Characterized by patches of woodland, herbs and grasses with few widely scattered deciduous trees.

5.2.5 Rain fall

Maiduguri is located within the Sub-Sudan climate zone. It is characterized by two distinct seasons: dry season (November to March) and wet season (April to October). The highest rainfall is recorded in August (Mean of 310 .5 mm) as shown in Table below

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2004	0.0	0.0	TR	15.7	102.1	46.1	226.2	464.0	106.0	5.5	0.0	0.0
2005	0.0	0.0	0.0	68.3	67.6	150.0	146.3	351.6	106.8	84.9	0.0	0.0
2006	TR	0.0	0.0	0.0	70.4	129.5	197.7	229.2	300.5	40.1	0.0	0.0
2007	0.0	0.0	0.0	23.7	60.3	128	269.1	263.0	132.6	TR	3.7	0.0
2008	0.0	0.0	0.0	26.9	125.0	110	107.3	314.6	190	72	0.0	0.0
2009	0.0	0.0	0.0	33.9	147.3	136	157.1	220.1	148.7	83.1	0.0	0.0
2010	0.0	0.0	TR	TR	34.4	144	181.6	138.7	110.7	77.9	TR	0.0
2011	0.0	TR	0.0	47.5	25.1	78	181.4	228.2	112.1	56.8	0.0	0.0
2012	0.0	TR	0.0	13.3	64.0	224.1	334.8	317.8	153.8	54.8	0.0	0.0
2013	0.0	0.0	5.1	2.0	68.3	155.6	137.4	577.9	82.6	60.4	0.0	0.0
Mean				**23.1**	**76.5**	**127.4**	**191**	**310.5**	**144.4**	**53.6**		

Table 5.1 Annual/ Monthly Rainfall Figures Of Maiduguri 2004-2013
Source: Federal Ministry of Aviation, Meteorology Unit, Maiduguri.

5.2.6 Evapotranspiration

Evapotranspiration is the combined evaporation from all surfaces and the transpiration of plants. The main factors that determine evapotranspiration rates include net radiation, water availability, wind velocity, atmospheric temperature and inflexibility of the land surface.

5.2.7 Temperature

The temperature is, as would be expected, generally high in the state. Mean monthly maximum temperature ranges from 32 degrees to 42 degrees. The mean monthly minimum temperature ranges from 16 to 28 degrees. Refer to table 5.

5.3 Site Water Analysis

5.3.1 Roof water

Using Waterfall (2004) Formulae. Supply = Rainfall (Mm) X Catchment Area (M^2) X Runoff Coefficient

		JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
	AREA					**76.5**	**127.41**	**191**	**310.51**	**144.4**	**53.55**			**TOTAL**
Q1	785.2195					51058	85038	127480	207245	96377	35741			**618356**
Q2	66.4293					4319	7194	10784	17533	8153	3023			**52310**
Q3	72.0898					4688	7808	11705	19029	8849	3281			**56775**
Q4	3709.742					241225	401759	602276	979124	455333	168858			**2921415**
Q5	326.9918					21263	35413	53088	86306	40135	14884			**257509**
Q6	293.9014					19110	31828	47714	77570	36073	13377			**231442**
Q7	191.1687					12430	20703	31036	50454	23464	8701			**150541**
Q8	94.0006					6112	10180	15260	24808	11537	4278			**74020**
Q9	57.4289					3734	6219	9323	15157	7048	2614			**45222**
10	34.3314					2817	4692	7034	11436	5318	1972			**34119**

Table 5.4 Roof Water Supply Worksheet

5.3.2 Storm water

Waterfall (2004) formulae Supply = Rainfall (Mm) X Catchment Area (M^2) X Runoff Coefficient

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	TOTAL
JANUARY	20259.63	9099.96	3933.16	3014.96	4859.46	8084.30	7572.08	3206.88	7232.58	4271.81	**71534.83**
FEBRUARY	24180.85	10861.25	4694.42	3598.50	5799.10	9649.01	9037.65	3827.57	8632.42	5098.61	**85380.29**
MARCH	26141.45	11741.89	5075.05	3890.27	6270.27	10431.36	9770.43	4137.91	9332.35	5512.02	**92303**
APRIL	24507.61	11008.02	4757.86	3647.13	5878.38	9779.40	9159.77	3879.29	8749.07	5167.51	**86534.06**
NOVEMBER	19932.86	8953.19	3869.73	2966.33	4781.07	7953.91	7449.95	3155.16	7115.91	4202.91	**70381.04**
DECEMBER	19606.09	8806.41	3806.29	2917.71	4702.70	7823.519	7327.82	3103.43	6999.26	4134.01	**69227.25**

TOTAL	1346 28.5	6047 0.72	2613 6.51	2003 4.9	3229 0.98	5372 1.5	5031 7.7	2131 0.24	4806 1.9	2838 6.4	47536 0.5

Table 5.21 Summary of monthly Plant water demand sheet from November to April for state specialist hospital Maiduguri

DESIGN BRIEF

The paper is to apply effective water management strategies in semi-arid region for sustainable landscape development of therapeutics garden in Maiduguri.

6.2 planning Concept

The plan evaluates the feasibility of various principle that, when fully implemented, will create a network of decentralized source controls to detain or capture more water on site that can be used for various non-potable uses. The concept chosen for the design is based on micro spaces.

6.3 Landscape Features Character

The landscape design try to create an environment that will induce a feeling of well and enhance healing through horticultural therapy as complementary to orthodox medical practice. paving material of low reflectivity, colorful and plants, water features circulations form are display to provide the sensory and physical demands of the mentally and physically challenge and psychological ailments.

Design Considerations

The design attempts to promote sustainability by using some of the principle below.

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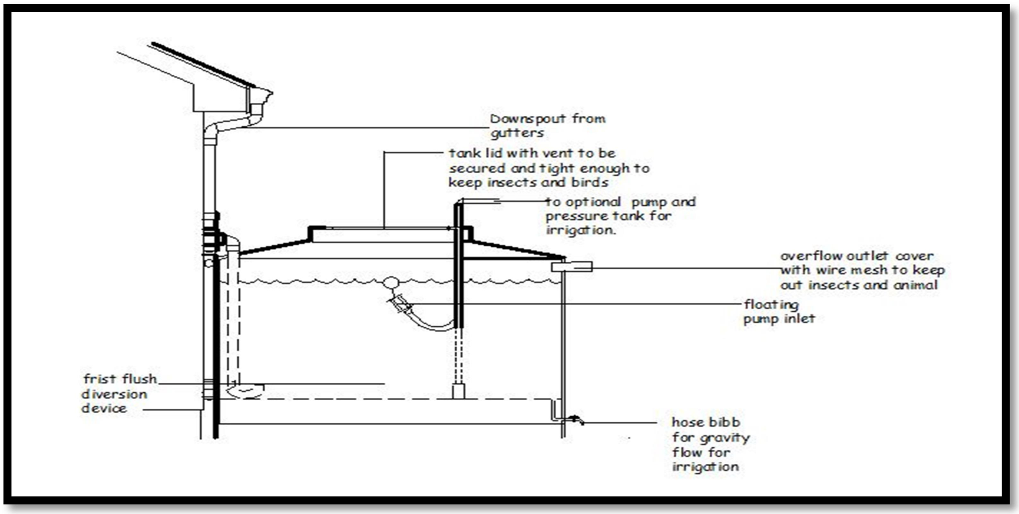

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6.4.2.4 Rain Garden

The Rain garden were design to retain storm water thereby reducing runoff and also allow for infiltration to recharge the underground aquifer.

6.4.3 Sewage water recycling

Water harvesting cannot provide a completely dependable source of water because it is dependent on the weather, and weather is not dependable. To get a more steady supply of water for landscape use, recycle waste water were considered because waste water is independent of weather

6.5.1 Planting

Plants were also group according to their water requirement, Grouping plants with similar water requirements into separate areas simplifies the system by making the amount of water needed to maintain those plants easier to calculate. However research has shown that succulent plants with medium water factor use can be use plant are more drought resistant.

4.6 conclusions

Rainwater harvesting, storm water management and sewage recycling in Maiduguri 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. 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.

RECOMMENDATION/CONCLUSION

Recommendations

The following are the sub-heading through which these recommendations are expected to be tackle.

a) Landscape improvement.
b) Road network and parking.
c) waste water recycling
d) Basic Facilities for physically challenge people
e) Minimize environmental pollution through the control noise, heat, odor, and inefficient circulation

7.1.1 Landscape Improvements

There is the general need to create and maintain various gardens especially in the orthopedic court garden and also the court yard between the various block of wards. This is especially important to those patients within the ward and those moving i.e. transport patients/ visitors. This can be achieved by as observed, learned and referenced from the journal "garden as a healer" by Mark Epstein (1998).

a. The use of lush, colorful planting that is varied and can reinforce the image of a garden and a healing place.
b. Using the flowering of the plants over several seasons to mark seasonal change and to provide a sense of cyclical rhythm throughout the tear.
c. Use of the trees foliage that moves easily and this creates noise even in the slightest of breeze movements. Created by placing trees to produce series of patterns of colours, shadow and light movement.

A landscape architect can be a valuable resource in helping lay out the garden and in selecting the right elements to make the garden a special place. But the garden must also be well maintained and, to be truly useful, must be known to patients and staff. Directional signs to the garden, perhaps with an identifying symbol, should be posted in the facility.

7.3 Open Spaces

There are various shapes and sizes of open spaces, most of them sizes of open spaces, most of them are formal with rectangular arrangement as they take alignment with the roads and buildings, while a few form court yards. Small flower beds are found with shrubs and lawns. The common shrub used here is *Duranta Spp*, which is pruned regularly. The components for such transformation includes:-

1. Choice of plants to be used in terms of form, shape, colour texture. For instance, *Tecoma stans, Nerium oleander, Cactus spp, Jatropha podrica, Thevitia perviana, Agave americana.* These plants have different shape, leaf texture, flower colour, which can be useful in a therapeutic garden. *Thevitia perviviana* for instance is a fragrant shrub.
2. A cool environment can be of immense benefit to Patients and workers in the hospital while cutting down on use of artificial cooling system such as air-conditioning. However additional trees need to be planted along the roads and within the open spaces as it was observed that many places are open. In doing this, different shapes, texture form and colors should be deliberately chosen in order to derive the benefits of therapy.

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