INVESTIGATION OF STORMWATER HARVESTING IN ILORIN METROPOLIS USING A COMBINATION OF GIS AND SYNTHETIC HYDROGRAPH METHODS

(Approved Final Year Project Proposal)

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1. Introduction

Stormwater is water flowing over ground surfaces and in natural streams and drains as a direct result of rainfall over a catchment (ARMCANZ and ANZECC, 2000). Stormwater consists of rainfall runoff and any soluble or insoluble materials mobilized in its path of flow. A growing public awareness of environmental issues in recent times has also elevated water issues to the forefront of public debate all over the world. The recent drought and concerns about climate change highlighted the need to manage water resources more sustainably. Expanding the use of stormwater runoff to add to the water supply and reduce water pollution are important objectives for most government in the developed economics. Stormwater is now recognized as a valuable resource rather than a nuisance to be disposed of quickly especially in large urban centres. In the recent years, stormwater capture and reuse have emerged as a new field of sustainable water management. Capturing and reusing stormwater offer both a potential alternative water supply for non-drinking uses and a means to further reduce stormwater pollution in natural waterways. Stormwater capture and reuse complements other approaches to sustainable urban water management including rainwater tanks, greywater systems, effluent reuse and demand management (Prahalad, 2007).

Stormwater management philosophy in most developed countries evolved over the last decades from the conventional, but still important, flood mitigation paradigm, to the current runoff quality control approach. In USA Hawaii, residential and commercial development occurred on all the islands which short-circuit the water cycle by increasing the amount of impervious surface in stormwater catchment areas thus decreasing infiltration and groundwater recharge. Development also increased the number of water users which placed additional demand on the finite quantity of potable water in the aquifers and increased the potential for more contaminants to enter all Hawaii's water resources. This combination of factors according to Prahalad (2007) led to the drawdown of the aquifers that supply some of the best quality drinking water in the world. The reduction of rainfall infiltration has led to an increase in stormwater runoff which impacted the water quality of inland streams and the near-shore coastal water with sediment and other pollutants. An increase in stormwater runoff during significant rainfall events can also result in flooding which can cause property damage and threaten life and safety. This led to the implementation of stormwater capture and reuse to supplement the existing water sources.

California also suffered from drought with near-record-low reservoirs, mountain snowpack, soil moisture and river runoff. As a direct result, far less water than usual was available for cities, farms and natural ecosystems. There were far-reaching effects that would intensify as dry conditions persisted. Several response strategies were available that would provide both near-term relief and long-term benefits. California could fill the gap between water supply and use with a strategy that is cost-effective, technically feasible, more resistant to drought than the former system and compatible with healthy river and groundwater basins which is stormwater capture and reuse implementation. Efficient water reuse and stormwater capture can provide effective drought responses in the near-term and permanent water-supply reliability benefits for the state. The stormwater runoff in Australia was traditionally treated as a nuisance and the solution was rapid conveyance directly to streams. Increased recognition of ecosystem degradation linked to stormwater runoff in the 1960s resulted in the first moves toward more holistic management of stormwater (Brown, 2007). The perception of stormwater runoff has changed from strictly a liability to having a value as a water resource and management of stormwater has shifted accordingly. Debate is also increasingly centered on how to achieve improved ecosystem health outcomes through management (Walsh, 2004). The management of stormwater quality and quantity is now considered a topic of national importance.

Nowhere is the need for stormwater capture and reuse more pressing than in Africa. Africa is urbanizing fast while the demand for water in African cities is growing. Over the next 20 years, Africa's urban population will double and demands for water will more than triple (World Bank, 2011). Increased water demand will bring competition over water for agriculture and power generation and put more pressure on dwindling water resources thereby exacerbating the economic, social and political challenges of cities. The city of the future in Africa needs to be designed to accommodate twice as many people and need to be planned now. Traditional approaches are unlikely to be able to close the gap between supply and demand for water. According to the World Bank's Africa Strategy (World Bank, 2011a), Africa has an unprecedented opportunity for transformation and sustained growth. The strategy asserts that Africa could be on the brink of an economic takeoff like China 30 years ago or India 20 years ago. Much of this growth is taking place in cities, traditionally the engine of economic growth. The population of African cities is expected to double over the next 20 years. This level of growth will have a tremendous impact on water management and the ability of cities to provide adequate water supply and sanitation to their population and to manage the impact of flooding, climate change and future uncertainties.

Rapid urban growth is occurring throughout the continent but access to water varies from country to country. In Uganda, the proportion of the urban population with access to improved water sources increased from 78 percent (1.5 million people) in 1990 to 91 percent (3.7 million) in 2008. During the same period in Nigeria, access to water in urban areas fell from 79 percent (27 million) to 75 percent (55 million). Both countries managed to double the number of people with access to safe water but in Nigeria the expansion could not keep up with population growth (WHO/UNICEF, 2012). Africa's climate is highly seasonal and varies widely from year to year. The continent's climatic zones range from humid equatorial to seasonally arid tropical to subtropical Mediterranean climates. Each climatic zone exhibits different degrees of variability in rainfall and temperature. Hydrological variability and extremes are at the heart of the challenge of achieving basic water security in Africa (UN-water, 2010).

Nigeria is experiencing increasing rate of changes in her population couple with increased urbanization and living standards. Thus, the increasing needs of water for domestic and other uses places an increasing demand on the water resources. Water as a vital resource is not in short supply but regulating its availability and ensuring even distributions is in fact a serious problem (Sule et al., 1999). However, the quantity of water available for use has received cries of inadequacies. For instance, Sule and Okeola (2002) studied the performance assessment of a regional water supply arrangement in Kwara State. The study revealed that increasing urbanization, population and ineffective management of water resources has been leading to water crisis. Fresh water in rivers, lakes and underground is a finite resource which is diminishing in relation to demands for drinking, irrigation, industries and other uses. For instance, agriculture uses 70 percent of fresh water through natural rainfall and irrigation practice. There is ample evidence that availability and quality are reducing everywhere (Sule, 2003).

It has been estimated that in the next 25 years, water will be the main source of conflict in Nigeria as other countries sharing rivers with Nigeria will fight for access to the scarce resources. If the population of Nigeria rises as predicted from 140 million in 2006 to 254.7 million in 2025 (Federal Republic of Nigeria, 2007), then there could be intense competition for the increasingly limited resource. Water conflicts are inevitable in Nigeria if nothing is being done to avert their occurrences. Water conflicts are exclusively discussed in Okeola and Balogun (2013). The country's finite fresh water resources cannot continue indefinitely to support the escalating demands if drastic measures are not put in place to properly supplement their supply. Competition for the available water supplies will continue to increase to the point where radical interventions are required (Gusikit and Lar, 2014).

The Nigeria water supply shortage has aggravated groundwater depletion due to mining from indiscriminate drilling of boreholes by the citizenry. Thus further stress the need for integrated approach to water resources development that should encapsulate stormwater capture and reuse. Artificial recharge of stormflow has successfully reversed groundwater decline ((konikow and Kendy, 2005). From the foregoing, there is an urgent need to incorporate stormwater capture and reuse in the Nigeria's water resources management. This project is therefore aimed at investigating the feasibility of incorporating stormwater management in Kwara State Water Resources Management taking the state capital as a case study.

2. AIM AND OBJECTIVES

This project aims at investigating stormwater capture and reuse in Ilorin metropolis. The following are the specific objectives:

1. To quantify stormwater resulting from runoff
2. To assess the vulnerability to flooding
3. To identify suitable stormwater capturing method and sites

4. To ensure that social, aesthetic and cultural values are recognized and maintained when managing stormwater

3. SCOPE AND LIMITATION OF STUDY

The scope of this study is investigating the feasibility of incorporating stormwater management in Kwara State Water Resources Management. However, the study area is limited to Ilorin metropolis.

4. JUSTIFICATION

Ilorin is urbanizing fast. Demand for water is growing rapidly and water supply is shrinking while quality is deteriorating. Despite abundant water resources, Ilorin still has difficulty meeting her water demand today when several volume of water is being annually wasted through stormrunoff. Instead of being a blessing, stormwater becomes a threat via flash flood in several areas like Post-office, Offa garage etc. There is pressure on groundwater via dug well and boreholes scattered virtually every dwelling. Hence, there is need to strategize effective way of capturing and reusing stormwater to reduce pressure on water resource, recharge aquifer and provide measure for urban water runoff management in order to safe guard live and properties.

5. LITERATURE REVIEW

5.1 Stormwater

Current configurations of urban water systems are being questioned due to the accumulated pressures of demand for finite fresh water sources for all uses, regardless of quality requirements and the environmental impact of the discharge of urban runoff to receiving waters. This has caused a rethink on urban water management that reflects the need to move towards more sustainable configurations by integrating the planning and management of water supply, wastewater services and stormwater (Brown, 2005). Under this integrated urban water management concept, the use of stormwater is considered a valuable resource, where it can be used on a fit for purpose basis to reduce demand for potable water and overcome current capacity constraints (Fletcher et al., 2008).

Extracting stormwater from a watercourse may reduce stream flows to below pre-urbanization levels. For on-line storage, this may occur during periods of low flow or where storage capacity and demand are large relative to inflows. Over-extraction of flows may impact on downstream aquatic ecosystems by reducing the available aquatic habitat, interfering with natural flow regimes to streams or wetlands. This is normally only a problem where the storage is very large or where demand for water is high (Fletcher et al., 2006). The runoff coefficient expresses the fraction of rainfall volume that is converted into stormwater runoff. The volume of stormwater runoff increases sharply with impervious cover. For example, a one-acre parking lot can produce 16 times more stormwater runoff than a one-acre meadow each year (Schueler, 1994).

Stormwater runoff from highly impervious urbanized or developed landscapes disrupts hydrology following storm events by causing large peaks in stream flow, large loads of pollutants and reduced infiltration in the watershed. As a result, the primary goals of stormwater reuse are to reduce downstream stormwater flows and pollutant loads. As the human population and urbanization grows, there is also a need to reduce potable water demand (Hatt et al., 2006). A review of stormwater harvesting and reuse by O'Connor et al. (2008) recommended that delivery and distribution systems of stormwater reuse require additional devices and regular maintenance. This will ensure reliable service because of greater corrosion and clogging of pipes resulting from higher sediment and microbial loads in stormwater than treated water.

5.2 Watershed

Watershed is a land area that contributes surface runoff to any point of interest. The location of the stream cross section that defines the watershed is determined by the analysis. The surface of a watershed can be measured using a variety of methods: superposing a grid over the watershed map, using a planimeter or digitalizing methods. In the delineation of a watershed, artificial barriers (e.g. roads, railways) must also be taken into consideration. The hydrological process takes place especially on the surface and it can be modified by artificial inflow (e.g. artificial derivation, drinking and wastewater networks, roads, pumps, reservoirs). The physiographical characteristics of a watershed influence to a large degree its hydrological responses and especially the flow regime during floods and periods of drought. The characteristics of a hydrographic network of a watershed are influenced by four main factors: geology, climate, relief and environment. The hydrographic network is one of the most important characteristics of a watershed.

Watershed delineation is the segmentation of an area into watersheds or sub watersheds for the purpose of assessing that particular watershed area. It is one of the most commonly performed activities in hydrologic and environmental analysis. GIS facilitates the watershed delineation by using Digital Elevation Models (DEMs). It provides a consistent method for watershed analysis using DEMs and standardized datasets such as land cover, soil properties, gauging station locations and climate variables. Digital Elevation Model (DEM) provides good terrain representation from which the watersheds can be derived automatically. The techniques for automated watershed delineation have been available since mid-eighties (Garbrecht and Martz, 1999). Watershed slope is derived from a relief ratio, which is the ratio of the elevation difference between two points to the horizontal straight distance between the two points (Mishra and Singh, 2003).

5.3 Review of Earlier Work

As water supplies become more stressed, water conservation and reuse become more attractive options. Wastewater disposal costs also encourage more water reuse. Asano and Levine (1996) provide a historical perspective and explore current issues in wastewater reclamation, recycling and reuse and outline the requirements for stormwater and wastewater reuse. Lejano et al., (1992) summarize the benefits of stormwater reuse as the following:

1. Water supply related

i. Supplement regional water supply by eliminating need to develop additional supplies
ii. Provide more reliability than the usual supply and is less affected by weather
iii. Provide a locally controlled supply thus reducing dependence on state or regional politics
iv. Avoid the operating costs of water treatment and delivery
v. Eliminate social and environmental impacts of diverting water from natural drainage ways
vi. Eliminate impacts of constructing large-scale water storage and transmission facilities

2. Wastewater related

i. Avoid the capital and operating costs of disposal facilities
ii. Avoid the costs of advanced treatment facilities needed to meet state and federal discharge requirements.

In the nature undisturbed environment rain that falls is quickly absorbed by trees, other vegetation and the ground. Most rainfall that is not intercepted by leaves infiltrates into the ground or is returned to the atmosphere by the process of evapo-transpiration. Very little rainfall becomes stormwater runoff in permeable soil and runoff generally only occurs with larger precipitation events. Traditional development practices cover large areas of the ground with impervious surfaces such as roads, driveways, sidewalks and buildings. In underdeveloped conditions runoff occurs even during small precipitation events that would normally be absorbed by the soil and vegetation. The collective force of the increased runoff scours stream beds, erodes stream banks and causes large quantities of sediment and other entrained pollutants to enter the water body each time it rains (Shaver et al., 2007). Watersheds fundamentally changes over time thus results in degraded aquatic ecosystems. In recognition of these, stormwater managers employed extended detention approaches to mitigate the impacts of increased peak runoff rates.

Harrison (1993) developed a spreadsheet model to estimate the amount of stormwater captured in a detention pond that could be reused for irrigation in Florida. His work is an application of earlier work by Harper (1991). The Southwest Florida Water Management District is interested in stormwater reuse as a way of increasing the treatment efficiency of detention systems. Their current design calls for storing the first inch of runoff and draining the pond over a five-day period. They are considering going to an average residence time of 14 days to improve performance from removal rates of 50 to 70% with a five-day drawdown time. Reusing stormwater would give them 100% treatment efficiency. Harrison (1993) uses a daily water budget to estimate the amount of captured urban runoff that could be used for irrigation. The basic storage equation is:

$$\frac{d}{d} = R + P + F - R \quad - D - E \qquad \text{(Eqt 1)}$$

Where: $\frac{d}{d}$ = change in storage, R = runoff volume, P = direct precipitation onto the pond, F = water inflow through sides and bottom of the pond which can be negative, RU = reuse volume, D = pond outflow and ET = pond evapotranspiration.

Butler and Parkinson (1997) suggests that reuse of the stormwater resource provides for a more sustainable urban drainage infrastructure by minimizing available stormwater that could possibly be mixed with wastewater and to minimize the use of expensive drinking water for irrigation purposes. Pitt (1996) suggests that residential stormwater (i.e. roofs and driveways, not streets) generally has the least amount of contamination and advocates infiltration of residential stormwater as a means of disposal with few environmental impacts.

5.4 Theoretical Background

I. Hydrograph

A hydrograph is a graph showing the rate of flow (discharge) versus time past a specific point in a river of other channel or conduit carrying flow. It can also refer to a graph showing the volume of water reaching a particular outfall or location in a sewerage network. The rate of flow is typically expressed in cubic meters or cubic feet per second. Graphs are commonly used in the design of sewerage, more specifically, the design of surface water sewerage systems and combined sewers. The discharge is measured at a certain point in a river and is typically time variant.

II. Unit hydrograph

A unit hydrograph (UH) is the hypothetic unit response of a watershed (in terms of runoof volume and timing) to a unit input of rainfall. It can be defined as the direct runoff hydrograph (DRH) resulting from one unit (e.g. one cm or one inch) of effective rainfall occurring uniformly over that watershed at a uniform rate over a unit period of time. As a UH is applicable only to the direct runoff component of a hydrograph (i.e. surface runoff), a separate determination of the base flow component is required. It is specific to particular watershed and specific to a particular length of time corresponding to the duration of the effective rainfall. That is, the UH is specified as being the 1-hour, 6-hour or 24-hour UH or any other length of time up to the time of concentration, there can be many unit hydrographs, each one corresponding to a different duration of effective rainfall. The UH technique provides a practical and relatively easy-to-apply tool for quantifying the effect of a unit of rainfall on the corresponding runoff from a particular drainage basin. UH theory assumes that a watershed’s runoff response is linear and time-invariant and that the effective rainfall occurs uniformly over the watershed.

III. Snyder method

The method required to determine the peak discharge, lag time and the time of peak by using characteristic features of the watershed. Ramirez (2000) reported that the hydrograph characteristics are the effective rainfall duration, the peak direct runoff rate and the basin lag time. From these relationships, characteristics of a required unit hydrograph for a given effective rainfall duration may be calculated. The five characteristics are the peak discharge per unit of watershed area, the basin lag, the base time and the widths of the unit hydrograph at 50 and 75 percent of the peak discharge.

IV. Hydrograph convolution

Hydrograph convolution is the procedure of deriving a storm hydrograph from a multi period of rainfall excess (Bedient and Huber, 2002). It involves multiplying the unit hydrograph ordinates (U_n) by incremental rainfall excess (P_n), adding and lagging in a sequence to produce a resulting storm hydrograph.

6.0 STUDY AREA

The case study is Ilorin metropolis. Ilorin is the largest city and the official capital of kwara state, Nigeria located on latitude 8^0 24′N and 8^0 36′N and longitude 4^0 10′E and 4^0 36′E with an area of about 2056.3km^2. It is situated at a strategic point between the densely populated south-western and the sparsely populated middle belt of Nigeria. The total annual rainfall in the area is about 1200mm. Relative humidity at Ilorin in the wet season is between 75 to 80% while in the dry season it is about 65%. The sun shines brightly for about 6.5 to 7.7 hours daily from November to May. The geology of Ilorin consists of Precambrian basement complex rock. The elevation on the western side varies from 273m to 364m. Ilorin is majorly drained by Asa River which flows in a south-north direction (Ajadi et al., 2011). Figure 1 shows the location of Kwara State on the map of Nigeria while figure 2 shows the location of Ilorin on the map of Kwara State.

Fig 1: Map of Nigeria showing Kwara State

Fig 2: Map of Kwara State showing Ilorin

7. METHODOLOGY

The methodological approach adopted in this study involves both desktop and field works. The desk work includes; watershed delineation, slope determination, drainage outlet determination, watershed area estimation, determination of length of the main river as well as its length from the centroid to the outlet within the watershed, determination of availability of land use and vegetation and potential stormwater volume computation. While the field work entails; tracing of the drainage outlet on the ground and justification of the drainage outlet as potential stormwater capture site.

7.1 Methodological Tools

I. Google earth

Google Earth is a virtual globe, map and geographical program. It maps the earth by the superimposition of images obtained from Satellite Imagery, Aerial Photography and Geographic Information System (GIS) 3D globe. Google earth displays satellite images of varying resolution of the earth's surface, allowing users to see things like cities and houses looking perpendicularly down or at an oblique angle. The degree resolution available is based somewhat on the points of interest but most land (except for some Islands) is covered in at least 15 meters of resolution. For other parts of the surface of the earth, 3D images of terrain and buildings are available. Google earth uses Digital Elevation Model (DEM) data collected by NASA's Shuttle Radar Topography Mission (SRTM). The study area will be mapped out with the aid of Google Earth to determine the availability of land and vegetation in order to validate the suitability of drainage outlet as a potential capturing site.

II. ArcGIS

Recent advances in computer technology have provided a means to rapidly process large arrays of spectral data for remote sensing and to combine these data with other geographical information such as topography, vegetation types, soil types and geology. The most important contribution made from the processing of spatial data is the assessment of hydrologically based indices estimated from digital terrain analysis with Digital Elevation Model (DEM). In addition, the development of GIS representations of model output provides an improved visualization of the hydrologic processes by combining several spatial characteristics to evacuate cause and effect relations or correlations. ArcGIS will be used to generate DEM from which watershed delineation, slope, drainage outlet, watershed area, length of the main river as well as length of the river from the centroid to the outlet shall be determined.

III. Global Positioning System (GPS)

GPS is a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the earth where there is an unobstructed line of sight to four or more GPS satellites. It uses satellites to pinpoint locations. A GPS receiver's job is to locate four or more of these satellites, figure out the distance to each and use this information to deduce its own location. This operation is based on a simple mathematical principle called trilateration. GPS shall be employed to locate the position of drainage outlets on the ground surface by using coordinates generated by ArcGIS.

7.2 Theoretical Framework

Snyder method of synthetic unit hydrograph to be adopted in computing potential stromwater runoff volume is as followed;

I. Lag time or basin lag

The lag time is the time from the center of mass of effective rainfall to the peak rate of flow (Viessman et al., 1989). The basin lag is given by:

$$t_p = C_t(L\ L_C)^{0.3} \quad \text{(Eqt 2)}$$

Where t_p = the basin lag (hours), C_t = a coefficient which depends upon the characteristics of the basin, L = length of the main stream of the catchment (km), L_C = distance from the basin outlet to a point on the stream which is nearest to the centroid of the area of the basin (km)

II. Unit-hydrograph duration

The duration of rainfall excess for Snyder's synthetic unit-hydrograph development is a function of lag time. The unit duration of the storm is given as (Arora, 2004):

$$t_r = \frac{t_p}{5.5} \quad \text{(Eqt 3)}$$

Where t_r = the unit duration of the storm (hours), t_p = the basin lag (hours). If the unit hydrograph of another duration t_r is required, equation (3) for the basin lag is modified as (Arora, 2004):

$$t_{p'} = t_p + \frac{t_{r'} - t_r}{4} \quad \text{(Eqt 4)}$$

Where t_r = the basin lag for a storm of duration $t_{r'}$

III. Peak discharge

Peak discharge is the highest volume of runoff over the basin. It is a function of the hydrographic time relation parameters. The determination and knowledge of peak discharge is very crucial to hydraulic designs and flood characteristics in basins (Ifabiyi, 2004).

$$Q_P = \frac{2.7\ C_p A}{t_p} \quad \text{(Eqt 5)}$$

The peak discharge is given by the equation below (Arora, 2004):

$$q_p = \frac{Q_p}{A} = \frac{2.7\ C_p}{t_p} \quad \text{(Eqt 6)}$$

Where: Q_p = the peak discharge (m^3/s), C_p = the coefficient which depends upon the retention and storage characteristics of the basin (values of C_P varies from 0.3 to 0.93). A = area of the basin (km^2), t_p = the basin lag (hours).

Also, the peak discharge per unit area is given by:

If an X-hr unit hydrograph is required or desired, equation (5) for the peak discharge is modified as follows:

$$Q_{P'} = \frac{2.7\ C_p A}{t_{p'}} \quad \text{(Eqt 7)}$$

And

$$q_{P'} = \frac{2.7\ C_p}{t_{p'}}$$ (Eqt 8)

IV. Time base or base period

The time base of a hydrograph is the time from which the concentration curve (rising portion of a hydrograph) as shown in figure 3 begins until the direct runoff component reaches zero. The base period (T) of the unit hydrograph is given as:

$$T = 3 + 3\left(\frac{t_p}{2}\right)$$ (Eqt 10)

Where: T = the base period (days), t_p = the basin lag (hours).

Equation (9) above can be modified as follows:

$$T' = 3 + 3\left(\frac{t_{p'}}{2}\right)$$ (Eqt 11)

V. Hydrograph time widths at 50 and 75% of peak flow

As a general rule of thumb, the time width at W_{50} and W_{75} ordinates should be proportioned each side of the peak in a ratio of 1:2 with the short time side on the left of the synthetic unit hydrograph peak (Viessman et al., 1989). U.S. Army Corps of Engineers gave the following expressions for W_{50} and W_{75} (Arora, 2004; Mustafa and Yusuf, 2012).

$$W_5 = \frac{5.9}{\left(q_{p'}\right)^{1.0}}$$ (Eqt 12)

$$W_7 = \frac{W_5}{1.7} = \frac{3.4}{\left(q_{p'}\right)^{1.0}}$$ (Eqt 13)

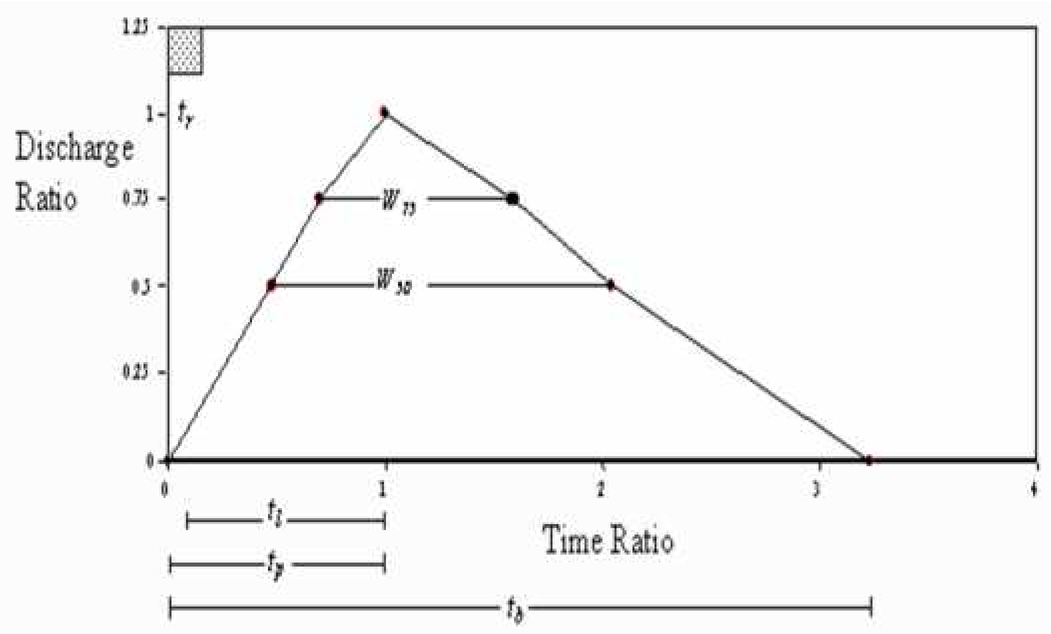


Figure 3: Sample of Unit hydrograph

VI. Development of design storm hydrographs

The real importance of the unit hydrograph approach is the development of storm hydrographs due to an actual rainfall event over the watershed. Design storm hydrographs for average annual rainfall data will be developed through convolution (adding and lagging procedures).

7.3 Data Required

Table 1 shows source and use of data needed;

Data	Source	Use
Administrative map	Kwara State Bureau of Land	To generate DEM
Topographical data	shuttle Radar Topographical Mission	To generate DEM
Rainfall data	NIMET	To compute stormwater volume

8. EXPECTED RESULT

At the end of this project, cost-effective strategy of stormwater capture and reuse should be confidently determined. Thus gives insight into more effective and sustainable stormwater management system in ilorin municipality. Thereafter, set the bench-mark for practice of stormwater capture and reuse and provide the know-how to achieve it in Nigeria urban cities.

9. PROJECT MANAGEMENT

This study is estimated to cost Eight One Thousand Naira (N81,000) and 32 weeks to execute as indicated in Tables 1 and 2 respectively. Figure 3 shows the monitoring ganttt chart for the project execution.

Table 1: Project Cost Details

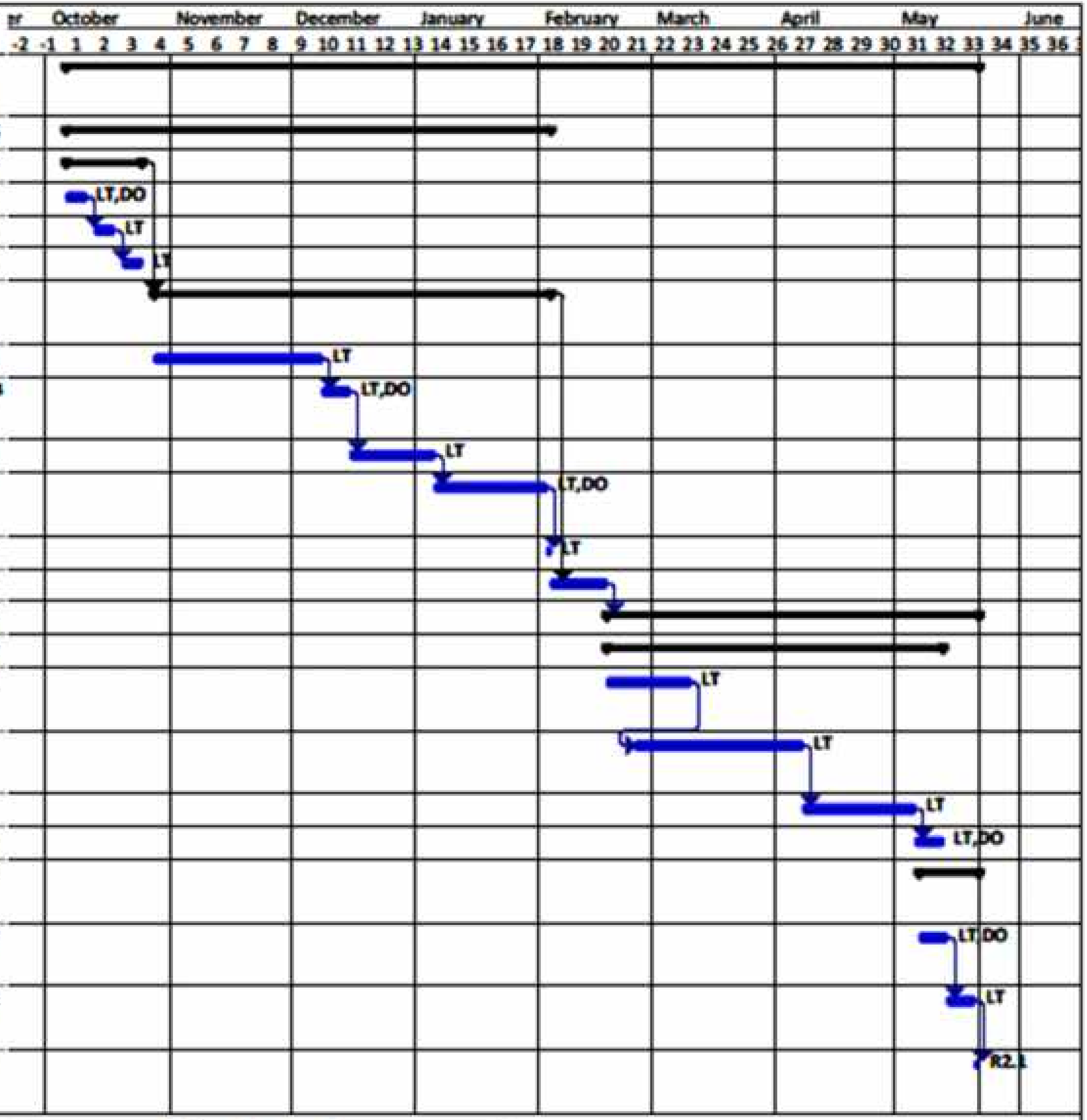
S/No. Item Description	Cost (₦)
1. Acquisition of Relevant Textbooks	4,000.00
2. Internet Facility (32 Weeks)	36,000.00
3. Logistics (Transportation/Telecommunication)	6,000.00
4. Acquisition of Data	20,000.00
5. Project Documentation	12,000.00
6. Miscellaneous	3,000.00
Total	**81,000.00**

Table 1: Project Work Breakdown Structure

Activity Code	Activity Describtion	Resources	Duration	Milestones
H	**Harmattan Semester**		**14 Weeks**	
H_1	**Project Initiation**		**3 Weeks**	
$H_{1.1}$	Preliminary Study on Project Topic	LT, DO	1 Week	
$H_{1.2}$	Information Gathering through Internet Sources	LT	1 Week	
$H_{1.3}$	Reading and Studying Relevant Materials	LT	1 Week	
H_2	**Final Year Project Proposal Documentation**		**11 Weeks**	
$H_{2.1}$	Submission of First Project Proposal Draft	LT	5Weeks	Milestone 1
$H_{2.2}$	Review of Project Proposal for Second Submission	LT, DO	1 Week	
$H_{2.3}$	Submission of Second Project Proposal Draft	LT	3 Weeks	Milestone 2
$H_{2.4}$	Review of Project Proposal for Final Submission	LT, DO	4 Weeks	
$H_{2.5}$	Issue Final Version of Project Proposal	LT	1 Day	Milestone 3
R	**Rain Semester**		**16 Weeks**	
R_1	**Project Execution**		**14 Weeks**	
$R_{1.1}$	Reconnaissance Survey of Ilorin Metropolis	LT	3 Weeks	Milestone 4
$R_{1.2}$	Data Acquisition	LT	6 Weeks	
$R_{1.3}$	Data Analysis	LT	4 Weeks	Milestone 5
$R_{1.4}$	Result Discussion and Conclusion	LT, DO	1 Week	
R_2	**Project Close-out**		**2 Weeks**	
$R_{2.1}$	Review of Final Draft of Report	LT, DO	1 Week	
$R_{2.2}$	Project Documentation	LT	5 Days	
$R_{2.3}$	Issue Final Project Report	LT	1 Day	Milestone 6

LT = Sulaiman, Lateef Taiwo
DO = Dr OG Okeola

ID	WBS	Task Name	Duration	Start	Finish
1	H	**Investigation of Stormwater Capture and Reuse**	**164 days?**	**Mon 10/6/14**	**Thu 5/21/15**
2	H1	**Harmattan Semester**	**87 days**	**Mon 10/6/14**	**Tue 2/3/15**
3	H1.1	**Project Initiation**	**15 days**	**Mon 10/6/14**	**Fri 10/24/14**
4	H1.2	Preliminary Study on Topic	1 wk	Mon 10/6/14	Fri 10/10/14
5	H1.3	Information Gathering	1 wk	Mon 10/13/14	Fri 10/17/14
6	H1.4	Reading and Studying Materials	1 wk	Mon 10/20/14	Fri 10/24/14
7	H2	**Final Year Project Proposal Documentation**	**71 days**	**Tue 10/28/14**	**Tue 2/3/15**
8	H2.1	Submission of First Project Draft	6 wks	Tue 10/28/14	Mon 12/8/14
9	H2.2	Review of Project Proposal for Second Submission	1 wk	Tue 12/9/14	Mon 12/15/14
10	H2.3	Submission of Second draft	3 wks	Tue 12/16/14	Mon 1/5/15
11	H2.4	Review of Project Proposal for Final Submission	4 wks	Tue 1/6/15	Mon 2/2/15
12	H2.5	Issue Final Project Report	1 day	Tue 2/3/15	Tue 2/3/15
13	2	EXAMINATION AND BREAK	2 wks?	Wed 2/4/15	Tue 2/17/15
14	R	**Rain Semester**	**67 days**	**Wed 2/18/15**	**Thu 5/21/15**
15	R1	**Project Execution**	**60 days**	**Wed 2/18/15**	**Tue 5/12/15**
16	R1.1	Reconnaissance Survey of Ilorin Metropolis	3 wks	Wed 2/18/15	Tue 3/10/15
17	R1.2	Data Acquisition	6 wks	Wed 2/25/15	Tue 4/7/15
18	R1.3	Data Analysis	4 wks	Wed 4/8/15	Tue 5/5/15
19	R1.4	Discussion and Conclusion	1 wk	Wed 5/6/15	Tue 5/12/15
20	R2	**Project Close-out**	**11 days**	**Thu 5/7/15**	**Thu 5/21/15**
21	R2.1	Review of Final Draft	1 wk	Thu 5/7/15	Wed 5/13/15
22	R2.2	Project Documentation	5 days	Thu 5/14/15	Wed 5/20/15
23	R2.3	Issue Final Project Report	1 day	Thu 5/21/15	Thu 5/21/15



Project: Investigation of Stormwa
Date: Mon 4/27/15

Task | Summary | Manual Summary | Progress

Figure 5: Gantt Chart of Project Work Breakdown Schedule

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