AFRICA ENVIRONMENTAL REVIEW Journal
ISSN: 1727-8341

AER Journal Volume 5, Issue 1, pp. 130-140, June, 2022

RESEARCH ARTICLE
Available Online at *http://ojs.uoeld.ac.ke/*

On-Site Runoff Management, Challenges and Prospects in Amalemba, an Urban Informal Settlement in Kakamega Municipality, Kakamega County, Kenya

P. K. Musonye*, E. K. Ucakuwun and T. M. Munyao
Department of Environmental Earth Sciences, University of Eldoret, Kenya
Corresponding Author's Email: musonye9@gmail.com

Abstract

This study investigated the challenges and prospects of on-site runoff management in Amalemba informal urban settlement in Kakamega Municipality, Kenya. The study followed a qualitative research design. Visual observations, photography, individual and focus group interviews were used to collect data. The findings indicate that on-site and institutional practices complemented each other in management of runoff. This study therefore affirmed the importance of meaningful participation of residents in runoff management interventions and approaches that sustain 'socio-human' capacity for response in relation to impacts of runoff in informal urban settlements. In conclusion, the benefits of catchment-scale model for runoff management, the potential of green infrastructure and the necessity for policy transition to sustainable drainage systems in Amalemba informal urban settlement are of critical importance.

Keywords: Runoff, Informal Settlements, On-Site Management

INTRODUCTION

Urban areas have up to 90% impervious surfaces, such as rooftops and pavements where water collects and flows rapidly (Parris, 2016). Urban runoff is one of the major non-point sources of water pollution. Non-point source of water pollution is difficult to avoid. Causes of such pollution include deforestation, drainage, yards, sidewalks, highways, building sites, agricultural activities and parking lots. It is a form of pollution that is not identifiable by a single source and occurs at sites dispersed across the drainage basin (USEPA, 2017). Consequently, there is need for urban infrastructural systems to assist in runoff and drainage management thereby reduce water pollution. Any drop of water into the terrestrial coverage of the municipality must be disposed of safely. A failure to correctly eliminate causes a wide range of flood and environmental health problems, in particular when settlements are not formally planned or have not been approved for planning (Button & Muniz, 2010).

Informal settlements are residential buildings that have not officially been approved in 'planned' and 'unplanned' areas. They are characterized by poor homes that lack or have insufficient social and amenity infrastructure (Srivinas, 2005). Informal settlements exist in areas where residential buildings do not comply with the existing regulations (UN, 2006). It is estimated that more than 60% of Africa's urban population live in informal settlements. The settlements often have poor runoff and drainage systems. The location characteristics of these settlements also exacerbate the problem. Many informal settlements are located on steep slopes, hillsides, lowlands, river banks, wetlands, which predispose these areas to hazards and disasters related to runoff (Schiariti, 2014).

Over the post-millennial era, informal settlements have gained the attention of county and national governments in developing countries. This resulted in attempts to provide basic facilities and amenities (including runoff drainage) to informal settlements as enjoyed in formal areas. Residents and community groups in informal settlements are also pursuing local projects aimed at providing a shortage of facilities and infrastructure, in particular runoff and drainage (Corburn & Karanja, 2014).

Kakamega Municipality's activities have a definite, substantial and cumulative environmental effects. If the town grows, there is growing demand for water, increased urban pollution and waste generated. Not only does urban development cause shifts in land use, but the region's emerging issues with increased demand for water supply by the people. To support the increasing population and activities of the municipality, an enormous amount of water is needed. The larger the urban area, the greater the hydrological aspect might impact the acquisition of its water supply. Even more, these demands usually exceed the supply of water provided either by surface or groundwater (Nazire & Michihiro, 2016). Kakamega Municipality’s roofs and pavements where water pools and flows easily has had a negative effect on the runoff system hydraulic load rate (KACWASCO, 2018). As a result, the volume of infiltration is decreased and the quantity of runoff increases. In view of these factors, urban activities impact the town and its ecosystem significantly through increased runoff and pollutant burdens. These effects create problems in relation with urban water supplies (USEPA, 2017). The effect of urbanization in the developed countries includes informal settlements. In Kenya, most people searching for new jobs in town areas illegally settle on abandoned, informal settlements. These settlements are very vulnerable to runoff effects for the Municipality of Kakamega due to their topographical locations and characteristics. Some of the townships are built on volcanic loamy soils. The easily saturated soils result in surface soil movements, erosion, water pollution and flooding during rainy season. This has serious knock effects on the shacks and drainages among other issues within the informal urban settlement. An increased peak runoff means that these poorly "infrastructured" settlements are more vulnerable. These potentially hazardous conditions require innovative solutions. Some of the innovative solutions may be a combination of structural and non-structural runoff management practices. This study explored runoff generation challenges and management strategies to alleviate or reduce its impacts in Amalemba informal urban settlement. This paper sought to investigate onsite and institutional runoff management practices in Amalemba informal urban settlement.

Best Management Practices

New Jersey Runoff Best Management Practices Manual (GoNJ, 2016) defines runoff management as: Any structural or non-structural strategy, practice, technology, process, program, or other methods intended to control or reduce runoff and associated pollutants, or to induce or control the infiltration or groundwater recharge of runoff or to eliminate illicit or illegal non-runoff discharges into runoff conveyances.

Runoff Management focuses on several environmental benefits including; reducing the risk and effects of flooding, enhancing the quality of runoff and creating additional water supplies to improve water availability (MOW, 2002). The relationship between the natural and constructed ecosystems is recognized as interconnected components of the same watershed (Backstrom & Viklander, 2000). The management of urban runoff is a knowledge used to understand, regulate and use water in its various forms within the hydrological cycle. Urban runoff control in areas with very strong human interaction with natural systems is applied. In urban areas, the hydrological phase takes place at a lower time and space level (Delleur, 2003).

The problem of runoff management is compounded by inappropriate urban planning and management, insufficient and under-implemented structures to regulate growth, and the proliferation of lower-income settlements with little or no concern for drainage (Armitage, 2011). Low-income, informal settlements are not ideal for residential development. In general, they are unplanned and sporadic in their spatial configuration. The places where such results are: near lakes, wetlands, deep ground (High Water Tables, issues with flooding), floodplains, previous waste disposal areas and rail/road lines and steep slopes/hillsides. These sites are subject to erosion and flooding which needs a lot of attention to runoff management and drainage (Murray, 2008). Research into New Delhi's slum networking shows that slum networking connects slums and the natural waterway that affects the infrastructure and the environmental environment. The slum matrix definition combines core services such as home-to-house water and underground waste water supply networks, storm drains, parks, landscape management as well as solid waste (Tripati & Jumani, 2001). Urban drainage systems cannot be built independently from their serving neighborhoods. The ties of the slum and natural drainage roads that affect urban infrastructure and the city environment are, for example, used by slum networking in India. This approach aims to solve flood problems for the whole town and also to provide services to urban residents in lowlands adjacent to natural waterways. This approach also aims to solve flood problems. Implementation may however be problematic because of inadequate solid waste management, and because slum residents may not be willing to invest in the household infrastructure to link with the urban waste drainage network (Jonathan, 2003). An analysis of the construction of an improved runoff management system in Nigeria shows the current status of the runoff collection network in the Federal University of Technology was not satisfactory since most roads and their sidewalk were not well maintained. Drainage channels were blocked by sewage and other wastes due to mismanagement of the drainage system (Adewumi & Ajibade, 2014).

Participation as a social aspect is an important factor in controlling runoff and enhancing drainage in informal low-income settlements. The role of a well-organized, mobilized society is crucial. In the preparation, implementation and maintenance processes, group approval, contribution, consensus and partnership are possible and indispensable. The case of urban environmental re-establishment in the Dominican Republic slum of Santo Domingo (Parkinson & Tayler, 2007) indicates opportunities in this regard. Volunteers and recruited members from the well-organized group carried out tasks such as clearance of waste heaps, digging trenches, constructing sewers and runoff drains.

In Lao, the Lao Women Union was active in project monitoring and encouraged drainage infrastructure maintenance activities. Runoff control for some residents, however, had low priority. Having collapsed frequently in communication and mistrust between residents and local authorities' hindered physical growth in settlement (ADB, 2008). This was the result of a two-year survey of 39 low-income unsewered settlements, which is consistent with Carden & Winter (2007). Education programs focused on settlement are of vital significance among other non-structural / operative steps for improving runoff quality in informal settlements (Owusu-Asante and Ndiritu, 2009).

Public engagement gives local authorities a chance to determine the communal viability of runoff and overflow response schemes in informal urban settlements. Experiences in high-income countries, such as the United States, show that urban runoff systems need public support and engagement to succeed; the effectiveness of runoff management initiatives needs strong incentive to take action (Jonathan, 2003).

A research on the climate change effect on the built environment of Nigeria has revealed that individual homeowners have an important role to play in reducing the risk of urban flooding in informal settlements while addressing infrastructural problems, by safeguarding their own houses and reducing their contributions of runoff into runoff systems (Okonkwo & Ezeabasili, 2013).

A major problem for runoff management is insufficient waste management within Kibera, an informal settlement within the capital of Kenya. Runoff management actions in non-formal areas must also be combined with effective waste management methods in order to be efficient and sustainable (Olumuyiwa, 2012). In its strategic plan (2017-2022), the Kakamega County Water Regulators (KACWASCO) found that the rivers in and around Kakamega Town were primarily captured by the traditional drainage scheme that caught water from impervious surfaces. These traditional structures were planned and installed many decades ago and are now insufficient and outdated. The collected water was transported by open drains to the nearby Isiukhu River. These traditional structures were planned and installed many decades ago and are now insufficient and outdated. The area needs current water and sewer infrastructure, physical infrastructure in place to cope with increased demand by a surging population (KACWASCO, 2018).

METHODOLOGY

Study Area

The study was conducted in Amalemba informal urban settlement in Kakamega Town, Kakamega County. The study was limited to investigating on-site and institutional runoff management practices in Amalemba urban informal settlement. It, however, did not neglect the fundamental, technical and environmental challenges in the drainage network and management of urban runoff in the context of informal settlements. Kakamega County is Kenya's second most populous county after Nairobi. Kakamega Municipality is located in western Kenya lying about 30 km north of the equator (GoK, 2019). The average elevation of Kakamega is 1,535 m (KACWASCO, 2018). Amalemba informal urban settlement is located in Shirere Ward situated to the southeast of the old township boundary, about 3 km from the town center. It is bounded to the North by the former township boundary, to the West by the Kakamega-Mumias road, to the South by the Amalemba-Airstrip road. The informal settlement lies between the longitudes 34º 45’ 8” E to 34º 45’ 10” E and the latitudes 0° 16’ 0” N to 0° 16’ 15” N.

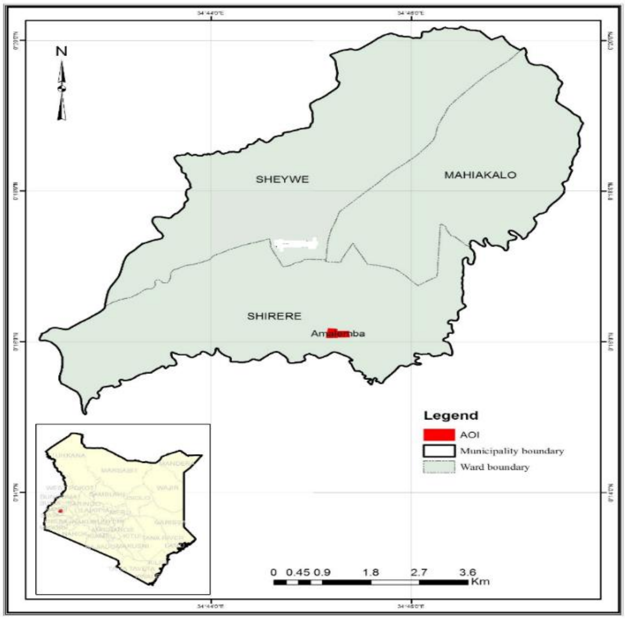

Figure 13**:** Geographical location of Kakamega.

The informal urban settlement spans a 25 ha (0.25 km^2) portion of land between Amalemba Primary, Orthodox Church, Joy Supermarket and Taqwa Jamia Mosque (GoK, 2019). The municipality is characterized by very high amount of annual precipitation that ranges from 1200 mm – 2000 mm per year and which is bimodal as it occurs in two rainy seasons. The seasonal distribution shows a long period of rainfall in the months of April to June and the short period in October to December (KMWS, 2020).

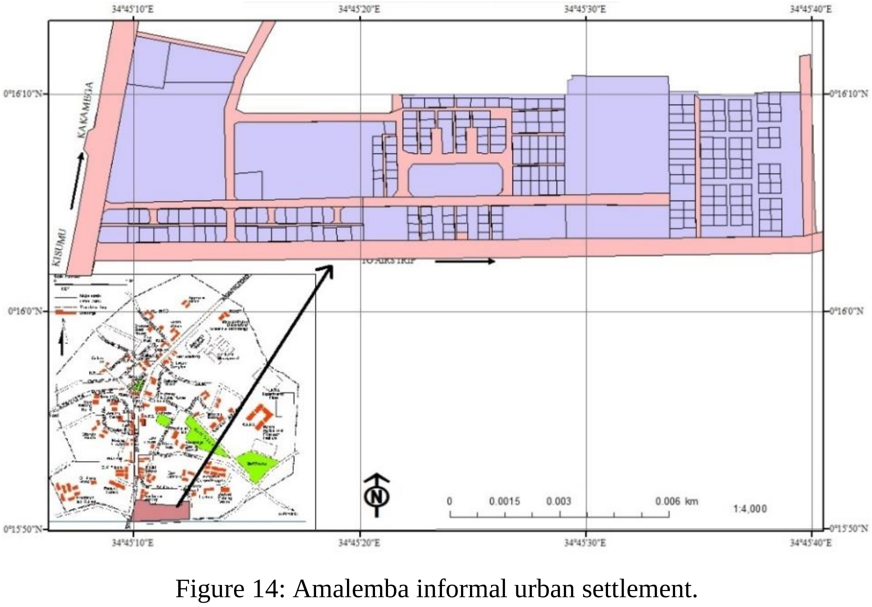

Figure 14: Amalemba informal urban settlement.

This study concentrated in Amalemba informal urban settlement because the area suffers incessantly from runoff challenges often resulting in disruption of transport and communication network, structural damages to buildings and properties. Reconnaissance field study was done between the months of January and March 2020 in the informal urban settlement.

Research Design

Survey research design was used to establish runoff management practices, challenges and prospects from the respondents' point of view in Amalemba informal urban settlement (Ranjit, 2011). The design was preferred for the study because there was need to have a holistic understanding of the challenges and prospects of on-site runoff management in Amalemba informal urban settlement. Survey research design was also preferred for the study because it sought key informants and residents opinions on generation and management of runoff in Amalemba informal urban settlement.

Sample Size

The sample size for residents of Amalemba informal urban settlement was based on the total number of the 122 households, Kenya population and housing census (2019). The sample size used for residents of Amalemba informal urban settlement was 55 respondents (household heads) in addition to two key informants. Purposive sampling technique was used to select the Water Engineer and the County Engineer (Construction Works) due to their expert knowledge that could address methods and challenges of managing runoff. The choice of the sample size was influenced by the need to actually target those who had experienced the impacts of runoff in the area. The households were purposively selected based on the proximity and physical characteristics that were of interest to the study.

RESULTS AND DISCUSSION

Residents' approach	Frequency	Percentage (%)
Open drains	22	40.0
Vegetation filter	19	34.6
Earth banks	8	14.5
Old tires & cement bags	4	7.3
Detention ponds	2	3.6
Total	**55**	**100.0**

Results as illustrated in the table above revealed that on-site approach was used to mitigate the adverse effects of runoff in Amalemba informal urban settlement. On-site runoff management was utilized by the residents own initiative. This approach had its own strengths and limitations, but more crucial was the complementary interaction of on-site and institutional strategies in the management of runoff. The residents own initiatives included deliberate runoff control activities to mitigate flood threats. Nevertheless, certain initiatives had a positive effect, rather than solely geared at runoff control. The shack or stand level was all weighed. The runoff management actions worked in four key ways: barrier, runoff channel/path, temporary storage or increased runoff penetration. From field observation, the study identified several methods that residents in Amalemba used to mitigate the quantity and effects of runoff, namely; planting grass or other ground covers, mulching gardens and digging diversion ditches.

Detention Ponds

Detention ponds were used to collect and infiltrate runoff to the underlying soils. The control of runoff volume using detention ponds was cited by residents during focus group discussion as one of the local methods that they used. The detention ponds provided temporary storage of runoff and quantity management by storing it temporarily, and then releasing it slowly to reduce downstream flooding.

In an interview, one resident observed that;

> …the rain water is a major problem in this area especially in March to June. In order to avoid the destruction of my house and vegetable farm I normally dig a ditch using a *jembe* (hoe) to reduce pooling of water around the house (Amalemba resident, personal communication, 2020)

Figure 3 illustrates a detention pond dug around Amalemba Primary School a higher ground of the settlement by Amalemba informal urban settlement residents to control runoff.

Figure 15: A detention pond near Amalemba Primary School in the study area.

Open Drains

Open drains were used by residents to manage runoff in Amalemba informal urban settlement and as an alternative to closed pipe systems, which provided opportunities to reduce runoff velocity and promote infiltration (Figure 4). It was established that the open drains had an average depth of 1 m and average width of 1.5 m. They had contrasting vegetation cover properties in different locations within the settlement ranging from bare ground to vegetated ones.

In an interview, the County Engineer in charge of construction works stated:

> …the vegetated drains reduce the time it takes runoff to reach the receiving stream by slowing velocity of runoff and providing some infiltration. Open drains also provides a low cost alternative to enclosed pipe system which offers some water quality benefits if properly designed (County Engineer, personal communication, 2020).

Figure 16: Open drains in Amalemba informal urban settlement.

Vegetation Filter

Vegetation was used to manage runoff in the stand where it was grown, although interviews with residents revealed that runoff management was not the primary purpose of planting the vegetation. Findings from the field observation demonstrated that the vegetation types included grass filter strips, vegetables and flowers. Vegetation also filtered runoff (Figure 5) besides increasing infiltration into the soil and reducing runoff velocity in the settlement. Most of the vegetation filters comprised vegetable gardens. The use of recycled mosquito nets on the small gardens was a common practice in the settlement (Figure 5). Most of the residents used the nets to protect the crop from invasive pests and chicken destroying the crop.

Figure 17: Vegetation filter with recycled mosquito nets.

In one of the focus group discussion with the residents, a respondent gave another perspective on the immediate use of the vegetated areas;

> ....boundaries of the plots are marked by planting of trees in line, by flowers, or by use of mosquito nets. Apart from that, some of the plants like Aloe Vera are medicinal, they serve as a fence and make the appearance of my compound beautiful (Amalemba resident, personal communication 2020)

Heaping Soil against The Base of the Shack

To avoid runoff infiltration into the shack through the base of the walls, most of the residents strengthened the wall base of their shacks seasonally by heaping laterite or mud against the wall base (Figure 6) or packing stones and hard substances to reinforce the wall base.

Figure 18: Heaping mud on shack base for stability.

The stability of the shacks in the case of wind-storm during rainfall is increased by this technique. These enhancements were usually made when the long rain season was about to or had just began in the Month of March.

Tyres and Cement Bags

From the focus group discussions, it was established that worn-out vehicle tyres were arranged to form a base for the cultivated plots in Amalemba informal urban settlement. Cement bags were used to form a retaining wall as well as act as footpath through the settlement (Figure 7). The footpath was used to prevent runoff from flooding the shacks as well as act as an obstacle to runoff, so that the cultivated area would not be flooded with water. As observed by one of the residents, these measures were overwhelmed by high volume of runoff that was generated in the informal settlement.

Figure 19: Used cement bags filled with soil to control runoff.

DISCUSSION

A majority of Amalemba informal urban settlement residents had devised means of protecting their personal effects from being carried away by runoff. One of the solutions used by residents to manage runoff was by a detention pond. It was used to dispose of water back into the natural circulation through seepage. Equally, small embankments and contrivances served as breakwater at the drainage channels close to houses. In this way, the effects of floods were mitigated besides protection of property from destruction. Vegetation filter provided limited runoff volume control; the method was more effective upon combination with other runoff volume management methods. Stands without vegetative materials like grass were at times flooded whenever it rained. The use of old tyres and used cement bags provided a physical barrier for the runoff. The inner wall chamber of the tyres where garden wastes were mixed with soil presented favorable conditions for the germination of seeds. This allowed soil and organic matter to be retained within the tyres favoring the development of a vegetative cover. The system for slope protection using scrap tyres reduced the erosive effects thereby improving the management of runoff. The findings in this study follow similar conclusions by Button & Muniz (2010), that onsite runoff management practices on a local scale have a high potential to manage runoff volume and mitigate its effects.

CONCLUSION AND RECOMMENDATIONS

Members of the settlement hardly came together to offer substantive solutions and strategies for mitigating the impacts of runoff. There was little or no concerted effort at the community level to address this problem. Based on the results, the study concludes that individual efforts to combat runoff and floods are not always successful.

Individualistic approaches to mitigation and reduction must now give way to a systematic and result-oriented strategy. This holistic approach must include all stakeholders in the informal process. The stakeholders here include Kakamega County Government, landlords or landowners, tenants and public service providers such as the Ministry of Works. A formidable team of stakeholders should come up with a workable plan to alleviate, handle and monitor the runoff crisis that is currently buffeting the informal urban settlement of Amalemba.

Acknowledgements
We thank the County Government of Kakamega, Ministry of Environment, Water and Natural Resources and Ministry of Roads, Energy and Public works, in particular Engineer Adeya Stanley and fellow staff at the Construction Works Department for their support during this study and the Regional Manager, Kenya Meteorological Services, Kakamega and his technical staff for recording and providing rainfall data.

References

ADB, C. (2008). *Lao People's Democratic Republic: Vientiane Urban Infrastructure and Services Project.* Phillipines: Asian Development Bank.

Adewumi, J. R., & Ajibade, F. O. (2014). Design of Improved Runoff Management the Federal University of Technology Akure. *Nigerian Journal of Technology*, Vol 33.

Armitage, N. (2011). The challenges of sustainable Urban drainage in developing countries. *Proceeding SWITCH Paris Conference.* Paris.

Backstrom, M., & Viklander, M. (2000). Integrated stormwater management in cold climates. *Journal of Environmental Science and Health,* A35(6), 1237-1249.

Button, K., & Muniz, E. (2010). *Adapting sustainable urban drainage systems to stormwater management in an informal setting. Bachelor of Science Qualifyng Project.* Cape Town: Worcester Polytechnic Institute.

Carden , F., & Winter, K. (2007). *The use and disposal of greywater in the the non-sewered area of South Africa. Water SA, 33(4), 433-441.*

Corburn, J., & Karanja, I. (2014). Informal settlements and a relational view of health in Nairobi, Kenya: sanitation, gender and dignity. *Health Promotion International*, 258-269.

Delleur (2003). The Evolution of Urban Hydrology: Past, Present and Future. *Journal of Hydraulic Engineering. vol. 129, Issue 8*.

GoK (2019). *Kenya population and Housing Census.* Nairobi: Kenya National Bureau of Statistics.

GoNJ (2016). *New Jersey Runoff Best Management Practises Manual.* New Jersey: Bureau of Environmental Services; Design Unit.

Jonathan, P. (2003). Draianage and stormwater mamanegement strategies for low-income urban communities. *Environment and Urbanization*, 115-126.

KACWASCO (2018). *Strategic plan 2017-2022*. Kakamega: Kakamega County.

KMWS (2020). *Kakamega Meteorological Weather Station Data.* Kakamega.

MOW (2002). *Stormwater Planning Handbook. Land and Air Protection.* British Colombia: Ministry of water.

Murray, M. (2008). *Taming the Disorderly City: The Spatial Landscape of Johannesberg.* Cape Town: University of Cape Town Press.

Nazire, H., & Michihiro, K. (2016). Specifying characteristics of informal settlements by comparing four areas from the aspects of houses, land tenure and social factors in Kabul, Afghanistan. *Journal of Architecture and Planning*, 2197-2206.

Okonkwo, A. U., & Ezeabasili, A. C. (2013). Climate Change Impacts on the Built Environment in Nigeria. *An International Multidisciplinary Journal, Ethiopia*, Vol.7: 288-303.

Olumuyiwa, B. A. (2012). *Nairobi Field-Trip Report: Perspectives on Stormwater Drainage Issues in Low-income Human Settlements.* Nairobi.

Owusu-Asante, Y., & Ndiritu, J. (2009). *The simple modelling method for Storm and grey-water quality management applied tp Alexandria settlement.* WaterSA, 35(5,), 615-626.

Parkinson & Tayler (2007). Planning and design of urban drainage systems in informal settlements in developing countries. *Urban Water Journal, 4(3),,* Pp 137-149.

Parris, K. M. (2016). *Ecolology of Urban Environments.* Melbourne: University of Melbourne.

Ranjit, K. (2011). *Research Methodology: A step-by-step guide for beginners. 3rd Edition.* London EC1Y 1 SP: Sage Publishers Ltd.

Schiariti (2014). *Basic Hydrology Tr-55 vs. MRM.* Mercer County Soil Conservation District: CPESC.

Srivinas (2005). *Urban Squatters and Slums.* Berlin: www.gdr.org/uem.

Tripati, D., & Jumani, J. (2001). *Change after alliance-Sequel to alliance for change.* New Delhi: Tata McGraw-Hill Publishing Company.

UN (2006). *Monitoring Human Settlements Abridged Survey. Indicators Program.* Nairobi: United Nations Center for Human Setllements.

USEPA (2017, January 19). *Nonpoint Source: Urban Areas*. Retrieved from https://www.epa.gov/nps: https://www.epa.gov/nps/nonpoint-source-urban-areas