Global Scientific JOURNALS

GSJ: Volume 10, Issue 6, June 2022, Online: ISSN 2320-9186

www.globalscientificjournal.com

The Major Challenges in Storm Water Drainage Management System of Assosa Town

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ABSTRACT

Urbanization is one of the key factors that contribute to urban flooding, which has caused major destruction to the environment, public and private buildings and disrupts public life. In particular, the increase in population and building density influence the change in hydrological characteristics in urban areas. Conversion of pervious areas into impervious areas increases the storm water runoff quantity dramatically.

One way of minimizing urban flooding is to convey storm water to receiving waters through storm water drainage systems, which has been practiced in some parts of Assosa town. In Assosa town, drainage problem become an issue during rainy season. This study deals with identify the major challenges in storm water drainage management system in Assosa town.

Keywords: Storm water drainage, runoff reduction, Assosa

INTRODUCTION

Urbanization alters the natural process of storm water runoff [1]. Consequently, it increases storm water runoff quantity due to the increase of impervious area, such as roads, parking lots, and rooftops. On the other hand, it has also been well acknowledged that processes which continuously take place in urban development can negatively affect storm water runoff quality. Such issues are further reflected in the subsequent impact of water quality of natural receiving water bodies by altering physical, chemical and biological conditions of water [2].

Storm water discharges are produced when the capacity of the land to retain precipitation is exceeded and runoff occurs. Runoff will be influenced by rainfall and intensity (millimeter of rainfall per hour) and duration, antecedent storms and a number of watersheds, and land use characteristics such as slope, soil type, and impervious surfaces [3]. Furthermore, the increases of peak flow, flow volume, flow velocity, as well as event frequency could deteriorate water quality in downstream areas [4].

The absence of adequate integration between road and urban storm water drainage network is also the other challenge in urban areas. This is due to the fact that the runoff generated with in a particular urban area will not safely be discharged in to the final receiving system. This will be the source of environmental problems like overtopping, erosion, pollution, barrier to traffic and other related problems. The expansion of Assosa town has been associated with the rapid conversion of land from rural to urban uses as other emerging town. For the last few decades it has been noticed that there is an intensive conversion of rural land to urban development like buildings, transportation networks, recreation areas and other manmade structures where most of them are impermeable structures.

Statement of the problem

In the last twenty years, quite tremendous efforts have been taken to construct significant number of hydraulic structures in Assosa to be used for drainage system. The urban drainage of these structures failed to serve for the intended purpose due to number of observed challenges. Some structures were blocked by sediments that emanate from the upland areas. On the other hand the existing drainage channels were found to be inadequate in their size to discharge the incoming flow. The problem associated with foundation conditions within the vicinity of storm water drainage channels is also one of these issues. Presently, some of the problems that have been observed in the Assosa town are either under the category of engineering (i.e. hydraulic,

hydrologic or structural) and management matters. Mainly, the management related problems are the results of lack of integration among stakeholders in the solid waste disposal mechanisms. The crucial problem in the town is the absence of proper Solid Waste Management System. Currently the existing storm water drainage systems in the town are not properly functioning because they are filled with solid wastes and silt from the runoff. Moreover the movement of cattle in the town and garbage thrown from the residential areas to the streets is also damaging the existing storm water drainage system. As a result of these, drainage channel bank destruction is quite common issue in the town.

LITERATURE REVIEW

Introduction

Storm water drainage is the process of draining excess water from streets, sidewalks, roofs, buildings and other areas. It can be any precipitation, such as rain, snow and sleet that falls on the surface of the earth. In general, areas with natural, unaltered groundwater, about 10% of the precipitation become runoff and about 50% infiltrates into the soil to form or replenish groundwater and flows into streams. Evaporation and uptake by plants accounts to the remaining 40%. When natural conditions change due to development, land use and other activities, this water cycle becomes altered .As the land becomes more covered with impervious surfaces, more precipitation converts as runoff. This runoff carries the dust, other loads, and pollutants. When the development is more as much as 55% may become runoff [5].

Basics of Urban Drainage System

Urban drainage is concerned with the collection and conveyance of wastewater and storm water from urban areas [6]. An important social aspect is to maintain public health and safety; hence an efficient drainage of storm water and wastewater is essential to avoid impact of flooding on life and property. In addition, the current environmental awareness involves the protection of the receiving waters from the pollutants that may be dragged by water flowing in the surface during heavy rain events [7].

The urban drainage system was first challenged due to the interactions between human activities and the natural water cycle, where this cycle was interrupted due to either (a) abstraction ofwater for drinking purposes and generating a wastewater also (b) increasing the impervious surfaces that causing rainwater diversion from natural drainage system and generating a considerable runoff. Consequently, both types of water need immediate drainage [8]. In this

thesis, the rainfall-generated runoff is only of concern and the urban generated wastewater won‘t be discussed further.

The runoff is a rainwater (can be also resulted from other forms of precipitation), which fallen on impermeable surfaces and caused distinguished damages, flooding and also further health risks due to the pollutants from air or the catchment itself [6].

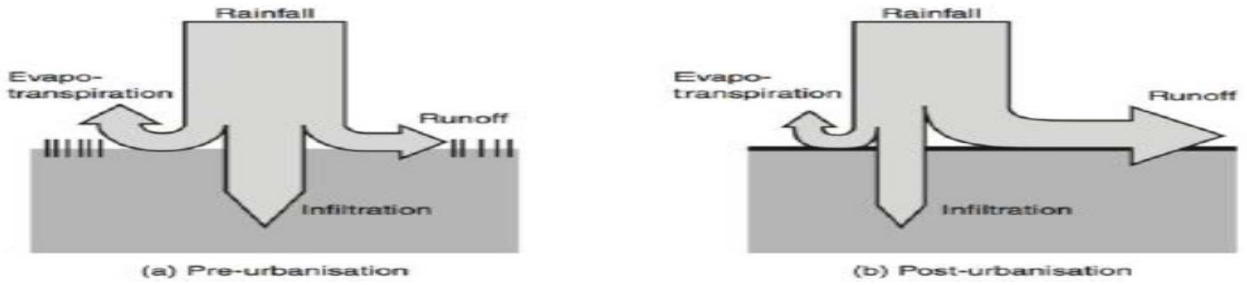

Figure.1: The impact of urbanization on the rainwater-generated runoff

The Storm water Runoff Generation and its Management

The urban runoff generation can be described in different ways. However, *Figure 3* explains the different processes that lead to the surface runoff formation, where storm water (A) runs over the impermeable surfaces and form the surface runoff (B) also the overland flow ((C) the surplus from infiltration) join together to the surface runoff and flow into the sewers (D). These different processes are mainly depends on the rainfall intensity and duration as well as on the nature of the catchment, nevertheless the nature of the surfaces [6].

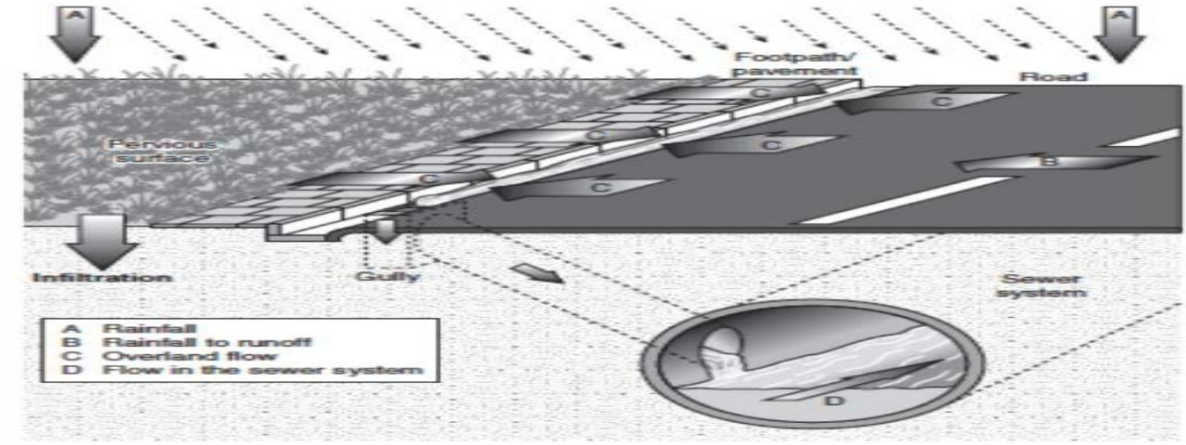

Figure.3: Runoff generation process

According to urban Storm water drainage design manual, storm water management is concerned with the collection, conveyance, storage, treatment and disposal of storm water runoff in a way

that minimize accelerated channel erosion, increased flood damage, and/or degradation of water quality and in a manner to enhance and ensure the public health, safety & general welfare, which shall include a system of vegetative or structural measures, or both that control the increased volume and rate of storm water runoff caused by manmade changes to the land [8].

While major problems associated with storm water include flash flooding, erosion and sedimentation, water quality degradation as well as surface pollution, the traditional concept for urban drainage design has been associated with storm water disposal, with the basic philosophy of transferring any amount of storm water as quickly as possible out of built-up areas. While this temporarily served to eliminate the local flooding problems, it only relayed the problem further downstream, where not only is flooding a concern but pollution and erosion of natural water courses are as well [9].

Similarly storm water management in the urban areas of Ethiopia has continues to predominantly focus on collecting runoff and channeling it to the nearest watercourse. This means that storm water drainage currently prioritizes quantity (flow) management with little or no emphasis on the preservation of the environment. The result has been a significant impact on the environment through the resulting erosion, siltation and pollution. An alternative approach is to consider storm water as part of the urban water cycle, a strategy which is being increasingly known as Water Sensitive Urban Design (WSUD) with the storm water management component being known as Sustainable Drainage Systems (SuDS).

Storm water management and their associated issues have been studied by many researchers. Most of them argued that integrated approaches are more realistic and worthy in urban developments. For instance, [9], indicated concept of storm water management at its source, in which storm water runoff is not immediately discharged to natural rivers but is stored and treated or re-used locally, at or close to its point of generation with the aim of making use of infiltration capacity wherever possible. He also noted that such management approach is found to be an ideal rehabilitation method, as it has the benefits of recharging soil moisture and groundwater; reducing peak runoffs as well as reducing total runoff volume to drainage systems. [10] has also noted that a major weakness of urban drainage management is the lack of holistic considerations of other integral parts. Similarly, [11] indicated that the problems associated with storm water shall be dealt in an integrated approach so that the effects of individual problems can be reduced in downstream areas.

Urban Storm water Drainage Experience in Ethiopia

In Ethiopian context, where watersheds of many urban centers receive significant amount of annual rainfall and where rainfall intensity is generally high, control of runoff at the source, flood protection, and safe disposal of the excess water/runoff through proper drainage facilities become essential [12]. Drainage problems in Ethiopian urban centers include flooding, deterioration of roads, land degradation, sedimentation, and blockage of drainage facilities, water logging and the like.

In order to establish the fact that drainage problem exists in the Ethiopian towns and to understand the works that are done, literatures are reviewed. The literatures showed no doubt on the existence of drainage problem in the Ethiopian towns. The presentations of the problems in the literature are presented either in the form of malfunctioning of specific component of the urban transportation or broader problems on urban drainage systems themselves. Some studies on drainage problems that exist in Ethiopian towns are reviewed in this section.

Table.1: Some storm water drainage related studies in Ethiopia

No	Topic	Study area	Author(s) (Year)	Scientific contribution	Model used
1.	Road and urban storm water drainage network integration in Addis Ababa: Addis Ketema Sub-city	Addis Ababa	Dagnachew (2011)	Published (*Journal of Engineering and Technology)*	-
2.	Assessment of the Effect of Urban Road Surface Drainage: A Case Study at Ginjo Guduru Kebele	Jimma	Getachew and Tamene(2015)	Published (*International Journal of Science, Technology and Society)*	SWMM
3.	An Approach to Drainage System Sustainability	Wolaita Soddo	Mitiku and Mekdes (2017)	Published (*International Journal of Waste Resources*)	-
4.	Urban stormwater drainage system in the central part of Addis Ababa	Addis Ababa	D. Muschalla and M.Ostrowski (2002)	Published (*Ninth International Conference on Urban Drainage (9ICUD*)	-
5.	Modeling and Analyses of Urban flooding in Bole Subcity System Performance	Addis Ababa	Nejib (2016)	Msc Thesis (*AAU-AAiT*)	SWMM

	and Evaluation of Possible Improvements				
6.	Highway drainage facilities problems (Case Study – Assessment of Drainage Problems in Adama)	Adama	Meraf (2015)	Msc Thesis *(AAU-AAiT)*	HEC-RAS
7.	Assessment of Stormwater Drainage Systems in Kemise Towm	Kemise	Biniyam (2016)	Msc Thesis (*AAU-AAiT)*	-
8.	Evaluation of Drainage system in Kebena stream catchment	Addis Ababa	Eskedar (2013)	Msc Thesis (*AAU-AAiT)*	-
9.	Integrated urban drainage system; the case of Ayat to Megenagna light rail transit system route	Addis Ababa	Anteneh (2015	Msc Thesis (*AAu-AAiT)*	-
10.	Investigation of Flooding Problems in Urban Drainage System: the case at Zenebe Werk in Addis Abeba, Ethiopia	Addis Ababa	Habtamu (2017)	Msc Thesis (*AAu-AAiT)*	-
11.	Investigation on storm drainage problem of Addis Ababa (case study at Gotera – Wollo Sefer, Saris - Gotera and Ring Road)	Addis Ababa	Desalegn (2011)	Msc Thesis (*AAu-AAiT)*	-

As we seen from the above table most of the studies were conducted on the assessment of urban drainage problems, and some of them have been studied by the concept of modeling of urban drainage. From the above mentioned studies some of them are summarized as follows. Dagnachew, (2011) has studied the Road and urban storm water drainage network integration in Addis Ketema Sub-city of Addis Ababa. In this study, the main challenge is the lake of adequate integration between road and urban storm water drain lines followed by blockage of existing channels by solid wastes. The undersized capacity of drainage channels are also found to be the major causes for overtopping during the rainy seasons. Similarly, with the objectives of surface water drainage problems and its network integration systems assessment, Getachew and Tamene, (2015) have conducted a study in Ginjo Guduru Kebele of Jimma town. Getachew and Tamene were concluded that road surface drainage of the study area found to be inadequate due to insufficient road profile, insufficient drainage structures provision, improper maintenance and lack of proper interconnection between the road and drainage infrastructures thereby resulting damages to road surfacing material and flooding problems in the area. The other study was conducted by Mitiku and Mekdes, (2017), with objective of assessing the approach to drainage

system sustainability in Wolaita Soddo town. Inadequate coverage, poor quality and inappropriate provision of drainage infrastructure were problems identified in this study.

From above mentioned studies some of them were conducted by using model and summarized as follows. Nejib (2016) has studied Modeling and Analyses of Urban flooding in Bole Sub city System Performance and Evaluation of Possible Improvements by using SWMM. Nejib was concluded that road surface drainage of the study area found to be inadequate due insufficient road profile, insufficient drainage structures provision, improper maintenance and lack of proper interconnection between the road and drainage infra-structures thereby resulting flooding problems in the area. Similarly with the objective of investigating of the drainage problems of Adama town along the Nazareth-Assela road and propose remedial measures, Meraf (2015) has conducted a study in Adama town by using HEC RAS.

After its inception, Federal Urban Planning Institute (FUPI) (the then NUPI) has been involving in planning and design of urban storm water drainage facilities as part of the Master/Development Plan of a city/town with the objective of keeping the life of urban infrastructure and to protect the urban environment like water pollution from non-point sources of storm water, Air pollution from stagnated water and Soil from erosion and degradation.

Before the establishment of the National Urban planning institute (NUPI) some twenty years ago, there has been no formal working organization in the area of urban storm water drainage system. Even now a day the attention towards urban storm water system is at its immature stage that is why most of the urban storm water drainage structures get blocked with solid waste of various types after huge money has been invested on them. In some areas they by themselves are sources of environmental problems [13].

MATERIALS AND METHODS

Description of the Study Area

This study is conducted in Assosa town which is the capital of Benishangul-Gumuz Regional State (BGRS) of Ethiopian. It is located at the north western part of the country, 678 km away from the nation‘s capital, Addis Ababa. The total area of the town is estimated to be 1345ha.

The town is situated on a relatively flat plane at an average altitude of 1525 m asl. Geographically, the town is located between 10000‘ and 10003‘ north and between 34035‘ to 34039‘ east.

Assosa town is located in the ‗kola‘ climate zone. It has mean maximum and minimum temperature of 33.70c and 11.60c respectively. The maximum temperature varies between 23.80c to 33.70c. The mean annual rainfall is about 991.5 mm. the rainy season extends from April to November, but the maximum rainfall occurs in summer season.

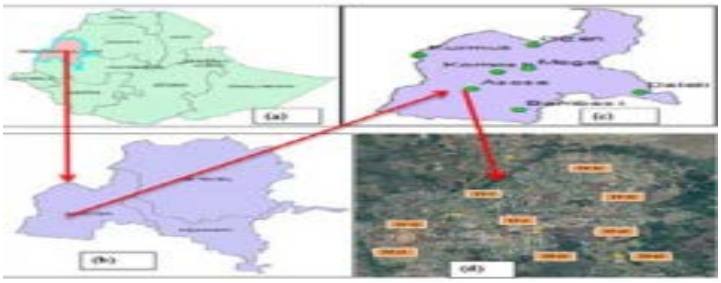

Figure.4: Location map of Assosa town

Data Collection Techniques

Field Survey

Field survey was employed to measure the dimensions of drainage lines located in the study area, to gather information about the current condition of the drainage system with the help of master plan and check list as per the objective of this study.

Interview

Generally, this was employed for the professionals in the study area to collect data related to flooding and major flood prone areas, major challenges to storm water drainage management, impacts of drainage system in the town and possible suggestions from expert point of view so as to handle the challenges of the drainage system in the study area.

RESULTS AND DISCUSSIONS

Urban Storm water Drainage Conditions in Assosa

The absence of adequate storm water drainage network in the town that feed the existing main channels resulted in underutilization of the channels discharge capacity thereby enhancing the problems of over flooding of residential, commercial, institutional areas and overland flow to create inconvenience on the traffic movement and urban sanitation.

The existing conditions of drainage system at the study area were investigated in detail, and photos are taken to show the existing conditions of each and every drain. Most of the existing urban drainage systems of Assosa town are not maintained and managed properly. As shown in figure 4, due to poorly defined inlets & outlets stagnant water is formed in the open drains.

Figure 5: Rectangular open drains with poor outlet

According to the Benishangul-Gumuz Regional State (BGRS) asset management plan report (2017), total roads length in the Assosa town is about 169.24 kilometers by considering all types of roads (primary, secondary and tertiary). Approximately, 26.5 % of the total length is covered by drainage facilities and remaining 73.5 % of the roads are not having drainage facilities. From this analysis the special integration between all roads and urban storm water drainage network is found to be 26.5 %. The implication of this is that for a kilometer of road about 265 meter of it has drainage line. Whereas 73.5% of the existing road does not have a drainage system, which implies that considering a kilometer of road 735 meter of it is without a drainage line. The main point that should be underlined here is that even if 26.5% of the road network is integrated with drainage line; a significant part of the network is integrated with one side drainage structure.

Solid Waste Management in Assosa

Dumping solid waste materials in to drainage is the major challenge of storm water drainage system in study area. After each occurrence of flooding and storm, wastes are dumped in ditches and drainage channels. Theses drainage channels remains unattended to and thereby get clogged. This causes blockage of channels for the subsequent runoffs and other contents. Urban litter (alternatively called trash, debris, junk, floatables, gross pollutants, rubbish or solid waste) has become a major problem in the study area it typically consists of manufactured materials such as bottles, plastic and paper wrappings, newspapers, shopping bags, cigarette packets and remains of chat. As a result of damping these solid wastes in to drains the drainage system has been clogged and causes flooding over streets and walk ways. Figure 5 shows the deterioration of the functionality of the drains in these areas of study. Also as this blockage exists, the road pavement attached to these drains is also under threat. Water builds up on the pavement (flood) thereby causing a wear and tear, with washing of bitumen and other road components into drains thereby causing further damage and leading to drain failures.

Figure.6: Excess sediment and dumping of solid waste in to drainage system

Similarly, some of the manholes or catch pits in the study area have been clogged with waste and blocked due to lack of clearance. As a result the runoff that is generated in that sub basin over flows with higher velocity which erodes the ditches as well as the road and walk ways. Figure 6 shows flow over the manholes.

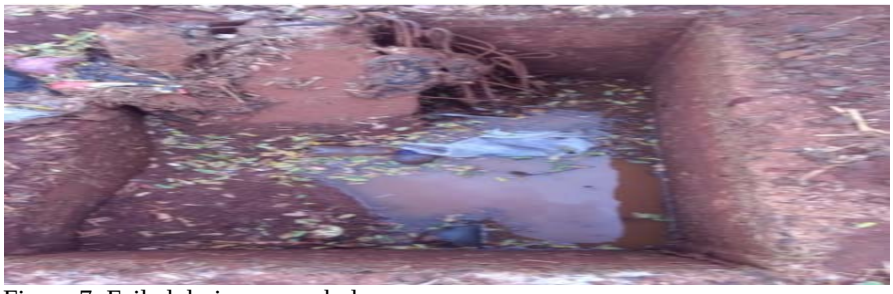

Figure.7: Failed drainage manhole

Liquid Waste Management in Assosa

Like solid waste management, liquid waste management has its own setback. Assosa city, as most of urban centers in Region, can hardly manage the liquid waste. In such away inadequacy

and loose organization towards such program is seen clearly within the realm of its administration; hence liquid waste management should be one of the issues for which the city administration has to give due attention.

The main sources of liquid wastes are households (residential units), commercial establishments and hotels. As there is no adequate provision for garbage container in the city, residents dispose wastes into the drainage channels, bridge/ culvert liquid open spaces. The conditions are more sever at flat areas.

The water that is running directly into the streams is often picking up pollutants along the way. These pollutants can include motor oils and gasoline that leak from vehicles, waste from sewer lines and anything else that will float or dissolve in water. Most of the drainage lines in study area oblige as waste disposal and clogged by liquid and solid wastes. Aside its‘ challenge to the drainage system, it could also cause a health problem and also it degrades the aesthetic value of the environment. Figure 7 shows the release of liquid waste in the study area.

Figure 8: Liquid and solid waste in the drainage system

CONCLUSION

In the study area it is observed that drainage problem is a cause of flooding on pavement, congested traffic flow and difficulty on day to day activity of people. To investigate the cause of the problem, we try to assess the drainage system in the flood prone areas and site investigation was done by collecting direct field data to assess the storm drainage condition and operation management problem.

Under the current rainfall conditions the system responded with serious problems and was not able to drain the generated runoff. So, the systems were vulnerable for flooding and surcharges atop the nodes were considerable in the most drainage systems. So this drainage problem in the study area is as a result of inadequate structure provision, which is the hydraulic capacity of the drainage structures, is less than the design discharge and blockage waste material respectively of the drainage structures.

RECOMMENDATION

Drainage problem become major challenge for recently constructed road as it is observed in Assosa town. As a number of road projects are constructed with huge investments, for drainage related issues emphasis shall be given. The following recommendations have been drawn from this study.

Design of the structures

- ✓ All consideration, such as appropriate design method which depends on the catchment area, variability of climate, future settlement of people, expansion of urbanization and other factors shall be taken into account during the detail design of the drainage facilities so as the structures capacity shall accommodate the design flood.
- ✓ In case if the problem occurs and the town administration shall to take action to keep the serviceability of the road, the rehabilitation needs to be supplemented by the detail design to alleviate the problem permanently with low cost.
- ✓ There is a need to introduce LID to reduce the runoff production and to minimize the receiving water pollution.

- Continuous Monitoring of the drainage facilities

- ✓ Continuous monitoring of the drainage facilities is required to take timely action where unexpected problem encounter that may create risk on the people, road and surrounding environment.
- ✓ Periodically, cleaning of the drainage facilities is also required to prevent of clogging of the drainage system.

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