

Wolkite University, College of Engineering and Technology Civil Engineering Department

Evaluation of Capacity and Performance Side Drainage Structure of Wolkite Town Main Road

Abrha Ge/abzgi T/medhin [1], Akalu Aboneh Tolossa [2], Kidus Mossa Abdo [3], Dirshaye Anbelko Ossacho [4], Albert Buche Ayka [5], Meron Liul Mekonen [6],

[1]Wolkkite University, Civil Engineering Department, ID Number ENGR 049/08,
[2]Wolkkite University, Civil Engineering Department, ID Number ENGR 070/08,
[3]Wolkkite University, Civil Engineering Department, ID Number ENGR 1025/08,
[4]Wolkkite University, Civil Engineering Department, ID Number ENGR 1034/08,
[5]Wolkkite University, Civil Engineering Department, ID Number ENGR 076/08,
[6]Wolkkite University, Civil Engineering Department, ID Number ENGR 599/08,

Advisor/s

Kibret G/medhin Hagos

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Civil Engineering Department

As members of the examining board of the final B.Sc. open defense, we verify that we have read and evaluated the final BSc thesis/project prepared by **Abrha Ge/abzgi, Akalu Aboneh, Kidus Mossa, Dirshaye Anbelko, Albert Buche, and Meron Liul,** entitled, **Evaluation Capacity and Performance Side Drainage Structure of Wolkite Town Main Road**, and recommended for acceptance as a fulfillment of the requirement of **B.Sc. in Civil Engineering**

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Chairman/Coordinator	Signature	Date
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Advisor	Signature	Date
_____	_____	_____
Internal Examiner	Signature	Date

Preface

This document is a report as a part of fulfilment for a Bachelor of Science in Civil Engineering. The study is conducted by Abrha, Albert, Akalu, Dirshaye, Kidus, Meron.

Abstract

The problem of side drainage structure is common in different cities of Ethiopia. The main aim of this study was to evaluate the capacity and performance of the side drainage structure on the Wolkite town main road. Descriptive and exploratory types of research was used for this study. This paper collected primary and secondary data. Primary data was collected from field observation, and measurement of drainage ditch, topography and Land cover. Together with field observation, a google earth was then used to estimate the catchment area for drainage ditches. Based on field observation, drainage ditch management was described. The rational method was used to estimate maximum design flood to drainage ditches. Side drainage current ideal and reduced capacities were estimated using manning equation drainage. Finally, the performance of drainage ditch was evaluated by comparing estimated flood to available current capacity. Results showed that the street flooding problem during rainy season is as serious to very serious problem in Wolkite town specially around Merkato village. The main reasons for the problem are blockage of the side drainage ditch by plastic bottles, chat sticks and other dry wastes and inadequate side drainage infrastructure.

Key words: Side drainage management, Urban waste on drainage performance

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1 Introduction

1.1 Background of the study

Side drainage structure problem is common in different cities in developing countries. The problem has become a topic concern on leading to significant environmental impacts in urban areas. These impacts are related to the quality and quantity variables of the hydrologic cycle(Tafete, 2013). Urbanization along with its impermeable structures and improper design are the major causes of flooding in most developing urban areas including Addis Ababa. Urban stormwater influences the service life of urban infrastructures(Belete, n.d.). The urbanization itself affected the side drainage structure the capacity and performance. In order to protect Drainage structures from any major problems of damage, identification of deteriorations and damages is very essential. To reduce any trouble and difficulty of travel due to drainage structures, correct measures through proper maintenance and repair must be used(Tamiru, 2015).

In developed areas, the capacity to retain rainfall decreases due to impervious surfaces like roads, gutters, buildings and a parking lot. Undeveloped areas have a greater capacity to retain storms/runoffs. Roads that intersect drainage basins generally modify the natural flow of surface water by concentrating flows at certain points and, in many cases, increasing the speed of flow. Depending on local conditions, these changes can contribute to flooding, soil erosion, channel modification, and the siltation of streams(Tafete, 2013).

Poor drainage can lead to flooding, resulting in property loss, and people may even be forced to move to escape floodwaters. Flooding may also damage water supply infrastructure and contaminate domestic water sources. Drainage problems include flooding, erosion of roads, land degradation, sedimentation, waterlogging, blockage of drainage lines, and others. With urbanization, impervious surfaces increase, drainage pattern changes, the overland flow becomes speedy, flooding and environmental problems such as land degradation increases(Tafete, 2013).

Adequate drainage is essential during the design of roadways since it affects the serviceability and usable life of the roadway, including the structural strength of the pavement. Satisfactory cross-drainage facilities will limit the build-up of pond against the upstream side of roadway embankments and avoid overtopping of the roadway. Information of pond on the carriageway occurs, hydroplaning (sliding of vehicles) becomes an important safety concern.

Rapid removal of stormwater from the pavement minimizes the phenomenon, which can result in the hazardous of hydroplaning. Adequate cross-slope and longitudinal grade enhance such rapid removal of stormwater. Drainage design involves providing facilities that collect, transport and remove stormwater from the roadway. The design must also consider the stormwater reaching the roadway embankment through natural streamflow or manmade ditches(Kassa, 2013).

1.2 Objectives of the Study

1.2.1 General Objective

The main objective of this research was

- To Evaluate the capacity and performance of the side drainage system of Wolkite town main road.

1.2.2 Specific Objectives

The specific objectives of the study are the following: -

- To assess the existing condition side drainage structure of Wolkite town main road and identify problems.
- To identify the impact side drainage structure of Wolkite town main road to the community as well as on the environment of Wolkite town main road.
- To recommend appropriate mitigation measures

1.3 Research question

This study answered the following research questions

- Is there a significant difference between design hydraulic capacity and the expected flood of a side drainage in Wolkite town main road?
- What factors contribute and what measures can be taken to improve the side drainage structure problems of Wolkite main road?

1.4 Significance of the Study

The output of this research will have administrative, policy and academic significances. The town can use it as a reference while they are preparing their annual plans related to spatial and financial plans for roads and urban storm water drainage system. Policy makers in the area of road and urban storm water drainage system can use it as a further reference to fill the existing gap between road and urban storm water drainage demand and supply. Concerned body can use it as a reference to minimize damaged pavements through proper drainage structure provisions.

1.5 Scope of the study

The main objective of this study was to identify evaluation capacity and performance side drainage of Wolkite town main road. There might be different factors that may cause road side drainage blockage. However, the scope of this study is limited to factors such as faulty design and construction or management of the drainage structure.

1.6 Limitation of the Study

This research was limited to Evaluation capacity and performance of side drainage structure systems on Wolkite main road. Insufficiency of existed information of the drainage structure on the study area. Due to limitation of budget accurate rainfall data from Ethiopian Metrology agency and accurate topographic mapping from Ethiopian Mapping agency could not be purchased. The rainfall intensity was estimated based on Ethiopian rainfall intensity maps. Whereas the catchment areas for each side drainage was estimated based on area measurement of Google Earth and field observation of slopes.

1.7 Organization of the Paper

This study organized into five chapters. The first chapter focused on the introductory part of the study, which includes background of the study, research question, objectives of the study, significance, scope and limitation of the study. The second chapter contains literature review part of the study. The third chapter deals about the research methodology: research design, approach and method; sampling design, sources of data, data collection methods, analysis and presentation were incorporated. The fourth chapter is all about the data analysis and interpretation, and finally the fifth chapter winds up by conclusion and gives recommendations to the problem related with Capacity and Performance Side Drainage Structure of the study area.

2 Literature Review

2.1 Introduction

Side drainage structures are essential for the highway. The main objective of the side drainage structure is to conveying, diverting, or removing surface water from the highway right-of-way and the side drainage also preventing from water standing on the surface road. Urban side drainage structure is an important feature in determining the ability of the road pavement to withstand the effects of traffic and the environment(*EUROPEAN ACADEMIC RESEARCH, VOL*, 2016). The side drainage structure should be designed to be commensurate with risk, construction cost, the importance of the road, the economy of maintenance, and legal requirements(Tamiru, 2015). these drainage structures are major causes of land degradation and gully formation(Hadera & Asfaw, 2016).

Road drainage structures that cross the rivers and valleys are vital components of the road network that contributes greatly to the national development and public daily life. Any damage or collapse of these structures can cause the risk of the lives of road users as well as create a serious influence on the entire country's economic development. Furthermore, the reconstruction of these road drainage structures needs a considerable amount of skilled workforce, money and time. Road drainage structures are essential components during the design development of road infrastructures. Drainage structures intended to allow the runoff of any flow of water with limited damages and disturbances to the road and to the surrounding areas(Tamiru, 2015).

The two main types of water flows that can be considered are the flows that usually crossing the area that could be diverted by the presence of the road, and the flows generated by the runoff of the rainwater falling on the carriageway and its surroundings. The basic design techniques in the roadway drainage system should be developed for the economic design of surface drainage structures including ditches, culverts, and bridges(ERA, 2002). A hydraulic investigation and analysis of both the upstream and downstream reaches of the watercourse is necessary to determine the best location, size, and elevation of the proposed crossroad structure, whether a culvert or a bridge. The investigation should ensure that any roadway structure or roadway embankment that encroaches on or crosses the flood plain of a watercourse will not cause significant adverse effects to the flood plain and will be capable of withstanding the flood flow with minimal damage.

It is significant to provide attention during the design of the magnitude, frequency and appropriate water surface elevations for the design flood, the 100-year flood, and the overtopping or 500-year flood for all structures(Kassa, 2013).

2.2 Development of modern urban drainage practice

The beginning of modern urban drainage practices was initiated in European cities during the nineteenth century. One critical turning point in urban drainage occurred during the middle of the nineteenth century. During the first half of the nineteenth-century sanitary wastes were discharged from buildings to privy vaults and cesspools. Most sewers were designed exclusively for stormwater drainage. Sanitary wastes accumulated in privy vaults and cesspools and were periodically collected by scavengers and transported to a suitable disposal location (e.g., farm, dump outside the city). As the nineteenth century progressed the concept of urban drainage changed with the incorporation of water-carriage sanitary waste collection into the urban drainage systems. Sanitary connections to the sewers were made legal and new sewers were constructed to drain stormwater and sanitary wastewater(Reynolds, 1946).

The public perspective of urban drainage changed during the nineteenth century from a neglected afterthought to a vital public works system. The public also shifted their stance regarding funding the construction and maintenance of sewer systems. The shift in public perspective was driven by many factors, but the most important was probably the scientific evidence accumulated during the second half of the century linking sanitary wastes and disease transmission(Ryberg, 1968).

The perspective of urban drainage also changed from a design standpoint during the nineteenth century. Most sewers constructed before the nineteenth century were not planned or designed by an engineer using numerical calculations. Instead, a trial-and-error process was executed, which in some cases eventually produced well-functioning systems(Reynolds, 1946)

2.3 Current urban drainage perspectives

Urban drainage in the early parts of the twentieth century was firmly established as a vital public works system. Engineers continued to improve design concepts and methods. During the second half of the twentieth-century regulatory elements were promulgated in the United States, Europe, and other locations addressing urban drainage issues(Burian Steven J. & Edwards Findlay G., n.d.). Extensive monitoring efforts vastly improved the understanding of urban drainage quantity and quality characteristics. Computer modelling tools advanced the methods used to design and analyse urban drainage systems. Regulations, monitoring, computer modelling, and environmental concerns have altered the perspective of urban drainage from a public health and nuisance flooding concern during the first half of the twentieth century into a public health and nuisance flooding with additional concerns for ecosystem protection and urban sustainability (Tafete, 2013).

Methods to design and construct sustainable urban drainage systems are currently being researched and tested. Alternative development concepts (e.g., low-impact development) are influencing development practices to minimize the impacts of development on stormwater drainage. In addition, alternative on-site wastewater management strategies are being touted as more sustainable than centralized wastewater management for some situations. Communities are searching for innovative techniques to capture, detain, and use rainwater within the watershed instead of constructing massive drainage structures. Many communities are developing watershed-wide stormwater quality management plans to meet the dual objectives of flood prevention and water quality control. Urban drainage has indeed expanded significantly during the past few decades beyond a technical challenge to drain the urban area expeditiously to include the consideration of social, economic, political, environmental, and regulatory factors(Tafete, 2013).

2.4 Road surface drainage

If surface water penetrates into the road body, it reduces the load-bearing capacity of the pavement, which may cause further damage to the road. To avoid these problems, it is important to secure adequate drainage of the road surface. According to the ERA geometric design manual(ERA, 2002). the normal cross-slope is not less than 3% in order to dispose of water from the roadway quickly that avoids infiltration of water into the roadway. If the cross-slope is less, water will get time to infiltrate into the roadway and weakens the pavement that cannot withstand traffic load.

2.5 Description and function of road drainage structure

Storm drainage facilities consist of curbs, gutters, inlets, storm drains, ditches, and culverts. The placement and hydraulic capacities of storm drainage structures and conveyances should be designed to avoid/minimize damage to adjacent property and secure a low degree of risk of traffic interruption by flooding. Different types of structures are employed in the drainage systems.

- Open channels whether artificial or natural convey the flows of water.
- Culverts and bridges convey flows under road cross-section.
- Energy dissipaters used to control the velocities of flows, especially at culvert outlets.
- Storm drainage facilities used to collect the runoff of the carriageway and surrounding areas and direct it to the channels(ERA, 2002)

3 Research Methodology

3.1 Introduction

The main aim of this paper was to evaluate the capacity and performance of the side drainage system of Wolkite town main road. In order to answer the research questions, this study first collected primary data from field observation, measurement and secondary data of published reports (Figure 1). Collected field data was then subjected to descriptive statistics. The rational method was used to estimate expected design flood to side ditches. Side drainage ditch capacity was then estimated using manning equation. Finally estimated design flood was compared to estimated capacity.

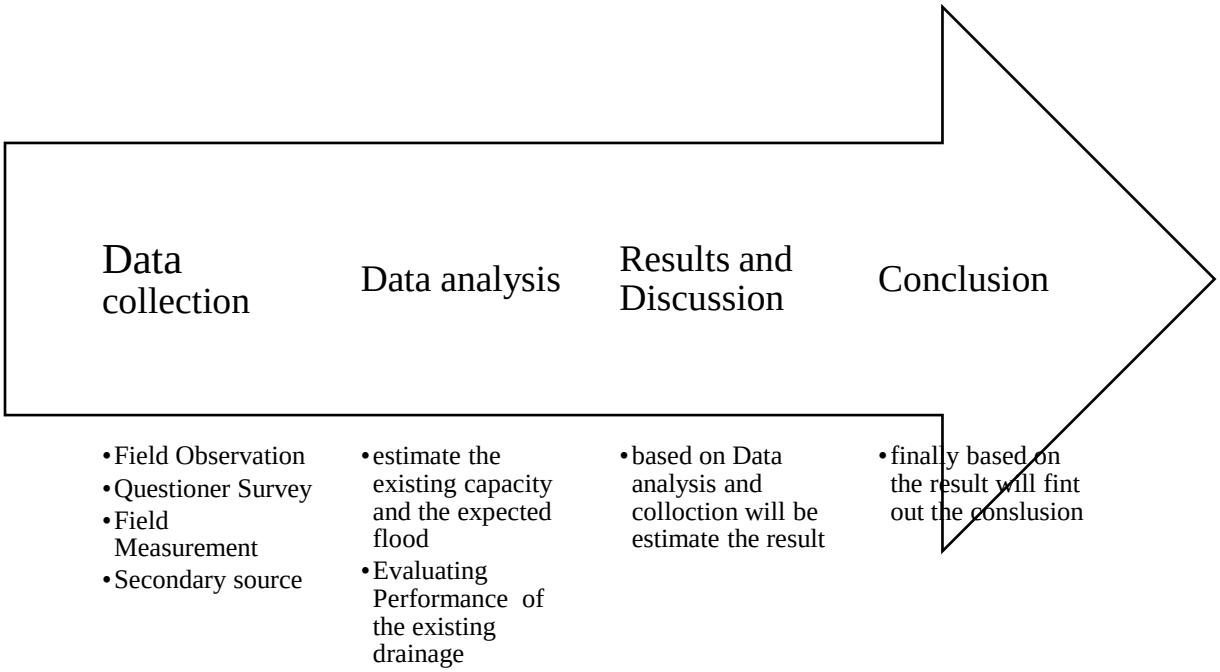


Figure 1 : Flow chart

The overall proposed research framework is demonstrated in figure 1.

3.2 Research Design

There are two types of research approaches, namely: quantitative and qualitative. Quantitative study is a study where purely quantitative data and analysis techniques are adopted while qualitative approach makes use of purely qualitative data and analysis.

3.2.1 Study Area

The study area is found in Wolkite town, which is the administrative centre of the Gurage Zone of the Southern Nations, Nationalities and Peoples' Region (SNNPR). Wolkite is found on the southwestern part of Ethiopia which is far 158 kilometres from Addis Ababa, the capital city of Ethiopia having an average latitude 8°17′N 37°47′E and 8.283°N 37.783°E longitude. The altitude of Wolkite varies between from 1910 meters to 1935 meters above the sea level. Wolkite town is located in Gurage zone of Southern Nations, Nationalities and Peoples Regional State (SNNPRS), Ethiopia (Fig. 2). Analysis of 30-year data from the National Meteorology Agency (NMA) (1988–2018) shows that the average annual rainfall varies from 856 to 1600 mm and the mean yearly temperature is 19.1 OC with the maximum and minimum values of 22.5 and 6.7 OC, respectively (Yenenesh et al , 2020). It is the capital town of the zone and located at 158 km South of Addis Ababa on the way to Jimma town and 427 km from the regional capital city, Hawassa. According to Gurage Zone Bureau of Finance and Economic Development projection, the total population of the town during 2013/14 was 42,812. Among these 8241 were household heads. The percentage of female population was 21,116 (49.3%) and that of male was 21,696 (50.7%) (Yenenesh etal,2020). Wolkite has access road that links the town with Addis Ababa, Jimma, Woliso, Hossana and Butajira town. The area has transport infrastructure such as paved roads and gravel(unpaved) roads of 130 and 386 km, respectively, which connect rural areas and the district's city. According to Central Statistical Agency of Ethiopia (Csa 2007), total population of the town was 28,856 of which 15,063 (52.2%) were male and the rest 13,793(47.8%) were female. In 2013, the total population size of the town is expected to be 33,877 of which male accounts 17,684 and female accounts for the rest 16,193. The population growth rate at medium variant was 2.9% (Csa 2007). The area is one of the densely populated areas in Ethiopia. Based on an Ethiopian Central Statistical Agency (Csa, 2007) report, the study area has an average population density of 283people/km2. The majority of the rural household's occupation in the area is subsistence farming (Aneseyee et al. 2020). The major economic accomplishments of the town are trade, transport, construction, agricultural products and other services.

Among these activities hotel and restaurants are the major activities since the town has major transportation pass, which country cross road from capital city of Addis Ababa to boarder region

of Gambella state. The physical characteristic of the housing units in the town has revealed that the majority of them are dilapidated and without the requisite services, however, there are newly emerging housing units at the centre and periphery of the town. Its proximity to Addis Ababa, Jimma and Woliso towns creates good opportunity of the future development of the town (Yenenesh et al, 2020).

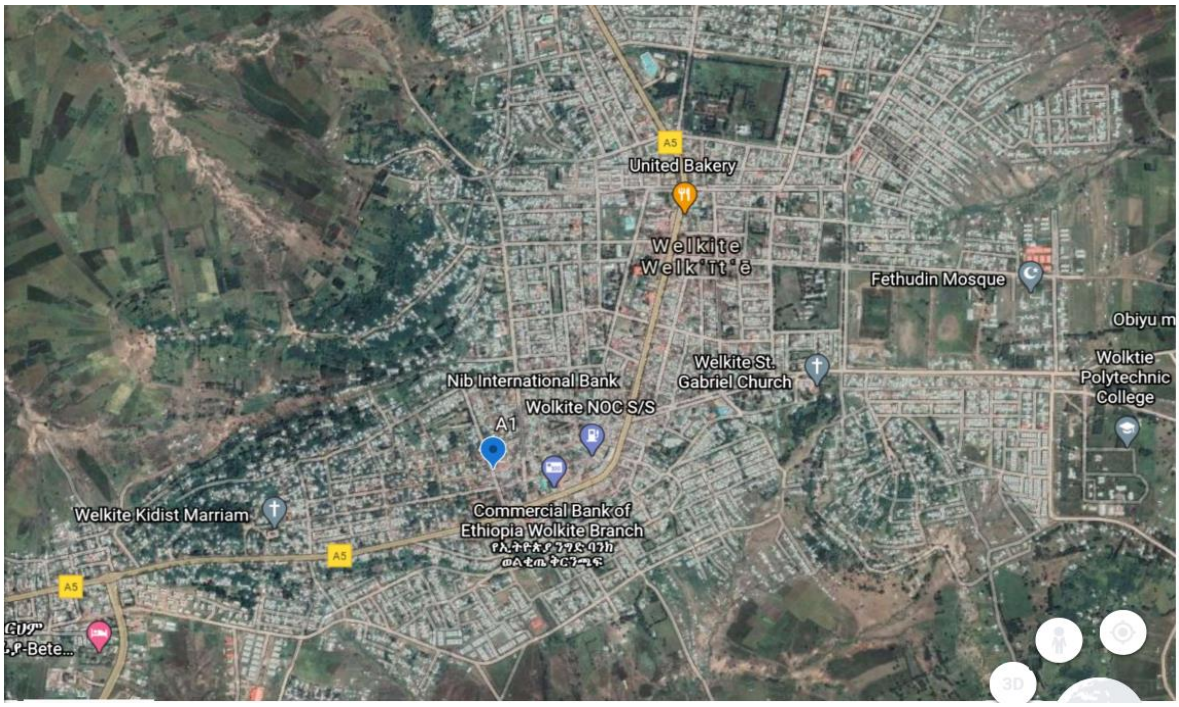


Figure 2 : Study area map

Climate

Climate is one of the vital elements that affect living and non-living things. Climate is also influenced by elevation and National vegetation.

Temperature

According to meteorological service agency, the mean annual temperature of Wolkite station ranges from 190 -210C. The average mean annual temperature of Wolkite station is 200C.

3.3 Sampling technique

3.3.1 Field observation

To ascertain the current conditions of the drainage system of the town personal observation of the site was necessary. During the field observation of the study area the existing performance and capacity condition of drainage structures are observed. Personal observations of the site and data collection including pictures of the current drainage system to show the true state of the current urban drainage conditions of the town, measuring the affected areas by using tap meters to show the length, width, radius of the ditch, and water depth of drainage system(Trapezoidal drainage) which shows the current conditions of the working space are carried out. Meters (measuring tapes), Mobile camera (to take photograph), pen& pencil (to writing the collected data) are used for collection of the data.



Ponding due to in appropriate slope



Ponding because of drainage blockage



Ponding because of drainage blockage



Eroded pavement surface

Figure 3 : Current condition of the road side ditch

3.4 Method of estimating design flood (The rational method)

The Rational Method is most accurate for estimating design storm peak run off for areas up to 50 hectares (0.5 square km). This method, while first introduced in 1889, is still widely used. Even though it has come under frequent criticism for its simplistic approach, no other drainage design method has achieved such widespread use. The rational formula estimates the peak rate of runoff at any location in a catchment area as a function of the catchment area; runoff coefficient; and mean rainfall intensity, for a duration equal to the time of concentration.

The rational formula is expressed as:

$$Q = 0.00278 * C * I * A$$

Where:

Q = maximum rate of runoff, m_3/s

A = catchment area tributary to the design location, km^2

C = Runoff coefficient representing a ratio of runoff to rainfall

I = Rainfall intensity for a duration equal to the time of concentration and for design return period, mm/hr.

3.4.1 Land-use and Run-off coefficient

Land use is the catchment area cover, and it includes both agricultural and non-agricultural uses. Items such as type of vegetation, water surfaces, roads, roofs, etc. are all part of the land use. And the runoff coefficient (C) is the variable of the Rational Method least susceptible to precise determination and requires judgment and understanding on the part of the designer. A typical coefficient represents the integrated effects of many drainage basin parameters. For this specific thesis, the runoff coefficient was determined from the Ethiopian road authority drainage design manual 2013 (Table 5-6).

Table 1 : Recommended Runoff Coefficient C for Various Land Uses (Drainage Design Manual, 2013)

Description of Area	Runoff coefficients
Business: Downtown areas	0.70-0.95

Table 5-6: Recommended Runoff Coefficient C for Various Land Uses

Description of Area	Runoff Coefficients
Business: Downtown areas	0.70-0.95
Neighborhood areas	0.50-0.70
Residential: Single-family areas	0.30-0.50
Residential: Multi units, detached	0.40-0.60
Residential: Multi units, attached	0.60-0.75
Suburban	0.25-0.40
Residential (0.5 hectare lots or more)	0.30-0.45
Apartment dwelling areas	0.50-0.70
Industrial: Light areas	0.50-0.80
Industrial: Heavy areas	0.60-0.90
Parks, cemeteries	0.10-0.25
Playgrounds	0.20-0.40
Railroad yard areas	0.20-0.40
Unimproved areas	0.10-0.30

(Source: Hydrology, Federal Highway Administration, HEC No. 19, 1984)

3.4.2 Rainfall intensity

Our study area is Wolkite Town. According to ERA drainage design manual, our study area is located on sub-region B2(*Drainage Design Manual*, 2013).

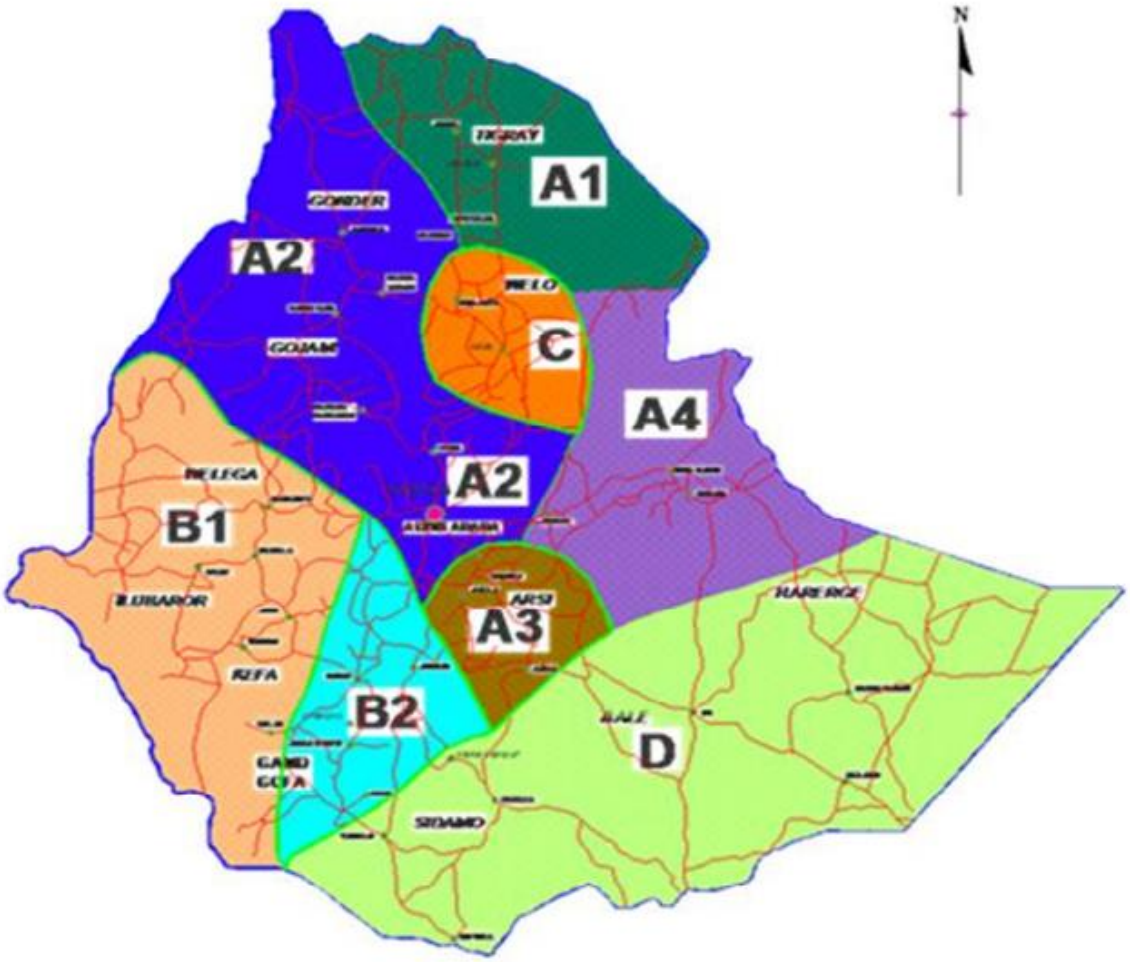


Figure 4 : Ethiopian Rainfall regions by ERA 2013 classification (source ERA, Drainage Design Manual, 2013)

From IDF curve for rainfall region B2, and for design period of 10 years, the 60minute rainfall intensity would be 48mm/hr (Figure 5) (*Drainage Design Manual*, 2013).

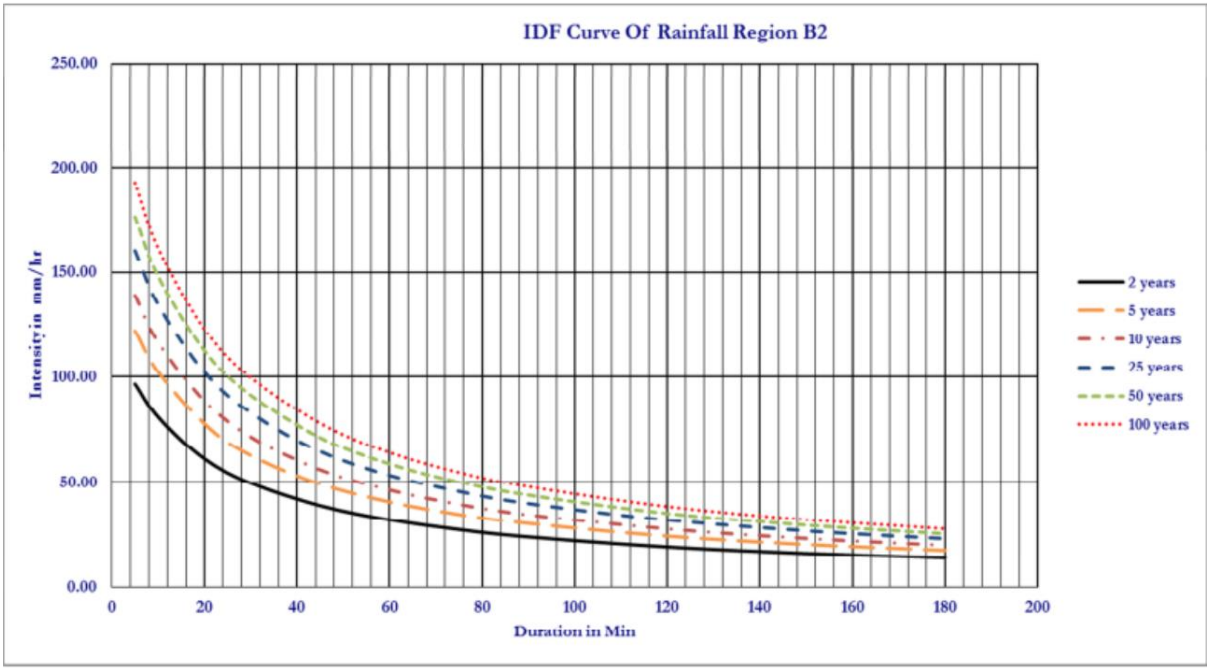


Figure 5-21: IDF Curve of Rainfall Region B2

Figure 5 :IDF Curve of Rainfall Region B2 (source ERA, Drainage Design Manual, 2013)

3.4.3 Catchment area

Based on a questioner survey to residents and a field observation, the maximum flooding of side drainage is usually observed around Merkato area of Wolkite Town. The catchment area to side drainages to the right and left side of main road was then estimated through three steps.

Firstly, a field site visit and ground slope measurement were used to identify the natural and artificial flows of runoff.

Secondly, turning points of natural flow (crust points), were identified considering the ground slope measurements for instance (Figure 6).

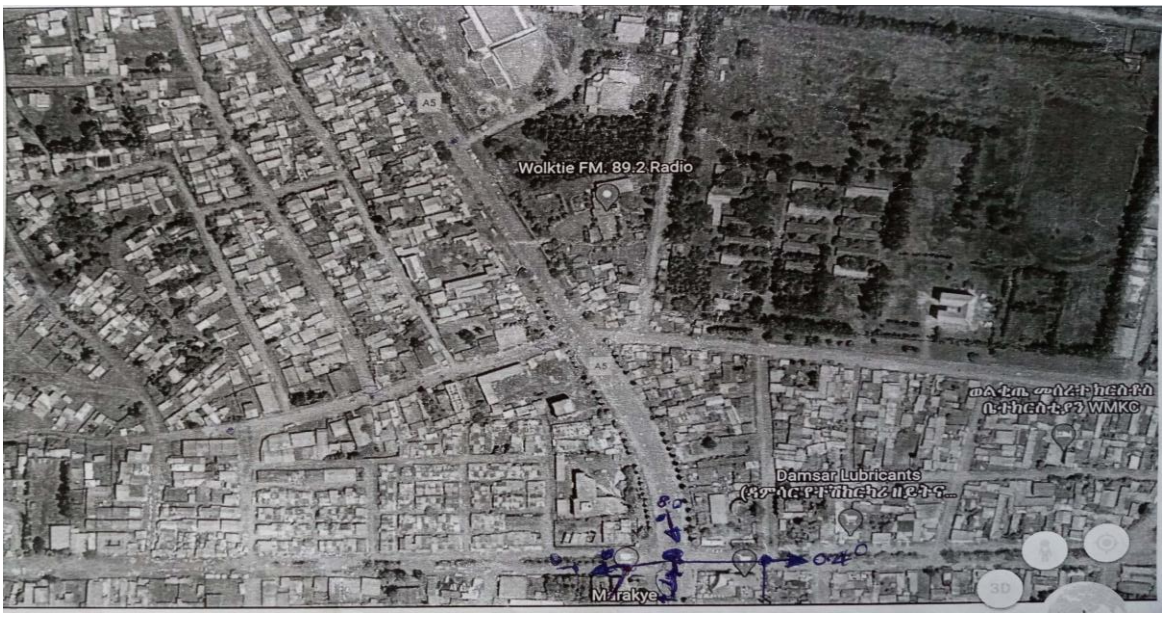


Figure 6 : Locating crust points on map from field measurement

Finally, the catchment areas were estimated by connecting turning points and considering locations of cross drainage culverts. A field examination of existing or proposed drainage systems have been done to determine the boundaries of the catchment and the location of the watercourses.

An online app, Google Earth, was then used to convert the manual catchment area in to a digital form and gain estimated catchment area.



Figure 7 : Estimated catchment area

3.5 Method of estimating side drainage capacity (The manning equation)

The performance and capacity of the side drainage structures has been analysed during field survey of the study areas (width, depth, slope) on a specific clean site and on a site that are decreased in depth.

The existing side drainage capacity is computed by using the manning equation (*Irrigation Engineering & Hydraulic Structures – GARG*, 2005)

$$Q = \frac{1}{n} * A * R^{\frac{2}{3}} * S^{\frac{1}{2}}$$

Where Q – discharge of the side drainage capacity

n – roughness coefficient

A – cross-sectional area of the side drainage

R – hydraulic radius

S – bed slope of the side drainage structure

3.5.1 Field observed cross-section

On December 10, 2020, a field observation and measurement were conducted on Wolkite Main road side drainage ditches. Details of field observation format is attached in Appendix C. Accordingly, the dimensions indicated in (Figure 8) were observed. The Side ditch was a concrete and trapezoidal section.

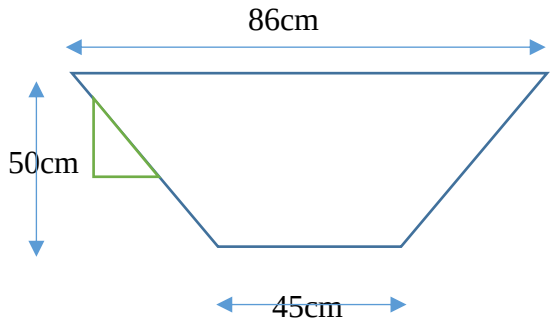


Figure 8 : Observed side drainage dimension from Wolkite main road

Although the ideal side drainage capacity is as shown in (figure 9), field observation indicated that the capacity is reduced by sediments and wastes such as plastic bottles, chat sticks etc. The wastes are estimated to reduce the hight of the drainage ditch cross-section by 20cm.



Figure 9 : Waste and sediments reducing the capacity of side drainage of Wolkite main road

The slope of side ditch was also measured using a mobile application (clinometer). The app provides proximate ground slope (Figure 10).

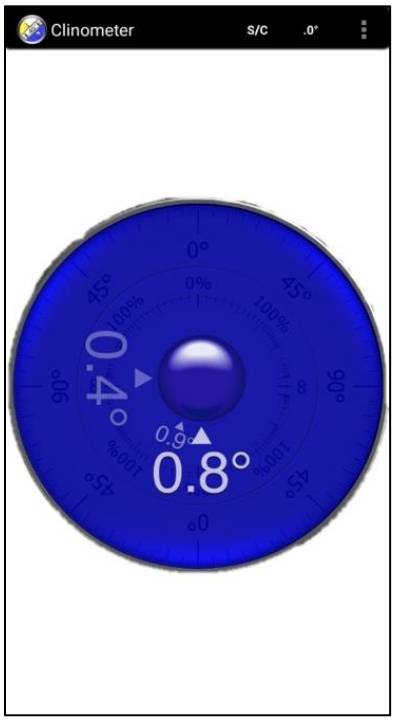


Figure 10 : Ground slope measurement using mobile application

Because the side drainage ditch is wet, the longitudinal slope of drainage ditch was assumed to be equal to the slope of the main road. Accordingly, the slope measurements were conducted by placing our smart phone on the main street (Figure 11).

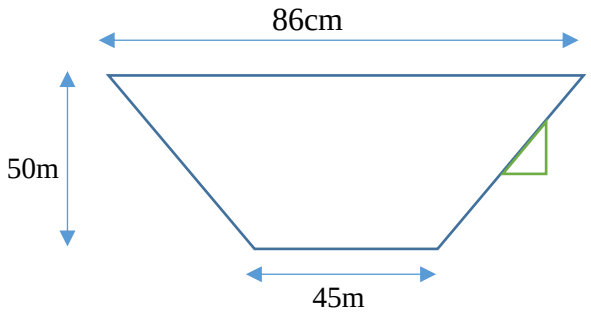


Figure 11 : Measurement of longitudinal slope using smart phone

3.5.2 Estimated Flow capacity

Full Capacity

By using manning equation, we computed the full capacity and reduced capacity of the road side drainage structure. Because the side drainage ditch is wet, the longitudinal slope of drainage ditch was assumed to be equal to the slope of the main road(s=1.2^0), roughness coefficient (n) depending on the material type for which our study area drainage structure is constructed from concrete so n = 0.012(*Drainage Design Manual*, 2013).



$$Q = \frac{1}{n} * A * R^{\frac{2}{3}} * S^{\frac{1}{2}}$$

Area

$$A = by + zy$$

$$= (0.45*0.5) + (1.2*0.5)$$

$$= 0.825m^2$$

Wetted perimeter

$$P = b + 2y\sqrt{1+m^2}$$

$$= 0.45 + 2(0.5)\ (\sqrt{1+1.2^2})$$

$$= 1.65m$$

Hydraulic radius

$$R = \frac{A}{P}$$

$$= 0.5m$$

Velocity

$$V = \frac{1}{n} * R^{\frac{2}{3}} * S^{\frac{1}{2}}$$

=5.7m/s

Discharge

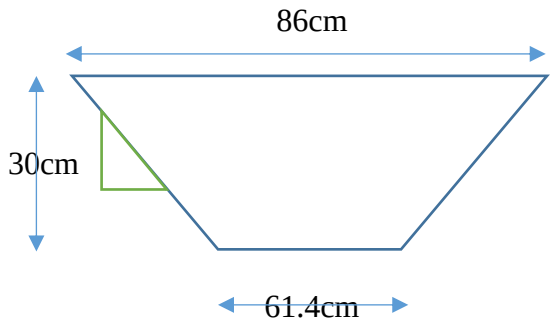
$$Q = VA$$

=5.7*0.825

=4.73m^3/s

Reduced Capacity

From our field observation and measurement, we estimated the depth covered by sediments and waste to be 20cm. Accordingly the remaining reduced capacity of the road side drainage structure.



Area

$$A = by + zy$$

$$= 0.544m^2$$

Wetted perimeter

$$P = b + 2y\sqrt{1 + m^2}$$

= 1.55m

Hydraulic radius

$$R = \frac{A}{P} = 0.35m$$

Velocity

$$V = \frac{1}{n} * R^{\frac{2}{3}} * S^{\frac{1}{2}}$$

V = 4.53m/s

Discharge

$$Q = V * A$$

= 2.46m^3/s

4 Results

4.1 Descriptive statistics of Field Observation

We have already conducted a questioner survey, present the findings in charts and tables by splitting in to subsections. The summary of questioner coded raw excel data Appendix B

4.1.1 Challenge of Street Flooding

The majority (89%) of the respondents stated that street flooding is a challenge on Wolkite main road (Table 2).

Table 2 : Respondents experience with street flowing in Wolkite

	Yes	No
Is street flooding a challenge to Wolkite?	89%	11%

Two-third (66%) of all respondents in Wolkite town rate the street flooding problem during rainy season as serious to very serious (Figure 12).

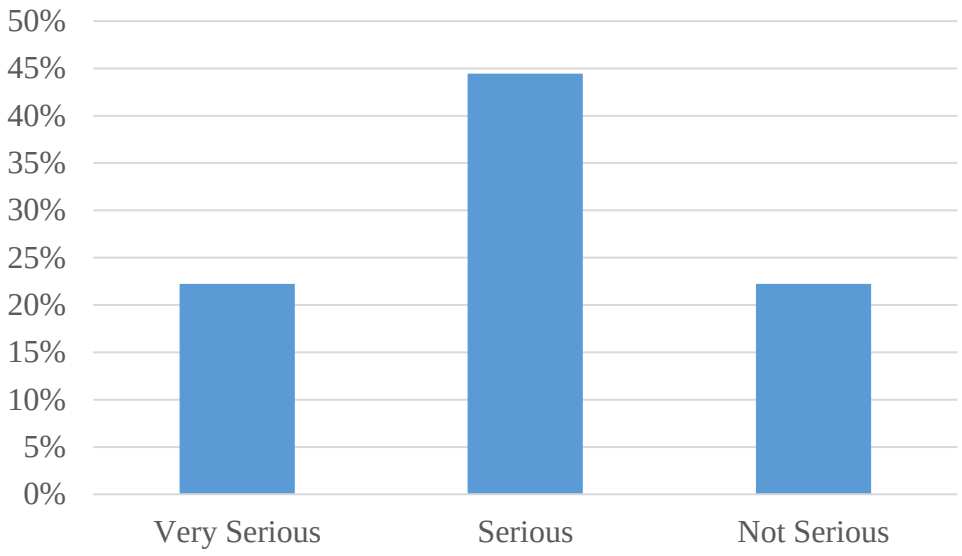


Figure 12 :Severity of street flowing in Wolkite

Two-forth (44%) of all respondents in Wolkite town rate Merkato village as the most flooding disposed site during rainy season (Figure 13).

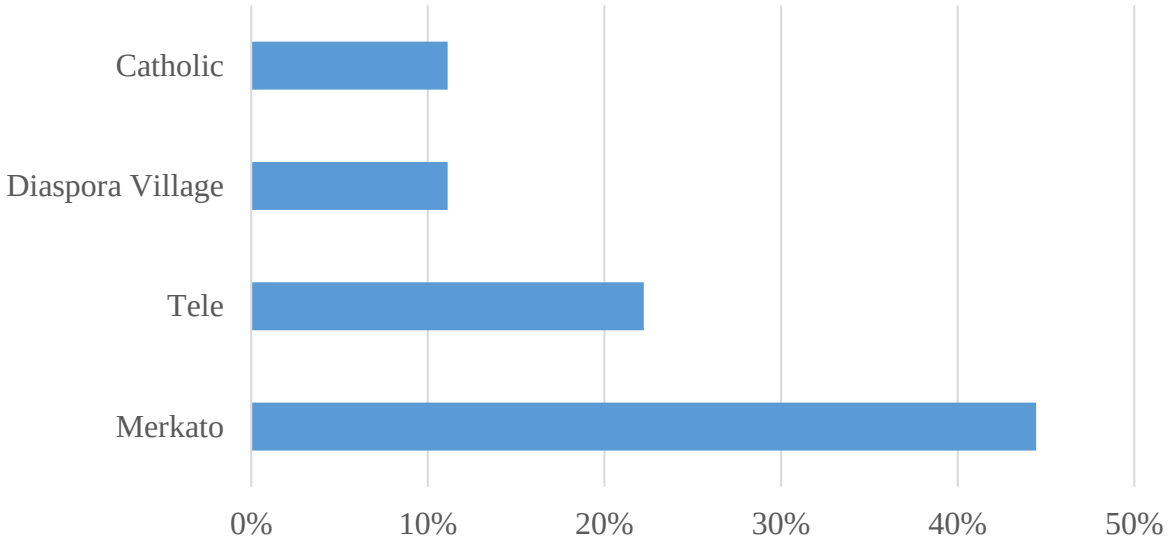


Figure 13 : Most flooding prone sites

4.1.2 Major cause of Street flooding

Over half (56%) of the all the respondents in the study area think that the major cause for the flooding problem in their site is blockage of the side drainage structure by plastic wastes and chat stick or other dry wastes (Figure 14).

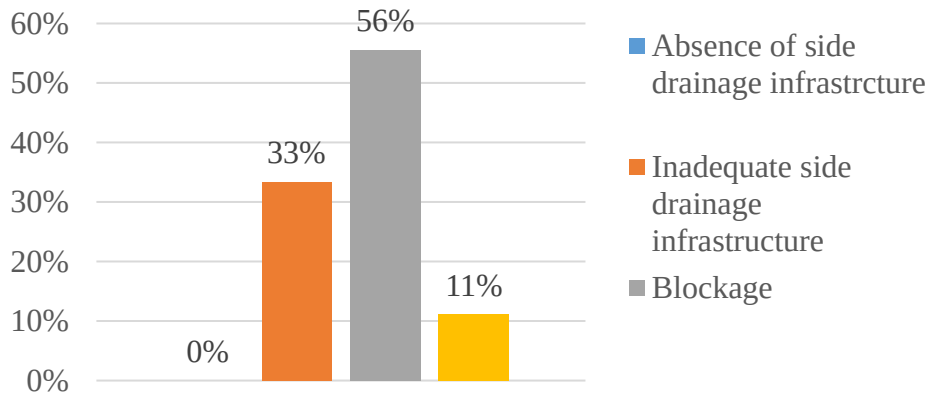


Figure 14 : Major causes of the flooding problem in Wolkite

Over one-fourth (33%) of all the respondents in Wolkite town rate the reasons for the neighbourhood to dispose dry wastes into the drainage systems is that because of lack of awareness (Figure 15).

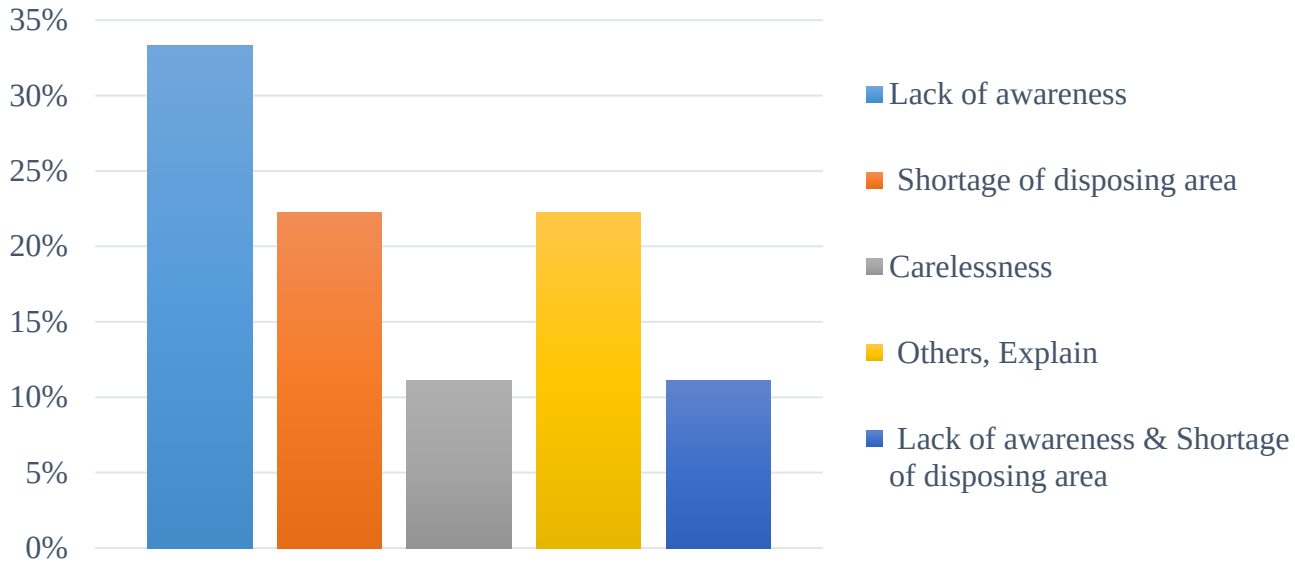


Figure 15 : Reasons for disposal of dry wastes into the drainage systems

The majority of all the respondents in the study area rate that improving the town's dry waste management system is the best solution for increasing the performance and capacity of the road side drainage structure (Figure 16).

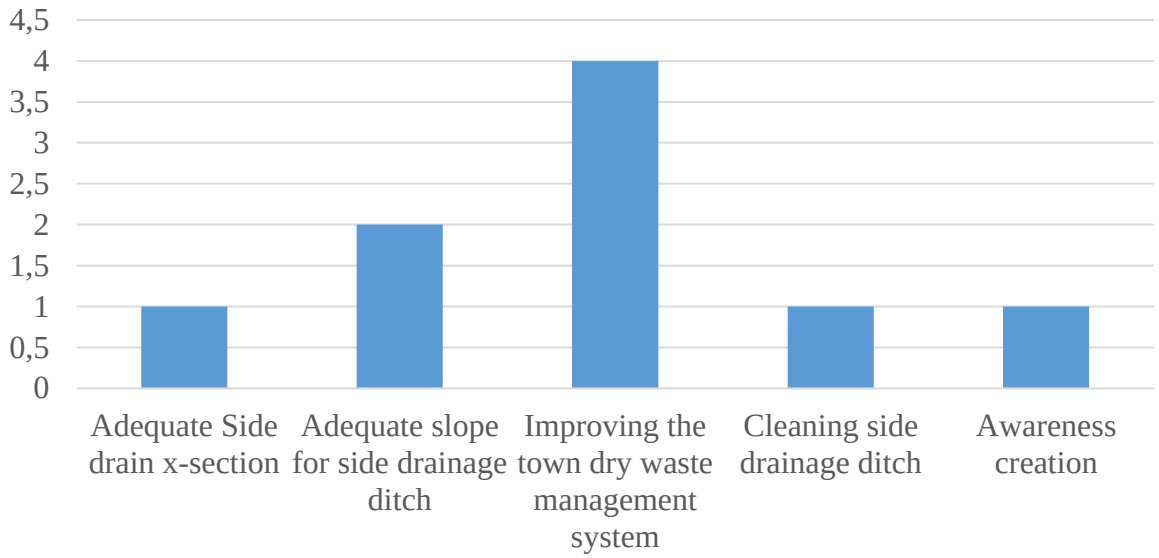


Figure 16 : proposed solution to tackle street flooding

The majority (78%) of the respondents stated that there are no solutions that have been taken by the municipalcity to overcome the problem on the road side drainage structure of the Wolkite main road (Table 3).

Table 3 : Solutions taken by the municipal

	Yes	No
Solutions taken by the municipal	22%	78%

4.2 Estimated Side drainage capacity

4.2.1 Full side drainage capacity

Full cross-section (Figure 1)By using manning equation, we computed Full side drainage capacity (Q=4.73m^3/s)

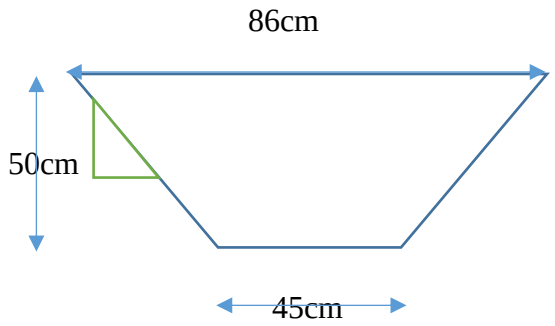


Figure 1: Full capacity of drainage ditch

4.2.2 Reduced side drainage capacity

Due to plastic and other urban wastes, the drainage ditch depth is reduced (Figure 2). By using manning equation, we computed reduced drainage capacity (Q= 2.46m^3/s)

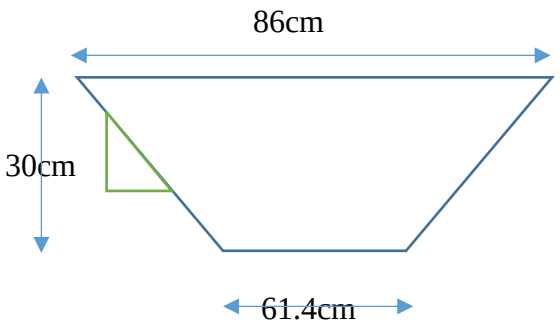


Figure 2: Drainage ditch with reduced capacity

4.3 Estimated design flood

By using rational method, for rainfall intensities of different return period are listed in Table 1. For example for 10 years, the computed design flood for catchment area one is Q=23m^3/s and for catchment area two Q=37.5m^3/s (Table 1).

Table 1: Expected flood on side drainage ditch 1 and 2

Return period (years)	Estimated flood on drainage ditch 1 (m^3/s)	Estimated flood on drainage ditch 2(m^3/s)
2		
5		
10	37.5	23

4.4 Evaluation of the existing road side ditch of the study area

Periodic inspection and evaluation of the road side drainage structure is essential to understand the area that are affected and take a maintaining measure.

Table 4 : Rate of existing drainage structure

Stations	Structure type	Rate
Marakye to Selam cafe	Trapezoidal side ditch	Poor
Selam cafe to Nib international bank	Trapezoidal side ditch	Good
Nib international bank to Total	Trapezoidal side ditch	Very poor

4.5 Evaluation of capacity of Side drainage (Comparison of side drainage capacity to design flood)

Comparison of estimated flood for rainfall intensities of different return period indicates that, the drainage ditch capacity is not sufficient for 10 year (Table 5).

Table 5 : Comparison of side drainage capacity to design flood

Year	Existing discharge capacity	Proposed discharge capacity	Excess discharge capacity
	Q(m^3/s) =V*A	Design discharge Q(m^3/s)	Q(m^3/s)
10 years	2.46m^3/s	4.73m^3/s	2.27m^3/s
2			

5 Discussion

The main aim of this study was to evaluate performance and capacity of existing side drainage ditch in Wolkite town, Ethiopia.

Result 1

From field observation, side drainage ditch was filled and blocked by chat sticks, plastic bottles, and other dry wastes. A study in Sudan, Khartoum has also found a similar result (Magdi Zumrawi, 2014).

Result 2

From Capacity analysis, Flood capacity is reduced by about half of the proposed discharge capacity.

Result 3

From resident's questioner survey, the side drainage management system is week in the town specially in rainy season, the major causes for the flooding problem is blockage of the side drainage structure by plastic wastes and chat stick or other dry wastes, lack of awareness and inadequate side drainage structure.

Result 4

In our study, most participants suggested improving Wolkite town dry waste management system to help prevent the street flowing due to side drainage filled with waste. The recommendation is consistent with previous findings in Ethiopia (Ydnekachew, 2019).

6 Conclusions & Recommendations

6.1 Conclusions

Adequate drainage systems are needed in urban areas because of the interaction between human activity and the natural water cycle. The impact of poor drainage condition at urban area is very damaging. It causes pavement distresses and deterioration which affect the safety and riding quality on the street, it also affects the life and properties of the people. Contrary to the general assumption that heavy rainfall is the major cause of urban flooding which mostly results into destruction of human lives and properties, the study shows that: inadequate drainage system, illegal sewer connection, solid waste dumping, and poor layout of road profile are the major factors responsible for street flood in Wolkite town.

6.2 Recommendations

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Appendix

Appendix A: Field observation of side drainage structure

Date: _____

Observer Name: _____

Observed Section: _____

Observed Side: _____

1. Nearby land-use
    a. Hotel
    b. Kiosk
    c. Residential
    d. Banks
    e. Schools
2. Drainage structure Geometry
    a. Shape
    b. Sketch and specify the dimension (length, depth, and width)
    c. Slope
    d. Material type
3. Condition of drainage
    a. Clear
    b. Filled with waste
        i. Plastic waste,
        ii. Solid waste
    c. Flowing water
        i. Clear
        ii. Organic waste
        iii. Household
4. Other observations

Appendix B: Data collected from Field observation

Respondents								
1	2	3	4	5	6	7	8	9
Does flooding a major around this site(station)?								
A	B	A	A	A	A	A	A	A
If your answer is yes, how do you rate the extent:								
A		C	C	B	B	A	B	B
What do you think is the major cause of the flooding problem on your site(station)?								
B	B	C	C	D	B	C	C	C
What are the reasons for the neighbourhood to dispose of dry wastes into the drainage systems?								
C	D	E	A	B	A	B	A	C
Which specific sites are most prone to flooding and why?								
Merka to-sefer	Catholic sefer	tele sefer	merkato sefer	merkato sefer	tele sefer	diaspora village	merkat o sefer	Ediget chora kebele
What temporary solutions/measures have ever been taken to the flooding problems?								
suctio n of the waste by truck	suction of the waste by truck	alerting the society	removin g obstacle wastes from the ditch	follow ups by the municipa l	alerting the society	digging the canals by groups	coverin g opened drainag e structur es	alerting the society
What permanent solutions have ever been taken to the flooding problems?								
haven notice d anythi ng tangib le	no permanent solutions have ever taken	NO	no permane nt solution s have ever taken	maintaini ng the suffered portion of the ditch	haven noticed anything tangible	nothing	NO	haven noticed anythin g tangible
What solutions do you suggest to handle such flooding problems on existing side drainage?								
provid ing an adequ ate x-sectio n	adequate slope of drainage structure must be provided	Providi ng disposa l progra m of wastes	providin g area for dry disposal s	removin g dry waste	adequate slope of drainage structure must be provided	governm ent must provide area for disposal	making awaren ess	providi ng disposa l area for dry wastes
Do the municipality act to provide some solutions to the problem?								
NO	NO	NO	Once	NO	NO	NO	YES	NO

6.3 Appendix C: Field Measurement of Longitudinal slope




10-12-2020
Google Earth
Marakye
United Bakery
Damena Sina
Anchebi Pension
Hayiru Super Market
Hiyar Yemuslim Resturant
Selam Café
MARK PECTUER
Commercial Bank of Ethiopia Bekur Branch
Yena Bar & Restaurant
100%
CNES / Airbus
Camera: 2,743 m 8°17'26"N 37°46'53"E 1,904 m
https://earth.google.com/web/@8.28970738,37.78151702,1903.01324675a,839.97947111d,35y,359.99450142h,0t,0r


10-12-2020
Google Earth
Yena Bar & Restaurant
Alefa Restaurant and Bar
Zemzem Bahil
Kana
Shopping Sentor
Yodi bar and
Nib International Bank
Mosque
100%
CNES / Airbus
Camera: 2,743 m 8°17'13"N 37°46'51"E 1,898 m
https://earth.google.com/web/@8.28551391,37.78057715,1894.07867959a,848.91397211d,35y,359.99450024h,0t,0r


Wolkite NOC S/S
A1
Commercial Bank of Ethiopia Wolkite Branch
Aba Dalecha Mosque
Foyat Tariqwa Hotel
Soresa
kokeb hotel
Total
A5
100%
CNES / Airbus
Camera: 2,743 m 8°17'00"N 37°46'46"E 1,888 m
https://earth.google.com/web/@8.28220479,37.77749341,1884.97345679a,858.01924566d,35y,359.99449831h,0t,0r


Welkite St. Mikael
Welkite Kidist Marriam
A5
100%
CNES / Airbus
Camera: 2,743 m 8°16'50"N 37°46'28"E 1,882 m
https://earth.google.com/web/@8.27994955,37.77079712,1872.50479973a,879.48786701d,35y,359.99449751h,0t,0r

6.4 Appendix D: Office task of identifying turning points and locating catchment area

