ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
COLLEGE OF DEVELOPMENT STUDIES
INSTITUTE OF REGIONAL AND LOCAL STUDIES

AN ASSESSMET OF ROAD AND DRAINAGE INFRASTRUCTURE SYSTEM INTEGRATION AND PROVISION IN SHIRE-INDASILASSIE TOWN, TIGRAY

By
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ACRONYMS

AAWSA → Addis Ababa Water and Sewerage Authority

BMP_S → Best Management Practices

DEFRA → Department for Environment, Food and Rural Affairs

NUPI → National Urban Planning Institute

SUDS → Sustainable Urban Drainage Systems

MWUD → Ministry Of Work and Urban Development

UDPD → Urban Development Policy Design

USWD → Urban Storm Water Drainage

USWM → Urban Storm Water Management

IUSM → Integrated Urban Storm water Management

WB → World Bank

ABSTRACT

With increasing trend of urbanization, provision of adequate urban storm water drainage facilities plays greater role in maintaining community safety and municipal asset from flood hazard. However, development of these systems is at its infant level in many of the secondary towns of Ethiopia. Shire-Indasilassie is one of the secondary towns in Ethiopia where huge amount of resource is depleted yearly at household and municipal level because of flooding. Despite the huge destruction of the public resource, seriousness of the problem is, however, not well recognized by municipal authorities. Nowadays, the ideal location of the town with respect to towns such as Gondar, Humera, and Mekele is attracting people from the nearby rural hinterlands and consequently exacerbate the problem of flooding and illegal multiplication of slums and squatter settlements in the town. These situations trigger the researcher to select this research problem in the town under discussion. Cognizant of the depth and breadth of the problem, the main intention of the researcher in conducting this study was to assess the condition of USWD system, determine the extent of road and USWD integration, and assess the risk of flood hazard within the context of the social, economic, physical and institutional atmosphere of the town. For the accomplishment of these objectives, the researcher employed mix of qualitative and quantitative data from households and various responsible municipal authorities. Result of the study clearly shows that the existing USWD facilities in the town are inadequate to properly remove urban storm water in the town. As a result of this, huge resources are depleted yearly both at household and municipal level. Result of the household survey on flood damage also reveals that income level of the majority of the households in the town is unable to solve the financial burdens of flood damage. The basic impeding factors for USWD development, according to the findings of this research, are disintegrated infrastructural management. lack of qualified human power and lack of adequate finance. Finally, the researcher recommends the municipality to strengthen the capacity of human power and establish workable organizational structures conducive for communication of the various stakeholders and integration of related infrastructural departments

Key Words: *Urban Storm Water Drainage, Road Infrastructure, Conventional Storm Water Drainage Systems, Source Control Measures to Flooding, Impervious surfaces, Infiltration.*

CHAPTER ONE: INTRODUCTION

1.1. Back Ground of the Study

Most cities of the developing countries face various highly interrelated problems, of which high incidence of poverty and unemployment; poorly developed infrastructure, inadequate public services; acute and ever worsening shelter deficits, and accelerated environmental deterioration tend to be significant. These problems are mainly the result of the mismatch between the rates of population growth and the pace of economic development.

Infrastructure is one of the indispensable elements in the process of urbanization and development of urban centers. It is considered as engine for economic development. It plays profoundly significant role in eradicating poverty and enhancing people's quality of life (WB, 2006).

In the absence of adequate infrastructure, other development activities will be halted. Development of urban centers cannot be imagined without integrated infrastructure development and management (MUWD, 2006).This is a clear manifestation of the importance of infrastructure provision for development.

Unlike the infinite importance that integrated infrastructure development and management provide for the development of urban centers and for the improvement in quality of the life of people. its existing status in Africa is at its infant level, which lags behind the rest of the world in terms of quality, quantity, and access. In Ethiopia, the problem is conspicuous owing to the very reason that there exists huge disparity between existing level of development and rate of population growth.

With increasing urbanization, a multitude of events can occur. These include, among others, increase in impervious area and increase in land demand. The increase in land demand would in turn result in the formation of illegal colonies, slums, and squatter settlements. Ultimately, the combined effect of these phenomena would result in an increase in the volume and pace of USW run offs which in turn, produces a multitude of social, economic, and environmental problems.

According to UN-HABITAT (2007), the inadequacy of coordination between different departments of infrastructure and among the different public agencies is the root cause for the poor infrastructure development. Recent public debate on Ethiopian Television and on a particular programme named *'Addis Zikre Hasab'* in 2009 also supports the idea of the UN-HABITAT,2007 that it pinpointed the lack of integrated planning, management, and implementation of projects among institutions, and between different departments as one of the major causes for the problem.

1.2 Problem Statement

Inadequate USWD problems represent one of the most common sources of compliant from the citizens in many towns of Ethiopia (GTZ- I, 2006).In fact, problems of USWD can be viewed from quantity, quality and management perspectives.

In terms of quantity, there is huge discrepancy between the entire built up area of Shire-Indasilassie and the capacity of drainage networks to carry the resulting storm water run off. Only a limited segment of the existing road system in the town is equipped with USWD facilities. As a result, storm water does not drain nor does it follow a designed drainage path, a problem that is causing serious damage to the roads, houses, properties, and electricity, communication and other utilities of the town. The combined effect of these problems in turn result in intense delay in transportation; huge investment for maintenance and significant decline in revenue that people could generate.

From quality aspect, owing to the inappropriate plan and the inadequate slope level of the town, storm water drainage systems of the town of Shire-Indasilassie are clogged by sediments eroded from the hilly areas which surround the town. As a function of this, the performance of the drainage systems is impaired and result in intense over flow and stagnation of storm water. Stagnated storm water and wet soils in the ditch, in turn, became convenient sites of malaria breeding, a new phenomenon occurring after the construction of the ditches (NUPI, 2004).

From management point of view, poor waste management, inadequate catchment management, and rapid expansion of slums and squatter settlements are among the principal factors that affect the quality and performance of the existing USWD systems in Shire-Indasilassie town. Furthermore, society's low level of awareness about the overall impacts of indiscriminate disposal of waste in relation to flooding and associated health hazards is another important factor that negatively affects quality of USWD system in Shire-Indasilassie town. It is common to see people discharging plastics, old clothes, and different household commodities in to the drainage channels and ultimately cause blockage of storm water drainage facilities.

In order to curb the aforementioned problems through better targeted programs, empirical works are essential. So far studies have focused on marginal issues.Besides; studies in Shire-Indasilassie are scanty. For instance, Tenagne (2009) studies the impact of urban storm water runoff and domestic waste effluent of Bahir Dar city on Lake Tana water quality. This study was conducted with a major objective of assessing the magnitude and type of the pollutant load in urban storm water runoff imposed by Bahir Dar city and the resultant water pollution in Lake Tana. This research describes the impact of the conventional urban storm water drainage systems and domestic waste effluent on water quality of Lake Tana, a problem beyond the reach of the level of economic development of municipalities of developing countries. Furthermore, this study disregards the current unmet needs of societies in Ethiopian towns.

Dagnachew (2009), in his enquiry on 'Urban Drainage System in Addis Ababa:Yeka Sub City', determined the extent of road and USWD integration, critically examine the major challenges in urban drainage management and the major impacts of USWD system on the existing natural water ways, and design USWD network as an option to sustainably manage the USWD system. Although he considered these varieties of important variables and determined the inadequacy of the existing USWD integration with the road system and the entire built up area of the town, the researcher did not assess the socio-economic impact of the inadequate integration on the livelihood of the people in the study area.

Gupta and Nair (2007), in their research on' Flood Risk and context of Land Use: Chennai city case', studied the impact of uncontrolled multiplication of built up areas to flood risk. This study tried to explain the impact of uncontrolled multiplication of built up areas on the performance of storm water drainage facilities and disregarded the effect of other most important variables such as poor catchment management and poor waste management that should be considered to ensure proper storm water drainage management.

Therefore, the writer's intension while doing this research is to investigate the existing condition and integration of the road system with USWD systems and to assess the impact and risk of flood hazard in the study area thereby fill the gap in the literature. While these all are about the identification of unexplored but important research area, the justifications behind the selection of the study problem within the context of the selected place of study area are clarified as follows.

1. The ideal location of the town Shire-indasilassie with reference to cities like Gonder, Humera and Mekelle is nowadays attracting people from the surrounding rural hinterlands. As a result, the number of slums is alarmingly increasing. This in the long term, coupled with the poor land administration system of the town, can highly reduce the permeable surface of the town, increase the speed and intensity of storm water runoff, and cause devastating damage on the livelihood of the town community.

2. The town Shire-indasilassie, more than any town in the region, is characterized by poor catchment management. As described in NUPI (2004), the hilly area in the northern direction of the town (Mt.May Emut and Mt.Adikentibay) is included in development plan of the town only recently. As a result of this, USWD system at the foot of these hills is blocked by eroded sediments. This in turn causes storm water over flow and intense damage on infrastructure and the livelihood of the urban residents.

3. The researcher had work experience of two months as an assistant infrastructure coordinator of the municipality in the year 2010. As a result, the researcher had closer attachment with the staff members of the municipality and gain valuable information on the overall barriers in infrastructure management. Besides to this the researcher is very familiar with the urban community.

1.3 Objective of the Study

1.3.1 General Objectives

Generally, the researcher tried to explain and investigate the existing condition and integration of road and USWD infrastructure and assess the impact and risk of flood hazard along with the multitudes of factors that affect the provision of adequate USWD system in the town.

1.3.2 Specific Objectives:

Specifically, the study has the following objectives:

- ✓ Assess the existing condition of road and USWD infrastructure
- ✓ Determine the extent of adequacy of USWD and road integration
- ✓ Assess the impact of flood hazard within the context of the physical, institutional, and socio-economic condition of the study area
- ✓ Explain the fundamental factors that affect road and USWD integration

1.4 Significance of the Study

This study deals with one of the major problems of Shire-indasilassie town, USWD. Therefore it is an advantage for the municipality to use the findings to improve the current situation of USWD integration with the road system of the town. Furthermore, this study can enable local authorities and other responsible organizations to have an insight into the extent and severity of the problem of the inadequate provision of USWD systems in the town. In so doing, this study can create an opportunity for residents of the town and the various stakeholders to communicate with the municipal authorities on their unmet infrastructural needs. By the same token it can be used as a catalyst for further research interests. However, if left untouched, inadequate provision of USWD facilities coupled with the rapid urbanization rate will exponentially increase the severity of the problem and can affect urban development in general and community safety in particular.

1.5 Scope of the Study

Geographically, the research is delimited to shire-indasilasse town. Areas of investigation for the research were existing condition of road and USWD, adequacy of the integration of the road system of the town and USWD facilities, impact of flood hazard within the context of the physical, institutional, and socio-economic condition of the town; and the fundamental factors affecting adequate provision of USWD facilities.

1.6 Limitation of the study

The sample size is limited to 200 households because of resource constraints. The other limitation encountered in this study was lack of adequate information due to improper document handling in the municipality of the town. It was difficult to get source documents in an organized manner.

1.7 Organization of the Study

The thesis consists of five chapters. The first chapter covers the introductory part which includes the background, problem statements, and significance of the study, objectives, research methodology, the scope, limitation, and organization of the study. Chapter two provides literature review. The third chapter describes the background of the study area. Chapter four discusses the results and findings. Finally chapter five presents conclusions and recommendations of the study.

CHAPTER TWO: REVIEW OF LITERATURE

2.1 Review of Theoretical Literature

2.1.1 Urbanization

Cities now house 50% of the world population, consume 75% of the world's resources, yet occupy only 2% of the land surface (Maksimovic N.D). In 1990, only 15% of the world's population lived in cities; today the percentage is more than 50% and the United Nations forecasted that between 1990 and 2025, the urban population will rise to 5 billion, 90% of that in developing countries (Tucci,N.D). As to cedo maksimoric, by the middle of the next century, it is confidently predicted that 70% of the global population will live in urban areas. The number of mega cities (>10 million people) will increase to over 20, 80% of which are in developing countries (Niemcynowicz, 1996).

A properly designed and operated urban drainage system with its interactions with other urban water systems is crucial element of healthy and safe urban environment (ibid).

As a continuation to this Price (2000) in his study of Hydro informatics and urban drainage: an agenda for the beginning of the 21^{st} century recommend municipalities to have a well organized computer data base on urban land use and over all infrastructure to cope the challenges for sustainability which will be inevitable in the period of urbanization during the next 50 years.

2.1.2 Urban Drainage: History

Drainage of urban settlements has been practiced for more than five thousand years, but the recognition and understanding of drainage impacts on the environment and the need for mitigation of such impacts has emerged fairly recently, during the last 40-50 years. Urban drainage was first built to improve living conditions in urban settlements by preventing water logging and draining marshes for new development. Historical records refer to early urban drainage structures in the Mesopotamian Empire (Wolfe, 2000), but the drainage construction skills flourished somewhat later in ancient Rome and Pompeii.

The best example of ancient Roman drainage achievements is the Cloaca Maxima, which was constructed in Rome around 510 BC to drain marshes and transport wastes to the Tiber River. The outfall of the Cloaca Maxima into the Tiber still exists today. Other remnants of urban drainage structures were preserved in Pompeii, where roadways were used for runoff conveyance (a concept rediscovered in the 1960s) and references to a drainage manual were found. After the decline of the Roman Empire, sanitation practices generally deteriorated, and open drains and streets were used indiscriminately for conveyance and disposal of all wastewaters. In later times (16th-18th centuries), some progressive strategies for managing wastewater and storm water emerged, with both effluents considered as valuable resources (Mangier, 1991). For example, faces were harvested for production of organic fertilizers, urine infiltrating into urban soils formed saltpeter that was used in making gunpowder and storm water was collected and stored in cisterns to provide an important water source. During this era, neither horses nor pigeons were allowed in these squares. However, the practices of wastewater disposal were generally not hygienic and numerous epidemics of typhoid and cholera in Europe and the United States, between the 1830s and 1870s, prompted city governments to find other solutions for dealing with sewage disposal and eventually its treatment in the form of sewer systems and wastewater treatment plants (Wolfe, 2000). In the 19th century, an empirical foundation for drainage pipe sizing was laid with the development of the rational method, which is generally credited to (Mulvaney, 1851). Variations of this formula have been developed in other countries. Use of the rational method dominated engineering drainage practice until the late 1960s, and it is still widely used in some parts of the world and in certain applications (i.e., small drainage areas with simple tree-type sewer systems, no controls, no storage, no backwater, etc.). During the rational method era, the general goal of urban drainage was to collect and quickly remove storm water from urban areas and discharge it into nearby receiving waters. Since the 1960s, rapid developments have occurred in urban drainage practice, particularly with respect to design methods. A number of runoff hydrograph methods were developed, starting with the Chicago Hydrograph Method, followed by the Road Research Laboratory method, the

Storm water Management Model (SWMM), and many other models. The introduction of computer modeling greatly advanced this field and led to the current state where it is possible to calculate sewer network flows with the accuracy needed for proper design, analysis and operation of sewer systems. The development of water quality aspects occurred somewhat later and focused on the quality of storm water, overflows from combined sewers, changes during transport, quality enhancement by control measures and treatment, and impacts on receiving waters. The complexity of water quality modeling is such that many challenges still exist in this field, but the available models, after calibration, are generally adequate for most of the engineering tasks. Major changes in drainage design philosophy were introduced in the late 1980s and the early 1990s, as a result of: (a) introduction of the sustainable development concept, (b) acceptance of the ecosystem approach to water resources management, (c) improved understanding of drainage impacts on receiving waters, and, (d) acceptance of the need to consider the components of urban drainage and wastewater systems (drainage, sewage treatment plants, and receiving waters) in an integrated manner

2.1.3 Storm Water Management: Key Issues

a) Urban Storm Water as a Resource

Storm water is water from rainfall (and in some cases snow melt runoff) that does not infiltrate the ground or evaporate because of impervious (unreceptive) land surfaces, but instead flows onto adjacent land or watercourses, or, is routed into drainage/sewer systems.

Cities are faced with increasing scarcity of fresh water resources. This is due to greater and competing demands as well as the impacts of climate change such as shifting or decreasing seasonal rainfall patterns and drought.

Storm water supplies do however serve as important local solutions and opportunities to deal with this scarcity. Storm water for use in urban agriculture, or for recharging ground water aquifers where relevant, has a double value as it provides not only an important additional source of water but also reduces the need for expensive storm water drainage facilities. However, it must be noted that recycling storm water can present certain hazards. Runoff from the first storm after a dry interval in an urban setting may be similar to raw sewage, especially where sanitation is poor, control of industrial wastes is weak, or where municipal solid waste management is deficient (Kalbermatten, 2000). Storm water quality and required treatment in relation to intended purpose should therefore be carefully considered prior to storm water (re-)use (Kalbermatten, 2000). Finally, the value of effective storm water management can also be seen in terms of reduction in associated costs of rehabilitation and reconstruction in the aftermath of extreme weather events.

As growing urban communities approach the economically viable limits of water supplies, opportunities associated with use of local water sources such as urban storm water and groundwater are being recognized. Better management of the water cycle at the residential lot needs to be achieved to reduce demand for domestic irrigation. Where urban areas are located over or adjacent to groundwater aquifers, there is potential for storm water to be used to recharge aquifers provided the water quality is protected. This requires very careful management.

b) Community Values and Participation

Informal and slum settlement areas do not enjoy the same benefit of flood protection as more established, formal and relatively 'richer' urban areas. Not only do they lack existing storm water conveyance systems as the development of slums takes place largely on an ad hoc and informal basis, but even where they have been officially incorporated into the municipal system and structure, they lack the political power, mandate and financial means to construct and maintain new ones. Additionally, there may be little community interest in storm water management except for periods directly following a damaging and disruptive flood event. Therefore, as with other aspects of environmental sanitation, community involvement in thinking and planning for storm water management will allow residents of a settlement to explore and improve their understanding of the problems, issues and their own values pertaining to protection against flood waters as well as the reuse of storm water for other purposes. Attention can focus equally on providing flood protection and providing improved environmental sanitation and productive opportunities. For these reasons, it is essential that storm water management programmers provide adequate opportunity for the community to be involved in the development and implementation of storm water management strategies.

Community involvement helps to:

- Explore and improve understanding of problems, issues, and community values;
- Identify and prioritize strategies that are responsive to community concerns;
- Generate a comprehensive and locally appropriate range of management options;
- Increase public ownership and acceptance of proposed solutions;
- Generate broader decision-making perspectives not limited to past practices or interests;
- Draw on the knowledge and skills available across the wider community;
- Provide opportunity for involvement from all sections of a community – poorer, richer, men and women, youth, etc. for greater effectiveness; and,
- Reflect the community's life style values and priorities.

2.2 Review of Empirical Literature

2.2.1 Challenges of Sustainable Urban Storm Water Management in Developing Countries

Sustainability is already recognized as a very important concept for the urban drainage management. There are, however, many difficulties to effectively implement a sustainable urban storm water approach in developing countries (silveriralet, 2001; silveria and goldenfum, 2004).

Urban drainage control measures include a series of different aspects, ranging from technical engineering solution, architectural design, legal, and economic questions. Each of these subjects has to be considered in an integrated view, so that the adapted measures can produce the desired results. In developing countries, the climatic and socio economic conditions bring difficulties to the use of solutions adapted in temperate areas. Problems such as greater capacity to generate run off, greater erosive capacity, favorable conditions for the proliferation of vectors or carries of tropical diseases, allied to uncontrolled urban expansion, precarious public works cleaning and inspection services, technically out dated and ill planned storm drainage systems can complicate, and even make not feasible, the use of some devices and structures already in use elsewhere (silverial *etal,* 2001). While the developed countries are concerned with problems related to diffused pollution on the pluvial waters, developing countries such as Ethiopian, turkey , India ,Iran still present low coverage on drinking water and sewerage networks, and precarious urban drainage infrastructure(Wondimu *etal*, 2004).The existing drainages systems become inefficient face to the rapid expansion of the towns and cities, and the usual practice to control urban drainage is the rapid out flow of excess storm water by open channels and buried conduits, usually mixed to the sewage. Sediments and solid waste bring more complexity to this situation, contribution to dissemination of disease to the population as commentated by Rahman (2004). According to Silveira *etal*, (2004). The use of technical solutions aiming to control run off generation at its source is in general, at initial stages of research and development, being applied neither in public nor in private works. Also, there are few resources for infrastructure implementation (Yilmaz and Rahman. 2004) and a weak optimization of these resources, as result of a bad management, where each sector develops its actions separately and with no integration with other areas, as stated by Wondimu (2004). Several structural or non-structural control measures could be adapted to climate and socio economic conditions in an integrated view, together with environmental planning of urban areas putting together all aspects involved. The development of urban drainage master plans and the implementation of compensatory techniques may possibly be valid instruments to tackle these limitations. However, these solutions face many obstacles such as: data deficiency, lack of knowledge and technical information of infiltration and storage devices, and water quality problems. All these problems bring resistance from designers, public managers and the population to the implementation of distributed and on-site flow control devices.

2.2.2 Physical Impacts of Inadequately Developed Drainage Systems

A study conducted in various Latin America and African nations reveals the existence of significant physical damage due to uncontrolled urbanization and inadequately developed drainage systems. For example urban growth in Brazil has been characterized by irregular expansion of the peripheral areas, not paying much attention to urban master plan, and specific land development rules, besides the irregular occupancy of public areas by low income populations. Thus, there are legal and illegal city. It requires law enforcement and more realistic policies regarding land use infrastructure development and investments. Storm water runoff can produce floods and impacts on the urban areas can produce floods and impacts on the areas due to low processes which could occur in integrated or isolated, flood plain and flooding due to urbanization.

In dealing with the physical impacts of uncontrolled urbanization and poor drainage system the experience of the West African nation Senegal is worth mentioning. Flooding is one of the most serious problems Senegal has been facing, making it a serious concern for the Government. At the end of August 2009, heavy rainfall once again caused serious flooding in Senegal, particularly in Dakar but also in the rest of the country. This has costed the country a huge sum of money 104 million USD [on line].

2.2.3 Environmental Health Impact of Poor Urban Storm Water Drainage: Particular Country's Experience

When urban development takes place on a natural landscape it changes the natural drainage pattern of the area. And in doing so it impacts up on the overland storm water runoff in two ways. The first change that urbanization causes to the natural land escape relates to the nature of the surface cover. Thus the permeable surface (i.e. the surface which allows water to permeate in to the ground) is reduced, while the impermeable surface (i.e. the surface which acts as a barrier to water seepage is increased. In addition the natural features that provide interception and depression storage are also lost (Parkinson, 2003).

The second impact of urbanization on the natural land escape is caused by the drainage systems that are designed to carry the storm water run off from the urban areas. The net effect of installing a drainage network is to speed up the flow of water through the area. And this in turn makes the town more vulnerable to smaller storms and increases the risk of serious flooding (GTZ-IS, 2006).

Inadequate development control mechanisms and their incompetent enforcement, which ultimately results in the formation of informal settlements, further exacerbate urban drainage problems.

The impacts of problems related to urban storm runoff and urban drainage can be illustrated from different physical and environmental health perspectives. Physically, flooding can cause wide spread disruption to transportation, power, and communications systems, as well as structural damage to buildings and infrastructure. The disruption, damage to properties, loss of possessions, as well as financial worries and other stresses mean that flood events can place a considerable strain on households. These problems are recognized to be significant even in countries such as the United Kingdom where flooding is typically small-scale, shortened and shallow. But they take an extra dimension in cities in tropical regions.

With respect to environmental health, large-scale flooding may disrupt water supply and sanitation systems and result in disease epidemics. In poorly drained areas with inadequate sanitation, urban run off mixes in excreta-spreading pathogens around communities and infiltration of polluted water in to low pressure water supply systems can contaminate drinking water and is frequently a source of gastrointestinal disorders. Wet soils in poorly drained areas, which become faecally contaminated due to poor sanitation, also provide ideal conditions for the eggs of parasitic warms, such as round worm and hookworm, which can cause debilitating intestinal infections (Jonathan, 2003).

Road pavements and other substantially impervious surfaces associated with vehicular movements including driveways and car parks can contribute as much as 70% of the total impervious areas in an urban catchment and are recognized as sources of various pollutants to the water environment.

A. Chennai city experience

Chennai, a costal mega city is fourth largest metropolis in India, has a history of 350 years of growth. Meteorologically there is there is no major up ward or down ward trend in rainfall during 200 years, and a decrease in last 20 years with a contrast record of increasing flood have been experienced. Analysis of land use changes over the temporal and spatial scale has been undertaken for Chennai city in order to understand the pattern on green cover, built up area, and consequences on hydrological settings.

Chennai lacks natural gradient for free run off. This necessitates an effective storm water drainage system. Since the beginning of the 20^{th} C, Chennai has witnessed a steadily deterioration of and decrease in water bodies & open spaces.

Chennai population has grown 8 times in 1901-2001 period and per hectare population density has increased form 80 to 247. There are three major water courses (Cooum, Buckngham, and Aydar) in Chennai and the banks of all the areas are highly encroached. The slums (recorded to be 30,922) have developed there with out basic amenities and area subjected to flood every year. They often pollute the water courses making health conditions worse (CPPREEC, 2008).The green covers reduced rapidly across the city between the years 1997 to 2001, at some what almost 99% of the green covers reduced/replaced by the non-vegetative development (www.hindu.com). As a result, the water holding capacity of the city's surface gone down drastically. The reduced city's water holding capacity combined with the augmented impermeable surface increased the peak flow, up to 89% from the year 1997-2001

Increased surface run off and reduced retention capacity of the land cover almost stopped the ground water recharging process in the city. The ground water level came down up to

10m from 1997 to 2001(CMWSSB, N.D). The green cover reduction and the increased impermeable surfaces lowered the ground water to the extent of 33% at some part of the city between 1997 to 2001. This eventually reduced ground water quality (the Hindu. 2004).

The study conducted by the (Hindu. 2004) identifies the major causes for increased flooding in Chennai. These include:

a. Uncontrolled multiplication of built up areas and loss of drainage. Drainage channels have been blocked and urban lakes filled and encroached, canals degraded and polluted, heavily silted and narrowed. A 1994 survey revealed water ways contamination and anaerobic digestion led to sludge accumulation causing hydraulic hindrances.
b. Inadequacy of storm water drainage system and lack of maintenance (Drescher *etal* 2007). Chennai city has only 855km of storm drains against 2847 km of urban roads, plastic and polythene constituents to the storm water stream along poor or no maintenance aggravates floods,
c. Increase in impervious surfaces: paving of road sides, park and open areas causing flood severity and condition for following draughts,
d. Lack of coordination between agencies: lack of unified flood control implementing agency that could integrate the functions of corporation development authority, public works department, slum clearance board, housing board, etc… adds to peak points.

The paper finally recommends land- use planners and disaster management experts to integrate their efforts for better and sustainable results.

B. Bogota city experience

As a major element of the environment and the general ecosystem, the issue of water and water quality is also a major concern while dealing with drainage systems. With respect to this, infinite numbers of works have been done through out the capital city of Colombia, with 7 million inhabitants and approximately 330km^2 of urban area. The urban drainage system in Bogota consists of combined and separate systems with a very large number of wrong connections. Direct discharge of waste water, combined sewer over flow discharges in to the streams is some of the problems associated with combined systems in Bogota. Based on flow surveys in some interceptors, the percentage of wrong connections from the storm drainage system in to the waste water system varied from 23% up to 90% (Grucon-IET-soprin, 1999).

As a consequence, the separated system exhibits poor water quality in the storm drainage channels and there is a high risk of sewer flooding during intense ran fall events.

Finally the paper concludes as this is the time to develop plans for an efficient integrated system which considers the existing technological, environmental and socio-economic elements and ultimately maximizes the benefits from the resources available.

D. Israel's Experience

The other indirect mechanism that urbanization and poorly developed drainage facilities affect the environment is through the process of erosion and sedimentation. Sediment problems associated with floods poses difficult challenges to planners and managers of towns in general and desert towns in particular.

A study conducted in sediment management and flood protection of desert towns: effects of small catchments in Eilat in southern Israel clearly explain the situation. In Eilat, up stream dams constructed to protect down stream towns and structures are occasionally subjected to surprisingly high rates of sedimentation, often by single high magnitude low frequency event. Their loss of storage increases the probability of subsequent breach by over flow, initiating a human-inducted flash flood. As most of these structures are earth dams, the possibility of a breach by seepage is not a rare occurrence and must be considered. Further down stream, much use is made of flow diversion by drainage ditches which often cause the flood water to be deflected at an angle beyond its natural tolerance. The result is the onsite deposition of nearly all the bed load (generally amounting to between one half and three quarters of the total sediment load) .Complete clogging of the ditch and a subsequent "jump out" of the flood waters. Much of the over flow, even if successfully, controlled further down stream, finds its way on to the artificially flattened urban areas (parking lots, air fields, recreation areas) where large sediment is deposited.

2.2.4 Technical, Financial, and Organizational Factors as Barriers and/or Drivers to Sustainable Storm Water Management

From the legalization point of view, for a storm water programme to be effective, it must be enforceable. State legislation may be necessary to establish local regulatory authority, to levy taxes or fees to finance such a program, or to allow creation of a special utility or control district. Consistently applied, well documented and technically sound policies and procedures are of vital importance to cities drainage development (Debo & Reese, 1995).

The issue of finance is also another critical factor which affects USWM profoundly. When compared to other infrastructures, the emphasis given to urban drainage facilities is lower and is chronically funded (Herz, 1998). The problem of fund in one way or another is closely tied with the lack of focused authority. The responsibility for management of the urban storm drainage and flood control system is not clear-cut. Other urban system such as water supply, transportation, and sewerage systems are provided as a necessary condition for urban development. For these services a management systems is created. Storm water facilities, although desirable, are not provided until need is demonstrated by flooding and subsequent inconvenience or hardship. Thus, systems for urban storm water lag behind other urban systems. Maintenance of storm water facilities is often neglected because of the lack of adequate management (Korbitz, &Reese, 1995).

Defra's integrated urban drainage pilot studies have confirmed that "current institutional arrangements mean that responsibilities for managing storm water in urban areas are complex, confusing and distressing for the public and this leads to:

- A lack of information for those affected by flooding; people may get passed between organizations with no one taking responsibility;
- Insufficient risk assessment, as no single organization has the incentive to carry it out;
- Development planning decisions being taken without a full understanding of the risks of urban flooding
- Separate organizations making investment decision based on priorities in their own area of responsibility, without considering the wider drainage issues.

The cause for the lack of single staff position for the management of USW is rooted again in the poor integration of municipal infrastructure. The increasing complexity and sophistication of infrastructure management processes resulted in creating diverse areas of knowledge, expertise, and responsibilities within and across municipal departments (e.g. water, sewer, and road management). As a result, a state of process fragmentation was created primarily due to the enormous volume of complex information that needs to be generated, exchanged, and the difficulty to streamline and coordinate these inter-dependent processes (Halfway &Parkinson, 2003).

The desire to implement efficient and optimized infrastructure management strategies has created a strong demand for "bringing the gaps" through adopting integrated approaches.

An integrated approach to infrastructure management can potentially eliminate many of the fragmentation inefficiencies given community and other stakeholder's inclusive administrative procedures which are clearly defined and efficient. Collaboration between government agencies and non-governmental organizations, in conjunction with communities, is essential but often challenging. However, many of these constraints may be over come if there is a political and institutional commitment to overcoming problems and, specifically, consideration of and concern with the needs of the urban poor (ibid).

The broad characteristics of urban storm water management problems in developed as well as in the developing world may include, among others, an increase in the frequency of floods, intensive erosion processes, and water pollution. To deal with the adverse impacts of urbanization, municipalities can use a wide range of technical, organizational, legal and financial tools and resources. In tropical cities, these resources and tools are frequently lacking, thus aggravating the effects of urbanization (ibid).Particular countries experience with regard to this issue is presented here under.

A. City of Belo-Horizonte

A study conducted on 'storm water management problems in a tropical city – the Belo horizonte case study' clearly analyzed and discussed these questions. Belo-horizonte is located in south east Brazil and has a population of 3.5million. The city lies as 20^0s 44^0 W and has an altitude of 750-1300m (Baptisa & Nescientto, 1996).

Planned to be the capital of the state of Minas Gerias, the cons traction of Belo Horizonte began at the end of the nineteenth century. The project was inspired by the strong positivist principles of the area and based on rigidly regular streets and broad avenues at right angles to form square blocks. Thus, the adapted urban model completely ignored natural, existing local characteristics such as the regions topography and hydrology. And result severe problems.

From technical point of view, the plan for Belo-Horizonte was strongly influenced by the then current concept of urbanization called hygienist. According to this concept, the main objective of urban drainage system was to remove, as quickly as possible, sewage and waste water from urban areas in order to reduce the risks of flooding and contagious water- borne diseases. The association of hygienist with the tropical cultural and economic conditions, how ever, led to typical set of storm water problems mainly due to the use of apparent simplicity of very simple design methods for storm water systems. Synthetic models were used which do not require observed data to celebrate parameters (e.g. rational methods)

As far as legalization of developments is concerned, previously urbanized areas are frequently impacted by new urban development. New urban development projects are not required by law to estimate or mitigate their impact on flow conditions down stream, nor to take in to account the impact of future up stream development.

Since municipalities do not demand impact assessment, new drainage projects are designed as independent unconnected systems. The consequences usually include an increase in the frequency of floods downstream and the rapid obsolescence of existing drainage systems. These problems are aggravated by factors like rapid urban growth and unequal income distribution among inhabitants, which generally leads to uncontrolled occupation of precarious areas such as flood plains and steep hillsides that risk land slides.

In Belo-Horizonte, 15% of the city's residents live in shanty towns which are normally located in high risk areas. The city was originally planned for 200,000 inhabitants and as previously mentioned, the metropolitan regions is now home to 3.5 million people. Although planned in outline, the city has grown in a disorderly manner. Geologically unstable areas and regions that are prove to flooding have been occupied with out proper planning and flood control measures, and with out regard to urban water courses.

The lack of legal recourse and institutional oversight also has an effect on storm water pollution and erosion processes intensified by urbanization. Although sewer systems are used to drain storm water and sewage, illegal dumping of waste water in to streams and illicit connections of sewers in to the storm water system are common. Dumping of garbage in to streams is also frequent in poor neighborhoods, which are under salved by solid waste collection services.

After intense discussion on the problem, the researchers confidently noticed the solutions to urban drainage problems are inhibited by weak municipal institution and poor organization. The lack of municipal offices devoted to storm water management, the dependence on political support, the absence of well-trained, up to date technical staff and an inadequate budget are identified as major causes of the problems described so far. Further more the research reveals the existence of numerous problems like inadequate legal tools to effectively regulate and control the illegal dumping, illicit connections and uncontrolled growth that ultimately lead to flooding, sedimentation, erosion, and pollution.

Cognizant of the already explored economic, social, environmental and political problems, the researchers conclude as there is a necessity for conceptual technical and political change in the way urban drainage problems are handled.

Ultimately, storm water master planning, regulatory enforcement and strong leadership were considered indispensable for effective storm water management.

B. Waitakere City Experience

An assessment of the impacts of urbanization, and in particular catchment imperviousness, on stream flow regime and aquatic ecosystem health was conducted in waitakere city under the heading *'pointing the way to reducing storm water impacts on urban streams'* waitakere city is typical of new Zealand's urban land. As a means to reduce impacts of storm water flow on urban streams, the researcher gave a top priority for the integration of road, water and drainage engineers with environmental scientists and urban planners to gain a better understanding of the interrelation ships between their respective fields of expertise.

As part of this process, the researcher in his conclusion emphasizes the need for adopting truly integrated planning approaches that are not discipline-or function-based, as is currently practiced. Having recommended this, the researcher continues by saying:

> *No longer should water, drainage, road engineers, urban and environmental planners work in isolation. These practitioners must jointly adopt an ecosystems-based approach to urban design that will ensure component of the urban environment complements and supports the sustainability of the entire system with development of new urban design and storm water management practice, these practitioners are in an ideal position to set new, more challenging goals to improve the quality of out towns and cities through implementation of water sensitive urban design.*

C. The Wuhan City Experience

With regard to the institutional problems for drainage development countries, the same history was also found in SUDS applicability study undertaken in Wuhan city. Compared to many other large cities in china, Wuhan has experienced a remarkable growth both in terms of the economy and the size of the population, during he last couple of decades. Between 2000 and 2007 the city's economy tripled in size (Arndt, 2008) and the population amounts to more than 8 million people (Wuhan Municipal Government, 2007). This development has increased the stress on the urban drainage system. Despite the rapid increase in the waste water in the city, release of large amount of untreated water is common (Hagbery, 2007). The urbanization processes equivalently increase the magnitude of storm water effect through its effect on the level of impervious surface. The combination of these factors makes improvement in the area necessary. With this intention, adopting the experience of Sweden, the municipality of Wuhan planed to develop a new area in the central part of the city to become a sustainable central business district. However, its implementation was severely tested because of the complicated structure of governmental institutions in Wuhan. There are for example agencies that are directly related to urban drainage and four other agencies that share the responsibility for maintenance of public land. Consequently, the absence of single agency responsible for the development of storm water drainage significantly diminishes the power of the municipality to influence development of storm water drainage.

D. Birmingham City Experience

Despite the relative disparity in the degree of impact that they produce, institutional, legal, and financial factors are acting as barrier and or drivers to effective implementation of SUDS in both developing and developed countries. Result of a research on *decision making processes and institutional mapping for storm water management in the city of Birmingham, UK* is concrete evidence.

A key characteristic of the institutional arrangement that characterize the regulatory and legislative environment for SUDS in England is that they are reliant on legislation designed and developed for other purposes, most notably legislation related to traditional 'hard' engineering and piped systems and that relating to planning (Green et.al, 2007).

Unfortunately, this legislation doesn't make provision for the wider range of components associated with SUDS, leading to a lack of legislative clarity regarding both the ownership and responsibility for SUDS maintenance and a reduction in their uptake (Defra, 2005). This further compounded by the fact that the sewerage system is not owned by only one stake holder, nor is it in common ownership. Instead, a wide range of stakeholders have ownership and maintenance responsibilities for both public and private drainage systems, leading to further institutional complexity, confusion and non-adoption of a number of SUDS (Defra, 2005). The end result is an institutional land scope which, arguably, in its present form is ill-equipped to deliver a sustainable system of integrated urban drainage management.

As to Defra (2008), the tenuous and sometimes ineffective lines of communication between the various stakeholders and the unclear boundaries of overlapping responsibilities can only be addressed throng amendments of legislation, institutional and planning arrangements;

Cognizant of the over all situation of problem, the writers conclude that the major impediments and barriers to integrated urban storm water management (IUSM) in Birmingham is not technology dependent but rather institutional and social. A recent review of international literatures also supports this finding.

2.2.5 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 storm water through proper drainage facilities become essential (NUPI,2000).

Drainage problems in Ethiopian urban centers include flooding, deterioration of roads, land degradation, sedimentation, and blockage of drainage facilities, water logging and the like. With urbanization, impermeability increases with the increase in impervious surfaces such as residential houses, commercial, buildings, paved roads and parking lots. As a result and drainage pattern changes, overland flow gets faster, flooding and environmental problems such as land degradation increase.

After its inception, Federal Urban Planning Institute (FUPI) (the then NUPI) has been evolving 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, urban pollution from stagnated water and soil from erosion and land 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 nowadays the attention towards urban storm water drainage system is at its immature stage that is why most of the urban storm water drainage structures get blocked with wastes of various types after huge resource has been invested on them. In some areas these systems are sources of environmental problems.

Generally, the urban storm water drainage system in Ethiopia is at its poor condition. Some basic witnesses of the poor urban storm water drainage systems include:

- The unforgettable flood hazard which occurred in Dire-Dawa in August, 2006
- The yearly repeated flooding problems in various parts of Addis Ababa, which have been resulting in congested traffic movement, property loss, soil and water degradation, and other infrastructure, particularly around "Filwoha", National bank of Ethiopia, Addis Ketema Comprehensive Secondary School, General vegetables market are some of the notable ones.
- The flooding and the sedimentation in Hawassa Town and its lake resource is also the other significant problem which has been occurring due to inadequate urban storm water drainage provision and management.
- The landslides and soil erosion problem in Dessie and Adigrat Towns.
- The run-off water stagnation problem in Bahir-Dar due to inadequate provision of urban storm water drainage system is also the other big challenge in spreading malaria and other water borne diseases.

These and other problems are the notable challenges of inadequate urban storm water drainage system in Ethiopia. The only mechanism to alleviate these all problems is adequate provision and integration of USWD systems.

Despite the multitude of benefits that source control measures to flood hazard such as construction of detention ponds and retention structures could provide, the country solely depends on systems that are economically unviable and environmentally unsustainable.

2.2.6 Road and USWD Integration in Ethiopia

Road and USWD integration in most towns of Ethiopia is at its infant stage. As can be inferred from Girma (2004) much of the asphalt roads in Axum and Combolcha towns are totally devoid of any drainage system. Regarding the numerical value of the level of road and drainage integration there is 49m, 9m, 18.33m, and 11m of urban storm water drainage system for every 1km of road in towns Dessie, Dilla, Axum, and Combolcha respectively. Dagnachew (2009) in his enquiry on *'The Study of Urban Drainage System in Addis Ababa: Yeka Sub City'* also determined the level of road and drainage integration in three kebeles in the sub city. According to his finding, for every 1km of road there is 336m, 184m, and 303m of storm water drainage system in kebeles 01/02, 08/15 and13/14 respectively. Furthermore, the researcher calculated the ratio of storm water drainage to the entire built up area of the three kebeles in the sub city. Accordingly, for every one hectare of built up area there is an equivalent of 0.036km, 0.0067km, and 0.0578km of storm water drainage system in kebele 01/02,08/15 and 13/14 respectively. The summary of the ratio of the entire built up area and existing storm water drainage system to the total road network in the Sub City is presented here under.

Table 2.1 Road and USWD Integration in Addis Ababa: Yeka Sub City

Kebele	Entire USWD Network / Entire built up area	Entire USWD Network / Entire Road network
01 02	3.6	336
08 15	0.67	184
13/14	5.7	303
Average	3.23	274

Source: Document Analysis (2011)

From this all the researcher conclude that the existing storm water drainage facility in the sub city is inadequate to safely convey storm water which comes from the surrounding hilly areas and/or generated within the kebeles. Unlike the studies conducted in much of the secondary towns of Ethiopia by Girma (2004), in which inadequacy of integration is judged based on the policy guidelines designed to improve low/ inadequate development of roads, Dagnachew (2009) used the Rational formula as a determinant factor of adequacy of the integration of USWD system with the road system and built up area of the kebeles. Despite the variation in the measurement parameters that the researchers used or considered, the final outcome of all the researchers however was one i.e. inadequacy of the existing drainage system.

The issue of drainage and road disintegration in many of the situations is much more pronounced in earth paved roads. As evidence to this, for example, very large segment i.e. 37km (44.5%) of the road system of the town of Dessie is earth paved. However, these roads are the least in terms of their integration with storm water drainage facilities than any other road type in the town. This situation is similar with the case in Dilla town where more than $1/3^{rd}$ (46.8%) of the entire road network is earth paved and is absolutely left without any storm water drainage facility. Generally, there is a progression of diminishing drains following road priority in towns of Tigray, Amhara, and DireDawa (Girma, 2004).Here the implication is that a very small percentage of the towns is being drained of storm water. As a result major flooding is experienced by all most all cities. This is a situation that becomes worse as cities continue to grow and the percentage of the town being covered by hardened surfaces increases.

2.2.7 Impact of Inadequate Road and Drainage Integration in Ethiopia

With regard to the case in Ethiopia, Dire-Dawa, which was established in 1910 and located at the foot hills of eastern Harerge highlands, have been repeatedly hit by powerful flood disasters. Of all the times, the unprecedented August 6, 2006 flooding was the worst. This causes severe direct and indirect damages on socio-economic sectors of the town. Infrastructure and the housing sector were severely damaged. In the housing sector, a total of 1628 houses with a total value of 10.23 million USD were damaged. Direct and indirect damages on agriculture, trade and industry including the cost of demolition and removal also accounts about 2.6 USD .Of all the sectors, the housing sector is the most severely affected sector by the 2006 flooding in Dire Dawa (Alemu, 2009).

2.2.8 Urban Storm Water Drainage Policy Issues in Ethiopia

For urban storm water drainage system to be effected appropriately in a given urban area, policy issues should get priority and thus must focus on the following significant points (FUPI, 2008):

- The overall policy goal should focus to improve and enhance the health, safety and quality of life of the urban and hinterland population and the environment in a sustainable basis.
- Storm water is a component of the total water resources of an area and should not be casually discarded but rather, where feasible, should be used to replenish water resource.
- Development of storm water drainage system is not possible in isolation from other infrastructure and environmental sectors. Coordination is necessary between different departments, government and other stakeholders and planning should take cognizance of processes such as integration. Storm water drainage planning design, and management activities should ensure the participation of the people and other stakeholders at all levels.
- Environmental considerations such as soil erosion and sedimentation must also be taken.

2.2.9 Institutional Framework for Drainage Management in Ethiopia

In the Ethiopian case, the history of drainage is full of difficulties. The institutional frame works of drainage planning and management have no clear structure. The municipality is often responsible for urban drainage planning and management. How ever, other departments like the National Roads Authority also take an important role in drainage issues mainly related to roads and highways. The problem is lack of coordination between and among these separate institutions.

Therefore, the overall management and control in drainage system planning. construction, operation, and maintenance become challenging. Thus, there is a serious need for institutions to integrate and efficiently manage the whole drainage related activities with in a clearly defined urban setup.

Further more, since the operation of the drainage system also depends on an efficient service for collection of solid waste, as with out this the drains will soon fill with rubbish, the street cleaning and solid waste collection services should be regularly accomplished through the municipal department. The health department will also be concerned to ensure that the cleaning is done well and regularly, and that the drains are built in such away to make this difficult for disease transmission.

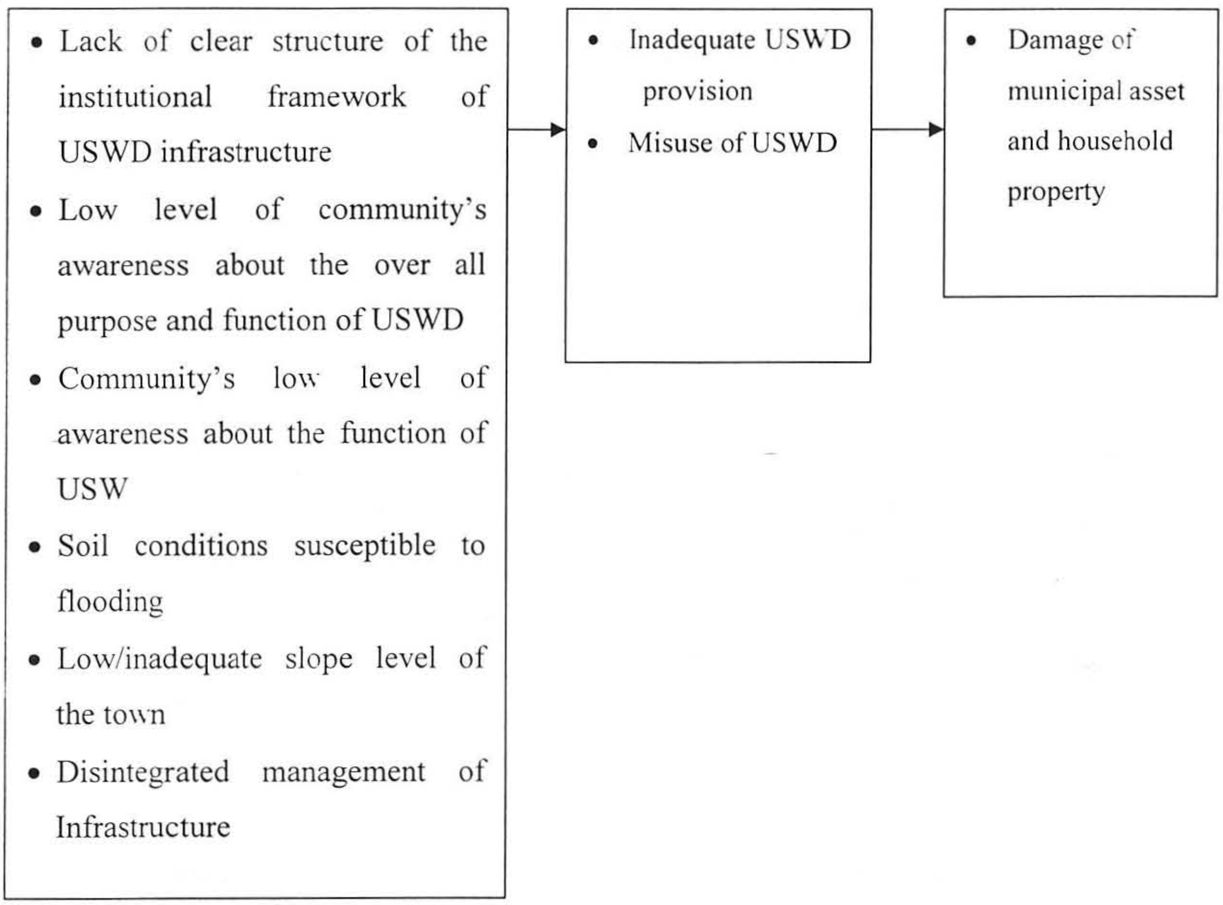
In general, in Ethiopia there is no clear definition of who is responsible for the overall management of the natural and man-made drainage system, and in some it is not even clear who is to build it, of which department is to finance major drainage works.

As a function of these multitudes of factors, there is series problem of periodic follow up inspection, and maintenance on continuous basis which in turn causes collapse and blockage of the already built up drainage channels.

2.3 Conceptual Framework

The enormous volume of literature on urban storm water drainage management in all developing and developed countries provides clear picture of the existing status challenges, and opportunities of USWD systems

Provision of adequate USWD systems depends on various organizational and financial factors. Lack of coordination between and/or among related infrastructural departments (Road, Land administration, and Environmental protection) and among the various stakeholders is the major principal factor behind the low development and inadequate provision of USWD in the municipality. As a result of these factors, the overall management and control in drainage system planning, construction, and maintenance have no clear structure and single autonomous department responsible for it. The ultimate effect of the disintegrated management is inadequate provision and deteriorated quality of the drainage systems currently exist in the town. Inadequate slope and high runoff characteristics of the soil type of the town are among the principal physical factors that affect the performance and quality of the existing drainage systems in the town. The cumulative effect of these all factors results inadequate provision of storm water drainage facilities and deterioration of the existing ones. This ultimately results intense deterioration of properties, houses, roads, wide spread disruption of transportation, collapse of power, communication and disease epidemics. Schematic representation of cause-effect relationship between the physical and human factors that affect adequate provision of storm water drainage systems and the resultant possible impacts is illustrated here under.



Source: Own presentation

CHAPTER-THREE: BACKGROUND OF THE STUDY AREA AND DESCRIPTION OF THE METHODOLOGY

3.1 Brief History of Shire-Indasilassie Town

The settlement at Adi Wenfito, which is located at the southern outskirts of the present town at the banks of the Gumelo River, about a km from the early settlement site Maiadrasha, was also occupied as early as the 14^{th}c. As sources from the Ethiopian Orthodox Church claim, the church of Debere Miheret Silassie (Thrinity), which is located at Adi wenfito and was closely related to the settlement was founded in 1352 during the region of emperor Seife Are'id (r.1344-1372).

This settlement, which was known as Shire since as early as its foundation (Gebrekidan 1988 E.C) grew gradually into a large town even after the destruction of the church and the settlement by the wars of Gragn Mohammed in 1527 and reconstruction of them by emperor Gelawdewos in 1544, the settlement showed a steady growth.

This being the initial settlement, which is said to be the embryo of the present town, the number of the local people gradually, grew around it. People, whose houses were destroyed at Adi Wenfito, began to flock to the new settlement and eventually settled down as they got encouragement from the part of the Italians. Other people were also came to settle in the would be town attracted by the free offer of land by the Italians. It was in such a way that the present town of Shire-Indasilassie grow.

3.2 Physical characteristics shire-Indasilassie Town

3.2.1 Location

Shire-Indasilassie town is located at $14^{0}06^{1}$ north latitude and $38^{0}21$ east longitudes at a distance of about 1064 kilometers from Addis Ababa. The town is the administrative capital of Northwest Tigray Zone and wereda capital of Tahetay Koraro. It is situated along the main Axum-Gondar road.

3.2.2 Area of the Town

The entire area of the town is 1300 hectare. Out of the entire area of the town,600 hectare is built up area and the remaining 700 hectare is potential expansion area currently included in the development plan of the town.

3.2.3 Topography

The town of shire-indasilassie is found on a site with a high proportion of flat topography. This can be substantiated by the altitudinal range and by the result of slope analysis. Elevation within the town ranges between 1984 m. a. s. l in the south east part around Abune Aregawi church and 2126 m.a.s.l at Adi Kentibay hill in the southern part of the town, which shows an altitudinal range of 142 m.a.s.l. This does not take account of May Emut mountain which is currently incorporated in the proposed development plan of the town

3.2.4 Climate

Due to its tropical location the duration of the solar radiation in the town is high. However, Due to the effect of altitude the town of shire-indasilassie experiences a subtropical type of climate. According to the traditional thermal zone classification of the country based on altitude, the town lies within Woina Dega zone where the altitude varies from 1500-2500 m.a.s.l. and temperature conditions moderate between $15^{0}c$ and $20^{0}c$ which is comfortable for human beings.

The town has a mean annual temperature of 20^0c and 13 5^0c of annual Lange of temperature .The hottest months in shire-Indasilassie occur between February and June while the coldest month in December .Regarding Rainfall Shire-endasilassie town receives rainfall during the summer season (kiremt) i.e. from June to September from moisture bearing winds of equatorial westerlies from the Gulf of Guinea when they blow over the area. The mean annual rainfall of the town is about 1080 mm most of which (79 5 percent) occurs between June and September.

3.2.5 Geological condition

The town of shire-Indasilassie is covered by trap volcanic rocks. Mesozoic sediments(red sandstone beds, mudstone siltstone, conglomerate and shale) and deformed basement complex rocks (occasionally lateralized) the trap volcanic series, dominantly basalts are forming steep ridge hills and builds elongated mountain chain north of shire-Indasilassie town, and further eastward it constitutes the water divide between Tekeze and Mereb Rivers Basins.

The basaltic rocks have different varieties based on their textural characteristics they are fine grained aphanitc, porphyritic and vesicular. The fine-grained verities are often used as masonry work for wall of houses, fences and other construction works. Amygdaloidal and vesicular varieties are most susceptible to erosion and intense weathering and alternation. They have less bearing capacity as compared to the former. The most flat parts of the town are underlying by trap series volcanic as observed in the excavation for footings and valley sides. They are weathered, often kaolinzed and found at 2 or more meters in southern to 1 to2 meters in central and to a meter or less depth in the northern parts of the town. The depth to the top of the bedrock varies form place as a result of previous topographic surface.

3.2.6 Effects of Geological Processes on Topography and Drainage

The town is located at the southern foot of the main ridge running east-west commonly known as Adwa-Axum plateau most portion of the town is characterized by flat topography, whereas the northern and southeastern part is constituted by rugged badlands, i.e. mountainous, dissected terrain and gullies. The landforms within and the surrounding areas of the town are the result of volcano-tectonic, sedimentation and erosion processes. Rejuvenated peneplain surfaces with occasional deep canyon and eroded gullies are the manifestation of these processes. The rugged badlands are mostly found along the streams and creeks segments, and topographic scraps, etc. The relatively loose and layered soil and weathered basaltic rocks could easily be less susceptible for erosion and thereby creating deep erosional landforms in some parts of the town. The stream and dry valleys at the southeastern portion of the town has incised gorges and v-shaped cuts. The tertiary volcanic rocks are building the elongated ridge north of shire-Indasilassie and further eastward, which constitute also the water divide between the Tekeze and Mireb river basin.

The drainage pattern of the area is characterized by semi-dendritic pattern. The lithology and tectonically weak ones are governing these drainage patterns.

3.3 Demographic characteristics

According to the 2007 report of the Central Statistical Authority, shire-Indasilasse town has a total population of 46382.Average rate natural increase of the population of the town is about 2.4%.Regarding the composition of the population, 36.5% shire-Indasilasse's total population are young. The productive and aged sections of the town population consist 58.1% and 5.4% respectively.

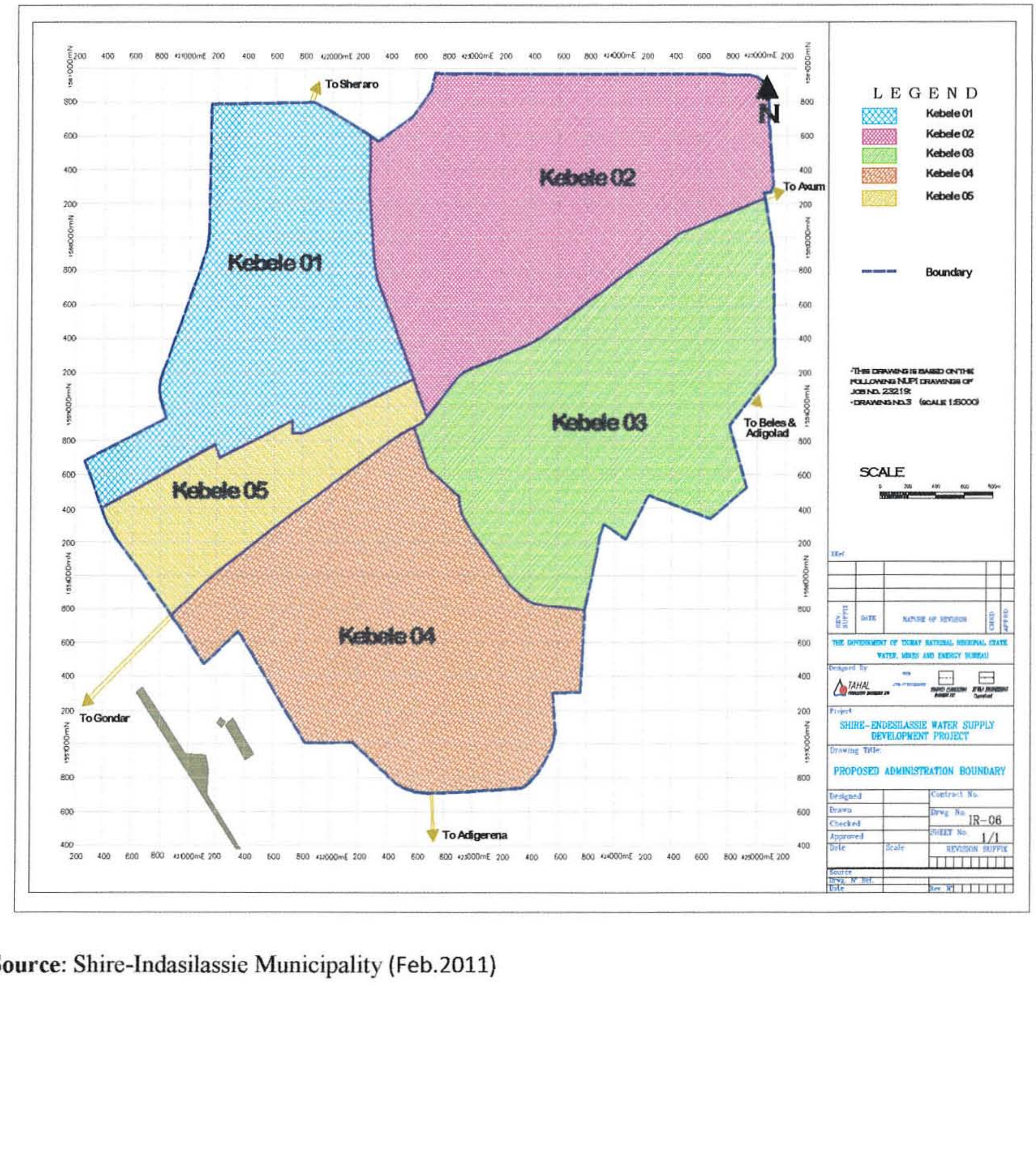
3.4 Economic Characteristics

Concerning the economic activities; trade, service provision, small-scale private formal and informal sectors are dominant in the town. However, based on the 1994 census report of the total urban population of Ethiopia 21% were employed under different public organizations, 5.4% had their own private organization and majority i.e. 66.5% were engaged in small-scale private activities.

3.5 Administration Structure of the Town

Shire-Indasilasse town is currently serving as capital of the North West zone administration and as Woreda administration of the town and residential rural administration of woreda Tahtay Koraro. The town consists of five kebeles in its administration jurisdiction. The five kebeles are the lower and autonomous administration units.

Fig 3.1 Administrative Map of the town of Shire-Indasilassie



Source: Shire-Indasilassie Municipality (Feb.2011)

3.6 Research Methodology

3.6.1 Data Sources

The study is both of qualitative and quantitative. Relevant information for the research was obtained from both primary and secondary sources. In the document review, books, research papers, academic journals, publications and other published and unpublished materials have been consulted to this end. The major primary sources of data used for the study was questionnaire survey of households and interview with the municipal administrator, infrastructure coordinator, environmental protection department, and land administration department authorities of the town. The questionnaire prepared for household survey was translated into Tigrigna for the purpose of simplicity and smooth communication. This is regarded as very important for the collection of reliable data, for it is easy for both the data collectors and the respondents to understand the questions and express ideas comfortably. In the absence of household heads, the possible respondents taken were any adult member of the family. The data collected in this way were used to clearly elaborate the impact of flood hazard on the livelihood of the urban community. Interview was used to complement the information obtained through questionnaire. Data obtained through this method were basically used to explain the fundamental factors that impede provision of adequate USWD systems. Observation by the researcher was also used as one way of data collection. Existing condition of USWD systems and roads, environmental degradation and resultant siltation of eroded sediments on USWD system of the town, impact of slums and squatter settlements on the existing USWD systems, waste clogged USWD systems were visited to get the right impression.

3.6.2 Method of Data Collection

To successfully collect the desired data, six enumerators were selected from Shire-indasilassie town preparatory school. The school administrator along with senior teachers selected the students based on their level of academic achievement, ethics in the class and were assigned on the kebeles they live in. The enumerators were given training on how to fill the questionnaire as well as on various issues of research ethics. Simultaneously the researcher was serving as a watchdog for the activities of the students in data collection.

3.6.3 Sampling Size and Sampling Technique

For the purpose of describing, exploring and explaining the integration of road and USWD system in the town, households are selected as the major units of analysis. According to the 2007 report of the Ethiopian Central Statistical Authority, the total number of households in the town was 11595. With the aim of exploring much more and valid information the researcher, however, focused on two of the entire five kebeles of the town, namely kebele 01 and kebele 02. The rationale behind the selection of these kebeles can be illustrated from two perspectives. Firstly, based on the major outlets, the town can be divided in to two major sub-catchments: the western and eastern. In the western sub- catchment storm water runoff is produced from parts of Mt.May Emut, Imba Danso, Adi Melkokes and Adi Kentibay ridges and from kebeles 01,04 and 05. This eventually drains in to Indabate stream. On the other hand, the eastern sub-catchment drains the runoffs produced from parts of May Emut and Adikentibay ridges and kebeles 02 and 03 down to Gumelo stream. Considering this fact, the researcher deliberately selected one kebele from each sub-catchment in the town. Having accomplished this, the researcher further select kebele 01 from the western sub-catchment and kebele 02 from the eastern sub-catchment of the town on a randomly basis. The second complementary factor that can justify the selection of the two kebeles is the fact that these kebeles are the source and recipients of storm water runoff. Having determined the representative kebeles, the researcher selected 88 households out of the 2046 households of kebele 01 and 112 households out of the 2614 households of kebele 02 using proportional sampling method. This sample size is assumed to be a representative and adequate sample size to reach a sound conclusion about the issue under study. The method of sampling applied is the probability sampling method particularly the systematic sampling technique where every household in the town had a known chance of being chosen for the study.

3.6.4 Method of Data Analysis and Presentation

The data obtained are described, summarized, and analyzed using appropriate data analysis technique. The data are presented using tables, percentages, and bar graphs to make generalizations and valuable conclusions.

CHAPTER FOUR: FINDINGS AND DISCUSSIONS

This chapter is the central part of the research in which the major research questions of the research get responded, analyzed, and presented in a way that readers can easily conceive and understand.

4.1 characteristics of respondents

Describing basic household characteristics would enable readers to have a mind map of the units of analysis of the research and thereby critically examine the research findings and the implication behind. Cognizant of this, the researcher briefly described the issue as follows. Basically, household characteristics can be defined from different perspectives. These include demographic, social and economic conditions.

Table 4.1: Sex Distribution of Households

Sex	Frequency	%	Cumulative
Male	121	60.5	60.5
Female	79	39.5	100
Total	200	100	

Source: Survey Data (Feb.2011)

Regarding sex distribution, result of household survey in Table 4.1 reveals that out of the 200 sample household heads,121(60.5%) were male while the remaining 79(39.5%) were female respondents. Age of respondents was also determined as an essential element of the study. Household survey on this issue vividly shows that the age of respondents ranges from a minimum of 20 to a maximum of 80 year. The mean age of respondents was about 46 years. Age of individual respondents vary with about 10 year from the average age of the entire households, on average. Mean age level of respondents found was an ideal age to critically understand the purpose and focus of the research and to ensure the validity of the response of respondents.

Table 4.2 Occupation Type of Households

	Occupation Type						Total
	Government employee	NGO employee	Private business employees	Business employees	Agricultural workers	Daily laborers	
Frequency	59	6	52	22	42	19	200
Percent	29.5	3	26	11	21	9.5	100

Source: Survey Data (Feb.2011)

From Table 4.2, 59 (29.5%) of the sampled households earn their livelihood by engaging in governmental works, 52(26%) in their own business, 42 (21%) in agriculture, 22(11%) employed in other peoples business, 19 (9.5%) daily laborers and the remaining 6(3%) in NGOs.

Table 4.3 Income Level of Households

Income level in Birr	Frequency	%
< 400	64	32
400-1000	56	28
1001-2000	44	22
> 2000	36	18
Total	200	100

Source: Survey Data (Feb.2011)

Income level is another most important dimension through which household characteristics can be defined. Table 4.3 illustrates that about 64(32%) of the entire households in the town earn less than birr 400 monthly on average .The monthly income for 56(28%) of the study households lay within income bracket of birr 400-1000.Only a tiny fraction of the households in the town i.e. 36(18%) earn an income which exceeds birr 2000.This shows that most of the households earn relatively low income.

4.2 Existing Condition of Road and USWD Network

4.2.1 Existing Road Network

Existing condition of road can be described in terms of length, pavement structure and hierarchy. In terms of road length and type, the existing condition in the town of shire-Indasilassie is as follows

Table 4.4: Existing Road Network in shire-Indasilassie

Road sub-category	Length in Km	%
Asphalt road	2.5	2.15
Gravel road	45.57	39.05
Earth roads and unclassified	68.60	58.8
Total	116.67	100.00

Source: strategic plan of Shire-Indasilassie (1998-2002 E.C)

From table 4.4, one can simply infer that the town of shire-Indasilassie is devoid of quality roads with much of the pavement structure of most roads being gravel. earth and other unclassified, which accounts as high a number as 97.85%.This manifests the very low level of road condition and poor road service provision in the town.

4.2.2 Existing USWD Network

USWD is one of the most important elements of urban infrastructure. With increasing trend of urbanization, the role of sustainable USWD is significant in ensuring sustainable urban development. Despite the key role that it plays the existing coverage, accessibility and quality of USWD, as repeatedly clarified in section two of this research. in most developing countries in general and in all most secondary towns in Ethiopia is at its lowest level. The condition in shire-Indasilassie is not also any different as is shown in the table below.

Table: 4.5 Existing Network of USWD Systems in Shire- Indasilassie town

Drainage Type	Drainage length	Percentage of total
Open masonry drains	8.3 km	84.9
Closed masonry drains	1.25 km	12.78
Pipe drains	0.225km	2.32
Total	9.775km	100.00

Source: Asset management plan for the city of shire-Indasilassie (2011)

Table 4.5 clearly shows that the total drainage network of the town is 9.775 km. Regarding the percentage share of the length of the different types of drainage systems of the town; the bulk majority (i.e. 84.9%) of the existing drainage system is open masonry type. Closed masonry and pipe drain comprise only 12.78% and 2.3% of the entire drainage network, respectively. This is a vivid manifestation that USWD system is at its inception in the study area.

Another equally important thing with drainage coverage is the issue of quality. Drainage systems can be operated successfully only if sufficient waste management, catchment management, and land administration systems are at work at the same time. Open channels in cities with no effective waste management or drainage systems in semiarid regions that are only intermittently used for carrying discharge are usually clogged and consequently exacerbate the problem of urban flooding. Health risks that emanate from open storm water drainage systems are much more pronounced in areas devoid of proper sewerage facility. No other Ethiopian town outside Addis Ababa have a piped sewerage service (waste water flows). Even in Addis Ababa the coverage of the conventional sewer system i.e. off-site treatment, covers only about 10% of the built up area and the people connected to the system constitute only 1.3%. Generally, the vast majority of households in urban Ethiopia make use of on-site sanitation disposal system for excreta disposed (UDPD, 2000)**.**Given such contexts in the country it may not come out as surprise that sewerage services are of poor quality in the study area.

As part of the solution to the problems associated with open drainage systems, urban drainage policy guidelines stated in urban development policy design of the FDRE encourage municipalities to avoid construction of open channel drainage system for its disadvantages of health risks like malaria breeding; accidental risks and occupation of huge spaces. This document further recommended that replacement of open drainage systems by pipe flow systems. However, the municipality of shire-Indasilassie does not implement the important guidelines set by the Federal government nor does it maintain the quality of the existing open channel drainage systems. Several factors could be attributed to this. One of these, according to the infrastructure coordinator of the town, is lack of adequate and coordinated effort among different stakeholders and responsible municipal departments.

Access to solid waste containers can also affect waste management of a town. For this, households in the town were asked to explain if there is any device/container in their locality on which they temporarily store wastes generated in their residence. Result of the household survey reveals that about 168 (84%) of the entire households have no access to solid waste storing containers in their locality and only a small fraction i.e. 32 (16%) of the households do have such facilities. Municipality of the town uses Block Method of solid waste collection using a single truck from Mondays to Fridays.

Absence of pre-determined places in which the community collect solid waste and presence of very narrow access roads highly impede movement of trucks and further aggravate the problem of solid waste collection process. Nevertheless, committed and aware residents of the town were observed travelling long distances carrying huge amount of wastes at times when the single truck move around main roads. This situation clearly shows the extremely haphazard way of solid waste collection in the town. The case with liquid waste disposal system is also the same. if not sever. Household survey on availability of separate sewerage disposal facilities indicates that the vast majority of the households in the town i.e. 161 (80.5%) lack separate sewerage disposal facility and the remaining 39(19.5%) of the entire households have the access. As a result of this, much of the wastes generated in the town are disposed to unauthorized places .The detail of the places to which the households dispose their wastes is presented here under.

Fig - 4.1 Places to which Households dispose their waste

From figure 4.1 what one can understand easily is that only 26.5% of the entire households in the town dispose their wastes into appropriate devices i.e. containers for solid waste and sewerage devices to liquid wastes while the remaining 73.5% of the entire households dispose to any dry surfaces and storm water ditches around the residences of households. Society's low level of awareness about the overall purpose and function of urban storm water drainage systems is another triggering factor currently diminishing the performance of storm water drainage systems. As frequently noticed during the field observation, significant number of households usually dispose their waste into drainage channels during night times. The following picture was taken at the early morning and in a place where the researcher is very familiar with.

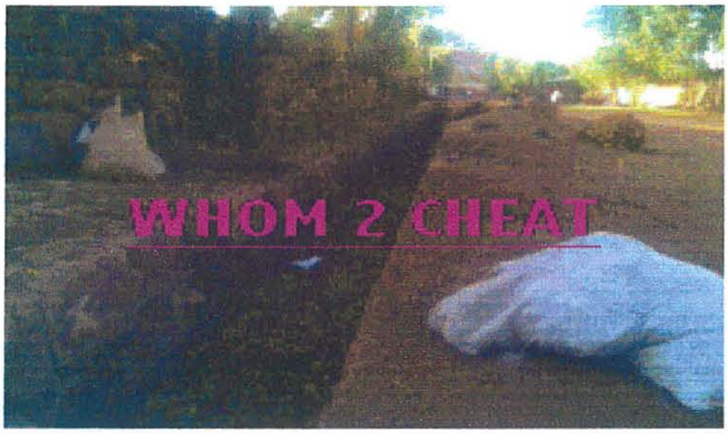


Fig- 4.2 Waste disposed into USWD during night times

During night time, residents of the town dispose of wastes in open places, but the question is as to whom they cheat. In fact, awareness problems could partly be the triggering factors. The cumulative effect of society's low level of awareness, inadequate access to solid waste containers and proper sewerage facilities ultimately cause drainage clogging, storm water stagnation and environmental pollution. On the other hand, improper liquid waste management systems have created conducive environments for malaria breed (see fig 4.3)

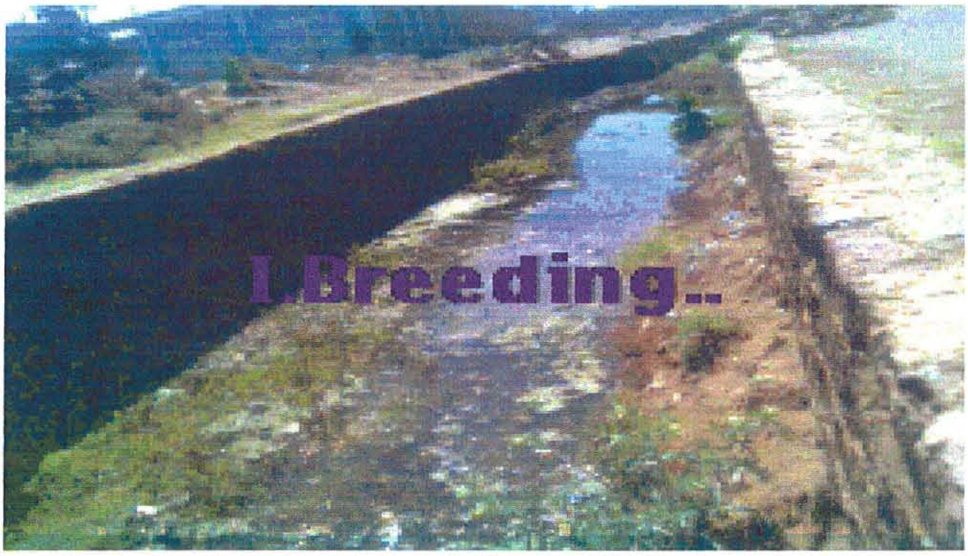


Fig-4.3: Urban Storm Water Drainage Systems become convenient malaria sites

Fig -4.4 Slums on USWD systems

According to observations made, interviews held and survey conducted, poor catchment management, manifested in the form of erosion and resultant siltation on drainage channels, and inadequate land administration system, reflected in multiplication of illegal slums and squatter settlements together affect the quality and performance of storm water drainage systems to safely remove storm water runoff particularly at the foot of the hills of Mt. May Emut and Adikentiby (northern parts of kebele 01 and 02 of the town).

Plan and management integration problems are also among the principal factors that affect the performance of the existing USWD systems in the town. Slums and squatter settlements constructed on the drainage systems of the town are clear manifestations of the problem.The picture below shows residential houses constructed on storm water drainage system of the town.

The above mentioned issues have resulted in degradation of the urban environment, creating deep gullies.

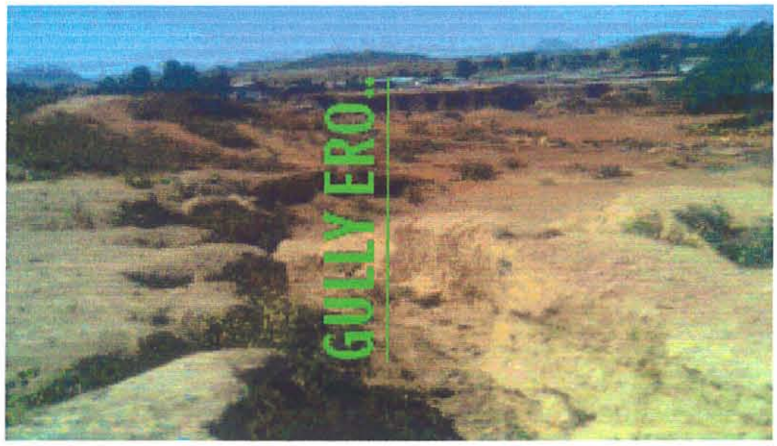


Fig-4.5 urban land degradation

4.3 Extent of Road and USWD Integration

Extent of integration between road and USWD infrastructure was assessed based on the policy direction designed to improve low development and/or inadequate access roads, one and integral element of Urban Development Policy Design of the FDRE. According to the guideline, low cost solutions should be adopted for the first stage of development; VIS-earth graded surface or gravel surfacing. They should, however, be provided with surface water drainage and road side foot paths. While this was the principle, the actual situation of USWD integration with the road system of the town of shire-Indasilassie is very limited. According to the current asset management plan of the city of shire-Indasilassie, the total road network and total USWD networks are about 116.67 km and 9.775 km, respectively. From this one can safely calculate the ratio of the entire USWD of the town to the magnitude of road network to know the degree of coverage. The result is shown in here

$$\frac{\text{Total USWD network of the town}}{\text{Total road network of the town}} = \frac{9.775\text{km}}{116.67\text{km}} = 0.09$$

Here, the figure 0.09 implies that for every 1 km of road, there is only 0.09 km of USWD facility. As a complimentary finding to this, the ratio of the total USWD network of the town to the entire built up area of the town is displayed here under.

$$\frac{\text{Total USWD network of the town}}{\text{Total built up area of the town}} = \frac{9.775\text{km}}{600\text{hectar}} = 0.01$$

The figure 0.01 implies that there is only 0.01 km of storm water drainage system for every one hectare of built up area of the town. The whole message behind these figures is the inadequacy of the existing integration of storm water drainage with the road system and the entire built up area. Here inadequacy of the integration is judged based on the policy guideline in the UDPD of the FDRE prepared to improve low/inadequate development of road, stated in earlier sections of this chapter. Similar studies on this issue were obtained by Girma (2004) in his study on ' *Living with Environmental Health Hazards in Ethiopian Towns' and by* Dagnachew (2009) on his enquiry on *'The study of Storm Water Drainage in Addis Ababa:Yeka Sub-City'.*

4.4 Flood Risk Assessment

To have a clear impression and help visualize the degree of severity of the flooding problem that the communities of the town under investigation face, background information on the overall physical characteristics of the area and socio-economic base of the dwelling society is critical. Basic information on these variables enables to determine the relative degree of the flood risk.

Risk is the probability of a loss, and this depends on three elements: hazard, vulnerability, and exposure. If any of these three elements in risk increases or decreases, then the risk increases or decreases equivalently.

Mathematically speaking, **Risk=function (Hazard x Exposure x Vulnerability)**.For simplicity of understanding the three terms which together comprise risk are defined as follows.

Hazard: Is occurrence of an extreme event such as (flood, drought, earth quake, storm, land slide etc…) caused by natural forces or by a combination of natural for human influences.

Exposure: refers in the context of flooding only to the question whether people or assets are physically in the path of flood waters or not.

Vulnerability: may be defined as "The conditions determined by physical, social, and economic factors or processes, which increase the susceptibility of a community to the impact of hazards (WMO/GWP, 2010)

Using the aforementioned guidelines as a base, extent of flood risk caused by poor quality and inadequate integration of road and USWD in the study area was assessed in the following manner.

4.4.1 Hazard

Hazard, as briefly described above, refers to the occurrence of an extreme event (flood in the context of this research). Result of household survey on the experience of households to flood damage show that, all in all, the households in the study area have experienced flooding in varied forms. Exposure to flood hazard can be defined from different angles. These include availability of USWD facilities alongside residents' nearest roads, mean road-residence distance and existence of slums and squatter settlements. Result of household survey on the availability of storm water drainage facilities alongside the roads nearest to their residence is stated here under.

Table: 4.6 Availability of USWD facilities alongside residents' nearest roads

Available	Frequency	%
Yes	64	32
No	136	68
Total	200	100

Source: Survey Data (Feb.2011)

Table 4.6 clearly shows that the nearest possible roads for about 136(68%) of the households of the town is devoid of any storm water drainage system and only 64(32%) of the households' nearest roads is equipped with storm water drainage facility. This implies that much of the storm water flows in a haphazard manner and cause devastating effect in infrastructure and the livelihood of dwelling urban communities.

As far as mean road-residence distance is concerned, there is short road-residence distance in the town. This increases the exposure to flood hazard and equivalently exacerbates the level of flood damage. Result of household survey on average residence-road is presented here under.

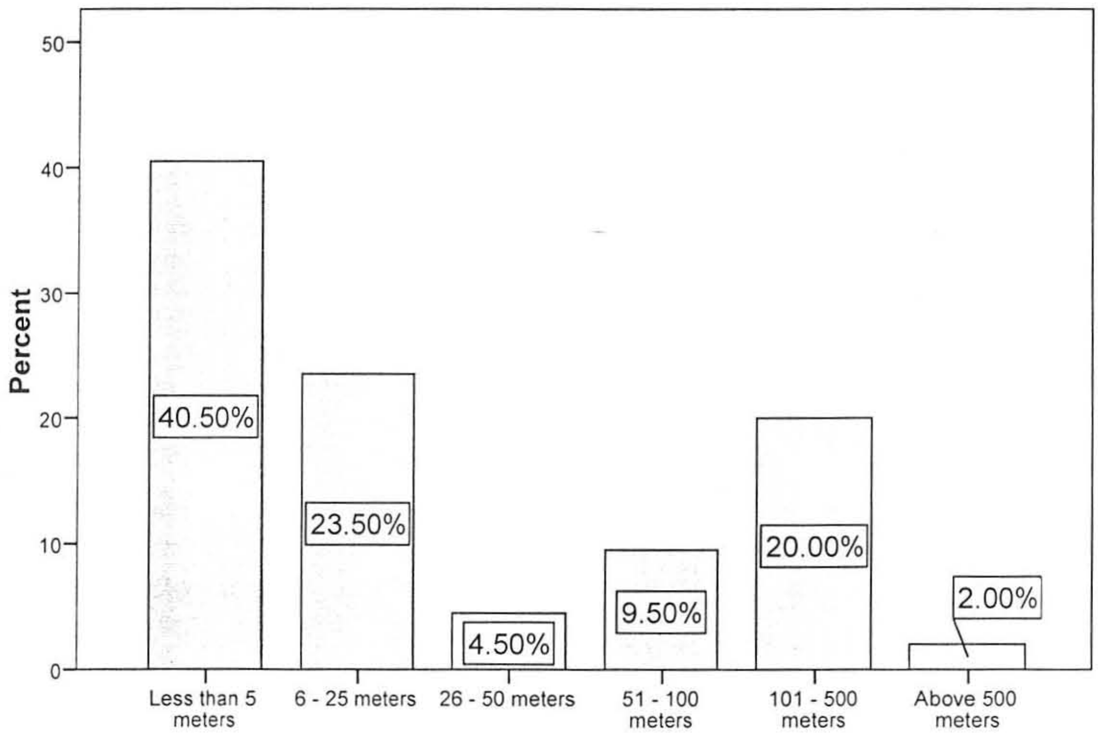


Fig-4.6: Average Road-Residence Distance of the Town of Shire-Indasilassie

Source: Survey result (Feb.2011)

From Figure 4.6 the residence- road distance for nearly half of the households in the town i.e. 80(40%) is below 5 meter on average and only 44(22%) of the entire households dwell beyond an average distance of 100m from the nearest possible road in their locality. The whole message behind this finding is that the majority of the households are confined in places susceptible to flooding.

Development plan of shire-Indasilassie town prepared by NUPI (2004), with regard to the institutional problems for drainage development in many other countries emphasizes that future settlement construction in the town should not be without the permission of the municipality and there must be a controlling mechanism. However, result of document analysis and field observation on the current status of slum and squatter settlement expansion clearly indicates that the number of slums and squatter settlements are growing rapidly. These settlements highly reduce the permeable portion of the town thereby increase the speed and intensity of surface water runoff and ultimately exacerbate the susceptibility of households to flooding.

4.4.2 Vulnerability

Another very important dimension that enables us to have a comprehensive understanding about risk (flood risk) is the issue of vulnerability. Vulnerability of a certain community to flood hazard is measured from different perspectives. These include physical, social, economical and institutional.

4.4.2.1 Physical Vulnerability

Within the context of the area under investigation, physical vulnerability is viewed from two angles. These are slope and permeability of a land surface.

BOX 4.1:Interview with Ato.Ayele Asgedom

Male

Age:36

Location of interview: Office of the Expert

Time:Feb.25,2011[10:15a.m-10:30a.m]

Interviewer: *How do you describe the performance of the existing storm water drainage system in your town?*

Respondent: *Well, storm water drainage is important for the progress of any town. However, the existing storm water drainage in our town is inadequate to safely remove the storm water that accumulate in the town and particularly that comes from Mt.May Emut and Mt. Adekentibay.*

Interviewer: *What do you think are the major technical challenges that affect the performance of the existing Storm water drainage?*

Respondent: *Actually the factors that affect the performance of storm water drainage systems are many in number and are tightly interconnected each other. As far as your question is concerned, the major technical challenge that we, as experts, are facing is the absence of adequate slope level to convey storm water flood. Slope level of our town is far below the minimum requirement used to convey storm water i.e.it is <0.4%.As a result, as you may observe in most of the of storm water drainage systems of the town, the direction of storm water flow is not easily identifiable and much of the storm water remain stagnated for longer times. In places devoid of the minimum slope level, construction of artificial slope is advisable. This however requires huge investment that currently is not on hand.*

B. Permeability of the Land Surface

The other important physical factor affecting vulnerability of the community to flood hazard is permeability of the land surface. From this point of view, geology of the area is typically characterized by hilly and flat topography. The soil groups derived from this geology and topography is generally of a silty clay or sandy and silty, highly clay nature. The run off potential for hydrological purposes from the area has been classified as semi-permeable (moderately high run off) potential) to impermeable (high run off potential)(Indasilassie Intra town drainage design, 2010).Holding other untouched factors constant, it is reasonable to conclude from this two different perspectives and findings that the town community is physically vulnerable to flood hazard.

4.4.2.2 Social vulnerability

A. The Way Households Define, Value, and Perceive Storm Water

To deal with social vulnerability to flood hazard, assessing society's level of awareness about urban storm water is critical. The systems, which used to have a simple function of collecting storm water and conveying it to nearest point of disposal as soon as possible have gradually evolved and are being replaced by the integrated flood control systems which are currently gaining importance. These systems protect flooding and improve society's quality of life. This is because these systems consider storm water as a precious resource which can be retained near the source to be reused for non- potable purposes such as washing, irrigation, toilet flushing and recharged to underground for aquifer replenishment (Maksimovic, 2001). This is particularly useful in semi-arid areas that experience water stress. Considering economic and environmental advantages and its potential for mitigation of urban floods, rain water harvesting is not only applicable in cities where fresh water resources are scarce, but constitutes a reasonable measure in almost all cities (WMO/GWP, 2010).Result of household survey on the way households perceive, value, and define USW is presented in the table below.

Table: 4.7 the Way Households Define and Understand USW

The way they define	Frequency	Percent	Valid percent	Cumulative percent
Water that the municipality should discharge in to the nearby water course through the use of channels, ditches	90	45.0	45.0	45.0
Water that causes flooding and damage to properties and houses	18	9.0	9.0	54.0
Water that affects the psycho-social condition of urban residents	20	10.0	10.0	64.0
Water that if systematically treated can re-charge ground water and reduce the demand for the scarce potable water	72	36.0	36.0	100.
Total	200	100.0	100.0	

Source: Survey Data (Feb.2011)

Table 4.7 clearly reveals that nearly half i.e. 90(45%) of the households of the town define USW as water that the municipality should discharge in to the nearby water course through the use of channels and/or ditches; 18(9%) as water that causes flooding and damage houses and properties; 20(10%) as water that affects the psycho-social condition of urban residents and about 72(36%) define USW as water that if systematically treated can recharge ground water and reduce households demand for the scarce potable water. What one can reasonably conclude from this finding is that the majority about 128 (64%) of the households in the town are less aware and misperceive the value that USW could have in reducing flood damage and improving their livelihood. As a direct function of this situation, the likelihood of the community in using USW as an additional means to satisfy their unmet water demand is too low. Regularity of households in using USW as an additional means to satisfy their unmet water demand is presented here under.

Table 4.8 Regularity of Households in using USW to Satisfy Their Unmet Water Demand

Regularity in use	Frequency	%	Cumulative %
Regularly	2	1.0	1.0
Sometimes	11	5.5	6.5
Rarely	21	10.5	17.5
Not at all	166	83.0	100.0
Total	200	100	

Source: Survey Data (Feb. 2011)

Table 4.8 dictates that out of the 200 sample households only 2(1%) use USW as an additional source of water to satisfy their unmet water demand on a regular basis while the vast majority of the households i.e. about 166(83%) do not use USW at all.

A. Community Awareness about the Purpose and Function of Storm Water Drainage Systems

Another most important dimension through which social vulnerability can be viewed is society's level of awareness about the very purpose and function of storm water drainage channels. Other things remain constant, better informed and aware community can better maintain the quality of existing USWD systems and ensure sustainability of their use. Community's responsible attitude helps to up keep, reduce the amount of rubbish thrown in to the drains; reduce the damage done to drains by vehicles, building works, or vandalism. A single uncooperative resident who blocks the water flow; neglects to clear his section of the drainage line can harm the interest of the whole community. The attitude and cooperation of residents, however, should not be something that we expect from God, rather it demands effective communication between or among leaders, educators, health workers and the community at large (UDPD,2000).

For this, survey was conducted on households' participation in municipal and/or kebele meetings on issues regarding planning, construction and maintenance of storm water drainage systems. Result of the household survey clearly revealed absolute ignorance of the general community. Out of the total households surveyed about 166(83%) have never participated and only finger counted households i.e. 2 (1%) participate. As a result of this and other related problems, societies' level of understanding about the purpose and function of the existing USWD systems and sense of ownership and belongingness over these systems in the town is extremely deteriorated. The whole idea behind the wide discussions implies that the society is less aware about the purpose and function of USWD system and is vulnerable to flood risk.

4.4.2.3 Economic Vulnerability

Economic vulnerability of people to flood hazard can be determined from different angles. One and most commonly used indicator is the level of income of households. As clearly stated in section one of this chapter, monthly income level for about 64(32% of the households in the town is less than birr 400; 56(28%) households with income level ranging from 400-1000 birr; and the remaining 44(22%) and 36(18%) of the total households with income level of 1001-2000 and greater than birr 2000respectively.

In conjunction with this, saving condition of households was assessed in similar fashion. Accordingly, out of the entire surveyed households about 98(49%) save certain amount of birr in *Ikub/Idir/*and/or in Bank. Household's saving amount varies from a minimum of Birr 50 to a maximum of Birr 10000 monthly. The mean saving of these households was found Birr 518, a figure which strongly deviated from the income level that the majority of the households earn on monthly bases. According to the finding on the saving condition again in average terms, the amount of Birr that an individual monthly saves vary by Birr 1198 from the mean saving of the entire town households. This is to mean that there are few very rich households within the universe of the mass poor. This in turn indicates that saving amount of the majority of the residents is inadequate to cope up with the cost that households incurred because of flood damage.

4.4.2.4 Institutional vulnerability

In the absence of adequate preventive flood control measures, municipality's reaction or emergency aid during and after flooding can significantly diminish society's level of vulnerability. Result of household survey on the municipality's condition of reaction during and after flooding hazard is presented in the table below.

Table: 4.9 Municipality's Reaction During and After Flood Hazard

Reaction Condition	Frequency	Percent	Valid Percent	Cumulative percent
As soon as the flooding occurs	13	6.5	6.5	6.5
After community complain	76	38.0	38.0	44.5
Do not react at all	111	55.5	55.5	100.
Total	200	100.0	100.0	

Source: Survey Data (Feb.2011)

Table 4.9 vividly shows that the municipality delivers quick and timely aid during and after flooding for only insignificant i.e. 13(6.5%) number of households, while it is passive and unresponsive for the extraordinarily huge section i.e. 187(93.5%) of the entire households in the town. This situation increases the likelihood of flood damage that the society can possibly incur.

4.5 Impacts of Inadequate Road and USWD Integration

Impacts of inadequate road and USWD integration in the area under investigation are multi-dimensional by nature and interfere in every aspect of the livelihood of the town community. Among others, impacts of poorly integrated road and USWD include environmental, economical and psycho-social.

4.5.1 Environmental Impact

Inadequate road and USWD integration causes urban land degradation. Degraded urban lands, in turn, become the storehouse of wastes and malarias, as discussed in the previous subsection (4.2.2). This ultimately reduces the aesthetic value of the environment to the community. With regard to the situation in the study area, shire-Indasilassie. as per the town wide observation made, depth and coverage of this problem is much more pronounced. The combined effect of inadequate integration of road and USWD systems, poor catchment management and inadequate land administration systems caused blockage of USWD, form deep gorges, degrade valuable urban land, water logging and ultimately cause environmental pollution and consequent health risks. Report of top ten diseases recorded in shire Hospital (2002) can justify the problem of the mix up of stagnated storm water and wastes of varied chemistry in the storm water drainage channels of the town. The detail of this report is presented here under

Table 4.10 Top Ten diseases recorded in shire Hospital (2002)

Ser. No	Diagnosis	Number of patients
1	Malaria	5423
2	URL	4077
3	Intestinal parasite	2575
4	PUD	1764
5	Active trachoma	1310
6	Skin diseases	977
7	Diarrhea	845
8	TB	572
9	Anemia	298
10	STD	274

Source: NUPI (2004)

Table 4.10 reveals that Malaria is the top one disease in the town. Holding other factors constant, the researcher believe that the poor quality storm water drainage systems in the town significantly contribute to the severity of this problem for the fact that insects that cause Malaria best prefer these drainage sites for breeding.

4.5.2 Economic Impact

Various literature from outside and within our country revealed that inadequate storm water drainage facilities in urban areas cause significant social and economic and environmental damages. The impacts of these damages are manifested at different levels and in varied forms.

With regard to this, the case of the West African nation, Senegal, and DireDawa in Ethiopia is worth mentioning.

Document analysis on the impacts of flood hazard within the context of the area under investigation, Shire-Indasilassie town, also reveals that significant amount of resource is damaged and/or destroyed yearly. At a municipal level, the existing condition of roads is highly deteriorated and consumes huge resource for rehabilitation. Table 4.14 shows degree of deterioration of the road system in the town.

Table: 4.11 Existing conditions of roads in Shire-Indasilassie

Road surface type	Road length (km)	Degree of road deterioration		%
Asphalt	2.5 km	0.7 km in a state of light (limited deterioration		28
		1.8 in a state of severe deterioration		72
Gravel	45.57 km	Light	31.46km	69.04
		Moderate	8.96 km	19.67
		Severe	0.445 km	11.29
Earth	68.60	Light	37.25 km	54.30
		Moderate	30.68 km	44.73
		Severe	067 km	0.97

Source: Asset Management plan of the city of shire-Indasilassie (2011)

What one can easily understand from table 4.11 is that much of the road system of the town is under heavy stress of flood. To explicitly state the degree of road deterioration, about 59.49% of the entire road network of the town is lightly deteriorated and about 33.97% and 2.49% of the total road network of the town are under moderate and severe deterioration respectively. Only a tiny fraction of the total road network of the town (4%) is under normal condition.

One more surprising issue that we can infer from table 4.14 is about the status of asphalt road deterioration. In principle, provision of adequate USWD facilities along side roads of varied pavement structures is mandatory, and for asphalt roads too, for the huge amount of resource that it demands for construction and maintenance. The case in shire-Indasilassie is, however, different. Of the entire asphalt paved road system of the town,72% are currently severely deteriorated. This situation indicates severity of the extent and depth of the problem of poor road and USWD integration and the low emphasis given by the municipality to USWD provision. Detail rehabilitation costs of the already deteriorated road networks of the town, categorized according to the nature of pavement structure and degree of deterioration for the town of shire-Indasilassie is presented in Table 4.15 below.

Table: 4.12 Estimated Rehabilitation Cost Of Shire-Indasilassie Town Road System

Condition indicator description	Unit	Quantity	Rate	Cost rounded to the nearest EB 1000
Asphalt roads				
Moderate damage	M^2			
Extensive damage	M^2	36,000	380	13,680.00
Sub total				13,680.00
Gravel roads				
Moderate	M^2	78,377	58.5	4,585,054
Extensive	M^2	2,360	63.5	149,860
Sub total				4,734,915
Earth roads				
In need or re-grading	M^2	215,095	18	3,871,656
In need of rehabilitee	M^2	1430	30	42900
Sub total				3,914,556
Total Rehabilitation cost				22,392,471

Source: Asset Management Plan for the Town of Shire- Indasilassie (2011)

Apart from the cost that the municipality incur to rehabilitate damaged infrastructure, urban flooding resulted from poor quality USWD and inadequate integration of USWD along side roads, have adverse economic, social, and psychological impact at a household level. Result of household survey on the kind of flood damage and resultant cost that households incurred is presented here under in table 4.16.

Table: 4.13 Flood Damage and Resultant Cost incurred by Households

Damage type	No	Minimum Birr	Maximum Birr	Mean	Std. deviation
Damage to house and properties	148	15.00	5000.00	518.5811	983.06633
Delay in transportation because of damage to road system	66	5.00	1500.00	204.0152	307.45133
Electricity interruption	15	50.00	5000.00	586.6667	1244.62655
Communication disconnection	10	150.00	4000.00	750.0000	1148.91253
Valid N(list wise)	4				

Source: Survey Data (Feb, 2011)

According to the result of household survey, vast majority i.e.148 (74%) of the entire households of the town are affected by house and property damage; 66(33%) by transportation delay: 15(7.5%) due to electricity interruption and about 10 (5%) and 4 (2%) by communication disconnection and other risk types respectively. Subsequent average cost incurred by households as estimated in Birr and per each damage type is about 518. 204, 586 and 750 for the first four damage types respectively. According to this finding, the amount of Birr that an individual household loss because of damage to house and properties vary by Birr 983 from the mean loss of the households in the town. This situation, in the context of the town under investigation, is attributed to the variation in the quality and the rehabilitation cost of damaged residential houses of the households. Regarding the cost that households of the town incur because of electricity interruption, the amount of Birr that an individual household loss vary by Birr 1244 from the average loss of the entire households of the town. This significant disparity is mainly caused by the variation in the occupation of the households of the town. Owners of business centers like electronics shops and internet service providers are more affected by electricity interruption and communication disconnection than those households engaged in other activities like agriculture and governmental offices. In comparative terms, of all the types of damage that the society is exposed for, damage to house and properties is much more pronounced in its coverage.

This finding coincides with the findings of the researches conducted in Senegal and in Dire Dawa in that in all the cases the housing sector is the worst bitten sector .This can be justified from two basic facts in least developed countries and towns. The first and most critical factor is the uncontrolled expansion of slums and low quality squatter settlements. Significant number of urban residents in many developing countries are unable to afford urban land in places ideal for settlement. As a result they reside in flood prone sections of towns, where the well to do people are less interested to dwell in. The nature of the houses usually constructed in these places are mud made inclined houses. The second factor is the issue of supervision in the design and construction of buildings. Standards for building construction are usually ignored. Report of NUPI (2004) on this issue in Shire-Indasilassie town reveal that the then flourishing buildings were not constructed in accordance to the standard for building construction and much of the buildings in the town lack adequate basement. The combined effect of these factors increased the likelihood of residential houses to flood damage.

4.5.3 Psycho-social impacts

Equally important thing about the impacts of urban flooding is psycho-social impact. Household survey on this issue clearly shows that about 104(52%) of the total households describe as if they are affected very seriously; 52(26%) less seriously and the remaining 44(22%) not affected at all.

4.6 Fundamental Factors Impeding Integration of Road and USWD and USWD Quality

4.6.1 Lack of Coordination between and/or among Different Responsible Municipal Infrastructural Departments.

Efficient operation of a drainage system requires specified institutional arrangements, preferably with a municipal department assuming the ultimate responsibility of the whole tasks related to drainage management.

In Ethiopia, the institutional framework for drainage planning and management has no clear cut structure. The municipality is often responsible for urban drainage planning and management. However, other departments like the National Roods Authority also take an important role in drainage issues mainly related to road and higher ways. In general, there is no clear definition of who is responsible for the overall management of the natural and man-made drainage systems; who is to build it; or which department is to finance it (UDPD, 2000). Findings of infrastructure assessment in 18 Ethiopian cities conducted by the Urban Development Capacity Building Office also recognized that there is fragmentation of management responsibility for network infrastructure. According to this finding, responsibility for network infrastructure management was divided between an infrastructure department responsible for roads and drainage and a second department responsible for solid and liquid wastes. Solid and liquid wastes department had different names in different cities and regions. These include sanitation department, beautification department and social and economic affairs department. The department responsible for roads and drainages was also responsible in most cases, for building plans and building permits.

The work of different scholars in different countries on this issue, as extensively reviewed in chapter- two of this research, also reveals the same i.e. the disintegration of the management of the various interrelated infrastructural departments. What all the researchers agreed is the absence of single and autonomous municipal department which its sole responsibility is management of storm water drainage. For this, they emphasize the need to integrate the various responsible departments for sustainable USWD system to build.

Coming specifically to the situation in the area under investigation, document analysis on asset management plan for the city of shire-Indasilassie show that road and drainage infrastructure are administrated by land development and data administration department while city beautification department is responsible for liquid and solid waste management. Beyond the aforementioned responsibility, land development and data administration department is also the sole responsible department to control and manage issues related to urban land use. However, these departments are 'hypothetical responsible departments' for there is no practical departmental organizational structure designed to guide every activity in implementation of projects. Information obtained from interview with the town administration and infrastructure coordinator witness that the municipality of the town is the one and sole responsible organ managing all elements of infrastructure. Therefore, there is no one clearly defined department which carryout responsibility of drainage management nor does any sort of integration between and/or among the various municipal departments which in one way or another affect the development and functionality of drainage systems.

Poor coordination of responsible departments and absence of single department to carry out responsibility for drainage management, according to the town administrator and infrastructure coordinator of the town, are mainly caused by highly interrelated and mutually interlinked institutional, financial and human factors. These include: lack of adequate and skilled human power, finance, and committed administration system.

4.6.2 Lack of Adequate and Skilled Human Power

Adequate and qualified human power is an engine of service provision. Among many other functions, infrastructure management requires huge number of qualified human power. However, the departments responsible for the management of infrastructure in general and network infrastructure in particular in shire-Indasilassie are under staffed.

Table-4.14 Staffing for Delivery and Management of Infrastructure in the Town of shire-Indasilassie

Infrastructure category	Responsible department	Available staff
Roads	Land development and data administration	3
Drainage	Land development and data administration	4
Liquid waste	City beautification	1
Solid waste	City beautification	1

Source: Asset management plan for city of shire-Indasilassie (2011)

Another worth mentioning factor aggravating the problem is the issue of quality. Although well documented source material on academic qualification and experience of staff members were not available, the town administrator explain that most of the staff members in the municipality are qualified in unrelated field of studies and some of the staff members under qualified. As a direct indication of this problem, information obtained from interview with Ato. Desalegn Teklu. department head of Environmental Protection, on the role that this department played in waste management of the town is presented here under.

BOX 4.2 Interview with Ato Desalegn Teklu

Male

Age:38

Location of interview: Office of the Respondent

Date:Feb.27,2011[10:00a.m-10:45a.m]

Interviewer: *How do you describe the quality of USWD systems in your town?*

Respondent: *The quality of USWD systems in our town is extremely deteriorated and is incapable to remove storm water during summer season. The fundamental factor behind this problem is the absence of regular inspection and maintenance of drainage systems. Besides to this, soil erosion from the rugged mountains that surround the town and the inadequate waste management system of the town are among the principal factors affecting the performance of USWD.*

Interviewer: *What role does your department played so far in waste management of Shire town?*

Respondent: *In what way are you going to relate the unrelated departments? Solid waste management and Environmental Protection department are two different and mutually exclusive departments. Our department is mainly concerned with catchment management, land degradation and related problems. The issue of waste management is the issue of City Beautification and Sanitation department.*

Response of the head department of Environmental protection, stated clearly in box 4.2 above, is clear manifestation of the extent of fragmentation of responsibility in infrastructure and service delivery and the low level qualification of the responsible authorities in the area of infrastructure management. Another most important area in which problem of inadequate and/or low quality human power reflected was the department of land administration. Adequate and qualified human power is critical in land use management. Information obtained on the fundamental factors behind the multiplication of illegal slums and squatter settlements from interview with Ato Tsegay Girmay, head department of Land Administration of the town, illustrated that the lack of skilled human power is the fundamental bottleneck that hinder the controlling and supervision process of slum and squatter settlement expansion. Full length of the interview with Ato Tsegay is presented here under as directly taken from his speech.

BOX 4.3: Interview with Ato. Tsegay Girmay

Male
Age: 34
Location of interview: Respondent's home
Date: Feb.22.2011

Interviewer: *How do you describe the state of slum and squatter settlement expansion in Shire-indasilassie town today?*

Respondent: *Well...as you may know people from surrounding rural hinter lands usually diffuse to our town in search of better job and living condition .At the beginning of their urban life these people dwell in rental houses but through time they construct their own residential houses from cheap and locally available construction materials on the fringes of the town and without the legal permission of the municipality. Today the number of people dwelling in such a mode is alarmingly increasing.*

Interviewer: *How do you describe the impact of Slums and squatter settlements on the performance of Storm water drainage systems of the town?*

Respondent: *Now-a-days the impact of illegal houses is becoming severe. In relation with drainage, these houses are causing blockage and subsequent overflow of storm water, especially in the eastern sub-catchment of kebele 02 of the town.*

Interviewer: *What measures have been taken so far to solve the problem of the illegal multiplication of slums and squatter settlements?*

Respondent: *Really there is big challenge in controlling illegal expansion of slums and squatter settlements. Since the time the municipality recognize seriousness of the problem, we had been engaged in extremely tiresome activities, conducting home-to-home supervision even at night times to identify the houses constructed without the legal recognition and permission of the municipality. However, no significant work was done so far, for which the very backward procedure in land use data management that we have been followed and are being using today is the critical bottleneck. Modern and sophisticated computer software (GIS) was introduced with the aim of computerizing the overall slum and squatter controlling process. However; we cannot use and exploit the technology for there is no skilled personnel to manipulate it. As a result the supervision activity is still disintegrated and ineffective.*

Qualified and skilled experts have a lot to contribute for town development beyond the solution that they can provide for the aforementioned problems. As to the outcome of the interview conducted with the town administrator, lack of qualified human power is the primary factor for the absence of workable institutional framework and the fragmentation of infrastructure management. According to the town wide observation made by the researcher, some of the ways in which disintegrated management in infrastructure manifested itself include: inconsistency in the timing of the various project phases of the related infrastructural departments and haphazard and incomplete infrastructural projects. The result of all this is inefficient use and mindless wastage of scarce resources widely observed in the town today.

Fig-4.8: Incomplete Drainage works and wastage of precious Concrete Slabs

4.6.3 Lack of Adequate Finance

Development of storm water drainage system is not possible in isolation from other infrastructure and environmental sectors. Coordination is necessary between different departments, government and other stakeholders. Planning should take cognizance of processes such as integration. Storm water drainage planning, design, and management processes should ensure the participation of the people and other stakeholders at all levels (FUPI, 2008).In line with this, the City Proclamation from Tigray states that cities May:

> *Engage in agreements with all levels of government, the private sector and the voluntary sector.*

To ensure an efficient delivery of services, a city may make on arrangement with the Government, engage NGOs, Cooperate with the public agencies, privatize services or take other measures that circumstances may justify. [Furthermore] a city shall have the authority to determine which option to use for which services and when (Source: Building Institutional Capacity for Infrastructure Management, N.D)

Despite the vast opportunities that city municipalities of the region are allowed to enjoy, information obtained from infrastructure coordinator and survey study of households in the town shire-Indasilassie reveal that NGO, private investors, and community involvement in the planning. construction and overall management of drainage system is almost negligible. As per the result of the household survey, about 83% of the entire households in the town had never get chance of participating in kebele/ municipal meetings on the planning, construction and overall management of USWD systems. About 97.5% of the households also witness that no any investment was made on drainage system in their locality by private investors and NGOs initiation. The only source of revenue on which the municipality largely depends is the system called 'Matching fund'. Matching fund is a system where by the World Bank, federal government, and the municipality of the town contribute 60%, 20% and 20% of the required budget for infrastructure development respectively .What the municipality rarely did is a onetime community mobilization to undertake drainage construction. This usually is done on voluntary basis and the kind of support the community made is usually labor force contribution. The whole idea behind the aforementioned discussions is the weak bond between and/or among relevant stakeholders (the community, private investors, and NGOs) and low revenue collection capacity of the municipality.

4.6.4 Lack of Committed Administration System

Commitment to achieve desired needs and expectations of the user community is one and major ingredient for responsible management. This requires communication with relevant stake holders, and reading the heartfelt needs of the user community. While this was the principle, municipality of the town does not involve much of the households of the town in urban storm water drainage planning and management. This is to mean that household' feelings, ideas and opinions are not considered as an input in the development of the drainage system in the town. This ultimately resulted deterioration of the sense of ownership of households over the already existing USWD systems and subsequent decline in the performance of these systems.

CHAPTER-FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Availability of adequate and quality USWD system is one of the requirements for urban development. However, due emphasis was not given so far in most developing countries. Investigation made on this issue in shire-Indasilassie, one of the secondary towns in Ethiopia, reveal that the quality of USWD, coverage and extent of integration with road system of the town is very low and inadequate. There is huge discrepancy between the total USWD network and road system of the town i.e. USWD systems constructed along side roads of varied pavement structure and function is extremely insignificant. The ratio of the entire USWD network to the whole built up area of the town is also extremely unbalanced. This implies again that the existing USWD system of the town is insufficient to drain storm water surface runoff generated within/or coming from upstream of the town.

Inadequate waste management; lack of town wide catchment management; and inadequate land development control mechanism are among the principal factors reducing the quality and performance of the already existing USWD systems in the town. The combined effect of inadequate coverage and poor quality USWD system of the town induced huge economical, environmental and psycho-social impacts on the livelihood of residents and revenue of the municipality at large. Although they are inherently related each other, for clarity of understanding, economic impact of poor quality and inadequate coverage of USWD in the town was assessed from two perspectives. These were impact on society's livelihood and impact on municipal revenue.

To have a contextualized mind map of the real impact of flooding on the livelihood of the urban community, risk assessment was conducted on important risk determinant variables such as existence of USWD facility alongside nearest possible roads of residents; mean distance between residence of households and nearest possible road in the residents locality; household's average income level; occupation type; saving condition; and society's level of awareness on the advantage and use of urban storm water and on the very purpose and function of urban storm water drainage systems and municipal curative measures during and after flooding.

Having critically examined these all parameters, the researcher assessed flood damage types and resultant costs incurred by the dwelling urban community. According to the result of the assessment, flood damage to houses and properties is the most direct and sever problem that the huge majority of the households in the town are exposed for. Delay in transportation; electricity interruption; and communication disconnection are also among the principal indirect ways that impact the livelihood of significant urban dwellers. At a municipal level, huge amount of municipal asset is redirected for rehabilitation of flood damaged roads and other related municipal utilities. Result of the overall assessment on the existing economical, environmental, physical, and social context of the area and the cost of flood damage both at a municipal and household level finally revealed that the majority of the residents are risky.

Identification of basic factors that impede the provision and quality of USWD system of the town was another most important mission of the researcher. For that reason, depending on the relevant and wide sources of information that the researcher employed, the researcher found that lack of practical and workable municipal infrastructural organizational structure is the primary factor responsible for the inadequate provision and low development of USWD system in the town. Infrastructural departments in the town are currently operating as stand-alone systems. Despite the enormous advantage that it provides, departmental/vertical integration (integration within individual infrastructural department) and inter-departmental /horizontal integration (integration between/among different infrastructural departments) is in work neither in the operational nor in the strategic levels of infrastructural management of the town. As per the result of the finding, the basic constraints behind the disintegrated infrastructural management are interrelated institutional, human and financial factors.

5.2 Recommendations

The major problems identified in the previous sections of this research have important implications for future policy intervention. In this regard, the researcher recommends the municipality to undertake the following activities:

- To enhance existing USWD development, setting workable municipal organizational structure and ensuring inter-departmental plan and management integration between/among different infrastructural departments should be the first task that the municipality should strive to achieve. Furthermore, the municipality should ensure participation of relevant stakeholders in the planning, construction and overall management of USWD systems in the town. In so doing, the municipality can enforce demand driven planning and prioritize provision of infrastructural services by reading heartfelt needs of the user community.
- It is advisable for the municipality to view the problem of waste management from the broader view of protecting environmental health of the town. Cognizant of this, environmental protection department in collaboration with the municipality should build waste management of the town on a sustainable basis. Furthermore, this department should protect the entire catchment of the town from erosion by enforcing various physical measures and setting workable regulations along with effective enforcement.
- Land administration department, in collaboration with the municipality and relevant stakeholders, should improve the supervision and control process of slum and squatter settlement expansion in the town.

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APPENDIX: I

Interview with Town Administrator and Infrastructure Coordinator

1. Is flooding a major problem in your town?
2. How do you characterize the flooding problems?
3. What is the geographical extent of the various problems?
4. Is there significant exposure to personal hazard or risk to peoples' economy?
5. How do you describe the existing condition of road and USWD system in the town?
6. How do you describe the balance between the total road network and total USWD system of the town?
7. Have drainage problems ever posed damage to the road system of the town? If yes, can you estimate the cost incurred in Birr?
8. How do you describe the integration of environmental protection, road, and land administration departments in planning, construction and management of USWD systems?
9. What are the basic financing methods used to support construction and maintenance of road and USWD system?
10. What factors inhibit realization of sustainable USWD systems in the town?

APPENDIX: II

Interview with Environmental Protection Department

1. Is flooding a major problem in your town?

2. What are the major causes of flooding?

3. How do you describe waste management of the town?

4. What roles does your department play so far in waste management?

5. What works have been done by your department so far in raising community's awareness about the possible negative impacts of improper waste disposal?

6. Are there defined rules and regulations set by your department to control illegal waste disposal? If yes, what about its enforcement?

APPENDIX: III

Interview with Land Administration Department

1. How do you describe the existing state of slum and squatter settlement expansion in Shire-Indasilassie?
2. How do you describe the impact of slums and squatter settlements on the performance of the storm water drainage systems in the town?
3. What measures have been taken so far to solve the problems of illegal multiplication of slums and squatter settlements?
4. What major factors affect the controlling and supervision process of slum and squatter settlement expansion?

APPENDEX- V

QUESTIONNAIRE FOR HOUSEHOLD HEADS

This questionnaire is prepared for two reasons:

- To explore the existing status of storm water drainage facilities of Shire-Indasilasse town and to forward workable recommendations for improved facility.
- To prepare thesis for the partial fulfillment of the requirements for MA in Urban development and management.

Hence, taking the above objectives in to consideration you are kindly requested to provide the appropriate answer for the following questions.

I. General Information

1. Age _______
2. Sex _______

II. Information on Occupation and Income of Households

1. In what kind of occupation do you engage to lead your family?

Occupation	Code
Governmental	1
NGO	2
Business owner	3
Business employee	4
Agriculture	5
Daily laborer	6

2. What is your average monthly income?

A. Less than 400 Birr

B. Above 2000 Birr

C. Birr 1001-2000

D. Above 2000

C. Is water that affects the psycho-social condition of urban residents?

D. Is water that if systematically treated can recharge ground water and reduce the demand for the scarce potable water,

19. How often do you use storm water as an additional means to satisfy your water demand?

A .Regularly C. Rarely

B. Some times D. Not at all

20. Are there any public open spaces, sporting fields or recreational areas/sites in your locality?

A. Yes B. No

21. If your answer to question number 20 is yes, are there any dams or ponds constructed in conjunction with these facilities?

A. Yes B. No

22. What do you recommend to improve the existing storm water drainage system in your locality?

___

___

___