

Analyzing the Impact of Inadequate Drainage Systems on Road Infrastructure: A Case Study of Mogadishu, Somalia

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Abstract: *This article delves into the repercussions of the collapsed central system on Mogadishu, Somalia, resulting in an economic, governance, and social development slowdown, particularly affecting road infrastructure and drainage systems. The study investigates the profound consequences of the absence of a functional drainage system on roads, encompassing aspects of transportation, construction, and pavement. Employing a research design comprising surveys and quantitative analysis, the study targets students, business communities, drivers, and engineers in Mogadishu, with a sample size of 80 determined through the Slovenes Formula. The research underscores that functional drainage systems are integral to efficient road networks and recommends urgent governmental intervention for the repair and reactivation of Mogadishu's drainage systems to avert social, economic, and environmental predicaments.*

Keywords: Road infrastructure, drainage systems, Mogadishu, transportation, economic impact

1. Introduction

Drainage is very important in any populous city, during the rains part of the rain water flows on surface and part of it percolates through the soil mass as gravitational water until it reaches to the ground water. Some water is retained in the pores of the soil mass and on the surface of soil particles which cannot be drained by normal gravitational methods and this water is termed as held water. It is required that the surface water should effectively be drained off without allowing it to percolate to subgrade. The surface water from adjoining land should be prevented from entering the roadway. The side drains should have sufficient capacity and longitudinal slopes to carry away all the surface water collected. Also in waterlogged areas special precautions should be taken. There are many such roads which are not having the proper drainage system. This causes the failure of the roads due to many reasons like increase in moisture content, decrease in strength, mud pumping, formation of waves and corrugations, cutting of edges of pavement.

For example In India as stated by Dawson (2008): 'Water and road construction do not make for a harmonious couple!' From this it can be seen that there is a very serious effect of poor drainage on the condition of roads. The different effects of water on roads which are supplemented with the case studies are given below.

Service road to Mumbai Pune Expressway

The construction of Mumbai Pune Expressway was carried out in 2004. The drainage conditions of this road are getting damaged by the passage of time. The service road provided to this Expressway is mainly getting affected by the poor drainage conditions. The blockage of drainage by derbies and vegetation causes the drain water to flow on the surface of the road. The condition remains same throughout the year. This causes the failure of pavement due to stripping of bitumen from aggregates. The pattern of failure is getting repeated at every 200 m distance on the service road.

Holkar Bridge Chowk, Khadaki

The present area is badly affected by the presence of water surrounding the road. The highest level of water table should be fairly below the level of sub grade in order that the sub grade and pavement layer are not subjected to excessive moisture.

From practical consideration it is suggested that the water table should be kept at least 1.0 to 1.2 m below the sub grade. But at this location the water table is very high and hence the capillary rise through sub grade is taking place. This causes the water to come out on road surface when vehicles are passing on this road, because of its load water is getting emerged from the road which also brings the clay particles on the surface. This causes the formation of potholes and the pavement is also becomes weak.

In Mogadishu After the collapse of the Central Government of Somalia, crucial infrastructure was not maintained and quickly deteriorated, causing further problems such as flooding. In Shangaani District, the drainage system fell into disrepair and caused massive flooding in the streets and negatively affected area businesses. IOM (International organization for migration) supported the Shangaani District administration to rehabilitate 500 meters of drainage and sewer canals. The project, which ended in July 2014, is a relief to many in the district, especially those whose livelihoods depend on flood - free streets. Fardows Aden, the breadwinner for her seven - member family, sells tea on the sidewalk in Shangaani District. "Before when it rained, floods came through here and we were not able to sell tea because the road was full of water. No one could pass through the water and it would take more than ten days to clear and those ten days were black days for us," she said, referring to the other 16 women who operate small kiosks in the area. She added, "After rehabilitation of the drainage and sewer, we see a big difference and even work when it is raining because the pipes of the drainage system are open."

Rehabilitating the drainage and sewer system will ensure

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that Fardow's tea stall remains open for business, regardless of the rain and increase the public's confidence in the government's ability to provide services, leading to stability.

Heavy rain and flooding have caused more problems in capital of Mogadishu the city recorded heavy rain from 10 to 11 may according to the WMO figures almost 60mm fell in the city in 12 hours on 11 may, streets were turned to rivers as the poor drainage system much of it blocked by garbage, was overwhelmed. Local media reported that some people have evacuated their homes five people died when the rain caused house to collapse, the victims are thought to be members of the same family.

The general objective is to analyze the impact of lack of functional drainage system on roads in Mogadishu, Somalia. While the specific objectives of this study were:

- Identify the effect of lack of functional drainage system on road transportation in Mogadishu, Somalia.
- Determine the effect of lack functional drainage system on road construction in Mogadishu, Somalia.
- Find out the impact of lack of functional drainage system on road pavement in Mogadishu, Somalia.

Therefore in this article as an author there is an expectation to clarify the impact of lack of functional drainage system on roads in Mogadishu, Somalia.

2. Methodology

The study was quantitative in design. In quantitative design, the researcher aims to determine the problem numerically. This type of design doesn't need to go deep into the details of the problem and it will be conducted through survey research design. The data collected from surveys is then statistically analyzed to draw meaningful research conclusions. It was used to collect a large amount of data in a relatively short period. Surveys can also be used to collect information on a broad range of things, including personal facts, attitudes, past behaviors, and opinions. We use this design drainage system in Mogadishu Somalia. This study was conducted in 100 people of target population this target population has been Chosen because it is the available populations and can collect the information easily and as soon as possible. The population consists of students, business community, drivers and engineers.

The sample size of the study was consisting of 80 to determine the best sample size for the population; it will also collect data from 80 respondents. A justification of sample size, because this study was used Slovenes formula which is $n = \frac{N}{1 + (N \cdot e^2)}$, where n = sample size, N = population size, and e = margin of error of 5% $N = 100 / (1 + (100 \cdot 0.0025)) = 80$ subjects.

3. Literature Review

Water is the most important compound ensuring life on earth but on roads the presence of water means mainly trouble, main cause damage and problems with the

serviceability of road networks is excess water filling the pores of road materials in the road and in the sub - grade soils. Drainage becomes a problem when a ditch is not functioning properly to direct and carry the run off away due to improper physical condition, capacity and maintenance. The effect of water puddles on the road is a weakening of the soil load carrying capacity followed by the acceleration of the pavement cracking process.

The efforts to maintain road failure are not only focused on improving the pavement (overlay and road reconstruction) but also in planning the construction of subsurface drainage infrastructure to be able to release water that can weaken the pavement of the road from within. The integration of drainage and the road system is done by concerning the factors that influence urban drainage systems, which are: a) rainfall intensity, b) catchment area, c) urban growth such as physical growth of the city, balance of development within city and between city and social factor, economy and culture, d) terrain and environmental factors such as topography and soil stability. However, in the implementation, road and drainage system management has not been integrated. The ideal road infrastructure provision requires a low maintenance cost, and good roads and drainage performance. Drainage plays a role in preventing the types of road construction failures caused by puddles on the road surface or water infiltration on the pavement.

Once a drainage system is constructed, it is not easy to replace or rebuild it during its entire life span. Thus, it is important to build a drainage system with a capacity to adapt well to uncertain conditions in the future. The quantity of wastewater discharge will face multiple influencing factors such as climate change, population change, and water consumption behavior change. (Effects of Urban Forms on Separate Drainage Systems: A Virtual City Perspective NingJia2019).

4. Impact of Lack of Functional Drainage System on Road Transportation

Roadway as part of land transportation is very important to actualize human or commodity movements. Roadway should be able to show good performance. It is known that inundation at roadway is very serious problem, and often causes disruption to road users. Conventional drainage system that has been applied with the concept of discharging or draining water to the drainage channel has not been able to evade rain water that falls on the road surface. To date, the load of drainage channel is increasing.

Roadway represents an infrastructure that functions as media of land transportation movement, either motorized or non - motorized vehicles, and also pedestrian. The roadway infrastructure is generally designed to be able to cater the vehicle movements for certain design period by considering various factors, such as construction material, and also the number of vehicle load repetition that will work on it. In service period, beside vehicle load repetition, natural factor in the form of rainfall can cause the presence of surface water run - off on roadway and the surrounding unpaved parts. The road surface will increase waterproof surfaces, therefore, high rainfall can increase the volume of surface

water run - off volume and as a result, inundation on roadway surface might be occurred if road drainage does not function well. This can be contributed by waste, such as organic waste (leave, plants, and so on), and in - organic waste produced by human, causing to heap or fulfill road drainage channel. Therefore, it could cork the road drainage channel and result overflow water when it rain is fall.

In particular, transport networks support the safety and wealth of communities, especially in the context of a global economy increasingly reliant on the mobility of goods and people (Rodrigue and Notteboom, 2013). Changes in the climate, rapid urbanization, and increased infrastructure interdependence are putting societies, assets, and the built environment under increasing pressure. This is particularly evident in urban areas when transport systems are affected by weather - related hazards. This problem is particularly acute on the road network in urban areas owing to the high proportion of impermeable surfaces that prevent the infiltration of water into the soil.

Heavy rain causes overland flow that can result in drains exceeding their capacity, and increasing the likelihood they become blocked by debris. On the 28th June 2012, 50 mm rain fell on Newcastle upon Tyne (UK) between 3 and 5pm, a time typically associated with heaving commuting and school collection traffic (Newcastle City Council, 2013). Most public transport was cancelled some roads were completely impassable whilst others experienced very slow running traffic for many hours. Drivers reportedly abandoned their cars and some ran out of fuel after several hours of slow movement. The event flooded more than 1200 homes and caused £8m of direct damage to roads and pavements alone.

Reliable transport systems are valued for their safety, cost, travel time, and regularity of service (Koetse and Rietveld, 2019). Maintaining the volume traffic flow on the network, whether public transport or private travel is fundamental for production, logistics, and business (Jenelius, 2006). Flooding impacts this in a number of ways through both direct impacts (e. g. physical damage to transport infrastructure) and indirect impacts (e. g. disruption to traffic flow, business interruption, increased emissions) (Brown and Dawson, 2016; Hammond 2015; walsh, 2012). Although direct damages could be consistent the reduction in performance of transport systems due to flooding is the most detrimental factor for the society and it has been estimated at around £100 k per hour for each main road affected (Arnell and Darch 2006; Hooper 2016).

It is obvious that roads are vital to a community's economy and well - being. Roadways with excess water covering a portion of them decrease the level of service and can increase the hours of traffic delays due to increased congestion (Zimmerman and Faris 2010). If flood waters flow completely over roadways, making them impassable, traffic delays are dramatically increased due to the detours around the closed road sections. It is also clearly appear that the waste of journey time as stated Dr. NdefoOkigbo "Useful time is wasted in playing faulty roads". The nature of roads in Nigeria is one of the main causes of excessive traffic congestion on our roads. Some of the times opposite

coming vehicles will have to share the same lane. Some of them do this to avoid pot holes, pavement gulley and other defected parts of the roadway.

This makes movement on the roads very slow and as such causes the waste of precious time. When the motorist decides to be on his own lane that is littered with cracks and potholes he must have to unduly slow down in order to save the vehicle from avoidable damages".

Access to roads and bridges and to basic institutions such as schools, hospitals, police stations, and fire stations can be severely impacted if roads and bridges are damaged or destroyed.

The aftermath of flooding has a larger impact because movement in and out of these areas is inundated by the lack of connectivity due to the damaged transportation network, which in turn will affect the socio - economic stability of the community.

Road networks represent a major feature in the developed landscape. Many of the impacts observed with watershed urbanization are closely linked with transportation infrastructure (Eyles and Meriano 2010). The linear nature of roads and the associated drainage infrastructure can significantly increase the portion of connected impervious surfaces within a watershed and can extend the drainage area outside of the topographic watershed boundary (Noll and Magee 2009). Roadway drainage infrastructure may also intercept natural topographic flow paths and bypass floodplains and other storage areas (Wemple 2013).

In India During monsoon season or rainy season, the road deteriorates due to various factors like poor drainage, low quality of pavement materials let the rain water to penetrate through the pavement due to which various distresses like cracks, potholes, depressions, rutting, raveling etc. take place. These stresses may cause premature failure and traffic hazards. Due to these failures and hazards delays in transporting freight and passengers occur which causes retardation of process of social and economic development of country because 90 percent of passengers travel by road and 65 percent of goods also transported by using road transportation. During rainy season road crashes also increased as compared to normal days which may also lead to death of person. Road accidents may be happened due to different parameters like road, vehicle, environment or human causes. Skidding of vehicle is major cause of accidents, which may be due to lack of tire to road friction. (ParshantRana, and Dr R. R. Singh, 2018).

Impact of lack of functional drainage system on roadpavement

Highway pavement is carried out to make travelling convenient. Road construction requires the creation of an engineered continuous right - of - way or roadbed, overcoming geographic obstacles that will make the foundation stable and having grades low enough to permit vehicle or foot travel and may be required to meet standards set by law or official guidelines. After road

pavement, erosion and sediment controls are constructed to prevent detrimental effects.

Drainage lines are laid with sealed joints in the road easement with runoff coefficients and characteristics adequate for the land zoning and storm water system.

And the drainage systems must be capable of carrying the ultimate design flow from the upstream catchment with approval for the outfall from the appropriate authority to a watercourse, creek, river or the sea for drainage discharge.

The primary source of water in pavements is atmospheric precipitation. This water can enter the pavement through several ways (e. g., cracks, infiltration, through shoulders and ditches, high groundwater) and is moved by an energy gradient, such as gravity, capillary forces, osmotic forces, and temperature or pressure differences. Dipnoan, (2014) studied highway surface drainage system and problems of water logging and concluded that adverse roadway elements contributing to highway accidents were substandard roadway alignment or geometry, lack of shoulders and shoulder defects, absent or inappropriate pedestrian facilities, narrow and defective lanes and bridges/bridge approaches, roadside hazards, undefined pavement centre and edge lines, poor sight distances and visibility, unmarked and inappropriate design of intersections, serious allocation deficiencies along the route, haphazard bus shelters/stops, and others are causes of water logging problem in highway. This research traced that Proper drainage is a very important consideration in design of a highway. Inadequate drainage facilities can lead to premature deterioration of the highway and the development of adverse safety conditions such as hydroplaning. It is common, therefore, for a sizable portion of highway construction budgets to be devoted to drainage facilities.

In a research on drainage on roads by Singh, Navpreet and Nitin (2014), Water in the pavement system can lead to moisture damage, modulus reduction and loss of strength. In order to prevent such damages to the pavement, it is essential to provide proper drainage to the roads. They maintained that the presence of water in a highway layer reduces the bearing capacity of the road, and in doing so it also reduces the structure's lifetime. Highway drainage is used to clear surface water from the highway. Roads need to be well drained to stop flooding; even surface water can cause problems with in the winter. Water left standing on roads can also cause maintenance problems, as it can soften the ground under a road making the road surface break up.

(Jitendra, 2013) carried out a framework for quantification of the effect of drainage quality on structural and functional performance of pavement by identifying a simple framework for quantification of the effect of drainage quality on structural as well as functional performance of the pavement.

He presented the structural and functional performance of the pavement in predicted terms of deflection and roughness respectively. His study was useful to reduce the maintenance cost of highway pavement system and to

preserve huge highway network in India.

Siddhartha, (2012) carried out a research on drainage and flexible pavement performance; in the research, they pointed out that providing adequate drainage to a pavement system has been considered as an important design consideration to prevent premature failures due to water related problems such as pumping action, loss of support, and rutting, among others. They continued that most water in pavements is due to rainfall infiltration into unsaturated pavement layers, through joints, cracks, shoulder edges, and various other defects, especially in older deteriorated pavements. Water also seep upward from a high groundwater table due to capillary suction or vapour movements, or it may flow laterally from the pavement edges and side ditches. Providing adequate drainage to a pavement system has been considered as an important design consideration to ensure satisfactory performance of the pavement, particularly from the perspective of life cycle cost and serviceability. To minimize premature pavement distresses and to enhance the pavement performance, it is imperative to provide adequate drainage to allow infiltrated water to drain out from the base and sub - base, thus avoiding saturation of base and subgrade soils.

Many researches clearly demonstrating that poor drainage can adversely affect pavement performance. Rokade et al [1] reported that inadequate drainage leads to major cause of pavement distresses due to large amount of costly repairs before reaching their design life. He found that pavement service life can be increased by 50% if water can be drained without delay. Similarly, pavement systems incorporating good drainage can be expected to have a design life of two to three times that of undrained pavement sections.

Cedergreenet evaluated early field tests that included both drained and undrained pavement sections. Based on these field data, he estimated that a flooded undrained pavement experiences 10 to 70, 000 times the damage from a load event compared to a drained pavement. As a conservative single value, he suggested that an undrained pavement experiences 15 times the damage compared to a well - drained pavement. To achieve proper drainage, drains (or ditches) a long side of road are essential to collect water from road surface and surrounding areas and lead it to an exit point where it can be safely discharged.

The Subsurface drainage is a key element in design of pavement. The NCHRP (National Cooperative Highway Research Program) performed an extensive study of many subsurface drainage systems, NCHRP Project 1 - 34, Performance of Pavement Subsurface Pavement Drainage, summarized findings on the effectiveness of subsurface drainage on flexible pavements. They found that structural capacity and drain ability were key factors in the performance of flexible pavements.

ParshantRana, and Dr. R. R. Singh, 2018 The drainage system of various cities like Delhi in India is not adequate as population is increased dramatically but drainage system is still old due to which the sewers become unable to handle the rain water and water flows over roads which

penetrate through pavement and make it weaker. The drainage may also be hampered by lack of maintenance or blockage due to some Plastic or other wastes. According to investigations by N. D Little and R. D Jones the moisture content, which increases during rain due to improper drainage causes deterioration of asphalt roads. They found that cohesion of asphalt layer lost due to which strength and durability of pavement affected.

Impact of Lack of Functional Drainage System on Road Construction

A drainage system includes the pavement and the water handling system; they must be probably designed, built and maintained. The water handling system includes road surface, shoulders, drains and culverts, curb, gutter and storm sewer. When a road fails whether it is concrete, asphalt or gravel inadequate drainage often is a major factor. Too much water remaining on the surface combine with traffic actions to cause potholes cracks and road failure,

The amount of rain, which falls in a specified time, is expressed as the depth of water it would produce on a large, level impermeable surface. Precipitation is measured daily (24 hours) by means of a rain gauge. Today's rain gauges are simple to use with pre - calibrated scales on their sides. The administration involves the expenditure of hundreds of millions of dollars annually for construction, reconstruction and maintenance. Also, it imposes the responsibility of selecting and designing new roads, and the planning of future construction and development. Design of new structure to serve the volume and type of traffic a roadway will carry.

Pavement engineers recognize the importance of good drainage in the design, construction, and maintenance of any pavement. The amount of moisture within a pavement layer will greatly affect the strength, and thereby, the performance of the layer. As the moisture content of a layer increases, the strength decreases.

If subsurface drainage is provided, the overall strength of the pavement section will be higher. Some pavement sections have drainable layers built into the structure for additional drainage capacity. These drainage features should be strongly considered when grouping pavement sections (OECD, 2008).

The accumulation of water in the sub - grade or in an untreated aggregate base course usually creates problems. When the condition of soil is saturated, its ability to bear any load is weaker than the dry soil condition. Some soils exhibit swells by adding water that causes differential heaving. These factors (rain, snow, etc) are weakening the pavement structure and minimize its capability to support traffic loads. Water in the pavement's asphalt layers can strip or could be stripped out get segregated separate the asphalt film from the aggregate.

Water logging problem has many different impact on our economy as well as environment and the local people of the area some adverse effect on road construction pavement

related to excess water. (Johirul Amin, 2017). Drainage is the natural or artificial removal of surface or subsurface water from an area of road. Drainage is important because without proper drainage the road structure may experience many problems such as.

- Excess moisture in soil sub - grade cause considerable lowering of its stability and lead the road to fail due to the sub - grade failure,
- Increase in moisture because reduction in strength in many road materials like stabilization soil and water bound macadam.
- In some clay soil variation in moisture content causes considerable variation in a volume of sub - grade which contributes to the road failure.
- On the most important road failure by the formation of waves and corrugation in flexible pavement is due to the poor drainage.
- Sustained contact of water with bitumen pavement causes due to the stripping of bitumen pavement layers and formation of potholes.
- The prime cause of failure in rigid roads by mud pumping is due to the presence of water in fine sub - grade soil.
- Erosion of soil from top of surface roads and slopes of embankment and cut side is also due to the surface water.

5. Conclusions

Lack of drainage system is a major obstacle to the various aspects of roads and the overall beauty of cities To prevent these conditions from having a negative impact on the mobility, economy, sanitation and beauty of the city to prevent all these things first must have a functioning draining system that is capable of transporting all the surface water that comes in different seasons especially during the rainy season. Care should be taken in the construction of roads as same as the drainagesystem.

The accumulation of water in the sub - grade or in an untreated aggregate base course usually creates problems. When the condition of soil is saturated, its ability to bear any load is weaker than the dry soil condition. Some soils exhibit swells by adding water that causes differential heaving.

The researchers found that transportation have serious problems if roads do not have functional drainage system. There is no doubt that the government is responsible for the construction of roads, so they should include the drainage system in the road plans.

6. Recommendations

Based on the results we found the research suggests the following points:

- 1) The government should urgently activate the drainage system in Mogadishu, since lack of drainage system can cause social, economic and environmental problems.
- 2) The government should protect the drainage capacity,

constructing pumping stations, and building flood diversion culverts.

- 3) The government should make major repairs to the old drainage system in Mogadishu that was in operation before the collapse.
- 4) Drainage pipes should be regularly removed from the west to prevent blocking or damage to the pipe.
- 5) A quality drainage system must be built as it facilitates traffic, maintains road safety and enhances the beauty of the city.

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