

ASSESSMENT OF INDISCRIMINATE HOUSEHOLD SOLID WASTE DISPOSAL AS A POTENTIAL TRIGGER OF FLOOD IN GESSE, BIRNIN KEBBI, KEBBI STATE, NIGERIA

Abraham Annah Oyikene and Aminu Zuni

Department of Geography, Faculty of Social and Management Sciences, Federal University Birnin Kebbi

Corresponding Author's email: abrahamannaoyikene@gmail.com



Abstract

This study aimed at assessing indiscriminate household solid waste disposal as a trigger of flood in Gesse, Birnin Kebbi, Kebbbi State, Nigeria. The study entailed a field assessment of waste dump sites, determination of man-made drainage capacity, street width pattern and slope profile characteristics. A Garmin GPS was used to determine waste dump locations. The slope angles, was determine with a 100m steel tape and ranging poles were used for profile length. Data obtained from the study were summarized using descriptive statistics. Results show that the largest waste dump, located at N 12° 26.561 E004° 12.682 along street N1 was 239.3 m³wide, with a volume of approximately 47.84 m³/yr. The streets width pattern assessment revealed that streets were often overtaken by wastes dump sites, such as street E2 which narrowed down from 7.2 m at the beginning to 4.3 m and 4m in the middle and end respectively. Results on drainage characteristics show that the drainages are few or non-existent in most parts of the study area. Similarly, the study identified four (4) classes of slopes in the study area with a dominant slope of 5%, indicating a gentle to moderate relief. Overall, the result shows that indiscriminately disposed household wastes significantly influence flood generation in the study area while other factors such as streets width, slope characteristics and inefficient man-made drainages were found to mutually affect the travel time of runoff flow, thereby generating floods in the study area. Recommendations from this study include improved technology in flood hazard mapping and land suitability assessments, linking research findings to infrastructural planning and developing strong public- private partnerships between government and residents for effective policy implementation.

Keywords: Household Waste, drainage, flooding, slopes, capacities

Introduction

Floods are defined as overflow of water that submerge land that are usually dry, it is a natural event that can have far reaching effects on people and the environment (O'Riordan *et al.*, 1996) Floods are common and widespread through severe weather events which happen very quickly when heavy rainfall occur in a short period (Aminu *et al.*, 2019).. When rainfall occurs in large amounts with high intensities and probably in quick successions, water may accumulate on the land as a result of decreased infiltration due to over saturation of the land surface and result in excess runoff (Aminu *et al.*, 2019).

Although rainfall characteristics are a major cause of flood occurrences, studies all over the world have identified modification of surface areas due to changing land uses brought about by urbanization as a major cause of flooding in urban areas (Aminu, 2011; Aminu *et al.*, 2019). As

rural-urban migration continues to rise due to increasing need for industrial based jobs and several other economic reasons, urban expansion is often accompanied by proliferation of unplanned urban structures which modify slope and drainage characteristics of urban areas (Aminu, 2019). Studies show that in areas with increase in development of settlement and rapid urban expansion, certain structures such as man-made drainages and solid waste dump site pose potential flooding problems (Aminu, 2011; Besufekad *et al.*, 2020).

Household solid wastes are garbage, unwanted materials resulting from human or domestic activities with adverse effect on human health and the environment (Ajay, 2019; Kapilan and Elangovan, 2018). They are non-liquid and non-gaseous waste resulting from day to day human activities (Ajay, 2019; Kapilan and Elangovan, 2018). There are many root causes to attribute the problem of solid waste in developing countries to; the increasing human population and the associated activities that have accelerated the generation of waste (Ajay, 2019; Kapilan and Elangovan, 2018).

The significant manifestation of indiscriminate disposal of household solid waste include detrimental environmental challenges and economic sufferings (Dankani *et al.*, 2016), disfigured and aesthetically unappealing landscapes, air pollution through burning, clogged drainages (Aminu, 2011; Aminu *et al.*, 2019), soil pollution, contamination of surface and ground water, spread of diseases such as cholera (Yongsi *et al.*, 2008), decreased soil porosity and impeded surface water movement (Niu *et al.*, 2016; Aminu *et al.*, 2019) leading to urban flooding (Aminu *et al.*, 2019). Similarly, these environmental challenges are associated with social, economic and land availability issues (Dankani *et al.*, 2016; Cabon *et al.*, 2018).

Besufekad *et al.*, (2020) observed that solid waste in Ethiopia pose a major environmental problem as solid waste are disposed indiscriminately in open spaces in residential areas, along roadsides, in drainages channel and in water bodies. In Nigeria, solid waste management problems are common to most cities. For example, it is not uncommon to see many citizens emptying their trash bins during heavy rains; these eventually end up clogging drains or the effluents end up in nearby streams or rivers (Aminu, 2011). Many industrial cities in Nigeria are threatened daily by heaps of wastes indiscriminately disposed (Aminu, 2011; Dankani *et al.*, 2016).

Similarly, poor sewage/garbage disposal methods where household trash are disposed into manmade drainages and result in clogged drains cause storm water in drains to overspill unto streets and result in localized flooding (Aminu, 2011), while waste dump sites along streets impede flow of storm water and often cause flood water to pound back into compounds/ houses of residents in such areas (Aminu, 2011; Yerima and Bello, 2014)

Kaoje *et al.*, (2016) in a site suitability analysis for municipal solid waste disposal in Birnin Kebbi, Nigeria, observed that lack of organized and effective management of municipal solid waste in the state as well as other cities in the country exacerbates the problem of indiscriminate solid waste disposal and the attendant problems associated with it. Flooding has been found to be a major consequence of indiscriminate household solid waste disposal in Birnin Kebbi (Yerima and Bello, 2014) as drainages are narrowed by trash and unable to adequately evacuate storm water after rains.

In the same vein,, Abdullahi and Yelwa (2020) observed that Birnin Kebbi experiences economic losses due to flood events generated from natural causes and misuse of the environment, attributed mainly to indiscriminate solid waste disposal into the drainage systems. Also, studies by Kaoje *et al.*, (2016) in Birnin Kebbi found that facilities for house to house collection of solid waste are uncommon and result to municipal solid wastes being dumped in open spaces.

Thus, while several studies on flooding (Yerima and Bello, 2014; Muktar and Yalwa, 2020) and municipal solid wastes management (Kaoje *et al.*, 2016) assessments have been carried out in the study area, field based assessments which examine the impact of indiscriminate household waste disposal on flood occurrences in the study area are yet to be carried out. Specifically, this study attempts to assess indiscriminate household solid waste disposal as a potential for flood generation in Gesse, Birnin Kebbi, Kebbi State, Nigeria. The objectives entailed a field assessment of the solid waste dump sites and estimating the volume of waste generated, characterizing the streets pattern, determining slope profile characteristics and man-made drainage capacities along affected streets and flood hazard mapping in the study area,

Conceptual Framework and Literature Review

This chapter deals with conceptual framework and relevant literature. The literature review is divided into two parts; floods and the waste.

Conceptual Framework

This study is framed under the concept of sustainable environment which is concerned with improving environmental health and quality of life. Sustainable environment is the responsibility to conserve natural resources and protect global ecosystem to support health, wellbeing, now and in the future. Acting in a way that ensures future generation have natural resources available to live an equal, if not better way of life as current generation (UN, world Commission on Environment and Development, 2002).

According to World Health Organization (WHO), environmental health and humans are two inseparable elements this is because over 24% of death can be traced to environmental factors that can be avoidable. The ability of future generation to meet their needs depends of the current sustainable environment, the environment suffers in response to consequences of exponential population increase, industrial growth and energy use (U.S. Environmental Protection Agency, 2015). People need clean air to breath, freshwater to drink and places to live that are free of toxic substances be it liquid, solid or gaseous and hazards since the quality of environment affects public health (Elkington, 2020).

Exponential population has led to increased waste generation, which leads to different form of environmental pollution. The consequences of the waste been indiscriminately disposed is environmental pollution which is why more needs to be invested in environmentally sustainable and socially responsible practices like locating appropriate dump sites, public awareness on the environmental effects of indiscriminate waste disposal, the risks of environmental pollution in order to secure a livable future. Human activity such as continues waste generation and indiscriminate disposal is affecting the environment posing flood threat and without application of environmental sustainability methods, long term durability will be compromise.

FLOODS

Flooding is a natural event and a major environmental problem confronting man with a far reaching effects on people and the environment (Environmental Protection Agency, 2011). Floods happen when the soil can no longer absorb the water falling directly onto the ground or overflowing from dams, rivers, pond and rainfall. Blaettlerr (2018) observed that as urban area grows, so does the threat of flooding, most floods occur due to heavy rain, prevention of infiltration due to non-biodegradable waste buried underneath the soil and increase runoff due to pavement and buildings. Floods causes widespread devastation, resulting in loss of life and damages to personal property public property and health infrastructure. Between 1998-2017,

floods affected more than 2 billion people worldwide. People who live in floodplains with non-resistant buildings, lack warning systems and awareness of flooding hazard, are most vulnerable to floods (WHO, 2010). Floods produce damage through the immense power of moving water and through the deposition of dirt and debris when floodwaters finally recede (Berry, 1997)

Floods event all over the world is becoming a major threat to human sustainable development (Aderogba, 2012). They are common natural disaster affecting developing and developed countries of the world. Therefore, it is important to device means to mitigate and reduce the economic losses that comes with it (UNIDR, 2019). The magnitude and intensity of flood varies in time and space and it have the tendency of cause severe effects on human system, infrastructure, destroys lives and property, cripples economic and social activities and destruction on cultural heritage and the environment (Merz *et al.*, 2010; Dutta *et al.*, 2006).

On a global level, between 1980 and 2017 flood economic damages are estimated to be US\$1.6 trillion with over 225,000 lost live due to rapid urbanization and climate change (World Bank, 2017). Urban expansion and population growth have increased the frequency and severity of flooding events which generated a lot of interest in conducting studies regarding flooding, it effect and causes in urban area.

Emergency Management Australia (2002) reported that in Australia, floods are the most expensive type of natural disaster with estimated cost from 1967-2005 of over \$377 million per year in 2008 Australian dollars. In 1974, when floods affects New South Wales, Victoria and Queensland it resulted to a total cost of \$2.9 billion. The Queensland Government estimates costs for the 2011 floods will exceed this figure for Queensland alone with the damage to local government infrastructure estimated at \$2 billion, and the total damage to public infrastructure across the state at between \$5 and \$6 billion (Emergency Management Australia, 2002).

Causes of Flood

Recent studies have shown that the causes of flooding events are partly related to climate change and other factors are: poor planning, poor drainage system, poor sanitation, topography and surface soil characteristics (Ozabor and Wodu, 2016).

Some of the major environmental causes of flood events are listed below:

Manmade or artificial causes: incidence of flooding events in the past and present times is associated with a lot of damages and death both in developed and developing world. Developing nations such as Nigeria is not environmentally sustainable because of blockage of drainage lines due to indiscriminate waste disposal, houses build on water ways and lack of information on how to manage flood hazards (Olanrewaju, *et al.*, 2003).

Indiscriminate use of the environment: vegetation cover are destroyed, houses are built without basic planning principles and population increased due to rural-urban migration and the migrants do not have good sanitary system that manage the waste they generate. This uncontrolled activities causes degradation, deforestation and over grazing giving rise to flood events during rainy season (Ozabor and Wodu, 2016).

Heavy rainfall or excessive rainfall: this a natural cause of flood event where excess rainfall result to excess runoff with no place to channel the flow and the surface is saturated giving rise to flood event (Ozabor and Wodu, 2016).

Effects of Floods

Flood have long and short term effect in urban and rural areas, the primary effect of flood is due to direct contact with rivers, streams and blockage of drainage line with high velocity. The secondary and tertiary effect are the long term changes that had taken place such as disruption of urban infrastructures and it effect economy, food, health and human activity (Aliyu *et al.*, 2016). The effects of flooding are linked to poverty, low level of infrastructural development, inadequacy of knowledge, low level of adaptation capacities and lack of insurance (Kolawale, 2011; Most *et al.*, 2017). Flood affects various aspects human world such as: individuals, communities, social, economic, and environmental effect depending on the location and extent of flooding, vulnerability and values of the environment (Bunn, 2002). Flooding mostly exacts adverse socio-economic impact on the wellbeing of flooded communities. It does cause displacement of people, collapse of buildings, loss of lives, damage to valuable documents, unplanned migration, among others. Individual and community wise, most people are aware of the immediate impacts of flooding include loss of human life, damage to property, destruction of crops, loss of livestock, and deterioration of health conditions owing to waterborne diseases (Komolafe, *et al.*, 2015). As communication links and infrastructure such as power plants, roads and bridges are damaged and disrupted, some economic activities may come to a standstill, people are forced to leave their homes and normal life is disrupted (Apan *et al.*, 2010). Floods can also traumatize victims and their families for long periods of time, displacement from one's home, loss of property and disruption to business and social affairs can cause continuing stress. For some people the psychological impacts can be long lasting (Kingsford, 2000).

There are certain types of losses associated with floods, these are:

Direct loss categorized into two: which are loss from contact with flood water that can be replaced or bought with money e.g. Buildings and contents, vehicles, livestock, crops, infrastructure and irreplaceable loss e.g. Lives and injuries, loss of memory, damage to cultural or heritage sites, ecological damage.

Indirect loss know as no contact loss categorized into two, the replicable loss e.g. Disruption to transport, loss of value added in commerce and business interruption, legal costs associated with lawsuits and the irreplaceable e.g. Stress and anxiety, disruption to living, loss of community, loss of cultural and environmental sites, ecosystem resource loss (Kingsford, 2000). In agricultural production areas, flooding can lead to widespread damage to crops, fencing and loss of livestock. Crop losses through rain damage, waterlogged soils and delays in harvesting are further intensified by transport problems due to flooded roads and damaged infrastructure (Poff *et al.*, 2002).

Damage to public infrastructure affects a far greater proportion of the population than those whose homes or businesses are directly affected by the flood, flood damage to roads, rail networks and transport hubs, such as shipping ports, which have significant impacts on regional and national economies. Short-term downturns in regional tourism are often experienced after a flooding event. While the impact on tourism infrastructure and the time needed to return to full operating capacity may be minimal, images of flood affected tourism areas often lead to cancellations in bookings and a significant reduction in tourist numbers. Flooding of urban areas can result in significant damage to private property, including homes and businesses (Prosser *et al.*, 2001).

Environmental Implications of Floods

Causes and implication of flood affect not just people but the environment. The destruction of structures such as bridges and roads add to the human disaster and prevent help from reaching devastated areas. Flooding of areas used for socio-economic activities produces a variety of negative impacts. The magnitude of adverse impacts depends on the vulnerability of the activities and population, the frequency, intensity and extent of flooding (Rutherford, 2001). Some of these impacts are shown below:

- i. **Loss of Lives and Property:** Immediate impacts of flooding include loss of human life, damage to property, destruction of crops, loss of livestock, non-functioning of infrastructural facilities and deterioration of health condition owing to waterborne diseases. Floods, with little or no warning time, cause more deaths and loss of properties.
- ii. **Loss of Livelihoods:** As communication links and infrastructure such as power plants, roads and bridges are damaged and disrupted, economic activities come to a standstill, resulting in dislocation and the malfunction of normal life for a period of time even beyond the duration of the flooding. Similarly, the direct effect on production assets, be it in agriculture or industry, can inhibit regularly activity and lead to loss of livelihoods. The effects of the loss of livelihoods can be felt in business and commercial activities even in adjacent non-flooded areas.
- iii. **Decreased Purchasing and Production Power:** Damage to infrastructure also causes disruptions to clean water and electricity, transport, communication, education and health care services. Loss of livelihoods, reduction in purchasing power and loss of land value in the flooded area lead to increased vulnerabilities of the people living in the area. The additional cost of rehabilitation, relocation of people and removal of property from flood-affected areas can divert the capital required for maintaining production (Rutherford, 2001).

Waste

Wastes are garbage, refuse, sludge, and other discarded materials, including solid, liquid or gaseous materials resulting from industrial, commercial, and agricultural operations (Sasikumar and Krishna, 2009). Waste from each stage of human life leads to adverse impact on human health and environment (Bringi 2007). Mostly wastes are sourced from residential waste resulting from day to day human activities and it impact on the environment causes detrimental pollution problems (Liu *et al.*, 2014). Residual waste decreases soil porosity and impedes surface water movement (Niu *et al.*, 2016).

Early 20th century, over 53% of solid waste in UK are generated from residents, markets, plastic containers without significant recycling activity causing environmental pollution (US. Environmental Protection Agency, 2015). In china the accumulation of waste is becoming increasingly serious amounting to 71.9-259.1 kg ha⁻¹ residual in the soil which poses direct threat to the environment, block drainages, affect run-off after a heavy downpour leading to urban flooding (Dong *et al.*, 2013; Guo *et al.*, 2016; Niu *et al.*, 2012). In developing world, the level of technology to handle the high rate of generated waste attributes to high effects of indiscriminate disposal (Baum, 1973). In African cities, especially the slum areas rapid growth has place lead to increase generation of waste and is often associated by uncontrolled dumping causing huge environmental effects (Hammer, 2003). Waste are dumped indiscriminately into landfills

worldwide, that occupy tons of hectares of land and emit dangerous methane and carbon dioxide gases as well as highly toxic leachates from these landfills during their decomposition stage. The indiscriminate dumping of waste creates unhealthy environmental challenges and economic sufferings (Dankani *et al.*, 2016).

Sources of Waste

Waste has its various source such as: households which contribute of solid waste products, industries, supermarkets, market place, shops, restaurants and hospitals. Waste accumulation is a growing problem across the globe which cannot be completely taken care for but to some extend it can be reduced.

Causes of Indiscriminate Waste Disposal

Industrialization on a massive scale, increasing urbanization, advance technology in agriculture and changing pattern of life have resulted to production of huge amount of waste (Baum *et al.*, 1973). Wastes are widely generated with the biggest percentage in the urban areas which has been an urban problem for years making human induced factors the most cause of indiscriminate disposal in drainages and on the street (FAO, 2014). Ignorance or illiteracy of the people, Lack of enough dumping sites, lack of effective waste management services and landfill site for waste, lack of strict laws on the dumping of wastes from the government are the major factors contributing to indiscriminate waste disposal (Environmental Protection Agency, 2014). People throw waste on the street without been punished which lead to continues improper disposal, the attitude of people towards waste disposal and management pollutes the environment and diminish the environmental sustainability (Ibrahim, 2016).

Methods of Solid Waste Disposal

Both developed and developing countries are faced with solid waste management challenges, most municipalities are unable to collect the increasing volumes of waste generated daily (Zhang *et al.*, 2010). Waste Management is critical for protecting urban environments, public health and the image of cities, urbanization has become means through which the collection and disposal of waste will increases in years to come, and therefore the current problem needs to be given due consideration and attention. (Habitat, 2010a). A means that deals with the control of generation, storage, collection, transfer and transport, processing and recovery, and final disposal of solid wastes in such a way that it will of no harm to public health, economics, engineering, urban and regional planning, conservation, aesthetics, and other environmental considerations which are as a result of public attitudes (Jaya, 2004). It is very common to see waste in places where they do not belong, lying by the road sides, within an area, in our drainages, on the streets, around packs and markets. There are actual ways this waste can be reuse or reduced not just by the government but also by individuals, families and schools. (Subramanian, 2000).

The issue of waste disposal is no longer an individual or local organization problem as it has graduated to national and international concern. In 1988 for instance there was problem of uncontrolled hazardous waste dumped by European countries in the developing countries (Istifanus, 1994). Increasing population give rise to continues waste accumulation polluting the environment if not properly managed or disposed. Yahaya, (2006) reviews that there is need for proper management and allocation of suitable site for solid wasted as residential, commercial, institutional, agricultural, municipal and industrial wastes are of great threat on the environment and to human health. Technology has helped a lot in the control of some problem of solid waste disposal but not actually brought solution to these problems (Berry and Horton, 1974). (Nayak *et al.*, 2007; Amadi *et al.*, 2012) observed that solid waste management is one of the major

environmental problems in developing countries. Sites and landfill for solid waste disposal are neither properly designed nor constructed and it becomes a point source for environmental pollution (Jha *et al.*, 2003; Sharholy *et al.*, 2008). Therefore, there is a need to develop proper means for disposal of increased amount of waste as more than 70% of wastes are disposed improperly. Report have it that land area of about 1400km² was occupied by waste as at 1997 and has continued to be on increase to the nearest future (Goswani and sarma, 2008; Sharholy *et al.*, 2008).

Methods of Waste Management

As a result of the effects of waste on the entire ecosystem, the public, activists and legislatures have expressed outrage on the degree at which national governments have stated a specific punishment on anyone caught indiscriminately disposing waste (Dascalopoulos, 2006). Improper waste disposal has become a major issue facing most developing countries (Elmira *et al.*, 2010). Several European countries have adopted a fee for indiscriminate disposal, taking into account the negative effect of waste on drainages leading to problems on environment (Jalil *et al.*, 2013). The method of waste management in an area depends on the attitude of the residents towards waste and the local condition of such an area. In many area different methods are practiced (WHO, 1970).

i. Recycling

This have to do with compost and waste-to-energy process use in recovering solid waste which can be used for another purpose (Orfano, 2018). This process makes the environment cleaner, reduce the chocking of animals, water ways blockage, increase volume of ground water, minimize water pollution and as well preserve some of this waste for further use (Finn, 2018). It is simply a process of converting waste product into new product, there was no means of recycling before but then now the government have provided means of solid waste collection. (Ogwuueleke, 2003).

ii. Open Dumping

It is the oldest and cheapest method of waste disposal involving the collection and dumping on an open fields or space. This indiscriminate practice of waste disposal can be found almost everywhere though it differs pending on what the resident decides. In some areas it is periodically leveled and compacted, in some, it is piled up as high as the refuse permit and in other areas it is burnt to give way for more. Generally, little or no effort is made to prevent open dumping (WHO, 1971).

iii. Sanitary Landfill

It is another method on waste disposal where waste is disposed little by little each layer is covered and compacted with soil so as to prevent foul odors and windblown litter. This method of waste disposal on land is done without creating hazards to public health and safety as it is reduced to the smallest practical volume at intervals. (Aziz *et al.*, 2010). In 1904, garbage were burnt to provide landfill and in subsequent years this method have been adopted in many cities, the practice did not emerge until in the late 1930s to 1945 and by 1960 almost all cities in the states adopt this method and more than 1400 cities use this method to dispose waste. (Sada 1997).

iv. Reuse

This is a process where waste products can be used as raw materials for the creation of new product so as to reduce waste potentials, extend the value of waste and optimize the world's

limited resources. It is an action taken to seek alternative use of waste (Guidelines for National waste Management Strategies).

Effects of Indiscriminate Waste Disposal

Filemo and Uriat, (2008) observed that in developing countries waste is now part of everyday living especially solid waste and that has become a problem to these countries. In Nigeria today, the appropriate method of disposing waste is ignored or giving little attention, which causes health problems and environmental degradation (Ali *et al.*, 2017). Economic changes, trends and urbanization complicate waste management in developing countries as it only not increased in quantity but also changing in composition, from organic matter to more paper, plastics, packaging materials, metal, glasses and other substances, caused by low rate of collection. (Bartone and Bernstein 1993; Medina 2002). On the average, out of the total heaps of solid waste only about 36% are properly collected and managed. As a result, the remaining are improperly dumped by the roadside and in the drains blocking waterways obstructing flow, causing public health issues and degrading the environment in general (Friedman, 1998).

Solid waste makes the environment unhealthy and when an environment is not hygienic, it is prone to harm and negative impacts on the residents especially around the dumping sites and outdoor workers making them vulnerable to different kinds of diseases (Yan *et al.*, 2013). Most places admit to their inability to cope with the problems associated with indiscriminate solid waste disposal (Ayuba and Manaf, 2013).

Indiscriminate Solid Waste Disposal as a Potential Trigger of flood for Flooding

Solid wastes are omnipresent in the environment, when not collected solid waste are indiscriminately disposed, they occupy the drainage systems and places not suit in the area and most times after a long period of time the affects the direction of flow during the rainfall leading to flooding mostly in urban areas (National Geographic Society, 2011). This solid waste disposed indiscriminately forces excess runoff in the area to close down the entire street flowing into buildings causing property damage as well as vehicular damage until they can clear the water drains and sewers (Sugii, 2008).

Habitats are being destroyed not just because of climate change or poaching but because of solid waste. Solid waste, once settled, get into soil and slowly release toxic chemicals (Simons, 2005). Solid waste poses serious environmental danger to human and animal health when not properly disposed, they impact the environment by causing litter and water drain blockage, the consequence of this would be the flood (Katsanevakis, 2008).

This environmental impact can be summarized as follows:

i. Blockage of Water Systems

Water is another sector that is highly important to man but has been disturbed by solid waste materials. Man is affected in various ways that cannot be fully explained. Water system like taps, ponds and rivers are blocked due to continuous dumping of waste materials. The water flow is affected and may be stopped causing floods, disease habitation and unpleasant scenery (Maulood *et al.*, 2015).

ii. Decrease in soil fertility

The soil has also not been spared by continues poor disposal of solid waste, lots of lands is continually lost to this cause. When the non-biodegradable materials from disposed solid waste enter into the soil, they block the passage of mineral salt and oxygen to the soil which are the

main component that makes up soil fertility (Nayak, 2007). Soil when deprived of minerals is unable to yield crops properly which causes problem to the farmers and consumers.

iii. **Incompetence of Government Policies**

The government through its failure to enhance strict rules that can help reduce the problem of poor waste disposal has failed to control the problem. The officials of the various organs of government has failed to provide sufficient supervisions of the dumping of waste as a result, solid wastes are continually damped improperly which is hazardous to the environment and people living around it.

iv. **Disease**

Due to the large number of solid wastes that are widely spread all over the city, disease has become one of the common problems in rural and some urban areas respectively because the heap of solid wastes improperly disposed serve as a breeding place for various kind of diseases carrying microorganisms in large number such as the deadly female anopheles mosquito that spread malaria and cholera germs which has led to the death of millions of people all over the world (Yongsi, 2008).

v. **Unpleasant scenery**

Wherever waste is improperly disposed, such place is best defined as improper for human settlement due to offensive odor and other effects and as such when waste is poorly disposed, the environment losses its natural beauty and as well scare off visitors in an area (Findikakis, 1997).

Material and Methods

Study Area

Gesse is situated in Birnin Kebbi Local Government Area of Kebbi State. Located on latitude 12° 10'.90"N to 12°40'.00"N and longitude 3°50'.00"E and 4°50'00"E (Fig.1), 234m above sea level. The climate is dominated by two air masses, Tropical Maritime and Tropical Continental which determine the two dominant seasons of wet and dry. The wet season lasts from April to October in the south and May to September in the north; while the dry season lasts for the remaining period of the year. Rainfall is highly seasonal and varies from over 1000mm in the southern parts to less than 500mm in the northern part (Aleiro *et al*, 2018). Average temperatures range from 21°C to 40 °C between April and June. Relative humidity is generally low (40 per cent) for most of the year except during the wet season when it reaches an average of eighty percent.

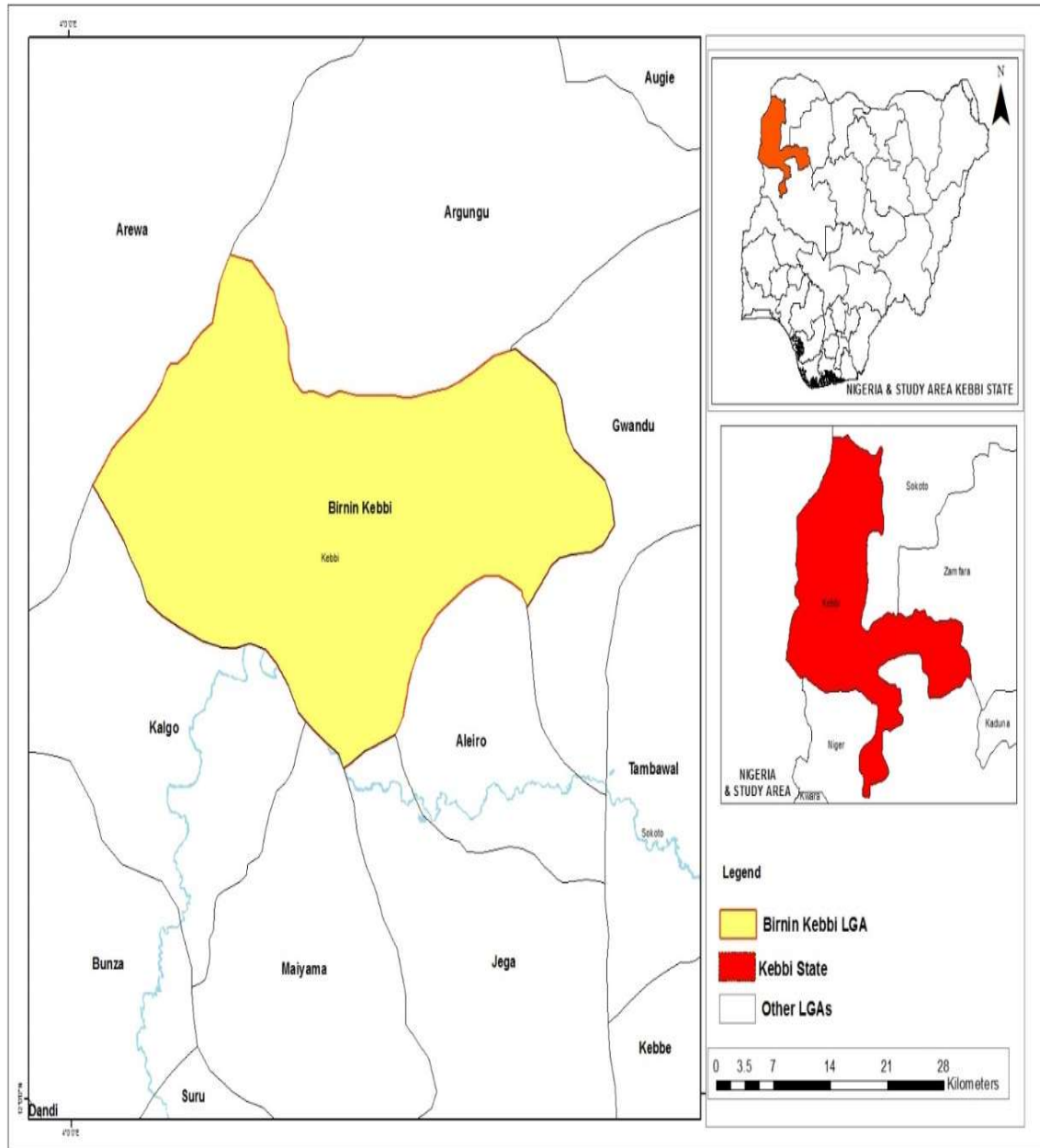


Figure 1 Map of the Study Area

Geographical Location of Study Area

Materials and Methods

The methodological approach was based on field assessment of the solid waste dump sites, determination of drainage capacity, slope profile characteristics, street width pattern and flood hazard mapping for the study area. Figure 2 shows the sampling points used during the study.

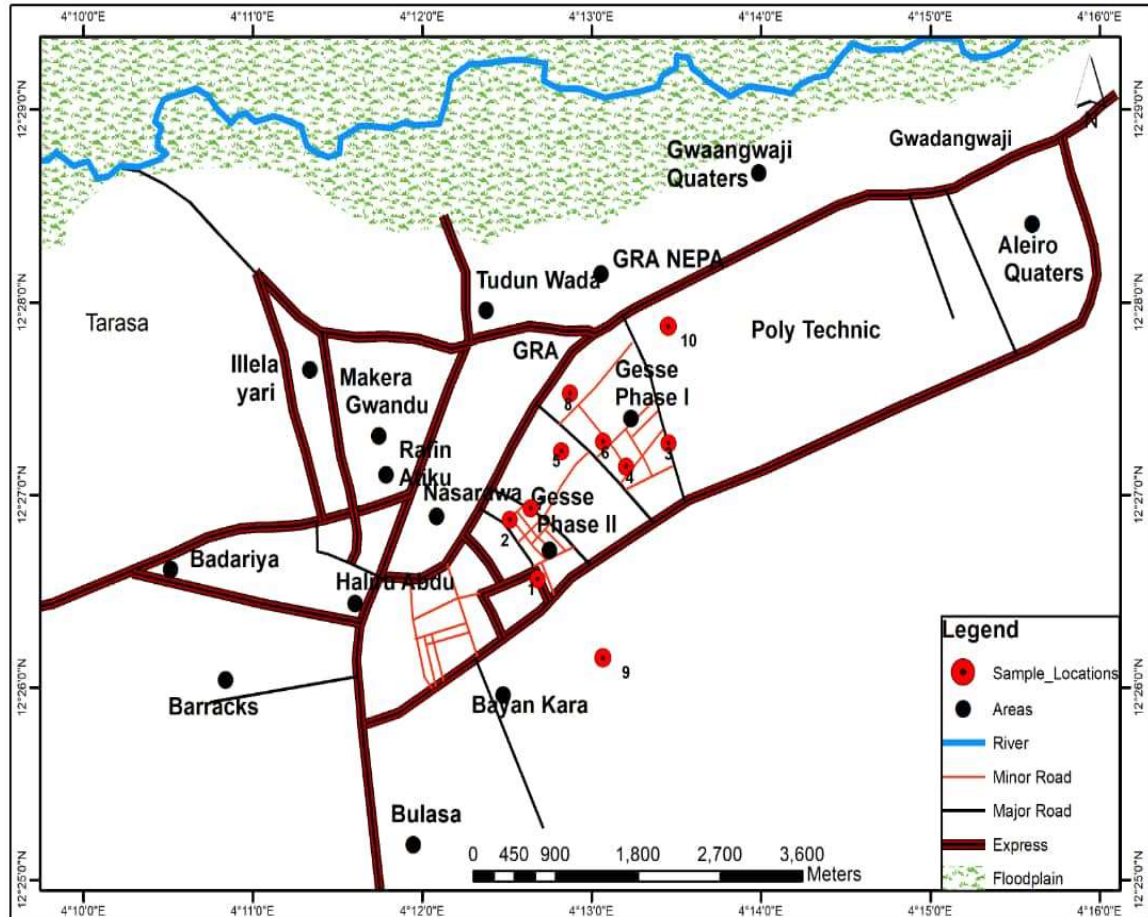


Figure 2 Sampling Points

Mapping and measurements of waste dump sites

The geographical locations of waste dump sites identified during the reconnaissance survey were recorded using a Garmin GPS and mapped with ArcGIS 10.3. Similarly, the age of each refuse dump site was estimated from the residents' viewpoint and the area of each refuse dump was determined. The data obtained from the measurements of the refuse dump sites were used to estimate the volume of the dumps, using the equation:

$$X = as/at$$

Where,

X = volume of sampled waste dump

as = area of sampled waste dump (m³)

at = age of sampled waste dump (years)

(Bello,1991; Aminu, 2011)

Determination of the streets' widths

The streets along observed waste dumps in the study area were grouped into two, the 'northings' and the 'eastings'. The 'northings' are those streets running northwards and are numbered 'N' and the eastings running perpendicular to the northings and are numbered eastwards (E). The

streets widths were measured at the beginning, middle and end to determine the extent to which solid waste dump sites have taken over the streets and how this influences the flow of runoff (Aminu, 2011;

Determination of drainage characteristics

The dimensions of existing man-made drainages were measured using a 100m measuring tape and ranging poles. The depths and widths were determined at the beginning, middle and end and their average capacities determined (Yerima and Bello, 2014).

Determination of the street profiles

Slope profiles of streets along observed waste dumps in the study locations were measured for slope angles and profile length. Slope characteristics are important in this kind of study because slopes influence the direction of flow of runoff (Aminu, 2011; Yerima and Bello, 2014). Slope angles were determined using the Garmin GPS, 100m steel tape and ranging poles. Slope gradients were calculated using the equation;

$$Gs = Vh/Hd \times 100 \text{ (Aminu, 2011).}$$

Where,

Gs = slope gradient (expressed in percentages)

Vh = vertical height difference (m)

Hd = horizontal distance (m)

Data obtained from the study were summarized using descriptive statistics and presented in tables and charts.

Results and Discussion Effects of Waste Dump Sites on Drainages

The results of measurements of waste dump sites are presented in Table 3. 1. The results show that the largest waste dump is located along street N1 and measured approximately 239.2 m³, followed by the waste dump site along N5 which measured about 225.6 m³ and along street E3 measuring approximately 197 m³. The results also show that the smallest volume of thrash is located along E4 (10.5 m³), E1 (10.3 m³) and N2 (9.38 m³). These dump sites are improperly managed causing blockage to drainages, leading to stagnant water pools that attract pests and increase in the risk of disease like malaria. Blocked drainages in the study area also causes flooding during heavy rainfall, damaging nearby ecosystem and infrastructure. With no waste collected at any given time of the year, the ages of the waste dump sites indicates that about 47.7 m³, 45.1 m³ and 28.1 m³ thrash are dumped annually along N1, N5 and E3 respectively.

Table 3.1: Measurements of Waste Dump Sites

S/N	Location	Length (m)	Height (m)	Volume (m ³)	Age (yrs)	Volume (m ³ /yr)	Coordinates (0)
1	N1	23	1.6	239.2	5	47.8	N 12 ⁰ 26.561 E004 ⁰ 12.682
2	N2	25.8	0.5	103.2	11	9.38	N 12 ⁰ 26.869 E004 ⁰ 12.516
3	N3	14	0.65	68.3	6	11.4	N 12 ⁰ 27.266 E004 ⁰ 13.454
4	N4	10	1.2	72.0	6	12	N 12 ⁰ 27.146 E004 ⁰ 13.203
5	N5	47	0.8	225.6	5	45.1	N 12 ⁰ 27.276 E004 ⁰ 13.068
6	N6	24	0.6	158.4	8	19.8	N 12 ⁰ 27.093 E 004 ⁰ 13.052
7	E1	14.40	0.5	72.0	7	10.3	N 12 ⁰ 27.226 E004 ⁰ 12.822
8	E2	35	0.4	72.8	3	24.3	N 12 ⁰ 27.448 E004 ⁰ 12.938
9	E3	41	0.6	196.8	7	28.1	N 12 ⁰ 26.929 E004 ⁰ 12.641
10	E4	19	0.6	42.2	4	10.5	N 12 ⁰ 27.526 E004 ⁰ 12.873

The results show that waste dump sites are common flood generating structures in the study area and agree with studies which have found that apart from constraining and clogging drainages, waste dump sites also narrow down street widths (Aminu, 2011; Nwachuku *et al.*, 2018; Besufekad *et al.*, 2020). Similarly, field observations indicate that the composition of waste dumps is mainly polythene and other household garbage, which may serve as impermeable layers hindering infiltration and resulting in flooding (Aminu, 2011; Nwachuku *et al.*, 2018; Besufekad *et al.*, 2020).

Street Characteristics

The characteristics of the streets layout are presented in Table 3.2a (Northings) and 3.2b (Eastings).

Table 3.2a: Street Pattern Measurements (Northings)

S/N	Street	Width (m) Beginning	Width(m) Middle	Width(m) End	Average Width (m)
1	N1	6.8	7.3	7.3	7.1
2	N2	18	12	17.5	15.8
3	N3	7	6.8	7.3	7.03
4	N4	9	6	9	8.0
5	N5	12.4	6	12.5	10.3
6	N6	8	4	8	6.7

Table 3.2b: Street Pattern Measurements (Eastings)

S/N	Street	Width (m) Beginning	Width(m) Middle	Width(m) End	Average Width (m)
1	E1	9	5.5	9	3
2	E2	7.2	4.3	4	5.2
3	E3	9	5.2	9	7.7
4	E4	9	4.4	9.1	7.5

Source: Field Work, 2021.

The results show that the streets widths were not regular from the beginning to the end. For example, Street N2 thinned out from 18m at the beginning to 12m at the middle. Streets N5 and N6 thinned out significantly from 12.4m and 8m at the beginning to 6m and 4m at the middle respectively. Similarly, street E2 narrowed down from 7.2m at the beginning to 4.3m in the middle and 4m at the end, while street E4 narrowed down to 4.4 at the middle. The results agree with Aminu (2011) whose study in the Brigade suburbs in Kano State, Nigeria, found that man-made modifications which narrow down streets widths affect urban runoff evacuation (Plates a, b, c, d). Field observations showed that the streets in the study area were characterized by waste dumps which take up portions of the streets (Plates C). These have implications for runoff evacuation because when streets which act as runoff arteries during rains are narrowed they tend to inhibit runoff movement and may result in localized flooding (Aminu, 2011; Aminu *et. al.*, 2019).

Drainage Capacity Measurements

The results of drainage characteristics are presented in Table 3.3.

Table 3.3: Drainage Measurements

S/N	Street	Beginning (m)		Middle (m)		End (m)		Average Capacity (m)	
		A	B	A	B	A	B	A	B
1	N1	0.22m	0.59m	Si	0.55	Si	0.54	0.22	0.56
2	N2	No	No	No	No	No	No	No	No
3	N3	No	No	No	No	No	No	No	No
4	N4	0.11	No	Si	No	0.22	No	0.11	No
5	N5	No	No	No	No	No	No	No	No
6	N6	Si	No	Si	No	Si	No	Si	No
7	E1	No	No	No	No	No	No	No	No
8	E2	No	No	No	No	No	No	No	No
9	E3	0.44	No	0.14	No	Si	No	0.19	No
10	E4	Si	Si	Si	Si	Si	Si	Si	Si

Si= Silted, No= No drain

The results on drainage characteristics show that the drainages are few and non-existent in most parts of the study area. The existing drainages were not continuous and they are poorly maintained with inconsistencies in capacity and distribution. For example, on street N4 the drain on the right hand side has a depth of 0.11 m at the beginning, is silted at the middle and 0.22 m at the end while across the street to the left hand side, there was no drain. With an average capacity of 0.22 m³ on the right hand side and 0.56 m³ on the left hand side of street N1, the result shows that the drains are inconsistent and inefficient to drain the large volume of runoff and waste discharged into them.

Many of the drainages have either silted up or blocked by household refuse as indicated in streets N6 and E4. The results of this study agrees with findings from Aminu, (2011) Nwachuku *et al.*, (2018) Besufekad *et al.*, (2020) which found that absent or inconsistent manmade drainage capacities were major factors in flood generation. This can be observed during and after rainfall events as excess runoff water overtops existing drainages and spill unto the access roads lining the drains.

Slope Profile Characteristics

The results of streets slope profile characteristics are presented in Table 3.4.

Table 3.4: Streets Slope Profiles and Distances

S/N	Street	Slope (%)	Distance (m)
1	N1	4	75
2	N2	4.2	95
3	N3	2.14	140
4	N4	2.5	154
5	N5	0.58	172
6	N6	0.75	265
7	E1	1.65	181
8	E2	1.13	88
9	E3	2	179m
10	E4	5.7	87

Table 3.5: Slope Classes and Frequencies

S/N	Slope Classes (%)	Frequency
1	Less than 1	2
2	Less than 2	2
3	Less than 5	5
4	≥5	1

Source: Fieldwork, 2021.

Slope measurements taken along the studied streets covered a total distance of 1257 m (approximately 1.3 km). The results from the analysis identified four (4) classes of slopes in the study area; Slopes <5% had the highest frequency of 5. This suggests that most of the study area is characterized by low slope angles to moderately gentle relief. However, a common sight in the study area is the heap of sand/sludge along most streets generated from cleared drainages. Similarly, household trash and heaps of waste are common along sample streets. These compact, causing obstructions along streets by raising the ground level of the streets above the general undulating surface. This agrees with studies by Aminu, (2011) Nwachuku *et al.*, (2018) Besufekad *et al.*, (2020).

Flood Hazard Potentials in the Study Area

The results from the study show that various factors along with inappropriate waste disposal methods were responsible for flood generation in the study area. The analysis of the data shows that the areas enclosed within streets N1 –E4 are prone to flood. Observations indicate that the tarred major roads which bound the un-tarred access roads within the study area form convex slopes and have been found to accelerate runoff flow (Aminu, 2011; Aminu *et al.*, 2019). On the

other hand, the gently sloping nature of the terrain and the concavities formed by erosion along the un-tarred roads may also be responsible for slow flow velocity of runoff water in the study area which results in 'ponding' of storm water after rainfall events.

Similarly, manmade drainages are near non-existent in the study area. Where drains were ever constructed, they have either been silted up by sand and sludge or plugged by household thrash from indiscriminate waste disposal methods. Streets widths pattern in the study area are also an important flood generating factor. Major roads and other minor access roads often act as flow paths for storm water evacuation during the wet season. However, the study showed that these have been narrowed down by waste dump sites. This has been found to constrict the flow of runoff and result in localized flooding even after rains of low intensities.



(a) Flooded street with silted drainages **(b)** Flooded street with no drainages **(c)** Street overtaken by household solid waste and impeded surface runoff **(d)** Flooded houses after rains

Conclusion and Recommendations

Generation of solid wastes from humans' day to day activities and its indiscriminate disposal is a major factor amongst the nature of soil, rainfall intensity and duration, and land use changes that influences flood generation in the study area. However, other factors such as street widths, slopes, inefficient man-made drainages have been found to mutually generate flooding in the study area. In a developing country such as Nigeria, indiscriminate household solid waste disposal is detrimental to environmental management and sustainable development. Flood generation assessment through combined determination of slope and street characteristics, drainage

capacity, spatial-temporal characteristics of major waste dump sites and flood hazard mapping in the study area is useful as it provides site specific results for effective management of flood occurrences.

Although the study has provided baseline data for flood hazard mapping in the study area, only the Gesse area of Birnin Kebbi was considered. To mitigate these effects, proper waste management practices including waste reduction, recycling, and safe disposal are essential. Future studies may consider a temporal and spatial expansion of the study. Recommendations from this study include improved technology in flood hazard mapping and land suitability assessments, linking research findings to infrastructural planning and developing strong public-private partnerships between government and residents for effective policy implementation.

Conflict of interest: the authors declare no conflict of interest.

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