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**2<sup>ND</sup> FINAL DRAFT REPORT ON  
ASSESSMENT AND CHARACTERIZATION OF SOLID WASTE  
POLLUTION SOURCES UPSTREAM OF THWAKE DAM  
CONTRACT NO.; WRA/RFP/03/2021-2022**

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## ABBREVIATIONS AND ACRONYMS

ARB	Athi River Basin
CBDs	Central Business Districts
CGs	County Governments
Covid – 19	Corona Virus Diseases
FGD	Focused Group Discussions
GoK	Government of Kenya
KAM	Kenya Association of Manufacturers
KEPSA	Kenya Private Sector Alliance
KNPC	Kenya National Cleaner Production Centre
NGOs	Non-Governmental Organizations
IWRM	Integrated Water Resources Management
ISWM	Integrated Solid Waste Management
SCMPs	Sub-Catchment Management Plans
SWM	Solid Waste management
TMWDP	Thwake Multi-purpose Water Development Program
TOR	Terms of reference
WRA	Water Resources Management
WRUAs	Water Resource Users Association

## **Glossary**

**Aerobic composting** - a method of composting organic wastes using bacteria that needs oxygen (aerobic bacteria). This requires that the waste be exposed to air, either via turning or by forcing air through perforated pipes that pass through the material.

**Anaerobic digestion** - a method of composting that does not require oxygen. This composting method produces methane. Also known as anaerobic composting.

**Ash** - the non-combustible, solid by-product of incineration or other combustion process.

**Biodegradable material** - any organic material that can be broken down by micro-organisms into simpler, more stable compounds. Most organic wastes (e.g., food, paper, etc.) are biodegradable.

**Bottom ash** - generally, a toxic residue of incineration that accumulates on the grate of the furnace and is relatively coarse and non-combustible.

**Capacity Building** - refers to activities that strengthen an organization or an individual and helps fulfil its mission better. Capacity building is often regarded as the assistance provided to the entities which have a need to develop certain skills or competence, or for general upgrading of performance ability. These activities include, among others, strategic planning, technology upgrades, operational improvements, and board development.

**Cleaner production** - processes designed to reduce the wastes generated by production.

**Collection** - the process of picking up wastes from residences, businesses, or a collection point, loading them into a vehicle, and transporting them to a processing, transfer, or disposal site.

**Compost** - the material resulting from composting. Also called humus, it is a soil conditioner.

**Composting** - biological decomposition of solid organic materials by bacteria, fungi, and other organisms into a soil-like product.

**Construction and Demolition (C&D)** - C&D waste includes all wastes arising from construction/building industry and demolition/destruction activities (either by man or the environment)

**Construction and demolition debris** -waste generated by construction and demolition of buildings, such as bricks, concrete, drywall, lumber, miscellaneous metal parts and sheets, packaging materials, etc.

**Controlled dump** - a planned landfill that incorporates, to some extent, some of the features of a sanitary landfill: siting with respect to hydro-geological suitability, grading, compaction in some cases, leachate control, partial gas management, regular (not usually daily) cover, access control, basic recordkeeping, and controlled scavenging.

**Disposal** - the final handling of solid waste, following collection, processing, or incineration. Disposal most often means placement of wastes in a dump or a landfill.

**Drop-off /transfer center** - an area or facility for receiving compostable or recyclable solid waste that are dropped off by waste generators

**Electronic Waste (E-Waste)** - a waste type consisting of any broken or unwanted electrical or electronic appliance. It is a point of concern, considering that many components of such equipment are considered toxic, and are not biodegradable.

**Fly ash** - a highly toxic particulate matter captured from the flue gas of an incinerator by the air pollution control system.

**Garbage** - also called refuse in everyday usage. Although not common, some MSWM manuals use garbage to mean “food wastes”.

**Groundwater** - water beneath the earth’s surface that fills underground pockets (known as aquifers), supplying wells and springs.

**Household hazardous waste** - products used in residences that are toxic to living organisms and/or the environment, such as paints and some cleaning compounds.

**Inorganic waste** - waste composed of material other than plant or animal matter, such as sand, dust, glass, and many synthetics.

**Integrated Solid Waste Management (ISWM)** - ISWM refers to a strategic initiative for the sustained management of solid waste through the use of a comprehensive integrated format generated through sustained preventive & consultative approach to the complementary use of a variety of practices to handle solid waste in a safe and effective manner.

**Leachate** - liquid (which may be partly produced by decomposition of organic matter) that has seeped through a landfill or a compost pile and has accumulated bacteria and other possibly harmful dissolved or suspended materials. If uncontrolled, leachate can contaminate both groundwater and surface water.

**Market waste** - primarily organic waste, such as leaves, skins, and unsold food, discarded at or near food markets.

**Materials recovery** - obtaining materials that can be reused or recycled.

**Mixed waste** - unsorted materials that have been discarded into the waste stream.

**NGO** – non-governmental organization. May be used to refer to a range of organizations, from small community groups to national and international organizations. Frequently these are not-for-profit organizations.

**Open dump** - an unplanned “landfill” that incorporates few, if any, of the characteristics of a controlled landfill. There is typically no leachate control, no access control, no cover, no management, and many scavengers.

**Organic waste** - technically, waste containing carbon, including paper, plastics, wood, food wastes, and yard wastes. In practice, the term is often used in a more restricted sense to mean material that is more directly derived from plant or animal sources, and which can generally be decomposed by micro-organisms.

**Pollution** - the contamination of soil, water, or the atmosphere by the discharge of waste or other polluting materials.

**Processing** - preparing MSW materials for subsequent use or management, using processes such as baling, magnetic separation, crushing, and shredding. The term is also sometimes used to mean separation of recyclables from mixed MSW.

**Producer responsibility** - a system in which a producer of products or services takes responsibility for the waste that results from the products or services marketed, by reducing materials used in production, making repairable or recyclable goods, and/or reducing packaging.

**Recyclables** - items that can be reprocessed into feedstock for new products. Common examples are paper, glass, aluminum, corrugated cardboard and plastic containers.

**Recycling** - the process of transforming materials into raw materials for manufacturing new products, which may or may not be similar to the original product.

**Resource recovery** - the extraction and utilization of materials and energy from wastes.

**Sewage sludge** - a semi-liquid residue that settles at the bottom of canals and pipes carrying sewage or industrial wastewaters, or at the bottom of tanks used for treating wastewaters.

**Segregation at source** - setting aside of compostable and recyclable materials from the waste stream before they are collected with other MSW, to facilitate reuse, recycling, and composting.

**Transfer point** - a designated point, often at the edge of a neighborhood, where small collection vehicles transfer waste to larger vehicles for transport to disposal sites.

**Transfer station** - a major facility where MSW from collection vehicles is consolidated into loads that are transported by larger trucks or other means to more distant final disposal facilities, typically landfills.

**Wastes** – All forms and types of waste

**Waste collector** - a person employed by a local authority or a private firm to collect waste from residences, businesses, and community bins.

**Waste dealer** - an intermediary who buys recyclable materials from waste generators and itinerant buyers to sell them, after sorting and some processing, to wholesale brokers or recycling industries.

**Wetland** - an area that is regularly wet or flooded and has a water table that stands at or above the land surface for at least a part of the year.

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## EXECUTIVE SUMMARY

This report acknowledges and adequately highlights the observations, findings and identifies stakeholders for collaboration in solid waste management. The integrated solid waste management is critical for sustainable solid waste management and pollution control to the water resources upstream catchment of Thwake dam.

The major rivers in the upstream catchment of Thwake dam include; Ngong, Mbagathi, Nairobi, Kirichwa, Mathare, Ruaraka, Kiu, Ruiru, and Ndarugo along the Athi river wing and Kaiti river being along the Thwake river. The ecosystems traversed by the aforementioned rivers include the agricultural, informal and formal settlements, industrial, artisanal *jua kali* and conservancy areas characterized with improper wastes management. Solid and liquid waste generation, handling, conveyance and eventual disposal remains a growing management challenge and pose ecological risks that include water pollution of varying magnitude on the fresh water resources both on spatial and temporal scales. The challenge is more pronounced in the urban and Peri-urban areas; where the situation is acerbated due to increasing population pressure, residents' poor waste management attitude, limited investments and adoption of technological approaches for best waste management practices, immensurate solid and liquid waste infrastructure and their associated efficacy.

The report finds that there are organic and inorganic solid wastes from agricultural/livestock, hospitality, industrial/manufacturing and *jua kali* sectors of social - economic developments. Notably during the field work, to a large extend, generally in regard to solid wastes;

1. They are not segregated at the source;
2. There are no proclaimed designated solid wastes holding/transfer sites;
3. The holding/transfer and dumpsites are on the riparian road, river lands and any unutilized land spaces;
4. There is no sustained adherence to the established solid wastes collection programs;

5. The designated dumpsites are unfenced and not regulated with regard to controlled entry, exit, quantity and category/nature of wastes received at the dumpsites;
6. There is low awareness levels on the sound solid wastes management amongst residents;
7. There is need for residents' capacity building on solid waste management;
8. There are no established and structured solid wastes recovery programs,
9. The residents are not adequately provided with solid waste bins.

# 1.0 INTRODUCTION

## 1.1 Background

The guaranteed availability of adequate and safe water resources, at Local, National, Regional and Global scales is increasingly becoming a challenge of concern. Water is pivotally recognized in the Sustainable Development Goals (SDGs) as a driver and enabler of the stable and critical pillars; social - economic developments and health environmental ecosystems. Unsustainable land use changes, social-economic investments, improper wastes management and uncoordinated livelihoods are some the key areas of concern that requires stakeholders' attention in an integrated manner.

In an effort to address the water availability, through the Thwake Multi-purpose Water Development Program (TMWDP), Kenya has endeavored to construct a Multi-purpose Thwake dam located approximately 1-kilometer downstream of the confluence of Athi and Thwake rivers; at the Makueni/Kitui Counties trans boundary area for water supply, hydropower generation and irrigation development. The dam will also provide regulation of flows on Athi River downstream of the dam for floods and drought mitigation.

The major rivers in the Upstream of Thwake dam include; Ngong, Mbagathi, Nairobi, Kirichwa, Mathare, Rui-raka, Kiu, Ruiru, and Ndarugu along the Athi river wing and Kaiti river being along the Thwake river.

The ecosystems traversed by the aforementioned rivers include the agricultural, informal and formal settlements, industrial, artisanal *jua kali* and conservancy areas characterized with improper wastes management. Solid and liquid waste generation, handling, conveyance and eventual disposal remains a growing management challenge and pose ecological risks that include water pollution of varying magnitude on the fresh water resources both on spatial and temporal scales. The challenge is more pronounced in the urban and sub-urban areas; where the situation is acerbated due to increasing population pressure, residents' poor waste management attitude, limited investments and adoption of technological approaches for best waste management practices, immensurate solid and liquid waste infrastructure and their associated efficacy.

Due to myriad human activities; some of them being anthropogenic, are environmentally unfriendly, this has many a times resulted into generation of solid wastes that pollute the aquatic ecosystems with surface water resources being more susceptible than the ground water resources. Pollution of the water resources compromises the health and sanitation status of the residents, makes the water unsafe for various uses including for drinking purposes, implies higher costs for water treatment and causes loss of biodiversity with regard to flora and fauna. Further, solid waste pollution to the water resources compounded by the emerging climate change results into unavailability of freshwater resources as well as escalating water conflicts.

The Constitution of Kenya (2010) recognizes water as a human right, while under Vision 2030; water is identified as an essential resource to support the country's development agenda. Further, the Constitution espouses the "Protection of the environment and natural resources with a view to establishing a durable and sustainable system of development". In lieu of this, the Government of Kenya enacted Water Act 2016, which stipulates that "every person in Kenya has the right to clean and safe water in adequate quantities and to reasonable standards of sanitation as stipulated in Article 43 of the Constitution". In addition, water is recognized as a critical Driver and enabler of the government Big 4 Agenda and realization of the Sustainable Development Goals (SDGs).

Water Resources Authority (WRA) is designated to serve as the Agent of the National Government to regulate the management and use of water resources and mandated among other tasks to liaise with stakeholders for the better management of water resources. The Authority has made this possible through various Integrated Water Resources Management (IWRM) approaches, which involve multi-faceted interventions to address the myriad of issues and challenges in water resources. The Authority has been working closely with the various stakeholder groups including Water Resource Users Associations (WRUAs), Private Sector, County Governments, NGOs, Academia and Public Sector Agencies among others.



In a bid to sustainably and effectively regulate the management of water resources within the upstream of Thwake dam and by extension sustainably improve the water quality, WRA requires scientific data and information on the sources of solid wastes, characteristics of solid wastes, the modes of handling and disposal, the environmental impacts of solid wastes and develop integrated modalities that incorporates collaboration with identified stakeholders in sustainable management of solid wastes. The solid wastes management approaches to consider amongst factors that include;

- (a) Innovations,
- (b) Paradigm shift from linear to circularity waste management,
- (c) Engineered landfills,
- (e) Enhanced awareness creation and
- (f) Advocacy for proper solid waste management.

## **1.2 Study Area Description**

Upstream of Thwake dam is an area that is also governed by the county governments to different spatial coverages, namely Kajiado County (approximately 20%), Nairobi County (100%), Kiambu County (approximately 40%), Machakos County (approximately 65%), Makueni County (approximately 50%) and Kitui County (approximately 5%). The major areas/towns/estates include Ngong, Kiserian, Ongata Rongai, Isinya, Kitengela/Athi River, Mavoko, Ongata Rongai, Kikuyu, Kibera, Kawangware, Kangemi, Nairobi City Central Business District (NAC-CBD), Mukuru, Gikomba, Dandora, Mathare, Korogocho, Kayole, Ruai, Githurai, Limuru, Kiambu, Ruiru, Juja, Thika, Majengo, Kilimambogo, Wote, Kalawa, Kibauni, Wamunyu, Kabaa, Masii and Machakos. It is also an area that is drained by major rivers that include; Ngong, Mbagathi, Nairobi, Kirichwa Kubwa, Kirichwa Ndogo, Mathare, Ruaraka, Kiu, Ruiru, Ndarugu along the Athi river wing and Kaiti river being along the Thwake river.

The ecosystems traversed by the aforementioned rivers include the agricultural, informal and formal settlements, industrial, artisanal *Jua Kali* and conservancy areas characterized with improper wastes management. It is also noted that the upstream of Thwake dam

greatly supports the social, economic and environmental pillars of the Athi Basin's and its downstream ecosystems and users.

### **1.3 Study Objective**

The objective of the wastes assessment and characterization is to ascertain the locations/sites, nature and types of wastes generated, storage, conveyance and disposal mechanism employed in the wastes management chain. The gathered data and information is aimed at guiding the stakeholders for enhanced and prudent management of solid wastes, protect the water resources from being polluted by solid wastes, develop integrated approaches for solid wastes management, development of solid waste management guidelines and stakeholders' engagement framework for implementation of the solid wastes' guidelines and plans and improve the water quality of water upstream ecosystems and harvested at the Thwake dam.

### **1.4 Scope of Solid Waste assessment and Characterization Task**

The intended activities under this consultancy is to guide and enhance WRA's approaches to regulate the management and sustainable use of water resources, enhance stakeholder understanding of the water regulations, participation and compliance, improved livelihoods and ecosystems health (including flora and fauna). In articulating the aforementioned study objective, the consultancy endeavored to undertake the solid waste assessment and characterization tasks upstream of Thwake dam under specific activities that included:

1. Delineating and mapping the catchment area upstream of Thwake dam;
2. Ascertaining the human/livelihood activities in the catchment upstream of Thwake dam;
3. Identifying, geo-referencing, mapping out solid wastes point and no-point sources upstream of Thwake dam;
4. Assessing the nature of solid waste and the solid waste management practices in place;

5. Characterizing the solid waste pollution sources;
6. Zoning the human activities and associated solid wastes generated;
7. Identifying and mapping the immediate pollution - threatened water bodies;
8. Undertaking stakeholders' mapping, their roles and responsibilities achievements, potential areas/issues for collaboration;
9. Ranking solid waste pollution sources, making recommendations for short- and long-term interventions and the framework of stakeholder engagement;
10. Developing guidelines for solid waste management;
11. Preparing and holding 1 No. workshop with identified key stakeholders for dissemination of the findings and guidelines.
12. Compiling and submitting technical reports to Water Resource Authority.

It is worth noting that this consultancy was carried out during the COVID – 19 Pandemic, and as such, adherence to the COVID-19 pandemic precautionary measures as periodically pronounced and released by the mainstream ministry was mandatory.

## **2.0 FIELD WORK**

### **2.1 Approach**

The representatives of consultant and the contractor had consultative meetings for planning in line with the consultancy. This involved introduction of the consultant to the stakeholders and some of the solid waste sites. The consultant team developed and internalized the data and information collection template for purposes of carrying out efficiently and effectively the activities in the assignment. The dry run of the template was done to ensure it will be appropriate for use in carrying out the work.

The consultant team also had secessions for visualizing the catchment upstream of Thwake dam and based on this developed field work plan and also the route plans. The maps herein show the delineation of rivers upstream Thwake dam. See iv enlarged map of delineation of rivers upstream Thwake dam.

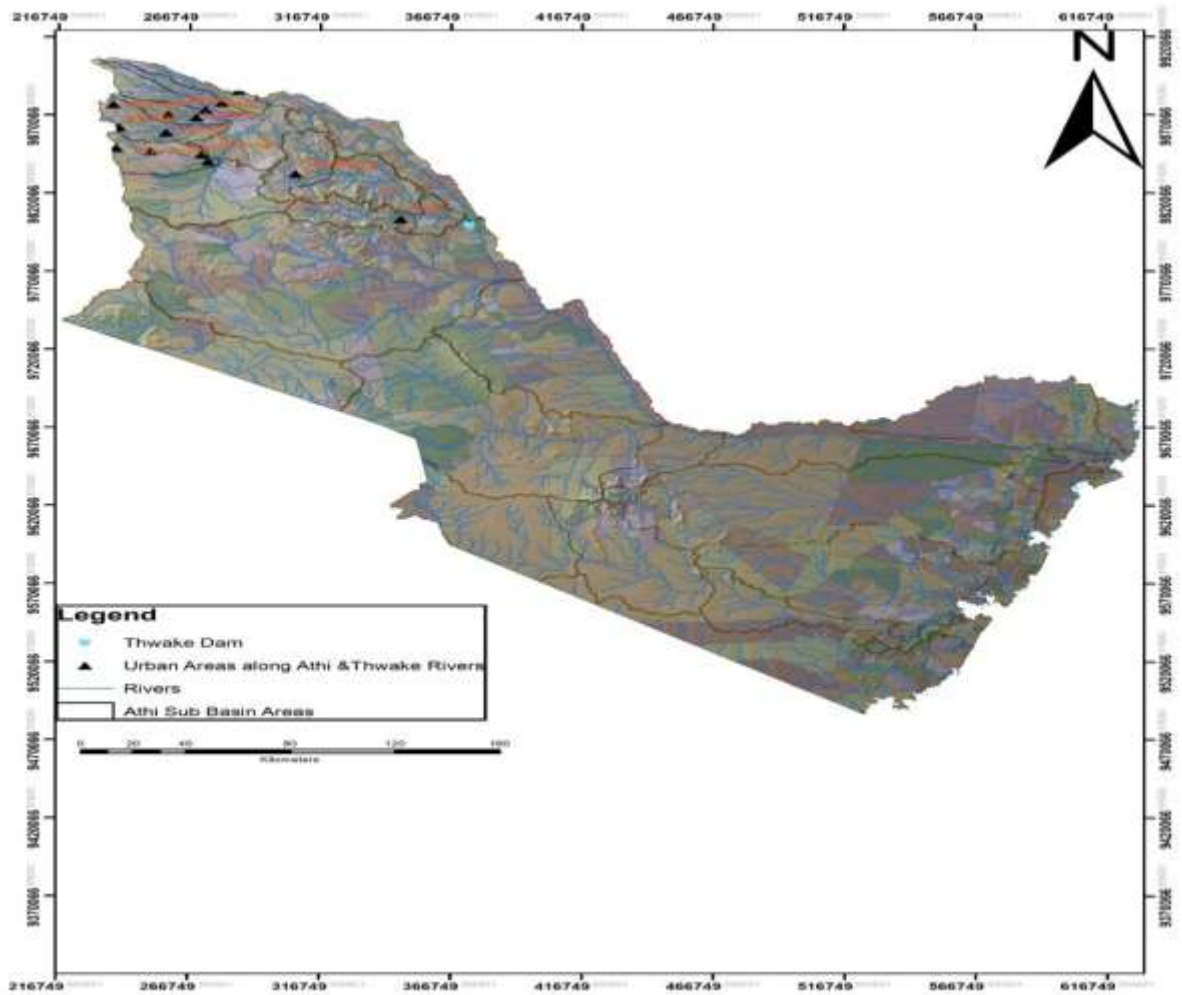


Figure 2.1: Athi Basin Area with Thwake Dam

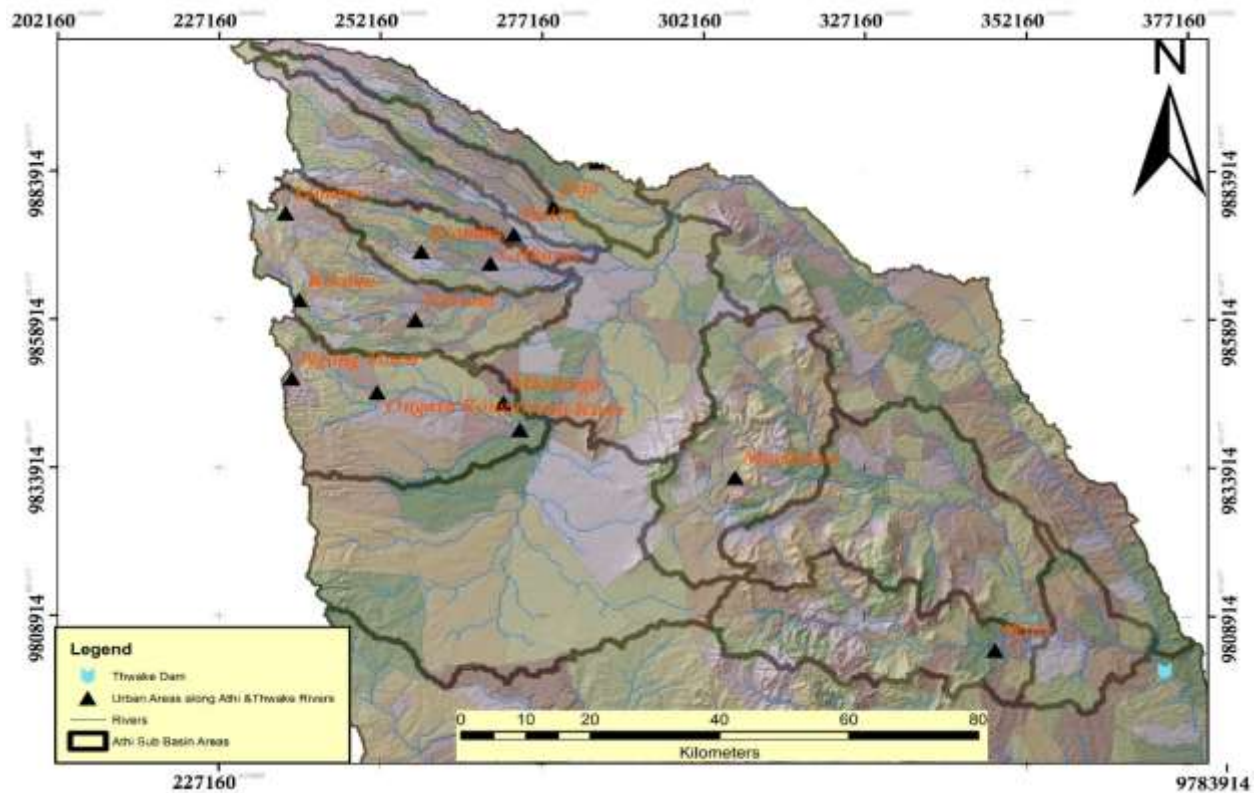


Figure 2-2: The map of Athi and catchment upstream of Thwake dam

The team also consultatively developed a tool in the form of the template for collection of field data and information. The template ensured systematic and consistent way of data and information collection at all times. The tool used is captured as annex 1 in the annexes. See v Annex enlarged map of Athi and Catchment upstream Thwake dam.

### 3.0 THE CATCHMENT AREA UPSTREAM OF THWAKE DAM

#### 3.1 Land use

The catchment area upstream of Thwake dam is characterized by Nairobi City and its environs, Kiambu, Machakos and Wote County headquarters and their environs. The City and County headquarters comprises of formal settlements, informal settlements, industrial/ manufacturing sector (chemical, construction, textile, printing, packaging industries among others), *Jua Kali* enterprises, Hospitality (food and beverages, accommodation, travel and transportation, tourism, meetings and events, entertainment, recreation among others), Medical and academic facilities, open market centers, closed

market centers, waste recovery systems (collection and holding yards). These ecosystems also have public and private conserved forests and parks.

In the suburbs, there are agricultural and livestock activities that are indoor and outdoor at both small scale and large-scale levels. Some of these agricultural activities include: domestic animals keeping, poultry rearing and greenhouse farming. In addition, the catchment has sand harvesting, quarrying, and wastewater treatment plants and dumpsites activities.

### **3.2 Human Activities Upstream of Thwake Dam**

Within the delineated area of study, there are myriad human/livelihood activities. These activities may have varying impacts to the environment in regard to effective and efficient management of wastes generated. These human activities are categorized into six broad bands as;

#### **Agricultural/livestock**

- (i) Horticultural farming.
- (ii) Greenhouse farming.
- (iii) Domestic animals (cows, goats, sheep, pigs, rabbits among others) keeping.
- (iv) Poultry farming (at individual/commercial levels for example Kenchic,)

#### **Domestic**

- (i) Formal settlements
- (ii) Informal settlements

#### **Industrial/manufacturing**

- (i) Primary processing
- (ii) Secondary processing
- (iii) Waste recovery
- (iv) Recycling

## **Hospitality**

(i) Hotels (food and beverages, accommodation, tourism, meetings and events, entertainment, recreation)

(ii) Medical

(ii) Academic/research

(iii) Travel and transportation

## **Infrastructure construction and demolition**

(i) Housing constructions

(ii) Road/railway network constructions

(iii) Demolition debris

## ***Jua kali***

(i) Vehicle garages

(ii) Open markets

### **3.3 Human Activities and Solid Waste**

As the human being strives for the livelihood, during the process, usually solid wastes are generated. However, most of the solid wastes are not appropriately handled during the entire process of solid wastes management chain, this is in regard to sorting, containment, transportation and disposal. Solid wastes need to be categorized and sorted for ease of management including value chain through waste recovery mechanisms that embraces waste circularity. This not only provides an additional livelihood but it minimizes wastes in the environment and in return minimizes environmental pollution and supports sustained healthy ecosystems.

### 3.4 Thwake Dam Catchment Zoning

During the execution of this exercise, the catchment upstream of Thwake dam was zoned as Up- stream (upper zone), Middle- stream (middle zone) and Lower-stream. (Lower zone). The up-stream zone comprises uppermost areas forming the sources of rivers feeding Thwake dam. These areas include Ngong hills and town, Kiserian, Matasia, Ongata Rongai, Isinya, Kikuyu, Waithaka, Limuru, Ruaka/Red hills town centers.

The mid-stream zone comprises of areas that include: Kitengela/Athi River, Mavoko, industrial areas, Nairobi City Central Business District, Kawangware, Kangemi, Mathare, Gikomba, Korogocho, Kariobangi, Kiamaiko, Kayole, Ruai, Luckysummer, Ngumba, Githurai,, Kahawa, Juja, Mangu/Ndarugu, Thika/Makongeni, Munyu, Kilimambogo town centers. The lower- stream zone comprises of areas that include: Fourteen Falls, Wote, Kalawa, Kibauni, Wamunyu, Mwala, Kabaa, Masii and Machakos town centers.

#### 3.4.1 The Upper Zone

The upper zone has been largely an intact natural ecosystem until as from the last two decades when people started settling and conducting social-economic developments. There is growing population and the status of the natural ecosystems is fast - declining. During the field exercise, the zone depicted agricultural and livestock activities as well as the upcoming urban centers. The solid wastes were largely of organic nature. The small amount of inorganic solid waste would be traced to the few areas of *jua kali* enterprises as industrialization is not significant.

At Ongata Rongai center, not much solid wastes could be noted. This was due to residents' compliance to the sub-county ward management programs where unsorted solid wastes are regularly collected and taken to Dandora dumpsite. Despite a few labeled bins solid wastes bins being in place, the residents are not yet complying in sorting and placing the solid wastes accordingly.





Figure 3.1 Labelled waste bins at Ongata Rongai

The Kajiado County Government will have to create attitude change and enhance the awareness to the residents in regard to sorting out the solid wastes accordingly. This may include hybrid systems where labeling as well as the pictorial displays on the wastes bins are incorporated (Fig 3.1).



Figure 3.2 Labelled and pictorial solid wastes bins at Kabete

The dumpsites with solid wastes was identified in Ngong town. On this dumpsite, the solid wastes comprised of plastic bottles and papers (single-use polythene bags), shoes, diapers, human beauty hair, glass bottles ,used car tires, animal bones ,cartons and



Figure 3.2 Sorted solid waste at Ngong next to Catholic Church



Figure 3.3 unsorted solid waste in Ngong town next to Police Station.

At Kiserian town, there was solid wastes holding site just next to the market. The limited observed wastes largely comprised of banana leaves wrapping and agricultural products. The market management explained that solid wastes (usually unsorted) from the market is transferred every after two days to the Dandora dumpsite. Still within the town at the Kiserian - Nairobi Matatu stage, there was a heap of solid wastes comprising of; diapers, plastics (papers and bottles), glass, cabbages, ash, egg shells. The residents were dissatisfied with the practice of unscrupulous residents who dump solid wastes at this site usually at night hours.



Figure 3.4 Unsorted Solid waste dumping site outside Kiserian Market



Figure 3.5 .Solid waste dumpsite next to Kiserian Market –Unsorted



Figure 3.6 Unsorted and sorted Solid Waste in Isinya town at Kaloleni Dumpsite



Figure 3.7 Solid Waste Dumpsite next to St Peter’s Catholic Church - Kikuyu



Figure 3.8 Unsorted Solid Waste at Waithaka Dumpsite – on private land – Kikuyu – next to Catholic Church



Figure 3.9 Unsorted Solid waste at Kawangware dumpsite -Gitanga



Figure 3.10 unsorted solid waste at Muslim Dumpsite -Kawangware



Figure 3.11 Unsorted Solid Waste along Gitanga Road Dump Site kawangware - KBS Garage



Figure 3.12 Unsorted and sorted solid waste in Kangemi Dump Site -Makaburini





Figure 3.13 Sorted and unsorted solid waste - Kibera Bridge Dumpsite



Figure 3.14: Unsorted Solid waste at Kibera Bridge dumpsite - Fort Jesus



Figure 3.15 Scattered and unsorted solid waste -Kibera Baptist Church Area



Figure 3.16 unsorted solid waste Kibera -Olympic Dumpsite



Figure 3.17 Unsorted Solid waste Kibera - Mashimoni area Dumpsite



Figure 3.18 Unsorted solid waste in Kibera - Daranjani - Dumpsite



Figure 3.19 Sorted and unsorted Solid waste Dandora Dumpsite



Figure 3.20: Sorted Solid waste -Likoni Road Bridge Dump Site (Express Kenya recycling area)



Figure 3.21 Unsorted Solid waste at Railway Training Institute Dump site (South B)



Figure 3.22 Unsorted Solid waste in South B Near Total Petrol Station

### 3.4.1 The Middle Zone

The middle zone is intensely inhabited and is characterized with formal and informal settlements, industrial areas, *jua kali* areas and CBDs. These is the zone which generates the highest quantities of solid wastes; originating largely from the domestic and industrial setups. Large quantities (approximately 90%) of solid wastes from domestic sources are organic (plant and animal – based) in nature and is easily biodegradable. The organic solid wastes if suitable systems are in place, they may be further be sources of other products including energy and fertilizer through aerobic composting or anaerobic digestion process. The portion of solid wastes from industrial setup is largely inorganic and non-biodegradable. Many a times persistent in nature. This results into most of the inorganic solid wastes requiring advanced technologies including recycling to eliminate them from the environment.

Solid Wastes holdings were noted at Ngong River Mombasa Road and other surrounding areas going in Mukuru Kwa Njenga and BAT area.



Figure 3.23: unsorted Solid waste dumpsite at Ngong River along Mombasa Road.



Figure 3.24 unsorted Solid waste partly floating on Mbagathi River -Crescent Mukuru Kayava Bridge



Figure 3.25 Unsorted Solid Waste –Likoni Road BAT/PRINTPACK



Figure 3.26 Unsorted Solid Waste at DONHOM ROUNDABOUT





Figure 3.27 Sorted Solid waste at DONHOM Power line



Figure 3.28 Sorted Salon Hair at INFILL DUMPSITE (UMOJA)



Figure 3.29 .Holding area dumpsite – Sorted and unsorted WADAU DUMPSITE



Figure 3.30 Sorted and unsorted Solid waste at -UNDERPOWER (JESKA AREA) UMOJA



Figure 3.31 Sorted and unsorted solid waste at under power umoja 1



Figure 3.32 Unsorted solid waste at -MUTHAIGA DUMPSITE (KAYOLE)



Figure 3.33 Holding area – Sorted and unsorted at Kayole Dumpsite (B3)

Solid wastes holding sites was also noted in several areas in the Nairobi CBD that included; Marikiti (KFA area along the Haile Selassie Road), Grogan stretch of garages, at Race Road/Nairobi river bridge and Kamukunji area along Nairobi river.



Figure 3.34 unsorted solid waste at City Stadium Roundabout



Figure 3.35. Unsorted Solid waste at Dandora Korogocho Bridge (CANAAN)



Figure 3.36 Unsorted Solid waste dumpsite -Racecourse Bridge



Figure 3.37. Unsorted Solid waste at Kamukunji Bridge (Near Kamukunji police station)



Figure 3.38: Solid waste into the Nairobi River - Gikomba Market



Figure 3.39 Unsorted waste at Muthurwa Jogoo road



Figure 3.40 Korogocho Kombgreen (Rehabilitated Dump Site)

Solid wastes were also observed at the City Stadium roundabout, Muthurwa, Kigomba market, along Juja road – especially the entire stretch from Stage No. 10 to the Moi Academy, with the heap of solid wastes at the Stage No. 10 occupying an entire lane of the road – interfering traffic flow.



Figure 3.41: Unsorted solid waste at Stage No.10 Juja Road (Next to Moi Airbase)



Figure. 3.42 Solid waste heap occupying road lane at Stage No. 10 along Juja road



Figure 3.43 Solid wastes along the road reserves in Ruaka town area





Figure. 3.44 Solid wastes along the road reserves in Ruaka town areas



Figure 3.45 Unsorted solid waste at Maregeta Dumpsite (Kamae) Northern bypass)



Figure 3.4 2Solid waste at Bridge Upstream Treatment Plant



Figure 3.46 Sorted solid waste at Njathaini (Ngomongo) Dumpsite



Figure 3.47 Solid waste at Gatundu Market



Figure 3.48 Solid waste at Gwakauro Ruiru (Near Railway line)



Figure 3.49 Sorted solid waste at Gwakairo dumpsite (reclaimed)



Figure 3.50 Solid waste at Gachororo dumpsite



Figure 3.51 Sorted and unsorted Solid Waste at Kangoki Dumpsite



Figure 3.52: Sorted and unsorted solid waste - Limuru town



Figure 3.53 Unsorted solid waste at Kiambu next to bus stage



Figure 3.54 sorted solid waste at Ruaka town dumpsite



Figure 3.55 Solid waste in Solid waste bins in Kiambu market



Figure 3.56 Unsorted Solid waste at Kahawa west (Kamiti corner)



Figure 3.57 unsorted solid waste at Kahawa west (Near ECDE college Jujen Education Centre)



Figure 3.58 Solid waste at Githurai Market

In most cases, such solid wastes would easily be washed by storm water into the rivers and ultimately to the downstream Thwake dam.

### 3.4.2 The Lower Zone

The lower zone is largely of rural setups characterized with peasant /horticultural farming, poultry rearing and domestic livestock keeping. There are some few areas of urban setups with formal and informal settlements. The large amount of solid wastes in this zone are organic in nature. A few enterprises like *jua kali* will be the source of inorganic solid wastes. As such, the lower zone contributes the lowest amount of solid wastes that would pose negative impact to the environment as compared with upper and middle zones. The notable solid wastes was in Machakos and Wote towns.

### 3.4.3 Solid Wastes Management Practices

During the field exercise, it came out in all zones that the solid wastes are not segregated at all. Segregation is not practiced in places and areas where solid wastes bins are elaborately labeled. In the formal settlement areas, the unsorted solid wastes are put in the plastic gunny bags. The gunny bags containing wastes would then be placed at



suitably accessible sites for picking by the contracted waste collectors following the established waste collection programme.

In the case of informal settlements and *jua kali* areas, there are few areas where solid wastes are collected and disposed in an established manner. In these areas, one will witness mushrooming solid wastes /transfer / holding sites and dumpsites. In all the zones, the dumpsites were on unutilized private or public land including along the riparian land.

Many of the dumpsites are not fenced and unregulated with regard to entry and exit points. The dumpsites are largely under the control of the self-established youth groups. At these holding/transfer sites or dumpsites, some youth would recover some solid waste materials depending on the drive of the market needs they are targeting.

The collected wastes will then be transported and disposed at the designated dumpsite like Dandora in Nairobi, kangoki in Thika or Mavoko quarry areas in Athi River.

In kayole and downstream of Korogocho open market, cases were noted where the woven carrier bags collected from the dumpsites were being washed in the river for purposes of recycling. While this practice is appreciated, it poses health risks to the practitioners and users of these recycled woven carrier bags.



Figure. 3.56 The washed woven carrier bags drying along Nairobi River in Korogocho Estate-(for resale in the nearby markets –possess a health threat)

It was also reported that, initially there used to be large quantities of banana leaves wrappings emanating from Korogocho open market to the Nairobi River. Currently, these quantities have significantly reduced due to the interventions by Practical Action group who convert the banana leaves to organic fertilizer.

Impressively noted at Githurai open market, the vegetable retailers would be seen with a beside gunny bags for holding organic wastes that is sold at a fee to the livestock farmers to feed their domestic animals.

Notably during the field work, to a large extend, generally in regard to solid wastes;

1. They are not segregated at the source;
2. There are no proclaimed designate solid wastes holding/transfer sites;
3. The holding/transfer and dumpsites are on the riparian road, river lands and any unutilized land spaces;
4. There is no sustained adherence to the established solid wastes collection programme;

5. The designated dumpsites are unfenced and not regulated with regard to controlled entry, exit, quantity and category/nature of wastes received at the dumpsites,
6. There is low awareness levels on the sound solid wastes management amongst residents,
7. There is need for capacity building the residents on solid wastes management.
8. There are no established and structured solid wastes recovery programme.
9. The residents are not adequately provided with solid waste bins.



Figure 3.57: Dumpsite along the Nairobi river riparian land in Korogocho Estate

We noted that majority of the dumping sites are unregulated and sitting on riparian and river reserves.

#### 4.0 SOLID WASTES POLLUTION SOURCES

The solid wastes are characterized as of organic or inorganic in nature. Both of them could be persistent or non-persistent and cause varying degrees of pollution impact based on their constituents/compositions and toxicity.

##### 4.1 Organic Solid Wastes

The organic solid wastes are largely plant and animal products from the agricultural and livestock farming practices. These solid wastes will largely originate from domestic setups and open market places from where the farm produce are sold. The organic solid wastes are biodegradable and hence through appropriate technologies, these solid wastes will be easily broken down by micro-organisms to other useful products that include organic fertilizer. The organic solid wastes includes cabbages, paper cartons, domestic waste – foods etc.



Figure. 3.58 Domestic solid wastes in Kahawa West

## **4.2 Inorganic Solid Wastes**

The inorganic solid wastes are largely from industrial, hospitality and domestic sectors. The majority of these solid wastes are non-biodegradable and persistent in nature. As such, they pose pollution to the environment over a longer time as compared to the organic solid wastes. The inorganic solid waste includes the plastics (bottles and papers), diapers, weaving hair, glass bottles, motorcycle tyres, vehicle parts, chemical cans/containers, e-wastes (electronic and electrical) among others.

## **4.3 Geo-referenced Solid waste Sites**

During the solid waste assessment and characterization exercise, the geographical positioning system (GPS) was used to take the coordinates of the dumpsites. Also, the various types of waste at the dumpsites were noted.

The areas visited covered comprehensively the upstream catchment of Thwake Dam and these were largely urban areas where solid waste management is of great concern and possess a challenge to the water quality in the rivers upstream of Thwake Sam.

Critical to note was that many of the dumpsites were found on public/private open land that included land next to the rivers. These sites are pictorial mapped as shown in figure 4.1 below and annex II enlarged map. Find also annex III showing Geo-referenced dump sites and detailed location.

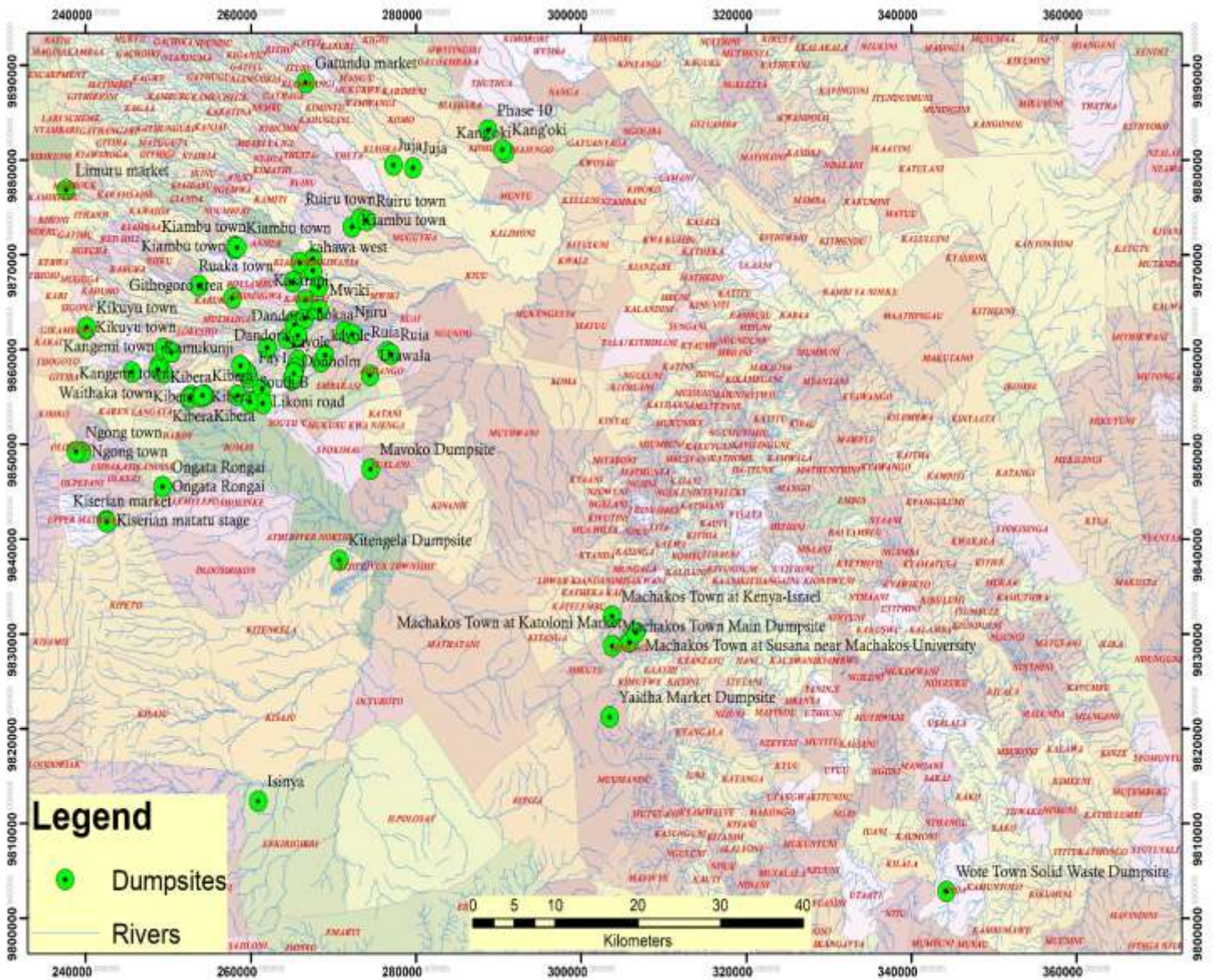


Figure 4.1: Geo-referenced Solid waste Sites

## 5.0 STAKEHOLDERS

In the entire solid wastes management chain, stakeholders have critical positive and negative influence to varying levels. As such, it is important to identify, categorize and ascertain their collaborative roles in the solid waste management. Integrated solid wastes management is required for sustainable sound wastes management for a healthy environment, scenic ecosystems, biodiversity and pollution control to the wetlands, surface water resources -streams, rivers, water pans and dams, sub-surface – shallow wells and deep ground water resources through leachates.

### 5.1 Stakeholder Mapping and Areas of Collaboration

The tables below therefore identify, map the stakeholders with areas of collaboration for the sound solid wastes management upstream of Thwake dam.

Table 5.1 Stakeholder Mapping and Areas of Collaboration

S/No.	Stakeholder	Roles and responsibilities	Areas of collaboration	Zone applicable (upper -U, middle - M, lower - L
<b>Policies</b>				
1	Ministry of Water, Sanitation and Irrigation (MWSI)	National policy formulation and coordination	Policies and coordination on conservation and protection of water resources from solid wastes pollution	U,M and L
2	Ministry of Environment and Forestry (MEF)	National policy formulation and coordination	Policies and coordination on environmental conservation and protection from solid wastes pollution	U,M and L

3	Ministry of Interior and Coordination of National Government	National policy formulation and coordination	Policies and coordination for compliance with water resources and environmental regulations	U,M and L
4	Ministry of Trade and Industry	National policy formulation and coordination	Policies and coordination for industrial production and wastes management regulations	U,M and L
5	Ministry of Education, Science and Technology	National policy formulation and coordination	Policies, research and technologies for wastes management	U,M and L
6	County Governments – Kajiado, Nairobi, Kiambu, Machakos and Makueni.	County policies formulations and By-laws	Implement and adhere to sound solid wastes management practices	U,M and L
Regulators				
1	Water Resources	Regulate the management	Monitor, protect and conserve water	U, M and L



	Authority	of water resources	resources from solid wastes pollution.	
2	National Environmental Management Authority	Regulate the management of environment	Monitor, protect and conserve the environment	U, M and L
3	Water Services Regulatory Board (WASREB)	Regulate the management of water services	Monitor the water supply and wastes management	U, M and L
Service providers				
1	Kenya association of Manufacturers (KAM)	Coordinate the industrial sector of manufactures	Enlighten the manufactures on sound wastes management including industrial symbiosis and circularity practices.	U, M and L
2	Kenya National Cleaner Production Centre (KNPCPC)	Promotes cleaner industrial productions	Awareness creation on industrial production and sustainable wastes management	U,M and L
3	Athi Water Works	Water infrastructural	Sound sludge waste treatment systems	U, M and L

	Development Agency (AWWDA)	developments		
4	Tanathi Water Works Development Agency (Tan AWWDA)	Water infrastructural developments	Sound sludge waste treatment systems	U, M and L
5	Water Resources Users Associations (WRUAs)	At grassroots levels supports the roles of WRA,	Supports WRA to monitor, protect and conserve water resources from solid wastes pollution.	U, M and L
6	Water Service Providers (WSPs)	Water services provision and solid wastes management	Sound sewage sludge wastes management	U, M and L
NGOs/CBOs				
1	Komb-Green Solutions	Wastes management and riparian land rehabilitation	Korogocho Estate areas	M
2	Practical Actions	Open market wastes management	Korogocho market	M
3	Sanergy	Circularity and	Converts wastes into	U, M and L

	Limited	waste management	valuable products including organic fertilizer	
4.	Wadau CBO – Power line (Power Collection WADAU).	Waste management and transfer	Umoja Estate-	M

**Annex 1: Field data and information collection tool Solid Waste Field Work Checklist for Assessment and Characterization of Solid Waste Pollution Streams Upstream of Thwake Dam)**

No	Name of Facility/  Dump-site - Regulated/ unregulated	Human /Livelihood activities	Nature/Types of Solid Waste	Site Geo-reference			Name of Threatened Water Body	Pollutant Status (Observations/ photos at the site, views of residents/ stakeholders)	Recommendations (Proposed best practices and mitigation measures in solid waste management)
				Lat	Long	Elev.			
		<b>Domestic</b> -Formal settlement -Informal settlement <b>Agricultural/Livestock</b> <b>Industrial</b> -Formal -Jua Kali <b>Market Centre</b> -Formal (regulated) -Informal (regulated/unregulated)	<b>Biodegradable</b> <b>OR</b> <b>Non-biodegradable</b> Plastic- HDPE -LDPE - PET Metals Glass Paper & Cardboard Textile Paint containers Animal waste Garden/Plant waste						

**Notes:**

**1. Biodegradable waste is what can easily be broken down by microbial processes that may include composting.**

**2. Regulated dumpsite means it is coordinated and under control of registered effective management.**

**Any other relevant information observed at the site in regard to the solid waste management and pollution to water resources:** .....

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## Annex II: Georeferenced Solid waste Sites

### Annex III: Geo-referenced dump site location details

Latitude	Longitude	Altitude (meters)	Site Name	Site description			
258420.015	9855155.794	1692.260864	Mombasa road	Ngong river bridge			
260743.417	9854728.413	1674.924444	Mukuru Kayaba	At Crescent next to Ngong river			
261380.378	9855815.469	1685.990723	Likoni road	Between BAT and Printpack			
264961.381	9856815.28	1672.15332	Donholm	At rounabout			
264958.881	9856877.107	1671.388184	Donholm	At high voltage powerline			
265694.861	9858870.946	1673.31958	Umoja one	December reyclers			
265410.185	9858085.41	1680.224365	Umoja one	Wadau Wasafi community			
265256.587	9857646.841	1680.224365	Umoja one	High voltage Powerline			
265206.094	9857454.898	1683.686035	Umoja one	High Voltage Powerline			
268495.185	9858719.707	1665.248535	kayole	Muthaiga dumping site next to ngong river			
269004.238	9859434.065	1662.290771	kayole	At B3 next Ngong river			
259759.315	9857052.137	1692.876709	Fay1				
259764.893	9857037.873	1630.855591	City stadium	At roundabout			
259571.596	9857472.073	1625.191895	Muthurwa jua kali				
259351.502	9857735.802	1621.142334	Kigomba market	At Kigomba -Kamugunji bridge			
258924.447	9858134.3	1625.182617	Kamukunji	Near kamugunji polisce station along Nairobi river			
258733.829	9858295.298	1626.703491	Racecourse road bridge	along Nairobi river			
261995.662	9860215.211	1611.074585	Juja road stage No. 10	Along the Moi Air Base fence upto Kwa Chief			
265196.406	9861270.468	1584.220825	Korogocho	KombGreen rehab site			
265122.829	9861259.902	1587.28125	Korogocho	At Korogocho/Danadora bridge on Nairobi river			
264425.274	9861116.324	1608.639282	Kariobangi	Kariobangi junction			
237619.821	9876839.929	2196.845947	Limuru market	Organic waste			
253726.496	9866755.17	1739.138306	Ruaka town	Next to the stage along the road			
257784.736	9865445.931	1692.064941	Githogoro area	Series of solid waste along the road			
265082.784	9867140.244	1576.476318	kahawa west	Njathaini area next to Njathaini church			

266993.377	9868434.797	1546.347534	kahawa west	At Kiu river bridge
267516.55	9869545.884	1571.829712	Kahawa west	
267536.055	9868334.668	1572.249512	kahawa west	Kongo area
265908.699	9869200.689	1589.875244	kahawa west	Kamiti corner
268237.933	9866615.306	1571.587036	Githurai market	Githurai bin
258097.466	9870656.72	1685.328247	Kiambu town	
258108.742	9870903.169	1692.848755	Kiambu town	Kiambu market
258330.732	9870768.507	1689.209717	Kiambu town	
272257.406	9872933.593	1533.144653	Kiambu town	
273297.43	9873822.573	1522.983521	Ruiru town	at Wakairo place under rehabilitation
274021.06	9873627.321	1528.358032	Ruiru town	Along the railway line at Wakairo
266632.501	9888163.032	1687.446289	Gatundu market	Bins place
277290.294	9879470.428	1541.131714	Juja	Gatundu-Juja road
279650.086	9879169.837	1532.482178	Juja	Gachororo near JKUAT
290823.225	9880791.525	1497.352051	Kang'oki	Thika/Makongeni
290466.818	9881108.81	1502.661255	Kang'oki	Thika/Makongeni
288731.679	9883173.696	1510.657715	Phase 10	Thika/Makongeni
265292.41	9863024.536	1554.978394	Lucky summer	Next to ruiruaka river behindd PAG church
265294.653	9862584.658	1575.571289	Luckysummer	Near the power-substation
266555.301	9863276.391	1560.576904	Luckysummer	At the quarry next to ruiraka river
266589.516	9865213.336	1582.130737	Kasarani	
268344.558	9864194.929	1569.842285	Mwiki	
271372.86	9861905.485	1517.375732	Njiru	Along kangundo road at the Ngong river bridge
272314.743	9861619.098	1519.764404	Chokaa	Along kangundo road
276515.002	9859768.706	1539.050903	Ruia	Ruia market along kangundo road
276945.108	9859508.8	1532.846069	Ruia	Ruia market along kangundo road
274424.757	9857281.777	1586.32019	Utawala	Next to JIA reserve
249312.177	9845526.752	1777.804688	Ongata Rongai	
249314.848	9845527.529	1777.804688	Ongata Rongai	Next to kajiado Sub-County offices
239553.557	9849166.686	1968.766602	Ngong town	Rehabilitated site next to catholic church

238838.16	9849221.965	1996.516113	Ngong town	Next to Jubilee offices and Sub-county offices
242465.973	9841957.199	1882.140503	Kiserian market	Open market
242571.55	9841812.059	1881.19812	Kiserian matatu stage	Kiserian - Nairobi stage
260894.52	9812338.809	1875.525024	Isinya	Isinya dumpsite
240045.869	9862131.427	2059.19043	Kikuyu town	Next to st. Peters catholic church
240142.986	9862352.095	2058.97583	Kikuyu town	Kikuyu market with bins
245608.057	9857617.072	1889.856934	Waithaka town	Next to st. Charles Lwanga catholoc church
249390.475	9857576.523	1848.363403	kawangware 46	Gitanga road_Dandora ndogo
248833.619	9858292.055	1854.232422	Kawangware 46	Near muslim school
248742.001	9857902.381	1858.972412	kawangware 46	
249450.702	9860124.961	1888.485352	Kangemi town	kangemi market
250396.287	9859711.966	1860.371948	Kangemi town	Makaburuni area
252625.748	9854977.823	1834.302002	Kibera	Kibera youth car wash
252754.873	9855123.838	1827.322632	Kibera	At forty jesus
252734.41	9855098.821	1827.546631	Kibera	At forty jesus
252546.381	9854839.706	1830.831055	Kibera	Near baptist church_along Railway line
252605.899	9854888.097	1834.581909	Kibera	Olympic bridge
254287.754	9855145.657	1764.25647	Kibera	Next to Kimungu drainage
254311.229	9855163.486	1762.763672	Kibera	At Darajani
254411.748	9855176.627	1757.351807	Kibera	At Darajani
254048.45	9855083.945	1766.505249	Kibera	At Darajani
253881.069	9855017.761	1777.011597	Kibera	At Darajani
254153.268	9855146.091	1774.100464	Kibera	At Mashimoni near bypass bridge
265703.513	9861378.386	1667.264038	Dandora	Dandora dumpsite at the Way bridge
265709.884	9861485.015	1668.803589	Dandora	Dandora dumpsite at Boma
261451.459	9854320.212	1705.519775	Likoni road	At the Likoni road bridge near Royal paints
259891.788	9854462.105	1705.519775	South B	Along the road
344274.4	9802828.3	1705.519775	Wote Town Solid Waste Dumpsite	Ntwangu-Kaiti rivers confluence
303460.6	9821223.7	1705.519775	Yaidha Market Dumpsite	At Yaidha Market pollutes Kimutwa river
305868.8	9829125.2	1705.519775	Machakos Town at Katoloni Market	Bin No 40 pollutes Mwanja river



306628.5	9830155.98	1705.519775	Machakos Town at Susana near Machakos University	Bin No 70 pollutes Mwanja river
303801.1	9828749.3	1705.519775	Machakos Town Main Dumpsite	Next to FTC pollutes Mwanja river
303774.4	9831877	1705.519775	Machakos Town at Kenya-Israel	Pollutes Maruba dam
274506	9847397.5	1705.519775	Mavoko Dumpsite	Next to Mavoko quarry pollutes Athi river
270725.1	9837785.3	1705.519775	Kitengela Dumpsite	Kitengela town

**Annex IV: Delineation of Rivers Upstream Thwake Dam**

## **Annex V: Athi and Catchment Upstream Thwake Dam**

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