SUSTAINABLE URBAN DESIGN APPROACH FOR DUMPSITE REHABILITATION

Case of Decommissioning Dandora Dumpsite for Urban Park

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A Research Project report submitted in partial fulfillment for the award of

Degree of Master of Architecture

School of the Built Environment

Department of Architecture and Building Science

University of Nairobi

2014

DECLARATION

This research project report is my original work and has not been presented for a degree in any other university.

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DEDICATION

TO MY FAMILY

Dad, Mom and my Brothers

ACKNOWLEDGEMENT

Staff at the University of Nairobi supported me in facilitating this work, I hereby acknowledge with gratitude. My supervisors from the School of the Built Environment of the University of Nairobi, Prof. Robert Rukwaro and Dr. O. K'Akumu, were particularly patient throughout the duration of the study, and to whom I am most grateful.

This work would have been impossible without the formal and informal support and guidance with scholars from a variety of academic institutions. At UoN assistance and guidance from the following is gratefully acknowledged: Prof. Magutu, Arch E. O. Abonyo, Arch. Kigara Kamweru, Mr. Oyugi.

I am eternally grateful.

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LIST OF ABBREVIATIONS

ACAP	Alternative Cover Assessment Program
ARRPET	Asian Regional Research Programme on Environmental Technology
BPEM	Best Practice Environmental Management
CBO	Community Based Organisation
CBD	Central Business District
CBS	Central bureau statistics
CCPE	Center for City Park Excellence
CCN	City Council of Nairobi
CLD	Causal Loop Diagram
CSO	Civil Society Organisations
CSR	Corporate Social Responsibility
EKK	Exodus Kutoka Network
EPA	Environmental protection agency
ET	Evapotranspiration
INTOSAI	International Organisation of Supreme AuditInstitution
ISWM	Integrated Solid Waste Management
JICA	Japan International Cooperation Agency
KAM	Kenya Association of Manufacturers
KARI	Kenya Agricultural Research Institute
KEPHIS	Kenya Plant Health Inspectorate Services
KNCPC	Kenya National Cleaner Production Centre
LA	Local Authority
LFM	Landfill Mining
MENR	Ministry of Environment and Natural Resources
MoLG	Ministry of Local Government
MoNMD	Ministry of Nairobi Metropolitan Development
MSW	Municipal Solid Waste
NCC	Nairobi City Council
NEMA	National Environmental Management Authority
NTT	National Task Team
MOE	Ministry of Environment
NCBD	Nairobi Central Business District
NGO	Non-Governmental Organization
SIDA	Swedish International Development Cooperation Agency
SoK	Survey of Kenya
SWM	Solid Waste Management
UN	United Nations
UNEP	United Nations Environmental Programme
USEPA	United States Environmental protection agency
UNEP	United Nations Environmental Program
UN-HABITAT	United Nations Human Settlements Programme
UNDP	United Nations Development Programme
UN-OCHA	United Nations Office for the Coordination of Humanitarian Affairs
USEPA	United States Environmental Protection Agency

ABSTRACT

Neglecting of 4R hierarchical solid waste management, reject, reduce, recover and reuse has led to questionable urban environmental qualities contrary to Nairobi the green city. Key to the study is investigating the rehabilitation strategies through landfill mining (LFM) concept, vegetative cover concept and their benefits to a sustainable urban environment. A literature review was done on hazards of waste, LFM process and its benefits, use of plant cover to 'cure' recovered soil and their secondary benefits, sustainability concept and its application in cities, cost-benefit model and best practices in LFM. Further the study examined the physical, social, environmental, and economic attributes in developing an urban design approach for dumpsite rehabilitation. However, environmental aspect were found wanting and formed the basis of study's approach. The research methods applied included interviews and observation. The findings from Dandora dumpsite revealed the reviewed concepts on sustainable approach for rehabilitating the landfills to improve the livelihood of urban dwellers in creation of urban Public Park and increase the environmental benefits. The study recommended use of LFM concept coupled with vegetative cover to create a sustainable Dandora urban park.

Key words: landfill, solid waste, sustainability, landfill mining, landfill rehabilitation, vegetative cover, evapotranspiration, phytoremediation

1 INTRODUCTION

Before the industrial revolution human and animals used the resources of the earth to support life and dispose of the wastes in early times. The disposal of human and other wastes did not pose a significant problem for the population was small and the land was available for the assimilation of waste

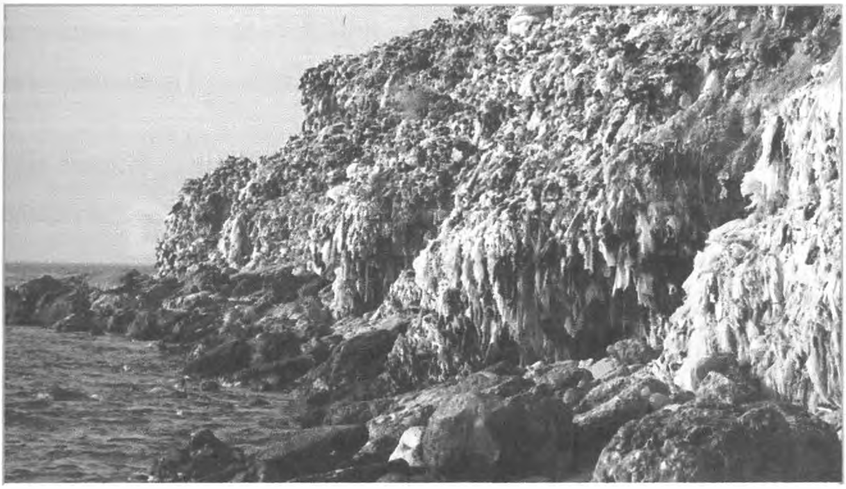

Plate 1.0 Mountain of waste near water body at Saida dumpsite
Source: - Saida Municipal Report, 2010

Population growth increased the demand for waste disposal creating mountains of garbage globally Plate 1.0. With the emergence of the concept of sustainable cities, there has been a growing interest in the role which cities could have in addressing global environmental issues and, in particular, climate change (Bulkeley and Betsill, 2003). Moreover, consolidating urban places and improving design is beneficial not only from an environmental perspective, but also as a means of improving the 'livability' of urban areas and provision of services, as well as providing the impetus for spatial regeneration.

This study is about urban dumpsite rehabilitation in a city setting. It investigates the conceptual approach to a closed dumpsite. Modern city has become unattractive forcing people to stay within the privacy of their homes (Moughghtin, 1992). The threatening environmental condition posed by mountains of garbage, is detrimental to human livelihood.

The dumpsites have lost their character or individuality and have become environmental threatening places; littered, nauseating, piled with rotting rubbish, sense of insecurity to the neighborhood. These problems are experienced in urban areas or urban places. Places matter much more than a single building (Tibbalds,1992).

This life threatening environment situation calls for an urgent intervention and a conceptual approach which has an environmental benefit. This study is focused on developing a rehabilitation approach for Dandora dumpsite with sustainable environmental benefits.

This chapter is an introduction to the topic of the study by looking at the background of the study, problem statement, objectives of the study, hypothesis of the study, research questions, assumptions of the study, study justification, significance of the study, and scope of the study, study limitations, definition of terminologies and the structure of the study.

1.1 BACKGROUND OF PROBLEM

Landfilling is one of the most common waste disposal methods in solid waste management system. Landfills were commonly located on the fringe of urban development in quarries that provided materials for urban development. Historically it has been the most economically and environmentally acceptable methods for waste disposal in both developed and developing countries (Rushbrook, 1999). However the site where to develop and establish a sanitary Landfill is a challenging process, as it requires taking into account the social, environmental and technical aspects. An appropriate landfill siting process aims to minimize environmental, social and economic hazards.

The success of dumpsite location is subjected to several linked factors such as landfill design, operation, management and landscape design upon closure (Environmental protection agency [EPA], 2007). However in countries such as Japan, it is becoming increasingly difficult to obtain public acceptance during the location of incinerators and landfills due to public concern over negative environmental impacts, health protection and awareness on persistent organic pollutants (United Nations Environmental Programme [UNEP], 2009). This reflects that the location of waste disposal facility is not an easy task, it requires seeking public compromise and is subject to inter-disciplinary and full community involvement in the decision making process. On the contrary, in most of the countries in developing countries, waste disposal facilities do not receive the attention it deserves in waste management system.

Crude open dumping approach coupled with indiscriminate disposal of waste with limited measures to control pollution and hazards to public health and natural environment has remained a predominant waste disposal option (Johansen and Boyer, 1999). In many cities in the developing countries like Nairobi, the only changes and improvement that can be observed in the waste management system are the ways of collection and transportation of solid waste to the disposal sites for which there is increased private, NGOs, and CBOs involvement based on public private partnership arrangement. The dumpsites on the contrary, continue to receive voluminous municipal garbage even when they are at full capacity to be closed.

The selection of the site for a landfill is considered as important decision to be made by the municipalities for the development and implementation of councils' waste management plan (Rushbrook, 1999). In developed countries, proper landfills location receives a high priority due to the fact that a poorly chosen site may require unnecessary expenditures on transport, site development, environmental protection, and protection of public health from hazards which can be developed by landfill (Tchobanoglous and Kreith, 2002). However, this is not the case in developing countries.

Nairobi city is the largest city in Kenya. The name 'Nairobi' comes from the Maasai phrase 'Enkare Nyirobi' which translates to 'the place of cool waters', popularly known as the Green city in the sun (Nevanlinna, 1996). The Nairobi city has a population of more than 3.2 million people with annual growth rate of 6% (Central bureau statistics [CBS], 2010). The city plays a major role in the countries' economic growth as it is the major industrial, commercial, and government centre of the Republic of Kenya. For the last 20 years, Nairobi city has been experiencing rapid urbanization coupled with uncontrolled city growth. Urban rural migration has been the main course for city growth and consequently leading to proliferation of unplanned settlements. More than 70% of the Nairobi residents are housed in informal settlements (CBS, 2010).

Boyer hints 90% of solid waste is disposed through open dumping (1999). Most of the municipal dumpsites have problems of shortage of cover, lack of leachate collection and treatment, inadequate compaction, poor site design, and rag picker invasions are common in these sites. Waste pickers often set refuse on fire in order to recover valuable inorganic items thereby creating fire hazards and adding to air pollution. The workers are exposed to risks from human feces, slaughterhouse wastes, infectious biomedical wastes, broken glass, toxic dusts, landfill gases, spontaneous fires and explosions. Often there is lack of technical knowledge, financial and human resources coupled with existing lacunae in policies limit the extent to which landfills can be maintained, operated and rehabilitated at minimum standards.

Thus, there is an emerging need for the local authorities to tackle these problems by looking for a more efficient and environmentally sound dumpsite rehabilitation method where landfill mining and vegetative to create a sustainable urban park has been identified to be one of the options. With its proper design, maintenance and post closure monitoring, urban park offers a sustainable way in handling closed dumpsites.

1.2 PROBLEM STATEMENT

Waste disposal is the final functional element in the waste management system that involves disposing of discarded items. Waste is worthless or unused for human purpose. It is a lessening of something without useful result; it is loss and abandonment, decline, separation and death. It is the spent and valueless material left after some act of production or consumption (Lynch, 1990). The disposed waste mainly comprises residue, which are remnant after processing or cannot be recycled. In many cities both developed and developing countries have adopted open landfilling as solid waste disposal techniques.

Like any other developing countries, municipal solid waste disposal facilities have become an increasing problem in Kenya's towns and cities. Overwhelmed by an overabundance of social economic problems, municipal city councils are generally seen as incapable of delivering services to its citizens. One major area in which city authorities appear to have failed to fulfill their duties is management of waste at the dumpsite.

The rapid population growth that has significantly increased solid waste generation is considered to impede the capacity of Kenyan municipal councils to effectively deliver solid waste management services.

The practice of City Council on waste disposal has been through crude open dumping often in selected natural depression, or abandoned quarry sites. Industrial solid waste containing hazardous components together with medical wastes are also disposed in these dumpsites. As such a large number of scavengers who extract valuable materials from waste heaps are exposed to health and physical hazards due to contamination and contracting of these wastes. This method has led to environmental pollution and has been a source of tension, especially in low income densely populated urban areas, where these dumpsites are located.

Attempt on the relocation of dumping location have been made. A master plan for the improvement of solid waste management (SWM) in Nairobi City was formulated in 1998, by JICA, on request by the Government of Kenya (GoK). The plan identified Construction of a new sanitary landfill site at Ruai and closure work of the existing Dandora dumpsite as priority projects. With the expiry of time and non-implementation of the priority projects a survey on integrated solid waste management was carried out between August 2009 and September 2010 which recommended urgent improvement and closure of Dandora dumpsite by Nairobi city council.

However, much planning must be undertaken to rehabilitate the closed dumpsite to public spaces, particularly ones that allow the emergence of green urban open spaces. Currently the studies undertaken explicitly look at waste management without addressing the rehabilitative approach to the poorly maintained landfill.

To remedy the stated problems this study investigates use of landfill mining (LFM) concepts and vegetative cover concept to achieve a sustainable urban park through environmental, spatial and socio economic variables.

1.3 RESEARCH OBJECTIVES

i. Establish the existing conditions of Dandora dumpsite.
ii. Analyse the socio-economic, environmental relationship between the dumpsites and the low income residential neighborhoods.

iii. Evaluate the relationship between sustainability factors of rehabilitated site and the landscape conceptual design plan.

1.4 RESEARCH QUESTIONS

- What is the existing Dandora dumpsite condition?
- Which social, economic and environmental threats does the dumpsite pose to immediate urban residents?
- How important is a landscape conceptual design plan in achieving a sustainable urban park?

1.5 STUDY JUSTIFICATION.

With growing population, new urban development's and rural-urban migration is contributing to a high waste production, Dumpsites will continue to be primary means for the disposal of solid waste so the need for their rehabilitative conceptual framework which can develop to green environment. This calls for introduction of better ways of waste management hence need for urban designers to encourage user interaction with nature benefits. The following provisions have been put in place for a safe environment.

a. The constitution of Kenya provides for access to a healthy environment to every human being, which has been considered as a basic human right.
b. The Millennium Development Goal 8 emphasizes on the provision of safe clean water and safe environment.
c. Kenya's Vision 2030 includes implementation of an integrated solid waste management system as a driver of development.

The Nairobi River Rehabilitation and Restoration Programme seeks to rehabilitate, restore and manage the Nairobi River Ecosystem in order to provide for improved livelihoods and enhanced biodiversity and sustainable supply of water for domestic, industrial and recreation purposes. During rainy seasons, tonnes of solid wastes are washed into the river both from Dandora Dumpsite and other illegal Dumpsites.

Dumpsite and contaminated sites are unrealized resources for urban rehabilitation and ecological restoration. These sites are often in advantageous locations, near city centers, adjacent to residential communities that offer a potential labor pool. Dumpsites are environmentally-impaired assets that need to be rehabilitated for productive use and integrated to surrounding community. Design approaches which integrate the ecological functionality, aesthetic appearance, recreational potential and spontaneous vegetation are likely to succeed than those which focus on ecology alone (Del Tredici, 2010).

Rehabilitation of Dandora dumpsite through landfill mining and vegetative cover will contribute to the achievement of these policy directions, strategic actions and their sustainability concept.

1.6 SIGNFICANCE OF THE STUDY

There is a voluminous documentation of best practices for waste including the hierarchical waste treatment of avoid, reuse, recycle and reduce. A conceptual framework approach of how to improve the conditions of a dumpsite upon its closure is a necessity.

This study intends to give an approach and requirements of rehabilitating a dumpsite more so one which had not been initially planned for and a proper framework conceptualised. A pre-planned approach would have had an environmental impact assessment carried out. A study of this nature would guide stakeholders on what is best for the neighborhoods and be a prototype to other unplanned dumpsites which have proliferated in low class residential neighborhood.

The positive impacts of this project are both short term and long term and include improved environmental quality, health improvement, improved water quality, improved education, improved infrastructure, employment opportunities to residents and landfill mining enhancement. Secondary benefits include elimination of odour smell, reduced crime rates, elimination of human degradation, improved urban aesthetics, increased urban livability and improved sustainable usage of the site contributing to realization of Vision 2030.

Plate 1.2 Artistic rendering for Ariel Sharon park, formerly Tel Aviv landfill, closed in 1999 to be transformed to 2,00acre urban park and ecological centre.
Source: Virskus , 2006

Through urban design interventions the problem can be transformed into an environmental haven. Some of the dumpsite has been rehabilitated to urban parks and ecological centre Plate 1.2. Just because a site contains a dumpsite does not mean it cannot or should not be developed. Over the years the dumpsites have been thought to be homes for the street families. This study guides urban designer in understanding benefits of rehabilitating a dumpsite.

1.7 STUDY SCOPE

Theoretical scope of this study is considering the environmental menace posed by unmaintained open dumps. It is paramount to address these hazardous issues which affect the residents. A sustainable rehabilitation approach one which integrates environmental benefits is what the study will look into. The study will look at the type of waste, methods of waste disposal, practices of rehabilitation limiting to landfill mining and vegetative cover concepts, ecological and environmental benefit, sustainability paradigm as used in cities and best practices projects which have used LFM concept to develop urbanism.

Geographical scope of this study is limited to rehabilitation of the main open dumpsite in Nairobi city. This study is limited to use of a sustainable urban design approach for rehabilitating Dandora dumpsite with the surrounding environmental benefits.

1.8 STUDY LIMITATIONS

The study revolves around a sustainable urban design approach through landfill rehabilitation using a concept of landfill mining.

Finance: to affirm some tests requirement of practical demonstration would have yielded accurate results. For example, taking a sample of waste by excavating vertically to the bed of the old quarry the study had to determine the waste layers and their content.

Inadequate data from institutions, the institutions which mange the waste fail to keep data as such the NCC data is inadequate on approximating the volume of waste and the soil volume expected.

Co-operation, people scavenging at the dumpsite felt their privacy is invaded and failed to cooperate. More so others were demanding 'listening allowance' arguing, information is money. Residents were failing to cooperate for fear that the researcher were government agencies and likely to demolish their structures. The study team sought assistance from administrative police for security.

Time: the time for the study was limited both in reviewing the theoretical writings and data gathering and analysis. The study would have required an accurate area of where the quarry was and its depth to determine the volume. The research would have gathered adequate information to generate a cost-benefit model for capital costs and operational costs.

1.9 DEFINITION OF TERMINOLOGIES

Evapotranspiration is defined as use of plants to minimize water percolation into contaminated soils via a 'sponge and pump' mechanism and prevent surface soil erosion.

Land ill is any location within a solid waste disposal site used for the permanent disposal of waste where the organic portion of the waste is subject to natural processes of aerobic and anaerobic decomposition.

Land ill Gas is any untreated, raw gas derived through a natural process from the decomposition of organic waste deposited in a solid waste disposal site or from the evolution of volatile species in the waste.

Land ill mining is the process whereby solid wastes which have previously been landfilled are excavated and processed with the objectives of rehabilitating the dump sites, conserving of landfill space, reducing landfill area, eliminating of potential contamination source and recover resources.

Leachate is an aqueous solution with a high pollution potential, which mainly results when water is permitted to percolate through decomposing waste. It contains final and intermediate products of decomposition, various solutes and waste residues.

Non-decomposable Solid Waste is Materials which do not degrade biologically to form landfill gas. Examples include, but are not limited to, earth, rock, concrete, asphalt paving fragments, clay products, inert tailings, inert plastics, plasterboard, vehicle tires, glass, inert slag, asbestos, and demolition materials containing minor amounts (less than 10 percent by volume of wood and metals).

Phytoremediation is the treatment of environmental problems through the use of plants that mitigate the environmental problem without the need to excavate the contaminant material and dispose of it elsewhere.

Dumpsite Rehabilitation Is the process by which disposed wastes in an existing dumpsite is excavated and either reused or disposed in an environmentally friendly manner.

Solid waste is all putrescible and non-putrescible solid and semisolid wastes, including garbage, trash, refuse, paper, rubbish, ashes, industrial wastes, demolition and construction wastes, abandoned vehicles and parts thereof, discarded home and industrial appliances, manure, vegetable or animal solid or semisolid wastes, and other discarded solid and semisolid wastes or animal solid and semisolid wastes, and other discarded solid and semisolid wastes.

Sustainability is defined as a development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Urban Park is a public open space in cities and other incorporated places to offer recreation and green space to residents and visitors.

1.10 STRUCTURE OF THE STUDY

Chapter one has featured introduction, problem statement, study objectives, study assumptions, justification, study scope, operational definition and study organization. Chapter two involves a critical review of relevant literature. This entails studies on types of waste, methods of waste disposal, landfill mining concept, vegetative cover concept, best practices of dumpsite rehabilitation, ecological/ environmental approach, the sustainability approach to cities. Chapter three presents research methodology, sampling procedure, data collection, and data recording tools, data analysis, data interpretation, data validity and data reliability. Chapter four dwells with data analysis, using graphs, tables, charts and interpretation. Chapter five contains summary of conclusions, recommendations and areas of further research

2 LITERATURE REVIEW

2.1 INTRODUCTION

Critical global environmental issues of greenhouse gas emissions and loss of biodiversity have led to increased advocacy for more sustainable land use practices (Vitousek et al., 1997).

This chapter reviews different literatures that are related to solid waste management with particular focus on waste disposal sites. It further provides an in-depth analysis of methods of waste disposal and problems caused by waste.. The chapter further highlights essential theories and concepts on dumpsite rehabilitation. Above all, the chapter draws practical experiences on successful rehabilitated landfills. To conclude, the chapter looks at the benefits of landfill rehabilitation using green urbanism.

2.2 METHODS OF WASTE DISPOSAL

Through urbanization and industrialization there has been an alarming increase of solid waste production in the urban areas all over the world. The reaction to this has been to designate certain areas for dumping known as landfills at the peripheries of the urban areas.

The study reached a stage in the development where we have the power to create environment we need or to destroy it beyond repair according to the use we make our power. The dumpsites have lost their character or individuality and have become threatening places littered, piled with rotting rubbish, sense of insecurity to the neighborhood. These problems are being experienced worldwide.

The solutions of the dumpsites are always sought but there is little done on the sustainability of dumping sites, some of these approaches to minimize non-biodegradable was the move by Kenyan government to reduce the use of polythene bags, initialization of decommissioning the Dandora dumpsite to accommodate the increasing number of the waste produced in Nairobi city.

The awareness on public health and environmental quality concerns are expected to provide the impetus that is needed to develop and implement a sustainable approach to manage solid wastes and rehabilitation of the existing open dumps. The environmental and social challenges of Solid Waste in urban environments have become an increasingly pressing issue. Disparities between the rich and poor continues to increase in many of these regions where growing urban areas often witness the worst signs of maltreatment of human labour and misallocation of waste as a resource.

Plate 2.1 Lack of daily cover to waste
Source: Sodokwon Landfill, South Korea, 2011

Unsustainable patterns of waste production, inefficient collection methods, unorganized human labour, insufficient coverage of the collection system, lack of awareness and absence of a civic culture on waste handling in concert with improper disposal of municipal solid waste, lack of knowledge and laxity in compliance to policies, are the foremost threats to human health and environmental quality.

Safe and reliable disposal of municipal solid wastes and residues is an important component of integrated waste management. Open dumps, commonly found in urban cities, are land disposal sites at which solid wastes are disposed of in a manner that does not protect the environment without applying daily cover Plate 2.1, susceptible to open burning, and exposed to disease vectors and scavengers. Waste disposal sites which are planned, designed and constructed according to good engineering practice, and operated so that they cause minimum environmental impacts, are called sanitary landfills. Landfill mining involves the excavation, screening and separation of material from landfills into various components. One major objective of landfill mining is dumpsite rehabilitation, which is defined as excavation of a portion or all of the dumpsite with the ultimate goal of reducing its volume through separation of materials into recyclable, reusable, and combustible components; reducing closure and post-closure costs by complete or partial exclusion of the landfill; creating capacity; and reducing environmental impacts.

2.2.1 Open dumping

Land filling is an important component of integrated waste management for safe disposal of the fractions of municipal solid waste (MSW) that cannot be reduced, recycled, composted, combusted or processed. About three-quarters of the countries and territories around the world use 'open dumping' method of disposal of MSW (Rushbrook, 2001). It is a primitive stage of landfill development at which solid wastes are disposed of in a manner that does not protect the environment, susceptible to open burning, and exposed to disease vectors and scavengers. Lack of adequate waste treatment and disposal infrastructure, large volumes of waste involved in metropolitan cities, proximity of disposal sites to the water bodies and ever-burgeoning residential areas even in the proximity of waste disposal sites has given rise to significant environmental deterioration and health impairment in most of the cities (Joshi and Nachiappan, 2007).

In many municipal counties, solid waste disposal by open dumping is rampantly under practice mainly because of the following. Ignorance of the health risks associated with dumping of wastes Plate 2.2, Acceptance of the status quo due to lack of financial resources, Lack of political determination to protect and improve public health and the environment.

Technical investigations assess the planning of the dumpsite and identify any flaws e.g sites situated in floodplains, watercourses or groundwater; or sites that adversely affect the environment and, because of insufficient buffer zones, adversely affect the quality of life of adjacent residents. The key steps towards upgrading the dumping sites include evaluation of some criteria to assess the risk of the current open dumping practices and to prepare an action programme for the dump rehabilitation as the following.

Plate 2.2 Chennai dumpsite, Presence of pigs in the dumpsite
Source: Perdido report, 2008

- Characteristics of the dumps, such as the depth and characteristics of solid waste and degree of compaction that took place, variability of wastes within the site, the size of the dumps as defined by the total amount of solid waste disposed of and the areal extent of the dumps.
- Environmental and health impacts of the existing dumps and definition of current contamination.
- Potential for "mining" decomposed organic materials (compost) from the existing dumps.
- Potential of using the compost mined or developed from the land dumps as the daily cover material.
- Occupational health of landfill scavengers and scope for assimilating these scavengers into the onsite activities during the up gradation of dumps.
- Number of people and especially any sensitive populations that could be influenced by the release of pollutants from the landfill and the duration of exposure

2.3 WASTE COMPOSITION

Decomposing waste has simple compounds are formed such as fatty acids, amino acids and carboxylic acids. The leachate during this phase is characterized by: high concentrations of volatile fatty acids, an acidic pH, high BOD, high BOD/COD ratio, high contents of NH4 and organic (Montelius, 1996). Due to the heterogeneous nature of the waste, such acid leachate can continuous for several years after disposal.

The level of recovery depends on the chemical and physical conditions in the landfill, and the efficiency of the equipment used (Cossu et al., 1996). The soil to waste ratio reported at various excavated landfills differs due to the amount of daily and final cover material employed, the size of the openings of the screens, type of landfill and waste., degree of compaction, age of landfill, and local conditions like moisture content in waste and degree of composition. Ratios in the range from 20:80 to 75:25 were found in different projects (Tammemagi, 1999), Depending on moisture content and decomposition rate (Hogland, 2002).

The most important variable in LFM is the amount of recovered fine soil fraction which could be used as cover or lining of new landfill or backfilled in a more sustainable way. (Hogland et al., 1999). It´s suggested (World Resource Foundation, 1998) that a landfill needs to be 15 years old before a successful mining project can be performed.

Although the research indicates, that large amounts of soil can be extracted, the chemical composition must be carefully investigated. Geusebroek (2001) reported contamination of etc. mineral oil and PAH, but Hull (2001) emphasized the importance of analyzing of material for VOC´s, metals, pesticides and PCB´s.

The non-recyclable part of the intermediate-sized and oversized materials is typically reburied in the mined area of the landfill. If this portion is reburied without further processing, this landfill mining operation typically achieves about 70% volume reduction (Cossu et al., 1995, Hogland et al., 1995). Facility operators considering the establishment of a landfill mining and reclamation program must weigh the several benefits and drawbacks associated with this waste management approach (Kurian et al., 2003).

Material contamination is a serious problem, and in order to re-use the soil it has to follow the national or local criteria's. However, it is possible that high concentrations of hazardous substances and heavy metal are found in dumpsite. Several safety equipments and precautionary measures are needed during a landfill mining project and after mining the design approach need consider the best remediation.

After mining and recycling the landfill the area can be used for different purposes. Landfilling new waste, commercial and recreative purposes or back to its natural status.

2.4 PROBLEMS OF WASTE

The state of dumpsites in developing countries is all similar at major towns: indiscriminately dumped, seemingly unplanned heaps of uncovered wastes, most of the times open burning, pools of leachate, rat and fly infestations, domestic animals roaming freely and families of scavengers picking through the wastes Plate 2.3. Open dumpsites do not have the necessary facilities and measures to control and safely manage the liquid and gaseous by -products of waste decomposition.

Plate 2.3 Old dried lake, 175ha, Mbeubeuss landfill, Dakar
Source: -ISWM Report, 2012

The biodegradable components of waste (food and commercial wastes) generally undergo anaerobic degradation in a dumpsite/landfill environment. The decomposition involves multistage dynamic processes, depending on the creation of a suitable environment subject to placement of wastes occurred at different times, heterogeneous nature of the wastes with different rates of biodegradability and the spatial variability in the physical and chemical environment of the waste materials.

Plate 2.4 Leachate flow to Msimbazi River, Kigogo dumpsite
Source: -Damas, 2013

Leachate is a liquid produced when the waste undergoes decomposition, and when water (due to rainfall, surface drainage, groundwater, etc.) percolates through solid waste undergoing decomposition. It is a liquid that contains dissolved and suspended materials that, if not properly controlled and treated, may pass through the underlying soil and contaminate sources of drinking water, as well as surface water Plate 2.4. The composition of leachate depends on the stage of degradation and the type of wastes within the disposal facility. In the first few years, leachate contains readily biodegradable organic matter, resulting in an acidic pH and high biochemical oxygen demand.

Plate 2.5 Waste burning, producing toxic substances
Source: - Jebel Ali landfill, Dubai, 2013

The decomposition of the waste also brings about the generation of gases, mainly methane (about 50-65%) and carbon dioxide (about 35-45%). As methane is formed, it builds up pressure and then begins to move through the soil, following the path of least resistance. Methane is lighter than air and is highly flammable Plate 2.5. If it enters a closed building and the concentration builds up to about 5 to 15% in the air, a spark or a flame is likely to cause a serious explosion, accidents causing human loss. Aside from being a flammable gas, methane released to the atmosphere greatly contributes to global warming as it has approximately 21 times the global warming potential of carbon dioxide. Estimates say that about 5-15% of the methane released to atmosphere is related to waste dumping and waste landfilled.

If open burning of solid waste is practiced (usually, to reduce volume), it results in the emission of toxic substances to the air from the burning of plastics and other materials. The toxic fumes can cause chronic respiratory and other diseases, and it will increase the concentration of air pollutants such as nitrogen oxides (NOx), sulfur oxides (SOx), heavy metals (mercury, lead, chromium, cadmium, etc.), dioxins and furans, and particulate matter.

2.4.1 Smellscape

Olfactory information is stored in long term memory and has strong connection to emotional memory. We can measure sound in decibels, colour in frequencies, touch in

2.4.3 Dumpsite closure

Dumpsites that have higher risks to environment and residents Plate 2.6 or exhausted their volumetric capacity to hold waste are suitable candidates for closure. An open dumpsite should not be converted to a more controlled operation if its estimated remaining lifetime is less than one year.

Plate 2.6 Children scavenging for selling materials at Umapad dumpsite, Philippines.
Source: Mandue city report, 2012

The basic requirements for closing an open dumpsite include providing final soil cover, vegetation layer, drainage control system, leachate and gas management systems, monitoring systems and site security (aftercare programme). The closure of dumpsites typically requires re-gradation of site slopes, capping of landfill with impermeable cover, placement of leachate collection and treatment systems, installation of landfill gas collection and flaring system and aesthetic landscaping of the closed dumpsite. If landfill gas volumes are significant, then a landfill gas utilization project by way of power generation/direct supply to neighborhood community for use as fuel may be installed.

2.5 REHABILITATION APPROACH

The function of landfill mining is to reduce the amount of landfill mass encapsulated within the closed landfill and/or temporarily remove hazardous material to allow protective measures to be taken before the landfill mass is replaced. In the process mining recovers valuable recyclable materials, a combustible fraction, soil, and landfill units of force and pressure, we have no scale for intensity scent, smell or odour. The dumpsite has grease, paint, plastics, cosmetics, household garbage smell give a cross cultural, homogenizing, globalized smell and it blankets the smells distinctive to a place.

Even hospitals are seeking to control the smell environment through herbs, such as the relaxing lavender, as awareness of the power of aromatherapy. Aromatherapy is the art and science of utilizing naturally extracted aromatic essence from plants to balance, harmonize and promote the health of the mind, body and spirit. We can rarely smell the city all in one so that we say that a city smell but the dumpsite smell is unitary. The sulphurous bad eggs, piercingly pungent, acrid smell which darts into your nose and catches a visitor unawares (Landry, 2002) dominates most dumpsites.

2.4.2 Visual spectacle

Through interacting with the environment we affect or get affected by it. (Bell at al., 1990) notes for this interaction to happen sight, sound and smell offer clues. As (Porteous, 1996) observes, vision is active and searching: 'We look; smells and sounds come to us.' Visual perception is highly complex, relying on distance, colour, shape, textural and contrast gradients, etc.

Landry (2006) argues the paradox of cities is our capacity to perceive is shrinking at precisely the moment when it needs to increase. Seeing the city as a field of senses is an invigorating experience. It generates pressure for ecological transport, for planting greenery or for balancing places for simulation and reflection in the city.

The look of the city depends on where you stand and its layout. From a distant a burning dumpsite would be equated to the gazillion lights in the city centre. Buildings will reflect the past, particular regional styles, and the materials available at various times in history. Green spaces contribute to a city quality of life but remember the green impression of a city can be misleading - much more if the green is in the private gardens.

According to (Nasar, 1998) people must pass through and experience the public parts of the environment as such aesthetic preferences, appreciation of space and design of urban space is critical.

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2.6 LANDFILL MINING CONCEPT

Landfill mining (LFM) projects have been used throughout the world during the last 50 years as a tool for sustainable landfilling rehabilitation. The first reported landfill mining project was an operation in Tel Aviv, Israel in 1953, which was then a method used to recover the soil fraction to improve the soil quality in orchards (Shual and Hillel, 1958; Savage *et al.*, 1993). It was later employed in United States of America (USA) to obtain fuel for incineration and energy recovery (Hogland, 1996, Cossu et al., 1996, Hogland et al., 1996).

The concept and utilization of landfill mining as a key part of this approach for sustainable landfill rehabilitation of Dandora open dump sites in urban city.

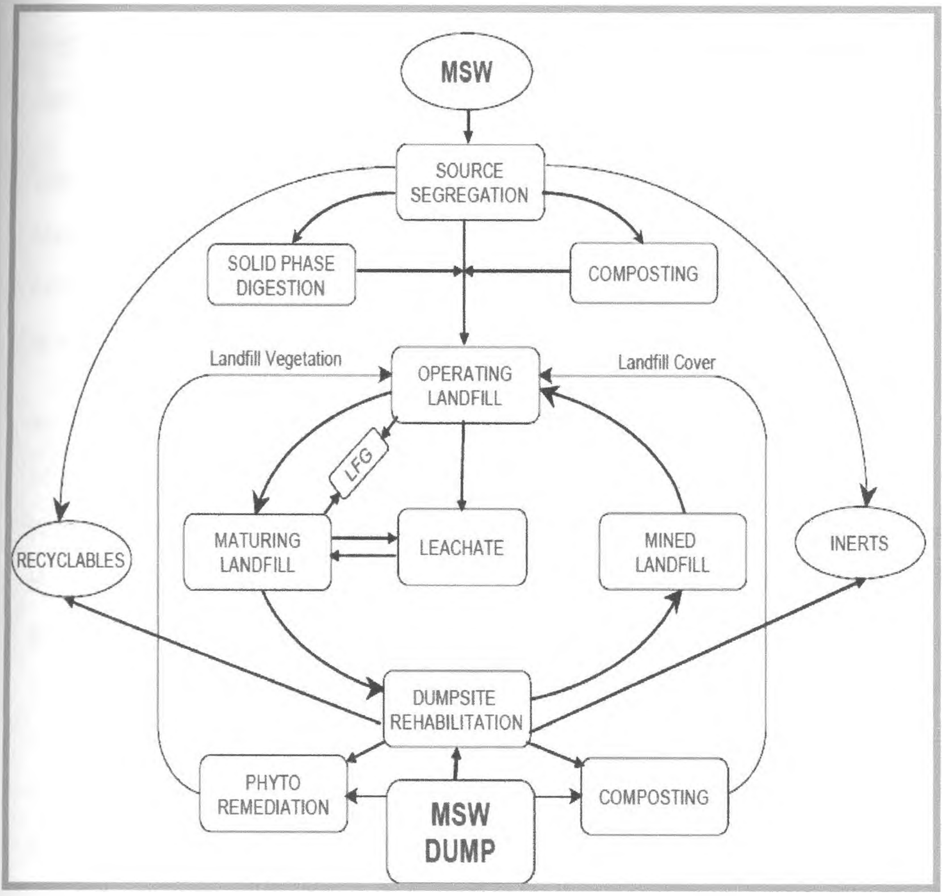


Figure 2.1 Integrated approach to sustainable landfill
Source: EPA 2007

"Landfill mining" is the process of excavating existing or closed solid waste landfills or dumpsites, and sorting the excavated materials for recycling, processing, or other disposition. It is the process whereby solid wastes which have previously been landfilled Figure 2.1 are excavated and processed with the objectives of rehabilitating the dump sites, conserving of landfill space, reducing landfill area, eliminating of potential contamination source and recover resources(Morelli, 1990). The success of materials recovery is dependent on the composition of the waste, the effectiveness of the mining method.

The primary factors that have motivated landfill operators to consider and implement landfill mining at their sites are to address groundwater contamination problems posed by wastes in old unlined landfills by removing the source of pollution, to create new capacity for future activities, to reduce closure costs by reducing the footprint of the landfill. Landfill mining reported in some cases is the recovery of recyclables, particularly metals, for resale (Nelson, 1994, Reinhart and Townsend, 1997). Landfill mining has also been considered to recover refuse-derived fuel from a landfill site for combustion at a waste-to-energy facility.

The excavated soil cover is contaminated and remediation process is necessary. This is attained through use of vegetative cover. The plants extracts the elements from the soil, reduce soil erosion thus prevent soil elements from been washed to rivers and add aesthetic to the environment.

Accumulated waste, however, is not only worthless; it has a negative value and pose a serious threat to humans and the environment, including the leakage of hazardous substances (Baun and Christensen, 2004) and methane emissions (Bogner et al., 1995). Hence, the orphaned, abandoned and neglected waste "bites back" (Tenner, 1997) on the society that created it. Increasingly, waste is defined as surplus material (Gourlay, 1992); a byproduct; material we have failed to use. From such a perspective, disposal is commonly regarded as a lost opportunity and a waste of resources. What is often forgotten in this context, however, is that the isolated events of deposition combined make a new potential resource base, which to some extent can be compared to traditional mines in terms of quality and quantity (Kapur and Graedel, 2006; Johansson et al., 2012). Research in industrial metabolism (Graedel et al., 2004) has shown how resources and metals in particular are extracted from the lithosphere, turned into products, consumed and then usually end up in landfills. In countries like Sweden, where incineration has largely replaced landfills, significant amounts of metals end up in ash, which is commonly landfilled (Kuo et al., 2007). *Landfill mining* (Krook et al., 2012), focuses on landfills in isolation by excavating and recovering deposited waste. Hence, it revives what is buried by digging up a landfill and gives the waste a new chance. landfill researchers have long underpinned the economic (Nelson et al., 1992) as well as environmental (Bogner et al., 1995) and health risks (Elliott et al., 2001; Baun and Christensen, 2004) associated with landfills.

2.6.1 Process of LFM

LFM is a relatively new approach used typically to expand municipal solid waste landfill capacity and avoid the high cost of acquiring additional land or other environmental purposes. Landfill mining typically consists of three basic operations: excavating waste, processing the excavated material, and managing the excavated or processed material. The excavated waste can be processed to meet several objectives, including separating bulky materials, sorting hazardous material and other unidentified waste, screening soils from waste, and sorting materials for recycling or use as fuel. Several common mechanical processes (such as magnets for ferrous metal and eddy current separators for aluminum) can be used to separate recyclable materials (Jones 2002; Figure2.2).

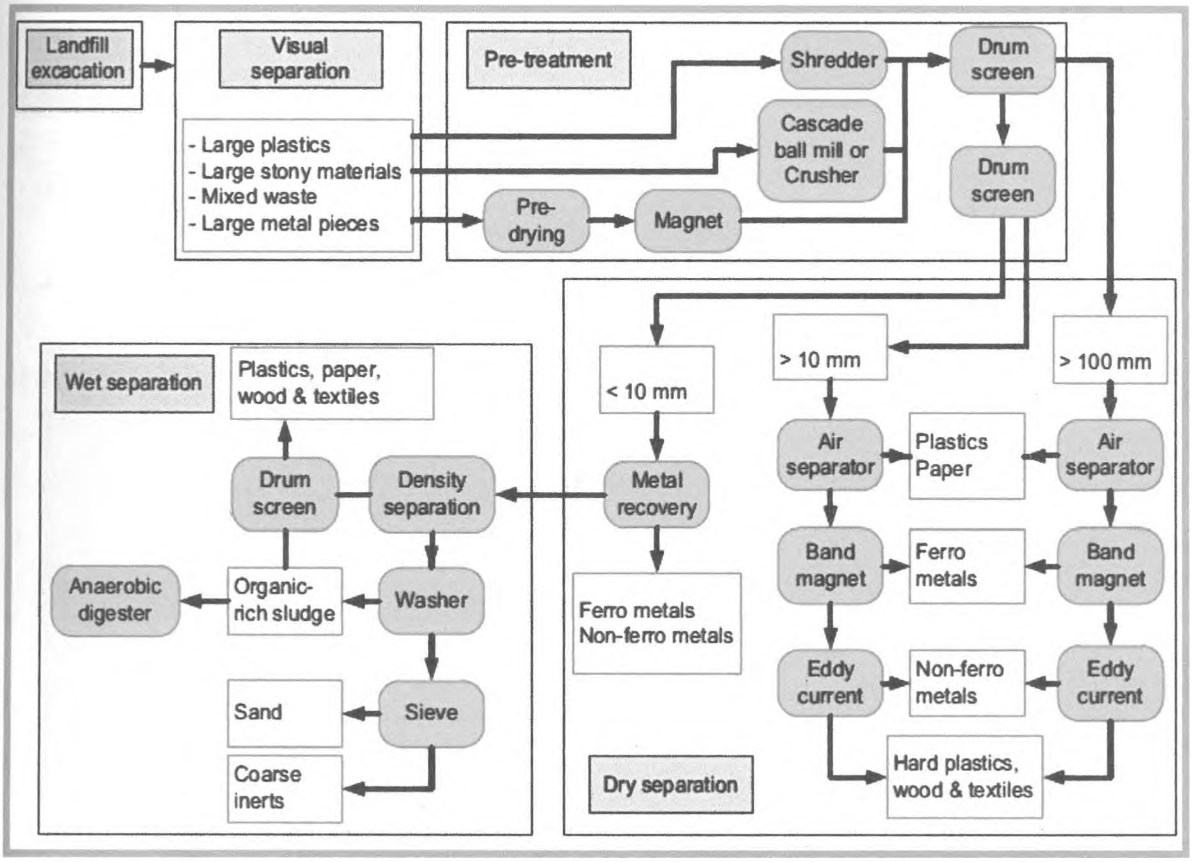


Figure 2.2: General flow sheet of intended material recuperation process
Source: Adopted from (Jones, 2002)

2.6.2 Tools and machinery

Mining process requires different machines. Depending on the complexity of the process more or fewer machines are used. An excavator or front end loader uncovers the landfilled materials and places them on a moving floor conveyor belt to be taken to the sorting machinery. A trommel is used to separate materials by size. First, a large trommel separates materials like appliances and fabrics Plate 2.7. A smaller trommel then allows the biodegraded soil fraction to pass through leaving non-biodegradable, recyclable materials on the screen to be collected. An electromagnet is used to remove the ferrous material from the waste mass as it passes along the conveyor belt. A front end loader is used to move sorted materials to trucks for further processing (re-landfilling or recycling processes). Odour control sprayers are wheeled tractors with a cab and movable spray arm mounted on a rotating platform. A large reservoir tank mounted behind the cab holds neutralizing agents, usually in liquid form, to reduce the smell of exposed wastes.

Plate 2.7: Trommel screen used for effective waste screening
Source: Perdido LFM report 2008

2.6.3 Mining process

The equipment used for reclamation projects is adapted primarily from technologies already in use in the mining industry Table 2.1, as well as in construction and other solid waste management operations (Hogland 2002).

Table 2.1 Plants and equipments used in land ill mining

PLANTS AND EQUIPMENTS FOR LANDFILL MINING			
EXCAVATION	**EXCAVATION AND LOAD**	**HAUL AND DEPOSIT**	**EXCAVATION, LOAD, HAUL AND DEPOSIT**
Rippers	Dragline	dumpers	Dozers

Drill and blast	Face shovel	Dump trucks	Tractor-drawn scarpers
Impact hammers	Forward loaders	Lorries	Motor-scrapers
Hydraulic	Grabs	conveyors	dredgers
Breakers	Bucket wheel		
skimmers	excavator		

Source: Author, 2013

The recovery system include soli recovery for sol amendment, moistened organic fraction and re-landfilling in a bioreactor for energy production , a new prototype of shredder for the breaking up of plastic and plastic recovery for the production of polyplanks. Polyplanks is a system of plastic planks and wood fibres. The emphasis is directed towards production of construction materials from waste plastic found in excavated landfills with industrial recovered waste plastic for new production (Carius et al., 1999, Hogland et al., 2001). In general the amount of pollutants increased with depth, but many substances were found at higher concentrations at a depth of 6 m than at the bottom of the landfill at 9 m. One reason might be that the landfill area excavated was relatively dry and the percolation of rain water through the material has been low, which also resulted in low decomposition.

2.6.4 Excavation and screening

Excavators dig up waste mass and transport it Plate 2.8, with the help of front end loaders, onto elevator and moving floor conveyor belts. The conveyor belts empty into a coarse, rotating trommel (i.e., a revolving cylindrical sieve) or vibrating screens separate soil (including the cover material) from solid waste in the excavated material.

Plate 2.8 : Excavator feeding the excavated waste to the shredder
Source:- Perdido LFM Report, 2008

The size and type of screen used depends on the end use of the recovered material. For example, if the reclaimed soil typically is used as landfill cover, a 2.5-inch screen is used for separation. If, however, the reclaimed soil is sold as construction fill, or for another end use requiring fill material with a high fraction of soil content, a smaller mesh screen is used to remove small pieces of metal, plastic, glass, and paper.

Trommel screens are more effective than vibrating screens for basic landfill reclamation. Vibrating screens, however, are smaller, easier to set up, and more mobile. The large holes in the screen allow most wastes to pass through, leaving behind the over-sized, non processable materials. The over-sized wastes are removed from inside the screen. The coarse trommel empties into the fine rotating trommel. The fine rotating trommel allows the soil fraction to pass through, leaving mid-sized, non-biodegradable, mostly recyclable materials.

The materials are removed from the screen. These materials are put on a second conveyor belt Plate 2.9 where an electromagnet removes any metal debris.

Plate 2.9: Conveyor belt system for soil transportation
Source:- Clovis city, for Clovis Mining Report, 2005

Depending on the level of resource recovery, material can be put through an air classifier which separates light organic material from heavy organic material. The separate streams are then loaded, by front end loaders, onto trucks either for further processing or for sale. Further manual processing can be done on site if processing facilities are too far away to justify the transportation costs.

2.6.5 Processing recovered materials

Depending on local conditions, either the soil or the waste may be reclaimed. The separated soil can be used as fill material or as daily cover in a sanitary landfill. The excavated waste can be processed at a materials recovery facility to remove valuable components (e.g. steel and aluminum) or burned in a municipal waste combustor (MWC) to produce heat and energy. The percentage recovery of a landfilled resource depends upon:

- The physical and chemical properties of the resource
- The effectiveness of the type of mining technology
- The efficiency with which the technology is applied

The types of materials recovered from an LFM project are determined by the goals of the project, the characteristics of the landfilled wastes, and the process design. In a typical LFM operation, once the oversize non-processibles, the dirt fraction, and the ferrous metals are removed, the remaining material may be recovered as fuel for a waste-to-energy facility, processed for recovery of other recyclables, or landfilled as residue.

The soil fraction recovered by mining typical landfilled MSW will probably comprise the largest percentage by weight of all materials. The ratio of soil to other materials depends upon the type of waste landfilled, landfill operating procedures, and the extent of degradation of the landfilled wastes (World Resource Foundation 1998). The major difficulty in marketing mined materials is in producing the necessary high quality. Another obstacle is the limited number of waste-to-energy facilities in some areas to serve as a market for combustible materials. (Lee and Jones, 1990; Hogland et al, 1997; Carius et al, 1999; Cossu et al, 1999).

2.6.6 Steps of project planning

Before initiating a landfill reclamation project, facility operators should carefully assess the following aspects of such an effort.

2.6.6.1 Site characterization study

The first step in a landfill reclamation project calls for a thorough site assessment to establish the portion of the landfill that will undergo reclamation and estimate a material processing rate. The site characterization should assess facility aspects, such as geological features, stability of the surrounding area, and proximity of ground water, and should determine the fractions of usable soil, recyclable material, combustible waste, and hazardous waste at the site (USEPA, 1997). Site-specific conditions will determine whether or not LFM is feasible for a given location. Key conditions include:

- Composition of the waste initially put in place in the landfill
- Historic operating procedures
- Extent of degradation of the waste
- Uses for the recovered materials

2.6.6.2 Potential bene its of LFM

Although economics are likely to serve as the principal incentive for a reclamation project, other considerations may also come into play, such as a communitywide commitment to recycling and environmental management (USEPA, 1997).

The environmental and economic benefits of landfill mining include the following:

- Use of recovered soil fraction as landfill cover material;
- Recovery of secondary materials
- Reduction of landfill footprint and, therefore, reduction in costs of closure and post-closure
- Reclamation of landfill volume for reuse.

Most potential economic benefits associated with landfill reclamation are indirect; however, a project can generate revenues if markets exist for recovered materials. Although the economic benefits from reclamation projects are facility-specific, they may include any or all of the following:

- Increased disposal capacity
- Avoided or reduced costs of:
    - Landfill closure.

- Post closure care and monitoring.
- Purchase of additional capacity or sophisticated systems.
- Liability for remediation of surrounding areas.

- Revenues from:
  - Recyclable and reusable materials (e.g., ferrous metals, aluminum, plastic, and glass).
  - Combustible waste sold as fuel.
  - Reclaimed soil used as cover material, sold as construction fill, or sold for other uses.
- Land value of sites reclaimed for other purposes.
- Current landfill capacity and projected demand.
- Projected costs for landfill closure or expansion of the site.
- Current and projected costs of future liabilities.
- Projected markets for recycled and recovered materials.
- Projected value of land reclaimed for other uses.

2.6.6.3 Health and safety plan

Drawing up a safety and health plan can be particularly challenging given the difficulty of accurately characterizing the nature of material buried in a landfill (EPA, 1997). Project workers are likely to encounter some hazardous materials; therefore, the health and safety program should account for a variety of materials handling and response scenarios. Although the health and safety program should be based on site specific conditions and waste types, as well as project goals and objectives, a typical health and safety program might call for the following:

- Hazard communication (i.e.,"Right to Know" component) to inform personnel of potential risks.
- Respiratory protection measures, including hazardous material identification and assessment; engineering controls; written standard operating procedures; training in equipment use, respirator selection, and fit testing; proper storage of materials; and periodic reevaluation of safeguards.

- Confined workspace safety procedures, including air quality testing for explosive concentrations, oxygen deficiency, and hydrogen sulfide levels, before any worker enters a confined space (e.g. an excavation vault or a ditch deeper than 3 feet).
- Dust and noise control.
- Medical surveillance stipulations which are mandatory in certain circumstances and optional in others.
- Safety training that includes accident prevention and response procedures regarding hazardous materials.
- Recordkeeping.

The program should also cover the protective equipment workers will be required to wear, especially if hazardous wastes may be unearthed. The three categories of safety equipment used in landfill mining projects are:

- Standard safety equipment (e.g. hard hats, steel-toed shoes, safety glasses and/or face shields, protective gloves, and hearing protection).
- Specialized safety equipment (e.g., chemically protective overalls, respiratory protection, and self-contained breathing apparatus).
- Monitoring equipment (e.g. a combustible gas meter, a hydrogen sulfide chemical reagent diffusion tube indicator, and an oxygen analyzer).

2.6.6.4 Cost Bene its Model

The costs and benefits of landfill mining vary considerably depending on the objectives (closure, remediation, new landfill etc.) of the project, site-specific landfill characteristics (material disposed, waste decomposition, burial practices, age and depth of fill) and l ocal economics (value of land, cost of closure materials and monitoring) (Cossu et al., 1996; Van der Zee et al., 2004). Cost heads related to project planning including capital and operational costs of the landfill mining project are as summarized below Table 2.2:-

Capital costs

- Site preparation
- Rental or purchase of reclamation equipment
- Rental or purchase of personnel safety equipment

- Construction or expansion of materials handling facilities
- Rental or purchase of hauling equipment

Operational costs:

- Labor (e.g., equipment operation and materials handling)
- Equipment fuel and maintenance
- Administrative and regulatory compliance expenses (e.g., record keeping)
- Worker training in safety procedures
- Hauling costs

The most potential economic benefits associated with landfill reclamation are indirect. The cost of landfill mining is expected to be less than about US $10/ton of waste mined. A large amount of that cost is associated with rental of the processing equipment. The rental fee is typically between US$16,000 to 19,000/month. For a large scale operating plant in Europe, a cost of $ 75-100 per cubic meter was reported (Cossu et al., 1996). The cost of landfill mining at the Filborna landfill in Sweden in 1994 was US $6.7/ton. In general, the economics of landfill mining depend on the depth of the waste material and the ratio of wastes to soil. The deeper the waste is buried, the more expensive it is to reclaim a landfill, per unit area (Salerni, 1995).

Revenue from:

- Recyclable and reusable materials (e.g., ferrous metals, aluminum, plastic, and glass)
- Combustible waste sold as fuel
- Reclaimed soil used as cover
- Materials sold as construction fill or sold for other uses
- Land value of sites reclaimed for other uses

Table 2.2. : scenario analysis for land ill (fictitious data) in us dollar (Van Der

	Worst case	**Realistic case**	**Best case**
Costs			
• Research	20,000	15,000	10,000
• Mining	1000,000	800,000	600,000
• Re dumping	300,000	200,000	100,000
Bene its			
• Regained land	1000,000	1250,000	1500,000
• recyclables	50,000	80,000	100,000
pro it	-270,000	315,000	890,000

By analyzing the economics of dumpsite mining calls for investigating the current capacity and projected demand of the landfill, projected costs for landfill closure or expansion of the site, current and projected costs of future liabilities, projected markets for recycled and recovered materials and projected value of land reclaimed for other uses.

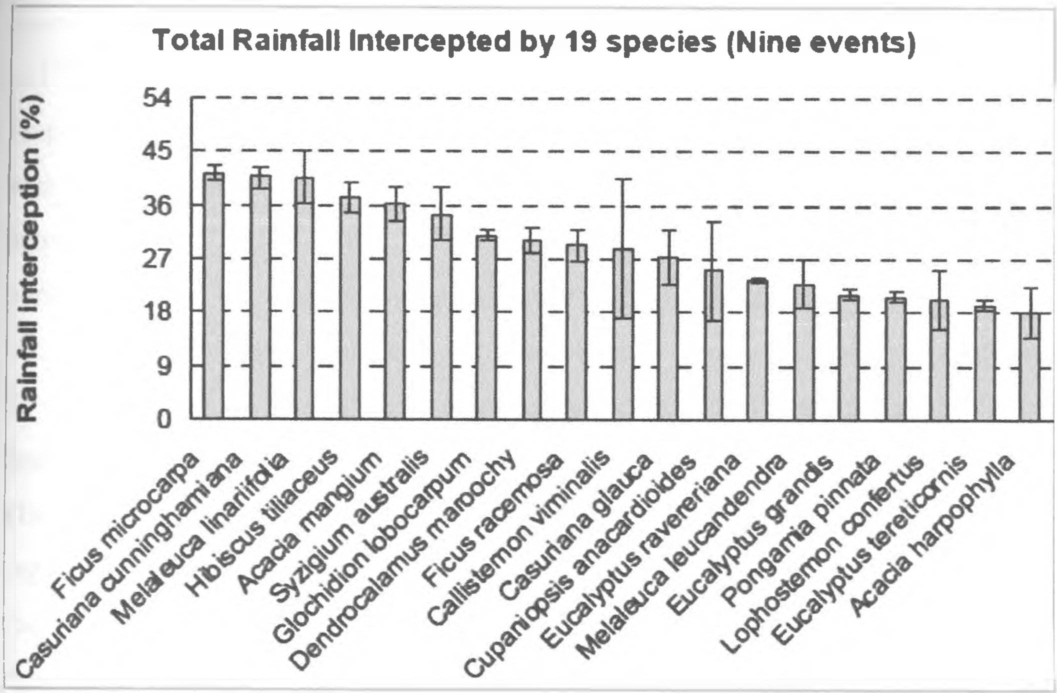
Major factors influencing the cost of such projects will include the volume and topography of the dumpsite; equipment parameters; soil conditions; climate; labor rates; the regulatory approval process; excavation and screening costs; sampling and characterization; development costs; the contractor's fees; hazardous wastes disposal; and revenue from the sale of commodities such as compost and recyclables.

2.7 VEGETATIVE COVER CONCEPT

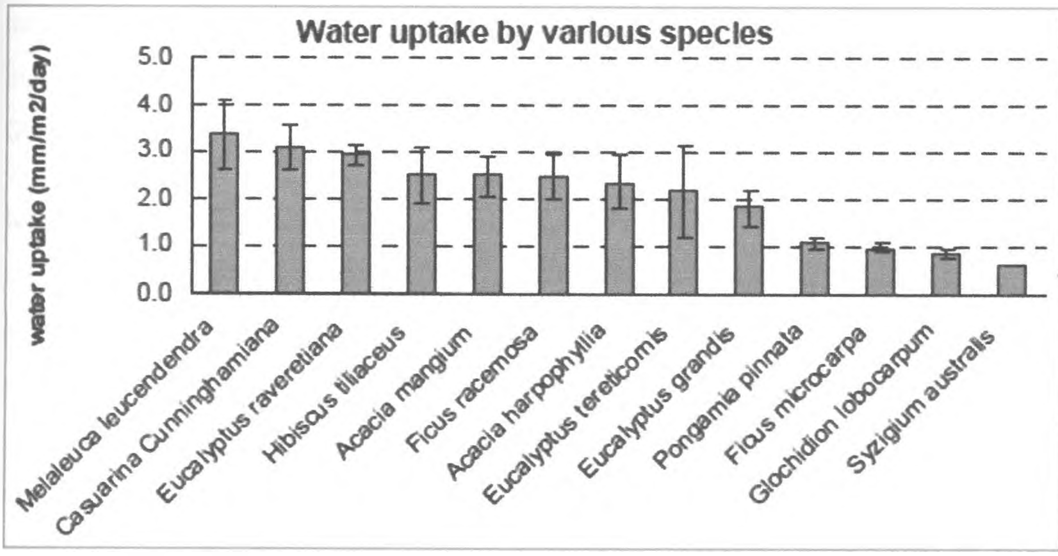
Vegetative cover is often referred to as evapotranspiration and phytoremediation. It's the use of perennial, fast growing and deep rooting trees to cover landfills and contaminated soils (Resource Conservation and Recovery Act [RCRA] 1976).

The regulatory standards focus on establishing low maintenance cover systems that minimize the infiltration of precipitation into the underlying waste. Traditionally, this has involved using a layered cap consisting of synthetic materials, clay, sand, topsoil, and vegetation to minimize percolation rates (USEPA, 1993). This general technique may effectively reduce infiltration, but these caps are expensive to construct.

The two primary goals of vegetative cover are to minimize water percolation into contaminated soils via a 'sponge and pump' mechanism and prevent surface soil erosion. The soil pores hold precipitation like a sponge until plants roots can access the water. Plants take up this water for growth and release it into the atmosphere by transpiration. The erosion control is achieved by canopy interception of rainfall, minimizing the' splash effect' and the growing of a root matrix that interlaces through soil particles (Licht et al., 2001). Canopy interception varies for different plant species Graph 2.1 and the water uptake is different for various plant species Graph 2.2.



Graph 2.1: Rainfall interception by different plants
Source:- Licht 2001



Graph 2.2: Water uptake by different plants
Source:- Licht 2001

2.7.1 Evapotranspiration cover (ET)

ET cover is used to inhibit the spread of leachate. ET covers are less expensive to construct; however, their application is infrequent due to limited cases in which their performance has been comparable to conventional caps in humid regions (Bolen *et al.*, 2001; Benson *et al.*, 2002; Albright and Benson, 2002; Albright *et al.*, 2004). The

Superfund Innovative Technology Evaluation Program (SITE) first addressed ET covers in 1998 (Bolen *et al.*, 2001) with the introduction of the Alternative Cover Assessment Program (ACAP). As described by ACAP, ET covers primarily consist of a thick soil layer with dense native vegetation that includes grasses (annual and perennial), shrubs, and hybrid poplars (Bolen *et al.*, 2001; Roesler *et al.*, 2002; Rock, 2003). To analyze the performance of ET covers under different climate conditions, the ACAP has multiple testing sites located in arid, semi-arid, and humid regions. Not surprisingly, research of ET covers in the various climatic regions by the ACAP strongly suggests that vegetation and soil composition be considered in order for them to perform properly (Rock, 2003). The most critical feature is that the plants will govern the performance of the cover by regulating the water balance via transpiration. There are many characteristics of plant species that benefit an ET cover, these include: native to the region and adapted to the regional climate; long-lived perennials that remain through numerous growing seasons; express rapid growth, thus able to begin performing in a short time period; adapted to a variety of soil conditions, such as those found at contaminated sites; have deep extensive root systems that provide erosion control and water uptake from deep soil layers; and transpire water over a long growing season (Hauser *et al.*, 2001; Hauser and Gimon, 2004).

Landfills without constructed barriers that prevent water from percolating through the contained wastes may generate leachate that contaminates adjacent groundwater (Cozzarelii *et al.*, 2000; Yoon *et al.*, 2003). Conventional caps (USEPA, 1993) and evapotranspiration (ET) covers (Hauser *et al.*, 2001) can be placed atop the recovered soil to limit water infiltration. Whereas conventional caps remove precipitation as runoff, ET covers store precipitation in the rhizosphere where it is later transpired to the atmosphere. When ET covers function correctly, the rates of transpiration substantially reduce the infiltration of water into the recovered soil (Rock, 2003; Licht *et al.*, 2004). ET covers are often less expensive than conventional caps (Dwyer, 1998) and offer additional benefits such as accelerated waste stabilization, reduction in greenhouse gas production, habitat enhancement, and improved aesthetics (Licht *et al.*, 2001). The U.S. Environmental Protection Agency (EPA) initiated the Alternative Cover Assessment Program (ACAP) in 1998 to compare the performances of ET covers and conventional caps (Albright *et al.*, 2003). As described by ACAP, these covers consist of a

thick soil layer, with dense vegetation that includes annual and perennial grasses, forbs, shrubs, and hybrid poplars (Bolen *et al.*, 2001; Roesler *et al.*, 2002; Rock, 2003). ET covers were noted to function comparably, except in relatively humid environments (> 20 cm precipitation/year). ET covers require well-designed, site-specific features (Albright, *et al.*, 2004), which should include the judicious selection of plants that are adapted to function within a given environment and climate. With proper vegetation selection, soil contamination could be reduced to the minimum, acceptable levels. Although, the comparative advantages of an ET cover are difficult to ignore, their application is infrequent in humid regions due to limited cases in which their performance was comparable to conventional caps (Bolen *et al.*, 2001; Albright and Benson, 2002; Benson *et al.*, 2002; Albright *et al.*, 2004).
The plant species are commonly found in many habitat types, they include: shrub and vine species –*Loniceratatarica* (tartarian honeysuckle), *Parthenocissusquinquefolia* (virginia creeper), *Rubusoccidentalis* (black raspberry), *Toxicodendronradicans* (poison ivy), and *Vitisaestivalis* (summer grape); herbaceous species - *Alliariapetiolata*(garlic mustard), *Barbarea vulgaris* (yellow rocket), *Melilotus alba* (white sweet-clover), and *Nepetacataria* (catnip); graminoid species – *Bromusjaponicus* (japanese brome), *Elymusrepens* (quack grass), *Elymusvirginicus* (virginia wild rye), and *Poacompressa* (Canada bluegrass).

Conventional capping is mainly efficient where waste had been managed properly to the standards specified (EPA, 1997). The advantages of LFM outweigh the use of conventional capping in issues of addressing the groundwater contamination for unlined landfill. Accumulated LFG which later causes fire is not addressed in the conventional capping and fails to recover valuable recyclable materials as a result of poor waste management. While LFM reduces landfill footprint and increase its useful life conventional capping fails to address these issues. A sequence of LFM followed with a vegetative cover yield the best result to realize sustainable concept in dumpsite rehabilitation.

2.7.2 Phytoremediation

This is the treatment of environmental problems through the use of plants that mitigate the environmental problem Figure 2.3. Phytoremediation consists of mitigating pollutant concentrations in contaminated soils, water, or air, with plants able to contain, degrade, or eliminate metals, pesticides, solvents, explosives, crude oil and other contaminants.

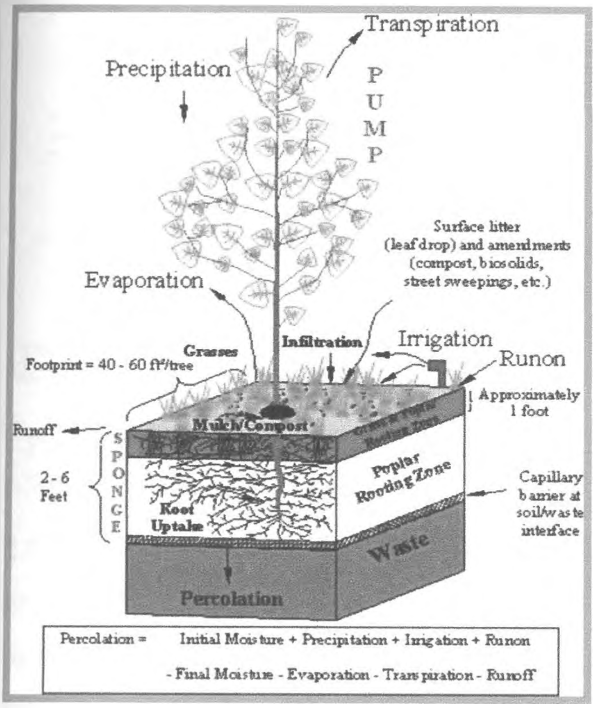


Figure2.3 Phytoremediation process
Source: Licht and isebrands (2005)

For organic pollutants, such as pesticides, explosives, solvents, industrial chemicals, and other xenobiotic substances found in the dumpsite, certain plants, such as Cannas, render these substances non-toxic by their metabolism. In other cases, microorganisms living in association with plant roots will metabolize these substances in soil or water. These complex and recalcitrant compounds cannot be broken down to basic molecules (water, carbon-dioxide, etc.) by plant molecules, and, hence, the term *phytotransformation* represents a change in chemical structure without complete breakdown of the compound. Hyperaccumulators Figure 2.4 plants which are tolerant to elements uptake are used to extract the heavy elements from the contaminated soils.

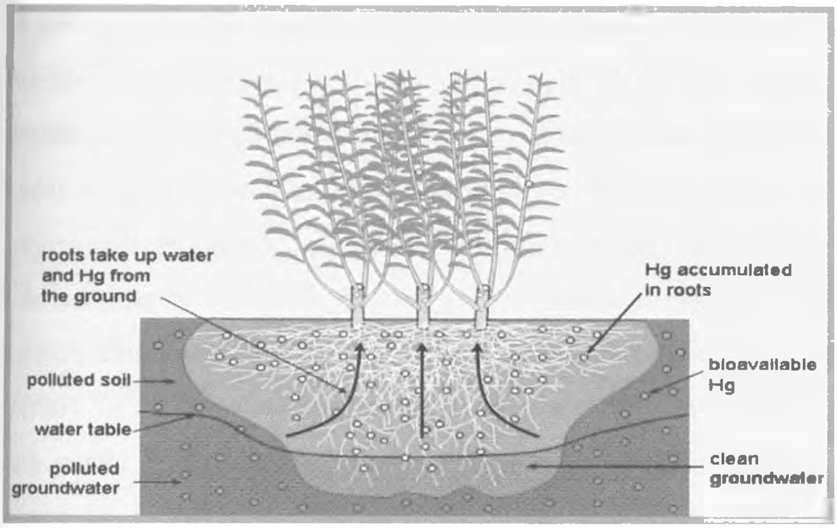


Figure 2.4 Hyper accumulators plants
Source: Sukopp, 1990

2.8 BENEFITS OF DUMPSITE REHABILITATION

Environmental benefits such as air and water purification. Health benefit: Provide social and psychological benefit. Nature encourages use of outdoor spaces, increase social integration, and biodiversity Economic benefits are indirect where purified air reduces costs of preventive measures for pollution.

These benefits could be accrued to urban parks, urban forest and recreational areas. Parks therefore offer relief to an otherwise confined if not sequestered urban population, and contribute significantly to fostering physical and mental health (Jim, 2008).

2.8.1 Bene its of urban parks

Increasing empirical evidence indicates that the presence of natural assets (i.e. urban parks and forests, green belts) and components (i.e. trees, water) in urban contexts contributes to the quality of life in many ways. Besides important environmental services such as air and water purification, wind and noise filtering, or microclimate stabilization, natural areas provide social and psychological services, which are of crucial significance for the livability of modern cities and the well-being of urban dwellers. A park experience may reduce stress (Ulrich, 1981), enhance contemplativeness, rejuvenate the city dweller, and provide a sense of peacefulness and tranquility (Kaplan, 1983). The hypothesis about the restorative function of natural environments has been tested in many empirical studies. Ulrich (1984), for example, founded that hospital patients who could look out on trees and nature from their windows recovered more quickly than those whose views where restricted to buildings. Later studies have lead to similar results, strengthening the assumption that natural environments have a positive influence on psychological and mental health. Contemporary research on the use of urban parks and forests, for example, verifies beliefs about stress-reduction benefits and mental health (Hartig et al., 1991; Conway, 2000). In a survey among park's visitors a significant relation was found between use of the parks and perceived state of health: those who used local parks frequently were more likely to report good health than those who did not (Godbey et al., 1992). Schroeder (1991) has shown that natural environments with vegetation and water induce relaxed and less stressful states in observers compared with urban scenes with no vegetation. This ability of natural elements to function as "natural tranquillizers" may be particularly beneficial in urban areas where stress is an all too common aspect of daily living (van den Berg et al., 1998). Beside aesthetic, psychological and health benefits, natural features in cities can have other social benefits. Nature can encourage the use of outdoor spaces, increases social integration and interaction among neighbors (Coley et al., 1997). The presence of trees and grass in outdoors common spaces may promote the development of social ties (Kuo et al., 1998). Kuo et al. (1998) also found out that greenery helps people to relax and renew, reducing aggression. Natural environments can also be seen as a domain of active experience providing a sense of challenge, privacy and intimacy, aesthetic and historical continuity. Beside the social and psychological benefits mentioned above, the functions of urban nature can provide economic benefits for both municipalities and citizens. Air purification by trees, for example, can lead to reduced costs of pollution reduction and prevention measures. Furthermore, aesthetic, historical and recreational values of urban parks increase the attractiveness of the city and promote it visitation, thus generating employment and revenues. Furthermore, natural elements such as trees or water increase property values, and therefore tax revenues as well (Tagtow, 1990; Luttik, 2000). Beside positive effects, parks may play a negative role on people's perceptions. Some surveys have reported residents' feelings of insecurity associated with vandalism, and fear of crime in deserted places (Melbourne Parks, 1983; Grahn, 1985; Bixler and Floyd, 1997). However, far larger is the empirical evidence of the positive functions of green areas; a study by Kuo and Sullivan (2001) even shows that residents living in "greener" surroundings report lower level of fear, fewer incivilities, and less aggressive and violent behavior.

"Humans' survival as a species depends upon adapting ourselves and our...settlements in new, life-sustaining ways, shaping contexts that acknowledge connections to air, earth, water, life, and to each other, and that help us feel and understand these connections, landscapes that are functional, sustainable, meaningful, and artful" (Spirn 1998).

2.8.2 Best practices Land ill rehabilitation cases

Filled landfills offer opportunities for landscaping and development of public open space in areas of former industrial or mining dereliction. Thousands of trees are often planted on the perimeter of a large modern site. Top soil is replaced to sufficient depth to allow landscaping material to be installed. When appropriate, the Regulatory Agency specifies a schedule of rehabilitation for portions of the property as their use for solid waste disposal operations is completed or terminated. The schedule shall is considered part of the rehabilitation or restoration plan. All excavations and pits are backfilled, leveled, contoured, or both, for the uses shown on the restoration plan and are compatible with the final depth and slope of the site.

2.8.2.1 Successful LFM projects

Limited information is available on landfill mining projects that have been carried out on a worldwide basis. Projects have been used throughout the world Table 2.3 during the last 50 years as a tool for sustainable landfilling.

The first reported landfill mining project was an operation in Tel Aviv, Israel in 1953, which was then a method used to recover the soil fraction to improve the soil quality in orchards (Shual and Hillel, 1958; Savage et al., 1993). It was later employed in USA to obtain fuel for incineration and energy recovery (Hogland, 1996, Cossu et al., 1996, Hogland et al., 1996). Pilot studies carried out in etc. England, Italy, Sweden, Germany (Cossu et al., 1995; Hogland et al., 1995), Asian projects are also reported.

Table 2.3, successful LFM projects

Land ill name		MSW Years	liner	Area acres	objective		Ratio of soil to waste	Excavated waste	cost
Naples land ill (USA)		15	unlined	33	Soil recovery	-	60:40	50,000 tons	$2.25 /ton
Success: *low operating cost through re use of cover material saving $1per ton, extended landfill life, reduced potential for ground water contamination and avoidance of future remediation.*									
Edinburg land ill (USA)		22	lined	1.6	Reduce footprint		75:25	31,000 tons	$3 / ton
Success: *securing offsite uses for the reclaimed soil, reduction of landfill footprint, decrease closure costs, reduction cost from $5 per yd³ because the town supplied required equipment and labour.*									
Frey farm land ill(USA)			lined		Fuel energy		41:56:3	350,000 tons	
Success: *offering supplemental energy production, reclaimed landfill space, recovered soil and ferrous metals.* ***Drawbacks:*** *increased odour and air emission distance of waste transportation, increased wear of equipments.*									
Perungudi(India)		Less 1	unlined		Soil recovery		40:55		
Drawbacks: *low soil content due to unorganized dumping practices and fresh waste was noted*									
Kodungaiyur (India)		10	unlined		Soil recovery		65:35		
Drawbacks: *heavy metal concentration which indicate poor solubility and slower leachability in water.*									
Shawano			lined	12	Increase size			350,000 tons	$3/ ton
Success: *Project conducted at winter to reduce odor issues.* ***drawbacks:*** *minimal amounts of hazardous material(Freon tanks, propane tanks)encountered. 2feet of clayliner was scraped*									
Wyandot			unlined	30	Water contamination			1,400,000 tons	$4/ ton
Success: Waste relocated at 300,000yd³ /year Improvement of ground water quality									
Central disposal systems			unlined	10	Recover airspace			250,000 tons	
Recover airspace and avoid groundwater contamination, reduction of odor, waste relocation at rate of 1200yd³/day									
Pike		16	unlined	40	Waste to cover acive Landfill			750,000 tons	
Relocation of waste at rate of 40,000yd³/month									
La Crosse		14	unlined	25	Recover landfill space			1,200,000 tons	
Despite presence of vertical and gas extraction wells GWC was observed									
Clovis		35	unlined	55	Address GWC		60:40	2,100,000 tons	$4.84 /ton
Airspace recovery, soil recovery, conveyor used to transport dirt, mining took 190days at 1100yd³/day									

Source : author, Adapted from Perdido project report 2007

After materials screening, the oversize materials may be managed in different ways depending on the material composition, processing level, and available markets. Although theoretically several components of recovered materials may have a value (e.g., plastic and glass) the most typical component recovered from landfill mining (other than soil) is metal. In some cases, the oversized material has been used as fuel in waste-to-energy facilities. If no end markets exist for the oversized material, it is typically disposed of in a lined landfill.

Potential reuse options for the recovered soil include use as daily and intermediate landfill cover material (uses inside the landfill) and as construction fill (uses outside the landfill) (USEPA, 1997). Other end uses will be dictated by available markets, the quality of the material, and the regulatory framework for reuse. Given that a large variety of household, commercial, and industrial waste containing chemicals are disposed of in MSW landfills, the potential impact of these chemicals on the environment if the mined residues were reused must be considered. When evaluating the likely chemicals of concern, it should be noted that most organic chemicals should eventually be biodegraded in the biogeochemical environment of a landfill (Field et al., 1995; Reinhart and Townsend, 1997; Atuanya et al., 2000; Cohen and Speitel, 2001). Non-degradable chemicals such as heavy metals, however, will remain in the waste unless extracted out using plants (Jain et al. 2005).

2.8.2.2 Conversion of Gardner Street Land ill to Park

Boston's Millennium Park was known as the Gardner Street Landfill. Today its 100acres Figure 2.5, Table 2.4, Plate 2.10, host sports fields, playgrounds, an outdoor classroom and amphitheater, six miles of walking and biking trails, and river access. Mayor Tom Menino stated at its opening December7, 2000, it is "a place for people of all ages and backgrounds to come for a picnic, a friendly ballgame, or some solitude."

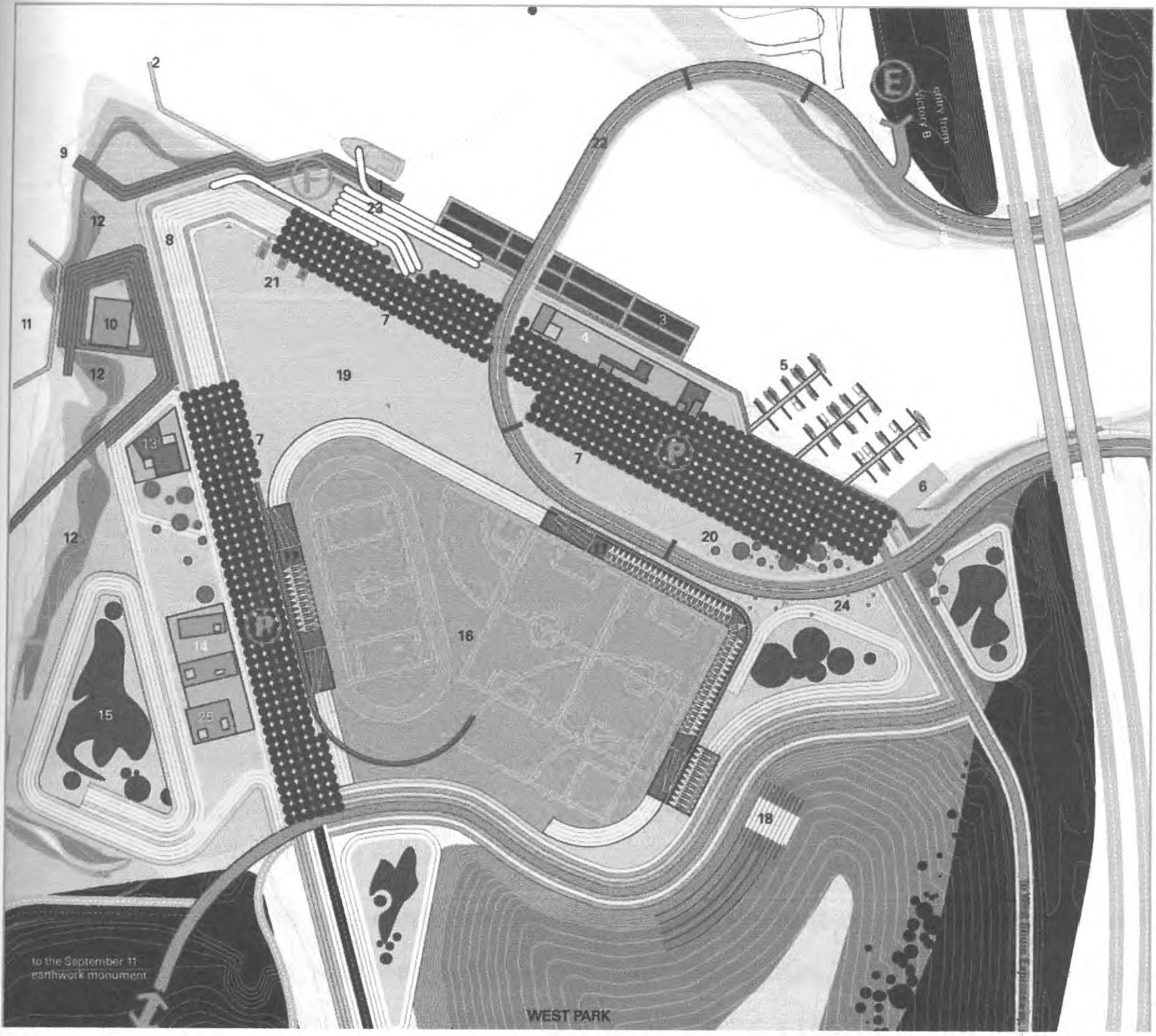


Figure 2.5 Master plan for Millennium Park showing activity distribution

Table2.4 Millennium Park after rehabilitation, area activities

					SIZE
1	Ferry landing	560M²	14	Art and community center	8,095M²
2	Fishing pier	455M²	15	Swamp forest exhibit basin	8,095M²
3	Barge gardens	4,040M²	16	Multi use sports fields	56,655M²
4	Restaurants	1,860M²	17	Bleacher seating	2,370M²
5	Marina for small boats	8,095M²	18	Amphitheater	2,000seats
6	Boat launch	630M2	19	Event lawn	40,460M²
7	Parking Bosque	20,235M²	20	Discovery center	n/a
8	Waterfront promenade	3,470M²	21	Landfill machine row	840M²
9	Pier overlook	325M²	22	Signature bridge	565meters
10	Exhibition hall	800M²	23	Market roof	3,040M²
11	Family picnic pier	380M²	24	Light towers	n/a
12	Restored wetland	12,140M²	25	Administration center	n/a
13	Banquet hall+ maintenance facilities	1,280M²		**M² for square metre**	

Plate 2.10 Aerial view for Millennium Park after rehabilitation
Source:- Millenium park, 2003

Depending on the age and contents of a landfill, the amount of groundwater or soil contamination present, and the planned new recreational uses, construction costs have ranged from $500,000for a two-acre site to $30 million for a regional park of more than one hundred acres. Costs further depend on such factors as topography, availability of materials, cover design, and quantity reductions. Overall, Center for City Park Excellence (CCPE) has arrived at a rough average cost for landfill-to-park conversions of around$300,000 per acre.

2.9 CONCEPTUAL FRAMEWORK

Urban growth lead to increased generation of waste which has significant impacts on biodiversity, natural habitats and ecosystems that society relies on. the challenges of urbanization are profound, but so are the opportunities. The rio+20 conference emphasize ' if landfills are well planned and developed in an integrated approach, they can promote economically, socially and environmental societies.

Well-designed rehabilitated dumpsites improve quality of life, allow greater resource efficiency and preserve large bio diversity areas. Additions of greenery in cities help in restoring the depleting forest coverage and thus mitigate global warming which is threatening the environment.

Globally large and enormous once dumpsites have been rehabilitated to vast public spaces and energy generation points. Studies with policy makers, planners, landscape architects, ecologists, hydrologists, urban designers, architects have contributed in realizing ecological urbanization for the benefit of humanity and cities.

In control of dumpsite most of the effort has been geared towards management of waste in an urban setting in the following order of preference:- Avoidance, Re use, Recovery, Treatment, Containment and Disposal (should be the last resort where no financial or technical practicable option)

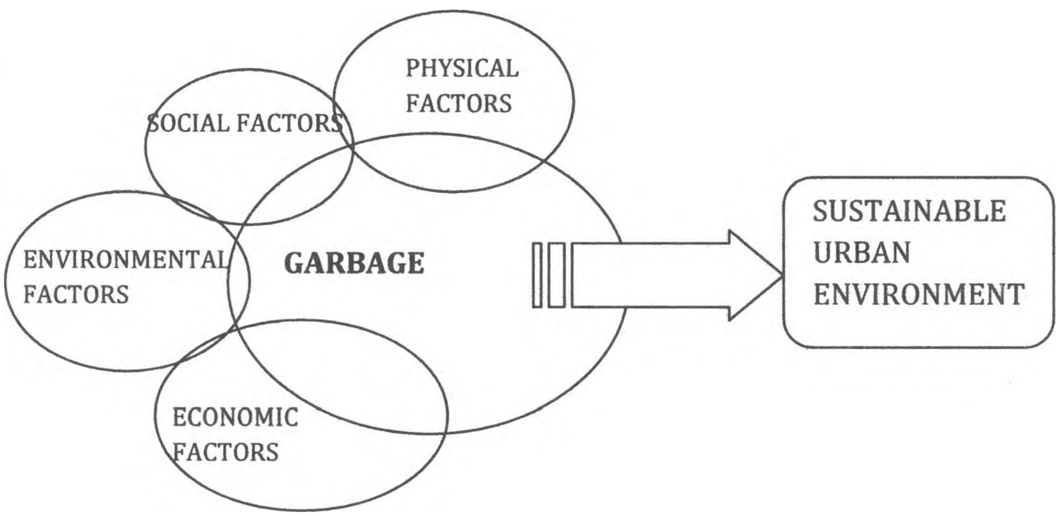


Figure 2.6 Variables in addressing dumpsite rehabilitation
Source: Author 2013

This has not been achieved due to the factors discussed earlier. Basic themes of rehabilitation are posed in economic, institutional, social and physical variables Figure 2.6, Table 2.5.The conceptual model illustrates the environmental benefits of landfill rehabilitation and forms the basis of research.

Table 2.5 Land ill Rehabilitation Variables

Main variables	Surrogate variables	Remarks
PHYSICAL FACTORS		
Location	Proximity to city center	The nearer the source the lower the cost of transport.
Social amenities	recreation	Relaxation and participation
Circulation	Type and size of roads/paths	Movement both pedestrian and vehicular
Boundaries	Type of buffer	Structure or plants
Topography changes	Slope levels	Their effects and how to be controlled
ECONOMIC FACTORS		
Occupation	Casual, employed	Garbage collection effects
Income	Earner Level in the system	reliability
Technology involved	Daily Soil cover	Excavation and machinery
SOCIAL AND HEALTH FACTORS		
Social organizations	Criteria of groups	Crimes and delinquency
Diseases and treatments	Ages affected	Effect to population
Household structures	Neighbouring Family units	Opinion on dumpsite

Source : Author, 2013

The literature has emphasis on waste management and downplays the role of creating a livable environment for low income dwellers who have suffered the plight of waste, which this study aims to bridge.

2.9.1 Sustainability concept

It is strongly believed that developing more sustainable cities is not just about improving the abiotic and biotic aspects of urban life; it is also about the social aspects of city life.

In the context of this study, the relation between urban parks and the value of urban nature as provider of recreational services essential to the quality of human life, which in turn is a key component of sustainable development (Prescott-Allen, 1991).

Illustration of the conceptual links and relationship assumed between urban park and city sustainability.

Plate 2.11 Millennium park sporting field
Source: Millenium park,2003

These include nature's services/ecological benefits (e.g. preserving biodiversity), social benefits Plate 2.11 (e.g. socialisation and healthy living) and economic benefits. Current research shows that greenspace benefits provide considerable potential costs-savings to local authorities (e.g. preventing health problems, increasing worker productivity, lessening infrastructure damage, attenuating flooding, cooling heat islands etc.) While not immediately obvious, translating these cost savings into monetary values shows that urban greenspace can save municipalities millions of shillings annually – money that would otherwise have to be spent on flood barriers, air-conditioning, sick days, stress leave.

2.9.2 Green urbanism

Greening of the city appears to be an important design concept for the sustainable urban form. Green space has the ability to contribute positively to some key agendas in urban areas, including sustainability (Swanwick, Dunnett, and Woolley 2003). Greening seeks to embrace nature as integral to the city itself and to bring nature into the life of city dwellers through a diversity of open landscapes (Elkin, McLaren, and Hillman 1991). Greening of the city makes urban and suburban places appealing and pleasant (Van der Ryn and Cowan 1995; Nassauer, 1997) and more sustainable

(Dumreicher et al., 2000). There are many other benefits from greening urban spaces (Swanwick, Dunnett, and Woolley 2003; Beer, Delshammar, and Schildwacht 2003): contributions to maintenance of biodiversity through the conservation and enhancement of the distinctive range of urban habitats (Gilbert 1991; Kendle and

Forbes 1997; Niemela 1999); amelioration of the physical urban environment by reducing pollution, moderating the extremes of the urban climate, and contributing to cost-effective sustainable urban drainage systems (Von Stulpnagel, Horbert, and Sukopp 1990; Plummer and Shewan 1992; Hough 1995); contributions to sustainable development to improve the image of the urban area; improvement of the urban image and quality of life (DoE 1996); and increasing the economic attractiveness of a city and fostering community pride (Beer, Delshammar, and Schildwacht, 2003).

Green urbanism also has health benefits (Ulrich, 1999) and an educational function as a symbol or representation of nature (Forman, 2002). Finally, greening aims also to preserve and enhance the ecological diversity of the environment of urban places. In Green Urbanism, Beatley (2000) emphasizes the important roles of cities and positive urbanism in shaping more sustainable places, communities, and lifestyles. He contends that our old approaches to urbanism are incomplete and must be expanded to incorporate more ecologically responsible forms of living and settlement. In Beatley's view, a city exemplifies green urbanism if it strives to live within its ecological limits, is designed to function in ways analogous to nature, strives to achieve a circular rather than a linear metabolism, strives toward local and regional self-sufficiency, facilitates more sustainable lifestyles, and emphasizes a high quality of neighborhood and community life.

2.10 SUMMARY

Landfill rehabilitation has realized both large and small scale urban parks. They offer a wide range of activities to be developed. Among is a 2315 acres Fresh Kills Park, Perdido landfill, millennium park public parkland, beautiful expanse of tidal marshes and creeks, trails and pathways, and significant recreational, cultural and educational amenities, engineered earthwork monument, mounds, diverse reserve for wildlife, plant materials cultural and social life, and active recreation Plate 2.12.

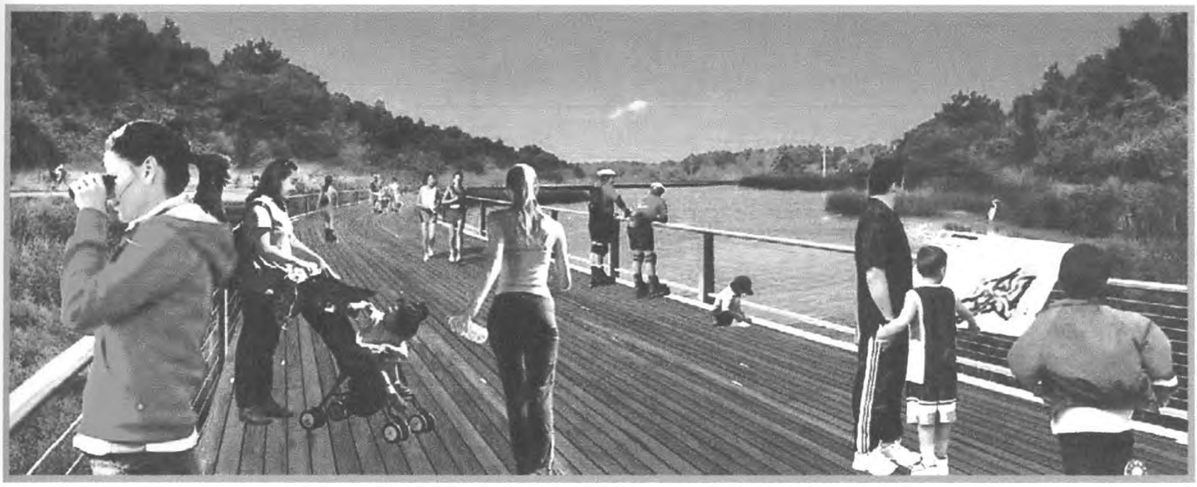


Plate 2.12 Fresh Kill park, wooden deck
Source: Millennium Park Report, 2003

Dumpsite Rehabilitation is an ecological process of environmental reclamation and renewal on a vast scale, recovering not only the health and biodiversity of ecosystems across the landfill, but also the spirit and imagination of people who use the parks. The process involves dynamic cultivation in ecologies of soil, air and water; of vegetation and wildlife. In realizing this vision: financing, stewardship, adaptive management, environmental technology, landfill mining, bio diversity, renewable energy, nature and education are paramount. In most of the parks their vision is responsive to the increasingly urgent demand of 21st century in solving global warming through green urbanism.

3 RESEARCH METHODOLOGY

The main goal of this study is to rehabilitate a dumpsite to an urban park. This chapter focuses on the research design and methodological procedures used in this study to systematically address the problem statement.

To remedy the discussed problems associated with dumpsites, this study investigates use of landfill mining concepts and vegetative cover concept to achieve a sustainable urban park through environmental, physical and socio economic variables as aforementioned in this study.

Qualitative research approach based on descriptive case-study has been adopted because it has the benefit of provoking open ended questions enabling the researcher to explain factual issues, thoughts and feelings in detail. Consequently, one can even ask a respondent to propose his or her own insight into certain occurrences (Yin, 2002).

Three data gathering strategies that typically characterize this methodology have been used, that is: in-depth open-ended interviews, direct observation, and written documentary or archival material. The idea of qualitative research is not to collate numbers but to be able to understand space and space users' feelings.

Both primary and secondary methods of data collection were applied to gather information from the site. Case study method was preferred and highly applied to gather and document information on the environmental effects from Dandora dumpsite.

3.1 RESEARCH DESIGN

This refers to the research blue-print specifying type, methods and procedures for acquiring the information needed to achieve a goal with minimal expenditure of effort, time and money (Yin, 2002). It is the specification of methods and procedures for acquiring the information needed for solving the problem. Questionnaires, interviews and samples for investigation were decided while framing research design. The process involved in conducting the study should also be described in detail to help other researchers in understanding one's study (Mugenda & Mugenda, 2002).

The study used the research design to deal with the following problem:

- **What questions to study** - actors, reasons, environmental, social and economic effect to residents and pickers
- **What data is relevant to collect**, location of the dumpsite, waste type, size of dumpsite, volume of waste, age of the dumpsite
- **How to analyze the results** – maps, graphs, tables

The case study design was identified as the most applicable approach for this research to answer the research questions, as discussed below.

3.1.1 The case study method

The case study method, was used for inquiry on the influence of design approach in dumpsite rehabilitation. Case study method is relevant when, a —how or —why question is being asked about a contemporary set of events, over which the investigator has little or no control (Yin, 2002).

Yin (2002) explains further that the case study design is used because the researcher wants to cover contextual conditions believing that they might be pertinent to the researcher's phenomenon of study.

Based on the above definitions, the case study design was chosen for the research due to the following reasons: First, since the main objective of this study is rehabilitation of Dandora dumpsite to a sustainable urban park. Second, the dumpsite being studied is within a residential neighbourhood context. Third, the study was taking place in a real-world situation, as noted by (Yin 2002) where it is not possible to separate the process (dumpsite rehabilitation) from the setting (Dandora low income residents) in which it is occurring. Fourth, Case studies contribute to the design of a professional repertoire. A designer's work relies on comparisons between known cases from the repertoire and the actual design situation (Schon, 1991). Although the Case Study methodology, developed within the social sciences, a prerequisite was the focus on contemporary events, within research in the field of architecture and planning, like in this work a urban park concept served as the focus of attention.

Indeed, this work sought to understand why and how dumpsites are rehabilitated using a sustainable approach to create an urban park. The case study use, involved in-depth understanding of the phenomenon with fewer subjects. Semi-structured questionnaires, protocols, and data sheets in gathering historical and biographical data, as well as observations were employed. The case study method is a more cost effective approach and saved time. The use of observation that exploited using digital photography, sketches and measured drawings, freed the respondents from answering questionnaires relating to observable facts of transformation. This was in line with (Zeisel's 2006) physical trace environmental behaviour study methods. He supports the approach as meant to gain unobtrusive insight into the meaning or use of environments so that quantitative methods could later be used to measure frequency of traces and related attitudes (Zeisel, 2006).

This research concentrates on dumpsite rehabilitation and its environmental benefits to people and the city. The study is therefore geared towards looking at the dumpsite as a whole and the effect it has on the objects around it as a system.

3.2 SAMPLING DESIGN

Dandora dumpsite was taken as the representative of other dumpsites. The intention was in order to have an in depth investigation and diagnosis of landfill rehabilitation and to gather specific information in relation to study object and context.

The study defined a definite plan for obtaining a sample from a given population. Sample design refers to the technique or the procedure the researcher would adopt in selecting items for the sample (Kothari 1990). The study laid down reliable and appropriate unit of analysis, the size of the sample, population frame and sample method.

3.2.1 The Units of Analysis

The units of analysis reflect the spatial levels and scales environment in rehabilitating dumpsite. The assumption is that the total environment is a composite of these layers and their inter-relationships, Figure 3.1. The dumpsite, the low income urban residential environment and the dumpsite pickers are the layers further elaborated below. A basic premise in the choice of the units of analyses was that they formed not only a physical strategic objective, but also possessed social and environmental qualities.

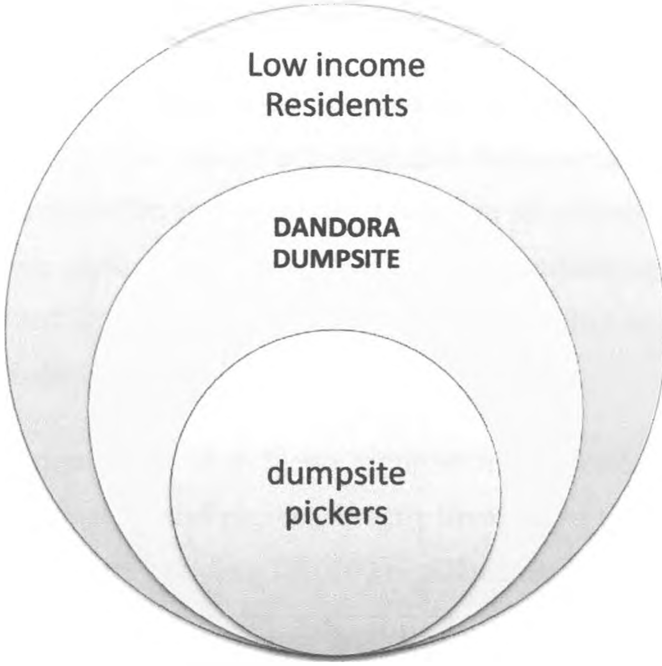


Figure 3.1 units of analysis
Source: author 2013

3.2.1.1 Dumpsite pickers

Generally, the investigation broadly gathered qualitative and quantitative information on; waste volumes (numbers, percentages), type of waste, the technology (permanent, temporary) used and the uses of waste (commercial, residential, agricultural). The choice of the dumpsite is informed by its intense waste pickers activities. The pickers are directly affected by the dumpsite through economic, physical and health challenges.

3.2.1.2 Residents

The physical entity is defined as the extent of the individual space control and public/ group space. Definition at this level reflected the individual nuances and efforts to personalize individual space: physically, socially, and economically. The key Space types distinguished were public spaces (groups gathering), semi spaces (crowd meeting), private spaces (individual setting), and others spaces (circulation, converge points). Their magnitude, use, location and other qualities guided their assessment.

3.2.2 Population frame

This study targets a sample population who live around the dumpsite and the everyday users of the facility. With an almost unpredictable framework, this study developed a working universe. Population is defined as a complete set of individuals, cases or object with some common observable characteristics (Mugenda&Mugenda 1999). Target population is defined as that population to which researcher wants to generalize the results of study (Mugenda&Mugenda 1999).

The study targets a population of residents living within a radius of 450 Meters from the centre of Dandora dumpsite and pickers directly involved in the dumpsite. The Nairobi city council estimates there are over 200,000 residents directly affected by the Dandora dumpsite 6000 pickers.

3.2.3 Sample size

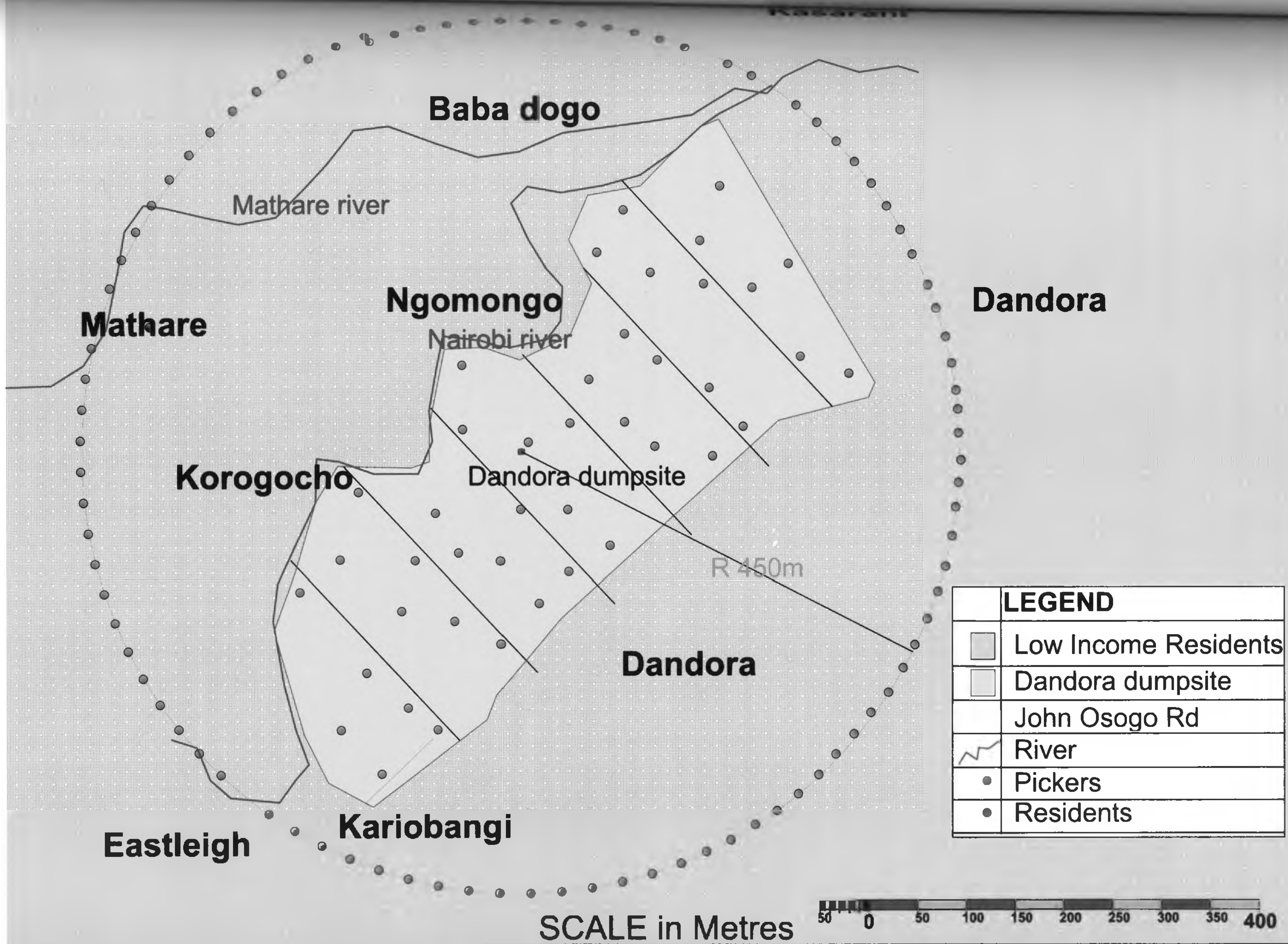
The sample residents were randomly selected from the circumference of the 450 meter radius from the centre of the Dandora dumpsite. The sample pickers were randomly selected from within the dumpsite. The study subdivided the dumpsite into seven parts dividing along John Osogo Road to Nairobi River. In each portion the study randomly selected six pickers. The sample pickers are a representation of low income urban dwellers who are directly involved in the dumpsite. This research has used a small sample population. A sample size of 42 pickers and 90 residents has been used for the study of the dumpsite.

3.2.4 Sample method

The aim here is to achieve desired representation of the population. A casual observation at the dumpsite and its surrounding portrays a uniform structure of the variables under study. To achieve a truly representative of the population, a devised pattern of sampling was used, one which involved people at the dumpsite and residents in low income residential. A random sampling at different areas at dumpsite was used.

3.2.4.1 Random Sampling

Random samples obtained from residential setting to analyse the environmental effects caused by the dumpsite included:- waste disposal methods, source of water, method



Baba dogo
Mathare river
Ngomongo
Nairobi river
Mathare
Dandora
Korogocho
Dandora dumpsite
R 450m
Dandora
Eastleigh
Kariobangi
LEGEND
Low Income Residents
Dandora dumpsite
John Osogo Rd
River
Pickers
Residents
SCALE in Metres
50 0 50 100 150 200 250 300 350 400

used in treatment of drinking water, effects of leachate and effects of LFG to the residents. Random samples obtained from residential setting to analyse the socio economic effects caused by the dumpsite included: - sources of income, diseases in the area, residents concerns to the development and residents contribution to the proposed development. This is with assumption that traits of the population are more or less reproduced in the sample.

3.3 DATA COLLECTION METHODS

The employment of each method of data collection was determined by the type of data the researcher intended to collect at each stage. The methods of data collection included: interviews, observation, questionnaire, graphic illustrations, archival sourcing, photography and measurements.

Research tools and sources of information were tabulated for concrete understanding of the third objective: evaluate the relationship between sustainability factors of rehabilitated site and the landscape conceptual design in Table 3.1.

Table 3.1: Research tools and sources

Research tools	Sources	Comment
Digital photographs	Field	Documenting Dumpsite and its environment current condition
Archival data	NCC, Libraries, Internet, Kariobangi catholic hospital	Questioning Spatial zoning and users.
Statistics	CBS, internet, KARI, KEPHIS, Libraries	Mainly Waste data, bio data on low income residential
Semi structured interviews	field	Recreational activities of the residents and pickers
Aerial photographs	Sok , internet	Been able to seek relevant and reliable information considering the vast spatial dimension
Literature	Libraries, Internet	Guidance in sustainability.
Architectural /measured Drawings	Field, NCC, Books	Generation of information for they were not available

Source: Author 2013

3.3.1 Interviews

An interview is a structured or unstructured oral questionnaire, with the intermediate being referred to as in-depth interviews. Interviews were particularly useful for getting the story behind some of the experiences as they made it possible to obtain data meeting the objectives and offers opportunities to clarify questions. Whereas structured interviews have a tendency of limiting respondents, unstructured interviews can be too amorphous, hence this study utilized in-depth interviews, where standardized open-ended schedules were used, on the assumption that the individuals or groups of residents may not be aware of the meaning of rehabilitation of dumpsites.

For reliable data collected through interviews, maximum co-operation of the respondents is required (Mugenda and Mugenda, 1999). It's necessary to explain in an interview when a need arises. This would enable the residents and pickers to make appropriate verbal responses and reduce no-response answers. If need would be, then it is necessary to use another language where necessary, to obtain information at a greater depth, to have a control on who answers which questions. A friendly relationship with the respondent was established prior to conducting the interview.

This research was concerned with responses on history of the site, resident methods of waste disposal, resident income, depth of the quarry, diseases suffered by children in the area, picker age, residents development concern and number of trucks ferrying the garbage to the site. Interviews made it possible to obtain data on the objective of establishing the current dumpsite condition

3.3.2 Observation

What the respondents say during interviews cannot always be trusted and needs to be cross checked against the scenario on the site because what people say represent the way they perceive issues or problems being investigated and to some extent depends on ones memory. I, therefore, relied on physical observations to identify the current state of the Dandora Dumpsite as part of the documentation.

Systematic behavior observations of people use their environment: individuals, pairs of people, small groups and large groups (Zeisel, 1981). Direct observation took the information from the uninterrupted activity of the participants who were unaware that they are supplying it. This method was used to eliminate subjective bias as well as to relate with what is happening at the moment. This method is independent of respondent's unwillingness to respond and is less demanding of active cooperation as in the case of interviews.

The study was concerned with observing the type of machinery used to maintain the site, the type of vegetation growing at Dandora dumpsite, measures put in place for picker health safety, environmental effects to the residents, environmental effects to Nairobi River, number of garbage trucks into the dumpsite. Recreational activities the residents engage in during their free time and the group structures the resident and picker form when doing activities. This data was useful in analyzing socio economic, environmental relationship between the dumpsite and low income residential neighborhoods.

3.3.3 Maps and Graphic Sketches

Observation and interviews were complimented with maps and sketches. Analysis of Nairobi city map was relied to draw comparison on growth characteristic of the city over the years, provide location of Dandora dumpsite and approximate the size area of the dumpsite.

Where necessary, measurements were carried out using tape or scaled-up drawings, to measure accumulated height profile of the garbage, circulation channels and to check scales and proportions.

Maps and sketches were essential in illustrating conditions of the physical environment. This involved recording elements that occur at various points of the area. Features that shape up the space under study were recorded.

3.3.4 Photographs

To be able to capture still images of the study area photography was employed. They aided in recording activities and consequent analysis of photographic occurrences. The photographs were used to record the current condition of the dumpsite, the type of waste, the users of dumpsite, and the infrastructure.

3.4 DATA ANALYSIS TECHNIQUES

Data Analysis was done descriptively using maps, photos, sketches, tables and analytical diagrams that simplify the data for ease of understanding and interpretation. Data analysis is the examination, categorization, tabulation and testing of data to address initial prepositions of the study (Yin, 2002). The study used qualitative approach to analyse data.

3.4.1 Qualitative and quantitative approach

The study mainly adopted descriptive analysis techniques to explore dumpsite rehabilitation phenomenon. Qualitative approach seeks out the **'why'**, not the **'how'** of its topic through the analysis of unstructured information –like interview transcripts, open ended survey responses, emails, notes, feedback forms, photos and videos. The approach is relevant since the study is investigating values, opinions, behavior and social context of residents and pickers within and surrounding Dandora dumpsite.

To substantially analyse data gathered from interviews, observation and photographs, qualitative approach is more flexible, iterative and allowed the study to identify intangible factors. The study picked each method of data collection to analyse specific data, Table 3.2

Table3.2 Relevant situations for different research strategies

Strategy	Form of research question	Requires control of behavioral event	Focuses on contemporary events
Experiments	How, why?	Yes	Yes
Survey	Who, What, Where, How many, How much?	No	Yes
Archival analysis	Who, What, Where, How many, How much?	No	Yes/No
History	How, Why?	No	No
Case study	How, why?	No	Yes

Source: Yin 2003

Case study field work findings were contracted and compared with literature review findings to check for validity and consistency. Such triangulation of the information obtained allows the researcher to increase the validity and credibility of the research because of the possibility of corroborating results from various data sources (Yin,2002). Unlike quantitative analyses where data collection and analyses tend to occur more sequentially, in case studies, qualitative data analysis begins in the field during data collection as notes are recorded and initial interpretations are made during discussions.

In analysis of case studies, there are inevitably more variables than cases, or data points, so traditional statistical analyses cannot be applied. Therefore, different techniques need to be used to organize and systematically review large amounts of information. The analytic focus in single case studies is on the overall pattern of variables within a case, looking at the parts in relationship to the whole.

The study analysed the observable by ticking responses at interviews against respective items then tallying the information using graphs. Basic statistics was used in analysisng data from structured questionnaires. Data gathered using human body senses that is feel, hearing, smell and sight and photographs, was analysed descriptively explaining the condition of Dandora dumpsite and its effects to the residential neighbourhood. Quantification of volume and establishment of linear measurements was used for data gathered through mapping and sketches.

4 DATA ANALYSIS

4.1 INTRODUCTION

The study analysed data on Dandora dumpsite. To ascertain the objectives of this study, both qualitative and quantitative data was gathered. This addressed physical, environmental and socio economic variables.

To analyse the objectives set in this study

- To examine the environmental relationship between the dumpsites and the residential neighborhoods objective. This study analysed sources of water, methods of treating water, landfill gas production, leachate production, flora and fauna.
- To establish the socio economic aspects in relation to dumpsite rehabilitation objective. The study analysed income sources of residents and pickers, pickers age, diseases in the area, methods of sorting waste used by residents, concerns on dumpsite rehabilitation and the contribution of residents to project development.
- To establish a landscape design for dumpsite rehabilitation. The study analysed the objective using physical variable on the waste characteristic, waste disposal methods, footprint on waste, the depth and height of garbage, the volume of the waste and basic infrastructure.

Dandora dumpsite is located 10 kilometers from the central business district of Nairobi city. The dumpsite covers an approximate area of 45acres. The dumpsite is at the confluence of Nairobi River and Mathare River which are joined by Ruaka River approximately two kilometers downstream figure 4.1.

Respondents interviewed stated the area was a quarry. In 1978 refilling of the abandoned quarry commenced, which has now risen to an enormous mountain of garbage. The dumpsite neighbours residential estate: -Kariobangi to the South, Korogocho and Ngomongoto the west, Dandora to the east and Baba dogo and Kasarani to the north.

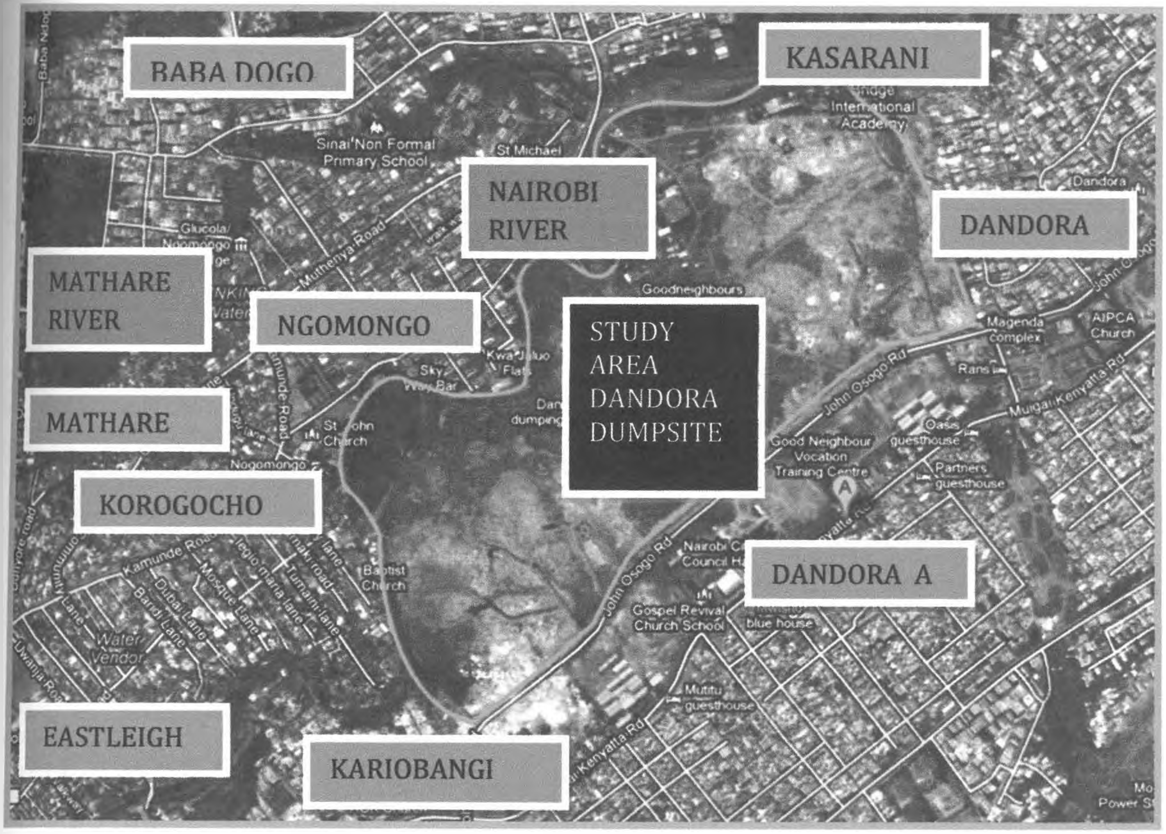


Figure 4.1 Study area Dandora dumpsite location and its environs

Following steps outlined by SIDA and ARRPET, on gradual transformation and rehabilitation of dumpsites, through observation the research revealed there was no adherence to the general steps Table 4.1.

Table 4.1 General steps set by SIDA and ARRPET on gradual rehabilitation of dumpsites

GENERAL STEPS	YES	NO
Covering newly deposited waste with approximately 150mm soil cover		√
Deposition of a thin layers of waste about 500mm with appropriate compaction		√
Restriction of waste tipping into small areas following disposal plan		√
Installation of systems for collection of landfill gas and diversion of rainwater		√
Keeping the access roads in good condition		√
Regulating deposits are made at designated places		√
Protection of disposal site from scavengers by having walls and fences		√
Maintaining records of waste deliveries		√

Environmental monitoring e. g hydrogen sulphide concentration, ground water contamination (from simple visual inspection to chemical analysis)		√
Provision of essential manpower – landfill manger, office clerk, security, traffic controller, equipment drivers and mechanic		√

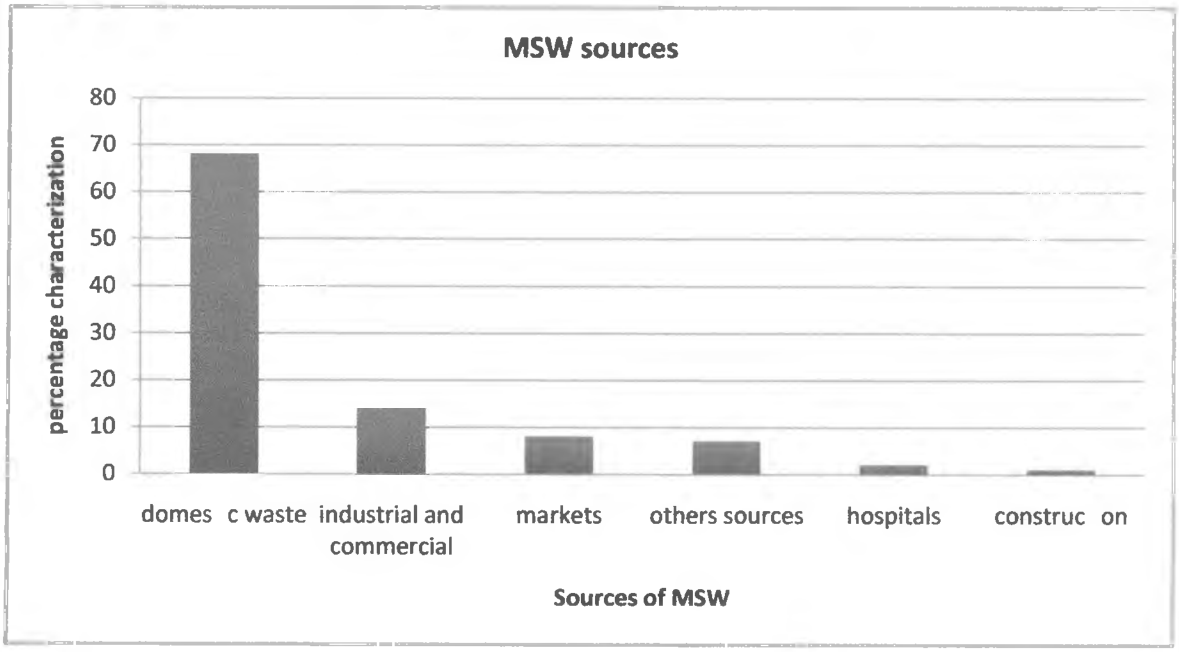
Source: adapted from ARRPET 2002

4.2 PHYSICAL VARIABLES

The study established a decade ago Dandora dumpsite was declared full, yet today it is still the only dumpsite serving Nairobi's 4 million inhabitants. What was once an abandoned limestone pit is now a mountain of decaying domestic, industrial, commercial and agricultural refuse. The physical variables will analyse the objective to establish a landscape design in dumpsite rehabilitation.

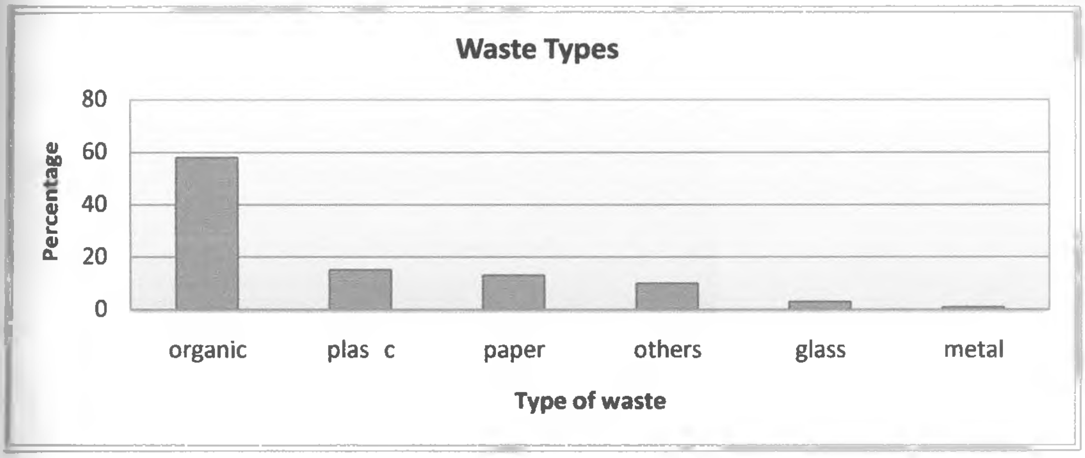
4.2.1 Dumpsite waste

Waste growth is a function of population and economic growth. For rehabilitation of a dumpsite it is paramount to know the composition of waste. The study established domestic waste contributes 68%, industrial and commercial 14%, hospitals 2%, markets 8%, construction and demolition1% and others sources7% Graph 4.1.



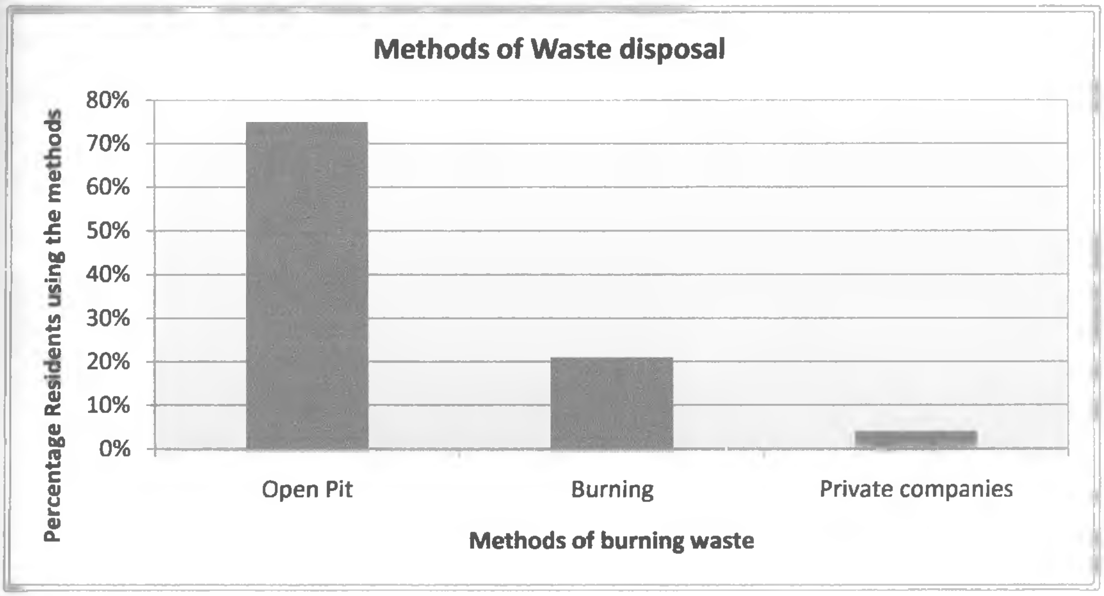
Graph4.1 Wastecharacterisation in Dandora dumpsite
Source: Author 2013

The study established 58% of waste at the dumpsite is organic, 15% platic and 13% paper. The study found 2% of waste is glass and 1% is metal Graph 4.2. the organic waste is recoverable and should be used as cover soil in rehabilitating the dumpsite.



Graph 4.2 waste types in Dandora dumpsite
Source: Author 2013

The study established 75% of resident households dispose waste through open pit dumping, with 4% disposing waste through private companies and 21% through burning Graph 4.3.



Graph 4.3 Methods of waste disposal
Source: Author 2013

4.2.2 Infrastructure

Roads and infrastructure were observed as impassable during rainy season. All the accessibility routes are earthen and they are affected by weather conditions. During the rainy season they become muddy Plate 4.1. This has resulted to massive dumping at undesignated areas.

Plate 4.1 Inaccessible road leading to Dandora dumpsite beside the road
Source: survey 2013

The study established in 2006 the NCC installed a weighbridge. The study respondents established the weighbridge was in operation for less than an year. During its operation low amounts of waste were received at the dumpsite. The decision by the Council to install the weighbridge was prudent. However since the site is not fenced or guarded some waste transporters still easily avoided paying the dumping fees by dumping their waste at undesignated areas.

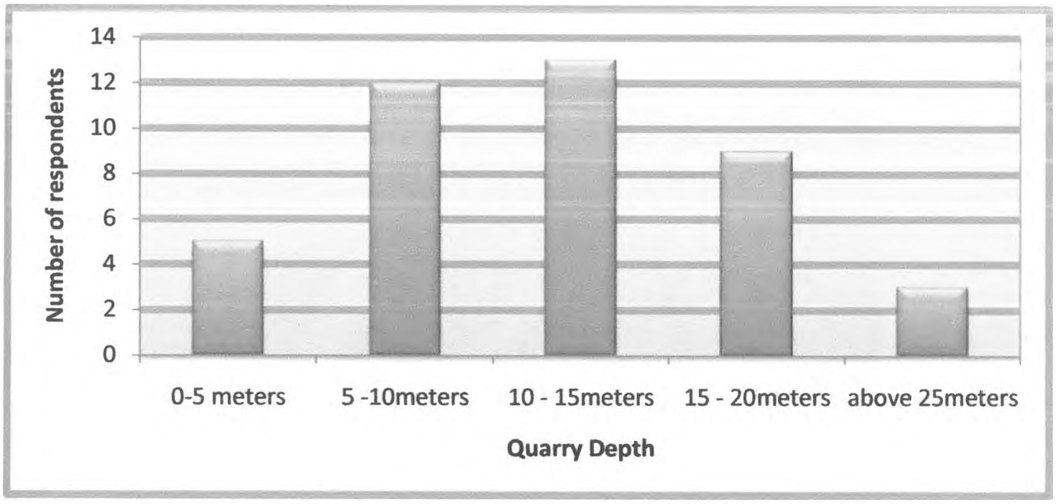
It is an environmental requirement to compact and apply daily cover to the dumped waste. However this requirement has not been observed in Dandora dumpsite.

Plate 4.2 Bulldozer and garbage trucks
Source: survey 2013

The research observed that the bulldozer and machinery are inadequate and old Plate 4.2. Currently only one bulldozer for hire operate rarely and is inadequate to cover the dumpsite. Those interviewed had observed there have never had application of soil daily cover nor has the compaction been adequate. The introduction of machinery after the dumpsite is piled and not following the general specification of maintaining the dumpsite was a too late to be effective operation.

4.2.3 Area and volume covered by waste

Respondents aged above 40years confirmed presence of a quarry before 1978. The respondents both residents and pickers used the surrounding buildings to approximate the depth of the quarry. Graph 4.6 shows respondents frequency on depth of quarry variation. The study found that the quarry depth varies with greater depths at the central lateral where also the height of the garbage is highest Graph 4.4.



Graph 4.4 Depth of the quarry before MSW in 1978
Source: Author 2013

The study also revealed cutting a section through Nairobi river from Korogocho informal settlements to Dandora residents, the quarry had variations with the deepest areas at the central areas Figure 4.2. This corresponds to the garbage heights at the central area.

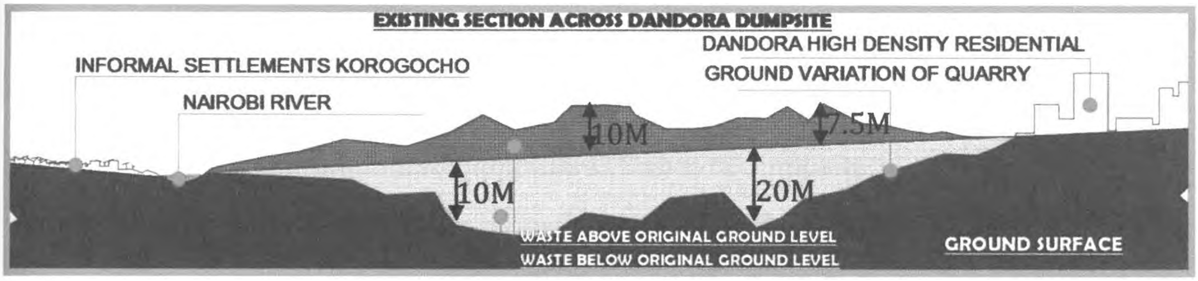


Figure 4.2cross section of varying average depths and heights of accumulated waste
Source: Author 2013

To understand the planning of LFM the study adapted a survey map to confirm the Dandora dumpsite occupies 45acres. The research observed waste accumulation was varied with average garbage mountains within same area. The respondents confirmed areas with more waste accumulation signify where the quarry was. Through interviews and observation, the study established a rough sketch on the spread of waste Figure 4.3

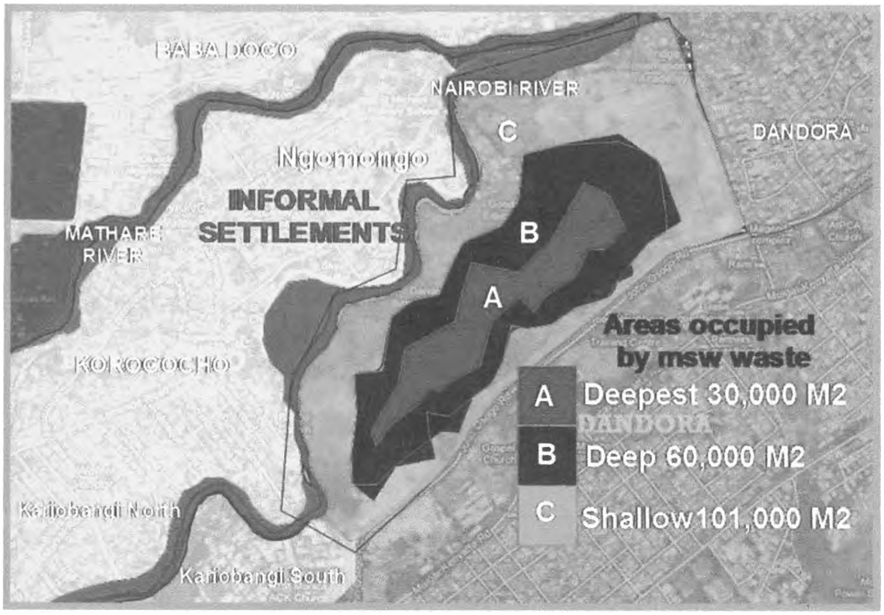


Figure 4.3 Area covered by waste at Dandora dumpsite
Source: Author 2013

Part A, shows 15% of the total area has most waste accumulated, part B represents 30% and part C occupies 55% of the area. The respondents confirmed part A shows where the quarry was deepest and part Bas shallow parts of the quarry.

With rapid urban growth, Dandora dumpsites continue receiving large amounts of unrestricted waste. The study established an average of 45 trucks per day dumping waste at Dandora dumpsite. The study estimates an average of 900tonnes per day is deposited; translating to an average of 22,500tonnes of waste is deposited monthly.

Using the average depths and heights of the waste accumulated as shown in waste footprint study, the current volume of waste is tabulated as in Table 4.2.

Table 4.2showing projected waste volumes at Dandora dumpsite

Section	Footprint in M^2	Average Quarry depth in M	Average Height of waste above ground in M	Total volume in M^3
A	30,000	11	10	630,000
B	60,000	5	7.5	750,000
C	101,000	-	5	505,000
Total	191,000			1,885,000

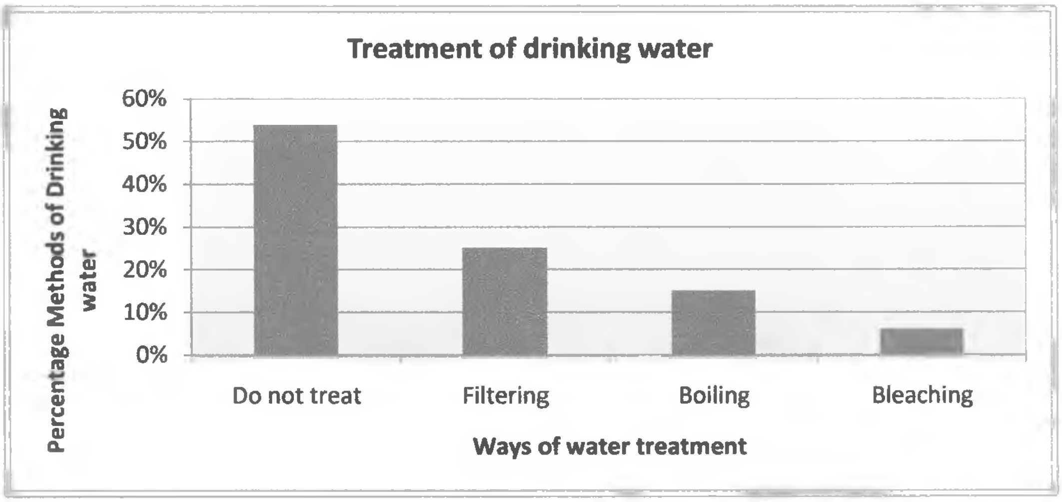
Source: Author 2013

4.3 ENVIRONMENTAL VARIABLE

The study objective using the environmental valuable is to analyse the environmental relationship between the dumpsite and the residential neighborhoods.

4.3.1 Surface water

The study established 54% of residents do not treat water, 25% treat water through filtering Graph 4.5. 79% of residents barely treat drinking water thereby exposing themselves to health hazards associated with water infections.



Graph 4.5: Methods of water treatment used by residents
Source: Author 2013

The research observed that the dumpsite is at the confluence of Nairobi River and Mathare River and further downstream river Ruaka joins in. The study observed animals eat toxic elements at the dumpsite creating a health hazard for humans consuming Table 4.3. Presence of unsorted waste has lead to accumulation of heavy metals elements in the soil and water causing several effects to the poor neighborhoods. The low income residential continue been affected by waste despite their production been low or negligible.

Table 4.3 List of heavy metals and their effects to residents

Heavy metals and their effects	
Heavy metal	Chronic exposure toxicity effects
Lead	Impairment of neurological development, suppression of hematological system (anemia), kidney failure, immunosuppressant
Mercury	Gastrointestinal and respiratory tract irritation, renal failure, neurotoxin etc
Cadmium	Irritation of lungs and gastrointestinal tract, kidney damage and abnormalities of skeletal system.
arsenic	Liver inflammation, neuropathy, liver cancer, skin and lungs, irritation of upper respiratory system – pharyngitis, laryngitis, rhinitis, anemia, cardiovascular diseases.

Source: KEPHIS records

The water has elements of lead, cadmium which affect the lively hood of the user. The research observed presence of carcass and polythene bags in the river Plate 4.3.

Plate 4.3 The river water has been polluted by dumpsite waste. Animals eat toxic waste creating a health hazard for humans consuming their meat and users downstream for irrigation and consumption
Source: survey 2013

4.3.2 Leachate

The research observed that rotting waste produce a smelly waterly liquid. The liquid percolates through the waste flowing to the river and forming pools which attracts flies and other vectors. The study observed presence of channels directing leachate to Nairobi river. Those interviewed oblivious of the danger of leachate channeled the waste into the river Plate 4.4

Plate 4.4 Leachate from the dumpsite flowing to Nairobi river
Source: survey 2013

As waste material rots it produces methane gas which is flammable. Accumulation of this gas leads to sporadic fires in the dumpsite Plate 4.5. The research observed during the dry season the gas accumulates in bottles thereby causing frequent sporadic fires. Gases produced are noxious and cause respiratory problems as evidenced in the Kariobangi Catholic Dispensary.

Plate 4.5 Sporadic fires due to accumulation of methane gas

4.3.4 Flora and fauna

The study observed the following avian species, the fischer's sparrow lark. Other species encountered in the dumpsite were Black Headed Heron, White Winged Window bird, Ring-necked Dove, Grassland Pipit, Little Swift, White Rumped Swift, Barn Swallow, Superb Sterling, Common Fiscal, red Winged Lark, Isabelline Wheatear, crowned Plover, Pied Crow, marabou stork, cattle egret and black kite.

The study established the herbaceous species was not diverse in terms of species composition Plate 4.6. The most dominant grass species in the dumpsite were *Hyperrhenia, Cynodondactylon, Bolticloraorientalis, Aristida sp.Panicum sp., Pennisetummezianum* and *Miccochloakunthii*. The Species are a mixture of good nutrition to livestock e.g. *Cynodon*and those showing range degradation i.e. *Pennisetum* and *Panicum* species. The forbs layer was characterized by *Commmelina sp., Psidiakilimadijaricum, Aspeliamossambisensis* among other. The *Psidia*was predominant in degraded areas along theold abandoned quarries. Other species were*Chenopodium album, Trichodesmazeylanica, Aristidakenyensis, Lactucainermis, Gutenbergiacordifolia, Solanumarundo, Schukhriapinnata, Monsoniaangustifolia, Chenopodiumalbum, Rhychosiaminma, Sansevieriasuffruticosa, Rumexusambarensis, Targetespatula, Indigoferanairobiensis, Circiumvulgare*and *Tridaxprocumbens*were dominant along the Nairobi river. No species belonged to any category of conservation concern.

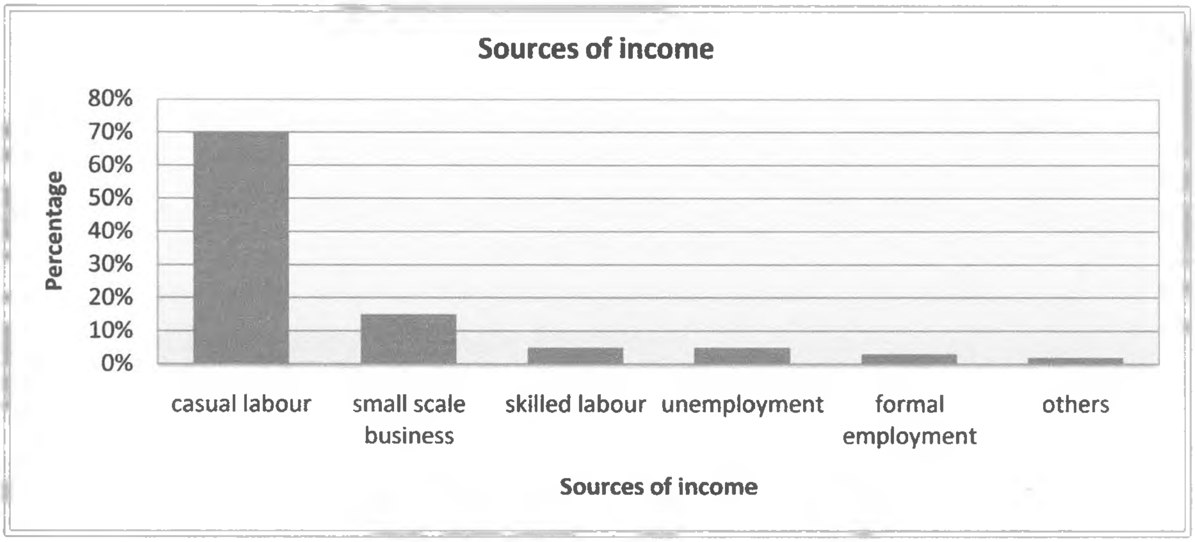
Plate4.6 Patches of vegetation at dandora dumpsite
Source: survey 2013

4.4 SOCIO ECONOMIC VARIABLE

The study objective is to establish the socio economic analysis associated with Dandora dumpsite as an attribute that relate to rehabilitation.

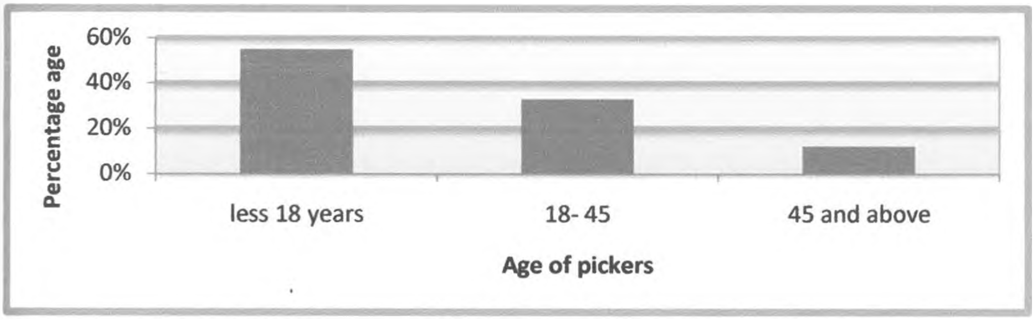
4.4.1 Sources of income

The study area is entirely in low income residential area where 70% of residents respondent sources of income is through casual labour and 3% of the respondents through formal employment Graph 4.6.



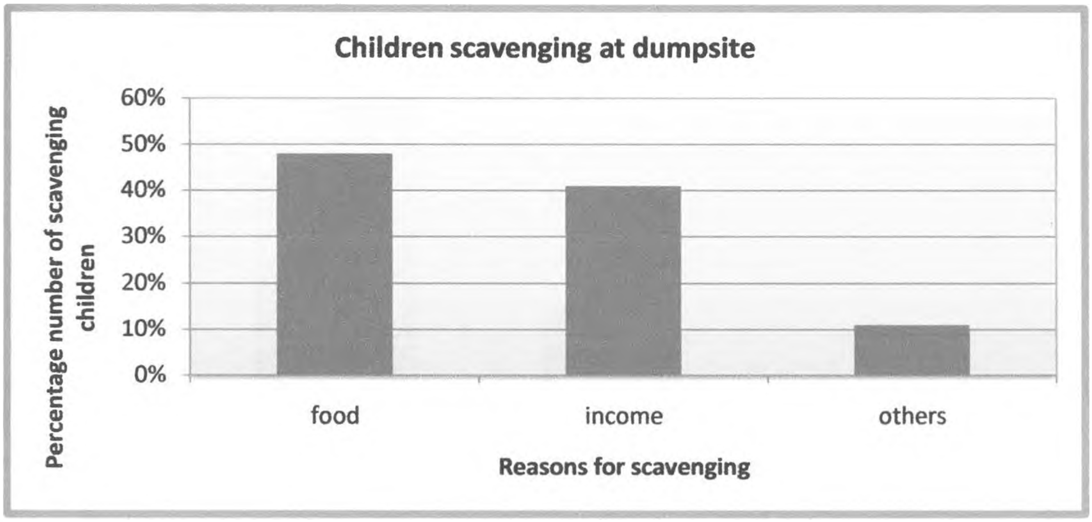
Graph 4.6 Sources of income for residents
Source: survey 2013

The study established 55% of pickers respondents are children below 18 years of age and some as young as 10years of age.33% of the pickers are youth between age 18 to 45 years of age Graph 4.7.



Graph 4.7 pickers age at the dumpsite
Source: survey 2013

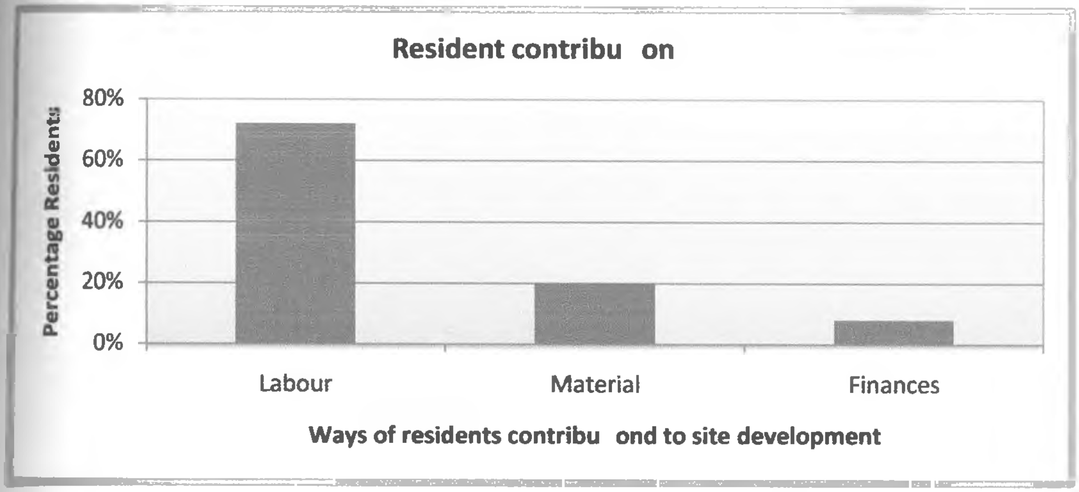
The study established children below 18years were interviewed and observed, 48% scavenge for food, 41% scavenge for income items Graph 4.8 and the others were involved in selling drugs, juvenile crimes.



Graph 4.8 Children scavenging at the dumpsite
Source: survey 2013

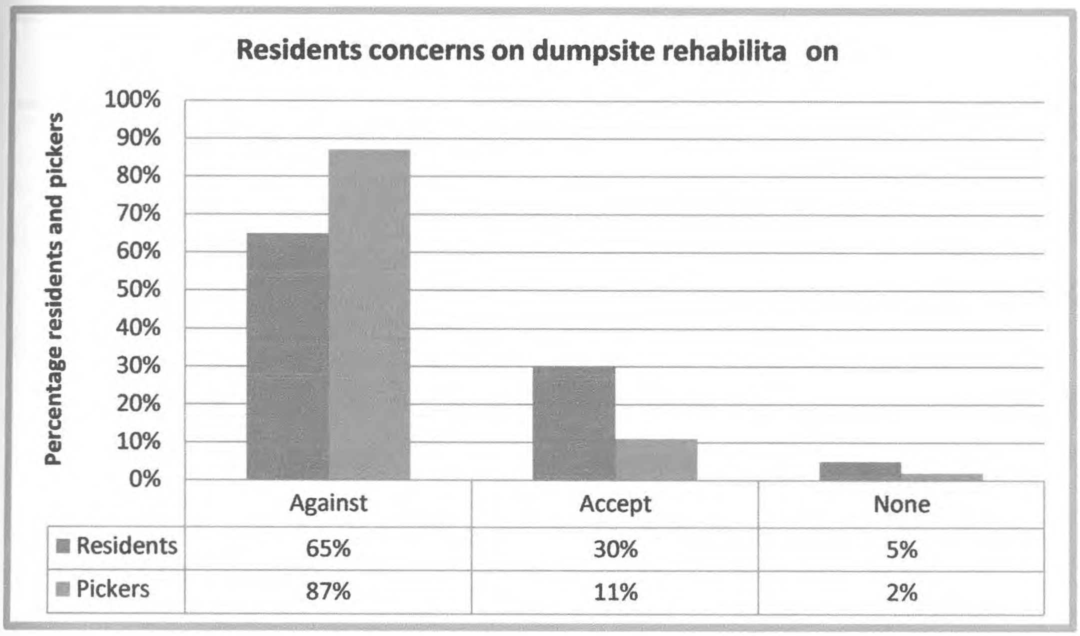
4.4.2 Dumpsite rehabilitation concerns

The study established 72% of resident respondents are willing to provide labour during dumpsite rehabilitation with 8% providing finances



Graph 4.9 resident contributions to dumpsite development
Source: survey 2013

The study established 64% of residents and 87% of pickers are against dumpsite rehabilitation and 5% of residents and 2% of pickers not sure whether to accept or oppose Graph 4.10.A higher number of residents accept development than pickers.



Graph 4.10 Residents concerns on dumpsite rehabilitation
Source: survey 2013

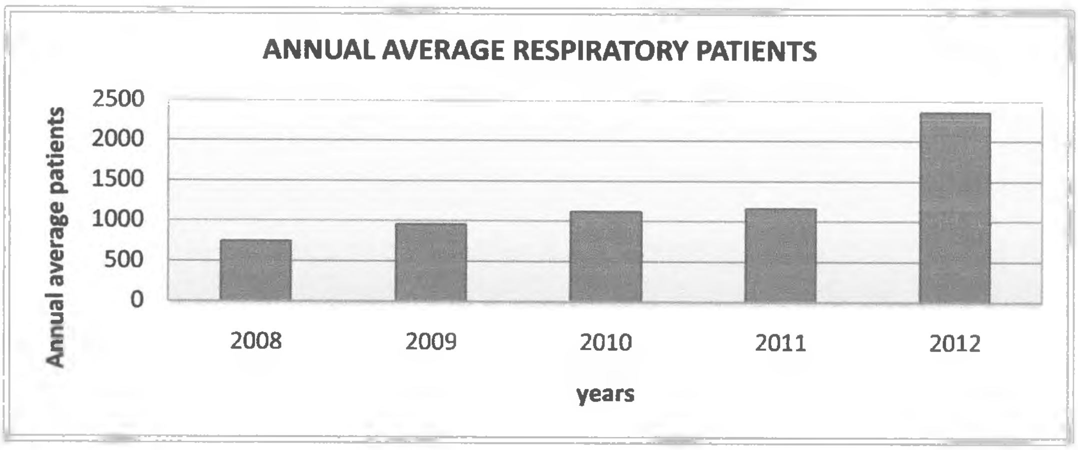
4.4.3 Diseases in the area

The study established waste pickers do not have protective clothes Plate 4.7

Plate 4.7 Unprotected waste pickers
Source: survey 2013

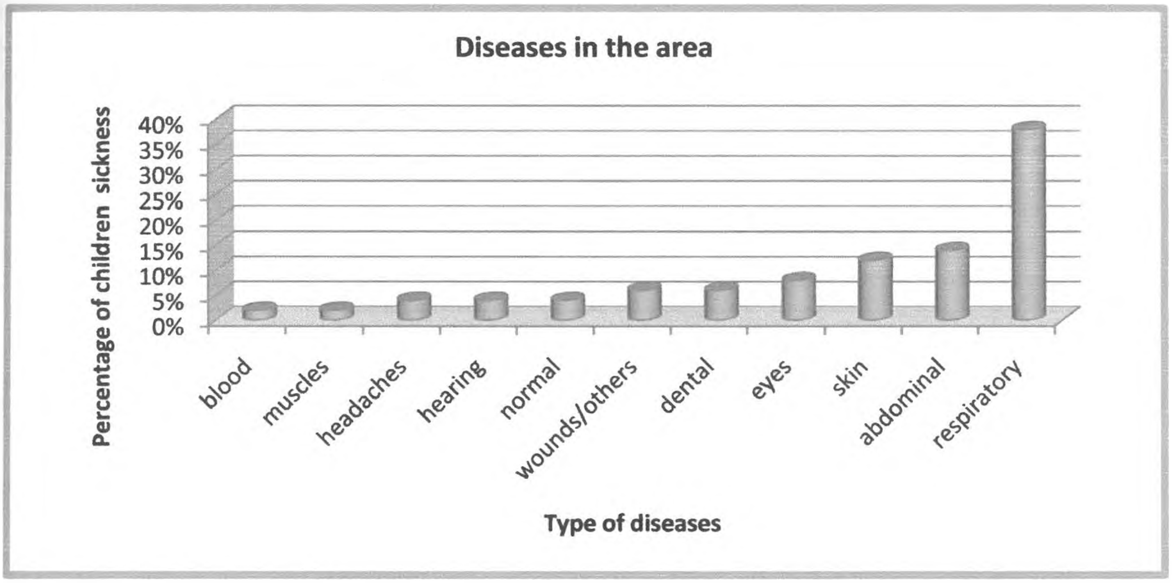
The study through desk study analyzed obtained Medical records from catholic dispensary, Kariobangi from 2008 to 2012 Graph 4.11.

Addressing the environmental concern by introducing a livable environment will reduce the rising respiratory problem.



Graph 4.11 Annual average patients treated with respiratory problems
Source: Author 2013

The study analysed diseases suffered by children Graph 4.12. 38% of respondents had respiratory complications, with 14% of the respondents children with abdominal ailments.



Graph 4.12 Sample for children health condition
Source: Author 2013

4.4.4 Solid waste low diagram

Through analysis of the authorities, stakeholders and management the study constructed a solid waste flow diagram.

In the solid waste flow diagram Figure 4.4, a positive or plus sign (+) at the arrow head between two variables (population growth and economic growth) A & B shows a positive relationship between the variables, i.e. an increase in A results in a an increase in B, likewise a decrease in A results in a decrease in B. A negative or minus sign (-) at the arrow head between two variables A & B shows a negative or counter relationship between the two, i.e. an increase in A results in a decrease in B, likewise a decrease in A results in an increase in B.

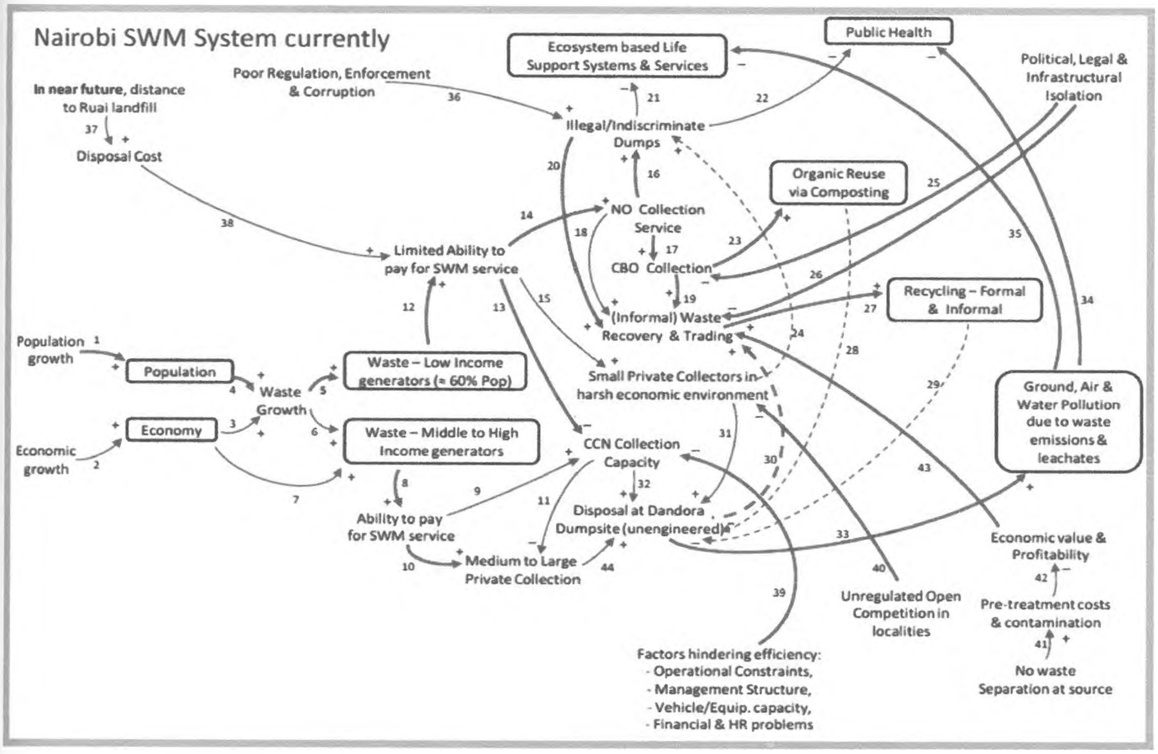


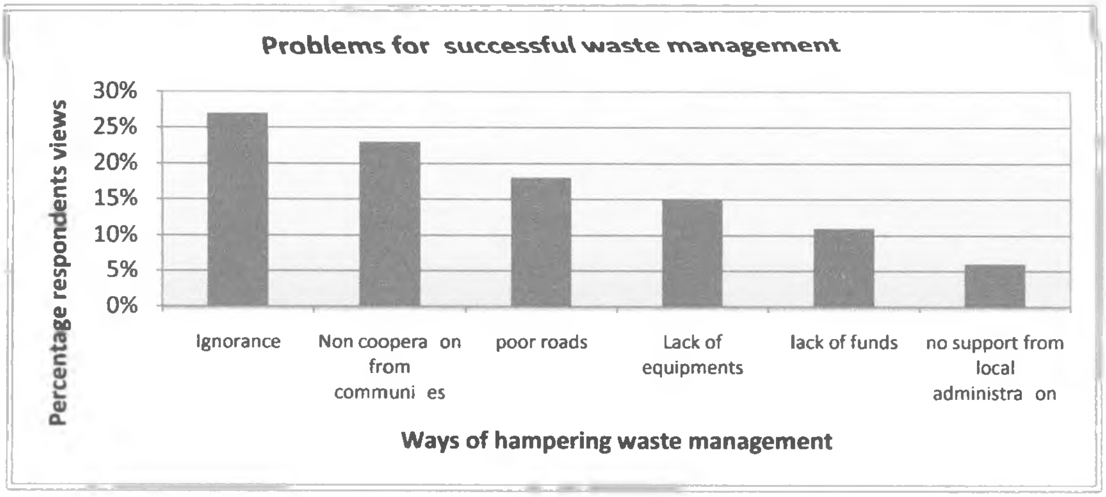
Figure 4.4 Solid waste flow diagram
Source: Author 2013

The generation of waste is generally a product of the City residents' day to day living activities and the City's economic activity expressed in business enterprise, commerce, industry and various public institutions (loops 3 & 4). These in turn are fed by the respective population and economic/commercial growths prevalent in the city at the time (loops 1 & 2). In Nairobi, the waste generated generally falls into two broad categories, that from low income and informal settlement areas, whose residents comprise about 60% of the City's population (loops 5) and that from middle to high income areas and whose residents comprise the remainder (loops 6).

4.4.5 Poor waste management

Poor waste management is directly associated with the type of waste in the dumpsite. Unrestricted disposal of waste results to a dumpsite with valuable, recyclable and recoverable materials.

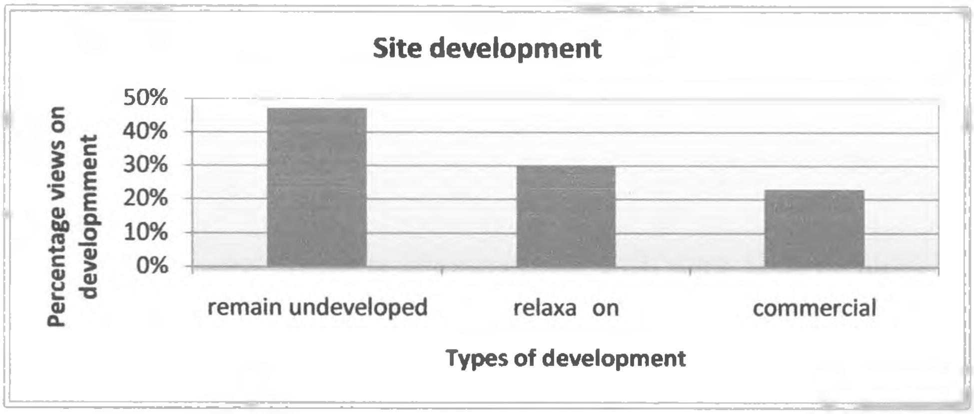
The study established 27% of the respondents associate poor waste management to ignorance of the residents, 23% associate the problem with non-cooperation of the communities Graph 4.13.



Graph 4.13 Problems hampering waste management
Source: Author 2013

4.4.6 Site development

The study established 47% of the respondents prefer the dumpsite not to be developed, 30% prefer the dumpsite to be developed for relaxation and 23% prefer the dumpsite to be developed for commercial use Graph 4.14.



Graph 4.14 site developments
Source: Author 2013

5 SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

Landfill Conceptual approach plan of a closed dumpsite has been overlooked in urban waste environment regulations. This study is focused in recommending a sustainable design for Dandora dumpsite rehabilitation with regard to developing a public urban park.

From the findings, the study established people living around the dumpsite are negatively affected by the dumpsite. The study chapter summarizes concludes and provide recommendations to creating a sustainable Dandora urban park.

5.1 SUMMARY OF FINDINGS

Dandora dumpsite has both positive and negative impacts to residents and city dwellers. In order to achieve the set objectives, the study summarized the gathered data to analyse the physical, socio economic and environmental relationship between Dandora Dumpsite and low income residential neighbourhoods.

5.1.1 Physical variable

The study summarized dumpsite waste, infrastructure, area and volume covered by waste as physical variables.

5.1.1.1 Dumpsite waste

Dandora dumpsite Waste is characterized with with high volumes of bio degradable waste. The findings indicate 68% of domestic waste, 8%of market waste and low volumes of hazardous waste of from hospitals 2%. High volumes of bio degradable waste signify an appropriate measure for LFM process.

The study established 58% of waste type is organic and a total of 32% (paper, plastic, glass and metal) for recyclable items. The findings established 90% of the waste is recoverable and 10% is unrecoverable. High volume of recoverable waste is appropriate for LFM process. The research found out that segregation, recycling, reuse and recovery of waste is done at the dump sites by community groups or individuals. Those interviewed stated they are involved in waste recovery, sorting the waste into various lots of polythene papers, plastics, battery shells, metal, paper and card boards and glass which are then sold to industrial and other enterprises that use them as raw materials for making their respective products.

Lack of regulations on segregation and recovery of waste at source has resulted in unnecessarily large volumes of waste to be transported to the dumpsite only to be transported back to the recycling plants or re-users after recovery. The City Council as well as residents therefore incurs transport expenses which could otherwise be avoided were segregation and recycling to done at source.

Further, the research found out, it is difficult to segregate the waste properly at the dump site because of the large quantities and varied nature of the waste dumped at the site. This results to voluminous accumulation of waste to mountains of garbage as observed.

The study established 75% of the residents at Dandora dumpsite use open dumping as a waste disposal method, 21% through burning and 4% use private companies to dump their unsorted waste. The study sample is a prototype of waste disposal method, with little sorting done. This translates to accumulation of unsorted waste at Dandora dumpsite.

5.1.1.2 Infrastructure

The study findings established access roads to Dandora dumpsite are seasonal, during rainy seasons they are impassable results to waste being dumped at undesignated areas. The inaccessible roads at Dandora dumpsite have resulted to waste been dumped haphazardly thereby there is need for LFM. Secondly, the study established the roads are used by both pedestrians and vehicles.

The study established a weighbridge was installed 2006. When the study was carried on September 2013 the weighbridge was not operating. Interviewed respondents established that the weighbridge was in operation for less than one year from when it was installed. The study also established, when the weighbridge was installed there was a decrease in waste deposited in the dumpsite due to increased fee for dumping. The study noted, installation of weighbridge when the dumpsite was already full was inappropriate and could not be relied to provide the total volume of waste which has been deposited at Dandora dumpsite.

The study established dilapidated machinery was used to compact the daily waste. Further the one bulldozer been used has been hired and paid on hourly basis. The bulldozer is incapable to compact the daily waste as required. Second, the study observed the trucks for transporting waste were not in the required condition. The trucks were not in the right colour, had overflowing waste resulting to environmental hazard as the waste is being transported to the dumpsite. The inadequate trucks results on an average of a third of the waste being transported to Dandora dumpsite.

5.1.1.3 Area and volume covered by waste

The study established the abandoned quarry was unlined at the surface when dumping started. Interviewed respondent provided an average quarry depth of 11 meters. The study established Dandora dumpsite area is not demarcated and is hard to establish its extent. However the study mapped an area of 45acres as littered with waste. Through mapping and measurement the study established three segments of waste footprint, 30,000m^2 as area with 11m depth of quarry and a 10m height of accumulated waste, 60,000m2 as area with 5m depth of quarry and 7.5m height of accumulated waste and 101,000m^2 as area with no quarry depth but with 5m height of accumulated waste. Referring to best practices in LFM as cited in literature, adequate waste footprint is appropriate when rehabilitation is for developing an urban park.

Through tabulation study established there is approximately 1.8 million cubic meters of waste deposited at Dandora dumpsite. The volume of waste is a direct determinant on LFM process, whereby adequate volume of waste translates to sufficient recoverable volumes.

5.1.2 Environmental variable

The environmental variable analysed the following to establish the relationship between the environment and the surrounding low income residents. The main problems associated with sustainable dumpsite rehabilitation are water contamination, landfill gas production, flora and fauna.

5.1.2.1 Water contamination

The study observed flow of leachate from the dumpsite to the surface water. Leachate has formed pools at the dumpsite with the one oozing at the periphery drained using channels to the water bodies.

The study established 54% of the residents do not treat water for drinking, 25% treat water for drinking through filtering, 15% through boiling and 6% through bleaching. A total of 79% hardly treat water for drinking posing healthy risk.

5.1.2.2 Land ill gas

The study evidenced foul and strong pungent smell emanating from the dumpsite. The foul smell was the smell of hydrogen sulphide from decomposing fresh waste. Respondents interviewed witnessed sporadic fires during dry season.

5.1.2.3 Flora and fauna

The study observed patches of flora and fauna at the dumpsite with more spread along the Nairobi River. The study also observed presence of a variety of avian species.

5.1.3 Socio economic variable

The socio economic variable analysed source of income, poor waste management and dumpsite rehabilitation concerns attributes to establish the socio economic aspects in relation to the dumpsite.

5.1.3.1 Source of income

The study established 70% of the residents source of income is been employed as casual labourers, 15% as small scale business, 5% as skilled laborers and 3% through formal employment. The study established mainly the casual laborers work in the informal industry. High number casual laborers are necessary in dumpsite rehabilitation for they will be need during development. Secondly the workers will feel as part of the development.

The study established 55% of the pickers are children below 18 years of age, 33% are youths age between 18 years to 45 years and 12% of the respondents are age above 45 years of age. The study established the pickers have no protective clothing thus exposing themselves to health hazard risk. The high numbers of children brave the dangers of the dumpsite to escape the ravages of extreme poverty. The high numbers of school going children are involved in picking waste to supplement their parents income.

The study established 48% of the children scavenge for food and 41% scavenge for recyclable and reusable materials for sale. Scavenging is done manually through laborious process involving poorly equipped and unprotected individuals working in small groups. Materials are 100% recovered through visual separation. Visual separation leaves a lot of valuable items unrecovered as the study established through observation. The study established the workers make meager income at great expense to their health from recyclable materials.

5.1.3.2 Poor waste management

The study established 50% of the respondents associate poor waste management to ignorance and non cooperation from neighbourhood communities, 17% attribute to poor roads to transport waste from its source to its destination, 15% associate problems of waste management to lack of funds and 11% claim there is no support from local administration to successfully manage waste.

The study established 38% of residents have respiratory tract infections, 14% have abdominal pains, 12% skin infections, 8 % have eye problems and 6% have fresh wounds. The high number of respiratory tract infections is also reflected in the increased figure at hospital records with an average of 750 patients annually in 2008 to 2350 patients in 2012. Respiratory tract infections are attributed to inhaling and ingestion of chemicals from the dumpsite. The study also established 2% of residents with muscle problems and 2% of respondents as having been diagnosed with blood ailment. Blood and muscle problems are associated with accumulation of heavy metals in the body system. Other health problems enlisted by the respondents include anaemia, nervous system dysfunction, hypertension, kidney problems, miscarriages, low birth weight and cancer.

5.1.3.3 Dumpsite Rehabilitation concerns

The study established 64% of the residents are against Dandora dumpsite rehabilitation, 5% of the residents are accepting the process while 31% are not sure whether to accept or oppose. This finding correspond to 87% of the pickers are against dumpsite rehabilitation and 11% not sure. The residents and pickers argue that they will lose income.

The study established 72% of the residents are willing to provide labour as contribution to development of Dandora dumpsite, 20% to provide material and 8% to provide finances.

The study established 47% of the respondents would prefer the dumpsite not to be developed, with 31% the dumpsite to be developed for relaxation and 22% the area to be developed for commercial use. Those who do not want the area to be developed argue that the government. Those against the development are unwilling to support any initiative without viable economic alternatives for waste pickers.

5.2 CONCLUSIONS

The study findings indicate Dandora dumpsite pose environmental, socio economic and health problems aggravated by its close proximity to CBD. The findings confirmed there are large quantities of waste which are deteriorating environment and livelihood of the residents through air pollution, water pollution and aesthetic blight.

5.2.1 Physical variable

This section dwells into study conclusion on dumpsite waste, infrastructure and area covered by waste.

5.2.1.1 Dumpsite waste

The study established of the estimated recoverable materials only less than a third is recovered by the pickers. This is attributed to the laborious process of waste recovery which is done manually. The study established only big plastics and valuable metals are recovered. Presence of unrecovered valuable materials prompts use of LFM to recover, reuse and recycle the materials.

The voluminous waste is both in the quarry mines and above the surface. Appropriate measures to deal with waste which is still decomposing need to be addressed. Due to the fact that the dumpsite was not planned, clear preparations have not been made to prevent environmental hazards.

Sporadic fires experienced during dry season are a result of methane accumulation, which is highly inflammable. Hydrogen sulphide is the foul smell of rotten eggs and ammonia is the strong pungent odor. The study established short term exposure cause coughing, irritation, headache and nausea causing health effects.

5.2.2.3 Flora and fauna

The low number of flora and fauna is attributed to the poor environmental condition in the dumpsite. The study concludes there has been small attempt to introduce plant materials which tolerate dumpsite condition. Some of the plant materials introduced are inappropriate since they edible and proper safety measures were not taken. This is associated with either the residents are unaware of health dangers associated with consuming such plants.

The study concluded there were few fauna varieties. Most of the fauna are scavenging birds which get food from the dumpsite.

5.2.3 Socio economic variable

The socio economic variable concluded on source of income, poor waste management and dumpsite rehabilitation concerns to establish the socio economic aspects in relation to the dumpsite.

5.2.3.1 Source of income

The study findings indicate a huge numbers of people relying on deposited waste for livelihood. Residents and pickers sort out recyclable materials in small scale which they sell to various agents. Sorting out is done in small scale since the waste is unmanaged. Pickers affirmed they are against closure of the dumpsite since that is where they eke a living. The residents and pickers have not been informed on how they will be incorporated into the development process. The pickers are school going children whose earnings supplement their parents income.

5.2.3.2 Poor waste management

The dumpsite poses health risks to the residents. The air the residents breathe is polluted as evidenced by diseases suffered by residents and pickers children.

5.2.3.3 Dumpsite Rehabilitation concerns

Majority of urban residents fear losing their source of income. Residents have not been educated on benefits dumpsite rehabilitation. The respondents stated the government and politicians have been giving promises on how to improve their living conditions. This has led to statements like "after substantive consultations" with the stakeholders, the government is closing the dumpsite due to "massive environmental degradation." The politicians also referred to pickers as a "shameful lot of scavengers who were trying hard to destroy our environment."

The study established most residents are against development of the dumpsite. Poor information dissemination, poor statements from government only serve to confirm the suspicions of the poor communities living near Dandora dumpsite that they will not benefit from the development of the dumpsite. This has also provided platform for antagonists of the Dandora dumpsite development who have rallied communities against the process. The study established scavengers are paid non-sustaining meager wages at the cost of their health.

5.3 RECOMMENDATIONS

The study recommendations aim at evaluating the relationship between Dandora dumpsite rehabilitation and landscape design proposed. To achieve this, the study recommended various factors in relation to physical, environmental and socio economic variables.

5.3.1 Physical variable

The study used the physical variables to recommend on the objective of physical relationship between the dumpsite and the neighbouring residents.

5.3.1.1 Dumpsite waste

For a successful LFM practice, the study recommends use of recover, recycle, reuse for excavated waste which is valuable. For the hazardous waste the study recommends the waste to be rejected and reburied in the same quarry.

For efficient waste management the study recommends borrowing fromWaste management approach used in Curitiba known as "Brazil's green capital" and is hailed as a prime example of a green economy in a developing country. The approach encourages slum dwellers to clean up their surroundings and improve public health by offering fresh fruit and vegetables in exchange for garbage and waste brought to neighborhood centers. For example, as of 2012, Curitiba had 96 exchange sites. Each month more than 6,500 people are exchanging an average of 255,416 kilos of collected garbage for 92,352 kilos of fruits and vegetables.

The study recommends promotion of artwork. The recovered reusable materials (rubber, plastics, wires, papers etc.) are used in encouraging art to add aesthetic to the urban park.

Proper planning should be emphasized to integrate urban growth with dumpsites. Due to CBD proximity and surrounding low income residential neighborhood the study recommends an environmentally friendly development. For example, urban park, urban forest.

5.3.1.2 Infrastructure

The study recommends provision of accessible roads to allow movement. In developing a sustainable urban park a conceptual plan on development is necessary. This will allow movement of machinery during LFM to be intensified in areas where it is fore-planned circulation to aid in settlement to achieve a successful urban park the roads are recommended to have clear demarcation of vehicular circulation and pedestrian circulation and one which allow communal interaction.

The study recommends weighbridge should be installed with the aim of accounting the total tonnage volume dumped. This facilitates data of the volume of the waste deposited for the LFM approach. Secondly, the weighbridge facilitates fee payment for dumping per tonne.

The study recommends use of adequate machinery to provide adequate compaction of waste. The study recommends the waste been compacted should be one which waste has been sorted. After compaction the daily soil cover should be applied at thickness of 300mm. compacted waste reduces decomposition of waste and thereby reduces landfill gas emission and leachate production. The soil cover will contain waste at the dumpsite and swirling polythene bags during dry season will be contained.

5.3.1.3 Area and Volume covered by waste

The study recommends LFM is appropriate considering Dandora dumpsite is mature at an age of over 35 years. The age of the dumpsite is essential in using LFM approach for waste to have decomposed and settled. The waste footprint covered be planted trees, shrubs and groundcovers for aesthetics, urban forest, recreation, air purification, bio diversity. Apply waste (soil or geo-sythetic) cover to contain waste

The study findings tabulated a volume of 1,885,000m^3 deposited wastes at the dumpsite. Based on the waste type a ratio of 60:40 for probable recoverable soil to recoverable recyclable materials is appropriate. The study established the total waste contain recoverable and non-recoverable materials. Through LFM the volume of waste will reduce by 40%, only 60% of the waste is organic will be reburied, mounded and compacted as cover soil. The study recommends hazardous waste will be reburied at the quarry after a 150mm liner has been laid at bedrock, to prevent ground water contamination.

5.3.2 Environmental variable

The study used the environmental variable to recommend the objective on environmental relationship between the dumpsite and the neighbouring residents.

5.3.2.1 Water contamination

The study recommends prevention of surface and ground water from being contaminated with leachate emanating from the dumpsite. Before establishing a landfill, the principle condition is to lay a liner and establish a system of pumping the accumulated leachate to a leachate pond. Since this approach was not adopted in Dandora dumpsite, there is need to mine the waste and establish a liner to prevent future contamination. Secondly, fresh dumped wastes decompose and produce leachate which flow to the river.

5.3.2.2 Land ill gas

To control the foul smell and LFG from the dumpsite, the study recommends, one, closure of the dumpsite so as not to allow fresh waste which produces hydrogen sulphide when decomposing. Second, the study recommends use of scented plants to provide fragrant environment to the residents. Uses of plants sequestrate carbons as cited in the literature and reduce global warming.

5.3.2.3 Flora and fauna

The study recommends closure of dumpsite to necessitate use of LFM concept and heavy planting along the river. Excavated and screen soil contaminated with heavy metals. For remedy, use of plants with high capacity to extract the metals is necessary *though phytoremediation.* To control erosion of the contaminated excavated soil, the study recommends grading of the site for development and use of evapotranspiration plants.

Primarily, the study recommends use of many plants. The study targets 80% of the area to be under vegetation and the remaining 20% for hardscape activities. The vegetation will include trees, shrubs, ground covers and lawn. This will translate to 3000 trees, 4500 shrub, 10,000m^2 being covered with ground covers and the rest lawn. The dense vegetation will have advantages ranging from air and water purification, wind and noise filtering, micro climate, natural areas for social and psychological benefits. Furthermore, aesthetic and recreational values of urban forest increase the attractiveness of the city.

The study recommends promotion of urban agriculture. Greater food self-reliance, cheaper food prices, greater accessibility to fresh and nutritious products, and poverty alleviation are all key benefits that can arise from urban agriculture with sound decision-making and planning of the cities' ecosystems.

5.3.3 Socio economic variable

To recommend the socio economic aspects associated with the dumpsite rehabilitation the study has recommended the following:-

5.3.3.1 Source of income

The study recommends provision of human friendly means of earning income to the residents and pickers. The respondents rummage through the waste looking for recyclable materials. The study recommends waste should be sorted at the source thereby making collection of recyclable waste easier and at large scale. During dumpsite rehabilitation the residents and pickers should be involved in management and labour provision thus earning an income.

5.3.3.2 Poor waste management

Residents are infected by waste from dumpsite through the following means ingestion, inhalation and skin. Ingestion of contaminated water and non-biodegradable organic compounds in the food chain has resulted to increased disease infection. The study recommends use of daily soil cover on waste deposited after compaction, to prevent leachate from accumulating and flowing to water bodies. The study also recommends use of protective clothing during waste recovery.

5.3.3.3 Dumpsite rehabilitation concerns

The study recommends educating the residents and creating an interactive public community strategy. The study recommends consultation with various stakeholders. This will change the perceptions of residents who view dumpsite landscapes as degraded or unattractive to an economic, aesthetic, and ecological asset. The holistic thinking has been applied in several cities to demonstrate how the needs of infrastructure, biodiversity, and local communities can be integrated in a mutually beneficial and sustainable manner.

The study recommends involvement of a technical team for Urban and environmental planning. The team will provide consultative opportunities and formal legal mechanisms to integrate the protection of biodiversity into the design, building codes, zoning schemes, spatial plans, strategic choices, and enforcement of city management.

5.3.4 Dandora landscape design

For a successful dumpsite rehabilitation design, the objective of landscape design to create a sustainable urban design is paramount. The design desires to borrow heavily from successful rehabilitated dumpsites as cited in the literature and rely on recommended aspects from the study.

The study concurs with the view that parks create new value to urban fabric, but also proposes a new ecology of parks is necessary that makes productive use of the rich riverfront lands and water as well as residents at its banks. The study recommends a strategic identity to natural assets to design an environmental network that protects and enhances critical natural and cultural processes. The proposal envisages a simple environmental design technique by rehabilitating Dandora dumpsite using pockets of dense tree cover, a central public space and symbolic representation of the existing dumpsite. The study proposes use of different species of plants to create a rich urban ecology, a strategic place monumental fountain to offer identity to the park and use of earth mounds to symbolize the existing mountain of garbage waste.

The study proposes a mix of uses and users, providing low income urbanite model for a sustainable park with coexistence of activities been encouraged. Cultural and recreational services include public to private urban spaces, individual to group settings, greenery to watery setting for recreation and open to canopied urban spaces.

New community elements to complement and link to existing assets in adjacent neighbourhoods, allowing current residents to occupy and steward the rehabilitated terrain, while inviting new users and visitors to find a place in Dandora park. These includes basic infrastructure (driveway, parking, walkways, lighting) dense plant materials , garden grounds with sculptural expressions, islands of hardscapes and softscapes, public gathering spaces (open amphitheatre and stepped plaza with a fountain), children recreational area with swings, sandboxes, slides, monkey bars, expression boards etc, active water activities (boating, swimming, slides to water),active and passive sports activities, visual composition for relaxation (nature trails, mounds, cascading waters, rock gardens, sculptors, pergolas, gazebos, decks, artistic expressions).

5.3.4.1 Concept design

Rehabilitation of Dandora dumpsite will require establishment of user spaces, there needs to be a recuperation period during which the soil is allowed to recover from the effects of movement, storage and replacement. Following this period, Nairobi County

Council will implement the landscape plan to establish, maintain and monitor in order to successfully restore the site to its intended use. This will include cultivating and improving the soil to allow for the establishment of vegetation. Timing of the final landscaping works will be influenced by ground settlement rates across the site. Settlement rate will be accelerated using the compaction method as shown in Figure 5.1.

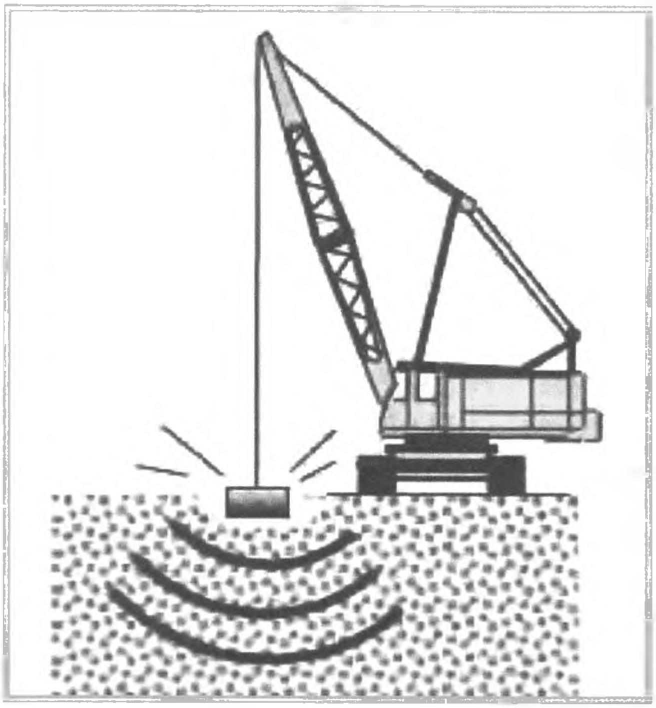


Figure 5.1 Compaction methods to accelerate settlement rates
Source: Author 2013

Landscaping is programmed to be undertaken in a staged approach following completion of capping works. During the first phase of the landfill restoration, the fence and hedgerow design shall be installed along the boundary. The remaining sections of the boundary shall be secured during the landfill operations with the existing fence.

After landfill mining where valuable components are separated. The recovered soil component is compacted into layers as shown earlier. The compaction of the ground is guided by a conceptual grading plan, which has established the drainage pattern, the sizes and position of mounds and all alteration on the ground.

Landscape design details of the operations will require the replacement of the soil to grade the land up to a design standard for afteruse. Such works will include proposal for both softscape and hardscape

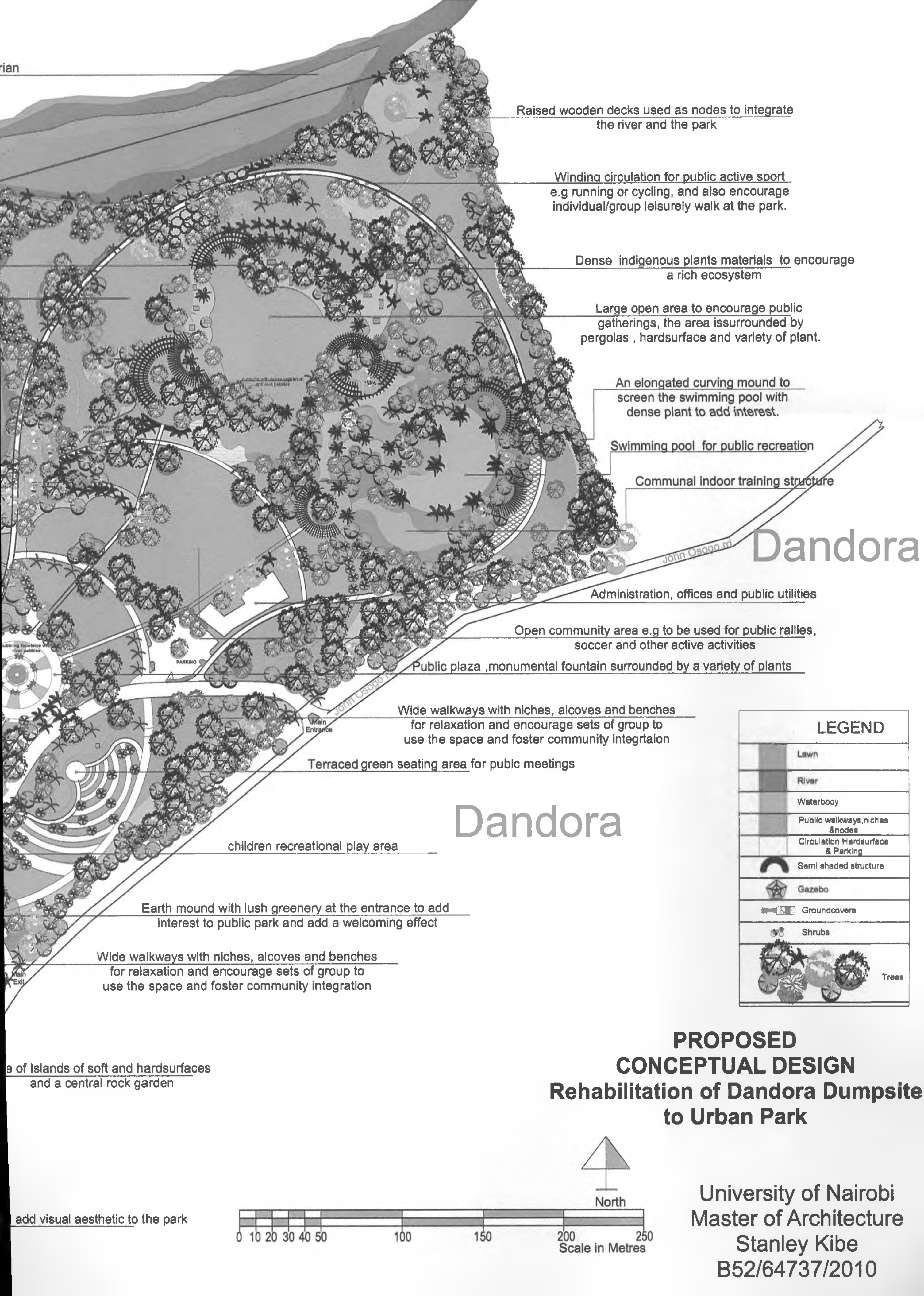
The conceptual design Figure 5.2 has all activities built within the following zones; trees, shrubs, groundcovers, lawn, water, hardsurface, circulation and buildings. Using the area occupied by each of these zones, the study established table 5.2 showing the percentage area in comparison to the whole park.

Table 5.1 PROPOSED DANDORA URBAN PARK LAND USE		
Types of spaces	**Area in square meters**	**Percentage area (%)**
Canopied space/ area with trees	90,500	47.3
Open space/ area with lawn and groundcovers open to sky	66,250	34.6
Water space/ area with pond, rivulets and fountains	5,250	2.7
Hardsurface/ area with niches and ungrassed surfaces for relaxation	14,875	7.8
Circulation, parking and driveway	9,375	4.9
Buildings/ and other structures	5,000	2.6
Grand total	**191,250**	**100**

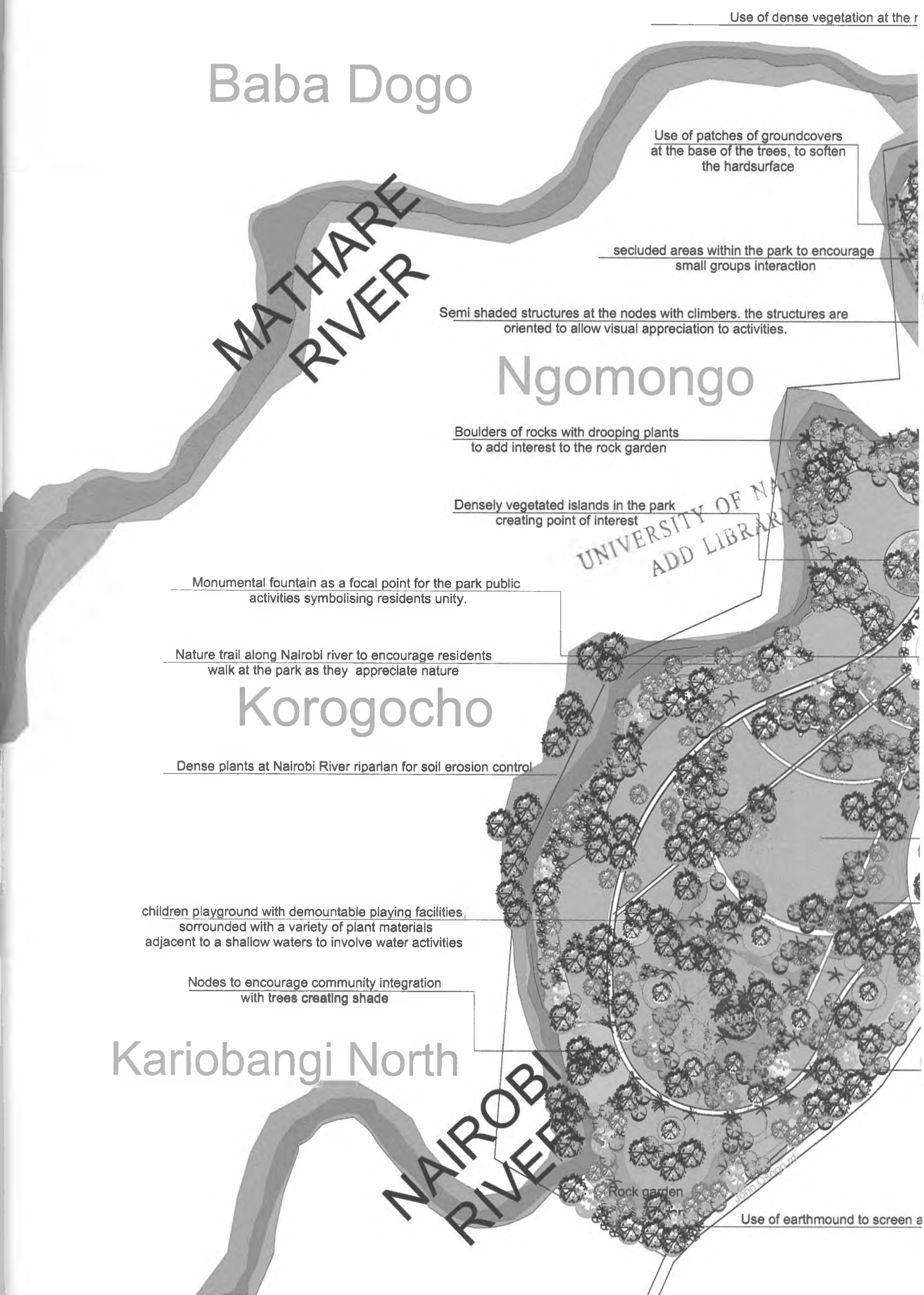
Source: Author 2013

The proposed Dandora park land use shows 81.9% of the park is occupied by plant materials (trees, shrubs, groundcover and lawn) with almost half of the urban park been canopied and a third been open to the sky. This approach allows the users to enjoy a substantial benefit of vegetation. The study recommends an average spacing of 5meters to 7meters between mature trees resulting to 3000 to 4000 trees. The larger number of trees will a rich vegetation and enhance sustainability.

Landscape design is broadly categorized into softscape and hardscape. The study proposes a 84.6% of softscape which includes vegetation and water. The softscape also provides adequate area to design symbolic features (earth mounds and cascading waters). The high percentage of softscape provides adequate area for recreational activities thereby creating an opportunity for a rich interactive urban park. The softscape is intensely used for various community activities (soccer, political functions, community gatherings, wedding activities and educational)



rian
Raised wooden decks used as nodes to integrate the river and the park
Winding circulation for public active sport e.g running or cycling, and also encourage individual/group leisurely walk at the park.
Dense indigenous plants materials to encourage a rich ecosystem
Large open area to encourage public gatherings, the area issurrounded by pergolas , hardsurface and variety of plant.
An elongated curving mound to screen the swimming pool with dense plant to add interest.
Swimming pool for public recreation
Communal indoor training structure
Dandora
John Osogo rd
Administration, offices and public utilities
Open community area e.g to be used for public rallies, soccer and other active activities
PARKING
Public plaza ,monumental fountain surrounded by a variety of plants
John Osogo rd
Main Entrance
Wide walkways with niches, alcoves and benches for relaxation and encourage sets of group to use the space and foster community integrtaion
Terraced green seating area for public meetings
Dandora
children recreational play area
Earth mound with lush greenery at the entrance to add interest to public park and add a welcoming effect
Main Exit
Wide walkways with niches, alcoves and benches for relaxation and encourage sets of group to use the space and foster community integration
e of Islands of soft and hardsurfaces and a central rock garden
add visual aesthetic to the park
LEGEND
Lawn
River
Waterbody
Public walkways,niches &nodes
Circulation Hardsurface & Parking
Semi shaded structure
Gazebo
Groundcovers
Shrubs
Trees
PROPOSED CONCEPTUAL DESIGN
Rehabilitation of Dandora Dumpsite to Urban Park
North
0 10 20 30 40 50 100 150 200 250
Scale in Metres
University of Nairobi
Master of Architecture
Stanley Kibe
B52/64737/2010


Use of dense vegetation at the r
Baba Dogo
MATHARE RIVER
Use of patches of groundcovers at the base of the trees, to soften the hardsurface
secluded areas within the park to encourage small groups interaction
Semi shaded structures at the nodes with climbers. the structures are oriented to allow visual appreciation to activities.
Ngomongo
Boulders of rocks with drooping plants to add interest to the rock garden
Densely vegetated islands in the park creating point of interest
Monumental fountain as a focal point for the park public activities symbolising residents unity.
Nature trail along Nairobi river to encourage residents walk at the park as they appreciate nature
Korogocho
Dense plants at Nairobi River riparian for soil erosion control
children playground with demountable playing facilities sorrounded with a variety of plant materials adjacent to a shallow waters to involve water activities
Nodes to encourage community integration with trees creating shade
Kariobangi North
NAIROBI RIVER
Rock garden
John Osogo rd
Use of earthmound to screen a

The study proposes minimal 15.3% hardsurface (walkways, niches, benches, pergolas and buildings).The hardsurface allows intense use of the park with low maintenance. To soften the wide walkways, the design proposes introduction of tree pockets thereby creating patches of softscapes. The trees provide shade and provide a micro climate to the users.

The design intends to provide for passive recreation through the construction of a network of pathways, steps, earthmounds, rock gardens, zen garden, adequate lighting, and other landscape features. Individual elements have been discussed below with a view to maximize on green urbanism which is a pillar phenomenon in sustainability and maximizing the access to site visitors.

5.3.4.2 Capping

The main factors which influence the rate of infiltration of rainfall into the waste and hence the generation of leachate are topography and configuration of the final top cover. These factors affect the sites run-off pattern and the amount of water percolating into the landfill. Generally steep slopes allow for high surface water run-off and gentle slopes are recommended in reducing run off.

In order to reduce the volume of leachate generated in the waste the final cover consist of a low permeability layer to reduce infiltration of rainwater and to increase surface water run-off. Final capping shall consist of the following Figure 5.2:-

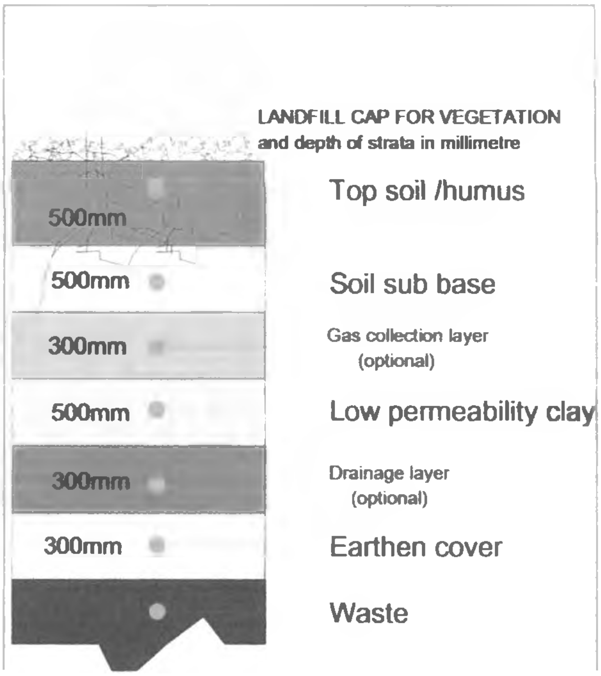


Figure 5.2 Landfill cap which emphasis on sustainable design, in supporting plant materials and harnessing drainage and permeability of water.
Source: Author 2013

The plants on the topsoil break elements concentration in the soil through phytovolatilization (removal of contaminants from the soil and subsequent release to the atmosphere), phytoextraction (extraction of contaminants by plant), phytodegradation (plant metabolism of contaminants) and rhizodegradation (microbial metabolism of contaminant in the rhizosphere) Figure 5.3.

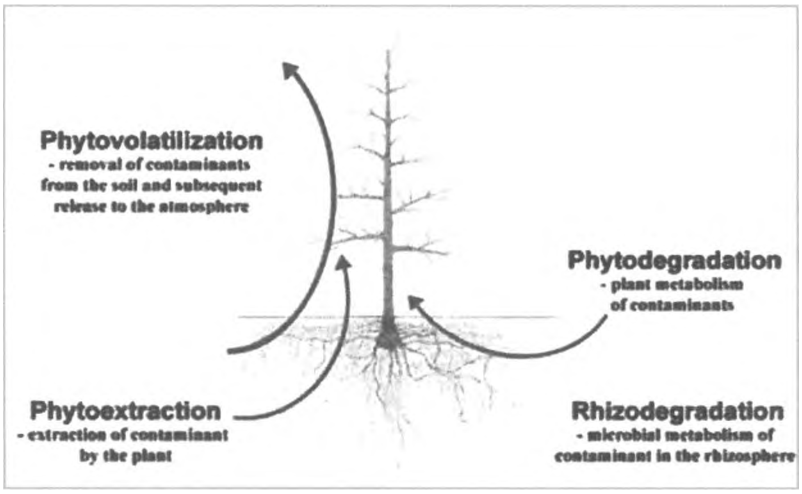


Figure 5.3 Biological soil elements extraction
Source: Author 2013

The design recommends higher plants usage requires greater depths of soils. A synthetic barrier to augment the clay cap where tree planting is proposed above waste filled areas is important. In addition a further 200mm of topsoil is placed in areas of dense planting to provide a sufficient base for tree planting. The use of recycled construction and demolition waste should also be considered for use in capping landfill.

5.3.4.3 Dense planting along the slope

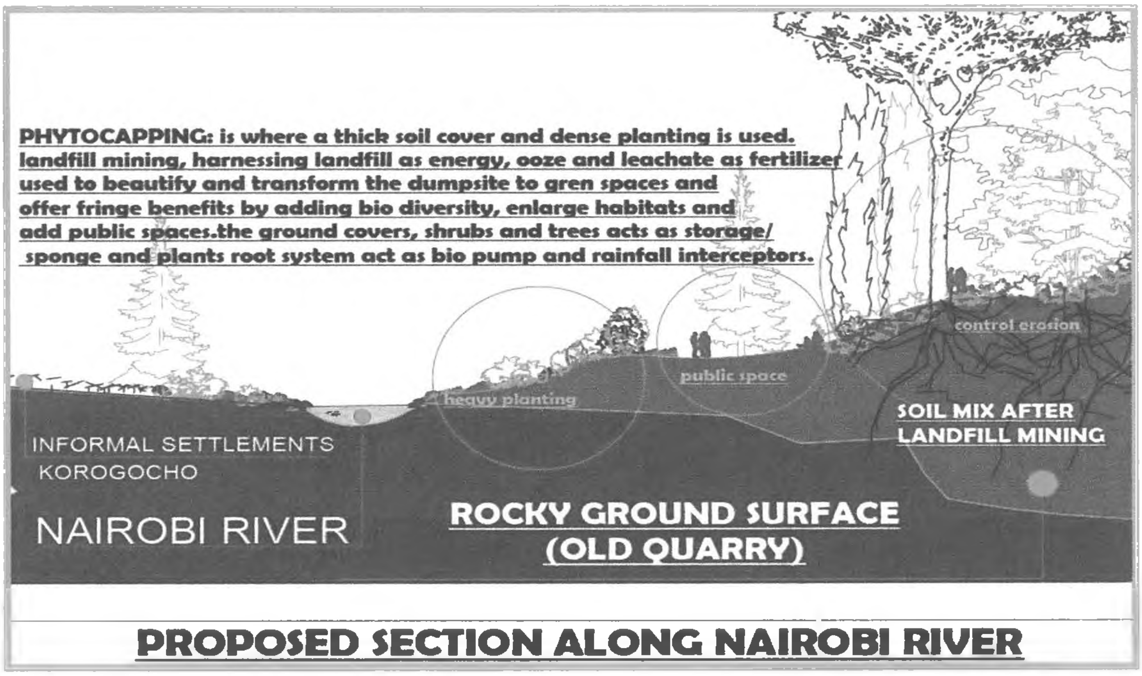


Figure 5.4 Hierarchal planting across Nairobi river, with dense planting up the slope. Source: Author 2013

Nairobi river has been contaminated both with leachate from the dumpsite and solid waste. To control water pollution dense planting is done along the river. The soil layer acts as storage or sponge and plants root system acts as a biopump Figure 5.4. The dense planting with addition of rocks add natural feel. The planting add bio diversity corridor, enlarge habitats and add secluded public spaces.

5.3.4.4 Greenery parking

The urban park parking is situated in a green environment. The ground has minimal hardsurface and patches of greenery. There is maximum creation of canopy at the parking thus reducing urban heat island Figure 5.5. The plants islands soften the hardsurface and a variety of plants trees, shrubs and groundcovers add aesthetics. The plants also attract wildlife (birds, insects). Also the planting bed has a natural outline mimicking nature.

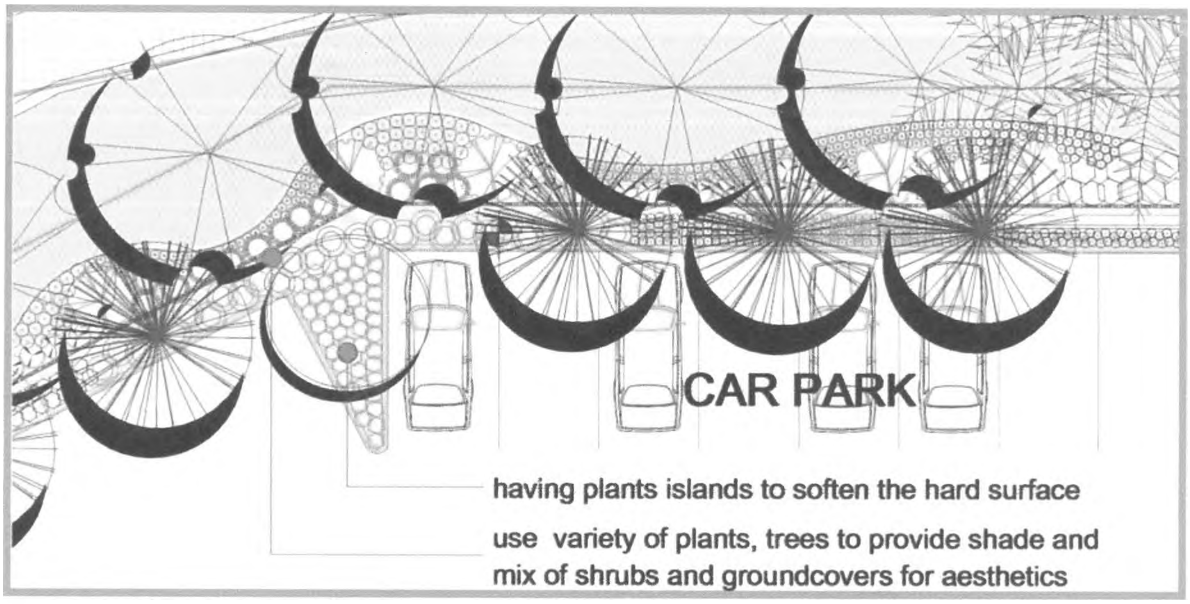


Figure 5.5 use of greenery in a parking to soften the hardsurface
Source: Author 2013

5.3.4.5 Semi shaded structures

Use gazebo for semi public areas Figure 5.6. The structures provide space to be used for groups of people or community. Mainly the gazebos allow users to be brought together and foster community relations in the park. Preferably they should be set in a open vast greenery with meandering path. To add a feel of sustainability there is inclusion of planting bed protrusion to add aesthetic and diversity.

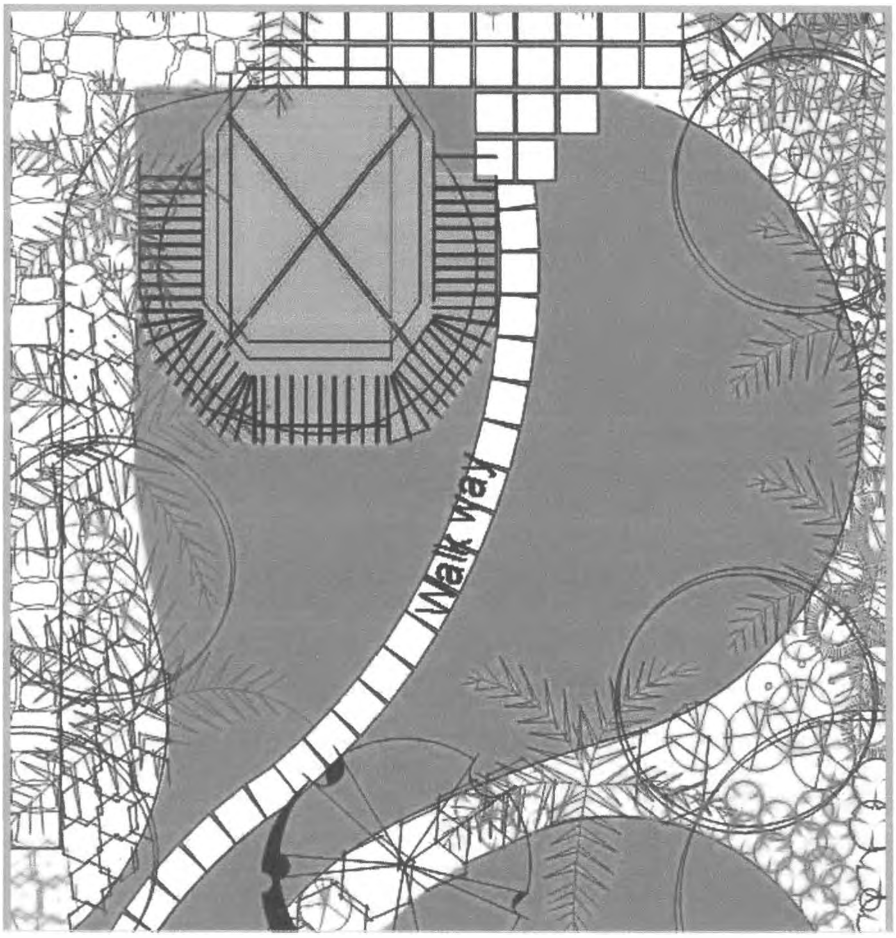


Figure 5.6 Provision of semi shaded structures where groups meet for communal integration in a rich greenery environment. The area has more groundcovers and shrubs.
Source: Author 2013

5.3.4.6 Conceptual driveway section

A detailed section is sufficient for an urban park with a section of driveway and either side being used for pedestrian Figure 5.7. There is use of mounds to add interest to the design and big trees to create canopy 'outdoor rooms' along the wide walkways. The medium where the trees are planted also have small plants which are flowery adding an appealing feel to the users.

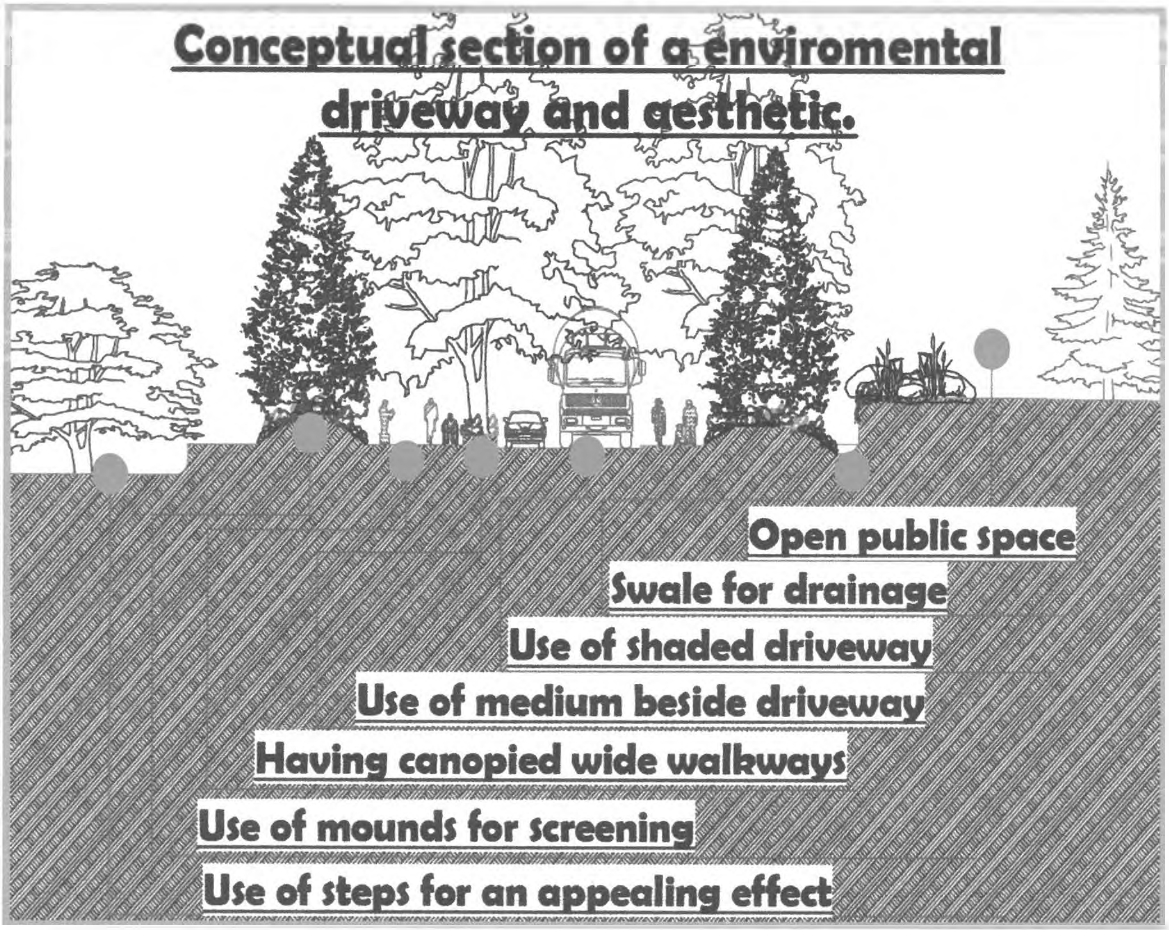


Figure 5.7 The conceptual driveway sections with different levels to control drainage (mounds, steps, swales). The plants traps dust and filter the air
Source: Author 2013

The wide ways allow free flow of park users and they allow introduction of benches and expression niches. Further across the section there be introduction of changing ground levels adding more design interest recreational features for urban park sustainability.

5.3.4.7 Seating points anchored on ground

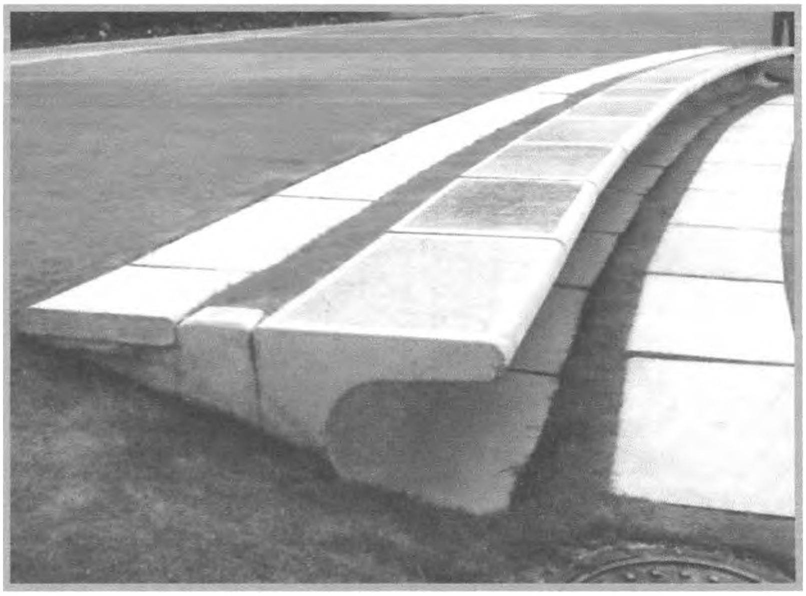


Figure 5.8 seating points anchored on the ground for low maintenance accommodate the public.
Source: Author 2013

Landscape features are used in urban park to ameliorate the physical urban environment. The design includes hard spaces with greenery reduces the harshness of the park. The seating points have low maintenance cost and withstand extreme climatic condition Figure 5.8.

5.3.4.8 Pergola with benches

The study found the need to use pergola as a structure in an urban park where urban users will use them as relaxation areas. The pergola be situated in areas to get clear visual views Figure 5.9. The relaxation areas open with plants climbing on top to add a semi shade. There is variety in pant materials and soften the hard spaces. The open vast green surfaces offer An appealing view to the once awful dumpsite.

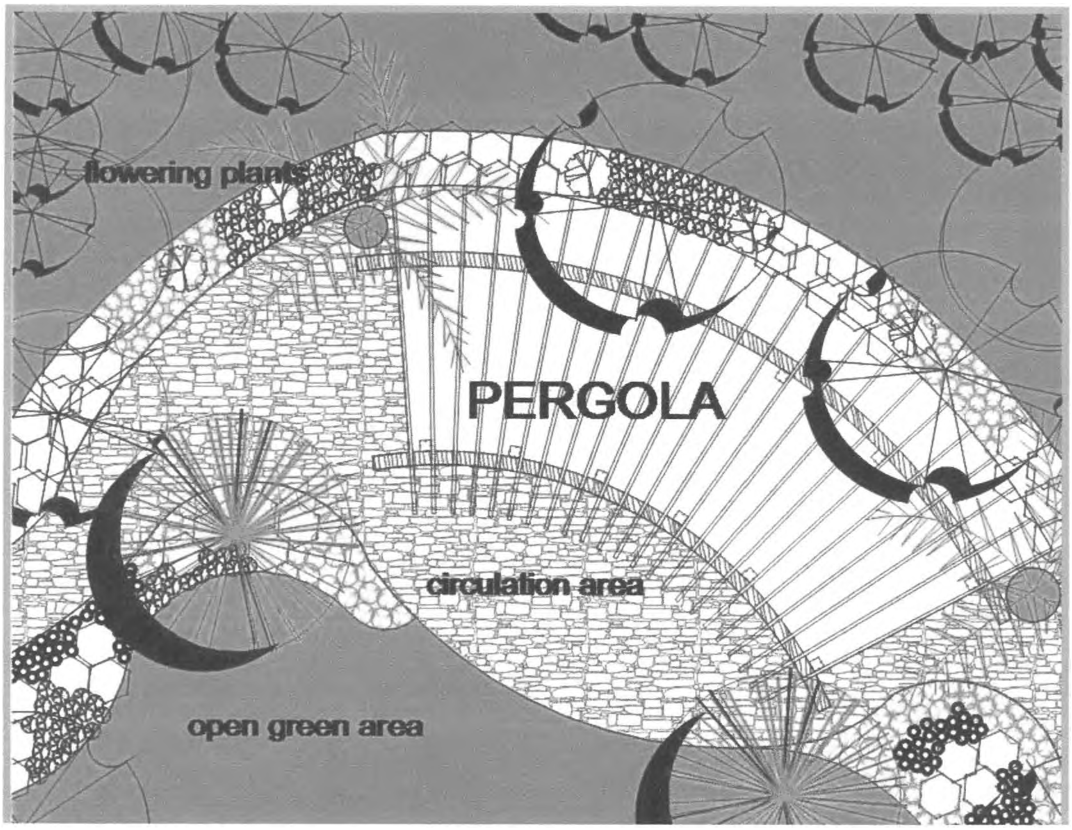


Figure 5.9 Pergola surrounded with a variety of plant materials and opening to a vast green area.
Source: Author 2013

The semi shaded structure to be designed to give a community identity. The plant materials surrounding the activity points create a diverse and appealing environment.

5.3.4.9 Local materials and Fountains

The study revealed there is need to create an enabling micro climatic environment Figure 5.10. This is achieved by use of local materials and jetting waters. The waters also produce sound and give a reflection feel adding aesthetic to the urban park.

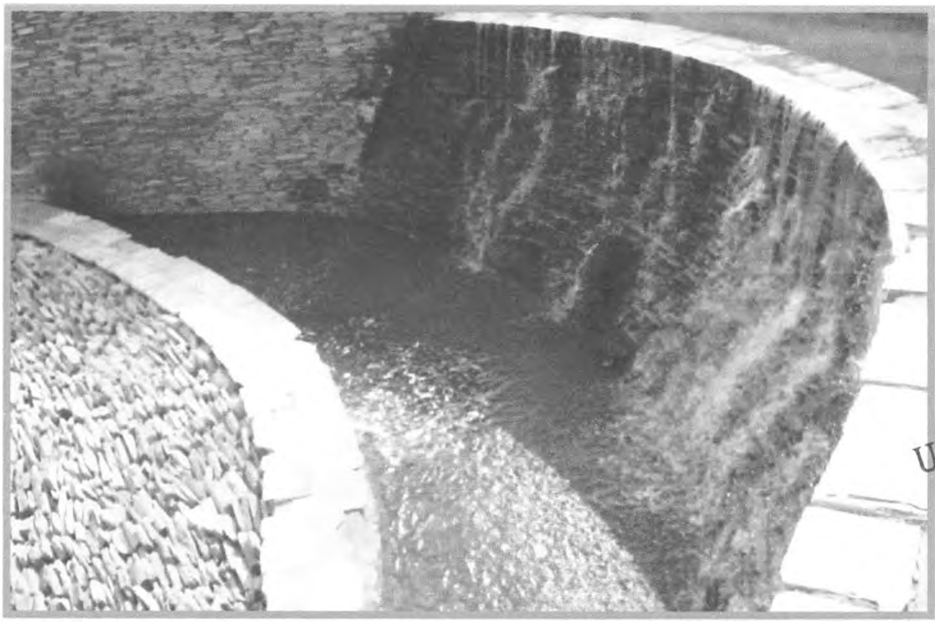


Figure 5.10 local materials and fountains to create a micro climate
Source: Author 2013

5.3.4.10 Use of water

The study found the need to improve the image of the urban area by combining different landscape features and reduce pollution Figure 5.11. The winding waters cascading down create a livable urban park which for many years has been at a deplorable condition. Due to reduced harmful elements, urban agriculture will be encouraged. This will also allow interaction of the users with the park and members of the community.

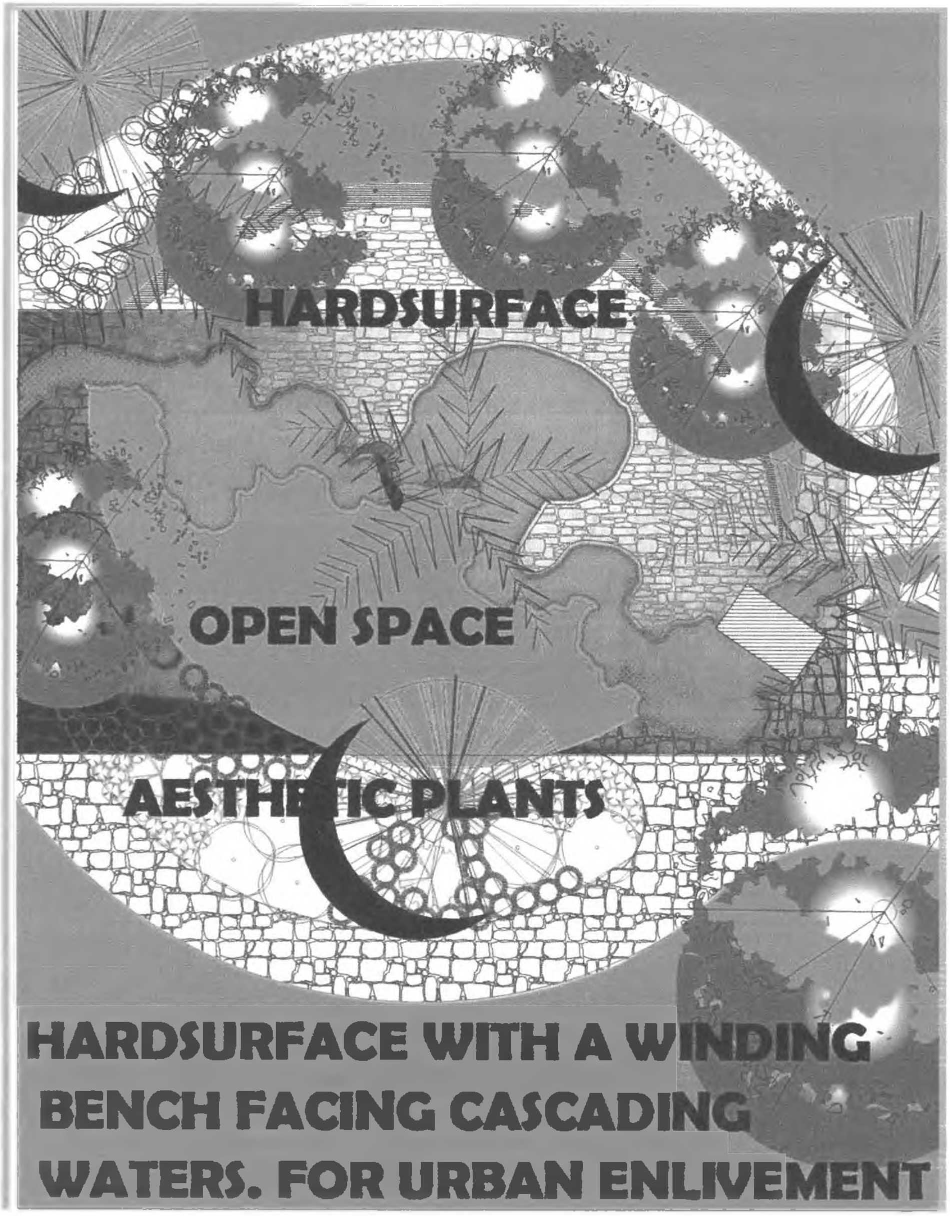


Figure 5.11 River integration with cascading waters down create richness in sensorial appreciation. Addition of plant materials provides open spaces to the sky as well as richness in naturality aspect.
Source: Author 2013

5.3.4.11 Environmental Monitoring

The Table 5.2 specifies the minimum monitoring requirements during the aftercare phase as outlined in the EPA Manual on Landfill Monitoring (1995). A topographical survey will also be required on an annual basis particularly in the first 5 years of rehabilitating to assess the settling behaviour of the level of the landfill body. In addition, stability assessment will be necessary to assess the structural integrity of the landfill body.

Table 5.2 Parameter Observation table in the first five years of rehabilitation.

PARAMETER	AFTERCARE PHASE
Surface water composition	Bi annually
Biological assessment	annually
Groundwater level	Quarterly
Groundwater composition	Quarterly
Leachate levels	Quarterly
Leachate composition	Quarterly
Landfill gas	Bi annually
Gas flare	weekly
Landfill stability and settlement	anually
Noise and dust	Monthly
Odours	annually

Source: Author 2013

During the aftercare phase the site operator shall examine all monitoring equipment on a monthly basis to identify areas where maintenance works are required. The site operator shall ensure that all works undertaken have minimal impact on the afteruse of the rehabilitated site.

5.3.4.12 Vegetation

The long-term aftercare site requires vegetation management and use management of the amenity area. This shall require fencing, weeding, cutting and fertilizing the chosen afteruse of the site. Personnel with appropriate landscape experience shall undertake such maintenance work. Specific plants will thrive well in this contaminated environment and extract elements through phytoremediation Table 5.3

Integrating urban biodiversity planning with public education and the work of health experts is essential. This can be achieved with urban policy and initiatives such as urban reforestation and wetland creation; the establishment of urban parks and outdoor gyms, paths, and trails; the promotion of urban and peri-urban agriculture; the development of ecological sanitation and water infrastructure; and location of community facilities that use the benefits of nature as a setting for other activities.

Table 5.3 Plants species for phytoremediation

SAMPLE PLANTS FOR PHYTOREMEDIATION				
Scientific name	Common name		Scientific name	Common name
Tageteseretа			Chlorisgayana	Rhodes grass
Cynodondactylon			Crotalanahollandiae	New Holland rattlepad
Gomphrena sp.			Cymbopogonambiguus	
Chrysanthemum sp.			Cymbopogonbombycinus	
Themendatriandra	Kangaroo grass		Triodiamolesta	spinifex
Cyperusvictoriensis			Gomphrenacanescens	
earthworms			Astreblasquarrasa	Bull mitchell
Canna sp			Papyrussp	

Source: Author 2013

5.3.5 Areas of further research

This study has looked at the conceptual approach in developing a sustainable urban park design through dumpsite rehabilitation and the steps taken in its realisation. To concretize the other stages of design work out on functionalism of spaces, the developer need a clear understanding in specification of plants, introduction of animals and wildlife, formulation of the master plant, rehabilitation of a electronic filled dumpsite.

- **Research in Plants speci ication**

There is need for the study to understand the specific trees, shrubs, and groundcover which will thrive in a dumpsite environment. Considering there is a lot of alien metals and non-metals, hazardous and electronic waste in the dumpsite soil and water. The researcher needs in depth understanding in phytoremediation and phytotechnology. This will help the implementation of a sustainable urban park in plant specification.

- **Form of urban park elements**

There is need to understand a variety of issues and information from all the institutions in developing a master plan. Sustainable design largely explains components and approaches required to attain. But it fails to address the issue of the best form which needs to apply to realise sustainability. In addressing form the study would seek to understand how form would be used to symbolize the urban phenomenon.

- **Rehabilitation of an electronic dumpsite.**

With the growing use technology and use of electronics, several municipal waste management institutions have set up modern landfills. An understanding of sustainable urban design for hazardous and electronic components is necessary.

- **Integration of land ills in urban setting**

With rapid urbanization it would be necessary to look for ways of integrating the landfills within the areas of activity. Rather than secluding places of dumping at city peripheral.

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