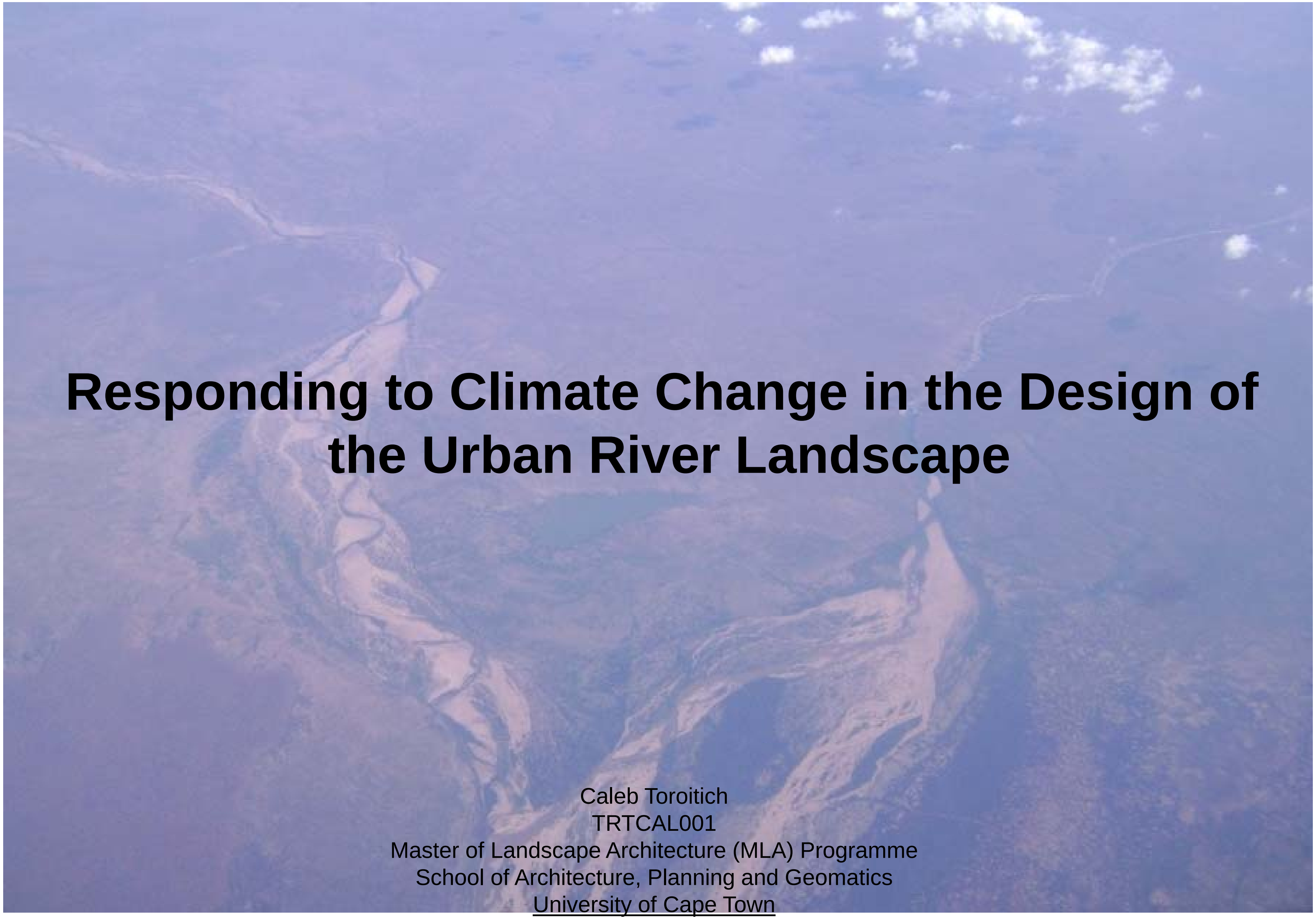

Responding to Climate Change in the Design of the Urban River Landscape

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List of Acronyms

IFLA	- International Federation of Landscape Architects
UNEP	- United Nations Environmental Programme
UN-Habitat	- United Nations Human Settlements Programme
UNEMG	- United Nations Environment Management Group
IPCC	- Intergovernmental Panel on Climate Change
UNFCCC	- United Nations Framework Convention on Climate Change
CRED	- Centre for Research on the Epidemiology of Disaster
GOK	- Government of Kenya
D/N	- Daily Nation –A daily newspaper publication in Kenya
EAS	- East African Standard–A daily newspaper publication in Kenya

1.0 Introduction

Abstract

Two main challenges facing humanity today are *sustainable development* and avoidance of human-induced *climate change*. In many ways these two threaten human civilisation and development and the very existence of life on earth. These words are mentioned in UN conferences; in professional bodies' workshops; in the corridors of government departments; in school classrooms and among the general public. There is also extensive amount of literature on the same subjects. Many recognise the problems and try to look for solutions.

Climate change has impacted negatively on both rural and urban landscapes. River corridors uniquely cross through many environments and ideally should exhibit same character wherever it crosses irrespective of adjoining land uses. However, where it crosses urban landscapes, places of intense and varied land uses, human interference and abuse is most witnessed and recognisable. As more and more people migrate to urban areas, the situation is bound to get worse. New ways of planning and design of this landscape, especially in the face of adverse effects of climate change, should be sought.

This dissertation seeks to be part of this endeavour: to propose methods of how the urban river landscape can or should be moulded to reduce the impact of climate change first on its ecological integrity and balance and secondly to its socio-economic and cultural aspects to urban dwellers.

1.1 Problem Statement

All human activity occurs within watersheds and whatever land use is applied to the watershed will have a direct impact on the river valley landscape. With climate change, the impact is bound to be more adverse.

First, the increase in frequency and volume of water during heavy storms cause a ripple effect of river landscape destruction: removal of vegetation cover, soil erosion, landslides, destruction of infrastructure (such as bridges, electric power lines) and human settlements being submerged. This also lead to increase in infectious disease such as malaria and cholera particularly in informal settlements.

Secondly, as temperatures rise, larger tracts of land become drier. This means human activities such as agriculture will be practiced more in the river landscape where the water table is high, soil is moist and there is relative availability of water. This demands a shift in the planning and design of these areas.

Thirdly, the integrity of the river ecosystem is interfered with because the natural regimes and cycles are disrupted. Furthermore, prolonged drought and increase in desertification lead to the destruction of some flora and fauna. The damage caused to natural and man-made landscapes also lead to disruption of ecological processes and environmental conservation. This contributes to the biodiversity and food crisis being experienced the world over.

Fourthly, eroded river banks, leaning electric power lines, collapsed bridges all contribute to destruction of the visual quality of the river landscape. This ironical y is the opposite of what river landscapes are as a resource environmental aesthetics and recreation.

In terms of socio-economic development, there are many losses incurred when the landscape base (spaces, buildings and other landscape elements are washed away by floods. Collapse of infrastructure (such as bridges) draws back development and sustainability as more resources are required to restore them.

Generally, this infrastructural and landscape destruction, together with human mortality, are experienced mainly in the developing countries because they are ill equipped technologically and expert wise to cope with changes. Within these countries the poor sometimes live in informal settlements usually along urban river edges or at the periphery of the city. They occupy land in floodplains near city centres that is not ideal for residential use.


CAPE TIMES TUESDAY, SEPTEMBER 4, 2007

KEY ROAD MAY NEED REROUTING

City warned to plan for 'devastating' climate change

Figure 1.1 Part of an article carried in the *Cape Times* daily newspaper. The effects of climate change have been felt across the world and many cities, governments and regions are planning on adaptation strategies. (source: Cape Times, 4th September 2007)

There is need therefore to rethink the approach the society has appropriated land near watercourses in urban environments. A change of attitude is necessary starting with the politicians through to the landscape professionals who advice on the actual planning and design.

Figure 1.2 image of a building that collapsed on the banks of Nairobi river, Kenya. This image appeared in a newspaper and the caption read: "This is what remained of a popular Riverside Hotel on Racecourse Road which had been built over the murky, rolling waters of the Nairobi River, whose banks caved in..." (source: Daily Nation (D/N), 31st January 1998)

Figure 1.3 A collapsing bridge on Kiambu road, Nairobi. (source: D/N, 19th January 1998)

Figure 1.5 Part of submerged Mathare informal settlement along the Mathare river, Nairobi. "No place to hide for Mathare residents whose makeshift shelters were submerged in the deluge." (source: D/N, 19th January 1998)

Figure 1.6 People fetching water for domestic use at Uhuru park, downtown Nairobi on 3rd October 2008 after the taps ran dry. "Water has become a scarce commodity in many parts of the city following low levels in the dams that supply water to the city" (source: www.nation.co.ke/News, 4th October 2008)

1.2 Scope and limitations

This research will concern itself with the landscapes of urban river valleys or river corridors. It will particularly look into the interface of natural and cultural elements: that is the meeting point of infrastructure and stream flow and flood plains and human settlement.

The dissertation will focus on environmental planning and design of the river landscape in response to climate change. It seeks to interpret scientific knowledge produced by experts in the fields of climatology, global warming and carbon emissions, civil and river engineering , ecology and from general environmental studies. It will limit itself to those issues of climate change that have bearing on the design responsiveness within the river corridor as it crosses the constantly changing urban environment.

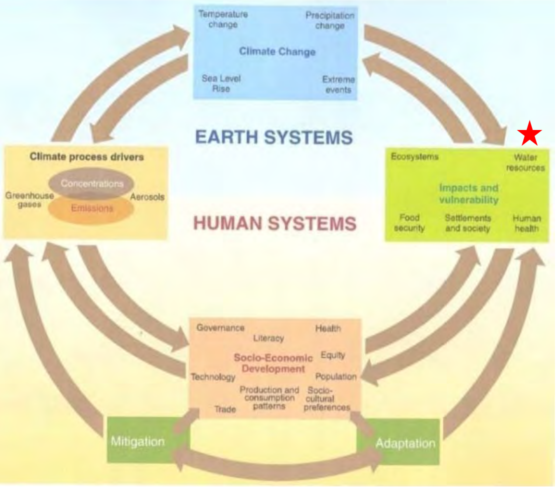


Fig. Schematic framework of anthropogenic climate change drivers, impacts and responses. This study seeks to understand and respond to effects of climate change on the river landscape, one of the 'containers' of fresh water resources (marked ★) (source: IPCC, 2007)

1.3 Research Questions

So the big question is what role does landscape architecture play in the efforts to mitigate on the impacts of climate change? Specifically , the study asks itself the following questions:

- Of what socio-economic, cultural, spiritual, aesthetic and ecological value is a urban river corridor to urban development
- What constraints and opportunities exist in the river corridor in the face of adverse effects of climate change
- How different are the effects of climate change on urban river landscapes compared in to seasonal or cyclic changes such as storm surges
- What are the specific stream bank, bed and floodplain protection, restoration and enhancement measures exist and/ or should be designed
- How can river edge landscapes be moulded for prevention of flood hazards, prevention of soil erosion, food production, safety, effective maintenance of landscape design elements (paving, lighting, seating, waste bins, signage) and for cultural and natural heritage
- What design and management steps should be taken to ensure quality of water in urban rivers is suitable for socio-economic and ecological purposes
- What are the appropriate design and technological approaches required for material specification and landscape elements placement along the river landscape

1.4 Study Justification

Today, no one may talk about sustainable development without addressing the issue of climate change. Human-induced Climate Change at the global level occurred due to cumulative effects of actions and human activity at the local scales. Whether it is inappropriate land use , industrialisation or clearance of vegetation cover that ultimately cause excessive carbon in the atmosphere, it is important to realise that all occurred at a specific landscape precinct and any efforts toward alleviating the problem or adapting to it should also be through appropriate design , planning and management of landscapes at the local or precinct scale.

This study focuses on the design of the river landscape because it is here that a greater impact of climate change is made manifest: extreme weather conditions cause two extreme periods of dry river beds and flash floods. Urban landscapes are the places majority of the human population live and therefore worthy of all attention in the management of such change.

The design part of this study focuses on an urban river landscape in the city of Nairobi, Kenya. The UN-Habitat and the government of Kenya have embarked on a Slum-upgrading project where informal settlements are being re-designed and new high density houses put up. Sadly, nearly all Informal settlements in Nairobi are in river valleys. It is therefore important that insights into sustainable design of such projects are sought for better decision-making. The ministry of Environment and Mineral Resources, Kenya in collaboration with UNEP has embarked on another project of cleaning Nairobi rivers, all rivers in the Nairobi River Basin. This initiative is in realisation of how a major natural resource, the river and its edge, has been abused and underutilised and that it can be designed and managed for socio-economic and environmental benefits to the city of Nairobi. This benefits can only be achieved through holistic design of the river landscape by landscape professionals rather than one-sided engineering or ecological professionals.

With rising temperatures and dwindling water resources, we must expand water storage and aquifer recharge capacities. Our survival depends on water. Growing populations and accompanying urbanisation are real threats to the supply and management of water -supply in terms of ensuring sustained river flow, aquifer recharge with enough quantity and good quality water.

2.0 Research Methodology

This study is divided into two parts (Table 1): Theoretical Research and Design Project. Both parts adopted qualitative and quantitative research methods.

2.1 Part one

This part is theoretical research in which existing information on climate change, its effects on river landscapes and possible landscape planning and design solutions is collected, collated and analysed. Part of this information is on relevant historical and recent projects or methods in which people in different parts of the world used to adapt to the constantly changing physical, biological and chemical properties/ variables of riverine ecosystems. The information sought was basically on what problems or design challenges were present (such as flood control) the size of projects and their qualitative aspects (such water treatment and state of biodiversity). Of importance was also the magnitude of changes in climatic conditions, first in the globe and in developing countries. Developing countries partly because part two focuses on design in a developing country, Kenya.

Data was primarily obtained from secondary sources such as existing literature (text books, recent journal publications, documents from various organisations/ cities, conference papers and media reports) as well as the World Wide Web and relevant films. This information is interpreted, analysed and evaluated to determine relationships of events (natural and human), their implications on other human and natural systems, design solution themes and so on.

Generally, the findings from this part are assessed for any contributions to adaptability, mitigations and sustainability of urban river landscapes. Finally, for part one, the findings inform the formulation of the overarching landscape planning and design principles relevant for adoption in the design and management the urban river landscape.

2.2 Part two

This is about application of the design principles formulated in the design of a selected urban river landscape. The landscape selected is along the Ngong river in Nairobi, Kenya. In addition to the principles, the design process must take into account the context of the project. This part therefore also involved collection of data to determine the opportunities and constraints relevant to the place.

Data collection in this part was also quantitative as well as qualitative. For example it was necessary to determine whether the river is permanent or seasonal, high and low stream flows, floodplains, level of bed and bank erosion, level of urban encroachment, changes in climatic conditions and so on. It was also important to determine the state of water quality and landscape visual quality. Data was collected through field survey. This is recorded in photographs, sketches and interview questionnaires and checklists. Useful information was also obtained through secondary sources such as topographic maps, aerial photographs, geology and soil maps and GIS for Nairobi; journal articles, daily newspaper publications and other media reports. The World Wide Web also came in handy.

Analysis of this data is divided into natural and urban systems. This is basically to determine how each has influenced the functioning of the other. For example it is important to determine the effect of road bridges and informal settlements on water flow and quality. Evidence and effects of climate change in the region and Nairobi are also analysed.

In consideration of all relevant opportunities and constraints, data analysis inform the conceptual planning, landscape design framework, specific site designs, details and specifications. These may finally lead to review of institutional and legislative framework for better and sustainable management of urban river landscapes.

Table 1

Research Method and the Design Process

	Part 1 **Theoretical Research**	Part 2 **Design Project**
Data Collection	**Secondary Data (Literature Review)** **Effects of Climate Change on River Landscapes** ❑ Global perspective ❑ Developing countries perspective ❑ River Landscapes ❑ Vulnerability ❑ Adaptation and Mitigation **Case Studies** ❑ Context and Problem or Design Brief ❑ Engineering and/or Landscape design responses	**Primary Data (Field Survey)** **Qualitative** ❑ Structure and pattern of land use in the selected urban river landscape ❑ Water quality ❑ Visual appearance ❑ Ecological integrity ❑ Biodiversity **Quantitative** ❑ River flow (seasonal and cyclic changes) ❑ Vegetation cover ❑ Animals ❑ Soil erosion ❑ Recreation ❑ Open spaces ❑ Flood plains **Secondary Data** **Contextual** ❑ Geology ❑ Topography ❑ Climate ❑ Soils ❑ Vegetation ❑ Hydrology ❑ History of place
Analysis	**Relationships and Implications/ River dynamism** ❑ Ecological issues ❑ Social issues ❑ River Engineering solutions ❑ Economic implications ❑ Infrastructural services ❑ Recreation ❑ Cultural issues **Design Themes** ❑ Lessons learned	**Natural Systems** ❑ Metropolitan Scale ❑ Local Scale ❑ Site Precinct Geology Topography Climate Hydrology Soils Flora and Fauna **Urban Systems** ❑ Metropolitan Scale ❑ Local Scale ❑ Site Precinct Movement Storm water Housing Infrastructure and Utility services Industry Open spaces
Findings	**Landscape design contribution** ❑ Sustainability of the Urban River landscape ❑ Benefits to Urban development ❑ Ecological integrity ❑ Recreation	**Constraints and Opportunities** ❑ Urban River landscape resources ❑ Land ownership/ Land use hazards /River integrity ❑ Concept formulation/ Mitigation Strategies ❑ Design Frameworks ❑ Site Planning and Design ❑ Details and specifications ❑ Space use guidelines
Conclusions and Recommendations	**Planning and Design of Urban River Landscape** ❑ Philosophical position ❑ Overarching design principles ❑ Management Framework	**Implementation and Management** ❑ Phasing ❑ Institutional framework ❑ Legislative framework

Responding to Climate Change in the Design of the Urban River Landscape

3.0 Literature Review

3.1 Effects of Climate Change on Rivers

3.1.1 Background

Climate Change is a function of global warming. Global warming is a function of increase in temperatures which is caused by the trapping of heat from the sun by greenhouse gases in the atmosphere. Atmospheric greenhouse gases such as carbon dioxide, nitrous oxide and methane have increased tremendously with global economic growth. Man's appropriation of land for economic development has not been consistent with the workings of natural systems; there has been growth in the worlds economic system at the expense of the environmental system –the ecosystem

Naturally, the earth with its complex systems, warm up and cool down. This is a continuous natural process, with or without human intervention, which cause changes in weather patterns that we are familiar with –dry or wet seasons. However, human activities have caused a steep and sudden warming mostly through indiscriminate, limitless and systematic exploitation of natural resources in the name of development. This has inevitably resulted in the devastation both natural and human systems. In the natural, we have seen ecological degradation and imbalance of delicate natural processes that cause extinction of some species of plants and animals. Humans in various places are affected by droughts and floods which in turn lead to human conflicts (mostly over water -springs and rivers and grazing land); economic stagnation due to destruction of infrastructure by floods; and social depravation caused by loss of life.

Intergovernmental Panel on Climate Change (IPCC, 2001) defines Climate Change as "the statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use." It is a trend in which one or more climatic variables is characterized by a fairly smooth continuous increase or decrease of the average value during the period of record (IPCC, 2001 in Mukheibir, P et al, 2007). This study concerns itself more with the aspect of land use: how we can plan and design our landscapes to adapt to climate change; mitigate on projected adverse effects and reduce on further change. This can be achieved by 'reading' and understanding the 'logic' of the natural landscape for its inherent carrying capacity, sensitivity and prohibitions to various land uses. It is what Spirn, A .W (2008) calls 'Landscape Literacy': "To be literate in landscape is to recognize both the problems in place and its resources, to understand how they came about, by what means they are sustained, and how they are related."

In rivers, it is expected that there will be extremes in flooding and dryness. This is already happening in most parts of the world. In most areas, their occurrence is much more unpredictable.

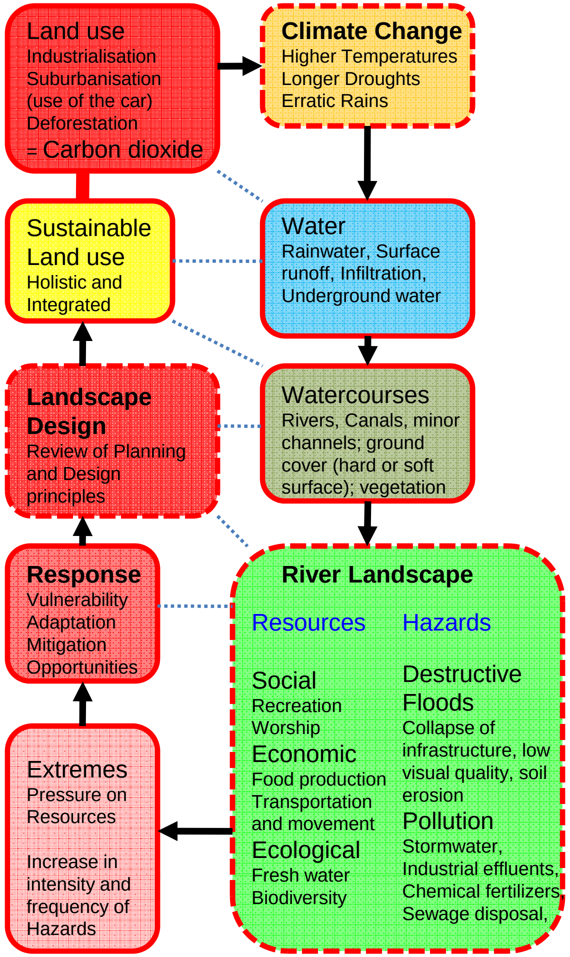


Figure 3.1 Overview of the link between land use, climate change, its effects on the river landscape and the need to adapt sustainable methods of design as well as natural resource and landscape management (source: author)

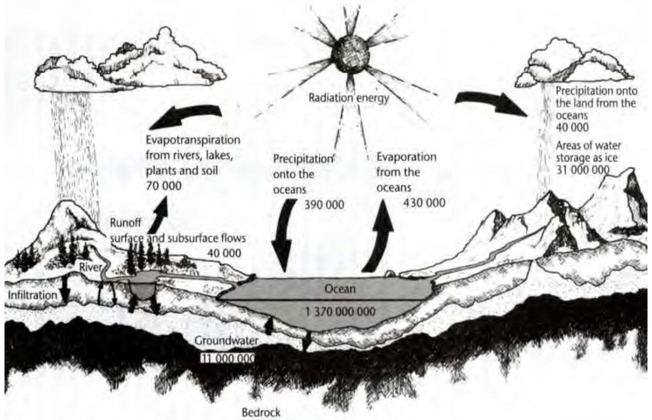


Figure 3.2 The water cycle. 'Water evaporate from surfaces of oceans, rivers, lakes and wetlands, condenses into clouds and falls again as rain, mist, snow and hail'. The nature of water is dependent on climate (atmospheric conditions) and land use (surface conditions). An alteration of one of this variables triggers change and a ripple effect on the others, globally as well locally. (Figures in km^3) (source: Davies, B., et al 1998)

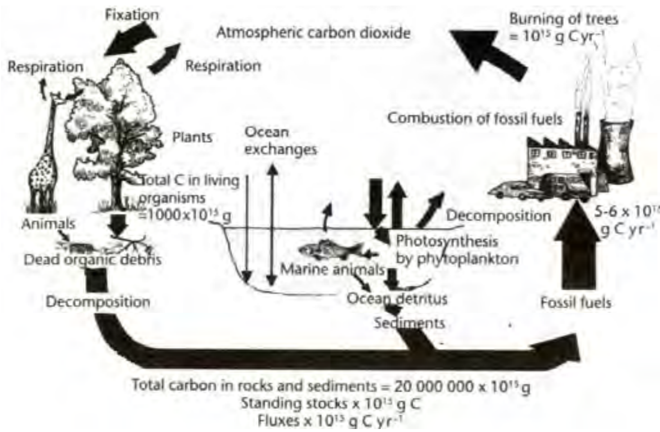


Figure 3.3 The carbon cycle. Like water, carbon naturally changes from one state to another with associated effects on the atmosphere and land. The way land is used determines how this is kept in natural balance. Values for standing stocks (such as plants and animals) x 10^{15} g C and for carbon fluxes (exchange) x 10^{15} g C per year (source: Davies, B., et al, 1998)

Climate change is inevitable, whether naturally occurring or human-induced. We must employ technological, biological, engineering and ecological methods to maintain and enhance both rural and urban landscapes through sound, holistic and integrated landscape planning and design. Where else does this most apply, if not in the riverside landscape, one of the most sensitive of natural environments worthy of non-negotiable protection.

3.1.2 The Global perspective

Much of the earth surface is covered with water which is salt sea water. The availability of fresh water required for human, animal and plant survival is limited. Fresh water (which comes as rain and/ or underground water) is scarce and is found in rivers, some lakes and wetlands (such as ponds, swamps, bogs). This scarcity is aggravated by climate change (due to increased evaporation and long droughts) and population growth. This study focuses on rivers, a dynamic system that supplies highest percentage of fresh water.

Excess carbon dioxide in the air is by far the cause of global warming and this is brought about by human activities: industrial pollution, use of the car and deforestation. The processes involved are beyond the scope of this study. But illustrations of the water and carbon cycle (Figures 3.2 and 3.3) have been shown to demonstrate interconnectedness of man's biophysical environment. Norberg-schulz, C. (1980) rightly argues that "places" are determined by the concrete properties of earth and sky; the ground obviously being the most stable element, although some of its properties change with the seasons, but the more variable and less concrete sky also plays a "characterising" role of decisive importance.

Martin, J. (2007) states that "in 1990 humankind artificially pumped about 16 billion metric tonnes of carbon dioxide into the atmosphere; by 1999 that figure had risen to 25 billion. In the last few decades the concentration of carbon dioxide in the atmosphere increased by 25%." According to the IPCC (2001), global surface temperature is estimated to have increased by 0.6°C since the late nineteenth century, with the 1990s being the warmest decade. Mean daily surface minimum temperatures appear to be increasing at a faster rate than maximum temperatures (0.2°/decade versus 0.1°C/decade). This has destabilised rhythms of natural processes in the atmosphere (such as air movement, humidity and on land over time.

The rise in global temperature triggers a series of change in other weather patterns such as frequency and variability of rainfall and creation of pressure zones that cause wind velocities not experienced before. The weather patterns are irregular: on the extremes of low and high, their occurrence and frequency unpredictable, their duration longer or shorter than known. All these have serious impacts on rivers and it behoves us to rethink the way we have used the land beside rivers in an attempt to ensure continued water availability among other benefits.

Martin further argues that "if today's energy technology is not changed, there may be an average temperature rise of 5 degrees Centigrade in the next 50 years. That sounds small, but, amazingly, the difference in average global temperature between today and the last ice age is only around 5 degrees Centigrade." Changes in temperature has caused the melting of ice fields in the Antarctic regions and ice caps on mountains and consequently the rise in sea level. "Glacier retreat will continue, and many small glaciers may disappear" (IPCC 2001).

McHarg, I. (1969) rightly argues that "despite nature's many early warnings, the pollution and destruction of the natural environment has gone on, intensively and extensively, for the last three hundred years, without awakening a sufficient reaction; and while industrialisation and urbanisation have transformed the human habitat, it is only during the last half century that any systematic effort has been made to determine what constitutes a balanced and self-renewing environment, containing all the ingredients necessary for man's biological prosperity, social cooperation and spiritual stimulation." Now climate change has forced humanity to reconsider the way it exploits natural resources.

In response and recognition of the global problem, organisations that research and report on the climate change phenomenon have been established. These are at the international as well as national and local levels. Many state governments, non-governmental organisations and individuals have initiated awareness campaigns to sensitise societies on the need for change of attitude and living styles. Their campaigns are in form of political, social, economic and environmental public awareness; and in scientific publications such as books, journals, websites, documentaries and films including the well known *An Inconvenient Truth* by Al Gore, former United States vice president.

Internationally, there are two main organisations that are recognised by majority of states (some people don't agree with their arguments or findings, for example in the documentary *The Great Global Warming Swindle*). These are the Intergovernmental Panel on Climate Change (IPCC) established in 1988 by World Meteorological Organization and United Nations Environnemental Programme (UNEP) and the United Nations Framework Convention on Climate Change (UNFCC). UNFCC was opened for signature in the UN Rio de Janeiro Summit in 1992 and came into force in 1994.

(a) (b)

Figure 3.4 (a) Flooded street in Cedar Rapid, Iowa, USA. (b) Areas of land flooded after levees breached In Illinois, USA. Water is the main issue as far as climate change is concerned –either too little, too much or none at all. The question is, how do we adapt? (source: www.yahoo.com, 18th August 2008)

IPCC role is to assess in a comprehensive, objective, open and transparent basis the latest scientific, technical, and socio-economic information produced worldwide relevant to the understanding of human-induced climate change, its potential impacts, and options for mitigation and adaptation (IPCC 2001). These organisations have well documented science-based research findings on climate change. UNFCC in particular, has published the various ways in which different communities at the local or site level have responded in their own ingenuity to the problem –in response to disasters such as flooding, droughts, aridity, soil erosion and sea level rise.

Tirpak, D. (2005) defines adaptation as "an adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits beneficial opportunities." He further argues that various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation and autonomous and planned adaptation. This study is concerned with all the above types except the reactive type. It is preferred that the society prepares for uncertainty and increase its adaptive capacity before hand. Adaptive capacity is the ability of a system to adjust to climate change, including climate variability and extremes, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2001).

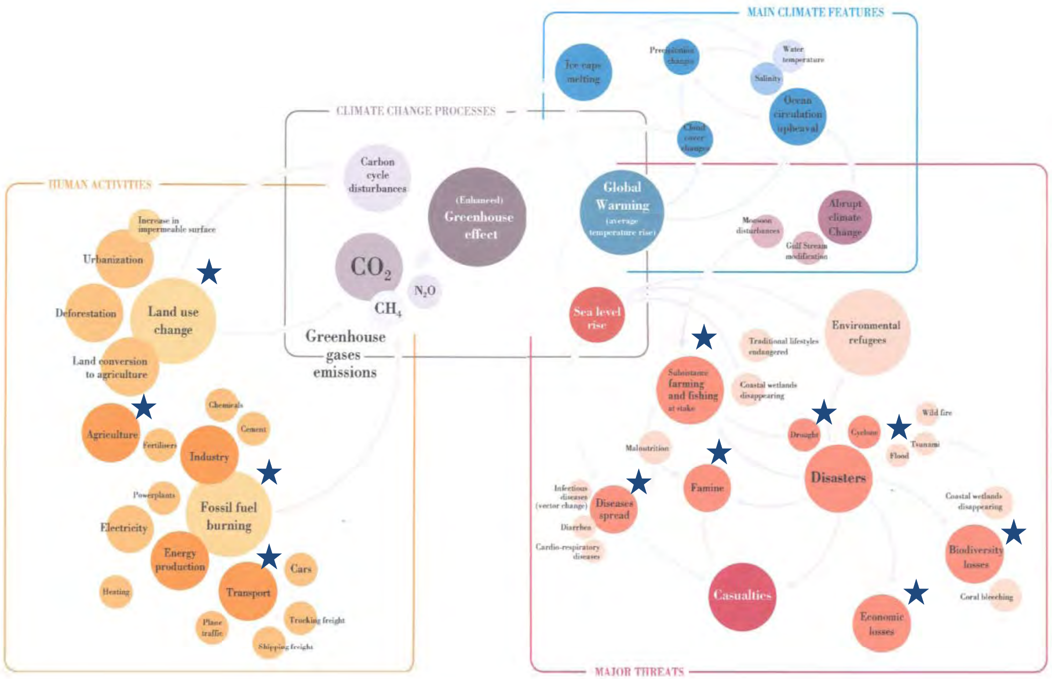


Figure 3.5 Climate Change global processes and effects. This study concerns itself with nearly all the human activities and major threats (marked ★). In many ways these have a direct impact on urban river landscapes (source: UNEMG, UNEP/GRID-Arendal, 2008)

Some of the actual and projected effects of climate change on water resources, particularly on steamflow include (IPCC 2001):

- Streamflow and groundwater recharge varies regionally and among scenarios, largely following projected changes in precipitation
- Flood magnitude and frequency are likely to increase in most regions, and low flows are likely to decrease in many regions
- There will be increase in streamflow in high latitudes and southeast Asia and the decrease in streamflow in central Asia, the area around the Mediterranean, and southern Africa
- Peak streamflow will move from spring to winter in many areas where snowfall currently is an important component of the water balance. This is associated with observed increases in temperature
- Increase in temperature lead to increase in evaporation leading to decreased streamflow (Figure 3.6)
- Water quality generally would be degraded by higher water temperatures. The effect of temperature on water quality would be modified by changes in flow volume, which may either exacerbate or lessen the effect of temperature, depending on the direction of change in flow volume
- Challenges to existing water resources management practices by adding uncertainty. Integrated water resources management will enhance the potential for adaptation to change
- The impact of climate change on water resources depends not only on changes in the volume, timing, and quality of streamflow and recharge but also on system (human and natural) characteristics, changing pressures on the system, how management of the system evolves, and what adaptations to climate change are implemented

Climate change will lead to poleward movement of the southern and northern boundaries of fish distributions, loss of habitat for cold- and coolwater fish, and gain in habitat for warmwater fish

(a) (b)

Figure 3.6 Changes in precipitation may lead to very low river flow. Or no flow at all. (a) Intermittent Augeigus River, South Africa and (b) "Not a road, but a dry river-bed in the Karoo," (source: Davies, B. Et al, 1998)

Demand for water is increasing as a result of population growth and economic development. Zevenbergen, C (2008) argues that cities are evolving systems that have limited capacity to adapt proactively to the rapid changes of urban growth, urban poverty and climate change and are losing the ability to anticipate and deal with natural hazards such as floods and droughts."

Droughts have increased in many areas of the world. Desertification is also increasing. Australia, for example, has had severe droughts, in some places cutting farm incomes in a half (Martin, J. (2007). The South polar area is cooler while Australia itself is becoming slightly warmer –this causes the wind system to spin faster, dragging the winter and spring rain into the ocean south of the country (ibid). Australia will thus experience severe droughts and reduced food production. The limited water resources must therefore be optimally harnessed for production. Water must be re-used and recycled, and waste avoided.

Generally, climate change is a global problem requiring collective effort in mitigating its adverse effects. Although global, the problem comes with local challenges and opportunities. Landscapes, particularly along rivers are extensively disturbed; hardly will you find a naturally functioning river system. River restoration and enhancement efforts are specific to river systems but the concepts of adapting to situations of excess or hardly any water flowing adopt general principles that 'relate to over-arching concerns and values that tend to be universal and normative in nature' (Oberholzer, B., 2007).

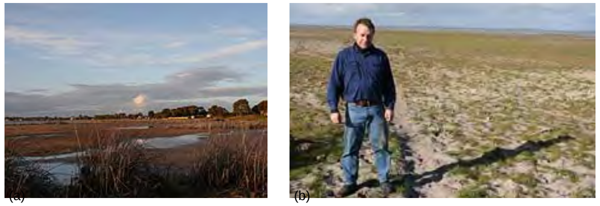


Figure 3.7 Long droughts means increased evaporation. (a) Lake Albert's, South Australia. The waterline has receded, leaving pools of acrid water. (b) Farmer Nigel Treloar on land once brimming with water, South Australia; the land is now a desert (source: www.bbc.com, 28th August 2008)

Adaptation requires a holistic long-term perspective that considers not only the risks, opportunities and limitations posed by current and future climate conditions, such as changes in mean climate, patterns of variability, and extremes – including Monsoon rains, hurricane seasons, drought periods, and the frequency of El Niños – but also societal changes due, for example, to population growth, changes in demographics, movements between rural and urban populations, the availability of and access to technology and information, and evolving systems of governance (Tirpak, D., 2005). All these are interrelated and should work together to cushion society's against environmental hazards and loss. The strategy is to increase landscape adaptive capacity and reduce vulnerability.

The ultimate goal should be to ensure continuity in people's social wellbeing, economic productivity, environmental conservation, spiritual enrichment, cultural preservation and political stability. We should strive to ameliorate on effects of climate change as much as we can: our heritage should not be washed away with the floods or dried away with the droughts when its within our power to act.

3.1.3 Developing countries

According to the United Nations, developing countries are countries whose income per capita is less than 1 US dollar. They are located in Africa, the Middle East, Latin America and Asia. But most of them are in Africa. They are generally characterised by socio-economic and political instability, short lifespan, high birth and mortality rates, abject poverty and high rural-urban migration.

More than anywhere else, African countries bear the brunt of climate change. "Africa is not a driver of climate change, but a victim." (Commission for Africa, 2005 in Douglas, I. et al, 2008). Although the climate change transcends regional or country boundaries (not only affecting the poor but also the rich countries) the vulnerability of the developing countries is evident mainly due to lack of economic power adapt. "Vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes." (IPCC, 2001).

IPCC (2007) report on specific forecasts of climate change in Africa is as follows:

- In the future, rising temperatures are projected to cause more frequent and more intense extreme weather events, such as heavy rainstorms, flooding, fires, hurricanes, tropical storms and El Niño events
- It is likely that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and heavier precipitation
- There is likely to be quite marked winter drying in southern and northern Africa, but an increase in December, January and February rainfall in equatorial East Africa

Majority of the people living in African cities are poor. Characteristically, most of them occupy public open spaces (including floodplains) close to places of economic activity such as industrial areas and city centres. They put up shanty structures that are not adapted to moist conditions or heat. Since they are usually illegal or informal settlements, they not in municipal and government's spatial development agendas. They therefore lack basic infrastructure such as for stormwater management; sewage and solid waste disposal; roads, cyclepaths, walkways and bridges.

As 'the weather become increasingly volatile in Africa' (Commission for Africa, 2005 in Douglas, I. et al, 2008), extremes of flooding and droughts are expected.

Flooding

Cities are expected to flood mostly because of the aforementioned informal set-up of most physical structures and infrastructure. This problem is confounded by increasing urbanisation (which lead to more impermeable hard-paved surfaces, less vegetation and thus increased run-off).

Adaptation to climate variability is nothing new. People since time immemorial have been responding to weather changes of wet and dry seasons. In a study undertaken by ActionAid (a humanitarian organisation) on 'flood problems in poor communities' to assess the vulnerability of people living in vulnerable areas in five capital cities representing different areas of Africa (Accra, Nairobi, Maputo, Lagos and Kampala) it was found that, "by identifying the causes of their vulnerability, communities can set up their own coping mechanisms to mitigate the effects of hazards such as floods." (Douglas, I. et al, 2008).

However, with climate change, the situation is worsening and local communities are unable to cope. Known seasonal changes are now unpredictable. For example in Accra, Ghana, respondents "noted that it used to rain heavily in June and July, but since 2000 the heavy rains sometimes start earlier than June or continue beyond July, making it difficult to prepare for flooding." (ibid)

Some storm and flood events that show climate changes in Africa and its vulnerability have been reported by Douglas, I. et al (2008):

- In February and March 2000, heavy rains and cyclones in Mozambique led to the worst flooding in 50 years and brought widespread devastation to the capital city, Maputo, as well as to the city of Matola.
- In 2002, heavy rains caused by unusually high temperatures over the Indian Ocean killed more than 112 people in East Africa (Rwanda, Kenya, Burundi, Tanzania and Uganda). For example in Kenya, floods and mudslides killed 46 people in two weeks. In Tanzanian urban communities, hundreds of families were left homeless, and damage to crops threatened food security
- In August 2006, in Addis Ababa, floods killed more than 100 people and destroyed homes in eastern Ethiopia after heavy rains caused a river to overflow
- Between 1931 and 1990 there were significant increases in the intensity of extreme rainfall events in about 70 per cent of South Africa. Increases in the intensity of high rainfall events have been greatest for the most extreme events.

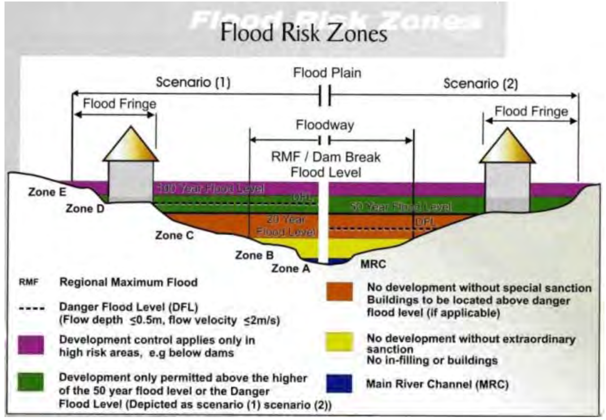


Figure 3.8 Flood Risk Analysis of a river landscape. This provides guidelines for 'where' and 'where not' to build. Rarely are these guidelines followed in cities and the consequences are dire (source: www.capetown.gov.za, 2nd July 2007)

Figure 3.9 'Displaced residents of Mathare North (informal settlement along Mathare river, Nairobi, Kenya) helplessly view the floods from the rooftops of their houses'. Occupation of floodplains is always inadvisable (source: D/N, 16th January 1998)

Figure 3.10 Flooded section of road in the North coast, Mombasa, Kenya. Flooding in urban areas cause damage to infrastructure and property as well as inconvenience and diseases to people (source: Daily Nation, 16th January 1998)

Droughts

Meteorological drought is defined as a sustained period (three months or more) in which monthly precipitation at a given location is significantly below the long-term average (CRED International Disaster Database and UNEP in City of Cape Town, 2002). A large portion of Africa is dry. There are large expanse of deserts: the Sahara, Namib , Libyan and Kalahari deserts among others. These are regions of the Earth that are characterized by less than about 250 mm of annual rainfall, and, in most cases, an evaporation rate that exceeds precipitation, and a high average temperature (Microsoft Encarta, 2006). Alteration of spatial and temporal patterns in temperature, rainfall, solar radiation, and winds from a changing climate will exacerbate desertification (IPCC 2001)

Long periods of drought are already being experienced in most parts of the continent. This has negative impacts on socio-economic systems of people in the continent. For example in Kenya, a country of about 34 million people, 1.2 million were exposed to droughts in the period 1980 – 2000 (Figure 3.12). In the same period there were reported, on average, about 8 deaths annually. In Ethiopia, there were reported about 12,000 deaths annually. This points to the fact that there is need to respond adequately by at least storing up water for use in times of need.

Besides the effects on people, ecological systems are also disturbed. Extremely long dry seasons may lead to extinction of some plant and animal species, even in areas that are not necessarily deserts.

The IPCC (2001) reported the following scenario for Africa:

- The dominant impact will be a reduction in soil moisture in subhumid zones and a reduction in runoff
- Over most sub-tropical regions, rainfall is likely to decrease by as much as 20 per cent
- A synergy of land-use and climate change will exacerbate desertification.
- Trends in regional per capita water availability in Africa over the past half century show that water availability has diminished by 75%

The existing shortage of water is bound to get worse. Water resources are a key area of vulnerability in Africa affecting water supply for household use, agriculture, and industry (IPCC, 2001). Developing countries have the highest number of people migrating to urban areas. By 2030, 80% of the population in Africa will live in cities; and as urban areas grow, their demand for water increases (Martin, J. (2007). There is need to consider possible water supply measures that could cushion this populations against water scarcity. Adaptive measures would enhance flexibility and have net benefits in water resources (irrigation and water reuse, aquifer and groundwater management, desalinization), agriculture (crop changes, technology, irrigation, husbandry), and forestry (regeneration of local species, efficient use of energy and sustainable community management).

The extremes of flooding and droughts are therefore a challenge that could be tackled with strategic solutions in urban landscape planning and design. It is clear that it is time for action to protect the integrity and productivity of landscapes, lives and lifestyles for today's benefit and the future. The issue here is water. As earlier mentioned, all water that falls within a particular river basin ends up in the river valley. In addition to water catchment protection strategies, the riverside landscape should be protected and utilised as well.

It should be designed to add value to its socio-economic, political, cultural, spiritual, environmental and recreational possibilities. This simply means increasing its adaptive capacity, specifically the ability to allow integrated water resources utilisation at regional, landscape and site levels. This certainly is a concern for landscape architects; to plan and design places that mitigate and adapt to such changes. The challenges are many and getting complex and 'it cannot be design as usual'

Figure 3.11 People fetching water for domestic use Uhuru park, downtown Nairobi on 3rd October 2008. Droughts lead to water scarcity. Although people live near flowing urban rivers, the water quality is poor and unfit for human consumption (source: www.nation.co.ke/News, 4th October 2008)

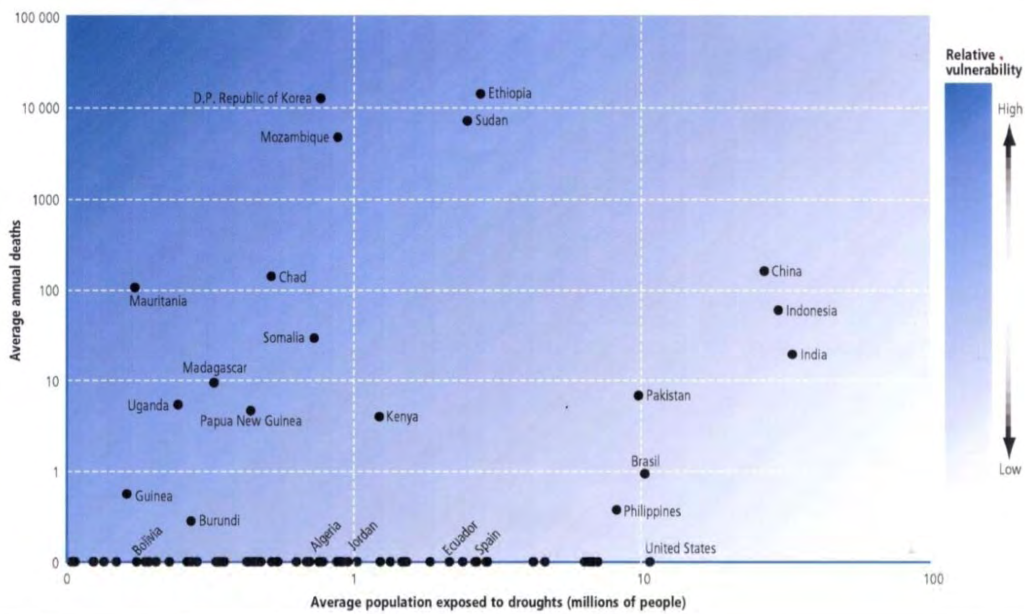


Figure 3.12 Relative vulnerability for Droughts in some countries of the world, 1980 – 2000. Developing countries especially in Africa are more exposed to droughts. This is bound to get worse with climate change (source: CRED International Disaster Database and UNEP/ GRID Geneva in www.capetown.gov.za, 3rd October 2007)

3.2.0 Design of the Urban River Landscape

3.2.1 The (Urban) River Landscape

A landscape is an area of land and the sky above it as shaped by natural processes and human actions over time – the outcome of natural and cultural systems. The size of the area may be 'a small patch of urban wasteland as much as a mountain range, and an urban park as much as an expanse of lowland plain' (Swanwick, C., 2002). According to Foreman R.T.T et al (1986) a landscape might range in size from hectares to square kilometres, comprising a heterogeneous area where ecosystems are repeated in similar form and interact. A river landscape is one of the most dynamic landscapes whose form and character changes drastically in time and space: from the river source to mouth; through steep slopes to floodplains; through undisturbed natural areas and disturbed urban settings ; from one weather season to another; and from one century to another.

In this study, the urban river landscape is that area of land where river flows through an urban area comprising varied land uses: industrial, residential, commercial, institutional, public and private open spaces and across, over, under different infrastructural utility elements (roads, sewer pipes, stormwater channels, oil pipelines and powerlines). The area of focus range in distance (transversely) from 100m to 300m from the river channel.

This study emphasises on the need to spare the urban river landscape for ecological functions that provide essential services to the city. This is in agreement with McHarg, I. (1969) ecological method of establishing metropolitan open space system: "the ecological method would suggest that the lands reserved for open space in the metropolitan region be derived from natural process lands, intrinsically suitable for 'green' purposes; that is the place of nature in the metropolis."

According to Penteado, M. (2004) the main ecological components of a river are:

- Hydrology processes including *river continuum* (river connectivity), floods, ground water, stormwater, and drainage
- Geomorphological structure/ function including soils, erosion, slopes
- Biological structure/ function including vegetation, seed propagation, habitats, wildlife (birds, terrestrial, insects), fish population.
- Particle flow including sediments, pollutants, nutrients

River continuum is an ecological concept that views all rivers as possessing continuous gradients of physical and chemical conditions are progressively and continuously modified downstream from the headwaters to the sea (Davies, B. et al, 19 98). For example "whatever happens in upstream reaches –a leaf being eaten, chemicals being leached from the soils, the death of an animal or plant –will influence downstream processes such as decomposition and nutrient cycling, and will also influence the communities of organisms downstream."(ibid)

In an urban river, the above components are modified by urban systems. Depending on each case, they could either be more complex or simplified than in a natural river. For ecological integrity, it should be intrinsic natural river processes that dictate what land use to be allocated . Generally they should be open spaces that accommodate only a limited number of light human activities (such recreation and informal trading). These activities should be in harmony with natural processes therein . It shouldn't be a mix of everything, as is the case in many cities today. It shouldn't be short-sighted urban developments based only on economic and political considerations. Such are not sustainable because the river landscape cannot contain all.

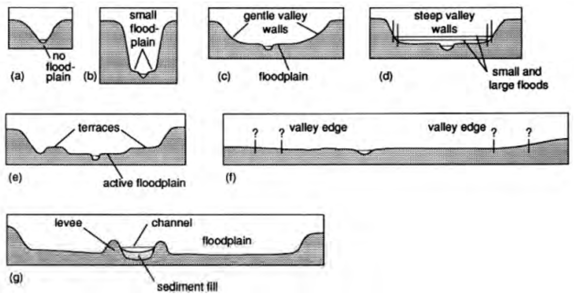


Figure 3.13 Common shapes of river valleys and flood plains. This study considers the river as it flows through an urban setting irrespective of the valley shape or flood plain size. (source: Marsh, M.W.,1998)

Figure 3.14 Illustration of some three river channel patterns. The patterns vary depending mainly on the geology of the place. Another factor is the level of maturity of the river, young (upper reaches) or mature (middle and/or lower reaches). Design therefore is in response to the dynamic characteristics of a particular section of the river (source: Hopper, L.J., 2007)

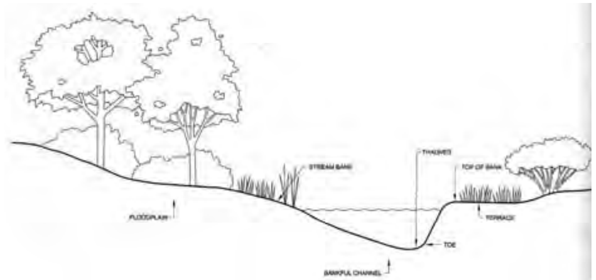


Figure 3.15 Components of stream. These are relevant to understanding the pressures on various components and therefore design for applicable adaptation and mitigation measures (source: Hopper, L.J., 2007).

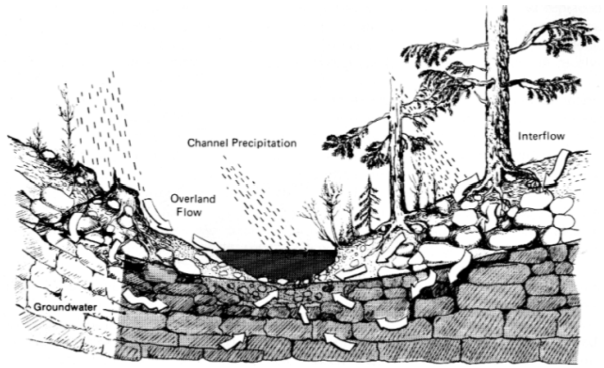


Figure 3.16 Sources of streamflow: channel precipitation, overland flow, interflow, and ground-water. The understanding of this is important in the design process as it relates to considerations for water quality and quantity in the river landscape. These must be analysed in consideration with geology, soils and vegetation of the place (source: Marsh, M.W.,1998)

3.2.2 Design

Landscape design is about creating environments in which there is harmonious relationship between people and place - natural place. Lynch, K., (1984) defines design as the search for forms that satisfy a programme, where a program is concerned with general characteristics and desired outcomes. Responding to climate change in the design of urban river landscape means to create places that adapt (are resilient) and mitigate (alleviate suffering and environmental degradation) on its adverse effects. Appropriate landscape forms and layouts should be sought to satisfy the need for sustainable urban environments. Unlike pure works of art that do not have functions, landscape designs, generally, do have functions; while they may also be works of art and significant interventions in the environment (Turner, T. 1996).

There is need to intervene in the way urban landscapes are moulded. These interventions range from urban and regional planning through to urban design and architecture and landscape architecture. Urban environments are constantly changing, becoming more complex and requiring holistic approach to its management. It is sad that, even where there is formal planning and provision of infrastructure services by municipalities, they are based on technical and mathematical calculations by engineers with little or no understanding of complex urban and natural processes. The places created are sterile, lacking in variety, choice and scale; are devoid of socio-economic and ecological considerations of users of urban spaces (such as recreation and informal trading); is archaic and without principles of environmentally sustainable landscape design issues of biodiversity, stormwater management (concrete water channels are provided instead), urban agriculture and plant and animal habitat. These are examples of what landscape architects can design for in our cities, mitigating on both global climate change, local floods and food crises resulting in sustainable urban landscapes. Unfortunately for developing countries, landscape architecture-skilled personnel are lacking and cities are run by engineers and architects.

"In its innate character it is landscape architecture that is integral and interdisciplinary." (Kuitert, W., 2008). Perhaps it holds the key to the solutions to complex urban problems. It is landscape architecture that can understand the complicated workings of the environment, the interdependence of man and nature, or man and water; that can present solutions on ways of shaping this interdependence into a new environment that works; that can create awareness that trascends the traditional technology-oriented manipulations of water in the landscape (ibid).

Design, as a process or product of analysis of existing human and natural physical and non-physical environment, must establish patterns and forms that fit desired human activity and in harmony with natural processes and change. Even without climate change, the river corridor requires special design strategies and approaches different from those of other areas of land. This is because of its centrality as the 'container of fresh water', the backbone of all human, animal and plant life. Most aspects of river planning, such as creation of ecological buffer zones and soft transition zones, are always non-negotiable. Any compromise lead loss of river connectivity causing hazards such as flooding of immediate riverside landscape and downstream.

The starting point is appreciation of the fact that the river landscape provides goods and services that cannot be obtained elsewhere. This include fresh water, green recreation environment and terrestrial and aquatic plant and animal habitats among others. It thus serves what Lynch, K., (1984) calls 'essential function': the designer first "abstract the 'essential' function of an environment, then develop a form that will best satisfy this general function, and finally adapt this ideal form to satisfy the other functions and constraints."

With climate change and its effects on rivers, its time we redefine the number one purpose of urban river landscapes. We must move away from the apathy and political indifference that has seen riverside landscapes being used for the most conflicting of activities such as industrial development and waste disposal. McHarg, I. (1969) rightly argues that "urban development must not be imposed upon the landscape regardless of the ecological consequences, but that necessary man-made structures can be accommodated with the existing natural order." People know how these landscapes should look like. Its only the economic forces of urban systems that lead to compromise. In the face of climate change, we have no option but to also change. We must respond for own good and survival.

Lynch, K., (1984) further argues that the discovery of a dominant function is analogous to linear programming: the optimisation of a single function, subject to constraints is a powerful way of dealing with complexity. He says the search for essential function is the working of designers who believe that places should have an all-encompassing, immediately grasped image, and are prepared to acquire that image at the expense of other ends. This, I belief, is the approach necessary in the design of urban river landscapes: first satisfy the ecological function since this is critical to satisfying the other functions (socio-economic, political and cultural)

Figure 3.17 Aerial view of a section of Liesbeeck river landscape, Cape Town. Wetlands are constructed along the river mainly for ecological purposes (Source: Rounsefell, M., 2005)

Figure 3.18 Aerial view of Trinity river corridor, Dallas –Texas (Source: www.trinityrivercorridor.org, 23rd August, 2007)

Figure 3.19 A recently restored urban river landscape along River Besos, Barcelona, Spain (source: Margolis, L. et al 2007)

Figure 3.20 The Don River Watershed, Toronto, Canada. The successful environmental restoration and protection of Don river landscape started with an environmetal analysis of the whole river basin (source: www.toronto.ca, 12th July 2008)

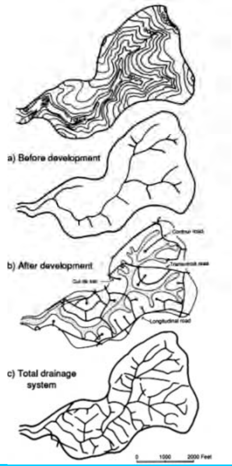
Design should proceed from an understanding of the conditions of land use within the whole river basin -a natural landscape unit. "The significance of catchments as the basic units of the landscape is this: except for water lost by evaporation, sooner or later all water failing as rain, mist or snow into a single drainage area or catchment will either be stored underground or it will reach the sea via a single estuary." (Davies, B., et al 1998). Adaptation or mitigation measures are better understood from an analysis of this basic unit, however small or large it is. For example, knowing the percentage of area urbanised within a basin is crucial in determining the amount of runoff and therefore, provision of retention ponds for flood control (Harris, W.C et al 1998). Furthermore, and as earlier mentioned, all natural and human activity that happens within a river basin ends up in the river. This is because it is the lowest point of the landscape transversely from ridgelines. Most material and energy flows are directed toward the river.

The next step is evaluation of existing urban and natural systems at different scales, in and outside the river basin. This is because no landscape area exists in isolation but is connected to other areas with varying human activities. The scales range from metropolitan through local and landscape precincts to detailed site planning and design.

In making planning and design proposals in either of the scales, there are general design principles that should be adhered to: "sense of life (creating awareness of life-cycles, seasonal rhythms and pulses), sense of the region (response to local climate, plants, building materials, and regional character), sense of unity (recognisable pattern or theme for overall identity, coherence and legibility) and a sense of scale (relationship to human scale in buildings and outdoor space)" (Oberholzer, B., 2007). In addition, appropriate selection, use, manipulation and management of materials and resources, both organic and inorganic, are central to the achievement of sustainable designed landscapes (Dunnett, N. and Clayden, A. in Benson, J.F et al 2000). The overall objective is the reduction of waste where energy, materials and water are recycled in the landscape during and after construction, and in use. Oberholzer, B. (2007) further identifies the criteria for gauging the performance of a designed landscape: integrity (ensuring intactness, functioning); amenity (ensuring comfort, enjoyment); conservation (protection, restoration of resources); efficiency (ensuring economy, effectiveness); safety (protection from hazards); diversity (ensuring clarity, legibility, choice, orientation).

Design in a river landscape is to a much or less extent design with water. Throughout human history, water has been the main determinant of where people settled in the landscape, and how the settlements are structured. As Spirn, A.W (2008) put it: designers are storytellers; among all the materials with which landscape architects craft their storylines, water is among the most powerful, both figuratively and literally.

Figure 3.21 The pattern of natural channels and roads (with stormdrains) before and after development in a small basin near Austin Texas. The increase in drainage density increases both the magnitude and frequency of stormflows.' Analysis of the whole basin is therefore necessary to determine the amount of runoff and the required mitigation measures (such as the number of retention basins required) (source: Marsh, M.W., 1998)



Changes in the quantity and quality of water as a result of climate change poses serious challenges. "Water is source of life, power, comfort, fear, and delight, a symbol of purification, of both the dissolution of life and its renewal"(ibid).

The competing uses for water resources demands critical evaluation to establish compatibility of use, reuse and complementary overlaps –such design of flood parks as recreation places as well as flood waters take-in area. In the design of a landscape development framework , it is therefore important to organise land uses along the river corridor based on existing and future opportunities, constraints and conflicts in a usually culturally and naturally dynamic river landscape.

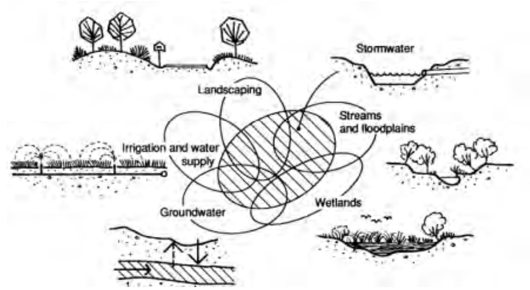


Figure 3.22 The principal systems involved in a comprehensive water management for development projects. A systematic and holistiic consideration of these systems in the design of the urban river landscape would increase adaptability and sustainability. (source: Marsh, M.W., 1998)

3.3.0 Design Principles

The principles of design are those landscape development guidelines that are necessary for adoption to increase the adaptive capacity of urban river landscapes to climate change. "The purpose of principles is to translate values held by the community or society, into a prescription for planning and design over the long term" (Oberholzer, B., 2007). In the face of climate change, these landscapes are vulnerable to: increasing urban economic and social pressures; ecological degradation and other hazards. The principles help to guide decision-making and serve as a useful measure for determining the performance of development proposals in terms of stated criteria (ibid). In this case, the criteria is resilience of the river landscape –'increasing the resilience of communities and ecosystems against adverse climate' (Tirpak, D., 2005). The principles may be categorised according to different approach scales: general, landscape design framework and detail site design.

3.3.1 General principles

3.3.1.1 Being proactive, rather than reactive to change

Planning and design of any space within urban rivers, whether private or public, should be done in anticipation of extreme fluctuations in water quantity and quality. This means moulding the land to adopt to rapid changes, cushioning it from the excesses of climate change and protecting both the landscape, property and life. It should not be the case of reacting, when the damage is already done. Martin, J. (2007) calls it 'catastrophe-first pattern' where, when "there are warnings of environmental danger, it is often the case that humans don't pay attention ....it is only after a catastrophe happens that appropriate precautions are taken." He says to avoid a catastrophe-first pattern, the politicians and the public must listen to the scientists.

With all the evidence of actual and expected climate change, there is need to respond appropriately. Policies on proper management urban river landscapes and stormwater have been formulated in many cities. Unfortunately, these have been left to gather dust on shelves and it is time they are retrieved and implemented. Many other cities, especially in developing countries, have no stormwater management guidelines but rather the old-fashion way of channelling water away and fast out of the city. Implementing sound environmental planning and design concepts along urban rivers may not be an instant thing to do. It will require political and legislative efforts together with getting into 'public consciousness' the need to change the way buildings are designed and sited; the way private gardens are sculptured; the conversion of river backyards into riverfronts; the turning of lifeless canals into active biological and recreational places, and so on.

3.3.1.2 Creation of more 'room' for water

In responding to situations of excess water in the city, Peters, R. and Hendriks, M.J.A (IFLA 2008) argues that "the starting point is that water must be allowed more space, before it takes it for itself." Today's trend of increasing river discharges and more extreme showers might force the streams to break out from their tightened systems of narrowed and straightened channels, filled-up ditches and impermeable surfaces (ibid)

Specific examples of achieving this include providing for wider and stepped river channel with soft surfaces (bed and banks); lifting up new building structures on columns or stilts and designing for boardwalks, where possible -this allows water flow underneath, improving space quality; legislating for low plot coverage of building footprint and so on. All these is in an attempt to return the landscape character to its pre-urbanisation state. Urbanization restricts where floodwaters can go by covering large parts of the ground with buildings, roads and pavements, thus obstructing natural channels, and by building drains that ensure that water moves to rivers more rapidly than it did under natural conditions (Douglas, I. et al, 2008)

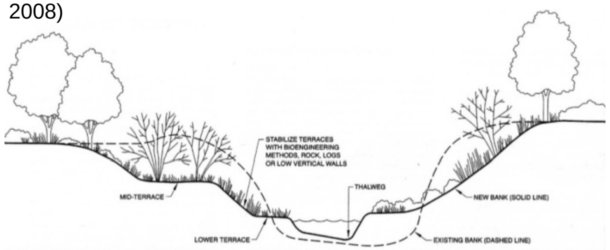


Figure 3.23 Creation of terraced banks to reduce slope gradient, achieve wider river channel, are some of the specific ways of creating more room for water. This increases the channel capacity as well as allowing for human or animal access/ habitat. (source: Hopper, L.J., 2007)

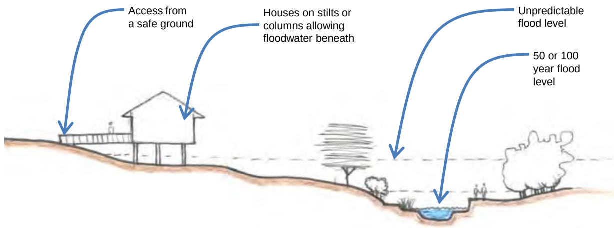


Figure 3.24 Climate change comes with uncertainty of the magnitude of its effects. To mitigate on flooding in the river landscape, perhaps it would be prudent to have buildings and walkways/ cyclepaths raised above ground. (see also figures 3.25 and 3.26) (source: author)

(a)

(b)

Figure 3.25 (a) Boarkwalk and houses on stilts in the La Plata port area, Argentina. Project designed to "provide flood-prone communities with protection and raised emergency 'lodges' which also act as community centres and ecological research stations" (source: Cumberlidge, C., et al 2007)

Figure 3.25 (b) A boardwalk in Lake Mitchell residential estate, Noerdhook, Cape Town (source, author, 2008)

3.3.1.3 Retain and store rainwater

Instead of directing rainwater to canals and draining it away from the city, water should be harvested and retained where it falls. This not only allows for slow infiltration and recharge of aquifers, but can also be used to define spaces, improve space quality and for visual amenity in both private and public spaces. Where possible, this water can be used to irrigate vegetable gardens, establish plants or just to make places greener.

There is also the opportunity of creating recreational water bodies and fountains. This becomes a flood control measure; where not much run-off is channelled downstream. Within the river itself, possibilities of navigation using small canoes can be explored. This is especially possible where the slopes are gentle to flat.

Figure 3.26 Residents of Anaroro, Madagascar "paddle through the streets of their village", heavily flooded after Madagascar was hit by cyclone Ivan in February 2008. River landscapes may be designed to adapt to such situations, making use of the water for navigation, and generally turning a constraint into an opportunity. (source: www.bbc.com, 9th March 2008)

(a)

(b)

Figure 3.27 (a) and (b) "Possible future images" designed as part of the Poelpolder Project, Sao Paolo, Brazil (source: Pellegrino, P., 2008)

(a)

(b)

Figure 3.28 Where a river is gently sloping, opportunities for navigation may be introduced. (a) a section of the Liesbeeck River floodplain and (b) a section of Ngong River, Nairobi (source: author)

3.3.2 Landscape Framework Principles

3.3.2.1 Stormwater Management

In the past, rainwater that fell on cities were drained into straightened hard concrete channels purposely to avoid flooding. This practice is thought to create, instead of solving water problems in the city (flooding of other parts downstream, damage to infrastructure and ecological degradation). Realisation of the problem lead to cities developing new stormwater disposal and use strategies. Stormwater management concepts are aimed at managing a resource, stormwater, in a cost effective, environmentally sound and creative way for continued benefit of the community (Oberholzer, 2007). These concepts should be applied integrally to the whole stormwater system. Stormwater system can be described as constructed and natural facilities, including stormwater pipes, canals, culverts, overland flood escape routes, vleis, wetlands, dams, lakes, and other water courses, whether over or under public or privately owned land, used or required for the management, collection, conveyance, temporary storage, control, monitoring, treatment, use and disposal of stormwater (city of Cape Town, 2002). Besides allowing for utilisation of stormwater for socio-economic, ecological and recreational purposes, the management concepts are first and foremost intended to help in flood control and water quality control.

Figure 3.29 Flooded downtown area of Grand Forks city, USA, in April 1997 (source: Marsh, M.W., 1998)

Figure 3.30 A motorist stuck in floodwaters on Kamiti road, Zimmerman estate, Nairobi Kenya (Source: D/N, 19th January 1998)

Figure 3.31 concrete water channel (canal) in the Liesbeeck river. Such engineering methods of stormwater disposal have proved problematic (source: author, 2007)

(i) Flood Control

The ‘best management practice’ in flood control is to retain water where it falls, or near where it falls. For example in a given urban development, retention basins (retention and detention ponds) could be created to retain water drained from roofs, roads and parking lots and stormwater channels could be vegetated (swales). Water could also be directed to roadside bioretention and infiltration filters which may also serve to treat the water. Dry, hard paved or vegetated shallow depressions that fill with water may also be designed for on private or public land. In rainy seasons they form pools of water that define spaces as well as adding to aesthetic value. The objective is to maximise on infiltration and minimise run-off.

Another way to prevent flooding is by use of constructed or natural wetlands. Davies, B. et al states that wetlands, by their physical presence and shape, and the vegetation they support act as massive hydrological controls of stream flow, attenuating the force of floods and store water which may be released slowly, sometimes over periods of months or even years. Wetlands are therefore important flood control landscape features.

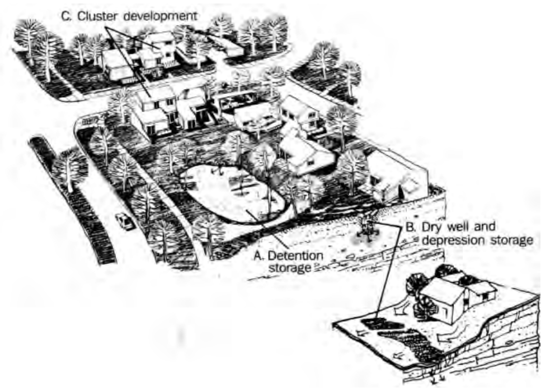


Figure 3.32 Examples of stormwater mitigation measures: (a) detention storage, (b) on-site infiltration, and (c) cluster development (source: Marsh, M.W., 1998)

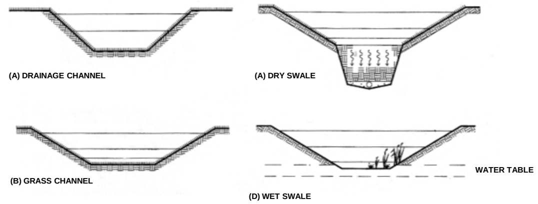


Figure 3.33 Basic Channel and Swale types. “All vegetated channels are provide significant amounts of storage and infiltration, and are excellent techniques for reproducing pre-development hydrologic conditions” (source: Harris, W.C., et al 1998)

(a) (b)

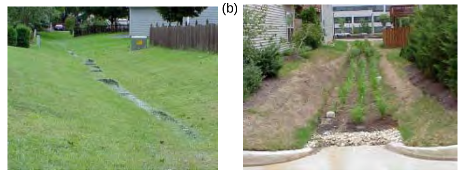


Figure 3.34 (a) Example of a grassed swale and (b) Infiltration filter (source: State of Virginia, 2006)

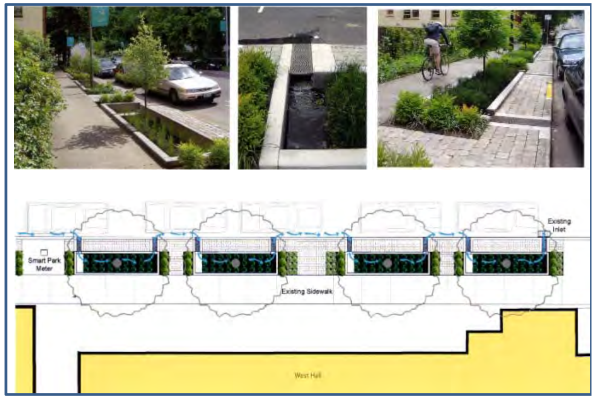


Figure 3.35 Roadside stormwater retention and treatment system, SW 12th Avenue Green Street Project, Portland, Oregon, USA. (above: plan and top: images) (source: Margolis, L. et al 2007)

(a) (b)

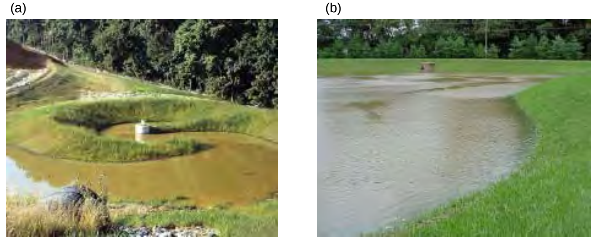


Figure 3.36 (a) and (b) Examples of grassed water holding basins. Such water features together with shallow depressions can be a good sight after rainfall (source: State of Virginia, 2006)

(a) (b)

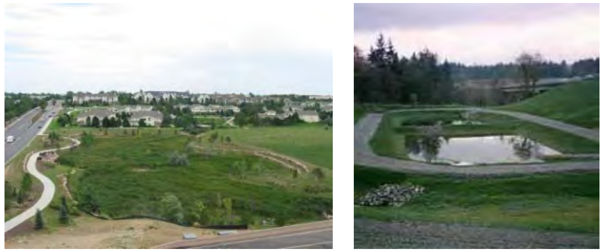


Figure 3.37 (a) An example of a water detention pond (www.us20pme.com) and (b) a water retention pond (www.wsdot.wa.gov)

(a) (b) (c) (d)

Figure 3.38 (a) and (b) Retention pond within the precincts of the University of Cape Town (UCT). Water impounding structures such as the embankment (c) are expensive engineering works that could be used for other purposes especially for recreation and fish farming. In this one at UCT, angling is allowed and people are occasionally seen praying or just meditating on the lawn embankment (by the quiet waters, and punctuations of bird sounds). It is also an exciting view point toward the city of Cape Town. Perhaps a waterfall could have been designed for (source: author)

To avoid the floods and waterlog in the landscape, the people of ancient China (Longshan period, Shang of 1700 -1100 B.C and Zhou Dynasties ,1100 – 256 B.C) who had settled on the agriculturally rich alluvial floodplains of the Yellow River developed survival strategies to protect their cities. These strategies were mainly: inhabiting high land; building circumvallation (city wall) and circumvallation levees and; conserving and excavating retention ponds (Kongjian Yu et al, 2008).

In principle, these strategies could also be adopted today. They could significantly ameliorate on the murkiness associated with increased urban flooding.

Inhabiting high land was in the form of 'choosing natural high land, elevating ground for roads, blocks, and buildings and building artificial high land for important architecture and as a refuge during floods' (ibid). Instead of having a level ground, mounds could be built within riverside neighbourhoods to act a places of rest and refuge in a flood event . Further still, walkways and cyclepaths could be placed on them thus creating a continuous, elevated and protected routes that could also have positive visual effect.

Figure 3.39 A productive lotus pond. The ponds created in the 'flood adaptive cities' in China served multiple functions: flood control, recreation, food production among others. Introduction of such wetlands in the river landscape is thus beneficial. (source: Kongjian Yu et al, 2008)

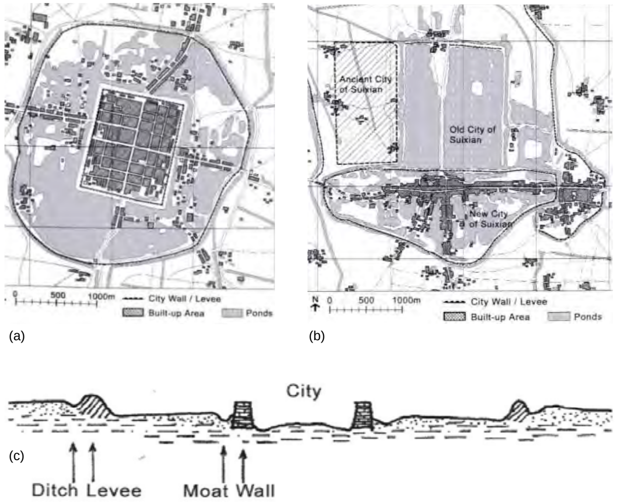


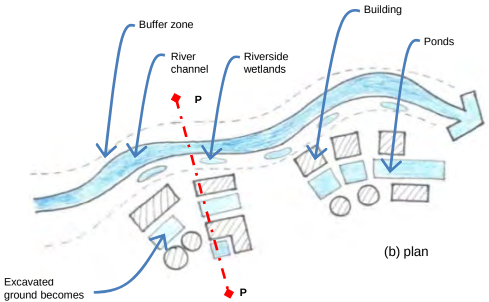
Figure 3.40 Examples of 'flood adaptative cities' in the flood plains of the Yellow river, China. (a) map of Shangqui county and (b) Map of Suixian county (c) typical section through the cities. Depressions created from excavation of soil to built city wall and levees are filled with water to form ponds. The ponds would be extended until a lake forms. 'The pond system was the major water drainage and storage system, and when combined with the circumvallation and circumvallation levee, they formed the whole flood adaptive defense system' (source: Kongjian Yu et al, 2008)

City	Heze city	Cao county	Chengwu	Xiayi	Changyuan	Feng county	Nanle
Percentage (%)	28.9	34.9	23.3	69.1	23.7	19.2	13.3

Table 3.1 The percentage of water surface in some of the flood adaptive cities within the Yellow River basin, China. The gross calculation are based on 1:50000 topographic maps of the cities from 1950s-1970s. "In 1949 Xiayi city had to develop a new city outside the former one due to the limited dry land for further development." (source: Kongjian Yu et al, 2008)

Retention and detention ponds are effective means of flood control in many cities. In planning for adaptation to climate change, the city of Cape Town proposes an extensive storm-water and flood risk infrastructure reflected in the following statistics (City of Cape Town, 2006):

- 150 000 gullies/intakes;
- 5 500 km of pipes and culverts;
- extensive surface channel systems in both formal and informal areas; and
- 650 detention ponds.



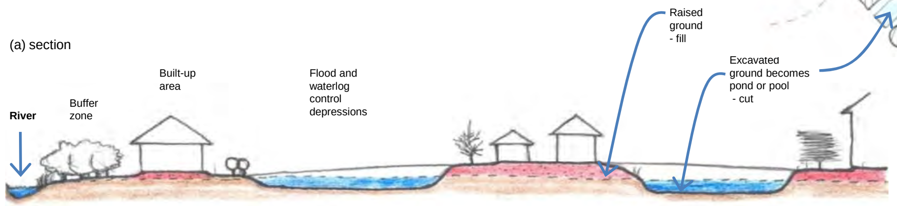


Figure 3.41 (a) Section and (b) are illustrations of how river landscapes could adapted to flooding and waterlog: More space is created for water to flow; Buildings and other human activities may be carried on the higher grounds (see also figures 3.25 -3.28) ".....when raising the ground for buildings and escape mounds, volumes of earth were needed which came from making of ponds that could store and reduce runoff and mitigate the waterlog problem" (Wang, 1968 in Kongjian Yu et al, 2008) (source: author)

Flood control has always been an engineering issue. Engineering methods are mainly based on technical calculations of for example speed and force of water flow, quantity and the required sizes of channels. With the uncertainty associated with climate change, and in addition to engineering methods, there is need to adopt flexible and dynamic methods of flood control. As Peters, R and Hendriks, M J.A (IFLA 2008) argue, one of the principles should be "to combine technical solutions with smart use of space, for example multi-purpose use of space like houses on water."

Building of dykes have been a flood control measure in the Netherlands for a long time. Dykes have significantly defined the water cultural landscape. If in response to climate change the raising of dykes would be the only measure taken, it would implicate a rise of 30 cm of all primary river dykes to deal with river discharges that are to be expected by the year 2050 - this would be undesirable, as higher dykes also mean bigger impacts in case of a dyke breach . This clearly illustrates how methods of flood control have to change in the future.

Some flexible engineering solutions to flooding problems have been developed an applied to many urban rivers. One example is the Inflatable Dam System used in the Environmental Restoration of Besos River, Barcelona, Spain (figure 3.42).

Figure 3.42 (top, above and right): Images and plan of the Besos river landcspe showing the 11 dams placed every 400m to create an illusion of a continuous river flow 44m wide and more than 4km long. They are inlated to detain water throught the year and deflate to release the water in a matter of minutes to accommodate a surge condition (source: Margolis, L. et al 2007)

Some of the system's features are (Margolis, L. et al 2007):

- Eleven dams are distributed through a portion of the Besos river that runs through a densely populated neighbourhood,
- The pneumatic dams, that contain water throughout year, are controlled remotely by a central system and can be adjusted to ensure the right balance between pool areas and water flow, even in drought conditions
- The flexibility of pneumatic infrastructure embedded into the landscape allows the dams 'to transform in a matter of minutes' to accommodate a storm surge condition
- They can inflate in 20 minutes to a height of 1.34 m and deflate to 80% of their volume in 2 minutes and completely in 15 minutes
- The adaptable feature is a crucial centre piece of a fluvial park that is otherwise limited by the river's surge conditions

(b) Water Quality

According to IPCC (2001) “population growth and degradation of water quality are significant threats to water security in many parts of Africa, and the combination of continued population increases and global warming impacts is likely to accentuate water scarcity in subhumid regions of the continent” The little water that is available must be therefore be protected from pollution. There are many sources of water pollution. Water flowing into rivers should be treated using the most efficient, cost-effective and natural way possible.

Water must be protected from pollution for obvious reasons of human, animal and plant consumption. However another problem, eutrophication, should be avoided as much as possible. Eutrophication is the combined processes of water nutrient loading (increase in dissolved nutrients such as phosphorous and nitrogen), accelerated biological activity and buildup of organic deposits. This may lead to the disappearance of wetlands, dams, retention ponds etc. It may also cause the ‘choking’ of rivers by narrowing the channels

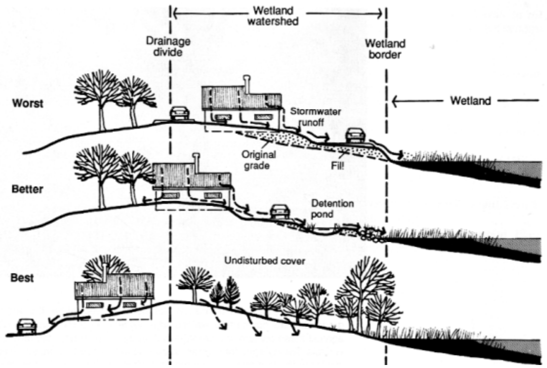


Figure 3.45 Illustration of different alternatives to siting of building structures and roads in relation to wetland. The best practice is where building structures are sited on slopes where runoff will drain away from wetland and there is bigger vegetation buffer. This protects the wetland from pollution (source: Marsh, M.W., 1998)

Natural and constructed wetlands have proved effective in treating water. Wet retention ponds are also considered useful ways of water treatment. Wetlands and retention ponds allow water to infiltrate or flow slowly allowing soil and treatment plants to absorb heavy metals and other particulate pollutants. Marsh, M.W (1998) listed the following wetlands water cleansing processes:

- Deposition of sediment as runoff slows down and plant stems, roots, and organic debris capture particles;
- Filtration of suspended sediment as water penetrates and percolates through the soil mass;
- Adsorption (bonding) of nutrients, organic compounds, and biological agents by organic microparticles (colloids)
- Plant uptake of nutrients and other dissolved chemical ions
- Breakdown of certain contaminants by microbial action within organic masses

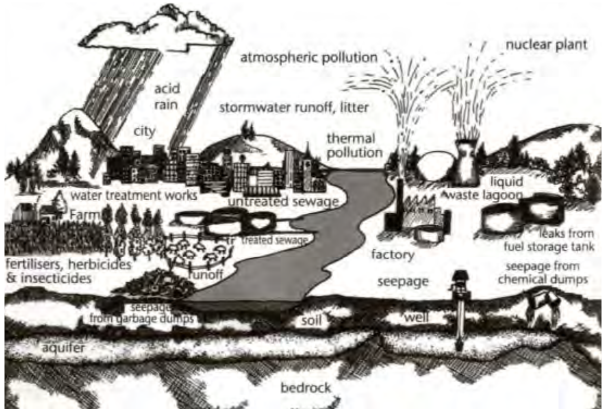


Figure 3.43 A schematic diagram of some of the sources of pollutants that reach aquatic ecosystems (source: Davies, B., et al, 1998)

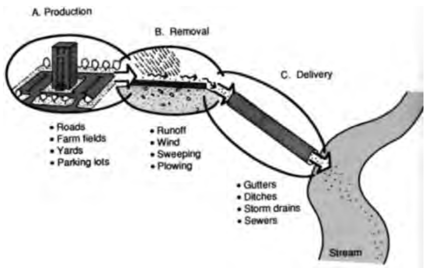


Figure 3 .44 Three –part stormwater pollution system: production, removal, and delivery (source: Marsh, M.W., 1998)

Figure 3.46 Culverts should be moved away from river banks and wetlands; runoff should be directed to infiltration trenches (source: Moosavi, S., et al (2008)

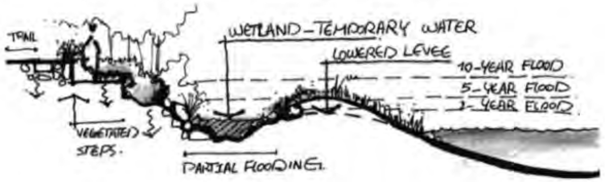


Figure 3.47 Vegetated steps also serve to slow flow thus cleaning the water. Flood water replenish wetlands and therefore lowering levees allows for this (source: Moosavi, S., et al 2008)

Figure 3.48 A wetland system constructed adjacent to the Liesbeeck River, Cape Town. Such a wetland system, including its reeds, play an important role in runoff treatment and flood control (Source: Rounsefell, M., 2005)

Generally, landscape water features that may help reduce water pollution are (Marsh, M.W., (1998):

- Filter berms: elongated earth mounds constructed along the contour of a slope
- Infiltration trenches: vegetated swale
- Filtration basins: concrete structures floored with several grades of sand and a filter fabric through which stormwater is conducted
- Vegetation buffers: effective in sediment removal (up to 90 per cent or more). Design criteria: continuous grass / turf cover; buffer widths generally greater than 15 to 30 m; gentle gradients, generally less than 1:10; shallow runoff depths, generally not exceeding the height of grass
- Holding basins: retention ponds and detention ponds; designed to hold stormwater from the flow system in order to reduce peak discharge and improve water quality especially the early runoff. Values tend to be higher for retention ponds because they hold water on a permanent basis and have a correspondingly higher potential for sediment settling and biochemical synthesis than detention ponds. Detention ponds hold water for a short time and releases slowly

Earth berms and infiltration trenches are generally applied in small scale (such as hard paved public squares, parking lots and road ways) while filtration basins and vegetation buffers are at neighbourhood scale (such as a few residential or industrial blocks) while holding basins are at a water catchment or regional scale (e.g. Harris, W.C et al (1998) Marsh, M.W., (1998). " With a majority of surfaces in the built environment being impervious, these methods of small-scale, local water retention and infiltration begin to compensate for the depletion of the natural sponge (soil and wetlands) that were once widely dispersed to attenuate the volume of surges, as well as facilitate ground water recharge." (Margolis, L. et al 2007). But more importantly, the places that contain these stormwater mitigation strategies should be designed as multifunctional open spaces: for recreation, informal trading, urban agriculture and so on.

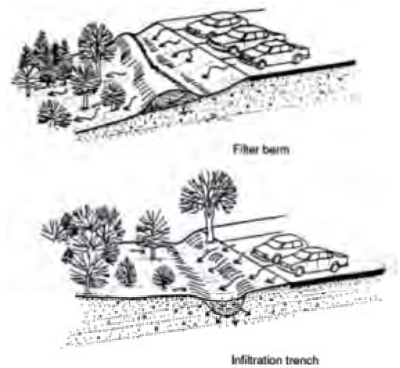


Figure 3.49 Illustration of a filter berm and a filter trench. These are simple, small-scale mitigation devices that reduce contaminant levels in stormwater (see also Figures 3.46 and 3.47). (source: Marsh, M.W., 1998)

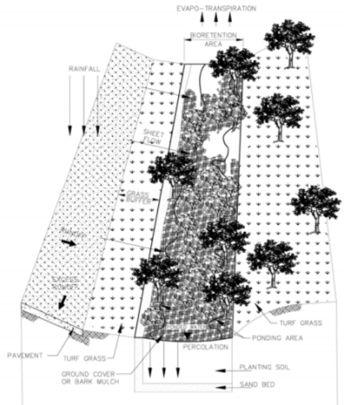


Figure 3.50 Illustration of Bioretention basin, a version of filtration basin (source: State of Virginia, 2006)

One project that employs the principles of stormwater retention, infiltration and treatment is 'Stormwater Garden' designed by Landscape Architects Landworks Studio, Inc.
It was part of the Blackstone Power Plant Renovation project , Harvard University, Cambridge, USA. Located along the banks of Charles river. Developed 'as part of Havard University's ecological initiatives' the project's highlights are (Margolis, L. et al 2007):

- Designed to detain a 3-month storm event for 72 hours, the garden captures and cleanses 90% of annual rainfall, consequently preventing polluted runoff and combined sewer overflow from entering rivers and streams
- The designers envisioned the stormwater garden as a sculptural expression of water movement across the landscape, where landforms of positive and negative relief orchestrate water flow from high points to low points of collection and conveyance
- A number of bio-swales (referred to bioretention cell) function to capture and cleanse runoff from the adjacent parking area
- A 1200 mm layer of designed soil positioned above a 300 mm layer of sand and below a 760 mm layer of organic mulch allows sedimentation, filtration, adsorption and microbial action to remove pollutants from runoff before it is collected in a crushed stone and perforated pipe drainage layer at the bottom of the cell

Figure 3.51 A seed mix of six Fescue species named "No Mow Fescue" cover the ground plane (source: Margolis, L. et al 2007)

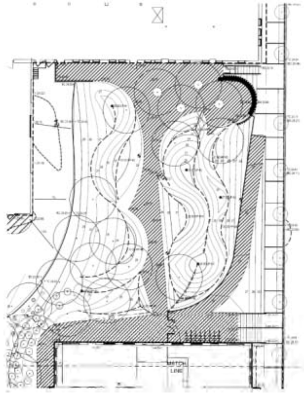


Figure 3.52 Grading plan of landfroms and bio-swales (source: Margolis, L. et al 2007)

Figure 3.53 A bioretention swale within the courtyard. This is part of the negative relief of low grounds. (source: Margolis, L. et al 2007)

Another flood control project based on engineering applications, with successful ecological and recreation solutions, is the ‘Drop Structures Stormwater Attenuation System’ in the Shop Creek, Aurora, Colorado, USA. With new suburban developments, an existing recreation reservoir was getting polluted with heavy metals such as phosphorous. This was causing the death of fish in the reservoir and euthrophication generally. Stormwater also caused soil erosion of creek bed and banks .

There was therefore need to control water flow and treatment. The following are important features of the project (Margolis, L. et al 2007):

- Runoff was treated in both a pond and wetland system, both protected by six drop structures
- Site sand and soil was mixed with Portland cement and rolled into large soil-cement crescents to create the drop structures
- During storms, the majority of the phosphorous are removed by the upper pond, where the phosphorous and other pollutants settle and are absorbed by sediment
- The wetland system, planted with pollutant up-taking cattails and willows polishes the water released from the pond augmenting removal of phosphorous and other pollutants
- The structures are wide crescents that turn the flow of the stormwater against itself, slowing its velocity
- Water is slowed as it interfaces with the increased surface area of the structures stepped profile – combination of the pond and structures slows the water velocity to 0.9m/sec during floods and 0.09m/sec during small events.

This project shows how degraded landscapes can be developed using both engineering and landscape design principles to create places that are protected from the impact of flooding on land and property, are ecologically sustainable and useful for recreation.

Figure 3.54 Six drop structures embedded in the creek. They act as energy dissipaters (source: Margolis, L. et al 2007)

Figure 3.55 Stepped surface of crescent to increase surface area (source: Margolis, L. et al 2007)

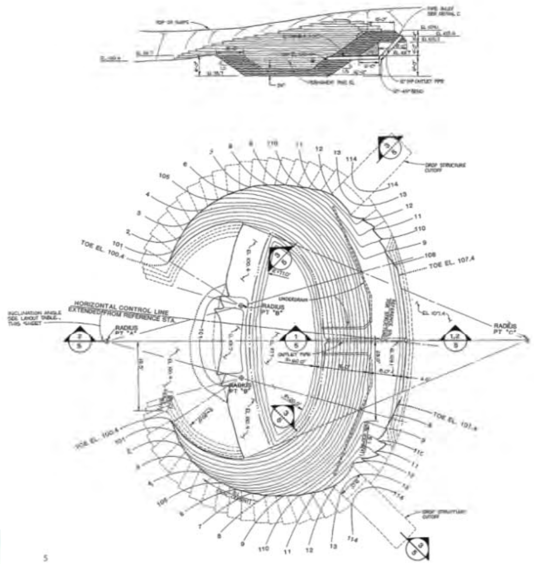


Figure 3.58 Drop structures section and plan: they form a wide crescent for energy dissipation (source: Margolis, L. et al 2007)

Figure 3.56 Drop structures in the wet season (source: Margolis, L. et al 2007)

Figure 3.57 Drop structures in the dry season (source: Margolis, L. et al 2007)

Figure 3.59 Erosion in the bank before installation of drop structures (source: Margolis, L. et al 2007)

3.3.2.2 Urban and Runoff Agriculture

Urban agriculture can be defined as the growing of plants and the raising of animals for food and other uses within and around cities and towns, and related activities such as the production and delivery of inputs, and the processing and marketing of products (Veenhuizen, van R., 2006). Urban farming may be practised in the small scale (such as on house front gardens, on balconies, in old polythene and plastic bags and along the street) and large scale (such as in community/ cooperative gardens, woodlands, orchards, allotments and as part of urban forests). With its multiple functions, urban agriculture plays an important role in urban poverty alleviation and social inclusion, urban food security, urban waste management and urban greening (www.ruaf.org, 23/08/07). It is generally characterised by closeness to markets, high competition for land, limited space, use of urban resources such as organic solid wastes and wastewater, low degree of farmer organisation, mainly perishable products, high degree of specialisation (Veenhuizen, van R., 2006)

Barrow, J.C., (1999) argues for the harvesting of runoff – overland flow, intermittent streamflow, or subsurface runoff – and use for irrigation for food production. He says runoff agriculture is "a generic term applied to cultivation, pastoral, forestry or conservation techniques that rely upon tillage or planting patterns , bunds, terraces, and other structures to delay and retain runoff, and to increase infiltration and counter soil erosion." According to him, runoff agriculture has the following advantages:

- Provides moisture by collecting surface and subsurface runoff where other sources are likely to be too costly, unsustainable or damaging. It effectively uses moisture which would otherwise run to waste
- It draws upon the techniques of Soil and Water Conservation and uses water harvesting, seasonal or ephemeral streamflows or floods, and snowmelt, rather than permanent riverflow or ground water
- Runoff agriculture can harvest and concentrate ephemeral flows so that crops, fodder, trees or natural vegetation may be better grown than environmental conditions would otherwise allow (after Lovenstein et al, 1991)
- It can be valuable in dry or humid environments and tropical to temperate regions. However, in high humidity areas, soil and water conservation efforts would be to control damaging overland flow than to increase moisture availability

Figure 3.60 Informal urban agriculture as practiced along 'city bypass' road reserve in Langata, Nairobi. The crops are most likely planted by people from nearby Kibera informal settlement down the Ngong river valley, less than 200m away. This contributes towards achieving food security especially to the urban poor (source: author, 2008)

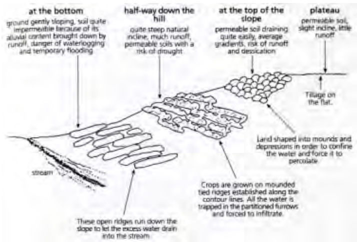


Figure 3.61 An example of comprehensive soil and water conservation in the Sahelian zone, West Africa –based on field studies in Benin (source: Barrow, J.C., 1999)

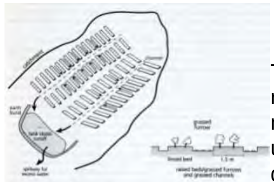


Figure 3.62 Broad beds, grassed furrows and grassed channels draining to grassed drains that feed runoff to a storage tank –based on studies in India (source: Barrow, J.C., 1999)

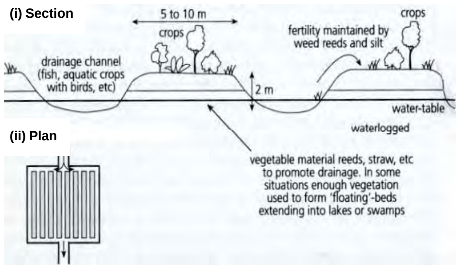


Figure 3.63 Raised bed system (*chinampas*), a technique that can be applied to harvest runoff and used in urban agriculture (source: Barrow, J.C., 1999)

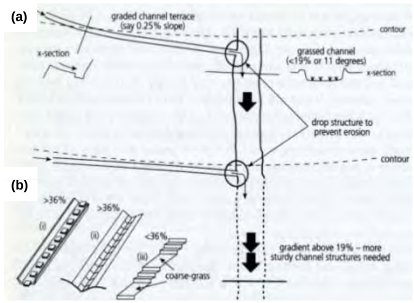


Figure 3.64 Disposal of excess runoff from terraces: (a) Graded channels or cut-off drains feed into waterway via suitable drop structures (b) Some of the types of runoff control device that ca be used to slow flow and reduce risk of damage (source: Barrow, J.C., 1999)

- Can improve quality and quantity of streamflow, increase groundwater recharge, and reduce risk of landslides and floods
- contains a diversity of approaches and techniques that help safeguard against large-scale failures
- Has less likelihood of causing waterlogging, salisation, pollution of rivers, groundwater or other waterboidies through return flows . One of the wet field techniques *chinampas* "Can sustain agriculture in waterlogged areas, even extending into swamps and lakes and may also counter frosts and other unfavourable climatic conditions. Is very productive, allows for diversified cropping and is sustainable without inputs from outside locality. It can also be integrated with aquaculture."

This study stresses to the need for practice of urban and runoff agriculture in all their possible forms. It is perhaps the most cost-effective strategies to ensuring food security for the urban poor, and to generally reduce transport costs. With global warming, it is assumed that the river landscape is likely to contain easily accessible water and soil that is moist, than any other area of land. Runoff agriculture "might be a way for rain-fed agriculture to respond if there is global climatic change towards less moisture availability." (Barrow, J.C, 1999). Martin, J. (2007) adds that "water supply can be enhanced if we put into place inexpensive means of capturing rainwater before it runs down the streets or goes into drains or unproductive earth."

Sample the effects of climate change on agriculture and food security in Africa, and the whole world generally (IPCC, 2001):

- Most countries in Africa are particularly vulnerable to climate change because of limited adaptive capacity as a result of widespread poverty, recurrent droughts, inequitable land distribution, and dependence on rainfed agriculture
- Desertification is a critical threat to sustainable resource management in arid, semi-arid, and dry subhumid regions of the continent, undermining food and water security
- The continent already experiences a major deficit in food production in many areas, and potential declines in soil moisture will be an added burden
- Africa is the continent with the lowest conversion factor of precipitation to runoff, averaging 15%. Current trends in major river basins indicate decreasing runoff of about 17% over the past decade.

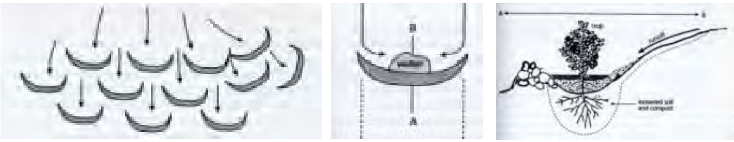


Figure 3.65 (a), (b) and (c) Half moon shaped(in plan) cut and fill runoff microcatchments (source: Barrow, J.C., 1999)

Figure 3.66 Other forms of microcatchments (source: Barrow, J.C., 1999)

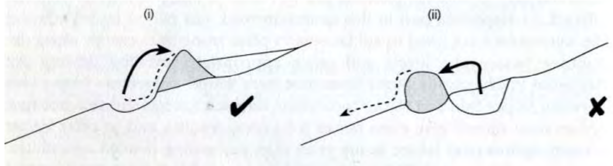
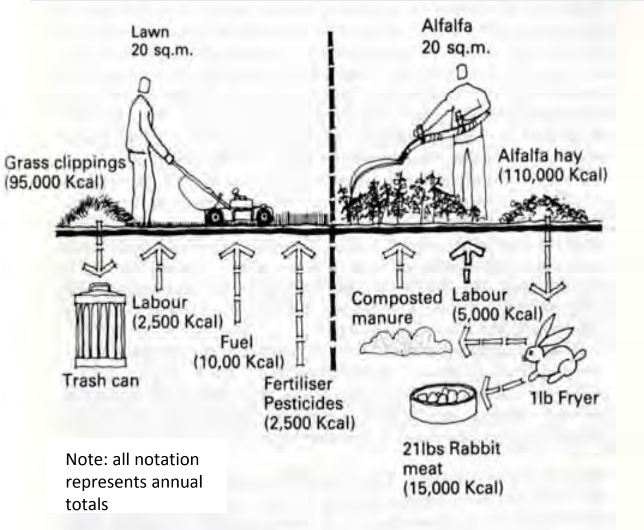


Figure 3.67 Soil and water conservation techniques: contour bunds (i) ideal – better to place bund upslope to reduce erosion and catch soil in ditch (ii) unsatisfactory –soil washed off the bund is lost downslope, and poses a greater risk of gullying (source: Barrow, J.C., 1999)

Yearly energy budget of a lawn compared to an alfalfa patch



	Energy input Kcal	Energy yield plant	Kcal: Human food
Lawn	15,000	95,000	–
Alfalfa	5,000	110,000	15,000

Figure 3.68 A comparison of the energy required to maintain a grass lawn and edible alfalfa ground cover (source: Hough, M. 1995)

Figure 3.69 Urban Agriculture as practised in a high density residential area in Havana, Cuba. (source: CPUL).

Figure 3.70 Edible Schoolyard project, Martin Luther King Junior Middle School, Berkely, California. "..uses the universal activities of growing food and eating to anchor important and neglected aspects of children's social and environmental education" (source; Cumberlidge, C., et al 2007)

There are a whole range of benefits to be derived from urban farming. Paxton, A. (1997) mentions the most significant ones:

- Community development -people involvement and empowerment leads to sense of ownership, for example by growing food from own culture, people ethnic origin begin to reclaim and revalue their cultural identity;
- Biodiversity -urban environment can be richer in flora and fauna than rural farmland, and growers can be involved in preserving rare and threatened varieties of fruit, vegetables, herbs and flowers;
- Tackling waste -reduction in production input such as elimination of need for packaging, transport and preservation, reuse and recycling of household wastes- old carpets, clothing, rubber tyres, plastics and more usefully, organic wastes;
- Parks as food growing places turning from an ornamental city landscape to a food -producing landscape (still planted with ornamental cabbages, pumpkins, attractive flowers, eye-catching vegetables, chillies and as attractive orchards);
- Regenerating housing developments -landscape designers can incorporate food growing into individual schemes such as housing developments and rehabilitation of derelict or under-used sites

This study emphasizes the importance of urban agriculture as one of the ways of utilising runoff and reduce use of fuel (whether fossil or bio fuel) to transport food from countryside or mow lawn. Hough, M. (1995) did the arithmetic of how city landscape can be made more productive and more importantly reduce on consumption. Figure 3.68 show a comparison of two equivalent-sized residential yards of 20 m2, one producing lawn grass, the other alfalfa. For every unit of energy invested (exclusively human labour) in the production of alfalfa, 22 units were returned in crop production. In the case of the lawn, the net production efficiency is zero. It has been calculated that the rate of energy use for the maintenance of some 16 million acres of lawns in America exceeds the rate for the commercial production of corn on an equivalent amount of soil.

Water flowing in urban rivers can be used for the practice of aquaculture farming. Martin, J. (2007) says that aquaculture is a rapidly growing form of food production in which world protein production by aquaculture is growing at about 11% per year.

Figure 3.71 An example of aquaculture farming (outdoor) (source: www.aquaculturebioengineering.com)

Figure 3.72 An example of aquaculture farming (indoor) (source: www.mahurangitech.co.nz)

Figure 3.73 "Over-abstraction of water for irrigation upstream leads to a stagnation of the Luvuhu River in the Kruger National Park, South Africa." This reflects the downside of irrigation. It is important then that runoff in urban areas is harvested and used for irrigation instead to depending on river water only. (source: Davies, B et al, 1996)

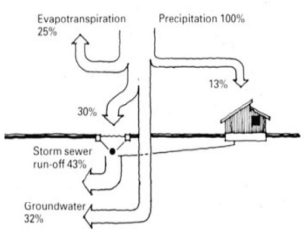
3.3.2.3 Increase vegetation cover

Deforestation is one of the causes of global warming. With increase in temperatures and floods, the importance of trees, shrubs and ground covers in the river or any other landscape cannot be overemphasised. In short:

- ❑ Plants ameliorate on excess heat
- ❑ Reduce both wind and water soil erosion (which is linked to increasing desertification)
- ❑ Freshens the air by absorbing carbon dioxide and other air pollutants. According to IPPC (2001) climate change will decrease air quality in urban areas with air pollution problems: an increase in temperature (and ultraviolet radiation) increases the formation of ground-level ozone, a pollutant with well established adverse effects on respiratory health
- ❑ Intercept rainfall reducing runoff
- ❑ and increases water infiltration

It should be noted, therefore, that leaving land as open spaces is not enough to adapting to climate change. Every effort must be made to increase vegetation cover, especially trees and shrubs, to create urban forests. Forests have a low coefficient of runoff. Coefficient of runoff is a number (between 0 and 1.0) given to a type of ground surface representing the proportion of a rainfall converted to overland flow; it varies inversely with the infiltration capacity such that an impervious surface will have high coefficient of runoff (Marsh, M.W., 1998).

(a)



(b)

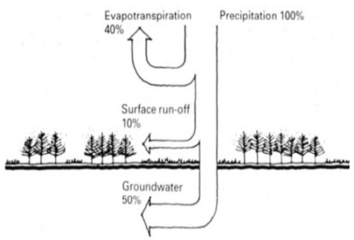


Figure 3.74 A comparison of percentages of infiltration levels for (a) an urban area – more impervious and (b) vegetated area –pervious. Clearly, vegetation helps in mitigating of excess runoff (source: Hough, M. 1995)

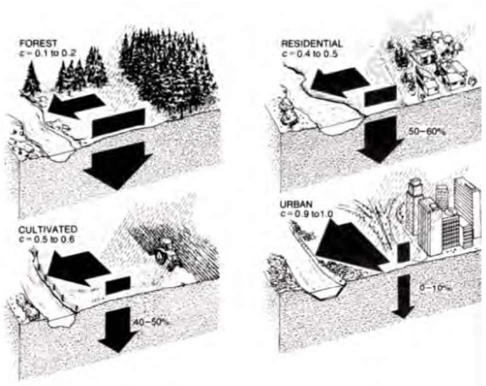


Figure 3.75 Changes in the coefficient of runoff with land use and land cover (source: Marsh, M.W., 1998)

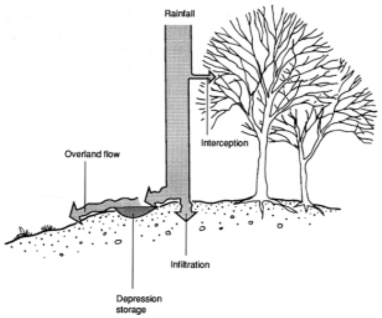
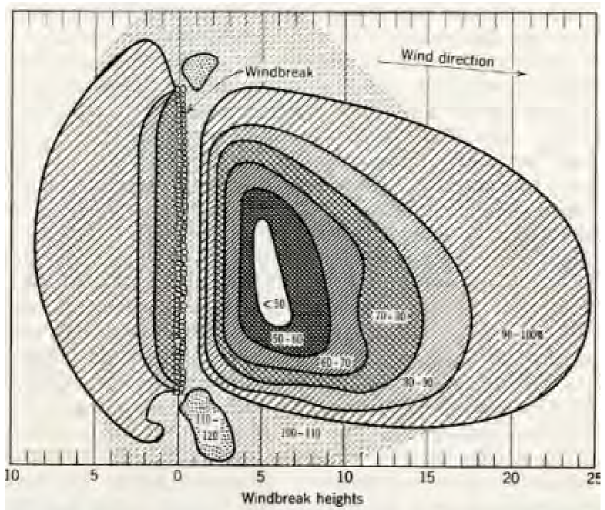


Figure 3.76 The disposition of rainfall in natural or partially developed landscape: interception, infiltration, depression storage and overland flow (source: Marsh, M.W., 1998)

(a)



(b)

Figure 3.77 (a) Percentage of normal wind velocity near a windbreak having an average density of 50 per cent. (b) Cross section view of a typical shelter belt (large scale windbreak). This is important in the design of a landscape vegetation framework particularly to prevent soil erosion and create sheltered places. The location, spacing, type (tree or shrub height and foliage) form (linear or clustered) and orientation of plant cover on land. For example 'since the wind velocity at the ends of the windbreak is as much as 20 per cent greater than velocities in the open, it is evident that long shelter belts are more effective than short ones' (source: Frevert, K.R. et al 1955)

3.3.2.4 Creation of ecological buffer zone

On a landscape framework scale, specific setbacks for building structures from watercourse edges should be established and where they have been established, should be enforced. This is to create an ecological buffer zone (EBZ) that serve the ecological 'essential' function mentioned earlier. The need to open up rivers and provide more room for water compliments the need for more green space in the city for growing food thus alleviating food shortages and reducing ecological footprint. In this zone, cyclepaths and walkways can be planned and designed for; ensuring continuity of a possible green corridor and encourage people to avoid the use of the car for transport and movement. Furthermore, these zones are required for plant and animal habitat and migration routes.

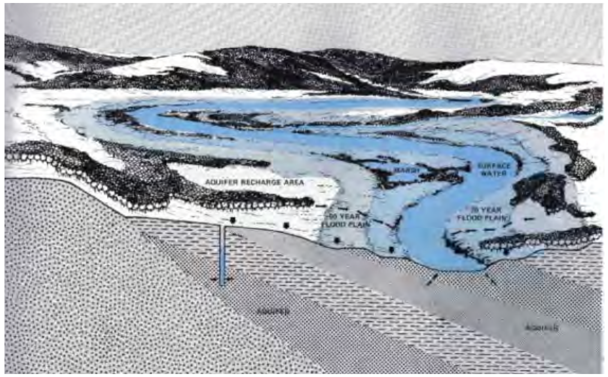


Figure 3.78 Image of a river landscape showing highlands (probably the water catchment areas), aquifer recharge areas, floodplains, wetlands and the river channel. An EBZ is typically to protect these features from the ever increasing 'land consumption' by urbanisation (source: Mcharg, I., 1969)

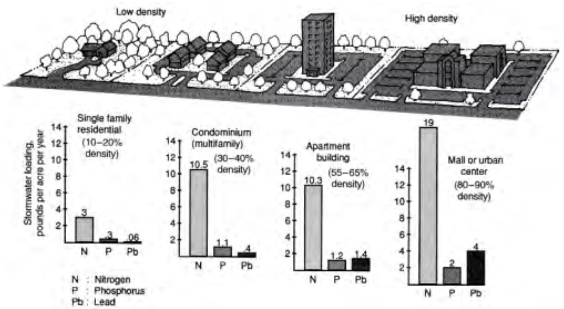


Figure 3.79 "The relationship of stormwater pollution and land use density in an urban region. Pollution loading increases with density from suburban toward the city center." Buffer zones shoul be of the lowest land use density in order to serve the ecological function they are created for. Rivers cannot therefore function as naturally in high density urban settings. The need for establishment or enforcement of EBZ guidelines mitigates on this (source: Marsh, M.W., 1998)

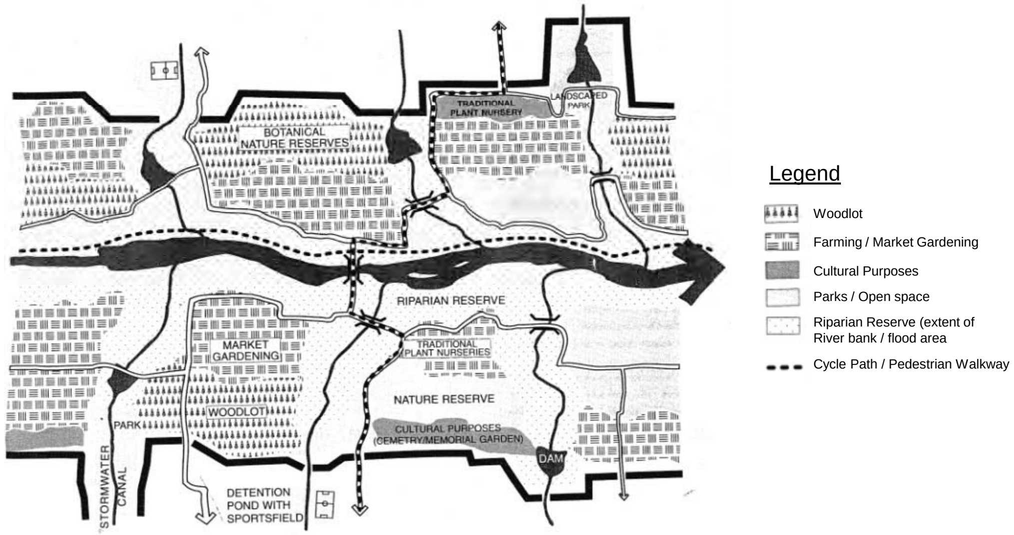


Figure 3.80 Conceptual Metropolitan Open Space System (MOSS) showing possible use of EBZ. The river corridor plays an important role in achieving a well balanced MOSS. As a linear open space, and beside providing ecological goods and services, the river corridor contributes immensely to the structuring of city development (source: CMA, 1995)

3.3.2.5 Biodiversity

Biodiversity (biological diversity) is the totality of the variety of living organisms, the genetic differences among them, and the communities and ecosystems in which they occur (City of Cape Town, 2003). A landscape with diverse plant and animal life is productive and sustainable. There are numerous benefits to be derived from protecting and maintaining biodiversity. Biodiversity adds value to landscapes and more importantly to peoples' lives: economic value of functioning ecosystems (e.g. clean water and clean air); social value through recreation and open space; intrinsic value through its mere existence; consumptive use value (e.g. harvesting); educational value; aesthetic value through beauty and scenic drives, contribution to tourism; spiritual value; bequest value – the value of retaining biodiversity for future generations; option value – the value of choice (ibid).

Man has however overexploited and altered the rich provisions of nature to the extent that they no longer function and produce optimally or just become extinct. Urban landscapes are evident examples of mans interference with the complex existence and interrelationships between different plants, different animals and different plants and animals combined and there habitats. "Nature is robust because it has developed through biodiversity and experimentation for hundreds of millions of years. To needlessly eliminate that diversity is folly." (Martin, J. 2007).

Unfortunately this is being made worse by the changing climate, itself another consequences of man's irresponsibility of the planet. As far as biodiversity and climate change are concerned, IPCC (2001) has painted the following picture:

- Irreversible losses of biodiversity could be accelerated with climate change

- Changes in the frequency, intensity, and extent of vegetation fires and habitat modification from land-use change may negate natural adaptive processes and lead to extinctions

- Climate change is expected to lead to drastic shifts of biodiversity-rich biomes such as the Succulent Karoo in South Africa and many losses in species in other biomes

- Without adaptation, climate change will reduce the wildlife reserve network significantly by altering ecosystems and causing species' emigrations and extinctions. This represents an important ecological and economic vulnerability in Africa

- Some species that currently are classified as "critically endangered" will become extinct, and the majority of those labelled "endangered or vulnerable" will become much rarer in the 21st century. This may have the greatest impact on the lowest income human societies, which rely on wildlife for subsistence living

- Populations of many species that are already threatened are expected to be placed at greater risk by the synergy between the stresses of changing climate, rendering portions of current habitat unsuitable, and land-use change that fragments habitats

Where there is water there is life. A riverine ecosystem is therefore one of the most bio diverse. Not appreciated for its biodiversity value, the urban river is usually considered a stormwater drain (with all the pollution associated with urban runoff), as a backyard for waste disposal, open space for street families and children among others. Davies, B. et al (998) considers canalisation of the urban river the 'ultimate insult' to the sanctity with which rivers should be treated – "an urban river becomes a lifeless canal.......probably one of the cruellest blows that any river can be dealt." (fig 2.) It is a failure to appreciate its biodiversity value. It is time peoples' attitude are changed so that urban rivers are considered for what they are: a resource, a life-giving resource with immense benefits. As Martin, J. (2007) put it: our survival as a species depends on respecting nature, with its living, self-creating, self-maintaining ecosystems that are of extraordinary complexity. Urban rivers must be turned from being backyards to resourceful riverfronts to industries, shopping precincts, urban agriculture and residential neighbourhoods.

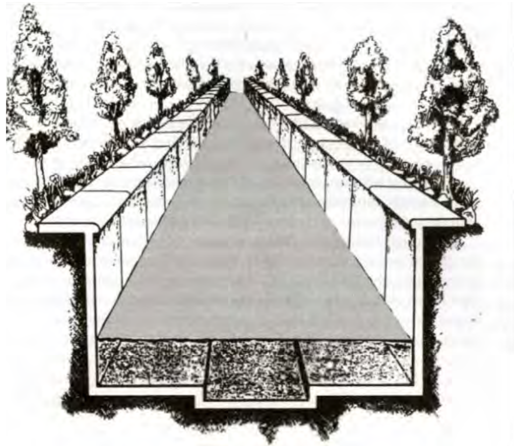


Figure 3.81 "The design of a typical riverine canal. The river is cut off from its bed and its banks." Such a canal can hold no plant or animal life (source: Davies, B., et al, 1998)

The understanding of the biodiversity of river landscapes starts from the understanding that rivers are changing four dimensional systems(ibid). This leads to planners and designers of river landscapes to cater for this dynamism through the use of methods and building materials that allow continuity of the processes therein . These are discussed under bioengineering (Item No.

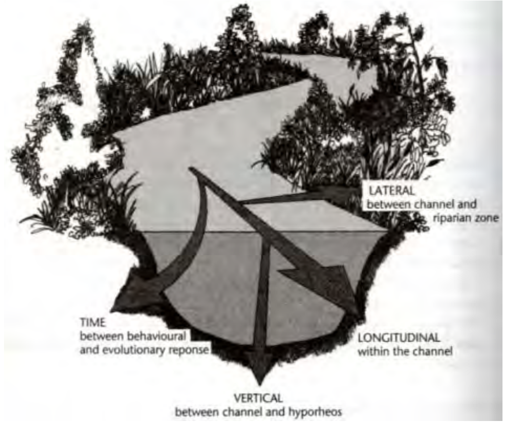


Figure 3.82 "Rivers are four dimensional systems....changing along their lengths, across their widths, through their depth and with time. They also exchange materials between bed, bank and water column " This is an important consideration when designing along rivers especially in catering for the river's dynamic processes (source: Davies, B. et al (998)

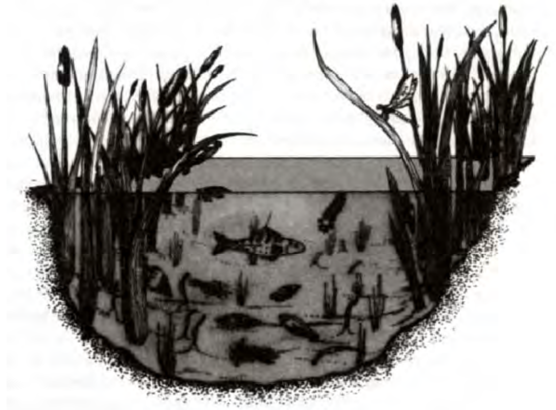


Figure 3.83 The river channel is itself a diverse place, full of life and variety of plant and animal species. The pollution of urban rivers unfortunately wipes out such diversity resulting in 'dead' water channels of little or no value. (source: Davies, B., et al, 1998)

Besides the diversity of the river channel, the river edges and floodplains are also part of the river landscape that is diverse because of their proximity water resources. Trees, shrubs and ground covers get nourished inviting other forms of life such insects, birds, reptiles etc. Within the river channel or by its edges/ floodplains are wetlands –places of still or gently flowing water.

“Wetlands are some of the most diverse ecosystems on earth, as well as among the most productive....rich in different kinds of habitats ...are valuable as ecological laboratories because of their diversity   ...are paradises for bird–watchers and anglers and for people simply wanting a rich ‘outdoors’ experience” (Davies, B. et al 1998). It is important therefore that existing wetlands are protected and where non-existing, they can be constructed.

Biodiversity also means the presents of varied plant and animal species. In most instances, some species are more tolerant than others to human influences such as noise and water pollution. The most sensitive of species (indicator species) have been used to monitor water quality and other variables. For example in the urban Don River in Toronto, “frogs including species like gray treefrog are key indicators of a healthy environment for plants and animals, including humans. For many people, the presence of frogs in the Don watershed has come to symbolise hope for a clean and healthy future.” (Don Watershed Regeneration Council, 2000).

Back to urban agriculture, there are many opportunities to increase the variety of crops and fruit trees to be planted. Many large scale farming practices focuses on planting one crop type (monoculture) such as maize, wheat, rice and so on. Martin, J. (2007) rightly argues that a “monoculture species can be harmed by soil degradation or wiped out by climate change” He advocates for organic farming that seeks to bring back, with efficient composting and animal fertilizers, the quality of soil that has been degraded and also restore nature’s complexity.

Figure 3.84   Wetlands in the Don River, Toronto, Canada. Wetlands control flood, are habitats for biodiversity and visually appealing. (source: www.toronto.ca, 10th July 2008).

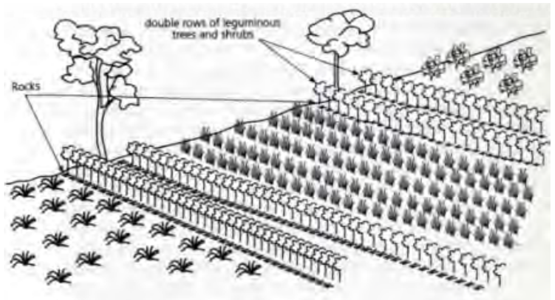


Figure 3.85   Illustration of ridge and furrows strip tillage, strip planting and strip cultivation where a variety of crops are planted. As part of Urban Agriculture, this increases biodiversity and prevents soil erosion. it also looks visually appealing. (source: Barrow, J.C., 1999)

3.3.3 Detail Design Principles

3.3.3.1 Bioengineering

Vegetation plays an important role in the process of moulding sustainable landscapes. This role is more apparent in the river environment. Here, plants are necessary for healthy terrestrial and aquatic ecosystems: maintenance of good quality water, biodiversity, structural stability of soil and/or rocks on river bed and banks, green aesthetics, fresh air and so on. IPCC (2001) reports that climate change leads to increased flood, landslide, avalanche, and mudslide damage leading to increased soil erosion. It is time more sustainable ways are adopted to protect and regenerate riverfront environments particularly in the urban setting. Even if not fully restored, a rehabilitated urban stream can provide wildlife habitat, improve water quality, enhance outdoor uses and add value to the community (Hopper, L.J., 2007).

Bioengineering techniques provide the base with which this may be achieved. They are used to stabilise the landscape for which economic, social and recreational activities may happen. On advocating for use of flexible materials in this era of climate change, Thompson, W. J et al, (2008) argue that bioengineering “combines living and inert structures into something stronger and more flexible than either” They say the ‘living structures’ reinforce vulnerable interfaces between soil and water, especially on steep slopes, streambanks, and shorelines.

Instead of employing forceful and rigid river engineering methods, that are in total conflict with natural processes, the use a combination of biological and simple structural methods would be more sustainable. “For instance when safeguarding engineered earthworks, it is more sensible to plant grasses, shrubs, and trees to hold and protect the soil than to use dead materials which are not only less effective but ugly.” (Schiechtl, H. 1980)

In urban areas, rivers have been narrowed by constructing costly canals that are not only unsightly and ‘dead’ landscape features but are also inconsistent with biodiversity strategies. Confining the river channel to a narrow corridor produces increased velocities, shear stress, and erosional forces which must be counteracted by more structural techniques (Hopper, L.J (ed.) (2007). Also, no plant or animal can inhabit a canal. In natural rivers, the hyportheos (area around the bed) is not only a repository of hitherto unrecognised food and nutrient resources to organisms, but it also acts as a refuge during violent floods (Davies, B. et al, 1996). Schiechtl, H. (1980) rightly argues that “man must learn to protect himself and his

Figure 8.86 Slope erosion resulting from alteration of drainage, vegetation and soil associated with residential development. Bioengineering techniques are aimed at mitigating on such landscape destruction (source: Marsh, M.W., 1998)

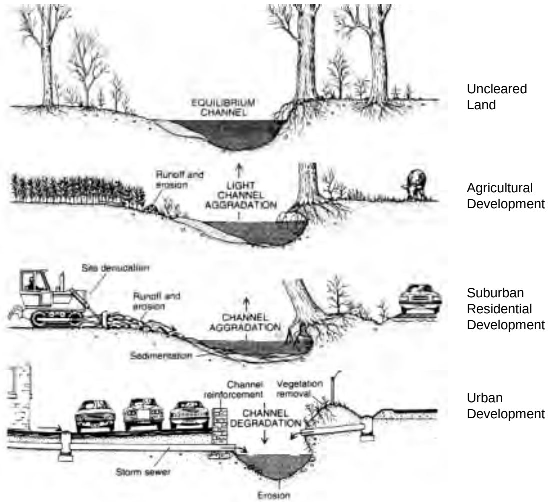


Figure 3.87 Stream channel changes associated with land use: aggradation with agriculture and suburban development and degradation with urbanisation. Bioengineering techniques are for safeguarding the river banks and bed to allow continued productivity of the landscape (source: Marsh, M.W., 1998)

environment by calling in nature as his working partner –learn how nature maintains her balance and work with it rather than fight against it .... products of scientific and technical research can be integrated with natural materials to obtain effective and economic methods of protecting, restoring, and improving our environment.” They represent a continuum from “hardscape” structural methods to “softscape” vegetative methods, applying engineering practices in conjunction with ecological principles; and frequently combining vegetative systems and manufactured products (Hopper, L.J (ed.) (2007).

A bioengineering project can be regarded as completed only when it is no longer obviously manmade, but appears rather to be a work of nature (Schiechtl, H.,1980). “This requires the skills of the engineer, the learning of the biologist, and the artistry of the landscape architect” (ibid).

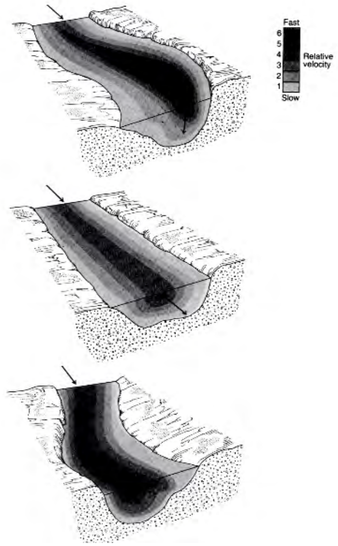


Figure 3.88 The distribution of streamflow velocity in three different channel forms. This understanding is crucial in guiding the designer on ‘where and what’ bioengineering technique suits ‘where’. It may also inform the resultant landscape form and placement of landscape features and elements. (source: Marsh, M.W., 1998)

Figure 3.89 “A slightly more ‘river-friendly’ canal built of blocks, which allow the development of some biological communities in the interlocking blocks.” This illustrates an ecologically friendly interface between inert materials and living things. (Davies, B. et al, 1996)

Application of these methods requires an understanding of river dynamics in terms of water flow patterns, volume and velocities, sediment deposition, eroding banks, turbulence, quiet areas, rapids and so on.

There are many and varied techniques of bioengineering. They are generally for river bed protection from scouring and for bank slope stabilisation. The goal is to enhance stream's hydrological and habitat functions, returning polluted or degraded environments to successful, self-sustaining ecosystems with improved water quality and habitat value (Hopper, L.J., 2007).

Gabions are the widely used because of there strength, low maintenance, durability, water cleansing qualities, planting opportunities, ease of construction, opportunity to reuse excavated rock material on site to name just a few. A gabion is "a modular containment system that enables rock, stone or other inert materials to be used as a construction material. The modules or cages as they are known, are formed of wire mesh fabric panels, jointed to form square, rectangular or trapezoidal shaped units." Cerana Limited (2007)

Hopper, L.J (2007) categorises bioengineering techniques into three:

- Structural techniques: gabions, concrete walls, rock walls, sacked concrete and articulated block walls;
- Biological techniques: Direct-seeded or hydroseeded grasses, planted grass plugs, transplanted cattails, tules, bulrushes, live willow stakes and planting of native riparian trees and woody plants;
- Soil Engineering techniques (a combination of the two above): live staking with geotextile fabric, joint planting, brush layering, willow mattresses with rock toe, contour wattles or fascines, vegetated soil cribbing, vegetated long crib wall and root wad and boulder revetment with live pole cuttings.

Besides Hopper, L.J (2007), other authors have also classified bioengineering techniques in different categories. They generally follow the same trend. Illustrations for some of the examples are shown in figures 3.90 to 3.97.

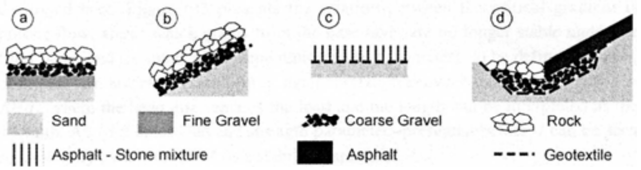


Figure 3.90 Illustrations of examples of soft methods of river bed and bank protection. These are referred to as filters (for porous flow) and they serve to: prevent erosion of the covered subsoil or prevent pressure buildup in the covered subsoil (drainage) or a combination of both (source: Gerrit J. S., 2001)

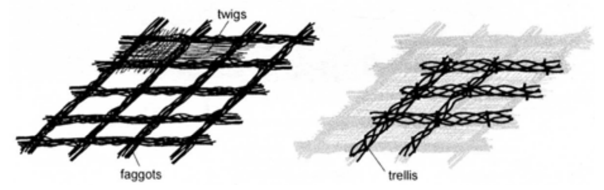


Figure 3.91 Fascine mattresses: for river bed protection. Consists of willow fagots. Bamboo or any other strong local vegetation may also be used. These mattresses can last up to 100 years under water. Commonly used in the Netherlands (source: Gerrit J. S., 2001)

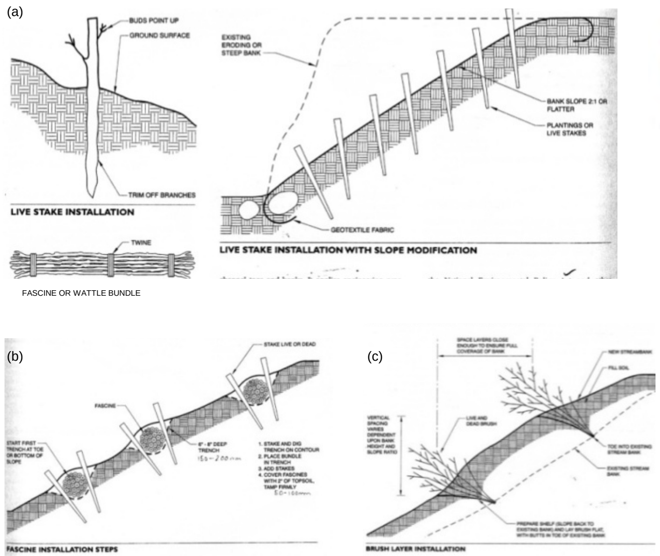


Figure 3.92 Slope modification and stabilisation methods using (a) live stake (b) fascine, and (c) brush layer installation (source: Hopper, L.J., 2007)

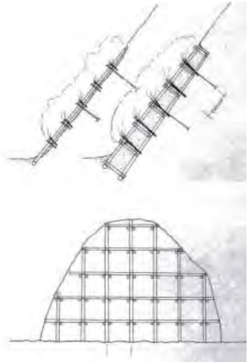


Figure 3.93 Illustration of a slope timber grating construction for the steep high breaks (source: Schiechtl, H., 1980)

Figure 3.94 Concrete gratings after plant growth has commenced (source: Schiechtl, H., 1980)

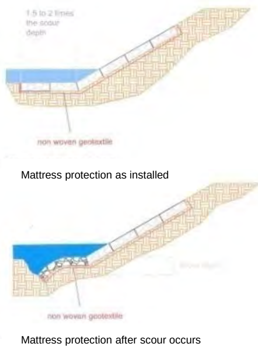


Figure 3.95 Gabions as used in protection of stream bed and bank (source: Cerana Limited (2007)

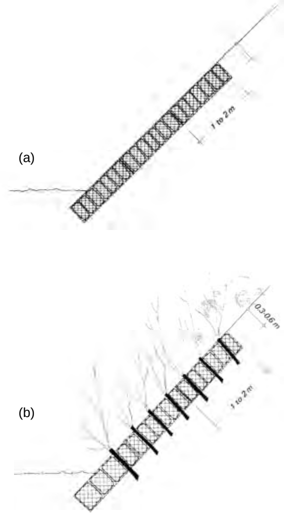


Figure 3.96 Diagram of (a) plain gabion construction (a) vegetated gabion construction with live branches (source: Schiechtl, H., 1980)

Figure 3.97 Gabions vegetated with live branch layering. In such a terrain, gabions remain completely elastic and permeable with no danger of water impoundment; on the contrary, the plants improve drainage through water absorption and transpiration (source: Schiechtl, H., 1980)

4.0 Design Project

“Capturing and using rainwater gives us not only an opportunity to rethink how we design and manage public and private open spaces in order to improve their environmental and aesthetic quality. But also through reducing the demand for water, the effects of flash floods and a treatment for the runoff, Landscape Architecture could assume a key role in restoring natural processes and making the city more liveable.”

4.1 The Brief

River valley landscapes are places that provide a number of resources and services for human use. They provide fresh water, fertile soils for agriculture as well as being green, bio-diverse corridors for ecological and recreational purposes.

In as much as they are a resource, these places are also susceptible to various kinds of hazards, natural and man-made. Climate change is certainly one natural source of hazard on this landscape on levels not anticipated before. Seasonal or cyclic changes (such as flooding) on river landscapes have become irregular and prolonged. In many places there is exchange of seasons of extreme flood conditions and dryness.

In response, man will try to protect himself and the landscape in various ways. One is by building defence structures such as dykes. Another way is to employ engineering and biological techniques or both (bioengineering) to protect river beds and banks from erosion and down-cutting.

These protection measures can only be effective if designed with natural processes in mind, to work with them rather than against. Success also means besides mitigation of hazards, the resultant landscape meets the ecological, socio-economic, cultural, aesthetic, safety and comfort needs of people.

The Design project focuses on the design of a river landscape along Ngong River in the City of Nairobi , Kenya (Fig. 4.1 – 4.4). The river is a tributary of the Nairobi River in the wider Nairobi River System. The site is located at the middle reaches of the river. Different land uses have been applied to the river edges. These unfortunately include, industries, informal settlements, solid waste disposal and inappropriate agricultural practices. Its a challenging site requiring holistic landscape intervention, especially in these days of extreme changes in weather patterns.

4.1.1 Objectives

- To identify appropriate techniques and materials required for adapting to different seasonal changes in the urban river landscape: storm surge control, soil conservation, infrastructure and habitat/ biodiversity protection
- To identify and evaluate natural systems of the watershed in which the river is located: geology, topography, climate, hydrology, vegetation
- To identify local or site specific natural conditions such soil types that affect slope stability, existing and expected channel parameters and dynamics and floodplains
- Explore man’s influence on the landscape: land use in the watershed, stormwater management, erosion control, infrastructure, human settlement/ land ownership
- Look into the history of the river channel to establish possible restoration measures aimed at achieving ‘dynamic stability’ of the river system even in the extremes of climate change
- Based on the above, identify opportunities and constraints for landscape restoration and enhancement for habitat and human needs/ use
- Identify relevant principles of design, appropriate placement of river landscape elements such as walks, lighting features, signage, seats, recreational facilities etc

4.1.2 Products

- Context: river location, natural setting/ geographical context
- Site analysis: Existing and expected river morphology in consideration of anticipated future conditions; geology, soils, water quality, flood plain, storm surge patterns, vegetation, flora and fauna (biodiversity status)
- Site analysis: Existing river edge land use, neighbouring land uses, land ownership, socio-economic pressures
- Layout of the landscape and riparian features including channel pattern, water retention or detention ponds, dams, and other structures
- River bed and banks design solutions: bioengineering techniques and appropriate choice of materials and technology
- Layout of landscape elements and features such as walkways, litter bins, seats, signage, play facilities etc
- Grading plans
- Planting plans
- Stream profile / sections
- Cross sections
- Details: river bank and bed protection, seating, lighting, paving etc

Figure 4.1 An image of the world showing the position of Kenya on the East Coast of Africa. (source: Google earth, 2008)

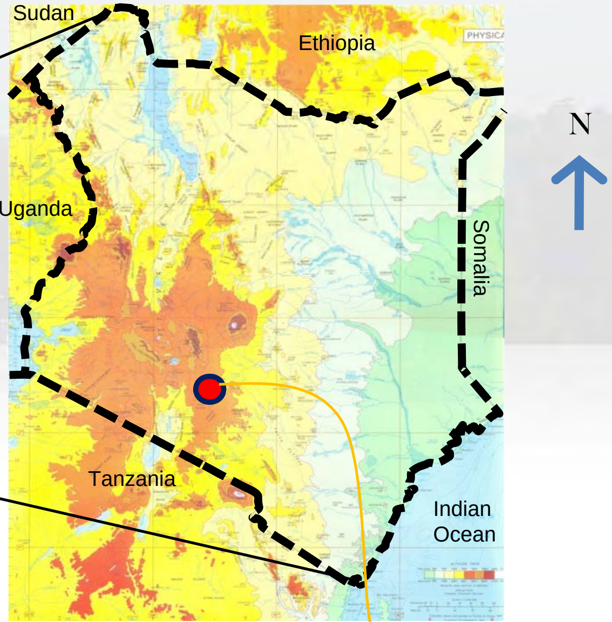


Figure 4.2 Map of Kenya showing neighbouring countries and location of Nairobi. (source: GOK, 2004)

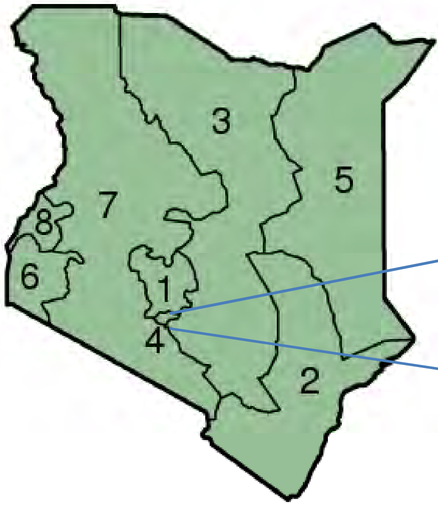


Figure 4.3 Map of Kenya showing the 8No. provinces. The city of Nairobi is in Nairobi province (No. 4) (source: www.google.com/ images, 12th October 2008)

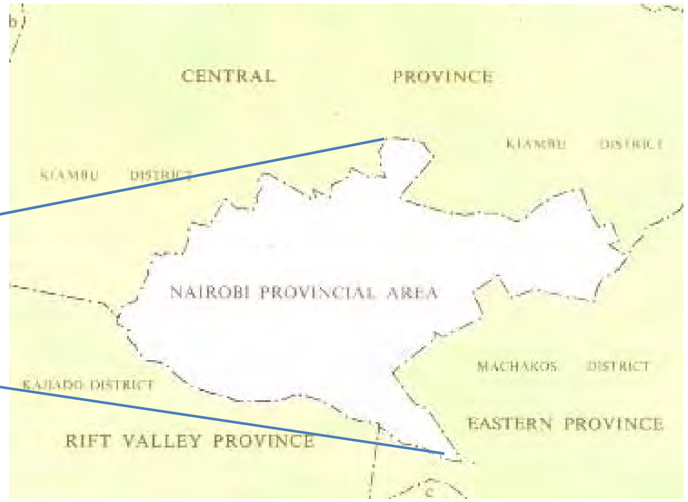


Figure 4.4 Administrative boundaries of Nairobi province and environs (source: GOK, 1978)

Figure 4.5 The skyline of Nairobi city centre and surroundings. (source: www.wikipedia.com, 16th August 2008)

Figure 4.6 Aerial view of Nairobi city center. (source: Google images, 6th July 2008)

4.2 Analysis

4.2.1 The Nairobi Metropolitan

The city of Nairobi is located in Nairobi Province, one of the administrative provinces of Kenya (fig.). Geographically, it sits on the east-facing slopes of the eastern flank of the Great Rift Valley. It is a place of many rivers (see contours). The name "Nairobi" comes from the Maasai (a tribe in Kenya) phrase *Enkare Nyirobi*, which translates to "the place of cool waters". However, it is popularly known as the "Green City in the Sun." (www.wikipedia.com, 16th August 2008). The city started as a resting place during the construction of the Mombasa –Kampala railway line in the 1900s. The existing main road and railway network in the city is therefore part of national and international transport network linking the port city of Mombasa (on the coast of the Indian ocean) (fig.) and other parts of the country and other countries especially Uganda, Sudan, Rwanda and Burundi.

The area once designated as Nairobi province with large tracts of rural land, natural tropical forests and savannah grassland ranches, is now more than 60% urban and sub-urban. The area around city centre (fig. 4.1) shows that the place was originally forested.

The remaining relatively large open spaces include the Nairobi National Park (entrance fig. 4.4), forest remnants (such as Karura, Ngong road , Kiambu and Dagoretti forests) and, some animal ranges toward the eastern boundary; airports (including Jomo Kenyatta International Airport, JKIA) are also visibly large open spaces (Map 2 *land use* , fig 4.2). Dagoretti forest is the source of Ngong river. Perhaps the province boundary should be defined as an urban edge for better management of the city's growth.

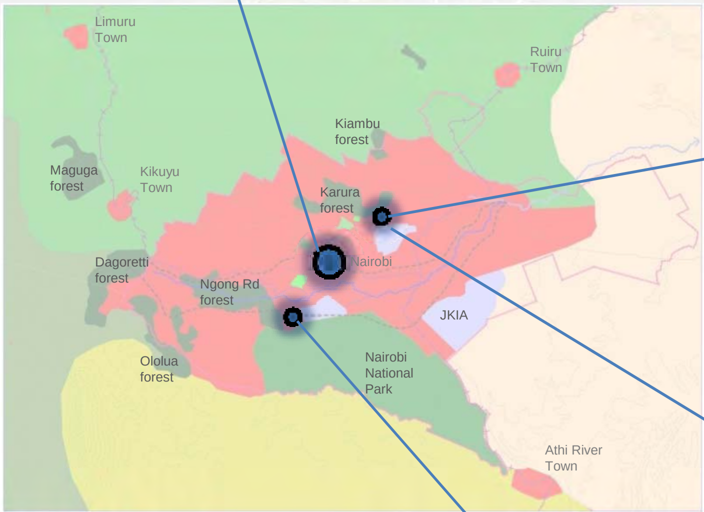


Figure 4.8 Diagram showing location of some places (in pictures) in Nairobi (source: author)

Reminiscent of cities worldwide, Nairobi has its share of income inequalities, social exclusion, formal and informal areas. The negative impacts of climate change mostly affects the urban poor.

As earlier mentioned, most of the poor live in areas vulnerable to urban floods (fig 4.5). In the course of this study, I realised that nearly 90% of all informal settlements in Nairobi are located by the river side – highly vulnerable. Ngong river, along the area of study, has its fare share of informal settlements including Kibera, the second largest informal settlement in Africa (www.wikipedia.com)

Figure 4.7 Nairobi is susceptible to flooding, especially in the informal settlements. The image shows displaced residents of Mathare North (informal settlement along Mathare river, Nairobi,) "helplessly view the floods from the rooftops of their houses" (source: D/N, 16th January 1998)

Figure 4.9 Residents of Mathare North walk to their places of work on a rainy day. (source: D/N, 16th January 1998)

Figure 4.10 Entrance to Nairobi National Park in 1961. (source: www.mccrow.org.uk)

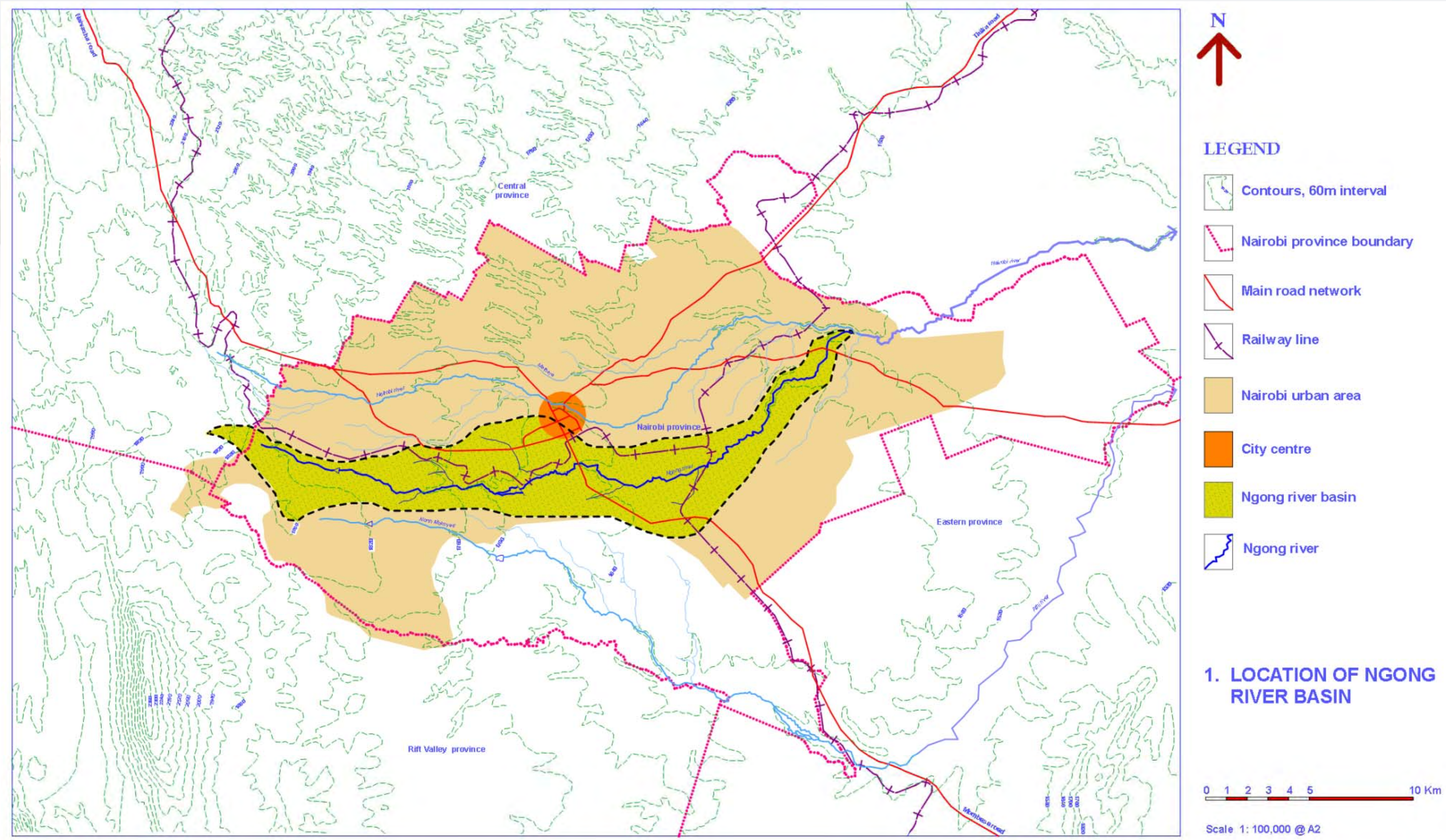


Figure 4.11 Location Map. The study area is located in the Nairobi Metropolitan area. This map shows Nairobi province administrative boundary, general topography (contours), location of Ngong River basin, main transport network and extent of the urban area. (source, author)

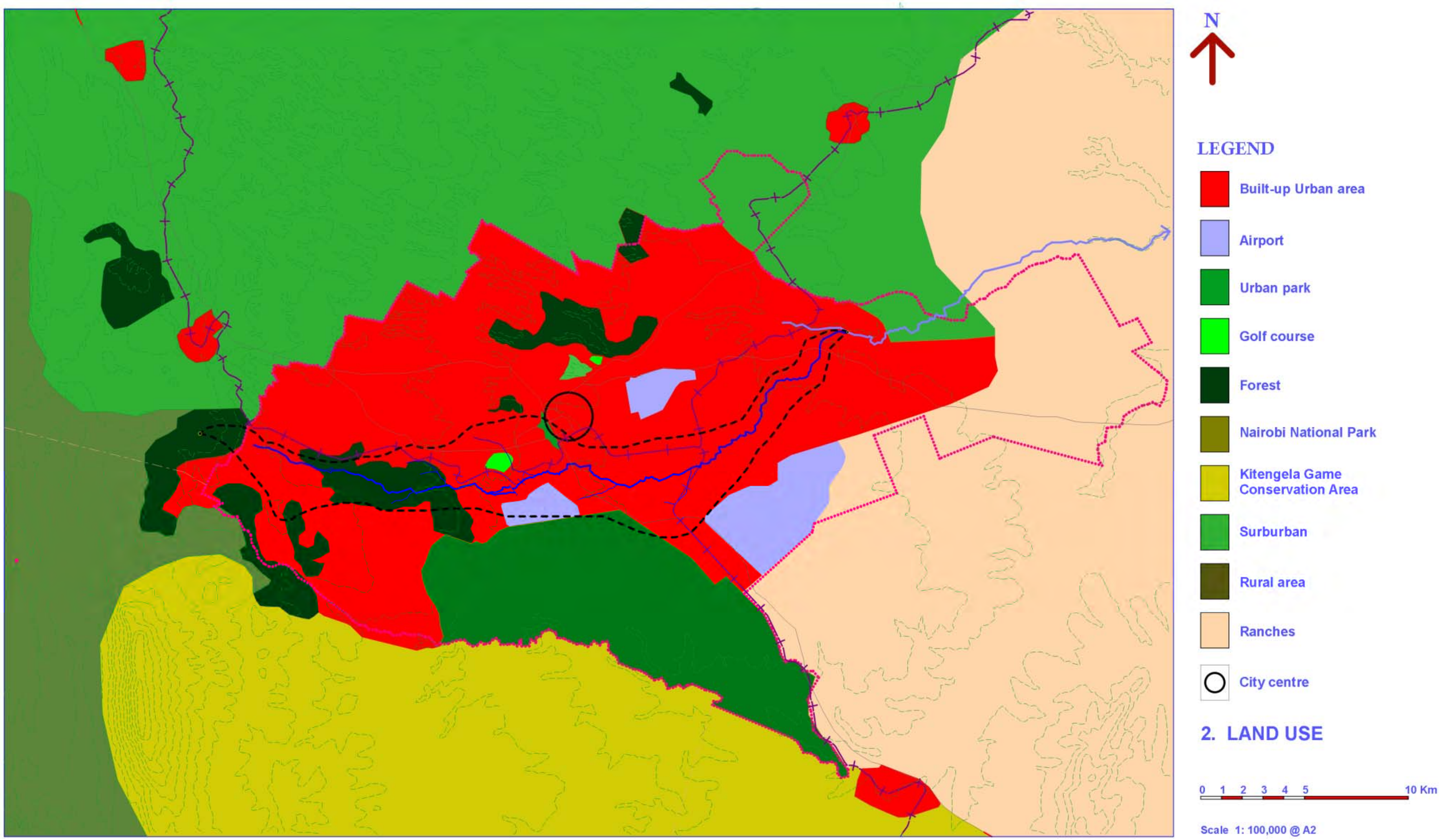


Figure 4.12 **Land Use Map. Almost the whole province in urbanised. Ngong River Basin is about 80% urban. (source: author)**

4.2.2 The Ngong River Basin

4.2.2.1 Natural Systems

Ngong River flows on gently sloping ground in a west to east direction (Figure 4.41). Ngong River watershed is crisscrossed by a number of busy national highways and other city roads. There is also a main railway line that crosses the basin. This impacts greatly on the functioning of the river in terms of its water quality and biodiversity.

An analysis of natural and urban systems that impact on the river basin is important in determining appropriate intervention measures for restoration and enhancement. In terms of natural systems, I will look at Geology, Topography, Climate, Hydrology and Vegetation. For urban systems: Land use, movement and water quality.

Geology (Figure 4.43)

Located on the east facing slopes of the eastern flank of the Great Rift Valley, Nairobi city sits on a volcanic rock substrata. The Ngong river emanates from Dagoreti forest on the Nairobi Trachyte (quaternary volcanics) and flows through the city on younger rocks, the Nairobi Phonolite (tertiary volcanics) before it joins the main Nairobi river on alluvial pans.

This geology influences the availability water in the Ngong river basin in that aquifer recharge areas are located in the upper reaches of the river, where faults exist and the ground surface is less paved (forests and surburban). "The volcanic rocks show a wide range of porosity and permeability and have developed aquifer units separated by lower permeability strata" (Foster, S., et al 2005). The ground water finally ends up in the river although this is threatened by privately-operated boreholes that has lowered the water table substantially (ibid). "In many parts of the world, aquifers are being run dry. The annual depletion of aquifers worldwide amounts to at least 160 billion tons of water per year." (Martin, J. 2007).

In Nairobi, water from wells are used to supplement pipe water in dry seasons. Scarcity of water may also be in cases of emergencies such as bursting of aqueduct that supplies water from Ndakaini dam 50 km away in the Tana River basin (inter-basin water transfer). Landslides (Figure 4.14) have been reported to cause the damage of the aqueduct.

According to Foster, the natural quality of groundwater in Nairobi is good, with the exception of fluoride, and that lower quality groundwater may be pumped if boreholes are drilled deeper and reach basement rocks. "Removal of ground water

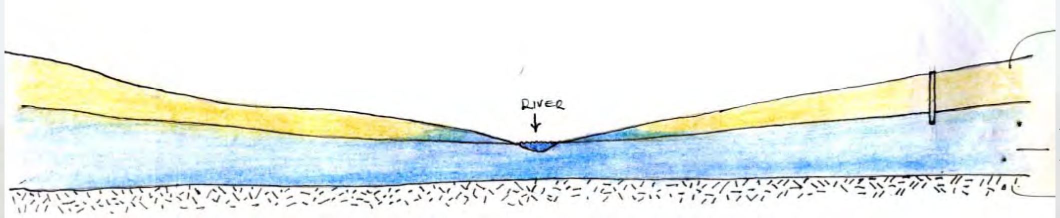


Figure 4.13 Diagram showing how the land near rivers is likely remain wet during droughts. The lowering of the water table (evident in Nairobi) also means its only in the river valley that water available. It will perhaps be the most viable area to practice urban agriculture and as source of water. (source : author)

Figure 4. 14 'Residents of Misri village in Limuru marvel at the destruction caused by a landslide that knocked down their houses and damaged property as a result of heavy rains' This shows how landscapes within Nairobi are susceptible to such water related hazards to buildings and infrastructure. (source: D/N 19th January 1998)

from boreholes for agricultural or domestic purposes, particularly if the water has been accumulating over a very long time, may drop the water table to the extent that surface vleis dry up, or the ground subsides" (Martin, J. 2007). To avoid such a scenario, the naturally flowing water in the river, where the water table is high, should be protected from pollution so as to remain a sustainable source of good quality water. "When an aquifer runs dry, the community that used it will have to live largely on the water it receives from the rain. There will be a time when most of humanity will have to live on rainwater. We must use it much more efficiently." (ibid).

Topography (Figure 4. 41 and Figure 4.45)

Ngong river basin is located at the toeslopes of the Aberdare ranges and Ngong hills. The land is generally gently sloping with most areas having slopes less than 1:30. This means there is a possibility of creating more room for water retention and detention ponds, pools, and other forms of wetlands for flood mitigation, recreation and agriculture.

The gentle slope allows for walkways and cyclepaths to be placed along the river edges for this is a more sustainable use of the river landscape than erecting buildings and walls that pose threats during flooding. The slopes also allow for channelling some of the water for use in irrigating gardens and/or small scale farming using gravity.

Figure 4.15 The gentle slopes of Narobi. This picture was taken near the upper reaches of Ngong river (source: author)

Soils (Figure 4. 50)

Soil within the basin vary according to slope and the underlying geology. On the upper reaches are fertile latosolic soils while in the middle to lower reaches are friable dark grey clay soil. Along the river, at the middle and lower reaches are shallow soils on laterite horizon or rock.

This study focus on developing a framework of an area in the middle reaches where the soil is predominantly black to dark-grey clays. The type of soil affects infiltration rates and amount runoff. It also determines the location, economic and ecological viability of building detention or retention ponds and wetlands. The soil also determines cost effectiveness of water impounding structures. Grassed clay soils have been found to create stable embankments (Gerrit, 2002)

Figure 4.16   Clay soils along the river.

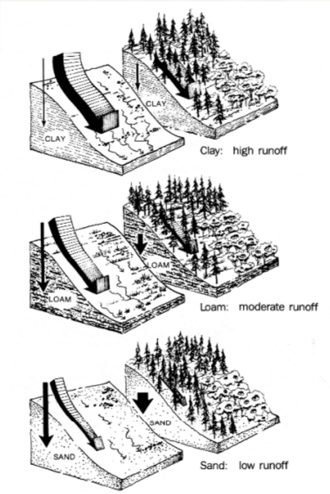


Figure 4.17   Schematic illustration showing the relative changes in overland flow with soil type and vegetation on sloping ground. There is high runoff in the precinct study area because of high clay content in the soil. (source: Marsh, M.W., 1998)

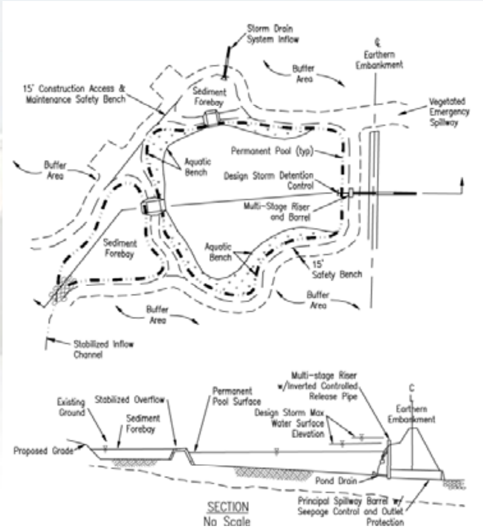
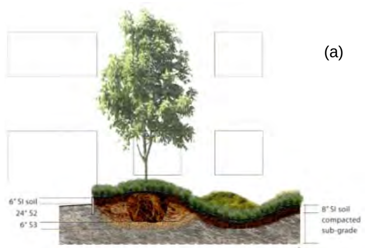
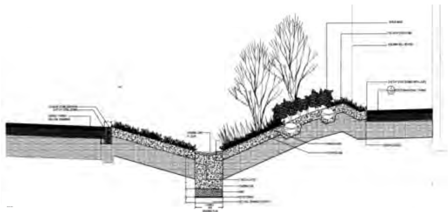


Figure 4.18   Diagram of retention pond. Clay soils are the most appropriate for wet retention basins. This is because of their low infiltration rate thus retaining as mush water as required. This leaves evaporation as the other way of water loss from the basin (State of Virginia, 2006)



(a)



(b)

(c)

Figure 4.19 (a) (b) and (c)   In the Blackstone renovation project mentioned earlier, a 300mm layer of designed soil was placed over the clay with the clay soil acting as a drainage conduit to the openings in the sides of the drainage inlets located in the low points. The clay was designated as the structural foundation of the positive landforms (source: Margolis, L. et al 2007)

Climate

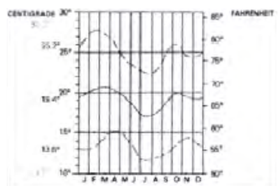
Nairobi enjoys a fairly moderate equatorial climate where throughout the year, solar radiation and temperature, wind, humidity and rainfall do not vary much. The differences between seasons in to the minimum because of its nearness to the equator.

Located about 1661m above the sea level, the annual average temperature is about 19.4 degrees centigrade. The annual average rainfall is between 1200 – 1600mm. According to the Survey of Kenya (1985) Kenya has a 30% and 20% rainfall reliability. This means the water that falls occasionally should be stored and used effectively. Landscape design features can contribute towards this. The low rainfall reliability significantly affects agriculture. Every available means to curb food shortage, especially for urban inhabitants, must therefore be thought of. The urban river landscape could come in handy.

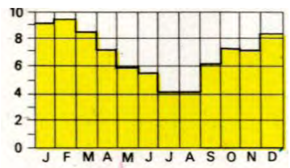
In the recent past, Nairobi just as in most parts of Kenya has been experiencing long droughts and erratic rainfall patterns that in most cases cause destructive flash floods: bridges and people swept away (even leading loss of life), settlements submerged and the after- effects of waterborne diseases such as cholera, dysentery and malaria.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average high °C	24.5	25.6	25.6	24.1	22.6	21.5	20.6	21.4	23.7	24.7	23.1	23.4
Average low °C	11.5	11.6	13.1	14.0	13.2	11.0	10.1	10.2	10.5	12.5	13.1	12.6
Rainfall mm	64.1	56.5	92.8	219.4	176.6	35.0	17.5	23.5	28.3	55.3	154.2	101.0

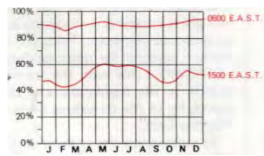
Table 4.1   Monthly average of Temperature and Rainfall for Nairobi (source: www.wikipedia.org)



Graph 4.1   Minimum, maximum and mean average temperature for Nairobi in a year. Data average for a period of 29 years (source: GOK, 2007)



Graph 4.2   Sunshine hours per day for Nairobi in a year. Data average for a period of 21 years (source: GOK, 2007)



Graph 4.3   Relative humidity for Nairobi in a year. Data average for a period of 27 years (source: GOK, 2007)

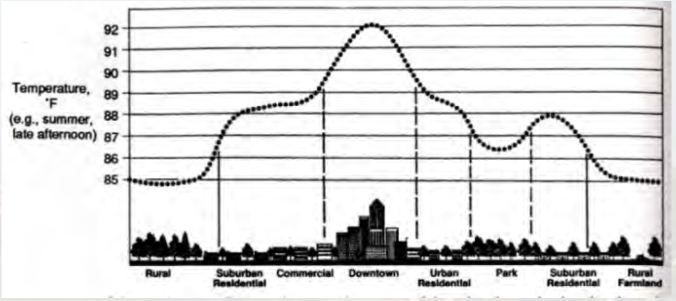


Figure 4.19 An illustration of how with increase in global and local temperatures, most areas of land become drier. The river landscape as such becomes the only place that is moist or wet and therefore there will be great pressure on its water and land resources. See also figure 4.20 (source: Marsh, M.W., 1998)

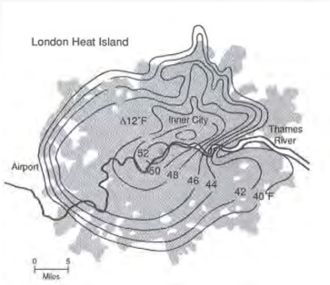


Figure 4.20 The configuration of the urban heat island over London, England, on a winter day (source: Marsh, M.W., 1998)

Figure 4.21 Scenes of flooding on some roads within the river basin. (source: D/N 25th January 1998)

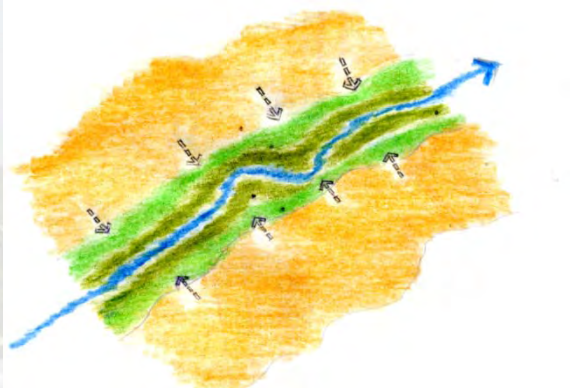


Figure 4.22 A schematic diagram with global rise in temperatures, urban areas will experience even higher temperature than surrounding rural areas. The river landscape, cooler than other areas, will be the most favourable place for human activities. This will increase pressure on the landscape and therefore the need for adaptation (source: author)

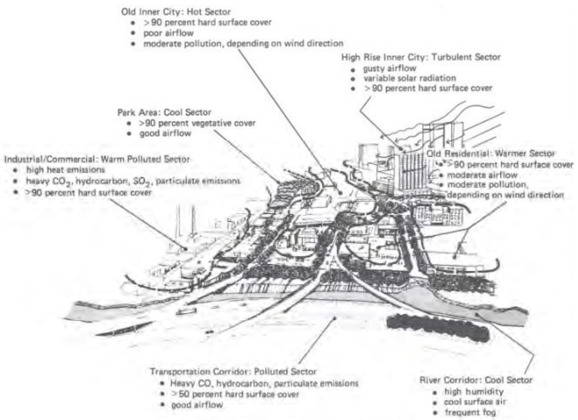


Figure 4.23 'Microclimate conditions associated with different sectors of a city. Conditions vary with surface cover, solar radiation, airflow and air pollution among other things'. Note that the river corridor is one of the cool sectors. This become a refuge area in times of high heat stress in cities. (source: Marsh, M.W., 1998)

Figure 4,24 Women queuing to fetch water in the dry season.

Vegetation (Figure 4.51)

A terrain analysis of the wider Nairobi area, and Ngong basin in particular reveals a vegetation pattern (native and exotic species) that can categorised from dense tropical forests to dry savannah grass lands. This is because of changes in geology, topography and altitude, climate and soils.

Mwaura, F.N (2005) indicates five zones of vegetation in Nairobi, however only four zones fall within the confines of the city boundary:

Zone 1
Dry montane forest -an evergreen hardwood forest composed of the East African pencil cedar (*Juniperus procera*), wild olive (*Olea europeae*), East African olive *(O. hochstetteri*), figs (*Ficus thonningii, F. sur, F. natalensis*), Muthaiga tree (*Warbugia ugandensis*) and Muhugu (B*rachylaena huillensis)* amongst others. The flat-topped Acacia abyssinica is also common.

Zone 2
Characterised by dry semi-deciduous vegetation type that varies from dry lowland forest and bush land. Common tree species include *Acacia Abyssinica,* umbrella thorn (*A. tortilis*), *A. hockii* and yellow-barked Acacia *(A. xanthophloea).*

Zone 3
This is the area around the city ccentre planted with exotic tree species such as *Jacaranda mimosifolia, Chorisia speciosa, Aloe bainesii, Bauhinia variegata, Brachychiton populneum, Grevillea robusta, Schinus molle.* Indigenous trees in this zone include *Acokanthera oppositifolia, Acacia xanthophlea, Combretum molle, Cordia africana and Encephalartos hildebrandtii.*

Zone 4
Vegetation within this zone includes dry woodland, bush land and grassland savannah. The whistling thorn (Acacia drepanolobium) is common within Nairobi National Park as well as the area around Jomo Kenyatta International Airport.

Mwaura further identifies the following tree species as alien invasive: *Mimosa pigra*, pampas grass (*Cotadeia sellona*), the privet (*Lugustrum lucidum*) , the Kudzu vine, the black rat (*Rattus rattus*) Sage brush (*Artemesia tridenta*) and Mesquite (*Proposis juliflora*).

Figure 4.25 Typical vegetation types of Nairobi and its environs. (a) and (b) show some of the indigenous acacia tree species and (c) exotic palm tress and bougainvillea shrub (source: www.wikipedia.com, 2nd May 2008)

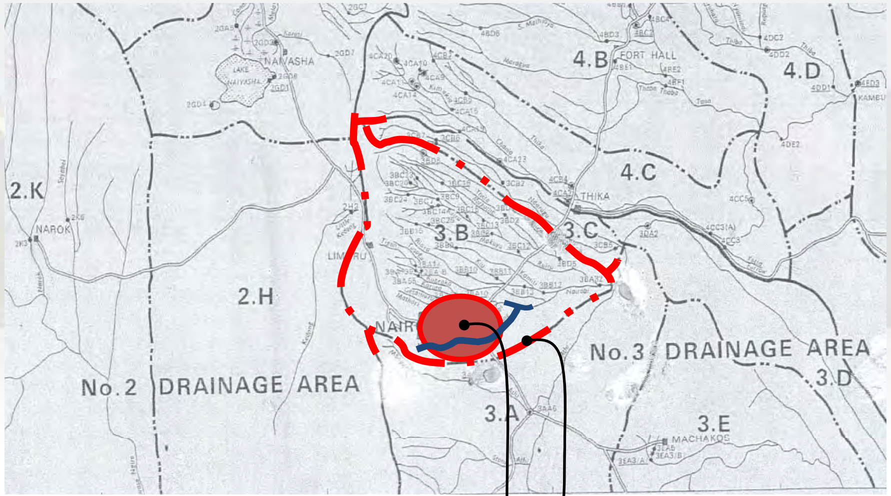


Figure 4.26 Drainage areas in and around the Nairobi River System. (Source: Ministry of Water and Irrigation, Kenya)

Hydrology (Figure 4.47)

Ngong River is a permanently flowing tributary of Nairobi River System in an area of many rivers (tributaries) (Figure 4.26). Nairobi River is a tributary of the Athi River that drains into the Indian Ocean. Ngong River is currently treated as a stormwater and sewage disposal channel. The quality of water is poor. It is contaminated by (1) industrial effluents drained at various places, (2) sewage wastes from informal settlements and (3) stromwater. Any intervention strategies for this river must begin with the cleaning of water discharged into it.

The river and its tributaries are impounded in for dams including the Nairobi Dam. The water reservoirs were intended for water supply to parts of the city as well as recreation. Some still work whereas many are choked with water hyacinth. There are many opportunities to create recreation points along the river especially as the river flows through residential and industrial landscapes.

Figure 4.27 Overflowing Ngong River. (source: D/N 18th January 1998)

4.2.2.2 Urban Systems

Land use (Figure 4. 54)

The Ngong river landscape is used for many urban purposes that has seriously interfered with its natural functioning. An ecological buffer zone is required right from the source to the mouth of the river.

Figure 4. 28 Illustrations of how the urban river landscape should be opened up to create green corridor (EBZ) (a). (b) shows how the Ngong river landscape is used for all human activities making it impossible to serve its ecological function (source: author)

Previous Design Solutions

Figure 4. 29 (a) to (c) show how the Kenya government in conjunction with the UN-Habitat has proposed to design for high density residential development on land currently covered by Kibera. This is in a programme 'Slum-Upgrading Programme.

Figure 4.29 Drawings showing how the government and the UN-Habitat are upgrading Kibera informal settlement situated along Ngong river. The approach is not satisfactory in that the design has not considered the essential functions of the river landscape as a green corridor. It also falls short of creating more room for water in the face of climate change (source: Ministry of Lands, Kenya)

Land use in history

Figure 4. 30 (a) to (c) show how Nairobi Dam was used as a recreation spot around 1961. Figure 4. 31 (a) to (c) and Figures 4.32 and 4.33 show how it is currently engulfed by Kibera Informal settlement and other urban land uses.

(a) (b) (c)

Figure 4.30 (a), (b) and (c) Images of how the Nairobi dam was in 1961: a recreation spot popular for boating; provided a wilderness feel, with indigenous vegetation, generally a clean recreational environment (source: www. mccrow.org.uk, 2nd October 2008)

(a) (b) (c)

Figure 4.31 (a), (b) and (c) Images of how the Nairobi dam is currently surrounded by informal settlements and other urban developments rendering it a wasted resource (source: author)

Figure 4.32 Aerial Image of Kibera Informal settlement and its environs (source: Ministry of Lands, Kenya)

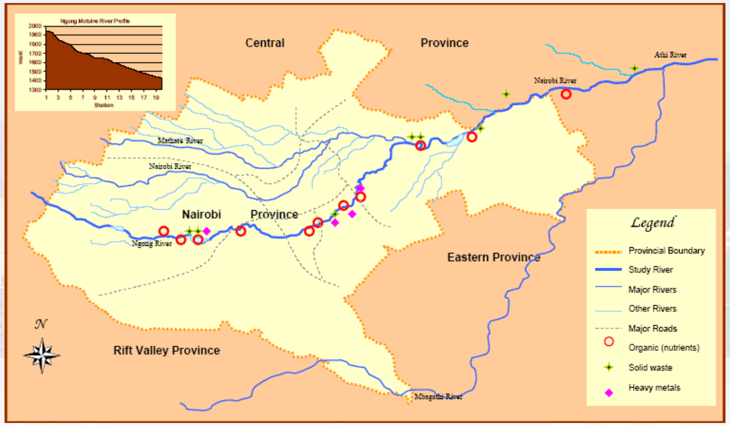
Figure 4.33 Image of Kibera Informal settlement and its environs (source: Google earth, 2008)

Figure 4.34 The ideal situation would be to set-back development and create ecological buffer zone. This will help mitigate on pollution as well as natural disasters such as flooding (source: author)

Water Quality

As earlier mentioned, the water flowing in Ngong river is not fit for either domestic or industrial use because of pollution 'on the extreme'. Pollution is mainly because industrial developments and informal settlements along the river.

"Poverty is not only a social ill: in almost every way it is an environmental ill as well....Very poor people are, naturally, concerned more about their own day to day struggles to survive than about their environments, and those environments themselves are often grim and hardly worth conserving." (Davies, B. et al 1998)



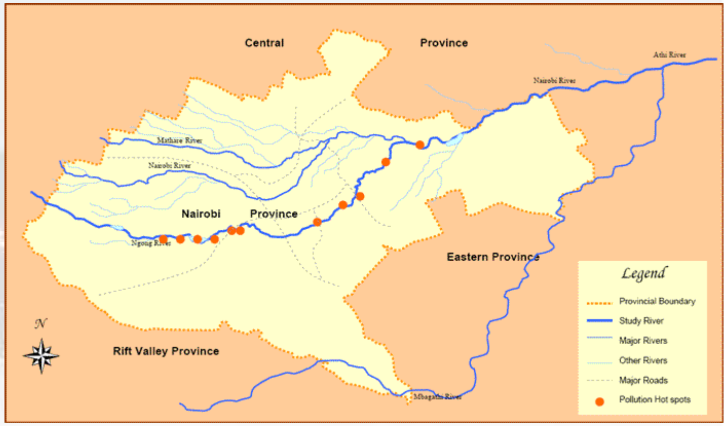


Figure 4. 35 Maps showing water quality assessment along Ngong river. The ministry of Environment and Minerals in collaboration with UNEP has embarked on a programme dubbed "Save Nairobi Rivers" aimed at 'cleaning' all river in the Nairobi river basin, Ngong river included. Sources of water pollution along Ngong river include car repair garages, car wash areas, direct drainage of sewage in river channel, industrial effluents, storm water, hospital chemicals, informal settlements, solid waste sort-out areas (source: www.unep.org, 4th June 2008).

Figure 4.36 Children play in polluted water in Kibera. (source: Ministry of Lands, Kenya)

Figure 4.37 Polluted river as it flows through Mukuru Kwa Njenga Slum (source: author)

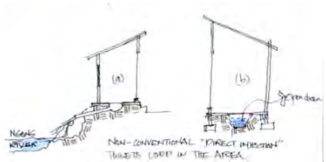


Figure 4.38 Illustration of how pit latrines are discharged directly into river in informal settlements (source: Karisa, D. C., (2004)

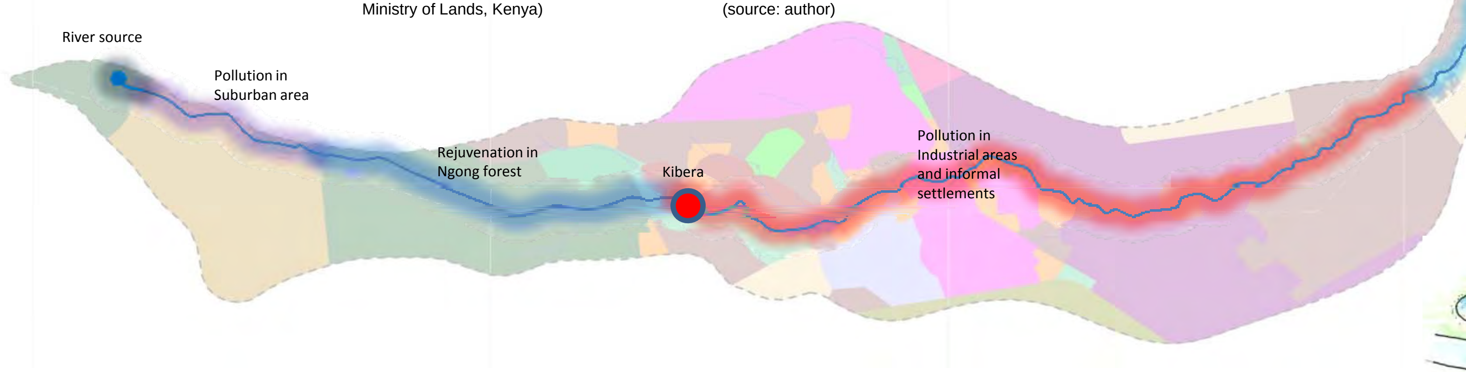


Figure 4.39 Diagram showing pollution consequences as Ngong river flows from its source through a surburb (slight pollution) then rejuvenation as it passes Ngong road forest before it is intensively polluted in the urban area particularly in informal settlements and industrial area. (Inset) is an illustration of the unhygienic systems of waste disposal into Ngong river. The government acknowledges that any restoration of this river must start with intervention strategies in these two key areas. The continuous red glow means that once polluted upstream the effects are felt for long distances downstream (source: author)

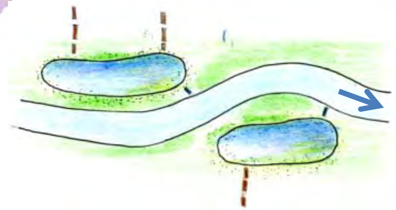


Figure 4.40 Illustration of how wetlands could be used to attenuate on stormwater and sewage before discharge into river (source: author)

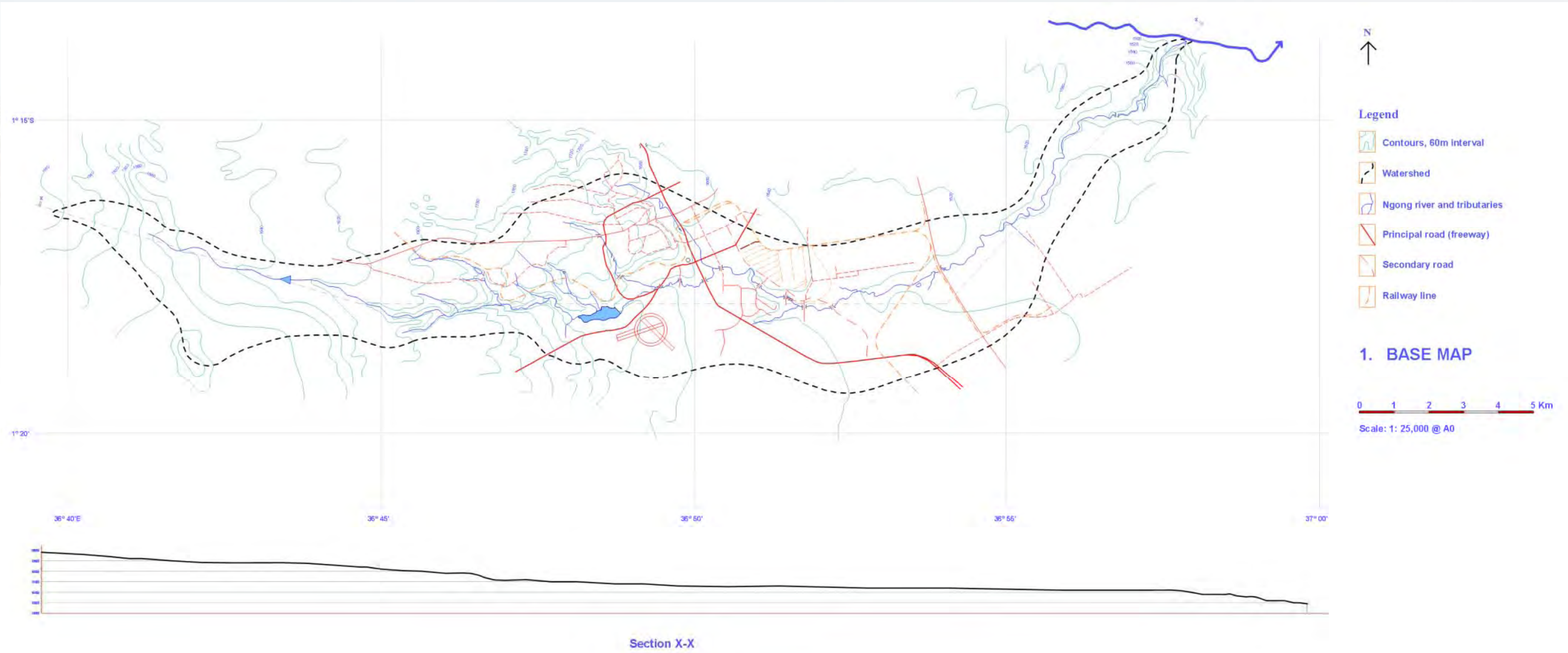


Figure 4.41 Topography Map and section showing the general terrain of the Ngong river basin, road and railway network (author)

(a) (b)

Figure 4.42 (a) Railway line and (b) principal road (Mombasa road) that cross the basin. (source: author)

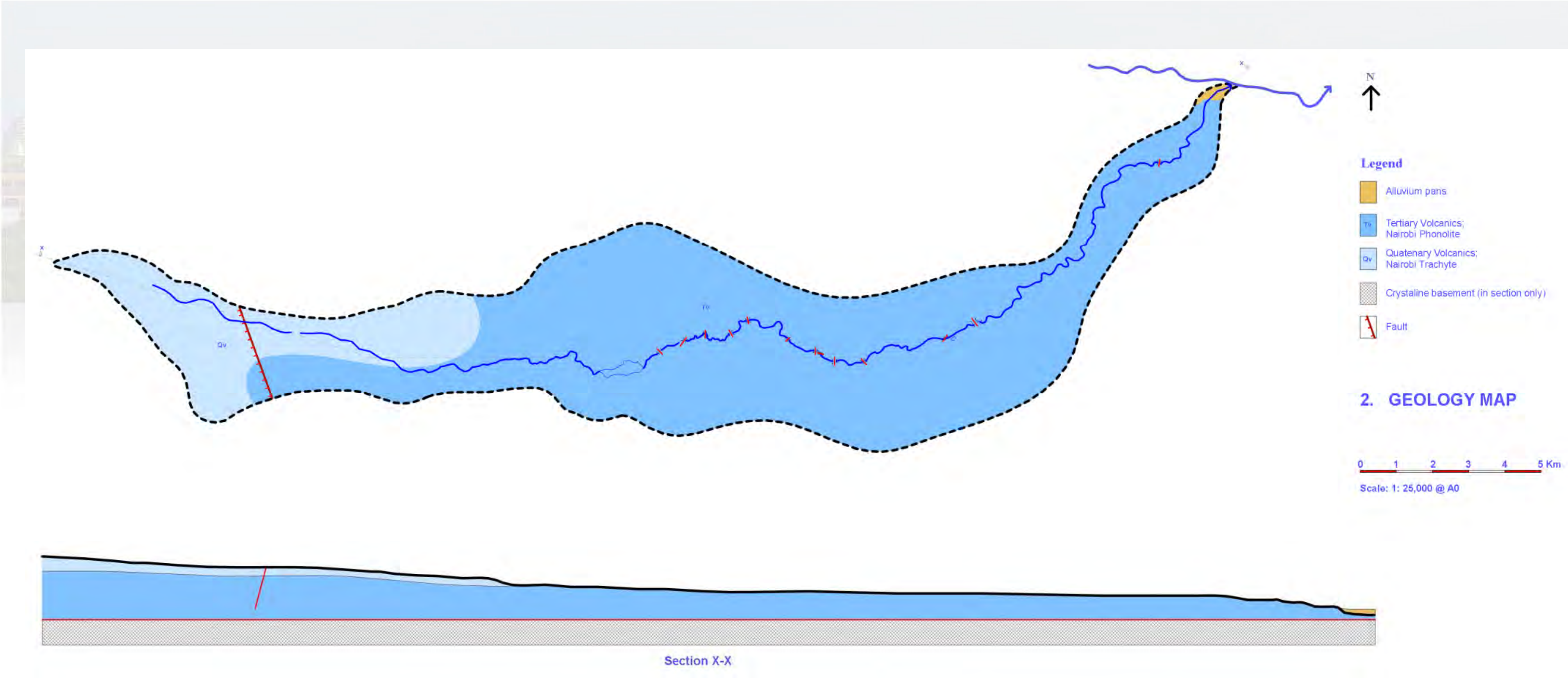


Figure 4.43 Geology Map and section showing the geology of the basin (source: author)

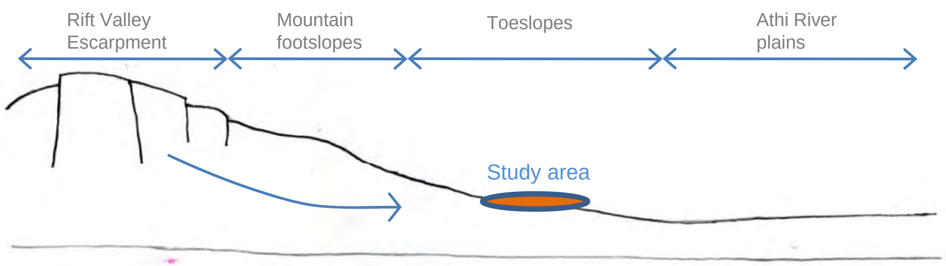


Figure 4.44 Diagram showing location of the study area on the gently sloping toeslopes of the eastern flank of the Rift Valley (source: author)

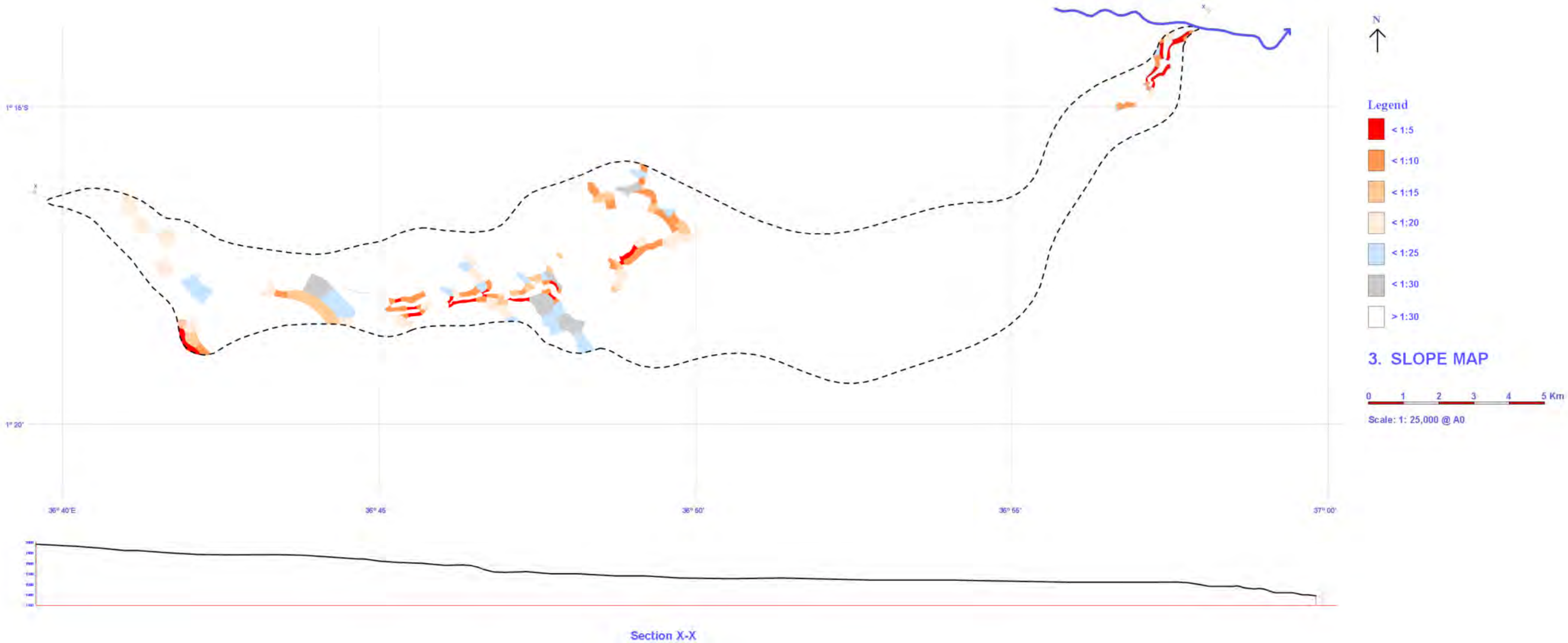


Figure 4.45 Slope Analysis Map. This shows slope gradients within the basin –from steep land (less than 1:5) to flat land (more than 1:30) (source: author)

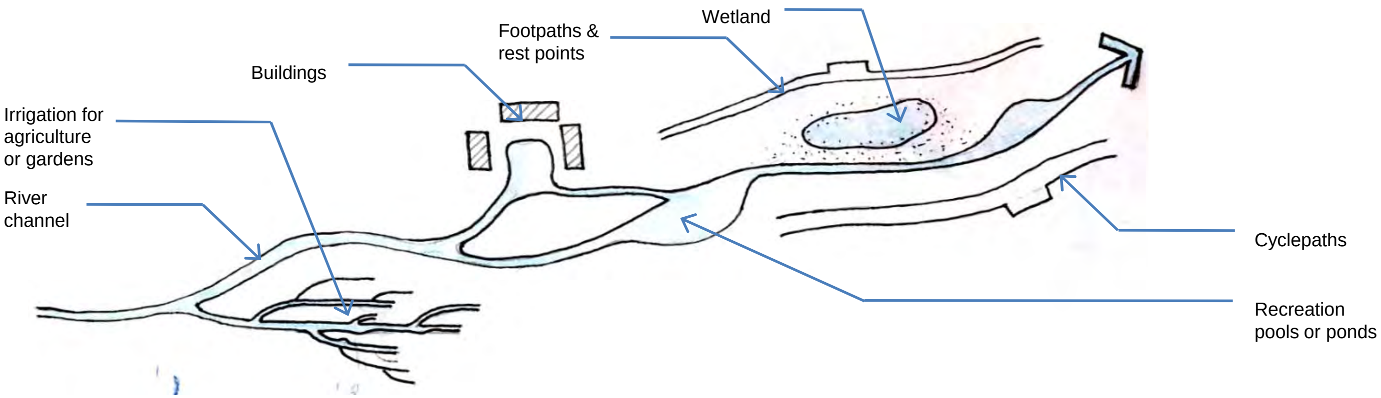


Figure 4.46 Diagram showing how the gentle slopes along Ngong river may be designed to create more room for water by letting it flow over other parts of riverside land other than in the river channel (source, author)

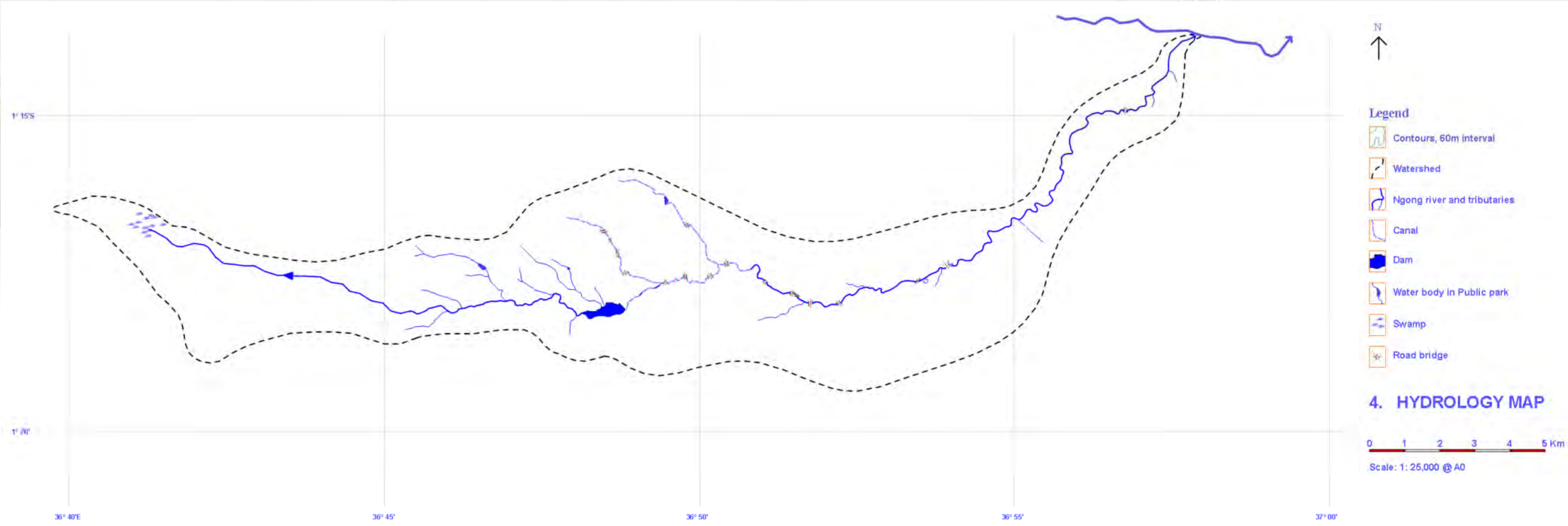


Figure 4.47 Hydrology Map. This shows the general flow direction of the river, tributaries and man-made drains (canals), dams and water bodies, swamps (source: author)

Figure 4.48 Flooding of properties and roadways within the basin (source: D/N, 24th December, 1997)

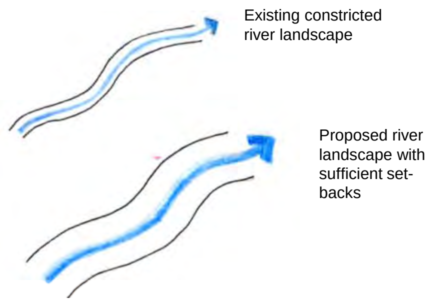


Figure 4.49 There is need to open up water courses in the basin currently 'choked' by urban development

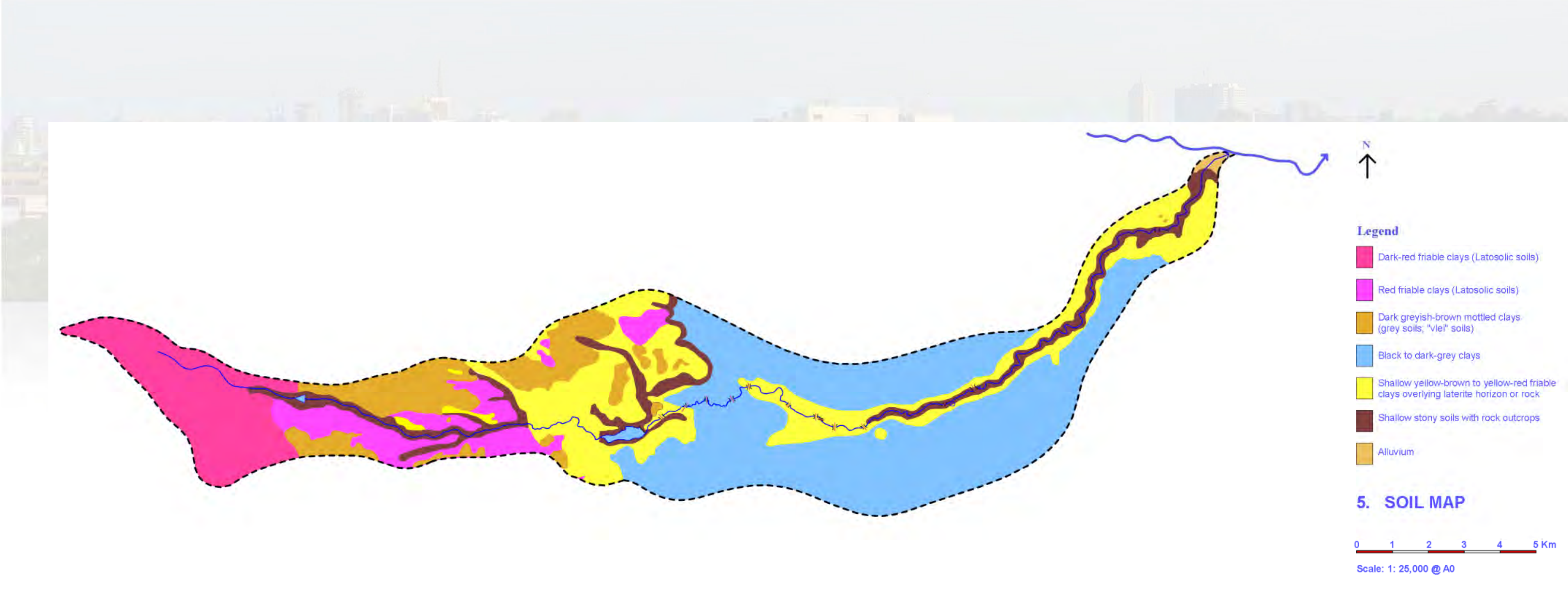


Figure 4.50 Soil Map showing the occurrence of different soil types in the basin (source: author)

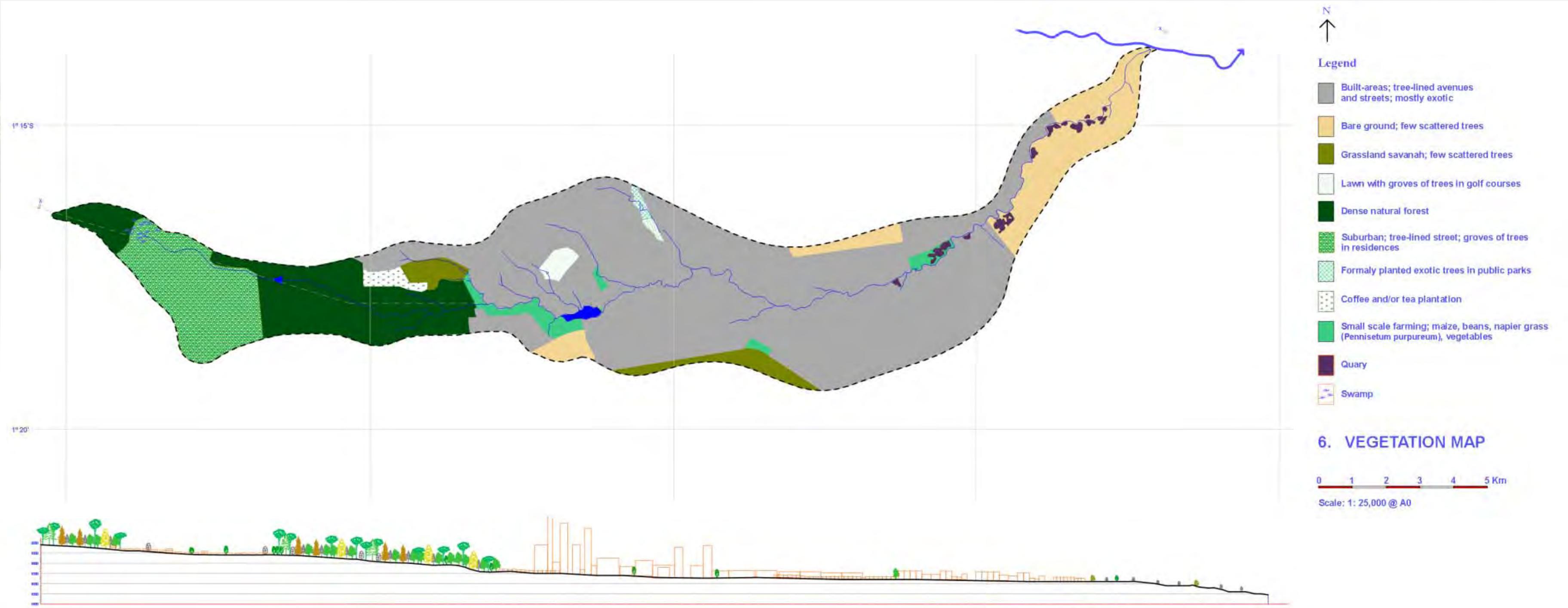


Figure 4.51 Vegetation Map showing existing vegetation cover. A large portion is urban. Urban areas are mostly planted with exotic plants; in parks, in private gardens and streets (source: author)

Figure 4.52 Urban Agriculture as part of vegetation cover in the upper reaches of the river (source: author)

Figure 4.53 A green corridor along the Urban Besos River, Barcelona, Spain. In the midst of the concrete associated with urban areas, the corridor serves as a contrasting feature. (source, Margolis., L et al 2007)

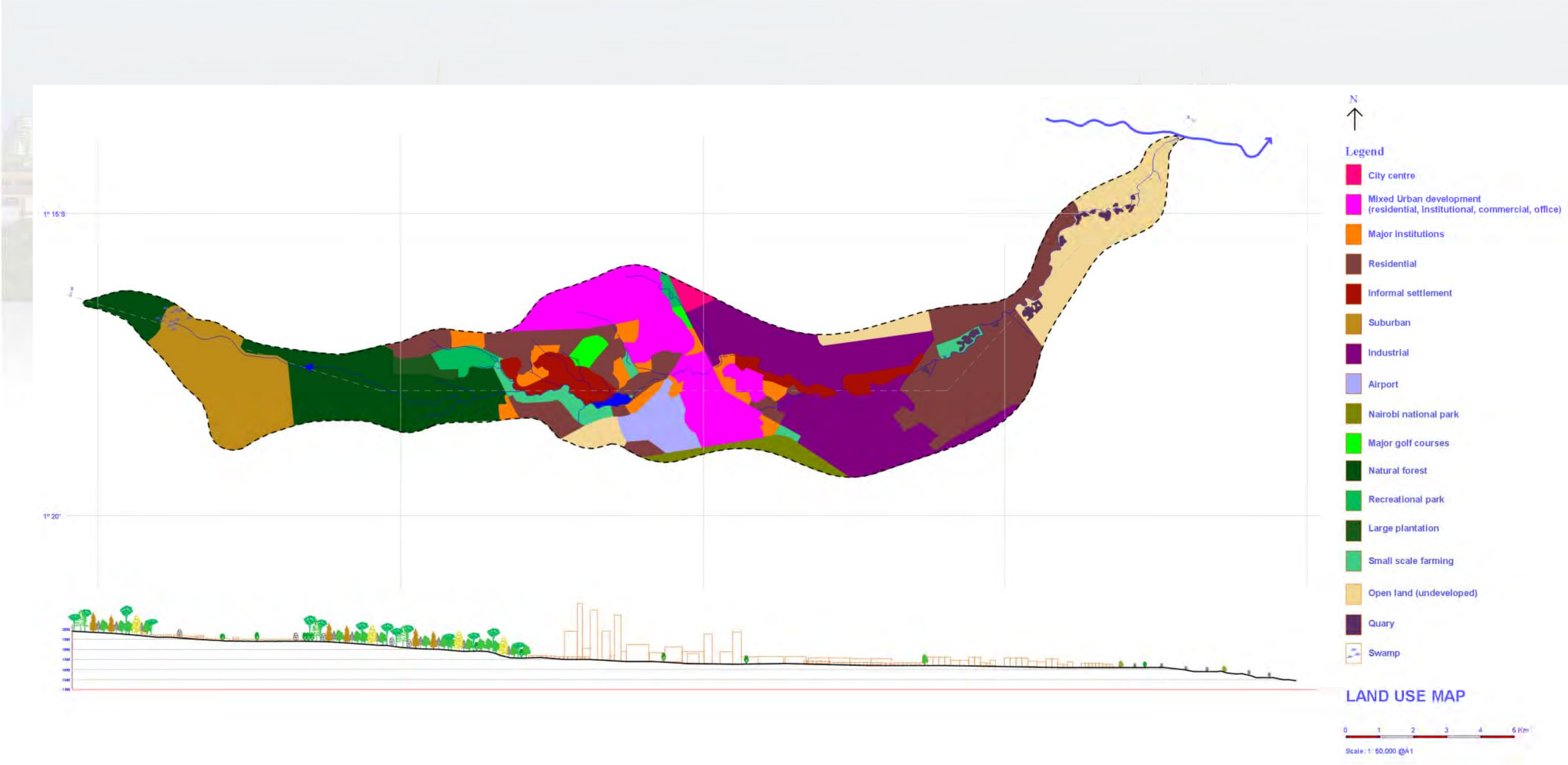


Figure 4.54 Land Use Map. There is indiscriminate placement of various land uses on the landscape irrespective of whether suitable or not. A landscape assessment exercise would reveal how the river landscape is abused. It is not used for purposes that suit it. The uses are not only inconsistent with natural rhythms and processes associated with rivers but also lack sound principles of natural resources and landscape management (source: author

Figure 4.55 Google Earth (2008) image of the Precinct site

4.2.3 Precinct Site Scale

The precinct site in this study is the urban area stretching from Mombasa road to Mukuru Fuata Nyayo informal settlement (Figure 4.56) In this area the river flows through a mix of land uses ranging from residential, industrial, informal settlements, urban agriculture (informal) as well as through semi-public institutions such as the Mater Hospital, colleges and schools, churches and mosques.

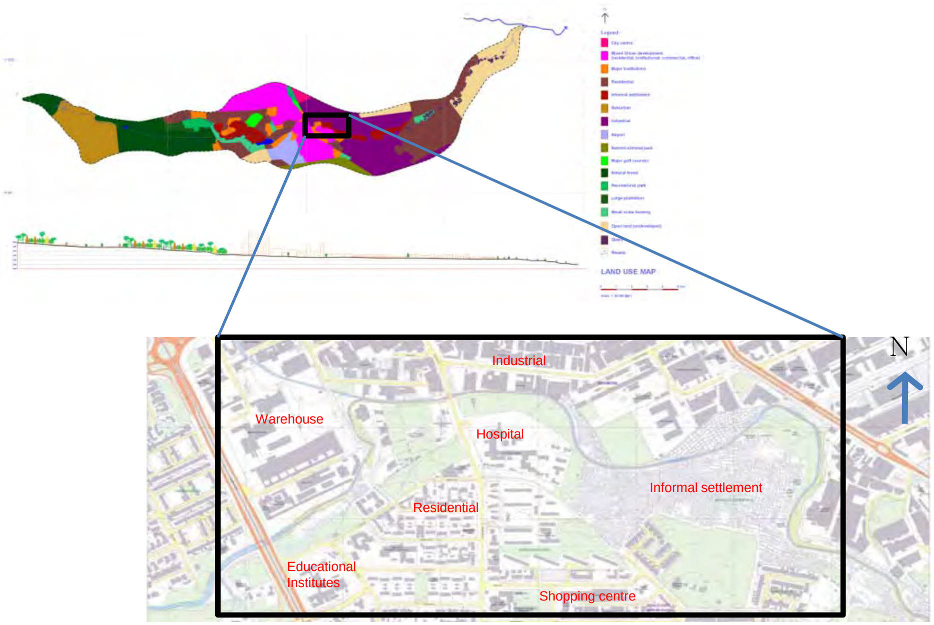


Figure 4.56 Location of Precinct site in which a landscape development framework will be designed. (source: GOK, 2005)

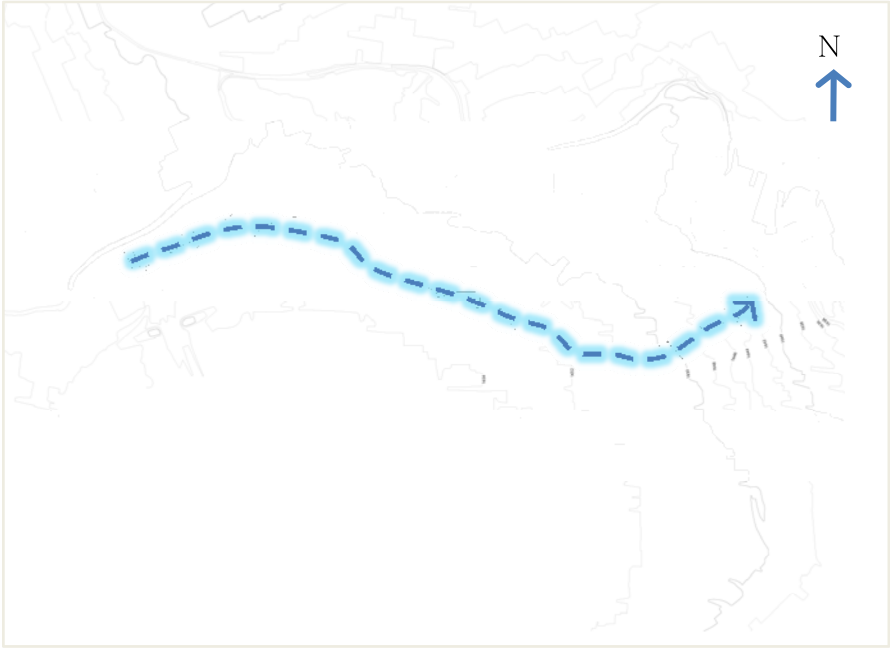


Figure 4.57 Topography Map of the site. The arrow line show stormwater retention strategy: slow flow through the gently sloping landscape rather than direct discharge into river (source: GOK, 2005)

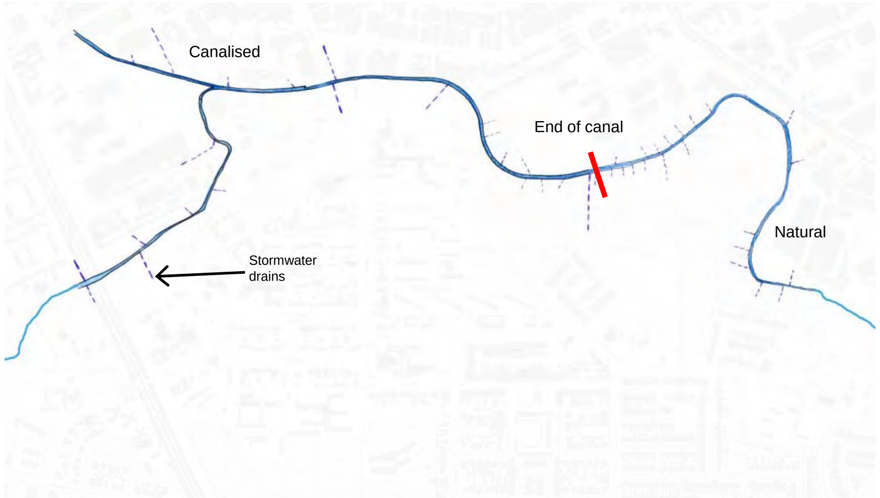


Figure 4.58 Existing river channel. It is narrowed by urban development, canalised on the upper part and naturally flowing on the lower part (source: author)

4.2.3.1 Natural Systems

Topography

The site is gently sloping at altitude between 1634 m and 1652 m (Figure 4. .57) This allows for a variety of possible design concepts with both river and storm water.

Hydrology

The river is canalised in some sections. The canal is not continuous. It only appears in the industrial area while in the informal settlement the river is natural.

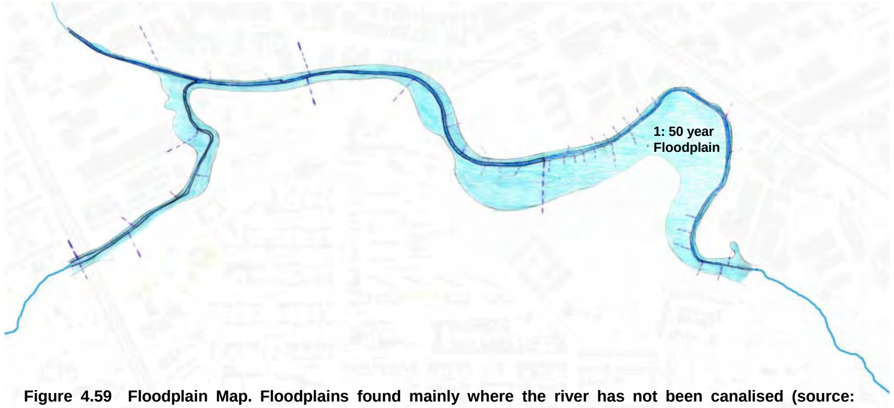


Figure 4.59 Floodplain Map. Floodplains found mainly where the river has not been canalised (source: author)

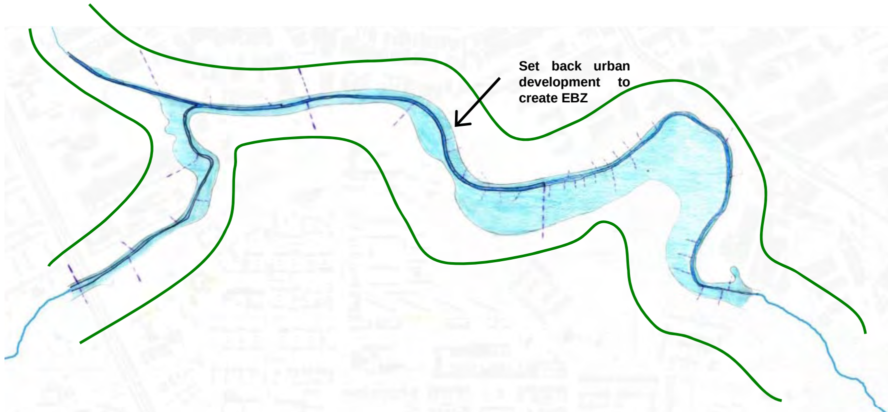


Figure 4.60 Image showing the need to create an Ecological buffer zone along the river (source: author)

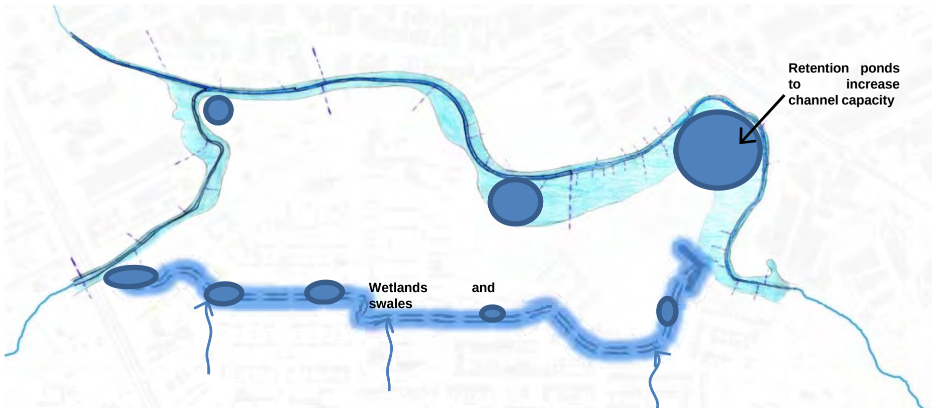
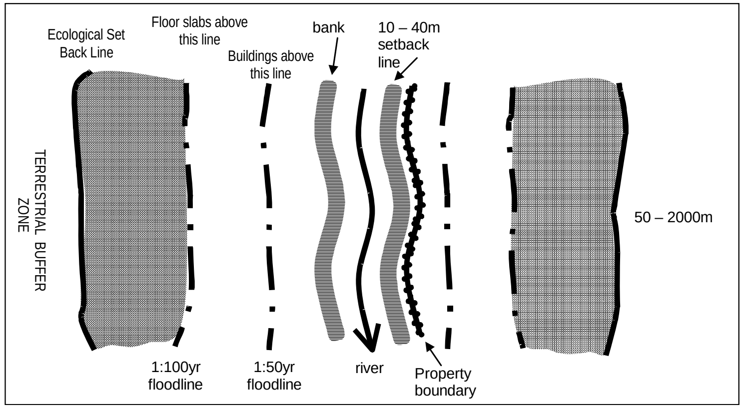


Figure 4.61 Stormwater could be captured in wetlands and swales before discharge into river. Retention and detention ponds could also be constructed along the river (source: author)

(a)



(b)

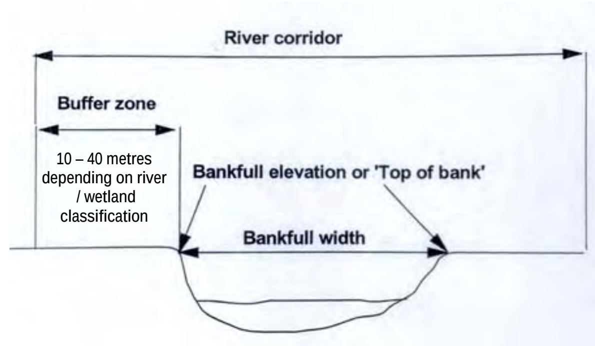


Figure 4.62 (a) and (b) City of Cape Town guidelines for provision of EBZ (source: City of Cape Town, 2000)

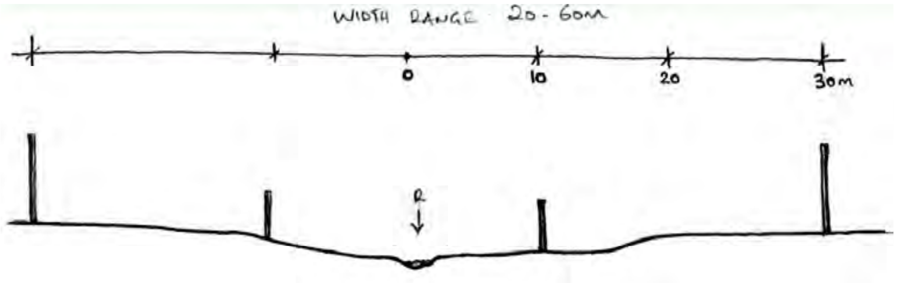


Figure 4.63 Illustration of a section across river showing appropriate width ranges for EBZ. (Drawn from City of Cape Town, 2002)

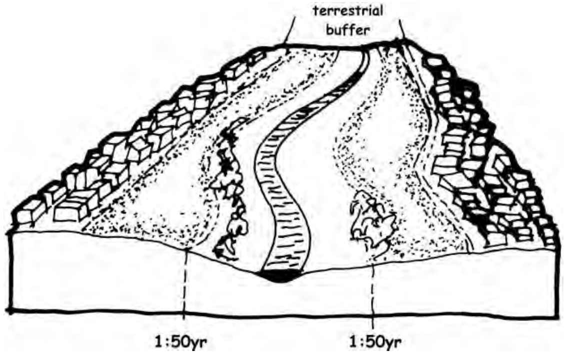


Figure 4.64 Another image showing City of Cape Town guidelines for provision of EBZ (source: City of Cape Town, 2000)

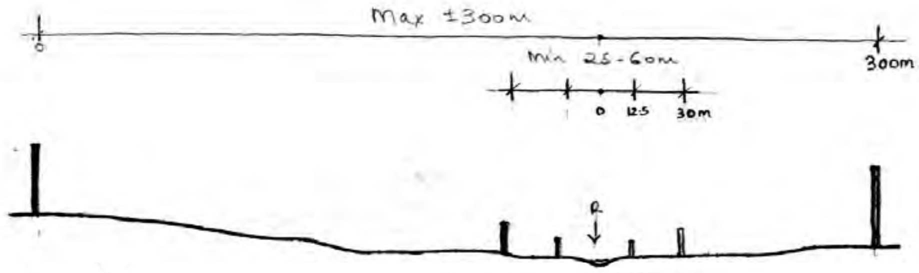


Figure 4.65 Guidelines for provision of quality Linear Parkways along rivers. They should generally be of minimum width 25 -60 m and maximum of 300 m. The required minimum is to allow for monitoring of the river and safety. The maximum width guideline is generally to allow for informal surveillance. (Drawn from City of Cape Town, 1996)

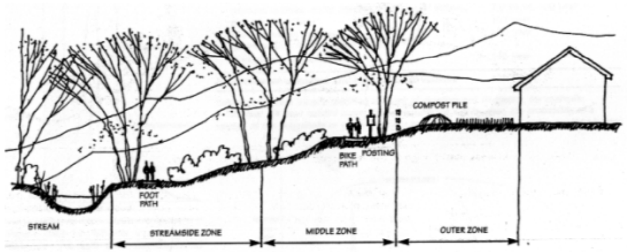


Figure 4.66 Schematic section through a river landscape showing zonation of the space from built-up areas to the river channel: space function, width, vegetative target and allowable uses (source: Harris, W.C., 1998)

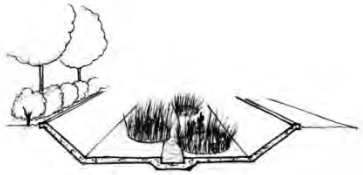
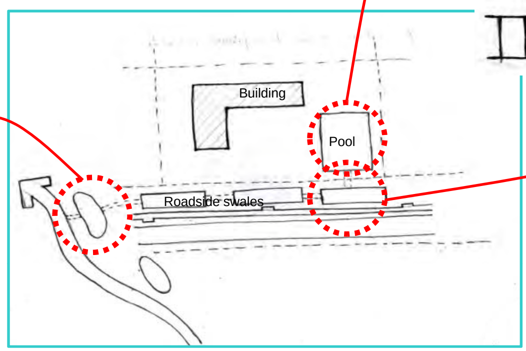


Figure 4.67 The Canalised sections of the river could be modified to create plant and animal habitats (source: author)

Plan

Section



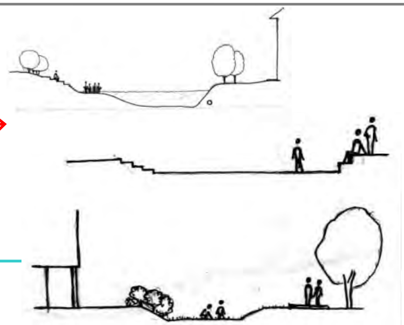


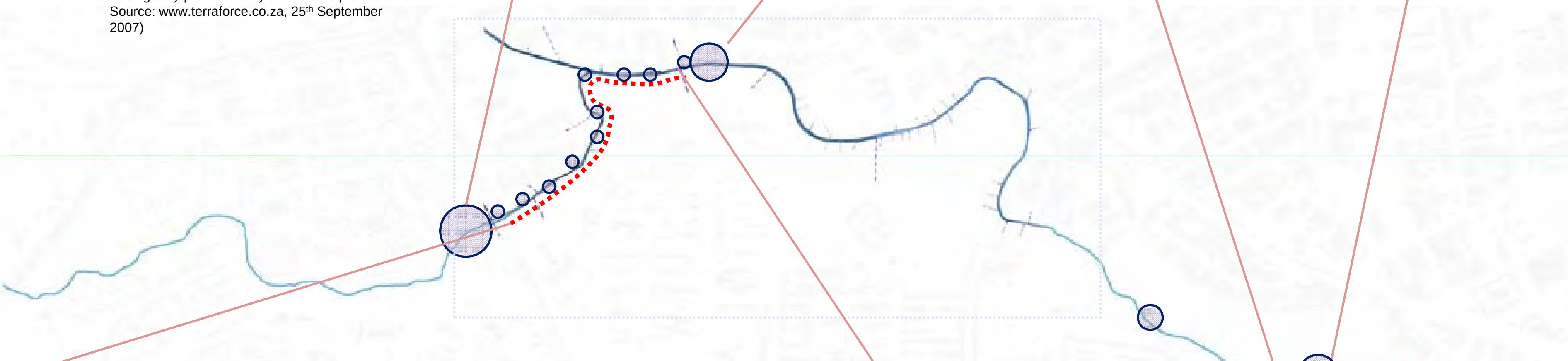
Figure 4.68 Stormwater attenuation strategies (source: author)

Figure 4.69 Hard paved depression in a pedestrian precinct, Cape Peninsula University of Technology, Cape Town. Such features help detention runoff. (source: author)

(a) (b)

Figure 4.70 A retention pond in Lebreton Park and surrounding residential housing, Ottawa. (a) The retention pond wet: during a rainstorm the pond fills to 450mm and takes on a very different character inviting unstructured water-related play and visual variety. (b) The retention pond dry: Flexipave surface provides a durable topcoat for a variety of dry weather activities (source: Hough, M. 1995)

Ecologically preferred way of river bed protection. Source: www.terraforce.co.za, 25th September 2007)



Images of sewage and stormwater drains that discharge directly into Ngong river within the section marked ( )

Children being assisted cross flooded Ngong river (Source: D/N 14th January 1998)

Women cross flooded bridge on Ngong river (Source: D/N 14th January 1998)

Images of different hydrological processes along the river. All images are author's except where otherwise referenced.

4.2.3.2 Urban Systems

Land Use

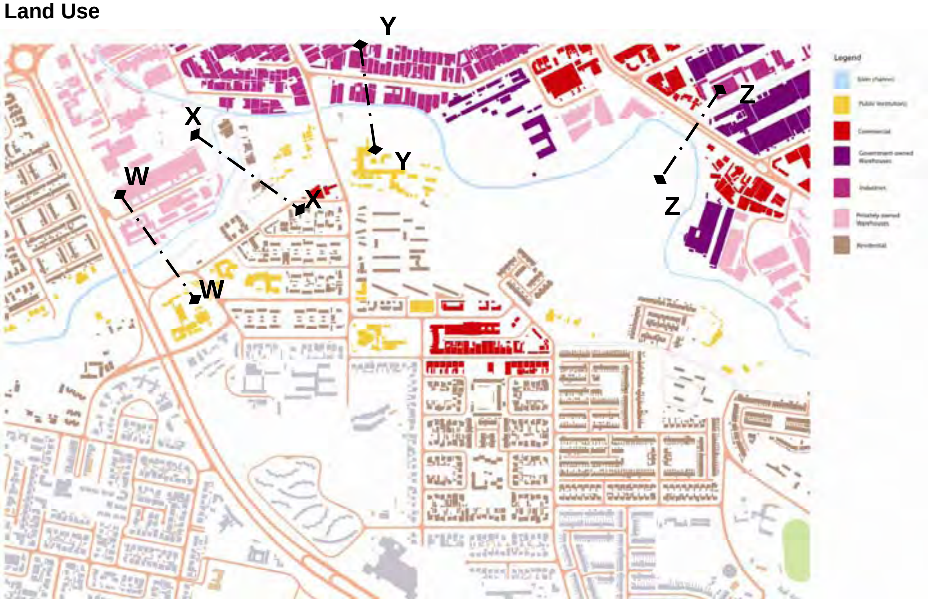


Figure 4.71 Land Use Map (source: GOK, 2005)

Section W-W

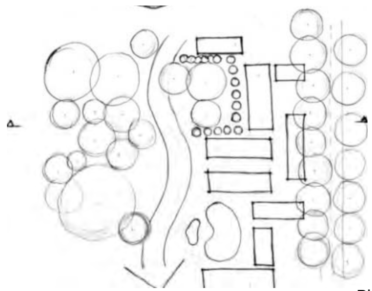
Section X-X

Section Y-Y

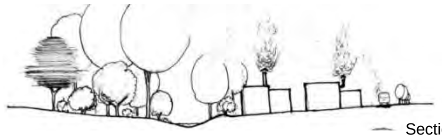
Section Z-Z

Figure 4.72 Map showing the extent of informal settlements. Industries and Informal settlements are the main sources of water pollution (source: GOK, 2005)

Figure 4.73 Diagrams illustrating increase in vegetation cover in EBZ and within the built area to help reduce on water pollution (source: author)

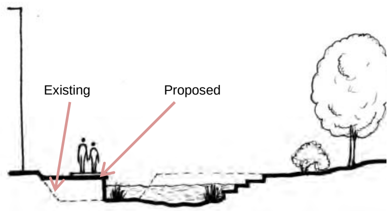


Plan



Section

Figure 4.74 Section illustrating how pedestrian riverfronts may be created by shifting the river channel in places where there are buildings on the river banks. (source: author)



Images of various land uses along the river and its surroundings. All images, unless where referenced, are author's

Source: Google earth, 2008)

Source: Google earth, 2008)

Source: Google earth, 2008)

Images of various open spaces along the river. All images, unless where referenced, are author's

Images showing various agricultural activities along the river. All images are author's

Images showing the different pollution hotspots along the river. All images are author's

Figure 4.75 Map showing main road network, existing paths and powerline (source: GOK, 2005)

Figure 4.76 Map illustrating how pedestrian and cyclists movement along the river should be encouraged. (source: author)

Figure 4.78 Illustration of how meeting point of pedestrian flow along rivers and public transport vehicle routes may result in creation of activity nodes. This will then encourage growth of socio- economic activities (see also Figure 4.81) (source: author)

Figure 4.79 A horse rider in Constantia River Trails, Cape Town. Opening up the Ngong river could allow for such kind of leisure activities (source: author)

Figure 4.80 A sidewalk along a road in the Cape flats, Cape Town. Design for such routes along roads and rivers can significantly contribute to sustainable city landscapes (source: author)

(a)

(b)

Source: www.bbc.co.uk, 12th October 2008)

(c)

Source: www.eastandard.com

(d)

Source: www.unep.org

Figure 4.79 Images of simple economic activities such as informal trading and hawking

Images showing means of transport in and around the site. All images are author's

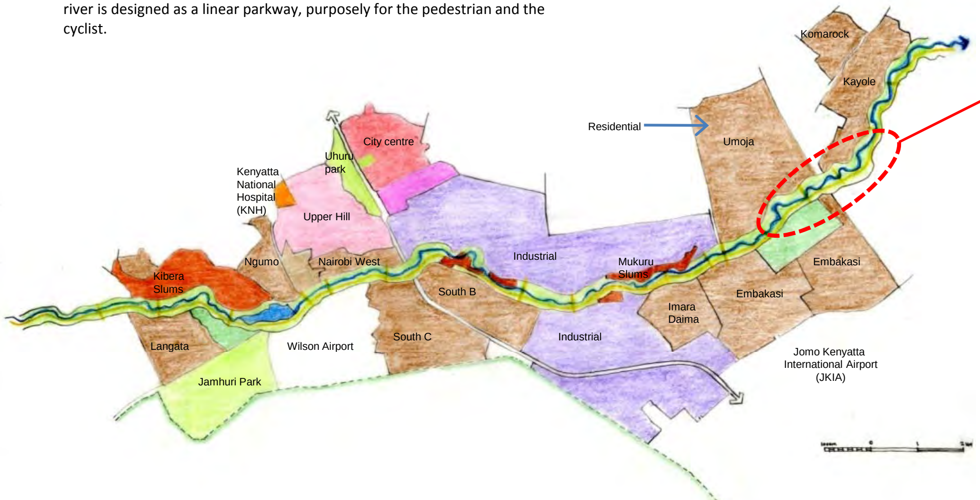
Images showing vegetation types on the site. All images are author's

Movement/ City Connections: The river landscape as the main 'connector'

Figure 4. Existing Metropolitan Open spaces. They are fragmented despite the presence of many river which can be used as linking green corridors (source: author)

Figure 4. Existing Metropolitan Open spaces. They are fragmented despite the presence of many river which can be used as linking green corridors (source: author)

Figure 4. Ngong river flows through many middle and low income residential estates, industrial area and very close to the city centre. The daily movement of people to and from these places is high. It is therefore important that the river is designed as a linear parkway, purposely for the pedestrian and the cyclist.



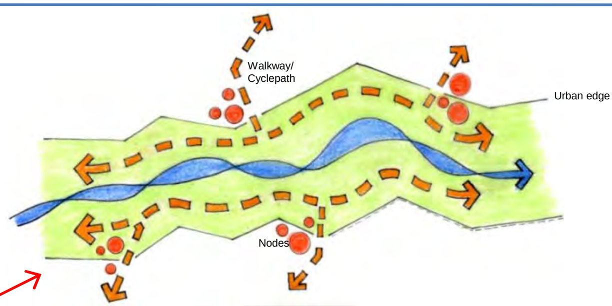


Figure 4 Many people in Nairobi walk to and from their workplaces (source: D/N, 4th April 2007)

(c)

(a)

(b)

Figure 4. (a), (b) and (c) Images of the Cheonggyecheon stream landscape, Seoul, South Korea. A project described as "a great victory in renewal and beautification of the city". Restoration and enhancement of the river landscape has made it the choice for people wanting to move from one place to another (source: Faizi, M., et al 2008)

Metropolitan Open Spaces: An opportunity to link public open spaces in Nairobi

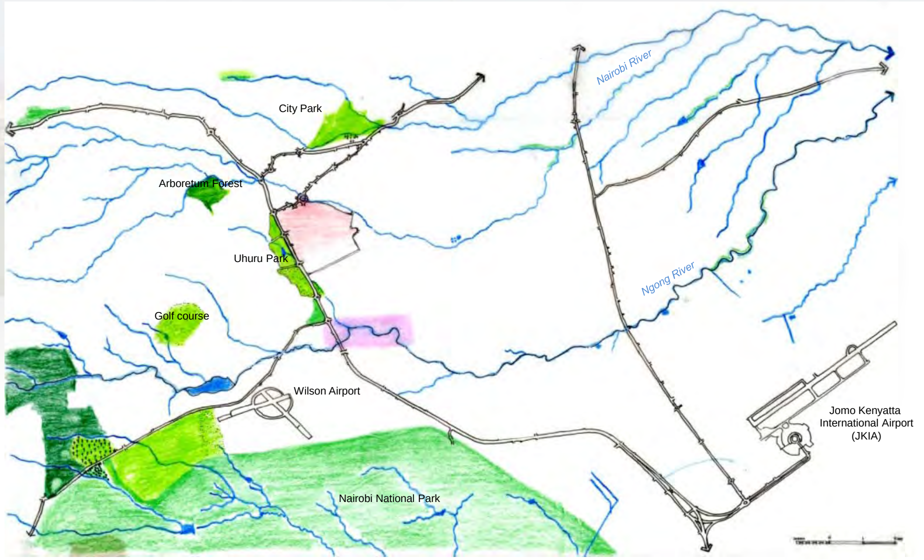


Figure 4. Existing Metropolitan Open spaces. They are fragmented despite the presence of many river which can be used as linking green corridors (source: author)

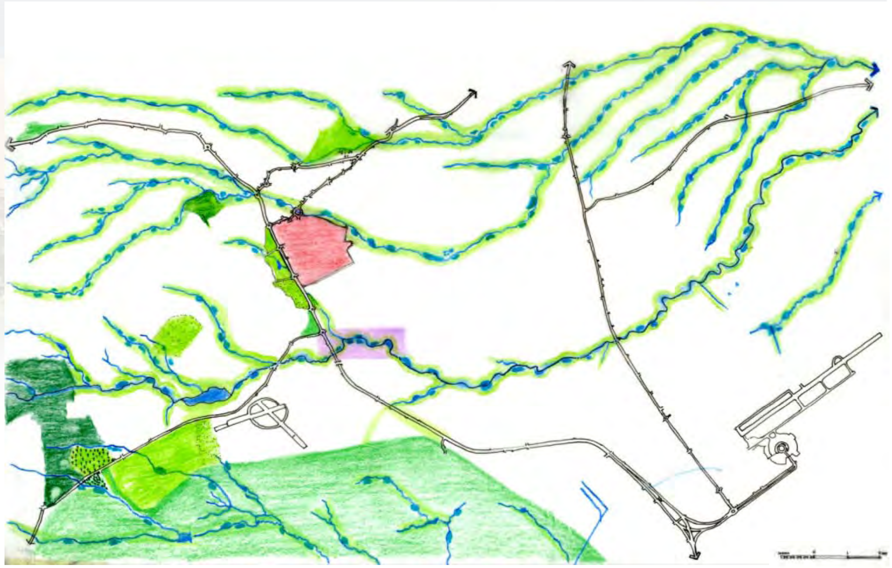


Figure 4.. Proposed linking of open spaces using water courses. By creating buffer zones , the river landscapes are opened up and maintained as linear parkways. This also makes the rivers more adaptive to climate change (source: author)

As people realise the need to adapt to the impacts of climate change on the river landscape, new opportunities arise such as establishing connections between the disjointed public open spaces (city parks, forests, game parks) using linear open spaces of river corridors and streets/ avenues. Nairobi river edges currently do not provide for green corridors because urban development is extended right down to the river bank and even the river bed.

In response to climate change therefore, we have little option but to open up these rivers to create wide, linear green corridors of Nairobi river and its tributaries one of which is the ngong river. These together with appropriately designed avenues and streets will link the city forests (Karura, the Arboretum, Ngong road forest, Dagoretti), the game parks (Nairobi National park up to the Ngong hills, giraffe centre, animal orphanage) and the city parks (Uhuru and Central park, City park, Jamhuri park, Jee van jee gardens, golf courses) among others.

Source: www.kenya-advisor.com

Source: www.ngongforest.wildlifedirect.org

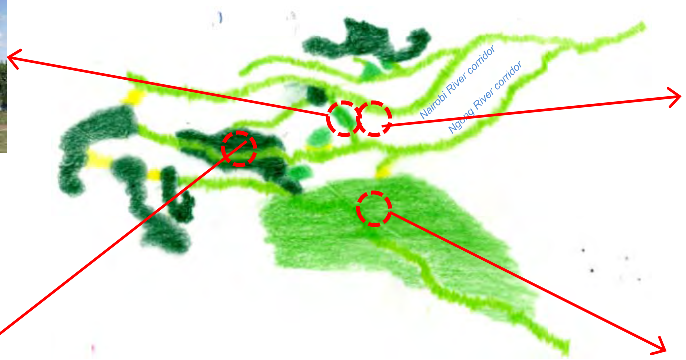


Fig. 4.1 Diagram showing possible open space system created from river corridors, parks and forests in the Nairobi area and around Ngong river (source: author)

source: www. mccrow.org.uk

Source: www.wikipedia.org, 5th July 2008

Stormwater Management: Retain, Store, clean, use and reuse

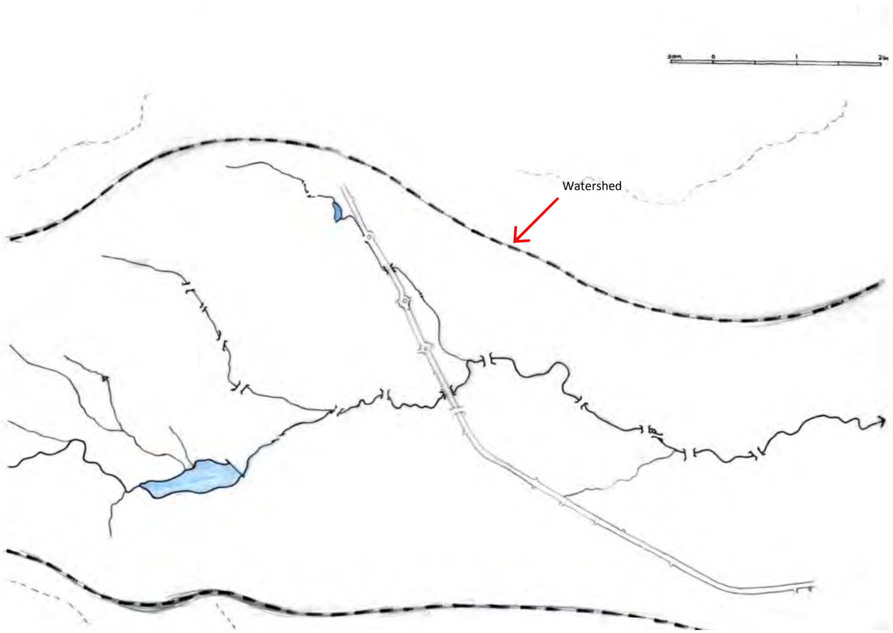


Figure 4. Existing river and tributaries used as stormwater and sewage disposal conduit. (source: author)

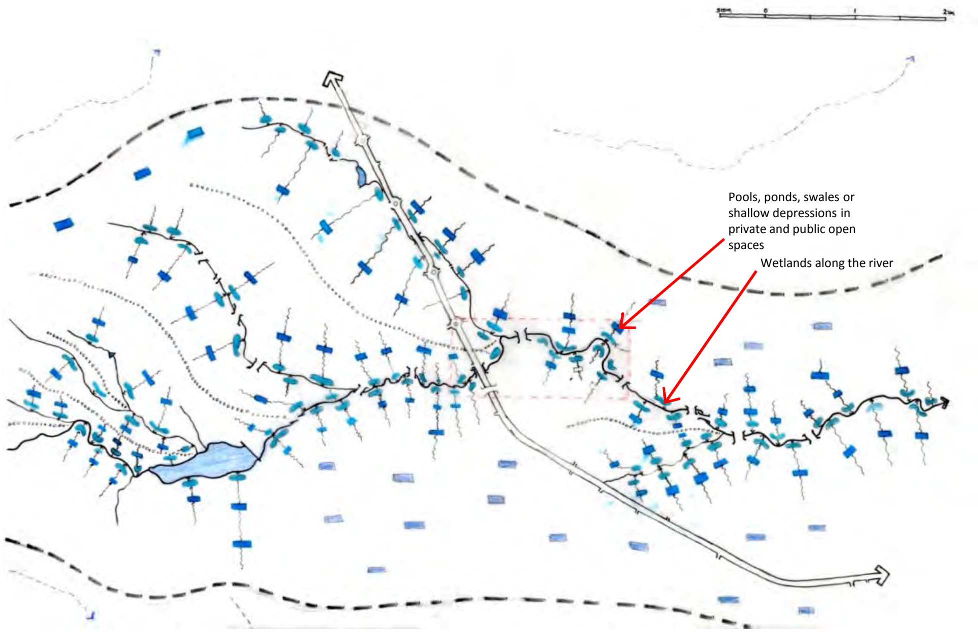
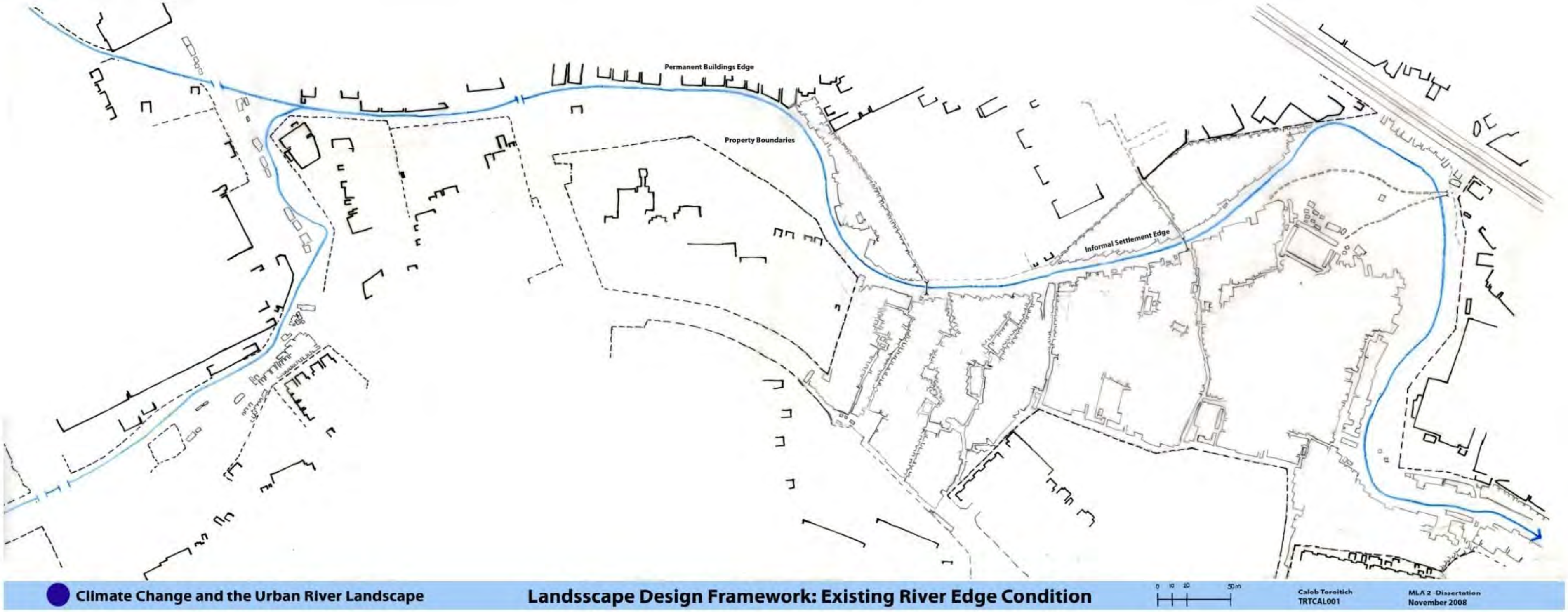


Figure 4. Proposed Stormwater management strategies. (source: author)



Permanent Buildings Edge
Property Boundaries
Informal Settlement Edge
Climate Change and the Urban River Landscape
Landsscape Design Framework: Existing River Edge Condition
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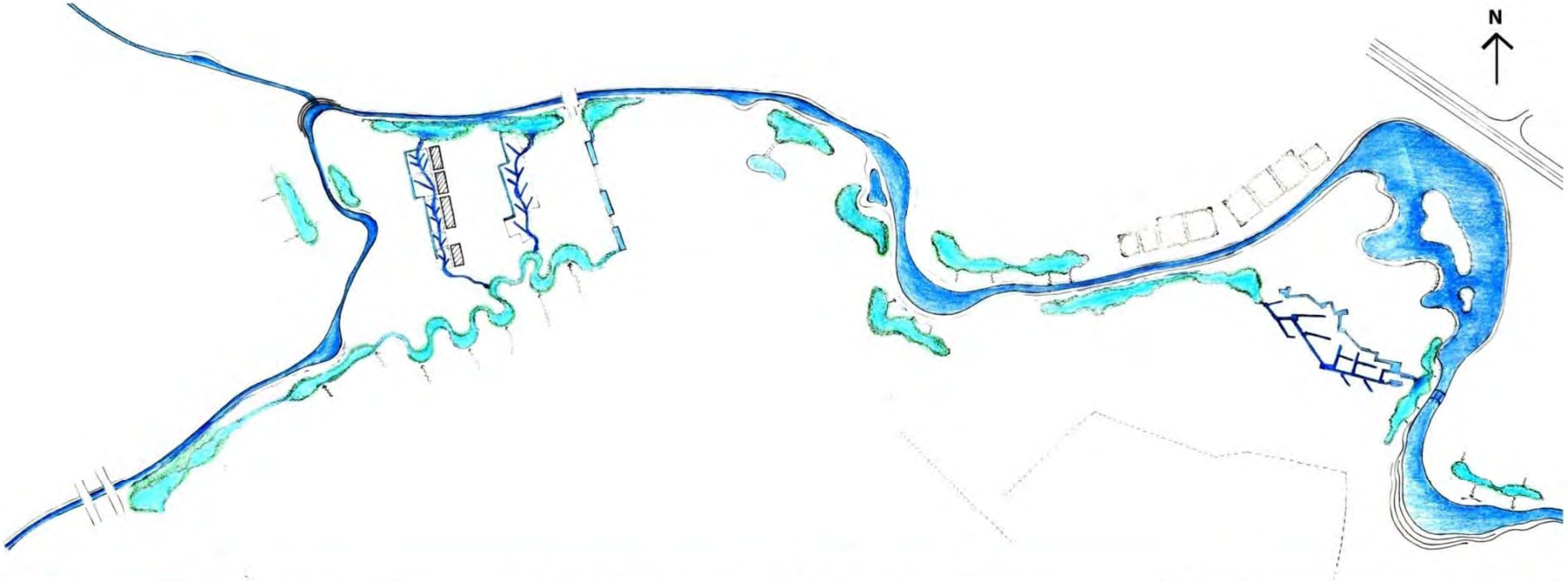
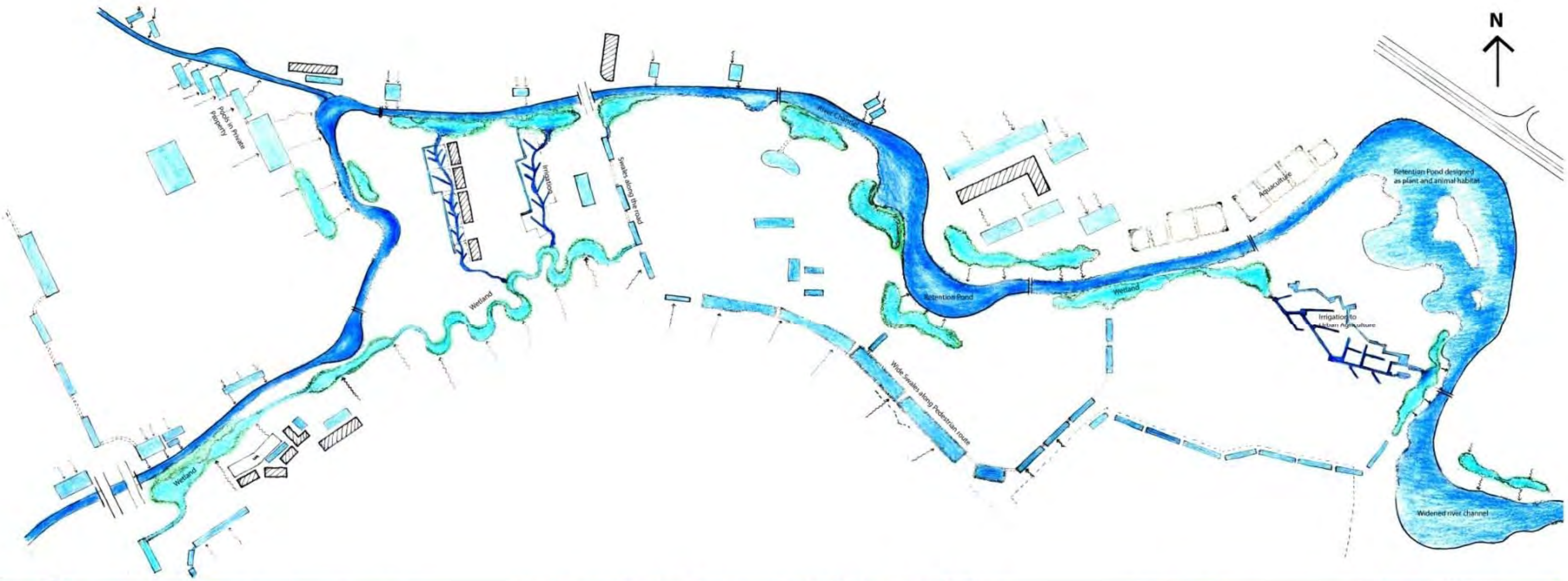
Caleb Toroitich
TRTCAL001
MLA 2 Dissertation
November 2008



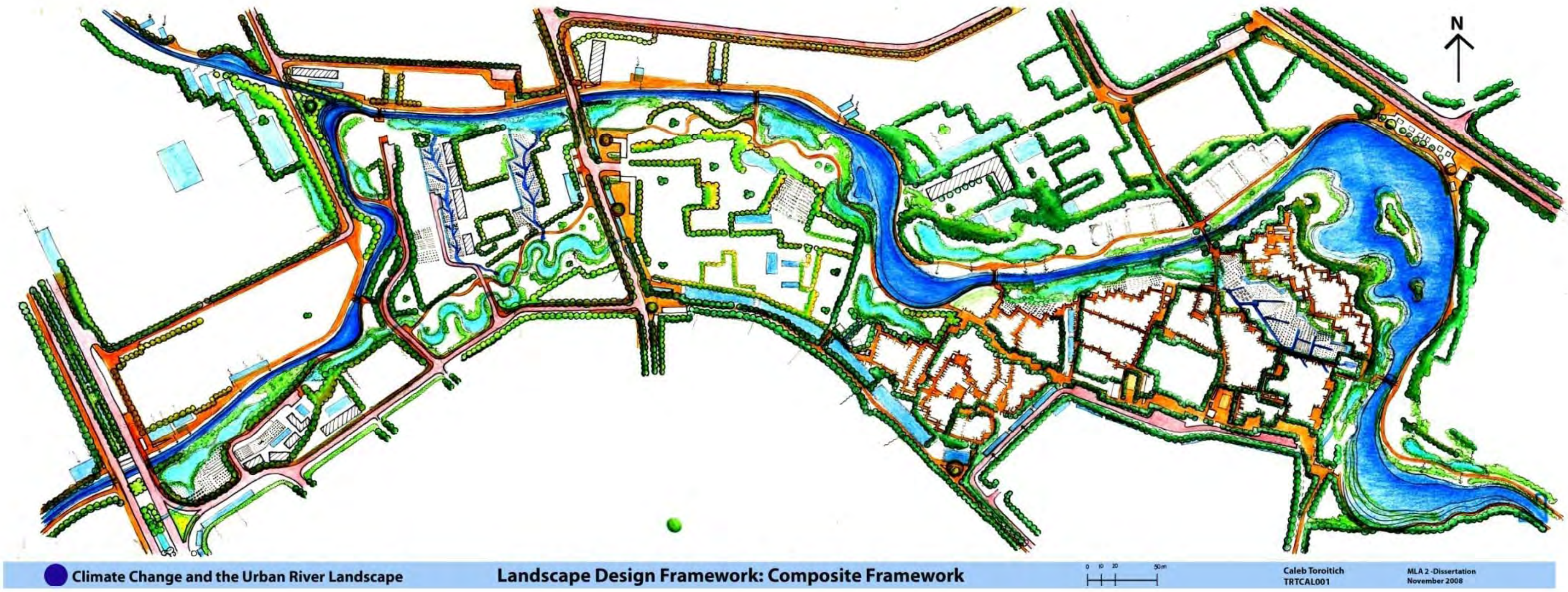
Climate Change and the Urban River Landscape | **Landscape Design Framework: Hydrology -Low Flow** | 0 10 20 50m | Caleb Toroitich TRTCAL001 | MLA 2 -Dissertation November 2008



Climate Change and the Urban River Landscape | **Landscape Design Framework: Hydrology -High Flow** | 0 10 20 50m | Caleb Toroitich TRTCAL001 | MLA 2 -Dissertation November 2008

Climate Change and the Urban River Landscape — **Landscape Design Framework: Circulation & Movement** — 0 10 20 50m — Caleb Toroitich TRTCAL001 — MLA 2 -Dissertation November 2008

Climate Change and the Urban River Landscape — **Landscape Design Framework: Vegetation and Urban Agriculture** — 0 10 20 50m — Caleb Toroitich TRTCAL001 — MLA 2 -Dissertation November 2008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Climate Change and the Urban River Landscape
Landscape Design Framework: Composite Framework
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Caleb Toroitich
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November 2008


N
Enterprise Road
Retention Pond
Aquaculture Farming
Kick-about
Buildings
Pedestrian Route
Urban Agriculture
Play Area
Wetland
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Climate Change and the Urban River Landscape
Sketch Plan
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Climate Change and the Urban River Landscape

Detailed Design

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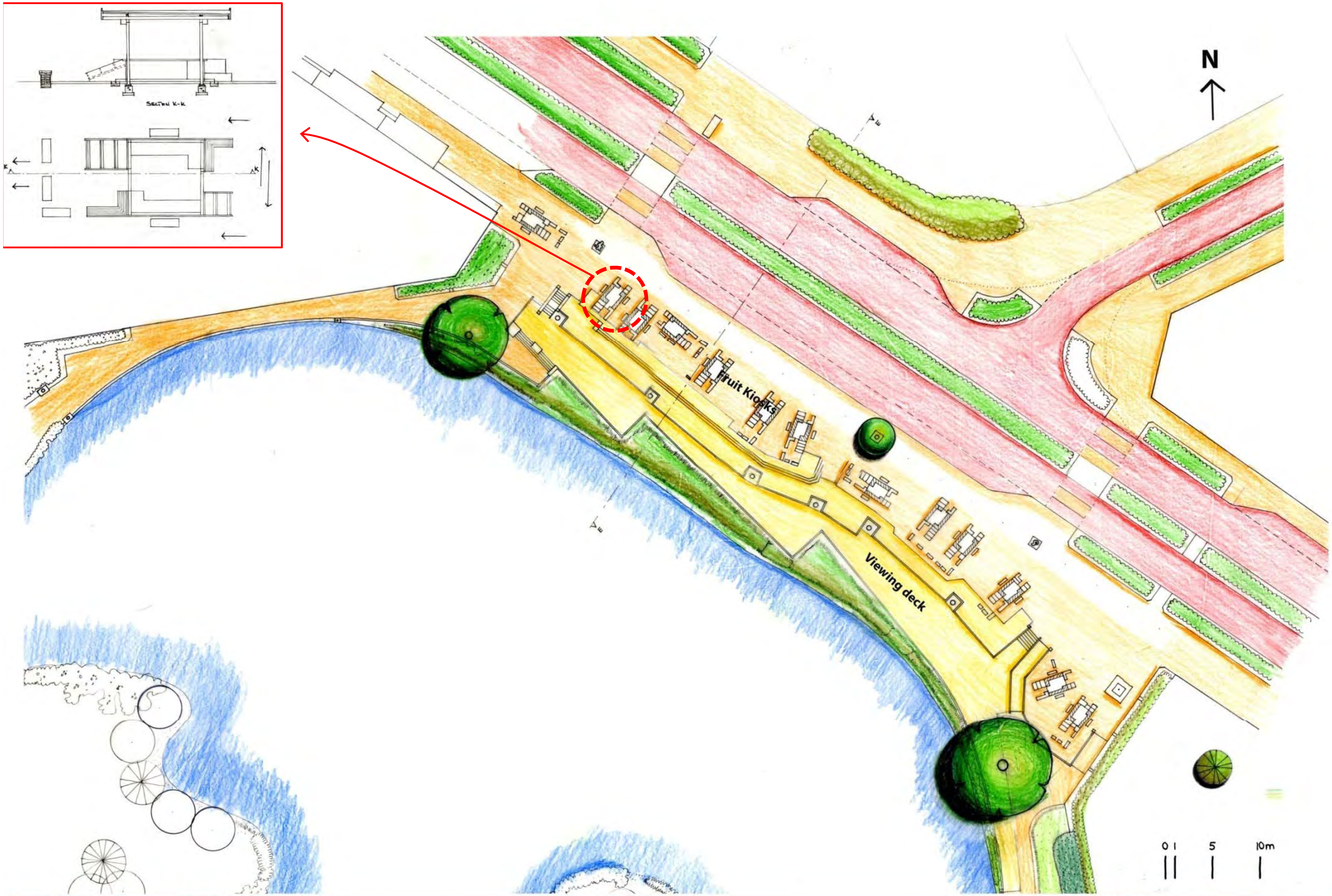
SECTION K-K
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Fruit Kiosks
Viewing deck
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Climate Change and the Urban River Landscape

Detailed Design

Scale 1: 250 @ A1

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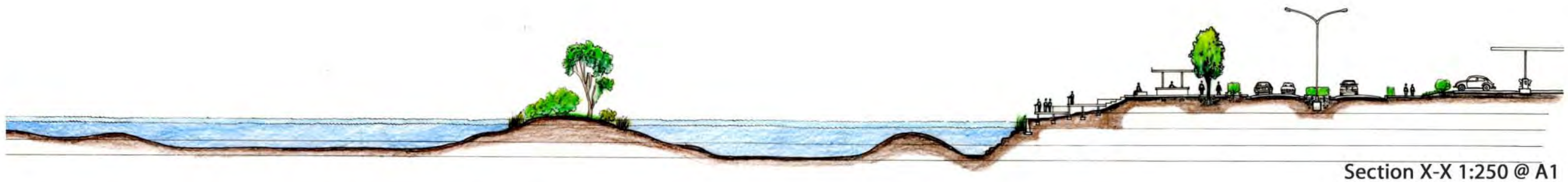
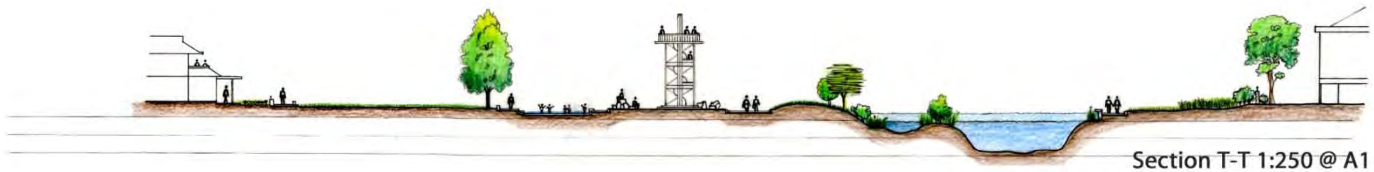
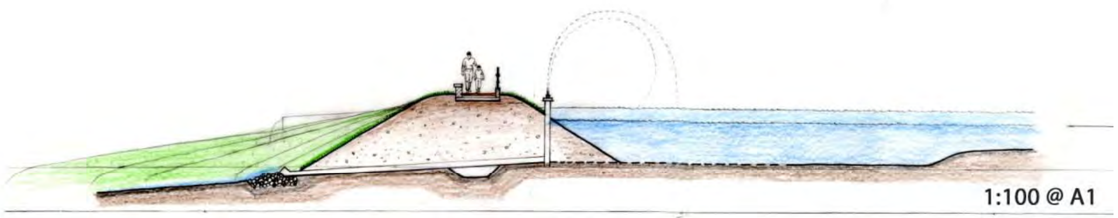


Section X-X 1:250 @ A1

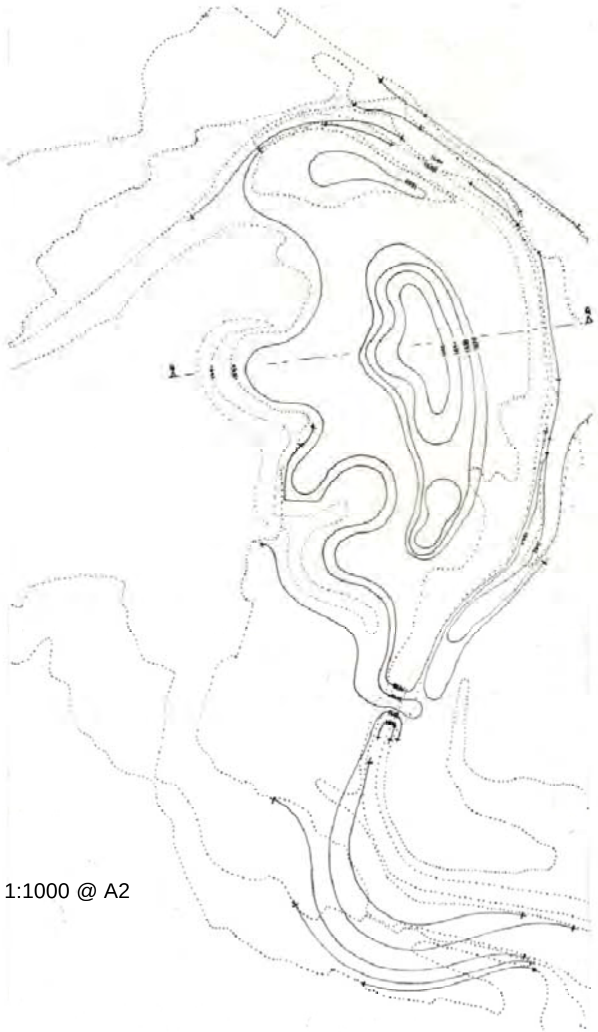


Section T-T 1:250 @ A1

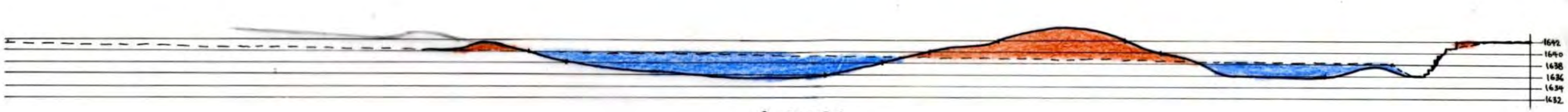
Section E-E 1:100 @ A1



1:100 @ A1



Plan 1:1000 @ A2



SECTION G-G

Climate Change and the Urban River Landscape

Grading Plan

Scale 1: 1000

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TRTCAL001

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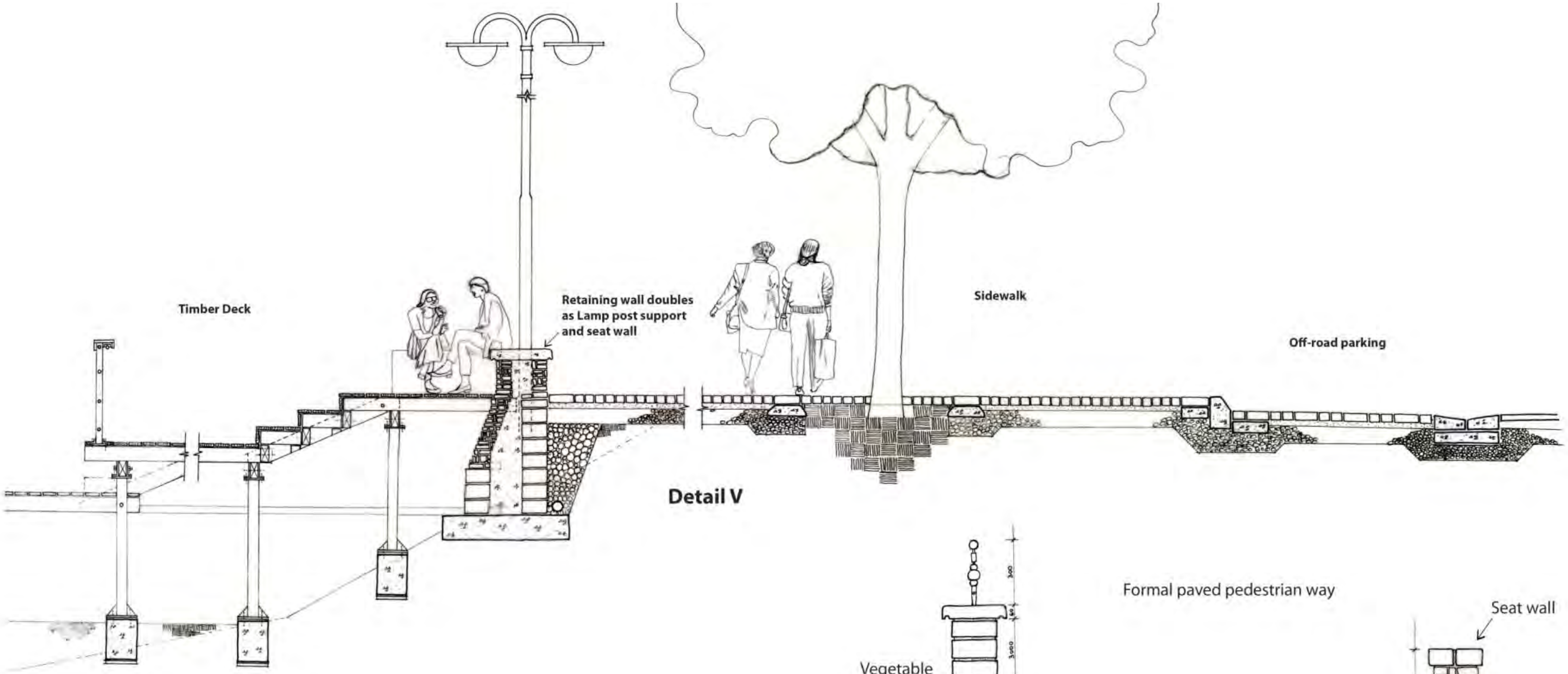
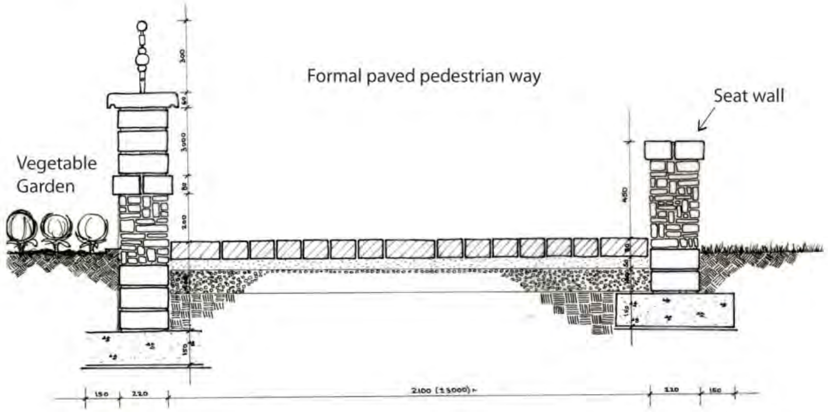
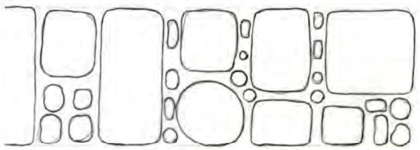


Detail V

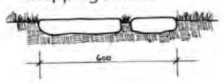


Heirarchy of Routes

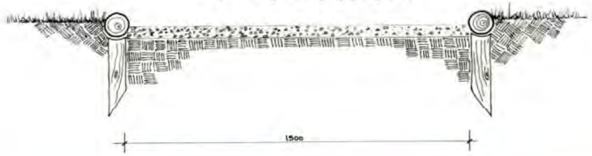


Plan

Discontinous path:
stepping stones



Informal gravel jogging path



5.0 Conclusion and Recommendations

The urban river landscape is one of the most sensitive environments that is greatly misused in many cities. Instead of it being a resource, adding value to the properties adjacent to it, it is a storm and/or a sewage water drainage channel. It is in the 'backyard' not on the front.

Climate Change presents difficult choices to be made, which have to be made, in order to ensure safety and continued use of the urban river landscape. Because of the extremes of weather events resulting in floods on one end and long droughts on the other, the river landscape is susceptible to great damage (such as soil erosion, collapse of infrastructure, submersion of human settlements) and pressure on water resources (such as water for irrigation, domestic and industrial use). Therefore, for sustainable urban development in the face of climate change, the planning and design methods of this landscape must be reviewed.

First, Ecological Buffer Zones along the rivers must be created. This could be achieved by establishing or enforcing building setbacks from the river channel. Secondly, the water holding capacity of the river channel and the created buffer area should be maximised. This could be by constructing retention and detention ponds and wetlands. Thirdly, open spaces in both private and public land in this landscape (and the city at large) must be used as a stormwater management tool: to ensure maximum water storage and infiltration, reduction of runoff, use of the stored water for irrigation and to improve space quality.

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DAILY NATION
The newspaper that serves the nation
Chaos, agony in torrential rains
❑City gets 180mm ❑Kericho 49mm ❑Dry at Coast
NATION
Landslide displaces Limuru families
... WE SHOULD DO EVERYTHING IN OUR POWER TO COMBAT GLOBAL WARMING...
When the going gets tough... Motorists, overwhelmed by floods, abandoned their vehicles on
Rains threaten 65 pc maize crop
Major city road
Plant trees, harvest fish and milk
By SUSANNA THORP
Rescuers help a man trapped in floods. In heavy downpour, rich top soils are washed away.
INSIDE
Chaos as skies open up
NATIONAL NEWS
RAINS HAVOC
EAST AFRICAN STANDARD, Thursday, November 6, 1997
EL NIÑO FLOODS SOAK KENYA
No end to flood victims' troubles
By PAUL KATANA
Top and bottom: Water, water, everywhere . . . Efforts by Zimmerman residents to re-route the water have proved unsuccessful yet it is causing untold damage to houses located in its path. (Pictures by NJERU NJAGI)


DAILY NATION
Thursday July 10, 2008
PROVINCIAL NEWS | 35
MUSIC FESTIVAL
Sh16bn needed to clean Nairobi River
By ALPHONCE SHIUNDU
Crop fails as rivers dry up in central
...om angry skies
Despair, pain and cha...
Govt starts food supply
dies in long jam
DAILY NATION
The newspaper that serves the nation
Hundreds stall in rain floods
...D ENVIRONMENT
...o take care of ...bi eye' syndrome
Soil erosion rate blamed on poverty
THE STANDARD
Shaken to the core
QUAKE FEARS
NATIONAL NEWS
Floods: Five drown in city
Sh6bn flood control project takes shape
Water is scarce and baboons aren't in the mood of sharing
Shortages loom as roads collapse
24
DAILY NATION, THURSDAY, NOVEMBER 27, 1997
NATIONAL NEWS
'Our pleas to the City Council have been ignored'
Roads of shame in city estate
By GAKIHA WERU
Road or River? A matatu ploughs through a flooded road in Umoja Estate.

THE STANDARD
For Fairness and Justice.

State to repossess open spaces and riverbanks

Friday, 19th September 2008

By peter orengo

The Government will repossess open spaces and riverbar
developers in Nairobi.
A 4.5-hectare Kibagare Riparian Reserve owned by PCEA
Parkview Shopping Arcade, Chalbi Drive in Lavington, Kar
plot in Village Market and South C, among others, have a
Green Belt Movement and the Government's attention.
Lands Minister James Orengo said grabbing of public lanc
problem that needed immediate redress.
Accompanied by Nobel Peace laureate Wangari Maathai,
spoke after visiting several riparian reserves around Nair
"No one should be allowed to own a river or even build c
trend is becoming too rampant in Nairobi," Orengo said c
four-hour visit.
Prof Maathai said: "Now riverbanks and water masses ar
from these greedy and corrupt individuals and it seems n
Kenya's resources is bothered."
Maathai asked Kenyans to support judicial laws set up by
instead of rushing to courts to put injunctions on cases tl
against them.
Orengo promised to convene a meeting between Lands,
Nairobi Metropolitan and Local Government ministers to
land issue.
He said the Government would gazette Nairobi waterwa
the would-be buyers of the reserves.

(www.eastandard.net/environment)


AGAINST THE TIDE

Residents of Majengo Village in Kanamai, Kilifi District, wade out of their houses following three days of heavy rains, which have destroyed more than 30 houses.

Floods: Thousands left homeless

By NATION Team


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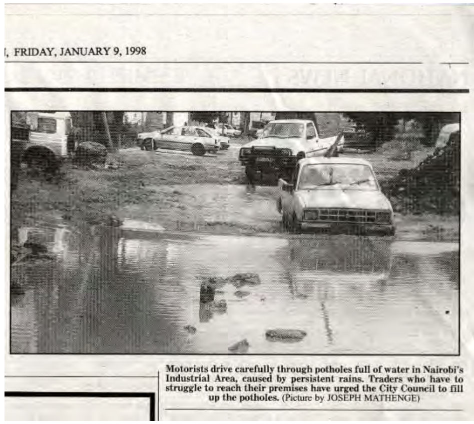
of fire


FRIDAY, JANUARY 9, 1998

Motorists drive carefully through potholes full of water in Nairobi's Industrial Area, caused by persistent rains. Traders who have to struggle to reach their premises have urged the City Council to fill up the potholes. (Picture by JOSEPH MATHENGE)


Growth figures revised as rains wreck havoc

El Niño havoc


Rain havoc leaves 5 more people dead

By NATION Team

of private power firms still unresolved


NATIONAL NEWS

Floods cut off Moyale

Residents forced to shop in Ethiopia

Take rats and mice by STORM

Firm called in to repair Kwale roads

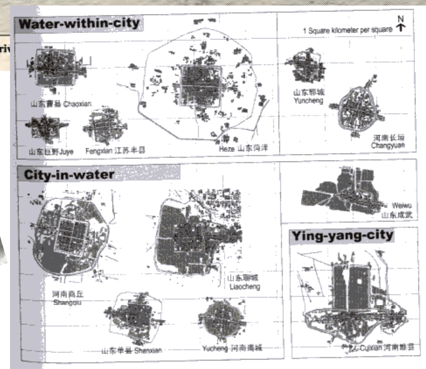


Fig.n Typology of flood adaptive city forms in the Yellow River alluvial plain.

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