Water Resilient Green Cities in Africa

Report 1: GREEN AREA TYPOLOGIES AND MAPPING OF GREEN STRUCTURES IN ADDIS ABABA AND DAR ES SALAAM

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1. INTRODUCTION

The Water Resilient Green Infrastructure in Africa (WGA) research project is aiming at testing the options for using urban green infrastructure for increasing the resilience of Addis Ababa and Dar es Salaam cities to water stress.Worckpackage 1 of the project focus on the use of green structure for stormwater management at different scale in the two case cities. This report summarizes the green space typologies, their current status, challenges and potential for stormwater management and mapping of the existing green structure at city, catchment and case site level.

1.1 Addis Ababa

Addis Ababa, founded in 1987, is the capital and largest city of Ethiopia and is located between $8^0 55'$ and $9^0 05'$ North Latitude and $38^0 40'$ and $38^0 50'$ East Longitude. The total area of the city is 520 km^2. Altitude in the city varies from 2100 m to a lit bit above 3000 m a.s.l. The 2007 population census reports the population of Addis Ababa 2.7 million, but various sources, including reports of the UN-Habitat estimate the population of the city is more than 4 million.

Addis Ababa is a self-governing chartered city with its own city council. The council, which is elected every five years, is the legislative body of the city. Administratively, the city is divided into 10 sub-cities and 116 Weredas (the lowest level of administration). For providing administrative and social services and for implementing infrastructure and economic development the city administration has organized several bureaus, authorities, agencies.

Flooding is one of the serious environmental problems affecting the city. During the rainy season (June to September) many areas of the city are flooded affecting infrastructure, and sometimes claims the life of people. An increase in the built up structure, river buffer degradation, poor solid waste management and low coverage of stormwater drainage structure are the causes for the occurrence of flood in the city.

1.2 Dar es Salaam

Dar es Salaam is a coastal and the largest commercial city in Tanzania. It is located between 6.360 - 70 South Latitudes and 390 and 33.330 East Longitudes. It borders Indian Ocean on the east and its coastline stretches about 100 km between the Mpiji River to the north and beyond the Mzinga River in the south. The total surface area of Dar Es Salaam City is 1800 km2, comprising of 1393 km2 of land mass with eight offshore islands.

Administratively, Dar Es Salaam City is divided into three municipalities and Districts of Kinondoni, Ilala and Temeke. The population of Dar es Salaam is estimated at four million (UN-Habitat 2010).

The most serious environmental problem in Dar es Salaam City currently is heavy rainfall and the accompanying floods largely caused by poor storm water management. There is a sporadic increase in rainfall intensity caused by climate change, and both droughts and floods are likely to increase in magnitude and frequency.The effects of floods are amalgamated with poor drainage, illegal construction and other infrastructure problems, and heavy rainfall that result into flooding which causes major losses and disruptions. Other causes that add to flooding in these settlements include flat topography, lack of storm water drainage systems, blockage of natural drainage systems, building in hazardous areas, and unregulated housing and infrastructure development.

Moreover, about 80% (3.2 million) of the city dwellers are currently living in 43 different informal settlements of various sizes. Inhabitants have continued to reside in these settlements despite flooding effects such as loss of human life, destruction of properties, environmental degradation, environmental pollution and disease outbreaks.

2. GREEN INFRASTRUCTURE DESCRIPTION AND MAPPING AT CITY LEVEL

2.1 Green infrastructure and green space typology

The term green infrastructure (GI) has been variously defined based on different contexts. The most commonly accepted definition hower is provided by Benedict & McMahon (2002) which define GI as an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations. Weber et al. (2006) describes Green Infrastructure as the abundance and distribution of natural features in the landscape which, in addition to supporting ecological processes, also contribute to human health and well-being. GI has been considered as the ecological framework needed for environmental, social and economic sustainability (Benedict & McMahon 2002).

Green space is any vegetated land or water within or adjoining urban area. There are different types of urban green space, varying in size, species composition and structure. Green spaces constitute parks, gardens, street trees, recreational vegetated lands, informal green spaces such as river, natural and plantation forest, grasslands, wetlands, vegetable farm, and crop land. Ownership of green spaces could be private, public or institutional.

Green spaces in urban areas provide multiple environmental, social and economic benefits to the inhabitants. These benefits are generally termed as "ecosystem services". The Millennium Ecosystem Assessment categorizes ecosystem services in to four categories: provisioning (e.g. food and water provision), regulating (e.g. temperature, storm water regulation), cultural (e.g. recreation) and supportive (e.g. soil formation). There are a wealth of literature evidencing the various benefits urban green spaces including absorption of air pollutants (Nowak et al., 2006; Escobedo et al. 2011), regulation of urban temperature (Armson et al. 2012), support biodiversity (Barrico et al. 2012), carbon sequestration (Nowak and Crane 2002), health benefits (Bedimo-Rung, 2005). Indeed, the quality of urban life is considered to be determined by the quantity, quality and accessability of gren spaces.

Green space typology. As green spaces exist in a great variety of shapes, structures and types within the city, they can be classified in various ways based on vegetation type, size, intended function, landscape context, location, form and scale. In fact, the identification of green space typologies could vary depending on the purpose of classification. Accordingly, different cities use different green space category. What is important is that the typology should allow collecting information about the quantity and quality of green space, assessing ecosystem services and preparing development plan and strategy, In the literature, urban green spaces have been worked out in various ways and grouped according to the functions they perform in three domains: environmental, economic and social (Alberti, 2005). The existing green space typology of Addis Ababa and Dar es Salaam are based on morphology and ecological function.

2.1.1 Description and mapping of green infrastructure of Addis Ababa

In Addis Ababa, the green spaces are categorized into field crop, vegetable farm, public recreational parks, riparian vegetation, plantation forest, institutional forest (mixed forest), street plantation, and grassland.

Assessment of the green space of Addis Ababa based on aerial photo taken in 2011 showed that field crop constitutes about 65% of the total green space of the city covering 14578 ha of land. However this green space has been reduced to 9835 ha in 2014; a loss of 5476 ha, largely due to conversion of the field crop land to residential (condominium) and manufacturing and storage land uses.

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Table 1. Area coverage of the various green spaces of Addis Ababa in 2011& 2014

No.	Green space	area (ha) in 2011	area (ha) in 2014
1	Field crop	14,578.3	9,834.7
2	Vegetable farm	341.1	341.1
3	Public recreational parks	69.3	69.3
4	Riverside (Riparian) vegetation	1,803.8	1,535.8
5	Plantation forest	3,372.8	3,372.8
6	Institutional (mixed) forest	1,598.8	1,549.1
7	Grassland	824.9	823.1
8	Street plantation	No data	No data
9	Bareland	4506.63	4110.26
	Total Green area	27112.3	21636.1

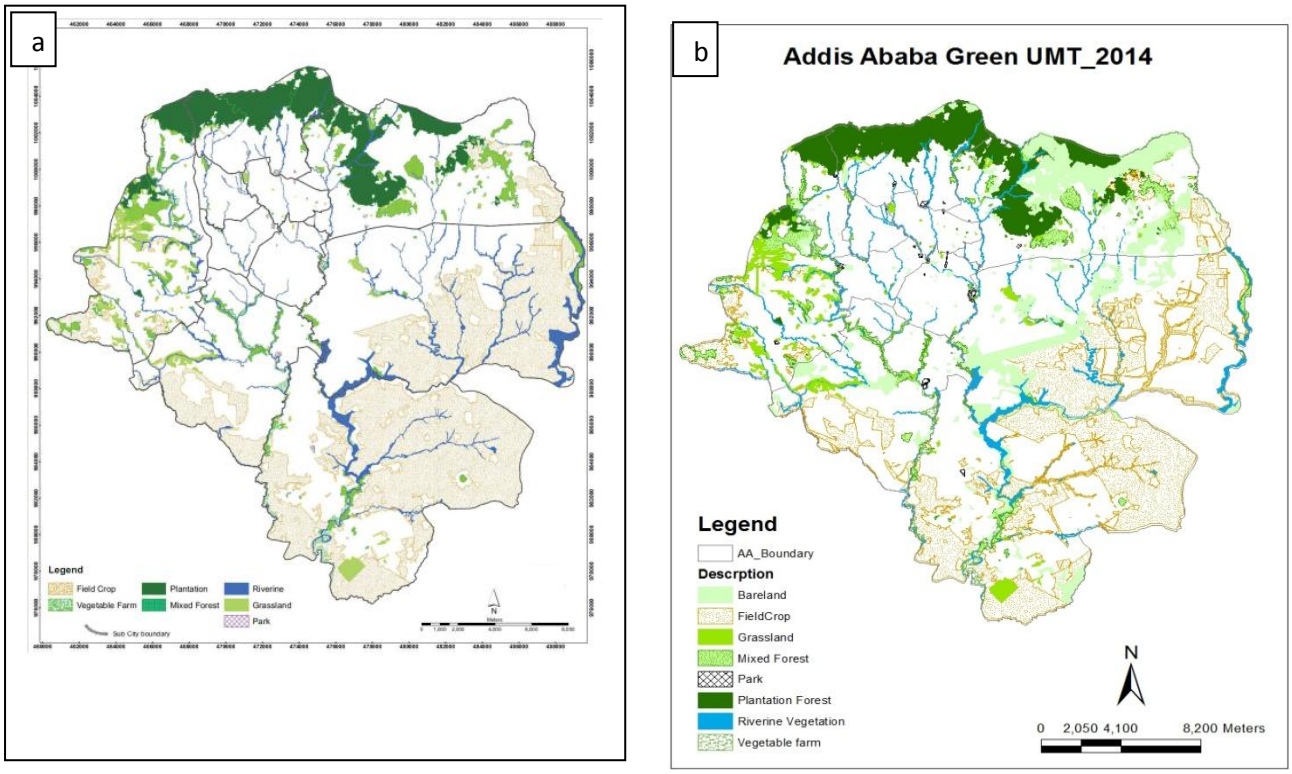


Fig. 1 Green space map of Addis Ababa (a) in 2011 (b) in 2014

1. *Plantation forest* is a vegetation type found on the upper catchments of Addis Ababa, especially on Mt. Entoto. *Eucalyptus* is the dominant tree in plantation forest, although in some places pure stands of *Cupressus lusitanica* and *Pinus patula* could also be found. When Addis Ababa was established in 127 years ago by Emperor Menilik II, getting fuel wood was a serious problem for the inhabitants and soldiers and followers of the Emperor. As a result, the Emperor ordered the introduction of Eucalyptus from Australia in 1904 and planted on Mt. Entoto. At present, Eucalyptus is more or less naturalized all over the country. The plantation forest cover of the city is 3373.6 ha which accounts about 15% of the green space of the city.

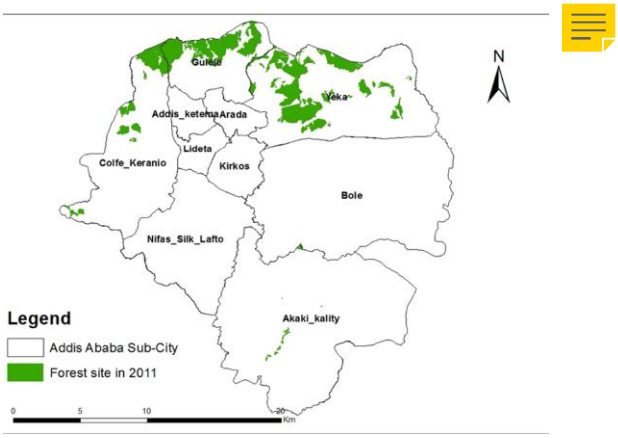


Fig.2 Map of plantation forest cover of Addis Ababa Fig. 3. Picture of plantation forest on Mt. Entoto

2. *Instituional forest:* This category includes forests that are found within the compounds of governmental and non governmental instituions. A mixture of both indigenous and exotic tree and shrub species constitute this forest. Large cover of institutional forest is found in the compounds British, Italy, French, German and USA embassies, and at the grand and national palaces of Ethiopia, various campus of Addis Ababa University, in the compounds of the Ethiopian Orthodox Tewahedo church. In old Ethiopian orthodox church compounds indigenous trees, especially *Juniperus procera* and *Olea europaea* subsp *cuspidata*, *Euphorbia candelabrum*, *Croton macrostachyus*, *Grewia amygdalina*, *Grewia auriculata*, and *Cordia africana*, are more abundant. In fact higher biodiversity is expected to exist in the institutional forest of the city.

Fig.4 Picture of institutional forest

3.***Recreational Parks*:** Parks are enclosed, designed and constructed green spaces covered with both trees and shrubs (perennial) and herbs and grasses(annual). Parks in Addis Ababa provide recreational and social (public gathering, wedding and birthday ceremony) services to the public. At present there are 18 recreational parks in Addis Ababa, ranging in size from 647 to 142,796 ha, providing recreational and social service to the city's residents.

In recent years, there have been some attempts to develop recreational parks in urban renewal sites of Addis Ababa. In the Lideta urban renewal site in Lideta sub-city, 4.3 ha of recreational parks were developed. In Lideta sub-city close to Immigration office, 0.7 ha of recreational has been developed. In the Basha Wolde Chilot urban renewal site in Arada sub-city, 1.17 ha of land has been designed for the development of recreational parks. Behind St. Estifanos church in Kirkos sub-city, 5.2 ha of recreational park is being developed. In Nifas Silk-Lafto sub-city at the Nations and Nationalities square, 30.5 ha green space is being developed.

Fig. 5 Picture of a recreational park

In order to ensure adequate provision of recreational facilities and dedicated park space cities usually provide standard which is usually based on the park area, accessibility and population. Such park standard has never been in place in Ethiopia. The master plan of Addis Ababa which is under revision, proposed recreational park hierarchy based on park size. Accordingly, four hierarchies are recognized, which are largely named after the city's administrative hierarchy. Accordingly, all recreational parks are classified into 4 types: city park, sub-city park, woreda park and neighborhood park.

Table 2. Recreational park hierarchy of Addis Ababa

Park Type	**Size**
City Park	>10 ha
Sub-city Park	1-10 ha
Woreda Park	0.3-1 ha
Neighborhood park	0.1-0.3 ha

Accordingly, the existing and newly proposed recreational parks of Addis Ababa have been designated to one of this classes and the city, sub-city and woreda parks have been included in the structural plan of the city. Because neighborhood parks are the most accessible and in Addis Ababa, immediate assessment and mapping of such parks is urgently needed

Table 3. Area coverage of existing and proposed recreational parks of Addis Ababa.

	Park hierarchy	**Area (ha)**
1	Woreda park	49.9
2	Sub-city park	160.3
3	City park	216.1
	TOTAL	426.3

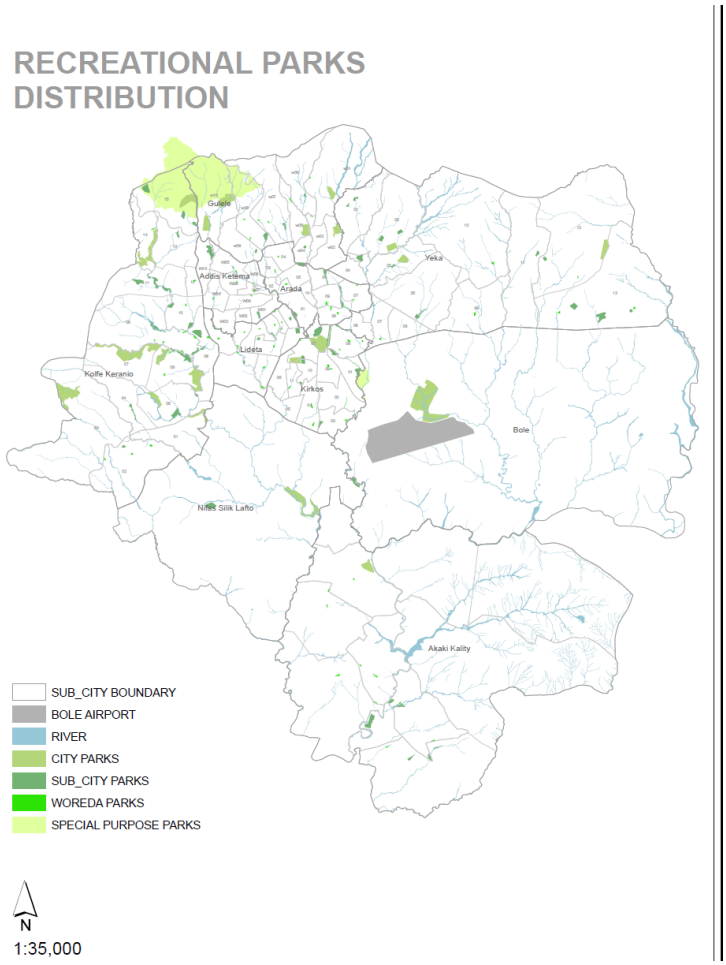


Fig. 6 Map of recreational park of Addis Ababa

4. *Special function parks*: These are green spaces established for purposes other than recreation, but also provide recreation service. The Gulelle Botanic Garden (GBG) and the Addis Zoo Park (AZP) fall into this category. The Gulelle botanic garden is established on 705 ha of land primarily for the conservation of plant species, but also for recreation, education and research. The former central (peacok) park which was used to provide recreational and social services is being developed into zoological park (now named Addis

Zoo Park) for the conservation of wild animals. The park will also be used for education, research and recreation purposes. The park is 3.6 ha in size. Both GBG and AZP have their own administration which are accountable to the city administration.

Table 4 Special function parks in Addis Ababa

No.	Park	Area	Sub-city	Function	Administration
1	Gullele Botanic Garden	705 ha	Gulelle/Kolfe-Keranyo	Conservation, education, botanical research and recreation	Gulelle Botanic Garden
2	Addis Zoo Park	3.6 ha	Bole	Conservation, education, zoological research, recreation,	Addis Zoological Park

5. ***Private gardens*:** Private gardens are small size green spaces located within the compounds of private houses and offices reserved for private uses. Ornamental and fruit trees and vegetables constitute this green space. The garden provides aesthetic service, provides fruits and vegetables, serve as stomwater infiltration and provide shading to houses.

6. ***Street trees***: These are planted trees on pedestrian roads, in road medians and road corridors. Street trees are part of the overall green infrastructure component of cities. Street trees provide shade to pedestrians and vehicles, increase the beauty of streetscape, mitigate air pollution, absorb carbon dioxide and emit oxygen. Street trees reduce the amount and intensity of rain water striking the ground thereby reducing erosion and stormwater management costs. Street tree plantation in Addis Ababa was based on aesthetic values (beautification). However, the shade provision service of street trees are found to be more important as the climate of cities gets increasing. Street plantation on the pedestrian roads and medians of Addis Ababa are few. Those that have been planted are not establishing and growing well because of improper site management and follow up. Tree species selection for plantation is also a problem. In several places trees planted along median create visual problem of vehicular movement thereby hindering smooth traffic flow. Many pedestrian roads are not planted with shade providing tree. Therefore, all roads with pedestrian walkway

need to be planted with shade providing trees. Plantation on road medians could focus on providing beautification, shade and stormwater regulation services.

7. *Rivers and riparian (riverside) vegetation*. Addis Ababa is drained by several rivers and stream which originate from the north, northwest and northeastern part of the city and flowing towards the south and finally drain into the Awash River. Some of these rivers are named as Great Akaki, Little Akakai, Kebena, Ginfile, Bantiketu, Buhe, Kechene, Jemo, Tafo, etc.

Different plant species grow along the riverside of Addis Ababa; however there is no documented information about the plant species composition of the riparian vegetation. In many places in Addis Ababa the riversides are occupied by informal settlements and industries. This opens access to direct release of both solid and liquid wastes to the river body which further blocks water ways resulting into flooding. The use of polluted river water for irrigation of vegetable farm in the southern part of the city is resulting in heavy metal contamination of vegetables.

In order to restore the ecological functioning and services of the river ecosystem the city master plan proposed a river buffer with width of 30 m which will be reserved for the development of green spaces (urban forest, recreational park, vegetable farm). The buffer area will be restricted from all other urban developments. However, such proposal has not been implemented even after 13 years since the master plan was approved.

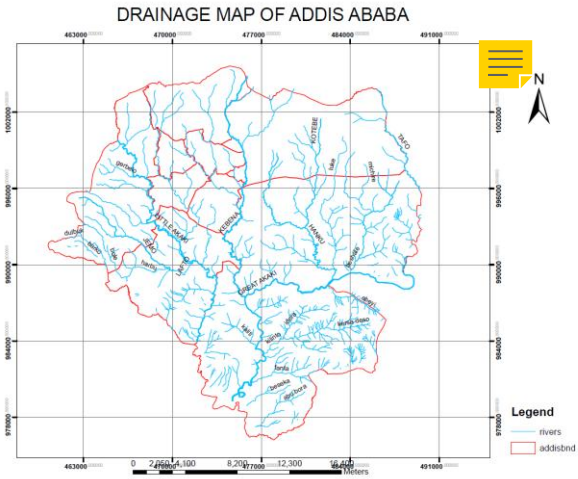


Fig. 7 Drainage map of Addis Ababa

8. *Grassland*. Green space largely covered with grasses are found in military compounds, golf field, church compounds, and airports. During the rainy season, grasses develop on barelands, changing the morphology of the landscape.

9. ***Field crop***: The field crops are grown using rain, therefore the land appears green during the rainy season (June to September). After crop harvest (usually in November & December), the land remains bare. During this time, the land could only be used for livestock keeping. Tef (*Eragrostis tef*), Wheat (*Triticum aestivum*) and Barely (*Hordeum vulgare*) are the common field crops planted in Addis Ababa.

Fig. 8 Field crop land in Addis Ababa

10. ***Vegetable farm:*** Vegetable farms are planted along river The vegetable farm is based on irrigation from nearby rivers. The major vegetables grown include cabbage (*Brassica oleravea*), tomato (*Lycopersicon esculentum),* potato (*Solanum tuberosum*), carrot (*Daucus carota*), onion (*Allium cepa*), garlic (*Allium sativum*), and lettuce (*Lactuca sativa*).

Fig. 9 Vegetable farming in Addis Ababa

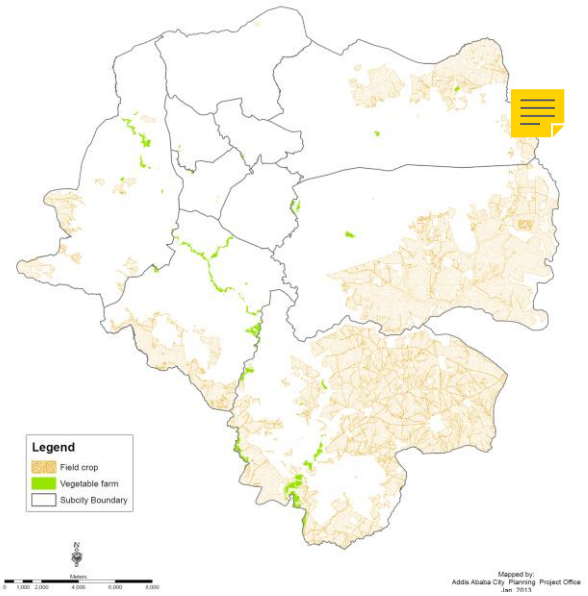


Fig. 10 Urban agriculture map of Addis Ababa

11. ***Bareland***: Bareland represents a land which has never been occupied by any structure or a land which used to be covered by built structure but is now demolished and the land remains bare. During the dry season the land is devoid of vegetation. during the wet season the land is covered with grasses and other herbaceous vegetation.

Land cover of Addis Ababa

Based on UMT based land cover assessment for 2011(CLUVA 2013), 47% of the land cover of Addis Ababa as a whole can be grouped as 'evapotranspiring'; this includes the land cover types of trees, shrubs, grass, field crop, vegetable, crop, and water. Field crops cover 21% of Addis Ababa. Bare ground accounts for 35% of the area. Built surfaces (buildings and roads) account for 18% of the area.

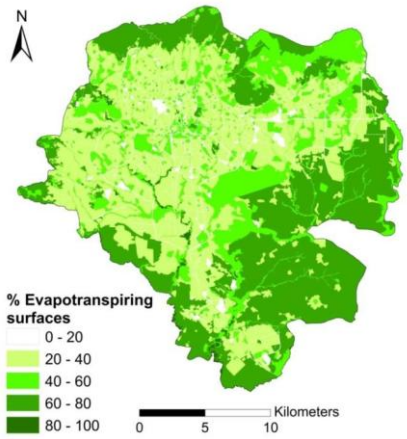


Fig. 11 Evapotranspiring surfaces of Addis Ababa in 2011 (Source: CLUVA 2013)

2.1.2 Description and mapping the green infrastructure of Dar es Salaam

Green structure in the urban Dar es Salaam comprises recreational parks and open spaces, farms/crop-lands/agricultural estate, and vegetable gardens, mixed forests, riverine vegetation, river, bushland, mangrove, marsh/swamp, street trees, field crops, horticulture and mixed farming (Fig. 12).

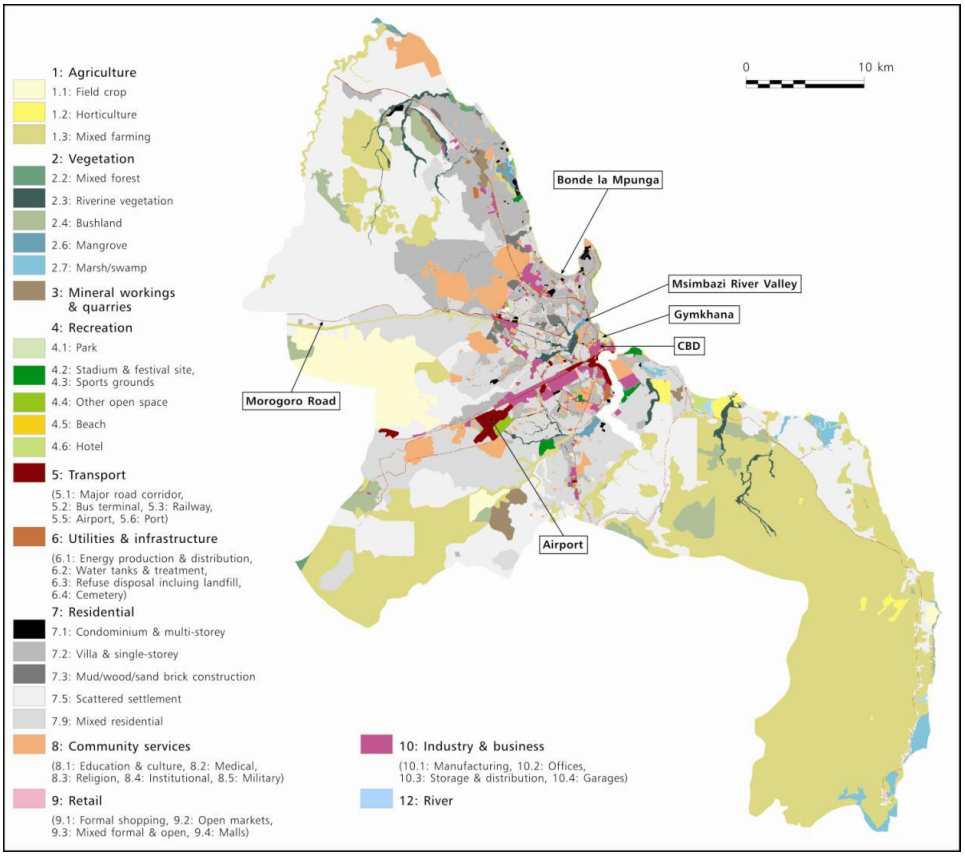


Fig. 12 Map of the UMTs of Dar es Salaam in 2008 (source: CLUVA 2013)

According to Urban Morphology Types (UMT) based green space assessment of Dar es Salaam (CLUVA 2013), the perennial green space also called vegetation UMT (bush land, mixed forest, riverine vegetation, mangrove and marsh/swamp) accounts for 5.1% of Dar es salaam. Of the vegetation UMT bushland constitute 51.5%, followed by riverine (22.5%), marsh/swamp (18.0%), mangrove (6.0%), and mixed forest (2.3%).

The recreation UMTs account for only 0.7% of Dar es Salaam. This category includes a mixture of detailed classes (parks, stadium and festival site, sport ground, other open spaces, hotel, and beach. Of these parks account for 6.1% of the category, and other open space accounts for 32.5%. The agricultural UMTs (field crops, horticulture and mixed farming) constitute 40.4% of the city. The mixed farming covers 35.6% of Dar es Salaam.

***Urban agriculture*:** Production of vegetables and other food crops is taking place on open spaces all around the City. These agricultural open spaces are either privately or institutionally owned land. Farming in river basins, road reserves, railway reserves, marshlands, and main power line- corridors are currently tolerated by the authorities. The types of vegetable crops in Dar es Salaam generally include leafy and non-leafy vegetables. The leafy vegetables in Dar es Salaam comprise African spinach (*Amaranthus* ssp., "mchicha"), sweet potato leaves (*Ipomea batatas*), pumpkin leaves (*Curcubita moschata*), cassava leaves (*Manihot esculenta*), cowpea leaves (*Vigna unguiculata*), Swiss chard (*Beta vulgaris var. cicla*), Chinese cabbage (*Brassica chinensis*), African kale (*Brassica oleravea var. acephala*) and nightshade (*Solanum scabrum*). The most often grown non-leafy vegetables are tomato (*Lycopersicon esculentum*), eggplant (*Solanum melongena*), African eggplant (*Solanum macrocarpon*), sweet pepper (*Capsicum* spp.), hot pepper (*Capsicum frutescens*), okra (*Hibiscus esculentus*), cucumber (*Cucumis sativus*) and carrot (*Daucus carota*). Other types of agricultural production include rice production, cultivation of fruit trees, cultivation of maize and livestock keeping. Home gardens are found in almost all areas of the city, producing mostly for the households themselves. Rice production is widespread in the urban area of Dar es Salaam especially in the river valleys. Fruit trees (mainly papaya, coconut, citrus, mango and cashew) and banana can be found all over the Dar es Salaam urban area. Cattle, goats and chicken are grazing along the streets in the city.

Vegetation along seashore and river. Along the beach of Indian ocean, there are large open green spaces with many large trees, low and medium density residential houses and tourist hotels. There are rivers which discharge into the Indian Ocean; these are the Mpigi River, the Tegeta River, the Mbezi River, the Mlalakuwa River, the Sinza River and the Kijitonyama River; others are the Msimbazi River, the Kizinga River, and the Mzinga River. At the river outlets to the Indian Ocean there are marshlands, many of them with mangrove forests.

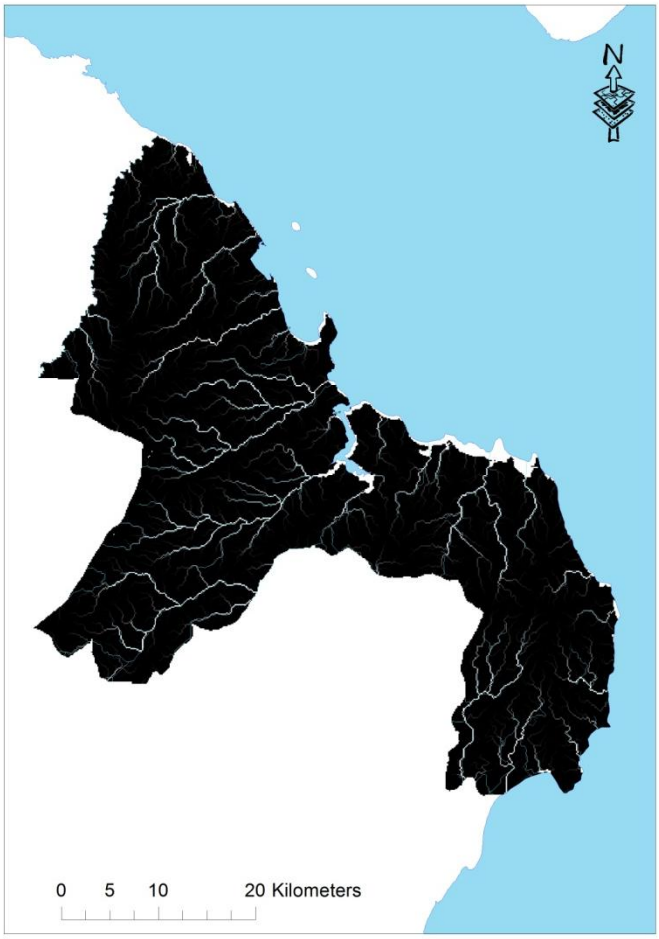


Fig. 13 Drainage map of Dar es Salaam

Major Public Open Spaces: In Dar es Salaam City there are large public recreation areas such as the Dar es Salaam National Stadium, the Karume Stadium, the Kaunda Stadium and the Azam Stadium. Moreover, large green open spaces that surround large institutions like universities and schools, hospitals, military camps, and malls fall under this category. Some of the examples are the University of Dar es Salaam, Ardhi University, the Gymkana Club, Boko Dawasco green space, the Tanzania Railway Station, the Mbagala Zakhiem green space, and the Tanzania Meteorological Agency green space.

Greening in Residential Areas: The difference between residential areas for high, medium and low income groups can be depicted by the scope of greening. This is particularly the case in the formal or planned areas where the plot coverage ought not to exceed 15% whilst in medium density areas the coverage is 25%. Low density housing areas which accommodate high income groups are green, with lots of big old trees, and green gardens surrounding the houses and roads. In some cases, plant nurseries run by informal petty traders especially on

the sides of the boulevards. These add important dimension in the green landscape features of the area. Such residential area includes Masaki, Osterbay, Mbezi Beach, Msasani, Mikocheni, Kinondoni, Makongo juu, etc. High density areas have plot coverage of 40%. However, in most cases home builders exceed the standard ratios leading to increased storm water runoff. In informal settlements plot sizes, plot coverage, plot ratios, and building setbacks are not regulated. What ought to be underscored, however, is the unregulated densification in informal settlements especially in inner and intermediate city areas that enormously contributes much to the increased storm water run-off, resulting into extensive flooding areas especially during heavy rainfall.

Figure 14:Vingunguti satuated informal settlement

Figure 15: Mwenge formal low income settlement

Street trees. Greening of the main transport corridors by tall trees and lawns between the dual carriage ways softens the hardness of buildings and pavements as it reduces glare, soil erosion, and dust.

Greening of Military Bases : In Dar es Salaam City there are military areas namely Lugalo, Changanyikeni, Makuburi, Kunduchi, Mbweni, and Kurasini, Gongo la Mboto, Mbagala, Mabibo, Kigamboni, Kawe and Ukonga military camps. Moreover, there are also large open land held by Ukonga and Segerea Prisons. These areas are restricted areas which are densely covered with native trees and bushes surrounding buildings in the landscape. Such green structures facilitate infiltration of storm water runoff in their respective areas.

Greening and Bluing of Shoreline, Marshlands, Ponds and Lakes: The Dar es Salaam shoreline extends from the northern tip of Bunju, which borders Dar es Salaam and Bagamoyo to the southern tip of Kigamboni which forms the boundary with Mkuranga District. The shore line that is characterized by white sand beaches, coral cliffs and

marshlands. The shore line is protected by the Government directive which restricts building construction on 60m buffer from the sea water margin; public area. All the rivers discharge into the Indian Ocean, and run through many built areas including residential, industrial and institutional premises. The rivers cut across flood basins where mud, silt and solid wastes such as papers and plastics ate trapped. Generally, the shoreline is tidy; however, in areas such as Kawe River, wastes including plastic bags, plastic bottles etc. are a common scene at the river out let. The management of the shoreline is under the respective municipalities.

Land cover of Dar es Salaam

Based on UMT based land cover assessment (CLUVA 2013) for 2008, almost half (49%) of the land cover of Dar es Salaam can be grouped as potentially 'evapotranspiring'; this includes the land cover types of large trees, small trees /shrubs, palm trees, grasses, cultivated crops, and water. Bare ground accounts for just over a quarter of the area (28%). Built surfaces (buildings and roads) account 21% of Dar es Salaam.

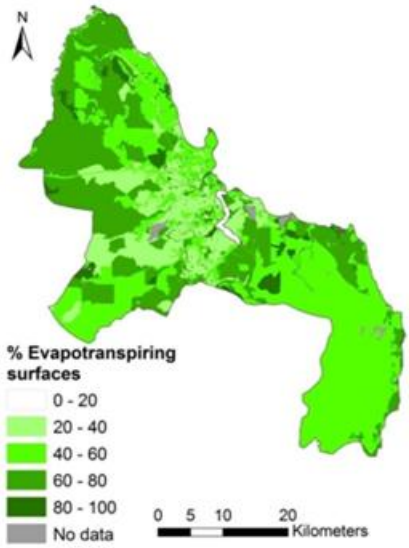


Fig. 16 Evapotranspiring surface cover of Dar es Salaam in 2008 (Source: CLUVA 2013)

3. GREEN STRUCTURE DESCRIPTION AND MAPPING AT CATCHMENT LEVEL

3.1 Existing green infrastructure in Jemo River catchment of Addis Ababa

Jemo River is a tributary of the Little Akaki river, originating from Jemo mountain in the northwestern part of the city. The Jemo river catchment is found in the western part of the city. The area has been intensively transformed in the last two decades not only due to planned infrastructure development (ring road and condominium buildings) but also large scale informal settlement, especially on and around Repi mountain. The Jemo river catchment area covers 2559 hectares of land made up of 13 different land use types.

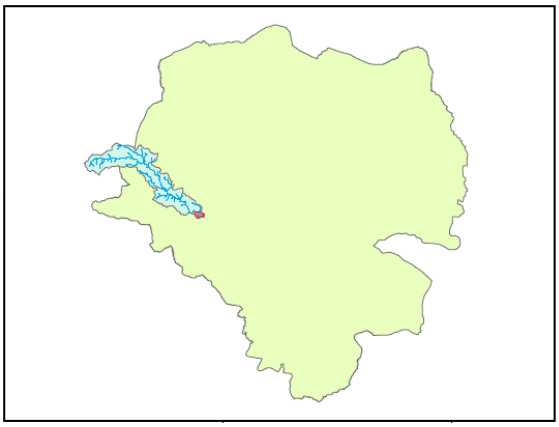


Fig. 17 Location of Jemo river catchment

The Jemo river catchment could be categorized into five slope classes. The catchment is dominated by flat land with slope less than 3% (60%), followed by moderate slopes (5-15% slope) covering 33.7% of the catchment, relatively flat slope (3-5% slope) constituting 26.3 % of the catchment, steep slopes (15-25% slope) covering 1.3 % of the catchment and very steep slopes (>25% slope) covering 1.3% of the Jemo river catchment area.

Residence, road and urban agriculture are the three dominant land uses in Jemo river catchment covering 35.6 %, 16.4% and 7.8% of the catchment respectively. Both planned housing and informal housing characterize the residential land use of Jemo river catchment. Informal housing occupies the steep slopes of the 'Repi' hill where the Jemo river flows on the foot of the hill. Housing development in the informal area is plot based and privately owned. There are two types of formal housing in the Jemo river catchment area: private and public housing. The former is the one built by individual home owners through personal initiative or real estate developers while the latter is part of the government's "build and transfer condominium housing program". In Privately financed houses, people have their own

houses and open space while in public housing the house is private, but open spaces are communally owned. This provides opportunity for community based green space development as well as landscape based stormwater management.

Fig. 18 Informal settlement along Repi mountain of Jemo river catchment

Fig. 19 Privately financed housing in Jemo and Lebu residential site

Fig. 20 Public housing in Jemo residential site

Green spaces in Jemo river catchment

Plantation forest, mixed forest, riverine vegetation, field crop, vegetable farm and bareland are the green spaces found within the Jemo river catchment that have relevance for stormwater management.

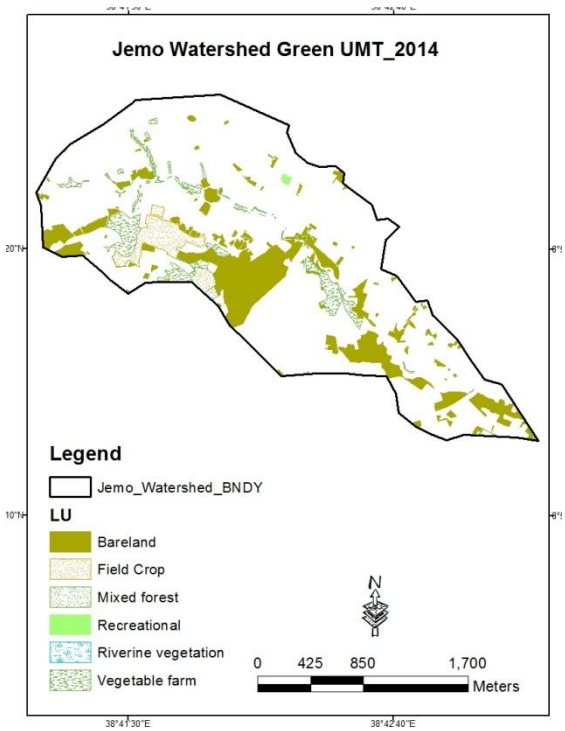


Fig. 21 Green space map of Jemo river catchment

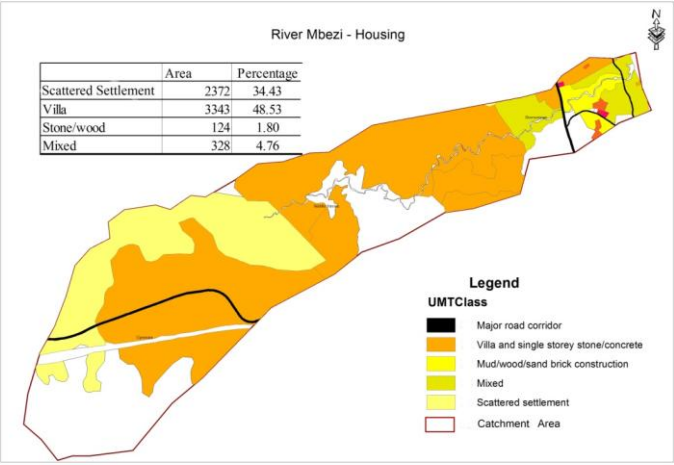
Mixed forest is found in the compounds of religious, governmental and non-governmental institutions as well as on Jemo mountain. *Juniperus procera* is the indigenous tree species commonly found in the mixed forest. Riverine vegetation is found along parts of the Jemo river where the river buffer is not occupied by other land uses. Field crop (barley and wheat) is being largely produced on Jemo mountain and a small part on Repi hill.

Urban Agriculture is the dominate green space in Jemo river catchment occupying a total of 227 hectares of land. Field crop farming is practiced predominantly on the Jemo mountain and scattered field crops are also found in some areas along river banks in Jemo condominium area.

3.1 Existing green infrastructure in Mbezi River catchment of Dar es Salaam

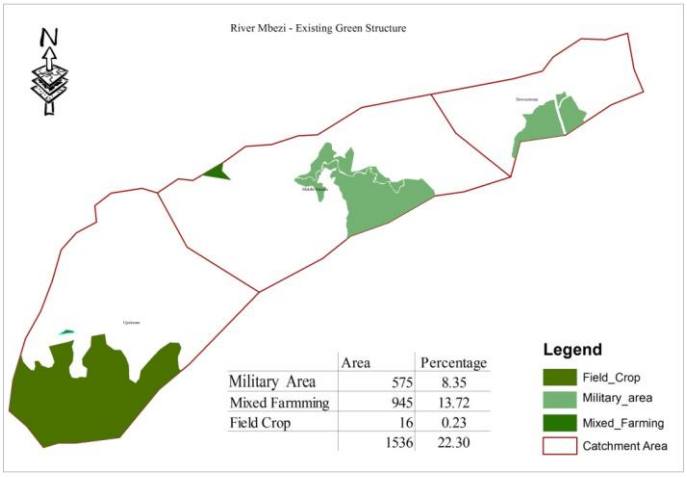
Mbezi River flows from south-west to north-east and discharges into the Indian Ocean. Mbezi River is a seasonal river. Therefore the amount of water in the river varies remarkably during the different seasons of the year. It is one of the main drainage systems in the City. In most areas, the river banks have shrubs and trees. However the densely built-up banks of the river are eroded, leading to landslides especially in Kawe Ukwamani settlement. In the densely built-up areas, the river banks are used as dumping sites for solid and liquid wastes.

The upper stream area of Mbezi River catchment covers 2974 hectares, while the midstream measures 2793 ha and the lower stream area comprises 1113 ha. The average slopes for the downstream, midstream and the upper stream areas are 7%, 42% and 63% respectively.



	Area	Percentage
Scattered Settlement	2372	34.43
Villa	3343	48.53
Stone/wood	124	1.80
Mixed	328	4.76

Figure 22 Residential land use map in Mbezi River catchment



	Area	Percentage
Military Area	575	8.35
Mixed Farmming	945	13.72
Field Crop	16	0.23
	1536	22.30

Figure 23 Existing Green Structure in Mbezi River catchment

Settlement: Housing in the catchment area is characterized by scattered buildings in the upper stream and middle stream areas, mixed densities (medium and low) in the planned Mbezi and Kawe settlements and densely built areas of Kawe Ukwamani. The land which is sparsely built especially the upper stream and middle stream areas cover 2372 ha which is equivalent to 34.4% of the total catchment area. Detached residential units are the most dominant house type (48.5%). Stone and mud and poles buildings occupy 328 ha which is equivalent to 4.8%. . The sub-wards found in the northern part of the upper stream are Makabe, Matosa, and Goba. In the northern part of the mid stream there are Mbezi Juu, and Mbezi Beach sub wards which comprise predominantly middle income households. To the Southern part of the upper stream there are Mbezi Louis, and King'ong'o, and to the southern part of the midstream areas there are Changanyikeni, Makongo, Lugalo and Kawe Ward which are fairly mixed, with quite a large number of low income and middle income households. The inhabitants of the lower stream catchment area (Kawe ward) encompass a fairly large number of the former employees of the defunct Tanganyika Packers, a government beef canning factory which was closed in the late 1980s.

In the upper and middle stream areas, 85% of the houses are owner-occupied; owner-tenants 10% and tenants only occupy 5%. The houses predominantly comprise single detached houses. In the informal settlements located in the catchment area, there are no organized housing clusters, orderly structure of roads, open spaces, road side drains, etc. Access to land is through informal subdivision and transfers between willing sellers and willing buyers. A few (3%) said they inherited the land from their ancestors. Asked about what is the price of land in the upstream, middle stream and lower stream areas, the *Mtaa* leaders reported that the price varies depending on the location and size of the piece of land. However, the range was between Tshs 5,000-7,500/= per m^2. Because there are no standards for local roads or plots sizes, the built environment is spatially irregular and lack of land for most public uses, including recreation open areas, access roads and community facilities. Most of the vegetation covers in the built areas are native plants, which seem to be quite appropriate to the local climatic conditions as most of them do not require any special care.

Green infrastructure. The upper and middle catchment areas are generally green, primarily because most of them are sparsely built. Most of the green structure is increasingly being depleted due to the increase of house construction and farming activities. The Lugalo and Changanyikeni military areas occupy 575 ha of natural green structure, which is 8.4% of the total catchment area. Most of the military areas still have natural shrubs, tall trees and grass. Mixed farming i.e. farming and animal keeping within the middle and lower stream areas occupies 945 ha or 13.7% of the total catchment area; the animals kept include cattle, poultry and pigs. Moreover, in the middle and lower stream areas there are also small parcels of land used as plant nurseries. Management of most green structures, including decision on the use or change of land use, is done by individuals. Hence fragile areas such as steep slopes and river valleys are being encroached upon due to the intensification of housing and farming activities. The change of land use from farming to housing is likely to increase in the coming years due to high demand for housing land.

Studies of green structures in the informally built lower stream area of Kawe Mnyamani show that there are no public open spaces. Due to excessive housing density of over 40 units per hectare, even land necessary for public uses such as roads and other public services, is lacking. Lack of public open spaces is similarly observed in the middle and upstream areas. However, in the latter areas, there are many green areas including farms and protected areas under the Lugalo Barracks. Apart from the protected (military) land, the rest of the land in the three study areas are privately held or occupied by individuals.

The common vegetation covers in the catchment area are coconut palms, flamboyant, banana, maize, green vegetables and native grass. Informal subdivision and transactions as well as house construction activities are the major threats to the sustainable and consolidated green structures in the Kawe catchment area. The problem of managing green structures is further compounded by informal/unregulated sand mining activities coupled with loose definition of land rights especially in areas close to the river banks.

Table 5: Plant Materials in the catchment area- Source: Field survey 2014 (Language of plant names : E = Emglish, K =Kiswahil

Trees	**Shrubs**	**Grass**
Military area in the Upper and middle stream areas: *Eucalyptus globulus* (Tasmanian blue gum (E) or mkaratusi (K)), *Ficus benjamina* (weeping fig, Java fig E), thevetia (E)), *Trema orientalis* (pigeonwood (E) or mpesi, mgendagenda (K)i, and *Coco nucifera* (coconuts), *Leucaena* (mlusina), and ashok. **Residential area in upper and mid stream areas** *Delonix regia* (flamboyant (E) or mkakaya (K)), M*usa paradisiacal* (plantain, starch banana (E) or mzuzu (K)i), *Melia azedarach* (Persian lilac, bead tree (E) or mwarobaini (K)), T*hevetia thevetioides* (yellow oliender, *Terminalia mantaly* (terminalia (E)), *Trema orientalis* (pigeonwood (E) or mpesi, mgendagenda (K) or muisi in Chagga), and C*oco nucifera* (coconuts), *Leucaena* (mlusina), and ashok. **Green infrastructure in Kawe Ukwamani – Lower stream area** *Musa paradisiacal* (plantain, starch banana (E) or mzuzu (K)), *Melia azedarach* (Persian lilac, bead tree (E) or mwarobaini (K)), *Trema orientalis* (pigeonwood (E) or mpesi, and *Coco nucifera* (coconuts), *leucaena* (mlusina), and ashok.	**Military area in the Upper and middle stream areas:** *Ziziphus mauritiana* (mkunazi (K)), *Acacia brevispica* (wait-a-bit acacia or mwarare in KiKiswahili), *Maytenus senegalensis* (confetti tree (E) or mdunga-ndewe (K)), *Pithacellobium dulce* (madras thorn (E) or mkwaju wa kihindi or maramata (K)), A*cacia Senegal* (three-thorned-acacia (E) or Kikwata (K)), *Carisa edulis* (mtanda-mboo (K), manka in Chagga), R*hus natalensis* (mkono-chuma, mkumba (K)), B*auhinia tomentosa* (bauhinia, camel's foot or musaponi (K)), *Caesalpinia pulcherrima salvadora persica* (tooth brush tree (E) or Mswaki (K)). **Residential area in the upper and middle stream areas** *Bambusa vulgaris* (golden bamboo (E) or mwanzi (K)), *Pithacellobium dulce* (madras thorn (E) or mkwaju wa kihindi or maramata (K)), *Bougainvillea glabra* (bougainvillea, paper flower), (pride of Barbados, Dwarf Poinciana (E) or mnyonyore (K)), *Carica papaya* (pawpaw, papaya (E) or mpapai (K)), thevetia Peruvian (thevitia (E)),	**In the catchment area** *Pennisetum purpureum* (Ugandan grass or Napier grass), *Miscanthus giganteus* (matete (K)), M*iscanthus sinensis* (Zebra grass (E)), fine fescues which tolerate poor soils, dry conditions and can be grown in sun or light shade. Sheep fescue (*Festuca ovina*) is commonly found in sandy soils and is quite drought and shade tolerant.
	Shrubs in the lower stream area *Rhizophora mucronata* (red mangrove (E) or mkoko, mkaka (K)), sugar cane, maize. *Carica papaya* (pawpaw, papaya (E) or mpapai (K))	

4. GREEN STRUCTURE DESCRIPTION AND MAPPING AT CASE SITES

4.1 Upper case site: Repi, Addis Ababa

Upstream project case site is found around Repi Hill. Repi Hill is a site proposed for green space development in the city's master plan prepared 12 years ago. However, most part of the hill is now occupied by informal settlements and industries. The settlements are found on the plateau, the side and foot of the Repi Hill. Industrial establishment took place on 110 ha on Repi Hill (Fig. 24).

Water shortage is a serious problem in the area. The northern face of the Repi Hill is seriously degraded due to quarry activity, resulting in a reduction potential of rainwater infiltration and loss of aesthetic. The quarry is owned by the city government, and is one of the biggest quarry sites in the city which is still operational. Its proximity to the Jemo river makes this one of the major contributors to flooding in the area as the remains are easily washed by the rain and carried to the river. Yet its future rehabilitation would provide a good opportunity for land scape based storm water management.

Fig. 24 Industrial establishment on Repi Hill

Six green land uses could be identified in the upper case stes (Table 6). These are field crop, vegetable farm, mixed forest, plantation forest, and riverine vegetation. In addition, there is proportionally large area of bareland whch are not covered with vegetation or imperious structures. There is no green space that functions as a recreational park in this case site.

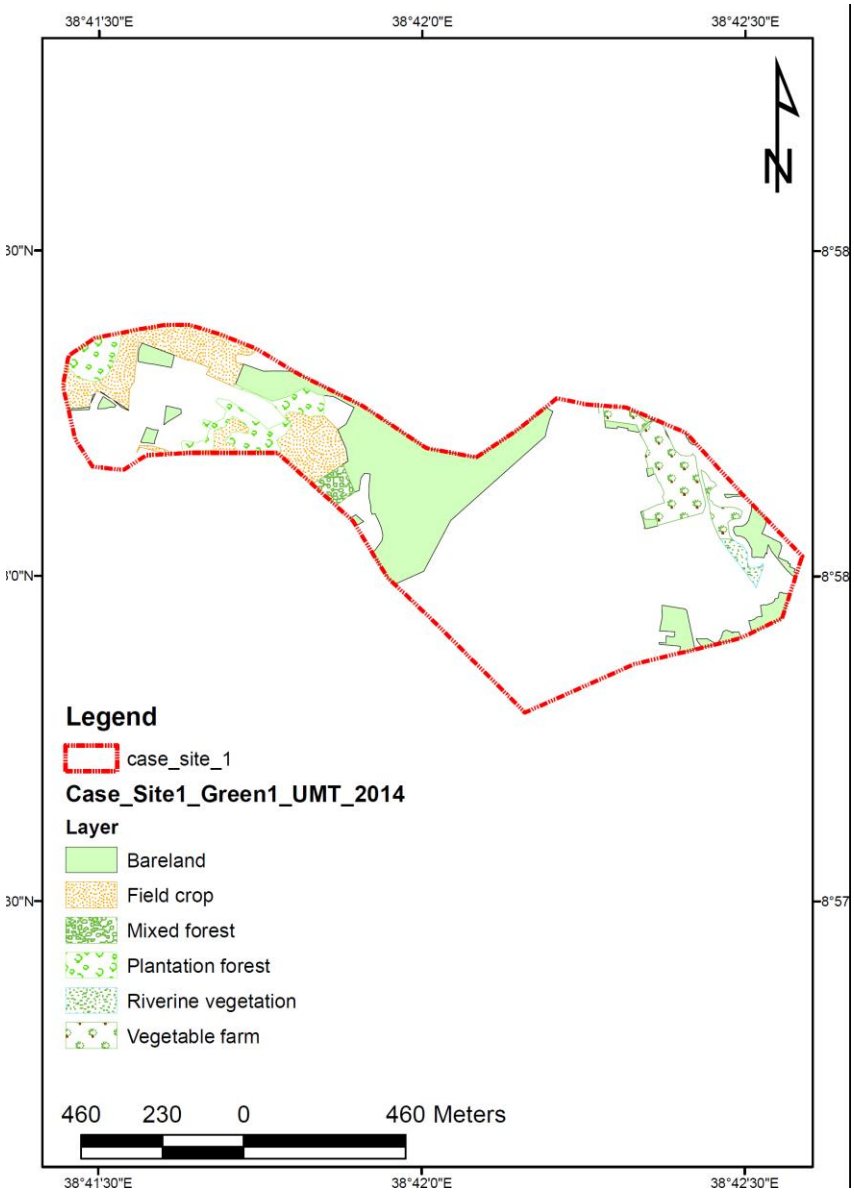


Fig. 25 Green space map of Repi-Upper case site

Table 6. Type and size of green space in upper case site

Green space	Area (ha)	% of total land use
Bareland	18.2	50.7
Field Crop	8.2	22.8
Vegetable farm	4.2	11.7
Mixed forest	0.7	1.95
Plantation forest	4.1	11.4
Riverine vegetation	0.5	1.4

4.2 Middle case site, Jemo Condominium, Addis Ababa

The middle case site of the project is located in the downstream part of Jemo river. Large part of the case site is a flat area and seasonally flooded. Because of this, the last master plan of the city reserved this site for the development of urban agriculture and stormwater management. In fact the area was a sinking ground for runoff coming from the upstream mountains. However, in the last ten years the land use of this area has been completely changed. At present thousands of condominium and multi-storey buildings have been constructed mostly for residence, but also for commercial activities.

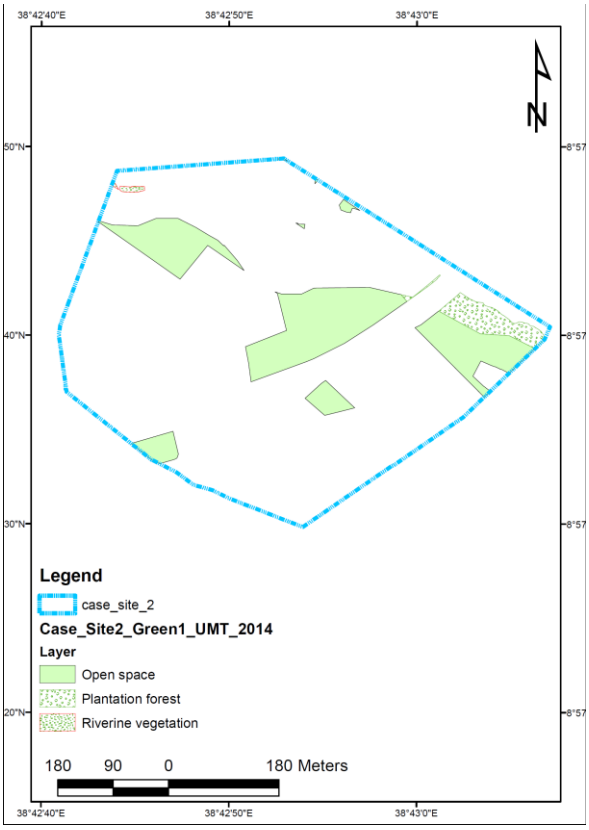


Fig. 26 Green space map of Jemo condominium (middle case site)

Table 7 Type and size of green space in middle case site

Green space	Area (ha)	% (of the total land use)
Bareland	4.5	4.5
Plantation forest	0.6	0.6
Riverine vegetation	0.39	0.04
Vegetable farm	0.56	0.06

4.3 Lower case site- Mekanissa Seminary, Addis Ababa

The area is named after the Evangelical Seminary which is one of the oldest and biggest boarding school training students in theology, leadership and management. Unlike the upper and middle case sites which are found within the Jemo river catchment, the lower case site is found in the middle part of the Little Akaki river catchment. The Jemo river joins the Little Akaki river a few km away from the lower case site.

Grassland, mixed forest, plantation forest, vegetable farm and riverine vegetation constitute the green land uses in the lower case site. The highest proportion of green space in this case site is vegetabe farm constituting 41.3% of the total green space of the site (Table 7).

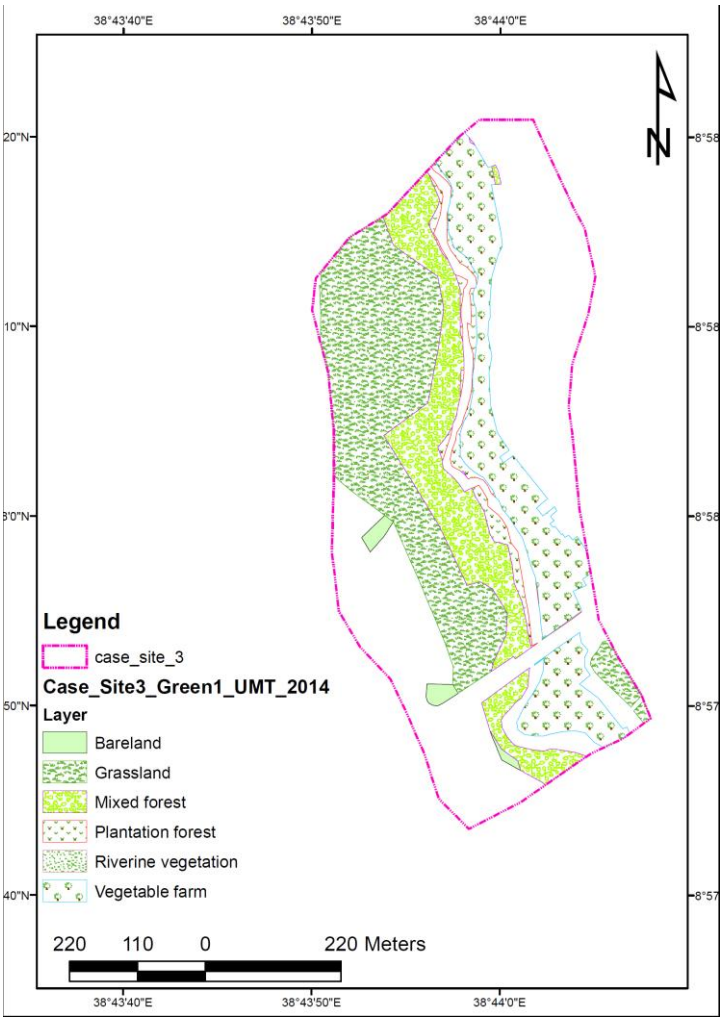


Fig. 27 Green space map of Mekanissa Seminary (lower case site)

Table 8 Type and size of green space in lower case site

Green space	Area (ha)	% of the green land use
Open space	0.33	1.1
Grassland	9.4	31
Mixed forest	5.4	17.8
Plantation forest	0.92	3
Vegetable farm	12.5	41.3
Riverine vegetation	1.79	5.9

Urban agriculture is being practiced along river bank in this case site. There are around 300 people organized into farming cooperatives to produce vegetables using using furrow irrigation of the Little Akaki river water. The Mekanissa-Gofa-Lafto co-operative farm located along this the Little Akaki river is the oldest and largest irrigation vegetable farming site in the city. The site stretches from Mekanisa in the north to the foot of the Lafto hill in the south, a three-to-five kilometer length. The cooperative farm cultivates a total of 370,733 square meters of land. Most of the farm plots are located on gentle slopes while a few are on flat grounds near the river. During rainy season, the urban agriculture gets flooded and thus the farmers have to wait until the excess water evaporates/drains in order to plant vegetables.

The most common vegetables produced include Swiss chard (*Beta vulgaris*), kale (*Brassica oleracea),* cauliflower (*Brassica oleracea*), lettuce (*Lactuca sativa*), leek (*Allium ampeloprasum),* cabbage (*Brassica oleravea*), beans (*Phaseolus vulgaris*), carrot (*Daucus carota*), cucumber (*Cucumis sativus*), pepper (*Capsicum annuum*), beetroot (*Beta vulgaris*), and potatoes (*Solanum tuberosum)*. Except during the heavy rainy months (July to August) vegetable cultivation is done year-round. Flooding, water-logging and weed infestation limit vegetable production during the rainy season.

Flooding during the rainy season is a serious problem in the lower case site. Instituions, settlements and urban agriculture along the Little Akakai river are affected by the flood. The Mekanissa seminary has in the past suffered seriously from river flooding and the seminary authorities are still struggling to overcome this problem. In addition to erecting new buildings with raised ground floor, retaining wall construction, raising of ground level in

some selected areas and planting of vegetation and trees are among the most common activities so far undertaken.

4.4 Upstream Areas - Mbezi Makabe, Matosa and Goba, Dar es Salaam

The upper stream area is dominated by clay and sandy-clay soils. The land is largely used for mixed farming that is mainly rain-fed. A number of households keep cattle which depend on water from the river. Water for domestic uses is bought from private water vendors. Moreover, the upper stream area is characterized by sparsely built (low density) informal settlements. In most cases, houses are surrounded by small farms measuring 0.25 to 1ha. The main green structures in the area include grass, and small farms with coconut, palm tree, banana, pawpaw, cassava, maize, and spinach. The river is generally flanked by small farms and the frontiers between the individual farms and the river bank are blurred. This implies that most of households occupy land close to the river and claim to own rights to land up to the water margin. The upper stream area is generally characterized by sparsely built houses. Many houses are surrounded by large green structures comprising farms and bushy open spaces. The existing public facilities such as primary schools and secondary schools have large open areas, which are used as playgrounds. Other green structures in the area are scattered trees, which include flamboyant (mjohoro), leucaena (mlusina), (Persian lilac, bead tree (E) or mwarobaini in KiKiswahili, *Polyalthia longifilia* (ashok), *Khaya nyasica* (East African mahogany), *Milicia excels* (African teak), and confetti tree (eucalyptus). Like in upstream area, utility plants such as coconut trees, cashew nuts, *Musa sapientum* (banana), and papaya are scattered in farms surrounding individual houses. In some densely built areas, there are fewer green structures comprising mainly scattered trees. Grass cover includes elephant grass and other types of tall and short grass. The current use of green structures includes provisioning of food and poles and sticks for building construction and fire wood. Other uses include regulation of wind speed, modification of relative humidity, provision of shade against the tropical sun, and increase of evapo-transpiration and precipitation. Some trees such as Persian lilac and *Trema orientalis* (muarobaini and muisi respectively) are also used as herbs. The green infrastructure provides habitats for animals. In most informal settlements, they are also used to demarcate boundaries of individual landholdings. In addition, trees soften the hard built environment, prevent glare, purify air, absorb noise and dust, prevent erosion, produce identity, and contribute to soil replenishment.

Although most of these green structures are private properties, some of them are in semi-public areas such as those within schools, churches, mosques etc. The sizes of these vary but many measure between 0.5ha and 1ha. Whilst the aforementioned green areas surrounding public facilities are used for recreation, ceremonies and meetings for specific members of the institutions, green structures or areas surrounding the private houses are largely used as spaces for parking (front of houses) or gardening/farming activities. The latter takes place in the backyard. As a principle, houses are often located on the upper areas of plots, while farming /gardening activities take place on the lower areas. Use rights and management of the green structures are solely under individual land owners. For instance, recreational open areas around schools or religious facilities are managed by the respective users. Whilst management and upkeep of green structures held by most public institutions (such as military and schools) and semi-public institution (schools, religious institutions) are fairly well done, those which are held by private persons are not always properly maintained. No wonder in some cases they are eroded and degraded by storm water (of the case of Msimbazi Valley). What is important to underscore here is that intensification of house construction activities and clearing of vegetation to pave way for gardening areas in upstream areas increases storm water runoff leading to severe flood effects in the mid and lower stream areas.

Like the upper stream area, the middle stream comprises informal development; the landform topography is hilly and ridged. The depth of the river gorge varies between 2m and 12m. The soils are clay and silt, whilst the dominant green infrastructure includes grass, shrubs and scattered trees. Just like in the upper stream area, mixed farming includes vegetables along the river bank. The main food crops grown that are part of the green structure include spinach, banana, pawpaw, and sugar cane. Within the middle stream area there are also two protected areas Changanyikeni and Lugalo military barracks which are dark green structures with natural vegetation. Like the upstream, most of the land rights (with the exception of the protected land) is held under informal tenure or quasi-Informal and very few Informal rights. For instance, out of 67 respondents, only 5 respondents (7%) have surveyed and acquired titles for their land.

Land in the lower stream area comprises loam and sandy silt soils; a large part of it is within the main flood basin of the Mbezi River. Unlike the mid and upstream settlements, Kawe Ukwamani informal settlement which is within the lower stream, is densely built (40-50units/ha) and comprises about 90% of the lower stream area. Compared with the upper stream and middle stream areas, there are relatively very few open areas (unbuilt) which are

mainly used for vegetable gardening. Like the rest of the catchment area, most of the land is held by private individuals under Informal and quasi Informal rights; a few households have tittles.

4.5 Green Infrastructure in Goba - Middle Stream Area, Dar es Salaam

As noted earlier the built up area that comprises the mid stream part of the catchment is used for various uses including residential, institutional (see military barracks, Figure 28), commercial facilities etc. as well as for farming activities. These include cultivation of vegetables, papaws, banana, and coconut and cashew nuts. The buffer zone along the high voltage power lines to Zanzibar which runs along from S-N act like an air tunnel. Like the upstream area the unbuilt land has a variety of plants including flamboyant (mjohoro), leucaena (mlusina), mwarobaini, and confetti tree (eucalyptus) and utility plants such as coconut trees, cashew nuts, *Musa sapientum* (banana), and papaya which are scattered in open areas surrounding the built areas of individual households. The valley that is suitable for vegetable gardening is divided into small parcels of between $80m^2$ and $200m^2$ by the original owners and rented out to small vegetable gardeners at a rate of Tshs 10,000/= to 25,000/= per month (see Figure 29). Local City leaders and the city in general have failed to protect the valley against encroachment, sand quarrying and crude dumping of solid wastes into the river. Subsequently, the valley is widening up and deepening due to erosion. About 95% of the houses found in the middle stream area are high quality detached single storey houses, whereas double storey houses comprise only 5%. Houses are made of concrete blocks; some are partially completed but already inhabited. The housing density for the middle and upstream area is between 35 units and 40 units per hectare.

Figure 28 Vegetable farming in Goba Ward

Figure 29 Changanyikeni Military green area

4.6 Green Infrastructure in the Lower Stream Kawe Ukwamani , Dar es Salaam

In the lower stream, there are only few patches of green structures, small gardening areas, and narrow roads and footpaths. Main green pastures include maize, vegetables, banana, and coconut palms. Small incidental open spaces that surround or front most houses are mainly used as outdoor resting, cooking and washing areas, most of these are bare without vegetation cover. Most open areas are in front of private houses and are semi-public spaces whereas those at the back are private spaces that are mainly used by the residents of the surrounding houses. There are no fences, hedges or any physical marks to mark the property boundaries and therefore the setbacks of houses create a series of irregular open spaces between houses. The unmarked property boundaries are within the shared open spaces between houses and in case of social conflicts between neighbours, often times one of the conflicting neighbours may decide to punish the other by blocking deemed public access to the portion of the open space belonging to him/her and subsequently, the open space is assumed to be a private ownership. The open space system is principally fragile as it is located in the private land where its existence is determined by good social relations among the residents. The semi-public spaces between buildings are clean and safe as residents resting at verandas and fronts of the abutting houses in those compactly built areas have their eyes on the street. Almost all houses (99%) are single storey detached, made of concrete block-walls and the rest made up of mud and poles. 95% of the houses are occupied by owners and tenants whereas only 5% are owners. Most of the plots are not accessible by vehicle. However building materials such as sand and blocks are easily available due to extensive sand mining and block making activities along the river bank. Lack of regulations and spaces standards to guide land development activities imply that land owners are free to parcel their land or construct their houses. The quality of individual buildings in terms of durability, functionality, spatial-social relations is satisfactory in spite of high density and irregular composition. In the downstream areas housing density ranges between 40 and 50 units per hectare.

5. SUGGESTION FOR INTEGRATING STORMWATER MANAGEMENT IN THE GREEN STRUCTURE

Based on the assessment of the green infrastructure and its role in stormwater management the following suggestions to integrate green infrastructure and stromwater management both at catchment, upper pilot site, middle pilot site and lower pilot site for both Addis Ababa and Dar es Salaam.

5.1 Suggestions on Addis Ababa at Catchment Level (Jemo river)

In the old unplanned settlement the government has two proposals of intervention: whereas the first is to demolish more dilapidated structures and substituting them with multi-storey development, the second is upgrading the informally developed housing by restructuring streets and open spaces for proper functioning of the livelihoods. In this regard, there is an opportunity to introduce different LSM options in communal open spaces and streets. In planned housing areas introduction of house hold level integration of LSM systems is suggested. In the condominium and other communal living areas, the available open spaces need to be used for the integration of the different LSM elements.

In the institutional plots, the available open spaces need to be used for managing stormwater generated within the institution. In addition, development of green space that could provide recreational, shade and stormwater management services need to be developed.

For the management of stormwater and the use of stormwater for urban greening LSM need to be integrated in the development and management of recreational parks (city, sub-city, woreda and neighbourhood parks).

For the river and riverbank, resettlement of the informal settlements on the river banks followed by rehabilitation with the development of green space that could provide recreational, stormwater regulation and fruits and vegetables is suggested. In addition proper control of the release of solid and liquid waste from domestic and industrial sources are suggested. In order to select plant species that could be used in stormwater and waste water management, inventory of some representative riverine vegetation is suggested. Multifunctional forest with components of conservation forestry, agroforestry and production forestry need to be developed on the Jemo and Wochecha Mountains. Settlement and field crop farming (apart in the form of agroforestry system) need to be prohibited on these mountains. Soil and water conservation measures need to be taken in areas where the landscape has been damaged. Hills within the catchment need to be planted with trees that

could provide multiple ecosystem services. The provisional (food) and regulatory (stormwater regulation) function of cropland of the catchment is quite immense. As the loss of cropland in Addis Ababa is very alarming, city authorities need to understand that urban agriculture is an integral part of the urban land use; therefore it has to be incorporated in the structure plan of the city. Further development on the fertile land of the city need to be restricted and the land should be reserved for field crop farming. River banks with gentle slope need to be developed for vegetable farming.

5.2 Suggestions on Dar es Salaam at Catchment Level (Mbezi river)

With respect to SWM in residential planned area, further regulations should be inserted to develop proper systems such as retention ponds, detention ponds, rain garden etc in individual housed or estimated cluster of housing for high density areas. In unplanned settlement within upstream (Mbezi Luisi) and midstream (Goba), since the areas are in early stage of urbanization and largely covered by green space, there is a potential of introducing development regulations to control dense urbanization and introducing controls that are in conformity with SWM.

In the densely developed settlement of the Kawe lower stream; an upgrading program should be employed that involves among others, introducing proper public routes and spaces. SWM elements should concurrently go with the upgrading strategy through minimal displacement of inhabitants in order to advance the livelihood of the area.

For the military based areas and the current Kawe beach; since they are potentially performing in terms of SWM, the study suggests maintaining the status. The grassland of the Tanganyika Packers plot is going to be affected by the planned development within Kawe area, therefore there is a need to introduce SWM elements in the landscape design stage.

Regarding the riverbank green structures, since the current ownership of the river banks is not clear; the study suggests the introduction of regulation to control the encroachment of the banks. Such areas are currently left as waste lands that lead to encroachment. If there are regulations, the study suggests reviewing them to conform to SWM.

5.3 Suggestions on Addis Ababa - Upstream Pilot site (Repi Hill)

In the area, encroachment of agricultural land by unplanned housing increases impervious surfaces. The study suggests protection of agriculture land by introducing

irrigation systems through introduction of storm water harvesting at catchment as well as house hold level. At house hold level the study suggests roof water harvesting, introduction of rain garden and storage basins. The quarry area should be rehabilitated by refilling through excavated soil from construction sites from different parts of the city.

5.4 Suggestions on Dar es Salaam - Upstream Pilot site (Mbezi Luisi)

Since the part is rapidly urbanizing due to its proximity to the main highway, the study suggests utilizing part of existing farmlands to introduce LSM that will help control development and benefit the dwellers in aspects of: water shortage, enforcement of irrigation based urban agriculture, improvement of green and social recreation spaces etc. At house hold level the study also suggests the use of storm water harvesting systems and introduce rain gardens, retention and detention ponds to control runoff from buildings.

5.5 Suggestions on Addis Ababa -Midstream Pilot site (Jemo condominium area)

The study suggests an introduction of roof harvesting at household level for formally and informally developed residential plots in order to contribute to solve the water demand problem. The study also intends to reduce runoff by utilizing permeable paving and rain gardens. In case of condominiums and residential subdivisions, the study recommends to use part of the available communal spaces for development of retention and detention basins. At the riparian zone adjacent to the settlement, the recommendation is to introduce retention ponds to reduce the impact of storm water runoff and at the same time to foster irrigation based urban agriculture.

5.6 Suggestions on Dar es Salaam Midstream Pilot site (Goba)

The area is characterized by hills and creeks with small water discharge to Mbezi river. The study suggests the use of creeks as neighborhood collection gutters of storm water to the proposed series of retention ponds to the riparian zone of Mbezi river. At house hold level the study suggests storm water harvesting for non potable uses and introduction of rain garden, permeable paving, retention and detention ponds according to availability of space in individual plots.

5.7 Suggestions on Addis Ababa -Lower stream Pilot site (Mekanissa Seminary)

The area is usually affected by floods. The institutional plots and urban agriculture are severely affected by recurrent over flooding of the little Akaki River. In this area the study suggests an introduction of sediment basin for controlling the surface runoff generated from the compound and in the surrounding residential areas. Regarding to recurrent flooding,

development of constructed wet land and retention pond in the available space within Seminaries compounds can be a temporary solution. In this regards, the water feature developed by looking into suitable landscape condition with respect to irrigation scheme, the water will be utilized for gardening and urban agriculture.

5.8 Suggestions on Dar es Salaam -Lower stream Pilot site (Kawe)

The area has been experiencing regular flooding during rainy season, landslides on some parts of river bank. The study proposes communal water retention ponds in the riparian belt along Kawe settlement to reduce the effects of runoff that contribute to flooding. The ponds will benefit the community through irrigation based urban agriculture, provide community space and improve greenery of the informal settlement. The riparian greenery is suggested to be improved along the river banks in order to keep a permanent course of the river and mitigate landslide experience. The study also suggests to use an opportunity of designing the new town in the Tanganyika packers plots by introducing a LSM and make it an example in the city of Dar es salaam.

6. SUMMARY OF TYPOLOGIES OF GREEN STRUCTUIRES AND SUGGESTED IDEA AND SOLUTION FOR STORMWATER MANAGEMENT

	Context	Ideas for solution	Test of solution
City level	**In Addis** the dominant GS is crop land, but it is threatened due to urban expansion and master planning malpractice	Master plan of the city should consider urban agriculture as an integral part of land uses as well SWM measures.	Spatial distribution of GS based on Satellite imagery, master plans regulations, legislations and other relevant document from city administrations
	In Dar es Salaam the residential G.S are the dominant, but those GS located in informal housing areas threatened from informal subdivision and densification	In those residential area urbanization is in its enfant stage, therefore there is a potential of introducing development regulations to control dense urbanization and injecting controls that are in conformity with SWM.	Spatial distribution of GS based on Satellite imagery, master plans regulations, legislations and other relevant document from city administrations
Catchment level	At **Jemo catchment**, institutional greens are in a good situation, however informal housing and agricultural practices threatened GS in high slop areas like Jemo mountain, Repi hills and on Riverbanks	Identification of different ecosystem services provided by GS in high slope areas in terms of SWM and overall environmental benefits for the city like heat island effect reduction, recreation and urban agriculture.	Integrated green-blue corridor development by focusing on some landscape based structural measures like terracing, riparian zone rehabilitation and water retention pond development.
	At **Mbezi catchment**, institutional greens in military establishments and resort hotels are in a good situation however GS at the lower catchment of **Mbezi river** is under threat due to informal urban densification and urban agriculture practices	Identification of different ecosystem services provided by GS in flood plains and mangroves in terms of SWM and overall environmental benefits for the city like heat island effect reduction, recreation and urban agriculture.	Integrated green blue corridor development by focusing on some landscape based structural measures like riparian zone rehabilitation and water retention pond development.

Pilot level	**Upper site (Repi):** degraded Repi hill and informal residential area with water shortage and risk of erosion and land slide **Mid site:(Jemo condominium)** Condominiums and formally developed residential areas are with water shortage risk during the dry season, and are affected by flooding from Jemo river overflow during the rainy season **Lower site (Mekanissa seminary).** The Seminary and the surrounding urban agriculture land and semi-formal residential development are with high risk of flooding and water shortage	In **upper catchment** integration of water harvesting mechanism with urban agriculture and rehabilitation of degraded natural landscape. **At mid-stream** consideration of water harvesting for none potable use and improvement of flood plains and riverine landscape through blue green infrastructure. **At lower site** river over flow management through landscape based structural measures for river ecosystem health and flood plain landscape safety	**In upper catchment** introduction of roof harvesting, rain garden and storage basins at household level and rehabilitation of the quarry at watershade level. **At mid-stream** roof harvesting, permeable paving, rain gardens and storage basins can be implemented at household & community level. Furthermore, rehabilitation of Jemo river bank & development of riparian vegetation and vegetable farming **At lower site** development of brand new water retention pond and wetland for SWM of the surrounding as well as to utilize the storage capacity of the pond during over flooding of Little Akaki river
	Upper site (Mbezi Makabe, Matosa and Goba) is rapidly urbanizing due to its proximity to the main highway and now it is at early stage of informal housing development on agricultural land **Mid site (Goba)** is predominantly occupied by military establishment from one side and informal	**In upper catchment** integration of water harvesting mechanism with urban agriculture and rehabilitation of degraded natural landscape. **At mid-stream** consideration of water harvesting for non-potable use and improvement of flood plains and utilization	**In upper catchment** at house hold level, the use of storm water harvesting systems and rain gardens, retention and detention ponds. Utilizing part of existing farmlands to introduce LSM and irrigation based urban agriculture. **At mid-stream** application of storm water harvesting, rain garden, permeable paving and storage ponds. At

	low density residential development from other side. The area characterized by hills and creeks that discharge to Mbezi river **Lower site (Kawe)** predominantly occupied by densely developed formal and informal houses together with different types of institutional and it is experiencing regular flooding during rainy season	of river landscape for conveyance. **At lower site** river over flow management through landscape based structural measures for river ecosystem health and introducing LSM into new development schemes	water shade level, use of creeks as natural neighbourhood collection gutters to the proposed series of retention ponds to the riparian zone of Mbezi river. **At lower site** communal water retention ponds in the riparian belt along Kawe settlement to reduce the effects of runoff that contribute to flooding and introducing a LSM into new mixed use development on Tanganyika packers plots

REFERENCES

Alberti, M. (2005). The effects of urban patterns on ecosystem functioning. *International Regional Science Review* 28(2): 168-192.

Armson, D. Stringer, P. Ennos, A.R. (2012). The effect of tree shade and grass on surface and globe temperatures in an urban area. *Urban Forestry & Urban Greening* 11: 245–255.

Barrico, L., Azul, A.M., Morais, M. C., Coutinho, A.P., Freitas, H., and Castro, P. (2012). *Landscape and Urban Planning* 106: 88– 102.

Bedimo-Rung, A., Mowen, A. J., & Cohen, D. A. (2005). The significance of parks to physical activity and public health. *American Journal of Preventative Medicine* 28:159–168.

Benedict M.A, and McMahon E.T (2006). Green infrastructure: Linking landscapes and communities. Island Press

CLUVA (2013). Green Infrastructure: An essential foundation for sustainable urban futures in Africa. CLUVA Report (www.cluva.eu).

Escobedo, F. J., Kroeger, T., & Wagner, J. E. (2011). Urban forests and pollution mitigation: Analyzing ecosystem services and disservices. *Environmental Pollution* 159(8): 2078–2087.

Nowak, D. J., Crane, D. E., & Stevens, J. C. (2006). Air pollution removal by urban trees and shrubs in the United States. *Urban Forestry and Urban Greening* 4: 115–123.

Nowak, D.J., and Crane, D.E., 2002. Carbon storage and sequestration by urban trees in the USA. *Environmental Pollution* 116: 381–389.

Weber, T., Sloan, A., and Wolf, J. (2006). Maryland's Green Infrastructure assessment: development of a comprehensive approach to land conservation. *Landscape and Urban Planning* 77 (1-2): 94-110.