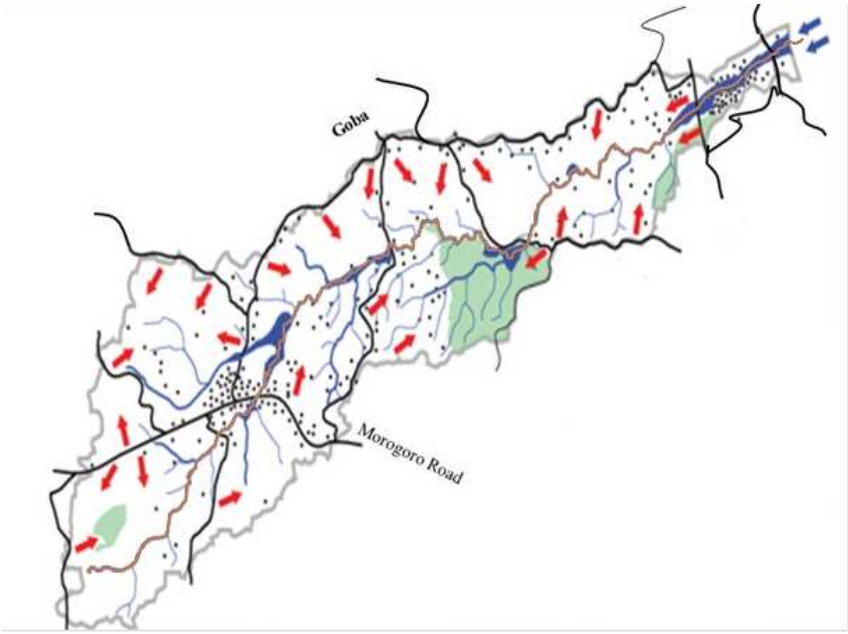
Municipal Level Policies and Site-specific Neighborhood Strategies for the Mbezi RiverCatchment, Dar es Salaam



September 2017
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1. Introduction

Rapid urban growth in Sub-Saharan African countries has resulted in extensive development of informal settlements. Inhabitants in most informal settlements suffer from a wide range of environmental problems that relate to lack of adequate and safe water as well as lack of storm water management infrastructure. As a result, such settlements are vulnerable to many problems associated with flooding and water scarcity. Water scarcity especially for domestic use, urban farming and other livelihood activities and frequent floods adversely impact local communities socially, environmentally and economically. The urban poor are often most hit because they often lack resources, reliable coping strategies and other support services.

Mbezi River catchment area (Figure 1) is one of the areas in Dar es Salaam Citythat represents the discussion above. The Upstream and Midstream areas which cover a total of 5,767ha, experiencesevere water scarcity, whereas the Downstream part which measures about 1,113ha faces frequent flash floods. In total, the river has more than 56 small valleys and tributaries.
An overview of the Catchment level land form depicts a mixture of gently and sharply undulating hills; these are often dissected by small and medium size valleys. Mbezi River is the major natural storm drainage system to which almost all tributaries in the catchment area channel storm water run-off.

The Upstream is vegetated with short grass, shrubs and scattered trees – both utility and ornamental plants. Compared with the military area on the opposite side of the river the vegetation is sparse, and much soil is left unprotected and exposed to erosion.The two areas are comparatively fairly sparsely built, with many pockets of open or un-built land, whereas the downstream area is quite densely packed. Owing to the unregulated land parceling, plot sales and house construction activities, the entire catchment is densifying quite rapidly. Downstream part of the catchment area comprises gently sloping land that is densely built; and with very few pockets of open land and scattered bushes. This is part of the Mbezi River Catchment area that is often flooded. Both the Mid-stream and Downstream areas of the River Mbezi are increasingly being eroded with many gullies which are widening as they run downstream into the river, in several places causing collapse of banks and serious landslides. This situation is observable in several other rivers that dissect Dar es Salaam. Overall the situation in the Mbezi River Catchment suggestsa strong case for Muncipal-wide support to site specific LSM strategies in combination with reestablishment of the landcover to address the problems of erosion, flooding and water scarcity.

Taking the Kibululu neighborhood of Mbezi River Catchment as case this report first presents site specific strategies as illustrated in Figure 3 (plan view) and supported with sections of details (Figures 4-8). Thereafter catchment and Municipal wide policies that emanate from the ideas developed in Kibululu are presented. The aim of presenting this in form of policy rather than strategies is to enhance broader application and operationalisation of the LSM concept at

catchment and municipal levels. These policies and area specific strategies will be presented and reviewed after consultations with Kibululu community leaders and Municipal officials.

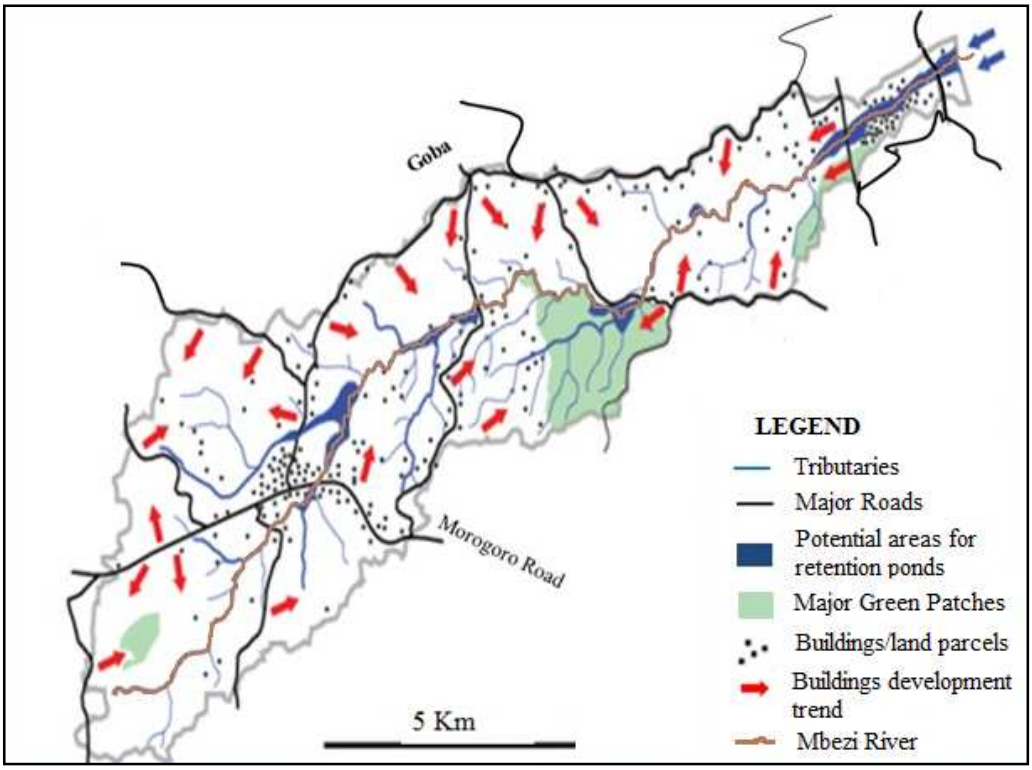

Figure 1: Mbezi River Catchment Area

1.1 Methodology for the development of the policies and strategies

The development of the policies and strategies were conceived and developed through the following interlinked steps and activities.

(i) Conduction of field (baseline) studies to map and document the existing situation;
(ii) Analysis of the maps and identification of the key physical characteristics or land forms and their implication for the management of storm water run-off;
(iii) Brainstorming by WGA project team members during project meetings/conferences;
(iv) City stakeholders' workshop to share initial observations and explore barriers to the application of LSM in the catchment area;
(v) Identification of pilot case study in GobaKibululu neighborhood area. This includedpreparation of the local community including their leaders for a design charrette;
(vi) Conduction of design charrette among the selected city level and GobaKibululu community residents and leaders;
(vii) Development of strategies specific to Kibululu Neighborhood;

(viii) GobaKibululucommunity consultations including presentations and discussions on the various strategies viable for addressing water scarcity and flooding at specific neighborhood sites in Goba Kibululu;
(ix) The formulation of municipal level LSM macro-policies; and
(x) Municipal level consultation on the macro-level policies.

1.2 Concept underpinning the strategies

The key concept on the basic of which the macro-policies and strategies for addressing water scarcity and flooding in the Mbezi River catchment is a "stormwater management train" that spans across spatial scales from the building level to the river catchment level while targeting new green field developments in a densifying suburban landscape (Figure 2).

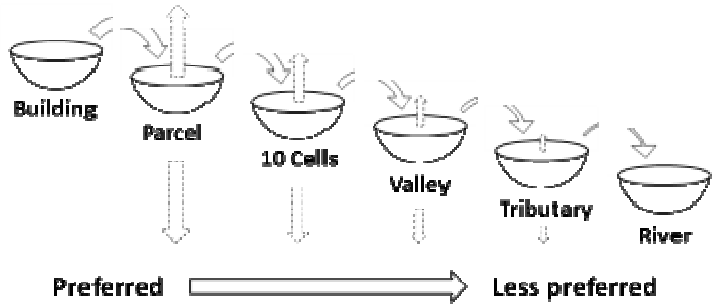

Figure 2. Conceptual diagram of the stormwater management for MRC (Source:Fryd et al., *Report II*).

1.3 The sub-strategies

Mbezi River Catchment strategy initially comprised 6 spatial scales which relate to specific sub-strategies as summarised in Figure 3.

Figure 3. Longitudinal section of the suggested stormwater management train at different spatial scales *Source (Report II)*

1.4 Entry points

In order to realise the implementation of the strategies proposed at various spatial scales, a number of entry points with specific users are identified and presented in Table 1. The idea is to ensure individuals appreciate and consider the implications of stormwater management decisions they have made or intend to make on the levels above and below. The fundamental principal that will facilitate effective water management in the catchment for each entry pointis to appreciate and recognise the indispensable link between one's specific spatial scale and the level above and below. In doingso, individual decision and actions will have to consider the adverse effects and or synergies in storm water management that can be realised through collaborative action.

As shown in Table 1, there are also opportunities to apply the strategies outlined in the table in the Upstream areas but with some limitations downstream. For instance, check dams or infiltration trenches are not quite applicable in the downstream due to excessive housing densification among other things.

Table 1.Summary of the strategiesand key entry points

Spatial scale	**Strategy**	**End user/ entry point**	**Replicability Upstream and Downstream**	
			Upstream	**Downstream**
Building	Rainwater harvesting	Household	✓✓✓	✓
Land parcel/Plot	Permeable pavers Bio retentions Grass/gravel lawns Infiltration trenches	Household	✓✓✓	✓
Neighbourhood[1]	Infiltration trenches and swales Green/soft boundaries Retention ponds	Household Adjoining neighbours Community groups Existing LSM practitioners	✓✓✓	✓
Valley/ Valley	Green terraces Detention and retention ponds Check dams	Ten cell leaders Sub-ward leaders NEMC Municipal planners	✓✓✓	✓

[1] Neighbourhood as used here refers to the specific geographical areas (site for strategy) carved out of the Kibululu sub-ward. It is therefore not synonymous with the urban planning neighbourhood concept.

River course	Green buffer Detention and retention ponds Check dams	Mtaa leaders, adjoining land property owners, ward leaders Municipal planners, NEMC Environmental engineers PMO - Dept. Of Environment Adjoining property and land occupiers	✓✓✓	✓

Key	✓✓✓	Highly relevant and applicable
	✓	Limited application

1.5Planning and formulation of the Strategies

During the charette, the community at Goba-Kibululu Sub-ward presented water scarcity and storm water management challenges facing the community as well as existing options/opportunities many of which are already being used at household level. The latter include rainwater harvesting, retention ponds for fish farming, terracing and the use of vegetations to preventerosion.

The solutions to address storm water management challenges which were collaboratively evolvedwith the GobaKibululu community formed the basis for the generation of macro-policiesand neighborhood levels strategies.

The main challenges identified by the local community living along the Mbezi River Catchment and specifically in Goba-Kibululuneighbourhood area were:

(i) Illegalsand mining;
(ii) Soil erosion;
(iii)Seasonal flooding;
(iv)Water stress;
(v) Encroachment onto the river banks by house builders; and
(vi) Clearance of bush/grass and tree felling.

The main opportunities include:

- Urban agricultural activities at household level;

- Expand existing LSM related local practices and norms that are used to copewithflooding and address water scarcity at household levels;
- Community members and groups engaged in water harvesting – urban gardening and fish farming;
- Small open areas (downstream) and extensive green areas (upstream and midstream); and
- Potential champions – community members practicing LSM and many others who are ready to learn more about LSM.

2.The Strategy

The main objective of the neighbourhood level strategies is to implement practical and coordinated intervention actions that provide for the improved and integrated management of stormwater and subsequent flooding using landscape based SWM concepts. This has to be achieved through collaboration with the community members and their leaders. The strategies aim at managing the storm water flow and intervene at different spatial scales along the catchment area.The ideas presented here (Kibululu Area) are being used as an example of what can be done atdifferent levels and geographic scales.

The specific objectives are to:

i. Reduce, delay run-off at the source as much as possible;
ii. Reduce the impact of storm water flows on flooding and erosion;
iii. Use storm water to promote livelihoods such as farming/crop production and animal husbandry; and reduce water stress at household and community levels; and
iv. Develop green infrastructure to support and promote stormwater management

2.1 Neighborhood Level Stormwater Management Strategies

Figure 4outlinesa detailed plan of a part of Goba-Kibululu area extracted from the 63 km^2 of Mbezi River Catchment.The plan is one of the products of the design charrette. The extract illustrates how rainwater and runoff can be managed at a neighborhood scale. Nearly all the proposed sets of stormwater management intervention that can be deployed at catchment scale are alsopresent in the elaborate illustrations (Figures 4-8). As pointed out earlier, as far as stormwater management is concerned, a neighborhood is a geographical area that includes:buildings and their corresponding plots, open/vacant areas, roads and footpath networks, valleys and a network of natural runoff routes that are draining stormwater towards a common outlet – the Mbezi River.

Other LSM strategies that will be applied in a neighborhood level also include the use of series of infiltration trenches and swales intersectingthe natural runoff routes, along the major roads and the use of green boundaries (soft walls) to demarcate the plots. In order to improve the management of stormwater run-off along the main roads more infiltration trenches and

diversion of excess water towards the most appropriate land areas as well as planting of more trees along the roads is envisaged. The latter will help stabilize the soil conditions along the roads. In some areas, these strategies and techniques will be challenged by congestion of building especially in the downstream part of the catchment namely KaweUkwamani. In these areas, alternative strategies are required as outlined in section 4.

It isproposed that all the roads and major footpaths are provided with roadside drainage channels that are diverted into a series of infiltration trenches. Some of these drainage channels could be open drains. To control erosion along the road front properties, depending on the terrain and slope, a series of diversions with proposed interval of 20m from each other can be proposed. (Clemens, et al,. 2008). Any excess runoff from the infiltration trenches is directed downstream via a gently sloping vegetated or gravel packed swales to new intersecting infiltration trenches. Buildings are proposed to be provided with rainwater harvesting systems connected to storage tanks. The overflow from the storage facilities are directed to irrigate the vegetated soft boundaries between plots that are preceded by shallow infiltration trenches packed with gravels. The excess water from the plots are therefore collected and directed downstream with swales. The amount of water that can be infiltrated through infiltration trenches will in addition to the size of the trench depend on the hydraulic conductivity of the soil)

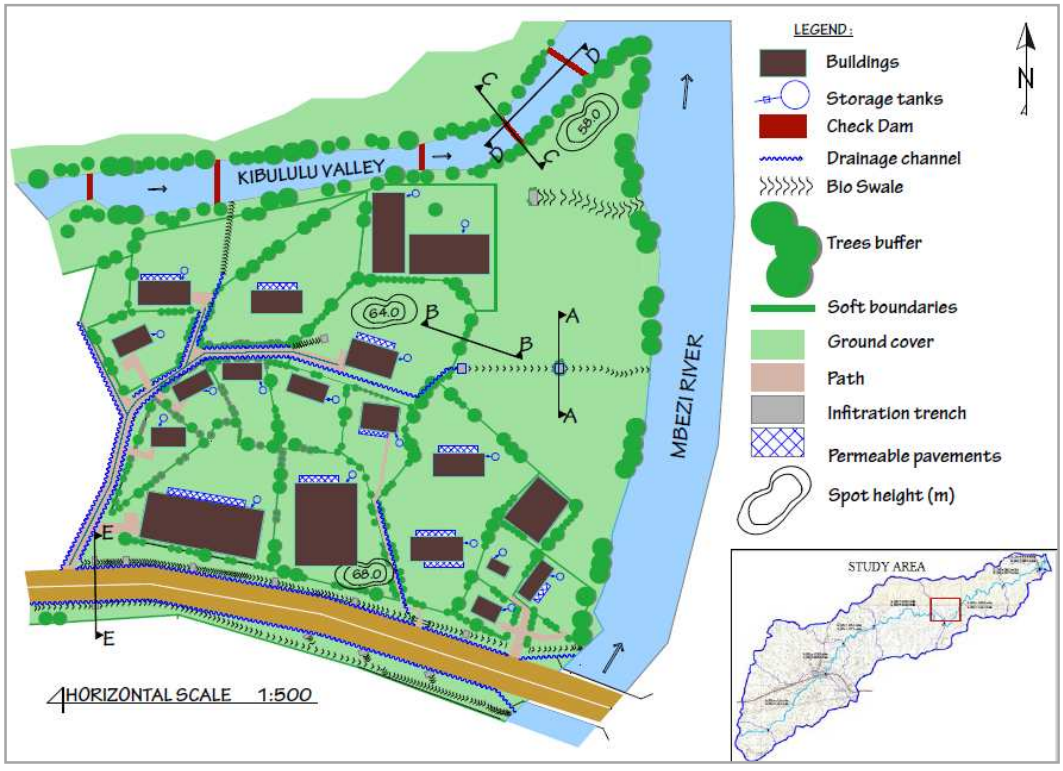

Figure 4:Detailed plan of neighborhood level storm water management strategies

Also, a series of check dams are proposed in the Kibululu valley which borders the mapped extract area to the northern side (Figure 4). This will create small ponds within the gorge of the valley. Kibululu valley is conceived as a catchment area of a small seasonal stream (Kibululu stream) that joinsMbezi River. Since there is a scarcity of water in the neighborhood, the water in the ponds might be used for other livelihood activities such as fish keeping and gardening. By retaining a fraction of the runoff behind the checkdams the risk of downstream bank erosion will be reduced.

2.2 The proposed site-specific strategies and their significance

(i)Rain water-harvesting

The major rainwater management strategy at building scale is roof top rainwater harvesting. The objective of rainwater harvesting is to provide complimentary water supply source mainly during the rainy season. That means water from other sources will still be used especially during dry season. Additionally, the harvested rainwater will reduce the runoff stream from individual roof tops.

Figure 5: Rain water harvesting systems at house level at Mbezi Luis sub-ward (Upstream)

As a simple technology, rainwater harvesting can be applied in most buildings in the catchment area. The limiting factor is on the size of the storage facility and affordability. Significant rainwater harvesting requires extensive sensitization of the community to develop interest and change existing perceptions that rainwater harvesting is too expensive and not as reliable as piped water supplies. In order to overcome this, alternative options such as construction of cheap storage tanks and training of some of the community members such as youth on such constructions techniques would be necessary especially after appreciating the value of rainwater harvesting and green structures for SWM. In addition, the provision of by-laws which would require homebuilders to provide for rainwater harvesting for every square meter area paved will add further value.

In addition, the use of bylaws that require incorporation of rainwater-harvesting systems as a requirement in acquisition of building permits will also oblige the residents to consider rainwater harvesting in design and construction of their dwelling units (details on sizing and other design requirements will be provided in the LSM operationalisation manual – see section 4).

(ii) Bio-swale with series of infiltration trenches (section A-A in Figure 4)

A cross-section of a gravel-filledswaleable to connect a series of intersecting infiltration trenches is illustrated in Figure 6. Such infiltration and conveyance elements are proposed to be built at the end of each open stormwater drainage channels (Fig 4). These should run along footpaths branching from the main road. The aim is to reduce the volume of storm water runoff by delaying the flow speedso as to give it more time for infiltration and at the same time providing better contact between water and soil.

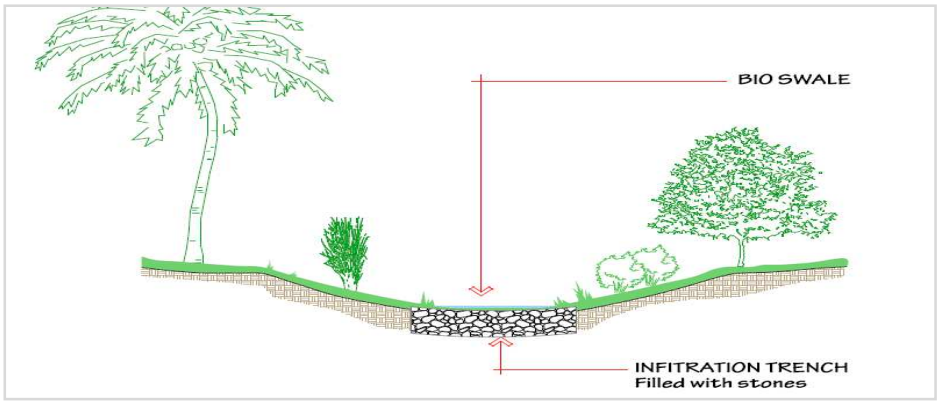

Figure 6: Cross-section of a vegetated swale connecting a series of infiltration trenches (Section A-A in Figure 4)

(iii) Terracing: Soft boundaries between plots (section B-B in Figure 4)

Figure 7 presents a detailed cross-section of a soft boundary between neighboring plots. A soft property boundary is proposed between two neighboring property land parcels especially where such boundaries are more or less parallel with the contour lines. The boundary is intended to improve the greenery and overall scenery of the neighborhood and serve other livelihood purposes. The soft boundary is basically a terrace-like ridge planted with various beneficial plants including shrubs. Other plants species may include elephant grass (*Pennisetumpurpureum*)**,** bananas, and sugarcane and mangoes trees which are commonly grown in the city of Dar es Salaam. These plants might either be used for feeding animals or for human consumptions.

The idea is to retain a certain amount of stormwater run-off behind the ridge/terrace so as to slow its speed and enhance infiltration while irrigating the vegetation planted over the terraces as indicated on Figure 7. When the runoff exceeds the height of the ridge, it overflowsinto the next boundary.

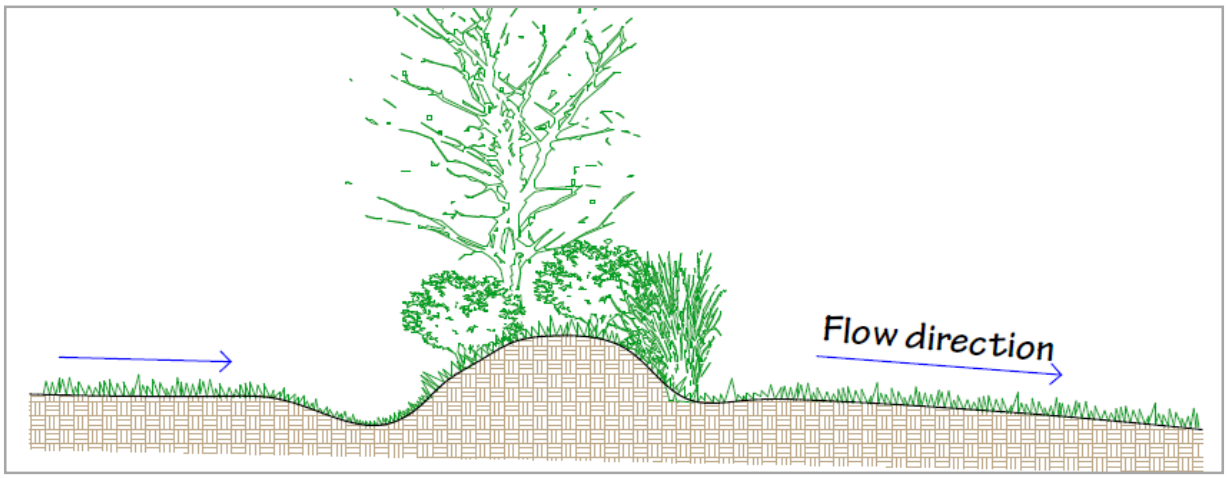

Figure 7: Cross-section of a soft boundary between plots(Section B-B in Figure 4)

(iii) Series of check dams (Section C-C in Figure 4)

In most areas of the Mbezi River catchment area, a number of neighborhoods often have a valley or a tributary of the main River (Mbezi River). Valleys and tributaries within Mbezi River catchment area, especially in the mid-stream area including parts of Kibululu sub-ward,have deep gullies with steep slopes which were caused by severe soil erosion. Therefore, the objective of LSM strategies at valley level is to promote as much as possible the infiltration of the excess runoff from the neighborhood level while allowing it to flow gently towards the main River.

A cross section of Kibululu valley which is one of the maincontributors of stormwater into theMbezi River is presented in Figure 8. In principle, the check dams operate like a terrace. However, these are engineered hydraulic structures installed so as to stabilize the river banks while slowing the speed of water by ponding it behind the dyke. Depending on the nature of the site and desired purposes of the resulting conditions, stone filled gabions work better if runoff ponding behind the dyke is not required while a concrete structure is suitable if water ponding before the dyke is desired. The latter is an ideal scenario for many areas along Mbezi River due to water shortage issues. The check dams are designed with a wear which allows the water to flow downstream, preventing the water from over-topping its ridges (Figure 8). As sand piles, up behind the check dams sand mining could be allowed.

In addition to the checks dams, a 3-mwide buffer of vegetation cover including trees, bushes and grass is proposed on either side of the stream. These vegetation stripsare also beneficial to the land owners. Utility plants like sugarcane, cassava, bamboo and other fruit trees will be preferred.

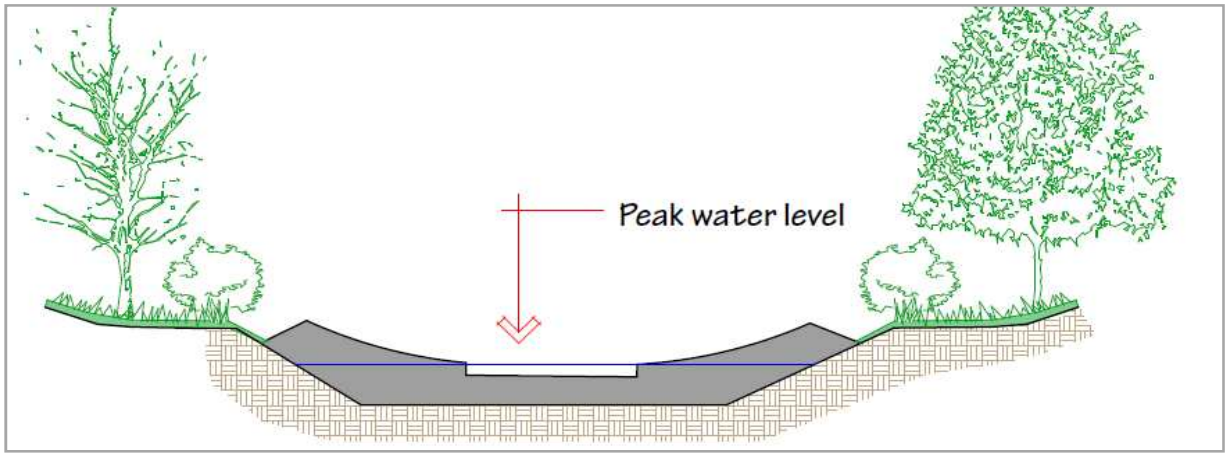

Figure 8: Cross-section of a check dam and its buffer zone (Section C-C in Figure 4)

(iv) Longitudinal section between check dams (Section D-D in Figure 4)

A longitudinal section between two successivecheck dams is illustrated in Figure 9. The section aims at showing a gradual decrease of height between two check dams. The retained water behind the check dam reduces both the speed and energy of water as it moves downstream. At the same time, the water retained will be made available for gardening and other purposes especially laundry purposes.

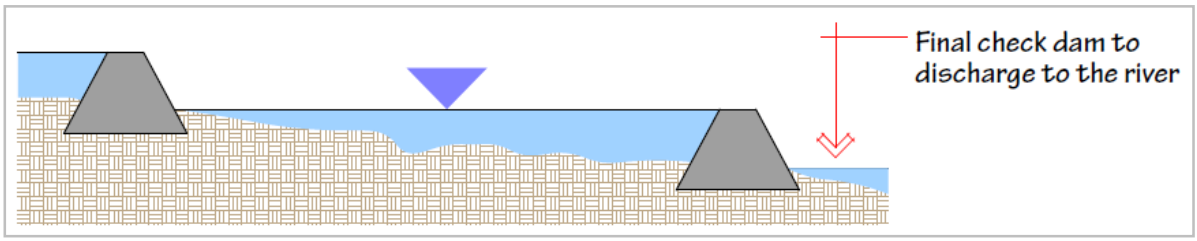

Figure 9: Longitudinal -section of two successive check dams (Section D-D in Figure 4)

(v)Combination of bio-swales and drainage channels: cross section of MakongoJuu – Goba main road (Section E-E in Figure 4)

Figure 10 illustrates a cross section of MakongoJuu – Goba main road. Road side drainage channels are proposed on either side of the road. The drainage channels are designed to discharge the runoff into the vegetated swale adjacent to it. The swales are also designed such that a seriesof infiltration trenches are dug and filled with cobble stones after every 20m run. A separate system of bio-swales and storm channels is proposed for major roads while for small roads and foot paths a combined system of bio-swales on top and infiltration trench underneath

can be desired. The design aims at delaying the runoff for infiltration to take place but also minimizing the erosive power of the runoff.

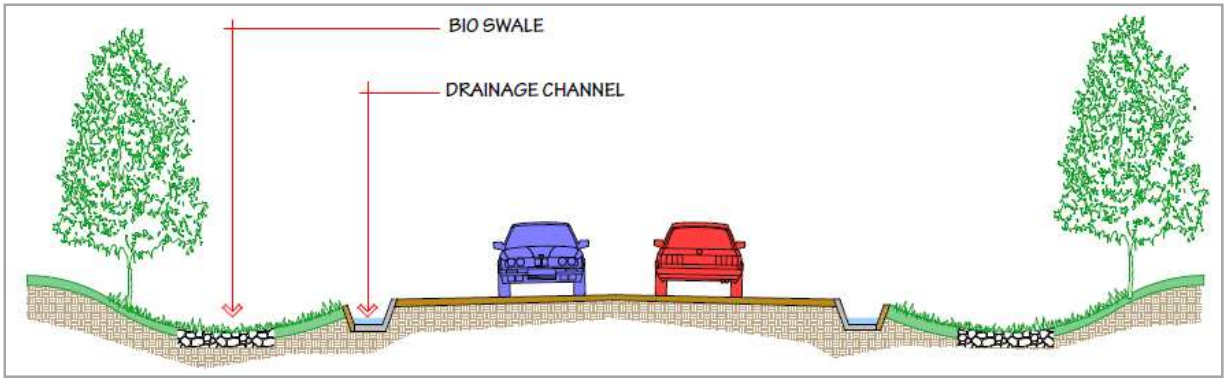

Figure 10: Cross-section of a main road (Makongo – Goba road at Kibululu) (Section E-E in Figure 4)

2.3 Implications on livelihoods

The strategies recommended at different scales and topographical areas are multi-purpose. They can be used to promote livelihoods and reduce water stress at household and community levels.

The strategies are meant to help check stormwater run-off including the adverse effects associated with it; as well as provide opportunities and improvement of subsisting livelihoods such as animal husbandry, vegetable and fruit farming. In addition, those who will harvest more rainwater are likely to sell some of it and therefore earn an incomeand at the same time have access to improved water supply for other household's activities i.e. food and vegetable vending, fish farming etc.

3. Summary of Proposed Municipal/Catchment Level Macro-Policies

In order to provide a wider framework to institutionalize and promote LSM at Municipal and Catchment levels it is deemed necessary to outline key policy intervention areas that may directly help consolidate Landscape-based Storm Water Management ideas in Kinondoni Municipality and Dar es Salaam City in general. Apart from water scarcity and flooding downstream, other key challenges in Mbezi catchment area and many other catchment areas in the city are erosion and loss of vegetationcover. Also, there is increasing destruction of buildings due to erosion especially along the river banks downstream and near valleys midstream.

Erosion and loss of land and even buildings can be prevented with an integrated catchment strategy, where the formation of gullies is prevented all over the catchment. A gulley starting in the most distant part of the catchment upstream is as bad as the runoff from close to the river. A gulley starts with the single drop that cannot find its way into the soil and is clearly observed

from dripzones of roof tops, and from runoff of compacted roads. It starts as a small, innocent little stream, but over few meters it may merge with others and grow to a bigger and bigger gulley that eventually forms a new valley with massive soil loss in consequence. To prevent this the runoff from rooftops and roads has to be directed into the soil by means of trenches and infiltration ponds like rain gardens or be retained already at the upstream and mid-stream of the terrain. If this becomescommon practice the problem with erosion will stop. Other complementary measures are to 1) reestablish vegetation along rivers and between plots and everywhere possible, and 2) make a vegetated buffer zone at some distance from the current location of riverbanks, as wide as possible, and provide a cross-cutting infiltration trench to trap water streams (gullies) that is still seeking towards the river, and diverting it into the soil. Some of these ideas are already illustrated in the strategies and sections presented earlier.

The wider policy and action areas that are proposed at catchment and Municipal level are as follows:

(i) Enforcement of urban planning regulations at local/community level; this includes the formulation and enforcement of land development and regulations in the informal settlement. At present, there is no regulatory framework. Therefore, there is a need to formulate regulations specific for informal land development. The regulation should aim at checking particularly construction of building in fragile areas such as river banks, valleys, steep slopes, and wetlands. They should be simple and enforced by local/Mtaaand Ward leaders;

(ii) Development of afforestation projects along the river to arrest erosion; this implies the demarcation and reclamation of the public land rights along rivers as provided for in the National Environmental Management Act (2004) in laws. In addition, it is important that NEMC in collaboration with the respective Municipal authorities and Ward Environmental Committees embark on the development of check dams along the major tributaries and gulley. Thereafter, the demarcated areas should be assigned to specific community level institutions for afforestation;

(iii) Definition and publicising of boundaries of the Riparian zones. This compliments the afforestation of the river banks in the catchment area it will require specific regulations that shall outline permissible or prohibited uses that will be enforced by Ward and Mtaa environmental committees. NEMC and Municipal authorities shall be responsible for defining these land uses;

(iv) Institute stringent enforcement of environmental laws – as outlined in National Environmental Act (2004);

(v) Review the environmental regulations (of EMA) so as to main-stream LSM ideas in the document;

(vi) Formulate user friendly informal sector land use subdivision and development guidelines with stakeholders from the local authorities. This includes prescribing of no-go areas (steep slopes, wetland and valleys) i.e. specify permissible land uses for areas where building construction are prohibited;

(vii) Prescribe minimum user-friendly land development standards for plot sizes and designate priority land use for public uses – i.e. for open green areas and access roads;

(viii) Prepare illustrated user friendly LSM operationalizationmanual that can be used to guide communities and individuals city-wide - at household, community and Municipal levels. Ideally the manual should be divided into two main components that can be used by community members/lay-persons and experts/professionals.

(ix) Densely built informal settlementsi.e. where the buildings are closely packed and the plots are smaller only one or two strategies might be used depending on the nature of the plot. In this area strategies such as infiltration trenches and the use of permeable pavements along the walk ways and small vacant areas can be applied through the formulation of by-laws.

(x) Review the existing building code so as to prescribe the minimum allowable water harvesting (cubic meters) per square meter fully paved/sealed area. As a rule of thumb and based on the average plot coverage in high density plots (300 -400 m^2) for every 100 m^2paved/sealed areas at least 15,000 $m^3$of rain water should be harvested.

(xi) Prescribe user-friendly guidelines for siting, design and construction of water harvesting tanks (i.e. underground tanks

(xii) Identify and develop alternative income and employment generation activities that can be support particularly youth who are currently engaged in illegal sand-mining. This requires concerted efforts by key stakeholders namely, the youth, communities, local community leaders at Ward and Mtaa levels, Municipal officials, NEMC and non-governmental institutions including development partners. It would also require extensive awareness creation and learning from successful stories or cases.

4. Conclusion/Way Forward

Operationalizing andimplementing the strategies and policies presented here requires processes that shall target the key recipients of the strategies. These include City and

Municipal engineers and planners as well as officials from relevant Central Government Ministries such as the Ministry of Water and Irrigation. Above all local communities in various neighborhoods in the City and beyond will be reached. The dissemination and reach strategy will involve champions from Kibululu and Kinondoni Municipal Council who have shown interest in the adoption of LSM. More specifically the actions are:

1. Further consultations and engagement with key stakeholders at community, municipal and city levels. These consultations should aim at seeking further input and comments and exploring priorities for action.

2. Refinement to incorporate the comments and engage in the final input from WGA partners.

3. Presentation of the strategies and policies to Kindondoni Municipal Council (Full Council meeting) in order to seek political support for city level sensitization on LSM and rolling out of the LSM strategies.

4. Preparation of the Action Plans for implementing the policies and strategies.

5. Preparation of a popular community friendly version of the Strategy after consultations and improvements;

6. Preparation of a Policy Brief for wider dissemination in the City.

Figure 9: Existing LSM based good practices along in Kirua ward, Moshi Rural district