Contents

Preamble

Storm water related flooding is one of the environmental problems that Addis Ababa city is facing, resulting in damage to infrastructure and properties and hindering traffic movement. The causes are poorly developed storm water management system, improper waste management and increasing impervious surface cover.

The Ethiopian Institute of Architecture, Building Construction and City Development (EiABC) of Addis Ababa University in collaboration with the University of Copenhagen, Denmark is conducting a four year research project with the aim of exploring the options of Landscape based Storm water Management (LSM) in Addis Ababa. The LSM approach focuses on the use of vegetation and soil in managing storm water.

The development of strategy and provision of policy recommendations are some of the expected output of the project. This LSM strategy for Jemo river catchment is the result a three year study on green infrastructure, storm water management system and planning and institutional aspects of storm water management in Addis Ababa.

Although this LSM strategy was specifically developed for the Jemo river catchment, the proposed LSM measures could easily be adapted for similar land uses of the other river catchments of the city. However, the research team suggests the development of similar strategy for the other river catchments of the city.

Since the proposed LSM measures focus on the development and use of green infrastructure, implementing these measures could increase the green space coverage of the city and improves the benefits obtained from the green spaces; thereby contributing to the implementation of the green space plan given by the city's master plan.

This landscape based storm water management strategy for Jemo river catchment has been prepared to provide strategic directions for the management of storm water using green infrastructure.

The Research Team

1. INTRODUCTION

1.1 Background

1.1.1 Landscape based storm water management (LSM)

Landscape based storm water management (LSM) is a storm water management strategy that seeks to mitigate the impacts of increased runoff and storm water pollution by managing runoff as close to its source as possible. It comprises a set of site design strategies that minimize runoff by disconnecting storm water generating surfaces from drainage lines and managing the storm water through the processes of infiltration, evapotranspiration, harvesting, and detention.

Since LSM measures are related to green infrastructure development and management, there are added benefits that the measures could provide. These include improvement of water supply, reduction in flood risk, production of vegetables and fruits, temperature regulation through shading and evaporative cooling, provision of space for recreation and other social and physical activity and generation of job opportunities.

To make a good design of landscape based storm water management a number of factors have to be taken into account, including rainfall patterns and catchment characteristics (land use, soil types, hydrology, slope, vegetation). In existing developed urban areas, conflicting land use interests present a challenge for implementing LSM. In new urban development areas however the conditions are better, because land can be allocated for water management when planning the new area.

1.1.2 Policy, plan, strategy related to LSM

The implementation of LSM measures requires appropriate policy, institutional arrangement and stakeholder involvement. In this section policy framework, plans, and regulations that have relevance to the implementation of storm water management are reviewed.

Federal level

The Federal Democratic Republic of Ethiopia (FDRE) constitution is the supreme binding legal and policy framework of any affairs in the country, which has given the power to enact laws for the utilization and conservation of land and other natural resources to the Federal Government.It also stipulates the power of Regional States, which is to administer land and other natural resources in accordance with Federal laws. Among the allocated powers and functions of the

Federal Government, is the determination and administration of the use of waters, rivers and lakes linking two or more regional states. Since Addis Ababa is physically located within Oromia Regional State, the Federal Constitution stipulated that the interest of Oromia Regional State is to be respected in regards to utilization of natural resources and provision of social services. However, full measure of self-government for residents of Addis Ababa is also given by the Constitution.

Ethiopian Water Resource Management policy is issued by the federal governmentwith the aim of enhancing and developing sustainable use of water resources for social and economic benefit.According to, the Ethiopian Water Resource Management Proclamation,the power and responsibility forplanning, management, utilization and protection of water resources as well as collection of water charges and issuance of permit for using water resources and for discharging treated water is vested upon the Ministry of Water, Irrigation and Energy Resources.
River Basin Councils and Authorities Proclamation, is issued to coordinate activities and create efficient mechanism for the implementation of the Ethiopian Water Resources Management Policy. Among the powers and duties of the Basin High Councils stated in this proclamation are to provide policy guidance, planning and oversee coordination of stakeholders in the implementation of integrated water resources management and to manage water use disputes between Regional States in the basins. Accordingly, the Awash Basin Authority, which includes the Addis Ababa area, is entitled to prepare basin plan and upon approval by the Awash Basin High Council to implement and to do monitoring.

The Environmental Policy of Ethiopia aims at ensuring sustainable use of resources. The Federal Environmental Protection Authority and Regional Environmental Agencies were established by proclamation no. 295/2002 in order to implement the federal environmental policy. The mandates of the Federal Environmental Protection Authority are to ensure environmental objectives of the constitution are met, to establish Environmental Impact Assessment system, environmental policies, laws, standards, educational programs and information system and to follow up of their compliance. The Regional Environmental Protection Agencies, on the other hand, are mainly mandated to formulate, implement and monitor regional conservation strategies in accordance to the federal frameworks. EIA proclamation and guideline is also issued, which

sets a pre-requist for screening of projects to EIA procedure that includes impacts on water systems and preparation of appropriate mitgation measures and environmental management plan in accordance of the results of EIA assessment. In general, these frameworks are supportive and could potentially be linked to the implementation of LSM, however enforcement based on the proclamations is weak that requires focus on strengthening the enforcement measures.

The Growth and Transformation Plan of Ethiopia envisioned at lifting the country to the level of middle income by 2025. To achieve this a pillar strategy of Building climate resilient green economy has been enacted.As this strategy is directly linked togreen development, it is thus supportive framework for the implementation of LSM. Therefore the implementation of LSM project could be linked with the implementation of climate resilient green economy strategy.

The Ministry of Urban Development and Housing provided strategies, standards, manuals related to green space development and management. Urban Development Policy iwas ssued with the objective to create habitable and role modelurban centers that consider environmenal protection and green infrastructure development. There is also a provision for regularization of informal settlement in the proclamation for those who are in conformity with urban plans and standards. The urban housing provision strategic framework provides policy statement for the development of green space and urban agriculture at plot level and at communal land.

The followings are different manuals prepared by the Ministry of Urban Development and Housing which have relevance for landscape based stormwater management.

1. Rivers and river buffer green infrastructure design standard implementation.
2. Cemetery Management
3. Development of Amenity Green Space in Residential Areas
4. Development of communal Housing Green spaces
5. Green Roof and Wall Establishment and Management
6. Urban green landscape manual
7. Institutional Compounds Green Infrastructure Development
8. Lakes and lake buffer green infrastructure development
9. Llocal development manual

10. Manual for Plaza and Holiday Celebration Area Management
11. Private Garden
12. Public Right-of-Way Management and Establishment
13. Recreational Parks Development and Management
14. Religious Compounds Green Infrastructure Development
15. Urban storm water drainage design manual

The Ethiopian National Urban Green Infrastructure standard provides the following standards with respect to stormwater management

- Storm water management should be combined in an efficient way to minimize the run-off and maximize the production of urban agriculture / horticulture.
- Storm water infiltration ditches, bio swales and rain gardens as storm water measures installed, could be of mutual benefit for the competent authority as well as for people engaged in urban agriculture / horticulture.
- The use of cisterns, ponds, collecting facilities for roof-top run-off
- Orders the use of public parks for effective storm water management and restrict enginered structures to bigger parks (sub-city and city parks)
- For rain water infiltration, a minimum of 12 % of a private residential plot area should be unsealed and covered with vegetation
- A minimum of 30% of the total area of an administrative and commercial compound should be open space and allocated for green space
- A minimum of 15% of the total land area of a manufacturing site should be allocated for green space
- Big factory building roofs may be transformed into ‘green roofs’ for cooling the buildings and to reduce storm water runoff.
- Competent authorities should provide systems to reduce storm water runoff from rooftops, paved areas, and lawns that carry plant debris, soil particles, and dissolved chemicals into the city’s sewage drainage system.
- Industrial site development plans should employ storm water management and engineering practices before releasing water into the city’s storm drainage system.

- Storm water shall not be released directly from industrial compound into the public storm drainage system without first going through a natural, landscaped rain garden, grass bio-swale or other natural feature to clean dirty water before it joins the natural waterway.
- The management of industries should make provisions to conserve water by utilizing alternative means such as water recycling or rainwater harvest.
- Competent authorities shall use natural and semi natural land for the city's storm water management system and enhance infiltration and groundwater recharge on such sites.
- Steep slopes of more than 30% should be exclusively allocated for trees and shrub planting
- Disturbed areas shall be replanted with native plants and plant species
- Terracing of steep slopes shall be considered to implement storm water management practices
- Urban agriculture should incorporate storm water infiltration ditches, bio swales and rain gardens as storm water measures

City level

The Addis Ababa City Council provided the Addis Ababa City Government Executive and Municipal Service Organs Reestablishment Proclmation No. 35, 2012. The duties and responsibilities of the city organs with respect to stormwater management is presented below.

The Addis Ababa Environmental Protection Authority (AAEPA) is generally mandated by the city proclamation to prepare environmental protection standards, design strategiues to protect the environment from pollutions and coordinate stakeholders with regards to environmental protection. The Authority has coordinated the preparation of climate change adapatation program of plan for Addis Ababa. Water has been considered as one of vulnerable sectors to the impacts of climate change. Implementation of catchment management and environmental development have been proposed as climate change adaptation measures. In this regard, the implementation of the LSM strategy of Jemo river catchment could contribute to local climate change adaptation.

The Addis Ababa Bureau of Construction and Housing Development, is mandated by to direct, coordinate and follow-up the City Government construction works and public participation and

mobilization. The construction of local drainage structure (e.g. for cobblestone streets) is coordinated by the Bureau. The Bureau has been coordinating and co-financing neighborhood conventional storm water management structures. It is thus important to include green space development and LSM as part of the nieghborhood development projects.

Bureau of Land Development and Management is mandated to coordinate and integrate land development, construction and urban planning preparation. It is also mandated to provide support for the organization of publc participation at areas of the city to create society based land and city development. Urban Plan Institute is mandated to prepare stucture plan, environmental development plan of the city and city plan standards.

Addis Ababa City Road Authority (AACRA),which is accountable to the Road and Transport Bureau, is mandated by the City Government to construct roadside drainage and protection of roads from flooding and identifying and determining type and size of roadside trees to be planted and designation of adequate green area during road construction.AACRA's role in street greening is important for the implementation of LSM, therefore the Authority need to adopt swales and other type of LSM measures for storm water management

Addis Ababa Water and Sewerage Authority is responsible for studying water sources, preparing water master plan, develop water supply and sewerage management projects, and administer water supply. A master plan for the rehabilitation and awareness creation for Gefersa, Legedadi and Dire river catchment areas is prepared by AAWSA, in order to protect the catchment and the dams from erosion and siltation.

The Beautification, Parks and Cemetery Development and Administration Agency is responsible for the development and administration of public green spaces, plaza and cmeteries. The agency usually involves private sectors in developing roadside greens and in turn the private sectors are granted rights for advertising their products and services. This arrangement has helped many roadside greens to be developed.

Fire and Emergency Prevention and Rescue Authority is responsible for the prevention and rescue of fire, flood and other disasters. The authority provides disaster control regulation and standard, devise strategies, gathering information and providing training on emergency prevention and preparedness.

The Addis Ababa River, River Sides and Climate Change Porject office is mandated to create clean, green and recreational river buffers by clearing them from construction and pollution; develop and coordinate climate change adaptation and mitigation projects.

1.1.3Storm water management in Addis Ababa

Addis Ababa is located in the upper part of the Awash River basin and in the Akaki catchment. The Akaki catchment is divided into two sub-catchments: Little Akaki and Big Akaki river sub-catchments. Kebena, Little Akaki, Big Akaki, Bantiyketu, Bulbula, Kechene, Jemo, Tafo, Hanqu are the major rivers that flow through the city.

Addis Ababa has only few formal drainage systems installed. Most storm water runs off on the surface by gravity to low-lying areas and into streams and rivers. The main formal provider of urban drainage infrastructure in the city is the Addis Ababa City Roads Authority (AACRA). Urban drainage is a requirement in the design and construction of roads. Hence roadside ditches or underground concrete pipes are installed along main roads. However, the design of roadside drains does not consider the respective hydrologic catchment of each drain. The increasing surface sealing resulting from urban development is generating more surface runoff, resulting in flash flood in the different part of the city and river flooding in the downstream parts of the river catchment.51% mud and wood houses, 34% of villa and single storey houses and 15% of condominium houses of Addis Ababa are located in flood prone areas (Jalayer et al. 2014).Current efforts to mitigate flooding include flood control structure, physical soil conservation measures and reforestation on Entoto Mountain and the provision of drainage ditches and embankment along rivers or streams. With a current built up area of approximately 290 km^2, the storm water volume is estimated to be in the range of 275 million m^3 per year. Removing this much amount of storm runoff is practically difficult using conventional drainage system. However, using the landscape for infiltration, harvesting, retention and evapotranspiration, this storm water could be potentially utilized as part of the city's future water supply.

1.2 OBJECTIVES

The objectives of the landscape based storm water management strategy for Jemo river catchment are:

1. To reduce flood risk through rain water harvest, infiltration, retention, detention and evapotranspiration
2. To reduce the amount of storm water runoff released from development to the public drainage network and waterways
3. To improve local water supply through storm water harvesting
4. To encourage storm water management measures which can integrate into the landscape so as improve the visual amenity, aid local temperature regulation, and enhance public space quality.
5. To integrate storm water management with household and community livelihood

2. METHODOLOGY

The following data were collected for the development of landscape based storm water management for Jemo river catchment using the methodologies listed below.

2.1 Baseline data collection

Baseline data related to the biophysical features, socioeconomic situation and water related challenges were collected from documents, field observation, discussion with local communities and city officials and experts.

2.2 Design charrette

A community design charrette was conducted at one of the project site in Jemo1 Biruh Tesfa condominium. Residents, condominium committee and block sub-committee members got together for a 3 day (26-28 June 2015) activity for identifying local problems. With this method, problems related to water shortage, flooding, development of green and open spaces have been identified. Planning solutions for managing storm water at the condominium site for reducing flooding and providing water supply and implementation mechanism of the proposed solutions were provided.

2.3 1:1 test

Based on the output of the design charrette, 1:1 pilot projects of bio-retention system and low-cost storm water filtration technology were tested at the open space of Jemo BiruhTesfa condominium. Infiltration trench with tree pit were tested on local cobblestone street of Repi hill.

2.4 Document review

Various federal and city level policies, plans and strategies and institutional arrangements that have relevance to storm water management were reviewed.

2.5 Questioner survey, interview, focus group discussion

Household and community livelihood activities derived from green space and water space; problem of water shortage and flooding, local coping mechanisms to water shortage and flooding were collected from Jemo Biruh Tesfa condominium, Repi Hill and Mekanissa-Gofa vegetable producer association.

2.6 Stakeholder consultation

City and local level stakeholder consultations were done to select river catchment for the LSM study, to identify champions, learn current green space and storm water management initiatives and get comments and feedback on draft LSM strategy.

3. DESCRIPTION OF THE JEMO RIVER CATCHMENT AND THE NEED FOR LSM INTERVENTION

3.1 Biophysical description

The Jemo River catchment (Fig. 1)is part of the Little Akaki River catchment covering an area of 2858 hectares, covering about 5.5% of Addis Ababa. The catchment starts from the rural Oromia region in the Northwest and extends to the Southeast through the areas of Alem Bank, Ayer Tena, Repi Hill, the Jemo condominium site until it merges with Harbu River in Lebu area of Nefas Silk-Lafto sub-city.

Fig.1 Jemo River catchment (Illustration by Ole Fryd).

The Jemo River catchment is characterized by high and steep hills in the rural upstream part of the catchment, Repi Hill as a geographical landmark located mid-stream in the catchment and the flatter wetland areas south of Repi Hill, around the Jemo condominium area. The main river course is located centrally in the catchment generally creating a V-shaped terrain profile. The river and its major tributaries provide the core blue-green corridors in the catchment. Green spaces are generally sparse, dispersed and under pressure by urban land use change.

The upper soil layers in most parts of the catchment are dominated by clay soil. Infiltration is generally problematic in the catchment due to low soil permeability. To facilitate infiltration under this condition, one option is to work with deep gravel-filled trenches that cut across existing soil fractures and create better contact between water and soil.

The catchment has been intensively transformed in the last two decades due to infrastructure development (mainly the construction of the ring road connecting it to the rest of the city),expansion of the city's high income housing and public housing projects and the expansion and proliferation of informal settlements. Ongoing urbanization puts pressure on the existing

green spaces with potential further encroachment on river buffer zones and currently undeveloped land.

3.2 Land use

The existing land use in the Jemo River catchment is made up of 22 different categories. Residential land use constitutes 35.6% of the catchment, open spaces 20.5%, road 16.7%, urban agriculture 7.7% and green space 3.7%.

Residential settlements include informal housing on the foothill and mid slope of Repi hill; formal and planned settlements which include plot based private development in Alem Bank area, and condominium public housing development in Jemo area. There is lack of communal open spaces in informal settlements whereas condominium and planned private settlements do possess open spaces.

Green spaces in the area include plantation forest (mostly Eucalyptus), riverine vegetation, vegetable farm, field crop and recreational parks.

Asphalt, cobblestone, gravel, and unpaved roads are found in the catchment. The informal settlements are provided with cobblestone, gravel and unpaved roads. Formal settlements are largely provided with asphalt and cobblestone roads.

3.3 Water related challenges

Expansion of settlement in the Jemo river catchment is creating challenge on water supply and storm water management infrastructure systems. Residents and industries in the catchment get water supply from Akaki deep well and Gefersa reservoir. Formal settlements get water supply from individual municipal pipelines. In informal settlements, water is collected from communal water tank supplied by Addis Ababa Water and Sewerage Authority. Generally water scarcity is common in all parts of the catchment. In most cases, water is only available for few days in a week. In some cases, residents have to fetch water from distant areas using donkeys and cars.

Due to the increase in asphalt roads and buildings and poor waste management in the Jemo river catchment, an increasing amount of storm water is being generated. The existing drainage lines in the catchment are not able to accommodate the storm water thereby resulting in flash flood. It is common to see residential areas and roads flooded during the rainy season (June to September). The damage to roads is quite significant where the city's road construction authority has to invest

million of birr each year to maintain the damaged roads after the rainy season ends. Alem Bank, Ayer Tena, China camp on the foot hill of Repi hill, and the Ayer Tena- German roundabout segment of the western ring road are areas commonly affected by flash flood.

The lower part of the Jemo river catchment between German roundabout and the site where Jemo River joins Harbu River gets flooded from river flooding during the rainy season. The release of storm water from drainage pipes to streams has caused the latter to increase in volume, resulting in flooding.

The investment for water supply and drainage infrastructure is very expensive and usually takes a significant amount of the municipal budget. In fast growing city like Addis Ababa, the provision of basic infrastructure is not catching up the urban development. A paradigm shift is thus needed in the urban management approach. One alternative approach for dealing with urban storm water is landscape based storm water management, also called low-impact development.

4. PROPOSED LSM MEASURES

Since the Jemo River catchment is urbanized, the recommended approach to improved water resilience is to develop schemes for the different types of land uses, where roads, buildings and green areas are retrofitted according to the density, topography and water quality conditions. Further, landscape based storm water management is expected to help achieving green infrastructure development goals outlined in the master plan of the city through better integration of blue and green infrastructures .

A retrofit LSM strategy for the Jemo River catchments is presented in Figure 2. The strategy suggests a number of retrofitting options that jointly will return a number of benefits.

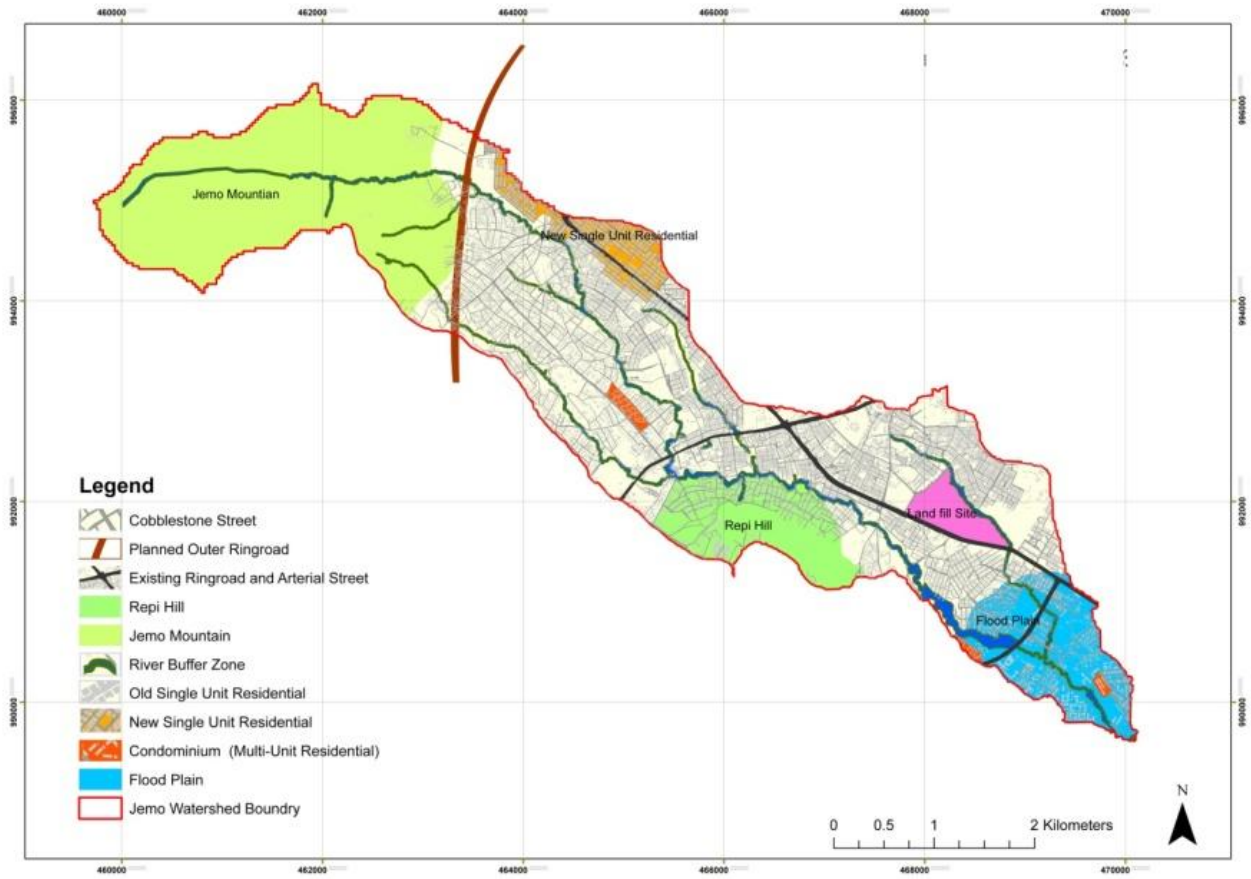

Fig.2. Layered retrofit approach for the Jemo River catchment

The catchment strategy comprises eleven sub-strategies (Table 1). Some of the sub-strategies are expected to be relatively simple to implement due to a low level of technical and social complexity.

Table 1.Jemo river catchment LSM layers

1	Jemo mountain
2	River buffer zone
3	Flood plain
4	Condominium residential
5	New single family residential
6	Old single family residential
7	Primary arterial road

8	Primary Arterial Street
9	Cobblestone street
10	Planned outer ring road
11	Repi Hill

4.1 Jemo Mountain

4.1.1 Description

The upper part of the Jemo river catchment is formed by Jemo Mountain which is partly found in the Addis Ababa city administration and most part in the Oromia Regional state (Fig. 3). The land use of the upper Jemo river catchment is dominated by field crop agriculture (Fig. 4). Bread wheat (*Triticum aesthivum*), barely (*Hordeum vulgare*), Teff (*Eragrostis tef*) , faba bean (*Vicia faba*), pea (*Pisum sativum*) are the crops usually cultivated. Cultivation of these crops starts in June when the rainy season starts and the crops are harvested in November/December. The landscape remains bare during the dry season (December to June).Small patches of Eucalyptus plantation and scattered rural settlement are seen on the agricultural matrix of Jemo Mountain. A small patch of *Juniperus procera* plantation forest is seen on Jemo Mountain within the Addis Ababa city boundary.

Fig. 3 Google Earth image of the Jemo Mountain In Oromia and Addis Ababa

Most areas of the Jemo Mountain have slope between 5 and 15%, followed by areas with slope between 15-25% and small areas have slope above 25%.Although the steep slope and hilly conditions of Jemo Mountain is not good for agricultural activity, more than 90% of the mountain is being cultivated. Until the cultivated crops cover the mountain, high runoff washes the topsoil of the mountain resulting in non point pollution of the Jemo River. Therefore, the agricultural landscape of Jemo Mountain requires the implementation of landscape based stormwater management, not only for reducing stomwater runoff generated from the mountain, but to improve agricultural productivity and enhance community livelihood too. Therefore, the following LSM measures are recommended for Jemo mountain.

Fig. 4 Field crops on Jemo mountain

4.1.2 Proposed LSM measures

1. Afforestation of steep slopes

The Addis Ababa city master plan proposes the development of multifunctional forest on mountains. Since the current agricultural land use of Jemo Mountain has aggravated stormwater runoff, one of the proposed LSM strategy is to afforestate the mountain in such a way that both conservation forestry, agroforestry and plantation forestry could be practiced. Conservation forestry could be developed on steep slopes, agroforestry and plantation forestry on the mountain top. The incorporation of high value fruit trees are recommended in the agroforestry practice.

2 Stormwater interceptor swale-dyke systems

Stormwater interceptor swales and dykes are stormwater conveyance channels constructed to control the flow path of runoff for slope protection. Earth dyke typically consists of a horizontal ridge of soil placed perpendicular to the slope and angled slightly to provide drainage along the contour. The dike is used in conjunction with a swale to convey the diverted water.In the moderate slope cultivated crop area of the Jemo Mountain, stormwater interceptor swale-dyke system is recommended for collecting runoff from slope and directing it to a stabilized outlet thereby preventing erosion on slopes.

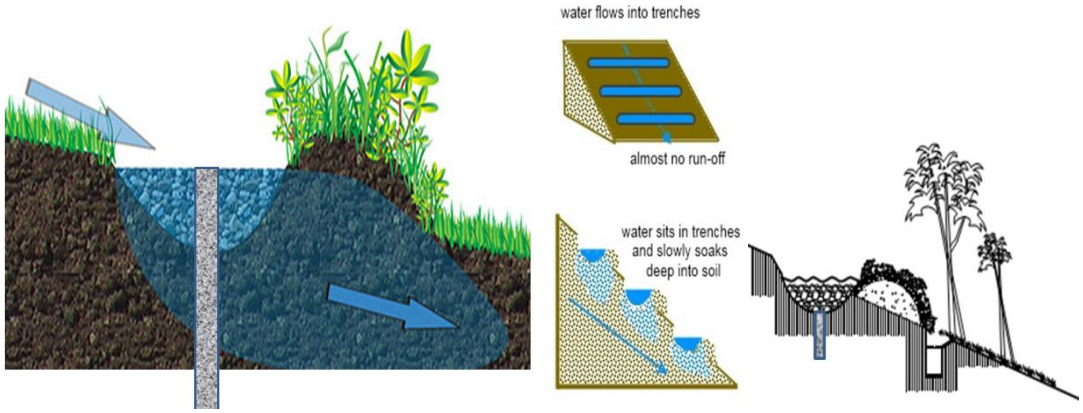

Fig.5 Stormwater Interceptor Swale and Dyke

3 Bench Terraces

In the high slope area of Jemo Mountain where agroforestry could be implemented, creating bench terrace and cropping along contour is proposed. Physical barriers (stone bunds, live hedges) should be created along the contours to retain rain water and make it infiltrate into the soil and to minimize soil erosion.

Fig. 6 Bench terrace

4.1.3 Synergies

In addition to reducing flooding, implementing the above LSM measures would provide the following synergies. Aforestation enhances biodiversity conservation, provides wood for construction and fuel, and provides oppourtunity for bee keeping activity. The proposed agroforestry system is expected to improve crop productivity, provide fruits for household consumption and market.

4.2JemoRiver buffer zones

4.2.1 Description

A river buffer zone is an area lying between a river and its neighboring land use/land cover. Designation of river buffer zone composed of strips of vegetation is usually applied to reduce human impact on river ecosystem and thereby maintain river water quality and ecological functions. Buffers are effective in removing pollutants and sediments coming from neighboring land uses, improving river water quality, providing habitats for wildlife, providing space for recreation and improving landscape aesthetics. River buffers could also be used to address the socio-economic needs of urban residents.

The previous master plan of Addis Ababa designated an arbitrary river buffer of 30 m on city centers and 100 m on the expansion areas. Because of weak enforcement of the master plan and disarray of institutional arrangement, the designated buffer zone has not been implemented, resulting in massive occupation of the buffer with settlement, industry and being used as site for disposal of waste. The 2017 revised master plan provided a 50 m buffer area throughout the city's river.

Jemo River doesn't have a buffer for most of its length. Based on a 50 m buffer width (Fig. 7), 14 land uses, occupying an area of 204 ha, have been identified on the Jemo river buffer zone (Table 2). Bareland and residential land uses are the two dominant land uses in the Jemo river buffer zone occupying 23.5% and 22.4% of the river buffer area respectively. The residential land use is found throughout the buffer area, except in the upper and lower parts of Jemo river. The residential units on the river buffer are mostly made from mud and wood.

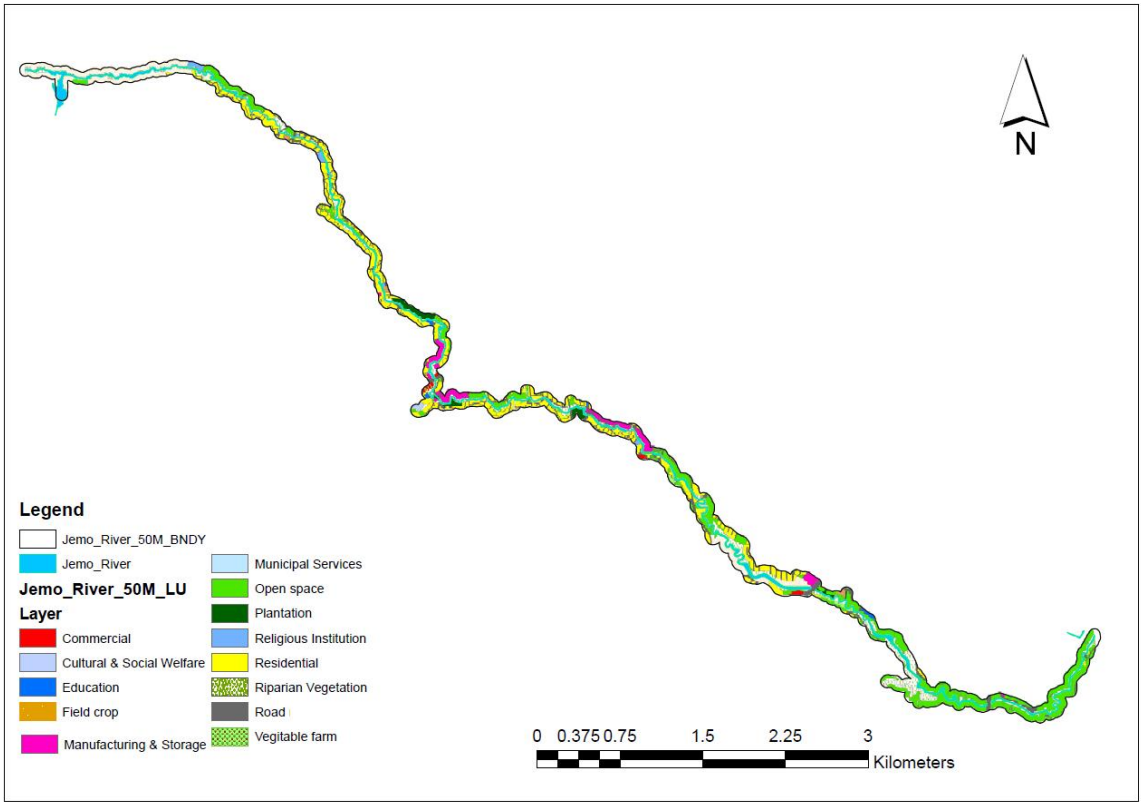

Fig. 7 Land use of the Jemo River buffer zone

Table 2 : Land use types and their area in the Jemo River buffer

Land use	**Area (Ha)**	**Area coverage in %**
Commercial	1.15	0.65
Cultural & Social Welfare	0.6	0.34
Education	0.93	0.52
Field crop	20.8	11.73
Manufacturing & Storage	8.01	4.52
Municipal Services	0.73	0.41
Bare land	47.95	27.05
Plantation forest	4.1	2.31
Religious institution	1.52	0.86
Residential	47.46	26.77
Riparian vegetation	23.9	13.48
Road	18.76	10.58
Vegetable farm	1.37	0.77
Total	**177.3**	**100**

About 55% of the buffer zone is occupied by evapotranspiring surfaces (bareland, field crop, plantation forest, and riparian vegetation) of which bareland covers 49%, riparian vegetation 24% and field crop 21% of the evapotranspiring surfaces.

The upper part of the Jemo river buffer which is found outside the Addis Ababa city boundary is occupied by riverine vegetation and during the rainy season, field crop (barely, wheat, bean and pea) cultivation goes up to the edge of the river.

The riparian vegetation of Jemo river buffer zone is composed of trees, shrubs, and herbs that are found on the river bank. Around 200 plant species were recorded based on field inventory from the 50 m buffer area of Jemo river. The dominant plants along Jemo river buffer zone is presented in Table 3.

Fig.8 Land use/land cover along Jemo river buffer (a) open space, (b) settelement, (c) riparian vegetation (d) wheat cultivation

Table 3 Dominant plant species in Jemo river buffer zone

No.	Species	**Habit**	**Abundance (%)**
1	*Eucalyptus globulus*	Tree	81.1
2	*Ricinus communis*	Shrub	75.7
3	*Vernonia amygdalina*	Tree	70.3
4	*Achyranthes aspera*	Herb	56.8
5	*Rumex nepalensis*	Herb	43.2
6	*Bidens pilosa*	Herb	40.5
7	*Bidens prestinaria*	Herb	40.5
8	*Grevillea robusta*	Tree	40.5
9	*Cynodon dactylon*	Grass	37.8
10	*Croton macrostachyus*	Tree	35.1
11	*Acacia mearnsii*	Tree	32.4
12	*Acacia negrii*	Tree	32.4
13	*Justicia schimperiana*	Shrub	32.4
14	*Persicaria senegalensis*	Herb	32.4
15	*Plectranthus punctatus*	Shrub	32.4
16	*Arundo donax*	Reed	29.7
17	*Cucurbita pepo*	Herb	29.7
18	*Buddleja davidii*	Shrub	27
19	*Galinsoga sp.*	Herb	27
20	*Rumex abyssinicus*	Herb	27

Slope

About 66% of the Jemo river buffer zone slope is flat and smoothly rooling (Table 4) and are found in the lower part of the river (Fig. 9). Slope of 8-20 is found in the middle part and slope of >20% on the upper part of Jemo river.

Table 4 Proportion of Jemo river buffer zone by slope class

Slope	Area (ha)	% area
0-3% (flat)	64.1	33
3-8% (smoothly rolling)	64.9	33
8-20% (rolling)	47.8	25
>20% (hilly)	17.2	9

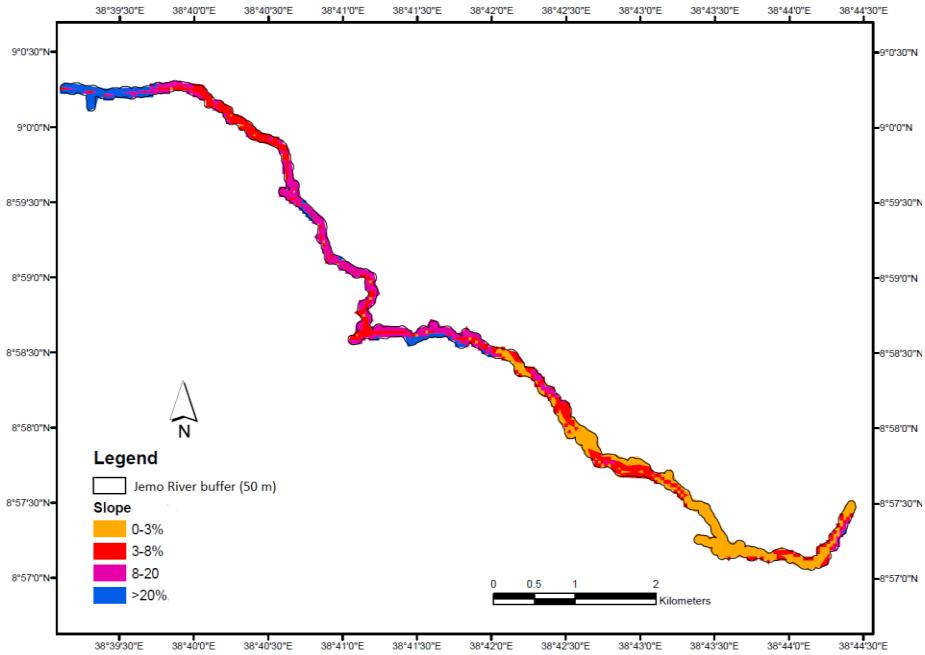

Fig. 9 Slope classes on Jemo rive rbuffer zone

For proposing LSM strategies, the 50 m buffer zone delineation proposed by the city's revised master plan of 2017 is considered. While the newly established River and Riverside project office might consider relocating the existing settlement and industries on the city's river buffer, the implementation of this could take several years. Since the Jemo River buffer is less inhabited compared to river buffers in the city center, the proposed LSM measures consider that all the river buffer area of at least 30 m width would be free of settlement and other built up structures.

4.2.2 Proposed LSM measures

1. Vegetating river buffer with trees and shrubs

Effective stormwater management strategy for river zones involve the establishment of vegetative buffer. To provide land for water retention and wastewater treatment, to serve as ecological corridor and flood protection zone, and to provide public recreational service establishment of vegetative river buffer is an important strategy. The river buffer areas with slope above 8% (upper and middle part of the Jemo river) are recommended for establishing vegetative buffer with perennial plants (trees and shrubs). In the upper part of the Jemo River catchment where field crop farmng is being practiced (Fig. 10), a stripe of perennial vegetation is recommended between the river water and the farmland.

Fig. 10 A riparian buffer between cropland and a river

Eucalyptus plantations are found in some places on the upper Jemo river buffer zone (Fig. 11). Since the plantation of eucalyptus in Addis Ababa is for commercial purpose, regular cutting of eucalyptus trees could reduce the stormwater management capacity of the river buffer and thereby increasing stormwater discharge to the river body. Therefore, the existing Eucalyptus tree plantation on the upper Jemo river buffer zone should be replaced by indigenous trees.

Fig. 11 Eucalyptus plantation on Jemo riverbank (Alem Bank area)

2. Establishment of recreational park and vegetable farm

In the flat and smoothly rolling buffer area of Jemo River, vegetable farm and recreational park development is recommended. Recreational park with lawn and shade trees is recommended on the Jemo river buffer at the Jemo condominium area. The open spaces around the streams draining to Jemo river are recommended for the development of vegetable farms.

3 Check-dam

To minimize direct discharge from stream to river and thus control fluvial flood, construction of check dam at tributaries and gullies based on hydrological standards is recommended. The water retained in the checkdam could be used for irrigating vegetables farms.

4.2.3 Synergies

By implementing the above recommended LSM measures, the following added benefits are expected (Table 5)

Table 5 Proposed LSM measures and synergy for the river buffer zone

No.	LSM measure	Synergy
1	Vegetating river buffer with perennial and annual plants	• River bank stabilization • Carbon sequestration • Recreation • Aesthetics • Biodiversity support
2	Establishment of recreational park and vegetable farm	• Provision of space for recreation • Vegetables and fruits
3	Check-dam with infiltration well	• Provision of water for irrigating vegetable farm

4.3 Floodplain

4.3.1 Description

River flood plains are part of river buffer where the water table reaches the surface. Floodplains provide a natural surface for storm water management by retaining water and reducing the speed of water.

Flood plain in the Jemo river catchment is found in the lower part of the catchment before the river joins Harbu River. Grass and other herbaceous vegetation are the dominant surface cover of the floodplain. The flood plain is being used for grazing land during the dry season.

4.3.2 Proposed LSM measure

1. Floodplain conservation. The existing evapotranspiring land cover of the Jemo river floodplain should be maintained in order to enhance the storm water management function of floodplains and urban development on floodplain should be restricted.

2. Retention pond. Retention pond could be established on floodplain close to the river to retain excess storm water that is release from the floodplain

4.3.3. Synergy

Livestock grazing could take place on the floodplain. The retained water in the retention pond could be used for livestock watering.

4.4 Jemo condominium

4.4.1 Description

Due to increasing urban population and dilapidation of existing houses, especially in the central business district areas, the Addis Ababa city administration launched the so called "grand ,housing program" in 2004. Since then, more than 175,249 housing units have been constructed and transferred to the beneficiaries. At present, additional 130 000 housing units are being constructed in different parts of the city.

The Jemo condominiums are part of this large scale mass housing project, which were inaugurated in 2010. The Jemo condominium site is found in the southwestern part of the city and contains three sites: Jemo 1, Jemo 2 and Jemo 3. In total, 17334 housing units have been constructed and transferred to beneficiaries in the three sites, the largest being at Jemo 1 with 9800 housing units. In addition to condominium houses, multi story commercial buildings have been built along the main road linking the three condominium sites.

Water supply

Providing water to the city's ever increasing population at the required amount and quality has always been one of the most critical problems of Addis. This problem of water supply is highly

felt by condominium residents due to, among many other factors, their location at the periphery of the city. For instance, in Jemo condominium area, residents have reported that they get water only twice a week and in most cases at night causing them many sleepless nights. Residents in the third and fourth floors suffer more than the others due to the fact that the water lacks enough pressure to be pumped up. Due to such shortage, residents have to pay up to Birr 12 to buy and bring a jerry can of water (20 liter capacity). The public water charge is 50 cents for a cubic meter of water.

The Jemo condominiums were built on the floodplains of Jemo and Harbu rivers which were reserved for flood regulation and green space development in the 2003 master plan of the city. However, due to the housing shortage in the city, the city administration decided to construct condominium houses on the site. Towards the mouth of Jemo river where it joins the Harbu river, the water usually comes to the surface during the rainy season, causing flooding in the surroundings.

Thecondominium housing sites have ample open spaces within and surrounding the different blocks which could be used for green space development and stormwater management.

4.4.2 Proposed LSM measures for Jemo condominium

Based on information collected from the Jemo Biruh Tesfa condominium (Jemo 1, blocks 24-24), the following five LSM measures are proposed. It is assumed that these LSM measures could also be implemented in other condominium sites in Jemo or other sites in Addis Ababa.

1. **Rooftop rain water harvesting**

   Rain water harvesting from roofs is proposed using both underground and above ground storage tanks. Cisterns (larger roof rainwater harvesting reservoirs) made from reinforced concrete pipes (each with 448 m^3storage capacity) are proposed for the underground option. A total of 6 underground citrines have been proposed with a total storage volume of 1536 m3.

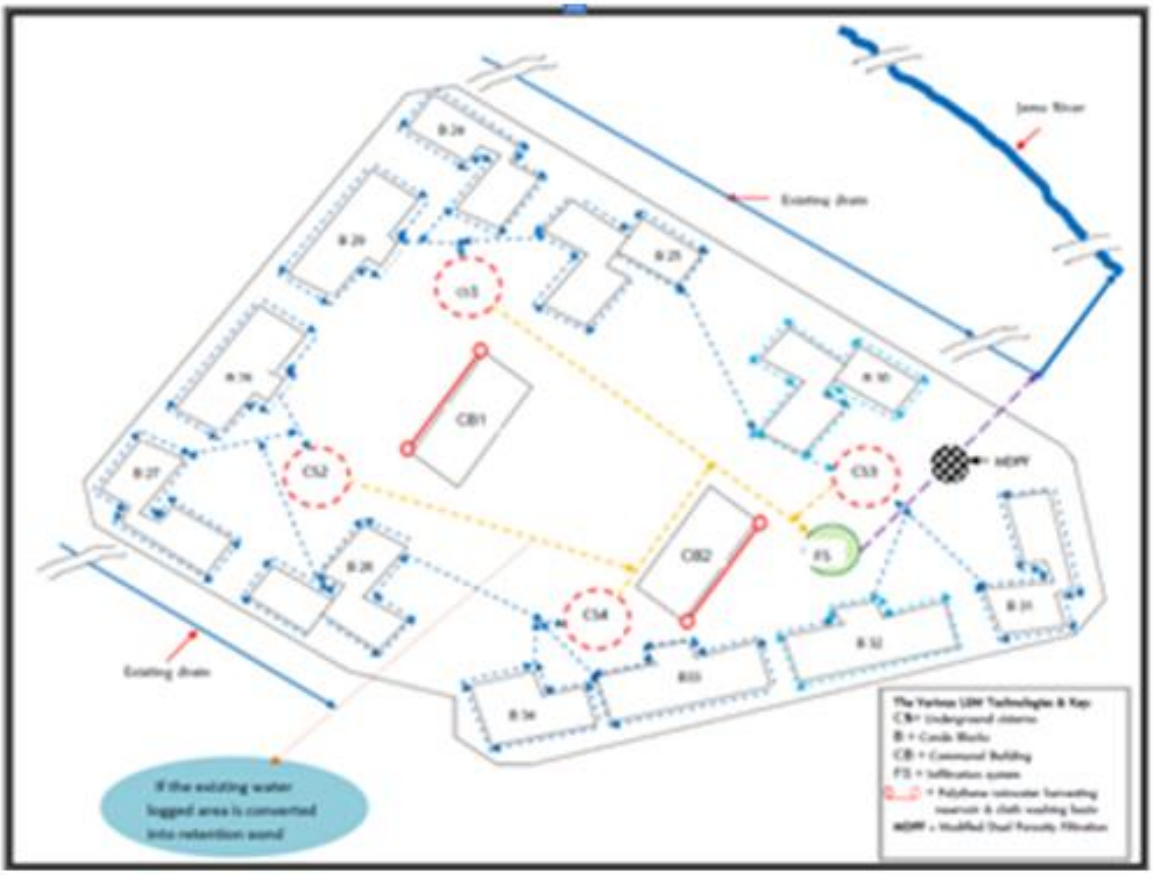

Fig. 12 Proposed water harvesting structures at Jemo Biruh Tesfa condominium

For the above ground, one polythene tanks, each 5 m^3 capacity are proposed for each condominium blocks. The existing downpipes will be modified to fit into the storage tanks. For harvesting rain water from the two communal buildings, four polythene tanks, each with $25m^3$ storage capacity could be installed.

Detention pond: The existing water logged areas at the condominium site could be modified into detention pond, so that excess storm water could be detained. This pond is located at the north east corner of the site. At the edge of the detention pond, fruit trees could be planted that could provide fruits and shading service for residents.

Fig. 13 Stormwater detention area (arrow)

2. **Vegetable farm development**

Development of vegetable farm in the north-eastern part of condominium, on the back yard of blocks 27-29 could be used for stormwater infiltraion and evapotranspiration.

Fig. 14 Layout plan of proposed agricultural field

3. **Grass space and playgrounddevelopment**

   To facilitate stormwater infiltration, the existing parking and drivethroughspacescould be converted into grass covered playing field.The pockets of green space in front of condominium blocks should be properly managed for stormwater infiltration.

Fig. 15. 3D illustration of proposed children playfield

4. **Tree plantation.**For enhancing evapotranspiration,plantation of trees with broader crown shape along walkways, boundaries of green space and condominium blocks is recommended. It is recommended that at least 50% trees should be fruit trees.

4.4.3 Synergy

Implementing the different LSM measures at the condominium site could provide the following added advantages

1. Improving water supply

Rooftop rainwater harvesting using the underground cisterns substantially supplment water supply. With an estimated per capita water demand of 60 liter and the assumption that rain water harvest would contribute to 50% of the daily water demand, then the water harvested in the six citrines would potentially serve the Jemo 1 Biruh Tesfa community of around 1264 persons for 110 days. The experts' assumption is that such water is to be used by residents during the first three to four months after the end of the rainy season. The polyethene tanks on the communal

buildings could be used as temporary storage for tap water until the short rainfall in February-March starts, which will then be used for rainwater storage again.

The proposed 11 above-ground storage tanks on the back sides of the condominium blocks would store 7985 m^3 of rain water.The stormwater which will be harvested daily from each rooftop during the rainy season wcould supplement 50% of the domestic water demand for 145 days. The above ground reservoirs on the communal condominium buildings shall have dual purpose to reserve potable water that is supplied at night time.

2. 2. Provision of space for play ground and recreation

The proposed detention pond could be used for recreation and social activities during dry time. The proposed stormwater infiltration area could be used as play ground for children during the day time and for car parking during night time.

3. 3. Provision of food

The development of vegetable farm on the back yard of blocks 27-29 would provide vegetables and fruits for the condominium community. The furit trees on the detention pond, sides of walwaysand play groundcould provide fruits.

4. Shade provision

Tree plantation along walkways, boundaries of lawns and condominium blocks would provide local temperature regulation by shading and evaporative cooling.

4.5 New single family residential area

4.5 1 Description

As part of city development and expansion strategy as proposed by the 2002-2012 Master Plan, new residential areas have been developed in the expansion areas of the city. In the Jemo river catchment, such residential areas are found in the Alem Bank area(see Fig. 2).

The new private residential areas are characterized by low rise (1-3 storey) single occupancy private house with plot size ranging from 72 to 175 m^2. The blocks as well as the plots are regular and most buildings have been developed using a standard design provided by the government. Although 19-42% of the individual plots are open, most of these have been sealed

with concrete tiles. Since the settlement developed formally,communal open spaces were incorporated from the outset (Table 6).

Table 6Built up and open space area in one of the new single family residential area

Plot size (m^2)	**Area of building (m^2)**	**Open space (m^2)**
72	58.49	13.51
80	60.39	19.61
84	48.52	35.48
105	76.10	29.90
110	78.97	31.03
120	84.81	35.19
130	85.43	44.57
140	94.65	45.35
150	99.00	51.00
165	111.68	53.65
170	111.35	58.65

Table 7Built up and open space coverage in three sites in the new single family residential area

Name of Sample sites	Block area (m2)	Built up area (m2)	Open space (m2)
New residential area 1	75757.4	26921.3	48836.1
New residential area 2	71218.9	38953.2	32265.7
New residential area 3	62944.9	31029.4	31915.6

Morphological transformation is clearly visible in the area. Most of the households in the area have started as one story units. Yet, with time, some households have sold their houses and moved out and new comers are developing multi story buildings in place of the original one story houses.

Fig. 16 Single story and three story buildings side by side (Alpha school area)

- **Water shortage:** water shortage is a major problemthough people are relatively well off and have their own water containers to hold water during scarcity

4.5.2 Proposed LSM measures for new single family residential areas

In the case of new single family residential areas, LSM interventions which could be implemented at individual plot (household) and block level.

Household level LSM intervention

The potential LSM intervention types at household level in these areas are

1. **Rain Barrel:**Rain barrel is retention devices placed below roof downspouts to collect water during storms. Using rain barrel, rain water could be harvested from roof for non potable use.
2. **Rain garden**: Up to59 m^2 of the individual plots in the new private residential areas are open spaces. Schools, and health centers in the new private residential areas have also considerable open spaces. Part of this space could be used for developing rain garden so that runoff from roof and sealed ground surface could be directed to it for detaining and infiltrating.
3. **Pemeable pavement:** Replacing the concrete tiles at individual plots with permeable pavement could enhance stormwater infiltration.Institutions in the new single family residential areas (schools, health centers, etc) that own large plots, are advised to use pervious pavement for car parking.

Block level LSM intervention

4. Green space development

The block level LSM interventions in new single family residential areasuse communal open spaces. There are a number of small open spaces distributed between blocks. Most of these spaces have been developed in to green spaces. It is recommended to incorporate stormwater detention pondwithin or around the green spaces for detaining stormwater.

Fig. 17 Green space in one of the new single family residential area

5. Connect road bumps with infiltration tree pits

Most of the inner roads in the new single family residential areas are made from cobblestone. Bumpers to limit vehicular speed are constructed on some of the cobblestone roads.Road bumpers could be combined with infiltration tree pit. The trench is dug on the sides of the bumper, filled with gravel, and topped with soil and planted trees. Storm water runoff from the cobblestone surface flows through a storm drain along the bumper into the storm water tree pit. Planted trees absorb some of the storm water through their root system. The remaining storm water will be stored in the spaces of the gravel and then slowly infiltrate through the bottom.

6. Dry pond

Stormwater conveyed through gutter placed along cobblestone roads could be discossnedted from drainage channel and captured in dry pond established within community green spaces.

Fig. 18 Gutter around public green space for runoff removal (left) and illustration of proposed dry pond for runoff detention (right)

4.5.3 Synergy

Implementing the different LSM measures at the new private development area, in addition to reducing stormwater runoff, could provide the following added advantages.

- *Improving water supply*. The rainwater harvesting measure could provide additional water supply during and after the rainy time. The harvested water could be used for watering garden plants and other non potable uses.
- *Provision of food and medicinal plants*. Rain gardens could provide vegetables, fruits and herbs for traditional medicine.
- *Aesthetics.* Rain gardens and communal green spaces could support ornamental plants that improve the asthetics of individual plots and neghiborhood.
- Tree plantation along cobblestone roads provide shade for pedestrians, cars and nearby houses.
- Communal green spaces could provide recreational and social services as well as play ground for children.

4.6 Old single familyresidential area

4.6.1 Description

Older single family residential areas are located on the South-western side of Jemo River. Residents of the area acquired land in two ways. The first settlers in the area had to buy land directly from farmers and peasant associations owning the area. Since this land was considered

rural with no condition attached to the maximum plot size, some of the old residents had the chance to buy big plots of land (500m^2-2000m^2 or more)

With the consolidation of the settlement, and the decline of land in the hands of farmers, the next group of migrants depended on land that was sold by the first settlers. What happened was then the re-parcelation of existing plots since those who had big plots of land had the option to divide their plots and sell some of it. Gradually, public services and infrastructure became available despite the fact that the settlement is still informal and land ownership illegal.

Table 7 Open space coverage in three sites in the old single family residential area

Sample site	Block Name	size of Block (m^2)	Area of buildings (m^2)	Open space within blocks (m^2)
Old single family residential_1	OLD1_00	6037.01	2006.73	4030.28
	OLD1_01	4696.20	2122.79	2573.41
	OLD1_02	10380.52	4171.51	6209.01
	OLD1_03	15050.48	5539.66	9510.82
	OLD1_04	5431.58	2517.67	2913.91
	OLD1_05	3960.78	1361.23	2599.55
	OLD1_06	3424.61	997.32	2427.29
	OLD1_07	3486.68	1328.44	2158.24
	OLD1_08	11925.44	3044.86	8880.58
	OLD1_09	11364.07	3831.05	7533.02
Old single family residential_2	OLD2_00	9114.79	2915.90	6198.89
	OLD2_01	2574.46	874.47	1699.99
	OLD2_02	11336.83	4090.17	7246.66
	OLD2_03	29832.89	8413.88	21419.01
	OLD2_04	13111.44	3711.96	9399.48
	OLD2_05	7719.96	2479.89	5240.07
	OLD2_06	7308.22	1500.72	5807.5
	OLD2_07	5960.80	1826.22	4134.58
	OLD2_08	5268.31	1457.46	3810.85
	OLD2_09	3961.00	1127.82	2833.18

In order to legalize some of the older informal settelements, the city government of Addis Ababa enacted regulations 80 and 81/2006. As a result, this settlement was one of the few chosen to be legalized and this process started in the last few years. One of the conditions of the legalization process was that residents were allowed to own 150m^2 of land and let the remaining land to the government or pay a fixed lease price. According to our informant, while many of the land holders paid the lease price, some particularly those of low income had no option but to give the land back to the government.

Since there is no standard plot subdivision in the old single family residential area, it was not possible to calculate the built up and unbuilt surface in individual plot.However, open spaces occupy 54 to 75% of the block area in the old single family residential area (Table 7).

- **Water shortage:** Water is upplied through individual connection and communal tap. However, water is only available for few days in a week and at unspecified time. The residents are forced to bring water from distant places such as 'Alem Bank'.
- **Flooding:**Due to lack of drinage infrastructure, flash flood occurs in some areas in the older private settelement.

4.6.2 Proposed LSM measures for old single family residential areas

Household and block level LSM measures are proposed for old single family residential area in the catchment.

Household level LSM intervention

1. **Rain water harvesting:** Since shortage of water is one of the critical issues in the area, harvesting rain water using rain barrel is an option in this area. Currently, some residents collect rain water from roofs using plastic containers.
2. **Rain garden**: Up to 59 m^2 of the individual plots in the new private residential areas are open spaces. Schools, and health centers in the new private residential areas have also considerable open spaces. Part of this space could be used for developing rain garden so that stormwater from roof and sealed ground surface could be directed to it for detaining and infiltrating.

3. **Permeable pavement:** Part of the open space within each compound is sealed for car parking. Replacement of the sealed surfaces with permeable pavement is recommend to enhance stormwater infiltration. Parking grounds and driveway in institutions iwith large plots should be covered with permeable pavement (e.g. cobblestone).

Block level LSM intervention

The block level LSM interventions in the old single family residential area cpould involve the existing open spaces and cobblestone local roads.

4. **Green space development**

   The open spaces found within and between blocks in the old single family residential areas could be used for block level LSM interventions through the development of green spaceand incorporating stormwater detention pond in appropriate places.

Fig. 19. Satellite image of old single family residential area aound Silte Sefer.

5**. Connect road bumps with infiltration tree pits**

Most of the inner roads in the olddense residential areas are made from cobblestones. Bumpers to limit vehicular speed are constructed on some of the cobblestone roads. Road bumpers could be combined with infiltration tree pit. The trench is dug on the sides of the bumper, filled with gravel, and topped with soil and planted trees. Storm water runoff from the cobblestone surface flows through a storm drain along the bumper into the storm water tree pit. Planted trees absorb

some of the storm water through their root system. The remaining storm water will be stored in the spaces of the gravel and then slowly infiltrate through the bottom.

4.6.3 Synergy

Implementing the different LSM measures at the old single family development development area, in addition to reducing stormwater runoff, could provide the following added advantages.

- *Improving water supply*. The rainwater harvesting measure could provide additional water supply during and after the rainy time. The harvested water could be used for watering garden plants and other non potable uses.
- *Provision of food and medicinal plants*. Rain gardens could provide vegetables, fruits and herbs for traditional medicine.
- *Aesthetics.* Rain gardens and communal green spaces could support ornamental plants that improve the asthetics of individual plots and neghiborhood.
- Tree plantation along cobblestone roads provide shade for pedestrians, cars and houses.
- Communal green spaces could provide recreational and social services as well as play ground for children.

4.7Primary Arterial Street

4.7.1 Description

The Ayer Tena - Alem Bank Primary Arterial Street (PAS) is found within the Jemo river catchment. The street is 40 m wide, 6 lanes with additional 10m wide right of way in the middle and 4 meter sidewalk. The driveway is made from concrete asphalt, the sidewalk with permeable pavement (cobblestone and concrete blocks) and the medianght of ways is simply bare without any plantation.

From the stormwater management point of view, this PAS plays a significant role as it generates a substantial runoff which goes to the undergound concrete pipe and eventually to the tributary of Jemo river. The following LSM interventions are proposed for managing stormwater from this PAS.

4.7.2 Proposed LSM measures for primary arterial street

1. Vegetated Swale on right of way

Vegetated swales are shallowlandscaped areas planted with grasses, shrubs and/or trees designed to capture, convey, and potentiallyinfiltrate stormwater runoff as it moves downstream.Vegetated swale is proposed on road right of way for stormwater conveyance and infiltration. Curb cut is provided for runoff to enter the swale from the impervious asphalt surface.

Fig. 20 (a) Road right of way of Ayer Tena- Alem Bank PAS and (b) swale on right of way

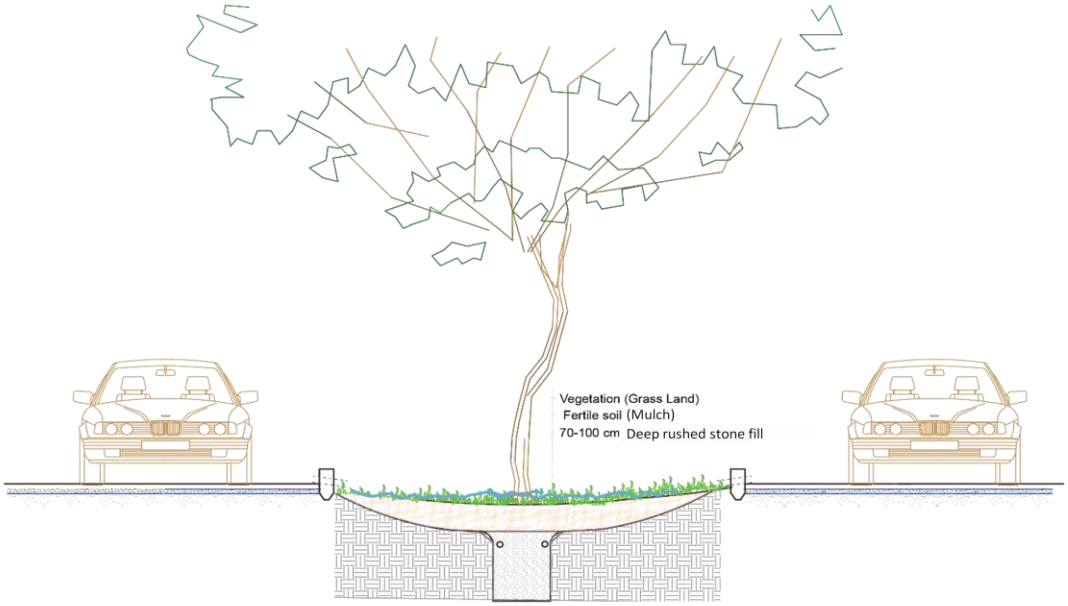

Fig. 21 Section of vegetated swell on road median

2. Rain garden on roundabouts

Rain garden could be developed on roundabouts of PAS to receive runoff from the impervious road. The existing curbs on round abouts (eg. Fig. 22) can be used to direct runoff from the road along a gutter to a low point where it flows into the rain garden on the roundabout through curb cut.

Fig. 22 Alem Bank Round about

3 Pervious pavors walkways

Pervious concerte paver blocks that provide void are recommended for walkways along the primary arterial street and ring road and on taxi terminal.

Fig. 23 Concrete pervious pavor on walkways (Picture from Alem Bank area)

4. Green gutterand Street Planter

A green gutter (Fig. 24) is a type of bioretention facility located between vehicular lanes and walkway. Stormwater runoff enters the green gutter through a curb opening (Fig. 25). Green gutter development and street planters are recommended between vehicular lanes and pedestrian walkway on primary arterial streets and ring roads.

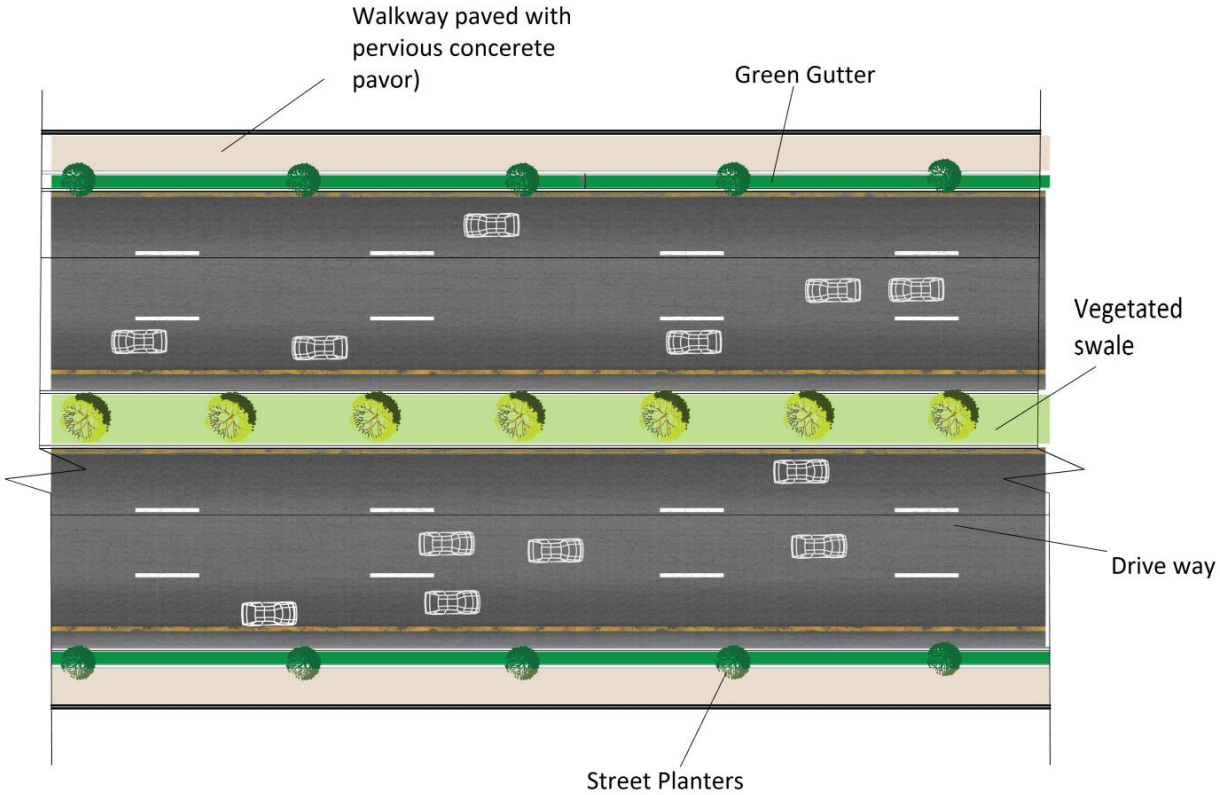

Fig. 24 A sketch of PAS showing the proposed LSM measures

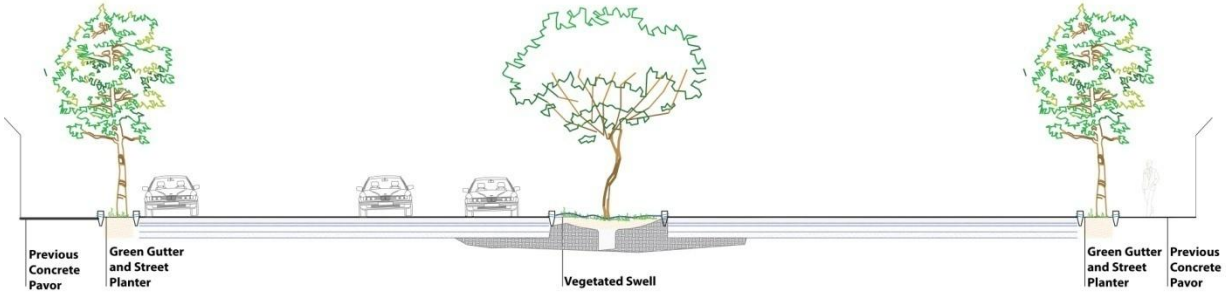

Fig. 25 Section of the green guter and street planter

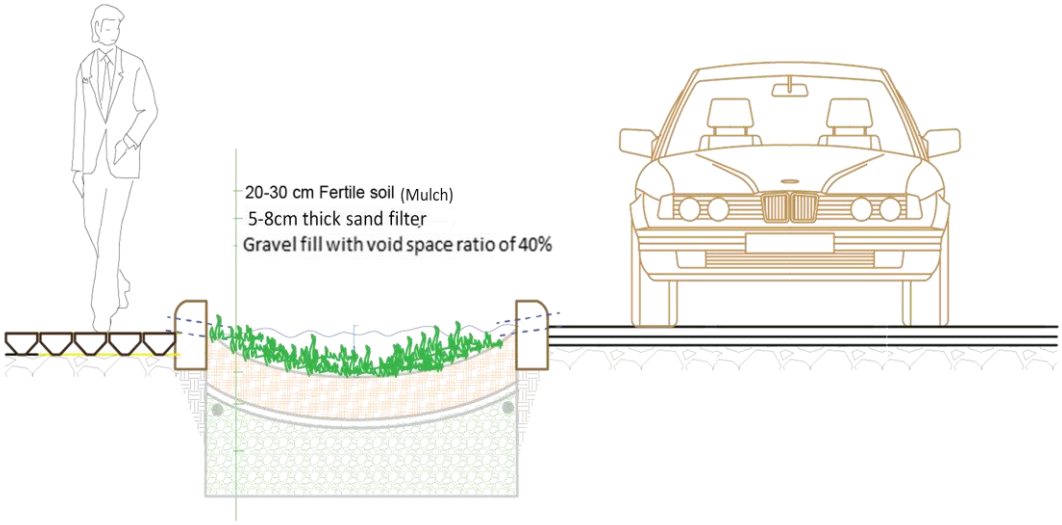

Fig. 26 Section of Green Gutter

4.7.3 Synergy

Incorporation of green space on PAS for storm water management provides additional benefits including shade provision to pedestrians and parked vehicles, aesthetics and absorption of air pollutants and vehicular emission.

The placement of green space between the road surface and sidewalk provides better protection of pedestrians from traffic accidents.

4.8. LSM sub-strategy for Cobblestone roads

4.8.1 Introduction

In order to provide alternative road construction in Ethiopia, cobblestones are being used in different cities and towns of Ethiopia. In Addis Ababa, road construction using cobblestones started in 2009. Although road construction with cobblestones is limited to neighborhood roads with width ranging 7 to 10 m, walkways, and car parks, the reduced construction costs and involvement of communities have brought the increasing importance of cobblestone as a way of

paving the streets of Addis Ababa. Until 2015 393 km of cobblestone roads have been constructed in Addis Ababa, covering 6.6 % of the total road surface of the city.

Cobblestone roads are usually permeable pavements and thus allow storm water to percolate through the pavement and infiltrate the underlying soils thereby reducing runoff from a site. However, the infiltration rate of cobblestone roads relies on their proper design, installation, and maintenance, as well as underlying soil conditions.

The cobblestone roads in the Jemo river catchment are found in residential area both in the formal and informal settlements. Local access within condominium sites is provided with cobblestone roads. The roads were constructed for use by light vehicles; however, heavy trucks are also using the roads and thus affecting the longevity of the roads. While it is a regulation to construct drainage ditch or underground pipe along cobblestone roads for transporting runoff from road surface, in some places in the Jemo catchment such structures are not provided. As a result, the roads in many places have been damaged.

As the history of cobblestone roads in Addis Ababa is a recent one, its contribution to storm water management has not yet been studied. However, one can simply see a reduction of flash flood in areas where cobblestone roads have been constructed. In some areas, especially in sloppy areas, flash floods are still being generated from cobblestone roads. In addition, because of poor construction, stagnant water is seen on cobblestones during the rainy season in several places. Therefore, there is a strong potential to diversify the design and construction of cobblestone roads with some LSM tools such as rain garden, tree pits, open and green spaces thereby increasing their potential as tool for storm water management.

4.8.2 LSM measures for cobblestone roads

1. Connect road bumps with infiltration trench and tree pits

In order to control vehicle speed on cobblestone roads, bumps are constructed at irregular intervalson cobblestone roads of residential areas. The bumpers are seen obstructing the flow of stormwater thereby accumulating stormwateron the cobblestone roads. In order to remove the accumulated water, road bumpers could be combined with infiltration trench and treepit (Fig. 27). Infiltration tree pits are contained landscape areas designed to capture and retain stormwater runoff.

The design solution here is based on bringing combined system of swale and dyke together with infiltration trench and tree planters to reduce stormwater runoff generated from the local cobblestone streets. The design element is developed based on customizing “traffic calming structure" or a street bumpers as a multifunctional urban street element which is common on the local streets of the Addis Ababa. In this regards, the bumper used as a dyke to intercept the flow of stormwater in the downslope direction and diagonal gutter as a swale utilized to redirect the stormwater into the tree pit. Furthermore, infiltration trench is installed under the gutter to increase the stormwater storage capacity of the system as well as to infiltrate more water laterally into the soil. In the process of diversion, retention, and infiltration, substantial amount stormwater is managed by retaining some water within crushed stone voids and infiltrating into the surrounding soil. The stored water within the system increases the soil moisture of the area and absorbed by trees planted along the side of streets.

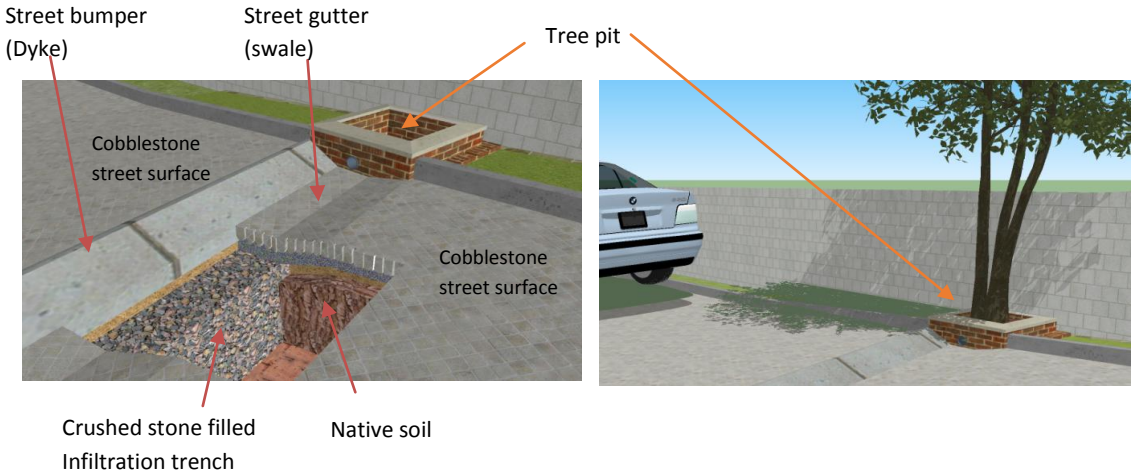

Fig.27 Illustration of cobblestone bumper with infiltration trench & tree pit (Design: Alazar A.)

2. Use more pervious base for cobblestone roads

From the point of view of storm water management potential of cobblestone roads, the permeability of sub-base material and the void left between cobblestones are crucial. To maximize permeability, the use of open graded base, which is a uniformly graded mixture of stone with the finer particles removed, is recommended.

Fig. 28 Section of cobblestone road (Photo by Dagnachew Adugna)

3. Tree plantation along cobblestone roads

In condominium compounds there are spaces on the sides of cobblestone roads which could be used for tree plantation. Shade providing and fruit trees are the possible options. Trees intercept rainfall before reaching the ground thereby reducing the amount of runoff. In addition, trees absorb the infiltrated water and release to the atmosphere through evapotranspiration, contributing to the local water cycle.

4.8.3 Synergy

The incorporation of tree planting in cobblestone roads, in addition to reducing peak storm-water runoff volume, would bring street comfort through shading and evapotranspiration and additionally creates aesthetically attractive environment.

In condominium compounds, the use of fruit trees for roadside plantation could contribute to the food supply of the condominium residents or generate income by selling the fruits.

4.10 Repi Hill

4.10.1 Description

Repi Hill is an elevated area from the surrounding flat area found south-west of the Jemo river catchment. Settlement, industry, road, urban agriculture, and quarrying are the current land use at Repi hill (Fig. 29).

The first settlers of the Repi Hill area were the farmers who were settling on the plateau and cultivating both on the plateau and on the sloppy terrain. Gradually, they started to informally sell a parcel to house builders. The few industry and storage owners located at the plateau also managed to settle in the area through buying land from farmers. Gradually, when land availability became scarce in the area, people started to construct more and more houses on the steep slope and in the foot hill.

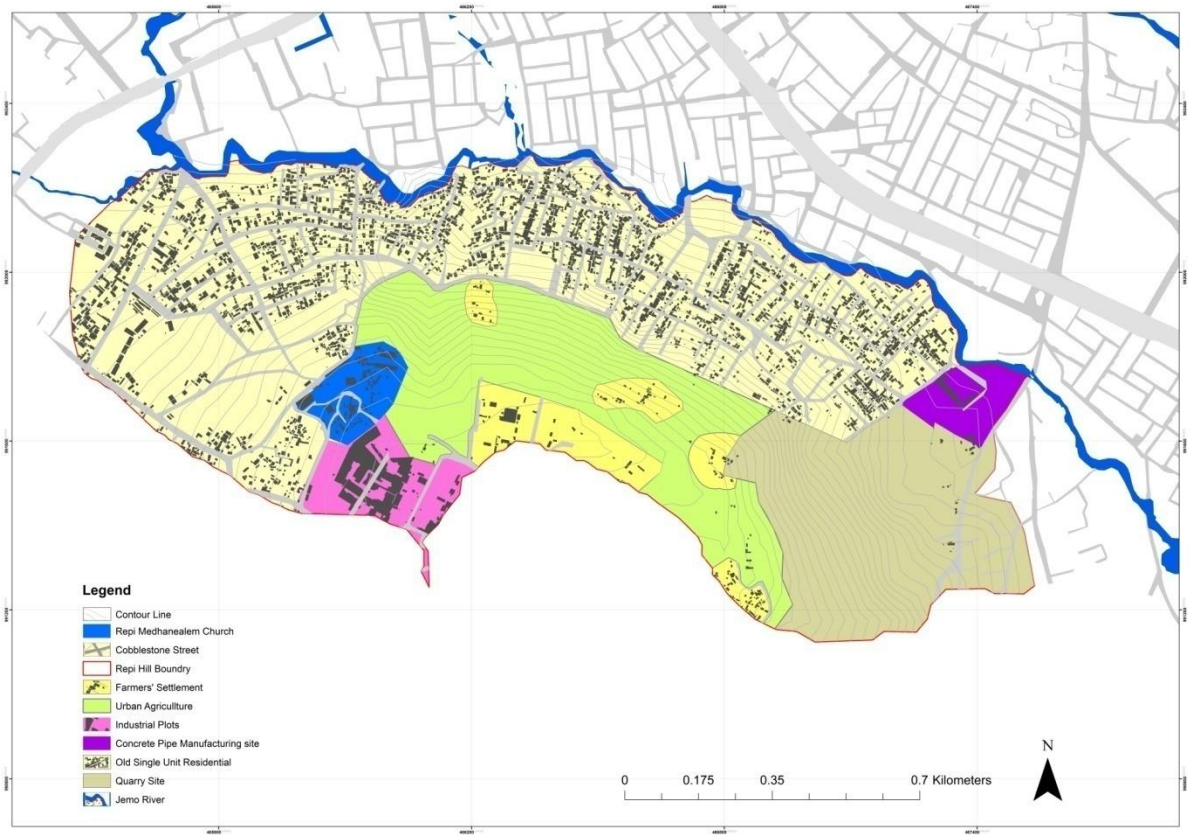

Fig. 29 Land use map of Repi Hill

Based on slope analysis, the Repi Hill could simply be divided into three zones:

1. Upper slope (the plateau)
2. Middle slope (the steep slope)
3. Lower slope (the foot hill)

The plateau: this site is located at an altitude of 2394 to 2458 meters above sea level (m.a.s.l.). The site is relatively flat ranging between 0-5 percent slope. Manufacturing industries, radio station and residential houses are found on the plateau.

The steep slope: this is the area having a slope ranging between 5% and 40%. Altitude of this site ranges between 2331 to 2394 m.a.s.l. The dominant land uses here are informal settlements, both active and abandoned quarry, field crop farming and plantation forests.

The foothill: the slope level at this location is moderate ranging between 2% and 10% and altitude between 2267 to 2331 m. The dominant land use in this area is settlement (informal). Part of the abandoned quarry and concrete pipe products manufacturing plant are also found here.

The Repi Hill is dominated by informal settlement. Due to such informality and insecurity associated with this, housing quality in the area is low. The most widely used construction materials are wood and mud.

On the upper part (plateau) of the Repi Hill are found manufacturing industries, primarily plastic industries (Fig. 30). Oil producing industry is also found on the plateau. The land surfaces of the manufacturing industries are paved with concrete and asphalt. Some of the industries have green spaces containing indigenous trees and grasses. Liquid waste disposal is through septic tanks and rain water is disposed through pipelines connected to open ditches along the main roads in the area.

Fig. 30 Industrial cluster on Repi hill

Quarry sites are found on the Repi Hill. Based on their operational stage, they could be categorized into active, abandoned and planned quarry site.

Abandoned quarry covers the largest share of the quarry site. This is the area that has been excavated for more than a decade and now abandoned from excavation. No landscape rehabilitation has been done since the quarry operation was ceased. The resulting landforms are ridged and very irregular and steep topographic features without soil cover. As a result vegetation growth is barely present. A Chinese construction company is currently using the lower slope area of the abandoned quarry site for the production of construction material (Fig. 31). Due to absence of vegetation and soil, storm water runoff generated on site simply runs down, causing flooding on the foothill.

Fig. 31 Concrete pipe production at the abandoned quarry site of Repi Hill

Operating (active) quarry site

Active quarry site is found in the eastern side of the lower slope area of the hill. This is the site where exploitation of the resource is underway. Stone is crushed on site to produce aggregates

and selective materials are excavated and transported to construction sites. As a result of such operation, the natural land feature is destroyed and what remains after exploration is a real hazard to nearby residents. Landslide resulting from excavation activities nearby the houses and flooding are common problems in the area.

The Nifa Silk Lafto sub-city land management office has identified additional quarry site for future excavation in the middle slope of the Repi Hill. Part of the plannedquarry area is currently occupied by informal settlers and the continuation of the extraction will be a major threat to their survival.

Green space at Repi Hill consists of Eucalyptus plantation forest, urban agriculture, and grassland, comprising 31% of the hill. Urban agriculture, especially field crops, exists on the upper and middle slope of Repi Hill. The most commonly produced field crops in the area are teff, wheat and maize.

Patches of plantation forests, dominantly eucalyptus trees, are covering large part of the upper part of the Repi Hill. There are also eucalyptus plantations in the informal settlement, around the industrial sites and in the institutional premises and warehouses. Grassland is found on the middle slope of the Repi hill and is used for livestock grazing.

Fig.32 Field crop land on Repi Hill(left maize and wheat, right bean)

Fig.33 Grazing land (front) and plantation forest (back)on Repi Hill

Road

There are three types of roads in the area: Cobblestone, gravel and asphalt roads. The most dominant both in terms of area coverage and length is the gravel pavement (Table 8). The second most dominant road type is the cobblestone. The only asphalt road in the area is the one that connects the upper side of the hill to the main Jimma road on the western side of the hill.

Table 8. Road Pavement type and coverage

Road Pavement Type	**Width (m)**	**Length (m)**	**Percentage**	**Surface Area (m^2)**
Asphalt	10-16	32.16	1.3%	3241.8
Cobblestone	6-12	40.76	1.6%	3944.03
Gravel pavement	2-16	2474.1	97.1%	237,961.5
Total road length		**2548.02**	**100%**	**245,147.4**

Fig. 34 Road types at Repi Hill

Water challenges

Water supply is a serious problem at the Repi Hill. This is due to the topography of the area which makes water pumping up the hill difficult, especially when there is electric power cut. There is a water reservoir built on the plateau of Repi Hill where water is distributed to individual household and to communal standpipe. When there is water scarcity, trucks carrying water serve the area.

Fig. 35 Water reservoir at Repi Hill

Fig.36. Truck delivering water

Storm water is being managed at the Repi Hill by draining excess water coming out of the residential, manufacturing and institutional areas to open ditches built along the cobblestone or asphalt roads. However, not all roads are provided with drainage structure, making storm water to find its own ways on the landscape (see Fig. 37). Apart from this, rain water that falls on the available green and open spaces is either infiltrated, or evpotranspired.

Fig. 37 Storm water flowing along local street

4.10.2 Proposed LSM measures for Repi Hill

The Repi Hill is a complex landscape with different land features and land uses. The best strategy for managing storm water generated from the Repi Hill landscape is to develop multifunctional forest that could support conservation, plantation and agroforestry activities. Since, the existing land uses, especially the informal settlement, are expected to continually exist; the proposed LSM strategy for the Repi Hill considers retrofitting different LSM measures in the existing land uses.

1. Rainwater Harvesting: The informal settlers both in the hill top and lower slope areas of the Repi Hill have a tradition of collecting rainwater from roof during the rainy season. Although the residents basically use rainwater harvesting as a means to solve the water supply problem in the area, the activity is also a good strategy to deal with storm water runoff at household level. Therefore, enhancement of the existing tradition of rain water harvesting from roof should be continued using big containers.

Rainwater harvesting from roof catchment area of industries and conveying using gutters and down pipes into rain barrel or underground cisterns is also proposed.

2. Rain Garden

Gardening is a common activity in the majority of households in the residential areas of the Repi Hill. Vegetables (e.g. lettuce, cabbage, onion, kocho, etc) and medicinal and spicy plants are usually planted in private gardens. However, the current design of the garden should be designed with ridges and valleys to allow for the crop on the ridges to grow in aerated drained/soil.

Rain garden using trees, shrubs and grasses is proposed for industrial compound. Excess rainwater from cisterns and runoff from driveway could be directed to the rain garden. Fruit trees are recommended for the rain garden.

3. Development of community green space

Public open spaces in the informal settlement area of the Repi Hill do not have vegetation; therefore a measure to develop green spaces (e.g. with trees and grasses) in these areas for storm water management.

4. Infiltration trench

Infiltration trenches are excavated trenches that are backfilled with an aggregate material to permit the filtration and percolation of water into subsoil. Gravel filled infiltration trenches could be implanted along the local streets of the informal settlement by creating shallow excavation and filling it with stones. Storm water from the driveway could be directed into the trench for infiltration.

Fig. 38 Local road at Repi Hill (a) and proposed infiltration trench on local roads ((b)

5. Permeable surface: Cobblestone surface cover for local streets in the informal settlement and for the driveway and the loading and unloading part of the industrial compounds is proposed for enhancing infiltration and reducing runoff. Cobblestone bumpers in informal settlement could be connected to infiltration tree pits.

6. Alley cropping: Transforming the existing field crop farming into alley cropping where field crops and trees (e.g. fruit trees) is a measure proposed for reducing runoff and soil erosion. In the middle slope area, construction of bench terrace further enhances soil and water conservation.

Fig. 39 Alley cropping on flat land (left) and sloppy land (right) (picture from web)

7. Replacement of Eucalyptus plantation forest with indigenous forest: Eucalyptus plantations on sloppy terrain do not support underground vegetation resulting in runoff and soil erosion. Replacement of the eucalyptus forest plantation on the sloppy terrain of the Repi Hill is with indigenous trees (e.g. *Juniperus procera, Olea europaea* subsp. *cuspidata*) is the proposed LSM measure in the middle slope area.

8. Greening excavated quarry pits: As there is high development pressure at the Repi Hill, storm water management using green spaces should better be done at the middle slope area of the hill. Terracing, filling in with soil and planting of trees are proposed at excavated and abandoned quarry sites. Fruit trees could be incorporated in the plantation.

9. Retention pond: The excavated pits on the lower part of the middle slope area could be used as retention pond for water harvest coming from uphill.

Fig. 40 Retained runoff at the abandoned quarry site

4.10.3 Synergy

Implementation of the above LSM measure, apart from storm water management, could provide additional benefits that could improve the livelihood of people, e.g. through water supply, fruit and honey production and the provision of important ecosystem services (e.g. aesthetics, support for biodiversity, erosion reduction)

Table 9. Summary of the proposed LSM measures for the Repi Hill and the additional expected benefits.

	Land use	**Proposed LSM measure**	**Synergy**
1	Informal settlement	• Roof water harvest • Rain garden • Community green space	• Improvement of water supply, • Aesthetics • Recreation
2	Industry	• Roof harvest • Rain garden • Pervious surface	• Improvement of water supply • Aesthetics and fruit production
3	Field crop farmland	• Bench terracing and alley cropping	• Provision of fruits and cereals • Erosion reduction
4	Plantation forest	• Replacement with indigenous trees	• Honey production through bee keeping • Supporting biodiversity • Carbon sequestration
5	Abandoned quarry	• Terracing and filling in soil and planting trees • Retention pond • Community green space downhill	• Fruit production • Erosion reduction • Livestock watering • Recreation
6	Streets	• Permeable pavement • Infiltration trench and tree pit	• Aesthetics • Shade provision

5. IMPLEMENTATION MECHANISM

5.1 Activities and actors for implementing the proposed LSM elements

Jemo River is a trans-regional river that crosses the jurisdiction of Oromia Regional State and Addis Ababa City Government. Furthermore, it joins the Little Akaki River, which is a tributary of Awash River that in turn crosses other regions of Ethiopia. On the basis of the national frameworks, the Jemo catchment plan directly involves the interest of Oromia Regional State. Therefore, it is important first to develop common understanding and clarity between the Addis Ababa city administration and the Oromia regional state in relation to the implications of the national and city level frameworks on the appraisal of Jemo catchment plan. This process also involves reconciliation of regional and local interests on the catchment plan. It is thus important to set appropriate platform for negotiation and discussion and to formulate consensus on the catchment plan. Accordingly this process should at least include the following actors; Ministry of Environment, Forest and Climate Change, Awash Basin Authority, Addis Ababa City Government, Oromia Regional State, local authorities (sub cities and weredas/kebeles) found within the catchment and local communities.

The following table shows the list of LSM measures, implementation activities and actors for each land use at the Jemo river catchment. It is assumed that the responsible institutions both in the Oromia region and in the Addis Ababa city administration will work out on the detail action plan for each proposed LSM measure and try to implement the measures.

Table 10: List of activities and actors for the proposed LSM measure of Jemo river catchment

N°	Land use/layer	LSM measure	Activities	Project strategies	Actors
1	Jemo mountain	Afforestation	• Development and preparation of nursery site	• Identification of land holders and users • Awareness of community • Creating financing source • Support farmers financially • Social awareness, social cohesion	• Addis Ababa Environmental Protection Authority • Oromia Forest and Wildlife Authority • Environemnt, Forest and climate change authority of Oromia
			• Mountain terracing and planting holes preparation		• Community, farmers, local administration
			• Transfer from the nursery to the mountain site		•
		Storm water interceptor swale and dyke system		• Training	• Addis Ababa Environmental Protection Authority • Addis Ababa Bureau of Construction • Addis Ababa Roads Authority
2	River bufferzones	Setting buffer zones & flood plains	• Piloting on specific river segment • Identification of properties & land users of adjacent areas • Reconciliation of stakeholders' interests on river buffer zone setting • Setting rules laws and social arrangements • Participatory resettlement of residents living in the designated buffer zones	• Differentiated strategy for open field areas and settled areas • Select open areas for buffering pilot project • Seek community consent • Institutional leadership • Green& health sensitization • Negotiation, cooperation & formulation • Creating employment opportunities	• Addis Ababa Environmental Protection Authority
		Vegetating river buffer with perennial and annual plants	• Identification of vegetative types to be planted • Selecting specific locations for plantation • Identifying properties		
		Storm water interceptor swales	• Same as above		

N°	Land use/layer	LSM measure	Activities	Project strategies	Actors
		and dykes			
		Check-dam with infiltration well at streams	• Selection of spots for the check-dams • Designing • Construction	• Recruiting, training and working with local masons	• Bureau of Construction • Woreda and sub city construction offices
3	Floodplain	Maintain vegetation	• Law enforcement	•	• Addis Ababa River and River side development project office
4	New ring road and primary arterial street	Vegetated swale	• Designing • Construction • Planting • Operation & monitoring	Application of full-fledged EIA and aligning designing and construction process in light of local green and water resources	• Ababa Environmental Protection Authority • Addis Ababa Roads Authority • Addis Ababa Beautification & Park Agency
5	Cobblestone road	Reduce storm water runoff and erosion	• Connect road bumps with infiltration tree pits • Use more pervious sub-base for cobblestone roads and walkways • Tree plantation along cobblestone roads	• Training MSEs • Government matching fund • Community contribution	• Addis Ababa Bureau of Construction • Addis Ababa Beautification & Park Agency • Sub city &wereda Construction & Beautification & Park Offices
6	Old and new single family residential	Preparation of local development plans	• Organizing working teams • Preparation of ToR • Organizing workshops • Finalization & compilation • Approval and agreements	• Participatory local development plans • Identifying retrofitting measures to LSM • Negotiation, cooperation, formulation •	• Sub city &Wereda Planning Offices • Sub city &Wereda Construction Offices
		Rainwater harvesting	• Identify practitioners & assess gap • Training & awareness • Organize MSEs • Credit schemes • Monitoring	• Revisit & set LSM requirement for title deed & building permit process • Technology transfer, transform and innovation	• Addis Ababa Bureau of Land Development and Management • Addis Ababa Bureau of Construction • MSE Development Bureau • Individual land holders • Research institutes (e.g.

N°	Land use/layer	LSM measure	Activities	Project strategies	Actors
					EiABC)
		Rain garden	• Identify local MSEs involved in nursery • Training & awareness • Credit schemes • Monitoring	Same as above	• Addis Ababa Bureau of Land Development and Management • Addis Ababa Urban Agriculture Office • MSEs involved in nursery • MSE Development Bureau
		Porous pavement	• Identify practitioners & assess gap • Training & awareness • Organize MSEs • Credit schemes • Monitoring	• Revisit & set LSM requirement for title deed & building permit process	• Addis Ababa Bureau of Land Development and Management • Addis Ababa Bureau of Construction • MSE Development Bureau • Individual land holders •
		Block level intervention	• Formulating participatory neighbourhood and block development projects •	• Organizing neighbourhood and block development forums • Government matching fund • Ensuring tenure rights • Community contribution	• Addis Ababa Bureau of Construction • Wereda and sub city Construction Offices • Neighbourhood& block committees • Edirs
		Introduction of a storm sewer user fee based on the area of impervious cover on a property that is directly connected to a storm sewer	• Enacting and implementing proclamation and regulation	• Awareness raising	• Addis Ababa City Council • Revenue authority

N°	Land use/layer	LSM measure	Activities	Project strategies	Actors
7	Jemo condominium	Rainwater harvesting from roofs	• Organize water committee	• Consolidation of condominium cooperative • Capacitating CBOs • Training in entrepreneurial, leadership & management • Creating source of income & economic bondage on the harvested water and urban farming • Gender sensitization & awareness • Networking with potential partners	• Jemo number one BiruhTesfa Condominium Unit Owners Cooperative • The Cooperative Condominium Block Committees • Addis Ababa Construction Bureau • Wereda& sub city Construction; Beautification & Park and Urban Agriculture offices • AAWSA • NGOs/bilateral organizations
		Retention/ detention ponds	•	• Consolidation of condominium cooperative • Capacitating CBOs • Training in entrepreneurial, leadership & management • Creating source of income & economic bondage on the harvested water and urban farming • Gender sensitization & awareness • Networking with potential partners	• Jemo number one BiruhTesfa Condominium Unit Owners Cooperative • The Cooperative Condominium Block Committees • Addis Ababa Construction Bureau • Wereda& sub city Construction; Beautification & Park and Urban Agriculture offices • AAWSA • NGOs/bilateral organizations

N°	Land use/layer	LSM measure	Activities	Project strategies	Actors
		Rainwater infiltration and evapotranspiration	•	• Consolidation of condominium cooperative • Capacitating CBOs • Training in entrepreneurial, leadership & management • Creating source of income & economic bondage on the harvested water and urban farming • Gender sensitization & awareness • Networking with potential partners	• Jemo number one BiruhTesfa Condominium Unit Owners Cooperative • The Cooperative Condominium Block Committees • Addis Ababa Construction Bureau • Wereda& sub city Construction; Beautification & Park and Urban Agriculture offices • AAWSA • NGOs/bilateral organizations
		Urban agriculture	• Organize condo unit owners in each block as cooperative	•	• Jemo number one BiruhTesfa Condominium Unit Owners Cooperative • The Cooperative Condominium Block Committees • Addis Ababa Construction Bureau • Wereda& sub city Construction; Beautification & Park and Urban Agriculture offices • AAWSA • NGOs,/bilateral organizations

N°	Land use/layer	LSM measure	Activities	Project strategies	Actors
8	Repi Hill	Participatory regularization & service improvement	• Organizing stakeholder and community forums for regularizing project • Jointly outlining principles for guiding regularization process • Identifying land for community level LSM interventions • Presentation, discussion & negotiations • Agreements and concessions • Re-blocking • Title deed provision • Utility and service improvement measures	• Enacting provisions of the federal land lease proclamation for regularization • Revisit provisions of the master plan in light of LSM • Revisit & set LSM requirement for title deed & building permit process • Provisions of progressive tenure rights	• Addis Ababa Urban Planning Commission • Addis Ababa Bureau of Land Development and Management • Addis Ababa Bureau of Construction • Wereda and Sub City Planning Offices, Land Development Offices & Construction Offices • Neighbourhood and block committees • Edirs
		Rainwater harvesting	• Awareness raising Training		
		Rain garden	• Awareness raising Training		
		Porous pavement & roads	• Awareness raising Training		

5.2 Instituional arranement of stormwater management

LSM should stand on two pillars, namely institutional arrangement and policy frames. Both pillars play vital roles for the enhancement of sustainable storm water for the community livelihoods. Hence, universal frames would set the roles set for the issues for assigning responsibility and accountability. Nevertheless, the universal definition may aid to consolidate the required provision after stipulating conceptual frames.

Instituional arrangment and appropriate policy framework are needed for the proper implementation of LSM. Institutions are principal social structure and tools which are used to organize, direct and execute essential tasks, while policy is articulated set of ideas that should be done in a particular sphere.

Stormwater management may not be the task of a single instituion within a city. In Addis Ababa stormwate management activities are being directly and indirectly carried out by the following instituions (Table 11).

Table 11 Instituions involved in stormwater management at Jemo River catchment

	Institution	**Current activities related to stormwater management**
1	Addis Ababa Environmental Protection Authority	• Provides regulation and standard for catchment and river protection • Develop and manage urban forest on mountains and riparian vegetation
2	Environment, Forest and Climate change Authority of Oromia	• Prepares legal framework for the development and management of environmental resources, forests and adaptation mechanisms to climate change
3	Oromia Forest and Wildlife Enterprise	• Performs soil and water conservation activities • Plant trees for production and conservation on mountains
4	Addis Ababa City Roads Authority (AACRA)	• Design and construct below ground stormwater drainage pipe • Design and constructcobblestone paver on walkway and local streets
5	Addis Ababa River, River side and Climate change Project	• Design and demarcate river buffers • Develop and manage riverside for their social, economic and environmental benefits
6	Beautification, Parks and Cemetery Development and Administration Agency	• Development of greenspace

7	Addis Ababa Construction Bureau	• Coordinates community based local drainage channel construction
8	Addis Ababa Water and Sewerage Authority	• Provide sewerage system for removing waste water
9	Ethiopian Railway Corporation	• Design and construct drainage pipe under light rail way
10	Addis Ababa Urban Plan Institute	• Planning of storm water management

Effective stormwater management in Addis Ababa could be achieved when catchment management plan is prepared involving all stakeholders and stormwater management is mainstreemed in each rsponsible instituions. For the preparation of cacthment management plan, a steering committee, consisting of all instituions involved in stormwater management, could be formed for the preparation of catchment management plan. The Addis Ababa Urban Plan Commission could take the leading role in the formation of the steering committe and coordinating the planning process. Eventually, the Addis Ababa Environmental Protection Authority could develop regulations and standards and follow the implementation of catchment management plan. Public instituions, real estate developers, industrial and commercial establishmentsand local communities could then be responsible for the implementation of the catchment management plan. The suggested responsibilities of for the implementation of LSM measures at Jemo river catchment is presented in Table 12.

Table 12. Proposed responsibility of actors for landscape based stormwater management

	Institution	**Expected activities related to LSM**
1	Addis Ababa Environmental Protection Authority	• Provides regulatory framework, regulation and standard for catchment management plan • Awareness raising on catchment management
2	Oromia Regional State and Addis Ababa City Government	• Collaborate in Jemo mountain management and implementation of LSM measures on the mountain
3	Addis Ababa City Roads Authority (AACRA)	• Be involved in catchment management plan prepaartion • Implement different LSM measures on roads
4	Addis Ababa River, River side and Climate change Project	• Be involved in catchment management plan prepaartion • Demarcate and maintain river buffers for stormwater management, pollution reduction and other benefits

5	Beautification, Parks and Cemetery Development and Administration Agency	• Be involved in catchment management plan prepaartion • Implement LSM measures on public parks, plaza and cemetery
6	Addis Ababa Construction Bureau	• Collaborate with communities in the implementation of LSM measures on local streets and communal green spaces
7	Addis Ababa Water and Sewerage Authority	• Implement reservoir watershed management
8	Addis Ababa Urban Plan Institute	• Integrate landscape based storm water management in the planning process
9	Real estate developers	• Implement site specific LSM measures on their development site
10	Industrial and commercial firms	• Implement site specific LSM measures on their site
11	House owners	• Implement plot level LSM measures on own residential plots
12	Community	• Implement site level LSM measures on communal green spaces and local streets