INTEGRATING CLIMATE CHANGE ADAPTATION AND WATER MANAGEMENT IN THE DESIGN AND CONSTRUCTION OF ROADS

Scoping study, Awareness and Fundraising in Somaliland

Hargeisa, Somaliland
February 2022

Green Roads for Water

Report on

Somaliland – Scoping Study, and Awareness and Fundraising

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Executive Summary

The Green Roads for Water Initiative was started in 2014 in Ethiopia and spread to more than 10 countries to promote the beneficial use of roads as instruments for better water management, landscape restoration, and climate change adaptation. Learning from international experiences and seeing potential to benefit from this concept, Welthungerhilfe (WHH) Somaliland took the initiative to undertake a scoping study on the opportunities for Green Roads for Water (GR4W) in Somaliland, which can be used for familiarization and policy development by the Somaliland Government, specifically the Ministry of Transport and Road Development (MoTRD) and related agencies. Accordingly, this a scooping study was undertaken in the Northern part of Somaliland engaging experts from MetaMeta, a social enterprise (www.metameta.nl), WHH, FAO, Road Development Agency (RDA) of Somaliland, and the Ministry of Environment & Rural Development (MoERD). Two workshops and additional discussions with heads of key institutions including the MoERD, the Ministry of Planning & National Development (MoPND), African Development Bank (AfDB), and potential beneficiary communities, were held to introduce the concept and discuss ways to implement GR4W in Somaliland. During these consultation processes, a common understanding on GR4W was forged and consensus was built on the way forward. Immediate actions were suggested on the need for partnerships for planning and fundraising. It was agreed that GR4W would be integrated into the programs of relevant ministries (Livestock, Forestry, Range, Environment, Water, Transport & Roads, Rural Development) and made part of the upcoming National Development Plan III.

Somaliland is a water stressed country. Access to water for livestock and grazing is a problem forcing frequent migration within Somaliland, sometimes to the highlands of Ethiopia. Depending on the various land uses, GR4W can be considered among the options for effective water and nutrient stress mitigation. The country has huge GR4W potential to be harnessed. However, road development in Somaliland is in its early stage, there is more 10 thousand km road length built so far. In addition to the burden of having new roads, maintaining existing roads is a big challenge, as the main cause of road problems is destructive road-water interaction. At the same time, the introduction of roads to an area brings environmental imbalances, including forest clearing, wildlife disturbance, erosion, flooding, and hydrological disturbances.

However, the rainfalls in Somaliland are erratic with high temporal and spatial variabilities, coupled with other multiple favorable conditions, the annual amount is sufficient for development. The mean annual rainfall ranges from below 200 mm in the coastal area of Lughayaa to 600 mm in the east of Borama and Gabiley. The potential to harvest beneficial water along roads in Somaliland is significant. From the annual average rainfall of 300 mm in Somaliland, up to 300 m^3 of water can be harvested from a watershed above the road, only from a 1 km road stretch. Although opportunities for GR4W intervention in the agriculture (livelihood development) and natural resources management sectors are enormous, little is done to maximize the benefits. Some of the problems observed during this study include:

- no to poor road development,
- less intensive land management practices
- uncontrolled grazing
- aridity (moisture insufficiency) and low biomass production
- climate shocks, drought, high rainfall variability, tropical cyclones
- poor soils with little water infiltration and absorption
- accelerated sheet and gully erosion,
- sparse population: sparse/thin population density/workforce might be a problem for

conservation works.
- degradation of existing vegetation cover

Integration of GR4W in the future implementation of the Hargeisa-Garbo-dadar Road, and on the planned and ongoing road projects like the AfDB-financed Borama-Hego and Borama-Djibouti projects and others that are under construction will have multiple benefits that can serve as a model for upscaling on projects to be implemented in the future and on existing roads. Among the many benefits and opportunities, the following are notable:

- Cash-for-work – humanitarian and transitional funding can be utilized for climate change adaptation and livelihoods.
- Employment opportunities: road maintenance by local community members linked to GR4W, offsetting commercial road maintenance with heavy and expensive equipment.
- Suitable topography and vegetation cover along road corridors.
- Suitable geohydrological conditions as well as suitable topography in many areas
- High demand for water for human, livestock, supplementary irrigation, and wildlife
- Increased fodder and agricultural productivity.
- Extensive road development that could incorporate road water management.
- Increased upstream-downstream links because of the construction of sand dams, drifts, and other water management structures along the road.
- Presence of sandy rivers with good potential for developing water retaining road crossings and controlled sandmining.
- Enhanced soil and water conservation/land management practices that could be linked to road water management.

The implementation of GR4W is a multi-sectoral task that must take place at landscape/watershed scale. Actors must synchronize their actions, as fragmented efforts will fail to bring anticipated results. The coordination level among major actors in Somaliland is not at the required level to implement GR4W. Making GR4W part of the envisaged NDP III and subsequent regional and district development plans will help to address various aspects of *Vision 2030* at watershed and national levels.

1. Introduction

The Green Roads for Water Initiative was started in 2014 in Ethiopia to promote the beneficial use of roads as instruments for better water management, landscape restoration and climate change adaptation. The aim of this initiative is to improve livelihoods and resilience of communities living around roads and reduce negative impacts such as erosion, flooding, sedimentation, and dust while improving the climate resilience of road infrastructure and reduce water-related road damage. Green Roads for Water (GR4W) interventions have been successfully taken place in more than ten countries across the world including Ethiopia, Kenya, Uganda, Malawi, Nepal, Bangladesh, Tajikistan, and Bolivia. Based on experience and learning through pilots, global guidelines have been drafted and officially published by The World Bank. Green Roads for Water services include:

- Road water assessments – identifying the best options along selected roads
- Working with engineers and implementers to design better practice
- Developing guidelines appropriate to specific countries and situations
- Training and coaching towards a change in culture and governance for green roads for water
- Developing strategies to optimize the wider socio-economic benefits of road development and road construction

Learning from international experiences and seeing potential to benefit from this initiative, Welthungerhilfe Somaliland (WHH) asked MetaMeta Research to undertake a scoping study on the opportunities for Green Roads for Water in Somaliland. Accordingly, MetaMeta Research undertook a preparatory desk study and field assessment. The field assessment was carried-out between 27 October and 7 November 2021. Experts from a consulting firm, MetaMeta, participated alongside experts from WHH, Road Development Agency (RDA) of Somaliland, and the Ministry of Environment & Rural Development (MoERD). Two national workshops were held to introduce the concept and discuss ways to implement GR4W in Somaliland. In addition to field visits, discussions were held with heads of key institutions including the MoERD, the Ministry of Planning & National Development (MoPND), African Development Bank (AfDB), district administrators in visited areas, and officials from the municipality of Baki. Discussions were also held with potential beneficiary communities and those affected by water stress and natural hazards.

This report documents the opportunities for GR4W along visited transect road and presents the results of discussions held with stakeholders at national and at regional levels that explored issues, opportunities, and ongoing programs in which the integration of roads and water management can be promoted. This report also identifies issues and opportunities for GR4W in Somaliland and plots the way forward.

1.1. Objectives and Scope of the Study

The scope and objectives of this study is to assess the potential for green roads interventions along the road from Hargeisa to Garbo-dadar and to identify:

- Current water-related damages and opportunities for water harvesting and regreening, and
- Suggest watershed management alternative options, recommended agronomic practices and possibilities for alternative livelihoods related to Green Roads for Water.

In addition to this, the project is aimed to trigger implementation of the GR4W at national level and **making its an integral part of the National Development Plan.**

1.2. Study Area

The survey was undertaken in the western part of Somaliland, in Awdaal and Woqooyi Galbeed Regions, and a detailed assessment along the 110 km Hargeisa-Daresalam-Garbo-dadar stretch was completed. Another 177 km of rapid assessment was carried out along the Garbo-dadar-Lughaya and Garbo-dadar-Baki-Borama stretches. The Borama-Gabiley-Hargeisa stretch was surveyed to identify existing practices and assess the possibility of implementing GR4W on existing tarmacked roads. The transect drive survey route is shown in Figure 1 below.

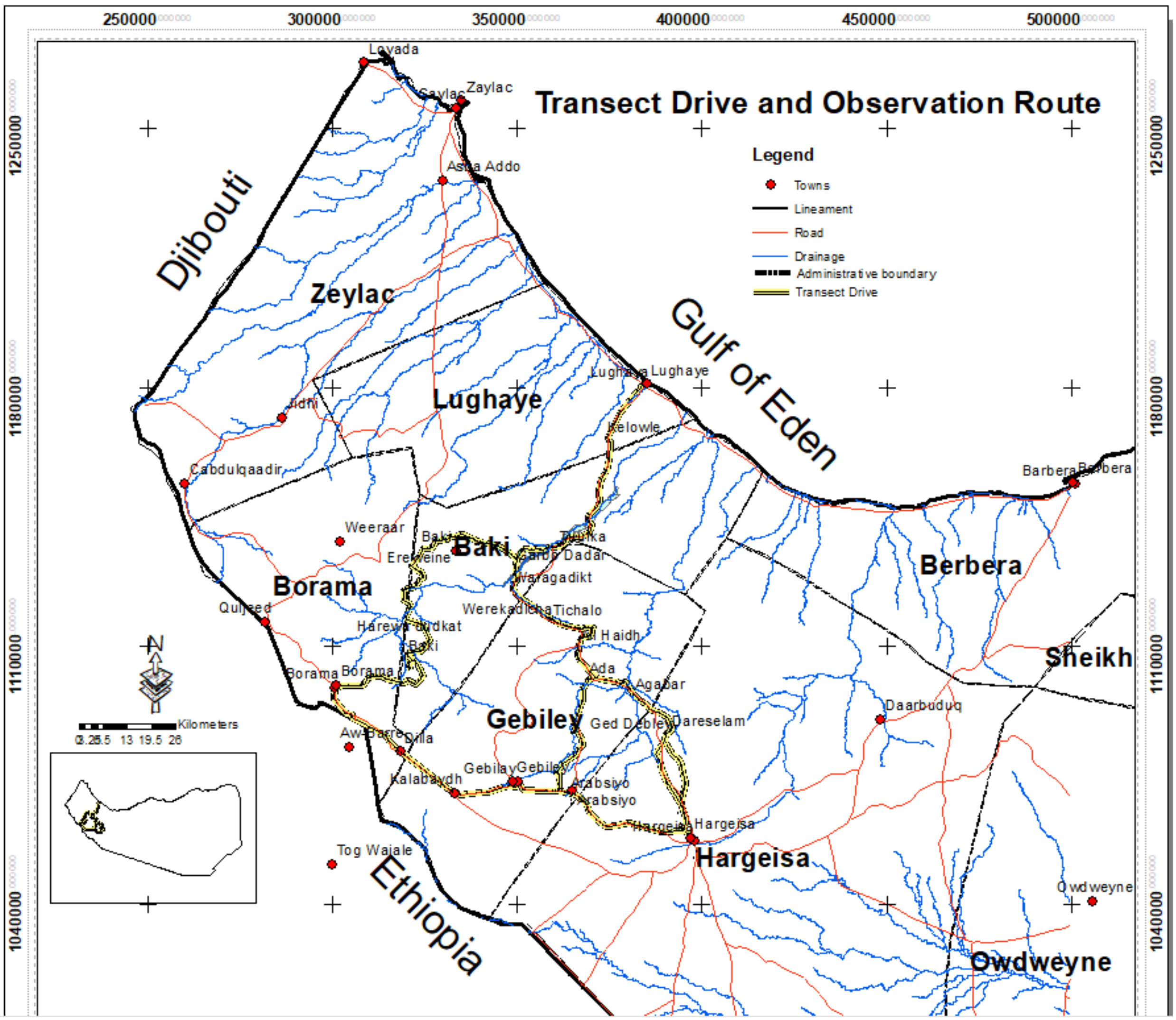

Figure 1: Location map of the study area showing routs covered.

2. Methods of the Study

The assessment was carried out along selected road stretches prioritized by the RDA and WHH in consultation with key stakeholders. Before starting the field work, the MetaMeta team presented the GR4W concept to experts from WHH, RDA, MoERD, WFP, FAO, and UNDP, the Ministry of Agriculture, and NRM experts. The next day, guided by the WHH Area Manager, the MetaMeta team was taken to short introductory field visit along the Hargeisa-Daresalam road. The field work that followed was organized in two phases. The first phase was a series of one-day visits aimed at familiarizing more stakeholders, including representatives from key ministries, UN agencies, NGOs, with GR4W. This was followed by a detailed assessment and a rapid assessment conducted with experts from RDA and WHH. A team of experts from MetaMeta, RDA, FAO, and WHH with varying professional backgrounds, including soil/natural resource management, civil engineering, hydrogeology, remote sensing and geographic information systems, and agronomy took part in the detailed and rapid assessment phase.

The detailed assessment considered variations in geology, geological structures, soil, hydrological features, landforms, and land use practices and conditions along the dry weather road. At all stages, discussions were held on existing and potential road problems related to water and the potential for GR4W and other recommended measures. Observations and measurements were taken. Additional discussions with individual community members were held at selected sites.

Figure 2: Discussion with individual community members (left) and Baki town municipality officials (right)

Further to this review of documents and secondary data and interpretation of remotely sensed data informed this work. Preliminary findings were presented to stakeholders to elicit feedback, collect additional information, and create awareness of the initiative.

3. General Biophysical Characteristics of Somaliland

Geology and Structures

The most important factor in determining the appropriate GR4W measures is the geology and structure that the roads cut through. Somaliland has a complex geology and structural setting that make it rich in mineral resources. The country is almost all rocks of the three major rock categories. The geology of the surveyed part of Somaliland is dominantly covered by eolian and marine sediments. More information on the geology of the study area can be found in Annex 1.

Geomorphology

Topographic features such as slope and elevation are also decisive elements for the sustainability of roads and the implementation of GR4W measures. The northwest and the southeast of western Somaliland have flat and undulating morphology. The central region is a highly rugged mountainous area with alternating valley floors between the east-west trending mountain ranges. More information on the slope of the study area can be found in Annex 1.

Soils and landform

Understanding the nature and types of soils and the soil forming processes is important in road construction and GR4W implementation. The soil types in Somaliland have a one-to-one relationship with the parent rock types, geomorphology, and climate elements. More information on the soil types in the study area can be found in Annex 1. The landform of the visited area falls under four major landform categories and four major soil units: mountainous and hilly; plateaus and level flat land; valleys and river fan; and coastal and piedmont. Detailed information on each landform category can be found in Annex 1.

Climate

The climate of the study area is characterized by hot semi-arid to hot arid conditions. Around Hargeisa, Daresalam, Borama Gabiley, and surrounding areas, semi-arid conditions prevail. Hot and arid conditions prevail in Garbo-dadar, the northern and eastern part of Baki, and the Lughaya area along the coastal plain (FAO-SWALIM, 2007). According to the same source, mean annual rainfall ranges from below 200 mm in the coastal area of Lughaye to 500-600 mm in the east of Borama and Gabiley. The rest of the study area around Hargeisa and Daresalam has a mean annual rainfall of 300-500 mm (FAO-SWALIM, 2007). More information on the rainy seasons, growing periods and future predicted climate conditions in the study area can be found in Annex 2.

Land use and Vegetation

Somaliland is a water stressed country. Depending on the various land uses, GR4W can be considered among the options for effective water and nutrient stress mitigation. Somaliland's agriculture and more importantly, animal husbandry is dependent on erratic, small amounts of rainfall. Access to water for livestock and grazing is a problem forcing frequent migration within Somaliland, sometimes to the highlands of Ethiopia. Low density pastoralism, mainly the production of shoats and camels, covers the coastal regions and is the dominant land use for more than 26% of the western Somaliland. Agropastoral maize, cowpea, millet, cattle, and goats is the second most common land use type (more than 22%) (Annex 2). Water from roads and the landscape, if properly managed, can be used to supplement the needs of these different land uses.

The vegetation type is dominated by relatively dense stands of low thorn trees, thorn bush woods, thorn shrubs, and various species of succulent herbaceous vegetation with sparse undergrowth of rain green herbs and grasses: the thorn bush-succulent savanna, thorn tree-short grass savanna, or acacia-short grass savanna. The woody vegetation (trees) is concentrated in the hilly and mountainous area but also in the valleys. In the drier area, the open semi-desert with its widespread small xerophyte shrub vegetation and poorly developed herbaceous layer predominates. In the arid area, the trees are generally low growing, using the rainwater that percolates through the subsoil. The water here can be accessed only by trees and shrubs, with their widespread, deep roots.

Land use is dominated by the nomadic pastoralism of browsing animals with a few agropastoral and irrigated orchard farming activities. Cropping is a kind of opportunistic farming. In good years with adequate rainfall, agro-pastoralists harvest and use the grain. In poor years, i.e., if the rainy season is too short resulting in crop failure, they only use the stalk for livestock feed. Sorghum is the main crop grown in the area with higher importance for fodder (stalks) then for food (grain). In general, the crop production system practiced is poor.

Around homesteads and on roadsides, communities are planting multipurpose trees such as neem, moringa, and damas. Entering Gabiley, several kilometers of roadside plantation, with eucalyptus dominating are found.

4. Road Development in Somaliland: Status and Challenges Related to Water

4.1. Road Sector Development in Somaliland: Status And Plan

Road development in Somaliland is in its early stage, presenting an opportunity to integrate GR4W in future projects. The total road length built so far is estimated to be about 1,000 km of paved roads, 1,225 km of unpaved roads, and 6,800 km of unpaved track roads. There are around eight major roads in Somaliland that connect to other parts of the country. The 253 km long Berbera-Hargeisa-Gabiley-Kalabaydh-Tog Wajale and Gabiley-Borama roads are tarmac and in a good condition. The Hargeisa-Berbera road is under final stages of renovation, the Berbera -Burao-Las Anod road is also tarmac but poorly maintained. The sandy 320 km long Berbera-Lughaye-Lowya Addo road that runs along the coastline continues to the Somalia-Djibouti border. There are other roads in the eastern parts of Somaliland that go from Berbera and Burao to smaller towns and localities. There are very few bridges in Somaliland. River crossings or Irish crossings are common for seasonal conditions. Few culverts have been observed on the newly built Hargeisa-Tog Wajale road. RDA has a total of 1,224 km road projects, of which 516 km are in progress and the rest have yet to start (Table 1).

Table 1: Ongoing and planned road projects

Project Name	Length in Km	Status
Burao – Erigavo	284	Construction in Progress
Hargeisa – Geedeble	28	Construction in Progress
Las'anod - Kalabydh	32	Construction in Progress
Berbera - Corridor	150	Construction in Progress
Hargeisa bypass	22	Construction in Progress
Aada - Gabiley	33	Construction About to Start
Berbera – Burao	160	Construction About to Start
Lawya ado – Borama	280	All evaluation is covered finalizing visibility studies
Burao – Odweyne – Hargeisa	183	Starting Assessment and Feasibility Study
Kalabydh – Wajale	19	Construction About to Start
Baki – Boram	33	Construction About to Start

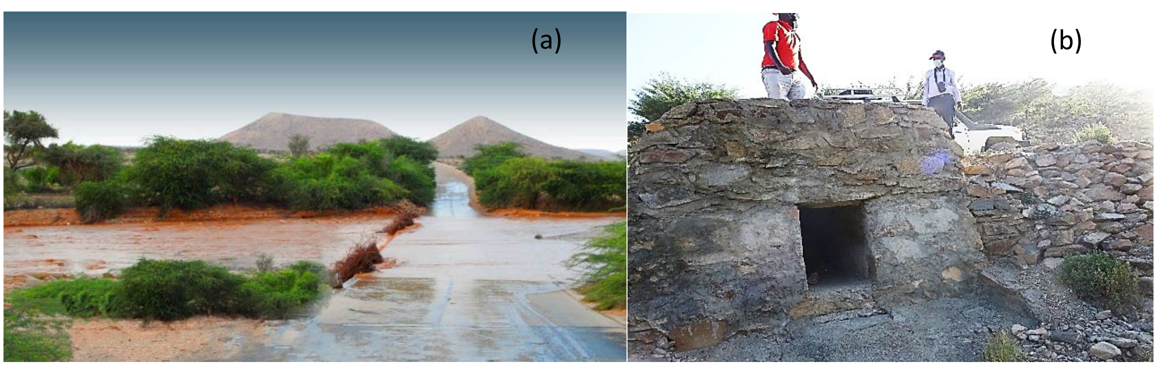

Figure 3: Road-crossing structures: (a) the Hargeisa-Berbera-highway drift crossing impassable during high flood (Photo: https://dekochi.com/); (b) a culvert built by WHH over basement rocks serving for the past 16 years without problem.

The Road Sector Administration Board (RoSAB), the Somaliland Road Development Agency (SRDA), and the Road Fund Administration (RFA) were officially established by Presidential Decree in March 2000. The Road Development Agency is in charge of highway maintenance, feeder roads, gravel roads, and construction projects including bridges, retaining walls, roads, and culverts (https://dlca.logcluster.org/).

There are road design and construction technical standards and specifications including the bridge and geometric design manual, drainage design manual, and pavement design manual. However, as practiced elsewhere, **there is no manual to manage road water for beneficial uses**. To tackle damage to roads, the agency follows protective, adaptive, and proactive approaches.

The District of Garbo-dadar is connected to Hargeisa through approximately 75 km of dry weather roads. This is an important route that also connects Darasalam, Agabar, Aada, Ali-Haidh, and Waraga dhigta with the coast and Hargeisa. This road has deteriorated and needs urgent rehabilitation. Although those roads carry a low volume of traffic, they are very important for the local community for selling their livestock and agricultural products. Eventually, this stretch of road also connects to Djibouti via Garbo-dadar and Garisa.

Figure 4: The deteriorated Hargeisa- Garbo-dadar Road: (a) Gully erosion development (b) multiple routes affecting the surrounding grazing land and creating soil hardpan and acting as a waterway

4.2. Water-related Roads' Challenges in Somaliland

Water generally causes 35-80% of road damage. Transect surveys undertaken along roads in upland Ethiopia and Uganda show that for every 10 km of road there may be 8 to 25 flash points, such as local erosion, flooding or sedimentation (MetaMeta - www.roadsforwater.org). In Somaliland, where rains are more torrential, the landscape is rugged and erosive, and road conditions are poor, the damage caused by water is unlikely to be less than this. During the assessment survey, varying degrees of water-related road damage have been observed along dry weather roads, low volume all-weather roads, and tarmac roads. Gulley development along roads that are lacking in water guidance structures and running across erosive thick soils, erosion at downstream of drifts and culverts, and water-related slope failures are the most dominant forms of road damage (Figure 4, 5 and 6).

Figure 5: Photo showing washed away drift on the road to Garbo-dadar gully deepening, gully side sliding and collapse near Daresalam area

Reasons for road failures and environmental deterioration along the visited roads include the absence and poor design of culverts along hydrological paths; inappropriate road crossing structures in accordance with bedrock, soil, slope, and climate conditions; and lack of or inappropriate land management practices. Tropical cyclones and frequent accelerated erosion due to high intensity rainfalls exacerbate water-related problems on roads. The high and elongated bunds built by the side of roads by individual landowners for the purpose of moisture retention and protection can also damage roads by not allowing runoff. Wrongly designed bund alignments also affect road safety.

Figure 6: Photo showing collapsing drift on the Garbo-dadar-Baki road; problem of sand management on Hargeisa- Tog Wajale road

5. Road Water Management Practices in Somaliland

5.1. Existing Practices

Road water management is an existing practice in Somaliland. Use of ponds to store water from mitre drains and culverts and measures to divert water from roads to plantation farms were seen during the survey. Some of those structures were built before the civil war and remain functional (Figure 7). During the road assessment, it was observed that **opportunities for GR4W intervention in the agriculture (livelihood development) and natural resources management sectors are enormous**.

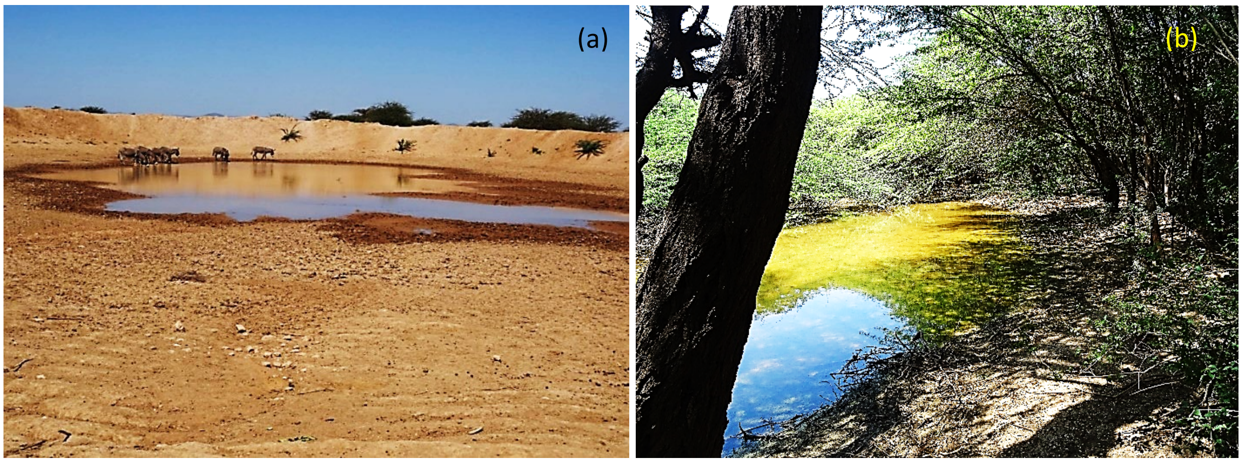

Figure 7: Roadside ponds: (a) A leaky pond dug over carbonate rock areas (on the road to Garbo-dadar) (b) Functional/ pond dug over a watertight basement ground, before the civil war is still functional

NGOs like Save the Children and WHH-Somaliland are promoting the use of interception bunds to divert road runoff to crops and fields and for range improvement. The biggest and widespread use of water from roads is seen in the wadis. Although there are sand storage dams that are fully built for water harvesting, drifts are built with dual advantages. Moisture enrichment is achieved in localities where roadside gullies have been rehabilitated by building loose stone check dams.

Runoff erosion diversion by a technique of soil bund interception for rain-fed crop production and range management is a common practice observed on the routes from Hargeisa to Garbo-dadar. Using existing knowledge and practices, one could easily introduce improved practices and harness the runoff from the road to improve the rangeland situation on both sides of the roads. Such practices include in-situ water harvesting techniques appropriate for storing water in the deep soil profile.

In a number of places (Figure 8), soil bunds intercept and divert road runoff water. Water is diverted from the roadside into the crop field to harvest runoff water and store it in the soil profile. Water diverted and intercepted through this technique seeps into the soil and may move downslope, just below the surface, towards the crops in the field below. Alternatively, it is ponded for a few days depending on the nature of the soil.

Figure 8: Photo showing an interception bund used to divert road runoff to crop a field (left) and a recently constructed bund with design problem.

Further to this, road runoff water collecting by pond construction locally called “Ballies”. This is an existing practice for livestock watering. Water is the scarcest resource in the area. Improving existing practices holds potential for introducing and diffusing GR4W practices in an area where it works for livelihood development.

Another community practice observed is floodwater harvesting within a dry creek valley or dry riverbed. Shallow wells reduce the speed of runoff or block the runoff water flow, allowing it to infiltrate and remain stored in sand storage dams for later use. Such practices could be integrated with a GR4W project by constructing a drift structure where the road crosses dry rivers or creek valleys.

Roadside tree planting activities are seen in small towns, like Garbo-dadar; and best ones along the road Borama to Gabiley (Figure 9). The widely used species are:

- **Azadirachta indica** (neem tree) from India/Burma. Grown for shade and serving as fuel. Fast growing.
- **Moringa oleifera** where watering is possible for high-quality vegetables, also fodder
- **Leucaena leucocephala** for shade and fodder
- **Eucalyptus camaldulensis**: best eucalypt for dry areas. Coppices well. Low value timber, windbreak and fuelwood. Very fast growing.
- **Damas tree**
- **Zizyphus mauretania** - excellent dry-season fodder
- **Acacia spp. (soksok)** - Acacia etbaica, nilotica, tortilis - largely fodder, some charcoal
- **Schinus molle**, largely shade

Figure 9: Roadside tree planting in Garbo-dadar town (left) and along the Borema – Gabiley road (right).

5.2. The Need for GR4W

As stated in section three, Somaliland is a water stressed country with underdeveloped and poor road conditions and a degraded environment. Problems observed during the assessment include:

- water scarcity
- no to poor road development,
- less intensive land management practices
- uncontrolled grazing
- aridity (moisture insufficiency) and low biomass production
- climate shocks, drought, high rainfall variability, tropical cyclones
- poor soils
- accelerated erosion
- sparse population: sparse/thin population density/workforce might be a problem for conservation works
- degradation of existing vegetation cover
- spreading of invasive species in productive lands

GR4W is one of the ways to mitigate many of the above listed problems. If properly managed, for example through drifts combined with elevated sand dams, many wadis in Somaliland can be used as storage for cheap and clean water for humans, livestock, and irrigation. GR4W interventions in the landscape help to enhance water recharge in other types of landforms: the eolian and unconsolidated sediments, the regolith, and the fractured rocks on the hills. As seen in several places, the use of road water for smallholder irrigation is emerging. A recently published story in the Financial Times highlights one such initiative in Somaliland (box below).

Water in wadis is on a continuous flow to the ocean. Unless checked it can drain out. Putting road crossing drifts across the water rich wadis of Somaliland will help to maintain water levels that retreat as deeply as 10 m, making the water lifting cost high for pastoralists and farmers.

Diverted road water in a pond can be used to supplement expensive waters from boreholes and pumped water from far-off places.

Figure 10: Wadi as a source of water for livestock and irrigation (a)One of the many livestock watering points (b) A farmer who used water from wadis for the past 20 years (c) failed sorghum by a roadside that could have been saved by water from road.

In arid regions like Somaliland, where flush floods cause significant damage to roads, converting harmful water to roads for beneficial use through GR4W measures makes the road sector the biggest beneficiary. The reduced maintenance cost of roads and reliable access to users are benefits that reduce the road sector's chronic problem. As Somaliland is increasing its investment in roads, the implementation of GR4W will benefit communities along the roads.

Entrepreneurs help farmers hold back Somaliland's desert

Diaspora money is starting to green a nation that has been neglected by many international donors

Mustafa Duale surveys a herd of camels in Qoolcadey, western Somaliland. The animals no longer have to be sent to Ethiopia for grazing as a result of the reservoir he built © Andres Schipani

Lifeline: the reservoir that Duale built in Qoolcadey. 'We are building an ecosystem,' he says © Mustafa Duale

… "Entrepreneurs are coming with their own money and expertise, establishing a water project or a farm — and they are capable," says Muse. "People are coming back just to herd camels and to farm. Some 15 years ago, you didn't have people from the diaspora coming back, or rich people in the business community creating farms, but now you have plenty of them. For that, they need a more constant source of water, so that's why they're building dams."

... Mohamed helped Duale — who invested $120,000 of his own funds — to design the reservoir, and persuaded aid agency USAID to donate $40,000-worth of polyethylene liner to prevent leakage.

https://www.ft.com/content/78d1b4ac-263a-4b3a-a3d3-1bfa38a06fa8

GR4W is also needed to mitigate impacts of the increased climate variability and the less predictable rainfalls. In times of high flood, the structures help reduce calamities from flooding and in times of drought help to retain moisture and increase productivity.

6. Potentials Green Road for Water in Somaliland

Somaliland does not receive high levels of rainfall. However, surface and subsurface flows from its western neighbor, Ethiopia, fills its wadis and recharges its aquifers. Several deep wells are sunk across the country, supplying water supply for humans, livestock, and irrigation purposes. Only a few rivers, like the Qabri Bahar, are semi-perennial. All other flows sink into the thick sand, eventually reaching the ocean as subsurface flows. The occurrence of numerous drainage paths filled with reservoir sand is the best opportunity for GR4W interventions. If properly managed, rainfall in Somaliland is sufficient to fill water supply gaps. Countries like Yemen and Australia harvest water even though rainfalls are less than that of Somaliland to secure their water demands.

This is a missed opportunity that the construction of roads can contribute to resolve. As roads are made watertight, the passage of water under them is only through road crossings. In absence of these crossings, roads act as water guiding structures that facilitate the collection of water for beneficial use. The potential to harvest beneficial water along roads in Somaliland is significant. From the annual average rainfall of 300 mm in Somaliland, up to 300 m3 of water can be harvested from a 1 km stretch of road from a watershed as small as 500 ha. The potential is higher than this for the southwestern and central parts of Somaliland, which receive higher rainfall rates than the country's average. Depending on watershed sizes, stored water can be used for irrigation, livestock watering, and environmental restoration. What makes the opportunity in Somaliland unique is the existence of several sand filled wadis across the roads in the lowlands, and farmlands and rangelands that can receive diverted water from roads in other parts of the country

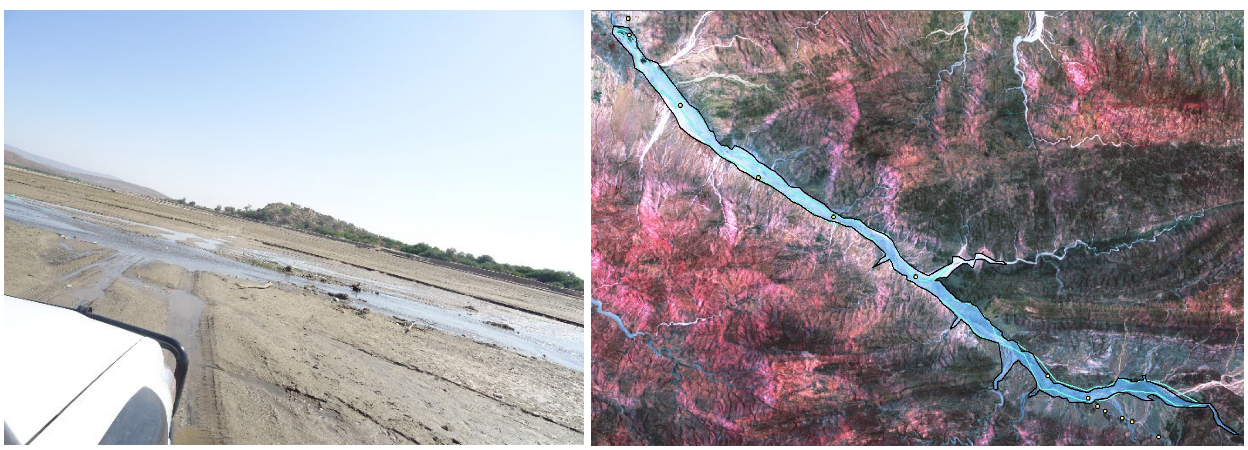

Figure 11: Water rich wadis good potential for GR4W (a) A wadi as wide as 2km on the Garbo-dadar – Lughaya Road. (b) 15 km road running within a dry wadi on Hargeisa-Garbo-dadar Road.

Significant potential to implement GR4W exists on already constructed highways. It can also be integrated into the design of planned road projects like the AfDB-financed Borama-Hego and Boraema-Djibouti projects and others that are under construction (Table 1).

7. The Hargeisa – Garbo-dadar Stretch

7.1. Characteristics of Hargeisa-Garbo-dadar Road

Four days of assessment was done along the 110km Hargeisa- Garbo-dadar dry weather road. More than 150 GPS control points were taken where hydrological features, variation in geology and structure, variation in soil, slope and land uses that are important elements to consider during the design of the road and integrated GR4W. Absence of real road and uncertainty about its future alignment was the challenge the team faced during the survey. According to the observation made and the analysis from secondary data, the followings are important features to be observed during the design and implementation of a road projects and integrate GR4W.

- **Rainfall:** ranges between 300 to 600mm (ICPAC, 2019).
- **Geology**: The first 7kms from Hargeisa is covered by Mesozoic sedimentary rocks dominated by limestone. Follow this, about 20 kms of the road is covered by Quaternary undifferentiated sediments (developed over underlying Mesozoic sediment), 20km on lower volcanics, 55km over basement, 4km on eolian sediments (Annex 1, Figure A1.2).
- **Slope:** The topography from Hargeisa to Gerbo-dadar is flat, undulating and rolling for about 50 kms. Finishing this terrain, the land becomes mountainous and rugged with steep slopes, until it approaches Grabo-dadar, where it becomes flat again (Annex 1, Figure A1.4).
- **Soil:** the soils along first 25kms from Hargeisa is sandy clay loam, derived from the underlying Mesozoic sedimentary rocks; and volcanic rocks at the northern end. Soils of loam texture dominate along 80km drive over the crystalline basement. The Garbo-dadar area has soils of clay loam texture (Annex 1, Figure A1.5).
- **Land use: The first** 35km from Hargeisa is a high-density agropastoral area with wood collection, sparce irrigation occurs. Fodder and sorghum cultivation; and camel and shoats dominate. The 70 kms stretch along the mountainous terrain -is categorized as agropastoral medium density- fields with- maize, cowpea, millet, cattle, goats. In areas closer to Garbo-dadar, for about 10kms, low density pastoral practice is dominant- shoats, camels (Annex 2, Figure A2.4).

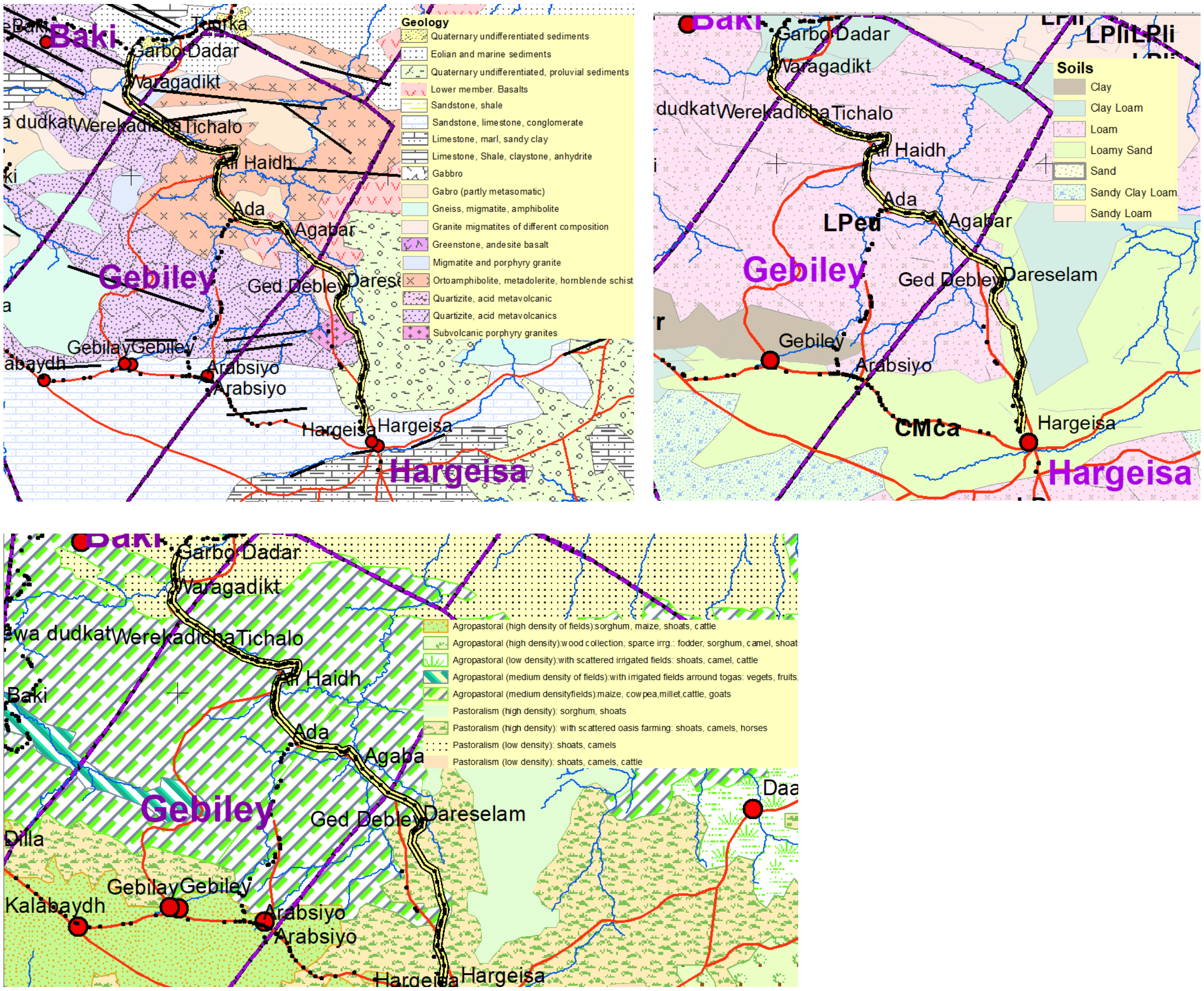

Figure 12: The geology, soil and dominant land use along Hargeisa – Garb-dadar road

7.2. Recommended Green Road for Water Measures

Limited efforts have been made to control road runoff gully erosion and natural resource management activities on the road from Hargeisa to Garbo-dadar. Among others, gabion check dams, masonry cement check dams, loose stone check dams, and soil bunds are prominent in the study area. Conservation of the catchment area that contributes runoff to the roadsides are almost entirely lacking. On top of that, the limited efforts are sporadic, and no effort has been made to support them with biological measures or to promote productive efforts.

However, the choice of appropriate road water and watershed management measures needs to be controlled by the above-mentioned characteristics of the watershed. Building an unlined pond over carbonate rock results in an empty pond immediately after the rainfall season. The inappropriate choice of groundwater recharge structures may trigger landslides in volcanic rock areas. Culverts built on unconsolidated sediments and in carbonate areas may fail due to erosion and karstification. Drifts built where sediment composition is not sandy may fail to hold water. For these and many other reasons, the following reference table is developed to guide the planning of GR4W measures in Somaliland (Tables 2, 3 and 4). Typical design and design requirements for GR4W measures for select GR4W measures are given in Annex 7.

7.3. Where to Apply Green Road for Water Measures

Criteria listed in Tables 2, 3, 4, and 5 can be used to select GR4W measures along the Hargeisa-Garbo dadar Road and landscape/watersheds on both sides of the road to be built. Percolation pits, bund structures, ponds, and additional technologies shown in Annex 7 can be used. River/stream crossings are the highest potential zone for GR4W implementation. The team identified 11 major crossings during the assessment. Proposed road-crossing structures with multiple benefits are proposed for consideration in road design (Figure 13).

Table 2: Suitability of rocks for GR4W measures

Major Lithology	Potential Challenge for GR4W
Carbonates, calcareous sediments,	Dissolution Porous & Erodible Ground
Calcareous Sandstone, siltstone	Dissolution & Erodible Ground
Sandstone, regolith and sandy recent	Erodible Ground
Basalt, rhyolites,	Flows, Cones, Plugs- not suitable
Basalt, trachyte, rhyolites	Moderate Water-Logged Ground
Sand, silt, SST, conglomerate,	Porous an erodible ground; capping and crusting in arid
Basalt, trachyte, aluvial & lacustrine	Water Logged Ground

Table 3: Suitability of soils

Soil type	Suitability for GR4W	Challenge	Intervention
Clay Loam	low	Water logging (slightly),	with lining and spill way
Loam	Excellent	construction	With/without lining
Rock Surface	Moderate	Lack of storage	Rock water harvesting
Sand	Low	Infiltration	with lining/recharge
Sandy Clay	good	Infiltration	with lining/recharge

Adopted from FAO, 1984

Table 4: Example for slope suitability range

RWH Technology	Rainfall (mm)	Slope %	Soil type	Catchment area (ha)
Ponds & Pans	>200	<5	➢ Sandy clay loam, Silty loam	<2
Check dams Terracing	<1000 200–1000	<15 5–30	➢ Sandy clay loam ➢ Sandy clay, clay loam and sandy loam	>25 -
Percolation tank Nala	<1000 <1000	<10 <10	➢ Silt loam, -Clay loam ➢ Silt loam	>25 >40

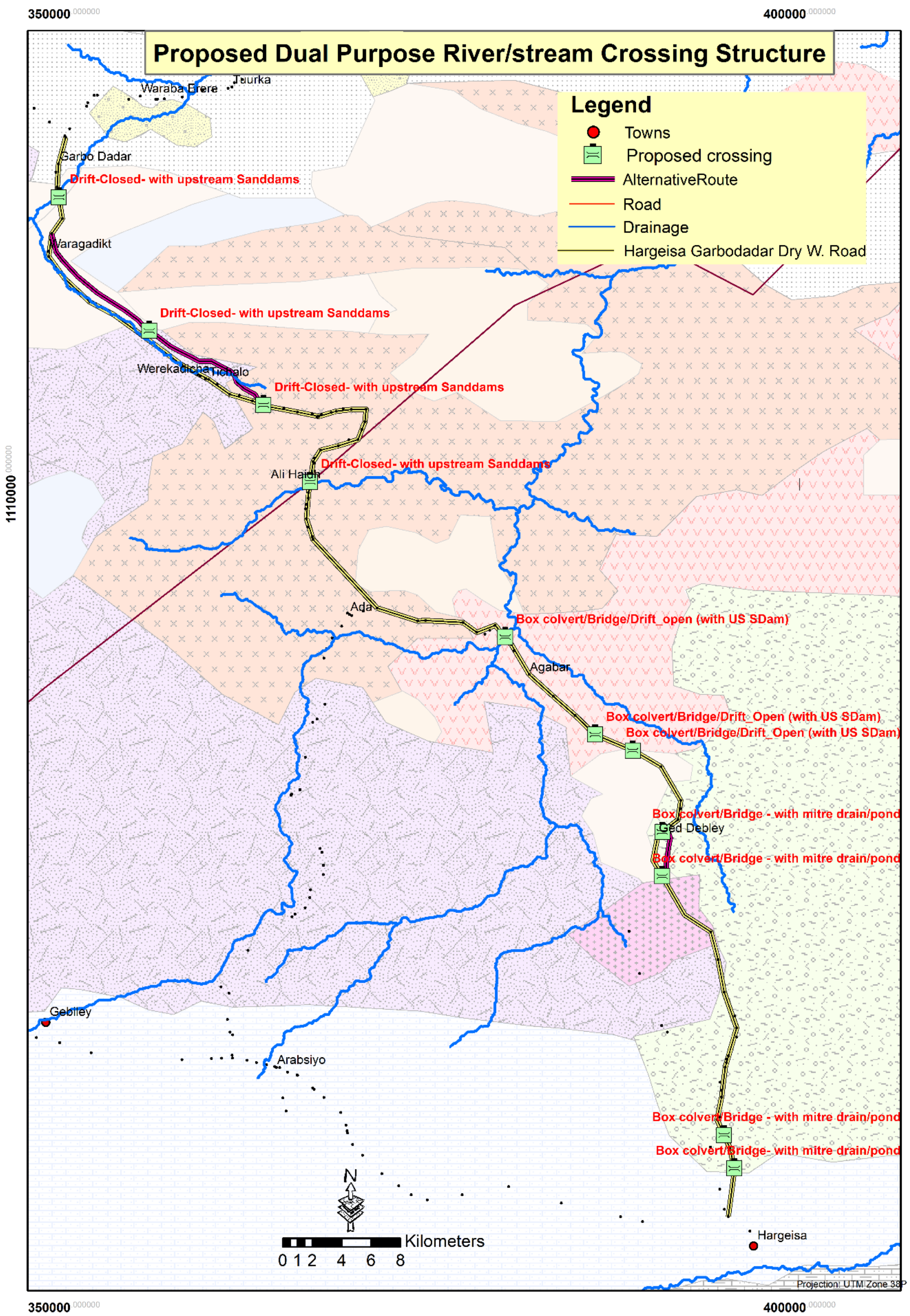

Figure13: Proposed Multipurpose River/stream Crossing and Alternative Route along Hargeisa – Garbo-dadar Ro

Table 5: Generalized Spatial GR4W Planning Guide

Parent Rocks			Major derived soil texture type	Recommended GR4W Measures and Most Suitable Areas				Allowable rainfall Range in mm	Slope range
Rock Group	Rock Type	Potential Threat for GR4W measure		Technology type (in priority order)	Aridity zone class				
					Dry Sub- humid	Semi- arid	Arid		
Crystalline Basement/Metamorphic Rocks									
Acid metamorphic rocks	– Schist, quartzite, gneiss, migmatite, slate, phyllite, pelitic rocks	– Leaking Structures- faults, joints fractures	Unconsolidated soil layer &	Sand dams, check dams, lined ponds, recharge wells, others	✓	✓	✓	<1200	0 to 50%
			Hard rock surface	Rock surface water harvesting	✓	✓	✓	All range	0 to 50%
Basic metamorphic rocks	– Schist, slate, phyllite, pelitic rocks, green, schist, gneiss rich in Fe–Mg minerals, marble, amphibolite…	– Leaking Structures- faults, joints fractures	Unconsolidated soil layer &	Sand dams, lined ponds, recharge wells, check dams, others	✓	✓	✓	<1200	0 to 50%
			Hard rock surface	Rock surface water harvesting	✓	✓	✓	All range	0 to 50%
Ultrabasic metamorphic rocks	– Serpentinite, greenstone,	– Leaking Structures- faults, joints fractures (check for heavy metal concentration, objectionable test & odour) - Water logging, - Check for WQ	Coarse-grained sand/Sandy soils/sandy loam	Sand dams, lined ponds, check dams & others		✓	✓	<1200	0 to 50%
			Hard rock surface	Rock surface water harvesting		✓	✓	All range	0 to 50%
Igneous Rocks									
Acid igneous rocks	– Rhyolite, diorite, grano-diorite, quartz- diorite, ...	– Leaking structures- faults, joints fractures	Sandy soils - soils that contain full range of particle sizes, from gravel and sand to very fine clays.	Ponds with lining, surface spread and GW recharge depending on soil conditions & others	✓	✓	✓	<1000	0 to 5%
				percolation pits, check dams, and bunds in areas of shallow bedrock conditions	✓	✓	✓	<1000	5 to 50%
Intermediate igneous	– Andesite, trachyte, phonolite, diorite- syenite	– Leaking structures- faults, joints fractures	- Sandy loam to clay soils	- Same as above	✓	✓	✓	<1000	5 to 15%
Basic igneous rocks	– Gabbro, Basalt, dolerite	– Leaking structures- faults, joints fractures – Increased evaporation in arid areas as the black color of basalt causes the soil to warm quickly	- Clayey and sticky alkaline soils.	Ponds with special design consideration to clayey wall and evaporation	✓	✓	✓	<1000	0 to 5%
				check dams& other moisture harvesting methods	✓	✓	✓	<1200	5 to 50%
Ultrabasic igneous rocks	– Peridotite, pyroxenite, ilmenite, magnetite, ironstone, serpentinite	– Structures- faults, joints fractures – Water logging, – Increased evaporation in arid areas – Check for WQ	- Clayey and sticky alkaline soils.	Ponds with special design consideration to clayey walls, water quality and evaporation	✓	✓	✓	<1000	0 to 5%
				check dams & other moisture harvesting methods	✓	✓	✓	<1200	5 to 50%
Pyroclastic rocks	– Volcanic scoria/breccia, volcanic ash	- High permeability, piping and dispersion during high flood	most of it develops into good-quality sandy loam soils	Ponds with lining, percolation pits, check dams, surface spread and GW recharge	✓	✓	✓	<1000	0 to 5%
	– Ignimbrite, tuff	- Water logging,	Clay/Clayey soils/	Ponds with special design consideration to clayey walls	✓	✓	✓	<1000	0 to 5%
				Check dams & & other moisture harvesting methods	✓	✓	✓	<1200	5 to 50%
Consolidated Sedimentary Rocks									
Clastic sediments	– Conglomerate, breccia, sandstone, greywacke, arkose,	– Highly permeable- Porosity Errodible; depending on the mineral composition of the cement. physical weathering can crack rock along bedding planes	Sandy soils, Sandy- loam soils	Ponds with lining, percolation pits, check dams, surface spread and GW recharge, if bed rocks are shallow	✓	✓	✓	<1000	0 to 5%
				Check dams & & other moisture harvesting methods	✓	✓	✓	<1200	5 to 50%
	– Silt, mud claystone, shale, ironstone		silts produce fertile agricultural soils with excellent water-holding capacities	Ponds with special design consideration to clayey wall	✓	✓	✓	<1000	0 to 5%
	– Shale	Rapid disintegration generally leads to deep soils, high in clay-size particles, so slow permeability for water.	Small particle size and poor cementation n leads to rapid physical and chemical weathering.	Ponds with special design consideration to clayey wall	✓	✓	✓	<1000	0 to 5%
Carbonatic sediments	– Limestone, other carbonate rocks, marl and other mixtures,	– Structures- faults, joints fractures – Karstification, dolins – Salinity, dissolution	Clay/Clayey soils/ as residue	Ponds, diversions to farms, bunds with special design consideration to clayey wall, joints and karsts	✓	✓	✓	<1000	0 to 5%
		Strongly affected by chemical weathering, leading to rounded edges							
Unconsolidated Sedimentary Rocks									
Weathered residuum	– Bauxite, laterite	Poor water quality-acidity objectionable test/odour	Clayey soils	Not recommended for direct use					
Fluvial	– Sand and gravel, clay, silt and loam	forms soils rich in topsoil materials brought	Sandy loam	Ponds, diversions to farms, bunds with special design consideration to structure failures	✓	✓	✓	<1000	0 to 5%
Lacustrine	– Sand, silt and clay	- possibility of salinity problem	Sandy loam, Sandy clay	Ponds, diversions to farms, bunds with special design consideration to structure failures	✓	✓	✓	<1000	0 to 5%
Colluvium	– Slope deposits, lahar	– Porosity	Sandy soils, sandy loam	Ponds with lining, percolation pits, check dams, surface spread and GW recharge, if bed rocks are shallow	✓	✓	✓	<1000	0 to 5%

Adopted from draft Road water Management Guideline for Ethiopia, 2017

7.4. Benefits from Implementation of Green Road for Water

Integration of GR4W in the future implementation of the Hargeisa-Garbo-dadar road will have multiple benefits that can serve as a model for upscaling on projects to be implemented in the future and on existing roads. Among the many benefits and opportunities, the following are notable:

A. Cash-for-work – humanitarian and transitional funding can be utilized
B. Employment opportunities: road maintenance by local community members linked to GR4W
C. Suitable topography and vegetation cover along road corridors
D. Suitable geohydrological conditions
E. High demand for water for human, livestock, supplementary irrigation, and wildlife
F. Increased fodder and agricultural productivity
G. Extensive road development that could incorporate road water management
H. Increased upstream-downstream links because of the construction of sand dams, drifts, and other water management structures along the road.
I. Presence of sandy rivers with good potential for developing water buffering road crossings and controlled sandmining
J. Enhanced soil and water conservation/land management practices that could be linked to road water management

7.5. Stakeholders' Interest

Two workshops and several ad-hoc discussions were held with various actors. The regional workshop at Borama was attended by 27 participants drawn from government institutions and NGOs working in the two adjacent provinces, Borama and Baki. The national workshop was attended by 42 participants drawn from government institutions, donor agencies, and NGOs. In addition, the national workshop was open and attended by minsters of key ministries and high-level officials. The national workshop was given a coverage by four media agencies.


In these two workshops, the concept of GR4W was introduced to participants and the potential and opportunities in Somaliland were discussed.

In addition to the two workshops, focused discussions and debriefs were held with MoPRD, MoERD, RDA, and officials from the AfDB on the way forward. In all of the discussions, the GR4W concept was highly appreciated, and the consulted institutions promised to play their roles, demanding that WHH play a proactive role in pushing for its implementation (see minutes of the national workshop in Annex 4). GR4W was also introduced to participants of a Public Dialogue on the national global environment nexus in Somaliland in the hall of the Ministry of Environment and Rural Development on 8 November 2021. During these consultation processes, a common understanding on GR4W was forged and consensus was built on the way forward. Immediate actions were suggested on the need for partnerships for planning and fundraising. **It was agreed that GR4W would be integrated into the programs of relevant ministries (Livestock, Forestry, Range, Environment, Water, Transport & Roads, Rural Development) and made part of the upcoming National Development Plan III.**

8. Recommendations

8.1. Coordinated Effort Towards Implementation of GR4W in Somaliland

According to the vision document, the Somaliland National Vision 2030, "A stable, democratic and prosperous country where people enjoy a high quality of life" is the road map for Somaliland's long term development aspirations and goals; and aims to achieve economic prosperity and social wellbeing for the people of the country, among others. The vision document sets out five economic pillars: economic, infra-structure, governance, and social and environmental. GR4W can contribute to these goals and is in line with at least four of the vision's seven guiding principles: citizen participation, sustainability, good governance, and preservation.

The term 'green-road' doesn't refer only to the road-corridors. A road in a degraded landscape/watershed, whatever beautiful and green it looks, cannot sustain its beauty without a healthy, landscape-level environment. Although they have reciprocal animosity, both water and roads are litmus papers of their environment - both indicate the level of the degradation of their respective environment. GR4W is a concept aimed in creating climate resilient roads.

Somaliland is a country under making. Its level of infrastructure development is almost at its beginning. The total road network length in the country is 9025km, of which only 1000 km is paved (1km/138km2). As more than 99% of movements of goods and people depend on roads (SRDA, 2020), and to attain the country's vision for infrastructure development, Somaliland has given the biggest emphasis for road development. There are 11 road projects of which five are under construction. Feasibility studies are underway for other projects. NGOs like WHH, Safe the Children and SOS are engaged in road construction and rehabilitation activities. SDF is financing the study, design, and construction of new roads. African Development Bank is also financing the feasibility study and construction of new roads.

In addition to the burden of having new roads, maintaining existing roads is a big challenge- the main cause of road problems being unhealthy road-water interaction. At the same time, introduction of roads to an area brings environmental imbalances including, forest clearing, wildlife disturbance, erosion, flood, and hydrological disturbances.

On the other hand, there is a missed opportunity that the construction of roads can provide. As roads are made watertight, passage of water under roads is only through road crossings. In absence of these crossings, roads act as water guiding structures that facilitate collection of water for beneficial use. The potential to harvest beneficial water along roads in Somaliland is huge. From the annual average rainfall of 300 mm in Somaliland, up to 300 m^3 of water can be harvested from 1 km stretch of road. Depending on watershed sizes, such stored water can be used for irrigation, livestock watering, and environmental restoration. What makes the opportunity in Somaliland unique is the exitance of several sand filled wadis across the roads in the lowlands, and farmlands and rangelands that can receive diverted water from roads in other parts of the country.

Easy and affordable GR4W measures minimize water loses to the Aden Sea, to which all subsurface and surface water flows. Combining multi-purpose road-crossings with watershed management makes roads resilient to climate change and minimizes the high cost of maintenance. In the Somaliland context, the implementation of GR4W measures reduces impacts from drought, floods, and cyclones, which are predicted to increase in frequency.

The implementation of GR4W is a multi-sectoral task that must take place at the landscape/watershed scale. Actors must synchronize their actions, as fragmented efforts will fail to bring anticipated results.

The coordination level among major actors in the country is not at the required level to implement GR4W. Each sector focusses on its mandate without considering what others are doing in the same watershed. Making GR4W part of the envisaged NDP III and subsequent regional and district development plans will help to address various aspects of Vision 2030 at watershed and national levels.

Major stakeholders:

- **The user community** – The community is responsible for implementation of GR4W measures at watershed and farm level. The implementation of GR4W will be the responsibility of the community and facilitated/mobilized by a village development committee/village level institution. Efforts will be organized following existing experience.
- **Ministry of Transport and Road Development** – The ministry is responsible for all affairs related to transportation and the rehabilitation of roads and bridges in Somaliland. It is also mandated to formulate policy and provide strategic guidance to other ministries and authorities, one of which is the Somaliland Road Development Authority.
- **The Road Sector** – The Road Sector Administration Board (RoSAB), the Somaliland Road Development Agency (SRDA), and the Road Fund Administration (RFA) are responsible for road development.
- **Ministry of Environment & Ministry of Rural Development** - The ministries are mandated to develop the pastoral sector and protect, conserve, and manage the environment through sustainable development aimed at eradicating poverty, improving living standards, and ensuring that a protected and conserved environment is available. As major environmental imbalances are happening along roads, the role of these ministries in implementing GR4W is vital.
- **Ministry of Water Resources Development** - The ministry is the national lead agency for the water, sanitation, and hygiene (WASH) sector and it is mandated to ensure that Somaliland citizens has easy access to clean, adequate, and affordable WASH facilities in a sustainable and environmentally friendly manner to which GR4W is instrumentally contributing.
- **Ministry of Livestock and Fishery Development** – The ministry is responsible for ensuring that livestock and fisheries resources are collaboratively developed and managed sustainably without damaging the environment. The implementation of GR4W in pastoral areas will help the ministry to deliver on its responsibility in a coordinated manner.
- **Mandate of the Ministry of Agriculture Development** – The ministry is mandated to create an enabling environment for the sustainable social and economic development of the sector with a view to improved food security. It is also expected to develop a competitive and sustainable agriculture sector

that meets household and national food security needs and ensures the prosperity of the agricultural and agropastoral communities in Somaliland.

- **Ministry of Planning & National Development** – The ministry is mandated to prepare national development plans, coordinate development efforts, and monitor and evaluate project implementation. With a mandate to coordinate various development efforts led by government, NGOs, donors, and others, the ministry can take the responsibility of ensuring that GR4W is incorporated in the sector plans of major actors and that funding is available and implemented.

Cooperating stakeholders:

- **The private sector** - Interested in contributing, because GR4W is beneficial to owners of commercial farms along existing roads. Areas of high investment potential need reliable access roads.
- **Donor agencies** - SDF, World Bank, AfDB, FAO, IFAD, KFW, SDF and WFP, ECHO, SHF as a contributor of cfw funding
- **NGOs** - WHH, Save the Children, SOS and many others
- **Ministry of Public Works**, Land and Housing - To allocate land and ensure land use is environmentally sustainable.
- **Ministry of Employment, Social Affairs and Family** - To use the opportunity of GR4W for job creation and youth employment, e.g., by specialized GR4W Work Teams along major roads under development.

Proposed Cooperation Arrangement and Roles of Lead Actors

The process of implementing GR4W in Somaliland may start with the establishment of a steering committee led by MoPND, with MoTRD/RDA as secretariat. The steering committee establishes a technical working group to prepare a joint plan and implementation strategies. Focal persons need to be assigned in key institutions for routine follow-ups.

Roles and Responsibility of Key Sectors

- National Planning**:** GR4W is a multi-stakeholder coordination effort, and it should be part of the national planning process. Joint planning, resource allocation, and prioritization of activities requires the inclusion of GR4W in the national development plan and coordination by a strong institution. In this case, as suggested above, MoPND is appropriate to play this role and MoAD and MoLFD to play the implementation role in collaboration with MoTRD and MoERD.

- Transport and Road Development**:** MoTRD/RDA a lead implementer of GR4W with the objective of making roads climate resilient, reduce maintenance cost and ensure multiple benefits of roads.

- Water: the water sector shall cooperate with the MoTRD/RDA to ensure that any road maintenance and road planning and construction plans do not disrupt beneficial water flows, help to protect communities from destructive flooding, strive to manage water in order to reduce loss of water to the sea, and provide water for rangeland, agriculture, and animal consumption.

- Environment: The MoERD will MoERD will cooperate with the MoTRD/RDA to ensure that no environmental damage occurs, such as erosion, destruction of valuable vegetation, or the disruption of environmentally beneficial water flows during the implementation of GR4W. Wherever possible, roads must be built to enhance stability and recovery of soils and vegetation, be it forest, single value trees or rangeland. This can be done through water retention and infiltration by the roads forming a dam, by spreading water passing through culverts evenly in open land or directed to specific environmentally valuable plots of land. Every major environmental project should include the 'environmental proofing of roads' under the activities.

- Agriculture and livestock: play active role in the implementation of GR4W to benefit the agriculture and livestock sectors by making substantial amounts of water and nutrients available for fodder production and supplementary irrigation, avoiding possible damage to grazing and agricultural lands, and minimize damage from dust.

8.2. Creation of Enabling Environment for Successful Implementation of GR4W

- Integrate GR4W into road and watershed management programs.
- Engage the community and the private sector.
- Revisit procedures, manuals, and standards for road development.
- Allow investment and maintenance budgets for GR4W components.
- Foster cooperation among key actors.
- Instrumentation- install gauging and monitoring stations.
- Build capacity:
  - Short courses
  - Introduce and provide tools - make use of available resources, like satellite rainfall estimates, images, ad DTMs, to fill planning data gaps.
- Road water assessments – identify the best options for GR4W along selected roads.
- Work with engineers and implementers to design better practices.
- Develop guidelines specific to the country and its context.
- Provide training and coaching towards a change in culture and governance for GR4W.
- Develop strategies to optimize the wider socioeconomic benefits of road development and road construction.
- Consider the formation of professionalized work teams with basic, high-quality equipment.
- Institutionalize a collection and documentation of best practice by NGOs and private entities and organize dissemination (responsible: MoTRD/RDA, secretariat WHH)
- Organize annual workshops to oversee progress in the GR4W development in Somaliland
- Create and link focal points for GR4W in all relevant Ministries, UN agencies and NGOs for ongoing exchange and preparation of annual workshops

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Annex

Annex 1: Geology, Geomorphology, and Soils in Somaliland

Geology

Somaliland has a complex geology and structural setting that make it rich in mineral resources. The country is almost all rocks of the three major rock categories. The geology of the surveyed part of Somaliland is dominantly covered by eolian and marine sediments. This unit covers areas along the coast and is dissected by radiating wadis. However, quaternary undifferentiated proluvial sediments are more abundant in the southeastern part of the mapped area, as shown in Figure A1.2. Mesozoic sediments, which are composed of sandstone and shale layers, are also exposed south of this unit.

Table A1.1: The lithological covers of Western Somaliland

Geology	Area in Ha	Percent
Eolian and marine sediments	1007052	24.4
Quaternary undifferentiated, proluvial sediments	1379658	33.4
Sandstone, shale	743795	18.0
Limestone, Shale, claystone, anhydrite	375196	9.1
Lower member. Basalts	281603	6.8
Crystalline Basement Rocks	347509	8.4

Areas between Hargeisa and Garbo-dadar, except for the southern and northern ends, are predominantly covered by crystalline basement rocks. The northwest-southeast trending faults dissect the area and control its hydrological characteristics. The same is true for the Garbo-dadar-Borama stretch, except for the for the occurrence of carbonate north of Baki. Areas around Hargeisa and the Gabiley-Hargeisa stretch are covered by limestone, shale, claystone, and anhydrite rocks (Table A1.1). Roads that cut through the Mesozoic sedimentary rocks are affected by deep karstification, which manifests as deep galleys. Roads cutting across the basement crystalline rocks along the Hargeisa-Garbo-dadar stretch are dry stream beds that are impassable during heavy rainy seasons (Figure A1.1 and A1.2).

Figure A1.1: Major rocks: Mesozoic Sedimentary Rocks (left) and the Crystalline Basement Rocks right

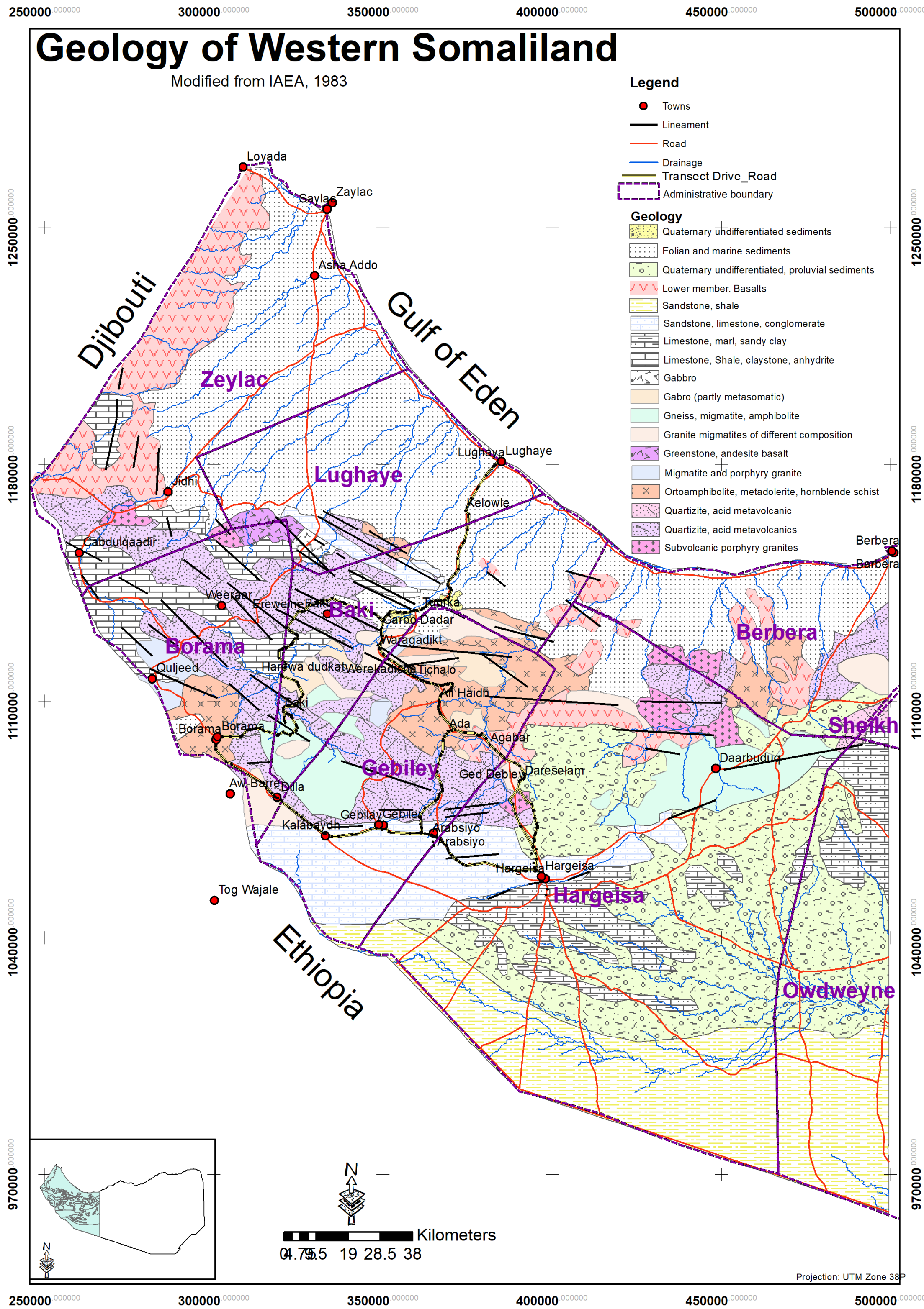


Figure A1.2: Geological map of Western Somaliland. Modified from IAEA, 1983

Geomorphology

The northwest and the southeast of western Somaliland have flat and undulating morphology. The central region is a highly rugged mountainous area with alternating valley floors between the east-west trending mountain ranges. Elevation ranges from below zero along the coast to 1,962 masl towards the central-eastern area (Table A1.2, Figure A1.3 and A1.4).

Table A1.2: Slope in western Somaliland

Slope Class	Slope in percent	Area in ha	Area in percent
Flat	Less than 2	487878	12.1
Undulating	2 to 8	2337030	58.1
Rolling	8 to 15	676477	16.8
Moderately steep	30 to 45	284213	7.1
Steep	45 to 60	149951	3.7
Extremely steep	Above 60	85780.5	2.1

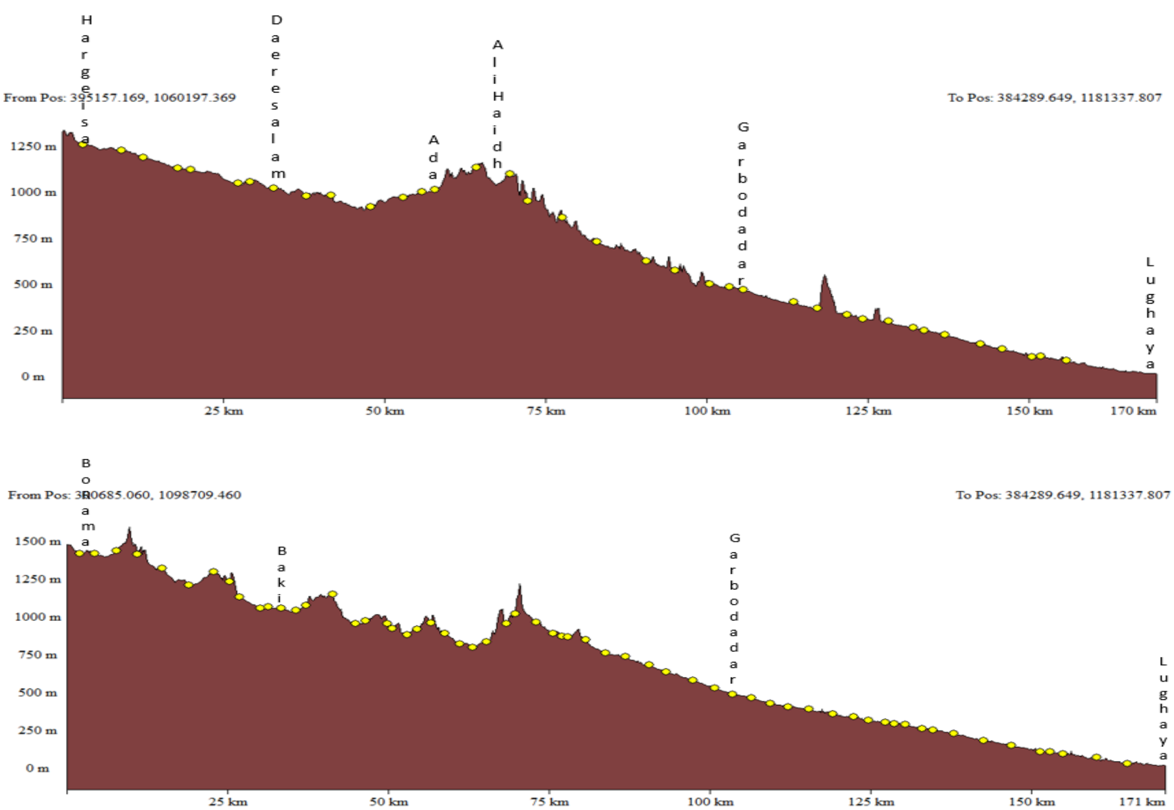


Figure A1.3: Landscape profiles: Hargeisa-Lughaya (top) and Borama-Lughaya (bottom)

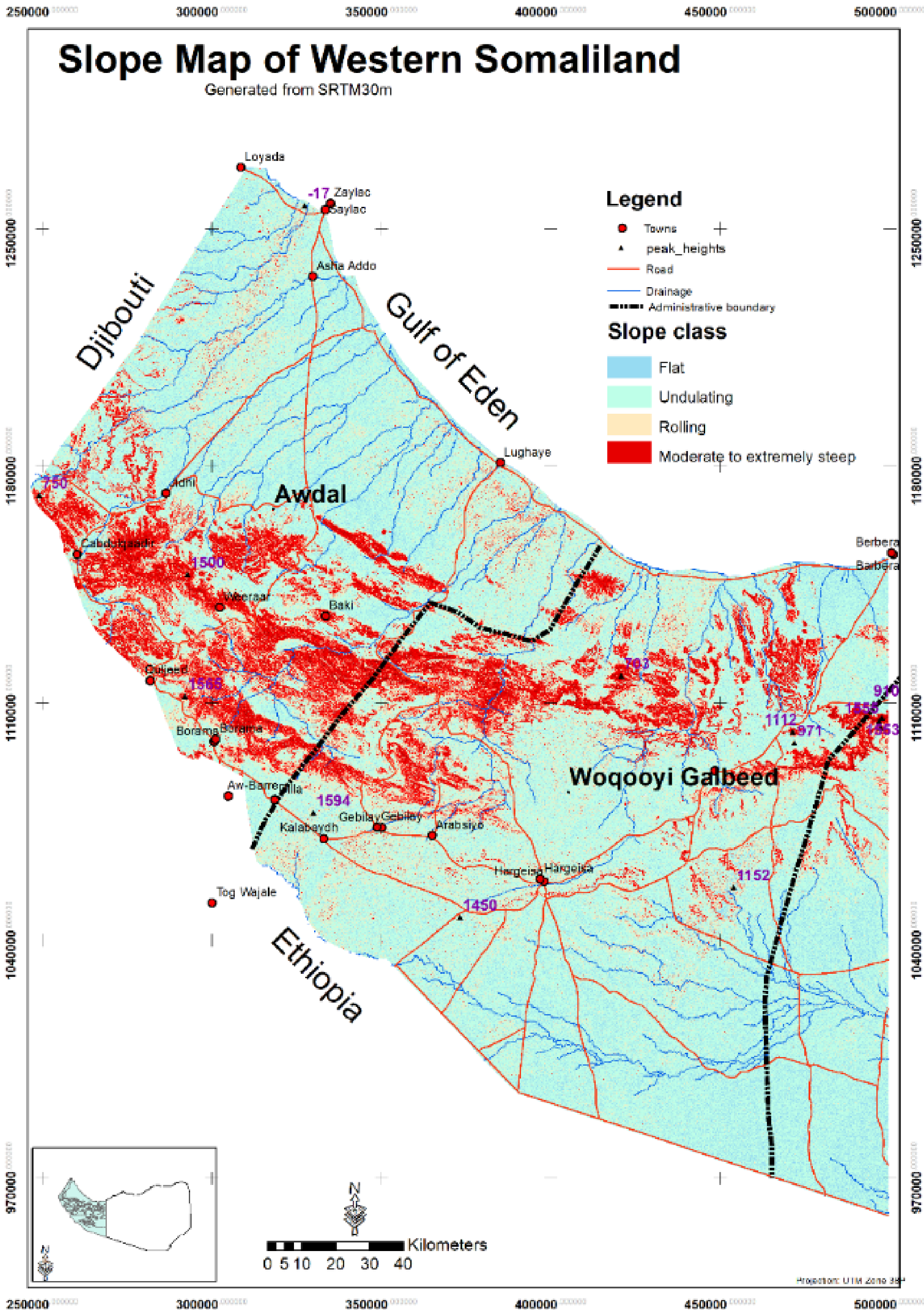


Figure A1.4: Slope map of western Somaliland generated from STM30m

Soils and Landform

Soils

The soil types in Somaliland have a one-to-one relationship with the parent rock types, geomorphology, and climate elements. The soils along the coast are haplic arenosols and sandy in texture. The central, predominantly basement and mountainous areas are covered by eutric leptosols of loamy texture. Petric calcisols and calcaric cambisols are dominant over the Mesozoic sedimentary terrains of the southeast (Table A1.3 and Figure A1.5).

Table A.1.3: Soils of western Somaliland

FAO Class	Texture	Area in ha	Area in Percent
Calcaric Cambisols	Loamy Sand	287856	7.0
Calcaric Regosols	Sandy Loam	260603.73	6.3
Chromic Cambisols	Clay Loam	381752.8	9.3
Eutric Cambisols	Loam	16.3943	0.0
Eutric Fluvisols	Sandy Loam	29855.26	0.7
Eutric Leptosols	Loam	709267.85	17.3
Haplic Arenosols	Sand	691132	16.8
Haplic Solonchaks	Clay Loam	90349.6	2.2
Haplic Vertisols	Clay Loam	19444.1	0.5
Lithic Leptosols	Loam	735879.81	17.9
Petric Calcisols	Sandy Clay Loam	845873.9	20.6
Vetric Cambisols	Clay	58166.4	1.4

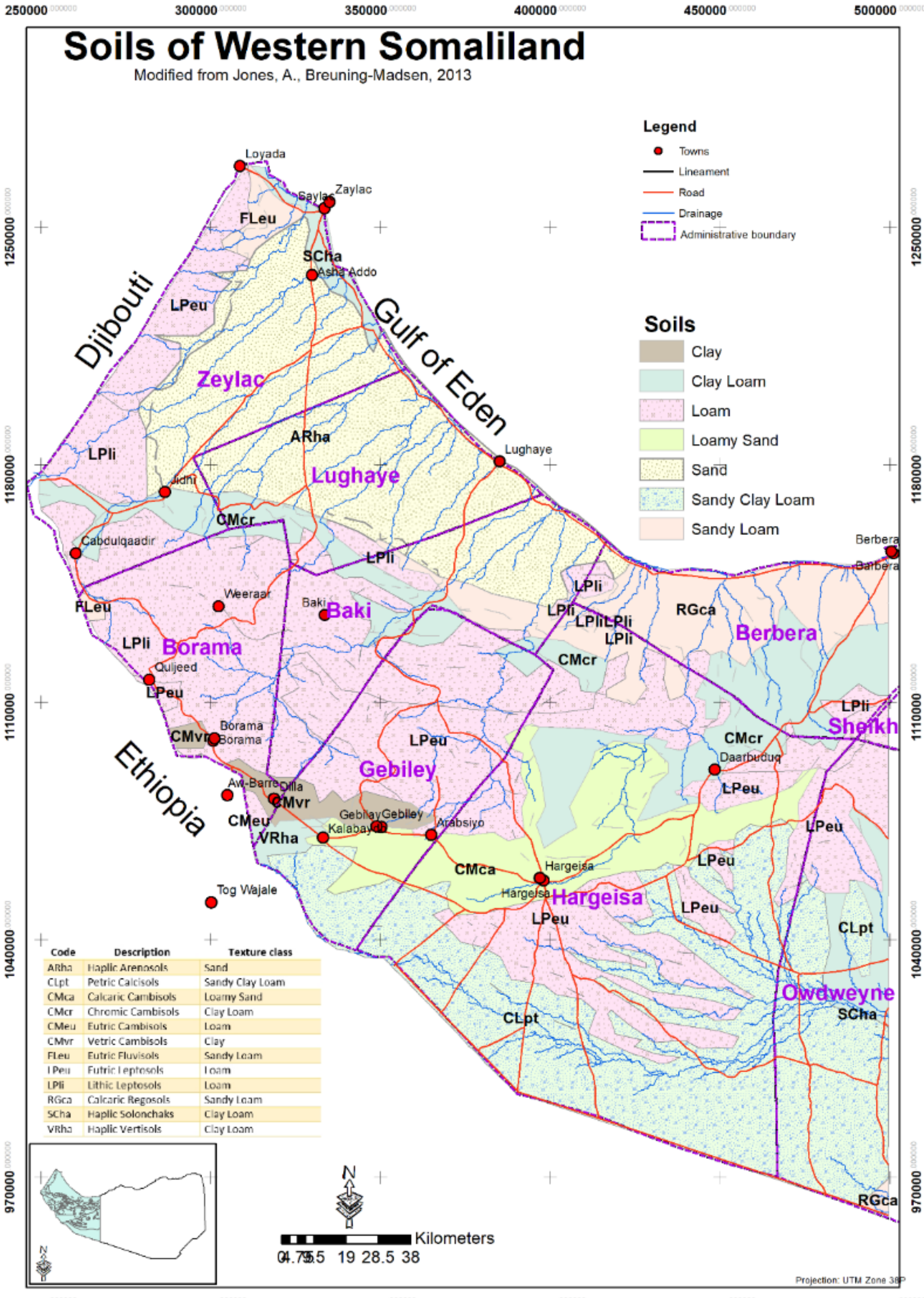


Figure A1.5: Soil map of western Somaliland modified from Jones, A., Breuning-Madsen, 2013

Landform and Soils

The landform of the visited area falls under four major landform categories and four major soil units: mountainous and hilly; plateaus and level flat land; valleys and river fan; and coastal and piedmont.

- <u>Mountainous and Hilly</u>

On the road from Hargeisa to Garbo-dadar, on both the right side (heading east) and the left (heading west), a very rugged mountainous and hilly topography surrounds the study area. The road is located in the plateau and level land, passing valleys and river fans at certain locations. The area's soils are characterized by limited pedogenic development and a weak soil structure. Most soils are very shallow.

In this land unit, the soils are Leptosols—shallow soils over hard rock and extremely stony soils with little fine earth. Trees and shrubs with their more extensive roots are better able to penetrate to deeper strata than annual crops and are often the best forms of land use. Currently, communities use this land unit for extensive nomadic browsing of goat, sheep, and camel. These mountains and hills are very steep. Almost all the rainfall is converted into runoff causing erosion unless it is protected with soil and water conservation measures or protected by natural vegetation.

This unit is the major runoff contributing area for the plateaus and valleys. The road crosses this area and causes erosion damage. Catchment treatment or conservation works on the upper catchment area, following wise use principles, is essential to reducing the impact of erosion on the lower slope areas.

Figure A1.6: Photo showing Mountainous and Hilly & Plateaus and Level flat Land around Garbo-dadar

- <u>Plateaus and Level flat Land</u>

Gently undulating, almost flatlands and plateaus at the foot slope position are characteristics of this unit. In terms of soils, the area is predominantly covered by calcisols and arenosols. The calcisols are mainly found along the route from Hargeisa to Daresalam and the arenosols are predominantly found from Daresalam to Garbo-dadar and towards the Aden Gulf coast.

Calcisols are widespread in the plateau and level areas of the study area from Hargeisa to Daresalam. This area is associated with highly calcareous parent materials and the substantial accumulation of secondary carbonates. Calcisols originated from the alluvial and colluvium matter of the surrounding hills and mountains. Vast areas of so-called natural calcisols are found under shrubs, grasses, and herbs that are used for extensive grazing and browsing. Drought-tolerant crops such as sorghum are cultivated sporadically with runoff interception bunds to supplement in-situ rainfall moisture. The soils are expected to be poor in terms of nitrogen and phosphurs thus, making them unsuitable for crop cultivation unless fertilized with these nutrient elements. Fertilization with animal dung, as informed by locals, is almost non-existent.

Arenosols (from Latin, arena, meaning sand) are soils with a higher proportion of sand. Arenosols are easily erodible sandy soils with low water- and nutrient-holding capacity. These soils are predominately found on the routes from Daresalam to Gabo-dadar and further to the coast. The soils are made of unconsolidated, structure-less, trans-located materials of sandy texture and predominate in the arid climatic zone. The landforms of the region range from recent dunes and sandy plains to very old plateaus. The vegetation ranges from desert to scattered vegetation (mostly grassy). With no soil development, the area is unfit for annual crop farming.

The arenosols of the study area developed as a result of the in-situ weathering of quartz-rich parent material of the up-slope position and from recently deposited sands (e.g., dunes). It is the most extensive soil type in the area. Soil formation is limited by a low weathering rate. The characteristic that all arenosols have in common is their coarse texture, accounting for their generally high permeability and low water and nutrient storage capacity. On the other hand, where moisture is adequate, arenosols offer ease of cultivation, rooting, and harvesting of root and tuber crops. Currently, the arenosols of the study area are predominantly used for extensive (nomadic) grazing and browsing. Low coherence, low nutrient storage capacity, and high sensitivity to erosion are serious limitations of arenosols.

With irrigation, the cultivation of sorghum, cowpea, fodder crops, pulses, and melons is possible. Deep rooting plants are more suitable than those with shallow roots. Uncontrolled grazing and clearing for cultivation without appropriate soil conservation measures can easily destabilize these soils, reverting them to shifting dunes.

- Valleys and River fan

The valley and river fan units are located between the dissected terrains of the above physiographic units. They are found in the creek valley and dry river valleys river fan area at the foot slope position of the above topographic units. The soils of these units are predominant arenosols and fluvisols that originated from eolian deposits and alluvial deposits respectively.

The fluvisols are soils of the fluvial deposit located in the dry river plains and or fans. The soils of these environments display evidence of stratification (layering), which reflects deposition of the parent material. As seen in the photos in Figure A1.7, the horizontal strata of the fertile loamy sediments are very evident. Changes in color and textural stratification reflect specific flood events or past soil development.

Fluvisols occur in all periodically flooded areas such as flood plains, river fans, and valleys. Fluvisols show a layering of sediments with pedogenic horizons as a result of deposition by water. Their characteristics and fertility depend on the nature and sequence of the sediments and length of periods of soil formation after or between flood events. Soil profiles with evidence of stratification, weak horizon differentiation, but a distinct topsoil horizon may be present.

Fruit orchard plantations such as lemon/citrus, guava, papaya, and mango and vegetable cultivation such as tomato, onion, and pepper are widespread in the fluvisols of the study area, with underground shallow well pumping combined with spate diversion commonly used in the management of these soils.

It is observed that these land unit are exposed to the risk of gully erosion by water due to the weak cementation, poor consolidation, and low cohesion of the soils.

- <u>Coastal and Piedmont</u>

This land unit is dominated by sandy soils along the coast. This unit is not addressed under the present study.

Figure A1.7: Photo showing fluvisols at the foot slope position left near Hargeisa and the right near Gabo-dadar

Annex 2: Climate, Land use and vegetation in Somaliland

Climate

The annual rainfall in Somaliland is distributed over a period of two rainy seasons -“Gu and Deyr”- indicating how short the rainy season is in the study area (Figure A2.1). The prevalence of arid and semi-arid conditions increases the risk of gully development because the presence of plants can be tentative and fragile. In these circumstances, understanding and maintaining the natural balance can be the key to gully prevention. Native plant cover needs to be protected. If native cover is gone, restoration, replacement, or other stabilization measures may be needed to control exposed soil, erosion, and the erosion caused by concentrated flow.

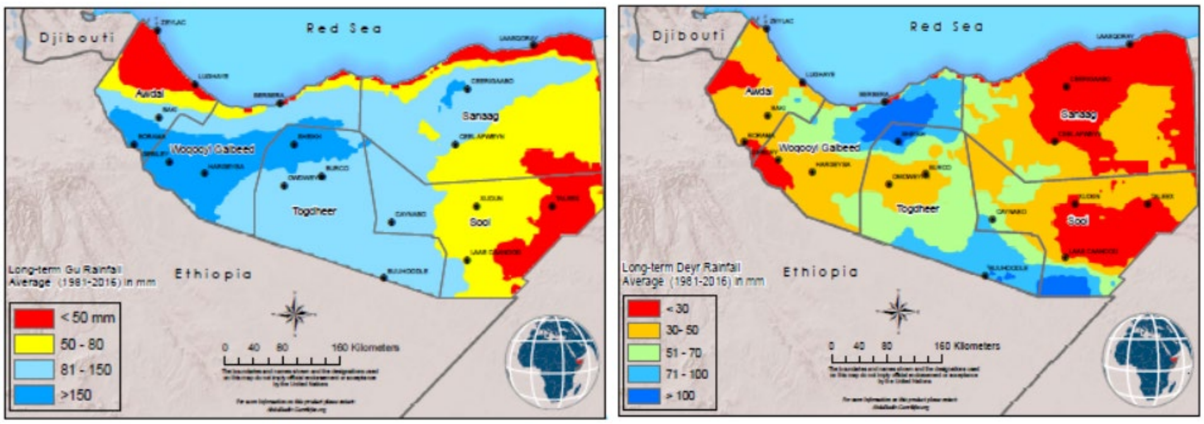
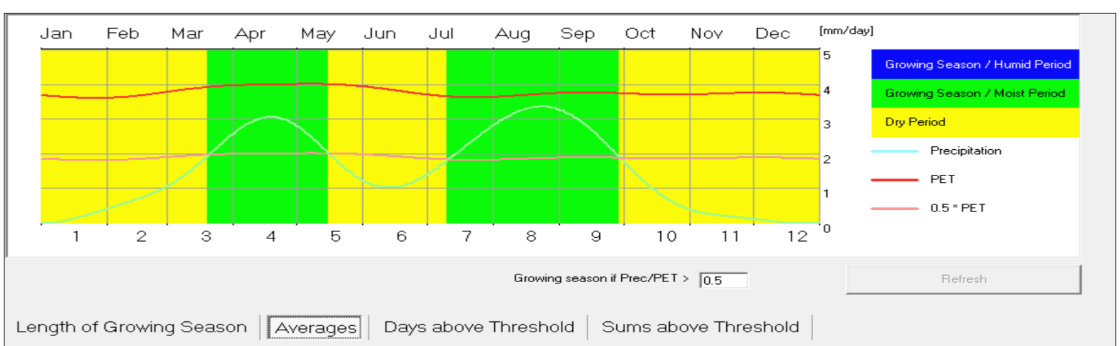


Figure A2.1: Rainfall distribution: Gu season from 1981 to 2016 (left); and Deyr season from 1981 to 2016 (right)

Based on information derived from the FAO’s local climate estimator (FAO, 2005), the growing period for the semi-arid area is 81 during the Gu rainy season and 57 days during the Deyr rainy season (Figure A2.2a). On the other hand, in the arid climatic zone there is no growing period (Figure A2.2b). The growing period is the period of the year when both moisture and temperature conditions are favorable for crop growth. The beginning of the growing period (the onset) starts when rainfall (RF) is equal to or greater than half PET (P≥0.5 PET), marking the start of the normal rainy season. The end of the growing period occurs when the precipitation curve re-crosses the half PET (P<0.5 PET) (FAO, 1983).



Period	Nr.	Length Days	Begin Date	Begin Day	End Date	End Day	T_Mean °C	T_Min °C	T_Max °C	Precip. mm/day	PET mm/day	Wind Speed km/h	Sun fract. %	Vapor Pressure hPa
Dry	1	55	16 MAY	136	9 JUL	190	20.6	15.2	26.6	1.3	3.8	5	52.2	15.6
Moist+Hum.	1	57	20 MAR	79	15 MAY	135	20.3	13.6	27.4	2.7	4	4.4	56.2	14.3
Dry	2	172	29 SEP	272	19 MAR	78	17.5	9	27.1	0.5	3.7	5.2	67.3	10.2
Moist+Hum.	2	81	10 JUL	191	28 SEP	271	20.1	15.3	25.9	2.8	3.7	4.7	47.3	14.9

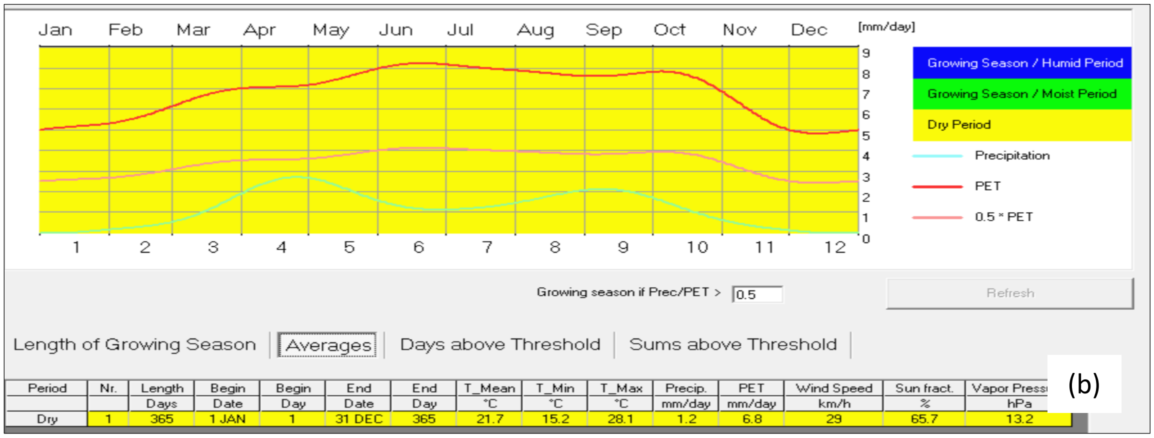


Figure A2.2: Length of growing periods: LGP in the semi-arid climatic zone (a) LGP in the arid climatic zone (b)

The very short growing period results in the need for proper conservation and use of available rainfall moisture through appropriate technologies that can include flood water diversion, flood water harvesting techniques and soil- and water retention structures for infiltration, both for rangeland management and dry-land farming from the road drain. One of the climate concerns that makes GR4W critically important for Somaliland is future climate conditions, which are predicted to have frequent extremes. The frequency and magnitude of hazards related to climate variability and extreme events has been increasing in recent decades. Tropical Cyclone Sagar, formed in the Gulf of Aden between Yemen and northern Somalia on 16 May 2018, gained strength by 18 May, reaching tropical storm-wind levels and causing heavy rains that washed thousands of tons of soils into the ocean (https://reliefweb.int/disaste) (Figure A2.3). The largest concentration of fatalities was reported in coastal Galbeed and Awdal, where the cyclone made landfall. Houses were destroyed and livestock washed away or killed by hypothermia. The heavy rains and subsequent flooding hindered the ability of aid workers to access some of the areas affected by the cyclone to assess the extent of the damage and assist. The tropical depression itself has remained over parts of Ethiopia, Djibouti, and northwest Somaliland, about 140 km from Hargeisa (OCHA, 20 May 2018)

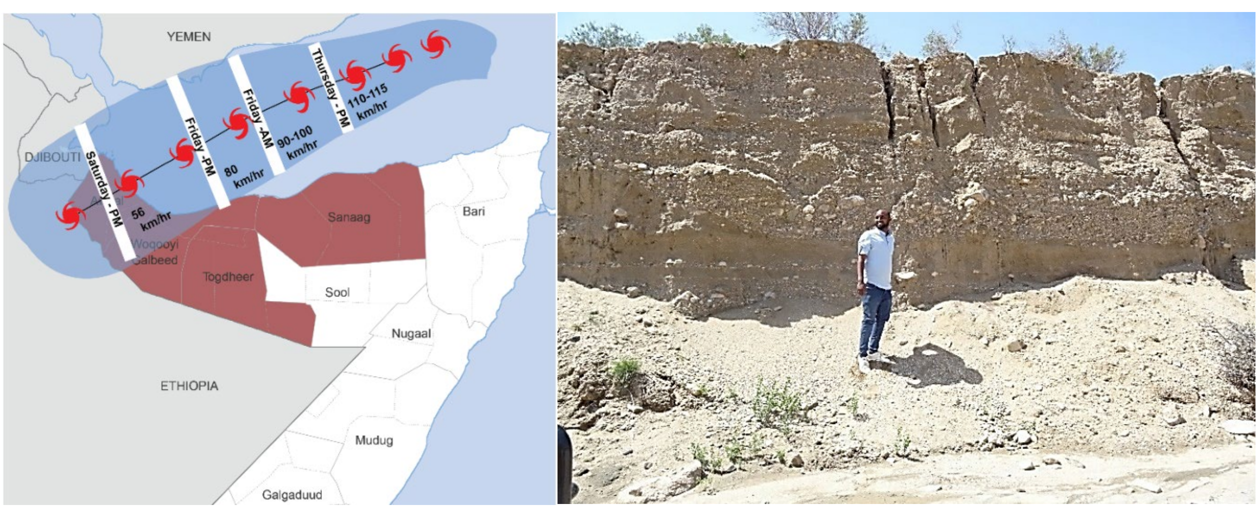


Figure A2.3: The Tropical Cyclone Sagar: The speed in the three days left (OCHA, 2018); and its impact on the vulnerable soils- about five meters of soil was washed away from this site; a village complete destroyed (Right)

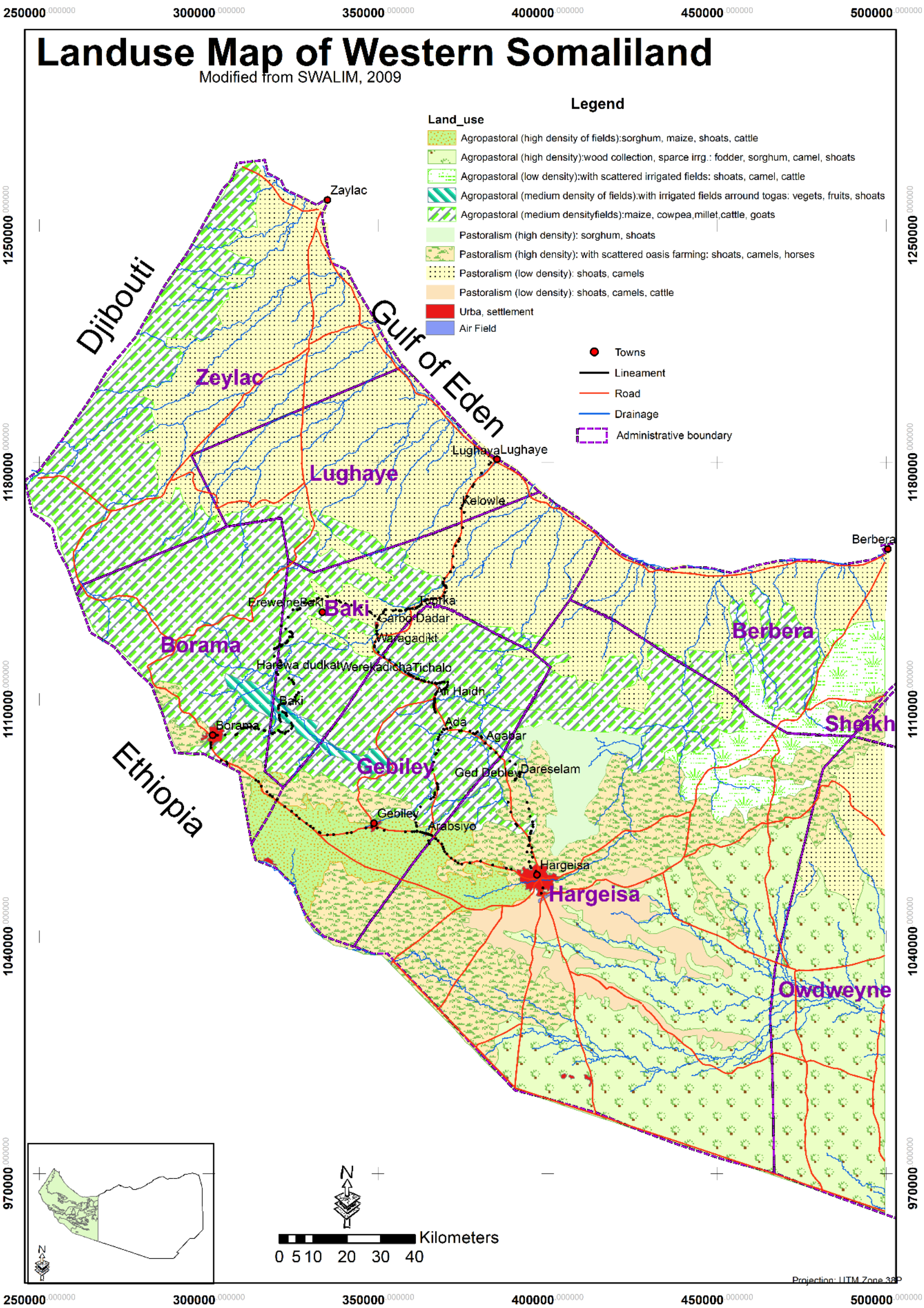
Based on estimations on Sentinel image of before and after the cyclone, we see a 55% increase in the size of dry wadis along the 65 km Hargeisa-Qabri Bahar stretch. The wadi, which was only 3,387 ha, has grown to 5,246 ha. Settlers who lost their arable land have moved to higher ground. Consulted community members are still afraid of wadi encroachment during every rainy season.

Land use and Vegetation

The land use types in western Somaliland are presented in Table A.2.2 and Figure A2.4.

Table A2.2: Land uses in western Somaliland. Source: SWALIM, 2009

Land use	Dominant Soil	Area in ha	Area in percent
Pastoralism (low density): shoats, camels	Haplic Arenosols	1083110.0	26.4
Pastoralism (high density): with scattered oasis farming: shoats, camels, horses	Eutric Leptosols	4039.5	0.1
Agropastoral (medium density fields): maize, cowpea, millet, cattle, goats	Eutric Leptosols	189186.0	4.6
Pastoralism (high density): with scattered oasis farming: shoats, camels, horses	Vetric Cambisols	31349.4	0.8
Agropastoral (low density): with scattered irrigated fields: shoats, camel, cattle	Chromic Cambisols	139325.0	3.4
Pastoralism (low density): shoats, camels	Eutric Leptosols	73526.2	1.8
Pastoralism (high density): with scattered oasis farming: shoats, camels, horses	Calcaric Cambisols	272644.0	6.6
Pastoralism (low density): shoats, camels, cattle	Eutric Leptosols	134618.0	3.3
Agropastoral (medium density fields): maize, cowpea, millet, cattle, goats	Lithic Leptosols	913416.0	22.2
Agropastoral (high density): wood collection, sparce irrigation.: fodder, sorghum, camel, shoats	Petric Calcisols	755855.0	18.4
Pastoralism (high density): with scattered oasis farming: shoats, camels, horses	Petric Calcisols	187281.0	4.6
Agropastoral (high density of fields): sorghum, maize, shoats, cattle	Calcaric Cambisols	152047.0	3.7
Pastoralism (high density): sorghum, shoats	Chromic Cambisols	61202.6	1.5
Agropastoral (medium density fields): maize, cowpea, millet, cattle, goats	Chromic Cambisols	71361.8	1.7
Pastoralism (high density): with scattered oasis farming: shoats, camels, horses	Vetric Cambisols	8163.8	0.2
Pastoralism (high density): with scattered oasis farming: shoats, camels, horses	Vetric Cambisols	6808.0	0.2
Agropastoral (medium density of fields): with irrigated fields around togas: vegetables, fruits, shoats	Lithic Leptosols	25161.3	0.6


Landuse Map of Western Somaliland
Modified from SWALIM, 2009
Legend
Land_use
Agropastoral (high density of fields):sorghum, maize, shoats, cattle
Agropastoral (high density):wood collection, sparce irrg.: fodder, sorghum, camel, shoats
Agropastoral (low density):with scattered irrigated fields: shoats, camel, cattle
Agropastoral (medium density of fields):with irrigated fields arround togas: vegets, fruits, shoats
Agropastoral (medium densityfields):maize, cowpea,millet,cattle, goats
Pastoralism (high density): sorghum, shoats
Pastoralism (high density): with scattered oasis farming: shoats, camels, horses
Pastoralism (low density): shoats, camels
Pastoralism (low density): shoats, camels, cattle
Urba, settlement
Air Field
Towns
Lineament
Road
Drainage
Administrative boundary
Djibouti
Gulf of Eden
Ethiopia
Zeylac
Lughaye
Baki
Borama
Gebiley
Berbera
Sheikh
Hargeisa
Owdweyne
Zaylac
Lughaye
Kelowle
Berbera
Hargeisa
Gebiley
Arabsiyo
Dareselam
Agabar
Ada
Ali Haidh
Garbo Dadar
Waragadikt
Borama
Kilometers
0 5 10 20 30 40
N
Projection: UTM Zone 38P
250000
300000
350000
400000
450000
500000
1250000
1180000
1110000
1040000
970000

Annex 3: Mission Program

Scope for Opportunities for Green Roads for Water in Somaliland

Green Roads for Water Initiative

MetaMeta is a social enterprise, deeply engaged in water and natural resources management. MetaMeta also works on climate resilience, land scape management, groundwater governance, regenerative agriculture, and innovative learning. Green Roads for Water, a MetaMeta Initiative promotes the beneficial use of roads as instruments for better water management, landscape restoration and climate change adaptation. The aim of this initiative is to improve the livelihoods and resilience of communities living around roads and reduce the negative impacts such as erosion, flooding, sedimentation, and dust while improving the climate resilience of road infrastructure itself and reduce water-related road damage. Green Roads for Water interventions have been successfully implemented in more than ten countries across the world including Ethiopia, Kenya, Uganda, Malawi, Nepal, Bangladesh, Tajikistan and Bolivia among others. Based on experience and learning through pilots, global guidelines have been drafted which have been officially published by The World Bank (access the Green Roads for Water guidelines through this link). Green Roads for Water services include:

- Road water assessments – identifying the best options along selected roads
- Working with engineers and implementers to design better practice
- Developing guidelines appropriate to specific countries and situations
- Training and coaching towards a change in culture and governance for green roads for water
- Developing strategies to optimize the wider socio-economic benefits of road development and road construction

Scoping Study in Somaliland (in collaboration with Welthungerhilfe)

As requested by Welthungerhilfe Somaliland, MetaMeta prepared a proposal to undertake a scoping study on the issues and opportunities for Green Roads for Water in Somaliland. The assignment would be based on previous work in other countries and would make use of materials developed by the Green Roads for Water Learning Alliance.

The activities will consist of:

- Preparatory and support activities
- Transect road visits to assess and document opportunities for road water harvesting/management
- Discussion in the country with stakeholders at the national and regional levels (the latter combined with transect road visits) to explore issues and opportunities and identify ongoing programs in which better integration of roads and water management can be promoted.
- One- or two-day workshop with the main stakeholders, discussing and agreeing on the opportunities of road water management in Somaliland – leaving behind a basic training package.
- Reporting on the issues and opportunities for Green Roads for Water in Somaliland and the way forward and after care (follow up discussion by video conference if required)

The deliverables include:

- Field assessment of opportunities in the shape of a report with images and clips.
- Report with agreed findings and way forward.
- Workshop presentation transformed into a training package.

Several road stretches would be selected for the assessment in collaboration with Welthungerhilfe Somalia. We proposed a 10-day road assessment (50 km per day including interviews along the roads). This required the work of two MetaMeta experts for three weeks. The timeline of the 3-week assignment is presented below:

Activities		
Arrival, kick-off briefing and preparation of the fieldwork in collaboration with Welthungerhilfe	Week 1 (1 day)	Prepare a daily schedule for the road assessment as well as logistical arrangements, agreeing on road section representative road sections
Visit to main organizations related to green roads for water,	Week 1 (1-2 days)	Collecting back ground data on road development, agricultural development, droughts and floods
Transect road visit in the selected road stretches to assess and document the opportunities for road water harvesting/ management (keeping notes and photo & video documentation)	Week 1 & 2 (10 days)	Also make visits to Provincial Offices Preference is: - feeder roads - all weather roads - diversity of conditions
Discussion with stakeholders at national and at regional levels (the latter combined with transect road visits) to explore issues and opportunities and identify on-going programs in which better integration of roads and water management can be promoted – discuss possible actions Report writing	Week 3 (6 days)	Suggested governmental departments/organizations to visit: - Disaster risk reduction - Water department - Agricultural department - Pastoralist livestock department - Forestry department - Roads department - Cash/ food for work programs - Welthungerhilfe and partner's offices
Workshop for one day with main stakeholders discussing and agreeing on the opportunities of road water management in Somaliland – make action plan	Week 3 (1 day)	Objective of workshop - present field assessment - explore scope for beneficial road water use for resilience discuss the way forward Welthungerhilfe to support with arranging the Venue for the workshop and suggesting participants.
Preparation of the report on 'Issues and Opportunities for Green Roads for Water in Somaliland'; after care contacts	Week 4	

<u>Protocol for road assessment as part of Welthungerhilfe's assignment on introducing Green Roads for Water in Somaliland</u>

In total, 500 km of roads would be assessed located in …. Area. The types of roads to be surveyed include highway/asphalt, feeder road/gravel and feeder road/earthen.

For selected road stretch**es**, a GPS, a camera and a vehicle should be used to move along. The coordinates at a point of interest and descriptive notes will be taken **based on interviews with local people** or by observation. A point on or along a road will be noted if it has one or more of the following:

- Faults, damages to the roads
- Main drainage structures (e.g. drains and culverts)

- Road side vegetation
- Road-induced erosion
- Road-induced/ influenced flooding
- Road-induced waterlogging
- Road-induced sedimentation
- Effect on well points
- Effect on wind erosion/ sand dunes
- Existing water harvesting, water recharge practices along roads
- Borrow pits nearby road, status and use
- Road crossings (design and issues)
- Trees by the roadside
- Other interesting features
- Current use/ non-use of water

In addition, in 10 selected communities (pastoralist, agro-pastoralist) focus group discussion will be held on: main live concerns and plans, droughts and floods, coping strategies, livelihood base and changes therein, vulnerability, food aid, livestock-agriculture-water/ road interaction. The well-being method will be used for this. The discussion will be for men and women.

Annex 4: Minutes Hargeisa National Workshop

Meeting Start:

Meeting Schedule Start: 8:30 am

Meeting Actual Start: 9: 00am

Agenda: See Annex 5a.

Opening Remarks:

- Thomas (WHH)
  - He welcomed the Minister, the directors from Government institutions to the workshop
  - He talked about the potential water that can be saved for the country and turned into productive and beneficial use.
- The General Manager (RDA)
  - I am very happy to participate in this great session which will be very useful to all Somaliland
  - He mentioned about the program objectives
  - He also noted that if this program become successful project, we will apply all Somaliland roads including existing, planned roads and those under construction.
- H. E. Sahal Mohamoud Jama - Minister for Ministry of Transport

The minister thanked WHH for the initiative of starting a discussion on how to start the green roads for water projects in Somaliland. He said that this project is very important for the transport sector and urged participants to learn from the workshop and see how to push the agenda forward to benefit the country.

- Ministry of Agriculture

H.E Ahmed Mumin Seed, Minister for MoA, talked about the importance of Green Roads for Water project of Somaliland and he mentioned that they are doing a Xeego in Borama and have seen farms that are washed away and big gullies have been formed due to road run off. The suggested project can be useful for soil erosion management and benefiting the farmers and range lands.

Presentation by RDA ENGINEERS AND METAMETA TEAM

The Roods Development Authority (RDA) Engineers together with MetaMeta team presented to participants the concept of Green Roads for Water while sharing the experiences from the 2 weeks field transect surveys done on roads in Somaliland.

Panel discussions and recommendations

During the panel discussion session, some recommendations as were suggested as listed below.

- ➢ Including and linking Green Roads for Water in the pillars of the National Development Plan III (NDP III).
- ➢ Involve all line Ministries such as Water, Environment, Local Government (Districts), Agriculture, Livestock among others

- Developing projects with the incorporation of Green Roads for Water as it facilitates trade, production for agriculture and livestock, provide rural jobs for the youth, enhance environment protection, climate change adaptation and mitigation, risk management by control of flooding among others.
- An Environmental Impact Assessment should be conducted before the construction of roads
- Consider including Green Roads for Water in Ministerial policies
- Have guidelines developed on the implementation of green roads for water projects.
- The panel recommended to have a Ministry or Authority that will drive the national policy development of Green Roads for Water and for this, MetaMeta was asked to suggest on how this can be done.

Closing remarks

When giving the closing remarks, the Director General, H.E. Mr. Ahmedyasin Muhumed Adde of the Ministry of Planning and National Development talked about the importance of the project in the country's development. He asked MetaMeta and WHH to suggest how the project can be integrated in the development of the National Development Plan III (NDP III) which is under development now.

Annex 5: Agenda and Participants of the Regional and National Workshops on GR4W

a. Agenda

Time	Activity	Responsible
08:30-09:00	Registration/ welcome	Participants
09:00- 09:15	Official opening of the workshop	Minister of MoTRD or appointed Deputy
09:15-09:30	Introduction to the Programme, Introduction of participants GR4W as a pillar of environmental and livelihood programming	WHH (Thomas Hoerz, Area Manager)
09:30 -10:30	GR4W: International Experience and Potentials in Somaliland	Taye Alemeyehu (MetaMeta)
10:30 to11:00 Coffee Break		
11:00-11:30	Livelihood/integration options with IWSM	Solomon Yilma (MetaMeta)
11:30-12:00	Lessons for Somaliland from Uganda	Hilary (MetaMeta
12:30 to 13:30 Prayer and Lunch break		
13:30-14:15	Status of roads in Somaliland and the potential for GR4W	Eng. Hamse/Abdishakur (2) (RDA)
14:15- 14:45	Reflections from MoERD, MoAD, MoWRD and	Panel discussion with Participants from Ministries
14:45 -15:30	Facilitated Plenary Discussion what are tangible opportunities for programming and fundraising how do we take it further institutionally (GoSL / UN / INGOs / Donors	Facilitation by WHH
15:30 to 16:00 Prayer and Coffee break		
16:00 – 16:30	Next steps for integrated planning and fundraising	Facilitation by MoPND or MoTRD
16:30 – 16:45	Closing Remarks by MoPND	DG MoPND or appointed Deputy

b. Participants of the Borama Regional Workshop on GR4W

Welthungerhilfe (WHH)
Training for Green Road in Borama-Somaliland
SOMALILAND
PROJECT NO. SOM 1046

Date: 06/11/2021

ATTENDANCE SHEET

No	Name	Organization	Title	Signature
1	Abdishakur Mohamoud Jama	RDA	Site Supervisor	[signature]
2	Abdichakour Abdilahi Omar	RDA	Chief Engineer	[signature]
3	Hamse Bashe Abdi	RDA	Engineer	[signature]
4	Galiwango Hilary	MetaMeta Research	Engineer	[signature]
5	Soloman Yilma	MetaMeta	Senior NRM Expert	[signature]
6	Abdikadir Dayib Nuh	WHH	NRM Expert	[signature]
7	Abdirahman Nour Ahmed	WHH	Water Engineer	[signature]
8	Abdirahman Mohamed Warsame	WHH	C-Water Engineer	[signature]
9	Ayanle Ahmed	HAVO	Officer	[signature]
10	Caras Diiriye	W Degaank	Kormeere	[signature]
11	Yassin Kalimieh Kahin	ASARDA	Manager	[signature]
12	Abdisalam Hamud Abdi	WHH	NRM Officer	[signature]
13	Abdikadir Ali Bade	WHH	HoP	[signature]
14	Cali Sahal Warsame	D/Hoose Bakr	exuti Officer	[signature]
15	Mohamed Hamud Jama	WHH	Deputy Area Manager / HoP	[signature]
16	Abdikadir Ahmed	RDA	R. RDA Eng	[signature]
17	Abubakar Hussein	ASARDA		[signature]
18	Abdigani Abdillahi Kahiye	SOSTA	Director	[signature]
19	Mubarak Mohamed	CWW	Program Manager	[signature]
20	Iskudhuwe Abdiwahab Hussein Muuse	MOERD	Regional coordinator	[signature]
21	Eng Amiin Faysal	Eelo University	Dean Civil Eng.	[signature]
22	Aden Ali Siid	Governor Office	Secretary	[signature]
23	Abib Hassan Yusuf	CWW	R. Coordinator	[signature]
24	Abdinasir Dahir Cige	Governor office	R. Coordinator (Awdal) G. office	[signature]
25	Sahane Osman Ibrahim	WHH	Driver	[signature]
26	Mahamdani Ali	P. focus Admin WHH	WHH	[signature]
27	Taye Alemayehu	"	MetaMeta	[signature]

Prepared by:	Checked by:	Approved by:
Name:	Name:	Name:
Title:	Title:	Title:
Sign: ______	Sign: ______	Sign: ______
Date: ___/___/___	Date: ___/___/___	Date: ___/___/___

c. Participants of the National Workshop on GR4W

welt hunger hilfe
For a world without hunger

	PROJECT NAME: STRUCTURAL FUND				
	WORKSHOP: GREEN ROADS FOR WATER IN SOMALILAND				
	PROJECT NO: SOM1046				
			Date: ____________		
ATTENDANCE SHEET FOR WASH LIFE CYCLE COST ANALYSIS TRAINING					
S/N	NAME OF THE PARTICIPANT	INSTITUTION	TELEPHONE NO.	EMAIL ADRESS	SIGNATURE
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Annex 6: List of Participants in the Field Assessment

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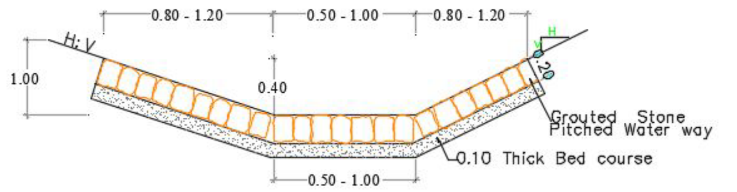
Annex 7: Design Considerations and Requirements for GR4W Measures

a. Overview of Water Storage Systems

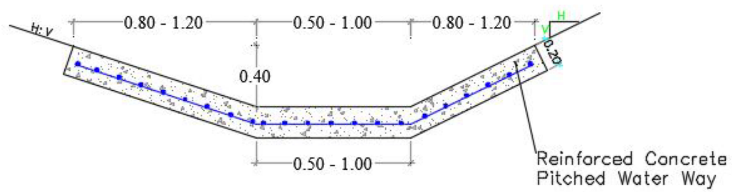
Water storage systems			
Options	**Possible area of application**	**Design Consideration**	**Remarks**
Detention/retention basin	▪ Upper slope catchment area ▪ Down slope area	▪ Topography ▪ Soil types and their infiltration ▪ Land use and land cover ▪ Catchment area and rainfall intensity ▪ Community needs ▪ Availability of land for basin development ▪ Distance of the basin from road and its effect on the safety of the road	❖ The location of the basin should be outside of the road reserve
Micro basin-from soil berm	▪ Upper slope catchment area ▪ Down slope area	▪ Topography ▪ Soil types and their infiltration ▪ Land use and land cover ▪ Catchment area and rainfall intensity ▪ Seasonal characteristics of stream flow ▪ Community needs ▪ Availability of land for basin development ▪ Distance of the basin from road and its effect on the safety of the road	❖ Micro basins are generally suitable to construct at locations with low storm water flow ❖ The location of the basin should be outside of the road reserve
Ponds	▪ Upper slope catchment area ▪ Down slope area ▪ Borrow pits as ponds ▪ Sides of road (to collect roadside runoff)	▪ Topography ▪ Soil types and their infiltration ▪ Land use and land cover ▪ Catchment area and rainfall intensity ▪ Community needs ▪ Availability of land for pond development ▪ Distance of the pond from road and its effect on the safety of the road	❖ Down slope pond inlet invert level shall consider drainage outlets and vice versa ❖ The location of the pond should be outside of the road reserve
Recharge wells	▪ Upper slope catchment area ▪ Down slope area ▪ Road sides	▪ Soil types and their infiltration ▪ Community needs ▪ Availability of land for recharge wells development ▪ Distance of the recharge wells from road and its effect on the safety of the road	❖ To increase the storage capacity of the recharge well, excavated material shall be stoke piled as a bank ❖ The location of the recharge well should be outside of the road reserve

<table>
<tr><th colspan="4">Detention/Retention basin</th></tr>
<tr><th>Options</th><th>Possible area of application</th><th>Design Consideration</th><th>Remarks</th></tr>
<tr><td>Detention/retention basin</td><td>▪ Upper slope catchment area
▪ Down slope area
▪ Road sides</td><td>▪ Topography
▪ Soil types and their infiltration
▪ Land use and land cover
▪ Catchment area and rainfall intensity
▪ Community needs
▪ Availability of land for basin development
▪ Distance of the basin from road and its effect on the safety of the road</td><td>❖ The location of the basin should be outside the road reserve</td></tr>
<tr><td colspan="2">Linkage between Road and Water Harvesting System
• Location of pond – Min. 50m from road slope-stake
• Linkage from side, mitre drains and / or cross drainage with provision of transit paved ditch (refer sketch)
• When transverse ground slope is greater than 20% consider provision of cascades, check dams (paved) etc.</td><td colspan="2">

Lined Ditch Type A



Lined Ditch Type B in Expansive Soil



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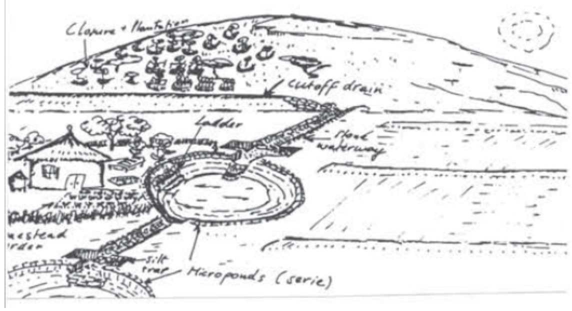
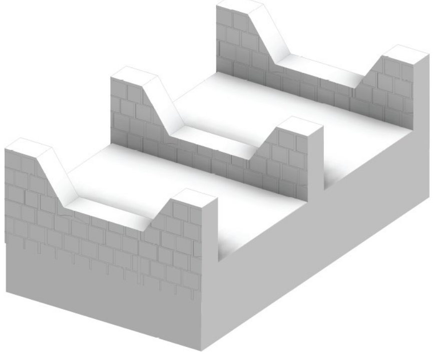
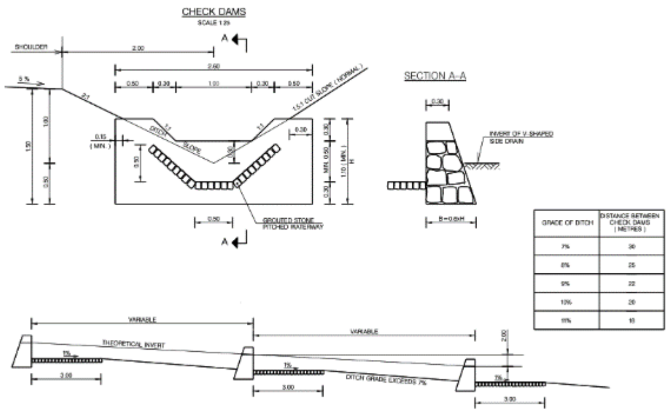
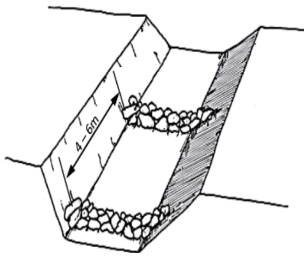
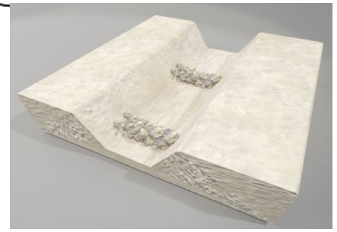
Micro basin from masonry / soil berm			
Options	**Possible area of application**	**Design Consideration**	**Remarks**
Micro basin from masonry / soil berm	▪ Upper slope catchment area ▪ Down slope area ▪ Roadsides drainages	▪ Topography ▪ Soil types and their infiltration ▪ Land use and land cover ▪ Catchment area and rainfall intensity ▪ Seasonal characteristics of stream flow ▪ Community needs ▪ Availability of land for basin development ▪ Distance of the basin from road and its effect on the safety of the road	❖ Micro basins are generally suitable to construct at locations with low storm water flow ❖ The location of the basin should be outside of the road reserve
 Unroofed Micro basin –built on the road side (Fereweyni-Megab)		<u>*Ensure Sustainability*</u> ▪ Provide paved transition ditch if the surrounding soil is erodible ▪ Provide silt trap at entrance using dry masonry cascade ▪ Provide shade to minimize evaporation ▪ Provide shallow rooted trees/grass as shade to minimize evaporation <u>*Safety*</u> • Protect accidents by planting trees around the pond • Protect accidents by fencing • Provide access to the pond in defined direction • Install signs which depicts prohibition of swimming	<u>*Illustrative sketch*</u> 1. Grass shade 2. Corrugated iron sheet 3. Trees 4. Safety Signs 5. Fence  Micro basin (Source: Desta 2005)

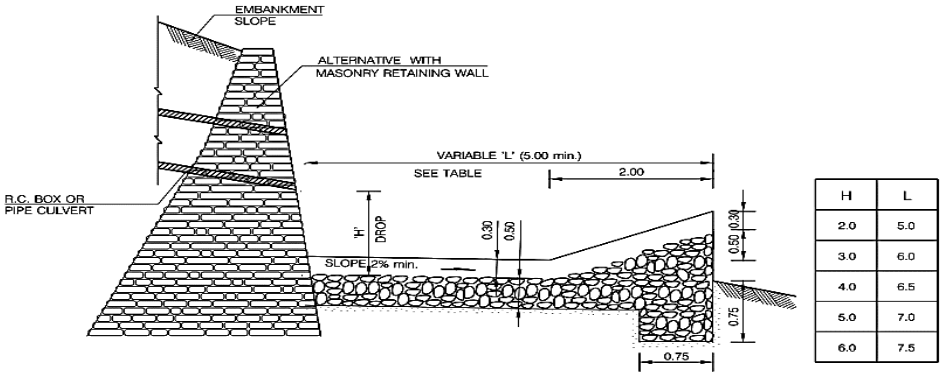
Ponds			
Options	**Possible area of application**	**Design Consideration**	**Remarks**
	▪ Upper slope catchment area ▪ Down slope area ▪ Borrow pits as ponds	▪ Topography ▪ Soil types and their infiltration ▪ Land use and land cover ▪ Catchment area and rainfall intensity ▪ Community needs ▪ Availability of land for pond development ▪ Distance of the pond from road and its effect on the safety of the road ▪ Design access in case of deep borrow pit to serve as pond	❖ Down slope pond inlet Invert level shall consider drainage outlets and vice versa ❖ The location of the pond should be outside of the road reserve
 Pond used for roadside runoff harvesting in Moricho-Dimtu, Ethiopia.		*<u>Ensure Sustainability</u>* ▪ Provide paved transition ditch if the surrounding soil is erodible ▪ Provide silt trap at entrance using dry masonry cascade ▪ Provide Bio engineering solutions to prevent erosions *<u>Safety</u>* • Protect accidents by planting trees around the pond • Protect accidents by fencing • Provide access to the pond in defined direction • Install signs which depicts prohibition of swimming	*<u>Illustrative sketch</u>* 1. Planting of Grass/cactus around the pond 2. Safety Signs 3. Fence

Recharge well			
Options	**Possible area of application**	**Design Consideration**	**Remarks**
	▪ Upper slope catchment area ▪ Down slope area	▪ Soil types and their infiltration ▪ Community needs ▪ Availability of land for recharge well development ▪ Distance of the Soak pits/dug-wells from road and its effect on the safety of the road	❖ To increase the storage capacity of the excavated material shall be stoked pile as a bank ❖ The location of the recharge well should be outside of the road reserve
 Recharge well for recharging of groundwater along Mekele-Hewane route, Ethiopia.		*Ensure Sustainability* ▪ Provide paved transition ditch if the surrounding soil is erodible ▪ Provide silt trap at entrance using dry masonry cascade ▪ Provide bio-engineering solutions to prevent erosion *Safety* • Protect accidents by planting trees around dug wells / soak pits • Protect accidents by fencing Install signs which depicts prohibition of swimming	*Illustrative sketch* 1. Planting of Grass/cactus around the pond 2. Signs 3. Fence

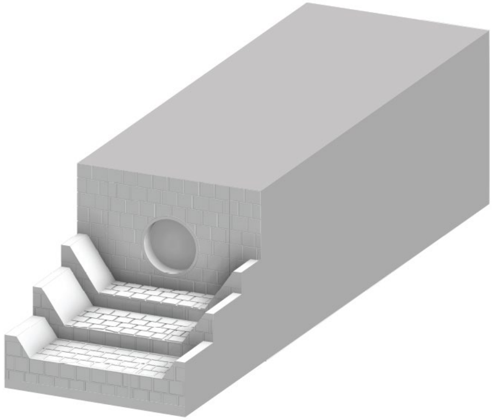
b. Erosion Protections and Water Guiding Systems

Erosion protections and water guiding systems			
Options	**Possible area of application**	**Design Consideration**	**Remarks**
Packed or dumped dry rock riprap - Helps to avoid and / or restrict erosion	▪ Upper slope catchment area ▪ Down slope area ▪ Rolling to mountainous terrain ▪ Fill slope surface ▪ Toe of fill ▪ Stream and river Bank as well as stream beds and water channels ▪ At outlet or inlet of drainage structures as energy dissipater structure.	▪ Topography ▪ Soil types and their erodibility ▪ Availability of construction material / rock source	❖ It enhances recharge by slowing down the run-off ❖ Serves as streambed erosion protection by reducing the scour in erodible canal
 Riprap used at outlet of culvert as energy dissipater Alamata-Mehoni Road		▪ Construction Considerations Packed riprap - constructed from rocks individually placed - Space shall be filled with spall and smaller stones - Stone shall be hard or quarry stone not susceptible to disintegration and resistant to weathering Dumped riprap - Shall be constructed by dumping stone and spreading with a bulldozer	

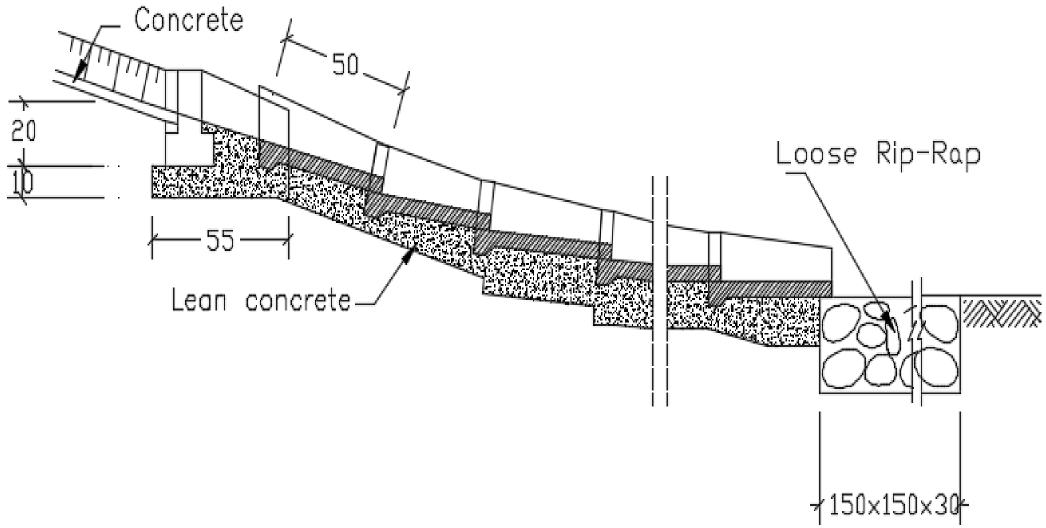
Erosion protections and water guiding systems			
Options	**Possible area of application**	**Design Consideration**	**Remarks**
Check dams, dry and mortared - It controls erosion - It controls sediment	▪ On side ditches with slope greater than 7%	▪ Road/ditch gradient ▪ Soil types and their erodibility ▪ Catchment area and rainfall intensity ▪ Community needs ▪ Availability of construction material source	❖ It provides proper guide of ditch flow, especially in steep gradient road sections, to water harvesting systems ❖ It helps to minimize sedimentation to water harvesting systems and protects erosion
 		▪ Construction Considerations - On steep gradient of ditch greater than 7%, apply mortared check dams - Apply dry check dam on less erodible section grade less than 7%	  

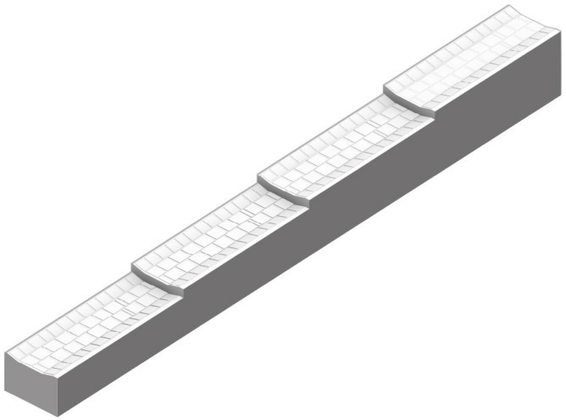
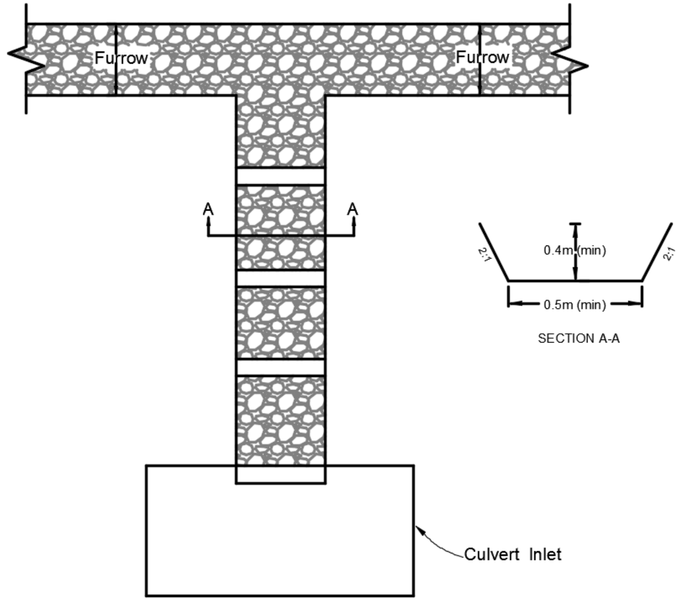
Erosion protections and water guiding systems			
Options	**Possible area of application**	**Design Consideration**	**Remarks**
Dry stone wall	▪ At toe of fill as a barrier to divert surface flow to farm land ▪ As retaining structure ▪ River and stream banks ▪ Steep eroded land	▪ Community needs ▪ Soil types and their erodibility ▪ Stone wall spacing ▪ Slope angle	❖ It enhances groundwater recharge and guides surface flow to farm land
 Road surface water guiding using dry stone walls Mekele-Wukro road		▪ Construction Considerations - When constructed at the toe of a fill to direct the road surface water flow, height of wall and thickness shall be minimum 40cm - Back of the wall shall be supported by soil	
Stilling Basin	▪ At culvert outlet: when invert level of outlet from the natural ground is 2m and above	▪ Topography ▪ Catchment area and rainfall intensity ▪ Position of culvert location	❖ It dissipates energy of water flow ❖ Protects erosion and retains sedimentation ❖ Regulates water for possible downstream use
			

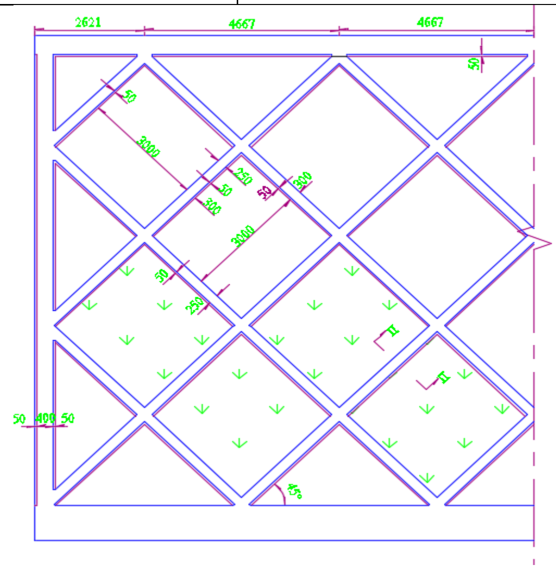
Erosion protections and water guiding systems			
Options	**Possible area of application**	**Design Consideration**	**Remarks**
Cascades - It Controls erosion - It is an energy dissipating structure	▪ Upper slope catchment area ▪ Down slope area ▪ On steep water channels ▪ Built inside or outside of the road reserve including channels to direct the course of the stream	▪ Topography ▪ Soil types and their erodibility ▪ Channel characteristics ▪	❖ It dissipates energy of water flow ❖ Protects erosion ❖ Guides water for possible downstream use



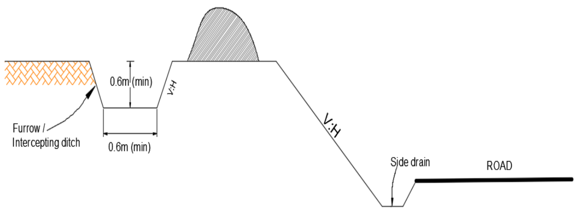
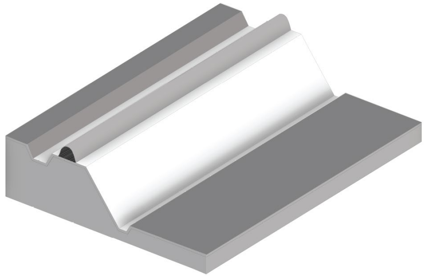
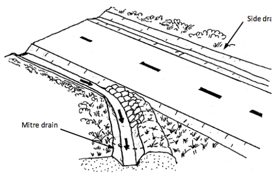
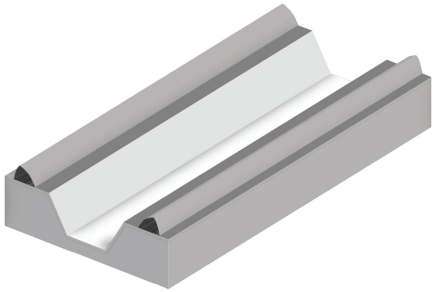
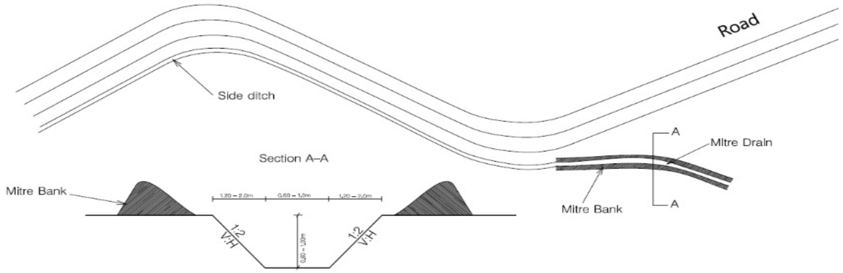
Cascade built at outlet of culvert
Alamata – Mehoni –Hewane Road

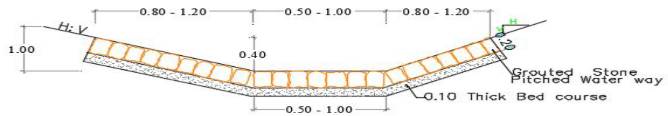
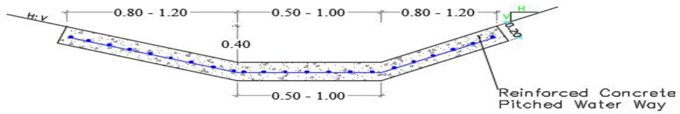
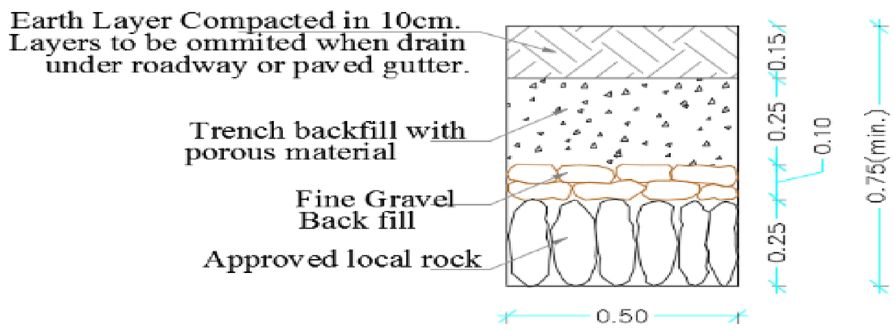


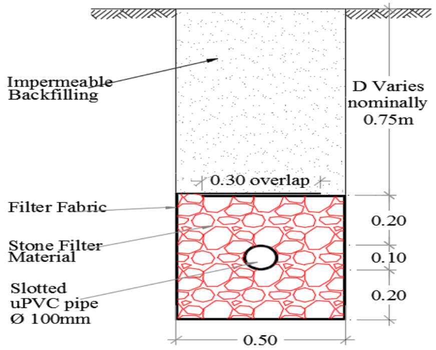
Erosion protections and water guiding systems			
Options	**Possible area of application**	**Design Consideration**	**Remarks**
Chutes	▪ Upper slope catchment area ▪ Down slope area ▪ On steep water channels ▪ Transition from furrow ditch to culvert inlet or side drain ▪ Transition to pond or water reservoir	▪ Topography ▪ Soil types and their erodibility ▪ Amount of flood (catchment area and rainfall intensity)	❖ Protects erosion ❖ Facilitates transition to inlet of culverts ❖ Guides water for possible downstream use
 		▪ Construction Considerations - When it is more than 6m length, provide check dam structure in between every 6m. ▪ The size of chute depends on the size of furrow or cutoff drain	

Erosion protections and water guiding systems			
Options	**Possible area of application**	**Design Consideration**	**Remarks**
Gridded channel on slopes - Takes away surface water from top of cut or from road surface - Supports the slope - Protects erosion	▪ Cut slopes and high fill slopes	▪ Fill height/cut depth ▪ Soil types ▪ Cut off drain	❖ Protects erosion of slopes ❖ Guides water flow from the road surface and slopes towards ditch and culvert inlet or outlet and to water harvesting systems
			

c. Surface Drains

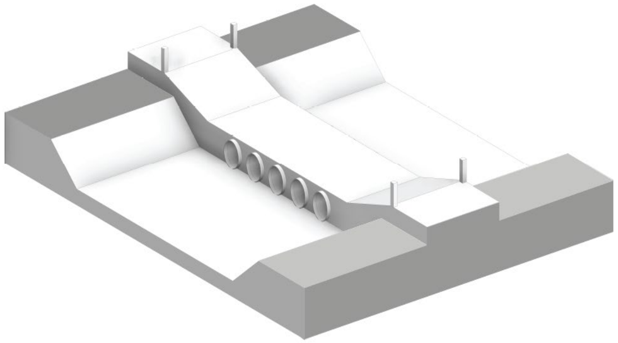
Surface Drains			
Options	**Possible area of application**	**Design Consideration**	**Remarks**
Furrow/intercepting ditches	▪ Top of mountain ▪ Top of deep cut section ▪ Intercepting ditches at the top and bottom of the slopes	▪ Topography ▪ Soil types and their erodibility ▪ Slope stability ▪ Cut depth	❖ Enhance slope stability ❖ To control the flow of water: flow can be directed to nearest water harvesting system
			
Mitre drains/ ditch out 	A mitre drain is a drain constructed at an angle to the centerline of the road to divert water from the side drains. Mitre drains will include mitre banks placed across side drains. ▪ On side ditches/drains: to provide flow relief of the side drain	▪ Length of side drains ▪ Road/ditch gradient ▪ Soil types and their erodibility ▪ Catchment area and rainfall intensity ▪ Community needs for water ▪ Suitability for water harvesting	❖ Commonly practiced in many water scarce areas of the country to guide water from side drains to farm land and other water harvesting systems
			

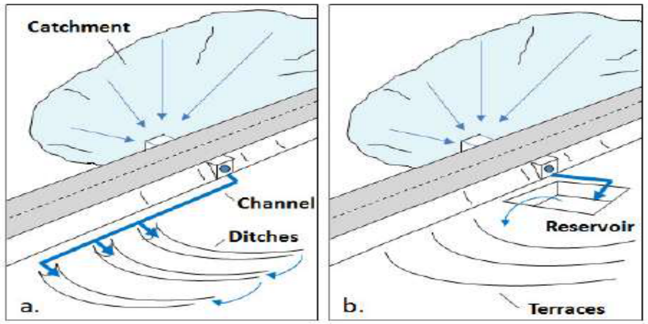
Surface Drains			
Options	**Possible area of application**	**Design Consideration**	**Remarks**
Earthen or grouted stone pitched side drains	▪ Road side drains	▪ Length of side drains ▪ Road/ditch gradient ▪ Soil types and their erodibility ▪ Topography ▪ Catchment area and rainfall intensity	❖ Grouted stone pitching drains shall be considered where there exists: -erodible soil (regardless of gradient) and ditch gradient ≥ 5%
		Lined Ditch Type A  Lined Ditch Type B in Expansive Soil 	
French drain	▪ Through side drains: especially in water logging area and springs	▪ Topography ▪ Road/ditch gradient ▪ Amount of subsurface water	❖ It is rock field trench ❖ Collects subsurface water and protects the road subgrade from saturation
			

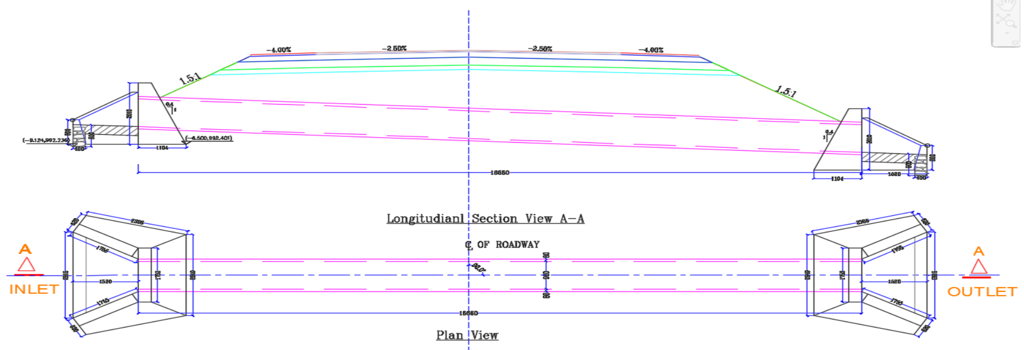
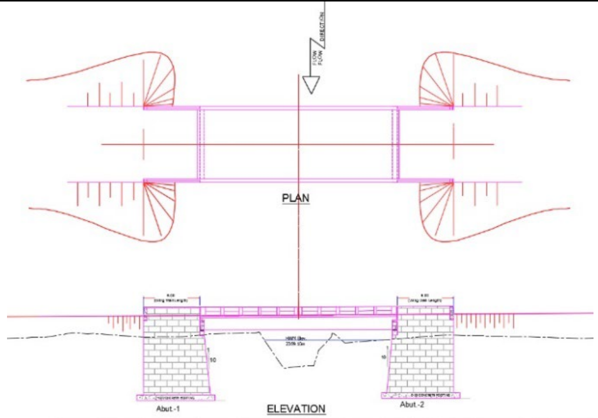
Surface Drains			
Options	**Possible area of application**	**Design Consideration**	**Remarks**
Slotted or perforated uPVC pipes	▪ Through side drains: especially in water logging area and springs	▪ Topography ▪ Road/ditch gradient ▪ Amount of subsurface water ▪ Diameter of slotted or perforated pipe ▪ Use of geotextile filter fabric	❖ Rock fill to a certain depth from invert and filled with impermeable back filling ❖ Collects subsurface water and protects the road subgrade from saturation
		 Subsoil Drain	

d. Cross-drainage

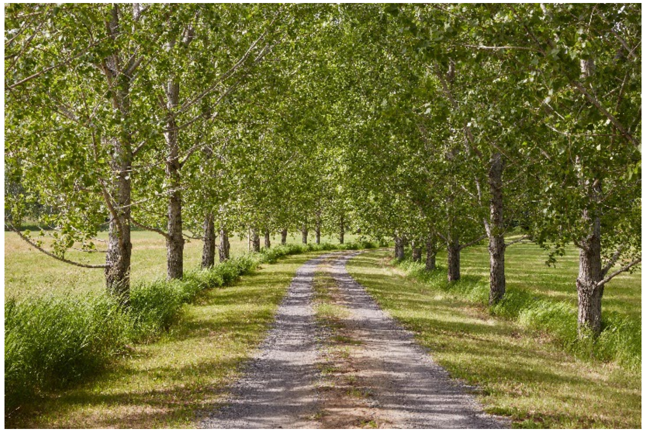
Cross-drainages			
Options	**Possible area of application**	**Design Consideration**	**Remarks**
Drifts/ Ford	▪ On low volume roads	▪ Topography ▪ Crossing location ▪ River characteristics ▪ Provision of surface roughness ▪ Community needs: for use as part of water harvesting system ▪ For further detail refer ERA-LVR Manual Part E Section 4.1 & 5.2.1	❖ Structure can be grouted stone pitching or reinforced concrete ❖ Surface roughness should be ensured to avoid slippery characteristics ❖ Possibly the lowest cost form of watercourse crossing construction ❖ Ideal structure type for water harvesting by raising the crossing from the stream bed level ❖ Easy to integrate with other type of water harvesting systems

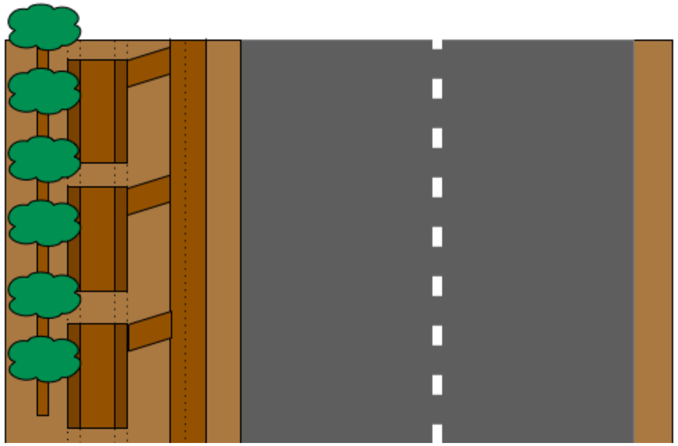
Cross-drainages			
Options	**Possible area of application**	**Design Consideration**	**Remarks**
Construction Considerations - Construct from stones not weathered - Minimum thickness of stone shall be 200mm - The top surface shall be roughened across the water flow to avoid growth of algae or other types of plant species			
Vented Fords/ Causeways	▪ On low volume roads	▪ Topography ▪ Crossing location ▪ River characteristics ▪ Provision of surface roughness ▪ Community needs: for use as part of water harvesting system ▪ For further detail refer ERA-LVR Manual Part E Section 4.3 & 5.2.3	❖ Designed to be over toped during flood periods ❖ Can be integrated with water harvesting system: by providing appropriate wall upstream side for water storage/recharge
▪ Construction Considerations - Concrete pipe shall be encased on top with mass concrete C-20 - The running surface shall be roughened - Install stone guiding post at the middle and corner part of the top running surface and paint with white marker		❖	
Sand dams	▪ Low volume roads in	▪ Topography ▪ Crossing location ▪ River characteristics	❖ It is a good structure for storing large volume of water in the river bed

Cross-drainages			
Options	**Possible area of application**	**Design Consideration**	**Remarks**
	combination with Fords ▪ High volume roads: 30m upstream and/or downstream of a bridge location	▪ Amount of sand deposition ▪ Catchment area ▪ Community needs: for use as part of sand sources and/or water harvesting system	❖ Structure can be grouted stone pitching or reinforced concrete ❖ Care shall be taken for timely removal of sand deposition otherwise it causes inundation of the surrounding area or farmland
▪ Construction Considerations - The running surface of the sand dam shall be roughened - Install stone guiding post at the middle and corner part of the top running surface and paint with white marker			
Culverts 	▪ Low volume roads ▪ High volume roads	▪ Topography ▪ Catchment area ▪ Soil type and their erodibility ▪ Land use and land cover ▪ Crossing location ▪ Stream/channel characteristics ▪ Community needs: for use as part of water conveyance to harvesting system ▪ For further detail refer ERA-LVR Manual Part E Section 4.2 & 5.2.2	❖ Consider provision of proper inlet and/or outlet transition structure for water harvesting system ❖ Culvert outlets invert level shall consider down side water harvesting systems and vice versa 

Cross-drainages			
Options	**Possible area of application**	**Design Consideration**	**Remarks**
▪ Construction Considerations - If soft, spongy or other objectionable materials such as black cotton soil are encountered, it shall be excavated to a minimum of 30cm and replaced with granular material - Pipe shall can be laid on Class A, B, C and D bedding			
Bridges	▪ Low volume roads ▪ High volume roads	▪ Topography ▪ Catchment area and rainfall intensity ▪ Soil type and their erodibility ▪ Land use and land cover ▪ Crossing location ▪ River characteristics ▪ Community needs: for use as part of water harvesting system ▪ For further detail refer ERA Bridge Design Manual 2013	❖ Sand dams can be provided 30m upstream and/or downstream side of the bridge location ❖ Diversion structures can be provided without endangering the bridge
			

e. Roadside Tree Planting





Design steps on how to plant trees along a road stretch

1. The trees are planted on a safe distance from the road.
2. Select tree species that:
    a. Grow vertically
    b. Are evergreen/remain green for most of the year
    c. Tolerant of harsh conditions, indigenous to the area
    d. Deep-rooted
    e. Fast-growing and provide produce (timber/fruits/etc)
3. Make the pits before the rainy season.
    a. Pits to be 40cm by 40cm.
4. Plant trees during rains, shield the seedlings to prevent damage.
5. The spacing should be 3-4 meters
6. Where the road stretch is curved, the spacing should be increased to 10-12 meters

Remarks:

Benefits of roadside tree planting:

- Reduce soil erosion by holding soil in place
- Remove dust and other pollutants from the air, protecting crops and people
- Flood control, by slowing and absorbing road run-off
- Improved water quality by trapping sediment and increase water infiltration.

It is important to:

- Ensure trees do not obstruct the visibility of the road for drivers
- Young trees need management, water them regularly during the, apply mulching, and monitor regularly.