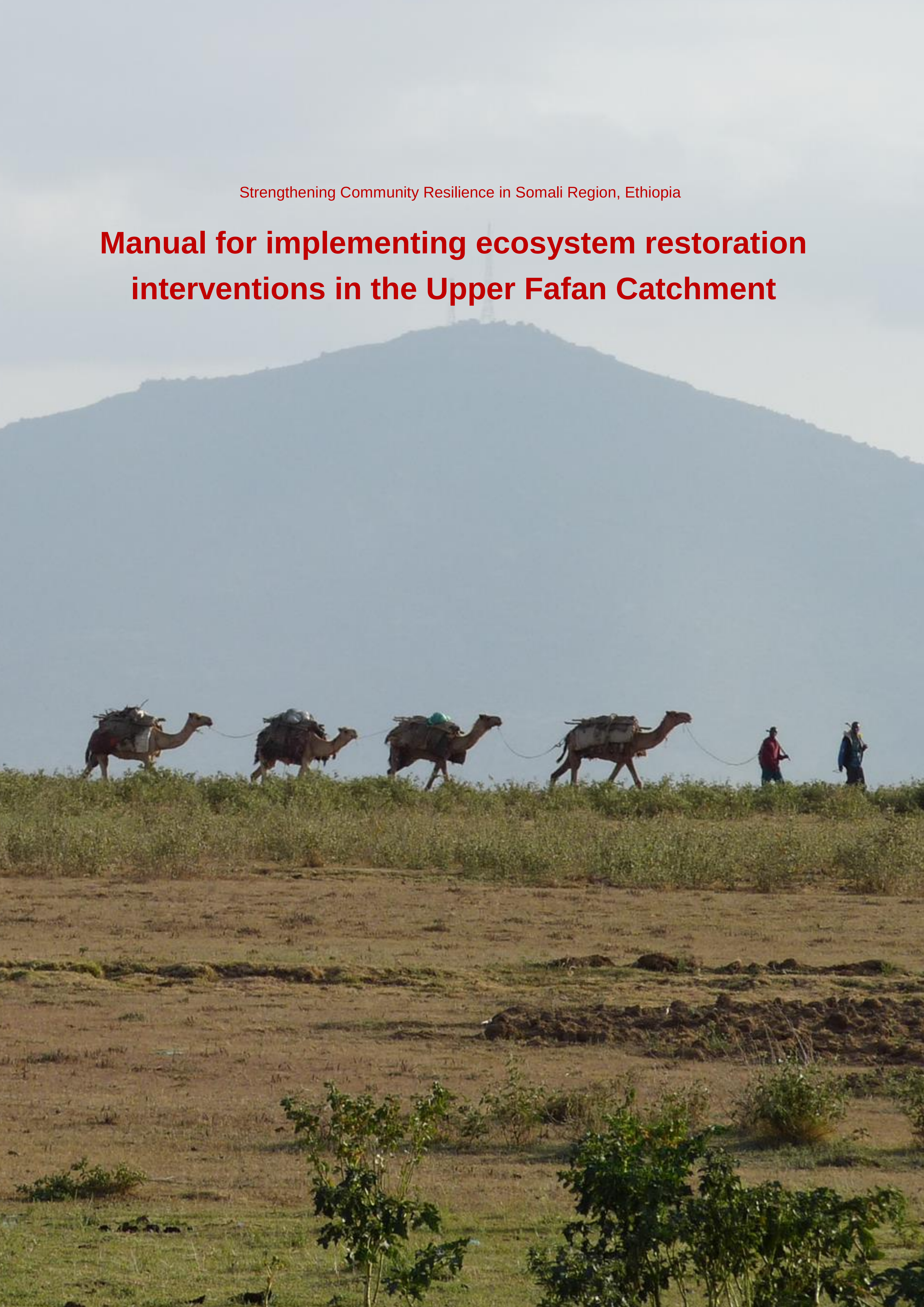
Strengthening Community Resilience in Somali Region, Ethiopia

Manual for implementing ecosystem restoration interventions in the Upper Fafan Catchment



Title	.	Manual for implementing ecosystem restoration interventions in the Upper Fafan Catchment, Somali Region, Ethiopia
Client	.	Wetlands International
Status	.	Final
Datum	.	09-09-2016
Project number	.	618
Project team	.	Mieke Hulshof, Reinier Visser, Yitbarek Tibebe, Lieselotte Tolk, Frank van Weert

Disclaimer

Summary

Ecosystem restoration is the “process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed” (SER Primer 2004). Which combination of ecosystem restoration interventions is most effective in a certain area depends on the landscape’s characteristics.

This manual aims to support capacity building and advocacy activities focusing on ecosystems restoration in the Upper Fafan Catchment. It describes where and when to implement protection and management, soil and water conservation, off-stream water storage and in-stream water storage interventions.

Implementation guidelines are provided along eight cases, with specific references to locations in the Upper Fafan Catchment:

- Case 1: Conservation practices on weak soils
- Case 2: Restoring severely eroded lands
- Case 3: Good agricultural practices on slopes
- Case 4: Sustainable rangeland and forest management
- Case 5: Recovering wetlands’ ecosystem services
- Case 6: Surface water reservoirs for integrated development
- Case 7: Control and management of invasive species
- Case 8: Nature conservation

For each of the cases the location and problem description, recommended interventions, expected results and beneficiaries, activities towards implementation and upscaling potential are specified.

In general, the following aspects are key to successful implementation of ecosystem restoration measures:

- Interventions should provide direct and immediate benefits to individuals, households and communities to motivate implementation without (or with minimal) external support
- Interventions should support the recovery of ecosystem services toward re-establishing landscape functionality, by limiting soil erosion, nutrient depletion and loss of biodiversity
- Interventions should help local users to make most out of the ecosystems goods and services in a sustainable manner
- Protection and management interventions should be prioritized to the detriment of hard infrastructure, this particularly important on communal lands
- When moving towards implementation, expert advice and supervision should always be hired to select, site, design, develop and/or construct interventions (be it infrastructure, policies or any other).

Table of contents

Appendices

List of acronyms and abbreviations

IUCN – International Union for Conservation of Nature
NGO – Non-governmental organization
SCRSE – Strengthening Community Resilience in Somali Region of Ethiopia Programme
SER – Society for Ecological Restoration
SWC – Soil and water conservation
WASH – Water, sanitation and hygiene

1 Introduction

1.1 The manual

Ecosystem restoration is the "process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed" (SER Primer 2004, www.ser.org). Which combination of ecosystem restoration interventions is most effective in a certain area depends on the landscape characteristics, such as the type of soils, land use and cover, steepness of slopes, geology, and the proximity of settlements and larger urbanizations.

This manual describes the most suitable interventions to each location in the Upper Fafan Catchment and how to combine and implement these to address major challenges. The content of the manual is based upon, and hence strongly linked to, the integrated assessment presented in the Atlas of the Upper Fafan Catchment (Visser et al. 2016).

1.2 Background

The manual aims to support capacity building and advocacy activities under the Strengthening Community Resilience in Somali Region of Ethiopia (SCRSE) programme. The SCRSE-programme is implemented by a partnership between humanitarian, development, climate and environmental organizations[1]. Through strategic interventions targeting water security, food security and disaster risk reduction the programme aims to improve long term community stability and resilience.

The SCRSE programme is anchored to the Ecosystem based Adaptation (EbA) framework through a landscape approach and catchment-based natural resources management. The EbA approach informs the selection, design and siting of ecosystem restoration interventions.

1.3 Reader's guide

This manual is organised along case studies. Chapter 2 presents the rationale behind ecosystem restoration, examples of interventions and the map of with the ecosystem restoration suitability zones. In Chapter 3 the case studies are presented one by one. For each case study the problem description, recommended interventions, projected results and beneficiaries, and the upscaling potential are included.

- Case 1: Conservation practices on weak soils
- Case 2: Restoring severely eroded lands
- Case 3: Good agricultural practices on slopes
- Case 4: Sustainable rangeland and forest management
- Case 5: Recovering wetlands' ecosystem services
- Case 6: Surface water reservoirs for integrated development
- Case 7: Control and management of invasive species

[1] The Netherlands Red Cross, Ethiopian Red Cross Society, Wetlands International and the Red Cross/Red Crescent Climate Centre with contributions from Acacia Water and HoAREC&N

- Case 8: Nature conservation

In the concluding chapter, cross-cutting issues relevant for implementation are highlighted and final recommendations are provided.

Note that the content of this manual is indicative. When moving toward implementation, expert advice and supervision should always be hired to select, site, design and construct the interventions. For additional information on water storage infrastructure and more elaborate guidelines for specific interventions refer to appendices I and II.

2 Ecosystem restoration

2.1 Rationale

As in many other regions around the world, ecosystems in the Upper Fafan Catchment were subjected to considerable rates of degradation over the past decennia to the detriment of nature and people's livelihoods. This degradation resulted in the loss of vital ecosystems services, such as water flow regulation, soil development and regulation of microclimatic conditions.

Livelihoods cannot be sustained with the conservation of critical areas alone. A coherent and integrated approach toward restoration is needed. Ecosystem restoration is such an approach. The proposed interventions

- provide direct and immediate benefits to individuals, households and communities, such as shortening the distance to water points and increasing crop production,
- support the recovery of ecosystem services toward re-establishing landscape functionality, by limiting soil erosion, nutrient depletion and loss of biodiversity, and, more in general,
- help to make most out of the ecosystems goods and services in a sustainable manner.

As the IUCN (2015) puts it: " [...] it involves tailoring the solution to the context in order to bring back or improve the productivity of the landscapes that are deforested or degraded to that they can sustainably meet the needs of people. "

2.2 Types of interventions

The ecosystem restoration framework offers a wide range of options for intervention. Each intervention has its own purposes, strengths and weaknesses. Whether interventions aim at improving vegetation cover and biodiversity, promoting soil formation, storing water or any other purposes, and the rate at which this happens differs per specific intervention. Within this project four categories of interventions were identified (see Figure 2-1 for examples).

- **Protection and management** of ecologically sensitive and valuable areas, so that these can recover and achieve their full-potential in terms of ecosystem system services. Experience shows that control or even exclusion of agricultural activities, grazing of livestock, and collection of natural products from delineated areas stimulates the germination of seeds, promotes seedling survival and allows vegetation to grow faster. These developments can be supported by planting trees and disposing urban waste(water) in a safe manner. Protection and restoration interventions are best implemented in close collaboration with communities, as implementation and enforcement are to a large extent dependent on communal efforts. In general protection and management measures contribute to erosion control, improve the availability of fodder, stimulate groundwater recharge have a positive impact on biodiversity.

- **Soil and water conservation (SWC)** targets the conservation of soil, water and related natural resources on agricultural land. SWC measures are often directed primarily to either soil or water conservation, but most contain an element of both. Water conservation mostly entails the implementation of land use changes or physical structures, which often also counteract erosion. Similarly, soil conservation usually involves reducing splash erosion, crust formation or breakdown of soil structure, all of which also increase infiltration, and hence contribute to water conservation. The application of SWC-measures results in higher and more reliable yields. Depending on the conditions the implementation of SWC measures may come with the possibility to produce higher market-value crops. SWC measures also improve groundwater recharge, water flow regulation, soil formation and biodiversity.

- **Off-stream water storage** includes many typical 3R-interventions (Recharge, retention and reuse of water). Off-stream water storage includes all those land interventions that collect water from surface run-off to store it either in open water reservoirs or in the ground. Rock catchments, birkads and ponds are examples of off-stream water storage interventions. Besides directly improving water availability, off-stream water storage contributes to water flow regulation and groundwater infiltration.

- **In-stream water storage** aims at water storage in riverbed sediments of seasonal rivers (shallow groundwater) or in open water reservoirs build across flow accumulation areas (surface water). As with off-stream water storage interventions, these are typical 3R interventions aimed at collecting runoff during the rainy season to make it available in dry periods. An additional advantage of water storage in riverbed sediments is that water quality is hugely improved and water flows are regulated.

Figure 2-1 (next page): Examples of ecosystem restoration interventions. The location and purpose determines which intervention is most suitable

2.3 Ecosystem restoration potential

Protection and management


Floodwater diversion ditch


Area closure with thorns


Riverbank protection (Google)

Soil and water conservation


Contour trenching


Stone contour bunds


Terracing

Off-stream water storage


Pond, land surface run off


Lined pond, road run off


Lined birkad, surface run off

In-stream water storage


Sand dam


Riverbank water abstraction


Check dams in a gully

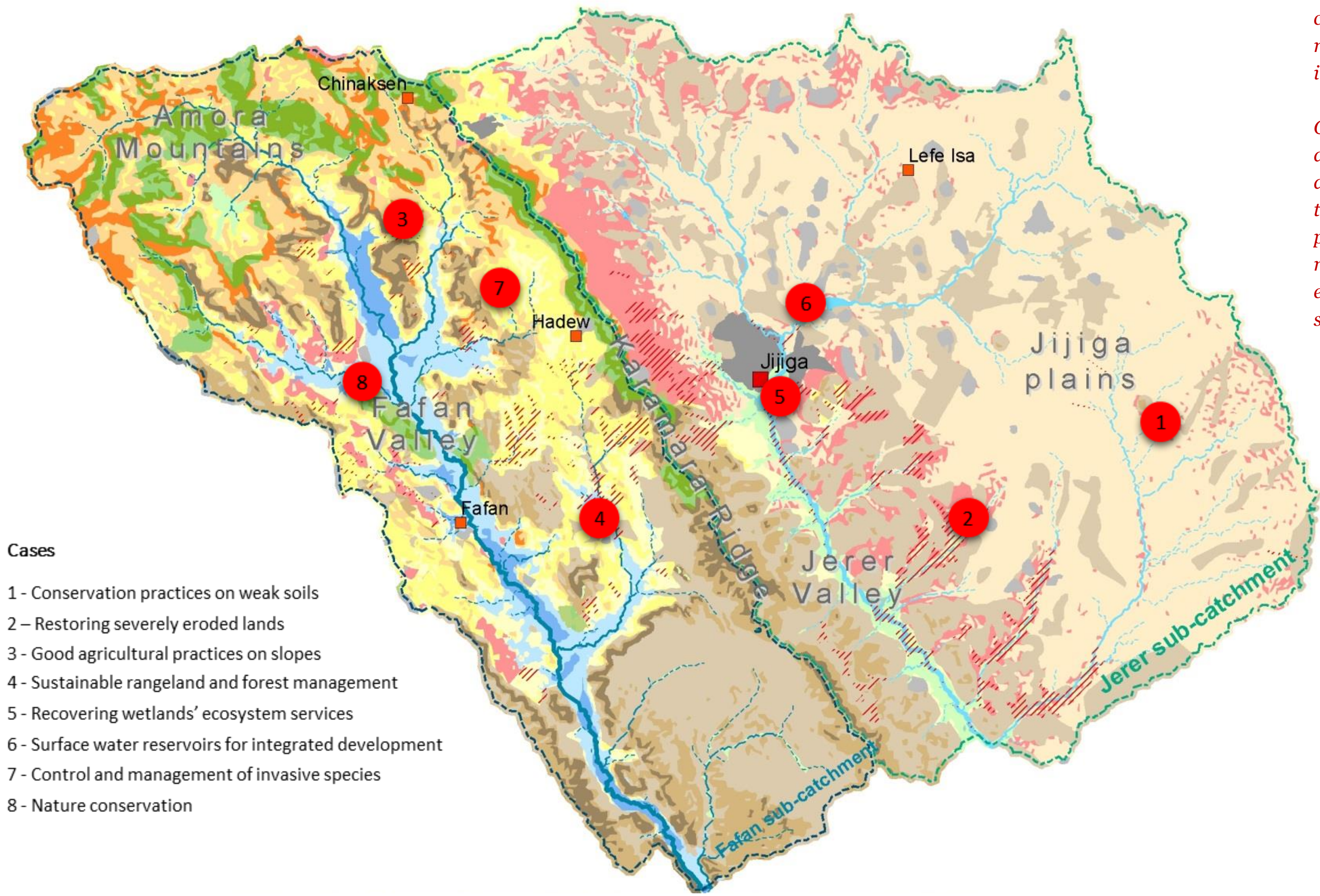


Figure 2-2 Map showing suitability zones for ecosystem restoration interventions and the location of the case studies presented in this manual. The legend of the map is included on the next page.

On agricultural lands mostly soil and water conservation measures are recommended. In all other areas the priority should be with protection and restoration measures. On the steepest and most erosion sensitive slopes agriculture should be discouraged.

*Table 2-1 Legend of the map in Figure 2-2**Error! Reference source not found.** showing the suitability for ecosystem restoration interventions.*

Zone	CHARACTERIZATION		RECOMMENDED TYPES OF INTERVENTIONS			
	Current land use	Slope and stream specifications	Protection and restoration	Soil and water conservation (SWC)	Off-stream water storage	In-stream water storage
A1	Arable land	Flat to gentle sloping areas (<5%)	-	Basic SWC, flood-adapted agriculture	Hafirs, ponds	
A2		Gentle slopes (5-10%)	-	SWC measures for slopes	Hafirs, ponds, hillside dams	
A3		Steep slopes (10-25%),	-	SWC for slopes or permanent agriculture	Hillside dams, rock catchments	
A4		Very steep slopes (>25%)	Discourage agriculture, forest management	Permanent agriculture	Rock catchments	
A5		Flat to gentle sloping areas (<3%), Weak Soils	-	Basic SWC, SWC for weak soils, SWC to control wind	Hafirs, ponds, micro dams, birkads	
A6		Slope > 3%, Weak Soils	Discourage agriculture, forest management	SWC for weak soils and slopes, permanent agriculture	Valley dams, micro-dams, birkads	
R1	Rangelands	Slopes < 10%	Rangeland management	Biological interventions	Hafirs, ponds, birkads	
R2		Steep slopes (10-25%)	Rangeland management	Biological interventions	Hill-side dams, birkads	
R3		Very steep slopes (>25%)	Area closures	Biological interventions	Rock catchments	
F1	Forests/ bushlands	Slopes < 10%	Forest management	-	Hafirs, ponds	
F2		Steep slopes (10-25%)	Forest management, area closures	-	Hill-side dams, rock catchments	
F3		Very steep slopes (>25%)	Forest management, area closures	-	Valley dams, rock catchments	
W1a	Wetlands/ River valleys (agriculture, rangelands, forest)	River valleys, Basement	Riverbank protection	Basic SWC, flood-adapted agriculture	Managed aquifer recharge, hafirs	
W2a		Regularly flooding, Basement	Riverbank protection	Flood-adapted agriculture	Managed aquifer recharge, hafirs	
W1b		River valleys, Limestones, Weak soils	Riverbank protection, conservation areas	Flood-adapted agriculture	Hafirs	
W2b		Regularly flooding, Limestones, Weak soils	Riverbank protection, area closures,	-	-	
W3		Artificial reservoirs	Riverbank protection	Life fencing	-	
B1	Built-up areas	Towns	Urban water and waste management	Biological interventions	Roof rainwater harvesting	
B2		Settlements	Forest management, SWC to control wind erosion	Life fencing	Roof rainwater harvesting, birkads	
E1	Eroded areas	Severe gully erosion	Area closures	Biological interventions, erosion control structures	-	
	Sandy sediment, on basement rock (Fafen)	Small sandy gullies, stream order 1	Riverbank protection	Biological interventions, erosion control structures		Check-dams, (small) valley dams
		Sandy gullies and streams, stream order 2	Riverbank protection	-		Check-dams, (leaky) sand dams, valley dams
		Sandy seasonal streams, stream order 3	Riverbank protection	-		Subsurface dams, sand dams, valley dams
		Sandy seasonal rivers, stream order 4	Riverbank protection	-		Subsurface dams
	Silty to clayey sediment, on limestone (Jerer)	Small clayey gullies, stream order 1	Riverbank protection	Biological interventions, erosion control structures		Check dams
		Clayey gullies, stream order 2	Riverbank protection	-		Valley dams
		Clayey seasonal streams, stream order 3	Riverbank protection	-		Valley dams
		Clayey seasonal rivers, stream order 4	Riverbank protection	-		Valley dams

3 Case studies

3.1 Case 1 – Conservation practices for weak soils

3.1.1 Location and problem description

Case 1 focuses on conservation practices on flat to gently sloping lands characterized by weak soils, limited vegetation cover, and mostly used for agriculture, indicated on the ecosystem restoration suitability map with zone A5 (see Figure 3-1 and Table 3-1). The case is representative for the lands of the Jigjiga Plains. The case is explained based on an example from Gumburkha-Khale.

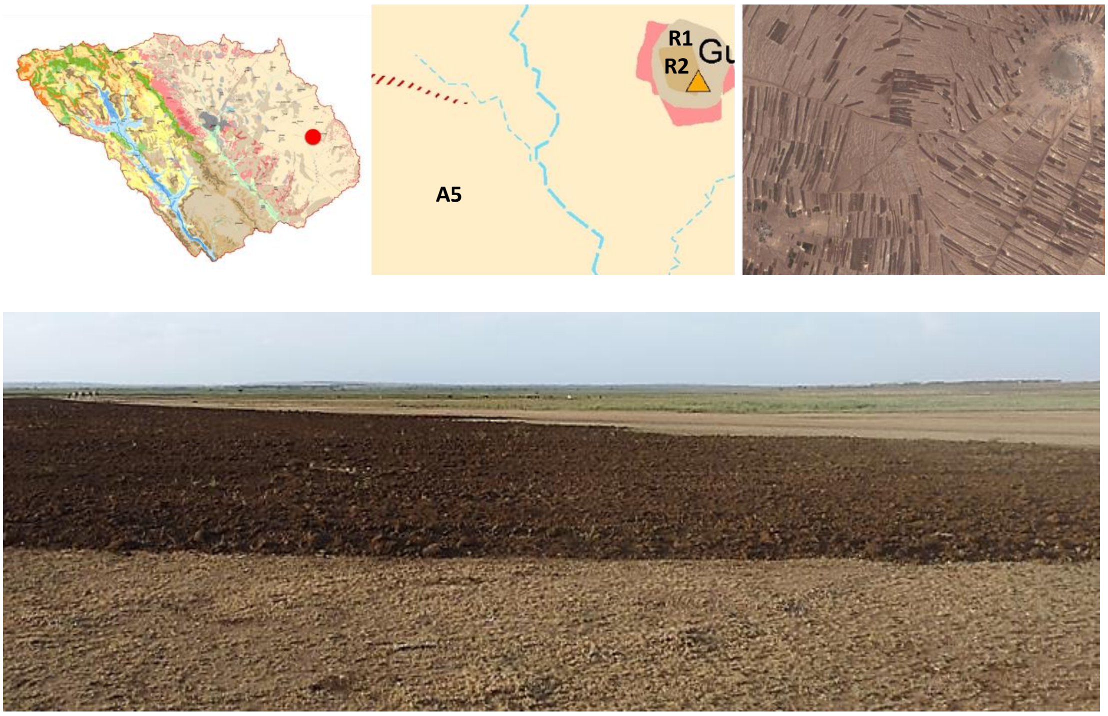


Figure 3-1 Location of the case in the project area on the larger map, on a snapshot and on satellite imagery (ArcGIS World Image), and a picture from the agricultural lands at the site.

The lands of zone A5 (see Table 3-1) are mostly under crop production. The soils are weak, typically of the FAO- type vertisol, which are susceptible to waterlogging in the rainy season, cracking in the dry season, gully erosion and wind erosion. Inselbergs are present throughout the landscape. These elevations are mostly steep, and either consist of bare rock or are covered with very shallow stony soils. Inselbergs are often used to establish settlements, such as Gumburkha-Khale, or when any vegetation is present as rangeland (zones R1 and R2 on the map, see Table 3-1).

Table 3-1 Ecosystem restoration suitability zones with characterization in terms of land use/sediment, slope and soil

Zone	CHARACTERIZATION	
	Current land use/sediment	Slope and stream specifications
A5	Arable land	Flat to gentle sloping areas (<3%), Weak Soils
A6		Slope > 3%, Weak Soils
R1	Rangelands	Slopes < 10%
R2		Steep slopes (10-25%)
	Silty to clayey sediment, on limestone (Jerer)	Small clayey gullies, stream order 1
		Clayey gullies, stream order 2

Most of the lands in zone A5 lay bare most of the year. After crop production, no grass, thickets, trees or any other vegetation are present to protect the lands against the erosive effect of water and wind. As a consequence, soil particles are easily detached and transported away, so that fertile lands and soils are lost. These challenges are strongly linked to deforestation, which is related to a high demand for wood, fences and forage, and suboptimal agricultural practices, such as cultivation with no or limited input of fertilisers. Water availability in the area could be improved if better use is made of opportunities for off-stream water storage.

3.1.2 Recommended interventions

Most of the agricultural lands in the Upper Fafan Catchment are dedicated to small-scale rain fed crop production by local farmers. In general, only low-value crops, such sorghum and maize, are grown, mostly for own-consumption. As such, the farmers' income is limited. The interventions selected (Table 3-2) are, therefore, mostly low-budget and implementable by the farmers and communities themselves with locally available inputs.

Table 3-2 Ecosystem restoration suitability zones with possible interventions

Zone	RECOMMENDED TYPES OF INTERVENTIONS			
	Protection and restoration	Soil and water conservation (SWC)	Off-stream water storage	In-stream water storage
A5	-	Basic SWC, SWC for weak soils, SWC to control wind erosion	Hafirs, ponds, micro dams, birkads	
A6	Discourage agriculture, forest management	SWC for weak soils and slopes, permanent agriculture	Micro-dams, birkads	
R1	Rangeland management	Biological interventions	Hafirs, ponds, birkads	
R2	Rangeland management	Biological interventions	Hill-side dams, birkads	
	Riverbank protection	Biological interventions, erosion control structures		Check dams
	Riverbank protection	-		Valley dams

Protection and restoration: Agroforestry and controlled grazing

Agriculture is feasible on flat to gently sloping lands with weak soils, but is only sustainable if appropriate management practices are applied. To limit wind erosion and improve microclimatic conditions it is recommended to promote permanent agriculture and agroforestry, so that a more or less permanent vegetation cover is guaranteed.

In areas used for grazing, establishment and enforcement of (improved) rangeland management practices is advised. It is recommended to, in coordination and close collaboration with community elders, agree on sustainable grazing patters, assign wet and/or dry season emergency grazing areas, and discuss sustainable wood harvesting and wildlife management. Along streams and gullies riverbank protection against grazing, arable farming and tree cutting, is recommended.

Soil and water conservation: soil conservation practices for weak soils

Widespread implementation and optimization of soil and water conservation practices in the area could allow intensification of agriculture, production of higher value crops, and support conservation and recovery of ecosystem services that are fundamental for long-term sustainability, such as nutrient cycling and soil structure development.

To counteract both wind and water erosion it is important to start with the application of basic soil and water conservation measures. To reduce the detachment and transport capacity of water, run off should be slowed down. Soils should be kept covered as long as possible, either with vegetation or organic mulch, and flow velocities should be lowered with, for example, soil bunds. As most of the soils belong to the very fragile type of vertisols, it is also recommended to consider the experiences and approaches described in the manual for management of vertisols (see Annex II). To limit wind erosion, improve microclimatic conditions on the plots and increase soil stability, it is recommended to plant trees and tree strips (also known as wind breaks), and to promote life fencing for fields and settlements.

In agricultural areas on weak soils with slopes >3% (Zone A6), it is recommended to add SWC practices for slopes, including the application of bunds, tied ridges, grass strips and contour trenches, and to replace arable agriculture with permanent crops, such as, for example, fruit trees. As the shrink and swell properties of vertisols can cause difficulties for trees and shrubs to grow, care should be taken when selecting tree species and planting locations. Soil improvement measures, such as planting pits, can also (partly) alleviate the challenges.

Off-stream water storage: improving open water reservoirs

Considering the non-functioning and poor water quality of existing birkads and hafirs, it is primarily recommended to improve their design and management. Currently, large volumes of water are being lost to infiltration and evaporation, and pollution of the reservoirs is a major challenge. Although often there are no or only limited alternatives, care should be taken when planning water storage structures on weak soils. The concentration of runoff could induce erosion, and the easy detachment and transport of soil particles frequently results in a quick siltation of reservoirs. When, nonetheless, reservoirs are built it is recommended to choose small-scale deep structures over larger ones, to equip them with silt traps and to make clear agreements on maintenance at the very start of the project.

There is a number of relatively simple adjustments to the design of traditional structures that could have positive effects on water quantity and quality. Lining reservoirs–with clay, concrete or plastic – could reduce infiltration. Deepening reservoirs, constructing silt traps and planting selected vegetation in the reservoirs could contribute to a reduction of relative evaporation losses. To improve water quality:

- Vegetation could be planted at the inlet of reservoirs to act as a natural filter;
- Life fencing could be applied to avoid the entrance of livestock and wildlife into the reservoir;
- Infiltration galleries connected with hand pumps could be built to filter water and avoid people entering the reservoir to fetch water;
- As livestock is a major polluter it should be prevented from entering the reservoir. This could be achieved by watering them from troughs or by constructing separate reservoirs. When livestock cannot be kept out of the reservoir it should at least be equipped with a cattle ramp to avoid siltation.
- Post-treatment is a must for human consumption; in this sense sensitization and awareness raising programmes are recommended.

Next to these traditional types of water storage, roof rainwater harvesting could also be an option for settlements where buildings with iron roof sheets are available. Roof rainwater harvesting makes use of a hard surface roof to intercept rainfall to, afterwards, conduct it to a storage reservoir.

In-stream water storage: open water reservoirs and soil moisture retention

The opportunities for in-stream water storage in the Jijiga plains are limited to open water reservoirs and soil moisture retention. In the upper reaches of the catchment (stream order 1 and above), check dams and micro dams could be feasible, but these will mostly serve the retention of soil moisture and not the increased availability of water for consumption. Experience shows that in-stream crop production directly upstream of these structures results in higher yields. Further downstream (stream order 2-3) valley dams are feasible. These dams should be able to withstand flash floods and soil and water conservation measures should be taken upstream to reduce siltation of the reservoir.

3.1.3 Expected results and beneficiaries

The recommended soil and water conservation measures will lead to a reduction of wind, sheet and gully erosion. This will reduce the loss of fertile soil, damage to infrastructure and the sediment load that leads to siltation of water reservoirs. Hence, soil and water conservation measures also contribute to the more effective and safe storage of water. In tandem with the improved design and management of existing reservoirs, and possibly the construction of new ones, water availability wand water quality will improve to the benefit of rural households, farmers and pastoralists.

The proposed measures also contribute to food safety. Soil and water conservation specifically aims at improving soil moisture and nutrient conditions, soil structure and microclimatic conditions. As a result the lands will be able to sustain higher yields and higher value crops, which is a direct benefit to farmers. Experience shows that these results may be expected within one growing season.

The plantation of tree lines and life fencing also comes with additional benefits. Next to erosion control, the plantation and protection of trees increases the availability of wood. Currently, barely any tree are present in the case study area, while the demand for wood, timber and charcoal is huge. Active plantation, protection and management of trees could form an additional source of wood, which could be kept for own use or marketed in the larger towns and markets generating additional income. To produce wood in a sustainable manner wood harvesting should be done in a tree saving manner, that a win-win situation is created with both direct and long-term benefits.

Regarding disaster risk reduction the proposed measures could contribute to improving health conditions, increasing food stocks and lowering the risk of flooding.

In terms of ecosystem functioning, particularly provisioning (water, food and wood production) and regulating (microclimate regulation, soil development, nutrient cycles, flood reduction) services are recovered.

3.1.4 Activities towards implementation

Interventions	Activities	How	Who to involve
Rangeland management	Establish no-, wet- and dry-season grazing areas, protect trees	Agreements with communities, introduction cut-and-carry practices, promote landscape stewardship	Community representatives, pastoralists, religious leaders
Basic SWC measures	Provide trainings in good agricultural practices	Farmer field schools, Exchange programmes to successful projects	SWC-experts, agricultural bureau, agricultural experts woredas, farmers
SWC for slopes and weak soils	Provide training on good agricultural practices and implementation of SWC measures specifically for slopes and weak soils	Farmer field schools, exchange visits	NGOs, SWC-experts, agricultural bureau, agricultural experts woredas, farmers
Permanent agriculture	Increase the availability of cheap tree seedlings, improve access to markets	Set-up tree (commercially viable) nurseries, provide trainings on product conservation	Agricultural and SWC experts, agricultural bureau, agricultural experts woredas
Upgrade reservoirs	Deepen earthen reservoirs, line birkads, protect inlet, plant vegetation filters and cover, construct infiltration galleries, improve maintenance	Invest in improved design and construction, establish agreements on maintenance	Experts, NGO's, water bureau, water experts woredas, water users
Knowledge dissemination	Awareness raising on water point protection and post-treatment of water	Sensitization campaigns	WASH-experts, NGO's, pastoralists, women and children
Construct check and valley dams	Provide trainings in soil moisture management and the role of check and valley dams	Provision of trainings, pilot project showing potential	Farmers, agricultural bureau, SWC- experts

3.1.5 Upscaling potential

The conditions described in this case study are representative for approximately one fourth of the project area (almost 950 km^2). Hence, the proposed interventions could be implemented throughout this area (identified on the map with zone A5), and even beyond on lands where agriculture is practiced on weak soils. The upgrading of the reservoirs with vegetation, infiltration galleries and improved management can be applied throughout the project area.

3.2 Case 2 – Restoring severely eroded lands

3.2.1 Location and problem description

Case 2 focuses on management of degraded lands, which are indicated on the ecosystem restoration suitability map with zone E1 (see Figure 3-2 and Table 3-3) and located mostly on the eastern side of Karamara Ridge. The case is explained on the basis of an example from the valley of the Tobi Jere Stream, which is in-between the villages of Waji 1 and Waji 2 (Figure 3-2).

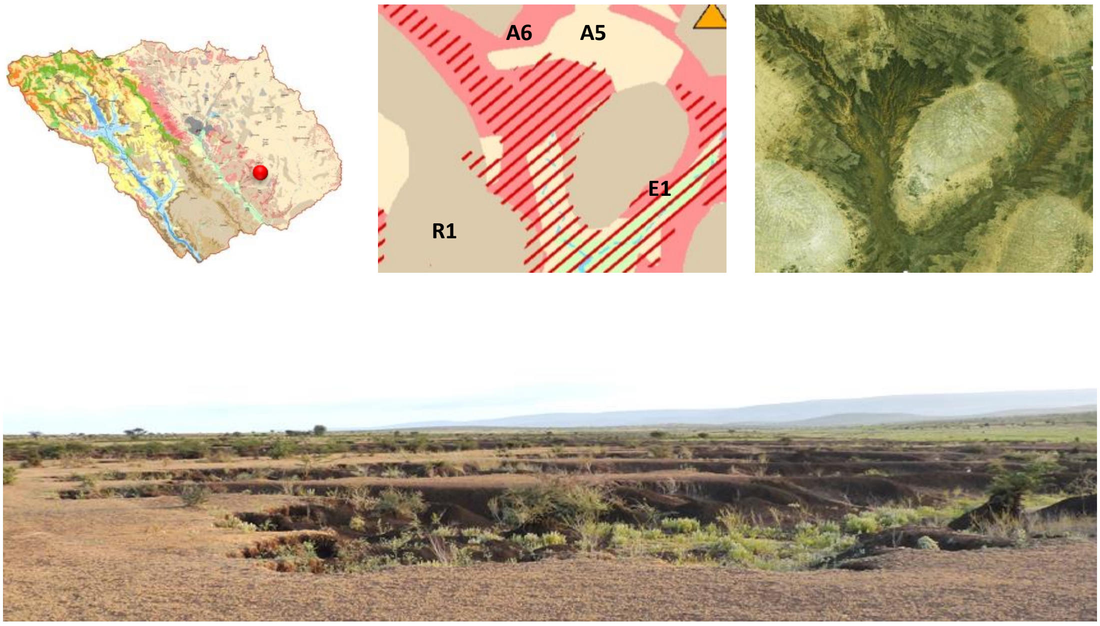


Figure 3-2 Location of the case in the project area , on a snapshot and on satellite imagery (ArcGIS World Image), and a picture from degrade soils on the site

The most degraded lands are often at the border between rangeland and agricultural areas, where poor soil management practices are applied and vegetation cover is limited. Often runoff comes from the stony soils with steeper slopes (zone R1/R2) and causes erosion when reaching the weak soils in the valleys (zone A5/A6). Erosion rates in these areas are high. Fertile soils are being washed away to the detriment of agricultural production, biodiversity and availability of pastures. Productive farm- and rangelands are being lost. At the same time, in downstream areas, reservoirs are being filled with large amounts of silt and clay.

Table 3-3 Ecosystem restoration suitability zones with characterization in terms of land use/sediment, slope and soil

Zone	CHARACTERIZATION	
	Current land use/sediment	Slope and stream specifications
E1	Eroded areas	Severe gully erosion
	Silty to clayey sediment, on limestone (Jerer)	Small clayey gullies, stream order 1

3.2.2 Recommended interventions

Despite the high erosion rates, these vulnerable lands can be preserved and recovered, and even have a high (agricultural) production, if proper conservation measures are implemented. These measures should at all times be implemented in an integrated manner: physical structures and revegetation could contribute to ecosystem restoration and provide direct benefits to rural communities, but are only sustainable if applied in combination with improved management practices. Priority should be given to addressing the underlying causes of degradation, such as overgrazing, deforestation and poor agricultural practices. In most cases this means banning all degrading activities from a delineated areas until vegetation and soils have recovered. Only after this basic protection is taken care of, biological and erosion control structures can be thought of. See also Table 3-4.

Table 3-4 Ecosystem restoration suitability zones with possible interventions

Zone	Soil and water conservation (SWC)	Protection and restoration	Off-stream water storage	In-stream water
E1	Biological interventions, erosion control structures	Area closures	-	
	Biological interventions, erosion control structures	Riverbank protection		Check dams

Protection and restoration: no-grazing and limited agriculture
In the case study area, and in all other areas threatened by similar challenges, first and foremost crop production and grazing close to and within gullies should be banned. A permanent vegetation cover is essential to stabilize the soils and slow-down erosion. Experience shows that these objectives can best be reached by implementing area closures and riverbank protection. Area closures are areas that are protected against all degrading human activities, including agriculture, grazing and tree-cutting. Gullies naturally have accumulation of water, fertile soils, and seeds (if retained), protection enables vegetation and soil to recover naturally, which can happen rapidly without any further interventions.

To be effective it is important to delineate these closure areas and establish rules and regulations in close collaboration with communities. Sometimes it is decided to allow cut-and-carry systems, fruit harvesting or back-up grazing during emergencies, but the overarching philosophy should be that no products are extracted from these areas, until soil and vegetation are fully recovered.

Within the project area some good examples of recovered gullies are present, and widespread implementation of such closure areas resulted in total regreening in project areas in, for example, Tigray Region, northern Ethiopia. Protection stimulates germination of seeds, promotes seedling survival and allows vegetation to grow faster.

Soil and water conservation: Biological and physical erosion control
In addition to improved management practices, in and along the rills and gullies erosion control structures and biological interventions could be implemented. Although dimensions of erosion control structures are variable, most are small scale and can be constructed with manual labour. Gully stabilization should start at its source. The first structures should always be placed in the upper reaches. Implementation further downstream should only be done after stabilization at the top.

Biological interventions are centred on the positive impact of vegetation on the functioning of the landscape. Biological interventions include, for example, afforestation and reforestation with tree and plant species that are effective in soil stabilization.

Off-stream water storage: improving water quality
All recommendations on off-stream water storage provided for case 1 apply (see Section 3.1.2).

In-stream water storage: slow-down water
Because of the fine texture of the soils opportunities for in-stream water storage are limited. Check dams are an option in the upper parts of the gullies, but primarily to slow-down water and sediment flow rates to counteract erosion. Depending on the weather conditions, no or few water will be made available for direct use. The structures, however, do contribute to improving soil moisture conditions, which could be used for crop production, and limit siltation of reservoirs downstream. Check dams

should only be implemented in combination with improved management practices, as else the chance of failure of the structure will be high. Refer also to Section 3.1.2.

3.2.3 Expected results and beneficiaries

The recommended interventions primarily aim at lowering erosion rates, so that fertile soils and lands are retained. As such, the interventions directly contribute to maintaining the accumulated production capacity of agricultural lands located close to the degraded areas. Farmers, and their households, are thereby benefitting from the measures. On the long term, closure areas often become highly productive in terms of berries, wood and may other natural products. If sustainable extraction is guaranteed the collection of these products could provide an additional source of food, energy and income to close-by communities.

Regarding water safety, the proposed measures are very important to downstream communities. When erosion is avoided, the sediment load during intense rainfall is limited and thus siltation of reservoirs with clay and silt is less of a problem.

Natural and human revegetation of degraded areas form a major contribution to mitigating flash floods. As the water retention capacity of the upstream areas increases, peak flows are attenuated and flood frequency is reduced. In essence, the flow regulation capacity of the ecosystem is recovered.

3.2.4 Activities towards implementation

Interventions	Activities	How	Who to involve
Reforestation	Increase availability of tree seedlings, provide training on reforestation practices	Farmer field schools, exchange visits to successful projects	Community representatives, Forestry experts with knowledge of local tree species, planning bureau
Closure areas	Promotion of closure areas, training on natural regeneration capacity of fallow lands	Exchange visits to successful projects; facilitation of agreements on delineation, rules and regulations of closure areas; farmer field schools	Communities, community representatives, agricultural bureau, agricultural experts woreda, religious leaders

3.2.5 Upscaling potential

Along Jerer Valley almost 73 km2 are threatened by severe erosion due the occurrence of conditions and processes as the ones described here. The proposed interventions could be applied in all areas identified by zone A6 and E1 on the ecosystem restoration suitability map. It should be said that these interventions are most effective if implemented on a large scale and in an integrated manner.

3.3 Case 3 - Good agricultural practices on slopes

3.3.1 Location and problem description

Case 3 focuses on erosion challenges agricultural land on (steep) slopes, which are particularly challenging in the more mountainous areas west of Karamara Ridge. On the ecosystem restoration suitability map these areas are identified by zone A2, A3 and A4 (arable land on steep slopes) (see Figure 3-3 and Table 3-5). The interventions recommended for zone E1 (overlaying red hatch) are described in case 2. This case is explained on the basis of deeply incising gullies in Dengego.

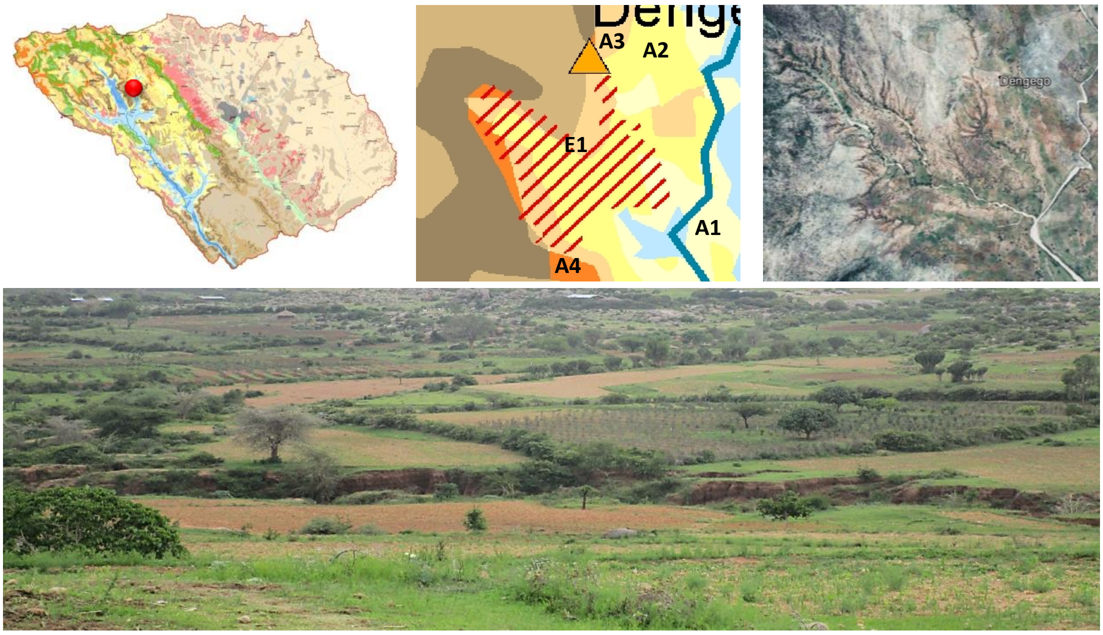


Figure 3-3 Location of the case in the project area, on a snapshot and on satellite imagery (ArcGIS World Image), and a picture showing gully erosion on sloping arable lands

In the project area, the population is growing, and livelihoods and lifestyles are changing. One of the major changes is the increased involvement in agricultural production and hence a high demand for agricultural land. Consequently, rangelands and forests are transformed into arable land, often without applying adequate land use planning and management practices and appropriate SWC measures. The trend is resulting in an aggravation of erosion processes, loss of biodiversity, and in a higher incidence and intensity of floods and droughts, which is undermining the natural carrying capacity of the area.

Table 3-5 Ecosystem restoration suitability zones with characterization in terms of land use/sediment, slope and soil

Zone	CHARACTERIZATION	
	Land use/ sediment	Slope and stream specifications
A1	Arable land	Flat to gentle sloping areas (<5%)
A2		Gentle slopes (5-10%)
A3		Steep slopes (10-25%),
A4		Very steep slopes (>25%)

3.3.2 Recommended interventions

The challenges associated with erosion on steep slopes are mostly concentrated in the area south of the Amora Mountains. Despite the steep slopes and a similar characterization of the soils in the Amora

Mountains itself erosion processes there are much less of a problem. This indicates that when erosion protection measures are implemented on a large scale, and the existing vegetation cover is kept in place, soil and water can be conserved. Successes have been reported from Chinaksen, Goggiar and Hariro. The interventions recommended in this subchapter are inspired on the successes achieved in these villages.

Figure 3-4 Example of sustainable management and good agricultural practices on slopes: agroforestry, forest on steepest slopes and SWC-measures are in place where needed

Table 3-6 Ecosystem restoration suitability zones with possible interventions

Zone	Soil and water conservation (SWC)	Protection and restoration	Off-stream water storage	In-stream water storage
A1	Basic SWC, flood-adapted agriculture	-	Hafirs, ponds	
A2	SWC measures for slopes	-	Hafirs, ponds, hillside dams	
A3	SWC for slopes or permanent agriculture	-	Hillside dams, rock catchments	
A4	Permanent agriculture	Discourage agriculture, forest management	Rock catchments	

Protection and restoration: toward a permanent vegetation cover

Degradation rates are highest on slopes where croplands and rangelands are alternating and vegetation cover is low. Particularly on slopes, vegetation cover is often determinant to the initiation and intensity of erosion processes. Therefore, first and foremost it is recommended to control the expansion of agriculture on the most vulnerable areas. Experience shows that to achieve this, it is most effective to establish rules and regulations concerning land use at community level, accompanied with raising awareness on sustainable land use and management.

In line with this approach, closure areas (which are protected against all degrading activities such as grazing, agriculture and tree-cutting) could be implemented. Closure areas allow the regeneration of (natural) vegetation, which is a relatively cheap and very sustainable approach to ecosystem restoration. For more details on closure areas refer to Case 2 (Section 3.2.2).

Soil and water conservation: SWC for slopes

Deforestation and current agricultural practices on these locations cause soil erosion. Locally, severe gully erosion is present. To address these challenges it would be best to either ban agriculture from the most vulnerable areas, to implement biological interventions or else to move toward permanent agriculture. As perennial species provide protection throughout the year they are more effective in counteracting erosion. At the same time these species could provide high-value products that could be processed or marketed generating additional income.

Where farmers keep to arable farming it is recommended to promote large scale implementation of simple and practical soil and water conservation measures developed specifically for steep slopes. Proposed interventions include contour ploughing, bunds, trenches, tied ridges, grass and tree strips, and hillside terracing.

As implementation of these measures on a landscape-large scale (as it is needed) is rarely feasible and sustainable when implemented by outside organizations, it is recommended to facilitate mobilisation and planning, promote and train farmers to do it themselves, but not to pay or compensate communities through cash or food for work. Often when the advantages are highlighted and success stories are shared, farmers are very willing to invest some of their time in protecting and upgrading their fields. On the contrary, compensation with cash or food for work often results in the opposite, as bad practices resulting in degradation are rewarded during the restoration projects .

Off-stream water storage: mostly small-scale reservoirs

Both on rangelands and on agricultural lands in the Fafan Sub-catchment there are multiple opportunities for surfaces water storage. Hence, wherever the preferred underground water storage is not feasible, one could turn to open water sources to avail water for domestic, agricultural and livestock purposes. In flat and gently sloping areas the number of hafirs, ponds and birkads could be increased to improve water supply. In slightly steeper areas, hill-side dams, which are smaller and less prone to failure on slopes, could provide additional water. Note , however, that prior to investing in new water sources it is advisable to upgrade existing ones, so that water quality from these source is improved. All recommendations given in Section 3.1.2 apply.

It is recommended to promote and support the implementation and upgrading of small-scale reservoirs. To assure long-term maintenance ownership is fundamental. Hence, it is advised to only provide support to the construction of these reservoirs in terms of expertise and maybe some materials. Excavation and construction should preferably be done by the communities themselves. As the soils are susceptible to erosion it is recommended to equip the reservoirs with silt traps and cattle ramps.

In-stream water storage: erosion control structures

Generally the rivers in Fafan Sub-catchment have a high potential for in-stream water storage. The sediment in Fafan River already has high potential for shallow groundwater and, therefore, there is no need to further increase its storage capacity. Depending on the type of erosion, in-stream small scale erosion control structures, such as check dams, could prove effective for soil conservation.

3.3.3 Expected results and beneficiaries

The implementation of soil and water conservation measures and the move toward permanent agriculture improves soil moisture content, prevents erosion and improves microclimatic conditions. Together these conditions are known to lead to higher yields, and a great potential to produce higher value crops and often higher quality products. The implementation of these measures, therefore, is an important contribution to food and income safety.

Lower erosion rates are also important in these areas because they are so remote. While infrastructure is already poor, mass movements often damage roads further increasing the distance to markets, school and other important institutions.

Discouraging agriculture and implementing closure areas on the most vulnerable lands at first instance may seem to have a negative impact on food and fodder production. On the long term, however, the balance is positive. If exploitation of these poor lands is continued, within a few years their productivity will collapse, as degradation will cut-down all natural underlying processes. Protection of these areas, on the contrary, will allow regeneration, and, thereby, production of wood, berries, and many other natural products that could prove crucial to food safety in the future.

Altogether, a more sustainable management of these slopes will accelerate the recovery of provisioning and regulating ecosystem services. The availability of food, fodder and energy resources will increase, while at the same time, for example, groundwater recharge, soil moisture conditions, soil formation and biodiversity are improved.

3.3.4 Activities towards implementation

Interventions	Activities	How	Who to involve
Biological interventions	Improving the availability of seedlings, protection of trees, tree-planting project, delineation of forest areas	Set-up tree (commercially viable) nurseries, establishment of conservation areas, plantation campaigns	NGOs, woredas, communities
Permanent agriculture	Increase the availability of cheap tree seedlings, improve access to markets	Set-up tree (commercially viable) nurseries, provide trainings on product conservation	Agricultural and SWC experts, agricultural bureau, agricultural experts woredas
SWC measures for steep slopes	Provide training on good agricultural practices and implementation of SWC measures specifically for steep slopes	Farmer field schools, exchange visits	NGOs, SWC-experts, agricultural bureau, agricultural experts woredas, farmers
Closure areas	Promotion of closure areas, training on natural regeneration capacity of fallow lands	Exchange visits to successful projects; facilitation of agreements on delineation, rules and regulations of closure areas; farmer field schools	Communities, community representatives, agricultural bureau, agricultural experts woreda, religious leaders
Rangeland management	Establish no-, wet- and dry-season grazing areas, protect trees. Reintroduction traditional agreements on sustainable grazing	Agreements with communities, introduction cut-and-carry practices, promote landscape stewardship	Community representatives, pastoralists, religious leaders
Open water reservoirs	Promote implementation of improved small-scale reservoirs by communities themselves	Agreements on (expert and material) support to own initiatives; development of promotion material explaining the need to upgrade existing reservoirs	Water resources expert, NGOs

3.3.5 Upscaling potential

Along Fafan Valley almost 100 km2 are currently threatened by severe erosion, in part due to expansion of agricultural practices onto (steep) slopes. The proposed interventions could be applied onto all areas indicate on the ecosystem restoration suitability map with zones A1, A2, A3 and A4, particularly where overlaid by zone E1 (severely eroded land). At the same time, there are many sloping areas where erosion is not yet a problem, but it is expected to become soon. Therefore, widespread implementation of the measures is recommended.

3.4 Case 4 - Sustainable rangeland and forest management

3.4.1 Location and problem description

Case 4 focuses on the management of degraded rangelands, which is particularly challenging in areas where rangelands border lands for crop production (Table 3-7). To protect crops, some farmers fence their lands diverting livestock to the steeper areas and valleys in their search for pasture. Deforestation and erosion are the most visible consequences of poor rangeland management. But, the impact of overgrazing also trickles down the biophysical cycles leading to, for example, establishment and growth of invasive species, worse soil moisture conditions, less groundwater recharge, reduced soil life and loss of biodiversity. Altogether, the degradation results in the lower availability and quality of pasture.

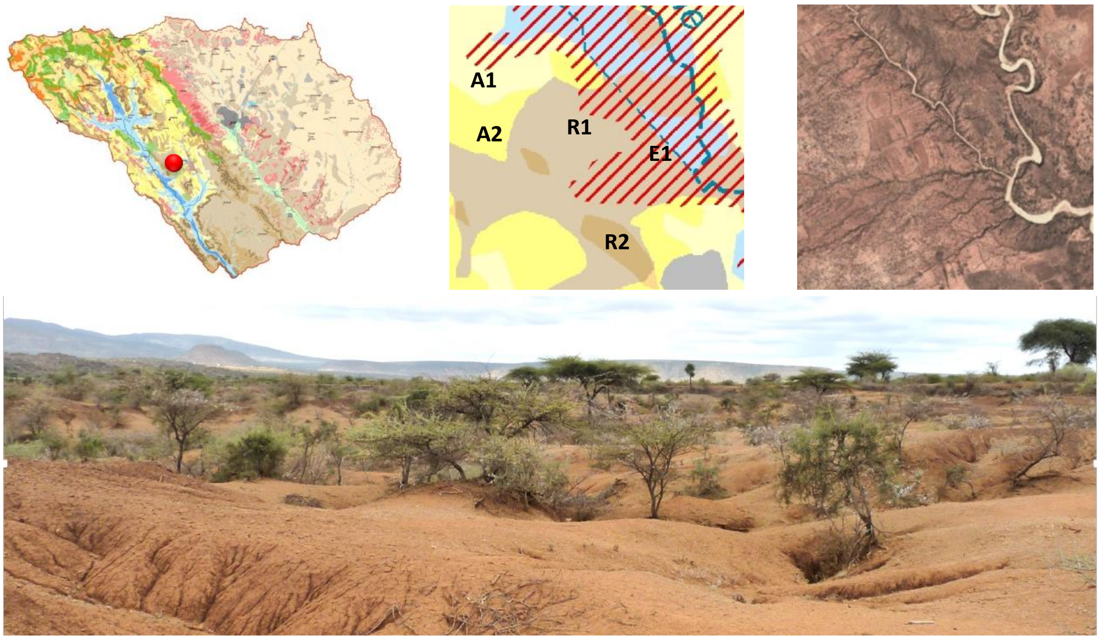


Figure 3-5 Location of the case in the project area, on a snapshot and on satellite imagery (ArcGIS World Image), and a picture showing gully erosion on sloping rangelands

On the ecosystem restoration suitability map the worst affected areas are identified with zones R1 and R2 (brown colours, rangelands) overlaid by the red-hashed zone E1 (Figure 3-5 and Table 3-7). Agricultural lands are indicated with yellow (A1 and A2). The case on rangeland management is explained on the basis of degradation processes observed along Shebele River, which is a tributary to Fafan River.

Shebele River is located west of Karamara Ridge. In the past decennia vegetation coverage in this area has been reduced to bare soil with some thorny bushes and shrubs. Barely any grass is available, also not in the rainy season. Rills and gullies are increasingly parcelling the landscape, and flushing away water, soil and seed(ling)s in times of heavy rainfall. Ongoing environmental degradation is expected to aggravate if no action is undertaken.

Table 3-7 Ecosystem restoration suitability zones with characterization in terms of land use/sediment, slope and soil

Zone	CHARACTERIZATION	
	Land use/ sediment	Slope and stream specifications
R1	Rangelands	Slopes < 10%
R2		Steep slopes (10-25%)

E1	Eroded areas	Severe gully erosion
— — —	Sandy sediment, on basement rock (Fafan)	Sandy gullies and streams, stream order 2

3.4.2 Recommended interventions

Vegetation plays a vital role in stabilizing soils and slopes. The foliage intercepts rainfall and reduces evaporative losses, roots and stems increase soil roughness and permeability leading to increased infiltration capacity, roots reinforce the soil and binds its particles, and tree roots often anchor into deeper geologic layers providing additional stability. Together these processes provide most of the necessary protection against erosion. At the same time, the living plant material in the soil supports water use and movement stimulating soil development. Especially a mixed vegetation cover often proves a blessing by improving soil structure and cohesion.

Overgrazing is the root-cause of the challenges threatening rangelands in the Upper Fafan Catchment. Experience from the past and from elsewhere shows that under proper management the lands can sustain large herds of livestock. The key to success is in controlling grazing, allowing seeds to germinate and seedlings to start growing, so that a healthy, dense and mature vegetation cover can develop from which natural resources can be extracted without undermining the functioning of the ecosystem as a whole. This can only be achieved by combined a series of interventions, see Table 3-8.

Table 3-8 Ecosystem restoration suitability zones with possible interventions

Zone	Soil and water conservation (SWC)	Protection and restoration	Off-stream water storage	In-stream water storage
R1	Biological interventions	Rangeland management	Hafirs, ponds, birkads	
R2	Biological interventions	Rangeland management	Hill-side dams, birkads	
E1	Biological interventions, erosion control structures	Area closures	-	
— — —	-	Riverbank protection		Check-dams, (leaky) sand dams, valley dams

Protection and restoration: Controlled grazing

Changing livelihoods have undermined traditional management systems, while the government does not have the capacity to take over these tasks. There is no simple solution to solve this management gap, but putting the issue onto the agendas, promoting the discussion and facilitating the organization could prove to be very effective in the long term.

When rangelands are managed adequately, there is no need for actively planting vegetation. Protection could be sufficient for the whole landscape to recover. Observations, for example, show that in some deeply incised gullies where livestock was no longer able to enter, natural gully regeneration occurred (see Figure 3-6). As the vegetation was protected against grazing, a dense vegetation cover with trees, shrubs and grasses developed.

Natural regeneration could be promoted through so-called area closures. Area closures are demarcated areas protected against al degrading activities. By means of fencing or community agreements grazing, agriculture and tree-cutting are banned allowing seeds to germinate, seedlings to grow, and vegetation to mature. Often, it is agreed that when the system is fully-recovered, for example, cut-and-carry systems and fruit harvesting are allowed. The closure could then also serve as a back-up grazing area for emergency situations.

Figure 3-6 Natural gully rehabilitation. At the gullies on the pictures, vegetation got the time and protection to recover without additional efforts being needed.

Next to closure areas, adapting and (re)introducing agreements on rangeland management practices could prove a great step forward to combating environmental degradation on rangelands. Agreements on rangelands management practices could include establishment of grazing patterns, assignment of wet season, dry season and emergency situation grazing areas, sustainable wood harvesting, and wildlife management. Additionally, new proven rangeland management strategies, such as intensive controlled grazing could be introduced. This grazing management method uses a system where cattle of a community is bunched into a large herd, which systematically grazes the area. Animals are kept in a fenced enclosure called Boma for one week, after which the enclosure is moved. Intensive controlled grazing has shown highly effective in Northern Kenya where perennial grasses recovered and soil structure improved significantly within one year after the method was introduced.

Locally successful rangeland management practices could be inventoried and studied by external parties, but the agreements itself should be designed and implemented at community level to be sustainable. That being said, promotion and facilitation toward implementing improved rangeland management is a very effective trajectory in ecosystem restoration.

Within the rangelands there are areas with dense shrubland and forest. In these areas forest management and protection should be actively promoted. Herein forest management refers to agreements on sustainable use of forested areas, including controlled harvesting of wood and other natural products. In addition, tree planting, wildlife management and control of invasive species could augment the ecological and economic value.

Soil and water conservation: Toward a higher vegetation density

On rangelands, in terms of soil and water conservation measures a combination of biological interventions and erosion control measures are recommended to improve vegetation cover. Biological interventions focus on the active plantation and protection of trees. Interventions could include afforestation and reforestation, preferably with native species that are known to promote soil stability. Erosion control measures include small and larger structures constructed with manual labour, such as gabion dams. Erosion control measures are, however, very prove to failure if not properly combined with improved management and maintenance. It is, therefore, advisable to only invest in these interventions on locations where there is a direct and very visible advantage to those foreseen to maintain the structure. Construction should at all times be supervised by an expert.

Off-stream water storage: upgrading and expansion
Similar potential as in Case 3, however, water demand in rangeland areas will mostly be for livestock. There is limited need for off-stream water storage due to the availability of shallow groundwater in many valleys and streams and high potential for instream storage.

In-stream water storage: Safe water supply
Downslope, Shebele River meanders through the valley. The riverbed is 30 to 50 meters wide and filled with a thick layer of medium to coarse sediments with shallow groundwater available throughout the year. Scoop holes are used to collect water from the river. The volumes of water abstracted could be increased by building check-dams in the upper reaches of the river to slow down the flow, and sand dams in the main course. For more information about sand dams the advantages and disadvantages of sand dams refer to Annex I. Generally, in Fafan Sub-catchment, sanddams are most feasible in the upper reaches where hard rock is found at shallow depth (stream order 1 and 2), while subsurface dams are mostly feasible in more gentle sloping river stretches with a thick sediment layer in the riverbed (stream order 3). Further downstream, most rivers have year-round shallow groundwater available, hence storage interventions are not a priority.

3.4.3 Expected results and beneficiaries

Improving rangeland management and implementing biological interventions increases the availability of natural products, such as wood, berries, fruits, leaves and forage. By protecting and restoring the functioning of the system as whole, the carrying capacity of the rangelands is recovered and food security conditions are improved, not only under normal but also under drought conditions.

Restoration of the rangelands also protects downslope agricultural lands. As rills and gullies are stabilized, mud and water flows no longer lead to mass movements that eat away lands used for crop production. As such, productive lands are protected and add to food security.

Expanding and upgrading water storage in river beds would avail more and more safe water to riverine villages. Hence, water safety both in terms of quantity and quality could be enhanced with implementation of these structures. Next to underground water sources, which are preferred, building and upgrading open water reservoirs and could contribute to improve local water conditions. In a more indirect manner, improved water availability also leads to enhanced food security, as agricultural yields could be stimulated with irrigation and livestock health is promoted by the availability of more and higher quality water.

On the larger scale, the proposed interventions reduce the frequency and intensity of flash floods and the sediment content of the flows. As such, the damage to infrastructure and agricultural fields would e reduced.

3.4.4 Activities towards implementation

Interventions	Activities	How	Who to involve
Biological interventions	Improving the availability of seedlings, protection of trees, tree-planting project, delineation of forest areas	Set-up tree (commercially viable) nurseries, establishment of conservation areas, plantation campaigns	NGOs, woredas, communities
Erosion control structures	To be built (only) in combination with area closures	Community mobilization	Woredas, communities, NGOs, SWC experts

Area closures	Promotion of closure areas, training on natural regeneration capacity of fallow lands	Exchange visits to successful projects; facilitation of agreements on delineation, rules and regulations of closure areas; farmer field schools	Communities, community representatives, agricultural bureau, agricultural experts woreda, religious leaders
Rangeland management	Establish no-, wet- and dry-season grazing areas, protect trees. Reintroduction traditional agreements on sustainable grazing	Agreements with communities, introduction cut-and-carry practices, promote landscape stewardship	Community representatives, pastoralists, religious leaders
Open water reservoirs	Promote implementation of improved small-scale reservoirs by communities themselves	Agreements on (expert and material) support to own initiatives; development of promotion material explaining the need to upgrade existing reservoirs	Water resources expert, NGOs
Sand dams	Inventory of water availability and demand, in-depth study on opportunities to build sand dams, construction of sand dams	Consultancy project with input from local organizations	NGOs, communities, water bureau

3.4.5 Upscaling potential

Rangelands are increasingly subject to environmental degradation. The interventions detailed in this chapter could be implemented throughout the areas indicated with brown colours on the ecosystem restoration suitability map (R1 and R2), while priority should be given to the most degraded (E1, red hash) zones and upstream areas.

3.5 Case 5 – Recovering wetlands' ecosystem services

3.5.1 Location and problem description

Case 5 focuses on the recovery and protection of wetlands and seasonal flooding areas, which is particularly challenging close to larger urbanizations and intensely cultivated agricultural lands. Wetlands in the Upper Fafan Catchment are land areas that are seasonally saturated with water. Wetlands form a distinct ecosystem with very specific and valuable ecosystem services. Amongst others wetlands contribute to water purification, flood control and sustenance of biodiversity. Soil moisture conditions in the vicinity of wetlands are, in general, very good. Hence, wetlands are also known to be high value grazing lands and important to crop production.

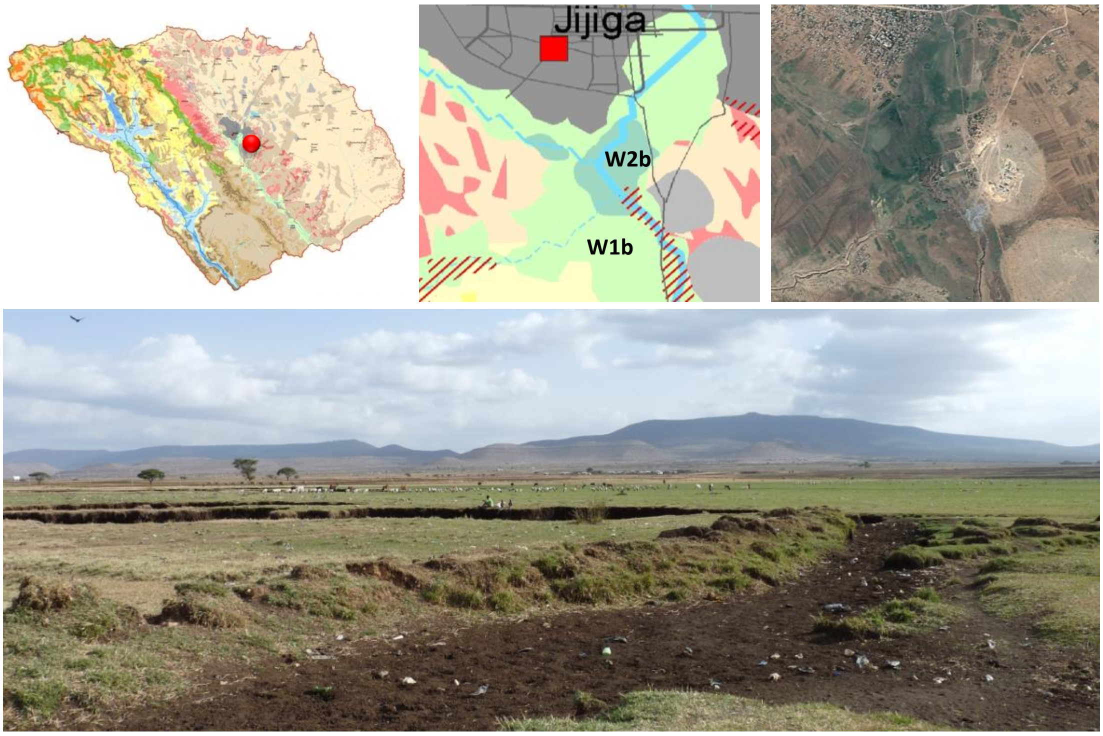


Figure 3-7 Location of the case in the project area, on a snapshot and on satellite imagery (ArcGIS World Image), and a picture with an impression of the wetlands south of Jijiga Town

Wetlands in the Upper Fafan Catchment are increasingly threatened by urban growth, pollution and encroaching agricultural lands. On the ecosystem restoration suitability map wetlands are identified with W1b and W2b (greenish colours) (see Figure 3-7 and Table 3-9). The case on the recovery of wetlands' ecosystem services is explained on the basis of the Sheik-Ali-Gure area.

Sheik-Ali-Gure refers to an area south of Jijiga Town where wetlands, built-up areas and agricultural fields border each other. The site is used for grazing and as a waste dump for the town. Erosion is also taking over, so that gullies over 4 meters deep are cutting into the soil. Fertile grazing lands, infrastructure, roads, electricity lines and water supply, are at risk. Altogether the various environmental degradation processes are negatively affecting food security, water security and disaster risk, in Jijiga Town and downstream Jerer River.

Table 3-9 Ecosystem restoration suitability zones with characterization in terms of land use/sediment, slope and soil

Zone	Land use/ sediment	Slope and stream specifications
W1b		River valleys, Limestones, Weak soils

W2b	Wetlands/ River valleys (agriculture, rangelands, forest)	Regularly flooding, Limestones, Weak soils
	Silty to clayey sediment, on limestone (Jerer)	Small clayey gullies, stream order 1
		Clayey gullies, stream order 2
		Clayey seasonal streams, stream order 3
		Clayey seasonal rivers, stream order 4

3.5.2 Recommended interventions

In this project, wetlands' recovery aims at returning seasonally flooded areas as close as possible to their pre-degradation condition and, if possible, increasing the functions performed by the wetlands. To achieve such condition, change is not only in the wetlands themselves, but also on the surrounding lands and upstream catchment. If an integrated package of interventions is implemented, processes will reinforce each other and large scale change is possible.

Zone	Soil and water conservation (SWC)	Protection and restoration	Off-stream water storage	In-stream water storage
W1b	Flood-adapted agriculture	Riverbank protection, conservation areas	Hafirs	
W2b	-	Riverbank protection, area closures	-	
	Biological interventions, erosion control structures	Riverbank protection		Check dams
	-	Riverbank protection		Valley dams
	-	Riverbank protection		Valley dams
	-	Riverbank protection		Valley dams

Protection and restoration: vegetation is key to success

Vegetation is key to protecting and recovering wetlands. When lands are left bare water and wind can easily detach and transport soil particles. This is a major challenge on the weak soil that predominate to the east of Karamara Ridge. Therefore, vegetation should be protected and given the opportunity to grow mature as much as possible.

Close to wetlands, on river banks and in severely eroded areas agriculture should be discouraged. In turn, wetland management and riverbank protection should be actively promoted. Herein wetland management refers to agreements on sustainable use of wetlands areas, including controlled harvesting of grass and other natural products. Riverbank protection comprises all those measures that promote the stability of the banks, including agreements and measures against grazing, arable farming and tree-cutting. In addition, tree planting, wildlife management and control of invasive species could augment the ecological and economic value of wetland and riverine areas.

Area closures could be implemented in the most severely eroded areas, so that all degrading activities are banned. Vegetation then gets the opportunity to fully recover and to effectively make available the full potential of ecosystem services held by wetlands.

Finally, it is recommended in solid waste and wastewater management from (larger) towns. These polluting streams are currently being disposed directly into the wetlands, polluting important sources of water of those living downstream and undermining the healthy functioning of the ecosystem.

Soil and water conservation: toward more sustainable agriculture practices

It is not recommended to use the central parts of wetlands (zone W2), which flood every year, for production of arable crops. On the contrary, crop production is possible in and close to seasonal floodplains, but only if adapted to flooding conditions and if combined with a series of erosion control interventions. To promote infiltration and slow down water during heavy rainfall, floodwater spreading and floodwater diversion by means of bunds and ditches could be applied. These interventions aim at decreasing the water's erosive capacity and availing time for infiltration to take place. To prevent crop failure either flood resistant crops should be produced or crops should be grown outside the flooding season. Erosion could be controlled on lands used for agriculture by combining a series of interventions, such as mulching, grass and tree strips soil bunds, and life fencing. In addition, agricultural practices in which different types of vegetation are combined, such as agroforestry and permanent agriculture, could be promoted.

Severely eroded areas within the wetlands (zone E1, indicated with the red hatch), can be restored with a series of measures, starting with improved management of the surrounding areas, and area closures at the eroded areas, as described above. Erosion control structures, such as gabion dams, could also prove to be effective. These structure are, however, highly prone to failure and only effective if applied in combination with area closures and other vegetation management interventions.

In addition to the mentioned interventions, expansion of life fencing and biological interventions could be supported in built-up and eroded areas to address erosion challenges. Strips, lines and patches of trees reduce wind speed and thus its capacity to detach and transport soil particles. Hence trees and shrubs could be planted in the form of fences, conservation areas or agroforestry.

Off-stream water storage: different opportunities

For off-steam water storage in open water reservoirs applies that first and foremost, as in all other areas of the Upper Fafan Catchment, that existing reservoirs could be upgraded toward supplying more and more safe water (see also Section 0). After considering whether existing reservoirs could be upgraded, on could check whether it would be effective and feasible to build more reservoirs.

The assessment undertaken in this study, points out that in the flat and gently sloping areas surrounding the wetlands (zone W1) conditions are suitable to construct ponds and large hafirs. Floodwater can be diverted and led into reservoirs in a controlled manner, including a by-pass (rather than an outflow) and a silt-trap, to avoid siltation. When siting and constructing open water reservoirs, it is important to take into account high evaporation rates. It is, for example, recommended to excavate and build relatively deep reservoirs to limit the evaporation surface.

In-stream water storage: check dams and valley dams

Water availability could be further improved by means of in-stream structures, such as check-dams and valley dams. Check-dams are small dams across a waterway that primarily aim at counteracting erosion. Valley dams, on the other hand, are concrete or earthen dams located in slightly larger streams on a concave location, so that water can be stored upstream.

3.5.3 Expected results and beneficiaries

Recovery of wetlands and their surroundings improve water availability, particularly in the form of soils moisture. This is highly valuable to crop production, as crop failure in the project area is known to often be linked to poor soil moisture conditions. Slowing down erosion rates at the same times also protects the fertile agricultural lands and soils. Crop production and quality is hence enhanced by the measures.

Implementation of protection and restoration measures aim at recovering the carrying capacity of the lands. If the, mostly managerial, interventions are applied, forests and rangelands will become more and more productive in the long term, and possibly even be able to provide the so-needed back-up for emergency situation. Protection and restoration interventions in this sense contribute to enhancing the availability of natural products.

In-stream and off-stream water storage, upgrading of existing reservoirs and safe disposal of both solid waste and wastewater all contribute to improving the availability of more and more safe water. Depending on the type, location, design and state of the reservoir, water will be usable for one or more purposes (domestic, livestock watering or agricultural).

As all interventions aim at recovering wetlands, the total package is highly valuable in terms of disaster risk reduction. If wetlands are recovered their regulating functions (hydrological, nutrient and carbon cycles) are restored and thus frequency of floods, droughts and other disaster is expected to decrease.

3.5.4 Activities towards implementation

Interventions	Activities	How	Who to involve
Flood-adapted agriculture	Provide training on flood-adapted agriculture and functioning of wetlands; study the opportunities for floodwater spreading	Farmer field schools, exchange visits, consultancy project	NGOs, SWC-experts, agricultural bureau, agricultural experts woredas, farmers
Basic, wind erosion and weak soils SWC-measures	Provide training on good agricultural practices and implementation of SWC measures	Farmer field schools, exchange visits	NGOs, SWC-experts, agricultural bureau, agricultural experts woredas, farmers
Riverbank protection	Promotion of riverbank protection, training on the functioning and importance of wetlands	Exchange visits to successful projects; facilitation of agreements on delineation, rules and regulations of closure areas; farmer field schools	Communities, community representatives, agricultural bureau, agricultural experts woreda, religious leaders
Area closures	Promotion of closure areas, training on natural regeneration capacity of fallow lands	Exchange visits to successful projects; facilitation of agreements on delineation, rules and regulations of closure areas; farmer field schools	Communities, community representatives, agricultural bureau, agricultural experts woreda, religious leaders
Waste and wastewater disposal	Study opportunities for alternative waste(water) disposal systems	Consultancy projects, feasibility study	Woreda, NGOs
Upgrade and expand open water reservoirs	Deepen earthen reservoirs, line birkads, protect inlet, plant vegetation filters and cover, construct infiltration galleries, improve maintenance	Invest in improved design and construction, establish agreements on maintenance	Experts, NGO's, water bureau, water experts woredas, water users

3.5.5 Upscaling potential

Both along Fafan and Jerer River there is a wide strip of wetlands and floodplains that deserve to be protected and recovered. These ecosystems, if restored, provide many of the services that sustain the landscape as a whole. The interventions described in this chapter are oriented toward the wetlands along Jerer River (zones W1b and W2b) and are based upon the conditions at Sheik-Ali-Gure site, but most also apply for the wetlands and floodplains along Fafan River (zones W1a and W2a).

3.6 Case 6 – Surface water reservoirs for integrated development

3.6.1 Location and problem description

Case 9 focuses on the improvement and protection of surface reservoirs, which are one of the most important sources of water for the rural population. There are no permanent natural surface water sources in the project area, only dams, hafirs, birkads, and balleys (traditional ponds in natural depressions). The largest dam in the area is the Elbeyih Dam (Figure 8).

Surface reservoirs face many challenges. The smaller ones often dry up during the dry season. Most reservoirs also face water quality problems. Reservoirs are mostly unprotected, very susceptible to contamination and loose large amounts of water to evaporation. Livestock is often entering the facilities, and most reservoirs are uncovered, without a silt trap, filtration or any other water treatment mechanism.

Figure 8: Location of the case in the project area, on a snapshot and on satellite imagery (ArcGIS World Image), and a picture with an impression of the Elbeyih Dam near Jijiga Town

Surface water reservoirs provide water to multiple purposes, including irrigated agriculture, domestic water supply (when treated), aquaculture and for livestock rearing. At the same time the reservoirs form important ecosystems and serve as a repository of biodiversity of rare and endemic species.

The high value of, for example, Elbahay dam also creates interesting opportunities for tourism, production of high value crops, aquaculture and more business oriented livestock rearing. With support from outside integrated development schemes could be established, which allow users to make an additional income from the reservoirs. These users could then also be made responsible for regulating water use and managing the resources from the surrounding landscape.

3.6.2 Recommended interventions

Irrigated agriculture. Agriculture is mainly rain fed. The construction of dams creates the opportunity for surrounding farmers and local investors to produce (relatively high-value) irrigated crops. The production of these crops would create an additional source of revenue on the local market.

The construction of dams and the introduction of relatively advanced irrigation techniques, such as sprinkler and drip, allows to diversify crop production into

- Cereals: Corn and beans;
- Vegetables: Pumpkin, potato, carrots, cabbage, tomato and Pimento;
- Fruits: Papaya, guava, oranges, Avocado, mango and tangerine.

Aquaculture. The reservoirs will come with the opportunity to establish aquaculture businesses. In collaboration with local research institutional and the Fisheries Department it is possible to start farming fish species.

Business oriented livestock rearing. The higher water availability allows the maintenance of vast pastures and watering areas for livestock. To do this in sustainable manner it is important to protect the pastures using cut-and-carry systems. The improved availability of pasture and water will increase the productivity of livestock, both in terms of milk and meat. The support which could be provided by the veterinary services from Jijiga Town could further improve the revenues from livestock rearing.

3.6.3 Expected results and beneficiaries

Using surface water reservoirs for integrated development provides an additional income to surrounding communities, local investors and agropastoralists and allows for a more sustainable management of the reservoirs.

3.6.4 Activities towards implementation

For the success of this scheme we propose a six-step strategy:

(1) local users should be encouraged to recognize the potential benefit of the dams, so that there is an intrinsic sustainably protecting and using the dams surrounding for developing alternative livelihood means;
(2) there must be adequate opportunity for local users to participate in solving perceived and existing problems;
(3) the alternative livelihood development mechanisms must be decided upon by the community;
(4) there must be cooperation between all the stakeholders including the government and the private sector;
(5) there must be no harmful effects on the local population due to the new development schemes planned;
(6) financial and other benefits must be provided by the surrounding area so that locals may control them.

3.6.5 Upscaling potential

After piloting the integrated development approaches at Elbeyih Dam, there are multiple opportunities for upscaling. There are many more dams in the project area that could also be more efficiently and sustainably used.

3.7 Case 7 – Control and management of invasive species

3.7.1 Location and problem description

Invasive species are plants or animals that do not naturally belong to certain ecosystem. Invasive species were, at some moment in time, intentionally or accidentally introduced to an area by humans (WWF 2016). When introduced species thrive in their new environment, they often become invasive and damaging to native species. As native species are unprepared to defend themselves against the newcomers, extinction may follow. This loss of biodiversity in turn may have huge consequences to the functioning of the ecosystems.

In the Upper Fafan Catchment, five invasive plant species have a significant impact on the availability of ecosystem services to rural communities. Apart from causing soil degradation and resulting in the loss of biodiversity, these five invasive species also have direct negative impacts on rural livelihoods in the Upper Fafan.

- Lantana camara is poisoning to livestock, harbors pest and diseases, augments run-off rates, and out-competes native vegetation
- Prosopis juliflora harbors pests and diseases affecting livestock health, prickles due to spines and thorns, slows down the growth of other species by means of allelopathy, results in the loss of pasture and rangelands, blocks the functioning of infrastructure and the access to natural resources
- Opuntia stricta (prickly cactus) produces spines and thorns blocking access to resources
- Calotropis procera (sodom apple) monopolizes resources to the detriment of native species and is poisoning to humans and livestock
- Parthenium hystorephorus is poisoning, induces hypersensitivity, transmits pest and diseases, and slows-down the growth of other species by means of allelopathy

As elsewhere around the world, thus far management of invasive species in the project area has been focused on control and eradication. Mechanical, chemical, biological, legislative and integrated interventions were applied, but the efforts have been largely unsuccessful.

3.7.2 Recommended interventions

As control and eradication efforts failed, communities started adapting to the presence of these invasive species. Furthermore, much of the recent scientific evidence suggests that invasive species are here to stay, so the newest insights indicate that it is better to start using them as beating them will not work (Sax and Gaines, 2008; Brendon, 2010; Davis et al., 2011; Essl et al., 2011). In this case we would like to elaborate on this approach. Opportunities for innovation and diversification of livelihoods in response to the increased abundance of the five invasive species are presented. The purposeful use of the different species also functions as a control mechanism.

Opportunities (for more details refer to Annex VI)

Species (name and picture)	Local use	Marketing products
Lantana camara 	Mulch, fertilizer, herbal medicines, articles for household utility	Handicrafts, pulp (paper), furniture, toys
Prosopis juliflora 	Energy, fodder	gum
Opuntia stricta (prickly cactus) 	Food, herbal medicine	Food colorant, anti-oxidant
Calotropis procera (Chinese road plant) 	Herbal medicine	Food coagulant
Parthenium hystorephorus 	Herbal medicine, compost	Biogas production, production of herbicides, insecticides and pesticides

Research

The examples show that there are multiple opportunities to make economic profit from invasive species. To tap into these opportunities it is recommended to invest in feasibility studies and development of sustainable business models. Research into all aspects of the production chain (harvesting, processing and marketing) is needed. Pilot projects may be an interesting opportunity to test how to make (additional) benefit out of invasive species. Success stories should be documented to promote the approach.

Trainings

The highest potential for using invasive is attributed to those opportunities that fulfil direct needs of communities, such as collection and harvesting of species to be used as food, fertilizer, fodder or firewood. To promote these uses awareness raising is the most important aspect.

Trainings will be required to inform, teach and create. Many of the identified opportunities are rather easy to implement and require low investments. Often the challenge is in the fact that the population unaware of the possibilities provided by the species. Trainings on the following topics could, for example, be arranged:

- Design and making of handicraft using Lantana camara wood and branches
- Use of Lantana camara as mulch/ soil fertilizer on farmlands
- Use of Prosopis juliflora as replacement of firewood
- Collection and storage of Prosopis juliflora gum
- Harvesting and processing of Prosopis juliflora pods into flour to feed livestock
- Production of Opuntia stricta syrup
- Basics of marketing and business development
- Production of Parthenium hystorephorus compost
- Processing and use of the different species as a herbal medicine

Access to markets

Apart from being unaware of the opportunities provided by the invasive species, there is also a challenge in marketing the products. Infrastructure is poor in the Upper Fafan, distances large and access to credit difficult. At the same time, products will have to be prepared and packed differently to facilitate transport, storage and use. Creating and facilitating access to markets will, therefore, be crucial to effectively make money out of the products. There are different possibilities to contribute to this process:

- Provide trainings, equipment and knowledge on how products are best prepared for the market (for example, Prosopis juliflora wood should be stripped of thorns and spines)
- Establishment of micro-companies could be facilitated
- Formation of cooperatives could be supported
- Linkages between large (medicine, cheese, food) producers and rural communities could be improved
- Creating awareness with regional and national processing companies about the potential of invasive species (Opuntia stricta syrup, Lantana camara pulp, etc)
- Strategic development and encouragement of the private sector
- Development of marketing policies and interventions (possibly start-up subsidies) by the government

3.7.3 Expected results and beneficiaries

Converting invasive species into valuable resources forms a great opportunity to Somali communities living in marginal areas. The examples show that invasive species could form an extra source of food (Opuntia stricta syrup and porridge, improving soil fertility with Lantana camara and Parthenium hystorephorus, prosopis pods as fodder for livestock), energy (Prosopis juliflora wood and Parthenium hystorephorus methane), and income (through marketing of handicrafts and medicines). Regarding the SCRSE goals utilization of invasive species contributes to food safety and disaster risk reduction.

Besides these direct beneficiaries there is a huge advantage in promoting the widespread use of invasive species. When invasive species are used at scale for benefit of the communities, control over their expansion will naturally follow, which is strongly contributing to ecosystem restoration processes.

3.7.4 Activities towards implementation

Interventions	Activities	How	Who to involve
Research	Expand inventory of opportunities, feasibility studies, development business models, pilot projects	Discussions with processing industry, Inventory of ongoing use of invasive species, consultancy assignment to look into the business opportunities	Economic experts, processing industry, private sector
Trainings	Define goals and objectives, Develop curriculum, Organize trainings (theory and practice), Organize follow-up trainings, Exchange visits or visits to pilot projects	Discussions with agricultural bureau, processing industry and economic experts, awareness raising and promotion	Agricultural bureau, processing industry, NGOs, economic experts, educational experts, rural communities
Access to markets	Trainings, subsidies, establishment of cooperatives, awareness raising, strategic development, development of marketing and policy interventions	Focus group discussions on strategic development; development of a programme on the beneficial use of invasive species, establishment of subsidy-programmes, facilitation of establishment of cooperatives	Woredas, State government, NGOs, processing industry, communities, economists

3.7.5 Upscaling potential

The opportunities that fulfil communities' direct needs, such as the use of invasive species as food, fertilizer, fodder and firewood, could become very successful once success has been proven locally and adopted by communities. Upscaling could follow automatically. For these opportunities creating awareness is the most important aspect.

For marketing products made of invasive species it is not possible to set-up a full-scale marketing programme for all invasive species, accessible to all rural communities within the short term. There is, however, a huge potential. Raw materials are available, knowledge can easily be made available, and the techniques for collection and harvesting are relatively simple. The challenge will be in closing the gap between producers and consumers. Interviewees and experts expect that large scale implementation is possible, but recommend to start with some pilot projects to show the potential of using invasive species for beneficial use.

3.8 Case 8 – Nature conservation

3.8.1 Location and problem description

Decreasing wildlife populations and loss of biodiversity in general are two of the major challenges in the project area with regard to conservation. Particularly in forested, but also in other important ecological areas, such issues may have a negative impact that has effects throughout the functioning of the biophysical and socioeconomic systems.

There is limited control over extraction of natural resources from these areas and many critical areas are becoming more and more isolated. Degrading activities result in a substantial decrease in effective protected area and isolation makes reproduction and multiplication of species difficult. Wildlife is endangered by the loss of suitable habitats and poaching.

In part due to a lack of resources, protection of ecological sensitive areas can barely be secured. At the same time, income from low-input rain fed agriculture and pastoralist activities is often insufficient to sustain the livelihoods of rural households.

3.8.2 Recommended interventions

By addressing the challenges in a combined and integrated manner, new opportunities arise. Ecotourism, for example, could generate an alternative income while also contributing to nature conservation goals. Ecotourism instils good conservation practices such as zoning land, regulating livestock numbers, and sharing of water and pasture with wildlife. In this case, we would like to point out the opportunities for community-oriented ecotourism. This type of ecotourism promotes the involvement of community members in the management and development of the resources.

An opportunity could also entail community-based management and administration of wildlife in controlled hunting areas (CHA). Local guardianship is often very effective in the conservation of biological diversity. According to local experts, local communities could organize themselves, apply for exclusive rights wildlife quota, and lease these concessions to the private (ecotourism) sector towards generating additional income to protect wildlife, conserve nature areas and invest in community development. As communities are not aware of these possibilities and unable to develop them on their own, supporting and facilitating these developments could prove to be great opportunity for sustainable development for rural communities.

Currently, most controlled hunting areas (CHA), for example, are managed by the Federal Ethiopian Wildlife Conservation Authority (EWCA), and so is Dembel Ayesha CHA in the Upper Fafan Catchment. Adjacent communities could organize, establish Community Based Organisations (CBOs), and apply for wildlife concessions in the park. By establishing hunting contract agreements with private parties, the so-called trophy hunting joint-venture agreements- employment opportunities and substantial amounts of money could be generated at community level.

The creation of buffer zones forms another great opportunity for managing critical areas together with the local population. Buffer zones:

- Allow non-degrading activities to take place (ecotourism, cut-and-carry systems, fruit harvesting)
- increase the number of wildlife habitats, while still meeting a large percentage of the villager's demand for fuelwood and fodder
- Improve the connectivity between different protected areas

The buffer zone model is economically and ecologically sustainable and has potential to become self-sustaining. Degradation challenges are overcome by creating economic opportunities. For a buffer zone to become successful it is important to involve communities from the beginning, invest in advocacy and policy development, build capacity on ecosystem protection and management, and institutionalize the ideas.

The ecotourism sector could very much be supported by the improved management. The scenery, biodiversity and population are such that the region holds a great potential for tourism. Amongst others, opportunities include the organisation of safaris, circuits and birding trips. Local communities could make money of travel services, lodging and catering. Promotion, support to start-up companies, capacity building, policy development and articulation, and many other could contribute to the development of the sector in the project area.

3.8.3 Expected results and beneficiaries

Communities benefit from an additional income, training and education programmes, new employment opportunities and the new infrastructure that comes with tourism development. Also fodder availability will improve.

Ecosystems and nature are helped in the sense that biodiversity levels increase, wildlife and their habitats are protected, and the preservation of endemic species is safeguarded for future generations,

3.8.4 Activities towards implementation

To bring nature conservation a step-further and to link it to ecotourism opportunities an assessment of the specific opportunities and options is recommended. In addition, for such a programme to be successful the following components will be essential:

- Awareness raising
- Mapping of areas, resources and boundaries, and determining the exact upscaling potential
- Advocacy and policy development
- Collaboration with investors, authorities and communities
- Formation and capacity building

See Annex IV for the set-up community-based organizations that management CHA.

3.8.5 Upscaling potential

In Somali Region, ecotourism is an opportunity that has potential, but is reliant on an effectively governed and peaceful region for development. In the Upper Fafan Catchment there are several areas that possess ecotourism potential, including Babile Elephant Sanctuary and Dembel Ayisha Controlled Hunting Area. Considering the current wildlife status and the beauty of the scenery there is a huge potential to develop ecotourism in the area.

4 Conclusion

Rural communities in the Upper Fafan Catchment are highly dependent on natural resources. Degradation is undermining their livelihoods. Failing natural resources management systems are the core problem. To address the challenges conservation of critical areas alone does not suffice. A coherent and integrated approach towards restoration is needed that enables sustainable livelihoods and resilience to disasters. Ecosystem restoration is such an approach.

Ecosystem restoration includes protection and management, soil and water conservation, off-stream water storage and in-stream water storage interventions. Landscape characteristics dictate which ecosystem restoration interventions are most suitable for a certain location. This manual explains when and where to apply which interventions, and which steps towards implementation should be taken. Specific cases for implementation of ecosystem restoration representative for the different landscapes and challenges present in the Upper Fafan Catchment are presented. The ecosystem restoration map identifies how each case could be scaled-up in order to reach optimal ecosystem services at a catchment scale.

In general, the following aspects are key to successful implementation:

- Interventions should provide direct and immediate benefits to individuals, households and communities to motivate implementation without (or with minimal) external support
- Interventions should support the recovery of ecosystem services toward re-establishing landscape functionality, by limiting soil erosion, nutrient depletion and loss of biodiversity
- Interventions should help local users to make most out of the ecosystems goods and services in a sustainable manner.
- Protection and management interventions should be prioritized to the detriment of hard infrastructure, this particularly important on communal lands
- When moving towards implementation, expert advice and supervision should always be hired to select, site, design, develop and/or construct interventions (be it infrastructure, policies or any other).

This manual informs strategic planning and decision making through a stakeholder participatory process. Knowledge of the biophysical system is combined with socio-economic aspects and stakeholder priorities to develop an Integrated Catchment Management Plan (ICMP). For the implementation of the ICMP priority should be given to 'soft' measures, such as regulation, awareness creation, training and facilitation of management processes. Hard measures can complement the efforts, but only when implemented by users based on self-motivation.

5 Literature

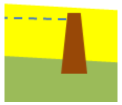
This manual forms an integral part of the Atlas of the Upper Fafan Catchment (Visser et al. 2016). Sources and credits can be found in the Atlas.

Appendices

Annex I

Information sheets of (some) ecosystem restoration interventions

Information sheets of (some) ecosystem restoration interventions

Technique	Advantages	Disadvantages	Special elements of attention for pre-construction phase
Sanddams  Dam raised above riverbed, increasing the sand volume, anchored in an impermeable layer, abstraction with handpump. Indication of usual storage capacity: 200-5,000 m³	+ Strengthen water resources (recharge) + Reduce flash flood and increase base flow + Natural storage of riverbed utilized and increased + Filtration and protection from evaporation + Relative simple abstraction (shallow well) + Low maintenance + Good water quality when surroundings and catchment are protected	- Limited storage - Solid construction required, dam needs to withstand flash floods - Activities in the catchment influence water quality and quantity - Risk of seepage	- Site requires shallow bedrock or clay layer and feasible banks for wing wall - Calculate discharge (peak flow, minimum flow) for design parameters, based on community information and/or catchment characteristics and rainfall data - Evaluate possible threats for water quality in the catchment - Start construction at the beginning of the long dry season, when the riverbed has dried (dewatering might still be required) - Ideally the dams is raised in stages during dry seasons to avoid trapping silt and the dam being washed away - Cost indication: USD 1 - USD 5/m³ stored volume
Subsurface dams  Dam constructed within the existing riverbed sediment, funded on an impermeable layer, abstraction with handpump or motorized pump. Indication of usual storage capacity: 1,000 - >50,000 m³	+ Strengthen water resources (recharge) + Natural storage of riverbed utilized + High storage volume to dams size ratio + Does not need to withstand floods + Construction from all kinds of impermeable materials (including clay or plastic sheet) + Can be constructed with community labor + Filtration and protection from evaporation + Relative simple abstraction (shallow well) + Low maintenance + Good quality when surroundings and catchment are protected	- Dam wall needs to be founded on an impermeable layer, which can require deep excavation and dewatering - Dam is not visible at the surface (can also be an advantage) - Activities in the catchment influence water quality and quantity	- Site requires impermeable layer under the riverbed for foundation of the dam - Evaluate river flow to determine if the minimum flow is sufficient to annually recharge the sandbody behind the dam - Evaluate possible threats for water quality in the catchment - Start construction at the beginning of the long dry season - Investigate potential local construction materials such as clay - Cost indication: USD 0.5 - USD 2/m³ stored volume

Closed tanks  Rainwater from roofs, rock catchments, roads, etc. Indication of usual storage capacity: 5-200 m^3	+ Low losses due to evaporation and leakage + Easy abstraction + Water available at household level + Reasonable quality when catchment and tank are properly managed	- Relative expensive per m^3 - Often not sufficient to cover the dry period for all water needs - Sensitive to breakdowns - Deterioration of water quality with time - High temperature of water	- First investigate potential for other water sources-either surface or groundwater - Calculate storage capacity based on surface volume and rainfall data - Incorporate 'first flush' provision in the system - Cost indication: 20 - USD 40/m^3 stored volume
Water pans  Excavated water reservoirs, also referred to as ponds, dug-out or valley tanks. Indication of usual storage capacity: 5,000-25,000 m^3	+ Strengthen water resources (recharge) + Reduce flash floods + Easy abstraction + Low maintenance	- High evaporation and possible leakage - Not reliable in dry areas - Low water quality - Activities in the catchment influence water quality and quantity - Environmental and health risks (mosquito breeding, etc.)	- Locations with a good natural clay lining are preferable, or lining should be applied. - Assessment of catchment area, calculate runoff characteristics, and determine if the reservoir should be in-stream or off-stream and if a silt trap and by-pass is required. - Cost indication: USD 1 – USD 5/ m^3 stored volume

Annex II

List of useful guidelines and manuals

Title	Author (year)	Organization/Institution	Keywords
Vertisols management training manual	Dubale, P., S. Tsertsu, A. Astatke, A. Kirub and T. Tesfaye		Vertisols, good agricultural practices, erosion control
Profit from storage. The costs and benefits of water buffering. The value of 3R	Tuinhof, A., Van Steenbergen, F., Vos, P. and L. Tolk (2012)	MetaMeta, Acacia Water, Aqua4All, BGR, RAIN, IGRAC, IFAD, BMZ	Storage, buffering, water management, case studies, 3R
100 ways to manage water for smallholder agriculture in Eastern and Southern Africa. A compendium of technologies and practices	B. Mati (2007)	ASARECA, SWMnet, ICRISAT, IFAD, UNOPS	List of interventions, agriculture, water smart, soil and water conservation
Water from rock outcrops	E. Nissen-Petersen (2006)	DANIDA	Engineering, rock catchments, dams, water storage
Water from dry riverbeds	E. Nissen-Petersen (2006)	DANIDA	Riverbeds, aquifer, shallow groundwater, storage
Water from roads	E. Nissen-Petersen (2006)	DANIDA	Rainwater runoff, roads, water collection, storage
Water-smart agriculture in East Africa	Nicol, A., Langan, S., Victor, M. and J. Gonsalves (2015)	CARE, IWMI, CGIAR	Agriculture, water-smart, soil and water conservation, yields, productivity, quality
Manual on small earth dams. A guide to siting, design and construction	T. Stephens (2010)	FAO	Dams, embankments, construction, design, sustainability, efficiency, flood regulation, water storage
Water from sand rivers. Guidelines for abstraction	S. W. Hussey (2007)	Loughborough University, Water, Engineering and Development Centre	Sand dams, zimbabwe, water storage, river beds
Water harvesting. Guidelines to good practice	Studer, R. and H. Liniger (2013)	WOCAT, MetaMeta, RAIN, IFAD, Swiss agency for development and	Water storage, retention, buffering,

		cooperation, Universitat Bern	harvesting, water management
Ecological restoration for protected areas. Principles, guidelines and best practices	Keenleyside, K., N. Dudley, S. Cairns, C. Hall and S. Stolton (2012)	IUCN, WCPA, Convention on biological diversity, Parks Canada, SER, protectedplanet	Ecology, ecosystems, biology, protected areas, interventions for restoration, case studies
Enhancing food security through forest landscape restoration: Lessons from Burkina Faso, Brazil, Guatemala, Viet Nam, Ghana, Ethiopia and Philippines	Kumar, C., Saint-Laurent, C., Begeladze, S. and M. Calmon (2015)	IUCN, UK aid	Ecological restoration, ecosystems, agroforestry, forest management, institutionalization, communal lands, case studies
Managing the water buffer. For development and climate change adaptation	Steenbergen, F. van and A. Tuinhof (ND)	MetaMeta, Acacia Water, RAIN, BGR, Co-operative programme on water and climate, UNESCO, IAH AIH, Federal Ministry for economic cooperation and development Germany, A4A, WAC, Partners voor Water, spate Irrigation Network, SearNet, GW-Mate	3R, water buffering, storage, small-scale solution, simplicity, efficiency, case studies
Manual on sand dams in Ethiopia		ERHA, RAIN, Acacia Water, SASOL	Sand dams, construction, design, sustainability, water quality
Community based participatory watershed development. A guideline	Desta, L., Carucci, V., Wendem-Agenehu, A. and Y, Abebe (2005)	Ministry of Agriculture and Rural Development Ethiopia	Water harvesting, community mobilization and engagement, catchment, hydrology
Building sand dams. A practical guide	Maddrell, S. and I. Neal (2013)	Excellent Development	Sand dams, dry river beds, design, construction, water harvesting
Soil and water conservation with a focus on water harvesting and soil moisture retention. A study guide for farmer field schools and community-based study groups	D. Duveskog (2003)	Ministry of Agriculture Zimbabwe. Farmesa	Learning, training, capacity building, soil and water conservation, water-smart agriculture, soil management, soil moisture, interventions

Subsurface dams: a simple, safe and affordable technology for pastoralists		Belgium Development and Cooperation, Dierenartsen zonder grenzen, PROTOS	Turkana, Kenya, subsurface dams, technology, construction, technical design, sustainability
Subsurface dams built of soil	E. Nissen-Petersen	ASAL Consultants Ltd	Subsurface dams, water storage, dry river beds, semi-desert regions
Water from sand rivers. A manual on site survey, design, construction and maintenance of seven types odf water structures in riverbeds	E. Nissen-Petersen (2000)	RELMA	Sand rivers, water extraction, water storage, sand reservoirs, construction
Some technical handouts for watershed development planning and soil and water conservation	T. Kebede (2008)	SWHISA	Watershed, planning, managements, agricultural experts, field resource assessments, land evaluation

Title	URL	Keywords
Agricultural Water Management Information System of Ethiopia (AWMISET)	http://www.mowr.gov.et/AWMISET/Pages/swc.php	Soil and water conservation, agriculture, irrigation
CGIAR Water-smart agriculture initiative for East Africa	https://wle.cgiar.org/content/water-smart-agriculture-initiative-east-africa	Agriculture, soil and water conservation, soil management, water , land and ecosystems, water sources
Library on water sources and rainwater harvesting	http://www.samsamwater.com/library.php	Rainwater harvesting, techniques and measures, documentation, guidelines and manuals
MetaMeta Publications	http://metameta.nl/publications/	Documentation on rainwater harvesting, 3R and sustainable water

		resources management
Open water and sanitation resource (Akvo)	http://akvopedia.org/wiki/Main_Page	Water, sanitation, finance, sustainability, decision and assessment tools, food and nutrition security
Water for arid land	http://www.waterforaridland.com/	Rainwater harvesting, budget interventions, manuals and handbooks, ASALs
A4A Rainwater harvesting	http://aquaforall.org/aquashareware/aquashareware-publications/rainwater-harvesting/	Downloads related to water harvesting, 3R, Recharge, retention and reuse, profit from storage
World Overview of Conservation Approaches and Technologies (WOCAT)	www.wocat.net	Sil and water conservation, innovation, development, deicion making, sustainable land management

Annex III

Benefits of interventions

Types of interventions	Categories of interventions	Explanation and examples	Benefits	
			To local users	To the catchment
Protection and management	**Riverbank protection**	Protection of riverbanks and flooding areas against overgrazing, arable farming, tree cutting and water erosion. In the case of artificial reservoirs also protect the inflow area.	Erosion control, increased production of forage and other natural products	Improved groundwater recharge, flow regulation, biodiversity, (micro)climate regulation
	Area closure	Protection of an area against degrading activities, such as grazing, agriculture and/or tree cutting. Often cut-and-carry systems and fruit harvesting are allowed. Sometimes closures function as back-up grazing area for emergencies. The closure can be realized by fencing or by (community) agreements		
	Forest management	Agreements on sustainable use of forested areas, including controlled harvesting of wood and other natural products. Increasing the ecological and socio-economic value through tree planting, wildlife management, control of invasive species, etc.		
	Rangeland management	Agreements on grazing patterns, assignment of wet/dry season and emergency grazing areas, sustainable wood harvesting, wildlife management		
	Urban water and waste management	Collection and safe disposal of waste(water)		
	Discourage agriculture	Limit agricultural practices in these areas. Ensure that in crop production areas due measures are taken to control erosion		
Soil and water conservation	**Basic SWC**	Mulching, grass strips, soil bunds	Higher yields, more reliable yields. Possibility to produce crops with a higher market-value	Improved groundwater recharge, water flow regulation and soil formation. Increased biodiversity
	SWC to control wind erosion	Tree planting, tree strips (wind breaks), life fencing, agroforestry		
	SWC for slopes	Terracing, contour bunds, contour ploughing, tied ridges, grass-strips, contour trenching		
	SWC for very steep slopes	Stone structures above ground such as stone bunds, trenches, hillside terracing, check dams, tree strips		
	SWC for weak soils	Soil moisture management, mulching		
	Conservation agriculture (CA)	The three main CA principles are: minimal soil disturbance, permanent soil cover and crop rotations		
	Permanent agriculture	Production of permanent crops such as fruit trees, tea, coffee, and qat		
	Flood-adapted agriculture	Produce crops outside the flooding period, or flood resistant crops. Apply flood control interventions, such as soil bunds and diversion ditches. Apply spate irrigation or floodwater spreading spreading		
	Biological interventions	Revegetation, afforestation, reforestation and protection of trees. Planting of species that promote soil stability. Controlled grazing		
	Erosion control structures	Small and larger scale structures constructed with manual labour to control erosion, such as gabions		
Off-stream water storage	**Hafir dams**	Also known asvalley tanks. Larger excavations for water storage on flat to gently sloping lands	Improved water availability	Groundwater recharge, flow regulation
	Ponds	Small natural depresssions in which runoff concentrates made impervious to prevent leaking		
	Hill-side dams	Small hill-side half-moon shaped embankments on medium-steep slopes used to promote infiltration and store water		
	Rock catchments	Open water reservoirs build to trap water coming of bare rock areas		
	Birkads	Undergound cisterns dug out and lined to store water, keep it cool and (when covered) prevent evaporation		
	Managed aquifer recharge	Infiltration of surface water into an aquifer via infiltration wells to store water and improve its quality		
	Roof rainwater harvesting	Use of suitable roof surface – tiles, metal sheets or plastics – to intercept rainfall, and conduct it to a storage tank		
In-stream water storage	**Check dams**	Small dams accross a waterway that counteract erosion by reducing flow velocity	Improved water availability and water quality	Groundwater recharge, flow regulation
	Micro-dams	Very small open water reservoirs consisting of a wall (earth or concrete) in a narrow valley aimed at storing water		
	Valley dams	Small open water reservoirs consisting of an earthen or concrete wall on a concave location to store water		
	Sand dams	Reinforced concrete walls across seasonal rivers capturing coarse sediments,thereby storing shallow groundwater		
	Subsurface dams	Reinforced concrete walls across seasonal rivers that store shallow groundwater		

Annex IV

Steps towards management of controlled hunting areas (CHA) by CBOs

Step 1. Communities around Dembel Ayesha Controlled Hunting Areas (CHA) wishing to obtain concession should have a series of community-level meetings and awareness raising workshops to discuss the formation of a representative community organisation. On this meeting communities hold an election of representatives and communicate the information on the structure and membership to the responsible regional and federal authorities.

Step 2. In order for this community to enter into agreements with any entity, they must form a legal Community Based Organisation. This legal entity must be registered with the government, which requires that it state (a) the goals, aims, and objectives of the legal entity, (b) the rules and regulations governing the body's administration, (c) the composition of the governing board of the legal body (d) a statement on the financial management of the organization, (e) a statement on the accountability of the body to its membership, and (f) annual meeting of the community organisation members and reporting of financial and management issues. One way to do this is to draw up a constitution that spells out the name, purpose, objectives, composition, and activities of the organization.

Step 3. Community areas, resources, and boundaries should be mapped. While this mapping need not be too detailed, and should not be too protracted, it should be sufficient to provide the basis for boundary determinations which combine social cohesiveness, ecological integrity, and economic potential. Both technical research and political consensus are required, and this is likely to require an iterative and consultative process.

Step 4. The community should host a Community Workshops like the awareness raising workshop; attended by as many community members as possible. The various options available to the community should be discussed, including (a) leasing part or all of the quota to a safari company, (b) establishing a community-based tourism program based on non-consumptive use of wildlife, (c) deciding to either lease or sell the wildlife quota for professional hunters, or (d) deciding to set aside areas within the community-controlled hunting area (CCHA) for conservation purposes. (e) distributing the benefits from the CCHA.

Step 5. The community committee or legal body and their collaborating support partner should undertake training and community centred learning activities, including undertaking tours to other places where community CHAs are available like the WAJIB CCHA in Oromia Region.

Annex V

Buffer-zone User Groups

1. Under the regional and district agricultural bureau and culture and tourism bureaus, Buffer-zone User Groups (BUGs) can be established as an independent organisation that allows managing the core area forest and its wildlife, for their own use and benefit. The BUG establishes its own operational plan, institutional setup to manage the core area forest and its wildlife.

2. The core area will then be officially handed over by the government authority to the chairman of the BUG; and based on their operational and management plan restoration and regeneration will be conducted wherever important.

3. The BUG spends money on habitat management, and arranges shifts for buffer area guards and one expert government staff-member to assist with protection activities. To further combat the major threats such as the high demand for fodder and fuel-wood, the BUG will plan to introduce different alternative energy programmes in collaboration with the regional stakeholders.

4. The area will, with good management, provide grass for thatching, fuel-wood, woody biomass which is also used for fuel, and fodder. Villagers are allowed to freely collect fodder from the buffer-zone. The community forest has also become a natural buffer-zone benefiting the local residents and the incidence of crop raiding by wildlife can decrease significantly.

Annex VI Use of invasive species

Lantana camara
On community scale Lantana could be used in handicrafts, medicinal and in soil fertility. On a more industrial scale, Lantana pulp has been used for making paper. Lantana camara could be used to make **handicrafts**, such as furniture, toys and articles for household utility. The products are last long and are not eaten away by termites. Lantana could also be used as a **herbal medicine**, as the leaves exhibit multiple healing properties (Saxena 2000; Sharma et al. 2007; Ghisalberti 2000; Begum et al. 2000). Lantana produces large amounts of biomass which can be used to restore **soil fertility** on agricultural lands and in forest restoration areas. This can be done by slashing lantana bushes before seed ripening, and lay branches and leaves on bare ground. Research demonstrated that Lantana can be used as a new source of **pulp** for the paper making industry (Ray et al. 2006; Naithani and Pande 2009; Bhatt et al. 2011).

Prosopis juliflora
Prosopis juliflora could be used as a source of energy, fodder and gum. Prosopis juliflora wood is hard, burns slowly and has excellent heating properties, so it could be used as a replacement for traditional sources of **energy**. Prosopis pods are edible for livestock, and could form an additional source of **fodder**. Care should however be taken that the percentage of prosopis in the animals' diet is kept below 50% to avoid digestion disorders (Pasiecznik, 2001). The **gum** that exudates from Prosopis trees is comparable to gum Arabica and could be used in the food-cosmetic industry.

Opuntia stricta (prickly cactus)
Opuntia stricta could be used as a food source, food colorant, anti-oxidant and herbal medicine. Elsewhere Opuntia stricta fruits are already used to make syrup, which is used in cocktails, teas and juices, and in porridge. The fruits are rich in minerals and vitamins and thus could form an important **source of food**. Next to vitamins and minerals, Opuntia fruits also contain high concentrations of **anti-oxidants** and **pigments/colorants** (Castellar et al., 2012; Obon et al., 2009), and as such are valuable for local consumption and the (healthy) food industry. Finally, research indicates that Opuntia stricta extracts have an anti-diabetic effect comparable to medications sold in pharmacies for type II diabetes (Kunyanga et al, 2014) and as such could be used as a **herbal medicine**.

Calotropis procera (Chinese road plant)
Research and experience from other regions shows that Calotropis procera could be used as a herbal medicine and milk coagulant. Calotropis is known to be effective drug in curing a variety of diseases and physiological disorders. Its active components have been shown to have amongst others would-healing, pro-coagulant, analgesic and anti-inflammatory properties (Sarkhel 2015). As such, Calotropis is a **herbal medicine** which may have multiple pharmaceutical applications. Calotropis extracts can also be used as a **milk coagulant** in the cheese making process (Upadhyay, 2014).

Parthenium hystorephorus
Parthenium hystorephorus could be used as a herbal medicine, as a substrate for biogas production and for the production of compost. Different investigations have shown that Parthenium could be used as a **herbal medicine** in the form of herbicide, pesticide and insecticide. The extract of the plant also has anti-oxidant and antimicrobial properties (Bezuneh, 2015). Parthenium could also be used as a fertilizer in the form of **compost**. Parthenium compost contains high levels of NPK (nitrogen, phosphorous and potassium) and enhances soil moisture levels. Research has shown that Parthenium green manure resulted in a significantly greater production of maize biomass compared to experiments with chemical fertilizers (Gunaseelan 1998; Javaid 2008). Finally, Parthenium mixed with cattle manure at a 10% level and allowed to digest anaerobically produces good quality methane. Parthenium could, therefore, considered as a substrate for the production of **biogas**.

For more information contact:
Acacia Water
Van Hogendorpplein 4
2805 BM Gouda
The Netherlands

T: +31 182 686424
W: www.acaciawater.com
E: info@acaciawater.com