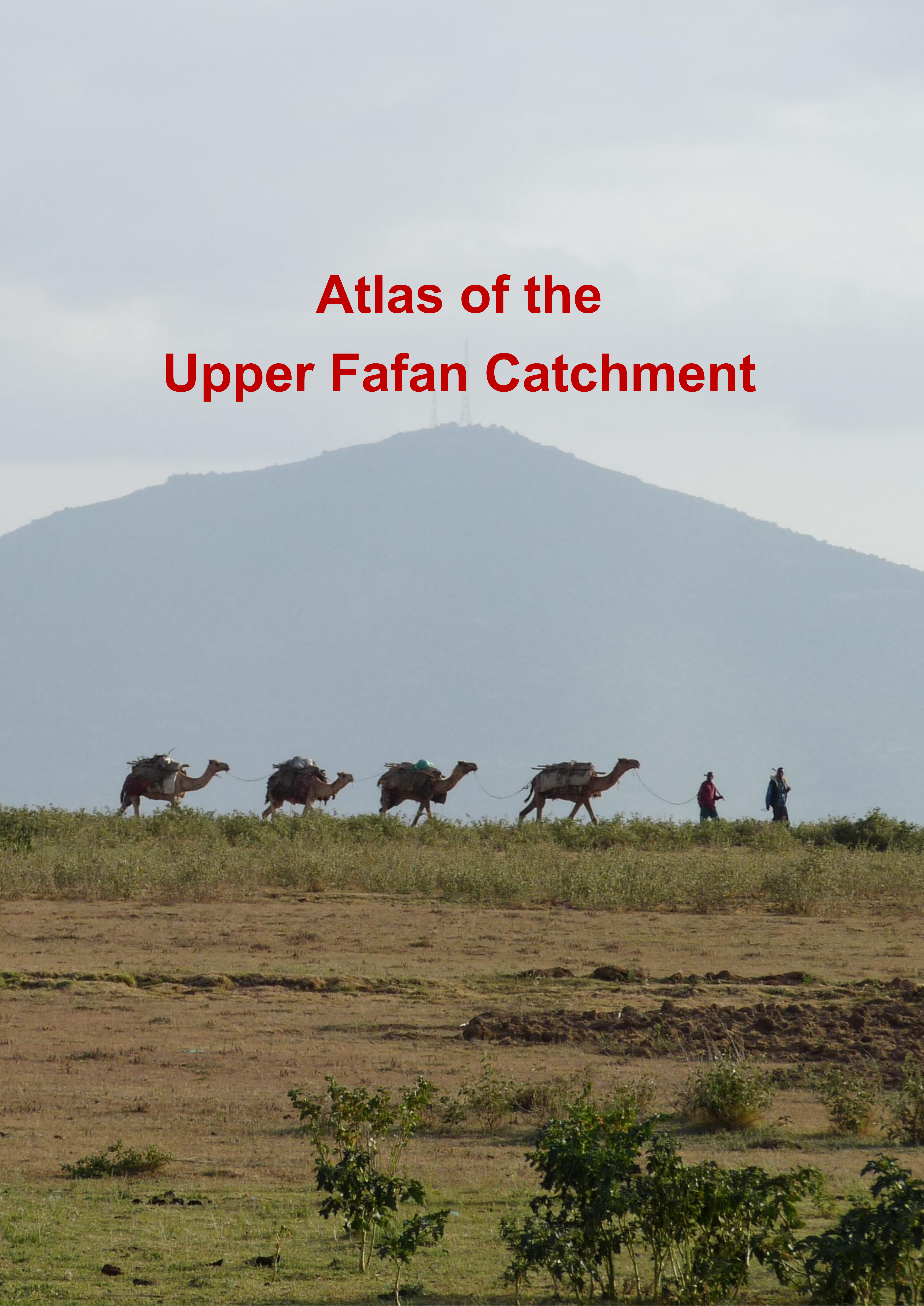
Atlas of the Upper Fafan Catchment



Atlas of the Upper Fafan Catchment

An assessment towards building resilience through ecosystem restoration in Somali Regional State, Ethiopia

An assessment by

Wetlands International

Acacia Water

The Netherlands Red Cross

Ethiopian Red Cross Society

Horn of Africa Regional Environment Centre and Network

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Project lead: Acacia Water. Content, analysis and reporting: Wetlands International and Acacia Water. Map production: Acacia Water. Design and editing Atlas: Acacia Water. Review by all project partners.

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Atlas of the Upper Fafan Catchment

An assessment towards building resilience through ecosystem restoration in Somali Regional State, Ethiopia

SUMMARY

The Upper Fafan Catchment in Somali Regional State in north-eastern Ethiopia is a disaster prone area where rural communities heavily depend on natural resources. Strategic ecosystem restoration targeting water security, food security and disaster risk reduction is key to building community resilience. To select the most effective interventions a good understanding of the landscape is essential.

The major challenges and opportunities provided by the landscape were mapped based on biophysical and socio-economic, land use and management, ecosystems and water resources assessments. These assessments incorporate data from a literature study, satellite imagery and GIS analyses, field surveys, focus group discussions and interviews with key informants. Results are presented in the form of maps and charts to allow non-experts to understand them, and hence to make it easier to substantively and functionally make use of them in policies and programs.

Failing natural resources management turns out to be the core problem in the project area. Disasters are becoming more frequent and intense essentially because traditional systems for natural resources management are weakening. The resilience of the landscape is low and further decreasing. Ecosystems are degrading at an alarming rate.

But there are also many opportunities. The potential to improve access, availability and quality of water is high and there are many possibilities to protect nature and develop alternative sources of income. Areas in the Amora Mountains show that with good management practices many challenges can be tackled.

An integrated approach that addresses the causes is recommended. The main focus should be on capacity building to self-motivate users to manage the landscape in a sustainable manner. Efforts can best be concentrated on soft ecosystem restoration measures (regulations, capacity building, coordination etc.). Hard measures (e.g. bunds, trenches, dams etc.) also contribute to restoration, but are less effective in the long term. Community mobilization, participatory decision-making and involvement of experts is crucial towards developing sustainable strategies to reverse the degradation trend.

The project team urges all stakeholders to invest more in strengthening natural resources management, at all spatial and temporal scales. This Atlas makes a case for communities, governments and NGOs to invest in small-scale measures, rangeland and forest management, sustainable farming practices, and soil and water conservation measures.

Gouda, The Netherlands, August 2016

The Project Team

CONTENTS

LEGEND

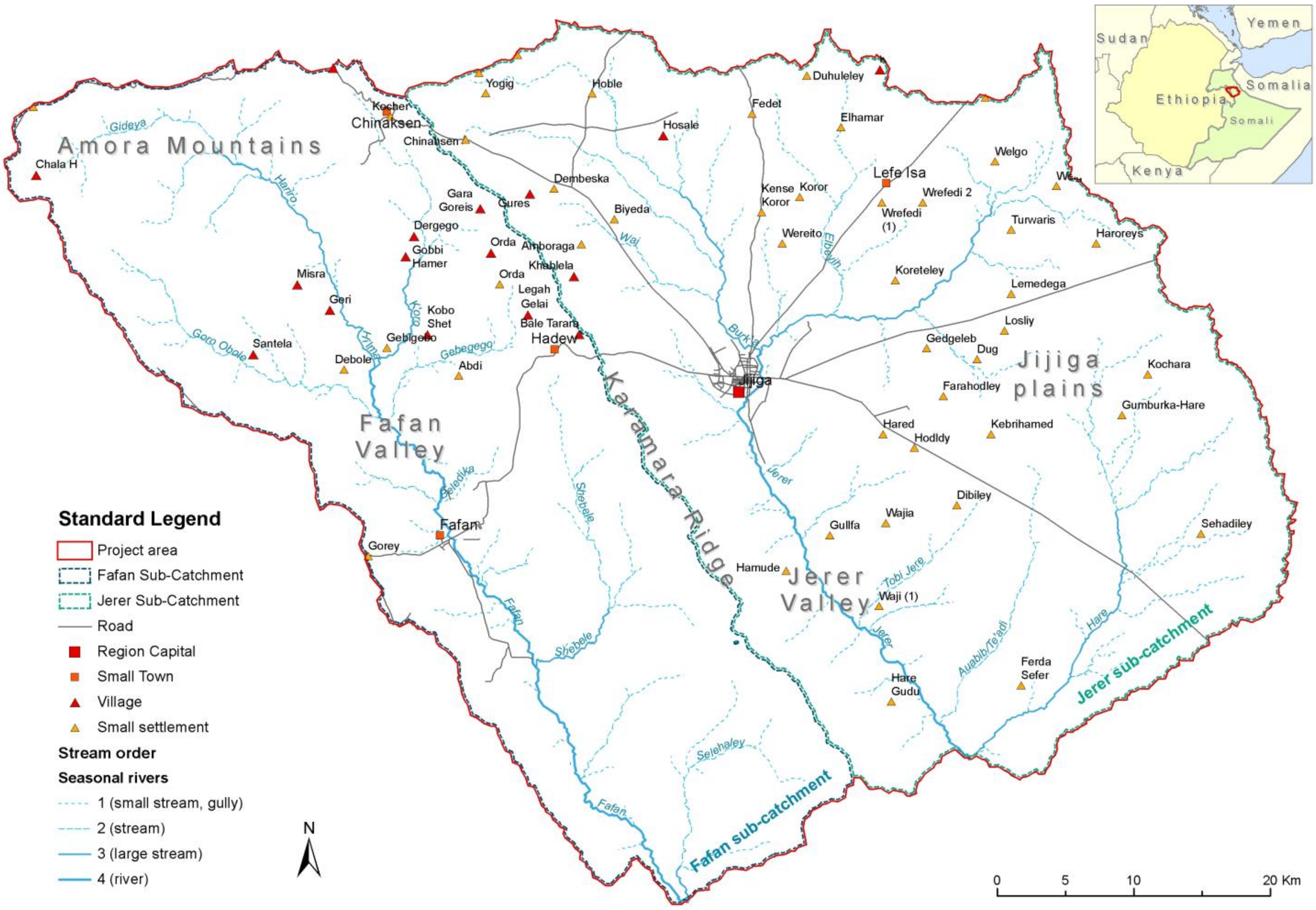


Figure 0.0 Project area with main reference features.

List of acronyms and abbreviations

IWRM	Integrated Water Resources Management
NRM	Natural Resources Management
SCRSE	Strengthening Community Resilience in Somali Region of Ethiopia Programme
EbA	Ecosystem based Adaptation
Pnet	Net precipitation
RUSLE	Revised Universal Soil Loss Equation
CICES	Common International Classification of Ecosystem Services
CN	Curve Number
SWC	Soil and Water Conservation

1

BACKGROUND

The current condition of the Upper Fafan Catchment is strongly linked to population growth, sedentarization, and changing livelihoods and lifestyles.

This chapter discusses the contextual background, the most important landforms, climate conditions, the recurrence and intensity of droughts, and the forecasted impact of climate change.

Figure 1.1 Lush pastures in Fafan Valley.

This Atlas

This Atlas presents the baseline assessment for the Strengthening Community Resilience in Somali Region of Ethiopia (SRCSE) Programme. The assessment informs decision makers about the current state of the system, the main challenges and opportunities, directions for strategy development and suitable interventions.

The Strengthening Community Resilience in Somali Region of Ethiopia (SCRSE) Programme runs from mid 2014 to end 2016 and is implemented by a partnership between humanitarian, development, climate and environmental organizations. Through strategic interventions targeting food security, water security and disaster risk reduction the programme aims to improve long term community stability and resilience. Interventions include the construction of infrastructure, institutional capacity building and advocacy.

Project Area - Upper Fafan Catchment

The SCRSE Programme targets Somali Regional State in Ethiopia, more specifically the Upper Fafan Catchment (see figures 1.2 and 1.3). The Upper Fafan Catchment covers 3709 km2, comprising parts of Gursum, Jijiga and Tuliguled woredas.

The project situated 450 km East of Ethiopia's capital city Addis Ababa, and is located at 60 km from the border with Somaliland (Somalia). The area is disaster prone and typically characterized by food insecurity and very low social and economic development levels.

Low development levels are largely attributed to droughts, floods and disease-outbreaks, resulting in the failure of crops, loss of livestock and high mortality rates. Trends indicate that the impact of extreme weather events is increasing. Agricultural productivity is decreasing, gullies are quickly encroaching into farmland and groundwater tables are dropping. More and more people depend on aid and safety net programs (ERCS 2014).

Vision and goal

There is a tendency to attribute the disasters threatening the Upper Fafan Catchment to climate extremes (e.g. droughts are caused by a shortage of rainfall). The consortium, however, finds that challenges are mostly related to failing natural resources management systems. Hence, the project is based on the following ideas:

- Hazards (heavy or little rainfall, for example) are a given. Disasters, such as droughts, floods and famine, can be mitigated. Building resilience reduces the frequency of disasters and limits their impact, hence reducing the dependency on aid and supporting sustainable development.
- Resilience can be built through ecosystem based adaptation and ecosystem restoration, so that ecosystem services, such as water retention, nutrient cycles and biodiversity, are protected and recovered.
- Biophysical characteristics determine to a large extent the challenges and opportunities. Hence the suitability of interventions is strongly linked to landscape characteristics.
- Fact-based decision making implies the identification of challenges, opportunities and target priority areas, in such way that the larger landscape profits from investments. Proper assessments, for example, inform where the potential for water abstractions is highest and how to effectively combat invasive species.

Following this line of thought, this Atlas runs from the factual presentation of the landscape characteristics and the description of challenges towards the identification of opportunities. This Atlas can be used as a base for Integrated Water and Resources Management, Catchment Management Plans and Land Use Planning.

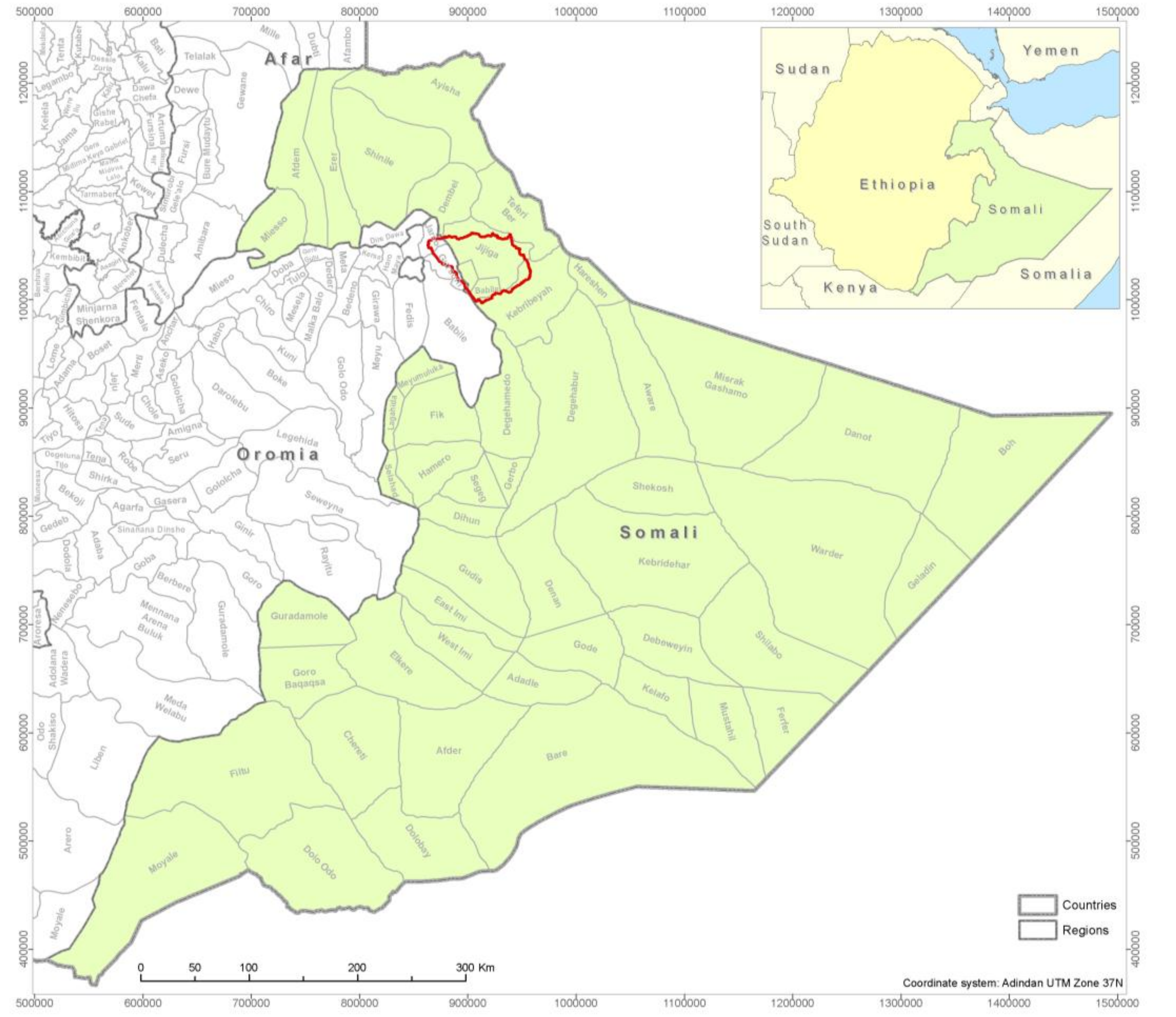


Figure 1.2 Location of the project area in Somali Regional State, Ethiopia.

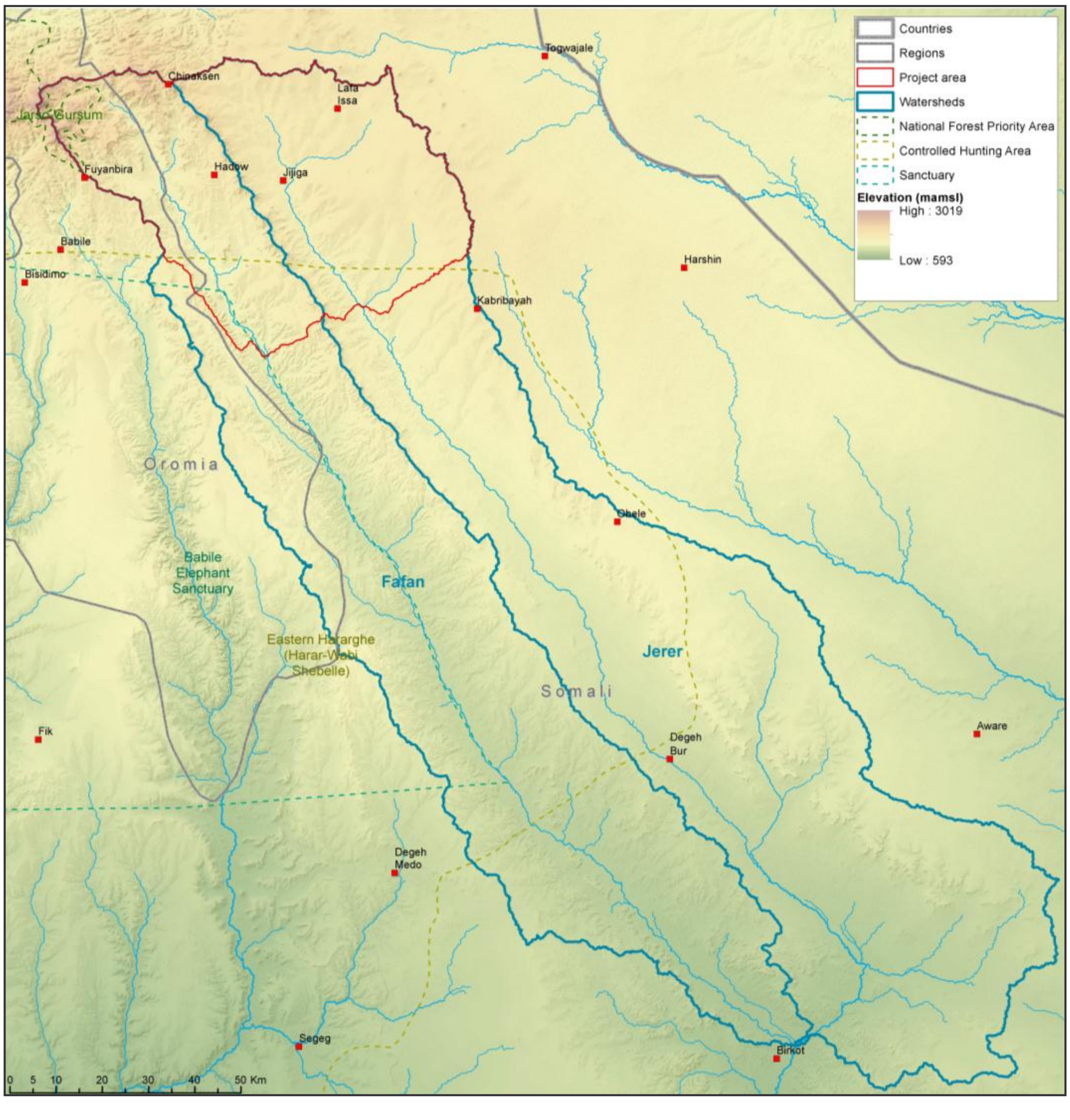


Figure 1.3 Location of the project area in Fafan Catchment. At Birkot Town Jerer River runs into Fafan River; as such Jerer Sub-catchment is part of Fafan Catchment. The project area is extremely disaster prone. Communities are vulnerable in multiple aspects, such as food and water insecurity, droughts and flash floods (ERCS 2014).

Problem analysis

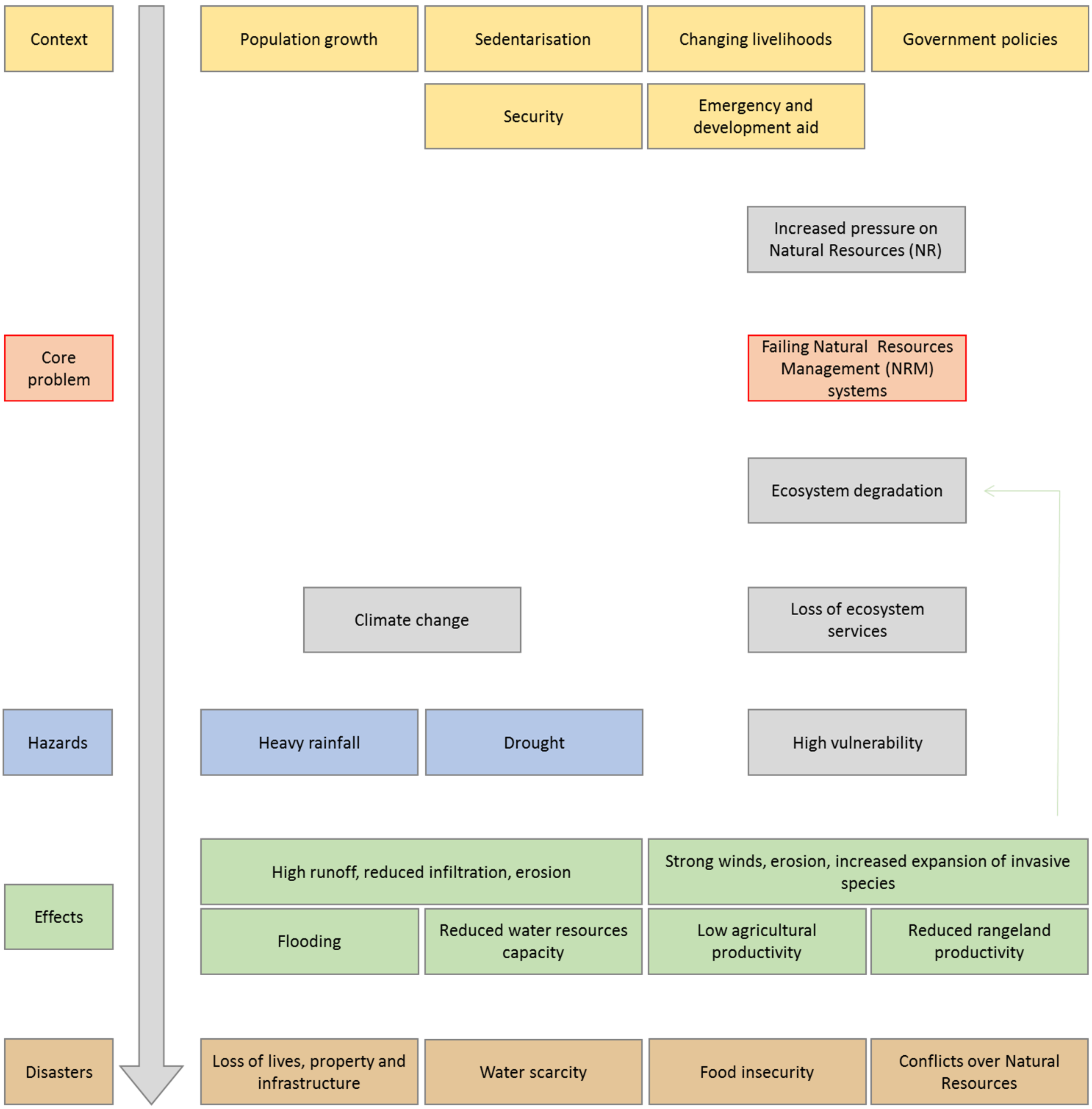
The problem analysis is based on the outcomes of the first stakeholder workshop.

Cause-effect chains are key to understanding the problem. Hazards, such as heavy or lack of rainfall, become disasters due to severe ecosystem degradation. Failing natural resources management (NRM) was identified as the core problem. Climate conditions contribute to the challenges, but are not the major problem.

As shown in the flowchart, failing NRM is (at least in part) a consequence of contextual changes. Population growth and sedentarisation, for example, are contributing to the problem to the weakening of management practices.

At the other end of the spectrum are the disasters. Solutions such as early warning systems, stocking and large-scale infrastructure, are important. When floods, droughts and famines are a fact then only emergency aid can help. These measures do, however, have a very limited impact in the long-term.

PROBLEM ANALYSIS



Methodology

The assessments in this Atlas are anchored to the Ecosystem based Adaptation Approach (EbA, see Box 1 and Figure 1.4).The EbA approach informs selection, design and siting of interventions. A good understanding of the landscape characteristics is, therefore, a priority concern.

The assessments started with a review of readily available reports and data and preparatory GIS-analyses (see Figure 1.5 and Table 1.1). These preliminary results provided a basic understanding of the biophysical and socio-economic context. Consecutive analyses of satellite imagery and field data collection were used to verify and validate the first results and fill data gaps.

Data collection in the field was organised along focus group discussions, interviews with key informants, surveys and field trips. Feedback loops and iterations were built into the analysis process to ensure that the required level of detail was achieved and that no elements were over-looked. After refining and updating the results, the findings were discussed with local experts and stakeholders.

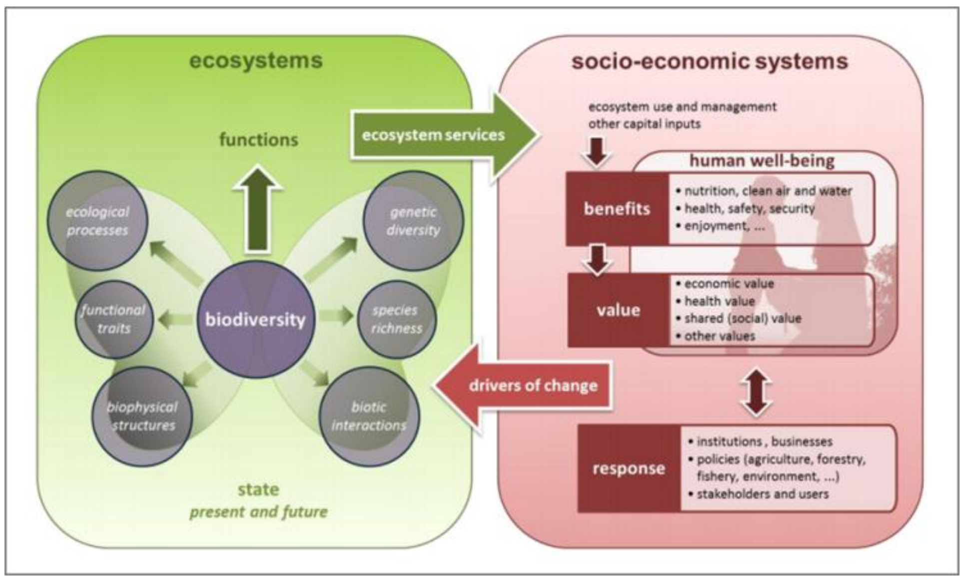


Figure 1.4 Schematic overview of the linkages between ecosystems and socio-economic systems in light of the Ecosystem based Adaptation approach (European Commission 2013).

Box 1.1 Ecosystem based Adaptation Approach

Based on Roberts et al. (2011)

'The systemic and proactive approach of Ecosystem based Adaptation (EbA) contrasts with the interventionist and reactive nature of many existing adaptation proposals and plans that portray adaptation as a tool of last resort in dealing with the threat of an unpredictable climate. This reactive approach supports the prioritization of "...already existing strategies" and results in "end-of-the pipe" infrastructural, land use planning and technological interventions that are responsive to only a narrow range of outcomes and probabilities. What is required is the development of conceptual frameworks that question how wealth, value and quality of life are understood and framed in relation to natural resource consumption over a broader range of scenarios. In this regard, EbA builds on the premise that "...in most places in the world, nature is the single most important input into local economies and human well-being." This "beginning-of-the-pipe" role for ecosystems creates new opportunities for more flexible, systemic and responsive win–win–win outcomes that address climate change (both adaptation and mitigation), biodiversity loss and the need for improved human wellbeing. It also increases the political agency of adaptation, making it a development response to the stimulus of climate change by harnessing the full potential of natural systems to ensure a sustained quality of life and by helping "...people, infrastructure and economies" to adapt to variable conditions'.

Ecosystem-Based Adaptation (EbA) addresses the links between climate change, biodiversity, ecosystem services and sustainable resource management and taps on ecosystem services as propellers of socio-ecological system resilience. Hence the need to assess the state of ecosystems and their capacity to provide services.

Figure 1.5 Steps followed to develop thematic maps

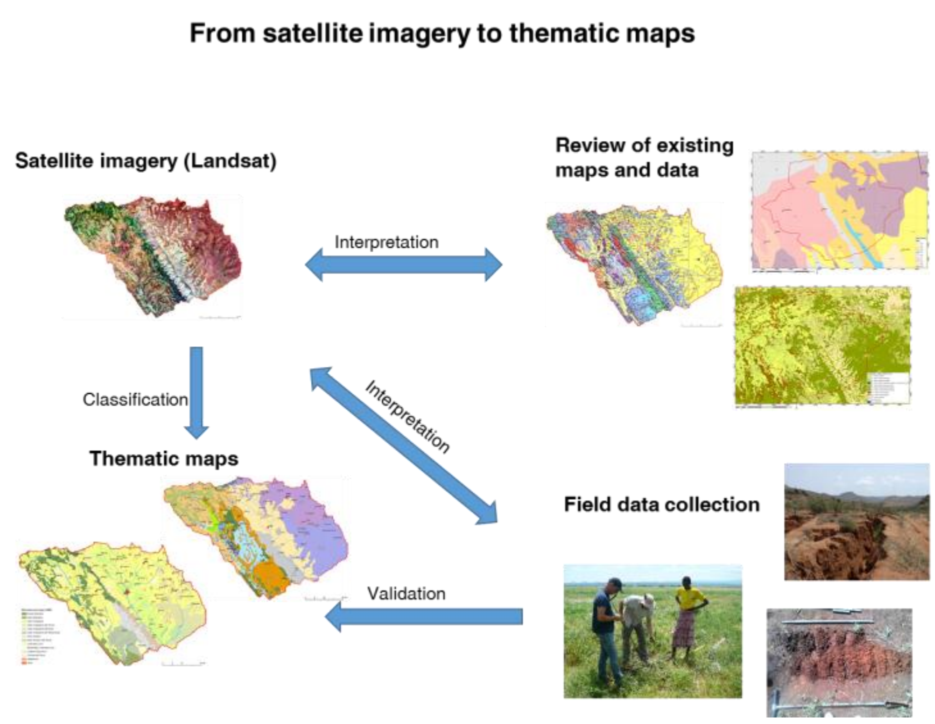


Table 1.1 Some of the datasets used in this project. Literature and other data sources are listed on page 55.

Data sources	Parameters, factors and/or subjects
SRTM 1-Arcsecond	elevation, slopes, catchments, flow accumulation, 3D-imagery
GlobalAdminAreas	administrative boundaries
GeoNames + local informants	gazetteer
gROADS	infrastructure
Landsat 8	geology, soils, land cover
FEWS-NET	precipitation
MODIS	evapotranspiration, NDVI
Geological Survey of Ethiopia 2009-2010	geology, groundwater potential, water sources
EU JRC Soil Map of Africa	soils
Landsat 8, Landsat ETM+, Landsat TM, ALOS, PALSAR, SRTM 1-Arcsecond	land use and cover
Ethio-GIS, Ethiopian Mapping Authority	protected areas
Inventory Water Sources Fafan Zone	water sources

Figure 1.6 Market in Jijiga Town. Access to markets is limited for the rural population.

Socio-economy

Socio-economic data is not specifically available for the Upper Fafan Catchment. In the following paragraphs data for Somali Regional State is assumed representative for the area.

The average population density is 16 inhabitants/km2. An average household consists of 5.9 members (Census Somali Region 2007). Statistics indicate that the number and the size of households are increasing due to early marriage practices, which is one of the strategies to cope with droughts. Following customary rules households, cultural practices and religious institutions are headed by males. On a daily basis household affairs are mostly controlled by women.

Over 97% of the population is from Somali origin. Other ethnic groups include Mahara, Oromo, foreign-born Somalis and Gurage. 98% of the population is Muslim (Census Somali Region 2007).

Socio-economic development numbers in the project area are amongst the poorest in Ethiopia (Census Somali Region 2007, MERET Pro Report 2014). Numerous factors are contributing to this situation, including the fragility of the local economy, poor health and education situation, and lack of infrastructure.

The local economy is closely linked to that of neighboring countries (Somaliland/ Somali, Djibouti and Kenya). Items traded include rice, flour, pasta, sugar, clothes, sesame, fodder, fruits and vegetables and livestock. Sometimes milk and ghee are also on sale. However, the number, access and options of marketing hubs for livestock, food and non-food commodities are limited (Figure 1.6).

Disruptions in the (international) flow of cash, livestock and commodities are a major threat to the availability of goods (MoA 2012). The indicative monthly income per household is between 510 and 610 birr, which is extremely low and does not allow for savings (personal communication M. Abdi 2015). Few people have access to financial credit. Farmland and livestock are by far the most important assets.

Despite the progress made over the past 15 years the morbidity and mortality rates remain high, also in comparison with the rest of Ethiopia. Major health problems are malaria, tuberculosis, maternal health, nutritional disorders and diarrhea.

Regarding education, primary and secondary school enrolment were respectively 64% and 12% in 2002 (Chronic crises report 2014). Both numbers are far below national averages and contribute to the low in socio-economic development of the region.

Infrastructure is minimal. Route National N10 connects Jijiga Town to Harar and from there to Addis Ababa (450 km) in the West, and to Kebri Beyah and Kebri Dahar (350 km) in the Southeast. There is one other small asphaltic road southwards through the villages of Fiq and Imi, but as for the rest the road-network is limited. Also access to electricity, schools, telephone coverage, safe human water supply, health post and veterinary services is minimal. Whereas in the urban areas in the North most basic needs are still met, the dusty landscape in the south is deprived of services (Ministry of Agriculture 2012).

Livelihoods

Four livelihoods systems are dominant:

- Pastoralism: About 60% of the rural population is engaged in livestock rearing (ERCS 2014). On average, pastoralist households hold a herd of between 12 and 25 cattle (Wetlands International 2015). When there is a surplus pastoralists sale milk and ghee.
- Agro-pastoralists, comprising about 25% of the rural population (ERCS 2014), pursue a mixed livelihood system wherein they are engaged in livestock herding and rain fed crop farming (maize and sorghum).
- Farmers living a settled existence produce rain fed crops for consumption and trade (15% of the rural population, ERCS 2014)
- Urban residents making a living from formal and informal employment (SCUK/ DPPB 2004).

The percentages of households involved in the different livelihood systems are highly variable over the project area, as this is strongly dependent on the suitability of lands for crop production, the distance to markets and local traditions. Migration towards larger agglomerations is increasingly taking place. The rural population searches for daily laborer jobs to supplement and diversify their income.

Without exception livelihoods have suffered a series of shocks in recent years, some natural (drought, livestock disease) others political (violent conflicts between clans, a crackdown on illegal trade, bans on import and export of livestock and products) (Environmental Protection, Energy and Mines Resources Development Agency 2011).

Vulnerability

The project area is extremely disaster prone. Communities are vulnerable in multiple aspects, such as food and water insecurity, droughts and flash floods. According to the communities environmental degradation and health problems, such as malaria, are amongst the main threats (ERCS 2014).

The region receives food aid since 2000. Hydrometeorological hazards, resource-based, ethnic and political conflicts, land degradation, and the lack of coping mechanisms and adaptive capacities are amongst the root-causes of vulnerability (Chronic Crises Report 2014). Sedentarisation and the move toward rain fed agriculture are aggravating the dependency on rainfall. Most crises in the zone are protracted, persistent and regular. Very limited effort is being made towards systematic disaster risk reduction.

Figure 1.7 Topography of the Upper Fafan Catchment with its three distinct landforms: the Amora Mountains in the Northwest, the Jijiga Plains in the East and Fafan Valley to the West.

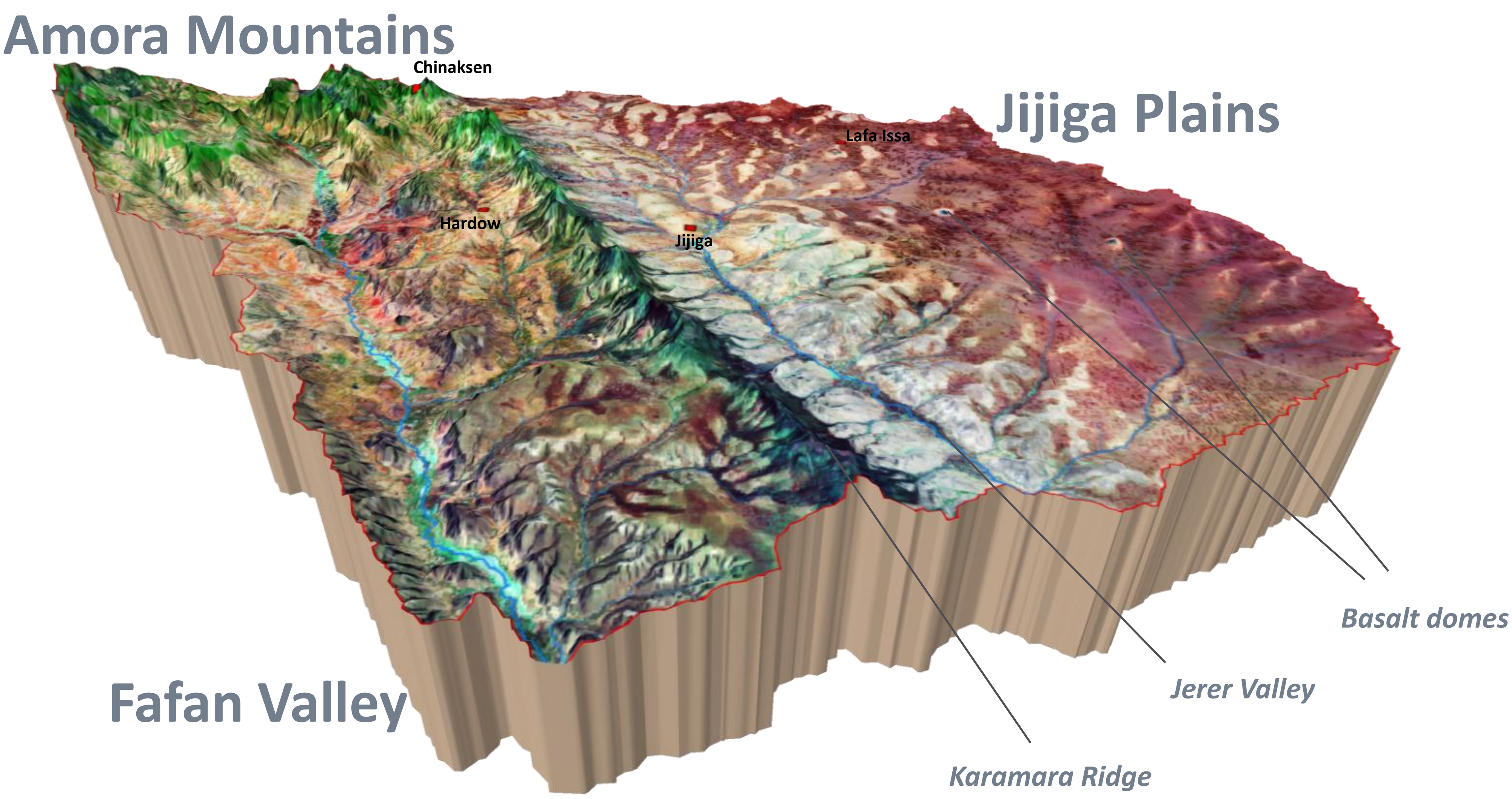


Figure 1.8 3D-visualization of Landsat 8 Imagery where geology and vegetation clearly stand out. The relatively dense vegetated Amora Mountains colour green in the Northwest. The sparsely vegetated Jijiga Plains take a red-orange colour in the East, while green and and orange alternate with each other in Fafan Valley (Southwest). The black spots dotted throughout the plains indicate the location of basalt domes.

One landscape, three landforms

Ethiopia is known as a plateau country with altitudes varying between 0 and well-over 2000 meters above sea level. Areas above 1500 meters are part of the so-called Highlands. All land below that altitude belongs to the Lowlands (Figure 1.9).

Apart from the division in High– and Lowlands, the Ethiopian landscape is characterized by the Great Rift Valley that runs across the country. The rift system is a geological feature that resulted from tectonic plates separating. The altitude and geologic variations associated with the system result in a strong differentiation of biophysical and socio-economic characteristics.

The Upper Fafan Catchment is at the southern rim of the Great Rift Valley (Figure 1.9) Because of this conspicuous location the landscape is made up of three very distinct landforms: the Amora Mountains, the Jijiga Plains and Fafan Valley (Figure 1.7).

Amora Mountains

The Amora Mountains make up the northwestern part of the Upper Fafan Catchment. The altitude of the highest peaks is over 3000 meters above sea level. The area has a typical basement of granites and gneisses, which is partly covered by a layer of limestone, locally up to 300 m-thick. Seasonal streams have cut deep into the limestone resulting in height differences of up to 800 meters.

In the Amora Mountains climate is sub humid with moderate temperatures and relatively short dry seasons. Steep slopes make this area vulnerable to water induced erosion, but good vegetation cover, slope-adapted agriculture and soil and water conservation measures counteract for the problem to a large extent (Figure 1.10 Top). The Amora Mountains are intensively cultivated with only some patches of grassland reserved for livestock grazing and fodder collection. Farming is the dominant livelihood system in the area.

Jijiga Plains

The Jijiga Plains form a more or less flat terrain at approximately 1700 m above sea level to the East of Karamara Ridge. The plains are made up by limestones covered with a thick layer of loose materials, which are pierced through by 10 to 150 meter high inselbergs (basalt cones and plugs). The plains are typically barren or with very little vegetation cover and, thus, exposed to wind erosion (Figure 1.10 Middle).

The plains are home to (migrant) pastoralists and agro-pastoralists. Pastoralists herd there cattle throughout the plains in search for browse-rich areas. Camels and goats are mostly satisfied with thorny bushes. When grazing sheep and cattle, herders also have to look for grasses. Agropastoralists make a living from subsistence farming. They mostly cultivate maize and sorghum.

Fafan Valley

West of Karamara Ridge is Fafan Valley, which is dominated by Fafan River. The basement in this area is formed by granites and gneisses. Remnants of a variable thickness limestone cover are present throughout the valley. At the higher altitudes often bare rock can be found. The valleys are filled with alluvial sediments, with the seasonal rivers and tributaries being filled with several meters of coarse sand and gravel.

In Fafan Valley the scenery is very diverse, from open and closed shrubland to grass- and farmland (Figure 1.10 Lower). Most people in the area make a living from a combination of pastoralist and farming activities. While most of crop production is rain fed, flood recession irrigation is taking place in some of the valleys. Next to erosion, irregular and extreme flooding is at times problematic in this area.

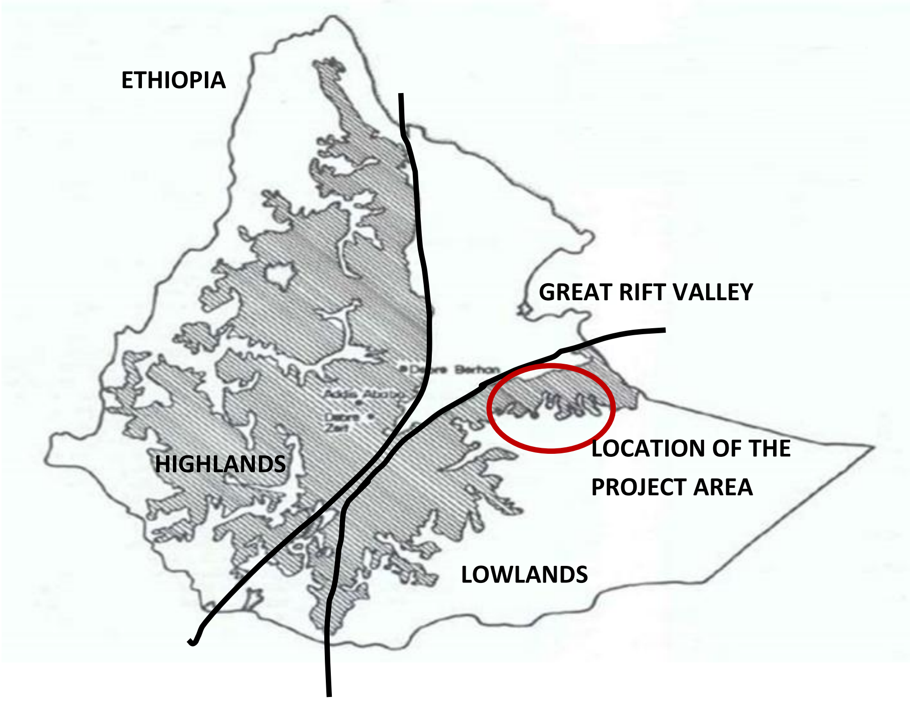


Figure 1.9 Location of the project area on the edge between the High– and Lowlands in Ethiopia.

Figure 1.10 Amora Mountains, Jijiga Plains, and Fafan Valley. Source: Acacia Water 2015.

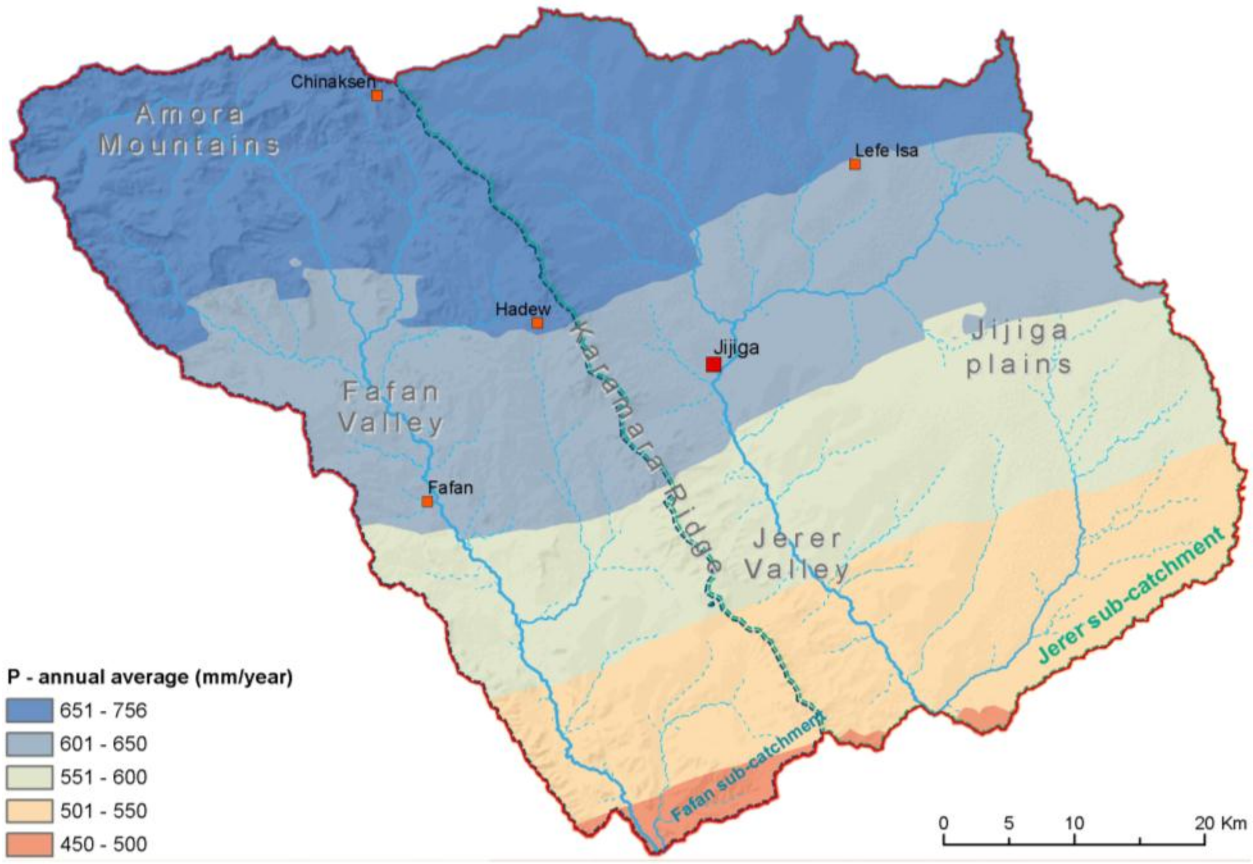


Figure 1.11 Mean annual precipitation (P). The climate in the Upper Fafan is semi-arid. Average yearly rainfall is a reasonable 500-700 mm per year. Rainfall comes in two short intense rainy seasons and has high seasonal and inter-annual variability, which results in regular droughts and floods.

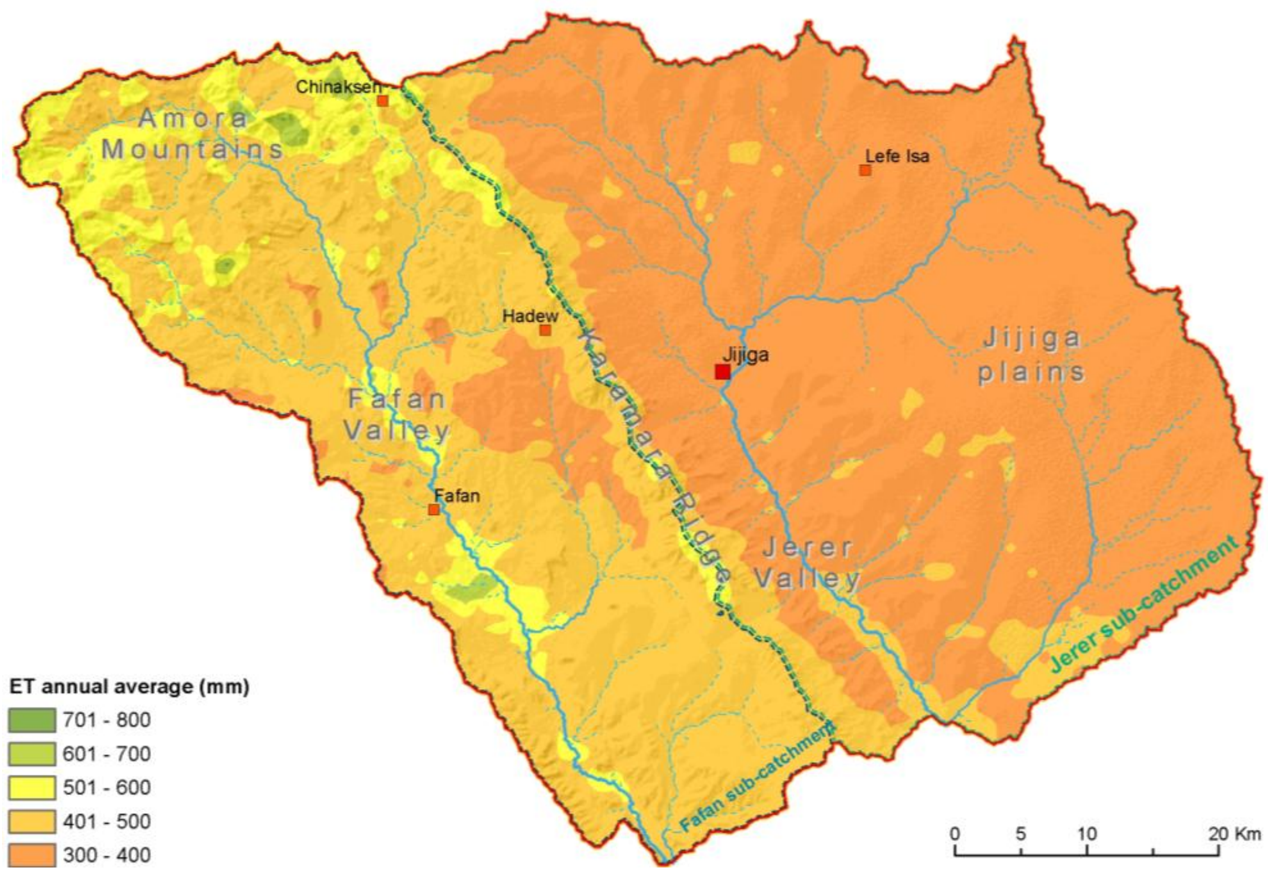


Figure 1.12 Yearly actual evapotranspiration (ET) . Evapotranspiration is an indicator for vegetation growth and is strongly influenced by water availability. Water availability is higher in the Amora Mountains and Fafan Valley than in the Jijiga Plains.

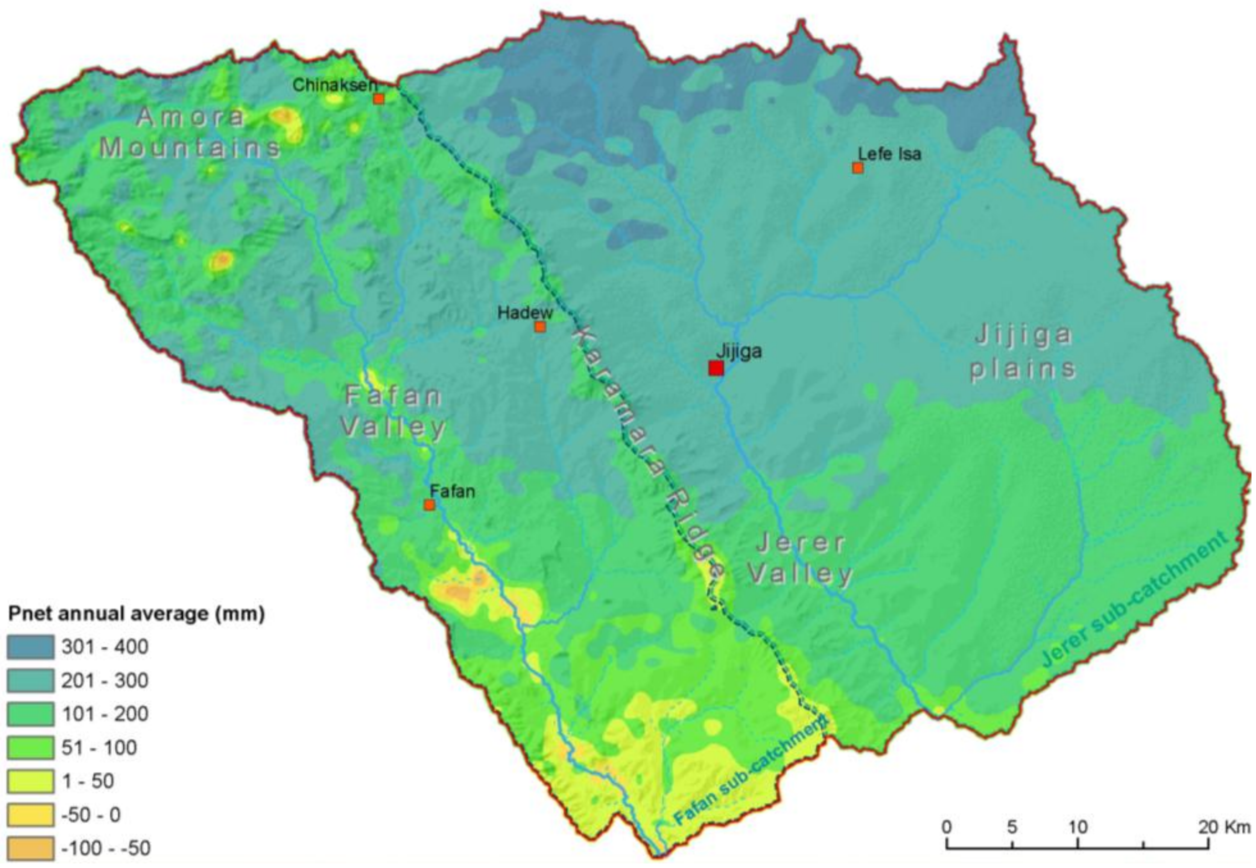


Figure 1.13 Net precipitation (Pnet), which is precipitation minus actual evapotranspiration. Although Pnet is relatively high, water availability is known to be low in the Upper Fafan Catchment. The reason is that high intense rainfall on poorly vegetated lands generates high runoff rates. Water is thus lost to downstream areas.

Climate data

Few climate stations are available in the project area and data series are incomplete. The data gathered at Jijiga Station was most valuable. There, precipitation, temperature, potential and actual evapotranspiration were measured over a longer period. To complete the data, all available daily precipitation records of the Africa Rainfall Climatology dataset (ARC-2) from the Famine Early Warning System Network (FEWS-NET) were downloaded. This resulted in a dataset of daily precipitation from 1983 to 2014 on a 0.1 arc-degree grid (10 by 10 km cells). Figure 1.11 provides an indication of mean annual precipitation. The model underestimates rainfall in mountainous areas.

Climate is semi-arid. Average yearly rainfall is approximately 700 mm per year, but variability is high in space and time. The Amora Mountains are relatively wet (735 mm/year). With an average precipitation of less than 400 mm/year the Jijijga Plains and Fafan Valley receive less rainfall, but still a reasonable amount.

Inter-annual variability in rainfall is high. At Jijiga Station, the highest rainfall amount measured was 1825 mm in 1976 (Figure 1.14). On the contrary, in 1999 a rainfall minimum of 321 mm was measured. These large differences stress the importance to store water for use during drier periods.

Actual evapotranspiration is used from MODIS remote sensing imagery that incorporates vegetation cover indices and stomatal resistance. Open water evaporation is not included. Evapotranspiration rates are highest in the Amora Moutains, along Karamara Ridge and on the flood plains of Fafan River. In the Amora Mountains and along Karamara Ridge, evapotranspiration is high because vegetation density is relatively high. In Fafan Valley evapotranspiration is high because of high soil water content in the floodplains.

Although evapotranspiration rates are relatively high, most of the area has a net precipitation (Pnet) of over 100 mm a year. Pnet is high in the Jijiga Plains because of the low vegetation cover. The low values in the mountainous areas are caused by the high evapotranspiration rates of the dense vegetation cover in combination with the underestimation of precipitation.

Seasonal variability

The rainfall pattern is bimodal. There are two dry seasons (Jilaal and Hagaa) and two wet seasons (Gu and Deyr). Most of the rains (40 per cent) come during the Deyr Season (Figure 1.15). The Gu Rains (28% of yearly rainfall) are, however, as important to local livelihoods. These indicate the end of the long dry season (Jilaal) and thereby the beginning of the crop production cycle and the regeneration of pastures.

As a consequence of the relation between topography and climate the chance for water shortages is highest in the southern part of the landscape. In these areas, measures should be taken to avail water in the soil profile and to enable complementary irrigation. Simple interventions can make the difference between total crop failure or a successful harvest.

Floods and climate change

Close to the wadis, floods are the second major threat to communities. Figure 1.16 shows the recurrence time of rainfall events in Jijiga. The line shows that, on average, every 5 years there is a rainfall event of 60 mm/day, and every 7.5 years a rainfall event of over 100 mm/day hits the project area. These rainfall amounts are not per se very high, but as events are stormy, rainfall is often concentrated in a one or two hours. This high rainfall intensity causes high surface runoff (overland flow) and thus comes with a very high erosivity and chance of flooding. Peak discharges can then result in destructive floods.

The UK Met Office climate change models predict a 10 to 20 per cent increase in rainfall, while intensity of rainfall is assumed to increase further (see Figure 1.17).

In order to address the flooding, peak discharges could be attenuated with storage and retention interventions, and run off could be redirected and slowed down by means of bunds and levies. Land use planning could take into account flood statistics.

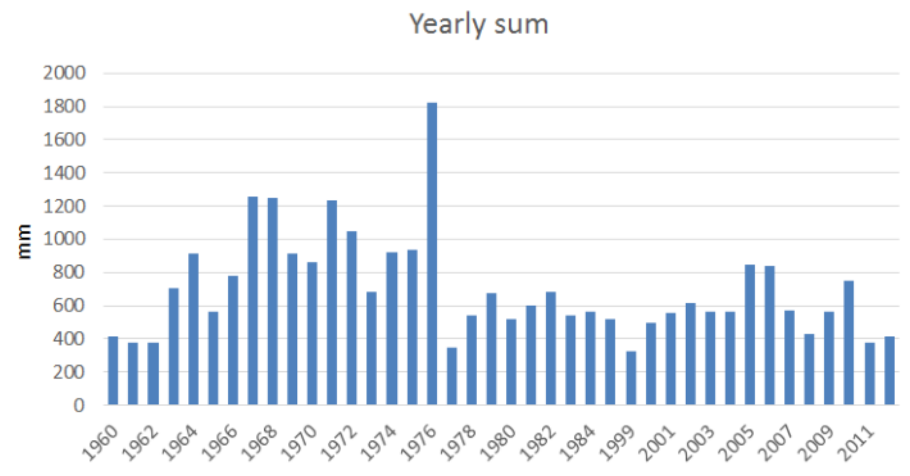


Figure 1.14 Yearly precipitation for Jijiga Town as calculated by the FEWS-NET model

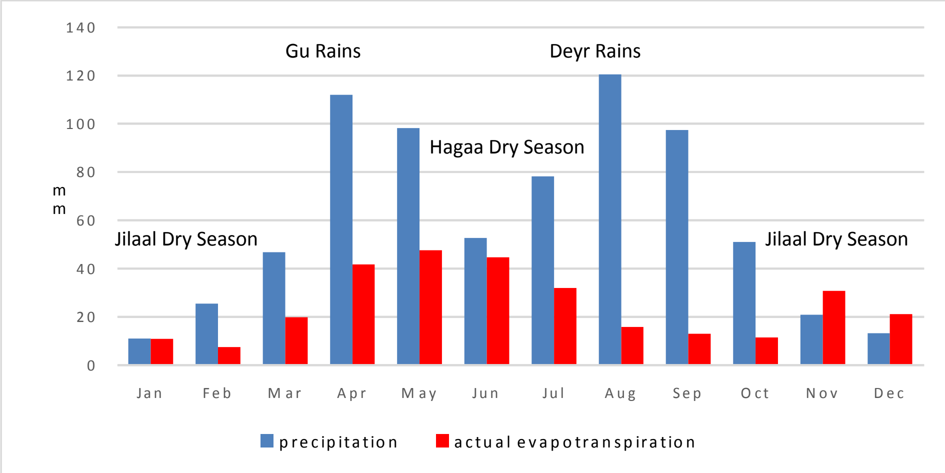


Figure 1.15 Monthly rainfall for Jijiga Town as calculated using the FEWS-NET model. Cimate is bimodal. In Jijiga Town, actual evapotranspiration exceeds precipitation during the Jilaal (long) dry season

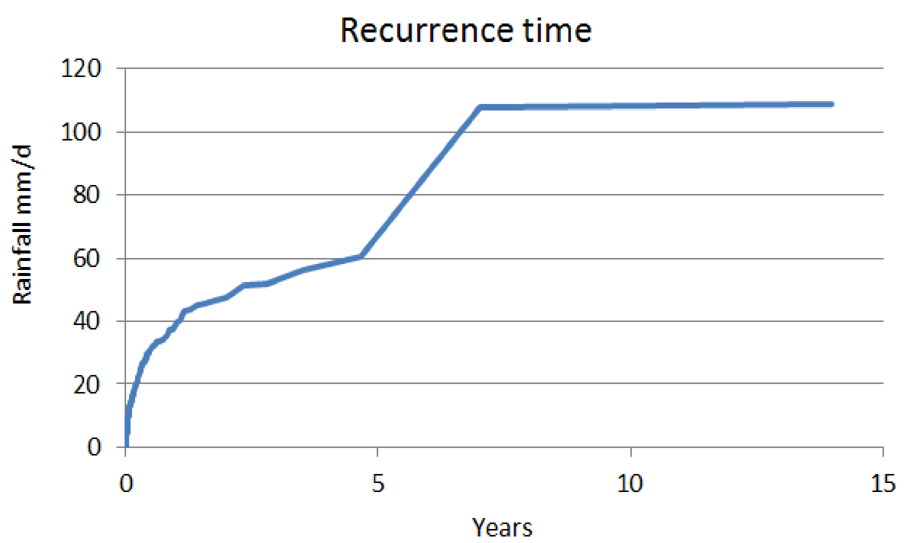


Figure 1.16 Recurrence time of rainfall events in Jijijga Town. Statistically, every 5 years a rainfall event of 60mm/d can be expected; once every 7.5 years an event of almost 110 mm/d occurs.

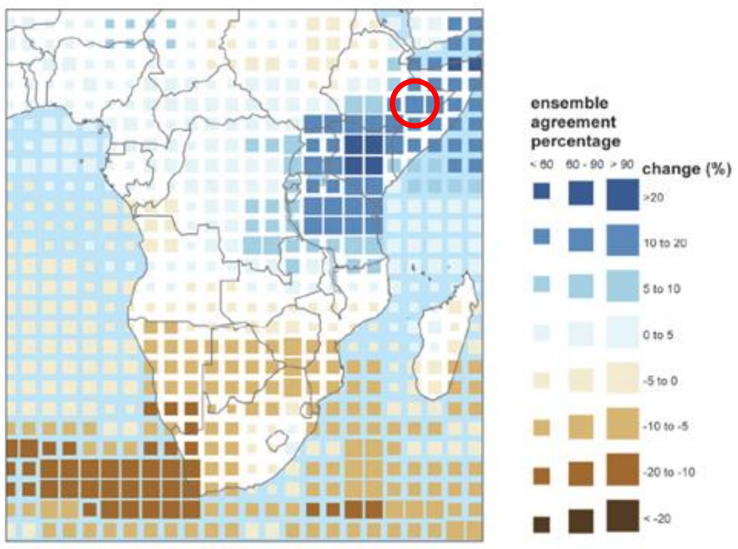


Figure 1.17 Projected change in precipitation due to climate change for southern Africa. A 10 to 20% increase in yearly rainfall is foreseen for the project area. Source: UK Met Office 2010.

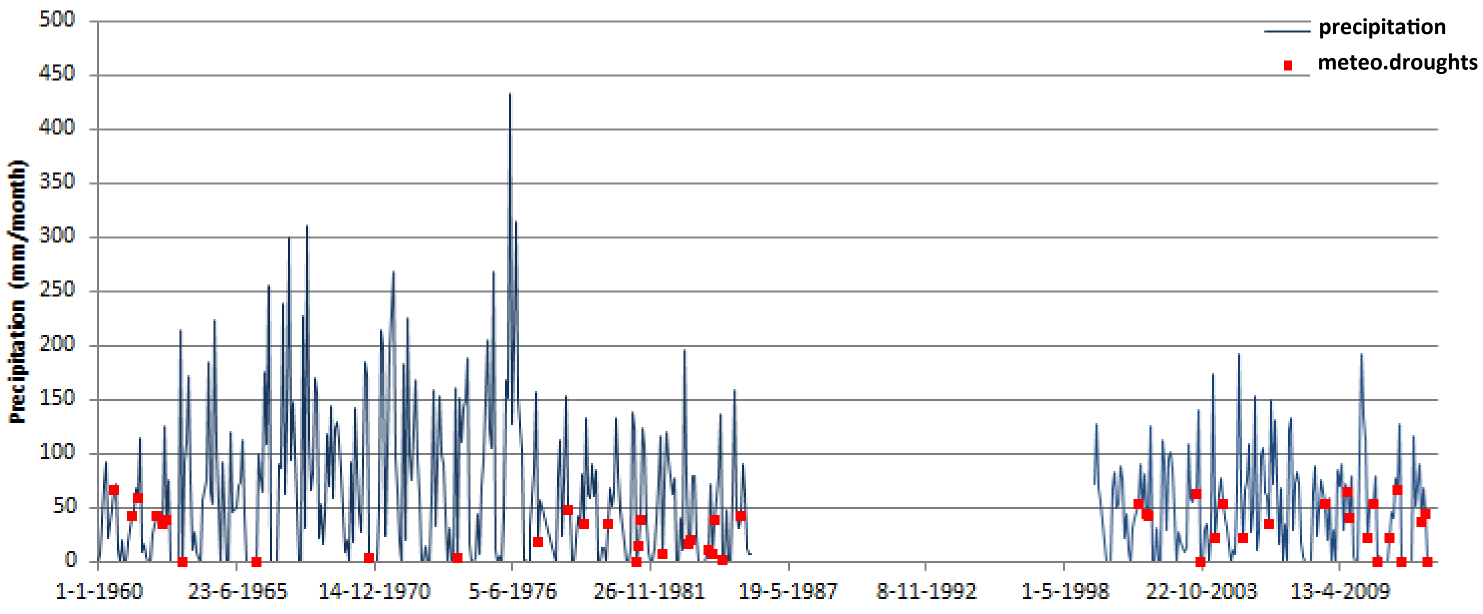


Figure 1.18 Occurrence of meteorological droughts. Droughts, as in 'water scarcity', are periods of below average water availability. The impact of droughts depends also on factors other than rainfall.

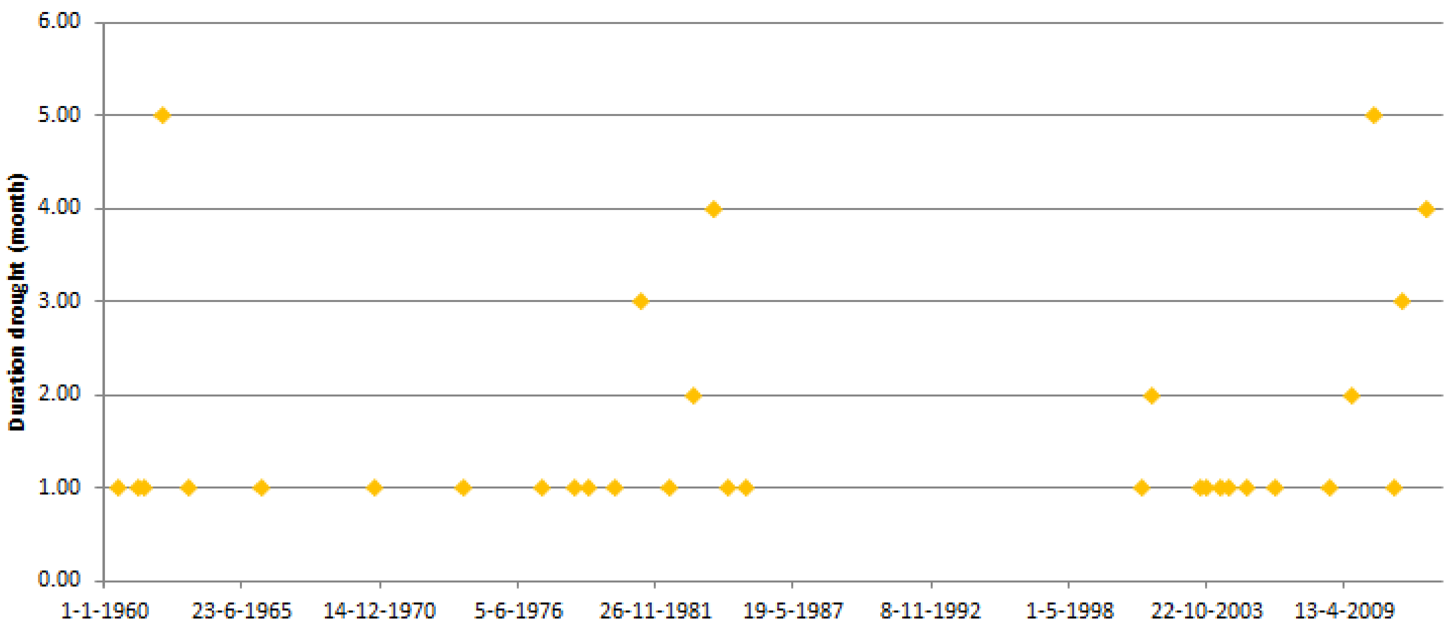


Figure 1.19 Duration of meteorological droughts. One-month droughts indicate a short delay of the rainy season. When below average rainfall persists, droughts can extend over four to five months. Clustering of such long droughts has the largest impact on water and food availability. There is no direct evidence for an increase in frequency or intensity of meteorological droughts. However, the impact of meteorological droughts has increased due to an increase in temperature, environmental degradation and livelihood changes.

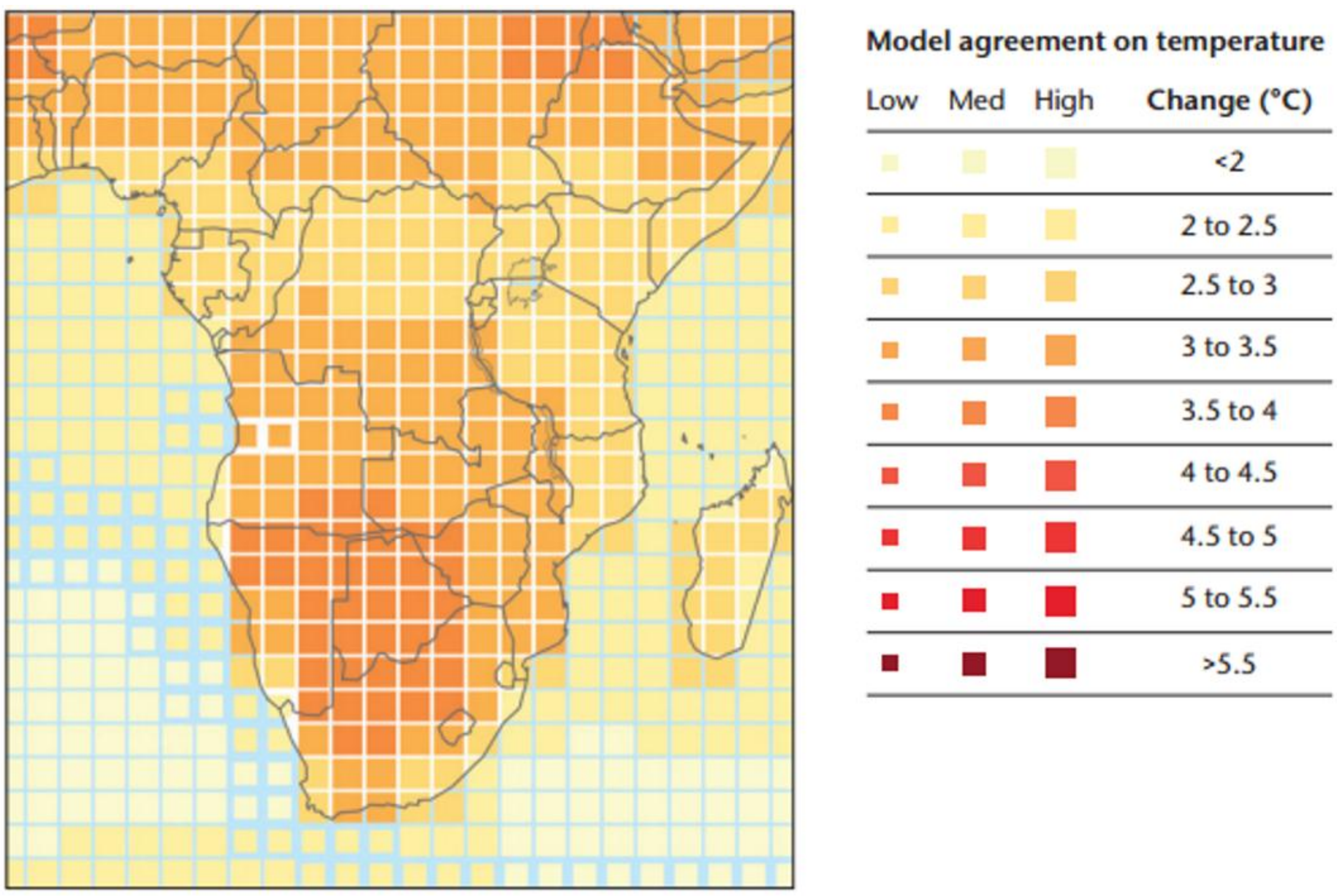


Figure 1.20 Projected changes in temperature due to climate change in southern Africa. For the project area an increase of temperature with 3 to 3.5 degrees is expected. UK Met Office 2010.

Types of droughts

Dry seasons refer to long periods without rainfall that are well-known and expected. Droughts are periods of below average water availability. Droughts as in 'water scarcity' or 'below average water availability' are composed events to which various factors contribute. To adequately address droughts it is essential to define droughts and understand their propagation through the system.

Huijgevoort et al. (2014) define drought as "a temporal, sustained and spatially extensive occurrence of below average natural water availability. […] Drought […] propagates from a lack of precipitation […] (meteorological drought), into the soil (soil moisture drought) and then into the aquifers, streams, lakes and reservoirs (hydrological drought), which again can have an impact on local atmospheric conditions. This [can lead] to agricultural drought (failure of crops), socio-economic drought (impact on goods and services) and ecological drought (ecosystem services)".

Quantifying and analyzing the characteristics, impacts and trends of all drought types is beyond the scope of this study. In this particular section, analyzes focus on the occurrence and duration of meteorological droughts.

Occurrence of droughts

To analyse meteorological droughts the Threshold Level Method (TLM) was used. A meteorological drought is defined as a period wherein rainfall drops below the drought threshold value. The threshold is determined for each month, based on the monthly precipitation values of rain gauge data. The threshold is defined as the 80th exceedance percentile for each month.

The occurrence of meteorological droughts was analysed for 30 years of rainfall-data at Jijiga Meteorological Station (no data for 1985-1999). Figure 1.18 shows the moments in which actual precipitation drops below the threshold value, thus showing the occurrence of droughts The graph shows that droughts concentrate in certain periods, such as the Early 60s, 1982-1984 and 2009-2011.

Figure 1.19 depicts the duration of the droughts. It stands out that 75% of the events does not last longer than a month. These relatively short drier than normal periods indicate a delay of a rainy season. Longer droughts can last up to five months, meaning that rainy seasons fail completely. In periods with many droughts, the events also last longer. Clustering of droughts is related to complex ENSO, SST and land-atmosphere feedbacks (see Box 1.2).

Altogether the analyses show that meteorological droughts are recurrent and intense, but there is no direct evidence for an increase in frequency or intensity. It is, however, possible that the impact of droughts has increased due to an increase in temperature (NMA 2007 in ERCS 2014), environmental degradation and livelihood changes.

Droughts in times of climate change

The impact of droughts are likely to aggravate due to climate change, population growth and environmental degradation. As a result of climate change:

- The total amount of rainfall is expected to increase with 10 to 20% and rainfall intensity will become higher. This will make it more difficult to buffer water in the project area
- Temperatures are projected to rise with 3.0 to 3.5 degrees Celsius. As a consequence, evapotranspiration rates are likely to increase, which leads to a lower water availability

Mitigation and adaptation

As a result of droughts, water reservoirs, including the soil, aquifers and manmade reservoirs, may not be replenished during the rainy seasons. The delay of the rainy season at the end of Jilaal is especially problematic to pastoralists because recovery of pastures is delayed.

Droughts during dry seasons are less of a problem since users are already accustomed to little rainfall. Yet, an unexpected harsh or prolonged Hagaa (short dry season) can be problematic for farmers. Farmers plant at the start of Gu rainy season; if rainfall fails two months later and no other water sources are available crop failure may follow.

Understanding drought processes allows to integrate efforts, reduce negative impacts and better anticipate for future droughts. To cope with droughts both mitigation and adaptation measures are recommended:

- Although mitigation of meteorological droughts (below average amounts of rainfall) is barely possible, microclimatic conditions can be improved through widespread regeneration of vegetation cover
- The risk for a meteorological drought to turn into a soil moisture, hydrological, agricultural, socio-economic or ecological drought can be reduced through improved ecosystem management (e.g. increase soil moisture holding capacity, augment the system's water storage capacity, revegetation). Ecosystem management improves the system's water retention capacity, so that water availability is improved in times of low rainfall
- Clustering of droughts stresses the need to cope with multi-year events. Water retention and storage interventions should allow for large amounts of water to be stored
- Lower dependence on water resources is another way to cope with droughts. Livelihoods that are less dependent on water could be promoted and access to drought tolerant crops improved
- In general, the progress on droughts risk management should speed up, also in light of possible worsening of the situation due to climate change. Interventions should prioritize addressing root causes, and not be limited to end-of-pipeline symptom alleviation
- Invest in drought early warning systems and further develop forecast-based approaches that release funds for disaster preparedness and response. A shift from humanitarian reactive system to one that looks forward saves live, time and money (IFRC 2015). The Red Cross Climate Centre currently pilots such programmes in Uganda.

Box 1.2 Droughts in Africa

Based on Masih et al. (2014)

Most studies indicate that droughts have become more frequent, intense and widespread in Africa during the last 50 years. The extreme droughts of 1972–1973, 1983–1984 and 1991–1992 were continental in nature and stand unique in the records. Additionally, many severe and prolonged droughts were recorded in the recent past such as the 1999–2002 drought in northwest Africa, 1970s and 1980s droughts in western Africa (Sahel), 2010–2011 drought in eastern Africa (Horn of Africa) and 2001–2003 drought in southern and southeastern Africa, to name a few. The available, though limited, evidence confirms the occurence of several multi-year droughts during each century. These droughts are related to complex and highly variant physical mechanisms such as El Niño–Southern Oscillation (ENSO), sea surface temperature (SST) and land–atmosphere feedback.

The future predictions of droughts based on global climate models indicate increased droughts and aridity at continental scale.

2

LAND USE AND MANAGEMENT

Challenges and opportunities provided by a landscape are to a large extent dependent on human activities, such as land use and management.

This chapter covers the characterization of soils and its meaning in terms of land use and management, spatial variability in land use, trends in type and density of vegetation cover, and environmental degradation.

Figure 2.1 Soils of the Upper Fafan Catchment. In the Jijiga Plains vertisols, which are very sensitive to wind erosion, predominate. Along Jerer River, in Fafan Valley and in the Amora Mountains there are mostly cambisols and luvisols, which are suitable for agriculture if proper management is applied. Next to vertisols, care should be particularly taken with leptosols since these are very sensitive to water erosion.

Cambisols **Vertisols** **Leptosols** **Luvisols** **Fluvisols** **Calcisols**

Figure 2.2 Soils of the Upper Fafan Catchment. Photo credits Acacia Water 2015, geo.msu.edu, ulrichschuler.net, and madrimasd.org

Table 2.1 Characterization and suitability of the soils present in the Upper Fafan Catchment.

Soil type	Soil class	Reference soil group	Description	Soil moisture holding capactiy	Infiltration capacity	Erosion sensitivity	Agri-cultural suitability	Main use
Luvisols		Soils with marked textural diferentiation	Soils in which clay is washed down the surface into an accumulation, potential for shallow groundwater	High	Low	Medium	Medium	If internal drainage is good, potentially wide range of agricultural uses
Cambisols	Moderately deep to deep soils with moderate high fertility	Soils with incipient soil formation	Soils are characterized by the absence of a layer of accumulated clay, humus, soluble salts or. Texture of the subsurface horizons is sandy loam or finer. Generally well drained.	High, but depending on texture	Medium, but depending on texture		High	A wide variety of agricultural uses depending on climate, topography, stoniness, or base states. In steep lands mainly grazing and/or forestry
Vertisols		Black cotton soils		Variable	High when dry almost nil when wet	High		
Fluvisols	Alluvial soils	Young, azonal soils in alluvial deposits	Soils developed in alluvial deposits, in periodically flooded areas or alluvial plains. Texture can vary from coarse sand in levee soils to heavy clays in basin areas	High	Medium-low, depending on texture		Medium-high	A wide variety of agricultural uses and grazing land
Leptosols	Other	Shallow sols	Generally young, very shallow soils over hard rock or highly calcareous material, but also deeper soils that are gravelly and/or stony	Low	High	High	Very low	Extensive grazing, but best kept under forest

Soil suitability and management

Soil characteristics strongly influence runoff, infiltration capacity, water buffering potential and groundwater recharge. Accurate soil maps help to identify areas prone to erosion, to assess agricultural potential and to guide land use. In this study, existing soil maps were updated and revised using supervised classification of processed multi-spectral Landsat 8 satellite imagery of January 2015. Training samples from existing soil maps were used.

Partly because of lithological and geological differences, the soil types in the Upper Fafan Catchment are highly variable (Figure 2.1, Table 2.1 and Figure 2.2). At high altitudes in the Amora Mountains and on the ridges leptosols and bare rock predominate. Leptosols are very poor soils, mostly used for extensive grazing, but best kept under forest or other permanent forms of vegetation to protect and stimulate soil development.

In the Fafan Valley luvisols are common, except for the floodplains where fluvisols have been deposited by seasonal streams. Luvisols' suitability for crop production is highly dependent on the characteristics of the clay accumulation horizon. When the horizon's permeability is low, the infiltration capacity is low, therewith decreasing the suitability for agriculture. The infiltration and moisture holding capacity of fluvisols is relatively high and, with application of propper structure and fertilization management, these soils can be suitable for a wide variety of agricultural uses.

Cambisols are dominant in the western part of Jijiga Plains, in the foothills of Karamara Ridge and around Jerer River. These soils are typically well-drained sandy loams, loams and sandy soils, and are characterized by the absence of accumulated clay, humus or oxides. Cambisols are known for their reasonable fertility and suitability for (mechanized) agriculture (UN FAO 2009).

To the East Jijiga Plains are covered by vertisols, also known as black cotton soils. Vertisols are normally black or dark grey soils with very high clay content. Because of the heavy soil texture and presence of expanding clay minerals the soils' range between moisture stress and water excess is very narrow. The soils are sticky when wet and crack when dry. Due to swelling the infiltration capacity is extremely low, resulting in high runoff rates. Vertisols are typically low in organic matter, have a medium moisture storage capacity, have a poor drainage capacity and are very prone to erosion.

Patches of calcisols are present throughout the landscape. Calcisols develop on highly calcareous parent material and can be highly productive. Stoniness and dryness, however, are a limiting factors. Drought tolerant crops can be grown rain-fed, preferably after a few fallow years, but Calcisols reach their full productive capacity only when carefully irrigated. Currently, most Calcisols are under open to closed shrubland.

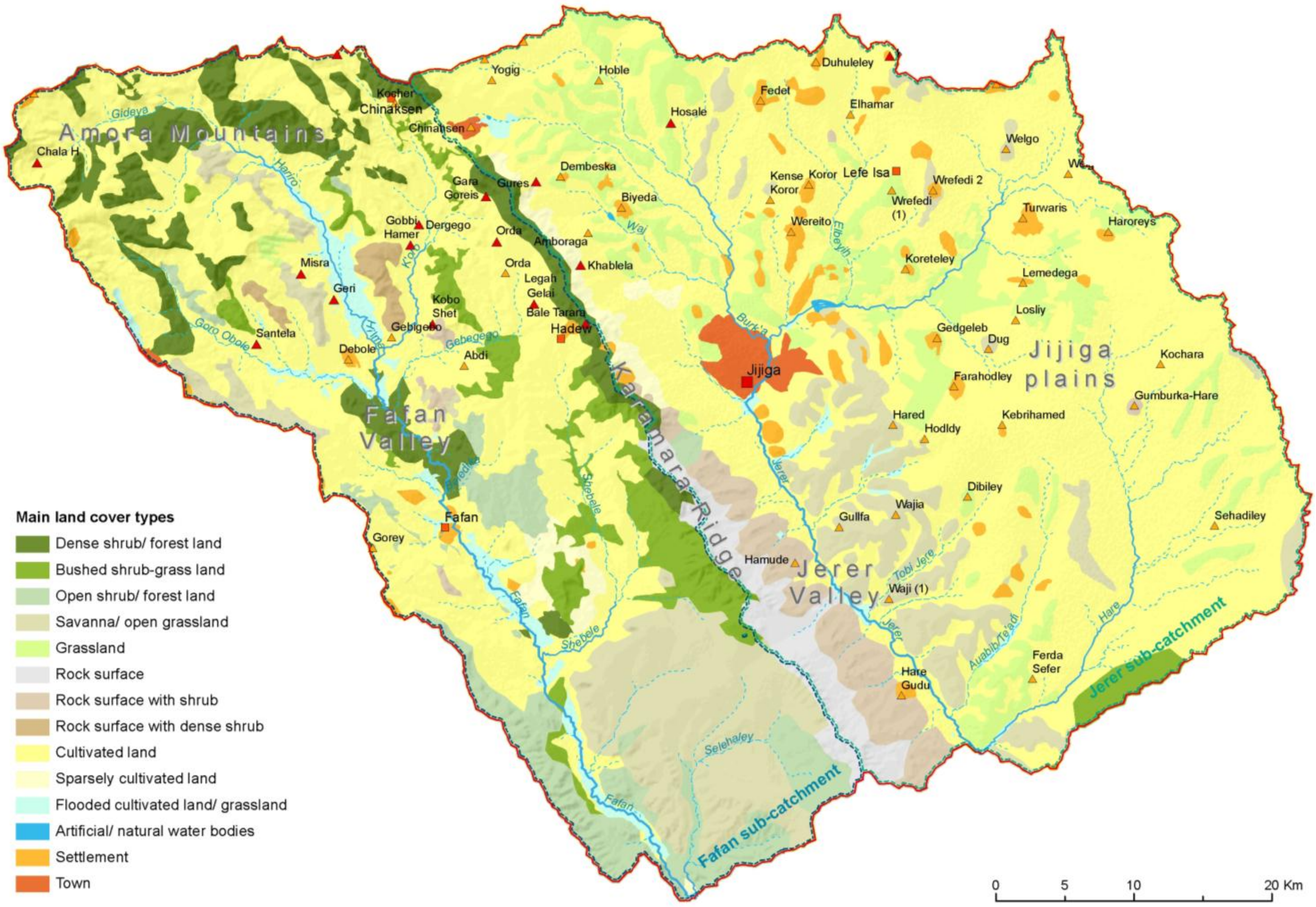


Figure 2.3 Refined land cover map. Increased agriculture and sedentarisation have significantly changed the landscape over the past 30 years.

Land cover

Land cover has an important impact on (micro)climate, biochemistry, hydrology, and the diversity and abundance of terrestrial species in a landscape.

Securing a good understanding of how vegetation cover and land use practices are evolving is fundamental to comprehend land degradation processes, assess the status of ecosystems, and design strategic interventions at landscape level.

The specifications, detail and accuracy of existing land cover maps did not meet the requirements for the analyses foreseen in this project. Therefore, a new land cover map was developed (Figure 2.3). The land cover map was generated using Landsat 8 Imagery from January 2015. Images were enhanced using ERDAS 2014, and spot5m and ALOS PADAR at 50m resolution. Validation of interpreted datasets was done using existing reports and datasets, and a set of observation points collected during the field visits.

The land cover map indicates that, in general, soil cover is sparse throughout the landscape with large areas covered with open vegetation, barren soils and bare rock.

In the Amora Mountains and most of Fafan Valley cultivated land predominates. Only in the southern part of Fafan Valley open grassland with shrub remains. Cultivated land is an important source of food and income for the regions, but is, at the same time, reducing biodiversity.

On the 2015 land cover map, Karamara Ridge stands out for its rocky surface. Vegetation is limited to some shrubs. Here, the absence of vegetation is increasing run -off rates and limiting climate regulation processes.

East of Karamara Ridge, in the Jijiga Plains, cultivated land and grassland dominates the scenery. Agriculture in the area is rain-fed and, thus, the decision to cultivate or not is highly dependent on rainfall. Areas may be cultivated one year, but in the following left fallow allowing grassland to establish.

Figure 2.5 Open shrubland

Figure 2.6 Bare land/open shrubland

Figure 2.7 Closed shrubland

Figure 2.8 Closed grassland

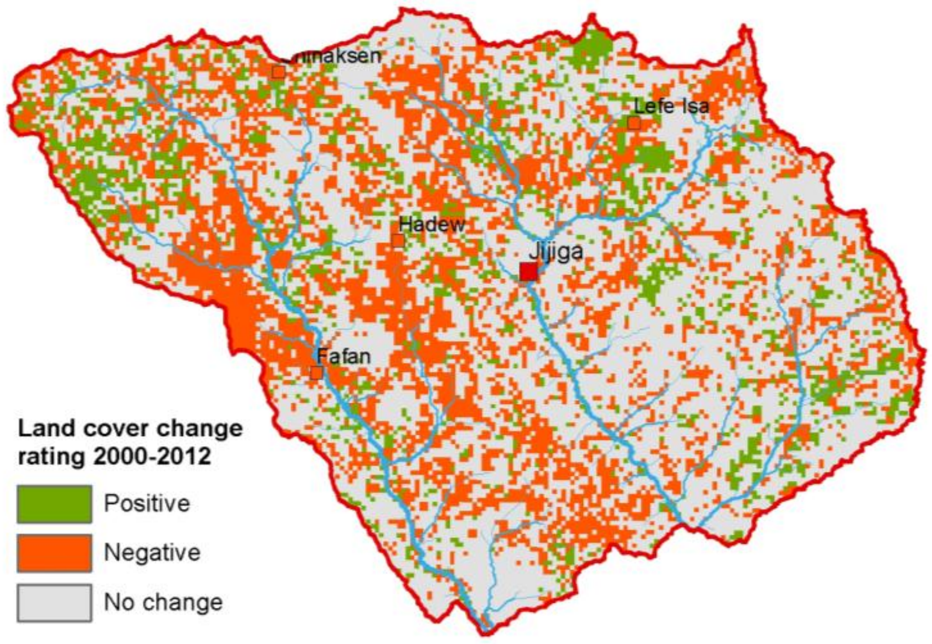


Figure 2.4 Weighted land cover change between 2000 and 2012. A decrease in vegetation cover was observed in 32% of the project area.

Table 2.2 Absolute and relative land use change between 1985 and 2015. The figures show that in the course of 30 years almost 70 000 hectares of forest and rangeland have been converted into lands for agricultural production.

Land use	2015 (ha)	1985 (ha)	1985 to 2015 in ha	1985 to 2015 in %
Agriculture	506711	437053	69,658	13.7%
Forest	112,661	139,704	-27,043	-24.0%
Rangeland	499,216	555,208	-55,992	-11.2%
Open water	143	0	143	100.0%
Built-up area	18,733	7,862	10,871	58.0%

Land cover and land use changes

Land cover changes over the period 2001-2012 have been derived from existing MODIS GLCF land cover data (Figure 2.4). This is a global dataset and local accuracy may vary. Yearly land cover changes can be related to evolving land use, but to some extent also reflect climate variability. The map should be interpreted with caution.

Land cover is strongly human driven through land use. Land use is obviously determined by environmental factors such as soil characteristics, climate, topography, and vegetation, but also reflects land's importance as a fundamental factor of production.

Unlike 30 years ago when rangelands dominated the Upper Fafan Catchment, nowadays agricultural lands and rangelands are more or less equally distributed, with each covering approximately 500,000 ha (Table 2.2). The move from traditional pastoral livelihood systems toward more agriculture-oriented ways of living explains this change. Rangelands and forests were cleared and converted into crop production fields. A side-effect of this change was the decreasing vegetation cover, which is visible throughout the project area, but is strongest on the river banks and floodplains North of Fafan Town and along Karamara Ridge (Figure 2.4).

Sedentarisation leads to a second major change in the landscape. Table 2.2 shows that between 1985 and 2015 the built-up area increased with almost 60%.

Agricultural production is mostly traditional, small-scale and rain fed. Although still on a very limited scale, vegetable gardens and orchards are expanding along the rivers. In areas with irrigation potential the government is promoting the growth of cash crops, such as haricot bean, mango, papaya, sesame, tomato and wheat, to supplement traditional sources of income.

Rangeland, forests and their management

Rural livelihoods in the project area are to a large extent dependent on products from rangelands and forests. Camels and goats browse the thick thorny bushes, sheep and cattle prefer the lush pastures of grasslands. Communities also cut grass and store it as fodder for the dry season. Trees provide wood for energy, livestock feed, medicines and to some extent timber, food and shelter. Particularly traditional tree species, such as *Acacia bussie* and *Combretumk collinum* are popular amongst the rural population.

Rangelands and forests, and even in many cases agricultural lands, are considered to be common pool resources in the Upper Fafan Catchment. The absence of a private land tenure system inhibits the will to invest in land management. Uncontrolled grazing, tree-cutting, land clearing for crop production, and the concentration of anthropogenic pressures due to sedentarisation are intensifying land degradation.

Field observations and stakeholder interviews indicate that the construction of physical structures, such as contour bunds and trenches, is unable to counteract the degradation challenges threatening common lands.

Figure 2.9 Rain fed agriculture (maize)

Figure 2.10 Mosaic vegetation/croplands

Figure 2.11 Forest along Fafan River

Figure 2.12 Settlement at Jijiga Plains

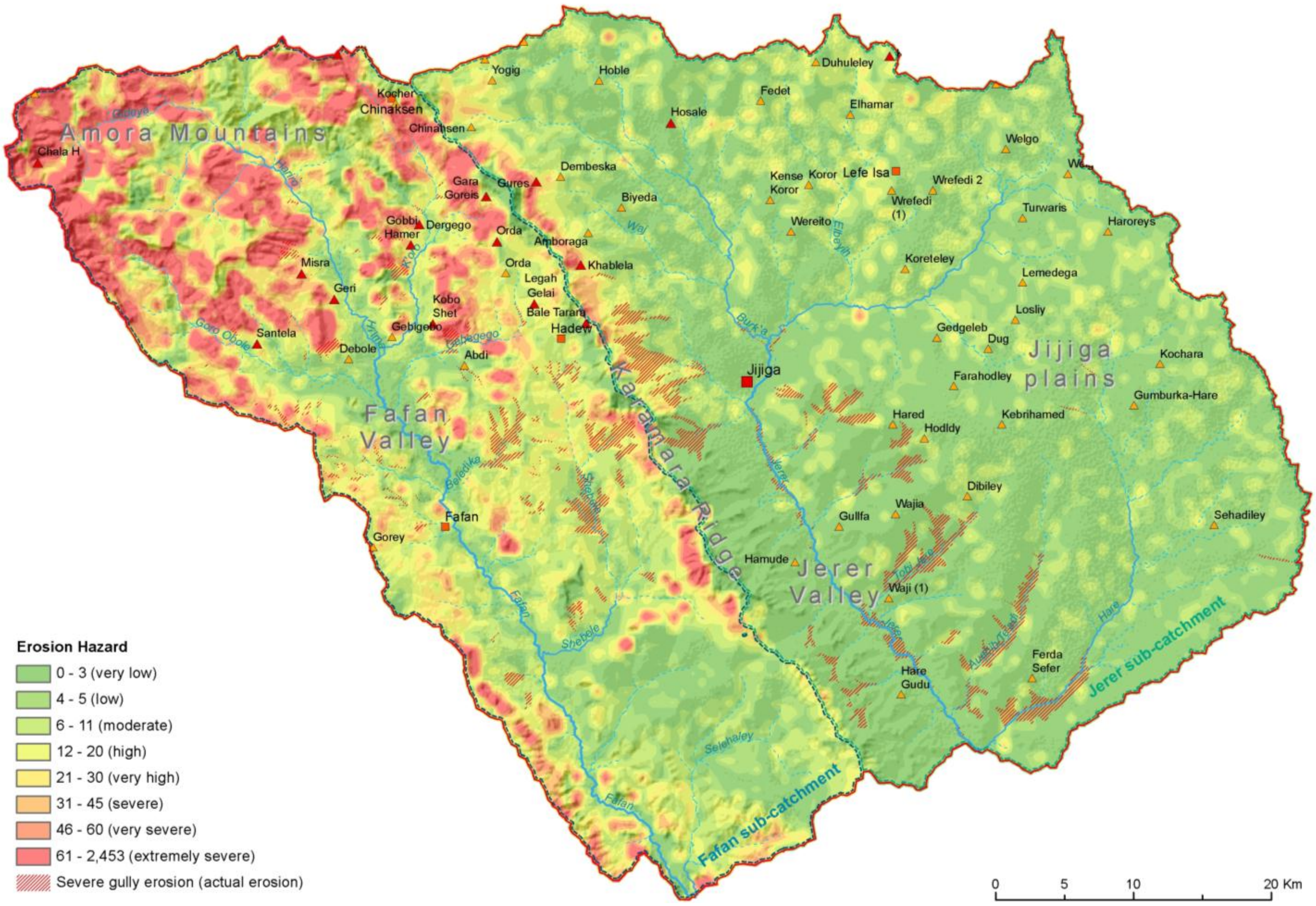


Figure 2.13 Erosion hazard (potential erosion based on physical and climate characteristics), and actual gully erosion. Remarkably, the most severe gully erosion is not taking place where potential erosion is highest. Erosion in the project area is largely a consequence of poor land use and management and less of soils, slopes and rainfall characteristics.

Sensitivity to erosion

Degradation in the project area is largely an erosion challenge. To estimate potential soil loss due to water erosion the Revised Universal Soil Loss Equation (RUSLE) was used (Morgan 2005). The RUSLE model uses rainfall erosivity, soil erodibility, and slope length and steepness to calculate erosion The modelled soil loss, shown in Figure 2.13 as erosion hazard, depicts the landscape's sensitivity to erosion as a consequence of physical and climate characteristics. The Amora Mountains and the adjacent slopes of the northern part of Fafan Valley are most sensitive to erosion.

Actual erosion

Remarkably, most severe gully erosion is not taking place in the Amora Mountains where potential erosion is highest, but along the tributaries to the rivers Jerer and Fafan. Wind erosion is common on the Jijiga Plains.

Field observations and satellite imagery analysis indicate that in the Amora Mountains degradation is limited. The area is green and well-protected. It turns out that application of soil and water conservation measures, such as contour bunds, terraces and cut-off trenches, in this area is widespread and land use planning takes into account the strengths and weaknesses of the landscape. Grazing is controlled; cut-and-carry systems are widespread. The broad scale application of measures is in many cases linked to government programmes promoting sustainable management of croplands, rangelands and forested areas.

The deepest gullies, up to six meter deep, occur to the west and south of Jijiga Town. Most of these erosion locations are located on dark clayey Vertisols and brown-red clay to loamy Cambisols (figures 2.14 and 2.15). Vertisols and Cambisols are very sensitive to erosion. As a consequence, mismanagement can lead to severe gully and wind erosion. Close to Jijiga Town, boreholes, houses and power lines have been destructed by the gullies. To avert the problems the government has been constructing check dams and gabion enforcement walls. Seemingly these are merely relocating the problem. Also the small stone bunds and terracing developed by communities are unable to address the ongoing erosion processes.

Box 2.1 Mr. Aden, forest guardian

Interview with Jama Aden, August 2015

Mr. Aden is a 51-year old voluntary guardian in the Gammaa Sinta Hills. His community has an agro-pastoral lifestyle; water shortages form the major threat to their livelihoods. During the rainy season water is fetched from a small pond. In times of drought the men and boys migrate with the livestock to areas where sufficient water and pasture are available. Women and children stay in the village, and collect water for domestic use from Jijiga Town (5km away).

According to Mr. Aden, erosion is caused by deforestation, drought, stone mining and overgrazing. Gullies have always been part of the landscape, but they are becoming bigger and bigger. Tree cutting, mining and overgrazing are exacerbating the erosion problem and are to a large part caused by incoming migrants from towns and far-away villages. Citizens from, for example, Jijiga come to collect stones and cut trees for construction.

The community has been involved in the construction of stone bunds on a project basis. The community is trying to protect the area and has appointed voluntary guardians to keep outsiders away. Upon request, the community stresses that they are very willing to be involved in gully restoration and area closure projects.

Wind erosion is less visible, but is no less detrimental than gully erosion. Wind erosion detaches the uppermost fertile soil layer (Figure 2.16).

The observations indicate that erosion in the project area is largely a consequence of poor land use and management, including: overgrazing; tree cutting for wood collection, construction purposes, fencing and charcoal production; land clearing for crop production; agriculture on poor soils and steep slopes without considering proper soil and water conservation measures; and encroachment of agriculture into flooding areas and wetlands. Without proper adaptations, agriculture on Vertisols and Cambisols is bound to fail on the long term.

Impact of erosion

The reduction of infiltration rates and storage capacity directly results in higher discharges during times of heavy rainfall, and lower water availability in dry periods. Erosion is a major composer of droughts. During interviews community members mention erosion as a major threat to their livelihoods (Box 2.1). Erosion results in the loss of ecosystem services, and thereby in the loss of natural resources that are vital to local communities. Erosion impacts are severe and widespread:

- Fertile soils are lost and agricultural productivity is dropping
- Infrastructure and buildings are destroyed
- Mobility and access to resources are limited
- Vegetation, including regulating riverine and wetland vegetation, is lost
- Infiltration, soil moisture and groundwater recharge are reducing, lowering the yield of water sources

Some of the above mentioned effects increase erosion, making it a self-increasing process.

Current interventions

Current physical soil and water conservation programmes seem to have limited impact. In some cases, especially when applied to large gullies, the impact is even adverse (Figure 2.17). In addition, the implementation of interventions is reported in areas where there is a limited to no erosion problem. These interventions have been done through food or cash for work arrangements with the communities. Experience shows, and is confirmed by local experts, that these programmes are not sustainable, because:

- Many of the physical interventions are applied in rangelands, which are communal lands.
- Communities often, particularly in rangelands, do not maintain the structures after construction is completed
- Even after physical measures have been applied, vegetation is not sufficiently protected, which is the ultimate cause of erosion
- Because communities get compensation for restoration of a problem which is mostly caused by themselves (overgrazing/deforestation), the incentive to deal with the challenges and upscale the interventions is limited

For effective and sustainable erosion control, more attention should be paid to 'soft' measures, such as regulation, awareness raising, training and facilitation of management processes. Hard measures can complement the efforts, but only if initiated by the users themselves. More information on erosion control measures is provided in Chapter 5 Ecosystem Restoration.

Figure 2.14 Gully erosion on vertisols

Figure 2.15 Gully erosion on cambisols

Figure 2.16 Wind erosion on Jijiga Plains

Figure 2.17 Example of ineffective physical erosion control interventions. The gabion dams widened the gully, while trees are still being cut.

3

ECOSYSTEM SERVICES

Pastoral and agropastoral communities are highly dependent on ecosystems and their services. Ecosystems are dynamic complex systems of plant, animals, microorganisms and the non-living environment that interact as a functional unit. Ecosystem services are the benefits that people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational and cultural benefits; and supporting services, such as nutrient cycling, that maintain the condition for life on Earth (UNEP 2005).

In this chapter, ecosystems and their services are identified and valued. In addition attention is paid to ecological sensitivity and invasive species.

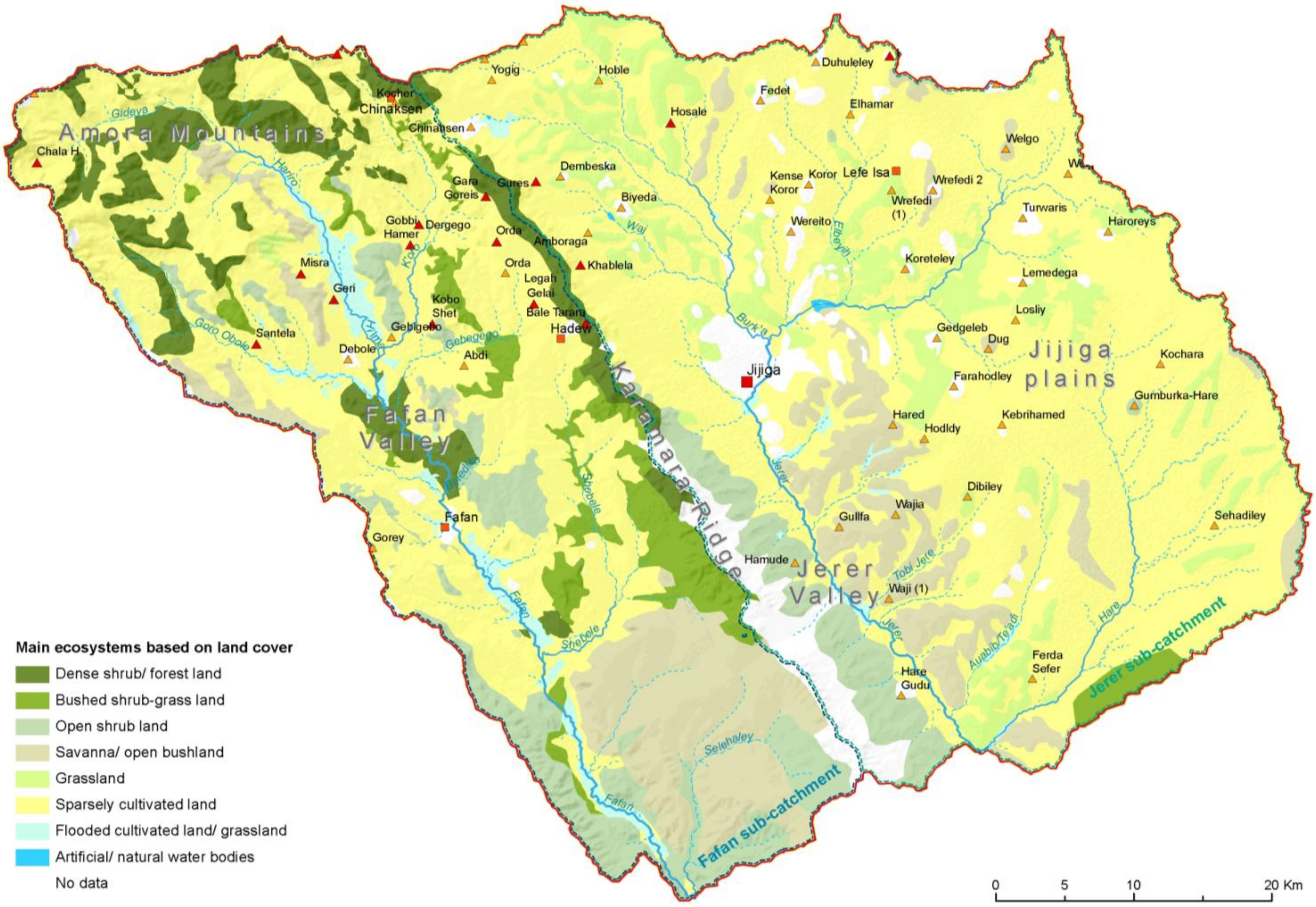


Figure 3.1 Ecosystems in the Upper Fafan Catchment.

Ecosystems

Ecosystems are interactions between living organisms and the physical environment. Ecosystems provide benefits to people. Collectively these benefits are known as ecosystem services (MA, 2003). The combined ecosystem services determine the capacity of a landscape to sustain livelihoods and reduce the frequency and impact of disasters.

Ecosystems in the Upper Fafan Catchment

As ecosystems are made up of elements that interact at multiple temporal and spatial scales it is difficult to set their boundaries. Ecosystems may vary from a single raindrop, to a lake, a watershed, or an entire region. Boundaries may overlap and depend upon the purpose of analysis, the processes being studied or the scope of questions to be answered.

From a practical point of view, however, there is a need to define and describe ecosystems. Considering the objectives and goals formulated in this project, it was found suitable to consider ecosystems at the scale of landscapes.

To spatially and functionally differentiate between ecosystems, we assessed how various regions show greater or lesser similarities in climatic conditions, geophysical conditions, dominant use by humans, surface cover (vegetation), species composition and natural resources management system. Based on this assessment, we categorized and spatially delineated the ecosystems based on the land cover classification (Figure 3.1):

- Dense shrub/ forest land
- Bushed shrub-grassland
- Open shrubland
- Savanna/ open bushland
- Grassland
- Sparsely cultivated land
- Flooded cultivated land/ grassland
- Artificial and natural water bodies

The Jijiga Plains, east of Karamara Ridge, are typically characterized by arable land dotted with patches of dry lowland grassland, urban areas and (particularly in the degraded areas) by dry shrubland. The most southern part of the project area, area around Shipford, Kampsayt and Dande villages, is very remote and mostly covered with dry shrubland. Dry forest mostly occurs in the Amora Mountains, on Karamara Ridge and close to Ala Hago in Fafan Valley. Finally, there are rather large areas of seasonally flooded agricultural lands along Fafan River.

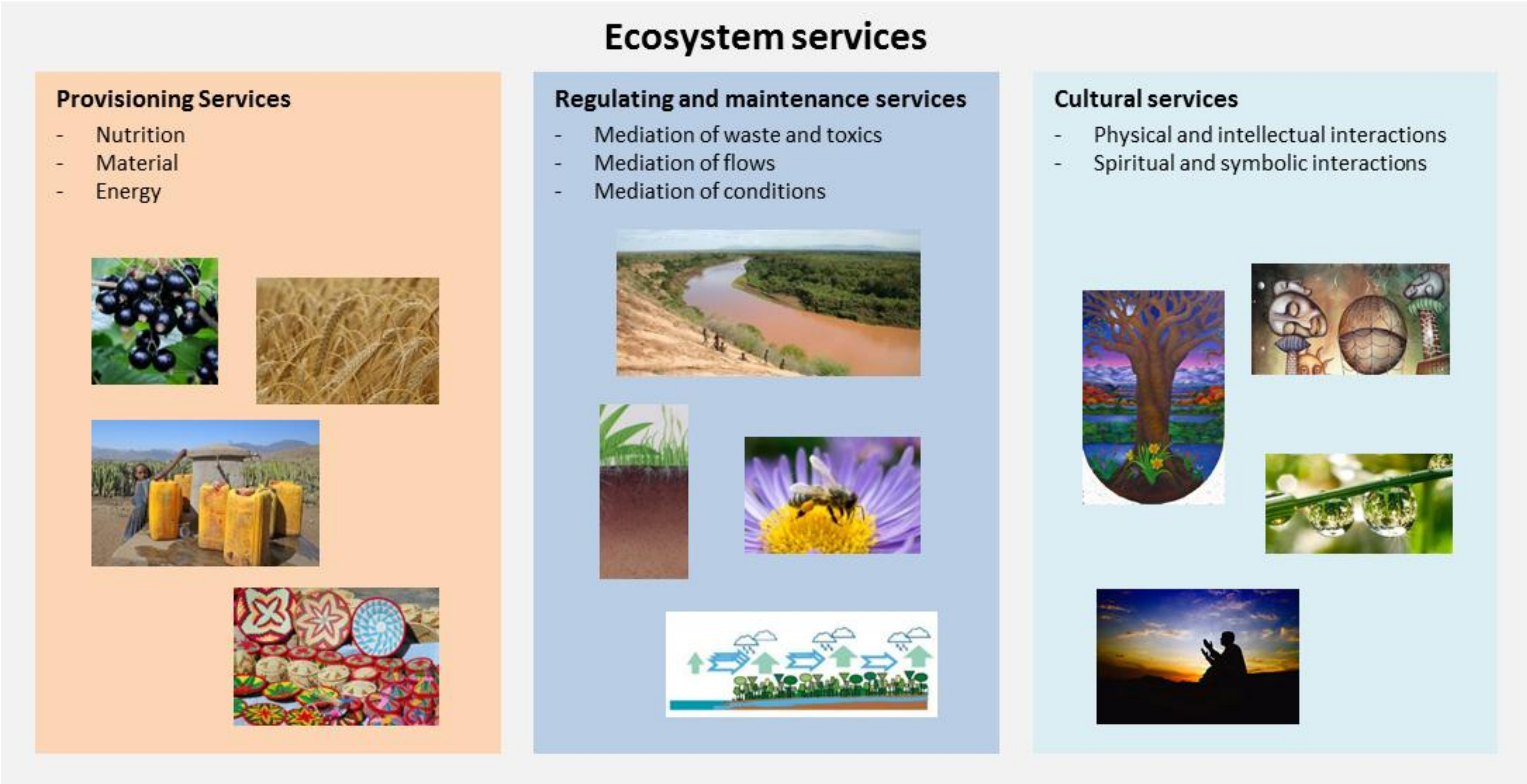


Figure 3.2 Types of ecosystems services with generic examples. Ecosystem services determine the capacity of a landscape to sustain livelihoods and reduce the frequency and impact of disasters. Supporting biodiversity is an important aspect of restoring and strengthen ecosystems services.

Types of ecosystem services

To support the understanding and facilitate the use of the ecosystem services framework, ecosystem services classification systems have been developed. In this study we apply the typology defined by the Common International Classification of Ecosystem Services (CICES) v.4.3 developed in 2013. The CICES-classification considers three overarching types of ecosystem services: provisioning services, regulating and maintenance services, and cultural services (Figure 3.2).

Provisioning services. Provisioning services include all material and biota-dependent energy outputs from ecosystems. Provisioning services are tangible products that can be exchanged or traded, as well as consumed or used directly by people in manufacture. Provisioning services include:

- Nutrition services, which refer to all ecosystem outputs that are used directly or indirectly as food, including potable water. Water provision is considered an ecosystem service because water availability and quality are at least partly steered by ecosystem functioning.
- Material or biotic services, which refer to all resources that are directly used or employed in the manufacture of goods. This ecosystem service includes the provision of water for non-drinking purposes.
- Energy or biomass services, which refer to biotic renewable energy sources and mechanical energy provided by animals.

Regulating and maintenance services. This type of service includes all ways in which ecosystems control or modify biotic or abiotic parameters that define the environment of people, i.e. all aspects of the 'ambient' environment. These are ecosystem outputs that are not consumed but affect the performance of individuals, communities and populations and their activities. Regulating and maintenance services include:

- Mediation of waste, toxics and other nuisances, which refers to all services that ecosystems provide in terms of detoxification or dilution of harmful substances (mostly) brought into the environment by human activities.
- Mediation of flows (air, liquid, solid masses), which covers services such as regulation and maintenance of land and snow masses, flood and storm protection.
- Maintenance of physical, chemical, biological conditions, which includes all processes that ensure sustainable living conditions, including soil formation, climate regulation, pest and disease control, pollination and the nursery functions that habitats have in the support of provisioning services.

Cultural services. Cultural services include all non-material ecosystem outputs that have symbolic, cultural or intellectual significance. Cultural services include:

- Physical and intellectual interactions with biota, ecosystems and landscapes to the benefit of people.
- Spiritual, symbolic and other interactions with biota, ecosystems, and landscapes to the benefit of people.

Biodiversity

Biodiversity refers to the variety of living organisms that live in a particular ecosystem. It includes diversity within and between species and ecosystems, and it is therefore explored at three levels: genetic (variety of genes within a species), species (variety of species) and ecosystem (variety of ecosystems in a given place) diversity. Species diversity could be seen as a very high order regulatory ecosystem service as it helps to protect the diverse gene pool which we think is needed to be able to constantly adjust to changing climatic conditions over long time periods or to major sudden differences in these conditions (European Commission 2013).

Biological diversity also supports the ecosystem functioning. For example:

- the existence of different plant species helps to develop different habitats which are occupied by other species,
- in the food chain, lower order species act as forage for the higher order species
- bacteria play an important role in bio-chemical processes and help to breakdown toxic substances in less harmful products, and
- numerous insect species are responsible for pollination processes that are essential for ecosystems to be able to deliver edible goods.

Protecting biodiversity is an important aspect of ecosystem restoration as it strengthens ecosystems services delivery.

Inventory of ecosystem services

In order to rehabilitate a landscape through ecosystem restoration it is essential to first make up an inventory of all ecosystem services, score and map the contribution of these services, and based upon these assessments prioritize which ecosystem should be protected and recovered first.

On the next two pages the ecosystem services inventory is presented (Table 3.1). The inventory is based upon discussions with experts, surveys among stakeholders, an ecosystem inventory exercise during a workshop and interviews with key-informants.

Table 3.1 Examples of services provided by the different ecosystems contributing to food security, water security and disaster risk reduction

	Dense shrub-forest land	Savannah/ open bushland	Open shrubland	Grassland
Water Security	• Trees promote soil stability and thereby infiltration, and as such improve water availability in the soil after the rainy season • Trees and shurbs minimize soil erosion on site, reduce sediment in water bodies (wetlands, ponds, lakes, streams, rivers) and trap or filter water pollutants in the forest litter • Trees and shrubs contribute significantly to reducing soil erosion and the risk of landslides and avalanches, natural disasters which can disrupt the source and supply of freshwater	• Savannah vegetation plays a significant role in recycling nutrients, in maintaining soil processes and hydrological balance at the top and bottom depth of soil for having 2-3 storey vegetation of 12 grasses, shrubs/bushes and trees.	• Shrubs reduce direct incoming radiation and contribute to the development of a layer of litter. As such, shrubs limit evaporation rates and increase soil water content, which in turn results in a higher water availability to other species.	• In lowlands, which are often flat or gently undulating areas, grass slows down runoff and promotes infiltration • Micro-organisms in grasslands promote bio-remediation, meaning that water quality is improved when running through this ecosystem
Food Security	• Hunted game from the forests provides an important source of proteins • Forest products such as berries, leaves and wild fruits are collected for own consumption and for sale in urban areas • Wood and charcoal serve cooking purposes and are sold in urban areas to make and additional income	• In dry savannnah areas hunting provides high-protein food to rural communities	• Goats and camels are often herded in shrubland areas. These animals can survive in very dry areas, and make most of the limited resources avaiable. In turn, they are highly important for the people living in these areas as they are an important source of milk and meat, which have a high nutritional value • Dry shrubland is also good for keeping bees, and as such contributes to the production of honey • Pollination and seed dispersal are important for plant development, which in turn will be a source of fodder and food	• Grasslands are important grazing areas for camels. Cattle, goats and sheep. Indirectly the ecosystem contributes to the availability of dairy products (milk, butter, yoghurt) and meat, which have a high nutritional value
Disaster Risk Reduction	• Leaves, fruits and seeds form resources to develop natural remedies and medicines • Trees stabilize soils protecting against sheet erosion, gully formation and landslides • Vegetation slows down water, thereby preventing flooding downstream • Trees contribute to global climate regulation through carbon sequestration	• Savannah trees help maintain low salinity levels by taking up water from the deep soil • Roots stabilize the soil preventing wind erosion	• Endemic species are important for pest and disease control	• Grasslands store water and release it slowly preventing flash floods and improving water availability throughout the year • Grasslands recover quickly after the long dry season supporting pastoral communities

Bushed shrub-grassland	Sparsely cultivated land	Artificial and natural water bodies	Seasonally flooded agricultural land
• Vegetation cover, and particularly grass, slows down runoff and improves the infiltration of water, hence augmenting the availability of water after the end of the rainy season	• During the cropping season water runoff is slowed down and water infiltrates fostering soil water content	• During the rainy seaon, ponds and rivers provide water for livestock watering, irrigation and other non-drinking purposes • Ponds allow for water storage, and as such improve water availability after the rainy season for drinking and non-drinking purposes • Dilution of solid waste and waste water streams improves overall water quality	• Seasonally flooded lands hold (non-fossil) groundwater that can be abstracted via simple dug wells and scoop holes • Sediments in seasonally flooded lands filter and clean water improving water quality • Seasonally flooded lands collect precipitation that after infiltration is suitable as a source of safe drinking water • Maintenance of baseflows. Particularly, in flat coarse sediment areas infiltration slows down the water cycle increasing water availability during the dry season • Downstream from urban areas, wetlands and floodplains serve as filters, improving water quality. Wet-vegetation contributes to biochemical detoxification and filtration of sediments. • Sediments adsorb nutrients, minerals and pollutants • Micro-organisms contribute to bio-remediation, and thus water quality improvement
• In the Upper Fafan Catchment, grasslands with dry forest are home to a variety of game. Hence, hunted game is an important additional source of protein	• Production of cultivated crops, which form the main source of food in the project area. • Cereals grown include wheat, rye, barley, sorghum, maize • Proper land use and management practices ensures that soil biogeochemical conditions, such as fertility and soil development, are maintained, and mineralisation and nitrification are ensured	• Ponds can be used for producing freshwater fish	• In seasonally flooded areas, farmers can grow vegetables (onions, tomatoes, peppers) and fruits (mango, papaya), which are important for their high nutritional value
• (Dense) vegetation slows down runoff and promotes infiltration, limiting flooding downstream	• Windbreaks, which are common in agricultural fields, serve as shelter belts and contribute to attenuation of sand storms	• In dry pastoral areas artificial water points, such as embankment dams and sand dams, are crucial for water supply in dry periods	• Wetlands and floodplains are important for water regulation, and thus for flood-prevention • Wetlands and floodplain contribute to microclimate regulation, including temperature, humidity, wind speeds, which are important for crop growth, and to the regulation of air quality and regional precipitation and temperature patterns

Ecosystem functioning: main issues

Ecosystems provide different types of services and contribute to water security, food security and disaster risk reduction in different ways. In order to conserve ecosystems and their goods and services the on-the-ground occurrence of each ecosystem must be known, and its functioning assessed.

During a stakeholder workshop experts and beneficiaries scored the ecosystems of the Upper Fafan Catchment for their capacity to provide ecosystem services. Table 3.2 gives the results of this exercise linked to water security, food security and disaster risk reduction. The maps (figures 3.5 and 3.6) give a geographical overview.

- Sparsely cultivated lands have the lowest overall scoring. Even for food security it scores only a 1 (low contribution). Although these areas provide an important food supply for communities, the contribution to food security is low because the yields are highly dependent on climate conditions. Experts indicate that the productivity of these lands is low and that most regulating and maintenance services have been lost.
- Densely natural vegetated areas score highest. Dense shrub-forest land, savannah/open bushland and bushed shrub-grassland all have an overall medium to high scoring.
- Seasonally flooded agricultural lands have a medium-high scoring. Wetlands, riverbanks and flood plains, are important in regulating water flows, food security and other services. However, these areas currently do not provide optimal services. Experts indicate that the regulating functions of these ecosystems are currently limited because of poor management practices.

More in general, the table and maps indicate that environmental degradation is a problem. Over three quarters of the project area scores low to medium in terms of ecosystem services.

Prioritization

The scoring and mapping clearly indicate which priorities should be considered when planning protection and restoration interventions in the Upper Fafan.

First and foremost action should be taken with regard to the status and functioning of sparsely cultivated lands. Relatively simple soil and water conservation measures, adjustments to production cycles and improved planning practices are the first steps towards restoring ecosystems. Such restoration will increase agricultural productivity and at the same time rehabilitate regulation and maintenance services. Prioritizing these areas is not only crucial because of their low scoring, but also because their areal coverage is large in the Upper Fafan Catchment.

Seasonally flooded agricultural lands should be the second on the priority list. These ecosystems are fundamental to regulating the hydrological system, maintaining good microclimatic conditions and keeping up biodiversity. Protection should feature heavily in the intervention plans. Agriculture in wetlands, on river banks and in floodplains should be regulated and where erosion takes place forbidden. Recovery of these systems is particularly important for disaster risk reduction.

While the above two priorities focus on restoration, the third and last one stresses the importance of prevention. In the table and maps the high-ranking of the more natural systems stands out. At local level, these systems are highly-valued for providing large quantities and diversity of natural products (e.g. game, berries, seeds, fruits, grass, and wood), stabilizing the soils and growing the resources for medicines and remedies. At catchment level, their role in erosion control, production of safe water, flood prevention and climate regulation are stressed. Protection of these ecosystems is essential to ensure that these services remain available for future generations as well.

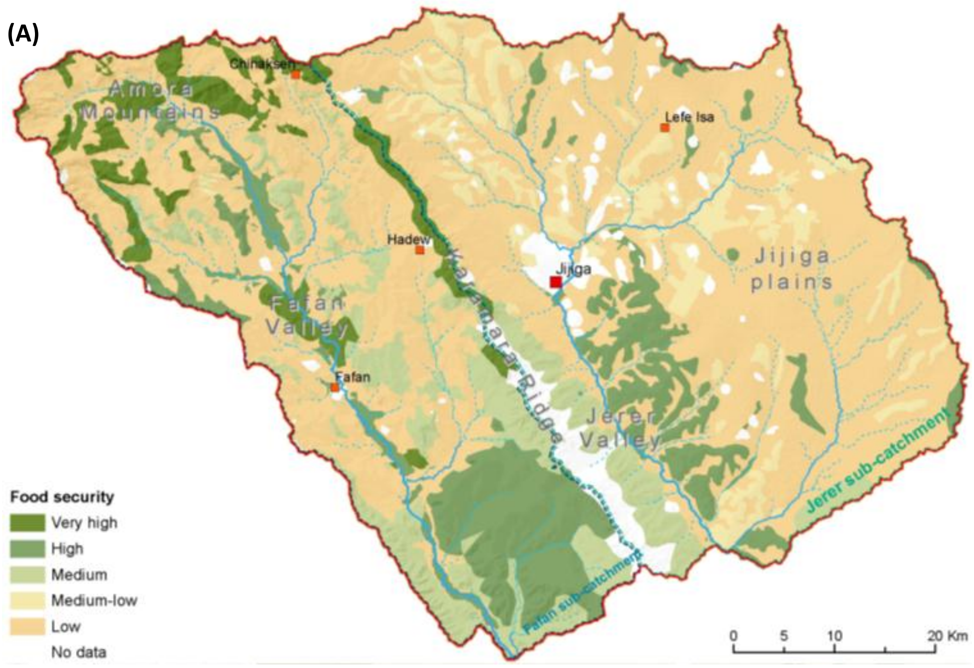
Which interventions to apply where and how best to do this is further detailed in Chapter 5 - Ecosystems restoration.

Figure 3.3 Grazing in the Upper Fafan Catchment: goats browsing for the very last vegetation on the slopes of a gully, thereby intensifying the erosion process.

Figure 3.4 Wood production at the Jijiga Plains: demand for wood in Jijga Town is high, leading to deforestation in the surrounding landscape.

Table 3.2 Scoring of ecosystem services level provided by the ecosystems of the Upper Fafan Catchment. 0 indicates no contribution, 3 indicates a very high contribution. The numbers are based on an assessment in which local experts scored the identified ecosystems for 27 different services.

	Dense shrub-forest land	Savannah/ open bushland	Open shrubland	Grassland	Bushed shrub-grassland	Sparsely cultivated land	Artificial and natural water bodies	Seasonally flooded agricultural land
Water Security	1.9	1.5	1.4	1.1	1.6	0.8	2.4	2.4
Food Security	2.0	1.8	1.8	1.6	1.7	1.0	0.8	1.8
DRR	2.7	1.7	1.6	1.3	1.9	0.7	1.2	1.9
Overall	**2.2**	**1.7**	**1.6**	**1.3**	**1.8**	**0.8**	**1.4**	**2.0**



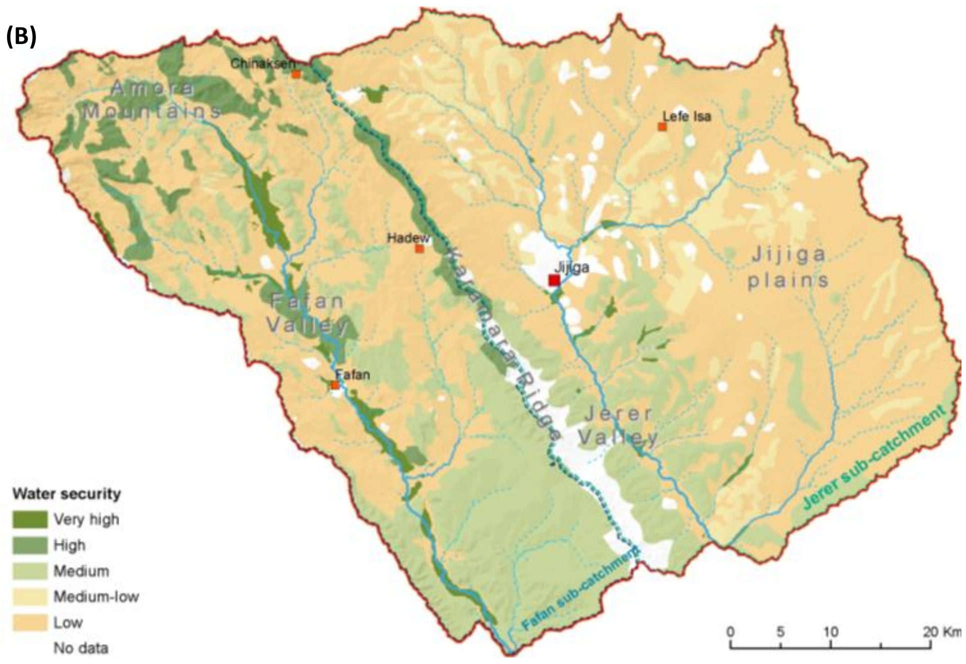


Figure 3.5 Current level of contribution of ecosystems to water security, food security and disaster risk reduction.

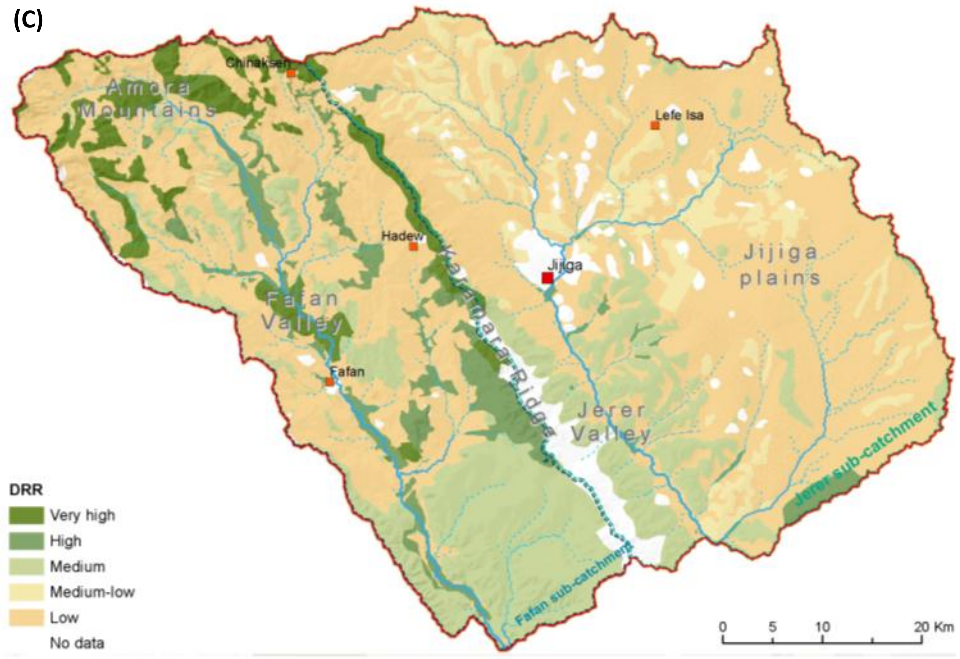


Figure 3.6 Total contribution of ecosystems to water security, food security and disaster risk reduction. The current capacity of the landscape to deliver ecosystem services is low to medium due to environmental degradation. High vulnerability to shocks is a direct consequence.

Land tenure and conflicts over resources

There are some additional challenges contributing to the loss of ecosystem services.

Land tenure issues and scarcity of resources at times result in conflicts. Most natural resources in the project area are common propriety. Clan groups and pastoralists are used to sharing resources, such as grazing lands and water. Resources belong equally to all members of a clan group (Flintan et al., 2011), but in times of drought resources area shared beyond clan boundaries. The borders of grazing zones belonging to the different clan groups are not strict. Sometimes conflicts arise along these boundaries.

Also despite most lands being common property increasingly individuals have begun to enclose pieces of land for their families and livestock. This privatization process has recently led to an increasing number of conflicts between communities (Hagmann, 2006). The private land enclosure issue started recently, elder explain. Now conflicts often arise over grazing lands, and water access, both for domestic use and livestock watering. In addition, private land holders often use their lands for crop production and firewood collection. Lands are then being degraded without elders knowing how to deal with it.

Next to erosion, waste dumps are also contributing to land (and water) degradation. Especially in the areas around Jijijga Town (Figure 3.7), such as Sheik Ali Gure, waste dumping is widespread in the wetlands and streams. After disposal, this waste is transported by flash floods, and pollutes the downstream Jerer River and wetlands. Apart from the visual pollution, the large amounts of debris, plastic and other remains are ideal breeding grounds for a variety of diseases (cholera, malaria, diarrhea), and form a major threat to nearby settlements and water points.

Invasive species

Invasive species are one of the major threats to sustainable livelihoods in the project area. Invasion is being accelerated by land degradation (deforestation, overgrazing and erosion) as many of the species thrive on barren disturbed soils (ERCS 2014). The most problematic invasive species in the project area are

- Lantana camara, which is poisoning to livestock, harbors pest and diseases, augments run-off rates, and out-competes native vegetation and other desirable species,
- Prosopis juliflora, which 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, and blocks the functioning of infrastructure and access to natural resources,
- Opuntia stricta (prickly cactus), which produces spines and thorns blocking access to resources,
- Calotropis procera (Chinese road plant), which monopolizes resources to the detriment of native species, is irritating, in contact with eyes causes temporary blindness, and is poisoning to humans and livestock, and
- Parthenium hystorephorus, which is poisoning, induces hypersensitivity, transmits pest and diseases, and slows-down the growth of other species by means of allelopathy

Various attempts have been done to eradicate invasive species. Training and mobilization of communities in removing invasive species locally has a positive effect, but is insufficient to solve the problem.

Some communities and experts, however, indicate that the invasion could also has some positive sides. Some plants can be eaten by livestock and form a reserve for droughts. Others can be used as bio-fuel or processed into medicines, food or soil fertilizer. Exploring and supporting these and other potential uses controls their proliferation and provides additional income to local livelihoods. Most promising are those applications that are simple and can at first be implemented at community level, such bioenergy (fuelwood) and soil structure improvement (fertilization, mulching).

Opportunities for conservation

The scoring and mapping of ecosystem value and functioning indicate a number of high-value ecosystems which are under pressure, such as wetlands and forests. These areas should have priority when considering conservation. Fortunately there is a range of institutional and socio-economic opportunities that enable sustainable conservation. Figure 3.8 provides an overview of high-value ecosystems.

Institutional setting

The history of nature conservation in Ethiopia began in 1909, when Emperor Menelik II declared a law that prohibited the killing of wildlife (Tadesse, 1992). Laws and legal frameworks that pertain to conservation and maintenance of protected area have slowly evolved (ÖBF, 2009). Considerate of the importance of biodiversity strong and enabling laws and legislation have been implemented (Yirmed Demeke, 2009). In regard of the project area, the following national legislations currently apply

- Regulations for wildlife conservation (Legal Notice No. 416 of 1972 and No. 445 of 1974)
- Proclamation No. 192 of 1980 for Forest and wildlife conservation and development
- Proclamation No.94 of 1994 to provide for the conservation, development and utilization of forests
- Wildlife development, conservation and utilization (Proclamation No. 541/2007)
- Wildlife development, conservation and utilization (Proclamation No. 163/2008)
- Ethiopian wildlife conservation authority establishment (Proclamation No.575/2008)

These legislative boundaries are a great start to nature and wildlife conservation. Enforcement in rural remote Somali Region, however, is challenging. As both experts and community elders indicate that the ecology of the area is fragile, capacity building and awareness raising will be fundamental to the protection of the most valuable ecosystems.

Wildlife and ecotourism

The project area is appreciated for hosting large numbers of wildlife. Species of interest include the black manned lion, leopard, bushbuck, Anubis baboon, Hamadryas Baboon, Salt's dik dik, Abyssinian Hare, Common Jakal and Egptian Mangoose. But also more common wildlife, such as monkeys, warthog, leopards, bushbucks, spotted hyenas, foxes, aardvarks, gazelles and many species of birds thrive. Wildlife is especially rich in grasslands, riparian woodlands and seasonal wetlands, including reserves and protected areas.

But wildlife is also under threat. Particularly during the drier periods, grazing lands and water are becoming scarce. Competition over resources is increasing.

Besides expansion of reserves and sanctuaries and enforcement of policies and regulations, also ecotourism could prove an option for protecting wildlife. If wildlife would provide additional income to local communities, through the organization of controlled hunting activities or guided tours for example, this would be a great incentive to counteract poaching and ecosystem degradation.

Figure 3.7 Waste dump close to Jijiga: waste dumps are a serious threat to human health and natural resources.

Hamadryas baboons

Warthogs

Tortoise

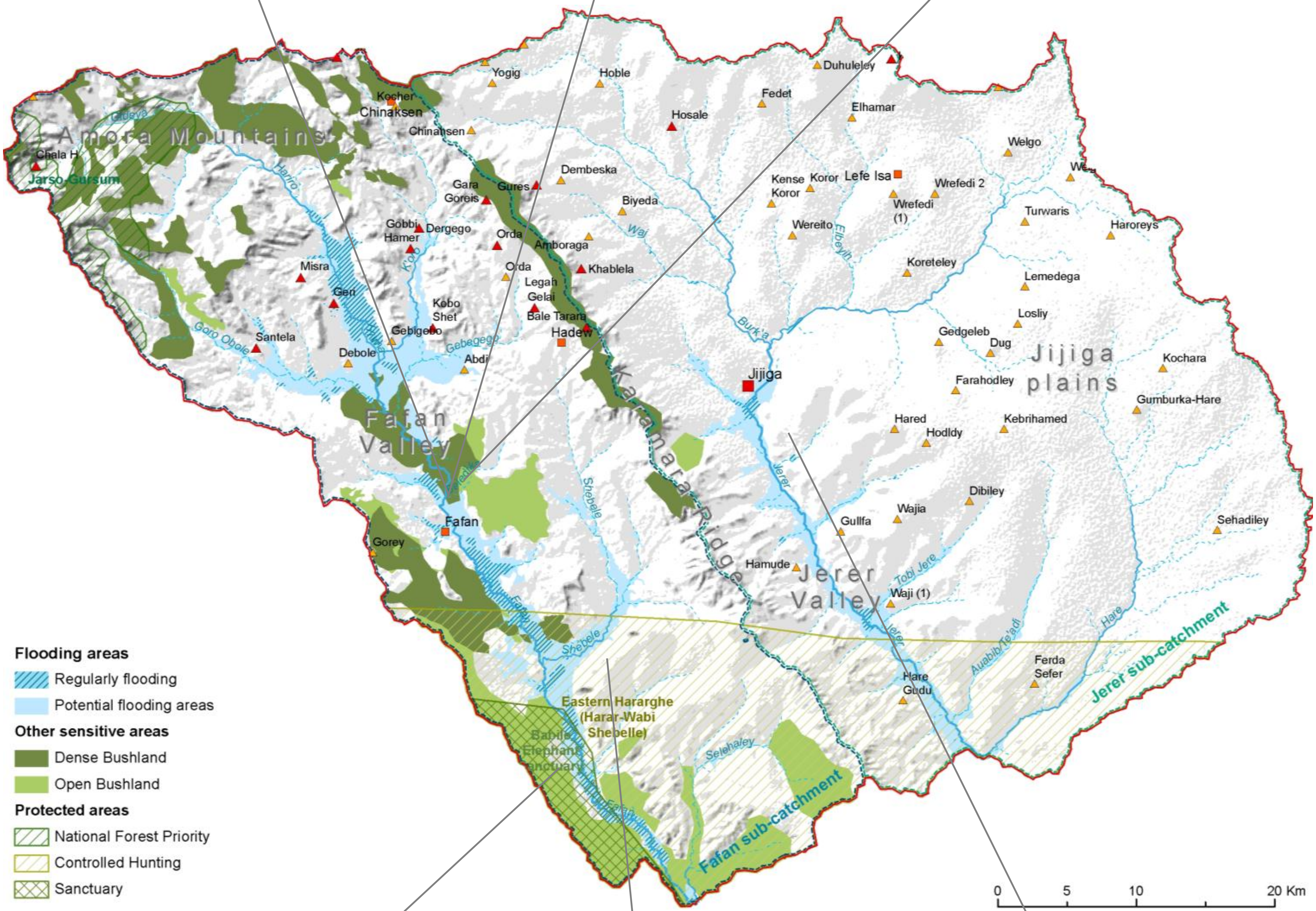


Figure 3.8 High-value ecosystems map with examples of interesting wildlife species. These areas should be prioritized for conservation. Fortunately there is a range of institutional and socio-eocomic opportunities to enable sustainable conservation.

Elephants

Common Jakal

Spotted hyenas

4

WATER RESOURCES

Water is often said to be life, especially in arid regions.

In this chapter:

- The existing water infrastructure is mapped
- Major water quality issues are listed and explained
- The hydrological functioning of the catchments explained
- The groundwater potential is mapped

Together the maps and descriptions give an insight in the opportunities to develop water sources for domestic, agricultural and livestock purposes.

Access to water

Limited reliable data is available on water demand and supply in the project area. The data depicted in Figure 4.1 was retrieved from the National WASH Inventory. Though it might not be complete, it provides a good first insight in the distribution of water sources. To complete the visualization, proposed water development sites to be implemented by ERCS within SCRSE are included.

There are no permanent natural surface water sources in the project area. Communities mainly use water from shallow wells and scoop holes in dry river beds, birkads, boreholes and balleys (traditional community ponds in natural depressions) (Box 4.1 and Figure 4.2). In the Jijiga Plains birkads and balleys predominate. In and nearby Fafan River hand dug wells, at times equipped with pumps, are common. Point sources connected to piped water schemes are only present on the western side of Fafan Valley.

In general, women and children are responsible for fetching water. Water access, also in comparison with national averages, is poor. Few sources are available, and many are non-functional. During the wet season most communities can collect water from nearby balleys, birkads and shallow wells. During the dry season trips up to six hours have to be undertaken to collect water because water levels drop (Box 3.1) (ERCS 2014). According to the ECRS (2014), water tables are receding deeper, and springs and wells are discharging smaller amounts of water or completely drying up. Five sand dams have been built in Gursum Woreda to prolong the productivity of shallow wells.

Water is mostly used for domestic purposes and watering livestock. Only in communities nearby the floodplains of Fafan River and up in the Amora Mountains some water is used for irrigation purposes.

Water quality

Water quality is a major problem (Figure 4.3). Boreholes provide safe water, but there are few and often communities have to pay to use them. Water quality in the river beds declines during the dry season. As the water level lowers in the bed, less and less water is available, and the taste and smell deteriorate. In turn, water from ponds is very susceptible to contamination, especially because of livestock entering the facilities. Further, birkads in the project area are mostly uncovered, without a silt trap, filtration or any other water treatment mechanism, which results in high degrees of contamination and loss of water through evaporation.

Low water quality has multiple and severe impacts on livelihoods. The time spent on fetching water is high, water-borne and water related diseases such as diarrhoea and malaria are prevalent, and the recurrence of losses of crops and livestock is high.

Infrastructure

Field observation and focus group discussions indicate that a large number of water structures are non-functional, often broken-down due to poor maintenance. Siltation and eutrophication are the most visible challenges. These are often forebears of worse. Many sources are contaminated with human and animal faeces, and thereby probably loaded with large numbers of life-threatening pathogens. To improve the sustainability of water infrastructure it is recommended to pay more attention to participatory planning, design and construction, and consider protection and maintenance from the very start of programs and projects onwards.

Toward a more robust water supply

There is a need to further develop and promote low cost water technology such as shallow wells, sand and subsurface dams, solar and hand pumps, but the functionality, safety and accessibility of the water sources should receive as much attention.

Field observations indicate that many interventions fail. A possible reason for this may lie in the fact that managers sometimes jump to implementation without proper (integrated) assessments, preparatory activities and without considering sufficient integration of socio-institutional and biophysical worlds, operation and maintenance, and local conditions.

Based on these impressions, it is recommended to

- improve the protection of sources through a combination of improved hardware and soft measures (regulations, by-laws),
- pay more attention to siting, and
- hire technical expertise so that the sustainability of structures is increased.

Box 4.1 Hamakil pond

During the field trip the water pond at Hamakil Village was visited. At the time of visiting ladies were fetching water for drinking and cooking. The ladies told the delegation that the pond had been recently rehabilitated by the community. When full the pond is approximately 1 meter deep. During the dry season the pond dries up, and the community starts collecting water from nearby birkads. Birkads are subsurface cisterns where water from rock catchments is collected. After emptying the birkads, the only source of water is a borehole further away- a round trip takes three hours. The ladies acknowledge that they use the water for all domestic purposes; no treatment is applied. Water shortages are one of the major challenges faced by their community.

A major issue with these open facilities is water quality. The ponds are open and unprotected. Livestock enters the ponds for drinking, while the community does not apply any treatment before consuming the collected water. There are few alternatives, however. Water-borne and water related diseases are common. From interviews it became clear that community members' awareness and understanding of water safety is very limited.

To alleviate the community's conditions Ethiopian Red Cross Society aims to construct a number of birkads and extend community ponds. In view of these plans, it is recommended to include water treatments faclities in the design, such as infiltration galleries, and sensitize communities about water quality and protection of water sources.

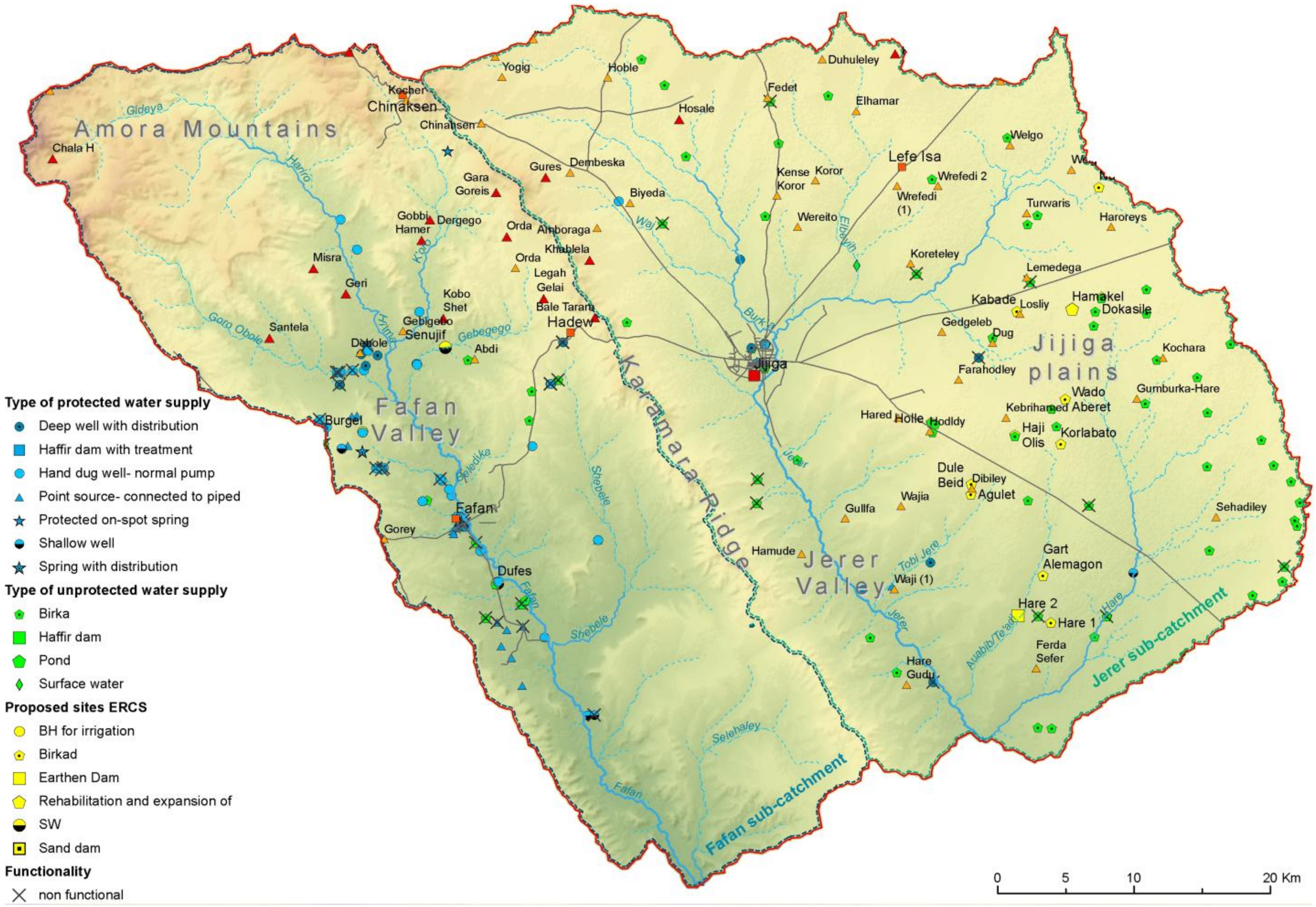


Figure 4.1 Water sources in the project area. In the Jijiga Plains, ponds and birkads are the main sources of water. These sources are often unable to provide a reliable water supply in both quantity and quality. Along Fafan River a combination of piped water schemes and shallow wells provides water to the rural communities. Many of the improved water sources are non-functional.

Figure 4.2 Different types of water sources present in the project area. From left to right: birkad, scoop hole and lined shallow well.

Figure 4.3 Polluted water sources. From left to right: birkad loaded with sediments and covered with duckweed, mud-pool around a shallow well, and surface water visibly contaminated with garbage

Figure 4.4 Surface water bodies, flooding areas and Hydro-ID used for rainfall-runoff calculations. For both Fafan and Jerer Rivers applies that floodplains and wetlands play an essential role in regulating flows and supplying groundwater for agriculture and domestic use.

Jerer and Fafan sub-catchments

Fafan and Jerer are seasonal streams (Figure 4.4). Jerer Sub-catchment is characterized by a clayey river bed, wide streambeds and floods during periods of heavy rainfall. It is threatened by gully erosion. Fafan River, on the contrary, is underlain by shallow basement formations and steep slopes in the upper catchment. More downstream the river runs through a thick 100 meters-wide layer of sandy sediment (Figure 4.5). For both rivers applies that floodplains and wetlands play an essential role in regulating flows and supplying (shallow) groundwater for agriculture and domestic use.

Rainfall-runoff model

A GIS based rainfall-runoff model was developed to provide an indication of the runoff at catchment level and river discharges.

Runoff characteristics depend on a combination of physical, climatological and hydrological conditions. The empirical Curve Number (CN) method was used to determine runoff. For each separate catchment the CN was determined using classifications for hydrological soil characteristics, slope and land cover, from which the total sub-catchment CN was derived.

Daily runoff was calculated in equivalent water depth (mm) and in million cubic meter (Mm^3) for each sub-catchment for the period 1983-2014. Table 4.1 provides a summary of the results for an average, a dry and a wet year. No gauging data is available. Results were, therefore, not calibrated and are only indicative.

Both Fafan and Jerer catchments have an average runoff of 90 Mm^3. Fafan River has a higher rainfall-runoff ratio than Jerer River. Although the steepest slopes are concentrated in the Amora Mountains, the highest runoff percentages occur in the downstream areas of Fafan Catchment. These high runoff rates are clearly linked to the limited vegetation cover.

One percent of the combined average runoff of the upper Fafan and Jerer catchments, could already fulfil the water demand of Jijiga Town. These huge volumes indicate that water access is rather a problem of seasonality and lack of infrastructure, than insufficient rainfall. Increased water storage could easily improve water availability during the dry seasons, and even provide water for irrigation.

The current model provides a first insight in the water balance of the catchment. When further improved and calibrated, the model could be used for testing of impact of changes in the catchment, including interventions such as water storage interventions, soil and water conservation, land use change (deforestation, increasing agriculture in wetlands etc.), and effects of climate change. In addition, it can be used as tool for water allocation.

Figure 4.5 Streams upstream, Fafan (1) and Jerer (2), and downstream, Fafan (3) and Jerer (4).

Table 4.1 Summarised results of the rainfall-runoff calculations per hydrological unit. ID=Hydro-ID (see Figure 4.4), CN=Curve Number, P = Precipitation, RO=Runoff, Mm^3=Million cubic meter. One percent of the combined average yearly runoff of the upper Fafan and Jerer catchments could already fulfil the water demand of Jijiga Town. Increased water storage could easily improve water availability during the dry seasons, and even provide water for irrigation.

Catchment			Yearly average				Dry year (90%		Wet year (10%	
ID	Area km^2	CN	P (mm)	RO (mm)	RO (%)	RO Mm^3	P (mm)	RO Mm^3	P (mm)	RO Mm^3
103	28	79	603	42	7%	1.1	371	0.2	748	3.1
104	134	86	590	80	14%	10.8	364	3.7	768	21.3
105	62	89	583	102	17%	6.3	361	2.8	764	11.7
106	127	87	554	76	14%	9.7	344	3.6	745	20.4
107	14	89	529	96	18%	1.3	340	0.5	750	2.7
110	27	77	614	41	7%	1.1	376	0.2	766	2.3
111	99	78	659	48	7%	4.7	420	0.6	888	10.9
112	185	77	664	43	7%	8.0	426	0.6	909	16.5
113	86	76	645	36	6%	3.1	382	0.4	825	7.5
120	61	73	617	25	4%	1.5	372	0.2	763	4.0
121	76	74	594	32	5%	2.4	352	0.3	774	5.5
122	235	74	622	25	4%	5.8	386	0.5	848	16.0
123	161	76	643	32	5%	5.2	405	0.4	853	13.2
125	52	78	589	42	7%	2.2	345	0.5	756	4.8
130	65	77	624	37	6%	2.4	377	0.3	793	5.1
140	58	78	573	38	7%	2.2	352	0.4	745	5.2
150	71	77	567	35	6%	2.5	350	0.4	770	5.9
160	28	78	553	36	7%	1.0	345	0.1	764	2.5
161	66	76	564	41	7%	2.7	334	0.2	782	6.1
170	474	76	565	36	6%	17.0	337	0.9	771	42.9
Jerer total	**2110**	**78**	**601**	**43**	**7%**	**91.1**	**322**	**27.0**	**700**	**115.1**
203	9	77	633	39	6%	0.3	414	0.0	802	1.0
204	243	83	634	65	10%	15.9	400	3.0	818	35.3
205	188	84	568	60	11%	11.3	352	3.4	742	24.0
210	345	81	661	43	7%	14.9	442	2.2	824	36.3
220	141	80	660	48	7%	6.8	426	1.0	851	13.6
230	182	81	633	52	8%	9.4	411	1.6	809	18.5
240	103	80	645	52	8%	5.3	392	1.0	826	13.0
250	226	86	626	84	13%	18.9	385	4.9	835	38.9
260	163	83	543	59	11%	9.7	326	2.7	746	19.9
Fafen total	**1599**	**82**	**624**	**58**	**9%**	**92.6**	**404**	**27.5**	**801**	**175.7**

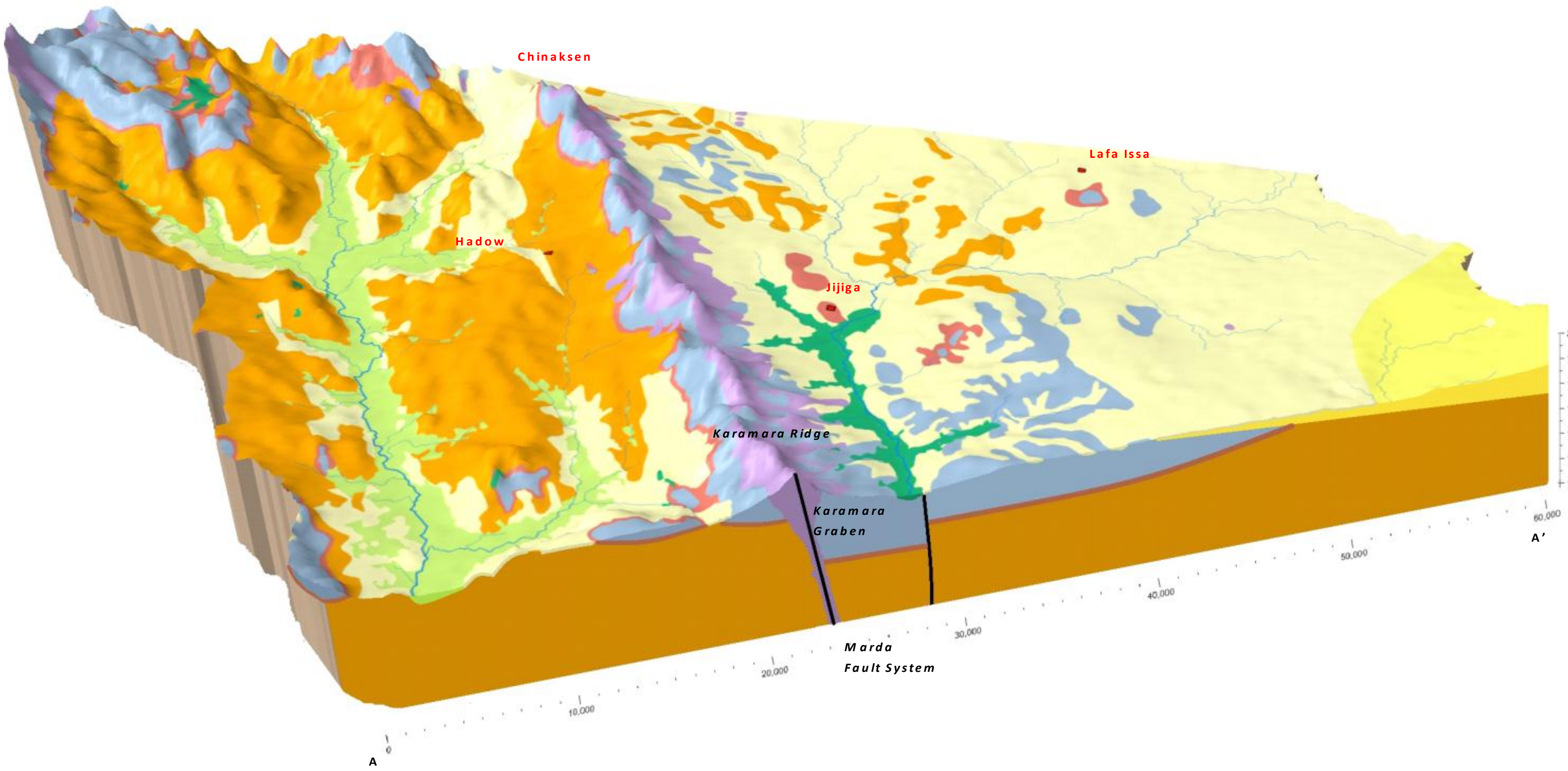


Figure 4.6 Three dimensional cross-section of the simplified geological map in the project area.

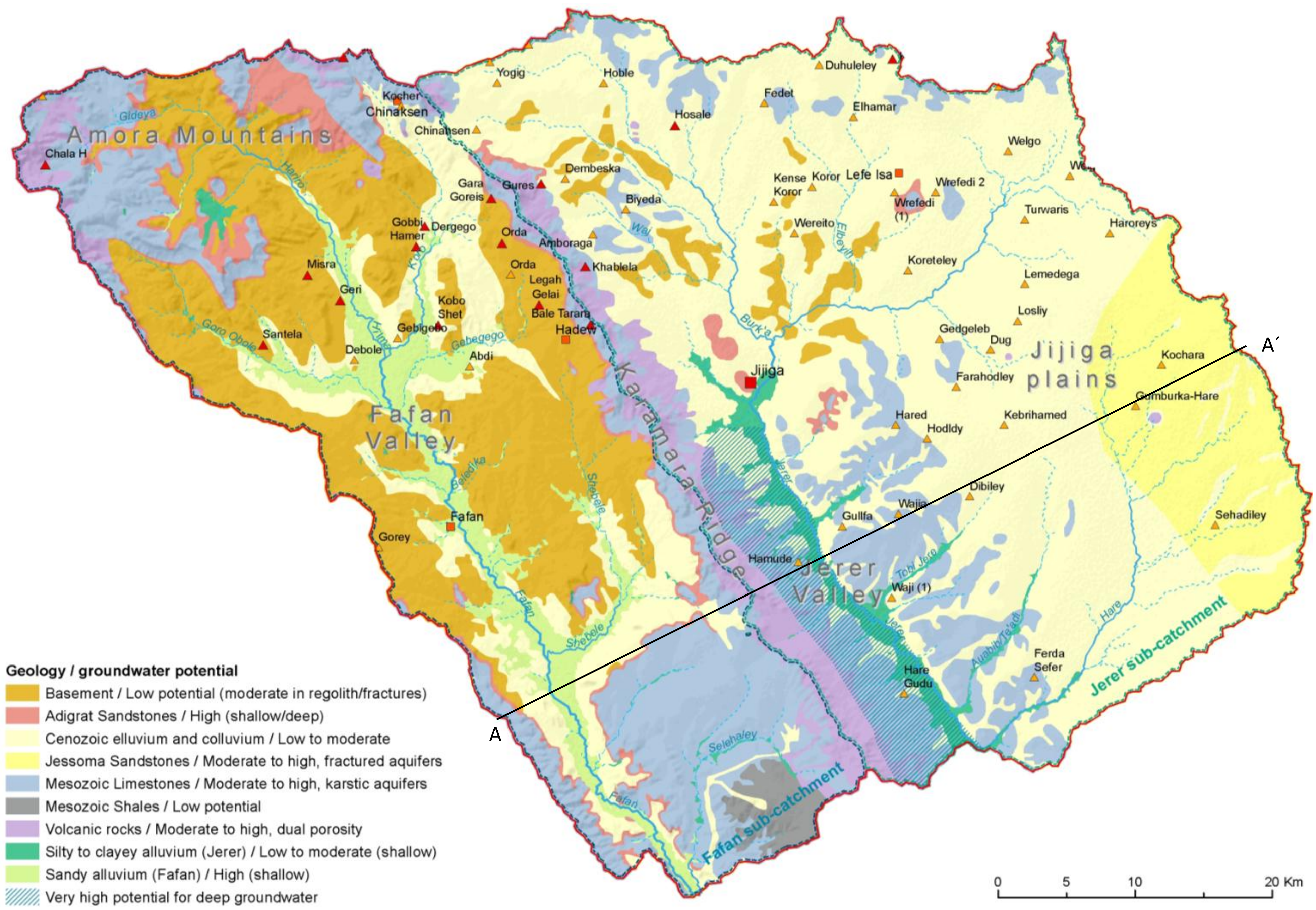


Figure 4.7 Simplified geology and groundwater potential. The sandy alluvium in Fafan Valley has a high potential for shallow groundwater and can be exploited using shallow wells. The Marda Fault System, a major structural trend east of the Karamara Ridge, comes with a very high deep groundwater potential.

Geology and groundwater potential

The distribution, movement and quality of groundwater in the soil and rocks is strongly linked to landscape's geological characterization. Groundwater follows pressure gradients often through fractures and conduits. Water quality is the result of the chemical, physical, biological and, at times, anthropogenic interactions between water, soil, rocks and vegetation.

Shallow groundwater can be found near-surface, mainly in alluvial aquifers, reaching to a depth of 25-50 m. Deep groundwater can be found in sandstone and karsted (fractured limestones) aquifers, and in conductive fractures in otherwise impervious rocks. See figures 4.6 and 4.7.

Basement is a metamorphic rock that underlays sedimentary formations. Exposed basement rock is generally impervious resulting in a very low groundwater potential.

Adigrat Sandstones are found in the most north-western corner of the project area and at the lower parts of hills and cliffs in the southern part of the Fafan valley. In the upper part of Fafan valley, the Adigrat Formation has a thickness of 20 m. A larger thickness might be found where the Adrigrat sandstones have filled ancient river channels (paleochannels). From oil exploration drilling in Ogaden, the expected average thickness of the Adigrat sandstones is 200 m (RTI, 2013).

The potential of the aquifer is highest in areas with high precipitation, and where the formation is fractured.

Mesozoic Limestones and Mesozoic Shales. Mesozoic limestones in the project area consist mainly of the Hamanlei Formation (also known as 'lower limestones') and the Gabredare Formation (the 'upper limestones'). The Hamanlei Formation close to Jijiga consists of well-bedded limestones, intercalated with thin marl beds and a maximum thickness of 250 m. The Gabredare Formation is made up of marly and gypsiferous limestones. The Mesozoic (gypsum-bearing) shales of the Uarandab Formation were deposited in-between the Hamanlei and Gabredare Formations. These shales are mainly found in the southern parts of the project area.

At the Marda fault zone the Hamanlei Formation most likely has a medium to high groundwater potential. Through karstification, which is the dissolution of soluble rocks, fractured areas develop a high secondary porosity and, thereby, good aquifer characteristics. The Uarandab Formation is impervious.

Cenozoic elluvium and colluvium, and Jessoma Sandstones. Loose Cenozoic sediments and Jessoma sandstones overly the Mesozoic limestones and shales. Jessoma sandstones tend to weather deeply forming a layer of unconsolidated sediments.

Jessoma Sandstones may contain groundwater of good quality, but low recharge rates and the inexistence of an underlying aquiclude result in a low groundwater potential.

Sandy alluvium (Fafan) & Silty to clayey alluvium (Jerer). Fafan Valley is filled with sandy Quaternary sediments. This sandy elluvium is formed by erosion of the quartz-rich basement rocks situated in the upper parts of Fafan Catchment. Jerer Valley, meanwhile, is made up of silty and clayey material originating from the limestones. Along hills and cliffs colluvial deposits are found, which are heterogeneous sediments ranging from silt to rock fragments of variable size. The composition mainly depends on the geology of the source material.

Alluvial aquifers are found along the Jerer and Fafan rivers. These aquifers are mainly recharged during periods of high river discharge, but in areas with many fractures, water may also originate from deeper aquifers. The sandy alluvium in Fafan Valley has a high potential for shallow groundwater and can be exploited using shallow wells. According to interviewees, there is already a number of high yielding boreholes tapping water from the alluvium in this area. High potential alluvial aquifers cover a surface of 460 km². With an assumed average thickness of 5 m and a porosity of 10%, these aquifers have a water storage capacity of 230 million m^3.

The groundwater potential in the alluvium in Jerer Valley is lower, because of the lower permeability of silts and clays.

Volcanic rocks. Volcanic rocks can form aquifers or impervious layers, depending on the composition and fracturing. The basalts capping Kamarar Ridge have a low aquifer potential, given their position at the top of the range.

Marda fault system and Karamara Graben

The volcanic system along Karamara Ridge reveals a major structural trend- the Marda Fault System - that comes with a very high groundwater potential. Purcell (1976) described the system as a complex of NW-SE trending faults. Most probably the fault zone extends beyond Karamara Ridge to the Belet Uen area in Somalia. Numerous linear faults have been identified.

In 2013, RTI identified a graben structure in the southern part of Jerer Valley, as a part of the Marda Fault system. The graben is situated between the Karamara Range and the Jerer river, south of Jijiga. The Karamara graben structure comprises permeable karstified limestones and Adigrat sandstones. The East Karamara Graben Aquifer is considered a structural trap, making it a high potential target for aquifer exploration.

The Marda fault system is represented by N45° to N60° and N130° to 160° structural directions. Fractures with a N45° to N60° orientations are more likely to be conductive fractures, due to the shear motion of the Marda fault system. Fractures that convey groundwater to the surface can be drilled with shallow wells and can be considered as targets for groundwater exploitation.

In addition to shallow groundwater, fractures may also have potential for deep groundwater exploitation. In order to identify where to drill deep wells trying to, for example, strike the high yielding fractures in the Hamanlei limestones and Adigrat Sandstones along the Jerer Valley, it is vital that a groundwater assessment, consisting of aerial photo interpretation, combined with geophysical research is conducted.

Groundwater recharge

Without an extensive measurement campaign, analysis of borehole data and development of specific groundwater models activities it is difficult to determine exact groundwater recharge. Experience with similar landscapes from other arid and semi-arid lands provide some indications.

Given that most of Fafan Valley is characterized by basement rocks, groundwater recharge will probably be in the range of a few dozens of mm/year, which could sustainably support a limited number of 1 to 2 m3/hour-boreholes for small settlements in rural areas.

Further southwards, groundwater recharge in karstified limestones could equal 100 to 150 mm/day, which would be sufficient for supporting highly productive boreholes.

Close to Fafan River, where sandy alluvium predominates, shallow groundwater concentrates due to high transmissivity and the valley's topography. It is well possible that abstractions of up to 10 m3/hour are possible in these areas.

In the Jijiga Plains groundwater recharge is probably severely limited by the high clay content of the Cenozoic elluvium and colluvium. Experts expect recharge rates of a few dozens of mm/year. The large area and slight inclination of the plateau could, however, result in large amounts of groundwater being available at specific spots.

All numbers are indicative. Before investing in groundwater abstraction infrastructure additional in-depth studies are needed.

Figure 4.8 Borehole drilling in Ethiopia (www.dando.co.uk, 2016).

5

ECOSYSTEM RESTORATION

Ecosystem restoration provides a major opportunity to build resilience. Ecosystem restoration interventions improve water availability, crop production and the condition of pastures on the short term, and ensure the maintenance and recovery of ecosystem services in the long term.

The effectiveness of ecosystem restoration interventions is strongly dependent on landscape characteristics. Selection, siting and design of these interventions is not straightforward. In this chapter, the functioning and benefits of ecosystem restoration are clarified, the suitability for implementing different types of measures is mapped, and implementation is discussed.

Rationale behind ecosystem restoration

Strengthening of ecosystem services in the Upper Fafan Catchment is essential to build resilience to disasters. Water security, food security and disaster risk reduction are highly dependent on the functioning of the landscape. By restoring ecosystem services that have been lost to environmental degradation and making more efficient and sustainable use of existing ecosystem services, this vital biophysical functioning of the landscape can be recovered. As such, restoration and strengthening of ecosystem services results in immediate and direct benefits, such as improved fodder availability increased water availability, but also ensures that in the long-term and in times of extreme climatic conditions water and food security are improved, and the frequency and intensity of disasters is reduced.

Four main categories of ecosystem restoration interventions can be distinguished based on their functioning, location in the landscape and main purpose (Figure 5.1 and Table 5.1)

- **Protection and management** refers to the active protection of ecologically sensitive and valuable areas, so that these can recover and achieve their full-potential in terms of ecosystem system services provided. Experience shows that control or even exclusion of agricultural activities, grazing of livestock, and collection of natural products from degraded areas stimulates the germination of seeds, promotes seedling survival and allows vegetation to grow faster. These developments can be supported by implementing erosion control structures, planting trees and disposing urban waste(water) in a safe manner. Protection and restoration are best implemented by communities, as implementation and enforcement are to a large extent dependent on communal efforts. Examples of interventions include riverbank protection, area closures and forest management.
- **Soil and water conservation (SWC)** targets the conservation of soil, water and related natural resources on agricultural land—the land used to produce food, forage, fiber and other products. Soil and water conservation 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, farming practices, or physical structures, which often also counteract erosion. Similarly, soil conservation usually involves improving soil properties, reducing erosion, crust formation or breakdown of soil structure, all of which also increase infiltration, and hence contribute to water conservation. Examples of SWC-techniques include mulching, contour bunds and trenches and permanent crops.
- **Off-stream water storage** includes many typical water recharge, retention and reuse interventions. Off-stream water storage includes all on-land interventions that collect water from surface run-off for storage in either open or closed reservoirs or in the ground. Rock catchments, birkads and ponds are examples of off-stream water storage interventions.
- **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 water recharge, retention and reuse 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 improved, so that it is relatively safe for domestic use. Examples of in-stream water interventions include sand and subsurface dams, and micro and valley dams.

Each category of interventions 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 category, and even per specific intervention. For example, where small tanks store small volumes to bridge for example a short dry period, large surface storage and particularly groundwater storage can help to bridge an unusual dry year or a series thereof.

Landscape characteristics dictate which ecosystem restoration interventions are most suitable for a certain location. Contour bunds and terraces, for example, can be best applied on cultivated slopes, whereas sand dams can best be applied in areas where sandy seasonal streams with shallow hard rock are available.

Figure 5.1 Examples of ecosystem restoration interventions. All pictures taken by Acacia Water in the project area. Strengthening ecosystem services is essential towards building resilience. Landscape characteristics dictate which ecosystem restoration interventions are most suitable for a certain location.

Table 5.1 Categories of ecosystem restoration with a specification into types of interventions belonging to each category.

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		

Opportunities for ecosystem restoration

The map with the suitability zones shows the ecosystem restoration opportunities in the Upper Fafan Catchment based on land use, slope, soil, geologic and hydrologic characteristics of the landscape. The map shows suitability zones with recommended interventions in terms of protection and management, soil and water conservation, off-stream water storage and in-stream water storage.

Note that this map shows should be used for indicative purposes only. Additional studies are always required for site selection, design and construction of interventions when moving towards implementation.

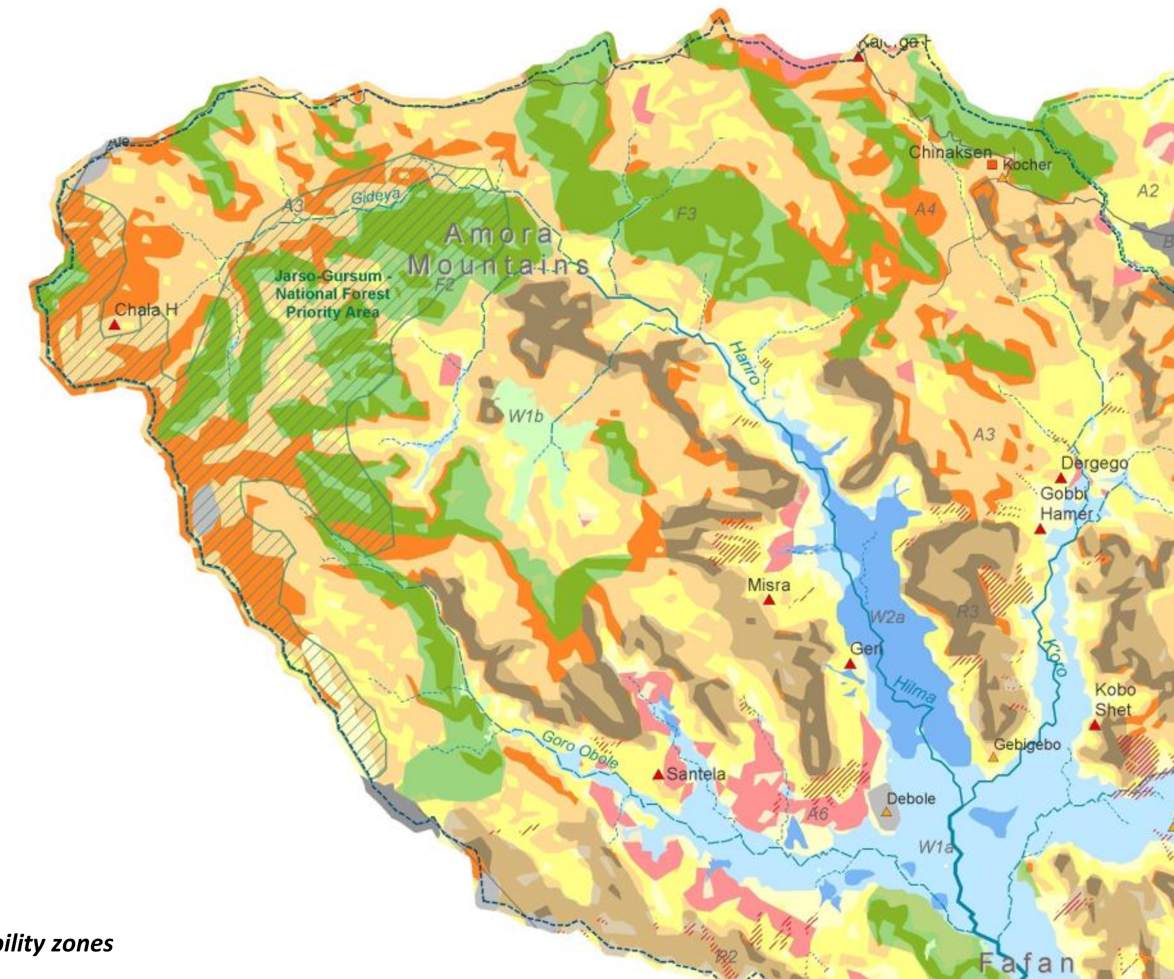


Table 5.2 Interventions recommended in the different ecosystem restoration suitability zones

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 erosion	Hafirs, ponds, micro dams, birkads	
A6		Slope > 3%, Weak Soils	Discourage agriculture, forest management	SWC for weak soils and slopes, permanent agriculture	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 (Fafan)	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

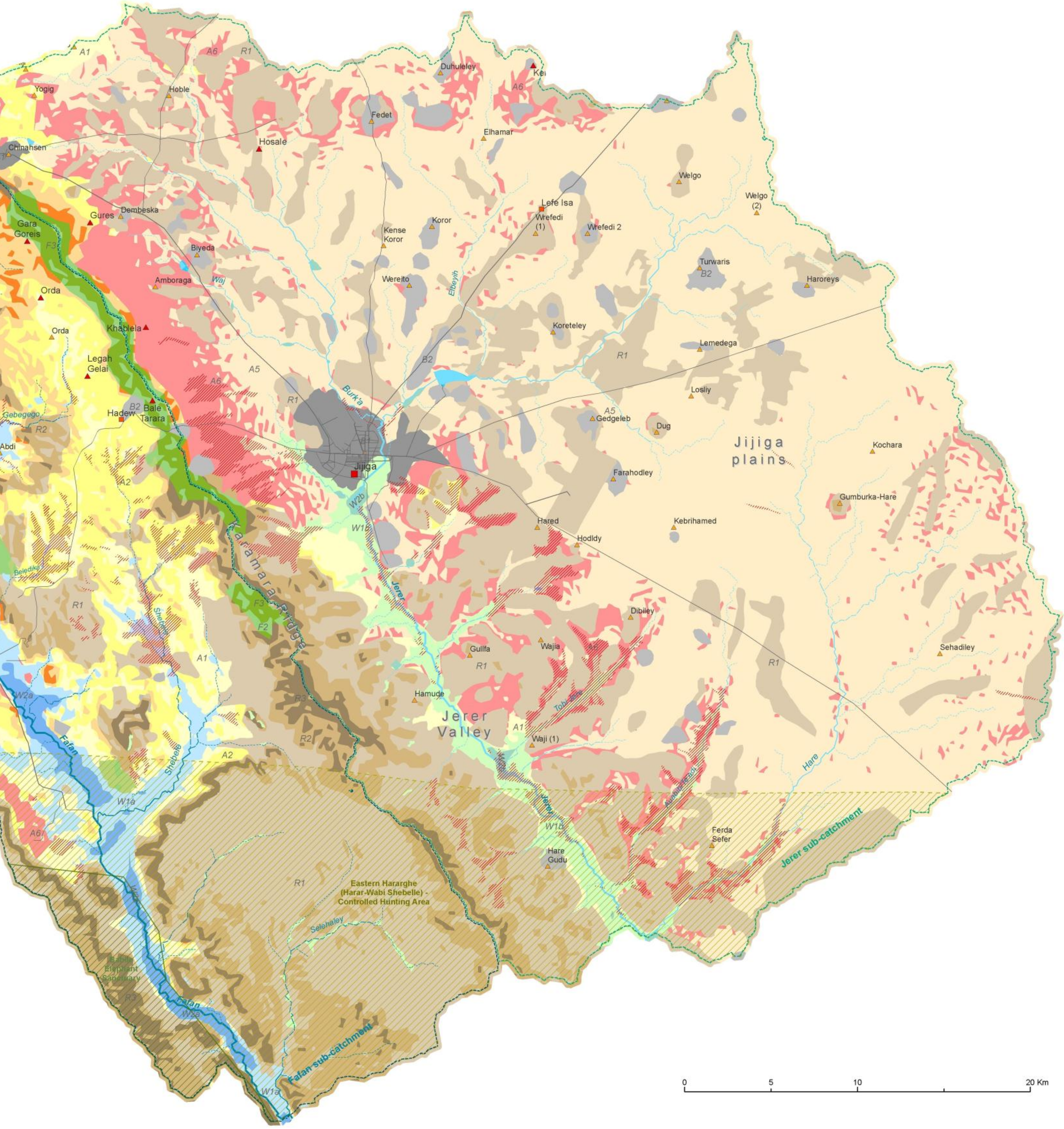


Figure 5.2 Map indicating suitability zones for ecosystem restoration, which provides input to the development of Integrated Water Resources Management plans. Planning and implementation should be done through a stakeholder participatory process where knowledge of the biophysical system is combined with socio-economic aspects and stakeholder needs and capacity. Priority should be given to 'soft' measures, such as regulation, awareness raising, training and facilitation of management processes. Hard measures can complement the efforts, but only when implemented by users based on self-motivation.

Intervention strategy per landscape

The suitability for ecosystem restoration interventions is determined by landscape characteristics.

The Jijiga Plains are characterized by very gentle slopes, weak soils and rain fed agriculture. As such, proposed interventions focus on sustainable land use and erosion prevention. The clayey soils are erosion prone and limit the opportunities for shallow groundwater storage.

In the Amora Mountains slopes are steep and soils are deep and fertile. Agricultural and forest management practices are relatively well-adapted to the local conditions. It is recommended to support ongoing practices (terracing, contour bunds and agroforestry, for example) and consider the opportunities for in-stream water storage. The sandy river beds with shallow bedrock are suitable for sand and subsurface dams.

Karamara Ridge is also characterized by steep slopes. There, however, soils are shallow and vegetation cover is low. To combat erosion and promote water infiltration, it is recommended to protect the area against all degrading activities (including agriculture and grazing) and promote reforestation.

In most of Fafan Valley, the landscape is undulating, with fertile soils, but largely poor vegetation cover, expanding invasive plants and erosion problems. Improved land use planning, conservation of sensitive areas and basic soil and water conservations are recommended, where possible in combination with off– and instream water storage interventions.

The different ecosystem restoration zones

At a different level, land use and cover are strongly linked to landscape characteristics and as such provide a useful system to analyse the ecosystem restoration suitability map.

Arable lands. Continuation of crop production is feasible on most arable lands if suitable soil and water conservation measures are implemented at scale. On flat to gentle slopes, mulching, tree and grass strips, life fencing (Figure 5.4) and agroforestry are recommended. On steep slopes terracing, contour bunds, contour ploughing, tied ridges and stone bunds are proposed. On the very steep slopes, arable cropping should be avoided. In these areas, it is recommended to promote forestry and permanent crops, such as tea, coffee or fruit trees. Slope-adapted agriculture is particularly important in Jerer Sub-catchment as soils are very weak. Soil and water conservation measures will prevent erosion and increase water availability in the soil. Hence, implementation of these measures will lead to higher crop-yields and lower vulnerability to short-term droughts.

Rangelands. As with arable lands the recommended interventions in rangelands are strongly related to slope steepness. Except for the very steep slopes where a replacement with forestry is recommended, rangelands could be kept as grazing lands as long as measures against overgrazing are implemented. Because of the large areas and communal land tenure traditions, physical structures are inappropriate for combating erosion on these lands. To sustainably manage these lands mostly governance interventions are required, such as agreements on grazing patterns, assignment of wet season, dry season and emergency grazing areas, and protection of trees. In this regard harvesting of branches with maintenance of trees and cut-and-carry systems could be promoted. With proper protection and management vegetation cover will probably quickly recover, resulting in an improved availability of fodder for livestock and lower erosion rates.

Forests. Existing forest and bushland should be conserved. On gentle slopes, forest and bushland can be used for fodder collection and grazing. Also agroforestry could be considered. In all instances, preservation of the natural ecosystem functions should prevail. Forest management and a ban on tree-cutting are essential to this end. Existing vegetation should be kept in place as much as possible so as to keep its soil and water conservation services. Non-degrading activities, such as grass cutting and fruit harvesting, can be allowed.

Wetlands and valleys. In Fafan Valley wetlands and valleys can be used for agriculture or grazing. Extra water can be made available through floodwater spreading. In areas that are regularly flooded, flood-adapted agriculture is recommended, with crops that withstand floods during the flooding season, and post-flood and early planted crops in the other seasons. As the soils in Jerer Sub-catchment are weak, agricultural practices should be adjusted to the erosion prone situation. In the regularly flooded area it is recommended to inhibit agriculture and grazing, for example though area closures, and focus on wetland conservation. Well-maintained and protected wetlands can be used as a reliable supply of fodder through cut-and-carry systems.

Built-up areas. In built-up areas, particularly around Jijiga Town, solid waste and wastewater pollution are major problems. Large urbanizations also put pressure on the functioning of ecosystems in close-by areas, as they lead to overexploitation of resources (for example though firewood collection). In the towns it is recommended to focus on urban water management, including recycling where possible, and waste management to prevent further pollution of the landscape. In smaller settlements, woodlots and life fencing could help wood and charcoal requirements.

Eroded areas. Eroded areas should be fenced and protected so that vegetation gets time to recover. Gullies often originate in areas where water, silt and organic matter accumulate. As such, conditions for plant growth are relatively good. If left undisturbed, natural vegetation will in most cases easily recover. To speed up the process biological interventions, such as tree planting, and physical interventions, such as gully plugs, could give natural vegetation a head start. After recovery, gullies should be managed in a way comparable to forest areas.

In-stream interventions

In-stream interventions improve water supply, slow-down runoff, increase base flows and reduce erosion through water storage in streams and rivers. Which type of interventions are most suitable depends on the stream order (see map previous page, 1 denotes the smallest stream and 4 the largest), the type of sediment in the rivers and the depth of the impermeable layer. Where the sediment is predominantly sandy, like in Fafan Valley, there is a potential for sand dams and subsurface dams, where the water is stored in the sandy sediment that accumulates behind the dam. Jerer Sub-catchment has more silty to clayey sediments, and is thus not suited for sand and subsurface dams. In the lower parts of the catchments, i.e. at the lower stream orders, spate irrigation can be applied, in the floodplains floodwater spreading is recommended, to increase the water infiltration into the soil increasing the soil moisture and fertility, and decreasing peak flows. In the map the streams with sandy sediment are indicated in dark blue, while the streams with silty to clayey sediment are indicated in light blue.

Figure 5.3 Small irrigated plots with fruit trees.

Figure 5.4 Example of live fencing.

Cumulative impact

Small-scale ecosystem restoration interventions are easily implemented in collaboration with, or preferably by, the local population. Usually different types of ecosystem restoration interventions complement each other. As consequence, the cumulative impact of the interventions is larger than just the sum of their individual effects. The sole construction of erosion control structures in gullies, for example, often is little effective. In combination, however, with an area closure, riverbank protection and rangeland management these structures often can rehabilitate a gully.

Therefore, where possible, ecosystem restoration measures should be implemented at scale, with a high variability and density of measures covering a large part of the area. Such an approach may make it possible to reach a tipping point so that entire ecological system can be recovered. Step-by-step ecological building blocks are recovered, up until the moment natural revitalization processes start up once again. Only then will ecosystems be able to provide ecosystem services to their maximum potential and can impacts be measured at landscape scale. This healthy system will then be much less disaster prone, and able to support its growing human population.

Steps towards implementation

In this atlas information about the biophysical characteristics of the landscape and the ecological values is provided to serve as a knowledge base for landscape development. This is a first step towards the application of sustainable and integrated landscape management. Based on the intervention potential maps the most feasible interventions can be selected and incorporated in implementation programs and management plans.

As shown on the previous pages, ecosystem restoration includes multiple techniques. The most appropriate combination of measures is selected by means of integrated assessments. These assessments include in-depth biophysical analyses as provided in this atlas, combined with an assessment on the stakeholders' needs.

Combination of ´hard´ and ´soft´ interventions

To increase the resilience against droughts and floods by restoration of the landscape and strengthening of the ecosystem services, focus should be on 'soft' measures, such as regulation, awareness creation, training and facilitation of management processes. This can be combined with hard measures, but these can only be effective in improving water, soil and nutrient conditions on large scale when implemented by the users based on self-motivation. Only then users are enabled and stimulated to deploy the approaches and implement the measures themselves.

For example, deep gully erosion results in a severe loss of soil and land. A single physical measure, like gully plugging, will not be sufficient to stop erosion and may even have an aggravating effect. To prevent erosion and support recovery, a combination of multiple hard and soft measures that reinforce each other is recommended. These include:

Soft interventions

- Regulation of grazing and tree cutting in erosion vulnerable areas
- Training of the farmers in erosion reduction measures (like contour ploughing, extended vegetation cover practices, etc.)
- Land use planning based on the physical characteristics of the landscape

Hard interventions (physical, mechanical and biological)

- Contour bunds or vegetation lines in the vicinity of erosion vulnerable areas (to decrease the run-off velocity and thus eroding power of the water flowing over the surface)
- Fencing of erosion vulnerable areas
- Tree nursing, and planting at specific locations in the erosion vulnerable area
- Gully plugs or gabions

Involvement of all relevant stakeholders

The strength of ecosystem restoration techniques is reinforced when biophysical opportunities are linked to local practices. Interventions should be in line with the local capacity for operation and maintenance, regulations and by-laws. Various groups depend on the natural landscape, ranging from farmers and pastoralists, to city dwellers. The combined uses of these different groups put a large pressure on natural resources. To revert the degradation of the landscape measures are required that reduce the pressure on vulnerable areas and increase the sustainable use of the landscape by all these groups.

To put this in practice it is essential to involve all relevant groups that make use of the ecosystem services. Agreements and regulations on the use of the natural resources are required, which may be strengthened if win-win situations or alternatives can be created. The overall goal of the interventions is to recover and protect ecosystem services that match the various stakeholders' needs. Therefore, the involvement of stakeholders from an early stage of the decision making process on is highly recommended in order to create practical and broadly supported plans.

Alternatives to cash/food for work

To create impact at scale a large number of interventions has to be implemented throughout the project area. Such a large scale implementation is beyond the capacity of the donor funded projects in the region. Moreover, the landscape restoration interventions require regular maintenance and/or behavioural changes. Therefore, long-term commitment of the local farmers, pastoralists, and other users of the natural resources is essential, and may not be reached by cash/food for work only.

Although cash for work or food for work can provide good results at the short term, there is often a less positive side to the approach. Existing legislation and agreements may be undermined, especially when conservation agreements are already largely in place. Good agricultural and pastoralist practices should be considered business-as-usual and not once– every now and then project. Further, it may reduce the motivation of the locals to implement the interventions at other locations or beyond the project horizon, if they are educated that they should be compensated for these activities.

Therefore, it is recommended to train the different user groups in good practices for example with farmer field school. This may reinforce the good legislations already in place. Additionally, motivation can be created by clear communication about the different practices, the win-win situations (e.g. increased agricultural yields, and improvement of grazing grounds), and the importance of the landscape sustainability to reduce of severe threats to the local livelihoods.

Instead of or in addition to cash or food for work, the application of project resources is recommended to be used for the construction of local demonstration areas. Here the combination of multiple hard and soft measures is show-cased, with the use of local labour. These sites can serve as inspiring examples for upscaling. This rather small shift in focus, from cash/food for implementation work towards cash/food for demonstration work, and the combination with a training targeting all users, provides a scalable approach that supports the ecosystem services at landscape scale.

Beyond the project horizon: institutionalization

The results that are presented in this atlas should be institutionalized by all relevant target groups. This is recommended at three different scales: (1) at plot level, for example by farmer field schools, (2) at community level, for example by community training, and (3) at the local government level, for example by including these results in the catchment planning of the water boards, the counties or the agricultural bureau. In this it is especially important to institutionalize the conservation of areas with all different stakeholders, and community activities should focus on awareness, training and mobilisation.

Currently Community Mobilization and Organization Guidelines on Watershed Development for Somali Regional State are under development. In addition, a Catchment Steering Committee has been established. To implement an Integrated Catchment Management Plan in which ecosystem restoration is integrated it is important to:

- Ensure Government support, policy development, institutionalisation
- Establish critical catchments and micro-watersheds
- Delineate intervention areas and prioritize
- Finalize the Community Mobilization Guidelines on Watershed Development for Somali Regional State
- Adapt the existing technical watershed management guidelines to the local context
- Refer to the ecosystem restoration implementation manuals that come with this Atlas for further details

6

CONCLUSIONS

In this chapter, the main challenges and opportunities are presented. Often win-win situations can be created: challenges can be turned into opportunities, so that combating environmental degradation through ecosystem restoration not only results in a more resilient system, but also improves livelihood conditions in the short term.

Conclusions

The Upper Fafan Catchment in Somali Regional State in north-eastern Ethiopia is a disaster prone area where rural communities heavily depend on natural resources. Strategic ecosystem restoration targeting water security, food security and disaster risk reduction is key to building community resilience.

To select the most effective interventions identification of the main challenges and opportunities provided by the landscape is essential. An integrated assessment was performed, which included socio-economic, biophysical, land use and management, ecosystems and water resources aspects. The assessment was based on a literature study, remote sensing and GIS analyses, field surveys, focus groups discussion and interviews with key informants.

Challenges

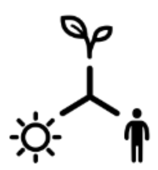
The resilience of the Upper Fafan landscape is low and further decreasing. In 32% of the project area a decrease in vegetation cover was observed between 2000 and 2012. Degradation results in erosion, loss of soil qualities, widespread presence of invasive species, deregulation of wetlands' functioning and changes in microclimatic conditions, and hence in a loss of resilience. Overgrazing, deforestation and expansion of agriculture all contribute to the challenge.

There are, however, areas less affected. In the Amora Mountains, for example, where land use and management are well adjusted to the predominant landscape characteristics, erosion is limited despite high rainfall amounts and steep slopes.

Droughts are not (solely) a climate phenomenon. Droughts occur more often and are more severe, but cannot be related to a decrease in rainfall trend. Droughts in the project area are periodic events linked to sea-surface temperature (SST), El Nino (ENSO) and land-atmosphere cycles, which threaten local livelihoods every 10 to 20 years. The impact of these periods of low rainfall, however, has increased. The capacity of the landscape to buffer water has been lost to degradation. Runoff rates increased reducing water availability in dry periods. Together with population growth and a higher demand for water this results in increasingly severe water, pasture and food shortages.

High climate variability in combination with a heavy dependency on rainfall forms a fragile balance. Prolongation of the Jilaal (long) dry season results in water shortages for domestic use and watering of livestock. A slight delay, or unexpected intermittency, of the Gu or Deyr (short) rains can result in total crop failure. Climate change projections indicate a 10 to 20 percent increase in rainfall, more intensive rainfall events and more erratic rainfall patterns in the future. In light of these changes it will become even more important to restore the water regulation capacity of the landscape.

Environmental degradation is strongly related to poor management practices, which in turn relate to a lack of knowledge, regulations and agreements. Communities are aware of the problems, but have limited knowledge on sustainable farming methods and soil and water conservation measures. Also, interdependencies between the different areas and characteristics are insufficiently used as a basis for planning. Erosion problems are, for example, often addressed with physical measures downstream, while the problems often develop in the upstream areas. Ultimately, the institutional setting could be further strengthened to uphold planning, use and management of natural resources.



Ecosystems and their provisioning, regulating, cultural and supporting services are being lost at an alarming rate. The water buffering function is decreasing, soil qualities being lost, rangeland production decreasing, and the availability of natural products such as wood, wild fruits and berries dropping. Ecosystem services relate on a one-to-one basis with the resilience of the system. The loss of these services directly results in a higher risk of disasters.

Natural resources management (NRM) systems are failing. Traditional NRM systems are weakening, while alternatives are not fully functional.

- The application of integrated NRM practices is not (yet) the standard
- There is a lack of understanding of how the larger landscape functions;
- Many interventions are poorly designed, sited, constructed, operated and maintained. The access and reliability of water points is low. Birkads and ponds are often silted and polluted, and do not last throughout the dry season. Many deep boreholes are unreliable due to electro-mechanical problems. The sites and technology could be better adapted to the local environment and capacity.
- There is a lack of technical capacity and shortage of monitoring data to base decision making upon;
- The linkages between policies, plans and frameworks, and stakeholders' needs and demands could be stronger; and
- The coordination and dialogue between government agencies, implementing organizations and communities could be strengthened.

Opportunities

Disaster risk reduction can best be achieved through integrated resilience building. Hazards are a given, but do not necessarily lead to disasters. Erratic rainfall, for example, cannot be avoided, but its effects can be mitigated. By implementing ecosystem restoration and management, stakeholders take control over the landscape and degradation can be reversed. Restoration of ecosystems is possible through improved land use, conservation of key-ecosystems and recharge, retention and reuse measures. The ecosystem restoration map (Page XXX) shows that there are multiple opportunities. For the best results:

- Priority should be given to protection of the highest-value ecosystems, such as forests, wetlands and rangelands;
- Focus should be on conservation and management, rather than on the implementation of physical structures.
- There is a need to invest in climate- and ecosystem-smart agriculture.
- Measures should be combined, and be part of an integrated NRM strategy.

Most soils are suitable for crop production. With adequate management, proper soil and water conservation measures, introduction of drought resistant crops and application of other smart agricultural practices crop yield can be significantly increased.

High potential to improve access, availability and quality of water. The water balance calculation indicates that large volumes of water are available periodically. For example only one percent of the average runoff of the upper Fafan and Jerer catchments, could fulfil the water demand of Jijiga Town. These huge volumes indicate that water access is rather a problem of seasonality and lack of water harvesting and infrastructure, than insufficient rainfall and water resources. Increased water storage could provide an enormous increase of water availability during the dry period, and even provide water for irrigation.

Strategies and feasible measures for water storage and water supply in the different landscape zones were identified. This indicated a large variety of options, which are included in the ecosystem restoration map (Page 47-48).

BIRR

Win-Win: multiple opportunities to protect nature and develop alternative sources of income. Challenges and opportunities are often linked. For example:

- Interventions to restore degraded lands increase ecosystem services, such as water regulation and food provision, but also provide opportunities for income diversification.
- The high demand for wood and food by the growing urban population poses a challenge, but also is an opportunity for increased income for rural population.
- There are many ecological sensitive areas with abundant wildlife that are worth to be protected for their ecosystem services and biodiversity, which at the same time provide opportunities for ecotourism.

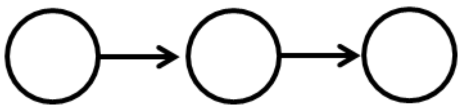
Stressing the linkages between the multiple challenges and opportunities, the long and short term benefits, and the impacts at landscape and community levels is important to ensure ownership and stewardship, and thus to achieve impact at scale.

Recommendations

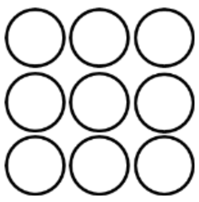
Impact at scale can only be achieved through the implementation of coherent and widespread interventions. It is recommended to start working towards integrated NRM, based on the Ecosystem based Adaptation approach. This approach should be based on factual knowledge, mobilize all stakeholders and be institutionalized as early as possible.

Capacity building. To efficiently deploy the available resources, it is recommended to start with knowledge and capacity building on systems thinking, integrated NRM and Ecosystem based Adaptation. Strengthening governmental and non-government extension services and effectiveness of front-line staff is an important step. Trainings and workshops should be designed for field-staff, policy makers and decision makers, include a practical component on spatial analysis, and focus on the need to:

- consider the whole instead of the parts;
- understand the linkages between up- and downstream, land use, management and degradation, hazards and disasters;
- restore ecosystems and their services;
- integrate disciplines and involve stakeholders; and
- consider the landscape characteristics when selecting measures to implement.



Visioning. To improve planning and coordination visioning will be important. Through multi-stakeholder participatory planning, community engagement and fact-based decision making goals and objectives should be defined, and priorities set. The involvement of local institutions and stakeholders, embedding in the existing institutional setting, consideration of traditional practices and alignment with ongoing plans and initiatives will be crucial at this stage. In addition, it is essential that throughout this process the developed knowledge on the biophysical system is well-represented. Visioning will support the development of sustainable and effective land and water management strategies and support the selection of technically feasible and socially supported interventions.

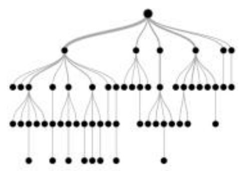


Multiplication and expansion. To create impact, widespread implementation of measures is needed and this can only be achieved if measures are implemented, maintained and replicated by the users of the landscape, i.e. through self-motivation. To enable this, direct incentives other than cash or food for work are required. This can be achieved through the identification of direct benefits to communities (e.g. higher water availability, improved access to fodder, food and wood during emergency situations, additional sources of income), combined with awareness raising, coordination, mass mobilization and capacity building. Ecosystem restoration provides a great opportunity to reduce disasters on the long term, but requires a joint effort, especially where it concerns the adjustment and enforcement of policies and regulations. Farmer field schools could play an important role in knowledge dissemination.

Strengthening the enabling environment. There is a dire need for policy adjustments, regulatory measures, coordination and dialogue, and the integration of traditional management practices into governmental guidelines. In this sense the advice is to invest in catchment management plans, and a simple monitoring network. Also, it is recommended to improve the access to data and information, for example, through the establishment of a knowledge centre, in which all relevant databases, reports and guidelines are gathered.

Subsidiarity principle and democratic decision-making. Deal with problems at the most immediate level consistent with the solution. Catchment management plans are initiated and institutionalized by regional and federal government, but its development and implementation should be organized at community level. Implementing organizations can play a very important supporting role, but should be careful not to take an imperative stance. National, regional and local authorities should guide and coordinate.

In general it is recommended to promote democratic decision-making at local level. Consultation, debate and discussions should include citizens and community groups, while the process of policy formulation and implementation should involve both community elders and state officials.



Selection and design of measures and expert involvement. Measures are most effective when hard and soft measures are combined. On farmlands, physical structures such as soil bunds, trenches and terraces can be effective, but only if ownership of the intervention is with the farmer.

In rangelands the focus should be on awareness raising and management, including agreements on controlled grazing and special conservation areas. In severely eroded areas the focus should be on biological conservation measures, such as closure areas that allow the regeneration of trees and vegetation and the plantation of seedlings. Priority should be given to the protection of high-value ecosystems, such as riverine areas, wetlands and forests.

Water storage for domestic and livestock watering purposes should be designed to bridge a period of approximately five months, the duration of the Jilaal (long) Dry season. Soil moisture conservation and measures enabling complementary irrigation are especially important during the Hagaa (short) dry season. More in general, all measures toward regulation of water flows and recharge of groundwater resources will have a positive impact on water availability.

It is recommended to hire expert knowledge to supervise siting, design and construction tasks, also when it concerns simple traditional structures such as birkads, so that these are equipped with appropriate water treatment facilities and silt traps to guarantee the best water quality. In addition, it is important to make clear arrangements for operation and maintenance to keep infrastructure functioning.

The way forward

The Atlas of the Upper Fafan Catchment informs strategic planning and decision making. Building resilient livelihoods in the Upper Fafan is feasible. The area is endowed with pro-active communities, and the government and NGOs are very willing to contribute. The project team is convinced that with multiple small but practical ecosystem based interventions good steps can be set towards a more resilient system, and thus towards increased water security, food security and disaster risk reduction.

Refer to the manuals that come with this Atlas for further information on implementation.

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Figure 6.1 Women fetching water for domestic purposes. In the back, livestock, goats and sheep entering the pond.

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