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SOCIO-ECONOMIC, AGRO-ECOLOGICAL AND TECHNICAL POTENTIAL OF THE PROPOSED ASCOMA SPATE IRRIGATION PROJECT

Ada'ar Woreda, Afar National Regional State, Ethiopia

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Cover image:
Caption: water spreading weir at Chifra, Afar Region.
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Synthesis report based on research conducted through the AKLDP Capacity Building Grant

Authors:
Nure Seid (Dr.)
Gebrehaweria Kidane Reda
Siraj Mohammed
Sadik Bedru
Kerim Ebrahim
Tariku Teshale
Natnael Demelash

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EXECUTIVE SUMMARY

This research was conducted in Ascoma district (Ada'ar *woreda*, Afar regional state), with the objective of assessing the potential of increasing fodder production for livestock through the use of spate irrigation. Spate irrigation captures and spreads seasonal rainwater runoff/floods and was used in this area thirty years ago when 500 hectares was planted with Rhodes and local grass species. The scheme collapsed due to lack of local maintenance after the phasing out of the project, but Samara University study is now part of a plan to revive the scheme learning from past mistakes. Three studies have been undertaken towards preparing a community-managed spate irrigation intervention. They cover the potential socio-economic impact of the scheme, its agro-ecological feasibility as well as its technical feasibility.

The technical feasibility study assessed the potential of the Jeldi River to allow spate irrigation at Ascoma. It looked at soil type, rainfall data, topography, the length and elevation of proposed diversion structures and the materials available and needed. The socio-economic and agro-ecological studies were carried out through in-depth consultations with individual interviewees and key informants, group discussions and visual observations. Enumerators were recruited and trained, and purposive sampling procedures were followed to identify and select respondents from among resident pastoralists—namely respondents with experience and knowledge of the study site. Secondary data relevant to the study were gathered from district level agriculture and rural development offices and reviewed and analyzed. The perceived importance of spate irrigation and status of existing water resources were also covered during these studies.

The research generated information on livestock production and production constraints, rangeland degradation and traditional measures used to address it, as well as vegetation potential. The latter covered native vegetation composition, diversity and palatability level, and also invasive species encroachment levels. Plant specimens were sent to Addis Ababa University for identification. The potential market for fodder was also assessed, particularly with reference to the proposed Mille Quarantine Center, other beef and dairy production centers, and the need in times of drought for livestock producers in nearby areas.

The research findings reveal 99% of the people of the district are categorized as pastoralists, with livestock rearing as their primary task. Multiple species are kept (including goats, sheep, camels and cattle), with goats and camels increasingly replacing the sheep and cattle. Natural pasture and browse are used alongside some purchased supplementary feeds. Shortage of water/rain, feed shortages, diseases, bush encroachment, lack of markets and conflict are the main constraints to livestock production; with herd mobility, use of fodder trees, sale of animals, and the purchase of animal feed as the primary solutions. The native herbaceous layer of the rangeland vegetation has decreased from season to season, and from year to year, due to recurrent droughts.

Almost 100% of the interviewees were agreed on the importance of reinstating the spate irrigation scheme, with spate irrigation considered to be a best solution to solve the problems of feed scarcity in the study area. Rhodes grass, *Panicum antidotalae, Panicum maximum, Cenchrus cilaris* and Sudanese grass are seen as the best grass species; while *lablab,* cowpea, *sesbania* and *leucaena* are recommended as the best legume forage species to be sown in the proposed project area. The technical feasibility assessment calculated the size and elevation of the diversion structures that would be needed; the repairs that would be necessary to rehabilitate the previous irrigation structures; and the amount of materials that would be needed to create diversion structures. It is hoped that the detailed work put into this study will encourage donors and other agencies to fund the rehabilitation of the Ascoma spate irrigation scheme.

1. INTRODUCTION

1.1. Spate irrigation

Spate irrigation is a resource management system whereby floodwater is discharged through normally dry *wadis* and conveyed to irrigable areas.[1] It is a type of water management unique to arid regions bordering highlands. The water management system requires the local construction of bunds and canals that are able to withstand flash floods. They must be designed to gently guide large volumes of water over large areas, slowing down their erosive power.[2] The key characteristics of spate irrigation are the unpredictability of the floodwater in occurrence and amount, and its high sediment load and destructive nature[3]—features that challenge the development of sustainable irrigation management systems.[4] In the Horn of Africa the area under spate irrigation is expanding rapidly, especially in Ethiopia and Eritrea where population pressure is encouraging settlement in the more habitable lowlands. In Ethiopia, through improvement of existing traditional systems and the development of unexploited areas, spate irrigation now has promising potential. In particular spate irrigation can help support the livelihoods of the often-poorest segments of the rural population.[5]

1.1.1. History of spate irrigation in Ascoma District, Afar Regional State

In the 1980's the North East Rangelands Development Unit (NERDU) of the Third Livestock Development Project (TLDP) initiated spate irrigation in Ascoma district. Ascoma is in Zone One of Afar region close to the River Ledi, which has high levels of seasonal flood flow. The area covered by the spate irrigation scheme at that time was 500ha, benefitting a large number of households by diverting the freely flowing floodwaters into grazing areas sub-divided into sections. Improved forage varieties were introduced in the irrigated area. According to communities living in the area at that time this enabled them to graze their animals for the long dry season. It is also stated that no households had to move from the area during the infamous drought of 1984/5, highlighting the importance of the scheme. Key to ensuring the sustainability of spate irrigation systems is the provision of simple but regular maintenance, but unfortunately at Ascoma the maintenance was only carried out yearly by NERDU. When the unit was dissolved following political change, the benefitting communities were insufficiently organized to undertake the critical maintenance work themselves and the scheme collapsed.

1.1.2. Livelihood challenges in Ascoma District

Ascoma is in the dryland agro-ecological zone, with evapotranspiration exceeding precipitation for most parts of the year. The *woreda* has three rainfall seasons: the main rainy season locally called 'kerma' (July to September), light rain 'dedha' (December), and rainfall with less distribution 'sugum' (March and April). The average temperature ranges between 28-320°C, with April, May and June the hottest months of the year when the temperature may raise to 42-450°C (source: *woreda* PAPO). The region is one of the main sources of livestock in Ethiopia, retaining a huge number of animals including endemic species, and contributing significantly to the domestic as well as foreign livestock markets.

Pastoralists in Ascoma district depend on their livestock and its by-products for both food and income. In order to maximize production and income generation it is essential that livestock are healthy and well fed. When feed sources are constrained by drought, bush encroachment and rangeland degradation, livestock productivity decreases. Recurrent droughts and disease are now steadily weakening the pastoralist management strategies in Afar, and over the last 2-3 decades a process of marginalization of prime grazing lands has also taken place.[6] The livestock dependent economy is now severely damaged, frequently creating a dependency on food aid. Although drought is the most common of all the environmental and socio-economic shocks and stressors the Afar pastoralists are facing, the situation is also worsened by the invasion of pastureland by two non-native plant species called *Prosopis Juliflora* ('woyane harha') and *Parthenium Hysterophorus* ('democracy').

1.1.3. Reviving the Ascoma spate irrigation scheme

With animal feed shortage the main limitation for the pastoral production system in Ascoma district, it has been agreed that the reintroduction of fodder production using spate irrigation may be a way of helping to reduce the severity of the problems. There is believed to be a huge potential for developing lowland spate irrigation systems in Afar region, with the main water resources in the area being flashy water and rivers, as well as ponds managed through pastoralist indigenous knowledge. The rationale behind the proposed revival of the spate irrigation scheme is the need to rebuild the capacity of pastoral livelihoods and generate drought resilience. The combined effect of spate irrigation and improved fodder production could vastly increase livestock productivity and improve livelihood situations considerably. If livestock fodder production can also be commercialized it could also increase pastoralists' cash income. The processing of fodder products, for instance baling, could improve the efficiency of fodder transport and sales.

To address the shortcomings of the previous scheme, it is now proposed that the Ascoma spate irrigation scheme be revived with a greater focus on community engagement. Technically it will involve diverting the floods from the Ledi River into the Ascoma basin, spanning over 500ha, through simple diversion weirs and appropriate channels. The intervention anticipates the following benefits:

- Biomass produced from local and imported fodder species will enable communities to graze their animals in the long dry season without the need to migrate elsewhere.

- The availability of fodder will boost household milk production improving the nutritional status of children. Household income will also increase from surplus milk sold at market; and communities may also accrue additional nutritional and income benefits through the introduction of dates, pistachios, sugar cane and the like on the irrigated site.

- Communities will be able to sell surplus fodder to the new livestock quarantine center (50 km away at Mille) with a capacity of some 300,000 animals. Communities will acquire new skills in fodder production and preservation techniques, with the income generated encouraging communities to safeguard the scheme through regular maintenance.

- Spate irrigation will boost the re-emergence of native vegetation, improving the ecology and attracting the return of wildlife into the area.

- The intervention may serve as an example of good practice for replication of similar community spate irrigation schemes in the region and in other parts of Ethiopia.

1.2. Feasibility Studies

Before proceeding with the intervention, it was agreed that a number of feasibility studies would be necessary, for which Samara University took the lead.

1.2.1. Socio-economic study

Samara University assigned an economist/socio-economist to extract relevant information through in-depth consultation processes on the following critical socio-economic parameters:

- The population number, number of households, number of livestock, living standard of the community, community perceptions on the spate irrigation scheme, impact of the project on downstream societies, management systems to be established by the communities and modalities for the continuity of the system.

- Setting the right priorities and avoiding unintended negative consequences of the proposed spate irrigation improvement intervention.

- Understand existing tenure systems and considering the implications of any possible intervention on tenure rights and arrangements, both in terms of management and in terms of distribution of benefits. Changes that would have implications in terms of tenure would need to be negotiated with the beneficiaries at the outset.

- Equitability study to ensure that improvements in spate irrigation projects do not increase inequalities and inequitable access to the resources among social groups.

1.2.2. Agro-ecology and fodder production

Samara University assigned a range ecologist and forage specialist to undertake:

- Mapping the physical environment and agro-ecology, land use and land cover, demographic features, livestock production and feed resources.

- Listing and classifying the indigenous vegetation species and present coverage level.

- Identification of beneficial local vegetation and fodder species and how they can be propagated in the irrigated fields.

- Identification of potential sites for the cultivation of dates, pistachios, sugarcane, etc.

- Recommending appropriate exotic fodder varieties for the scheme.

- Studying the fodder market potential in the region and outside of the region.

1.2.3. Technical feasibility study of the spate irrigation scheme

For the survey and design of the civil works, the University employed a consulting irrigation engineer and a retired surveyor from outside who were involved in the survey, design and actual implementation of the previous Ascoma spate irrigation scheme. The engagement of these personnel would also help in developing the technical capacity of an engineer and a surveyor from Samara University, plus one other engineer from the regional water bureau. This team became responsible for the survey, design and cost specifications of the civil works for inclusion in a final project document. Soil samples taken from different sites were sent for laboratory analysis in Addis.

The remainder of this document is a synthesis of the three detailed reports that have been now been produced by Samara University as feasibility studies towards preparation of a project document for Ascoma spate irrigation scheme. The studies were undertaken with the support of the AKLDP whose capacity building grants program helps improve the technical capacity of Ethiopian universities. The Samara University work will provide the basis for solicit funding from donors and other agencies for the implementation of the Ascoma spate irrigation scheme.

2. RESEARCH METHODOLOGY

2.1. Description of the Project Area

Ada'ar woreda is in Zone One of Afar region. It has an areal coverage of 5,840 km^2 and is bordered by Chifera and Mille *woredas* to the north, Telalak and Gewane to the south, and Bati to the west. The proposed project area is in Ascoma, one of the five *tabia* (sub-*kebele*) in Jeldi *kebele*. Jeldi is in Ada'ar *woreda*, whilst Ledi and Adaytuna Abeko are the two *kebele* bordering Jeldi downstream of the proposed project area. Danidaba*tabia* (in Adaytuna Abeko *kebele*), and Kesaltuladora and Abakatibola tabia (in Ledi *kebele*), are also expected to be immediate users of the project alongside households in Ascoma *district*.

The site for the proposed spate irrigation has GPS coordinate values of northing 1241899m and easting 0660041m, with an elevation of 612 meters above sea level. In a given year, at least two and occasionally three torrential floods pass through the Ledi River in the proposed project area, with massive volumes of water. Each year the floods widen and deepen existing gullies while creating new ones, making livestock and human movements increasingly difficult and shrinking the rain fed grazing areas.

2.2. Research strategy

The major purposes of the socio- economic feasibility study were to:

- Assess the socio- economic features of the study area.
- Assess potential downstream impacts of the project.
- Assess the effects of the project on existing land tenure practice and potential distribution of benefit among social groups.
- Forward potential remedies to any kind of negative impacts that might emerge because of intervention.

In order to initiate spate irrigation a study of the agro-ecological potential of the area would also be needed, together with research on whether there is community commitment for the process. A clear understanding of existing rangeland management would also be necessary. The following specific objectives were defined for the agro-ecological study:

- To assess agro-ecological perspectives and the ecological potential of Ascoma rangelands.
- To list and classify the indigenous vegetation species and present their current status/trends.
- To identify the most valuable local vegetation for fodder production and recommend appropriate exotic fodder varieties for the scheme.

And lastly a technical feasibility survey would be needed, and preparation of a design for the works, in consultation with communities for the command area. Activities in the technical feasibility study included:

- Reconnaissance survey and site selection
- Topographic survey of the command area and mapping
- Soil test and flood intensity study/season/year
- Material specification, thickness and dimension of the diversion weir
- Layout of canals and sub canals and irrigable land units based on contour lines
- Cost specifications of the civil works.

2.3. Data collection

For the socio-economic feasibility study, both primary and secondary data was collected. The primary data was collected from pastoralists (at household level), agricultural and pastoralist development office experts, and community leaders. The data was collected using structured interviews, focused group discussions and discussions with the community. A random sampling lottery method was applied to select individuals for structured interviews. Secondary sources of data that were relevant for the study were collected from different offices of the *woreda* and Central Statistics Agency (CSA) sources. Finally, tabular and descriptive statistics were used to analyze the collected data. The main limitation that faced by the study was the absence of complete and organized secondary data that was essential for the study: The *woreda* has no strong recording system requiring extra efforts at collecting and organizing scattered data.

For the agro-ecological study a reconnaissance survey was conducted to obtain preliminary information on vegetation diversity, levels of encroachment and to know the neighboring *kebeles* of the project area. To assess community perceptions on grazing land, spate irrigation, vegetation composition, grazing land management, feed resources, weed encroachment and livestock production, purposive sampling techniques were then employed to select study *kebeles* and respondents. Three *kebeles* (Jeldi, Ledi, Adayituna abeko), which are adjacent to the project

site, were purposefully selected; and ten (male and female headed) respondents from each *kebele* were randomly selected.

Data related to vegetation and livestock production were collected in October and November 2015 as part of wider survey to generate a baseline report for Ascoma fodder production project in Jeldi *kebele* (Ascoma village). Semi-structured questionnaires were designed to generate information on livestock production, feed and water resources, fodder production, wildlife potential, challenges related to livestock production, and the perceived importance of spate irrigation. Identification, distribution, potential and desirability of native forage plants and wild animals were recorded through visual observations, personal interviews and focus group discussions (FGD). Primary data were collected using structured questionnaires administered through face-to-face interviews by the researchers in a participatory approach, with the help of enumerators and development agents. A range of PRA tools were applied to study community perception. Physical and agro-ecological data were assessed from pastoralist interviews and secondary materials (published and unpublished regional documents). Soil type, topography, rainfall, temperature, vegetation, livestock type and number, human population, land use, rangeland resource utilization, and rangeland-livestock management practices were all assessed. The *woreda* and region pastoral and agro-pastoral offices, as well as disaster risk management, other GO and NGO offices, were all used as sources of secondary data to strengthen the information obtained from the field and from the respondents.

For the full agro-ecological study respondents in the three *kebeles* were selected purposively, with their age category above 40 years old, as they were expected to provide relevant information about the past spate irrigation project. 67 respondents were male and 33 were female. Survey data obtained from the respondents were summarized using Statistical Package for the Social Sciences software (SPSS v 16.0). Each household was considered as a unit of analysis. The summarized data were analyzed using descriptive statistics. Ranking was utilized to list constraints and solutions identified by the community.

For the technical feasibility study, data was collected on the geographic coordinates of the proposed engineering structures, the soil characteristics of the diversion area and irrigable area, as well as extensive records on historical rainfall data from the different locations that contribute water to the Ledi River (Bati, Wuchale, Hiyk and Eliwula).

3. RESULTS

The full results and data from the three studies are available within the individual reports, with just the summarized findings presented here.

3.1 Socio-economic study - critical factors relevant to project feasibility

The socio-economic study provides the details on the livelihood characteristics relevant to the need for spate irrigation, and in particular the current vulnerability context of potential beneficiaries. A review of the current trends illustrates a climate that is becoming increasingly drier, growth in human and livestock populations, and the delineation of communal rangelands for other uses. Pastoralist migration patterns are shrinking, with evermore households competing for diminishing rangeland resources. The levels of poverty in this community, as in others, are on the increase. The seasonal migration patterns of the last three years in the project area shows 62.5% of the respondents had to migrate to other places within Afar region, with the majority migrating for feed and water for their animals. Often migration leads to conflict over competition for grazing land, with 54.54% of migrants being involved in conflict. Due to fragile environmental conditions and erratic rainfall, the pastoralists of the *woreda* are now highly vulnerable and persistently food insecure. Depending on rain-fed pasture is becoming increasingly difficult as the rain-fed pastureland faces more frequent hazards. On-going shocks include droughts, floods, pests, diseases and conflict—all of which will impact on the viability of the proposed scheme.

Resource access

In the study area the land tenure system is communal. Lands belong to clan leaders and are administrated by clans. Each has its own territorial unit for exclusive use of the respective clan. The clan has the right to utilize the communal land and the resource available on it. The household survey data of sampled respondents all favor this existing land tenure system for two reasons: for self-defense when conflicts arise and for the free grazing and watering of livestock.

The Ledi River flows from Bati in south Wollo Zone, Amhara region, in a west to east direction to the Afar region. The proposed project site is located in the middle reach of the river. The river provides drinking water for humans and animals but is not available throughout the year. During the dry season the pastoralists must travel with their livestock more than 35kms to Awash River to get water for them and their livestock. Both the downstream and upper steam *kebeles* use this river as the only source of water for themselves and their livestock.

Economy and infrastructure

The socio-economic situation across the study area is broadly similar with 100% of livelihoods dependent on livestock and animal products. Camel, goats and sheep are the dominant livestock respectively, with the number of cattle decreasing over time because of the increasing and repeated droughts in this area. Livestock are the key household assets capable of productivity in the arid conditions of the region. Most households are seasonally dependent on movement for accessing pasture and drinking water. Secondary assets are from government and safety net support, as well as emergency and nutrition support for malnourished children and mothers.

In the study area all of the households are traditional Afar houses. Settlement is highly seasonal with people moving to access resources for their animals. Sons usually construct houses around their family home and settlements are based on close blood-related kinship households. Education and health care provision is poor. There is a lack of paved roads, with camels and donkeys the main means of transportation. Veterinary services are largely unavailable and the existing technical personnel are insufficient by comparison with the livestock resource potential of the area.

Conflict over resources

Inter and intra-clan conflicts over rangeland resources—mainly grazing land and water points—have partly contributed to the decline in the rangeland resources. Conflict not only reduces resource access, but also causes human and livestock losses as well as destruction of property. While inter clan conflict exists for a shorter period of time and is solved through traditional social organization, conflict between major pastoral clans has far greater consequences and longer term impacts. The Afar and Issa are considered traditional enemies, with one FGD stating the Issa once burned to ash the community's stored fodder when the Ascoma spate irrigation was operational. The causes of the conflict relate to grazing land and water points, although according to Afar elders the causes are often beyond these. There has been less inter clan conflict in recent years and different clans are now using rangeland and water resources commonly with minor restrictions. For example, a clan has no right to own a hand dug well in other clan's area but it can share the water with them for themselves and their animals. According to FGD participants, clans in Jeldi *kebele* have prevented other clan members from digging wells on Jeldi River.

Community attitude

Despite the challenges they face the community showed a positive interest and attitude towards restarting the spate

irrigation intervention, and to diversifying their livelihood sources by introducing farming practices alongside the expected fodder production. Focus group discussion was undertaken with elders, community leaders and key informants to assess the attitudes of both the direct and indirect beneficiaries of the proposed project. Positive ideas were put forward, as were promises to contribute to the extent of their ability during the construction of the project. A majority (78%) of respondents believed that overall gains of the project outweighed any negative impacts that may occur; but because they use Ledi River as the only source of water for themselves and their livestock there was concern that its diversion, without providing alternative drinking water sources, will create water shortage problems.

3.2 The agro-ecological study - critical factors relevant to project feasibility

The agro-ecological study assessed the ecological potential for the spate irrigation scheme, with a thorough assessment of existing rangeland management practices that would be impacted by the scheme.

Rangeland productivity

From the total area of the *woreda*, 9% is cultivable land, 2.54% covered with trees and shrubs, 12.27% grassland, 26.19% bush land, 1.68% water bodies, 29.24% stony and 16.8% covered with sand. More than 2% (11,000 ha) of the *woreda* (mainly rangelands) have been invaded by *Prosopis juliflora* locally called 'woyane harha' and it is invading the areas alarmingly (Source: *woreda* Pastoral and Agro-pastoral Office). The area is characterized by homogeneous flat topography (plain), with a slope range of 0 to 2%. The soils of the area are mainly as vertisols, fluviols and cambisols. Cultivable lands of the district have also been invaded by *Parthenium hysterophorus* locally called 'democracy' after its free spread to the potential lands.

The total human population of the study district is estimated to be about 64,570; of these 99% are pastoralists. Livestock population figures are always difficult to estimate, but in the study area the figures for each species are estimated at: 166,964 cattle; 494,571 sheep and goats; 4,982 camels; and 12,478 equines (source: *woreda* Pastoral and Agro-pastoral Office). Under extensive pastoral production systems livestock production depends on exploiting extensive rangeland resources. The replacement of native, palatable and nutritious grasses by unwanted browse and shrubs means that cattle numbers are now decreasing. The majority of respondents (58.1%) are also now using supplementary feeds for their animals during periods of critical feed shortage. Group discussion highlighted the major consequences of livestock feed shortages in the area including: low milk and meat production, low disease resistance, death of grazing animals specifically, the need for migration to other potential areas, and food insecurity. Bush encroachment, the lack of markets and conflicts with neighboring Issa communities also has a significant impact on livestock productivity.

Vegetation assessment

A total of 35 herbaceous and 26 woody species plants were identified in the study area. Out of the total plant species, 19 herbaceous and 11 woody plant species were highly desirable, but according to the respondents, grasses and palatable legumes have declined both in quantity and quality over much of the grazing lands, and the project area in particular. Elders and experienced herders stated that during the former spate irrigation project, grasses stayed green until the middle of the dry season due to the availability optimum moisture. Important and nutritious grasses like 'Durfu' (*Chrysopogon Plumulosus*), 'Melif' (*Andropogon canaliculatus*), 'Mussa' (*Dactyloctenium aegypticum*), 'Bunket' (*Tribulusterrestris*) and 'Dankito' (*Eleusine multiflora*) are now being lost to the area; as well as browse plants like 'Keselto' (*Acacia nilotica*), 'A'ebto' (*Acacia tortilis*), 'Angaleta' (*Cadabarotun difoilia*) and 'Medirto' (*Cordia sinensis*). Before the seed bank of the soil is diminished there is an urgent need to protect some of the nutritious species. Some local grasses are already likely to be extinct whilst other local grasses may not produce the expected amount of forage due to lower genetic potential. Hence, in addition to local forage varieties, other improved forage species will be needed for the area.

Much of the area now contains either bare ground or invasive plants, with animals selecting undesirable and poisonous plants to satisfy their hunger irrespective of its nutritional importance. *P. juliflora* (woyane harha), *P. hysterophorus* (democracy) are the major alien invasive plants dominating the rangelands in the project area. In addition to these, *Bunket atuyke, Eliykehna* and other unnamed invasive plant species are also invading the rangelands. It was pointed out that the milk produced from animals feeding on such weeds has a bitter taste or taint, and the meat is poorer quality. When animals graze only on *P. hysterophorus* nobody is willing to drink the milk making it difficult to sell. The tree invasive species are major causes for injury and restrict animals' movement when searching for feed. *P. hysterophorus* and *P. juliflora* are the major causes of bloating, deformed mouths, constipation, diarrhea and coughs in animals. Invasive plants are hazardous for human health too, especially *P. hysterophorus*, causing skin itching, continuous coughing, asthma, bronchitis, lung disease, high fever, allergies and swelling.

The area is expected to be conducive for date and other crop cultivation, such as maize and sorghum. The pastoralists were practicing maize and sorghum production during the previous spate irrigation, as a good means for an alternative livelihood strategy and as a source of stover

for their animals. However, this option was ended after the final damage to the dam.

Existing rangeland management

Effective grazing management is crucial for sustainable use of rangelands and to keep plants in optimum condition with high nutritive values. Communal rangeland management has been widely practiced in the study area, with controls over the utilization of communally owned water and pasture resources applied through decision-making structures at clan level and between clans. Local negotiation procedures within the existing institutions cover the use of water harvested from ponds in terms of the time for accessing it; herd composition; and restrictions over cutting of useful trees. Access to the grazing territory of other pastoral groups, particularly during dry seasons, is allowed based on negotiation with community leaders. The Afar community has a culture of common resource utilization with neighboring communities, sharing the surplus resource they have, with no culture of selling forage to other communities. During periods of scarcity pastoralists may come from far distances to utilize the available forage and water resources, and there is no culture of preventing incoming clans.

The rangeland management strategies are critical pre-conditions that outsiders must respect and abide by while using others' resources. The cutting of trees for example is traditionally culturally unfamiliar: trees serving both as browse and a source of edible fruits for humans. When tree cutting is necessary to feed animals during drought, the regenerative capacity of the trees is maintained. Recognizing that rangeland resilience is dependent on maintaining soil seed bank reserves, pastoralists exercise careful timing of grazing to safeguard plants during their seed production phase. Unfortunately these traditional management practices are eroding over time however due to lack of optimum return from the resources. Traditional institutions are also being weakened by strong interference of government actors.

Existing water management

Water is the single most limiting element in arid and semi-arid rangelands. Erratic and inadequate rainfall, recurrent droughts, uneven distribution of water sources (rivers) and a lack of an efficient water distribution infrastructure, causes shortage of water for human and livestock consumption. Respondents reported their major sources of water are ponds, deep wells (*Birkas*), rivers and/or flashy water. They see the inadequacy of the water sources as related to deterioration of ground water resources due to shortage of precipitation, and the invasion of the area by *P. juliflora*. The pastoralists' indigenous knowledge on locations of water resource and utilization is rich and is their means of survival in this harsh climate.

The communities have a long experience of digging very deep wells and utilizing labor and locally made traditional instruments to lift the water to the surface. In doing so the pastoralists have a good culture of water management at community and household level. They even share water to the incoming pastoralist groups during drought with some levels of restriction. Community members also have traditional knowledge in identifying groundwater that can be found at a short excavation depth. Despite this, during the harsh dry season animals must move long distances to get water— moving towards the Awash River or neighboring regions.

3.3. Technical feasibility study

A satellite image of the canal that was previously used to spate the water over the irrigable area is shown below. The canal covers about 2535m but about 60% has now reverted into gully water because of a lack of repair. In order to recover the canal to its previous condition it needs maintenance in about 8 locations, as shown below in the satellite image, each with 6m of stone and concrete.

Figure 1: The canal locations that need repair.

The proposed diversion structures will have a trapezoidal shape with different slopes on upstream and downstream sides. A canal is the main way to distribute the water over to the land area for spate irrigation. Fortunately the existing canal needs only silt maintenance to recover it to its original function.

Design criteria for an earthen dam

- A fill of sufficiently low permeability should be developed out of the available material.
- Sufficient spill way and outlet capacities should be provided so as to avoid the possibility of over toping during flood.
- Sufficient freeboard.
- The seepage line (phreatic line) should remain well within the downstream face of the dam so that no sloughing of the face occurs.
- There should be no possibility of free flow of water from the upstream to downstream.
- The upstream face should be properly protected against wave action, the downstream face against rain and wave action up to tail water.
- The upstream and downstream slope should be designed as to be stable under the worst conditions – loading (i.e. should be flatter).

Design for flood estimation

Data availability: The availability of consistent data of flood records or rainfall records of more than ten years is required at the site for exact estimation of the design flood. As the catchment area covers two regions—Amhara and Afar regions—both region's rainfall data were used, and the other methods of flood estimation alternatives—like estimation from observation of flood marks or empirical formulae—were needed for this case. The researchers tried to observe the maximum flood mark that has ever existed in this area over the last 50 years, but this was impossible since the cross section of the river is not defined. Empirical formulae were therefore employed, developed based on the catchment characteristics.

Catchment and River Characteristics: The catchment of Eliweha River emerges from the highlands of Eliweha *woreda*, especially from Bati forest. The elevation of the catchment ranges from as low as 637 to as high as 1236m a.m.sl. (Altitude above mean sea level). The average slope of the catchment is about 50% in the upper reaches of the catchment and 2% around the command are. It covers an area of 349 sq km.

Methods for calculation: The methods available to be used include: Tekeze Basin formula; Dr. Admasu formula; Dr. Kidane formula; and the envelop method.

Upstream and downstream slope of the dam:

Dam height	FB	Top width	U/S slope (H:V)	D/S slope (H:V)
4.5-7.5	1.5-1.8	1.85	2.5:1	1.75:1
7.5-15	1.85	2.5	3:1	2:1

Then the bottom width of the dam
U/s slop =3:1
8*3 = 24m
For Downstream slop =2:1
8*2 =16m
Total bottom width = 24+16+2.5 =42.5m

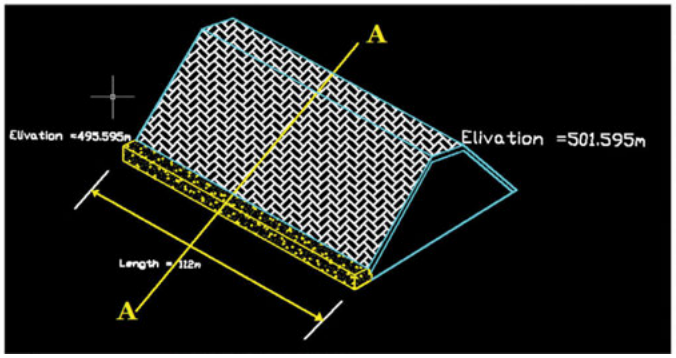


Figure 2: isometric view of diversion structure

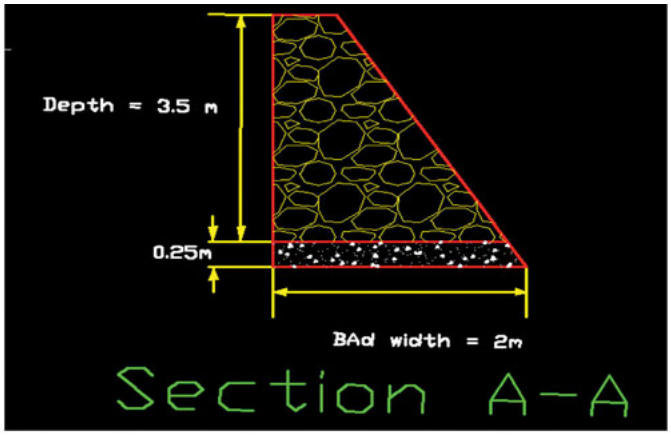


Figure 3: Cross section view of canal structures needed to recover the canal's function

a) Flood estimation by Tekeze Basin formula - This is an empirical formula developed for Tekeze basin:

q = 33.3 A -0.609 where q = discharge intensity and A = catchment area in km2
The total discharge Q = q *A
q= 33.3* A-0.609 = 33.3 (349)-0.609= 0.933111
Q= A*q= 0.933111*349 = 325.6557m3

b) Dr. Admasu method - According to Doctor Admasu the peak discharge is also a factor of catchment area and discharge intensity.

Qp = Cf * Qmd
Where, Qmd = 0.87(A) 0.7
Cf = 1 + 5(A)-0.2
Qm = 0.87(349)0.7 = 52.42
Cf = 1+ 5(349)-0.2 = 2.550261
Qp = 2.5550261*52.42 = 133.7 m3/sec

c) Dr. Kidane Formula

$$q = \frac{29.51}{(A+25.11)^{0.547}} = \frac{29.51}{(349+25.11)^{0.547}} = 1.154885$$

Q= 1.154885*349 = 403.0547m3/sec

Result for design flood estimation: The maximum flood for the designing of the diversion structures and the bank protection will be established based on the design flood computed by the Tekeze basin and Dr. Kidane formulae, the result from Dr. Admasu deviates from the two. Therefore, the design discharge will be 403.055 m3/sec.

4. DISCUSSION AND RECOMMENDATIONS

4.1 Socio economic impacts and recommendations

The socio-economic study set out to determine the community's priorities and thereby avoid unintended negative consequences of a spate irrigation improvement intervention. Assessing the impact of the project on downstream societies, and establishing a community management system for the continuity of the system, was a key priority. The socio-economic research has revealed that the project area reflects the current bigger picture of natural resource issues in Afar Region: loss of grazing land due to large scale irrigation projects and the expansion of *prosopis*; reduced mobility creating further pressure on existing resources; and fragile livelihoods exacerbated by increasingly frequent droughts.

The discussions with the community indicated that many similar studies by government and nongovernment organizations had been undertaken in the area but practical responses have not yet been seen. The proposed spate irrigation project has a broad socioeconomic development objective, expecting to increase livestock productivity by securing pasture, and thereby improving living standards of the target population. To mitigate against existing vulnerability it will be essential for the project to enhance existing natural resource management strategies in terms of governance, local knowledge, collaborative resource management, and wider rangeland management.

The research also identified some of the potential negative impacts. Malaria and water born diseases could potentially increase in the project area and will need attention. The expansion of malaria in particular may increase with the swamp area that may be created around the spate irrigation area. Consideration should therefore be paid to the provision of health services, which the area currently lacks. The household survey also demonstrated that the major sources of water used for cooking and drinking in the project area are boreholes, hand dug wells and shallow wells in Ledi River. If the project diverts the current direction of the river, communities living in Ascoma, Eremile, Keseltoledora and Abaketibolo will lose their sources of drinking water. This will need to be addressed. A further issue is the number of animals that will come from different *kebele* for grazing once the project is operational. These movements may contribute to the spread of disease and will be compounded by the lack of animal health workers in the region.

Proposed organizational structure and management of the project

The life expectancy and sustainability of the proposed spate irrigation scheme is not only dependent on the appropriateness of the design and construction, but also on the effectiveness of the operation and maintenance of the project by the concerned bodies. This requires a well-tailored management structure, system and plan, with the pastoral community around the Ascoma district particularly in the frontline to manage the project. Community participation must happen from the planning stage of the project. Since within Afar communities, decision-making and conflict resolution rests largely with elders and religious leaders—through traditional institutions—the participation of these community leaders will help guarantee effectiveness and sustainability of the project.

In order to manage the Ascoma spate irrigation scheme effectively, a suitable approach should be joint management by a specialized government agency and the pastoralist primary beneficiaries. It is recommended that the Afar Region Bureau of Water Resource Development (BOWRD) in collaboration with Samara University (SU) be the government agencies that make direct contact with the funding agencies and other governmental bodies. The BoPARD and SU will assign a competent development agent to provide technical support and extension services to the beneficiaries. In addition to BoPARD and SU, Ada'ar *woreda* administration will also assist in giving administrative support when problems arise during the progress of the project, and in coordinating governmental organizations to support the project when the need arises. The pastoralists will be directly involved in planning and implementation of the project, making close contact and receiving technical advice from the *woreda* Agricultural & rural development office through the development agent.

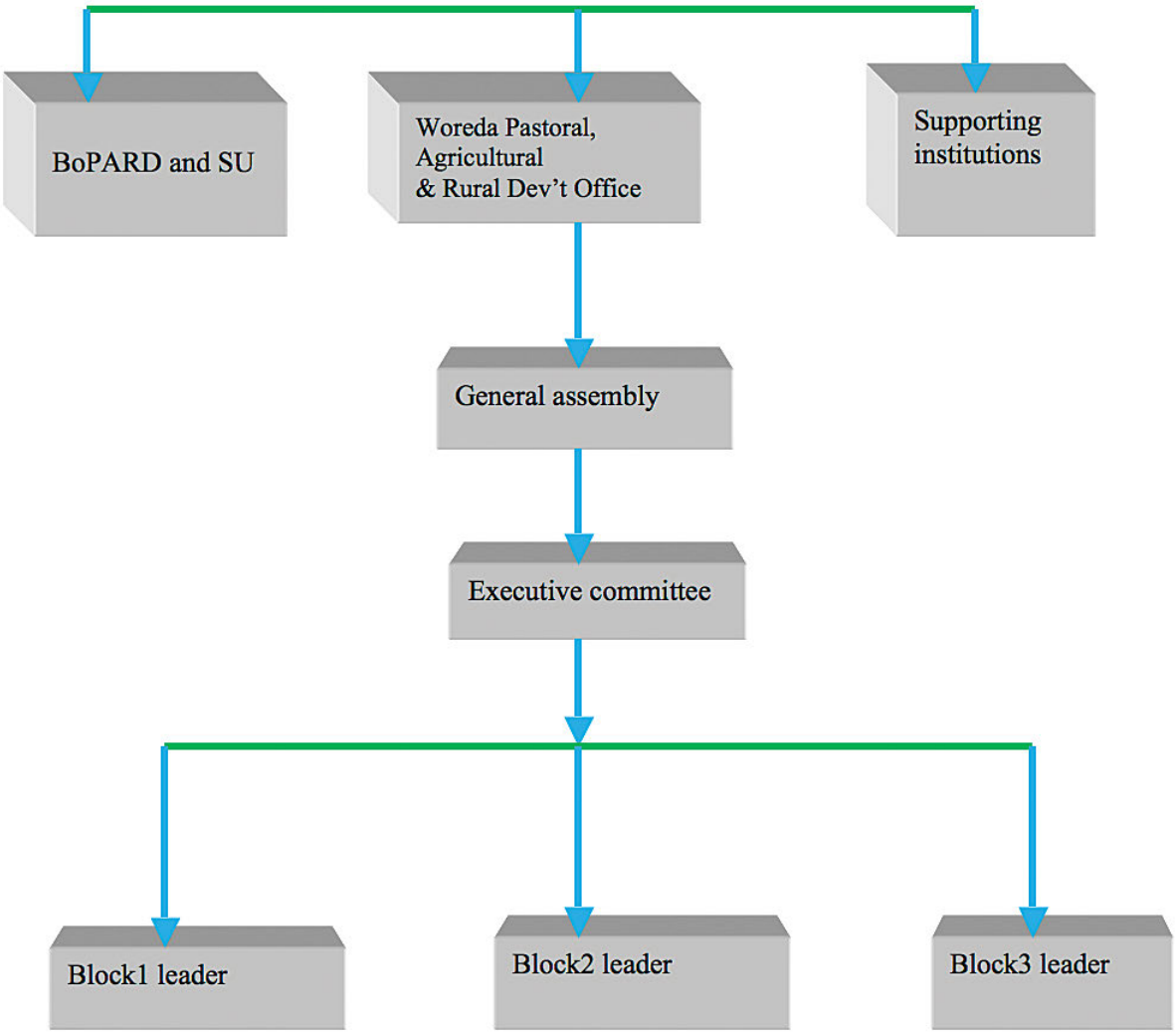
Pastoralist institutions, such as a fodder users association (FUA), and their efficient coordination will be quite important for the successful implementation of the project. To manage the distribution of irrigation fodder to the project beneficiaries in a proper way, a fodder users association (FUA) will be formed by voluntary participation of the members. The FUA will take the responsibility of managing and administrating the irrigation practices. The FUA will have an executive committee, which will be accountable to the general assembly. The general assembly will be responsible for electing and removing the executive committee, deciding contributions in terms of labor or fees, and make and revising bylaws. In addition the executive committee will share the responsibility of designing fodder distribution,

leading the association and resolving disputes, collect contribution fees, designing the maintenance program for the canals and follow up its implementation.

Under the executive committee there will be block unit leaders, which will be responsible for supervising the distribution of fodder, mobilizing the labor force for maintenance, and controlling the application of recommended fodder planting patterns. The members from each block will be selected from the primary beneficiary *kebele's*/districts, Adayituna Abeko, Jeldi and Ledi. A proposed organizational chart is given below.

In Afar, including the project area, indigenous pastoral law determines access to and control of natural resources. Each clan usually presides over a number of strategic resources, such as wet and dry season grazing areas and water points. Decisions on access to and control of natural resources are made by the village council, which consists of the clan leader, clan elders, local wise men and a traditional rule-enforcing unit. At the focus group discussion held with project area the pastoral communities revealed they are ready to use the irrigation depending on an agreement in accordance with their traditions. Keeping tradition in mind, the project will have two potential groups of beneficiaries, primary and secondary. The primary beneficiaries are the communities living around the project area alongside the river, Adayituna Abeko, Jeldi and Ledi. The secondary beneficiaries are pastoral communities living in Ada'ar Woreda and a relatively far distance from the project. This group will use the project after consultation and agreement with the primary group community clan leaders and FUA. The secondary beneficiaries will mostly use the project during the dry season period.

Figure 4: Proposed organizational chart of the project



NB= One block is assumed to comprise 10 – 15 members and they should be selected from the three districts, Adayituna Abeko, Jeldi and Ledi.

4.2 Agro-ecological feasibility and recommendations

Ada'ar *woreda* has high livestock rearing potential due to its agro-ecological situation, but livestock production is being constrained by environmental and natural disasters. Drought, feed shortage and bush encroachment are now the most challenging constraints. Rainfall is decreasing both in overall amounts and distribution, and noxious invasive plants are encroaching upon native grasses and trees. Pastoralist coping mechanisms include migration with their livestock in search of feed and water, diversification of livestock species, early animal sales, borrowing/lending of livestock for re-stocking.

Based on the elders' perceptions, the previous spate irrigation project was seen as successful, even though it was terminated due to lack of community awareness on its maintenance. Conflict between the Afar and Issa also contributed to the destruction of the structures. Reinstating the scheme by diverting the direction of flashy water and rivers to promote the cultivation of fodder is a viable option for increasing the productivity and marketing of the district's livestock potential.

In terms of improving forage species for the Ascoma rangelands, there are different native nutritious grasses with high potential in the area. Improved grass varieties such as Rhodes grass *(Chloris gayana), Panicum antidotalae, Panicum maximum, Cenchrus cilaris* and Sudanese grass, and legume forages like *lablab*, cowpea, *sesbania* and *leucaena*, could also easily be adapted to the area to increase livestock productivity. The researchers had problems studying the herbaceous grasses biomass productivity of the study area due to the severe drought that happened in this year. The 'El Nino' in the study area was found to be affecting the total livelihood of the community. Large numbers, may be more than half of their animals, had died for lack of feed and water. Herbaceous plants, specially the most desirable local species, had not grown.

Due to the drought it was also difficult to determine the surplus feed for sale to neighboring communities and organizations. The nearby organizations did however show strong interest in purchasing conserved feed from the area according to the simple assessments conducted. One issue however is that there is no culture of selling fodder in the community to neighboring communities of either the same clan or different. The Afar people have strong traditional institutional laws that support the welcoming of nearby communities to utilize existing livestock feed and water during the period of the dry season and elongated droughts. They always expect that they could face the same challenge in their area, and hence incoming communities are always given a positive response. Newcomers are accepted with some sort of restriction or payments against the existing resources however. Community-based participation will therefore be needed in: environmental rehabilitation and conservation of natural resources; the development of infrastructure and water systems; improvement to livestock development and grazing management systems; and enhancement of drought mitigation strategies.

Recommendations

- Spate irrigation is seen as the best solution to increase the rangeland productivity of the vast land of Ascoma district. The district has a large river with tributaries from upper streams flowing through a large cavity right at Ascoma district. Therefore diverting the seasonal flow of floodwater to the large area of rangeland may solve livestock feed problem of the area. Fodder production via spate irrigation once implemented in the district could be expanded to other areas.

- The project will need to follow up to protect gully formation in the flat area of the rangeland.

- The community of Ascoma and neighboring districts should be involved in the management and utilization of the project.

- The area studied is highly encroached by noxious rangeland weeds such as *Prosopis juliflora*. Strict control mechanisms should be practiced prior to the implementation of the project since it could hinder the entire activity.

4.3 Technical Recommendations

In designing spate irrigation improvement, the trade-offs between investment costs, maintenance costs and the level of service deserve more attention. Provision for rebuilding parts of the system after major floods are often a more cost-effective option than designing permanent structures. Spate irrigation has many advantages: simple technology that can be easily maintained; it is less dependent on heavy machinery and imported materials and supplies; most of the construction works can be carried out by farmers themselves; repairs are less costly and can be executed faster as only locally available materials and/or skills are required; and the impact of failure is partial as diversion structures have smaller command areas. With this in mind the quantities and engineering estimate for Spate Irrigation at Eliweha is given below:

I/no	Description	Unit	QTY	Rate	Amount
	1. Dam Section				
1.1	Clearing and grabbing to uproot bushes and remove unwanted materials to a depth of 300mm.	m^2	500.00	5	2,500.00
1.2	Excavation of Dam site foundation to a depth not xceeding 3 m the levels, widths & grades as shown on the drawings or as directed by the engineer	m^3	9,520.00	25	238,000.00
1.3	Dam section embankment back fill using suitable selected material and compacting in every 30cm layers thick to the levels shown and watering for better strength on the plan or detail drawing	m^3	29,680.00	55	1,632,400.00
2	**RIP RAP or Dump stone construction**				
2.1	Construction of Concrete toe wall in class C-15 with min. cement content of 360kg/m3 filled into form work and vibrate the shape and dimension shown at the drawing located all upstream bottom width	m^3	84.00	1500	126,000.00
2.2	Provide, cut and fix in position wooden or metal form work provided and price includes cutting, placing in position	m^2	170.00	100	17,000.00
2.1	Construction of Rip Rap or stone dumping in all external body of the dam the dumping thickness is 0.40 m is constructed without any cementing material only by stone like dry masonry the stone must place properly to prevent sliding	m^3	1,987.99	540	1,073,515.16
	SUBTOTAL				**3,089,415.16**

I/no	Description	Unit	QTY	Rate	Amount
	2. Canal Section				
2.1	Clearing and grabbing to uproot bushes, Prosopis and remove unwanted materials to a depth of 300mm.	m^2	500.00	25	12,500.00
2.2	excavation of Trapezoidal canal the dimension of the canal and canal profile is listed on the drawing	m^3	1560	35	54,600.00
	SUBTOTAL				**67,100.00**

I/no	Description	Unit	QTY	Rate	Amount
	3. Diverting structure along the canal Section for dissipate Energy				
3.1	Excavation for foundation to a depth not exceeding	m^3	11.25	45.0	506.25
3.2	Lean concrete depth not exceeding 0.30 m	m^2	12.00	1200	14,400.00
3.3	Masonry work				
3.3.1	Construction of stone masonry along the canal cross section The shape and the dimension was shown on the drawing	m^3	26.25	1300	34,125.00
3.3.2	Plastering all the masonry wall	m^2	24.00	250	6,000.00
	SUBTOTAL				**55,031.25**

	No of the wall = 8	**440,250.00**

ENDNOTES

[1] Mehari, A., Van Steenbergen, F., and Schultz, B., 2007. Water rights and rules, and management in spate irrigation in Eritrea, Yemen and Pakistan.

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[4] van den Ham, J. P., 2008. Dodota Spate Irrigation System Ethiopia: A case study of Spate Irrigation Management and Livelihood options. *Irrigation and Water Engineering Group Thesis Report*. Master thesis Irrigation and Water Engineering submitted in partial fulfilment of the degree of Master of Science in International Land and Water Management at Wageningen University, The Netherlands.

[5] van den Ham, 2008. *ibid*

[6] Abera, S. and Chukalla, D., 2012. The experience of Spate Irrigation in Aba'ala plains, Afar National Regional State, Ethiopia.