Case study review of investigated irrigation projects in Ethiopia

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Abstract

Within the project "*Impact of Irrigation Development on Rural Poverty and the Environment*" emphasis was given to the rural development of communities performing irrigation. Main goal was to analyze the potential of irrigation development, which should be performed in an environmentally sound way to ensure good living conditions for future generations. Environmentally sound means to maintain soil fertility, water quality, to be concerned about health impacts and maintaining biodiversity.

The starting point for this review is an irrigation database, a classification of irrigation schemes in Ethiopia and the resulting selection of case studies of irrigation schemes. The study aims to support the clarification of environmental factors and processes related to irrigation development. The socioeconomic implications of environmental impacts of irrigation investments such as links to poverty, health and policies and institutions will also be treated. The methods used include field measurements and observations, laboratory analyses, structured questionnaire surveys and PRA.

The investigated field studies performed under the project's specific task "*Assessment of generic environmental and health issues as related to irrigated agricultural development*" are presented. The collected material is compiled and made accessible through a data base. The case studies results are critically reviewed and conclusions for future field investigation are drawn.

Key words: Irrigation development, impact assessment, environmental factors, Ethiopia

Introduction

It is commonly agreed that irrigation intensification contributes to poverty alleviation. Access to water, poverty and people's livelihoods are interlinked (Figure 1). These linkages are both direct and indirect. Direct linkages operate via localized and household-level effects, and indirect linkages operate via aggregate or national level impacts (Hussain and Hanjra, 2004). At the same time, water is becoming a scarce resource in many countries, particularly in Sub-Saharan Africa. This is also reflected in the Millennium goals of the UNITED NATIONS (2005) especially in Goal 7: ensure environmental sustainability. In the project "*Impact of Irrigation Development on Rural Poverty and the Environment*" this was one of the working hypotheses, but set in a wider environmental and socio-economic context.

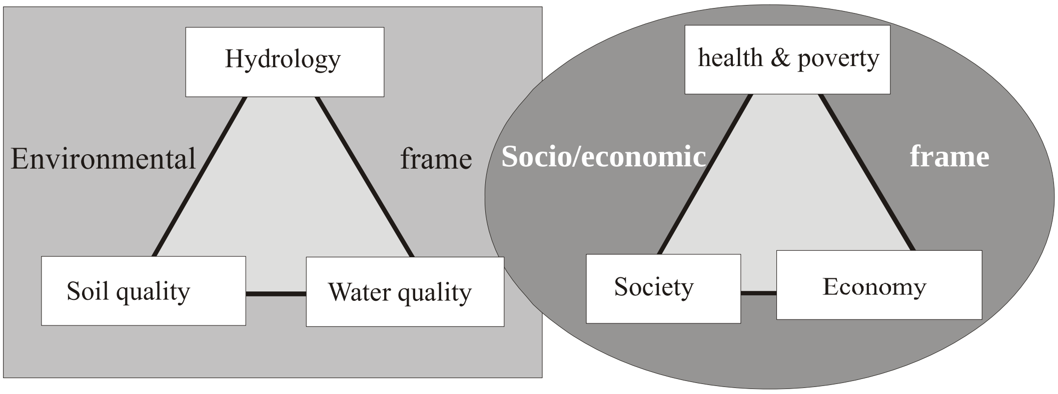

Figure 1: Interdisciplinary frames for case study investigations.

The overall goal is the understanding of impacts of past interventions and investments in irrigation. This will significantly contribute to the planning of new investments and the design of interventions for enhancing agricultural production. Emphasis is given to biophysical aspects such as ground and surface water use, soil quality parameters, land use patterns, nutrient recycling, agrochemical use and its associated risks, and wildlife and agro-biodiversity. The findings of the investigated case studies are of relevance for an improved planning and managing of irrigation and water resources in Ethiopia and other countries with similar climatic conditions, especially in Sub-Saharan Africa.

To quantify the significant positive and negative impacts of irrigation development in Ethiopia the following five specific objectives were defined (Awulachew, 2004):

1) to generate information that can be used to improve the performance of irrigated agriculture and enhance its positive benefits while minimizing its negative externalities,
2) to guide future irrigation investments and fill the gap in knowledge about the total impact of irrigation development on economy, society and environment,
3) to address specific health and poverty alleviation issues,
4) to develop methodological guidelines for assessing the impact of irrigation investment,
5) to strengthen Ethiopian capacity for interdisciplinary research and political implementation.

The assessment of irrigation practices (AIP) has to trigger actions. A prerequisite is the collaborative work with partners, based on their individual roles and mandates. This is supported by an EU sponsored co-project “Dissemination of research results in semi-arid and arid ecosystems with a focus on sustainable water resource management in Ethiopia" (short name WATERMAN). This Specific Support Action (SSA) focuses on analysis and dissemination of research results in sustainable, integrated water resource management at river-basin scale in Ethiopia. The SSA takes advantage from the existing collaborations linking together partners from different regions in Ethiopia and the creation of an inter-Ethiopian-network is supported.

Case study review of irrigation development in Ethiopia

Irrigated agriculture is a priority of the agricultural transformation and food security strategy of the Ethiopian Government. Increased availability of irrigation and less dependency on rainfed agriculture is taken as a means to increase food production and self-sufficiency of the rapidly increasing population of the country. In line with the development policy regional states and NGOs are promoting irrigation development so as to increase and stabilize food production in the country.

Under the 15- year Water Sector Development Program (WSDP), irrigation development subprogram, a total of 1606 small-scale irrigation schemes planned to be implemented mainly for the provision of food requirements (Ministry of Water Resources, 2001). Foreign governments and multi-lateral agencies are expected to co-operate with the government of Ethiopia and Non-government organizations (NGOs) to foster this program. Other non-governmental organizations and communities are also undertaking water resource development activities with the same objective. For example a large number of earthen micro-dams and river diversions have been built in the Awash Basin. Besides the development of new schemes, some traditional systems are also being rehabilitated.

The irrigation scheme classification used in this paper follows the work of Philippe Lempérière who divided irrigation projects in Ethiopia in four groups, (cited by Werfring, 2004):

- Traditional irrigation schemes that have been practiced for centuries by using perennial or seasonal streams. These schemes usually were developed by the farmers themselves without any government involvement.
- Modern communal irrigation implemented by regional governments. Rivers and run-off water, lakes, springs and groundwater are used. Generally modern communal irrigation schemes are more sophisticated than traditional ones.
- Modern private irrigation schemes started in the 1950s initiated by Dutch companies that implemented sugar estates. With the adoption of a market based economy the private schemes re-emerged in the 1990s. Water is mainly from rivers or lakes by pumps or diversions, although some small farms use water harvesting techniques.
- State farms operated by state owned enterprises, such as the Upper Awash Agro Industry Enterprise. Water is abstracted from rivers or lakes by pumps or diversions. Most of the public irrigation schemes can be found in the Awash River Valley.

For detailed studies irrigation schemes were selected and investigations were performed according to the various assignments of the project. The following aims to synthesize the case studies, highlights the main findings and reflects them in terms of the assigned deliverables of the project. Out of 26 project case study sites eight were selected for the environmental impact assessment (Table 1, Figure 2). Included in Table 1 is also a case study outside the project from Dominik Ruffeis (2006c): the Lomi Wuha irrigation scheme, for which the same approach was used. The investigation of Wagnew Ayalneh (2004) was performed at a selected case study site, but not as part of the project. In total 12 case studies, performed by ten investigators from Ethiopia and Austria, are analyzed in this report. Additional information is provided when accessible and relevant. The fieldwork took place at 13 irrigation schemes in three mayor river basins of Ethiopia, with Awash River basin, where most irrigation activities happen, being most prominently represented. The presented case studies are a good sample in terms of different irrigation scheme sizes and management practices.

Table 1. General case study site specification, numbers are given for each individual report, e.g. thesis works or unpublished documents.

Nr	Investigator	Scheme	Basin	Type of irrigation
1	Wallner/Ruffeis	Wonji/Shoa Sugar Plantation	Upper Awash	State Farm/Gravity
2	Wagnew Ayalneh	Doni, Batu Degaga, Markos, Godino	Upper Awash	Modern/Traditional Communal/Gravity
3	Ruffeis	Godino	Upper Awash	Modern Communal/Gravity
4	Damtew	Goha Woriko	Upper Awash	Modern Communal/Gravity
5	Zewdie	Amibara II	Middle Awash	State Farm
6	Ebissa	Ziway Holota	Middle Awash Upper Awash	Modern Communal/Gravity
7	Wallner/Ruffeis	Indris/Guder	Blue Nile	Modern Communal/Gravity
8	Ruffeis	Lomi Wuha (MfM)	Blue Nile	Traditional/Gravity
9	Ruffeis	Finchaa Valley Sugar Estate	Blue Nile	State Farm/Sprinkler
10	Ahmed A.	Finchaa Valley Sugar Estate	Blue Nile	State Farm/Sprinkler
11	Judt	Hare	Rift Valley Lakes	Modern Communal Traditional/Gravity
12	Ruffeis	Hare	Rift Valley Lakes	Modern Communal Traditional/Gravity

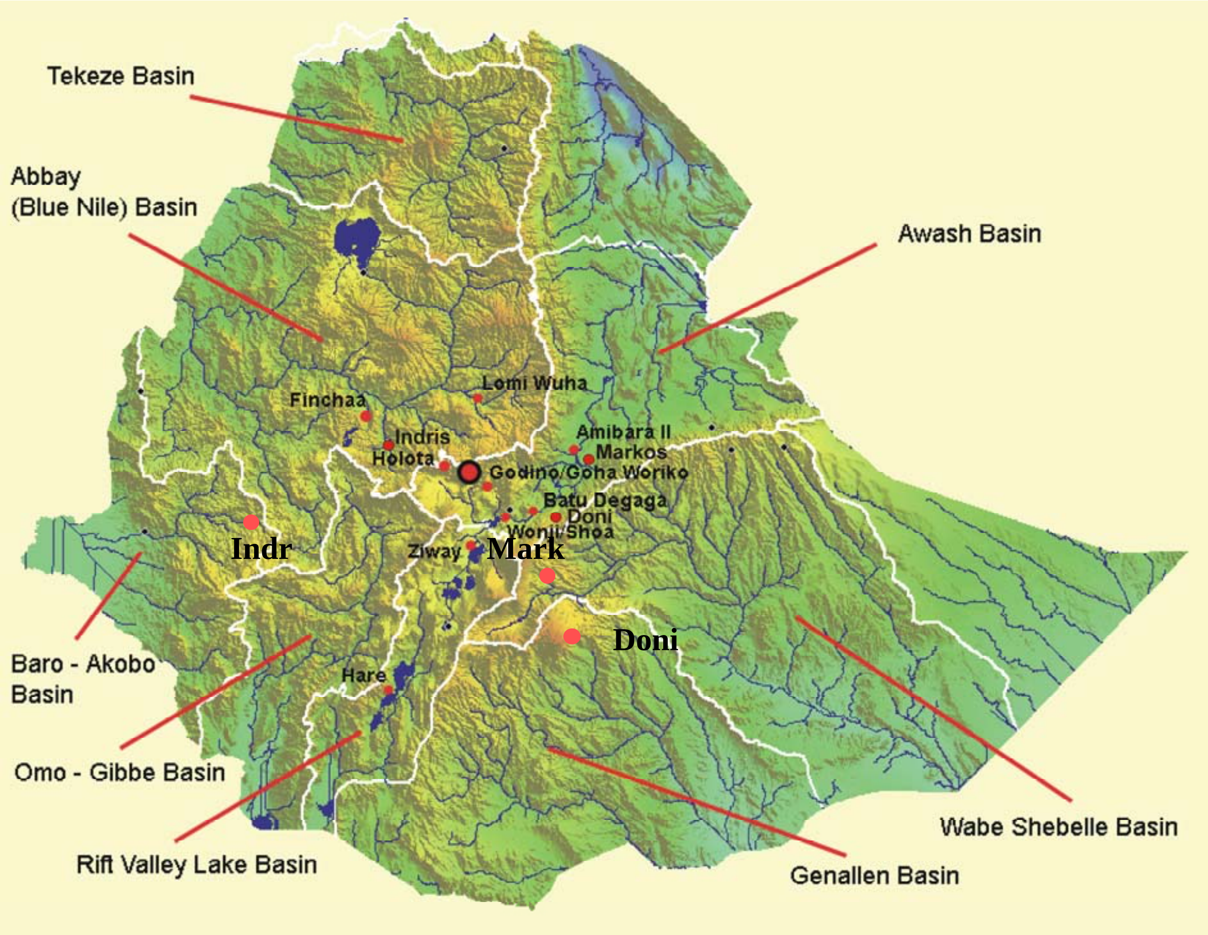

Figure 2: Investigation field site locations

Presentation of field sites and discussion of results

The investigated field sites should be considered in the broader context of irrigation in Ethiopia. The river basin development master plan studies of the Ministry of Water Resources (2001) provide an excellent overview of intervention potential in Ethiopia. Experiences and opportunities for promoting small-scale/micro irrigation and rainwater harvesting for food security in Ethiopia are presented by Seleshi B. Awulachew et al. (2005). Another broad overview of irrigation development in Ethiopia covering all river basins is provided by Seleshi B. Awulachew et al. (2007).

For better comparison of the results obtained at different locations the most important analyzed parameters and the main focus of the respective studies are presented in an investigation matrix (Table 2). The summary of performed work shows a concentration on water and soil analyses in a strong relation to environmental issues. For most of the investigated sites the other aspects of poverty alleviation, health and socio/economic considerations were treated as well or were available from other sources. Further detailed information may be obtained through the cited reports, thesis works and other literature sources.

Table 2. Investigation matrix

Nr	Environment/ natural resources	Water quality	Soil quality	Poverty alleviation/ health	Socio-economic	
1	XX	XXX	XXX		X	Awash
2	XX	X	X	XX	XXX	
3	X	XXX	XXX		X	
4	X	XXX	XXX		X	
5	XXX	X	XX	X	XXX	
6	X	XXX	XXX	XXX[1)]	X	
7	X	XXX	XXX		X	Blue Nile
8	X	XXX	XXX		X	
9	X	XXX	XXX	XXX[2)]	X	
10	XXX	XX	XX	XX	X	
11	X			XXX	XXX	Rift Valley Lakes
12	XX	XXX	XXX	XXX[3)]		

Investigation XXX high, XX medium, X low

[1)] Alemu (2007) & Kibret (2008), both for Ziway only; [2)] Chala (2007); [3)] Mabedo (2003)

As a general characterization of the investigated field sites various climatic data and the elevation, which are also important in relation to health aspects, are presented in Figures 3 and 4. For each irrigation scheme a short description and main results are provided in the subsections below.

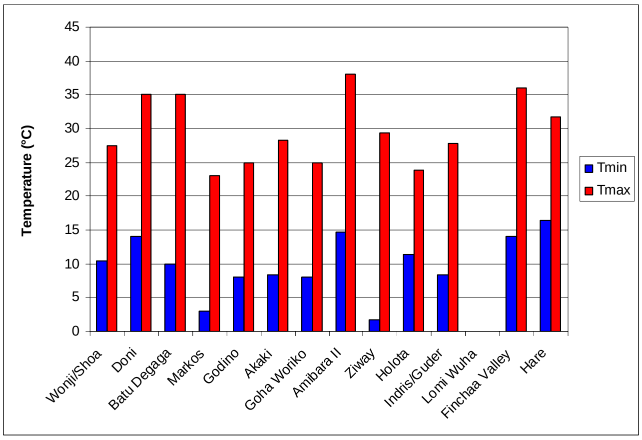

Figure 3: Temperature values of case study sites (NMA, 2006)

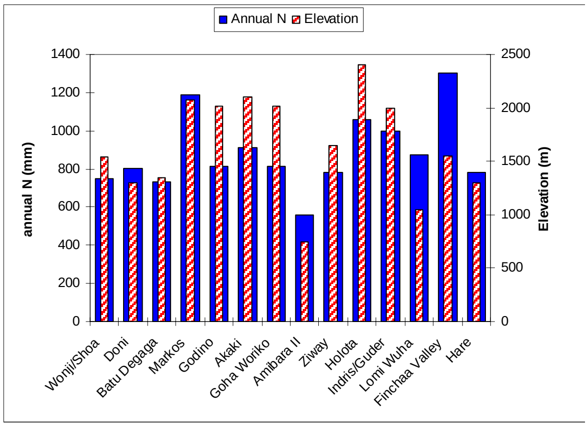

Figure 4: Elevation and annual precipitation of case study sites (NMA, 2006)

Wonji/Shoa Sugar Plantation

The first large public irrigation scheme Wonji/Shoa Sugar Plantation was constructed in 1956 as a private farm by HVA (Handels Vereniging Amsterdam). The sugar production is now subordinated under the authority of a government agency (Ethiopian Sugar Company). The scheme is located about 80 km south east of Addis Ababa, 15km south of the town of Nazareth in the Upper Awash Valley. The irrigation schema has good structures and is visibly well managed. Awash River is the irrigation source of the scheme which is located down stream of Koka dam. Koka dam was originally constructed for hydropower production in 1960. Irrigation water is diverted from the Awash River with electrical pumps and the plantation is managed as a gravity system. Excess water is stored in night storage reservoirs which cover a total surface area of 60 ha. Wastewater from the sugar factory and domestic supply is blended with freshwater and used for irrigation on some of the fields.

The whole irrigated area (6000 ha for the state farm, additionally 1000ha for the out-growers) is drained by a constructed, open surface drainage system.

Girma A. (2005) states that in most sugarcane fields of Wonji/Shoa slight to moderate soil infiltration problems are expected if groundwater occurs at shallow depths. Field observations confirmed that the groundwater depth was at all the times too shallow (in the root zone) for nearly all sugarcane fields considered in this study. Hence in Wonji/Shoa, sugarcane fields are prone to water logging and physical degradation of topsoil (Wallner, 2006; Ruffeis et al., 2007).

Doni, Batu Degaga, Godino, Marko, Goha Woriko - Oromyia Region

The Godino and Goha Woriko irrigation schemes are on both sides of the Wedecha River, located in East Shewa zone, in Oromia region near the town of Debre Zeit about 70 km from Addis Ababa. The schemes are part of a cascade system which includes two earthen dams and reservoirs. The upper dam which is located north of the two schemes Godino and Goha Worko is called Wedecha dam and is the main water source of both schemes. The dam was constructed in 1980 by Kuba Construction Brigade having the Agricultural Development Minster of Ethiopia as a client. Wedecha dam lies at an altitude of 2437 m.a.s.l. and the two schemes on an average altitude of 2010 m.a.s.l (Damtew, 2006).

Wagnew Ayalneh (2004) gathered information at household level on crop production, market and irrigation management. Investigated are four small-scale irrigation schemes, namely Doni scheme from Boset woreda, Batu Degaga scheme from Adama woreda, Godino scheme from Ada Liben woreda and Markos scheme from Wolemera woreda. The selection was based on accessibility, experience and type of scheme. 240 farmers were selected from the respective peasant association (30 irrigators and 30 non-irrigators for each woreda). The total population of irrigators and non-irrigator farmers of the four peasant associations are 627 and 3207 respectively.

The study of these small-scale irrigation schemes in the Awash Basin revealed some factors that are important for the successful implementation of small-scale irrigation schemes. The system of furrow irrigation, which is practiced in most of the schemes, has high labor demands and hence some farmers practice a flooding system. This will aggravate erosion especially in sloping plots. High electricity, repair and maintenance cost of pumps in Batu Degaga showed that electric powered pumps might be too costly for smallholder farmers (Ruffeis, 2006a). Systems that require less cost like gravity diversion systems should be looked at seriously. In the analysis of the schemes it has come out clearly that small-scale irrigation projects built or upgraded by NGO’s and government are often handed over to the farmers without proper completion of construction or technical training and without proper management establishment. This creates problems at such schemes as farmers are left with the understanding that the government or the NGO are still responsible.

Amibara II

Amibara Irrigation Project II is located in the south-eastern flood plain of the Awash River 250 km away from Addis Ababa, in a typical semi-arid agro ecological zone with an extensive pastoral production system based on with camels, cattle, goats and sheep. In 1980 the Amibara Irrigation Project II (AIP II) was established and production is mainly focused on cotton for foreign markets. Socioeconomic and environmental data were collected through informal discussions with the local community elders who were relocated from their original living area due to the irrigation development (Zewdie, 2005). Changes in the living conditions (social and cultural settings) of the rural Afar people were recorded. In addition to the survey data, secondary data on surface and ground water hydrology, production and land productivity, and primary data on soil physical and chemical properties were collected.

In this system the irrigation development considerably contributes to the local economy through establishing profitable enterprises and improving the livelihoods of thousands of people (mainly migrants who newly settled in this area) through providing job opportunities and good income. On the other hand diminishing livestock holding forced the rural pastoral community to lead under subsistence lives and some of them to migrate to towns in search of work. So the total contribution of the irrigation development in improving the livelihoods (income) of the native community of the area is none, even negative.

Ziway and Holota

Ziway is located 170 km from Addis Ababa on the way to Awassa. At Ziway, the study was carried out in the peasant association (PA) called Edo-Gojola, which was established in 1992 by SEDA (Selam Environmental Development Association). The total command area of the scheme is 2440 ha whereby only 32 ha of the farm are currently operational. Water for irrigation is diverted from Lake Ziway using motor pumps and distributed to the fields by gravity (Ebissa, 2005). Rainfall is not satisfactory and as a result low yields have been recorded that need to be supplemented with irrigation.

Holota is situated approximately 45 km west of Addis Ababa. At Holota the study was carried out in the Misrak-Shola-Ber peasant association (PA), which was established before 1971. The total irrigated area is 90 ha (Ebissa, 2005). The water source of the scheme is Holota River. The irrigation water is diverted from the river and distributed to the fields using gravity. The total area of the site is 680 hectare of which irrigation occupied 90 hectare. Clinical data from the health center data and a questionnaire were used to generate additional information.

Technical skills and innovative irrigation technology are absent in these two schemes. Both irrigators and non-irrigators use similar types of land management techniques (traditional technology). Some irrigators were found to increase their production by expanding land size and changing to other land uses while they might have better improved their poor land's condition through intensified management. Provision of training to empower farmers with new land management techniques is crucial. There is a need to have alternative water sources to alleviate the water shortage problem at Ziway and Holota. Land ownership and land use policies are very important as these determine the productive lifespan of the land through the type of investment farmer make in land management.

The overall study indicates that community-based irrigation schemes are more feasible at highlands (Holota) than at lowlands due to health impacts and water and soil deterioration, probably linked to the original water quality of the source. Improving the local supporting infrastructure such as health centers, transport, input supply institutes and credit organizations would greatly help to contribute to the sustainability of the systems. An EIA with the active participation of the whole community on the onset of the project could have removed or at least minimized the negative impacts of the irrigation scheme observed on health, environment and social conditions.

Indris

The Indris irrigation scheme is located in the western Shewa administrative region of Ambo Awraja, about 110 km west of Addis Ababa and about 10 km west of Ambo near the town of Guder. The scheme was established in 1985/86 to produce vegetables on approximately 400ha of land using irrigation (Halcrow & partners, 1989). In 1991 further plans had been made to modernize the irrigation scheme as the old structures like the weir, flumes and the channels were in poor condition and partly damaged (OIDA, 1991). Since about 1995 the command area of the system is approximately 1000ha. The whole irrigation system is divided into several smaller irrigation schemes situated along Indris River, which is its water source. The water of the investigated schemes is diverted by two different dams situated about 10km and 2km south (upstream) from Guder, respectively.

Severe downstream impacts of irrigation have been noted under low flow regimes (Ruffeis, 2006b; Wallner, 2006). In the dry periods practically the whole discharge is diverted from the river into the irrigation system. Directly after the diversions only water seeping through the diversion dam supplies the riverbed. Tributary rivers of Indris are providing the discharge for the second river diversion.

Lomi Wuha

This case study site is located in Merhabete district in Northern Shoa zone of the Amhara Regional State about 180 km north of the Addis Ababa. The topography of Merhabete is predominated by two valleys formed by the Jema and Wenchit Rivers. The infrastructure of Lomi's irrigation scheme is very basic. Three springs or spring areas are used as water source for irrigating the farmland. The water is collected in natural basins and is diverted with two earth canals supplying different parts of the scheme. The size of the command area of the system is approximately 24 ha and on-field water distribution is done with furrows.

Main hydrological impacts result from reduced run-off water, but there are no downstream users (Ruffeis, 2006c). A conflict appears between the destruction of natural vegetation in the adjacent spring area versus food security in the region. Soil conservation and protection against erosion and land degradation is provided through irrigation because of a permanent vegetation cover. Soil physical analysis results compared with parent material may explain the different soil types within the area.

Finchaa Valley Sugar Estate

Finchaa Valley is located about 330 km west of Addis Ababa in the western part of Ethiopia, eastern Wollega zone in Oromiya region. In 1975 the state farm was established that mainly produced food and commercial crops until 1991. Starting from 1991 up to now more than 8064 ha of land has been cleared and irrigated for sugar production (Ahmed Amdihun, 2006). The water source is the reservoir of Finchaa Dam (Lake Chomen) initially built for hydropower production. 25 pumps at 5 pump stations divert the water serving 34 % of the command area. 66 % of the area is irrigated using gravity off-takes at 3 locations. The Finchaa Valley Irrigation System is equipped with sprinkler irrigation devices.

Observations made during the field visit indicate that the obvious malfunction of the waste water treatment plant of the sugar factory poses a threat to downstream water bodies, especially to Finchaa River and its ecosystem. The project opened up large scale job opportunities for many thousands of people. It has also many socio-economic benefits for the valley and surrounding people. In addition Finchaa Sugar factory plays a key role in addressing the current sugar demand on the local market. There are many efforts to exploit the by-products of the factory for additional purposes like using ethanol for fuel. The estate has also an important role in the growth of national GDP and GNP (Ahmed Amdihun, 2006).

The analysis of measured water parameters at different dates shows no significant differences (Ruffeis et al., 2007). The soil degradation is in its early to moderate stage and not difficult to be addressed by alleviation measures. No further adverse impacts are to be expected caused by the water source, though malaria transmission seems to have increased because of the irrigation (Chala, 2007).

Hare

Hare River irrigation schemes are located in the Gamo Gofa Zone, in the Southern Nations and Nationalities Peoples Regional State of Ethiopia (SNNPR), about 495 km south of Addis Ababa. The irrigation systems are located between the shore of Lake Abaya and the escarpments of the highlands. Hare Irrigation System comprises three different irrigation schemes with a total irrigable area of 2224 ha belonging to four kebele administrations, Kola Shara, Chano Mille, Chano Chalba and Chano Dorga. The three irrigation schemes use Hare River as water source but have to be classified differently due to differences in abstraction and delivery structures (Ruffeis, 2006d). Chano Dorga can be classified as traditional. In the case of Kola Shara a traditional delivery system is used to allocate the irrigation water that is diverted from Hare River by a modern diversion structure. Chano Chalba and Chano Mille can be classified as modern.

Farmers complain about insufficient amounts of water for irrigation. The cause is decreasing rainfall over the last decade in the highlands, which minimized the discharge of Hare River and therefore the availability of irrigation water. The mentioned problems related to the high variability and low availability of water disproportionally affects farmers having their farmland located at the tail end of the scheme. In order to solve these allocation and availability problems one possible solution could be the construction of a reservoir to store the run-off water of Hare River (Judt, 2007). On the other hand this might have severe impacts on the hydrology of Lake Abaya, due to a reduction of annual inflow rates. The options for design and water management to control malaria in this region were investigated by Ashenafi Madebo (2003).

Summary of irrigation development impacts on the environment

From the results a standardized sampling procedure such as checklists and guidelines for field work could be developed for future investigations. Standardized does not mean that the investigations are exactly the same in each site, but that the results are presented in an easily comparative way. An example of a checklist applied at the fields sites of Wonji and Indris was provided by Wallner (2006) in her work.

Most important general findings for locations with similar conditions are summarized in Table 3. In this table a picture of the project investigations is provided and hence we do not claim it is complete. Still it may serve as a starting point for sharing knowledge and experiences. The impacts shown are the challenges for the future and need to be considered in irrigation planning and management activities. The more we know the more we can optimize our interventions for the benefit of poor people.

Table 3: Impact matrix of irrigation development on the environment and health

Nr	Scheme	Basin	Hydrology/ natural resources	Water quality	Soil quality	Poverty alleviation	Others
1	Wonji	**AWASH**	Rising water table, Seepage of reservoirs	Slight EC increase	Water logging Infiltration		Heavy machines
2,3 4	Oromyia		Inefficient water use (except Marcos)	Stagnant water	Salinity	Marketing, poor access to health facilities	Need for education, management Water conflicts
5	Amibara II		Flood hazard, degradation	Linkage with Lake Beseka (very high sodium cont.)	Salinity	questioned	livestock, Negative Social effects
6	Ziway Holota			Toxicity	Salinity Permeability increase	Malaria, Market access	New plant diseases, training
7	Indris	**BLUE NILE**	Water diversion		Risk of water logging Low fertility		detailed soil sampling needed
8	Lomi Wuha		Erosion risk		Nutrients deficit, alkaline		
9, 10	Fincha		Destruction of Ecosystem	Low EC	Low organic matter, Infiltration	Employment possibility vs. destruction of ecosystem, Malaria	Impact of sugar factory on downstream water body
11, 12	Hare	**Rift Valley Lakes**	Degradation, erosion, deforestation	Water logging	Low organic matter	Malaria, questioned	

Conclusion

The assessment of irrigation practices (AIP) claims not to be a new method, but tries to take advantage and adapt existing practices for irrigation projects. A step forward to quantify the significant positive and negative impacts of irrigation development in Ethiopia was achieved and the risk assessment of future irrigation investments is supported. The development of methodological guidelines for assessing the impact of irrigation investment has started. The knowledge of the total impact of irrigation development on economy, society and environment could be substantially improved. Health and poverty alleviation issues have been addressed to some extent. Data sheets and concepts for field investigations are developed and applied at field sites. Standardization of the assessment of irrigation practices and field investigations is especially useful for designing fieldworks and the comparison of results. The development of guidelines for decision makers, planners and farmers depends on standardized methodologies and procedures.

Integrated multi-purpose water utilization for irrigation has to be considered. This increases the demand for good management and the awareness of possible conflicts that may arise due to competing interests. Efficient use of irrigation water is required to avoid water loss and to control vector breeding and water-related diseases. Well planned and maintained small-scale irrigation schemes are a contribution to economic development through increased incomes, employment creation and food security. Negative environmental effects could be minimized. Salinity and its mitigation measures are a mayor concern. Large scale irrigation schemes show mostly a better management and maintenance, but are at risk of more negative environmental impacts.

A major challenge concerns the application of hydrological research for surface and groundwater resources development and management, surface water harvesting and its effect on groundwater recharge with implication to the conjunctive use of water resources. Infrastructure and market access of is a key feature of the success of an intervention. Other issues like improves health care, improved communication or a rural credit system could also support the development of rural areas.

The role of universities is to connect research and education, to share and support partners in the southern hemisphere, which is clearly visible by the “work force” named in this report. The importance of education to improve livelihood and food security is not questioned. Education in this context must reach out to all stakeholders involved in irrigation practice. Especially education and training in water management, marketing and general crop production is of high important. Finally it is believed that this project provides a contribution to strengthen Ethiopia’s capacity for interdisciplinary research and political implementation.

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