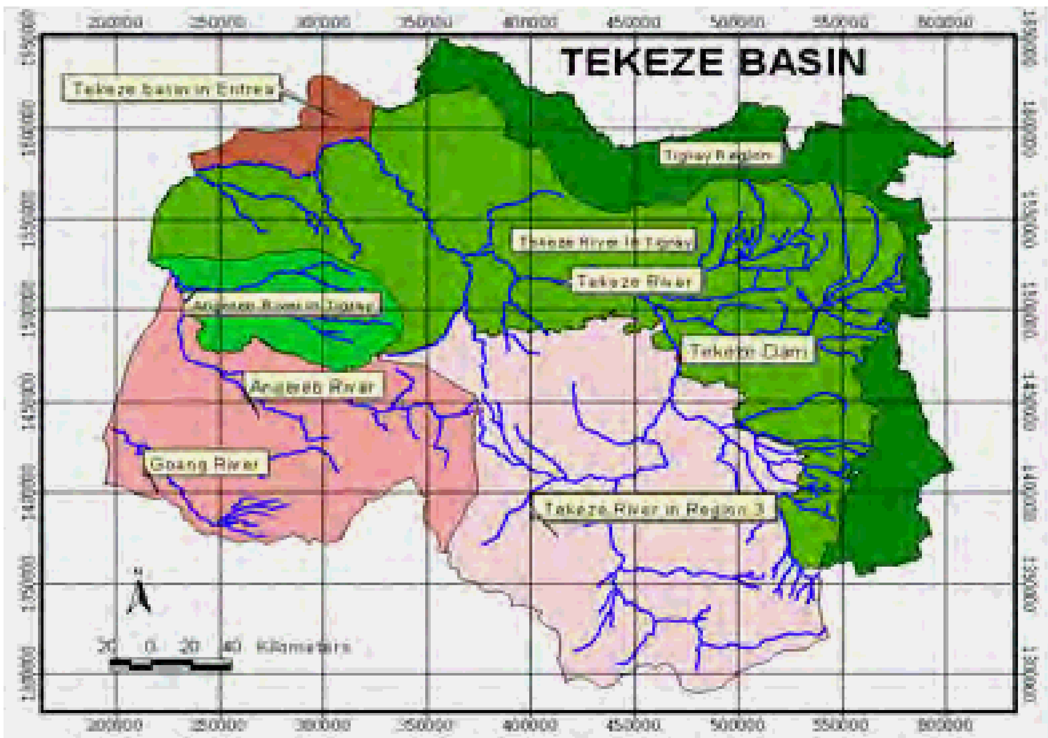
Productivity of Water in Agriculture and Interacting Systems: Approaches and Options for Eastern Africa (a case study in Tekeze basin, Ethiopia)

Collaborating partners: SUA (SWMRG), ICRISAT,
ODG – UEA, and MU



ANNEX 1B

INCEPTION REPORT

Part - Mekelle University
CA –IWMI program

Prelude

Of the few awards of the IWMI - (CA) comprehensive assessment of water for agriculture program, PWAIS (productivity of water in agriculture and interacting systems) was selected to enjoy funding.

PWAIS partners (Soikoine, ICRISAT and ODE) visited Mekelle University during 05 April and 08 April 2004 to develop the detail research protocol and select experimental site for the Ethiopian part of PWAIS project. The visit helped us to discuss the concept of water productivity, review research methodologies and develop work plan.

This report presents the outputs of the planning meeting. The report provides a background to the context under which PWAIS will be conducted in Ethiopia. The last part gives details of the methodology and work plan that will be followed in implementing the project.

1.1 Facts and Figures about Ethiopia

Ethiopia, with a total population of 60 million, lies between 5^{0}45' to 15^{0}N latitude and 31^{0}25' to 48^{0}35' E longitude, having an altitude ranging from 180 m below sea level to 4620 m above sea level. The total geographic area of Ethiopia is about 112 million ha, of which 66 % is estimated to be suitable for agriculture. At present, only 14.8 % of the total land is under cultivation of annual and perennial crops. The potential irrigable area is estimated to be 3.5 million ha; to date only 5 % of this potential is utilized.

Ethiopia has abundant water resources that can be used for irrigated agriculture. There are nine major rivers (7000 km long) and a number of lakes (7400 km^2 in area). Because of this, the country is often referred to as the "water tower" of northern Africa. The country's total surface water availability is estimated to about

110 billion m^3. On the other hand, the nine great river systems have an estimated annual discharge of 102 billion m^3.

Although the country lies within the tropics, temperature ranges from a mean annual of above 30 °C to a mean annual of below 10 °C. There are two rainy seasons in Ethiopia. These are short rainy season (locally called Belg) during February to April and main rainy season (locally called Meher) covering the months of June to September. Rainfall ranges from 2200 mm in the south-west, decreasing to below 100 mm in all coastal plains.

1.2 IRRIGATION IN ETHIOPIA

Irrigation development in Ethiopia has long history. Small-scale irrigation started before 2000 years. In terms of irrigation potential, there have been different estimates and the issue has not been satisfactorily resolved. One of the earliest estimations was made by the World Bank (1973), which suggested a figure of between 1.0 and 1.5 million hectares. The International Fund for Agricultural Development (IFAD 1987), on the other hand, gave a figure of 2.8 m, while the Office of the National Committee for Central Planning (1990) estimated about 2.7 m. WRDA's river basin level estimates are given on Table 2.

Table 2. Irrigation potential at basin level

River Basin	Irrigable Land (ha)
Abbai	760,000
Tekezze	200,000
Baro-Akobbo	600,000
Gibe-Omo	250,000
Rift Valley (Lakes)	50,000
Genale-Dawa	300,000
Wabe Shebelle	355,000
Awash	185,000

Total	*2,700,000*

WRDA's Estimate of Irrigation Potential (1986)

Currently, the total land managed under irrigation is about 190,000 ha and concentrated in the Awash valley, which accounts for 48% of the total water managed area and 92% of the large schemes built before 1990.There are three types of irrigation schemes:

- Small-scale (63,581 ha): smallholder projects for a single peasant association and up to 200 ha in size, for which assistance in development or improve-ment is carried out on a self-help basis, eventually with support from the Ministry of Agriculture. About 359 000 farmers are involved in traditional small-scale irrigation.
- Medium-scale (41,917 ha existing and 2 920 ha under construction in 1990): schemes between 200 and 3 000 ha, extending beyond one peasant association, and requiring a greater degree of government assistance in development, provided through the Water Resources Development Authority (WRDA). At first intended as self-help, low-cost developments, they were later modified to include commercial production (coffee, sugar or cotton).
- Large-scale (46,328 ha existing and 34 810 ha that were under construction in 1990): centrally managed state farms for commercial production, and covering 3 000 ha or more, to be planned and designed by WRDA and constructed under its supervision. It is difficult to assess the area actually irrigated in Ethiopia. Some schemes have been damaged and are currently not operational. Some other schemes, built and managed by the Producers' Cooperatives but not used by the farmers, who mostly did not want to join these cooperatives, are deteriorating.

1.3 Irrigation Experience

Although irrigation has long history in Ethiopia, the traditional small-scale schemes are simple river diversions. The diversion structures are rudimentary and subject to frequent damage by flood. 'Modern' irrigation was started at the beginning of the 1960s by private investors in the middle Awash valley where big sugar estates, fruit and cotton farms are found. With the 1975 rural land proclamation, the large irrigated farms were placed under the responsibility of the Ministry of State Farms. Almost all small-scale irrigation schemes built after 1975 were made into Producers' Cooperatives.

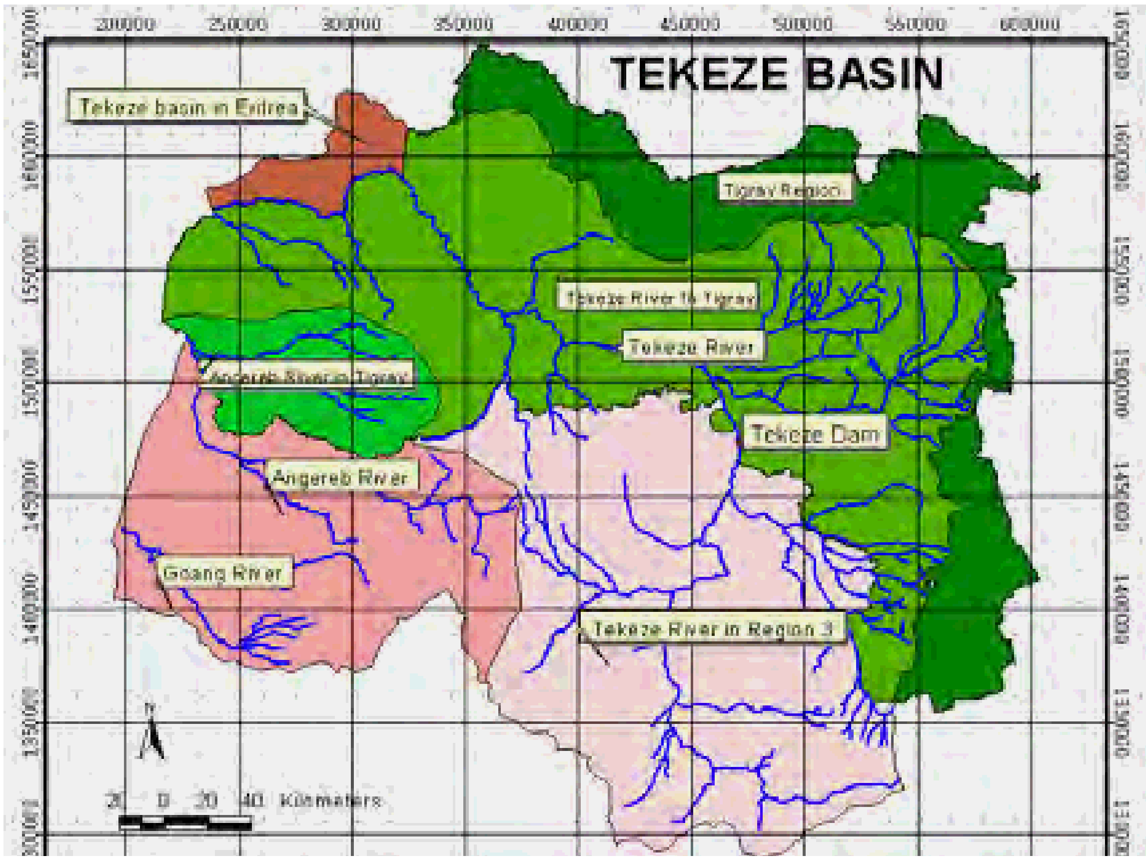
Over the last decade government agencies and NGOs have intervened to develop new irrigation schemes and improve the indigenous irrigation schemes by constructing more stable hydraulic structures.

1.4 The Tekeze basin

The Tekeze River commences from the highlands in the south and drains central, southern and a larger portion of western Tigray westward to the Nile. The length of the Tekeze River from its source down to the Sudanese border is more than 600 Km. The basin has an average elevation of 1,850 m above sea level and a catchment area of about 68,000 km2. About 70 per cent of the basin lies in the highlands at altitude of over 1,500 m above sea level. The upper reaches of the Tekeze are surrounded by mountain ranges, the elevation of which is over 2,00 m above sea level, attaining a maximum altitude (4, 620 m above sea level) at the mountain of Ancua, part of the Ras Dashan system. The area of land above 2, 000 m elevation covers almost 40 per cent of the total basin area.

The lowlands are found in a strip of land of about 150 km long and 30 to 100 km wide along the Sudanese border. Here the elevation varies between 500 and 1000 m above sea level. In the western section, the topography is almost flat or slightly undulating, becoming more and more undulating to the east. The lowland region of the river basin includes about 5 000 km^2 of almost flatlands, of which 3, 500 km^2 to the north of the Tekeze river forms the wide plain from Guluj to Omhager, which is located in Eritrea. The remaining 1, 500 km^2 is located to the south of the river in Ethiopia.

Figure 1 Tekeze River Basin



Source: MoWR/NEDECO. Tekeze Master Plan. 1997

The importance of irrigation in the Tekeze basin has been recognized many generations back according to members of the indigenous irrigation schemes. Field observations made in most part of the basin show that almost all of the available perennial surface water source is used for irrigation, except those found in deep gorges, as of many decades back. In Tigray alone, the total area irrigated by 2002 was 4773ha or 0.44% of the total arable land (BOANR, 2003). In some unpublished reports the total irrigated area is stated as 6500ha. The fluctuation in size of irrigable area from one year to the other could be due to the drying of the water source following drought or shortage of rainfall.

Over the last decade government agencies and NGOs have intervened to develop new irrigation schemes and improve the indigenous irrigation schemes by constructing more stable hydraulic structures. As yet, a total of 56 irrigation schemes with a potential irrigable area of 3845 ha have been designed and constructed by COSAERT alone. But, very little has been done in improving the agronomic and water management practices. Thus, more work is still required to maximize benefit per unit volume of water.

1.5 SITE SELECTION WITH IN THE TEKEZE BASIN

Soikoine, ICRISAT and ODE partners visited MU during 05 April and 08 April 2004 to develop the detail research protocol and select experimental site for the project. The visit helped us to discuss the concept of water productivity in Ethiopia, review research activities and methodologies and to develop work plan.

During the first day the members are briefed on the field visit programs and the establishment of Mekelle University by Dr. Mintesinot Mehailu, vice president of Mekelle University. Campus tour was also made in the same day.

Three potential sites were chosen for the project; namely Haiba, Gindae and Teghane. During the visit, the first reservoir was dry and no irrigation at the moment, except the 6 ha irrigable land in the downstream reach mainly using water from the small stream running bordering the command area and with small supplemental irrigation from the reservoir before it dried up. The second and third site visited were Teghane micro dam where a number of irrigation activities are going on. In this dam it was seen the crops under irrigation and farmers in action doing irrigations. The participant also made discussions with some farmers in order to get primary information.

This visit opened the eyes of the participant for the next day discussion and familiarize them the kind of irrigation done using micro dams, the crops under irrigations, the types of irrigations used, livestock situation and other technical and social problems with regard to using water harvested from micro dams for irrigation.

The fourth day was dedicated to brainstorming discussions. The discussion points were:

1. Concept of water productivity
2. Methodology to assess PWA in Ethiopia
3. Work plan and output

1.5.1 PWAIS concepts in Ethiopia and Tanzania

There are some slight differences between PWAIS concepts in the Ethiopia and Tanzania. In Ethiopia the research is on micro dams where water is stored in the reservoirs and used for irrigation. Raising irrigation water productivity helps to increase the existing irrigable area and to achieve high crop productivity and these helps to bring food self-sufficiency in the study area. On the other hand, PWAIS in Tanzania is to enhance irrigation water productivity so that water can be freed to other sub sectors. But water stress is a common agenda in both countries.

Even if there is a site-specific difference between the two countries, with regard to the way irrigation is practiced, the overall objective of the project is the same in both countries. Hence during the discussion it was agreed that PWAIS works can be done parallel both in Ethiopia and Tanzania. Even if, the initial assumption is to pilot test the best options from the Tanzania in Ethiopia, there is a fear that what is best in Tanzania may not be best in Ethiopia.

The first issue raised was the reconstruction of base line information on the micro dams to compute the 'before' and 'after' scenarios of water productivity. The second important issue was the delineation of the boundary of the study where PWA to be assessed in the river basin.

A number of issues were raised as to we can assess water productivity in micro dams in Ethiopia in the different sub sector: agriculture, livestock. The following were identified as checklist by dividing the sturdy site into three: catchment, reservoir and command area.

1.5.2 Hydrology of the catchment

Input variables

- Land use
- Rainfall (from rain gauge installed)
- Stream entering the reservoir (top map)
- Evaporation and evapotranspiration (from long time record)
- Previous rainfall and runoff study
- Water harvested in the reservoir (long time record and reading the gage in the reservoir)
- Primary canal flow (weir, flumes or floating method)
- Spillway flow (gauge/ observation)
- System outflow (surface and seepage outflow)- stage discharge
- Dam (evaporation from water body)

Output

- Water balance in the sub catchment

1.5.3 Water productivity (In the catchment, reservoir and in the command area)

In the catchment

- Rainfed agriculture (production)
- Livestock
- Fuel wood
- Other biomass production
- Other natural resource livelihoods gains (e.g. honey bee.)
- GPS survey
- Mapping villagers

From the reservoir

- Fishing
- Drinking (livestock and humans): this includes water used from the reservoir and filtered water from downstream of the dam using boreholes
- Environmental (ducks swimming in the area, micro climate created in the area, malaria)
- Wildlife
- Fro the villagers (washing and swimming)
- GPS survey

I**rrigated command area (**Full irrigation, Supplemental irrigation, Rainfed)

- Agricultural crops (grain)
- Crop residue
- Forage crops
- No. Of household supported
- Land out of command
- Cropping pattern (type, sequence)
- GPS survey

1.5.4. Data collection methodology

- Both Random, group and detail survey will be conducted to access the data required for assessing productivity of water

- Actual measurement and through questionnaire

1.5.5. Sampling

- Depending on the time available it will be tried to select representative samples, to accommodate more variability. Wealth ranking can be done to see the different input use, because input use mainly depends on the wealth status of the farmers. The data to be collected includes both primary data (Actual measurement and through questionnaire) and secondary data. There is also a practice of collecting yield from sample key farmers by the bureau of agriculture, such types of data can also be taken a primary data for t he study.

1.5.6 Detailed data to be collected:

In the catchment under Rainfed agriculture

- Area under different crop
- Total yield (grain and biomass)
- Farmers interview
- Observation
- Bureau static's
- Sampling size
- Other questions on crop husbandry
- Farm type
- Crop type
- Soil type
- Wet or dry year
- Price of crop (wet and dry season)

Livestock

- Number of livestock in the catchment and command area in the different months and their time of stay (through household livestock survey)
- Livestock density in the region
- Carrying capacity (T.L.U/km2 –per mm of rainfall)
- Household livestock survey + range survey
- Water uses for dry and wet seasons (drinking, lit/day)
- Daily feed requirement
- T.L.U, KG and price

How to assess PW in livestock sector

- By calculating the amount of water consumed by the livestock?

- Or by knowing the amount of water used to grow grass?

Fuel wood and biomass

- Literature review of rainfall –biomass relation for livestock
- H.H survey (kg/ha) – total biomass from the catchment and command area

1.5.7 In the reservoir

- All uses through observation, H.H survey, literature review
- Drinking (m3/day, lit/p/day)
- Value of water

- Selling
- Willingness to pay
- Payment to collect/ or payment saved
- Opportunity cost

1.5.8 In the command area

Technical survey

- GPS survey to know and map area under different crop and to deduct land out of command if available- it has to be done once per crop season (full irrigation, supplementary irrigation, pure rainfed) – reading will be taken on crop belts
- Cropping pattern of the different practices
- Intensity of irrigation
- GPS on the canals and branch points
- Inputs
    - Fertilizer
    - Agro chemicals
    - No. Of irrigations per crop type
    - No. Of Hours of irrigation per crop type
    - Labor operations

- Flow rate of main, secondary, tertiary and field canal (flumes and floating method)
- Yield (grain and biomass)
- Price of crop (formal market and informal for the wet and dry season)

Social survey

- WUA's
- Institution interaction
- Sharing water (water distribution pattern)
- Drought decision making
- Mapping problem

2. Options in improving productivity of water

If the above variables are collected and the farmers practices are observed closely, it may help us to identify the major production constraints in the selected sites. When we come to the irrigated lands of the Tekeze river basin, salinity is of the major challenge, hence overcoming this big challenge is one option for increasing the level of water productivity in the basin.

Other options:

- Increasing the area under irrigation
- Water saving
- Fertility management
- Price of products
- Idea sharing between different kinds of farmers, different kinds of expertise
- Mapping problem during social survey

- Salinity problem
- Pests
- Input (seed, fertilizer, labor, technical
- Climate variability
- Water shortage
- Land problem
- Etc.

And if all these ideas are collected and discussion made through workshop/meetings, it is possible to identify or look for the options.

2.1 Visited sites and existing situation

1. Hayba microdam

This is one of the largest irrigation schemes in the basin and cultivating at the moment more than 200 ha of land with different combinations of crop from cereals (maize, wheat, barely), vegetables (onion, potato, tomato, paper). The site also has automatic rain gauge installed and water level indicator inside the reservoir. This dam was located in the mid altitude zone with elevation around 2200m a.s.l and the site was accessible and near by to the university around 50 km.

2. Tegehane microdam

The climate and the cropping pattern is almost the same as that of Hayba, except that this one represents typically the high land part of the river basin (around 2700 m a.s.l.). At the moment the area under irrigation is around 100 ha. As a result of the seepage water from downstream of the dam this area was wet and supports a number of livestock. This site was around 80 km from the university.

3. Gindae microdam

This dam contains no water at the moment, and it has littlie irrigation history as compared to that of the other irrigation schemes, except the 6 ha which was irrigated

Taking in to consideration the time and resource availability it was agreed to conduct the study on one of the three micro dams visited. With through discussions and seeing the specific site condition and the advantages with regard to accessibility and availability of existing rain gauge stations and a gauge to record water level in the reservoir it was to decided to select Hayba as a study sites for PWAIS in the Tekeze river basin in Ethiopia.

3. Conclusions

From the raid reconnaissance survey made on the three microdam sites, only the Hayba microdam was selected for the PWAIS project on the basis of agro ecology, availability of secondary data and accessibility to the sites. The site is located in the more representative sub basin of the major Tekeze river basin. Information on the selected irrigation scheme is available at the following offices (BOANR, SEART & REST). It was agreed to go in action immediately so that the needed data can be collected before the irrigation seasons ceases.

4. Work plan

For the Irrigation season: February –June, and for wet season: June – October the following tentative plan was drawn

Type of work	From	To
Selection of the study sites	Mar.	April
Studying hydrology of the catchment:	April	June
Description of the irrigation schemes	April	June
Identifying Methodological Tools Used to Assess Productivity Of Water In Agriculture.	April	May
Assessing the level of Productivity of Water • Under irrigation • Rainfed condition	April June	June September
Identifying Options In Improving Productivity Of Water	Sep.	October
Identifying Promising Approach To Disseminate PWA Ideas.	April	September
Data processing and report writing	Sep.	October

5. List of participants

No	Name	Profession	Position	Institution	E-mail address
1.	Dr.Mintesinot Behailu	Irrigation water management	Vice President for Academic and Research	Mekelle university, Ethiopia	Muc.rug@telecom.net.et
2	Prof. Henry Mahoo	Hydrologist	Professor	Sokine University of Agriculture, Tanzania	hmahoo@suanet.ac.tz
3	Dr.Bruce A Lankford	Irrigation and water resource	Lecturer	University of East Anglia,UK	b.lankford@uea.ac.uk
4.	K P C Rao	Soil scientist	Senior soil scientist	ICRISAT - Nairobi	K.P.Rao@cgiar.org
5	Dr.Nata Tadesse	Ground water engineer	Assistant professor	Mekelle University	Tafesse24603@yahoo.com
6	Zakaria J. Mokoga	Agricultural engineer	Agr. Researcher	Shardi Uyole, Mebeya, Tanzania	mkogazi@yahoo.co.uk
7	Abiot Legesse	Irrigation engineer	Assistant lecturer	Mekelle University	aboit66@yahoo.com
8.	Mohamed Abubakar	Irrigation engineer	Lecturer	Mekelle University	
9	Atinkut Mezgebu	Agricultural engineer	Assistant lecturer	Mekelle University	atinkutM@freemail.et

Members of the research team at Mekelle University

Dr. Mintesinot Behailu (leader, agrohydrologist)

Dr. Nata Taddesse (Researcher, ground water specialist)

Mohammed Abubeker (Researcher, Surface water hydrologist)

Abiot Legesse (Junior researcher, irrigation Enginneer)

Atinkut M (Junior researcher, Agricultural Engineer)

REFERENCES

- Mintesinot B. Verplanacke H. Vanranst E. & H. Mitiku. 2003. Examining traditional irrigation methods, irrigation scheduling and Alternate furrow irrigation on Vertisols. AGWAT 1855 1-11
- Mintesinot B. & Mitiku H. 2003. Water harvesting experiences in Tigray (Northern Ethiopia). (In press)
- MoI.2002. EFDR Government rural development policies and strategies. MoI, press and audiovisual department.
- MoWR, H. Halcrow. 1989. Master Plan for the development of surface water resources in the Awash basin.
- MoWR, Walta. 2001. Water resource development and management in Ethiopia. Proceedings of a panel discussion.
- REST. 2000. Studies on Traditional Irrigation System in Tigray. Concert Engineering. Mekelle.
- Rongfang.L, Dagen.X, Junzu.X. 1996. Final report on medium and large scale water resources and irrigation development in Giba and Rama basins of Tigray. COSAERT. (unpublished).
- UNDP/ECA/FAO. 1994. Sustainable agriculture and environmental rehabilitation in Tigray (SAERT), Working document. ECA.
- Yigzaw H. 1998. Case on Causes of harvest failure of dams bordering the eastern escarpment. (Unpublished).