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THE ETHIOPIAN WHIST PROJECT – AN INSTITUTIONAL STRENGTHENING CASE STUDY

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LE PROJET RERIT EN ÉTHIOPIE - UNE ÉTUDE DE CAS DE RENFORCEMENT INSTITUTIONNEL

Albert Edward Engel [1]

ABSTRACT

The Prairie Farm Rehabilitation Agency (PFRA) - Agriculture and Agri-Food Canada (AAFC) was contracted through the Canadian International Development Agency (CIDA) to provide institutional strengthening for integrated water harvesting and irrigation development in the northern Ethiopian province of Tigray. The WHIST (Water Harvesting and Institutional Strengthening Tigray) project is part of an overall goal to achieve food security in Tigray through integrated water resource development. Technical assistance is being provided to two relatively new provincial agencies with relatively inexperienced staff; Commission for Sustainable Agriculture and Environmental Rehabilitation of Tigray (COSAERT), and Bureau of Agriculture (BOA). This is being done through short term assignments of senior technical staff and specialists; staff training and mentoring for the planning, design, construction, and operation and maintenance of irrigation projects including the water storage, diversion and conveyance works. The skill development areas include various engineering disciplines (hydrology, hydrogeology, geology, geotechnical, hydraulic and structural design); agricultural fields (extension agronomy, soil and water compatibility); and integration with areas such as socio- economics, environmental, construction management and quality control, and management information systems.

Various gaps have been identified, and measures are being taken to address these gaps. As is typical of many third world countries, lack of data has been a constraint, and a program of data collection and analysis to facilitate regional studies and better project planning and development has been initiated. Catchment rehabilitation and agronomic extension has lagged behind the remainder of project development, and steps are being taken to ensure holistic sustainable watershed development.

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RÉSUMÉ ET CONCLUSIONS

Au cours des sécheresses généralisées des années 1980 et des conflits intérieurs continus, l'Éthiopie a subi plusieurs famines, surtout dans les provinces du Nord comme le Tigré. Le problème continu de l'insécurité alimentaire a été aggravé par des habitudes d'utilisation des terres insoutenables telles que le déboisement et le surpâturage qui ont occasionné l'érosion des sols et la dégradation des terres et une perte importante de terrains agricoles productifs. Après la chute du régime dergue en 1991, la Commission pour l'agriculture durable et la réhabilitation de l'environnement du Tigré (CADRET) a été établie pour plannifier, concevoir et aménager de petits projets de récupération d'eau et d'irrigation dans le Tigré. L'objectif principal était de réaliser la sécurité alimentaire à l'aide de l'aménagement intégré des ressources en eau. On a contraint un personnel relativement jeune et inexpérimenté à aménager un nombre considérable de projets de récupération d'eau et d'irrigation durables afin d'accroître la production agricole dans la région.

Les origines du CADRET rappelle celles de l'Administration du rétablissement agricole des Prairies (ARAP), direction générale du ministère canadien de l'Agriculture et de l'Agroalimentaire. Au fil des ans, l'ARAP a acquis une quantité considérable de connaissances et de compétences dans plusieurs domaines, y compris la plannification, la conception, l'aménagement, l'exploitation et la maintenance de barrages et d'installations d'irrigation, tous intégrés à des pratiques soutenables de conservation des ressources en sol et en eau. L'ARAP a conclu un accord avec l'Agence canadienne de développement international (ACDI) où elle s'engage à renforcer les institutions dans le cadre du projet RERIT (Récupération de l'eau et renforcement institutionnel dans le Tigré). L'ARAP fournit de l'aide technique à deux nouveaux organismes provinciaux, le CADRET et le Bureau de l'agriculture, dont le personnel est relativement expérimenté. Ceci s'effectue au moyen de l'affectation à court terme de techniciens supérieurs et de spécialistes, et à l'aide de stages de formation et de mentorat en matière de plannification, conception, aménagement, exploitation et maintenance d'ouvrages d'irrigation, y compris d' ouvrages de retenue, de déviation et d'adduction. Le perfectionnement se poursuit dans plusieurs disciplines de l'ingénierie et de l'agronomie et comprend les dimensions socio-economiques et environnementales, la gestion de construction, le contrôle de la qualité et les systèmes d'information de gestion.

On a découvert certains problèmes liés aux petits barrages nécessitant des réparations (réservoirs imparfaitement étanches qui requièrent des tapis de protection amont, érosion des déversoirs et des chenaux de dérivation, fissuration et érosion souterraine régressive des levées). La surveillance continue et, selon le besoin, la réhabilitation des ouvrages sont indispensables à leur durabilité. Ayant constaté certaines insuffisances telles que des problèmes liés à la conception et au contrôle de la qualité de la construction, on a mis en place des mesures pour y remédier. Comme dans bon nombre de pays du tiers monde, le manque de données est une contrainte. Aussi a-t-on a entrepris un programme de collection et d'analyse de données pour les études régionales et amélioré la plannification et l'élaboration de projets. La réhabilitation des bassins versants et la diffusion agonomique prennent du retard par rapport aux autres aspects de l'élaboration des projets; toutefois, on prend des mesures qui assureront une approche globale à l'aménagement durable des bassins versants hydrographiques.

HISTORY

Throughout the wide-scale droughts of the 1980's and on-going internal civil conflict, Ethiopia experienced several famines, and particularly provinces in Northern Ethiopia like Tigray. This continuing problem of food insecurity was aggravated by unsustainable land use practices such as deforestation and overgrazing, which was causing considerable soil erosion and land degradation, and associated loss of productive agricultural land. Following the fall of the "Derg" regime in 1991 and the subsequent adoption of a new constitution, there was a desire to improve food security, and particularly in the more drought prone areas of Northern Ethiopia such as Tigray. This led to the formation of a new provincial agency in Tigray in 1993/94, the Commission for Sustainable Agricultural and Environmental Rehabilitation of Tigray (COSAERT).

COSAERT was created specifically for the planning, design and construction of integrated sustainable small-scale water harvesting and irrigation projects in Tigray. COSAERT's ultimate goal was to help the people in Tigray to move toward food self-sufficiency and sustainable resource development. The staff included multi-disciplinary teams of various engineering and agronomic disciplines integrated with some socio-economic and environmental staff. The majority of the professional and technical staff was relatively inexperienced personnel who had recently graduated from various Ethiopian educational institutions.

The urgency for the relatively new and inexperienced staff to develop a considerable number of water harvesting and irrigation schemes to facilitate increased agricultural production in the region, placed extreme pressure on the organization to deliver sustainable projects. Projects were rushed to the construction phase without completed construction drawings and in some cases without full and complete engineering investigations. This situation was compounded by a general lack of baseline data (meteorology, hydrology, agronomy, etc.) and a corresponding over-reliance on empirical and generalized textbook information. Limited topographic maps, air photos, technical reference materials, data bases, records, standards and in-house manuals were available for investigations. In addition, because of limited labor availability, catchment rehabilitation was often neglected.

The Prairie Farm Rehabilitation Administration (PFRA) had similar origins to COSAERT. It was created by the Government of Canada during the "Great Depression", widespread drought, catastrophic soil erosion, rapid desertification, and abandonment of agricultural land in the southern Prairies of Western Canada in the 1930's. PFRA was given authority to rehabilitate and reclaim the devastated lands through sustainable soil and water conservation development. This included the promotion of water harvesting and storage schemes, and irrigation development. Over the years, a great deal of knowledge and expertise had been gained in many areas including the planning, design, construction, operation and maintenance of dams and irrigation works integrated with sustainable soil and water conservation practices.

Through various meetings and discussions with FAO in 1995 and 1996, there was a desire on the part of the Government of Canada to participate in the Special Program for Food Security (SPFS) in Ethiopia. Following a Canadian International Development Agency (CIDA) mission to Ethiopia in 1996, the WHIST (Water Harvesting and Institutional

Strengthening Tigray) project was approved. Because of PFRA's history, experience and expertise in dealing with drought related issues and soil and water conservation development, they were chosen to deliver the 6 year, CAN $7.5 million project. WHIST's goal is to strengthen the technical and management expertise of both COSAERT and BOA (Bureau of Agriculture). To accomplish its task WHIST is using a mentoring program that uses short term assignment of Canadian experts in a number of fields to train staff in sustainable resource development. A number of skill development or mentoring areas are involved, including hydrology, hydrogeology/groundwater, geology, geotechnical engineering, hydraulic and structural design, soil and water conservation, soil and water compatibility, extension agronomy, socio-economics, environmental, construction management, and management information systems.

A Phase I planning and early technical assistance mission was undertaken early in 1998. However, delivery of the project was interrupted for about 3 years by the war between Ethiopia and Eritrea, and the project was resumed in 2001.

HYDROLOGY

The Ethiopian Highlands in Tigray have a relatively low average annual rainfall with distinct dry and wet seasons. Surface runoff normally results only from intense rainstorms during the wet season. Some streams are fed by springs and show a more perennial character, although their dry season discharge is usually very limited.

To design the size of a reservoir and spillway, runoff characteristics for varying frequency events is required for the watershed being investigated. The total volume of the wet season runoff is required to determine optimal reservoir sizing and water supply potential for irrigation. The shape of the runoff hydrograph including the peak flow rate along with the storage capacity curve, are required to size the spillway. In addition potential sediment loads are required to determine reservoir life and catchment rehabilitation development.

Minimal precipitation and virtually no runoff or sediment load data exists for smaller watersheds in Tigray. The runoff was usually calculated using indirect methods with limited precipitation data. This quite often involved the selection of an appropriate runoff coefficient. The reservoirs were intended to be designed to fill 75% of the years; however, for initial investigations too high runoff coefficients were selected resulting in oversized reservoirs and a reduced irrigation command area. In addition spillways were designed on the assumption that peak inflows could be reduced by temporary reservoir storage, and the assumptions made regarding the shape of the hydrograph and duration of the flood event were critical in determining spillway capacities.

To allow for better project design, the WHIST project is encouraging the collection of precipitation and runoff data at existing reservoirs. This is being done by periodic recording of manual rain gauge and reservoir staff gauge water level readings. To provide better continuous data, some automatic reservoir level and precipitation recorders have been installed and more are planned for the future. The reservoir capacity curve and spillway rating curve along with the reservoir water level data can be used to determine runoff volumes and peak flow rates. The runoff volume along with the precipitation records will

allow the determination of accurate site specific runoff coefficients, which will assist in the design of future projects. In addition the site specific inflow/outflow hydrographs can be determined for various runoff events which will assist in the design of future spillways. The measurement of sediment depths and calculating sediment volumes and relating it to the runoff will assist in determining sediment loads and reservoir life. Once enough data is collected and analyzed for a number of sites, the information can be used to develop regional studies and unit runoff maps showing isopleths. This will not only avoid repetitious calculations for each new project, but also will ensure design consistency between projects.

HYDROGEOLOGY / GROUNDWATER

There is some potential for the development of groundwater for irrigation in Tigray; however, there is very little data for smaller watersheds as to recharge rates. There is a concern that the development of irrigation wells could result in unsustainable "groundwater mining". In addition, pumping from irrigation wells could have a detrimental effect on the perennial flow in streams and the sustainability of long standing traditional irrigation projects that divert water during the dry season.

Of more interest than irrigation well development is the potential for enhancing perennial stream flows through catchment rehabilitation, resulting in an increased potential for traditional irrigation development. The present types of catchment rehabilitation used are stone contour "bunds" and re-vegetation on the steep slopes to reduce erosion. The increased infiltration and resulting reduction in the runoff coefficient and reservoir yield can be accounted for in new projects by designing smaller reservoirs. However, potential benefits such as the reduction in sediment load and longer life reservoirs would far outweigh any negative impacts. Even though the irrigation command area from the reservoir would be smaller because of the water lost to infiltration, most of this infiltrated water would reappear as increased base flow in the river and increase potential for traditional irrigation. In addition, reduced silt loads, would reduce maintenance costs of permanent weir diversions. To assist in assessing the benefits of catchment rehabilitation, WHIST is assisting in establishing some pilot projects to collect data to quantify the effects of catchment rehabilitation on base flows.

GEOLOGICAL / GEOTECHNICAL INVESTIGATIONS FOR RESERVOIR AND DAM EMBANKMENT DESIGN AND CONSTRUCTION

In Ethiopia, there is a lack of training of experienced personnel in geotechnical engineering for the investigation and design of dam embankments. This was also reflected in COSAERT's staff, in that the geotechnical investigations were being done by geologists and design engineers with very little training and experience in the field. Even though these are interrelated disciplines, the site investigation team for a dam embankment/reservoir, requires the input of two separate disciplines. Some of the information used by both disciplines may be the same, such as test hole logs; however, each is responsible for a different aspect of investigation and design.

The geologist uses information such as drill logs, geological maps, are geophysical investigations to determine bedrock characteristics. Bedrock information such as fault lines will assist in siting of the dam embankment. The fracturing and porosity of the bedrock and

overburden characteristics are used to determine reservoir seepage potential. In addition, the location of the existing water table information is used to determine potential groundwater mounding and its influence on reservoir seepage.

The geotechnical engineer is interested in the engineering soil mechanics of the embankment foundation and the borrow materials used to construct the earth embankment. Soil samples from drill holes and test pits are analyzed in the laboratory to determine geotechnical characteristics of unconsolidated materials. This information is used to determine the foundation stability and settlement for the proposal embankment. In addition, it is used to determine the seepage potential under the dam, around abutments, and through the reservoir, to facilitate the design of embankment cutoffs and/or upstream blankets. Potential borrow materials are sampled and tested and the results used for embankment stability design, including items such as the filter and upstream slope protection.

Until recently, COSAERT primarily relied on manually dug test pits for soils information, which was inadequate for many of their dam/reservoir investigations. Compounding this was inadequate geotechnical laboratory testing facilities along with inexperienced staff. Plans are in progress to provide better lab facilities, drilling equipment, and training for lab personnel and drillers, through the WHIST Project.

Another area of concern with COSAERT's operations was the construction quality control, particularly with respect to the earth compaction in dam embankments. Embankments were being constructed of dry soil considerably below optimum moisture content with inadequate compaction. This was partly caused by inadequate field inspections, and site and laboratory testing, of the soils (density, water content, atterburg limits, standard proctor, grain size, etc.), which was aggravated by the lack of specifications. In addition, the lack of adequate equipment for adding and mixing the moisture, spreading and compacting the soil, was also a factor. Initially the hauling and spreading of material, and the addition of moisture was done manually ("food for work"), which also complicated quality control. More recently earth moving equipment such as backhoes, trucks, and graders have been used along with motorized compactors and water trucks with somewhat better success. However, COSAERT still requires adequate mixing equipment such as a double disc to ensure will compacted embankments at optimum-moisture content.

One important aspect of project development is post construction evaluation, and this is particularly true for dam embankments. All projects, not only ones with problems, should be monitored, and their performance evaluated. This will not only allow post construction modifications to be made, but also will facilitate improved design of new projects. Some of the reservoirs constructed by COSAERT have experienced significant seepage and associated loss of water and irrigation command area; and WHIST is assisting COSAERT in the monitoring, evaluation, and rehabilitation (e.g. upstream blankets) of these reservoirs.

WHIST is also assisting COSAERT in the post construction monitoring and evaluation of projects, particularly with some of the dams constructed mainly of dry soil. A few dams are experiencing significant longitudinal and transverse cracking and continued monitoring and evaluation is imperative in ensuring the safety of the dam, and the

sustainability of the project. Very little published information exists on dams of this size constructed of dry earth. Some work was done in Brazil to evaluate "Alka-Seltzer" dam embankments constructed of dry soil, and similar cracking has been observed on some of the COSAERT dams as in the Brazilian dams (Figure No. 1) [2].

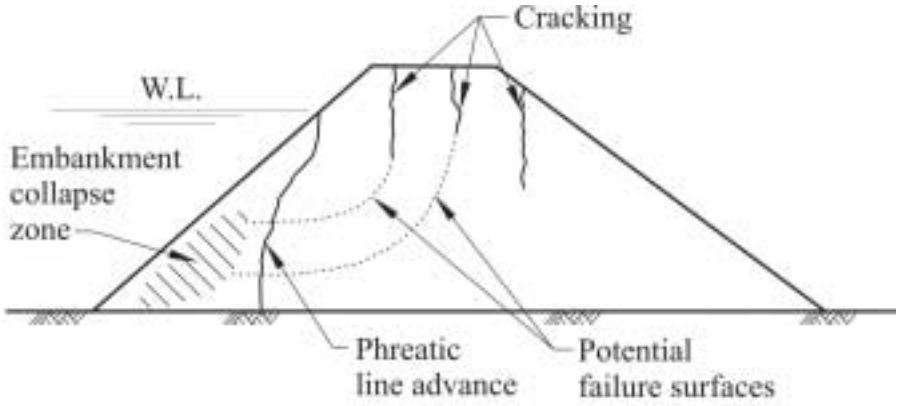

Figure 1. Slope instability failure on earth dams during the first reservoir filling (Défaillance due à l'instabilité du talus des barrages en terre lors du premier remplissage du réservoir)

HYDRAULIC STRUCTURES

With respect to the COSAERT storage dams, next to the embankment, the spillway was usually the next most costly item. As mentioned previously, the lack of accurate hydrological parameters was problematic in the design of safe economical spillways for the storage projects. Also of as much importance is the siting of spillways. For some projects, a considerable portion of the stone masonry spillway is founded on competent bedrock, which is the ideal. However, this was not always possible, and the cost of a safer spillway needs to be evaluated on the basis of risk and consequences of damage and/or failure. Some COSAERT projects have incorporated innovative designs to lower the cost and risk of spillways. One example of this is a project where the diversion channel from an adjacent watershed and associated hydraulic structures also served as a spillway for the project. Another area of concern for some of the COSAERT spillways is the lack of adequate tailwater for stilling basins and the potential erosion of exit channels.

The outlet works for COSAERT projects is generally a stone masonry inlet structure, steel pipe conduit joined by flexible couplers and a dual valve outlet. Some problems have been experienced with conduit joint leakage. Initially these were repaired by encasing the joint in reinforced concrete; however, more recently some of the new conduits have been entirely encased in reinforced concrete. Some concern exists regarding the long term sustainability of the reinforced concrete encased conduit beams, particularly with respect to foundation settlements and potential concrete cracking.

[2] Pereira, Jose Henrique Feitosa, 1996. "Numerical Analysis of the Mechanical Behavior of Collapsing Earth Dams During First Reservoir Filling". University of Saskatchewan PH.D Thesis. Saskatoon. Saskatchewan. Canada

For the irrigation distribution system unlined earth canals are used. Generally stone masonry structures (drops, checks, division boxes, etc.) are used. Some steel pipe flumes have been used for river and stream crossings, and precast concrete pipe for road crossings. Generally the irrigation distribution systems have functioned reasonably well. To date only minor problems with seepage from unlined canals have been noted.

More recently COSAERT has been replacing temporary weirs with more permanent stone masonry weirs for traditional irrigation projects diverting base river flows in the dry season. Many of these weirs are constructed on rivers with very erodible watersheds, and the flood flows carry considerable silt, sand, rocks and ever boulders. Because of this, the design and maintenance of these weirs can be problematic. WHIST is assisting COSAERT in assessing these problems, and evaluating solutions, such as catchment rehabilitation.

SOIL AND WATER COMPATIBILITY

The importance of local community involvement in the investigation of water harvesting and small irrigation projects is recognized by COSAERT. This is particularly true in determining suitable irrigation command areas. Air photos, visual inspections, test pits, classification of soil profiles, estimation of soil types and textures, field measurement of permeability, and delineation of land units are utilized to assist in this decision. Recommendations are made with regard to cropping systems, crop rotation, irrigation scheduling and soil management for each of these land units. A detailed estimate of crop water requirements is determined from the cropping recommendations and agro-climatic data such as evapotranspiration and precipitation.

The COSAERT agronomists and soils staff are making excellent use of the resources at hand in preparing the soil and agronomic feasibility study reports. However, they are lacking basic equipment and materials, such as field kits, and transportation to and from the field. In addition, standard charts and soil samples would not only be useful references for correlation of soil types and consistency between study teams, but would also be beneficial in training new staff in soil identification.

Each report is prepared as an independent report with little correlation of soil or land units. As time goes on there is a need to incorporate all available soils information into a soils data base and prepare regional level reports. This would reduce the time required for field descriptions and measurements, ensure consistency of descriptions and interpretations, and would be beneficial in training new staff.

COSAERT staff put a significant effort towards calculating the potential evapotranspiration and crop water requirements for the command area. However, the reality of the situation is that there is limited agro-climatic data available for the areas and at this time, limited ability to control application rates. A regional determination of evapotranspiration and crop water requirements and isoline maps to apply to projects in a similar area, would reduce the time spent on this component, without reducing the necessary accuracy of the estimate.

COSAERT staff determine the potential for salinization mainly by visual observations of things such a soil salts and vegetation. However to adequately quantify the

level of salinity there is a need for more chemical and physical analysis of soil samples, ground water instrumentation, and salinity monitoring using electro conductivity (EC) and electromagnetic conductivity (EM) meters. This is being addressed, along with the need for proper agronomic soil laboratory facilities, and adequately trained staff.

There is a need for more irrigation agronomy research in Tigray. WHIST is encouraging COSAERT and BOA to work together with research agencies or institutions (e.g. Ethiopian Agricultural Research Organization, Mekelle University) to further this.

IRRIGATION EXTENSION AGRONOMY/ ADVISORY SERVICES

Even though irrigation is not new to Ethiopia, for any new projects there is a need for an active and will informed extension service for the introduction of irrigation into the local agricultural community. Right from the start, WHIST has recognized the extension component as a vital part of the equation because if the end user, the farmer, cannot use the water efficiently to produce more food then the whole project is unsuccessful. Ensuring the scientific correctness of crop water requirements is not as much of an issue as how such information can be used practically for optimal crop production. Services and advice have to be tailored to reach the grassroots farmer, who is trying to increase food production on a subsistence level, labor intensive, small scale irrigation plot.

Extension agronomy has been overshadowed in COSAERT simply by the number of engineers compared to agronomists, especially during the early mandate of COSAERT primarily directed towards infrastructure development. In addition, the roles and responsibilities of COSAERT and BOA for extension agronomy are not clearly delineated, and it is important for these two agencies to work closer together to ensure successful projects. BOA has the mandate for making the irrigation agronomy extension happen; however, it is often overshadowed by BOA's overall mandate. (The amount of irrigated land is still a mere pittance compared to rainfed land.) WHIST is encouraging BOA to raise the profile of its irrigation extension component. Some progress is being made in this area; namely, with the formation of an irrigation unit, training of extension workers in irrigation agronomy, and the establishment of irrigation demonstration sites.

There are a significant number of agronomists in COSAERT and BOA, with relatively good knowledge levels. There is a need not so much for mentoring in irrigation agronomy but rather management support (e.g. - adequate operating budget), and logistical support for transportation and plus some basic tools for extension (e.g. - library information, field and laboratory equipment, computers, and vehicles). Other agency involvement is also needed, such as the Relief Society of Tigray (REST), research agencies and institutions, Ethiopian Ministry of Agriculture (MOA), and international agencies, for funding, collaboration of data and standards, and research. In addition there is a need to coordinate the work of various international aid organizations to try and interrelate and coordinate overlapping initiatives.

Advisory services is probably a better term than extension agronomy because the need for advice goes beyond just irrigation agronomy, to the complete development and implementation of the scheme, including integrating technical structures with a package of

agricultural and institutional improvements. One of the ongoing areas of concern with the COSAERT projects and the assistance provided by WHIST, is ensuring the provision of appropriate advisory services to the local communities in the participatory planning and management of water harvesting schemes. Community involvement in all aspects of the project development (site selection, planning, design, construction, operation and maintenance, and land re-allocation) is essential for success of the project, not only to ensure the technical correctness of the infrastructure design and construction, but in particular to ensure that such structures are technically, socially, and environmentally sustainable. The catchment area rehabilitation was recognized as an important element; however, because of constraints such as lack of local labor, it often was not completed for projects.

In a recent reorganization of the regional government, more emphasis is being placed on capacity building right to the level of the farmer. A Project Management Committee (PMC) has been organized to provide a unifying body in which all stakeholders have a voice, and will hopefully act as a monitoring group that will organize and coerce each other into doing their part of the project. One member of this group is the Cooperative Promotions Office (CPO), whose mandate is to organize Water User Associations (WUA's), a key body not only to ensure successful operation and maintenance of the projects, but also to promote and disseminate irrigation agronomy technology. Some WUA's have been organized; however, they need more help in development.

OTHER

Other areas have also been identified where gaps exist. There is a need for better trained staff in the area of socio-economics. There is a need to have more women involved in the entire project development. WHIST has identified a need for formal training in Environmental Management to facilitate the environmental impact assessment process. Construction Management training and mentoring, particularly with respect to quality control is lacking. Results Based Management workshops have been organized to assist in ensuring the appropriate linkages between the agencies involved in the measurement of outcomes. To assist in the improvement of management information systems, recommendations have been made for modifications to COSAERT administrative practices to provide the necessary support services; to develop technical information systems to assist with project design; and to determine what systems are required to provide the information for a results based management framework.

CONCLUSIONS - PAST, PRESENT, AND FUTURE

COSAERT, a new provincial agency in Tigray, was formed in the early 1990's comprised of mainly inexperienced personnel. In the earlier years there was considerable pressure on the multi-disciplinary teams to investigate, design and construct dams and irrigation projects. A lack of base line data for design complicated the process, and indirect methods of design involving numerous assumptions were utilized. Some design and construction quality control problems were encountered. Catchment rehabilitation and agronomic extension lagged behind the remainder of project development. Some institutional strengthening was provided in 1998 by the WHIST project; however, this was interrupted until 2001 by the war between Ethiopia and Eritrea.

Some micro dam problems requiring repair have been encountered (leaky reservoirs requiring upstream blankets, erosion of spillways and diversion channels, embankment cracking and piping). Continued monitoring of the projects and rehabilitation as required is imperative for sustainability. More recently the emphasis has changed from the construction of micro dams to permanent traditional irrigation diversion weirs. Because of the relatively heavy bed loads of rivers in Tigray, there are some concerns with the sustainability of these permanent weirs with respect to their operation and maintenance.

The WHIST project continues to provide institutional strengthening through short term missions of experienced personnel who provide on-the-job mentoring and training. To facilitate this process and the development of water harvesting projects in Tigray, various material, office and field equipment are being acquired.

To ensure future holistic and sustainable water development in Tigray, more emphasis has to be placed on catchment rehabilitation, extension agronomy, and the formation of, and transfer of projects to Water User Associations. This will not only ensure the sustainability of the micro dam irrigation projects that rely on water harvested during the rainy season, but will also enhance the traditional irrigation projects that rely on the base flows during the dry season. More data collection and analysis to facilitate regional studies and better project development, is also key to future success. As COSAERT evolves, the WHIST project will provide technical assistance in other areas as the need arises (e.g. hiring and monitoring of consultants involved in watershed planning studies and the design of medium sized dams).