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Office for the Coordination of Humanitarian Affairs (OCHA)
Ethiopia

Ponds filled with challenges

Water harvesting – experiences in Amhara and Tigray

Assessment Mission: 30 Sept –13 October 2003

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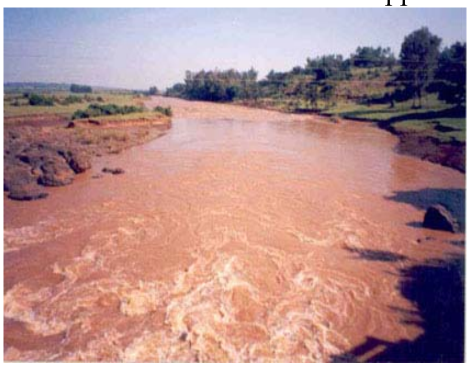
1 Introduction: Ethiopia is rich in water

In many respects water is the most crucial element in the lives of Ethiopian people. It means health, food and survival, and the lack of it - disease, starvation and death. Water also contributes to determining who is poor and who is wealthy, who has power and who loses out. It is a constant source of conflict but also a source of hope, progress and development.

Cracks in the water-harvesting program: 500 water-harvesting experts were trained in Gubalafto, North Wollo (photo H. Rämi, UN-OCHA, Oct. 2003)

Ethiopia is also known as the "Water Tower of East Africa" referring to the high plateaus and mountain ranges of Amhara Region, where one of Africa's most important rivers has its source in Lake Tana. Today the Blue Nile is a thick brown liquid, carrying with it millions of tons of Ethiopian soil into Sudan where it piles up in sediments several hundred meters thick. This is the effect of decades of deforestation and overexploitation of natural resources caused by a rapidly growing rural population and poor land-use practices. It is also a stark indication of a lack of effective management of the most precious resource that Ethiopia has: water.

Excluding the purely pastoralist areas, more than 90 woredas with a total of more than 2 million households in the country are drought prone and regularly hit by severe water shortages according to the Ministry of Agriculture. This seriously threatens the lives of more than 12 million people. But Ethiopia is not a country poor in water. The challenge is keeping and preserving the precious resource when it falls abundantly from the sky and then to store it and distribute it wisely for efficient use when the rains stop. Ethiopia's mean annual rainfall reaches approximately 1090 mm. However 70% of the total arable land receives annual rainfall of less than 750 mm, while an estimated 110 billion cubic meters of rainwater annually are lost through surface runoff. This is the equivalent to a one meter deep square pond with sides of 330km or a full river ten meters deep, 100 meters wide and a hundred and ten thousand kilometres long! The ground water resource is impressive as well, estimated at 4.6 billion cubic meters. Ethiopia's water potential is huge and harnessing it is the challenge facing the government and the people of Ethiopia.



110 billion cubic meters of run-off, millions of tons of Ethiopian soil flow to Sudan: Little Abbaya River laden with silt (photo H.Rämi, UN-OCHA, Oct 2003).

1.1 Objectives, Methodology

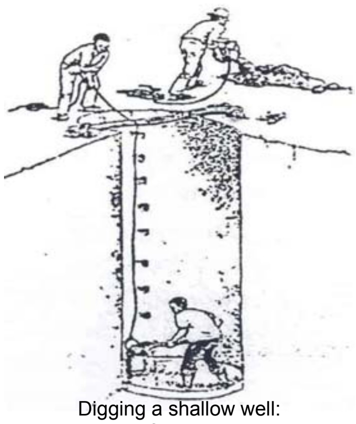
The main objective of this UN OCHA field mission, which took place from September 30 to October 13 2003, was to observe the progress made in the construction of water harvesting schemes and related experience during the last rainy season in Amhara and Tigray Regions. Firsthand information was gathered from various parties involved in the development, implementation and use of the water harvesting schemes. Data, analysis and information were gathered from Government bodies, communities, implementing agencies, NGOs and farmers. Numerous site visits were undertaken in different agro-ecological zones and in woredas with specific water and food security problems. Discussions with builders and beneficiaries of water harvesting structures were made to understand the various aspects of the current water harvesting activities in these areas, activities that may have the potential to improve agro-pastoral production and food security and to thus reduce the need for future humanitarian food assistance, a major concern of the Office for the Coordination of Humanitarian Affairs (OCHA) in Ethiopia.

At about the same time as this mission the European Union was conducting a similar assessment, but in Tigray only. A further assessment looking at use of irrigation water gathered in water harvesting ponds will be made early next year.

2 Water harvesting: A main pillar in the national food security strategy

Engineered water management systems, dedicated to irrigation with a high level of technology, bureaucracy and material input, have a recent history of success and failure in Amhara and Tigray [1]. Large-scale dam and irrigation projects have not been widely implemented in Ethiopia as they have often proved to be too expensive and demanding in construction and maintenance. Therefore, water harvesting tanks and ponds at the village or household level are proposed as a practical and effective alternative to improve the lives of rural people at little cost and with minimal outside inputs. In theory, household water harvesting can be done mainly through the effort of the individual farmer. Use of stored rainwater could supplement natural rainfall and make farming families less vulnerable to drought and therefore less dependent on outside help in harder times.

[1] Box 2: *Water harvesting in the past – history of success and failure*

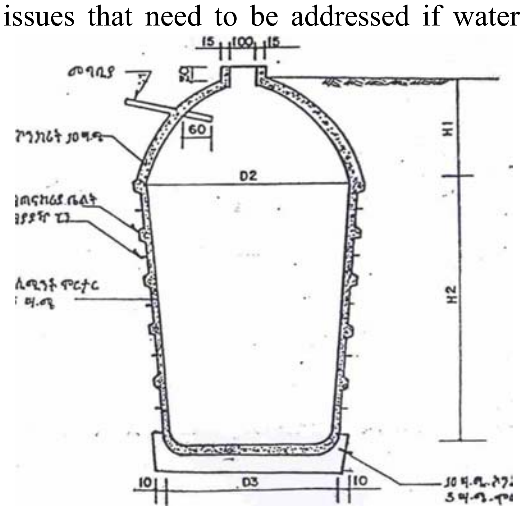


Digging a shallow well: Manual from the Amhara Regional Bureau of Agriculture

One of the main pillars of the Ethiopian government's food security strategy is the development and implementation of water harvesting schemes mainly in the drought prone and chronically drought affected areas of the country. In the last fiscal year, the federal government allocated ETB 100 Million for food security programs to the regions, and this year the amount programmed is ETB 1 Billion. Much of this money is used by the regions for the implementation of water harvesting programs, many of which are based on the construction of household ponds and cisterns planned and implemented with direction and assistance by the federal Ministry of Agriculture (MoA).

2.1 Ambitious and fast

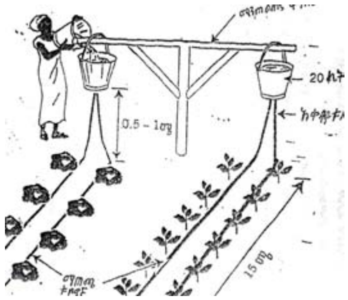
In Amhara and Tigray a total of approximately 70,000 ponds and tanks were constructed last fiscal year alone. A few hundred thousand more are to follow with the aim to reduce poverty and increase food security on a massive scale by making water available to irrigate and produce higher value crops and provide water for livestock. Implementers on all levels struggle with a range of problems, many of which originate from the speed and scale on which the water-harvesting program is being implemented. Flaws in the design of the structures, insufficient building experience, lack of skilled personnel and shortage of materials are some of the problems. Currently, a very large number of completed tanks simply don't hold water and are leaking. This of course does not necessarily mean that the concept is wrong. However, it does point to issues that need to be addressed if water harvesting is to have the impact to improve food security that the government and people of the country desperately wish to see.



Sketch from the construction manual distributed by the Amhara Regional Bureau of Agriculture: Cylindrical water harvesting tank made of cement plaster covered with a bottle neck shaped reinforced concrete cap.

Some critics of the approach argue that it has also never been established to what extent the water harvesting ponds are able to increase food security during potentially bad times. They note that in years with minimal rainfall, when water and food are most needed, the ponds, intended for irrigation and backyard gardening, will most likely dry up before the harvest is made *(see 4.3.6.4)*. The opinion is widespread that an approach with a bigger variety of options, less top down and simpler might be more appropriate. While it is clear that water harvesting at household level with tanks and ponds is one option to increase water availability and agricultural production, it is certainly not clear whether it is the most appropriate or the most cost effective, and under what conditions it might indeed be the best approach.

The mission did find many positive experiences with water harvesting schemes, some of which were not necessarily expected. For instance, in parts of Tigray and Amhara, farmers discovered ground water when digging holes for water harvesting ponds, and subsequently built shallow wells, producing perennial sources of water for both domestic and irrigation purposes. In Amhara and Tigray, experts and farmers are also experimenting with low-cost water harvesting systems that are not presently in the mainstream of the government promoted water-harvesting approaches. Some of these are natural systems (e.g. gully rehabilitation with grasses, reed, trees and shrubs as the German GTZ is developing in Debre Tabor and some places in Tigray). Others include simple structures without industrial or commercial input like cement, steel bars, etc, that help collect water and recharge to the ground water table to be tapped by wells *(see Chapter 8)*.



Drip irrigated vegetable garden: Manual Amhara Bureau of Agriculture (2002)

Even if the ongoing water-harvesting program has its problems and weaknesses – if done flexible and in a variety of ways – it could be an important technology that can help to improve the lives of many in the long run.

3 Only one trial site for the whole country

In Ethiopia, it is estimated that only 23% of the rural or 31% of the total population have access to safe and clean water. During long dry seasons and in the more arid areas, women regularly travel as far as 15 km or more to fetch water for household purposes. This search for water is extremely time-consuming, putting restrictions on other activities that could support food and household security. In light of this, the Swedish International Development Agency (SIDA) in support of the Regional Land Management Institute (RELMA) in 1997 organized a training in Adama (also called Nazreht) in East Shewa Zone, to demonstrate and promote roof water harvesting systems.

Onions growing on top of dome shaped water-harvesting tank: Trial site in Adama, East Shewa (photo H. Rämi, UN-OCHA, Sept 2003)

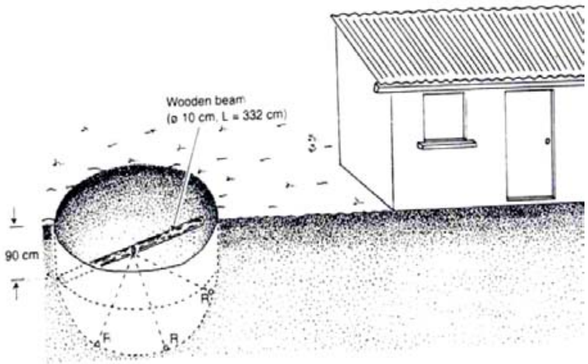
In the same year, RELMA financed two two-year field trial fellowships, one for an expert from Kenya, the other for a senior soil and water conservation expert from the federal Ministry of Agriculture (MoA) in Addis Ababa. Their job was to find low-cost technologies for rainwater storage tanks. In the process, both experts produced designs for a number of structures several of which are still in operation in the trial sites in Adama *(box 1)*. The NGO Sasakawa – Global 2000 is currently supporting a program to improve the technology.

The Adama field trials used well-supervised local farmers and resulted in the production of guidelines for a “rainwater harvesting and utilisation techniques extension package”. The package was produced by a MoA-task force comprised of a sociologist, soil and water, livestock and crop experts. It includes a technical section, extension approach and livestock and crop components.

In 2001, the package was published and sent to 11 regions for study and modification. After practical trainings by the MoA and based on a final document the regions produced their own packages. They are all based on the same study and - with the exception of plastic lined ponds, which were autonomously designed by some regions - they have not been sufficiently tested under different conditions and adapted to the specific environments of the different regions. This can have expensive consequences as was observed and reported in the chapter 4 on Amhara.

Succesful model farmer on the trial site in Adama: Drip irrigation for vegetable production (photo H. Rämi, UN-OCHA, Sept. 2003)

The trials in Adama represent 5 years of experience. They were undertaken in the Rift Valley with its specific characteristics: deep sandy soils with a very deep ground water table, torrential and erratic rains and – very important - no alternative water source, spring, river or ground water. Soil and groundwater conditions in many areas of Tigray and Amhara are entirely different and the water production alternatives are actually more varied.



Hemispherical tank: Manual Ministry of Agriculture

Box 1

Field trials in Nazreth Developed and tested in Adama were four different structures of which the hemispheric concrete tank (above) proved the easiest to build and thus became the most popular. Bottleneck structures consume less land, due to their underground construction (page 3), dome shapes protect against mosquitoes and malaria (page 4). Cylindrical shapes above ground are the most costly and rarely built. All tanks have a water holding capacity of $60m^3$. Materials used are sand, gravel, stone, cement, wire mesh, steel bars and steel sheets for covers. The costs of commercial materials and skilled labour per tank vary from approximately ETB 3500 for hemispherical tanks to ETB 5000 for covered structures.

4 Amhara: 365,000 structures planned for 2003-4

4.1 Experiment on a vast scale - Quotas not reached in 2002-3

The Regional target last fiscal year was the construction of 95,000 water schemes, of which 42,000 were completed *(table 1)*. Most of the structures were planned and built in the 52 food insecure woredas and partly paid through food for work (FFW). In a few food secure woredas, ponds as well as river diversions and hand-dug wells were constructed also. Amhara has a total of 106 woredas.

The schemes were all built according to a manual produced by a committee of experts in irrigation agronomy and soil and water conservation of the regional Bureau of Agriculture (BoA) in Bahar Dar. The manual is based on the designs from the Federal MoA *(box 1)* and the designs had not been tested in Amhara itself according to the BoA experts in Bahar Dar. Therefore, Amhara's very ambitious water-harvesting program last year (July 2002 – June 2003) turned out to be an experiment on a gigantic scale.

For this fiscal year, which started in July 2003, the region has set a target of 365,000 structures to be built. According to the BoA in Bahar Dar this figure is likely to be revised since, in their view, it is too ambitious. The region is also learning from previous mistakes. Last year it imposed quotas for each type of structure in each woreda. This year the woredas are free to decide on the types of structures and on how to implement them. However political pressure to pursue rapid expansion of the program is likely since the government is keen on alleviating food insecurity through its food security strategy within the next three to five years *(updated food security strategy 2002, Addis Ababa)*.

Table 1: Discrepancy between plan and implementation in Amhara Region

Type of structure	**Planned**	**achieved**
Dome shape, cement	2305	279
Cylindrical, cement	57	35
Bottle shape, cement	169	16
Cone shape, cement	70	5
Hemispherical, cement	26,804	3842
Micro ponds	30,001	8772
Hand dug wells	29,255	22,830
Spring developments	3733	4272
River diversions	3064	1932
Total	***95,458***	***41,983***
Potential in hectares	7244	2698

Source: BoA Bahar Dar

4.2 Financing: in the future partly on credit

The implementation of the water harvesting schemes in Amhara is under the responsibility of the Bureau of Agriculture and funds are provided through the regional food security program. Last years budget was 20 million ETB, excluding the cost of plastic linings, the importation of which proved to be quite difficult. This year's budget has not yet been finalized but the amount allocated for water harvesting schemes will be significantly higher in light of the larger number of water harvesting schemes that are to be implemented.

In the last fiscal year, ponds and tanks were implemented free of charge for the beneficiaries, who only had to contribute their own labour, usually paid by Food for Work or through EGS schemes. This fiscal year, the BoA in Bahar Dar plans to collect 15% of the material cost from the beneficiaries, probably in form of credits that are to be repaid after one or two planting seasons. This will be the real test whether farmers accept the technology or not.

4.3 Implementation facing major problems

4.3.1 Training: Junior experts educated on tanks that leak

The Regional Bureau of Agriculture organised 20-day training courses in Woldya, Debre Tabor and Kemissie for a total of 1005 woreda water harvesting experts. Their future jobs were to train Development Agents (DAs), communities and farmers in the planning and implementation of the schemes and monitor their construction. Regional and federal experts conducted the training of the woreda water-harvesting experts.

Leaking from outside in: Hemispherical tank built on a slope in Dessie Zuria with groundwater seeping through the walls into the tank (photo H. Rämi, UN-OCHA, Oct.

The newly trained water-harvesting experts then trained DAs in site selection, construction and supervision. Many of the DAs however were only 12th grade school graduates with little or no experience on extension work themselves. The reason for this selection was a lack of available BoA professionals. Following newly established policy, regular extension experts must undergo specialists' courses over a period of several years. This program, which started only recently, has tied down human resources.

One batch of 500 water-harvesting experts was trained in Woldya, Gubalafto Woreda, in December. During their course, they participated in the construction of three different types of tanks all made of cement: Dome-, hemispherical- and bottleneck shaped. Plastic-lined ponds were not included in the training.

16 structures were built during the course. They are the oldest of their type now in operation in Amhara and give an idea of potential problems with this design. After 10 months of experience of the 16 tanks constructed all but two were leaking heavily. At the end of the good rainy season and a day after heavy downpours, an inspection of several of the structures revealed that none of them contained more than a foot of water. According to the beneficiary farmers, they were never full during the entire rainy season. Silt marks confirmed this. The tanks bore numerous wide cracks at different levels on the walls of the structures *(photo page 1)*.

Some farmers have tried to patch the cracks with cement, without success. The cracks reappeared shortly after. One farmer complained that not only money was wasted on his tank, but also his time. He spent three weeks excavating the four-meter deep hole. Other tank beneficiaries indicated that they would not spend their own money on the structures.

One water conservation expert present during the seminar in Woldya explained that the instructions of the manual were followed. However, the completed tanks still leaked. Materials used were: wire mesh for reinforcement of the tank walls, which are made of several layers of a sand-cement mixture in all about 5 cm thick, and stone-mortar for the flooring. The dome and bottle shaped tanks also used steel bars for reinforcing the tank cover. It seems that the construction-guidelines in the manual contains some major mistakes either in the design of the structure, in the use of materials or both.

4.3.2 Quota system leads to inferior work

One major problem was the quota system imposed by the region that put the junior experts and the DA's under pressure to construct tanks quickly. Without previous experience, the newly trained men had to monitor up to 20 sites simultaneously, select appropriate sites and supervise foremen and masons who had never before built water harvesting tanks. The DA's job proved extremely difficult without having vehicles or even animals for transport. This resulted in a lack of supervision and subsequently inferior work.

4.3.3 Site selection: conflicting priorities

Selection of sites generally is the responsibility of kebele committees. Implementing supervision is done by the woreda council, which is guided by water-harvesting experts and DAs who make the decision about the location of the structure once the beneficiaries are selected. Main criteria for site selection – farmers' behaviour and topographical location – are often conflicting.

Never filled up: Tank built for poor women's cooperative in an area without water catchment (photo Rämi, UN-OCHA, Oct. 2003).

The beneficiary must be food insecure and "an industrious, good farmer, willing+ to adopt the new technology" - farmers selected were usually not the poorest. The site must lie within a water catchment area with access to run-off water. Whether the catchment area is forested, treated against erosion with natural or physical means, was generally not taken into consideration, which can create problems of siltation in the tanks (Ponds and tanks are fitted with silt traps built at a short distance from the water-inlet. During strong rains however the silt traps are easily flushed out by the torrents, carrying stones, sand and silt into the tanks). Other water potential in the area (eg. ground-water for shallow wells) was often not adequately considered. Mistakes in site selection are responsible for most of the failures.

4.3.3.1 Wells show greater potential than ponds in Meket

Meket in North Wollo is just one of many woredas that experienced problems with site selection. It has 3 agro-ecological zones and receives on average 700-800 mm of rainfall. The lowlands suffer from the most chronic water shortages, but are difficult to access for transport of cement and heavy plastic linings. Ponds and tanks therefore were constructed mainly in the midland *(woyna dega)*. But mid and highlands with their swampy plains of black cotton soil have a very good ground water potential and often a very high water table *(picture overflowing shallow well same page)* which makes them much less suitable for ponds and tanks than the lowland *kola* areas.

One farmer in Warkaja kebele – known to be very industrious – was advised to dig out and cement a dome shaped underground-structure in order to collect roof water. At a depth of three meters he found ground water and was forced to stop digging – the planned concrete dome turned into an expensive well with an inadequate shape. The selection criteria focused on farmer behaviour and not on site potential.

Overflowing: Shallow well built in Meket nearby roof-water harvesting tanks (photo H. Rämi, UN-OCHA, Oct. 2003)

In another site, a cooperative of fifty poor women, growing vegetables with the support of an NGO, benefited from the provision of two large concrete tanks, one hemispherical, the other rectangular. The hemispherical tank was found to be leaking through a large crack where stone-mortar from the bottom joins sand-cement plaster walls. In consultation with his manual, the mason combined two different construction techniques because the underground was not uniform - silty loam at the top and black cotton soil at the bottom. The major problem though is a lack of water runoff. The tanks are built in a totally flat area away from any water catchment and they don't fill up easily *(picture previous page)*. In this case, no obvious benefits were available from the construction of the tanks to increase productivity of the women's' cooperative vegetables growing project. While it was commendable to focus on the level of poverty as the most important criteria for selection of the target beneficiaries, the more practical criteria of run-off and water collecting potential was neglected.

One model farmer along the Chinese road was advised to construct a 60m^3 hemispherical pond to collect water from his corrugated iron sheet roof, with a total material cost of about 3000 ETB. At the same time he constructed two perennial shallow wells with a combined material cost of the same amount. While the hemispherical tank was only half full, both wells were overflowing, irrigating a vegetable garden of more than 2000 m^2 *(picture same page).*

These are just three examples of many. According to the experts in Meket and other weredas, ponds and tanks only make sense if no other alternatives are available.

Investments into other schemes like river diversions, small-scale irrigation, hand-dug and deep wells are generally favoured in this area *(table 2)*.

Table 2: Meket favours wells, river diversions, springs

Structures	Planned 2002-3	Constructed	Planned 2003- 4
Hemispheric	90	108	108
Dome shape	10	6	0
Shallow wells	2276	2486	2604
small ponds, clay	400	662	440
Big ponds, clay	4	4	8
Tradition. river divers.			107
Modern river diversion			4
Traditional spring devt.			99
Drip Irrigation			271
Total projects	2790	3269	3640

Source: Office of Agriculture Meket

4.3.4 Lack of skilled labour

A widespread constraint observed was shortage of skilled labour. The construction of hemispherical cement ponds with their semi-circular shape requires a minimal amount of engineering know-how. However, people with experience in the composition of sand-gravel-cement mixtures and skills in plastering are very difficult to find in most rural areas. Even skilled masons had no experience in the construction of tanks and concrete ponds and in most cases did not observe basic rules of curing. Curing of cement structures with water over a period of several days is essential in order to avoid cracks during the drying up of the concrete.

4.3.5 Black cotton soil not suitable, tank structures too weak

A major problem is the ground in which the tanks were erected, black cotton soil, which is very common in many parts of Amhara. It expands after rains and contracts and cracks during dry times. The manuals do not recommend building tanks in black cotton soils, but woreda officials felt forced to fulfil quotas regardless.

In one site in the highlands near Dessie, the mission witnessed a half empty hemispherical tank built on a slope. On the side facing the valley, with little water pressure from the mountain, the structure was leaking, not from inside out, but from outside in *(photo p. 7)*. This is a clear indication that either the structure was built by an inexperienced layman or that the design of the structure itself is too weak. The walls of hemispherical tanks are made of a sand-cement plaster mixed 3:1 but are only five centimetres thick, which seems insufficient to withhold the pressure of $60m^3$ of water. Unfortunately the BoA did not consult a structural engineer when the manual was produced.

4.3.6 Materials: Lack of cement, plastic, causes extra cost, failures

A major problem all over Amhara region was the lack of materials; cement and wire mesh for plastered tanks and polyethylene membranes for ponds. This has some costly consequences.

Originally it was planned to construct 29,005 tanks made of cement plaster in various shapes *(table 1)*. 27,955 holes were dug for this purpose but only 12,614 structures were actually completed. The problem was a delay in the arrival of funds for the purchase of cement, which delayed construction into the rainy season in some places.

Lack of materials: Plastic lining instead of concrete in hemispherical excavation (photo H. Rämi, Oct 03)

Due to previous negative experiences with concrete structures, the BoA officials now want to reshape the more than 15,000 remaining hemispherical holes into trapezoidal ponds that will be lined with plastic membranes rather than using a concrete lining. This carries the danger that the structures are less stable.

Construction of plastic-lined ponds had their own problems as well. The polyethylene membranes did not arrive in time and in the quantities required. The Region received only 2442 plastic linings for a planned 30,000 ponds, most of them from their neighbours in Tigray, who from the start, opted for plastic and clay lined ponds only *(5.4)*. ORDA (Organisation for Relief and Development Amhara) who had difficulties to procure the goods in South East Asia, has been in-charge of purchase and welding of plastic sheeting. The following are some other examples of problems encountered.

4.3.6.1 No material, experts in Dessie Zuria

In Dessie Zuria woreda 310 ponds with plastic liners were planned. The material was supposed to be delivered in May, but arrived only at the end of September. It is now warehoused at the BoA compound in Dessie and cannot be used, because the expert, who was trained in Meket to weld the plastic sheets together to obtain the right size had left. He was also supposed to train Developments Agents (DAs) and farmers in the construction of the ponds.

Because there was no plastic, the Dessie Office of Agriculture decided to build 52 hemispherical concrete tanks with money from the regular woreda budget. But the material cost of 5000 ETB was more than three times greater than for plastic lined ponds, thus reducing further the ability to comply with the quotas. For this fiscal year, the Dessie Office of Agriculture plans to downsize its target of 500 tanks and ponds.

4.3.6.2 1000 holes collapse in Dalanta

Some highland woredas, like Dalanta in South Wollo, are unable to construct concrete tanks because sand for the concrete mix cannot be found there. Dalanta receives an average of 600mm rain/year, has no rivers, which can be diverted and ground water tapping – though possible according to experts – is largely unknown. The local farmers were very enthusiastic about the construction of plastic lined ponds and excavated more than a 1000 holes for the purpose. Since plastic membranes did not arrive, most of the holes eroded and collapsed during the last rainy season and now have to be rebuilt. The farmers are frustrated, claiming that the land, which was wasted for the holes, would better have been used to plant crops under the prevailing favourable conditions.

4.3.6.3 Gubalafto: River diversions much more cost effective

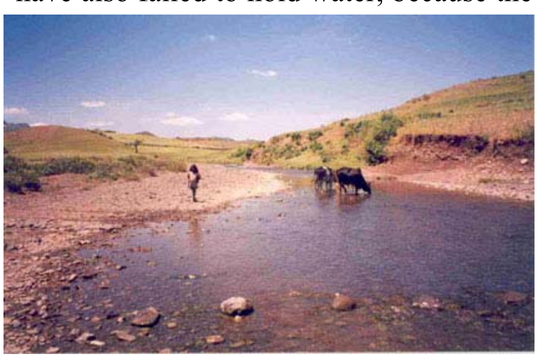
Gubalafto wanted to build 274 plastic ponds, the holes were dug, but only material for 10 ponds arrived. However the technology for plastic ponds was never introduced there and the experts say that it was difficult to reshape the holes for the construction of cement tanks, which was the same problem Dessie Zuria Woreda experienced. Money from the food security budget also arrived only by the end of May coinciding with the onset of the rainy season, which made it impossible to construct any tanks or ponds. Due to the negative experience, plastic ponds are no longer included in the action plan for next season. Moreover, concrete tanks, which were built in December, were disappointing, since they were almost all found to be leaking heavily *(4.3.1)*.

According to experts from the Offices of Agriculture and Rural Development in Weldya, the structures, plastic and concrete are too costly for the amount of water they produce. They would preferred more irrigation schemes fed by river diversions, which they believe are more sustainable and suitable to their area. The Office of Agriculture in Dessie for example computed that river diversions cost 15,000 ETB per hectare of irrigated land. This is at least 15 times cheaper than irrigation with the use of ponds and tanks.

15 times more cost effective: Experts prefer river-diversions to tanks and ponds (photo Rämi, Sept 03)

4.3.6.4 *Leaking tanks in Ibnat, but also some positive experiences*

Ebnat is a seriously drought prone and food insecure lowland woreda. Water is a constant problem for most of the population and the farmers have invested much effort into the water- harvesting program. However, they have encountered numerous problems. Wire mesh, which is used for reinforcing the plaster walls of concrete structures, never arrived. The tanks were built without the reinforcing, with the result that all of the structures cracked, preventing the tanks from holding any water. Some of the plastic lined ponds have also failed to hold water, because the trapezoidal polyethylene membranes were sunk into hemispherical holes originally intended for cement structures for which no cement was available. Farmers were also not aware of how to repair and seal the membranes. Two ponds built by the woreda office of Agriculture in 2002 dried up quickly last year, when rains were more scarce, raising the question among officials as to the benefit of the tanks in a dry year. A perennial river that runs through parts of Ibnat has good diversion potential, but is only partly utilized *(picture left)*.



Potential to be exploited: Perennial river running through Ibnat (photo H. Rämi, UN-OCHA, October 2003)

However, there were also a number of very positive experiences made in Ebnat. Water collected in extra large unsealed ponds was used to recharge the ground water table, which could be accessed by new shallow wells *(chapter 8)*. Around Ibnat town, 10 shallow wells provide water all year round, also during dry years. According to the agriculture office the ground water potential and recharging possibilities should be exploited before building additional ponds.

Table 3 shows the differences between what was planned in Ibnat and what was finally constructed.

Table 3: Availability of material causes confusion in Ibnat

Structures	built in 2003	Planned for 2003	Planned 2004
Hemispheric structures cement	80	500	0
Plastic-lined ponds	46 (hemispheric)	0	850
Traditional ponds	85	78	
Shallow wells	1500	755	1600
Trenches on hill sides	5000	3944	

Source: Office of Agriculture Ibnat

5 Tigray- 500,000 ponds in five years

5.1 Increased food security in three years

In Tigrays' 35 woredas, 621,000 households or 75% of a total population of four million are food insecure and seriously threatened by droughts, which hit the region every 3-4 years. Major climatic limitations for agricultural production are erratic rainfall, often combined with intermittent dry spells that regularly threaten the survival of crops. According to the Tigray Bureau of Water Resources variability of annual rainfall is high with 20%-40%. Like in most other regions, the amount of rainfall is not the main problem; but collection and storage is.

Supplementary irrigation during dry spells: Farmer with his plastic lined pond, covered by stones in Wukro woreda (photo H. Rämi, UN-OCHA, Oct. 2003)

In order to reduce dependency on large amounts of assistance, the regional government has set itself the ambitious goal to eradicate 88% of the food deficit within the next three years. It is formulated in a "Rural development strategy plan" based on water, agriculture and cooperatives. Water harvesting with ponds and ground water extraction by shallow wells is one of its main components, which is intended to increase agricultural production during relatively good times and secure crop production during dryer years.

The Regional Bureau of Water Resource Development estimates that "Tigray can potentially irrigate 50,000 ha, using various water management schemes": Micro and medium sized dams (Box 2) river diversions, ground water exploitation, pumped irrigation and - at present the favoured choice – ponds and shallow wells. The Bureau this year received an order by the regional government to "plan as many schemes as possible, regardless of the budget".

The goal is to construct half a million ponds in the next five years. The target for the last fiscal year was to construct 40,000 ponds, 80% made with plastic liners, the rest with clay lining. 28,000 were built. The target for this fiscal year is 160,000, 60% with plastic liners. Shallow wells are the second largest component in the water-harvesting program with 5000 wells planned each for this and for the next two years. 7 river diversions and one spate irrigation system with a total of 630 hectares are also planned.

The lead agency for the implementation of the water-harvesting program is the Regional Bureau of Water Resources (BoW), which is responsible for the structural part and irrigation technology. The Bureau of Agriculture is in charge of the agronomic and livestock components. The main partner is the NGO REST, which until now has helped develop and build most of the schemes.

Box 2

Water harvesting in the past – history of success and failure

Tigray has experimented with water harvesting systems for many years. Traditional ponds built by farmers and the previous Derg regime, are a common site in the region. They are used for animal watering mainly and are not much more than a 10-20 meters wide and a few meters deep excavation in clay soil, usually with a very good water holding capacity.

Sustainable and cheap: Community pond in clay soil built during the Derg time (photo H. Rämi, UN-OCHA, Oct 02)

In 1995 with population, livestock numbers and the need for increased food production growing, the regional government of Tigray embarked on its first ambitious water harvesting plan: 500 micro dams to be constructed within 10 years, intended mainly for irrigation agriculture. But the program was initiated without initial assessment, and stopped in 2001, achieving less than 10% of the target. An evaluation study in 1998 showed that the initial assumptions of potential water resources available were overly optimistic: the cost was significantly higher than estimated and technical skills, human capacity and equipment were lacking. In the end, 46 micro dams were constructed of which 37 are still operational. Some have sedimentation problems or are seeping, others were never filled because rainfall and catchment capacity were overestimated.

5.2 Financing: Farmers must pay in the future

Funding for the water-harvesting program comes from the food security budget and from budgets of line ministries. REST provided plastic sheets and also paid for cement and labour. With the exception of skilled work, labourers were paid in grain. This years (2003-2004) food security budget, however, does not foresee grain-payments to farmers except for those in deficit areas. Peasants are expected to provide their labour for free and plastic sheeting will probably be provided on credit according to the Food Security Bureau. This will be a good test to find out whether the farmers are willing to pay themselves for the program.

5.3 Irrigation objective has limitations

The major objective of the water-harvesting program in Tigray is to provide supplementary irrigation of staple crops during frequent dry spells that often make harvests fail. Extension

200m^2 of vegetable garden: Farmer fetching water from his plastic lined pond in Alamata woreda (photo H.Rämi, UN-OCHA, Oct. 02)

experts also propose household ponds and shallow wells for irrigation in the production of fruits, cash crops and vegetables, which should help the individual farmer to obtain additional income and increase household consumption.

The idea is to start growing vegetables during the rainy season, and then - with the help of irrigation - extend the growth period into the dry season when crops receive good prices. According to agriculture experts, vegetable growing with simple bucket irrigation is feasible for a plot size of 150-200 m^2 only. Limiting factors are the labour force of the farmer, the availability of water from ponds and the vegetation period of different crops.

Supplementary irrigation of staple crops has its limits also. REST estimates that one plastic pond is sufficient for supplementary irrigation of 0.3 hectares of staple crops. However crop type, length of dry spell, content of tank, evaporation rate in the tank and soil and evapotranspiration rate in plants are variables that can easily change the computation.

Experts calculate that for effective plant growth a minimum of 6mm of water is needed per irrigation application. This is 30 m^3 per half hectare or 1/6 of a full tank. Although lots in Tigray are small – 0.5ha-0.8ha in mid and highlands and 1.5 ha in the lowlands – it is very difficult if not impossible for a farmer to irrigate his entire plantation of maize, wheat or barley without the help of pumps. Manually he can haul little more than 3 m^3 into the field in a single day. To irrigate his whole half-hectare just once, it would take him no less than 10 days of hard work – unless gravity irrigation is possible, which is often not the case.

So far a cost benefit analyses for ponds has not been made.

5.4 *Plastic-lined ponds first choice*

Following an assessment, which ranked different water harvesting technologies according to cost, skill needs, replicability, Food for Work (FFW) links, etc., the NGO REST last year tested 80 pilot ponds in the different agroecological zones of the region. Based on a SWOT analyses (Strength, Weakness, Opportunity and Threat) of the pilot ponds, the NGO in cooperation with the BoW and the BoA produced a regional water harvesting program plan and a manual for the construction of ponds and wells.

5.4.1 Plastic ponds much cheaper than concrete tanks

The standard design produced called for plastic-lined ponds with a dimension of 12x12x3 meters and a capacity of 180m^3. The lining is made of black polyethylene membranes, 0.5 mm thick and treated against the corrosive effects of ultraviolet sunrays. Standard expected life is 10 years. The cost per unit is 1500 ETB, which is less than half the material cost of 60m^3 concrete tanks built in Amhara. The construction of ponds with plastic liners is about 10 times cheaper per cubic meter that that of concrete tanks.

Sustainable: Large clay lined community pond, Dawro Watershed

Cheaper than concrete: Plastic lined pond Alamata

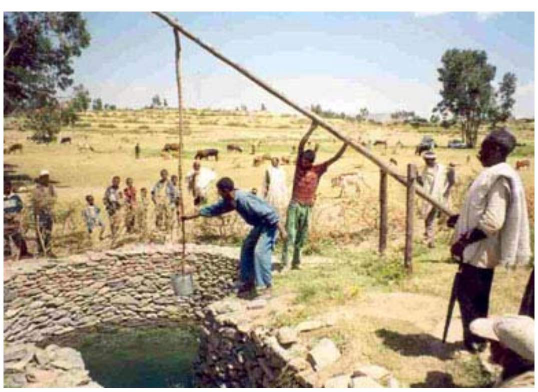
While plastic-lined ponds have a good water retention capacity and are relatively cheap, their sustainability is under question. Plastic sheets, once punctured, are difficult to repair and trained personnel, not found in most rural woredas, must weld plastic sheets. The construction guidelines recommend covering the plastic membranes with flat stones once the sheeting is placed into the hole. This however increases the danger of puncture, when people walk on them while gathering water.

The second choice is the use of clay lining for areas, where the material is easily available. These structures have a lower water retention capacity than plastic ponds but are sustainable without input of commercial materials that have a limited life span.

Where ground water is available shallow wells are proposed as the best alternative.

5.5 Ground water potential largely unknown

The Tigray Bureau of Water Resources based in Mekele in March 2003 estimated that 75% of Tigray has little or no potential for ground water sources. However so far no comprehensive assessment on the ground water potential of the region has been made and the knowledge of the extent of ground water is very sketchy. Practical experience shows that in many areas ground water can be very promising. In a number of places farmers have discovered ground water only two or three meters below the surface, while excavating ponds.



Groundwater discovered while excavating ponds: Farmers use the Egyptian Shaduf for water lifting in Tsebele Tabia (photo Rämi, Oct 03)

The Tigray Bureau of Water Resources, with the help of a Dutch consulting firm, produced a master plan for the Tekeze River basin where shallow wells are now planned for irrigation. An integrated rural development study also assessed the ground water potential in Raya Valley. The highly productive area is benefiting from water it receives from the surrounding mountain ranges either as ground water or as run-off. Run-off water from spatial rains is channelled with extremely simple means for spate irrigation, a traditional technology, which is cheap, efficient, highly cost- effective and used in many parts of Ethiopia *(Chris T. Annen, Sept. 2001)*

5.6 Problems in implementation

Tigray and Amhara encountered similar problems during implementation. Experienced water-harvesting technicians and DAs are in short supply. Many of them are 12th year school graduates without practical experience in water harvesting and extension *(4.3.1)*. Last year, REST organised a training of woreda trainers, who then selected 2000 foremen or DAs and trained them in their home places. This year 3000 more junior trainees will follow. Selection of sites and work supervision during construction are their main tasks.

Seeping clay pond, Alamata Woreda (photo Rämi, Oct 03)

Some problems are also specific to the construction of ponds with plastic liners. The second shipment of polyethylene membranes from the producer in Indonesia was substandard and had to be rejected. This caused delays and in some places a change from plastic to clay ponds.

Site inspections have revealed that the lack of experience is responsible for a number of preventable mistakes. Major problems include the wrong estimation of water run off, distance to fields, siltation and slipping plastic lining. Clay ponds often did not seal properly because the clay cover was not well puddled.

Often farmers also found ground water when they started digging ponds, which suggests that the foreman had little knowledge about the area he was working in or lacked flexibility. Many shallow wells collapsed because of hurried implementation, inferior riprap material and stone cutting skills and mistakes in the design. Uncontrolled expansion of shallow wells creates problems in areas where the resource threatens to be overexploited.

Lacking treatment of watersheds and catchment areas with reforestation or physical erosion control measures was widespread, leading to rapid siltation of silt traps and further loss of agricultural and potential forestland.

Experience seems to indicate that the construction of plastic-lined and the more traditional clay ponds is easier to manage and results in less structural deficiencies than that of cement structures favoured in Amhara.

According to REST about half of the ponds can be considered as successful. An upgrade training for foremen should help eliminate some of the mistakes.

5.6.1 Ponds leaking, personal safety issue and land loss

Drowned: Like many rural people her child did not know how to swim and died in a pond (photo H. Rämi, UN-OCHA, Oct. 2003)

Alamata woredas lies in the Raya Valley, a mostly flat area with great irrigation potential, high productivity and numerous traditional ponds. Despite very good rains this year statistics from the woreda Office of Agriculture show limited success in use of the ponds in the area. Out of 471 plastic-lined ponds, only 314 were full and out of 484 clay-lined ponds, only 207 filled completely *(table 5)*. Reasons for problems were site selection with lack of runoff and also leakage. Due to shortage of materials only 471 out of 875 planned plastic-lined ponds were constructed *(table 4)*. Most plastic-lined ponds lacked the stone lining, which is required by the manual; the reason was a lack of stones in the area.

One child and a goat drowned in one tabia (village) when they fell into a pond and could not get out because of the slippery plastic surface. The pond area was not properly fenced, which is the case almost everywhere the mission visited.

Many of the clay-lined ponds were seeping. The major reason was the local soil characteristics, being a silty-sandy loam. The clay layer, which was applied to the pond walls, was often too thin and not properly compacted. Onions planted during the rainy season were doomed to wilt beside the empty clay ponds. However, farmers said that the seeping ponds had a positive effect on lower lying fields, which may have gotten some additional moisture from the seepage into the ground.

Table 4: Alamata – plan not achieved

Structures	**Planned**	**Constructed**
Plastic lined ponds	875	471
Clay lined ponds	481	484
Cement lined tanks	0	0
Total	1356	955

Source: Office of Agriculture Alamata

Table 5: Alamata - Many ponds leaking

Ponds filled with water	**Total**	**Plastic** (total 471)	**Clay** (total 484)
100% full	521	314	207
50-75% full	218	49	169
Rest leaking, seeping or not finished			

Source: Office of Agriculture Alamata

Excavation material consumed valuable arable land. The farmers obviously did not know what to do with it, piling it up on large heaps around the tanks.

Women who usually have to carry water for a couple of kilometres were happy about the ponds. One said they all used the water for drinking until after the rains stopped and it started smelling. Now they use it only for cooking. Runoff is taken from the road, where livestock droppings, excrements and garbage are common. Without proper education and extension work, ponds can create serious health problems *(chapter 6).*

Some plastic-lined ponds, which were well built and close to the house of the owner showed good results in terms of production. One farmer successfully planted onions and pepper and started with a few fruit trees *(picture page 15)*.

5.6.2 Successful vegetable and cash crop production with plastic-lined ponds

Dangolo Tabia is a model village in Wukro Woreda. It boasts 30 ponds, mainly clay and plastic-lined serving a total of 80 households. Small gardens with peppers, tomatoes, maize and root crops, which were planted during the rainy season, and freshly planted fruit and coffee trees, were found around most of the ponds. While all of the ponds remained full during the rainy season, only the plastic-lined ponds contained water, remaining about one-half full since the cessation of the rains three weeks earlier. There was sufficient water for irrigation until crop maturation. Most clay-lined ponds though were seeping heavily and almost empty. According to experts from REST, the clay layer was not compacted well enough but the ponds could be repaired. Nearby a community livestock-watering-pond constructed two decades ago was still almost full, proof that clay ponds if properly constructed can work and are sustainable if properly maintained. The old pond was sunk into thick clay ground, which was well compacted through the yearlong use by livestock and therefore did not leak nor seep.

For home consumption and sale: mother with irrigated cabbage in Wukro (photo H.Rämi, Oct 03)

One farmer/priest who owned a plastic-lined pond himself said he would prefer community ponds, stating that individual household ponds create jealousy and friction in the community if everybody doesn’t have one.

An obvious problem also in this village was the selection of suitable sites. While some ponds collected the water from a nearby walkway leading down the water catchment area others were constructed in places with practically no run off, and thus were empty.

5.6.3 Lack of watershed – management

Rapid siltation: Full silt trap due to lack of watershed treatment, Geteb Dawru watershed (photo H.Rämi, UN-OCHA, Oct 03)

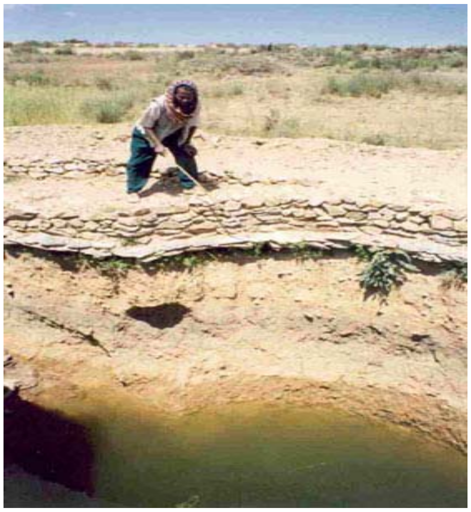
In the Geteb Dawru watershed in Adolisho Woreda, a community of 120 HH built 34 ponds, lined with compacted clay. Many of them were large community ponds, some built in series, that were still nearly full at the time of the visit. The silt traps provided with the ponds however were full of silt and the water inside the ponds was muddy brown. The watershed was totally barren and eroded. If the silt traps are not regularly emptied and the watershed reforested or treated with physical erosion control measures the ponds will not be sustainable – a management problem. After construction and training the water harvesting structures were handed over to a village-watershed-management committee.

5.6.4 Wells often cheaper than ponds, more efficient, sustainable

In Tsebela Tabia, Sasetsadamba worda, a program to construct water-harvesting ponds was initiated, apparently with little knowledge of the ground water potential in the area. When the farmers started digging the ponds, they soon found abundant ground water and abandoned the pond project and instead built eight shallow wells with the help of REST. Shallow wells are the most efficient, sustainable and probably cheapest component in the regional water-harvesting program, if groundwater is available. Their construction involves mainly labour – on average about 10 people working during the period of one month. Cement is not required provided workers are skilled in cutting of square stones used for reinforcing the well shaft. Normally, one or two households, who use it for irrigation, own a shallow well. Neighbours often share the well, but only for household and livestock consumption, not for irrigation.

For shallow wells, without pumping, water extraction is extremely laborious which limits the area that can be irrigated. The cheapest and most simple technology for water lifting known so far in Tigray is the egyptian Shaduf (picture page 17). With the help of the lift, farmers are able to irrigate lots of about 200m2. To make water extraction less time and energy consuming, REST wants to distribute treadle pumps on credit to farmers, at a price of approximately 400 ETB without hose. Some family drip irrigation systems are also planned.

5.6.5 *Lack of skills and know how - wells collapsing*



Collapsing well in Sendeda Tabia: lack of material, skills, and experience are major problems (photo H.Rämi, UN-OCHA, Oct. 2003)

In Sendeda Tabia many shallow wells, which were constructed through FFW did not meet minimal construction standards and collapsed during heavy rains. One beneficiary farmer complained that his neighbours were more interested in the food they received than in the quality of the structures they built. Many ponds built by individual farmers on their own initiative and cost also collapsed due to lack of experience, wrong design, and lack of skills. Wells constructed with a rectangular shape generally were much weaker, than wells with a round shape that distribute the pressure evenly to all sides.

Another problem is the availability of adequate building materials for the shafts. Basalt stones, the only construction material available in the area is difficult to cut into cubical pieces without adequate tools and experience. The uneven shaped blocks are difficult to fit together and many wells, hurriedly constructed did not withstand the water pressure during the rains.

Despite such setbacks farmers obviously benefited immediately from the wells. One farmer and his wife were able within a single season to repay their old extension credits of more than 1000 ETB through the planting and sale of vegetables: cabbage, tomatoes, beans and peppers.

6 Human health: Malaria and death by drowning

Malaria poses a major threat to people who live near ponds filled with water, particularly in the warm lowlands. It was stated by some informants that the official opinion in many places is that "the disease is widespread anyway during the rainy season and that ponds therefore don't increase the health danger". However if ponds remain filled into to dry season, until all the water in the ponds is consumed, people could be subject to malaria for a longer period.

In some low lying areas in Amhara people complained about an increase in incidence of malaria since the ponds were built. However, farmers in Tigray, who utilise plastic-lined ponds, claimed that due to the heating up of the water in the black plastic ponds the larvae of malaria mosquitoes were killed. This needs further investigation.

Death trap: With vertical walls and no ladder or rope to hold on to, even a good swimmer cannot get out of this hemispherical concrete tank alone (photo H.Rämi, UN-OCHA-EUE, October 2003)

The regional government of Amhara now has commissioned the Bureau of Health in Bahar Dar to undertake a study looking at all the waterborne diseases that could possibly spread through water harvesting structures: Malaria, Amoeba, Dysentery, Typhoid and Paratyphoid fever, Parasites, etc. The study will be released soon. Under study is also the use of chemicals or biological means to kill malaria-carrying mosquitoes in the ponds.

Safety is also a major issue, which has not yet been properly addressed. The majority of Ethiopians don't know how to swim, particularly those people who live away from water bodies. The way tanks and ponds are constructed it is almost impossible to avoid deaths by drowning as noted by dozens of drowning accidents that are reported from Amhara and Tigray. In many cases, life-saving fences were absent. Many concrete tanks neither have a ladder, steps, nor a simple rope to hold on to. Due to their vertical walls at the top it is even impossible for a good swimmer to get out. Plastic-lined ponds are very slippery when not covered with a layer of stones and also have resulted in numerous deaths according to BoA officials and farmers, but no statistics were available on exact numbers of deaths.

7 Water utilisation – wastage, ingenious inventions

Wastage and uneconomical use of water is a major problem everywhere where water harvesting is practised. Farmers either shower their crops with uncontrolled gulps out of buckets or flood the fields through treadle pumps and hoses. Due to the high evaporation rate, especially during the dry season, a lot of water is lost before it reaches the roots. Much water evaporates when it is still in the ponds. Most affected are the plastic-lined ponds with their wide area, which is difficult to cover. The black colour of the polyethylene membranes heats up the ponds further increasing evaporation.

In order to minimise the problem of water losses, some experts and farmers invented quite ingenious drip irrigation systems. In Meket, experts from the Office of Agriculture collect plastic dextrose containers from the local clinics and use them as drippers. Bamboo- and reed poles, locally called Shamboko, are another alternative. The poles are sunk beside a tree or vegetable seedling, water is poured into the pole opening and the water is slowly discharged into the ground without much wastage.

Convinced by the successes of shallow wells initiated by the government many farmers who were not yet benefiting from the program have built heir own shallow wells. During excavation some have even hired diesel-pumps at a charge of 60 ETB per operating day. The rapid spread of shallow wells however carries the danger of over overexploitation. Due to an all too extensive extraction of the resource, the ground water table sinks and can be exhausted before next years rains set in, which causes springs to dry up downstream. Threats are also by diesel pump operators who hire out their equipment for irrigation to wealthier farmers.

In Amhara, REST, BoA and BoW have tried to establish ground water management systems in affected locations. As a rule wells shall not be closer than 70 meters in areas with a very good recharge. In other places the recommendation is 150 meters.

8 Ground water tapping: At least 5000 m^3 of water per hectare to be harvested

Harvesting the rainwater where it falls: Recharging of ground water in Ibnat Woreda with large unsealed ponds collecting run-off water (left) and trenches planted with sunflower and ground wedge in Tigray (below) (Photos H. Rämi, UN-OCHA, Oct. 2003)

Recharging and tapping the ground water is one of the most promising technologies in many areas in Amhara and Tigray. Even in places with minimal rainfall, the potential is tremendous, illustrated by a simple calculation. An area with an annual rainfall of only 500mm in effect receives 5000 m^3 (!) of rainwater per hectare. This stands in sharp contrast to the only 60 m^3 an average concrete tank or to the 180 m^3 a plastic-lined pond can store. The challenge is to harvest this huge amount of water where it falls and prevent it as much as possible from running off. There are a number of tested technologies available – excavation of ditches and trenches or unsealed ponds and semicircles that collect the water and discharge it slowly into the ground water where it can be tapped afterwards with wells. The key point is to keep the water from quickly running off so that it can be absorbed into the ground. Important experimental work is presently being done in Tigray and Amhara by GTZ (Gesellschaft für Technische Zusammenarbeit) and by GAA (German Agro Action).

9 Conclusions and recommended actions

This mission cannot be considered to provide an exhaustive survey of the results of water harvesting initiatives in Tigray and Amhara. It does however point towards some of the positive results of water harvesting approaches as well as some of the problems and issues associated with the current technologies being employed, and some human resource concerns.

- Water harvesting can have an important role in achieving food security of Ethiopia. It helps bridge the dry times between the rainy season to the benefit of human and livestock consumption and for agricultural and garden production through irrigation. However water-harvesting schemes have limitations to different degrees. The natural environment and human capacity play major roles. Design, technology, type of inputs, size and cost are also factors contributing to success and failure of ongoing implementation programs.

- The different schemes are not applicable to all geological and geographical areas. While concrete tanks maybe perfectly suitable in the sandy loam soils of Adama, they are a total failure in the black cotton soil plains of Wollo, where ground water is abundant or where rivers could be diverted for irrigation.

- Due to their small capacity, ponds and tanks are only economically viable if no other water source is present and has potential. They are justified under certain environmental conditions and therefore represent a niche technology that may be suitable only in certain specific areas or situations.

- The construction of ponds and tanks is also not an enduring solution to the more underlying problems of water scarcity in Ethiopia: Deforestation and overexploitation of natural resources. Tanks and ponds often fill up with silt. Sustainability is also a question mark in terms of materials used and the skills by which the structures are made.

- The ongoing water-harvesting program is implemented under intense pressure to achieve quantitative results. On the speed and scale by which the programme is being pursued, quality is likely to suffer. Site selection and work is done hurriedly and without experience, with the consequence that many projects fail. In many places the schemes implemented are not the most appropriate ones. Efficient monitoring does not exist due to capacity constraints.

- A slowing down of the program and improved monitoring would help to improve quality. A thorough evaluation and assessment of the already implemented program should have the intent to adjust for previous mistakes and give room for more flexibility. Even more important, the quest for achieving quotas and the limited designs offered take away initiative and decision making from farmers concerning the most appropriate technologies for given local circumstances.

- The structures themselves have problems with layout and design. Plastic-lined ponds heat up, increasing already high evaporation rates or – if covered with stones- are in danger of getting punctured. Many concrete tanks were found to be leaking. Their design and construction specifications should be thoroughly scrutinized. Clay ponds are cheaper and more sustainable but often seep and leak due to either lack of good clay material or inferior quality of work. Wherever applicable clay ponds should be favoured over plastic and concrete structures. However they require proper lining to eliminate leaks.

- Health and Safety are issues concerning peoples' lives that have not been adequately addressed. Death by drowning is common and the spread of waterborne diseases is under investigation.

- An integrated approach to water harvesting is lacking in most places. Watershed management with reforestation and other erosion control measures is often missing or not adequate where ponds and wells are built. Siltation is a major problem. Integrated extension work concerning health, safety and the proper use of the ponds for agricultural production is mostly lacking.

- It is too early to assess the impact on agricultural output since the program has just started this year. Production achieved with the help of water harvesting schemes though is likely to differ substantially between years with high and low rainfall. It is questionable whether water harvesting ponds and tanks help substantially improve production during dry years.

- Harvesting of ground water with shallow wells is cheaper and more sustainable than ponds and tanks and should be promoted wherever possible. However extraction of ground water needs extensive assessments, proper planning and management.

- In order to increase the resource, efforts should also be made to replenish ground water with all possible means, many of which are purely natural – forest and ground vegetation - or require simple water retaining structures that can be built with minimal means – trenches and unsealed collection ponds along denuded mountain slopes and cultivated hills, absorbing and storing water during heavy rains and gradually releasing it into the ground. River diversions are another favourable option where applicable.

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Annex

Abbreviations

BoA	Bureau of Agriculture (regional level)
MoA	Ministry of Agriculture (federal level)
OoA	Office of Agriculture (woreda level)
BoH	Bureau of Health (regional level)
BoW	Bureau of Water (regional level)
ETB	Ethiopian Birr
FAO	Food and Agricultural Organisation
NGO	Non-Governmental-Organisation
REST	Relief Society of Tigray
UNCT	United Nations Country Team
UNDP	United Nations Development Programme
UN-EUE	United Nations Emergencies Unit for Ethiopia
UNHCR	United Nations High Commissioner for Refugees
UNICEF	United Nations Children Fund
UNMEE	United Nations Mission to Ethiopia and Eritrea
WB	World Bank
WFP	World Food Programme

Glossary

dega	Expression for one of the altitudinal agroecological belts in Ethiopia. In Tigray between 2500 to > 3400 m a.s.l.
kebele	Smallest administrative unit in Ethiopia
kolla	Expression for one of the altitudinal agroecological belts in Ethiopia. In Tigray between ~1400 to ~1800 m a.s.l.
tabia	is the Tigrigna language name for 'kebele' that is the smallest administrative unit of the Ethiopian Federal Government.
woreda	Local administrative unit
weyna dega	Expression for one of the altitudinal agroecological belts in Ethiopia. In Tigray between ~1800 to ~2400 m a.s.l.

Glossary of important meteorological and seasonal terms used for Ethiopian highland areas

Meteorological Drought Defined

Drought is a period of insufficient water initiated by reduced precipitation. The impacts of drought on crops and society are critical but not easily quantified. The result is that "drought" does not have a universal definition. "Meteorological drought" is defined as a sustained period of deficient precipitation with a low frequency of occurrence. While crops may be damaged by lack of precipitation and high temperatures in just a few days, such short periods are not considered to be meteorological droughts. A three-month period is defined by the American Meteorological Society to be the shortest period that can be defined as a drought. (Source: *The American Meteorological Society*)

Ethiopia's 'Keremt' or 'Meher' Rains Defined

Since Ethiopia and Eritrea are in the tropics, physical conditions and variations in altitude have resulted in a great diversity of climate, soil, and vegetation. Rainfall is seasonal, varying in amount, space, and time. There is a long and heavy summer rain, normally called the big rain or *keremt*, which falls from June-September. It is followed by the *baga* hot, dry period from October through February (see below for definition). In some areas there are short and moderate spring rains in March and April known as the little rains or *belg*. These rainy periods correspond to Ethiopia's primary and secondary agricultural seasons, known as the *meher* and *belg*. (Source: *FEWS*)

Ethiopia's 'Belg' Rains Defined

In spring, a strong cyclonic centre develops over Ethiopia and Sudan. Winds from the Gulf of Aden and the Indian Ocean highs are drawn towards this centre and blow across central and southern Ethiopia. These moist, easterly and south-easterly winds produce the main rain in south-eastern Ethiopia and the little spring rains to the east central part of the north-western highlands. The little rains of the highlands are known as *belg* rains, referring to the second most important sowing season of the region. (Source: *FEWS*)

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