Analytical documentation of successful traditional practices and farmers Innovations in agricultural water management in the Amhara Region[3]

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Abstract

Amhara region is one of the regions in the country with vast potential for irrigation development. In the region more than 86% of the irrigated land is served by traditional schemes. The traditional irrigation belong those schemes that are designed, developed and operated by farmers themselves. Generations of farmer have developed different water management technologies applying their indigenous knowledge of crop characteristics, soil condition, topography, climate, hydrology and social values that allowed them to live under harsh conditions.

The paper encompasses diverse farmer's innovation in traditional irrigation schemes. With the help of Woreda agricultural office experts and development agents' successful traditional schemes were selected and beneficiaries and water committees of the schemes were discussed using informal tools and semi-structured interviewing. The paper also discusses opportunities to promote farmers' innovations by linking innovative farmers with each other and with formal research and extension.

Key words: *Traditional irrigation, innovation, farmers practice, water management*

Introduction

Amhara region is one of the regions in the country with vast potential for irrigation development. The region is endowed with four river basins having a total potential area of more than 0.57 million ha, however, till recently, only less than 2% (73, 035 ha) has been developed both by modern and traditional irrigation. In the region more than 86% of the irrigated land is served by traditional schemes. The traditional irrigation belong those schemes, which are designed, developed and operated by farmers themselves.

Currently small-scale irrigation is highly favored by Government as a means of bringing about household food security, reduced dependence on food aid and economic growth. Hence, the traditional schemes both at communal and household level are now in a better position from the point of land coverage. The practice includes diverting small streams and springs, constructing ponds and shallow wells (Muluken, 2005). In addition, the over all land coverage of modern irrigation schemes indicated they were working below 50% of their planned capacity. Traditional irrigation schemes are started long years ago due to multifarious reasons and farmers have developed their own indigenous knowledge and

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skills range from designing, operation, maintenance and equitable distribution of water resources to maximize benefits from both rain fed and irrigation farm activities.

Population pressure on a limited natural resource base appears to be an important incentive for innovating and investing in agricultural diversification, where farmers have their "backs against the wall" and few options left, experimentation and innovation find fertile ground. Farmer innovators frequently recount that they were driven by the need to feed their families. Farmers are keen to experiment with technologies that promise to create substantially increasing production and at the same time, maintaining or improving the environment. Higher yields are important not because they improve food security at household level, but also because more agricultural products can be sold to generate cash for other expenditures (Hassane et.al. 2000).

In the region as well as in the country traditional irrigation schemes take the lion share of irrigation practices. So it is important to document and understand their knowledge of irrigation water management and the practice they use successful practices and be used in improving efficiency of modern irrigation schemes, which are currently operating below 50% of efficiency (irrigation Inventory, 2005). Such research undertakings are more important in areas like in Amhara region where agricultural water management technologies are scare or entirely absent.

For centuries, farmers have developed technological innovations, to produce improved crops, livestock, tools and machinery and manage their resources in a sustainable manner. Yet in many countries, this kind of intuitive experimentation remained untapped, and farmers receive scant credit for their contributions.

Objectives

- To describe the traditional practices and farmer innovations in agricultural water management in detail, context of their development, benefits from such practices and their strengths and weaknesses
- To analyze the underlying principles of the innovations used by the farmers and factors that sustain these practices and their successful adoption so that those principles and factors could be used in improving the quality and relevance of formal research
- To assess potential to extrapolate such practices and innovations in similar agro-ecological environments and socio-economic conditions
- To assess potential to improve the performance of such practices through formal on-farm and/or on-station research

Methods of Data Collection and Analysis

The study was carried out in different parts of the Amhara Region: eastern, northern and western parts of the Region. In the eastern part of the Region (north and south Wello): Gurd shola and Sanka traditional irrigation schemes were selected for the case study. Gurde shola traditional irrigation scheme is found in Girana kebele of Harbu district located 15km from the high way of Woldia to Dessie with an altitude of 1473 masl longitude $11^0$33’44.6” N and Latitude $39^0$41’57.1” E while Sanka traditional irrigation scheme is situated in the main road from Woldia to Woreta at a distance of 35km from Woldia with a geographical location of 2100 masl altitude, $11^0$53’43.2” N longitude and $39^0$27’7.0” E latitude.

In the northern part of the Region (North Gonder): the two irrigation schemes used for this case study were Beles and Zarima Traditional Irrigation Schemes. The former scheme is found in Amba-chira *Kebele* of Gondar-zuriya district and the later in Zarima *Kebele* of Adi-arkay District. Both districts are found in North Gondar Administrative Zone of Amhara region, Ethiopia. Geographically, Beles irrigation scheme is located at 2529 m.a.s.l on 12^o23’52.5’’ Northing and 37^o41’32.9’’ Easting about 60 km SSW from Gondar town while Zarima Traditional Irrigation Scheme is situated at 1213 m.a.s.l on 13^o20’44.76” Northing and 37^o52’9.13” Easting and 140 km NN from Gondar town. Agro-ecologically, Zarima is *kola* and Beles is *dega* with mean annual rainfall 1170mm and 740mm, respectively.

The third study locations were selected from the western Amhara region ((Agewawi, east and west Gojam, and souoth Gonder); these include**:** Banja Shukudad (Ascuna Abo kebele), Ankesha (Shumata & Bekafta kebeles) Jahbi Tahnan (Mankusa Abdokoma kebele), Deby tilat Gin (Wodebe Yesus & Debre Yesus kebeles) and Fogera (Bebeks Kebele) woredas

Primary data were collected by surveying the schemes with interdisciplinary team using semi-structured questioner. Water users and leaders of the schemes were discussed using informal tools and semi structured interviewing. Development agents and district agricultural experts were also participating in the interview process. Transect walks and other rapid appraisal techniques have been employed to get an overview of the whole scheme. Group of farmers who are assumed to be front liners in brining new or innovative ideas and practices in designing, operation and maintenance of irrigation schemes including water fathers or Yewuha committees are interviewed. In addition, secondary data were collected from different sources about the scheme. More over, photos have been taken showing general overview of the schemes and particular innovations with in each scheme. Collected data have been analyzed using descriptive statistics.

Result and discussion

I. The case of Eastern Amhara (north and south Wello)

Gurdshola traditional irrigation scheme is literally started in 1971 by elder fathers of the present water users. In the beginning water is diverted from the other side of the river with a flume made traditionally from corrugated iron and wooden pillar 1km down from the current point of diversion. But farmers found up stream see their neighbors benefited from irrigation, and then they think over to use the river together with the downstream beneficiaries by searching a new point of diversion which covers the majority of the land.

As a result farmers found the current point of diversion 1km upstream from the earlier point of diversion, which helps the farmers to irrigate additional land. Since then experienced farmers choose the diversion point every year by looking the river trend and slope of the land. The headwork structure is constructed traditionally every year with mud and stone and it takes about three months to lead in to the farm. The canals are aligned unexpectedly in a very steep slope with minimum slope difference with out any external technical assistance and engineering equipment. They divert the water in 12m deep gorge. They dig the canal on hill sides in a trapezoidal shape to protect the canal from land slide. Secondary and tertiary canals are seen aligned depending on the topography of the land. Seepage losses are controlled by lining the canal with crop remains and mud. In the previous years gullies are crossed using corrugated iron and wooden flumes but now it is replaced by a permanent structure made from metal and this helped them to irrigate additional two hectares of land. Gullies and canals are stabilized by planting bamboos, grass and shrubs on the border of the canal and gullies. Water is distributed to the farm rotationally according to the order. Each team leader of the block distributed to each plot sequentially with specific time allocation, but farmers that grow crops that demand high water will be given a priority through negotiation. During water shortage farmers practice deficit irrigation and reduce land size. In addition, they use mulch and cultivation. Farmers claims that these practices conserve moisture, close soil pore spaces and reduce evaporation. In dry seasons, irrigation of the crop starts at the commencement of the command in order to reduce conveyance and other losses. However, in good season, when the flow of the river is high, it is given with agreement those who need more water.

Sugarcane, onion, mango, maize, avocado, tomato and papaya are the major crops grown in the scheme. Crops were selected mainly by their high-income return (sugar cane & onion), the time it takes to harvesting, farmers choose early maturing crops (onion), and resistant to crop pests. The interest of farmers to plant pepper drops due to disease problem. The cropping intensity is 200% and some times it exceeds from this by choosing early maturing crops. For example, during irrigation from January to April they plant onion then with supplementary irrigation they grow tomato from April to July finally they grow tef from August to October. Except tomato and onion, farmers usually plant local crop varieties. Synthetic fertilizers are not dominantly used in Gurdshola traditional irrigation scheme; rather they largely apply compost and farm yard manure. Farmers rotate crops considering their nutrient demand, for example, onion sown under irrigation is given high organic and inorganic fertilizer as a result farmers believes high soil nutrient is accumulated in the soil. Then during the wet season they saw crops that demand high nutrient. Hence farmers are utilizing the carry-over-effects of both irrigated and rainfed systems.

In Gurdshola traditional scheme the majority of crops are irrigated by flooding while onion and tomato are irrigated by furrow or with in the ridge and basin irrigation for fruit crops. Depending on the availability of water the irrigation interval varies from 10-30 days for sugar cane, 5-10 days for onion, 10-15 days for tomato, and 20-30 days for maize. The amount of irrigation to each crop is determined when the infiltration of water into the soil is ceased and water logging started to occur.

Table1. Irrigation frequency, method of irrigation of crops grown in Gurdshola traditional irrigation scheme

Crop	Irrigation frequency		Method of irrigation
	Good flow	Scarce	
Sugar cane	10-15 days	30 days	Flooding
Onion	5-7 days	10 days	Furrow/between the ridge
Tomato	10 days	15 days	Furrow/between the ridge
Maize	20 days	30 days	Flooding

Farmers themselves determine the frequency of irrigation by looking the soil moisture and physiology of the crop based on their century old experience. Water is mainly allocated on the type of crop planted i.e., crops that demand more water will be given frequently. A number of wooden culverts are constructed at footpaths and animal crossings to protect canal damage.

There are water management committees (*Yewuha* committees) comprising of three members elected by the beneficiaries to manage the overall irrigation system. Under Yewuha committees there are 'Yewuha abats' (father of the water management) in each block principally working on managing of secondary and tertiary canals. There is no defined time for reelection of the committees but it is according to his/her managerial efficiency. They have unwritten traditional bylaws fully respected by all the beneficiaries. Some of the bylaws are:

- A person who is absent during water abstraction and canal clearing will penalized by giving a labour work service to the members;
- A person who divert water illegally will penalized 50 birr;
- Conflicts among water users will be resolved by the decision of Yewuha committees.

However, all the beneficiaries are respecting the bylaws and accept the decision of Yewuha committees and also they compromise with their local justice. As a result, no person is getting the highest penalties yet.

The main market place for Gurdshola traditional irrigation is Girana, which is in the midst of the scheme. Most of the farmers in the scheme have sugar cane plantation. Therefore, to get better price farmers remain harvesting until the price of sugarcane escalates. To get better price, one farmer is planting onion early in the irrigation season alone, and what he believes is that it will help to escape from mass production of all the farmers at the same time, which results low market price of the product. But farmers are getting problem due to the brokers. The brokers fix their sugar cane product on the farm at low price and went to the merchant and deal with another high price and get higher amount of money without any contribution on the farm. So, farmer's service cooperatives are essential to assist for maintaining better market opportunities and to timely harnessing other input delivery and credit services.

The other case study is Sanka kebele traditional irrigation schemes where tremendous traditional irrigational activities are undertaken ranging from water abstraction to wonderful land husbandry system. In the kebele there is one big river called Gimbora and other small streams and springs which covers a total irrigable land of 142.71ha and 691 beneficiary households. Farmers of this area utilize these water sources more proficiently by diverting on very steep slopes crossing big gullies, high ways and undulating topographies starting long years ago. *Bariyaayemotem* is one of the streams in Sanka which farmers' of Geshober and Debot kebeles used for traditional irrigation. Water abstraction is done with simple stone bund and straw. Farmers put big stones before summer season starts at the point of diversion to protect the area from high flood erosion, as a result it would be easy for next irrigation season water abstraction. Farmer's of Geshober kebele and Debot divide the water at the point of diversion equally by floating method. i.e. at the upper area from the point of diversion they drop a leaf and allow it to float down to the two kebeles dividing point, then when the leaf move to one side of the canal, they realized that the canal carries high volume of water, then reconstruct the diversion point until the leaf remains the head point of the two diversions which they thought equal amount of water is flowing in the two diversions. The canal is aligned in a very steep slope ranging up to 80% with minimum slope difference and without any external technical assistance. Secondary and tertiary canals are aligned based on the topography of the land by minimizing the flow of water to reduce erosion. To stabilize the canal they grow eucalyptus trees and fruit trees like coffee, and banana. More over, at hillsides they support with stone bund. They cross gullies using a flume made from stone and mud. One famous work of the farmers is that, due to the construction of the road from Woldia to Woreta their traditional canal crossing the road was destroyed, at this time the farmers realigned their canal in another way to pass through the old road culvert used for flood drainage with out any reduced irrigated land. Seepage loss is minimized using clay and grass and if the loss is very high they used to redesign the canal in another place. Repeatedly looking the size of the land and the time it takes to irrigate it, they decide the amount of water to irrigate a given land.

The major crops grown are sugar cane, maize, shallot, potato, tef and coffee. Farmers usually rotate maize with tef, tef with fababean, potato with tef and tef with wheat. They are growing crops two times a year. The majority of the farmers in most of the crops used local varieties. However, improved varieties of wheat, maize and tef were used in the previous years. But currently, due to lack of an organization which delivers inputs, they are forced to use their local varieties. For maize, tef, wheat and potato they use inorganic fertilizer, however compost and farm yard manure were prominently used for all crops.

Table 2. Irrigation frequency, method of irrigation and of crops grown in Bariya ayemotem traditional irrigation scheme

Crop	Frequency of irrigation	Method of irrigation
Maize	15-21 days	Flooding
Potato	10-12 days	Furrow/flooding
Sugar cane	10-20 days	Flooding
Shallot	5-8 days	Furrow/flooding
tef	15-20 days	flooding

Water is distributed to each farm rotationally with specified time. During water shortage they cover with leaves after irrigation to reduce evaporation loss and cultivate it to increase percolation. For easiness of work and to use the time allocated for irrigation effectively the majority of the farmers practice flood irrigation. However, vegetable crops like onion and potato are irrigated by furrow, but this also becomes flood irrigation after two or three irrigation due to sandy nature of the soil and the furrow will be mixed up. The depth of application is determined until the soil is saturated.

The scheme is mainly administered by 'yewuha abates' or water fathers who are elected by the beneficiaries. They have traditional bylaws worked for as the age of the scheme. The bylaws are more or less similar to Gurdshola traditional scheme like a person who divert water illegally will pay the estimated price of the crop failed due to lack of water during his illegal diversion; and a person who is absent during development work will be penalized his water schedule. However, with their social interaction and living together for so many years, they compromise each other and resolve with their local justice.

The market place for the produce is Sanka and Woldia towns. Farmers are staring to legalize water users associations which they believe that it creates an opportunity for better marketing of their product and service deliveries.

II. The case of norfthern Amhara (North Gonder)

1. Zarima irrigation scheme

Traditional irrigation practice in Zarima is started during the *Derg* regime (1986) and widely practiced since 1994 when the government provides water pump to deliver water from Zarima River to the schemes so as to secure food production to the local community. Due to improper operation and lack of maintenance, the generator is failed to work a year later. Since then, the farmers traditionally divert water from the river to their fields.

In terms of water source and coverage, the only water source in Zarima traditional irrigation scheme is Zarima River. Zarima River is a perennial river flowing year round. From the 50 total irrigators, 18.5% used pump to deliver water from the river and 81.5 % use gravitational flow in canal. Water from the river is diverted to a big primary canal and directed to secondary and tertiary canals during the dry season through temporarily constructed diversions to irrigate 42ha of land while during wet seasons it flows its natural way. To satisfy the needs of irrigating additional land, Organization for Rehabilitation and Development in Amhara (ORDA) has been upgrading the canals by cement and concrete.

The temporary diversion structure is just like a canal which has wider inlet and receiving water from some part of the river as shown in the Figure 1 below. The canals are constructed by stone, lined with plastic sheet, and supported by sand/soil sacks. The diversion structure is laid down inside the river bed/side and goes down up to 2km.

Primary and secondary canals are constructed by stones and lined with plastic sheet, and has 1.20-2m wide and 20-30cm depth. Its shape is Trapezoidal. Making most canals wider and shallow in depth for sufficient water flow is unavoidable means to overcome the difficulty of excavating the stony and outcropped rocky area of the river bed.
Why plastic sheet? Farmers are using plastic sheet as lining material because of

- Most soil in the area is sandy for lining purpose
- It is relatively lower expense than constructing by cement and concrete
- Its easiness to construct, replace, maintenance, etc

Figure 5. Diversion structure and primary canal at Zarima

Usually farmers in Zarima used furrow irrigation for tomato, maize, pepper and cabbage; controlled flooding for shallot and banana; and pit for perennial crops like papaya, coffee, guava, and avocado. Farmers have skill about the relationships between soil texture and furrow width. Width of furrows depends up on the soil texture, that is sandy the texture the wider and deeper the furrow is and vice versa to deliver sufficient stream size to the downstream. Field observation shows that

- Wider (40-75cm width) furrow for sandy soil to get sufficient stream size
- Narrow (≤40cm width) furrow soil for clay soil
- Pit for tree

In rugged topography, sending water across gullies and river is costly and sometimes not possible at all. According to farmers, gully and river crossing structures are different depending on the depth and width of the gully/river bank i.e. the depth and width of gully/river governs the type of crossing structure and the material used for construction. Field observations are summarized in the Table 3 below.

Table 3. Summary of gully crossing structures

Depth	Width	Material used	Action taken
≤1m	≤12	Soil, Stone , plastic sheet	• Restructuring or reshaping by earth moving • Filling the gully by stone and lining by plastic sheet
1-2m	≤5m	Stone, plastic sheet	• Construction stone to bridge the gap and lining by plastic sheet
≥2m	≥ 4m	Wooden pole, metal pole, plastic sheet	• Suspending wooden/metal poles on the embankment and lined by plastic sheet

Figure 2. Different types of gully/river/ hilly area crossing structures

Not only gully/river crossing is problems for the area but also hilly and rock-out-crop areas are hindering water flow (Figure 2). In this case, deep digging is the means to maintain the

water flow gradient. Since most canals are constructed by stone alone, collapse of canal structures and canal seepage are common problems of the area.
To mitigate such problems:

Canals are stabilized by

- Where the area is stony, the canals are supported with sacks containing sand/soil
- Where soil is available, compacting the stony canals by soil-crop residue mixture
- Keeping ungrazed the plants on the canals

Seepage minimizing by

- Lining the canals by plastic sheet
- Compacting the stony canals by mixture of soil-crop residue

Crops and cropping pattern

Tomato, pepper and onion are produced mainly for market purpose but also for household consumption. Pepper, tomato, maize and onion are also grown as pure stand or intercropped with each other. Banana, mango, guava and avocado are planted on farm borders for land demarcation as well as for market purpose. Most farmers in Zarima prefer to produce pepper because of its profit margin.

Table 4 shows the types of crops grown in irrigation, yield and irrigation frequency practiced in Zarima area. The frequently practiced crop rotation system is that pepper and tomato is planted at the end of rainy season (when the depth of Zarima River is lowered) in October. After its harvest in January/February; maize, onion or potato as pure stand or intercropped is followed at the end of February. Potato and onion is harvested in June/July while maize stayed until the end of August. Tomato and pepper are followed after land preparation in October. Maize and potato as pure stand or intercropped is irrigated at the beginning of until the rain begins in June/July. So farmers are utilizing the synergetic effects of both irrigated and rainfed systems.

Table 4. Irrigation frequency and estimated average yield of crops grown in Zarima Traditional Irrigation Scheme

Types of crops	Yield (t/ha)	Irrigation frequency
Tomato	6.7	3-5 days
Pepper	1.7	3-5 days
Cabbage	31.3	3-5 days
Potato	13.3	4-7 days
Onion	15	3-5 days
Potato intercropped with maize		
Potato	13.3	3-5 days
Maize	1.2	3-5 days

Access to input and market

By its nature irrigation agriculture requires skill, intensive labor and capital investment. Irrigation is related with the access for irrigable water and demands higher marginal amount of labor as compared to rain fed agriculture.

Many farmers need to borrow to purchase farm implements (especially water pump) and micro financial institutions like Amhara Credit and Saving Institute (ACSI) are there to deliver the service. The institution gives credit service to the farming community with group guarantee method. 60% of the farmers included in the interview replied that they are users of credit from ACSI and all of them are using the credit for the whole production activities not for a specific enterprise.

Farmers in the study area are not using inorganic fertilizers and improved seeds in their irrigated farms rather they apply farm yard manures and pant their own local varieties. Even if farmers have shown interest to use improved seeds, there is no seed and inorganic fertilizer supply during the irrigation season.

Farmers accessed seeds/seedling from

- Farmers to farmers seed exchange mechanisms
- Raising the seedling in their garden (especially pepper, onion and tomato) and
- From extension agents (perennial crops like avocado, mango etc.)

In the farming community, irrigable land is more valuable as compared with rain fed farm. About 60% of the household in Zarima cultivate their irrigable land where as 40% of irrigators rented the land from farmers that are involved in non-farm income generating activities, aged, disabled or female headed households. Female headed households rent out their land to other because they cannot afford labor to irrigate especially in night. Male headed households who involve in non-farm income generating activities also rent out the land. The productivity of the farm is deteriorating due to lack of farm input supply and decline in soil fertility. In addition, lack of efficient market sink lower the potential production.

Like any other agricultural output market, the vegetable market in Ethiopia failed to benefit small scale producers by receiving the minimum share from sales and there has been seen long chain in the marketing system of horticultural products. Potential market places are Debark, Gondar and Shire towns which are 40, 140 and 140km far from the scheme respectively. Since tomato and shallot are perishable and farmers have not any storage facilities, selling prices during harvesting time are low. Limited access of vehicles also aggravates the problem. The average farm gate price per kilogram for onion is 1.75 Birr and for tomato is 0.50Birr. However, the retail price per kilogram for these commodities is Birr 4.50 and 2.00 in Gondar respectively. This shows that whole sellers and retailers take the largest margin of the sales price. Therefore, farmers are establishing cooperative to buy their own vehicle to looking for better market opportunities.

Their living condition is much better than those practicing only rain fed agriculture. Farmers have expressed that sending of children to school, having of houses with corrugated iron roof and some savings would have been unthinkable without the existence of the scheme.

Water allocation and controlling systems
Everyone who possesses irrigable land has got equal access to water regardless of the size of the farm and the type of commodity the farmer cultivates. Water is allocated in rotation and all farmers use their turn until they satisfy the farm water demand. The water in the whole irrigation scheme is administered by one "Yewuha komitie" (water committee). The water committee has five members that are elected by water users democratically every year. If water users agree, they can be elected again and again. Members of the committee are serving the community with out any kind of incentives. The farmers in Zarima traditional irrigation scheme has unwritten and traditional bylaws, which are respected by all water users.

Among the bylaws the following are the main ones:
- Users who are absent during diversion construction will pay 500 Birr, the money is used for daily laborer wage
- Watering on others' turn may penalize 10 Birr for the first time and then 50 Birr for the second mistake. If it happened for the third time, the man will be in prison for a month.
- Conflicts among water users will be resolved by the decision of the *water committee*.

Therefore, everybody is respecting the decision of *water committee* and informants even do not remember any water user who has been experienced such highest level of penalty. *Water committee* controls especially the water sharing of users from the main canal. Those farmers having land to be irrigated from a given secondary canal are organized in a group so that partitioning of water among them is again controlled by the group leader. Any maintenance and controlling at secondary canal in a given day is carried out by the individuals that irrigates on that specific day. Any problem raised in a given group which is beyond the capacity of its leader, will be resolved by the decision *water committee* and then by Kebele officials.

Keeping the farm from animals grazing, rodents and thieves are the main challenge. In Zarima, farmers have constructed a guarding house and staying there throughout the night. In addition, dogs are serving as farm guard.

Gender in irrigation scheme
Farmers irrigate their farm in days and nights according to their shift. Female headed households are obliged to rent out their irrigable land since they didn't afford labor in nights. However, females equally contribute in other farm activities like planting, weeding, transplanting and harvesting. Women are also responsible to sell the farm produce.

Farmers' innovation in Zarima traditional scheme

Canal shape

The farmers make the canal trapezoidal shape (1.2-2m wide) while canal depth is 20-30cm. Farmers develop the experience of making the canal wider for sufficient water flow rather than excavating and out cropped rock. Moreover, farmers are keeping un-grazed the plant around the edge of the canal embankment so as to protect the flowing water in the wider canals from sunlight so as to minimize evaporation as well as for canal stabilizing.

Crop selection

In 2007/08, market oriented crops like tomato, pepper, mango, avocado, banana and papaya cover 75% of irrigated area because of its higher market price and the remaining is composed of potato, shallot, and maize for household consumption.

Table 5. Trends of crop selection from 1993 to 2008/09

Year	1993-1998	1999-2003	2004-2007/08
Produced crops	Chick pea	Cabbage, shallot, perennial crops	Pepper, tomato, potato, maize, perennial crops
Purpose	Local consumption	Local consumption as well as for market purpose	Focused for market purpose

Table 5 shows that the farmers produce for local/household consumption at the earlier stage of the scheme and now it is focused on market oriented crops like pepper and tomato.

Crossing the structure

In rugged topography, sending water across gullies and river is costly and sometimes not possible at all. Farmers in the study are used locally available materials such as wooden poles, metal poles and plastic sheets to construct crossing flumes across big gullies and rivers.

2. The Beles traditional irrigation schemes

The second case study is Bales traditional irrigation scheme. Traditional irrigation in Beles started during the Italian invasion to cultivate *Rhamnus (Gesho)* for processing and making *Tela* (local beer). Then after, farmers in the area produce cereals like barley, wheat, Fenugreek, Coffee, and now Garlic contributes 60% of the irrigable area and fenugreek, shallot and potato, barley, cover the remaining portion.

In terms of Water sources and coverage, the sources of water in Beles traditional irrigation scheme is ground water as well as Beles River. The ground water discharged from bed and side of Beles River covers 65% and the remaining 35% from Beles River. All of 252 irrigators (11.1% female headed households, 88.5% male headed households and 0.4% local institution) use gravitational flow as means of delivering the water in canal. Ground water and Water from the river is diverted to a big primary canal and directed to secondary and tertiary canals during the dry season through temporarily constructed diversions to irrigate 61.4ha of land while during wet seasons it flows its natural way. To satisfy the need of irrigating additional land, farmers have diverted the water by constructing five temporary earth and stone diversion dams.

Figure 3. Diversion structure in Beles Traditional irrigation scheme

Diversion structure and shape

The dominant source of water is from the near ground water discharged from the sides and beds of Beles River (Figure 3). Making embankments across the river bank is the means of harvesting (collecting) the ground water. The embankment is constructed from stone and *lata* (part the soil that grass roots are more concentrated). To prevent water flow through the pores of stone mound, *lata* is highly compacted using wooden mortar. The primary canal is laid on extreme of the embankment.

Canal structure and shape

Both primary and secondary canal constructed by excavating/digging the earth in rectangular shape. The width of the primary canal is wider (2m) at the inlet and narrower (about 40cm) at secondary canal, and the depth of the canal is 40-75cm. Making the canal deep and narrow minimize surface area of water exposed to seepage and that in turn minimize loss of water through deep percolation as farmers explained. Farmers also compact the side and beds of the canal with *lata* to reduce seepage loss. Moreover, leaving un-grazed the grass/plant on the canal embankment is means of reducing evaporation from the water surface in the canal.

Methods of irrigation, Furrow types and spacing

Farmers in Beles traditional irrigation scheme are used furrow irrigation for garlic, onion and maize where as controlled flooding for potato, fenugreek and barley; and using bucket for seedling preparation (Figure 4).

Spacing of furrows is depending up on the crop type. For instance

- Broad bed (60-100cm) and furrow (20-40cm) for garlic and shallot
- 30-40cm spacing furrow for maize.

Since the normal plant spacing is narrow for shallot and garlic, farmers used broad bed and furrow to minimize the area lost by furrow.

Crossing structure

Depending on the gully/river width and depth, Farmers around Beles traditional irrigation scheme are used wooden flume when it is wide and deep, restructuring the gully using stone and earth to restore the ground surface when the gully/river is narrow and shallow, or reshape the hilly areas by digging deep to send water across the gullies, rivers or hilly area (Table 6). The flume indicated at Figure 5 is put off during the wet season to protect from carrying away by flood.

Figure 4. Methods of irrigation at Beles traditional irrigation scheme

Table 6. Summary of gully/river crossing structure based on their depth and width

Depth	width	Material used	Action taken
≤2m	≤5m	Stone and *lata*	Refill the soil by lata by constructing the stone and compacted by lata as cement
>2m	>5m	Wooden pole (Eucalyptus)	Making wood flume and suspended on the bank of gully/river

Figure 5. Wooden flumes

Canal stabilizing and minimizing seepage

Canal stabilizing materials

- Keeping the growing grass on canal embankment.
- Compacting with lata (the grass root provides compacted soil).

Minimizing seepage

- Compacting the canal seepage area with *lata*
- Using wooden flume.

Crops and cropping pattern

Base on crop coverage, 63.6 % of irrigated land is covered by garlic because of its storage ability and profit margin, and the remaining is composed of fenugreek, potato, shallot and maize in 2008 (Table 7). Garlic and fenugreek are produced mainly for market purpose. But potato, barley and shallot are produced for consumption as well as for market purpose. The crop rotation system in Beles traditional irrigation scheme is that garlic, barley and fenugreek are planted in September/October. After their harvest in March; maize, potato and barley as pure stand is followed in April. Potato is harvested in July while maize stayed until the end of August. After land preparation either garlic, barely and fenugreek is followed in September/October. It is interesting to mention here that garlic or barely sown at the end of September make use of the soil moisture or late rain showers to germinate and grow. Depending on the duration of the rainfall, irrigation of crops is followed beginning in November /December. On the contrary, maize and potato as pure stand is irrigated at the beginning until the rain begins in May. So farmers are utilizing the synergetic effects of both irrigated and rain fed systems.

The irrigation interval is different for different crops as shown in the table above. It is depending on the soil texture and type of crop grown. Farmers irrigate in 7-14 days interval for fenugreek, maize and barley, and 4-14 days interval for garlic and shallot. More frequent for sandy soil and less frequent for vertic soil.

Table 7. Estimated average yield and irrigation frequency in Beles Traditional Irrigation Scheme

Types of crops	Yield **(t/ha)**	Irrigation frequency
Garlic	3.2	4-14 days
Fenugreek	0.45	7-14 days
Barley	1.2	7-21 days
Potato	4.1	5-14 days
Shallot	3.6	4-14 days
Maize	1.2	7-21 days

Access to input and market

Credit opportunity doesn't exist for the communities in the scheme which might have hindered farmers from using inputs. Like in Zarima, Farmers in the Beles traditional irrigation scheme area are not using inorganic fertilizers and improved seeds in their irrigated farms rather they apply farm yard manures and plant their own local varieties. Even if farmers have shown interest to use improved seeds, there is no seed and inorganic fertilizer supply during the irrigation season. Farmers accessed seeds/seedling mostly by raising the vegetable seedling in their garden and from local market.

The proportions of farmers in Beles that irrigate their own land are 86% where as 14% of them rent the land from aged, disabled farmers or female headed households. Female headed households rent out their land to other because they cannot afford labor to irrigate.

Everyone who possesses land has got access to water depending on size of the farm and the type of commodity the farmer cultivates. Farmer that grows garlic and shallot has got maximum time to irrigate where as minimum time for potato. Because farmers believed that water requirement of potato is lower than that of garlic or shallot. All of farmers understand that the water is limiting due to the increase in the number of beneficiaries. The productivity of the farm is deteriorating due to lack of efficient water and decline in soil fertility.

The potential market places are Maksegnit and Gondar towns which are 20 and 60 km far from the scheme respectively. The average farm gate price per kilogram for garlic is 6 Birr, for fenugreek is 6 Birr, for shallot is 0.75 Birr and for potato is 1.50 Birr. However, the retail price per kilogram for these commodities is Birr 12, 15, 4.50 and 4.0 in Gondar respectively. This tells us that whole sellers and retailers take the largest margin of the sales price. Transportation and lack of cooperatives are the main problem here. Here in Beles, Their living condition of farmers is also much better than those practicing only rain fed agriculture. Farmers have expressed that sending of children to school; additional employment and having of houses with corrugated iron roof are the main benefits of irrigation agriculture.

Water allocation and controlling systems
Water is allocated in rotation and all farmers use their turn until they satisfy the farm water demand. The water in the whole irrigation scheme is administered by one "Yewuha komitie" (water committee). The water committee has 25 members (group of five for each diversion) that are elected by water users democratically every year. If water users agree, they can be elected again and again. Members of the committee are serving the community without any kind of incentives. The farmers in Beles traditional irrigation scheme has written traditional bylaws, which are produced and respected by all water users.

Among the bylaws the following are the main ones:
- Users who are distract any structure will pay 50 Birr and will stay in prison for a month
- Watering on others' turn may penalize 50 Birr
- Any farmer keep watering on his turn only
- Any user who will not respect the decision of water committee will pay 40 birr and will stay in prison for a week

Conflicts among water users will be resolved by the decision of the *water committee*.
Water committee controls especially the water sharing of users from the main canal. Those farmers having land to be irrigated from a given diversion are organized in a group so that partitioning of water among them is again controlled by the group leader. Any maintenance and controlling activity at secondary canal in a given day is carried out by the individual that irrigates on that specific day. Any problem raised in a given group which is beyond the capacity of its leader, will be resolved by the decision *water committee* and then Kebele officials. To protect the farm and their product farm from animals grazing and rodents, each farmer has fenced the farm plot with shrubs and human like doll has also put to protect the farm from animal grazing. Dogs are serving as farm guard as well.

Gender in irrigation scheme
Female headed households are obliged to rent out their irrigable land since they didn't afford labor to irrigate at nights. However, females equally contribute in other farm activities like weeding, transplanting and harvesting. Women are responsible to sell the farm produce especially when the amount of sale is small in amount.

Farmers' innovation in AWM in Beles Irrigation scheme

1. ***Social institutions***

Farmers in Beles establish functional water users association (water committee) with written bylaw stating the role and responsibility of each member and the penalty paid for abuse. According to the respondents, these social institutions have been seen efficient in resolving disputes. All of the respondents support the presence of written bylaws. 45% of them replied that it is the responsibility of the committee which to look after defaulters and to accuse them.

2. Canal shape

The farmers make the canal rectangular where the canal deeper and narrow in width (Figure 6). The main reason is to minimize the surface area of seepage of flowing water. Moreover, farmers keep the grass on the canal embankment to protect the canal water from direct sunlight to minimize evaporation loss.

Figure 6. Canal shape

3. Determining when to irrigation and water management in extreme cases

In addition to their turn, farmers in Beles traditional irrigation scheme have experience of determining when to irrigate the crops. Such as

- By judging root zone soil moisture content by feel and appearance method. According to the informants, the soil is moist when on squeezing wet outlines is left on hands and the soil is water stressed when it appears to dry.
- When the soil surface shows cracking
- When the plant starts to wilt

In addition farmers have experience of Managing of excess or deficit water conditions such as in water logged situation

- Spreading wood ash
- Extending the irrigation interval and Draining excess water

Water stress situation

- Mulching
- Planting crops that have lower water requirement (Example: planting potato than garlic or shallot)

4. Mulching

Mulching is one of the simplest and most beneficial practices one can use in the garden. Mulch is simply a protective layer of a material that is spread on top of the soil (Figure 7). Using crop residue as mulching is widely practiced for the following purpose in order of the farmers' preference

1. to improve the water holding capacity of the soil since mulching improves porosity by reducing soil compaction
2. conserves moisture, reducing the need for frequent watering
3. reduce water runoff and soil erosion
4. reduce evaporation
5. For its residual effect as organic fertilizer

Figure 7.6 The use of mulching in conserving soil moisture

5. Spreading HH wood ash

Farmers in Beles spread wood-ash on their farm land so as to drain the excess water on the field. Farmers have the experience of spreading wood ash primarily to improve water logging situation especially on potato field (Figure 8). Their principle is that wood ash is the capacity to absorb excess water.

Figure 8. Spreading wood-ash on excess water condition

6. Crossing the structure

In rugged topography, sending water across gullies and river is costly and sometimes not possible at all. Farmers in the study are used locally available materials such as wooden flumes, are the main structure to cross water on wider (>5m) gullies and rivers (Figure 9).

Figure 9. Wooden flume

7. Crop selection

In 2000, garlic covers 63.6% of cropped area because of its higher market price and the remaining is composed of fenugreek, potato, shallot and barley respectively. The trend of crop production since 1938 is summarized in Table 8.

Table 8. Trends of crop selection in Beles Traditional Irrigation Scheme

Year	1938	1965-1975	1975-1994	1995-2007/08
Produced crops	Rhamnus	seedlings	Barley, Wheat, Potato	Garlic, Fenugreek, Potato
Purpose	Local consumption	Local consumption	Local consumption as well as for market purpose	Focused for market purpose due to their marginal profit and storage ability

Table 8 shows that the farmers produce for local/household consumption at the earlier stage of the scheme and now it is focused on market oriented crops like garlic and Fenugreek.

8. Minimizing seepage and canal stabilizing

Farmers use *Lata* to prevent seepage loss through the diversion structure as well as through canals. *Lata* also used for stabilizing the diversion and canals. Farmers also keep grasses ungrazed on canals' embankment to stabilize the canal.

III The case of western Amhara (Gojam and Awi Zones)

All irrigation schemes visited in this survey were traditional and even some have about centuries of experience.

Important Innovations and Traditional Practices
Farmers, through experience, know very well about where and how to divert the water (Figure 10). They also know how to convey & distribute water to the farm. The following pictures are some of the examples of innovative practices observed in the field.

Figure 10. How farmers traditionally divert river water

Figure 11. Use of 'GENDA'

Very important innovation is the use of "GENDA" (which is a traditional wooden or iron sheet gutter like conveyance system to pass obstacles like gullies, roads, etc…) (Figure 11).

Strengths of some of the traditional practices
Farmers use rectangular canals that can minimize evaporation due to minimum surface area. The canals covered with grass reduce evaporation but vegetation might cause competition for water (Figure 12).

Figure 12. Stable and semi covered canal

Another important practice is to convey water in a difficult topography. They follow exactly the contour without using any instrument.

In water administration & equitable use, almost all farmers know the idea of resource allocation. From the survey result farmers use the following criteria in water allocation.

1. Land size based
2. Crop type based
3. Time base

According to the farmers the last method is the best for equitable allocation of irrigation water.

- Farmers use cash crops like onion (shallot), vegetables, coffee, pepper, mango, sugarcane, etc, than cereals to maximize profit.

Shortcomings of some practices

The problem in the use of 'GENDA'

There is leakage problem due to technical limitation and the quality of the material used for construction (Figure).

Figure 13. Leakage loss due the poor use of 'GENDA'

Figure 14. Unstable ditches

The problem in shape and depth of channels

Rectangular ditches are susceptible to side sliding because of straight edges of the wall (Figure 14).

Labor demand for frequent maintenance of structures

Annual maintenance of structures is a serious problem farmers faced in these areas for maintaining collapsing ditches (Figure 14).

Having all these, farmers have the following questions and problems.

- In all schemes farmers need help from government (any other concerned body) to construct permanent weir (structure). This will help them to reduce their labour cost that would otherwise be wasted for frequent maintenance of structures, promote early sowing (so as to increase cropping intensity) and stabilize the market price of farm products.
- Water shortage during peak time. This could be due to similar sowing & harvesting date

- Since most farmers grow same crop at the same time, price fall is a common problem.

However, our observation in the field, the problems can be summarized into the following three points:

- The Most serious problem, but that farmers did not worry about, is water wastage at conveyance and distribution system.
- Most farmers use irregular shaped and rectangular channels. This will have its own problem on sustainability of the channel bank. Both types of ditches have no fixed depth. This leads to unequal water allocation among the beneficiaries.
- Most farmers do not have practices on water harvesting technologies. They simply depend on River diversion. There are only few farmers who use this technology.

Conclusion and Recommendation

These case studies have shown that farmers have plenty of indigenous knowledge in developing irrigation schemes and water management abilities. The study presented here tries to see farmer's indigenous knowledge of water abstraction, conveyance and distribution; crops and cropping systems; water use (methods and frequency of application), management of the scheme and marketing of products.

It was found that farmers in the studied traditional irrigation schemes were highly innovative in searching the diversion point in which it is difficult to determine the exact point where the river is flowing in deep gorges and undulating topography. Canals were constructed in a very steep slope which seems unthinkable without any engineering knowledge and equipment. Farmers cross gullies using a flume made of corrugated iron, wood and stone bund & mud. A number of wooden culverts were made at footpaths and animal crossings. Gullies and canals were stabilized by planting trees, shrubs and grass.
The method of irrigation, frequency and depth of application for irrigated crops is developed and practiced by farmers accordingly. It is also interesting to note that the scheme management of the farmers is another good example of farmers' innovation. The schemes are administered by water or *yewuha* committee which is elected by water users. They have bylaws set by all the beneficiaries, resolve conflict according to the bylaw and distribute water evenly to each farmer. As a result the schemes were managed without any big conflict for centuries. Despite all these, traditional irrigation schemes were encountered problems i.e. in all the schemes diversions and other structures were constructed by local temporary materials, consequently farmers are forced to construct each irrigation season which takes their time, labor and money every year; no input and credit service; poor extension service and scant irrigation technologies complementing them. Therefore, replacing temporary structures with permanent structure has a paramount importance in using traditional irrigation schemes more effectively.

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