ANALYTICAL DOCUMENTATION OF TRADITIONAL PRACTICES AND FARMER INNOVATIONS IN AGRICULTURAL WATER MANAGEMENT IN TWO TRADITIONAL IRRIGATION SCHEMES IN NORTH-WEST ETHIOPIA

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Abstract-*The farmers have been continuously experimenting informally and innovating new practices by using their indigenous knowledge since the dawn of agriculture to adjust to their circumstances so that they can maximize or optimize benefits from the use of their natural, human and financial resources. Some innovations and adoption may take place on farms of individual farmers but quite often action leads to large-scale adoption. Results of such innovations lead to practices, which are in most cases sustainable, practical and within the limits of their capabilities. Through century old practices, farmers of Amhara Region have used their indigenous knowledge to innovate sustainable irrigation practices to address their water management needs. As the Amhara Regional State Government is emphasizing on developing irrigation-based agriculture to attain food security at household and State levels, it is important that appropriate technologies are available for adoption by the farmers. Through the assistance of the local level agricultural offices, successful traditional schemes were identified and water users and the leaders (water committee) of such schemes were discussed using informal tools and semi-structured interviewing. An iterative process was used to seeking clarifications from the water users on new questions and issues. The paper also discusses opportunities for further strengthening these practices and integrating the knowledge of farmer's innovations in formal research.*
Key words: Traditional Practices, Farmer Innovation, Amhara Region, Ethiopia

INTRODUCTION

The farmers have been continuously experimenting informally and innovating new practices since the dawn of agriculture to adjust to their circumstances so that they can maximize or optimize benefits from the use of their natural, human and financial resources. Some innovations and adoption may take place on farms of individual farmers but quite often community action leads to large-scale adoption. Results of such innovations lead to practices, which are in most cases sustainable, practical and within the limits of their capabilities. Such practices may include areas of soil and water conservation, abstraction of water for irrigation, conveyance of water, methods of application and scheduling of irrigation water to crops, choice of crops, other agronomic practices for irrigated crops, and management of the water users in making decisions to share water, maintenance of irrigation scheme, conflict resolution, etc.

As the Amhara Regional State Government is emphasizing on developing irrigation-based agriculture to attain food security at household and State levels, it is important that appropriate technologies are available for adoption by the farmers. As the status of formal research in Amhara is in its nascent stage while farmers in the State have been practicing irrigation for centuries, it is important to document and understand their knowledge of irrigation water management and the practices they use successful practices. Such successful practices can be made available to farmers in other areas with similar environments for adaptation and adoption. This can significantly reduce the time usually needed for formal research to come up with appropriate solutions. On the other hand, understanding the principles behind the successes of the practices can help researchers and extension officials in evolving new technologies or practices. Over all, the process can reduce the time and cost involved in making appropriate and sustainable technologies to the farmers. It can also facilitate improving some of these practices through infusion of knowledge of scientists and extension officials.

For the purpose this study, Traditional practices are the ones developed and followed by farmers since long time, whether they are best performers or not. However, Farmer innovations are those that farmers have developed in the recent past (may be 5 years or so) in response to their needs and circumstances. These could be the results of their own experimentation at the site, and/or adaptation of (i) a technology that they have seen somewhere else or (ii) of a technology or practice recommended by research or extension system. Such adaptation are usually are made to fit to their circumstances.
The aim of the study are to describe the traditional practices and farmer innovations in agricultural water management (AWM) in detail context of their development, benefits from such practices and their strengths and weaknesses ; to assess potential to extrapolate such practices and innovations in similar agro-ecological environments and socio-economic conditions ; and 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 two irrigation schemes used for this case study were Beles and Zarima Traditional Irrigation Schemes. The former scheme is found in Gondar-zuriya district and the later in 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°24' Northing and 37°41' while Zarima Traditional Irrigation Scheme is situated at 1213 m.a.s.l on 13°21' Northing and 37°52 Easting. Zarima and Beles have mean annual rainfall 1170mm and 740mm, respectively.

The two districts are selected with the support of zonal office of agriculture and water resources development. Then, these two schemes were identified with the assistance of the

local level office of agriculture in both districts as successful schemes. Primary data were collected by surveying the schemes with an interdisciplinary team using semi-structured questioners. Water users and leaders or traditionally called "Yewuha committee" of those schemes were discussed using informal tools and semi-structured interviewing. An iterative process was used to seeking clarifications from the water users on new questions and issues.

Development agents and 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 bringing new/innovative ideas and practices in designing, operation and maintenance of irrigation schemes including water father or "*water abbat"* are interviewed. In addition, secondary data were collected from Agricultural office at district level. Moreover, photos have been taken showing general overview of the schemes and particular innovations with in each scheme. Collected data have been then analyzed using descriptive statistics.

FINDINGS AND DISCUSSIONS

1. Zarima Traditional Irrigation Scheme

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. 18.5% of the farmers 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.

1.1 Diversion Structure and Shape

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 filled sacks. The diversion structure is laid down inside the river bed/side and goes down up to 2km.

1.2 Canal Structure and Shape

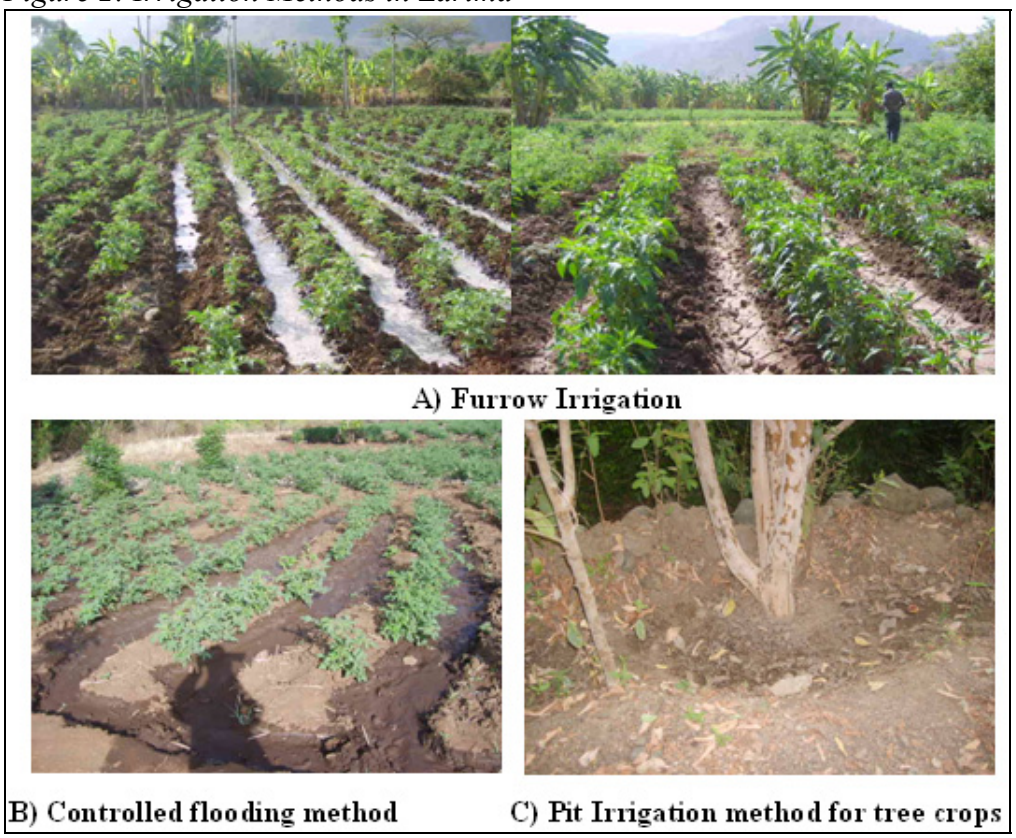
Primary and secondary canals are constructed by stones and lined with plastic sheet, and has 1.20-2m wide and 20-30cm depth. Its shape is Trapezoidal. Making most canals wider and shallow in depth for sufficient water flow is unavoidable means to overcome the difficulty of excavating the stony and outcropped rocky area of the river bed. Farmers are using plastic sheet as lining material because most soils in the area is sandy that have less important for lining purpose ; It has relatively lower expense than constructing by cement and concrete, and Its easiness to construct, replace and maintenance.

1.3 Methods of Irrigation, Furrow Types and Spacing

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 the furrow is and vice versa to deliver sufficient stream size to the down stream. 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 and Pit for tree as shown in Figure 2.

Figure 1: Diversion Structure and Primary Canal

Figure 2: Irrigation Methods in Zarima



1.4 Gully/River Crossing structures

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.

Not only gully/river crossing is problems for the area but also hilly and outcropped rocky areas are hindering water flow. In this case, deep digging is the means to maintain the water flow gradient. Field observations are summarized in the Table 1 and Figure 3 below.

Table 1: Summary of gully crossing structures

Depth	Width	Material used	Action Taken
≤1m	≤12	Soil, Stone, plastic sheet	• Restructuring or reshaping by earth moving • Filling gullies 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 and metal pole, plastic sheet	• Suspending wooden/metal poles on the embankment and lined by plastic sheet

Figure 3: Different types of gully/river/ hilly-area crossing structures

1.5 Canal Stabilizing and Minimizing Seepage

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 sand/soil containig sacks (Figure 1)
- 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

1.6 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.

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. Irrigation frequency and estimated average yield of crops grown in Zarima Traditional Irrigation Scheme are summarized in Table 2.

Table 2: 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

1.6 Access to Input and Market

By its nature irrigation is skill, labor and cost intensive; socially dependent; and cost lies at 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 Amhara Credit and Saving Institute (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 out put 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. How ever, 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 with out the existence of the scheme.

1.7 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, every body 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 district officials.

1.8 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.

2. Beles Traditional Irrigation Scheme

2.1 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.

2.2 Canal Shape

The farmers make the canal rectangular where the canal deeper and narrow in width. 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.

2.3 Determining When to Irrigate 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 Water logged and dificit situations as shown in Figure 4. During water stress, farmesrs use mulching or planting crops that have lower water requirement such as potato than garlic or shallot. Farmers in Beles scheme also 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. Their principle is that wood ash is the capacity to absorb excess water.

Figure 4: Water management During Extreme cases

A) Mulching B) Spreading Wood-ash

2.4 Crop Selection

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 the table below.

Table 3 Trends of crop selection in Beles Traditional Irrigation Scheme

Year	1938	1965-1975	1975-1994	1995-2007/08

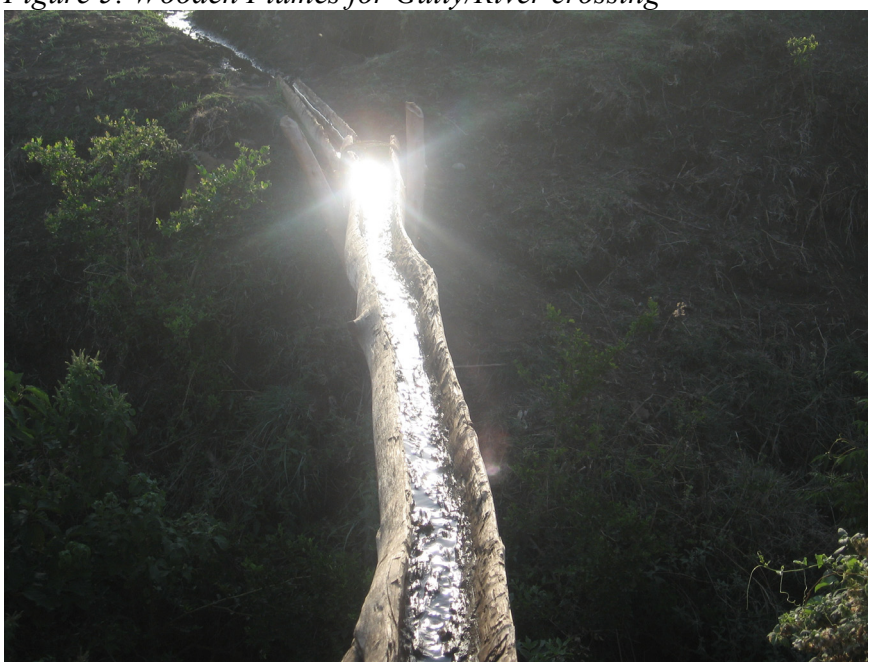
Produced crops	Rhamnus	Tree Seedlings	Barley, Wheat, Potato	Garlic, Fenugreek, Potato
Purpose	Local consumption	Local consumption	Local consumption as well as for market	For market due to their marginal profit and storage ability

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

2.5 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 5: Wooden Flumes for Gully/River crossing



2.6 Minimizing Seepage and Canal Stabilizing

Farmers use *Lata* (soil layer where the grass root is more concentrated) 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.

MAJOR PROBLEM OBSERVED IN BOTH SCHEMES

In both schemes the major problems are lack of input supply during irrigation season, disease and pests related to water management, Seepage and expansion of gully, lower extension, recurrent collapse and reconstruction of diversion structures, and lack of sufficient credit service.

CONCLUSION AND RECOMMENDATIONS

The two case studies show that

- Farmers have their own indigenous knowledge of developing irrigation schemes and utilizing them with out any external interventions. Farmers of both schemes have

progressively expanded their irrigated area by reshaping sloppy farm lands to bench and by discovering additional water sources.

- Canals are aligned following contour lines and done perfectly using the minimum slope differences with out any necessary engineering equipment. Farmers are able to construct canals having more than 3 kilometers from the point of diversion to their farm plots. In this regard, one can conclude that the basis of innovation and further improvement of a given skill and practice should be the existence of that particular farm practice in a given place.
- Big gullies and rivers are crossed using flumes constructed from local available materials like eucalyptus poles. Stabilizing the canals bank and diversions with lata, grass, shrubs and sand/soil sacks made them sustainable. Protection of diversions, canals and farm lands from animal interference with shrub fences; minimizing seepage by compacting diversion and canal surfaces with *lata* and by reducing base area of the canal is vital experience of to be learned from the schemes
- Farmers in Beles traditional scheme prefer to produce garlic because of its storage ability and high profit margin where as farmers in Zarima prefer to produce pepper because of its profit margin and tomato due to its productivity. Generally, Farmers shift from consumption to market oriented farming system .They focus on crops that give high price per yield, high yield per unit area and market oriented agricultural system
- Spreading wood-ash on farm plot during water logging situation and using mulch in water stressed condition are also crucial experience to be adopted by modern schemes
- Farmers of both schemes are trying to minimize their benefit through utilizing the synergetic effect of both irrigated and rain fed systems i.e. some crops are sown under irrigated systems but are grown and matured in rainy season and vise versa. This helps to increase irrigation intensity by harvesting and replanting crops at any time of the season
- The methods and frequency of irrigation, and depth of application of water for each crop is developed and fine tuned by farmers themselves
- The schemes are administered and run by the traditional but democratically elected "Yewuha Committee" who has implementing the traditional bylaws but served with out any incentive. It should be considered and adopted in modern schemes. Violating the bylaws could lead to penalties up to 500 Birr and in prison for 3 months. Thus, the way how farmers share the water resources among members and how bylaws are respected and implemented among all users is live example of for modern irrigation schemes
- The social institution, water committee, has been seemed efficient in administrating the schemes, in resolving disputes and disagreements among users, and implementing the traditional bylaws
- The driving force of their innovation is seemed to be drought, population pressure and need of more food for the families, income opportunity and well be of the community

To make traditional schemes more effective

- Temporary structures should be replaced by permanent ones to reduce high labor requirement of putting the structure every year
- Farmers should be assisted by demonstration and providing improved agricultural technologies
- Providing better access to credit
- Assisting them to establish cooperatives for better market options, input supply and to increase their bargaining power
- Water allocation and distribution systems among users should be adjusted by considering problems of female headed household and elders.