Agricultural Water Management: Technology Options and Adoption under Hydro Climatic Constraint. The Case of Halaba Special Woreda

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Abstract
The ultimate purpose of this study was to assess the agricultural water management practices in Halaba special district where hydro climate constraint is prevalent and framers were straggling with water shortage. The study area was selected purposively, while 247 respondents for questionnaire survey were identified through simple random sampling technique. Moreover, focused group discussion, key informants interview and field observation were conducted for the same purpose. The collected data was analyzed using descriptive statistics and linear regression analysis. The result of the investigation shows that farmers were using several agricultural water management technologies including river diversion, rain water harvesting, ground water extraction and demand management. The commonly used agricultural water management technologies were relatively cheap and mainly demand labor of the farmer. In spite of having a number alternative technologies, lack of the private investors participation in water resources infrastructure development and community views "water as free gift of God and has no economic value" were the challenges for sustainable water management in the area. Hence, it is important that the local communities to recognize fresh water is finite and has opportunity cost of capital.
Keywords: Agricultural Water, Technology, Adoption, Halaba Special Woreda

INTRODUCTION

Agriculture is the major economic activity for Ethiopia and it accounts about 46.6% of the gross domestic product (GDP) and 85% of total employment. In spite of having the large contribution for the country's economy, its production is generally low. Ethiopia's agriculture is characterized by its reliance on rainfall, and climate variability most obviously manifested in endemic, devastating droughts and floods shocks the country's economy (World Bank, 2006; Yalew, 2006). The situation is aggravated by water scarcity where many parts of country are below the per capita water security threshold of 1,000m^3 per year and low investment in agricultural water management (Naod, 2015). Moreover, the spatial and temporal distribution of the water resources of the country is also hindering the agricultural development. Majority of water resource is situated in west and southwestern parts of the country, where not more than 30% of total population found. On the other hands, not more than 20% of water resource is found in East and central parts of the country where great majority of total population found in this region (MoWR, 1999).

Ministry of water resource of Ethiopia assures that an annual rainfall apparently adequate for country's agriculture. The spatial and temporal distribution of the rainfall, however, is too uneven. Reliable food production is almost difficult due to the temporal imbalance in the distribution of rainfall and the consequential non-availability of the required water at the required period. This is a frequent phenomenon in Ethiopia. Sometimes even the western highlands of the country suffer from food shortages owing to discrepancies in rainfall distribution (Ibid).

As it was stated in water resource policy document of Ethiopia, the National Economic Development Strategy places heavier emphasis on the agricultural sector to enhance food-self-sufficiency and ensure food security at the household level and to develop an agriculture-based industrial development in the long run. This strategic approach can be achieved through the augmentation of agricultural productivity which calls for mitigating water shortage problems as a pre-condition. Moreover, limited availability of water calls the farmers to adopt efficient and effective water management technologies so as to enhance agricultural production and productivity (Naod, 2015). In line with this, the effort to mitigate the impact of hydro climatic constraints on agricultural food production and productivity through adoption of water management technologies at farm level have indispensable role. The effort of both government and local community is appreciated through the use of new technologies and improvement of indigenous methods with adequate water resource management. In recent years, the government has embarked integrated water resource management in a bid to utilize every sources of water in a holistic manner. The historical evidences also show that local communities in different parts of the country adopted several water resource management strategies. During the Aximite period (560B.C) rainwater was harvested and stored in ponds for agriculture and water supply purposes (Getachew, 1999; Ngigi, 2003). During king Lalibela's region over 800 ponds and underground tanks and Brikas were constructed in the Somali region (Hune, 2003 and Yohannes, 2004). The Konso people had a long and well established tradition of building level terraces to harvest rain water.

Having the efforts done so far, the agricultural production and productivity is still constrained by water shortage in Ethiopia. To overcome this challenge, besides to recent campaign of soil and water conservation, farmers in the country at large and in Halaba special Woreda specifically adopted different agricultural water management strategies. Hence, this paper is targeted to assess agricultural water management practices in Halaba Special Woreda, SNNPRS. Halaba special Woreda is characterized by its climate variability and rainfall shortage. The annual per capita water availability is less than 1000 M^3 and characterized under water scarce region (Yericho *et al.*, 2015).

MATERIALS AND METHODS

Study Area Description

The study area, Halaba Special District, is located in the upper rift valley region of southern central Ethiopia. It covers an area of 991 sq.km. Astronomically it lies between 7.21 ^{o}- 7.62^o North latitude and 38.05^o- 38.44^o East longitudes. Moreover, it is situated in north eastern part of SNNPR state of Ethiopia at 310 km along the main highway from Addis Ababa (capital) to Jinka (Southern extreme of the country). It is bordered with Oromia regional state in east, the Siltie zone in northwest, Hadiya and Kembata Tembaro zones in south and southeast(Idid). The mean annual temperature ranges between 17.6 to 22.5°C with the highest 34.45 °C during the month of January and the lowest 36.42°C during in the month of April. Based on Meteorological Agency's long term rainfall data analysis, the seasonal distribution of rainfall of the district was 401mm, 394mm and 163.6 during *Belg, Kiremt* and *Bega* seasons respectively (NMA, 2015).

The elevation of the area descends from 2500 m.a.s.l in western escarpment to 1500 m.a.s.l in the east. The topography is in general characterized by sloppy hills in the western half and a gradually descending to undulating plains and it is drained by intermittent streams and Bilate River.

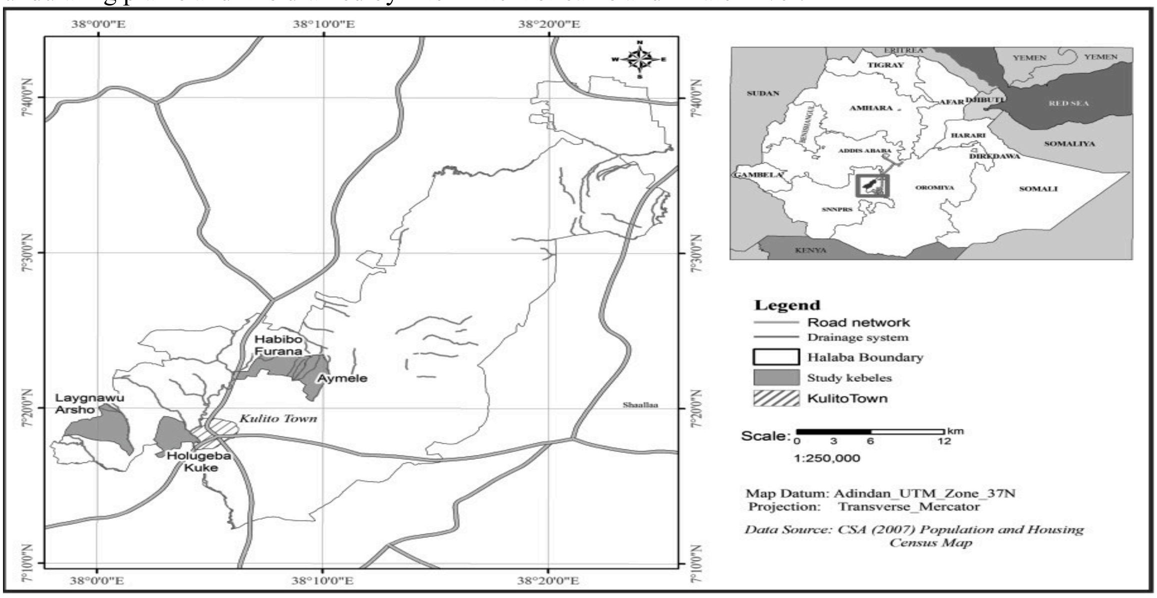

Figure 1: Map of the study area
Source: (CSA, 2007)

Methodology

The Halaba Special district was selected purposively as it is one of the most drought prone areas of the Southern Nations Nationalities and Peoples regional state, where farmers frequently struggle with food insecurity and hydro climatic variability (Yericho *et al*., 2015). The district comprises a total of 79 sub districts that show difficulty to include the entire district for investigation and hence, 4 sub districts namely: Habibo Furana, Haymele, Hulegeba Kuke and Layignaw Arsho were selected based on accessibility. The individual household from each sample sub district was selected using simple random sampling techniques. The sample size was determined by using the following formula (Cochran, 1977).

$$n = \frac{\left(Z_{\frac{\alpha}{2}}\right)^2 * p(1-p)}{d^2}$$

Where n is the sample size needed to include the number of household. P is the proportion of households in the selected sub district and the value is 0.5 that is obtained using pilot survey. The term d is called margin of error *such that the value for it is 0.07. This value is acceptable since it is less than 10%.* $Z_{\alpha/2}$ *is the critical value using* $\alpha=0.05$ *and has a value 1.96.*

$$n = \left(\frac{(1.96)^2 * 0.5(1-0.5)}{0.065^2}\right) = 247$$

The study was used both qualitative and quantitative data. The data was collected using a structured questionnaire survey, focus group discussion, key informant interview and field visit in the selected sub districts of the study area. Besides to the field observation, eight focused group discussion was conducted to identify the relevant and major issues in agricultural water management practices in farmers. Moreover, the household survey provided relevant information on the characteristics, challenges, determinants and experiences in agricultural water management in smallholder agrarian system. Twelve key informants interview was also conducted to make assessment of the capacity, role, and challenges of relevant stakeholders involved in agricultural water management. In this regard, the relevant information was collected from water associations, district water desk, sub district water committee, farmers training center and agriculture and rural development office of the Woreda. The collected data was analyzed using descriptive statistics such as frequency, percentage, mean and standard deviation. Linear regression analysis was employed to identify the factors affecting the adoption of agricultural water management technologies. Moreover, the observed results were triangulated and verified through comparing it with the findings of other studies.

RESULTS AND DISCUSSIONS

As it was stated in introduction, this study was designed to investigate agricultural water management practices in Halaba Special district of Southern Nations Nationalities and Peoples regional state, Ethiopia. Accordingly, study has assessed the household agricultural water management and conservation practices, technology options, challenges and the adoption intensity at farm level in smallholder agrarian system, and the findings were presented in sub topics as follows.

Household Agricultural Water Management Technology options

The water for agricultural uses was obtained from several sources including ground water extraction, river and river diversion, rain and rain water harvesting, and soil and water conservation. The technologies commonly used were cheap and mainly demand manpower/labor (Table 1). The reported AWMT were similarly adopted by most Ethiopian farmers in other regions (Adinew, 2006; Evans *et al*., 2012; Regassa *et al*., 2012; Yacob and Melaku, 2006 and Yalew, 2006).

Table 1: Agricultural Water Management Technologies Used by the Households in the area

Agricultural Water Management Technologies	**Users response n= 247**		**Main Purpose**
	Yes (%)	**No (%)**	
Ground water extraction through motorized pump	45.7	54.3	Livestock
Hand dung well	68.4	31.6	Livestock + Crop
River for livestock from the source	100	0	Livestock
River diversion for irrigation	15	85	Crop
Rainfed Agriculture	100	0	Crop
Rainwater Harvesting	33.2	66.8	Livestock + Crop
Soil and water conservation	98.79	1.21	Crop

Ground water extraction using motorized pump is adopted by nearly half of the farmers in the area (Table 1). The water from this source is used mainly for livestock drinking purposes, while they didn't used for crop production. It is because of that the water point is owned by the public at large and far away from individual households farming land. In contrast, the previous studies show that farmers in Harareghe and Oromia region use this technology to irrigate high value crops (Evans *et al.*, 2012). Similar study also assures households are adopting motorized pumps to lift water in their agricultural activities. Moreover, the Ethiopian government promotes the uses of this technology to get alternative water resources. This result is argued the finding of Regassa *et al*., 2012. They concluded that motorized pumps were not adopted in east Africa, while the evidence of this study shows that the technology is used in Halaba special Woreda, Ethiopia (Figure 2). The reports of Regassa *et al*., 2012 reasoned out that high cost of motorized pumps, lack of spare parts, high fuel cost and limited market for high value products were the limiting factor to use the technology in Africa. Having those constraints poor farmers in Halaba special district was using the motorized pump, since it was public watering point and in which the local government is responsible for the installation, operation and maintenance. The responsibility of the society to use the water from this technology is that they have to pay for the water they use.

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Figure 2: Livestock at water point extracted motorized pump

Hand dung well is also used by majority (68.4%) of farmers in the area (Table 1). The water from this technology used for both crop cultivation and livestock drinking purposes. Similar to motorized pump, it is public owned. The relative distribution of hand dung is higher than motorized pump since the area is located in the rift valley region where the ground water table is found at shallow depth and easy for extraction (Figure 3). The water from Hand dung well is free of charge. Due to its high availability (prevalence in the area) to farmers land, they use it for crop production. According to key informants' information, Hand dung well was originally designed for domestic consumption especially for drinking purpose, while the community uses not only for its designed purpose but also for agriculture. It is because of that the high shortage of water in the area and the free charge of water from this source forces the community to use it for all water demand in the area. The others related study shows that Hand dung wells were common in Africa like Ghana and Ethiopia (Tsion, 2014). The same study proved that people use water from shallow dung well for domestic, livestock watering and irrigation, which is in line with findings of current study.

Figure 3: Women and children were searching for water (water shortage)

Water from rainwater harvesting is also other option for agricultural water use in the Halaba Special district (Figure 4). Rainwater harvesting was advocated by local government for the last two decades in the district. So far, the government has done huge investment for expansion of rainwater harvesting technology in the country at large and Halaba Special district in particular. In spite having the effort done by government, farmers who have adopted rainwater harvesting were the less number of respondents. This is because of that majority of the farmers were laggard to accept it, since the cattle's and children damaged by entering in the pond prepared for this purpose. Moreover, the FGD and Key informants stated that the expansion of malaria were the other reason that the farmers to resist to adopt rainwater harvesting in the area.

Figure 4: Water harvesting scheme in the area.

River diversion for irrigation is also used by farmers in the area (Table 1; Figure 5). The FGD state that river diversion is promising to produce crops during dry season, while the available main river in the area is only one which is called Blate. This hinders the use potential of irrigation through river diversion. During field observation, it was noted that river diversion used were responsible for water loss due to seepage and evaporation (Figure 5).

Figure 5: diverted River for crop cultivation

Direct uses water from river for livestock is common in the area (Table 1). The water uses source is free from any charge, while farmers were forced to travel long distance with their cattle to get the river. Accordingly, one of the key informants stated that *we paying our labor and time for water through travelling long distance for searching it, but not money.*

Soil and water conservation in the farm land has been implimented in the area. In situ SWC technologies were used by entire community since the government supports the development of soil and water conservation in the country . Besides to individual farmers efforet, the campaign work on watershed management has contributed a lot in insute soil and water conservation in the area. The FGD and key informants infromation shows that these technolgies contributed that the soil to be suitable for cultivation during short rain seson.

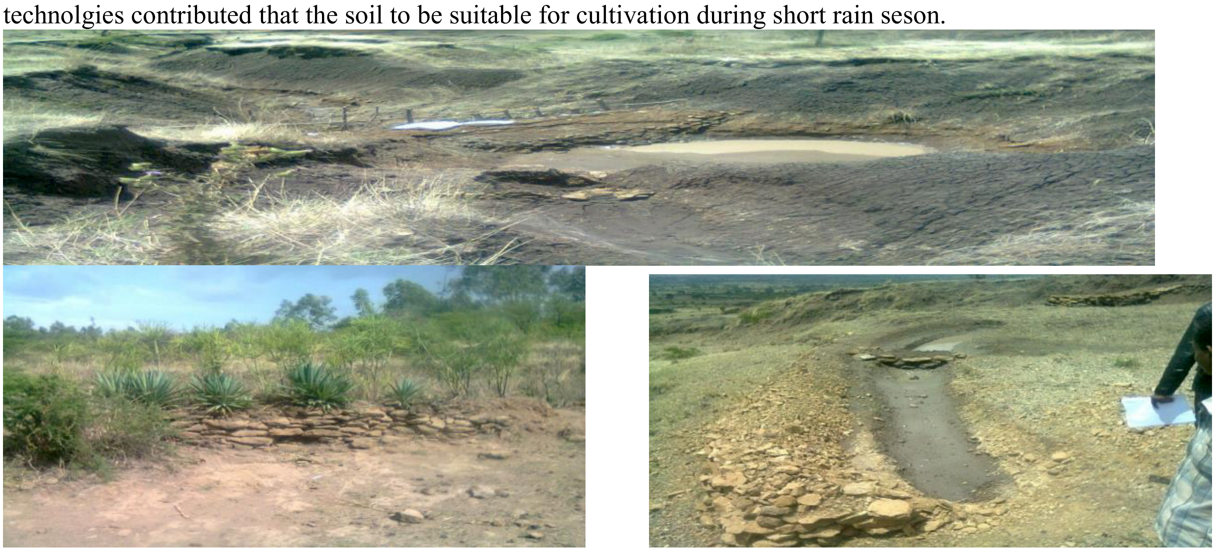

Figure 6: Soil and water conservation structures implemented in the area

Moreover, these structures has contributed significant role in reducing land degradation. The findings of Regassa *et al*., 2012 witnessed that the in suit SWC technologies has good role to maximize productivity through improving nutrients availability in the root zones of crops. Due to similar reason, majority of farmers (nearly all) has positive willingness to expand these structures in their land.

Agricultural Water Demand management

Agricultural water demand management has been manifested in the Halaba Special Woreda. It is one of the convincing technologies of Agricultural Water Management. The community pays for the water they use for livestock watering. Water from motorized pump is fully charged, and it forces the farmers to use the water from this source for only watering cattle during dry season. On the other hands, the community uses water for all uses from hand dung well. This indicates that the community was forced to manage water demand when they are requested to pay for the water they have been used. The result assures that motorized water pump adopted not only water supply purpose but also it contributes for demand management.

Agricultural water demand management technology has good start in the district, yet it is not fully adopted at large scale. According to FGD and Key informants information, the community considered water *as free gift of God for human being and it should be free from any charges*. This thought of the society contradicts with the

Dublin agreement that water has not only social value but also has economic value (Agrawal *et al*., 2000).

Household Agricultural Water Management Adoption intensity

The household survey result shows that an individual household uses at least three agricultural water management options. The majority (44.5%) of respondents are adopted five water management technologies in their land (Table 2).

Table 2: Distribution of the Amount of Technologies used by individual Households

Number of technology	Frequency	Percent	Cumulative percent
3	1	0.4	0.4
4	78	31.6	32
5	110	44.5	76.5
6	54	21.9	98.4
7	4	1.6	100
Total	247	100	-

This shows that individual household uses several technologies of agricultural water management to cope up with water shortage. Besides to community effort, the government support on soil and water conservation campaign has made its role to that the number of technologies used by individual household to be high.

Factors Affecting the Adoption intensity of Agricultural Water Management technologies

The regression analysis yields the following result for the factors that governs the intensity of agricultural water management.

Table3: Factors affecting the intensity of AWMT in the area

Variables	B	t	SE	Sig
Sex*	0.012	.071	.166	.005
Age	0.004	.798	.005	0.058
Marital*	-0.073	-.573	.128	0.042
Education	0.038	.734	.052	0.052
Income	0.111	1.464	.076	0.104
Responsibility	-0.047	-.831	.056	0.057
Family size	-0.016	-.703	.023	0.052
Cultivated land size *	0.000	.005	.022	0.000
Decline water availability *	-0.120	-1.048	.114	0.019
Constant	4.820	14.709	.328	.000

* shows significant variable at 95%

The result presented in Table 3 shows that sex, marital status, cultivated land area and decline in water availability affects the intensity of farmers water use in the area. The result shows that male headed household uses dominant water management technology than female headed households. It is because of the uses water technology demands labor like construction of SWC is labor demanding and hence it was adopted by majority male headed households than female. The data also indicates that the household which has married was better in uses of agricultural water management than the others. The size of land available for cultivation also matters the intensity of the technology in uses. Those farmers who have higher land size have high probability to uses agricultural water management than those whom have less land for cultivation. The land size more than one hectare is considered as high and less than one hectare as less land size. The decline in availability of water in the area also matters the intensity of technology use. The farmers who have less water availability have larger intensity of agricultural water management technologies.

Challenges in Agricultural water Management

The major observed challenge in water management in agricultural sector is shortage of water in the area. FGD and key informants interview has identified that economic water scarcity is prevalent than that of absolute water scarcity. Similarly, the findings of Sara, 2012 assures that lack of capacity to enabling the finances of the Agricultural water sector is the challenge for west and central Africa. There was no strong formal institutional setting which promotes AWMT interventions. The previous study of Adinew, 2006 stated that institutional weakness of farmers' organizations and limited coordination in backward and forward linkages was among the bottlenecks in the sector. Moreover, the lack of the participation of private investors in water resources infrastructure development is also other challenge. The community thought water as free gift of God and they didn't consider that water has economic value. Due to this reason they weren't volunteers to pay the water they use for effectively.

CONCLUSION

The communities adopted different agricultural water management options to maximize the agricultural production with hydro climatic constraints in Halaba Special district. Water harvesting, irrigation, in situ soil and water conservation and buying water for livestock consumption are mainly utilized water management technologies in the area. Ground water extraction through motorized pumps and river diversion for irrigation were also used in Halaba special district. However, the intensity of agricultural water management is the function of sex, marital status, available land size for cultivation and availability of water resources.

The communities in Halaba special district used not only supply side management but also demand management. In spite of having good start in water charging for demand management, the community thought water as social good and has no economic value of water is among the hindering factor for sustainable Agricultural water management in the special district.

RECOMMENDATION

The local government should create awareness on the economic value of water and also attract the private investors in water resource investment for the community. The formal and strong agricultural water management institution should be established and promoted for better uses of scares water resources in the area.

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Abbreviations

NMA: National Meteorological Agency
CSA: Central Statistics Agency
SNNPR: Southern Nation Nationalities and Regional state
AWMT: Agricultural Water Management Technology
SWC: Soil and Water Conservation
FGD: Focused Group Discussion

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