Introduction

In Ethiopia, the population is growing rapidly and is expected to continue growing, which inevitably lead to increased food demand. To maintain self-sufficiency in food supply, one viable option is to raise the productivity per unit water use. A favorable method for raising yield per unit of water use is through irrigation. The question, how is irrigated agriculture performing with limited water and land resources, however, has not been satisfactorily answered. This is because of that we are not able to compare irrigated land and water use to learn how irrigation systems are performing relative to each other and what the appropriate achievement targets are (David, et al, 1998).

In Ethiopia, where the principal component of project development (i.e., finance) is a constraint to incur huge investment for irrigation, small scale irrigation can be an alternative solution to enhance food production. Small scale irrigation structures, owing to their relatively small investment cost, ease of construction, simplicity of operation and maintenance have been a strategic target of the country for achieving sustainable food security and self-sufficiency (IFPRI, 2009). A number of such schemes have been designed and constructed in the previous years. However, while some schemes are performing successfully, others have failed to serve the intended purpose. Frequent operation and maintenance needed so as to sustain the schemes (FAO, 1986).

The variables that influence performance of irrigated agriculture are infrastructural design, management, climatic conditions, price and availability of inputs, and socioeconomic settings. International Water Management Institute (IWMI) has qsfqbsfe! ejggfsfou! dpnqbsbujwf‘! joejdbupst! uibu! bsf! ifmqgvm!gps! dpnqbsjoh! jssjhbufe! agriculture between countries and regions, between different infrastructures and management types, and between different environments and for assessment over time of the trend in performance of specific project. According to David et al. (1998), the indicators have the following features:

- The indicators are based on relative comparison of absolute values, rather than being referenced to standards or targets

- The indicators relate the phenomena that are common to irrigation and irrigated agricultural systems
- Data collection procedures are not too complicated or expensive
- These set of indicators are designed to show gross relationship and trends and should be useful in indicating where more detailed study should take place, for example where a project has done extremely well, or where dramatic changes take place

This study has covered the comparative performance of two selected irrigation schemes in north Gondar zone. An attempt was made to see the causes and effects of the variation in these schemes. Frequent monitoring of the performance of irrigation systems assists to distinguish whether the targets and objectives are being met or not; provides system managers, farmers, policy makers a better understanding of how a system operates; helps to identify the strengths and weaknesses, consequently alternatives that may be both effective and feasible in improving system performance to achieve maximum efficiency. Hence, the study was carried out with the objective of evaluation of the performances of selected small scale irrigation schemes in North Gondar Zone.

Materials and Methods

Description of Study Area

The study area is located within the Lake Tana sub-basin, Gondar Zuria Wereda of North Gondar Zone in Amhara Region. The rivers, Fana and Arno, used as irrigation source, drain into Lake Tana. Both schemes show almost similar climate since they are found in the same basin. They have a mono- modal rainfall pattern and the humid period for Arno and Fana consists 131 days (1 June 9 Oct.) and 106 days (6 June -19 Sept.) respectively. The mean annual rainfall of Arno and Fana is 1099 mm and 1008 mm and mean monthly temperature is 19.8 and 20.9 $^{o}{}_{C}$ respectively.

Fana with potential irrigable area of 31 ha is found in *Fana* gott, *Das-Dinzaz kebele*. Fana was constructed in 2007. It is located at about 45 km southwest of Gondar town.

Its altitude also ranges from 2040 to 2458 m a.s.l. The topography of the area covers from gentle slope to steep. The type of diversion is traditional canal intake. Most of the dvmujwbufe! bsfbt! tpjm uzqf! is clay loam. Garlic, potato, maize and perennial fruits are dominant irrigated crops in the area. The farmers have competitive use towards scarce water and exercise both crop and livestock production to improve their livelihood. Similarly, Arno River is found in *Arno gott Sendaba kebele* with the potential irrigable area of 61 ha and is at a distance of 50 km to the south east of Gondar. Its altitude also ranges from 2010 to 2315m a.s.l. The topography of the area covers from gentle to steep slope. It has broad crested diversion weir and its water source is a perennial river. It was dpotusvdufe! jo! 3111! boe! bmmju! n bjo! dbobm! mfohui! jt! njofe/! Nptu! pg! uif! dvmujwbufe! bsfbt! soil type is silt loam. Garlic, potato, maize and onion are dominant irrigated crops in the area. Farmers practice both crop and livestock production.

Data collection method

Discharge rate was measured on spatial and temporal basis i.e. following the production season on the field canal outlets. The recorded discharge values have established a linear equation which relates time versus discharge and time versus the distance from field canal outlet to intake canal using the JMP-5 statistical software. This could enable to estimate the amount of water that actually arrived on the field. The agronomic practice was surveyed using actual measurements. The existing crop spacing was measured for fruit crops. In addition, farmers and Development Agents in the kebele were interviewed to put standards that estimate variables like farm gate prices of irrigated crops, cost of production, area irrigated per crop per season and per year, crop types, major crops frequently produced, etc.

Estimated values

These values are calculated through known parameters. Irrigation and water demand have been calculated using CROPWAT for window version 4.2 software (Clarke, 1998). Peak consumptive use of crop has been calculated by selecting a crop that needs highest water supply (l/s/ha) in the CROPWAT model and assuming all the irrigated area to be covered by this crop which has high atmospheric demand in the season. To calculate scheme relative irrigation supply, relative water supply and output per unit water consumed, one should determine the estimated total net irrigation requirement, total net water requirement and total water consumed by ET_0 respectively. The input data for determination of estimated crop water requirement, irrigation water requirement and water consumed by ET_0 for CROPWAT model are climatic, rainfall, soil, crop data and cropping pattern. These data values which represent for each irrigation scheme were added to the model and the scheduling criterion was adjusted using optimal irrigation scheduling. The results are listed in the table below. Secondary data like cost of infrastructure and number of beneficiaries were collected from Gondar Zuria Wereda Bureau of Agriculture. Climate data such as temperature (mean maximum and mean minimum), sunshine hours, humidity, wind speed and rainfall was collected from the Regional Meteorological Agency. These data are further used for estimation of real water and irrigation requirement with the assumption of irrigation efficiency of 70%.

Measured values

All calculations of standard indicators (Table. 1) were carried out based on collected data during one year for both irrigation schemes. To collect discharge data, velocity-area method and flow measuring devices were used (Figure 1). The flow measuring devices were cutthroat flume and partial flume. The data values that were found using the above methods were averaged. Discharge diverted from the source was calculated by Velocity-Area method i.e., measuring the mean flow velocity across a cross section and multiplying it by the area where flow measurement was undertaken.   Crop rotation (Table. 2) was developed for six rounds for both schemes by using crop family rotation system so as to avoid nutrient depletion and disease infestation referred from Marshall Bradey (1997). In Fana irrigation scheme majority of the crops are perennials, which cannot allow crop rotation.

Fig.1. Devices used to measure discharge: cutthroat flume (left) and partial flume (right)

Table 1. Mjtu! pg! JXNJ s Standard Comparative Indicators used to evaluate the performance of Arno and Fana irrigation schemes and their description

Performance Indicator	Description
Output per cropped area (birr/ha)	Production/irrigated area
Output per unit command area (birr/ha)	production/production command area
Output per irrigation supply (birr/m^3)	Production/ Diverted irrigation supply
Output per unit water consumed (birr/m^3)	Production/ Volume of water consumed by ET
Relative water supply	Total water supply/ Crop demand
Relative irrigation supply	Irrigation supply/ Irrigation demand
Water delivery capacity	Canal capacity at the system head/ Peak consumptive demand
Gross return on investment (%)	Production/ Cost of infrastructure
Financial self sufficiency (%)	Revenue from irrigation/Total O&M expenditure
Conveyance efficiency (%)	Discharge at canal outlet/discharge diverted from the source

Table 2. Rotation system used for irrigated crops in Fana and Arno irrigation schemes

Round1	Round 2	Round 3	Round 4	Round 5	Round 6
Garlic	barely	Potato	onion	maize	tomato
Fenugreek	garlic	Barley	potato	apish	maize
Potato	Maize	Garlic	tomato	barley	onion
Onion	barley	Potato	garlic	maize	tomato
Tomato	onion	Maize	potato	garlic	barley
Maize	garlic	Tomato	barley	onion	potato
Barley	potato	Onion	maize	tomato	garlic

Results and Discussion

The water delivery capacity, financial self sufficiency and conveyance efficiency of Arno scheme is better than that of Fana (Table 3). As shown in Table 4, output per cropped area of Arno is greater than Fana but, in terms of area coverage, Arno produces less than half of its potential. The mean value of relative irrigation supply is 2.04 and 1.275 for Arno and Fana irrigation schemes, respectively. This implies Arno supplies more water (i.e. double of the irrigation demand that is estimated by CROPWAT model) while, in Fana it is equivalent to its irrigation demand. This occurrence is due to the reason that, Arno scheme has less competition for irrigation water than Fana. In terms of relative water supply, Arno (1.99) has lower mean value than Fana (0.925) irrigation scheme. Water delivery capacity of the schemes is 0.96 and 0 .32 for Arno and Fana, respectively. This implies that, Arno can meet the irrigation demand of the crops even if all the area of the irrigation scheme is covered by a single crop having high water consumptive use.

Table 3. Summary of comparative analysis results for Arno and Fana irrigation schemes

No	Indicators	Unit	Arno irrigation scheme	Fana irrigation scheme
1	Water delivery capacity	-	0.96	0.32
2	Financial self sufficiency	(%)	100	-
3	Conveyance efficiency	(%)	58	48.43

The financial performance shows that, financial self sufficiency for Arno is 100% which implies that the entire collected water fee is allocated for operation and maintenance. But this does not mean that the operation and maintenance demand of this scheme is gvmgjmfe/! Po! uif! puifs! iboe! xbufs! vtfst! jo! Gbob! jssjhbujpo! tdifnf! epfto udpousjcvuf! water fee that is why this indicator equals to zero. The Gross returns on investment of Arno and Fana irrigation schemes are 51.927 and 1280.817% respectively. The gross return for Fana irrigation scheme was higher due to low investment cost.

Conclusion

Despite the fact that every scheme has a contribution towards food production, the degree of its contribution vary from scheme to scheme since crop production is affected by multiple factors. So, the comparison of irrigation schemes helps to point out the weaknesses and strengths of irrigation practice in the region, and is helpful for managerial decision and technical measures to be taken for their future improvement.

Fana irrigation scheme have more constrained supply of irrigation water as compared to Arno irrigation scheme due to the competitive use of scarce resources among farmers. Moreover, productivity per unit of water is 2.477 and 1.38 for Fana and Arno respectively. Hence it calls for management intervention for wise use of irrigation water in the Arno scheme. Through wise use of water its actual water supply can be minimized and used for irrigating additional land and increased production per unit of water. On the other hand, higher return on investment of Fana irrigation scheme implies that its irrigation scheme is constructed with low investment cost and produces more production per year. T-test analysis revealed that, output per irrigation supply and relative irrigation supply showed highly significant difference (at 5%).The lower relative water supply and relative irrigation supply of Fana irrigation scheme is due to the fact that most of the area is covered by perennial fruits and the application of water is at longer intervals. Regardless of its longer canal length, Arno has better conveyance efficiency due to its lined canal system.

In general, the comparison of the performance of irrigation systems will help to know the present status of irrigation schemes. It helps to point out the strengths and weaknesses of existing practice and search for possible interventions in time. Therefore, for scheme level irrigation water management and irrigation system improvement, conducting frequent performance evaluation on selected schemes is imperative. The limitation of this paper is that the research work was done for one year. Duf! up! ui jt ! jul dpvmeo ul cf! qptt jcmf! up! tff! ui f! usfoe! pg ui f! joe jdbupst over time.

Table 4. Results of T-uftu!bobmzt jt!gps!Bsop!boe!Gbob!tn bmmtdbmf!jssjhbujpo!tdifnft!vtjoh!JXNJ!t!dpnqbsbujwf!joejdbupst!!!

Rotation No	Output per cropped area		Output per unit command area		Output per consumed (ETo)		Output per irrigation supply		Relative irrigation supply		Relative water supply		Return on investment	
	Fana	Arno	Fana	Arno	Fana	Arno	Fana	Arno	Fana	Arno	Fana	Arno	Fana	Arno
1	9255.2	20089.3	34264.0	39581.3	5.06	9.26	2.87	2.27	1.09	2.33	1.17	2.22	1487.5	85.5
2	7174.0	5211.9	26559.5	10268.9	2.89	2.03	2.23	0.59	1.16	1.97	0.87	1.96	1152.6	22.2
3	9206.8	11961.6	34085.2	23567.5	8.40	3.89	2.86	1.35	1.35	1.80	0.97	1.77	1479.2	50.9
4	7654.5	19528.7	28338.5	38476.8	3.25	9.12	2.38	2.21	1.35	2.37	0.84	2.26	1229.8	83.1
5	6469.7	4833.2	23952.2	9522.7	3.85	1.88	2.01	0.55	1.35	1.97	0.87	1.96	1039.4	20.6
6	8070.0	11606.9	29876.7	22868.8	3.42	3.77	2.51	1.31	1.35	1.80	0.83	1.77	1296.5	49.4
Mean	7971.7	12205.3	29512.7	24047.6	4.48	4.99	2.48	1.38	1.275	2.04	0.925	1.99	1280.8	51.9
Lsd (5%)	**0.271**		**0.142**		**0.760**		**0.006**		**0.002**		**0.000**		**0.000**	

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