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Performance Assessment of Small-Scale Irrigation Schemes: A Case Study of Upper Blue Nile, East Dangila Woreda, Ethiopia

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Abstract

Performance assessment of irrigation systems plays a big role to evaluate the productivity of schemes. Such practices could help to design possible intervention mechanisms that could be made to improve the performance of the schemes. Consequently, the aim of the study is to assess the performance of small scale irrigation systems in Dangila Woreda, to know the achievement of the schemes, the performance of system operations, and the causes that leads to under- or over-performance of these small-scale irrigation schemes.This study was conducted to assess the performances of schemes through three major categories of indicators including: (i) engineering, (ii) water use and, (iii) physical performances indicators. The outcome of water delivery performance ratio of Ashar, Zuma-1, Upper Quashine and Zuma-2 were found 0.56, 0.58, 0.87 and 0.95 respectively. From The physical performance indicators, Zuma-1, upper Quashine, Zuma-2 and Ashar which had 30, 14, 10 and 4.55 percent of command area of the schemes were under irrigation and 90, 86, 93 and 95.45 percent of the schemes were sustainable respectively. The effectiveness of structures of all schemes dictates that high system maintenance was required.

Keywords: Conveyance • Performance indicators • Irrigation schemes • Small-scale irrigation

Introduction

Irrigation practice is one of the important factors that play major role in the development of many countries. Like countries in the different part of the world, the majority of population of Ethiopia is dependent on rain fed agricultural production for their livelihood. However, estimated crop production is not enough to fulfill the food requirements of the country as it is practiced through rain-fed agriculture. Therefore development of irrigation in various scales (i.e. small, medium, or large) and type (i.e. diversion, storage, gravity or pumped) has been getting due attention in scientific researches [1].

Irrigated agriculture requires intensive management as compared with rain-fed agriculture. Among others, land holding size per household has significant impact on effective management of irrigation and its productive capacity [2].

The irrigation development is increased when the construction and the function of irrigation scheme increases. However, performance of irrigation in developing countries in general and in Ethiopia in particular is still not the expected standard. Two researchers Awulachew and Ayana [3], conducted performance issues of irrigation practices in Ethiopia and concluded that most small scale irrigation schemes are low productive capacity.

Performance evaluation is a practical tool to assess the successes of irrigation management at the scheme to meet growing challenges; increasing demand for irrigation to meet the growing food demands of the population: the competition for water allocation from high priority non-agricultural sectors and technical infeasibility [4].

Irrigation performance indicators are the advantages that used to measure performance and it describes the level of actual goal in respect of one of the objective of irrigation. Indicators are used to simplify the otherwise complex internal and external factors affecting the performance of irrigated agricultural systems [3].

Performance evaluation for any irrigation system is basic to assess how far achieve the goals and set of objectives at the time of project formulation of the system. This is the basic need tool to provide necessary feedback for improving the systems management by initiating remedial measures [5]. Therefore, this study was conducted to assess DangilaWoreda modern small-scale irrigation schemes using engineering, water use and physical irrigation performance indicators from the long list irrigation performance indicators.

Systems of these modern small scale irrigation command area may vary in size from 5 to 200 hectares and may include river diversion, small dams or pump schemes [6].

Materials and Methods

Description of the study area

The present study is conducted in DangilaWoreda, which is one of the seven Woredas in the Awi administrative zone in the Amhara regional state. The capital of the Woreda is located at about 80 kilometers south west of the regional capital, Bahir Dar. The climatic zone is classified as Dega, weynadega and kola. Fourirrigation schemes sites were selected in this study which are geographically located between 11°5'0" N and 11°25'0" N latitude and 36°35'0"E and 37°0'00"E longitude. Based on 23 years rainfall data of the station, the area receive peak rainfall in July and August and receives on average 1600.7 mm (i.e. 133.4 mm/month) but, it varies between 1198 to 1731 mm. About 76.66 percent of the rain falls in main rainy season,which starts June and extends to end of September. The mean annual temperature ranges from 9.4°c to 25.2°c. In the Woreda, there are

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27 rural kebeles among which 16 of them have access to perennial rivers. Abay, Zuma, Ashar, Guder, Quashine and Awsi are the major perennial rivers in the Woreda (Figure 1).

Materials and Tools

Materials

GPS (geographical positioning system)

Current meter

Measuring tape and Digital camera

Tools

GIS (Geographical Information System)

Autodesk and AutoCAD

CROPWAT Data collection

Discharges of the conveyance system were measured by current meter. GPS also used to conduct field survey in the irrigated land. Farmers' questionnaires were very important at the conveyance systems of the canal and discharge conditions in the study area. Accordingly, selected farmers' from WUA were consulted from all schemes to fill the questionnaires.

Measurement and questionnaire were taken in the head, middle and tail reaches of the schemes. Three up to five WUAs or farmers were asked at each reach and measurement was taken to get accurate values. Actual discharge measurement in the main canals at the inlet and final outlet of the canal, measurement of actual irrigated land, irrigated crop with its area cover, failure of structures by observation, questionnaire of the water users and WUAs was done during the assessment.

Equity and reliability of irrigation schemes (actual areas irrigated) among the distributaries on head, middle and tail reaches were assessed by questionnaire of farmers. The data on planned irrigated areas are the basis to arrive the equity factor relating to areas irrigated between tail reach areas and head reach areas on main canal and major distributaries.

According to [5] data relating to actual areas irrigated and under ratios of water received at the head reach and tail reach distributaries on the main canal are essential for complete analysis and evaluation. The schemes equity and reliability of water supply based on farmers' interview for all study schemes were done at the head, middle and tail reaches. The questionnaires were done by random technique of data collecting method and the number of peoples asked per each scheme depends upon the area of the schemes. The total farmers questioned at (head, middle and tail) reaches was as shown the Table 1 below.

The Ratios of WUA wise areas actually irrigated to planned area of irrigation (at the head, middle and tail reaches) was computed by direct interview of WUAs. These were conducted by ask WUAs actually irrigated

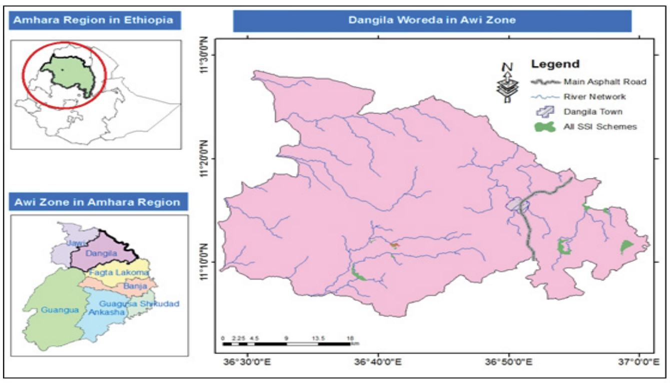

Figure 1. Location of the study area.

Table 1. Number of farmers questioned for equity and reliability of water supply after formation of WUAs.

S. No	Schemes	Number of farmers asked
1	Ashar	12
2	Upper Quashine	9
3	Zuma-1	12
4	Zuma-2	10

area to planned/designed irrigable area for each head, middle and tail reaches of the schemes.

Secondary data such as: actual discharge flow in the main canals, irrigated crops, and area irrigated per crop per season or per year, failed structures, hydrological data, climate data were collected from the concerned offices in the Woreda. Metrological data were collected from National Meteorological service agency.

Methods to evaluate the performance of irrigation schemes

There are many methods to analyze the system whether it was achieving the goal of the schemes or not. Evaluation of the performance of small-scale irrigation scheme with regard to performance indicator was an important aspect of the methodology. There are large numbers of indicators proposed by different researchers to evaluate the performance of irrigation systems. The robust and widely used approach in the one proposed by [7]. From large number of irrigation performance indicators; engineering performance indicators, water use performance indicators and physical performance indicators were selected. The table of performance indicator was as shown in the Table 2.

Results and Discussions

Performance evaluation system

The parameters used to assess the performance evaluation of SSIS are; Engineering performance indicators (operational and maintenance), water use performance indicators and Physical performance indicators Table 3.

Engineering Performance Indicator

Ratio of actual flow at main canal head as a ratio of their planed flows:

The analysis show that the actual flows to planned flows were not good specially two schemes that are Ashar and Zuma-1. The reason for low performance of water delivery of Ashar and Zuma-1 schemes are the failures of head regulator gate, unable to fully open of the gates and the inlet of the canal were closed by trash materials and died animals. These schemes need high response of maintenance of diversion headwork, inlets of the canal, head regulator and irrigation conveyance systems. Zuma-2, and Upper Quashine are performed 87 and 95 percent the water delivery system (Figure 2).

ii. Conveyance efficiency of the main canals

The average conveyance efficiency value of the Ashar, Upper Quashine, Zuma-1 and Zuma-2 schemes were 94.5, 91.5, 89 and 94 percent respectively. The main canals are good enough to deliver the inlet discharge to the secondary and tertiary canals of schemes.

iii. Equity and Reliability of water supply

From the result farmers' interview of equity of water supply all the schemes were ranges from 80 to 89 percent and the reliability of schemes ranges from 75 to89 percent. But, some farmers tell that still there was lack of wise use water distribution system to irrigable command area. This shows that needs strong and organized WUAs in the schemes to be increase the performance further.

Table 2. Selected performance indicators of the study.

No.	Categories	Sub-Categories	Indicator's	Equations
1.	Engineering performance indicators	Operational performance indicators	Flow ratio	$\frac{\text{Actual flow in canal}}{\text{planned flow in canal}}$
			Conveyance efficiency	$\frac{\text{Canal outlet discharge}}{\text{Canal inlet discharge}} * 100$
			Equity of water distribution	$\frac{(\text{No. of people say yes or no}) * 100}{\text{total No. sample people}}$
			reliability of water distribution	$\frac{(\text{No. of people say yes or no}) * 100}{\text{total No. sample people}}$
		Maintenance performance indicators	Irrigation area	$\frac{\text{Total actual area of irrigation}}{\text{planned area}}$
			Ratios of WUA area irrigated	$\frac{\text{Total actual area of irrigation}}{\text{planned area}}$
			Cropping intensity	$\frac{(\text{crops grown area}) * 100}{\text{Total command area}}$
2.	Water use performance indicators	Water use	relative water supply (RWS)	$\frac{\text{TWS (m3)}}{\text{Croped demand (m3)}} * 100$
			relative irrigation supply (RIS)	$\frac{\text{Irrigation supply (m3)}}{\text{Irrigation demand (m3)}} * 100$
3.	Physical performance indicators	Irrigation physical performance indicators	Irrigation ratio Sustainability of irrigated land Effectivity of infrastructure	$\frac{\text{Irrigated area}}{\text{Irrigable area}}$
				$\frac{\text{current irrigated area}}{\text{initially irrigated area}}$
				$\frac{\text{number of functioning structure}}{\text{Total number of structure}}$

Table 3. Water use indicators of the schemes.

Schemes	Total rainfall Vol,(m3)	Total water diverted (m3)	Total water supply (m3)	Crop water demand (m3)	Irrigation demand (m3)	RWS	RIS
Ashar	134400	3240000	3374400	318887	278919	6.21	6.62
UpperQuashine	116400	2332800	2449200	468170	406770	5.23	5.73
Zuma-1	52325	1652400	1704725	414260	319393	4.11	5.17
Zuma-2	1344400	1166400	1300800	365015	322764	3.56	3.6

Figure 2. Cause of water shortage in the conveyance.

A: Zuma-1 seepage of weir body B: Ashar head regulator closed by died animals

iv. Actual area irrigated as a ratio of planned area

The ratios of actual area irrigated to planned area to be irrigated were greater than 76 percent. This means these schemes are good performance with regard to irrigated land of the system. But discharge delivery conveyance structure failures leads to seepage and lose of water and farmers grow plants instead of cultivated crops on the irrigable command area were increased through time (Figure 3).

Water use performance indicators

There are no constraining water availability situations during the study period. irrigation season for total demand because RWS and RIS were greater than 1 [8]. Generally, the RWS and RIS values alone in this study indicate that the system should be managed well to control water logging case of rainfall and water coming from the canals in to the irrigated crops. Therefore, drained of excess waters and manage the delivered water in the canals during rainfall should be control well (Table 4).

Physical performance indicator: During the study period, the irrigation ratio and sustainability of the scheme of Ashar were satisfied fully irrigation requirements than others. Whereas; Zuma-1, Upper Quashine, and Zuma-2 which were 30, 14, and 10 percent of command area of the schemes were under irrigation respectively. The main reasons for these are failures of conveyance structures that cannot be performed well the expect achievements and the other reason might be weak institutional set up of water association at the schemes. Because some farmers said that the water user association was not well organized to use the irrigation land effectivel

Figure 3. Plant cultivation in the irrigable land.

Figure 4. Ashar main canal division gates unable to control water loss.

The major challenges, in modern small-scale irrigation schemes

Some schemes, the conveyance systems are not well organized by WUAs or farmers and the broken division boxes and conveyance canals were not maintained when failures occurred (Figure 4).

Generally, from the result of the study there are the causes of low performance. These are;

- ❖ Lack of well irrigation management,
- ❖ Lack of knowledge about applying crop water requirement for irrigation or irrigation scheduling,
- ❖ Lack of regular maintenance and operation of conveyance structures,
- ❖ Lack of water laws and policies, Unorganized WUAs in the schemes, absence of irrigation association by laws, conflicts among the same and different users of water, sense of ownership and lack of accountability are the critical limitations observed in almost all of the surveyed irrigation schemes.
- ❖ Market - Market problem could occur due to inaccessibility of market service and/or due to non-market oriented crops production. Farmer's growth plants than crops from the irrigation command area for charcoal purpose (market condition).

Conclusions

In Ethiopia irrigation plays a vital role to ensure food security and remains a high priority consideration in development strategy and privation of food shortage. Based on data availability, performance indicator approaches to the research three performance indicators were selected. These are Engineering, water use and physical performance indicators.

The engineering performance indicators computed the delivery condition of the conveyance system and the irrigated command area. The water use performance indicators were computed the condition of supplying water and irrigation water requirement. The physical performance indicators analysis sustainability of irrigated land and effectively of infrastructure of the schemes.

Water use performance indicators, RWS and RIS for all schemes were greater than one which indicated that enough water was supplied to the schemes to satisfy the irrigation requirement or irrigation demand. From physical performance indicators; sustainability of the scheme, irrigation ratio and effectively of infrastructure of the schemes result showed that the system were under performance and the effectively of infrastructure condition direct affects the irrigation ratio and sustainability of the schemes.

Generally, from the result of the study there are two approaches of causes of low performance. The first one is due to lack of well irrigation management, lack of knowledge about applying crop water requirement for irrigation or irrigation scheduling, and lack of regular maintenance of structures, unorganized WUAs in the schemes. The second reason was farmer's growth plants than crops from the irrigation command area for charcoal purpose (market condition).

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