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Evaluation of Golda Small Scale Irrigation Scheme Using External Indicators in Assosa District, Benishangul Gumuz Regional State, Ethiopia

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Abstract

The objective of this study was evaluating Golda small scale irrigation scheme using external performance indicators. The external indicators like water supply, agricultural out puts, physical, financial and organizational indicators were used. The value of relative water supply and relative irrigation supply were 1.6 and 1.2 respectively. The result of output per unit command area, output per unit irrigated area, output per unit water supply and output per unit water consumed were 3542.66US$, 4306.76US$, 1.42 and 0.69, respectively. The result of the physical indicators, which were irrigation ratio and sustainability of irrigated area, were found to be 0.82 and 1, respectively. Around 54*percent* of gross return on investment was obtained. About 67.6*percent* of respondents reflected the maintenance condition of the irrigation scheme was bad. Unfair distribution of water was due to water scarcity and illegal water users as the beneficiaries responded.

Introduction

According to Haile and Kassa (2015), the policies and strategies of Ethiopia strongly support irrigation developments especially small scale irrigation (SSI) through the Water Sector Development Programs (WSDP) and Ethiopian Irrigation Development Plan (IDP). This irrigation development is mainly expressed in the development of small scale irrigation (SSI) schemes by the government, donors and Non-Governmental Organizations (NGOs).

The aim of applying external indicators is to evaluate outputs and impacts of irrigation management practices, interventions across different systems and system levels, as well as to compare various irrigation seasons and technologies with one another (Kloezen *et al*., 1998). Evaluation of Golda Small Scale Irrigation Scheme using external indicators had not been done before this study. So that, this study was conducted for the objective of evaluating Golda small scale irrigation scheme using external indicators and organizational setups and their performance for irrigation water management& scheme maintenance.

Material and Methods

Description of the Study Area

The study was conducted at Assosa Woreda, Benishangul gumuz Regional state, found in the Upper Blue Nile (Abay) River Basin, Ethiopia. It is located at a distance of about 665 km to the North West of Addis Ababa. It is located at 9040'0'' N -10023'20'' N latitude and 3408'20'' E-34051'40'' E longitude at about 1560 meters above sea level (m.a.s.l).The scheme is located at a distance of about 18km from Assosa to the west direction, the capital city of the region.

The agro-climatic zone of the area is hot to warm moist lowland plain with unimodal rainfall distribution pattern. The rainy season starts at the end of April and lasts at the end of October with maximum rainfall in June, July, August and September. The mean annual minimum and maximum temperatures of the area for the same years were 14.63 and 28.61OC respectively.

Figure 1: Diversion Weir of Golda Irrigation Scheme

Data Collection and Analysis

Water Supply Indicators

A. Relative water supply

As Molden *et al*. (1998) stated those relative water supply and relative irrigation supply were calculated using equations 1 and 2 respectively.

$$RW(m^3) = \frac{\text{Total water supply}}{\text{crop water demand}} \text{-------------- (1)}$$

Where, total water supply (m^3) is diverted water for irrigation plus rainfall, crop water demand (m^3) is the potential crop evapotranspiration (ETp), or the real evapotranspiration (ETc) when full crop water requirement is satisfied.

B. Relative Irrigation Supply

$$RIS\ (m^3) = \frac{\text{Irrigation supply}}{\text{Irrigation demand}} \text{---------------------- (2)}$$

Where, irrigation supply (m^3) is surface diversions for irrigation, irrigation demand (m^3) is crop ET minus effective rainfall. Net crop water requirement and irrigation requirement calculated are by CROPWAT 8.0 model (FAO, 2009). The reference evapotranspiration (ETo) is calculated on a monthly basis using FAO Penman-Monteith (FAO, 2009).

Agricultural Output Indicators /Land and Water Productivity

A. Land productivity indicators

Land productivity quantifies change in crop yield or value per unit area (Bos *et al.*, 2005).These indicators were computed using Molden *et al*.(1998) equation.

$$\text{Output per unit irrigated area (\$/ha)} = \frac{\text{Production}}{\text{Irrigated crop area}} \text{------- (3)}$$

$$\text{Output per unit command (\$/ha)} = \frac{\text{Production}}{\text{Commmand area}} \text{--------- (4)}$$

B. Water Productivity Indicators

Water productivity quantifies change in crop yield or value per m^3 water supplied (Bos *et al.*, 2005). The following two water productivity indicators were calculated based on Molden *et al*.(1998) equation.

$$\text{Output per unit irrigation supplied (\$/m}^3\text{)} = \frac{\text{Production}}{\text{Diverted irrigation supply}} \text{--(5)}$$

$$\text{Output per unit water consumed (\$/m}^3\text{)} = \frac{\text{Production}}{\text{Volume of water consumed by ET}} \text{---(6)}$$

Where:

Production: the output of the irrigated area in terms of gross or net value of production measured at local or world prices.

Irrigated cropped area: The sum of the areas under crops during the time period of analysis.

Command area: the nominal or design area to be irrigated.

Diverted irrigation supply: the volume of surface irrigation water diverted to the command area and Volume of water consumed.

ET: the actual evapotranspiration of crops.

Physical Indicators

Physical indicators are related with the changing or losing irrigated land in the command area by different reasons.

A. Irrigation Ratio

According to Bos *et al.* (1994), it is the ratio of currently irrigated area to the command area.

$$\text{IR} = \frac{\text{irrigated area}}{\text{command irrigable area}} \text{---------------------- (7)}$$

Where:

Irrigated crop area (ha): the portion of the actual irrigated land in any given irrigation season.

Command area (ha): The potential scheme command area.

B. Sustainability of Irrigated Area

According to Molden *et al*.(1998), it is the ratio of currently irrigable area to the initial irrigated area.

$$\text{SIA} = \frac{\text{current irrigable area (ha)}}{\text{Initial irrigated area}} \text{---------------------8)}$$

Where:

Current irrigable area: the area currently irrigated (ha).

Initially irrigated area: the designed/nominal/ irrigable area (ha).

Financial Indicator

A. Gross Return on Investment

It was calculated according to Molden *et al*.(1998).

$$\text{GRI(\%)} = \frac{\text{Production}}{\text{Cost of irrgation infrastructure}} \text{--------9)}$$

Where:

Cost of irrigation infrastructure: considers cost of the irrigation water delivery system referenced to the same year as the production.

The cost of irrigation infrastructure was estimated as present net worth (PNW), through average interest rate of the service years.

PNW=p*(1+i) n

Where:

p: initial investment cost
i: average interest rate in the service years(*percent*)
n: number of service years

Organizational Setup and Performance for Irrigation Water Management and Scheme Maintenance

For this assessment house hold survey was held.

House Hold Survey

Issues related to water management experience, their felling due to the construction of the irrigation scheme, maintenance of the scheme, canal cleaning, organizations, community level problems and experiences, etc. were collected through questionnaire.

Sampling Technique

The total beneficiaries in the selected command area were 210. The representative sample size was determined using Yamane (1967) simplified formula (10). Finally, the calculated samples were used for house hold survey.

$$n = \frac{N}{1+N(e^2)} \quad (10)$$

Where:
n: sample size
N: population size
e: level of precision

The calculation was carried out using 95*percent* confidence interval, 10*percent* precision level and 50*percent* degree of variability (P). Accordingly:

$$n = \frac{210}{1 + 210(0.1^2)}$$

n=68

Simple random sampling technique has been used to select male and female respondents from each canal reaches. The collected data were analyzed with SPSS 20. software and interpreted using descriptive statistics.

Results and Discussion

Relative Water Supply

The calculated value of relative water supply was 1.6 as indicated in (Table 1). As result shows, it was greater than one which means total supplied water was above sufficient to meet crop demand or excess water was used beyond crop demands as Bos *et al*. (2005), categorized relative water supply values ranging from 0.9 to 1.2 as adequate, and from 1.2 to 1.8 as excess, and values from 1.8 to 2.5 as very excessive. Similarly, value less than one does not mean insufficient water supply rather it means farmers can apply deficit irrigation.

Relative Irrigation Supply

The computed value of relative irrigation supply was 1.2 which means that diverted irrigation supply was sufficient for irrigation demand of the crop. Higher value of irrigation supply was due to absence of irrigation water fees. Similar result was obtained by Dejen *et al*. (2012) at Wedecha scheme (Godino sub-system). It is better to have a relative irrigation supply near one than a higher value. Lower value of RIS obtained due to contribution of effective rainfall for crop water demand during irrigation seasons (Molden *et al*., 1998).

Table 1: Parameters and Calculated Water Delivery Indicators

Irrigation Demand m^3	Crop Water Requirement	Effective Rainfall m^3	Irrigation Supply m^3	RIS	RWS
259,003	317,054.5	58,051.5	4,403,051	1.2	1.6

Agricultural Output Indicators

A. Land Productivity Indicators

Land productivity was evaluated using the two indicators which were output per unit irrigated area and output per command area.

I. Output per Unit Irrigated Area (OPUIA)

According to the analysis of the result the output per unit irrigated area was 4,306.76US$/ha as indicated in (Table 3).This finding shows that the scheme has better value than Haluk small scale irrigation scheme found in Adami Tulu Jido Kombolcha Woreda, Central rift valley of Ethiopia, the output per irrigated area was 2,852.77US$/ha as reported by Shiberu *et al*.(2019). The similar result also was reported by Degirmenci *et al*. (2003) who found the output per irrigated area was varied between 308 and 5771 US$/ha for twelve irrigation schemes found in the Southeastern Anatolia Project.

II. Output per Unit Command Area (OPUCA)

It is an indication of whether all the command areas generating returns or not. The output per unit command area of the irrigation scheme was 3,542.66US$/ha as indicated in (Table 3). The result was higher than results obtain in Turkey (hayrabolu irrigation scheme) and in Ethiopia (Dodicha small scale irrigation scheme) values of 709 US$/ha and 1,278.59US$/ha reported by Sener *et al*.(2007) and Shiberu *et al*.(2019) respectively. However the calculated value was smaller than values of 4,746US$/ha and 8,704US$/ha at Selamko and Shina-Hamusit small scale irrigation schemes respectively (Shenkut, 2015).

B. Water Productivity Indicators

I. Output per Unit Irrigation Delivered (OPUID)

This indicator shows the revenue from agricultural output for each cubic meter of irrigation water supplied. It is a useful external indicator because it addresses output per drop of water irrigation actually delivered to the user. The output per irrigation delivered was calculated and the result was 1.42 as indicated in (Table 3).

II. Output per Unit Water Consumed (OPUWC)

The output per unit water consumed is used to describe the return on water actually consumed by the crop. This indicator gives due attention to the water consumed by the scheme and tell us how water is efficiently utilized by the scheme from economic point of view. The values for this indicator was found to be 0.69US$/$m^3$ as indicated in (Table 2) and it was in the range of 0.03-0.91US$/$m^3$ (Molden *et al*.,1998).This result shows that the water use efficiency is lower than Selamko irrigation scheme which was 1.15US$/$m^3$ as Shenkut (2015) reported.

Table 2: Parameters and Calculated Land and Water Productivity Indicators

Parameters	Values
Irrigated cropped area (ha)	51
Command cropped area (ha)	62
Irrigation water supplied(m^3)	4,403,051
Water consumed ET (m^3)	317,054.5
Production (US$)	219,644.80
OPUIA (US$/ha)	4,306.76
OPUCA (US$/ha)	3,542.66
OPUID (US$/$m^3$)	1.42
OPUWC (US$/$m^3$)	0.69

Physical Indicators

Irrigation Ratio

The irrigation ratio of the scheme was 0.82 which means 82*percent* of the command area was currently under irrigation and about 18*percent* of the command area was not under irrigation during the study period as indicated in (Figure 1).The current finding in line with a similar result was reported by Dejen *et al*. (2012) at Wedecha sub system of Gohaworki irrigation scheme. The irrigation ratio of the scheme was better than Dodicha small scale irrigation scheme as reported by Shiberu *et al*. (2019) which were 0.59.

Sustainability of Irrigated Area

Lower values of this indicator would mean abandonment of lands which were initially irrigated; and hence, indicate contraction of irrigated area over time. On the other hand, values higher than unity indicate expansion of irrigated area and would imply more sustainable irrigation (Bos *et al*., 2005). Sustainability of irrigated area was 1.0 as shown below in (Figure 2). As the result indicates there was no contraction and expanding of initial irrigated area. In principle, neither extension nor shrinkage is desired (Dejen *et al*.,2016).

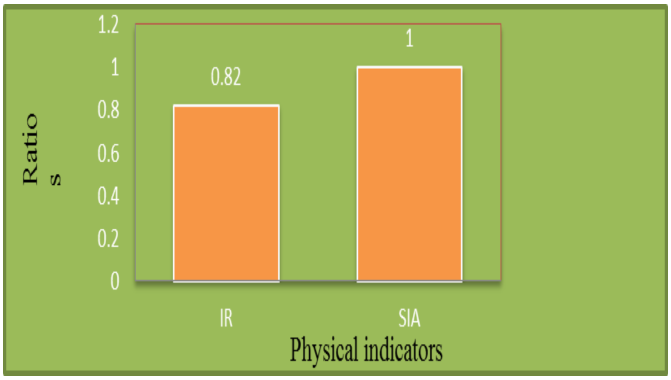

Figure 2: Calculated Value of Irrigation Ratio & Sustainability of Irrigated Area

Financial Indicator

Gross Return on Investment

For the determination of gross return on investment, 2018/2019 production values were used due to lack of long term production value data. As a result the cost of irrigation infrastructures were done in cost in present net worth and this cost was only considers on irrigable area rather than command area. The calculated gross return on investment was 54*percent* as indicated in (Table 3).

Table 3: Investment Cost of the Irrigation System

Irrigable area (ha)	N	Cost (birr)	Cost (birr/ha)	Cost in PNW (birr/ha)	Production cost (birr/ha)	GRI *percent*
51	6	6,669,861.7	130,781.6	231,687.6	124,803.9	54

N- Number of service years

N.B: 1 US$ = 28.9786 Ethiopian Birr rate, July, 2019

Organizational Setups and Performance for Irrigation Water Management and Scheme Maintenance

The organizational setup of Water Users Association with collective participation of individual user's in irrigation activities has positive impact on sustainable management (Sharma *et al*., 2016).

Organizational Structure of WUAs

In Golda irrigation scheme there were five Gotes and three ketenas which were organized for management purpose. There was no clear organizational structure of water users association rather they were organized as water users committee which has been eleven members; nine were males and two of them were females. The WUA committees are male dominated and the views of women are hardly represented in the decision making. The structure was as Chairman, Vice-chairman and Secretary. When I was discussing with Woreda experts, they were organized for the purpose of only water allocation or arranging water distribution period and conflict management. The water committees were not working their tasks accordingly because they were need incentives.

Bylaws and Fee Collection

In Golda small scale irrigation scheme there was no clear written rules and regulations related to water allocation and distribution. As the Woreda irrigation expert told to me, the new proclamation was reaches to Woreda but not applicable, they were in the process of training to implement the proclamation of water users association. The absence of bylaws increases illegal water users and thefts who were taking the gate. Fee collection was not applicable in the irrigation scheme due to this beneficiaries were not care about the scheme and they were irrigated crops once per year, during rainy season the area was not covered by crops which was covered with weeds. So that, fee collection should be applicable that helps for maintenance purpose.

Participations of Users in Operation and Maintenance

The irrigation users participation at the time of planning and construction period had a positive impact to create sense of ownership and sustainability of the irrigation scheme. According to house hold field survey users were never participate during planning as well as construction of the diversion wire. The regional government was taken the responsibility, but they were interesting on the diversion site. Beneficiaries did not participate in the maintenance of the irrigation scheme, but as Limperier *et al*. (2004) states that, this task was the mandate of WUAs. Irrigation users were participated in cleaning of canals before starting irrigation practice. As 67.6*percent* of irrigation users respond that the maintenance condition of the irrigation scheme was bad as indicated in (Table 4).

Table 4: Perceptions of Respondents on the Maintenance Condition of Irrigation

Maintenance conditions	Frequency	Percent
Good	5	7.4
Medium	11	16.2
Bad	46	67.6
Very Bad	6	8.8
Total	68	100

Water Allocation and Distributions

The water allocation and distribution was implemented by water users committee. The allocation of water was rigid rotational which was fixed time and it was not consider the area size of irrigation beneficiaries. Whatever they have, for all the same amount of water was distributed. The distribution was also never considered the type of crop and their growth stage, for different irrigated crops the same distribution was applied; this leads to low production and productivity. As 75*percent* of beneficiaries respond, there was fair distribution of water but some beneficiaries respond that due to head users and illegal water users unfair distribution was happened (Table 5). Head and Illegal water users were above the control of water users committee so that they did not respect their time of rotation. As a result, tail users were faced water scarcity and irrigated crops were wilted. There for, water users committee should be strengthen to keep their performance.

Table 5: Main Criteria Used To Scheduling Irrigation

Scheduling Criteria	Frequency	Percent
Condition of the Plant	3	4.4
Fixed Time Interval	59	86.8
Water Supply Availability	6	8.8
Total	68	100

Table 6: Levels of Water Distribution

Level	Frequency	Percent
Very Fair	3	4.4
Fair	51	75
Unfair	14	20.6
Total	68	100

Table 7: Reasons for Unfair Distribution of Water

Reason	Frequency	Percent
Head Users	6	42.8
Corrupt Officials/WUG	2	14.3
Illegal Water Users	4	28.6
Non-reliability of water sources	2	14.3
Total	14	100

Conflicts and Conflict Managements

Most conflicts were happened among irrigation beneficiaries especially between head and tail users. The capacity of the scheme was decrease time to time so that water scarcity was happened and there was a computation with in irrigation water users, this leads to conflict. Water thefts that were not follow their irrigation turns was challenging water user committees due to absence of bylaws in the irrigation scheme. The water user committees were tried to solve the conflict by local negotiation. There for, the kebele administer staffs should be support the water user committees in conflict resolution.

Table 8: Beneficiaries Response on Conflict over Irrigation Water

Response	Frequency	Percent
Yes	43	63.2
No	25	36.8
Total	68	100

Table 10: Causes of Conflicts over Irrigation Water

Cause of Conflict	Frequency	Percent
Water Scarcity	19	44.2
Computation due to increasing number of Users	7	16.3
Water Theft	17	39.5
Total	43	100

Conclusion and Recommendations

Strong water users association has a great contribution on the performance of the irrigation scheme but in Golda irrigation scheme there was no strong water users association. Unfair distribution of water was happened because head users did not keep their rotational turns. Absence of bylaws increase illegal water users and this leads to scarcity of water at tail reach of canal users. Beneficiaries did not have sense of ownership on irrigation scheme because they were taking metal sheet gates. The allocation of water was rigid rotational which was fixed time and it was not consider the area size of irrigation beneficiaries. Even though conflicts were happened, the solving mechanisms were poor. The following recommendations were forwarded.

- The Irrigation scheme users should produce more than once per year to get high production that could increase gross return of the investment.
- Clear organizational structure would be required for making the irrigation users responsible which helps the sustainability of the irrigation scheme.
- Fee collection should be applied that could increase the irrigation users sense of ownership and also brings economic value.
- The proclamation regarding to water users association should be implemented.
- The water users committee should be strengthened by training and there should be monitoring and evaluation by respected bodies to increase their performance.

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