Shiberu et al., Irrigat Drainage Sys Eng 2019, 8:1
DOI: 10.4172/2168-9768.1000226

Irrigation & Drainage Systems Engineering

Research Article Open Access

# Comparative Evaluation of Small Scale Irrigation Schemes at Adami Tulu Jido Kombolcha Woreda, Central Rift Valley of Ethiopia

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## Abstract

Evaluating the performance of irrigation systems will assist to distinguish whether the targets and objectives of the irrigation projects are met or not. In this study, a comparative performance evaluation was made on two small scale irrigation schemes in Adami Tulu Jido Kombolcha district Oromia Regional State Central Rift Valley of Ethiopia. The irrigation schemes were Haleku scheme with a command area of 42 ha and 96 beneficiaries, and Dodicha scheme with 75 ha irrigable lands and 150 beneficiaries. Primary and secondary data were collected for the study. The primary data include discharge at diversion point, moisture contents of the soils before and after irrigation, measurement of depth of water applied to the fields. The secondary data include total yields, farm gate prices of irrigated crops, area irrigated per crop per season, crop types, incomes generated by the irrigation associations, investment costs and cost of production and metrological data. The two-irrigation schemes were compared using the IWMI (International Water Management Institute) minimum sets of comparative indicators. The comparative indicators used were Agricultural performance, water use performance, Physical performance and Economic performance. From the analysis of Agricultural outputs, the outputs per cropped area were found to be 2,852.77 US$/ha and 2,179.41 US$/ha for Haleku and Dodicha irrigation schemes respectively, but the values of the output per command area of the schemes in the same order were 2,852.77 US$/ha and 1,278.59 US$/ha. The output per unit irrigation supply of Haleku was 0.18 US$/$m^3$ and of Dodicha was 0.13 US$/$m^3$. Output per water consumed was 0.53 US$/$m^3$ and 0.43 US$/$m^3$ for Haleku and Dodicha irrigation schemes, respectively. With regard to the water use performance, water supply and relative irrigation supply were found to be equal which amount 2.89 and 3.34 for Haleku and Dodicha schemes respectively since all the water is supplied through irrigation; there was no rain fall during the study period. The irrigation ratio of Haleku is 1.00 which means 100% of command area was under irrigation and that of Dodicha was 0.59 which means about 41% of command area was not under irrigation during study period. The gross return on investment was 2.33 and 4.66 by ratio for Haleku and Dodicha irrigation schemes respectively. The financial self sufficiency of both schemes show that 5.29 for Dodicha scheme and 27.76 for Haleku scheme. In general, based on the assessment carried out, it can be concluded that the Haleku irrigation project performs better than Dodicha scheme. For improved performance of the schemes, farmers should share operational experience to one another, and get water management training. Further, it is good to provide simple hydraulic flow metering structures on the canals to monitor water supply and utilization.

**Keywords:** Dodicha; Comparative; Evaluation; Haleku; Irrigation; Schemes; Performance

## Introduction

Irrigation is an agricultural operation supplying the soil moisture deficit with water for the purpose of crop growth. It is a component of successful crop husbandry practice particularly in a dry climate. A reliable and suitable irrigation water supply can result in improvements in agricultural production and assure the economic vitality. Some have estimated that as little as 15-20 percent of the worldwide total cultivated area is irrigated. Comparing irrigated and non-irrigated yields in some areas, this relatively small fraction of agriculture is contributing as much as 30-40 percent of gross agricultural output [1].

Ethiopia has a total land area of about 1.14 million $km^2$ and about 55 million ha of arable land while only 40% is under cultivation [2]. The agricultural sector is the leading sector in the Ethiopian economy contributing 47.7 percent of the total Gross Domestic Products (GDP) as compared to 13.3 percent from industry and 39 percent from services and provides livelihood to 85% of the population [3]. Both industry and services depend strongly on the performance of agriculture which provides raw materials, generates foreign currency for import of essential inputs and food for the fast growing population.

Despite its importance for the national economy, agriculture is largely based on subsistence farming. The productivity of the agricultural sector is very low and lags behind the population growth rate resulting in food insecurity. To address this problem, the Ethiopian Government designed an Agricultural Development Lead Industrialization (ADLI) strategy which aims to use agriculture as the base for the country's overall development [4]. This strategy aims to enhance the productivity of small-scale farmers and to improve food security both in the rural and urban areas. One of the policies within this strategy is stimulate and/or support the development of small-scale irrigation.

Ethiopia has an estimated irrigation potential of 3.7 million hectares of land [5]. During 2006, the total estimated area of irrigated agriculture in the country was 625,819 ha, which, in total, constitutes about 17% of the potential [6]. Despite its enormous potential to boost the country's economy, irrigated agriculture is facing a number of problems. One of the major concerns is the generally poor efficiency with which water resources have been used for irrigation. A relatively safe estimate is that 40 percent or more of the water diverted for irrigation is wasted at the farm level through either deep percolation or surface run off [7].

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**Received** November 26, 2018; **Accepted** February 07, 2019; **Published** February 14, 2019

**Citation:** Shiberu E, Hailu HK, Kibret K (2019) Comparative Evaluation of Small Scale Irrigation Schemes at Adami Tulu Jido Kombolcha Woreda, Central Rift Valley of Ethiopia. Irrigat Drainage Sys Eng 8: 226. doi: 10.4172/2168-9768.1000226

To achieve sustainable production from irrigated agriculture, it is obvious that the utilization of the important resources in irrigated agriculture; water and land must be improved. Comparative (external) irrigation performance indicators are useful tools for improving irrigation management and making optimization possible. They are capable to examine performance both across irrigation systems and within a system. They are preferred for analyzing the performance of various aspects of irrigation systems as they relate outputs from irrigated agriculture to the major inputs of water, land, and finance unlike the commonly used process indicators which focused management targets such as duration, flow rate of water, area irrigated; and cropping patterns in a system.

International Water Management Institute (IWMI) has prepared different "comparative" indicators that are helpful for comparing irrigated 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. The set of indicators is small, yet reveals sufficient information about the output of the system. Therefore, performance of irrigation scheme has to be evaluated periodically, both at system and at farm levels against the performance of some other similar scheme so that operational experiences are shared to improve for future use. Hence, this study was undertaken with the objective of evaluating the performance of Haleku and Dodicha small-scale irrigation schemes at Adami Tullu Jido Kombolcha Woreda, Central rift valley Ethiopia using comparative indicators.

## Material and Methods

### Description of the study area

The two small scale irrigation projects selected for the study, namely Haleku and Dodicha are found in Adami Tulu Jido Kombolcha district of the Oromia regional state, Ethiopia. The district is geographically located at latitude of $7^0$50' North and longitude of $38^0$ 42'East. Haleku irrigation scheme is located at a distance of 172 km from Addis Ababa and 9 km from Ziway town, along the Bulbula River at an elevation of 1646 m above sea level (asl). The scheme comprises an area of 42 ha and 96 beneficiary households. Whereas, Dodicha irrigation scheme is located at a distance of 174 km from Addis Ababa south, and 11 km from Ziway town. It is located 4 km north east of the Haleku irrigation project. The designed command area of the project is 75 ha and with 150 household beneficiaries. The source of water for the schemes is Bulbula River and is supplied to the schemes by pumps. Haleku scheme uses electric pump whereas Dodicha uses diesel pump. The project area belongs to the semiarid drought prone areas of the country. It receives average annual rainfall of 690 mm mainly received from June to August which is characterized by erratic type of rain fall, which is followed by a distinct dry spell up to January. This is often preceded by secondary or small rainy season running from February to April. The mean daily minimum and maximum temperature in the area is 12.6°C and 28.2°C, respectively.

### Methodology

Performances of the selected schemes were evaluated using external process indicators. The indicators employed were the standardized performance indicators established by IWMI which include agricultural performance, water use performance, physical performance and economic performance. To determine these indicators the following methodological steps were followed.

**Data collection:** Both primary and secondary data were collected. The primary data include discharge at diversion point, moisture contents of the soils before and after irrigation, measurement of depth of water applied to the fields. Secondary data were collected from the district Agricultural Rural Development Office and Water Resource Office, Irrigation offices at regional, zonal and central levels. These data include the investment costs of the schemes, average yield per ha as well as an average price for each crop per kg, total yield, farm gate prices of irrigated crops, area irrigated per crop per season, crop types, production cost per season, incomes generated by the irrigation associations and cropping pattern. Climatic data of each irrigation projects were collected from the nearby weather station which is located in the compound of Adami Tulu Research Center.

**Crop water requirement and irrigation scheduling:** To estimate irrigation scheduling and irrigation water requirement (IWR) of the irrigated crops CropWat 8.0 Model was used [8].

**External performance indicators:** External or comparative performances of the schemes were evaluated using the indicators in the four groups of comparative indicators standardized by IWMI [9].

**Agricultural performance:** There are four standard indicators related to the output of different units for the evaluation of agricultural performance. These indicators were calculated as follows [9]:

$$\text{Output per cropped area (US\$ / ha)} = \frac{\text{SGVP (Production)}}{\text{Irrigated cropped area}} \quad (1)$$

$$\text{Output per unit command area (US\$ / ha)} = \frac{\text{SGVP (production)}}{\text{Command area}} \quad (2)$$

$$\text{Output per unit irrigation supply (US\$ / m}^3\text{)} = \frac{\text{SGVP (production)}}{\text{Diverted irrigation supply}} \quad (3)$$

$$\text{Output per unit water consumed (US\$ / m}^3\text{)} = \frac{\text{SGVP (production)}}{\text{Volume of water consumed}} \quad (4)$$

Where,

$$\text{SGVP} = \left[\sum \text{AiYi}\frac{\text{pi}}{\text{pb}}\right]\text{P world}$$

SGVP=the output of irrigated area in terms of gross or net value of production measured at local or world prices;

Irrigated cropped area=the sum of areas under crops during the time period of analysis;

Command area=the nominal or design area to be irrigated;

Diverted irrigation supply=the amount of water diverted from the source;

Volume of water consumed=the actual evapotranspiration of crops, ET which is calculated by: $ET=ET_o \times k_c$ in which ETo is the reference ET, and kc is the crop coefficient.

**Water use performance:** Two types of indicators were used for evaluation of water use performance [10]:

$$\text{RWS} = \frac{\text{Total water supply}}{\text{Crop water demand}} \times 100 \quad (5)$$

$$\text{RIS} = \frac{\text{Irrigation supply}}{\text{Irrigation demand}} \times 100 \quad (6)$$

Where:

RWS=Relative water supply

RIS=Relative irrigation supply

Total water supply=Surface diversions plus net groundwater plus rainfall.

Crop demand=Potential crop ET, or the ET under well-watered conditions.

Irrigation supply=Only the surface diversions and net groundwater draft for irrigation.

Irrigation demand=The crop ET less effective rainfall.

Both RWS and RIS relate supply to demand, and give some indication as the condition of water abundance or scarcity, and how tightly supply and demand are matched.

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

$$\text{Irrigation ratio} = \frac{\text{Irrigated cropped area}}{\text{Command area}} \quad (7)$$

where,

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

Command area (ha)=the potential scheme command area.

**Economic performance:** Economic indicators deal with how much investment costs and yearly maintenance and operation expenditures are spent on the project in comparison with total production and revenue from the project. It also deals whether system is self–sufficient or not [11-16]. The economic performance indicators used in the evaluation for this particular research were:

$$\text{Gross returns on investment} = \frac{\text{Production}}{\text{Cost of infrastructure}} \quad (8)$$

$$\text{Financial self seficiency} = \frac{\text{Revenue from irrigation}}{\text{Total O\&M expenditure}} \quad (9)$$

## Results and Discussion

### Water distribution systems

Irrigation management is carried out in both schemes in rotation. In Haleku Scheme, it is rotated among six groups of farmers while in Dodicha among eight groups of farmers. As there is sufficient water in both schemes, the availability of water for upstream and downstream farmers is the same. There is no constant irrigation interval adopted by the farmers. It is 4-7 days in Haleku scheme and 5-7 days in Dodicha scheme depending on the growing stage of the crop.

### Crop water requirements and irrigation scheduling

The major crops grown during the study period and which are common to both schemes are onion, tomato and snap beans as shown in Tables 1 and 2. The water requirements and irrigation scheduling of these crops were calculated using CropWat 8. As a result, the crop water requirements of onion, tomato and snap beans were estimated to be 589.4 mm, 620 mm and 366.2 mm respectively and all were fulfilled by irrigation as there was no rain during the study period.

### External performance indicators

The crops grown are cash crops and the farmers use the same markets and prices to sell their products. The production, productivity and price related inputs that were used for determination of the comparative assessment indicators are shown in Tables 1-4.

**Irrigated agriculture performance indicators:**

**Output per unit-cropped area:** The output per cropped area shows the response of each cropped area on generating gross return. This parameter is giving clue about the management practice in every scheme. According to data collected from each irrigation schemes output per unit-cropped area were found to be 2,852.77 US$/ha and 2,179.41 US$/ha for Haleku and Dodicha irrigation scheme, respectively. It implies that there is a better irrigation management in Haleku than Dodicha scheme. This might be associated with the input use and strong institutional set up in Haleku irrigation scheme.

**Output per unit of command area:** This indicator expresses the average return per each design command area. It is an indication of whether all the command areas generating returns or not. The output per unit command of Haleku and Dodicha irrigation scheme is 2,852.77 US$/ha and 1,278.59 US$/ha respectively.

**Output per unit irrigation supply (USD/m$^3$):** This indicator shows the revenue from agricultural output for each cubic meter of irrigation water supplied. The output per unit water supply for Haleku was found to be 0.18 US$/m$^3$ and that of Dodicha was 0.13 US$/m$^3$. It implies that there is excess supply of water in Dodicha than Haleku irrigation scheme.

**Output per unit water consumed:** The output per unit water

| No | Crop Type | Total Area (ha) | Productivity (quintals/ha) | Total products (quintals) | SGVP (US$) | Production costs (US$) | Revenue in (US$) | Price per kg (US$) |
|---|---|---|---|---|---|---|---|---|
| 1. | Snap beans | 16 | 64 | 1024 | 22287.06 | 3952.94 | 18334.12 | 0.22 |
| 2. | Tomato | 1 | 220 | 220 | 3882.353 | 607.06 | 3275.29 | 0.18 |
| 3. | Cabbages | 1 | 32000 heads | 32000 heads | 4705.882 | 477.65 | 4228.24 | 0.15 |
| 4. | Onion | 24 | 180 | 4320 | 88941.18 | 10051.76 | 78889.41 | 0.21 |
| | Total | 42 | - | - | 119,816.5 | 15,089.41 | 104,727.06 | - |

**Table 1:** Crop production, productivity, and production costs and prices Haleku irrigation scheme.

| No | Crop Type | Total Area (ha) | Productivity (quintals/ha) | Total products (quintals) | SGVP (US$) | Production costs (US$) | Revenue in (US$) | Price per kg (US$) |
|---|---|---|---|---|---|---|---|---|
| 1. | Snap beans | 22 | 50 | 1100 | 23941.18 | 7661.18 | 16280.00 | 0.22 |
| 2. | Tomato | 8 | 148 | 1184 | 20894.12 | 4894.12 | 16000.00 | 0.18 |
| 3. | Cabbage | 5 | 32000 heads | 160000 heads | 23529.41 | 2647.06 | 20882.35 | 0.15 |
| 4. | Onion | 8 | 160 | 1280 | 26352.94 | 5176.47 | 21176.47 | 0.21 |
| 5. | Garlic | 1 | 20 | 20 | 1176.471 | 470.59 | 705.88 | 0.59 |
| | Total | 44 | | | 95894.12 | 20849.41 | 75044.71 | |

**Table 2:** Crop production, productivity, and production costs and prices Dodicha irrigation scheme.

| No | Type of costs | Amount of money in US$ |
|---|---|---|
| 1 | Initial investment cost | 51,346.28 |
| 2 | Operation & Maintenance cost in 2010/2011 | 2,703.07 |
| Total | | 54,049.35 |

**Table 3:** Investment and operation costs of Haleku irrigation project.

| No | Type of costs | Amount of money in US$ |
|---|---|---|
| 1 | Initial investment cost | 20,588.24 |
| 2 | Operation & Maintenance cost in 2010/2011 | 14,188.24 |
| Total | | 34,776.47 |

**Table 4:** Investment, Operation and maintenance costs of Dodicha irrigation project.

consumed is used to describe the return on water actually consumed by the crop. This indicator gives due attention to the water consumed by each scheme and tells us how water is efficiently utilized by the scheme from economic point of view. The values for this indicator were found to be 0.56 US$/m$^3$ for Haleku and 0.45 US$/m$^3$ for Dodicha irrigation scheme. This result shows that the water use efficiency is higher in Haleku than in Dodicha irrigation scheme. The reason for this might be a better institutional set up in Haleku irrigation scheme.

**Water use performance:**

**Relative water supply:** Relative water supply depicts whether there is enough irrigation water supplied or not. The RWS value below one normally indicates that the water applied is less than crop demands. But the value above one indicates extra water is added to root zone beyond plant demands. The relative water supply of Haleku irrigation scheme was found to be 2.89 and that of Dodicha scheme was 3.34. These results indicate that excess water was used beyond plant demands in both schemes but the case of Dodicha scheme is relatively higher than that of Haleku. In order to maximize water use efficiency of the projects, it is required that the amount of water supplied be reduced in both schemes.

**Relative irrigation supply:** Relative irrigation supply shows whether the irrigation demand is satisfied or not. Since there was no rainfall in the area during research period the value of relative irrigation supply and relative water supply is the same which means 2.89 for Haleku irrigation scheme and 3.34 for Dodicha scheme.

**Physical performance:** Physical indicators are related with the changing or losing irrigated land in the command area by different reasons. Irrigation ratio for Haleku irrigation scheme was 1.00, which means that total command area of the scheme was under irrigation during the study period, but the irrigation ratio of Dodicha irrigation scheme was 0.59 which means about 41% of command area of scheme was not under irrigation during study period. The main reasons for this were farmers' capacity to afford inputs and fuel costs to pump water from the river, and weak institutional set up of water use association at the scheme.

**Economic performance:**

**Gross return on investment:** This indicator considers the production and the total cost of infrastructure for each scheme. The gross return on investment of Dodicha was found better than Haleku irrigation project. The values in the same order for the schemes are 2.33 and 4.66. This is mainly associated with high infrastructure cost incurred in Haleku. However, the area irrigated was 100% and 58.66% of their design potential for Haleku and Dodicha schemes, respectively.

**Financial self-sufficiency:** Financial self-sufficiency indicates the ratio of revenue from the irrigation to the expenditure for operation and maintenance. It shows the compensation ratio of management and maintenance costs for irrigation system based on the income obtained from the irrigation. This in other words implies the sustainability of the schemes, perception of the farmers towards the irrigation scheme. The financial self-sufficiency was found to be 5.29 for Dodicha and 27.76 for Haleku scheme. Both schemes are financially self-sufficient but Haleku scheme is in a better position.

## Conclusions and Recommendations

### Conclusions

The assessment of the performance of the two irrigation schemes under study (Haleku and Dodicha) indicates that the availability of irrigation water was not a constraint. Based on the output per cropped area, the irrigation practice in Haleku scheme was relatively good. From the output per unit command area, large amount of command area was not under irrigation in Dodicha due to low farmers economical capacity to afford high inputs (Fertilizers, crop protection chemicals and improved seeds) required for cash crop production and high fuel price to pump water. From the return from one cubic meter of irrigation water, the water utilization in Haleku was better than Dodicha scheme. The relative water and irrigation supply for both schemes recorded a high ratio, which implies the amount of water applied during irrigation events is much higher than what is required by the schemes. The gross return on investment was recorded lower in Haleku due to high infrastructure cost of Haleku irrigation project. In general, based on the assessment carried out, it can be concluded that the Haleku irrigation project performs better than Dodicha scheme.

### Recommendations

Comparison of the performance of irrigation systems will help to know the present status of these systems and to apply possible measures for improvement. From the results obtained, the following recommendations are forwarded.

- Water management practice of Dodicha scheme was relatively poor. So it should be improved by experience sharing from Haleku and other surrounding schemes. But to improve performances of both schemes, farmers, Development Agents (DAs) and concerned bodies at the two schemes should share experience by visiting the sites one another. Concerned bodies should also arrange training on water management for farmers and development agents working in the area.

- The financial self sufficiency of Dodicha scheme was relatively very low. In order to improve the revenue from Dodicha scheme, the productivity should be improved by using appropriate agricultural inputs or cost of production should be minimized. The main cost of production in Dodicha irrigation project was fuel costs to pump water from the river so the Diesel pump should be changed into electric pump since the electric line passes over the scheme; and they should use this opportunities.

- Hydraulic flow metering structures should be constructed at different levels of the canals. This will assist to monitor the activities in relation to water utilization and irrigation efficiencies. Moreover, this is a preliminary work for the equitable payments for water they use. That is to make water pumping service payment or electric fee based on the amount of water consumed not based on the area they irrigate.

### References

1. Shiferaw T (2008) Socio-ecological Functioning and Economic Performance

of Rain-fed farming Systems in Adami Tulu Jido Kombolcha District, Ethiopia.

2. Awulachew SB, Merrey DJ, Kamara AB, Van Koopen B, De Vries Penning FDV, et al. (2005) Experiences and Opportunities for Promoting Small-Scale/ Micro Irrigation and Rainwater Harvesting for Food Security in Ethiopia.
3. http://documents.worldbank.org/curated/en/947951468140975423/World-development-indicators-2005
4. Ministry of Water Resources (2001) Data collected from different river basin development master plan studies. Planning and Projects Department, Addis Ababa, Ethiopia.
5. Awulachew SB, Yilma AD, Loulseged M, Loiskandl W, Mekonen A, et al. (2007) Water Resources and Irrigation Development in Ethiopia.
6. Ministry of Finance and Economic Development (2006) Ethiopia: Building on Progress: A Plan for Accelerated and Sustained Development to End Poverty (PASDEP), (2005/06-2009/10).
7. Walker WR (1989) Guidelines for Designing and Evaluating Surface Irrigation Systems.
8. FAO (1992) Ninth Meeting of the East and Southern African Sub-committee for Soil Correlation and Land Evaluation. Soil Bulletin.
9. Molden, DR, Sakthivadivel CJ, Perry CF, Klozen WH (1998) Indicators for comparing performance of irrigated agricultural systems. International Water Management Institute, Colombo, Sri Lanka.
10. Perry CJ (1996) Quantification and measurement of a minimum set of indicators of the performance of irrigation systems. International Irrigation Management Institute, Colombo, Sri Lanka.
11. Vermillion DL (2006) Lessons Learned and to be Learned about Irrigation Management Transfer.
12. Joss S (1999) CropWat 8 Windows: User Guide Version 8: Water Resources Development and Management Service of FAO, Rome.
13. Molden D, Burton MA, Bos MG (2005) Guidelines for irrigation and drainage performance assessment.
14. OESPO (2003) Adami Tullu-Jido Kombolcha Woreda Based Development Programme. Regional Government of Oromia, Oromia Economic Study Project office.
15. Pereira LS (1999) Higher performance through combined improvements in irrigation methods and scheduling: a discussion. Agric Water Manag, 40: 140-150.
16. Pereira LS, Trout TJ (1999) Irrigation Methods, Land and water engineering, CIGR handbook of agricultural engineering. ASAE.