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# Performance Evaluation of Sanko Small Scale Irrigation Scheme at Basketo Special Woreda in SNNPR, Ethiopia

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**Abstract**

This study conducted to evaluate the performance of Sanko small-scale irrigation scheme at Basketo Special Woreda, South Nation Nationalities Peoples Regional states. The irrigation scheme includes command area of 120 ha and 600 beneficiaries. The scheme was evaluated using internal and productivity performance indicators. From the analyses of the internal performance indicators, the conveyance efficiency of the main canal was found to be 69.3% and application efficiencies at head (61.6%), middle (63.4%) and tail (46.5%) with average application efficiency of 57.2%. A light soil with high infiltration rates favors deep percolation losses at the top of the fields, resulting in low field application efficiency in tail end part of the scheme. A deep percolation ratio and storage efficiency of the scheme was found to be 42.8% and of 78.5% respectively. Generally overall scheme efficiency of scheme was 39.6%. From the evaluation of productivity indicators, the outputs per cropped area found as at head (84,706 Birr $ha^{-1}$), middle (220,690 Birr $ha^{-1}$) and tail (69,686.4 Birr $ha^{-1}$) and the value of the outputs per command area of scheme was 15,003,276 Birr per command area. The output per unit irrigation supply of irrigation scheme was at head (13.5 Birr $m^{-3}$), middle (33.95 Birr $m^{-3}$) and tail (22.12 Birr $m^{-3}$). Relative water supply and relative irrigation supply; found to be 1.28, which was the same for both since there was no rainfall during study period. From the analysis result, there was lower water use efficiency (WUE) at upper head (23.37 ton/$m^3$) as compared to middle (48.78 ton/$m^3$) and tail (60.22 (ton/ $m^3$) part of the scheme in relation to yield obtained. Based on the evaluation result, highest yield was obtained from at middle part of irrigation scheme and lower yield was obtained from both upper and tail end part of the scheme. The yield reduction in upper and tail part of the scheme was due to over and under irrigation. However, there is still a room for improvement at all system levels. Therefore to reduce over and under irrigate; farmers should get awareness how to use, when to use and how much water used on their fields.

**Keywords:** Irrigation scheme; Performance indicators; Irrigation water management

## Introduction

There are mixed perceptions about the contribution of small-scale irrigation (SSI) interventions in particular for poverty reduction and food security improvement [1]. In Ethiopia, although irrigation has long practiced at different farm levels, there is no efficient and well managed irrigation water practice [2]. The reason could be little efforts made to investigate the irrigated land management and water use in the country. Even some research results have indicated that sometimes no difference observed between rain fed and SSI user smallholders in their food security status [3]. The World Bank, other development banks and numerous countries have invested in large irrigation projects. There have been conflicting opinions about the wisdom of investing further in new irrigation projects, primarily due to the questions about the performance of existing projects [4]. According to Small and Svendsen [5], the evaluation of irrigation performance is clearly important to managers of irrigation projects, but it seriously neglected by those who allocate public funds for irrigation and by researchers. According to Awulachew et al. [6], reported that improving low-performing schemes specifically small scale irrigation schemes requires incorporating applied research on irrigated agriculture. According to Luis [7] field evaluation play a fundamental role in improving irrigation systems. Generally, IWMI developed two types of indicators to evaluate irrigation systems: internal and productivity indicators. This study intends to evaluate the performance of irrigation scheme using internal and productivity indicators.

## Materials and Methods

### Description of the study area

Basketo special woreda found in Gamo-Gofa zone of SNNPR, which is 310 km, 460 km and 626 km from Arba-Minch, Hawassa and Addis Ababa respectively. It is located geographically at latitude of 6°5′ 0″ to 6°25′ 0″N and longitude of 36°25′ 0″ to 36°40′0″E. Sanko small-scale irrigation scheme was constructed by regional water and irrigation development bureau in year 2002 E.C and which is 18 km far from the main road of the district. Command area covered by the scheme was 120 ha. The scheme was located geographically at 36.55°E longitude and 6.26°N latitude (Figure 1). The elevation variation of the catchment upstream of the irrigation diversion point ranges from 813-894 m.a.s.l. while, the woreda ranges from 780-2200 m.a.s.l.

### Determination of crop water requirement

Crop water requirements (CWR) refer to the amount of water required to compensate for evapotranspiration losses from a cropped field. CROPWAT 8.0 computer program was used to estimate the total water requirements of onion crop. According to FAO [8] Penman-Monteith method was selected to calculate the reference crop evaporation.

$$ET_c = (ET_o * K_c) \quad (1)$$

Where: $ET_c$ is actual evapo-transpiration of crops (mm), $ET_o$ is reference evapo-transpiration (mm) and $K_c$ is the crop coefficient.

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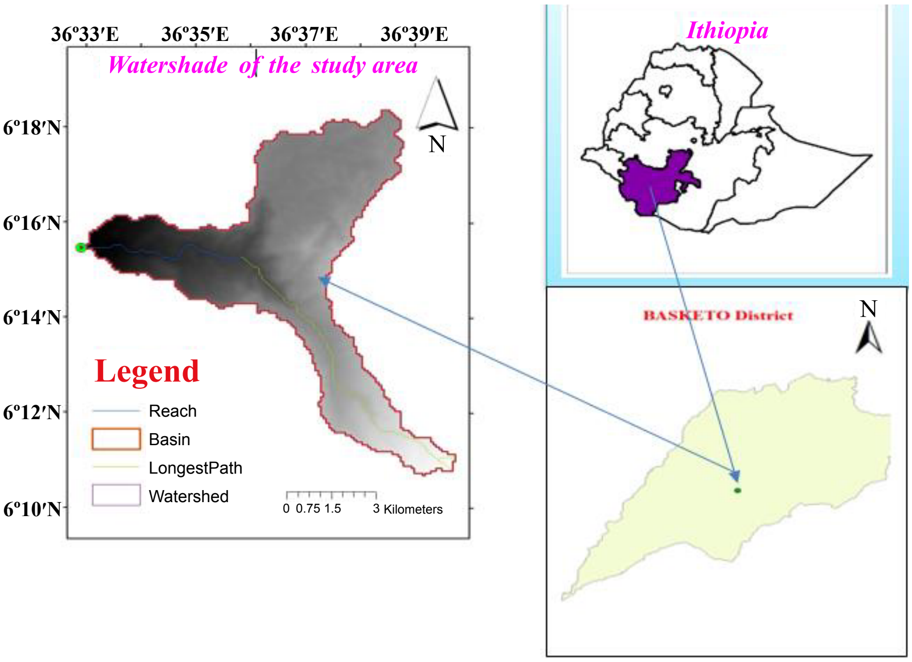


**Figure 1:** Topographical map of study area.

## Bulk density of the soil

Bulk density refers to compactness of a soil and should be distinguished from the soil density of the solid soil constituents, usually called the particle density. The bulk density is also the ratio of oven-dried mass of a soil to its volume for undisturbed soil condition and is expressed on dry weight basis of the soil as [9].

$$B_d = \frac{M_d}{V_c} \quad (2)$$

Where: $B_d$ is the soil bulk-density (gm cm$^{-3}$), $M_d$ is the weight of oven-dried soil (gm) and $V_c$ is the volume of core (cm$^3$).

## Moisture content of soil

The moisture content of soil samples were determined using gravimetric method. Soil samples were taken with soil auger and weighed and dried in an oven at 105°C for about 24 hours, until all the moisture is driven off. The difference in weight is the amount of moisture in the soil [10].

$$W_{\theta} = \left( \frac{W_w - W_d}{W_d} * B_d * 100 \right) \quad (3)$$

Where: $W_\theta$ is gravimetric soil moisture content (% volume bases), $W_w$ is wet weight of the soil (g), $W_d$ is dry weight of the soil (g) and $B_d$ is bulk density of soil (g cm$^{-3}$).

## Total available soil water

Soil water content at field capacity (FC) and permanent wilting point (PWP) is important for irrigation scheduling; assessing plant water requirement and soil suitability for different land uses [11]. The total Available Soil Water (TAW) was computed from the soil moisture content at Field Capacity (FC) and Permanent Wilting Point (PWP) using expression:

$$TAW = \left( \frac{FC - PWP}{100} \right) * B_d * Rz \quad (4)$$

Where: TAW is total available water (mm), FC and PWP in % on weight basis, Bd is the bulk density of the soil in gm cm$^{-3}$ and Rz is the maximum effective root zone depth in mm.

## Readily available water

It is the portion of the total available water (FC-PWP) which is most easily extracted by the plant roots without creating stress. The term Maximum or Management Allowable Deficiency, (MAD) can be used to compute the amount of water that can be used without adversely affecting the plants.

$$RAW = (TAW * P) \quad (5)$$

Where: RAW is readily available water and P is in fraction for allowable soil moisture depletion for no stress.

## Irrigation scheduling

The depth of water applied to the field was obtained by dividing the total volume of water applied to the area irrigated. Considering the daily CWR, TAW, Dz, Bd and p, the irrigation interval could be computed from the expression [12]:

$$\text{Interval}(\text{days}) = \frac{RAW}{CWR} \quad (6)$$

## Performance evaluation methods

Performance of the scheme was evaluated using both internal and productivity performance indicators. A total of nine locations were selected based on distance apart from the irrigation scheme, i.e. three from the head ($H_1$, $H_2$, and $H_3$); three from the middle ($M_1$, $M_2$, and $M_3$) and three from the tail ($T_1$, $T_2$ and $T_3$) end water users of irrigation scheme which was represent appropriate sampling of study [13]. The standardized performance indicators established by IWMI was taken to measure productivity indicators.

**Internal performance indicators:** These indicators examine the technical or field performance of a project by measuring how close an irrigation event is to an ideal one. An ideal or reference irrigation is one that can apply the right amount of water over the entire depth of root zone [13].

***Conveyance efficiency:*** The surface velocity is obtained by measuring the time (t in sec) for a float to travel a straight distance about 30 m long over a ten repeated t runs in each of upper and lower main canal. A reduction factor of about 0.85 should be used to convert surface velocity to average velocity [14].

$$\text{Surface velocity}\left(\frac{m}{s}\right)=\left(\frac{L}{t}\right) \tag{7}$$

$$\text{Average velocity}\left(\frac{m}{s}\right)=\left(\frac{0.85*L}{t}\right) \tag{8}$$

Geometry of the Sanko irrigation canal is rectangular; so cross sectional area was calculated [15].

$$A = (b*y) \tag{9}$$

Where: b is base width of canal and y is water depth in the canal.

Discharge can be calculated by multiplying average velocity and cross sectional area of the irrigation canal [14].

$$Q\left(\frac{m^3}{s}\right)=\left(\frac{0.85*L*A}{t}\right) \tag{10}$$

Conveyance efficiency is the ratio of water delivered in to the field from outlet point of the canal ($Q_o$) to water entering in to the canal at it staring point ($Q_i$). The measurements also were taken throughout study period at initial and final points of main canal [16].

$$E_c = \frac{Q_o}{Q_i}*100 \tag{11}$$

Where: $E_c$ is conveyance efficiency (%), $Q_i$ is depth of water diverted from the source ($m^3$) and $Q_o$ is depth of water applied to the field ($m^3$).

***Application efficiency:*** The application efficiency was computed as the ratio of quantity of water stored in to the root zone of crops (NIR) to the quantity of water actually delivered in to the field (GIR). Application efficiency was computed as follows [16]:

$$E_a = \frac{NIR}{GIR}*100 \tag{12}$$

Where: $E_a$ is application efficiency (%), NIR is average depth of water stored to the root zone (mm), and GIR is average depth of water applied to the field (mm).

The amount of water applied through parshall flume to a field is a function of time, flow and area [17].

$$t = \frac{A*GIR}{6Q} \tag{13}$$

Where: t is time of application (min), A is area of the plot ($m^2$), GIR is amount of water applied to the field (cm) and Q is flow rate or discharge (l/s).

***Deep percolation ratio:*** The runoff ratio was normally being considered for this particular study as zero as the farmers' are using furrows whose tail ends are closed. However, the deep percolation ratio was computed as the ratio of the percolated water beyond the root zone to the volume of water applied to the field [17].

$$DPR = (100-E_a-RR) \tag{14}$$

***Storage efficiency:*** The storage efficiency is the ratio of the quantity of water stored in the root zone to that intended to be stored in the root zone. After determining the storage and the required depths, the storage efficiency was calculated using the following formula [16].

$$E_s = \frac{NIR}{W_n}*100 \tag{15}$$

Where: $E_s$ is storage efficiency (%), NIR is water stored in the root zone (mm) and $W_n$ is water desired to be stored in the root zone (mm).

***Overall scheme efficiency:*** As reported by the MoAFS [18] for small irrigation schemes in Tanzania typical values of overall scheme efficiency proposed were 28 and 34% for poorly operated and for well operated canals, respectively. Overall scheme efficiency was calculated as the product of conveyance and application efficiency. It was computed using following formula [16].

$$E_p = (E_c * E_a) \tag{16}$$

Where: $E_p$ is overall scheme efficiency (%), $E_c$ is conveyance efficiency (%) and $E_a$ is application efficiency (%).

**Productivity performance indicators:** The productivity performance indicators are normally classified into four groups, namely agricultural, water use, physical and economical performances' as standardized by IWMI. The selected indicators of agriculture performance are output per cropped area (Birr $ha^{-1}$), output per command area (Birr $ha^{-1}$), output per irrigation supply (Birr $m^{-3}$), Output per water consumed (Birr $m^{-3}$) as the ratio of production per volume of water consumed (Birr/$m^3$) [19].

***Agricultural performance indicators***

*Output per unit irrigated area (Birr/ha):* It was computed as the total value of production per harvested area in the irrigation season. The harvested area includes the areas that were irrigated in the irrigation season.

$$OPUIA = \frac{\text{Seasonal value of production}}{\text{Irrigated harvested area}} \tag{17}$$

Where: OPUIA is output per unit irrigated cropped area, Seasonal production is the output of the irrigated area in terms of gross or net value of production measured at local price and Irrigated harvested area is the areas under crops.

*Output per unit command area (Birr/ha):* This indicator quantifies the value of production that obtained per unit command irrigable area. High value result shows good intensive irrigation while small values are not pertinent from land productivity point of view. Command area is the nominal or design area to be irrigated [19].

$$OPUCA = \frac{\text{Seasonal value of production}}{\text{Command area}(\text{Nominal})} \tag{18}$$

Where: OPUCA is output per unit command area, Seasonal production is the output of the irrigated area in terms of gross value of production measured at local price and Command area is the nominal or design area to be irrigated.

*Output per unit irrigation water supply (Birr/$m^3$):* Water productivity indicators are calculated as the total value of production per unit water diverted. Supplied irrigation water is the volume of surface irrigation water diverted to the command area can estimated by equation below [20].

$$OPUIS = \frac{\text{Seasonal value of production}}{\text{Total diverted irrigation water}} \tag{19}$$

Where: OPUIS is output per unit irrigation water, Seasonal production is the output of the irrigated area and total diverted irrigation supply is the volume of surface irrigation water diverted to the command area, plus net removals from groundwater.

*Output per unit water consumed (Birr/m³):* Consumed water is the actual evapo-transpiration or process consumption from only irrigated crops (ET); it excludes other losses and water depletion from the hydrological cycle. It has a contribution for irrigation management aspects; to take measurements those minimize evapo-transpiration losses [20].

$$\text{OPUWS} = \frac{\text{Seasonal value of production}}{\text{Total water consumed by the crop}} \quad (20)$$

Where: OPUWS is output per unit water consumed, Seasonal production is the output of the irrigated area in terms of gross or net value of production measured at local price and Total volume of water consumed by ET is the actual evapotranspiration of crops.

***Water use performance indicators:*** These indicators depict the state of water availability or shortage and how tightly supply and demand are related. Both RIS and RWS relate supply to demand and show some indication as the condition of water abundance or scarcity and how tightly supply and demand are matched.

*Relative irrigation supply (RIS):* This is the ratio of annual irrigation supply (which excludes rainfall) to annual irrigation demand. It is the inverse of irrigation efficiency presented by [21]. Values of Relative Irrigation Supply (RIS) higher than one indicate that excess irrigation water is being supplied. The indicators are estimated as per the equations below [20].

$$\text{Relative irrigation supply} = \frac{\text{Irrigation supply}}{\text{Irrigation demand}} \quad (21)$$

*Relative water supply (RWS):* This is the ratio of total annual water supplied (irrigation plus rainfall) to the annual crop water demand can estimated by equation below [22].

$$\text{Relative water supply} = \frac{\text{Total water supply}}{\text{Crop demand}} \quad (22)$$

***Physical indicators:*** Physical indicators are related with the changing or losing irrigated land in the command area by different reasons. The selected indicator used for evaluation of physical performance is irrigation ratio which can be expressed as the follows [20].

$$\text{Irrigation ratio} = \frac{\text{Irrigated crop area}}{\text{Command area}} \quad (23)$$

Where: irrigated crop area (ha) is the portion of the actually irrigated land (ha) in any given irrigation season and command area (ha) is the potential scheme command area.

***Economic performance indicators:*** The economic performance indicators for this particular study are gross returns on investment and financial self-sufficiency. The gross return on investment is calculated as the ratio of production to the cost of infrastructure at the irrigation scheme and the financial self-sufficiency was calculated as the ratio of revenue from irrigation to the total operational and maintenance expenditure [21].

$$\text{Gross return on investment} = \frac{\text{Production}}{\text{Cost of irrigation structure}} \quad (24)$$

$$\text{FSS} = \frac{\text{Revenue from irrigation charges}}{\text{Total operation and maintainance expenditure}} \quad (25)$$

Where: FSS is financial Self Sufficiency.

### Economic analysis of irrigation scheme performance

The productivity indicated by measuring these outputs in gross terms or relative to input utilized. The inputs of interest in irrigation are land, water and finance for different purpose of the system. Benefit-Cost ratio method used for economic analysis of irrigation scheme.

$$\text{BCR} = \frac{\text{PV}(\text{B})}{\text{PV}(\text{C})} \quad (26)$$

Where: BRC is benefit-cost ratio, PVB is present value of benefit and PVC present value of cost. The BCR shows the overall values for money of the project. If the ratio greater than one, the approach is acceptable.

## Result and Discussion

### Soil physical properties

Textural class soil was clay loam for the selected farm fields at upper head and middle reaches and sandy clay loam at tail end part of the irrigation scheme by using textural triangle. The bulk density values ranged from 1.15 to 1.25 g $cm^{-3}$ at irrigation scheme. Bulk density at both upper and middle part of the scheme was higher than tail end, since soil with textural class clay loam was more compacted than sandy clay loam. The volumetric moisture retained at field capacity of the soil was at head (180 mm), middle (202.5 mm), and tail (96.6 mm) whilst the volumetric moisture at permanent wilting point was at head (90 mm), middle (97.5 mm) and tail (41.4 mm). The average field capacity and permanent wilting point of study area were 159.8 mm and 76.3 mm respectively. Furthermore, the total available water holding capacity of soil in selected fields from the scheme ranged from 55.2–105 mm $m^{-1}$ (Table 1).

### Irrigation water requirements of onion crop in the study area

The seasonal and irrigation water requirements of the crop Onion, grown in the study area during the study period was estimated by the CROPWAT 8.0 model. The results indicated that for crop, the seasonal

| Field code | Soil depth (cm) | Particle size distribution (%) | | | Textural class | Average bulk density (g $cm^{-1}$) |
|---|---|---|---|---|---|---|
| | | Sand | Silt | Clay | | |
| H | 0-60 | 32 | 20 | 48 | Clay loam | 1.25 |
| M | 0-60 | 45 | 34 | 21 | Clay loam | 1.25 |
| T | 0-60 | 50 | 24 | 26 | Sandy clay loam | 1.15 |
| H | FC | | PWP | | Bd $gcm^{-3}$ | RAW (mm) |
| | % | mm/m | % | mm/m | | |
| | 24 | 180 | 12 | 90 | 1.25 | 22.5 |
| M | 27 | 202.5 | 13 | 97.5 | 1.25 | 26.3 |
| T | 14 | 96.6 | 6 | 41.4 | 1.15 | 13.8 |

**Table 1:** Selected soil physical characteristics of the irrigation scheme.

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crop and irrigation water requirements were equal since there was no rainfall during the study period. The crop onion is mainly practiced in the study area from November to March rather than other short season crops. Accordingly, the seasonal crop water requirement determined was at 414.71 mm (Table 2 and Figure 2).

## Internal process indicators

**Conveyance efficiency:** conveyance efficiency evaluation revealed that this indicator varied within a at different points, of the scheme. The average conveyance efficiency value was 69.3% which is below the recommended value i.e.70 percentage unlined poorly managed main canals (Table 3) [18].

**Application efficiency:** The application efficiency of selected fields at the irrigation scheme was at head (61.6%), middle (63.4%) and tail (46.5%) with an average application efficiency of 57.2% which is under recommended value of 50-70% for properly designed furrow (Table 4) [22].

**Deep percolation ratio:** Deep percolation ratio indicates the irrigation applied to a field percolates into the soil below the root zone. As depicted in Table 5; average deep percolation ratio at irrigation scheme found to be 42.8%. In the schemes, there is high deep percolation ratio, which indicates over irrigation.

**Storage efficiency:** Storage efficiency of selected fields from irrigation scheme was at head (86%), middle (74.8%) and tail (71%) with an average storage efficiency of 78.5% (Table 5). In general the

| Months | Dev. stage | No-of days | Kc | $ET_o$ (mm/day) | $ET_c$ (mm/day) | $ET_c$ (mm/period) | $ET_c$ (mm/month |
|---|---|---|---|---|---|---|---|
| January | Dev. t | 2 | 0.75 | 3.96 | 2.97 | 5.94 | 124.225 |
| | Mid | 29 | 1.03 | 3.96 | 4.08 | 118.285 | |
| February | | 6 | 1.03 | 4.32 | 4.45 | 26.6976 | 109.856 |
| | Late | 22 | 0.875 | 4.32 | 3.78 | 83.160 | |
| March | | 18 | 0.875 | 4.34 | 3.80 | 68.355 | 68.355 |
| November | Initial | 15 | 0.5 | 3.84 | 1.92 | 28.8 | 28.8 |
| December | | 3 | 0.5 | 3.71 | 1.86 | 5.565 | 83.475 |
| | Dev.t | 28 | 0.75 | 3.71 | 2.78 | 77.91 | |
| Seasonal $ET_c$ | | | | | | | 414.71 |

**Table 2:** Seasonal crop water requirement for onion based on crop calendar.

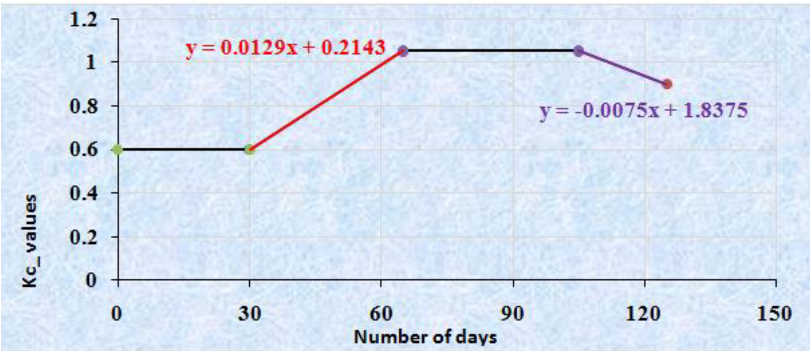


**Figure 2:** Graphs growing period of onion.

| Canal Section | Average Water depth (m) | Average Width (m) | Area (m²) | Length (m) | Time elapsed (sec) | Velocity (m/s) | Discharge (m³/s) | Conveyance Efficiency (%) |
|---|---|---|---|---|---|---|---|---|
| UMC | 0.17 | 0.41 | 0.07 | 30 | 47 | 0.54 | 0.04 | 69.3 |
| LMC | 0.15 | 0.42 | 0.063 | 30 | 58 | 0.44 | 0.028 | |
| UMC: Upper Main Canal, LMC: Lower Main Canal | | | | | | | | |

**Table 3:** Average Conveyance Efficiency of main canal.

| Field code | Before irrigation | After irrigation | Moisture stored (mm) | Water applied (mm) | $E_a$ | Average $E_a$ |
|---|---|---|---|---|---|---|
| $H_1$ | 17.04 | 37.45 | 20.41 | 31.4 | 65 | 61.6 |
| $H_2$ | 15.81 | 34.75 | 18.94 | 31.4 | 60.3 | |
| $H_3$ | 14.40 | 33.07 | 18.67 | 31.4 | 59.5 | |
| $M_1$ | 16.88 | 38.11 | 21.23 | 32.5 | 65.3 | 63.4 |
| $M_2$ | 13.84 | 34.11 | 20.27 | 32.5 | 62.4 | |
| $M_3$ | 15.65 | 35.93 | 20.28 | 32.5 | 62.4 | |
| $T_1$ | 16.65 | 27.14 | 10.49 | 21.0 | 50 | 46.5 |
| $T_2$ | 14.79 | 24.86 | 10.07 | 21.0 | 48 | |
| $T_3$ | 16.20 | 24.91 | 8.71 | 21.0 | 41.5 | |
| Average application efficiency of the system | | | | | | 57.2% |

**Table 4:** Average field application efficiency of Sanko small-scale irrigation scheme.

storage efficiency of the scheme was very good as compared to 63% storage efficiency usually found in typical furrow irrigation systems [23].

**Overall scheme efficiency:** Overall efficiency is the product of conveyance efficiency and application efficiency. In the present study, the overall efficiency of the irrigation scheme was 39.6% (Table 5). The result indicated that the irrigation scheme was relatively poor. The overall efficiency values (40-50%) commonly observed in other similar African irrigation schemes [24].

## Productivity performance indicators

**Irrigated agriculture performance indicators:** This includes performance indicators, which are associated with the production. The major of such performance indicators included are output per unit-cropped area, output per unit of command area, output per unit irrigation supply and output per unit water consumed.

***Output per unit cropped area:*** The yield obtained and evaluated from the three reaches of the irrigation scheme; outputs per unit-cropped area was head (84,705.88 Birr $ha^{-1}$), middle (220,689.6 Birr $ha^{-1}$) and tail (69,689.4 Birr $ha^{-1}$). Average value of output per unit-cropped area of 125,027.3 Birr $ha^{-1}$ obtained from the irrigation scheme (Table 6). From the evaluation it is possible to say that income per cropped area at middle part of the irrigation scheme was relatively better than that of upper and tail end part of irrigation scheme, since farmers in the middle part of the scheme were relatively well practiced about use of irrigation water.

***Output per unit of command area:*** This indicator expresses the average return per design command area. It is an indication of whether all the command areas are generating returns or not. The outputs per unit command area of irrigation scheme was 15,003,276 Birr per command area, which was very low production value as compared to good yield bulb under irrigation 76,800,000 Birr per command area as stated in [25]. The details of outputs per unit command area in the irrigation scheme shown in Table 6.

***Output per unit irrigation supply:*** The outputs per unit irrigation supply show the revenue from agricultural output for each meter cube of irrigation water supplied. The outputs per unit irrigation supply obtained were head (13.5 Birr $m^{-3}$), middle (33.95 Birr $m^{-3}$) and tail (22.12 Birr $m^{-3}$ ) and an average output per unit supply of the scheme was 23.2 Birr $m^{-3}$. This indicates that production value per unit irrigation supply in middle reach is better than head and tail reach. Higher value of this indicator in the middle reach indicates lower irrigation supply and lower value obtained in upper and tail end of the scheme indicates lower production due to over irrigation and under irrigation respectively.

| Internal performance Indicators | Average values obtained from the scheme |
|---|---|
| Conveyance efficiency (Ec) | 69.3% |
| Application efficiency (Ea) | 57.2% |
| Dee percolation ratio (DPR) | 42.8% |
| Storage efficiency (Es) | 78.5% |
| Overall scheme efficiency (Ep) | 39.6% |

**Table 5:** Different values of selected internal performance indicators of the scheme.

***Output per unit water consumed:*** The output per unit water consumed describes the return on water actually consumed by the crop. The outputs per unit water consumed in this study were at head (20.41 Birr $m^{-3}$), middle (53.18 Birr $m^{-3}$) and tail (22.12 Birr $m^{-3}$) and average output per unit water consumed of the scheme was 34.93 Birr $m^{-3}$. This result indicates that water use efficiency in the middle part of the scheme was good as compared to outputs per unit water consumed at upper and tail part of the scheme.

**Water use indicators**

***Relative water supply:*** The relative water supply depicts whether there is enough irrigation water supplied or not. Both the relative water supply and relative irrigation supply relate supply to demand. The relative water supply value below one normally indicates that the water applied is less than the crop demands and values above one indicate extra water added to the root zone beyond plant demands. Relative water supplies in the three stages of the system were at head (1.51), middle (1.57) and tail (0.76) and an average relative water supply of 1.28 (Table 6).

***Relative irrigation supply:*** The relative irrigation supply depicts whether the irrigation demand is satisfied or not, since there was no rainfall in the area during study period. The value of relative irrigation supply and relative water supply is the same, which means at head (1.51), middle (1.57) and tail (0.76). The result indicates that there is irrigation water scarcity at the tail end of the scheme, which is less than crop water requirement (Figure 3).

**Physical performance indicators:** Physical indicators are related with the changing or losing irrigated land in the command area by different reasons. Irrigation ratio for irrigation scheme was 1.00, which means that 100% of command area was under irrigation and additional 25 ha expansion was under construction during the study period.

**Economic performance indicators**

***Gross return on investment:*** This indicator considers the production and the total cost of infrastructure for the irrigation scheme. The result 4.7 implies that the gross return on investment was relatively good as compared to benefit cost ratio greater than or equal to one (Table 6).

***Financial self-sufficiency:*** Financial self-sufficiency indicates

| External Indicators | | Average value obtained from the scheme |
|---|---|---|
| Agricultural Performance | Output per cropped area (Birr $ha^{-1}$) | 125,027.3 |
| | Output per unit cropped area (ton $ha^{-1}$) | 7.81 |
| | Output per unit command area (Birr per command area) | 15,003,276 |
| | Output per irrigation supply (Birr $m^{-3}$) | 23.2 |
| | Output per unit water consumed (Birr $m^{-3}$) | 31.9 |
| Water use Performance | Relative water supply (ratio) | 1.28 |
| | Relative irrigation supply (ratio) | 1.28 |
| Physical performance | Irrigation ratio | 1 |
| Economic performance | Gross return on investment (ratio) | 4.7 |
| | Financial self-sufficiency (ratio) | 0.33 |

**Table 6:** Different values for selected external performance indicators of the scheme.

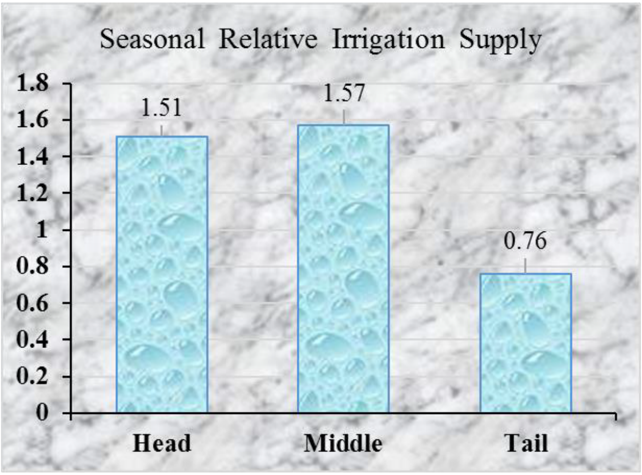


**Figure 3:** Seasonal relative irrigation supply.

| Field codes | Yield (ton/ha) | WUE (ton/ha $m^3$) |
|---|---|---|
| H | 5.00 | 23.37 |
| M | 13.00 | 48.78 |
| T | 4.00 | 60.22 |
| CV (%) | 7.87 | 19.97 |
| LSD (5%) | 1.3 | 19.97 |

H: Head, M: Middle, T: Tail, CV: Coefficient of Variance and LSD: Least Significance Difference

**Table 7:** Mean analyzed results of Sanko irrigation scheme.

the ratio of revenue from the irrigation users' to the expenditure for operation and maintenance. The total operation and maintenance cost was 1,980,992.59 Birr of which 1,181,534. 45 Birr for head work maintenance and 799,458.14 Birr for tail end part maintenance of irrigation scheme and the annual revenue from irrigation users' was 648,000 Birr which was very low according to cost expended for operation and maintenance. The financial self-sufficiency of this particular research value 0.33 indicated that the revenue collected from irrigation charges was not sufficient for operation and maintenance of the project (Table 6).

### Statistics analysis of yield and water use efficiency of the irrigation scheme

Average onion yield obtained from head (5,294.12 kg/ha), middle (13,793.10 (kg/ha) and tail end part (4,355.40 kg/ha). there is considerably lower yield was obtained in head and tail part of the scheme due to over and under irrigation respectively. Average amount of irrigation water supplied at head (628 mm), middle (650 mm) and at tail end part (315 mm). From the analysis result; there was higher water use efficiency at middle and tail end part of the scheme in relation to yield obtained the three reaches of the scheme (Table 7).

## Conclusions and Recommendations

### Conclusions

The performance evaluation of the irrigation scheme indicated that the availability of irrigation water is not a constraint at farm level and higher amount of water diverted in upper and middle part of the system. The conveyance efficiency of the scheme at the level showed some low values, even in the lined part of the main canal due to lack of regular maintenance, sediment deposition, use of illegal diversion gates for irrigation water. The application efficiencies in both upper and middle reach of the scheme have however, showed good when compared with application efficiency of 50-70% for furrow irrigation observed in other African countries.

The relative water and irrigation supply for both upper and middle was greater than one, while, in tail end of the scheme lower ratio of relative water and irrigation supply, which was much lower than desired amount of water applied. The output per cropped area at upper and tail end was extremely low as compared to middle reaches of the scheme, implying that the irrigation practice in upper and tail end of the scheme was relatively poor due to over and under irrigation respectively. In general, output per unit command area observed relatively low in the irrigation scheme; as compared to a good bulb yield under irrigation in Irrigation and Drainage paper 33. Therefore, for the improvement of the irrigation system management and the irrigation practice frequent performance evaluation is very important.

### Recommendations

Huge amount of money invested to operation and maintenance in addition to investment cost for construction of modern irrigation scheme and farmers must be expected to use water efficiently. Farmers must be advised to appropriate irrigation water management to get much return from the production. Assigning DAs and office assistants for improvement of irrigation scheme and used as mechanism to develop healthy perception of farmers about irrigation water. Earlier to developing an irrigation scheme for farmers, the capability of farmers whether they manage it or not must considered. Moreover, close monitoring practiced than completely left the operation and maintenance for farmers. Instead the excess water were diverted to tail end part of the scheme receiving less water than needed to produce potential yields, then the production would have increased. Therefore, to reduce over and under irrigation, the farmers should be get awareness about how to use, when to use and how much to be used on their fields.

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