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Technical Performance Evaluation of Irrigation Scheme at Boloso Sore, Southern Ethiopia

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Abstract
Performance evaluation of irrigation scheme is essential to identify the existing status and entry point to improve irrigation water management. This study was undertaken on Soke irrigation scheme in Boloso Sore district, Southern, Ethiopia. Evaluation was conducted at three selected canal reaches at head, middle and tail of the scheme by technical indicators such as application efficiency,conveyance efficiency, distribution efficiency, water storage and deep percolation ratio using standard equations. The study revealed that conveyance efficiency of scheme was 66.82 % and application efficiency was 55.29%. The conveyance efficiency was low due to unauthorized turnout, leakages loss, and over-topping problems were observed in an unlined main and secondary canal. Water storage, distribution uniformity and deep percolation ratio were showed 89.60, 91.39 and 44.71%, respectively. Water distribution uniformity and storage efficiency were performing in adequate manner. However, the overall scheme efficiency was relatively low which is 36.94 % due to high deep percolation loss and a low-conveyance efficiency were to blamed. As the above observation, some effort should be required to line the earthen canal section at main and secondary canal, maintaining distribution (division boxes), frequent supervision, and monitoring to improve conveyance efficiency. Improving on-farm water management practice of the water users through training and experience sharing.
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Introduction

Agriculture is considered the backbone of the Ethiopian economy and a key driver for long-term development and food security. About 34% of the GDP is generated by agriculture in 2019 and 90 percent of the population is dependent directly or indirectly on agriculture in Ethiopia(FAO,2016). Irrigation has positive contribution to food security, poverty reduction and improving the standard of life for the rural population (Worku, 2013). But, sustainability of irrigated agriculture is being questioned technically, economically, and environmentally (Habineza *et al.,* 2020). Sustainable agricultural production increase can be achieved in two ways in irrigated agriculture; either by building new irrigation projects or by evaluating an existing one and improving their performance (Sener *et al.,* 2007).

Available water resources become scarce, and more emphasis is given to the efficient use of irrigation water for maximum economic return and water resources sustainability(Irmak *et al.,*2011). It needs appropriate ways to measure and evaluate how effectively water diverted from water source for production of crop yield. Insufficient and unpredictable water deliveries in the main system cause farmers to face shortages of water application contributing to declining crop yields and incomes as well as forcing them to irrigate smaller areas than designed. Also, improper land leveling and poor on -farm water management are contributed to water losses and the decline in yields.

Performance evaluation involves measuring conditions at one or more points in a field selected to be typical or representative for irrigation projects(Pereira and Trout, 1999). Internal indicators are used to assess actual irrigation performance relative to system-specific management goals and operational targets (Kloezen and Graces, 1998). It is aimed to identify the status of the scheme with respect to the selected indicators and will help to identify 'why the scheme is performing so' which in turn implies means of improvement(Seleshi and Mekonen, 2011).

Hence, the study area as well as the other area of the country focus only on building new irrigation schemes and existing traditional schemes. As result, existing modern schemes are under low performance due to improper operation, maintenance, and limitation on irrigation water management like water measurement techniques, irrigation scheduling, and water-saving technologies(Seleshi and Mekonen, 2011). In general, it is vital to identify the gaps for better improvement options. Therefore, it is realistic to evaluate the technical performance the of Soke irrigation scheme located at Boloso Sore Woreda, Wolaita Zone, Southern Ethiopia.

Materials and Methods

Description of the Study Area

The study irrigation scheme is located in Boloso sore district, Wolaita Zone, in Southern Ethiopia, where is located about 300km south of Addis Ababa. Geographically at 6^0 05' 0" to $7^0$11'0"N and $37^0$0'0" to $37^0$50'0"E and has an average altitude is 1830 m.a.s.l. The average monthly maximum and minimum rainfall totals are 224.8mm (in July) and 25.88mm (in August) (in December). The mean maximum temperature ranges from 22.66 to 28.86 °C, while the minimum temperature ranges from 13.8 to 15.8 °C. During February, the temperature in the study area reaches maximum values.

Soke irrigation scheme was built in the Soke River with a modern weir and water abstraction by a gravity system, and 150 ha of command land was established in Tiyo Hembecho kebele. The main canal is 3.3 km long and made up of 1.05 km-long unlined and remaining was masonry canals. Almost all farmers widely practiced furrow irrigation with lengths ranging from 16 meters to 7 meters.

Data Collection and Analysis

All required primary and secondary data were gathered from the beginning of November upto the end of March 2021/2022. Based on their proximity to the water source, three fields from the head, middle, and tail end-users were selected to study the technical performance. Based on resemblance in a crop, growth stage, dominant crops, and farmer willingness, the nine farmers fields were selected.

Soil Texture and Bulk density

Disturbed samples for soil textural analysis and undisturbed samples for bulk density were gathered from selected farmers' fields in a diagonal way at soil depths of 0-30 cm, 30-60 cm, 60-90 cm, and 90-120cm. Hydrometer techniques were used for textural analysis. Finally, Soil textural class was assigned using the USDA textural triangle (Bouyoucos, 1951).

The bulk density was estimated by using Jaiswal (2003.) equation (1):

$$Bd = \frac{\mathrm{Md}}{\mathrm{Vc}} \tag{1}$$

Where: Bd:- Bulk density of soil (gm/cm^3),
Md:- Weight of oven-dried soil (gm) and
Vc:- Volume of soil in the core (cm^3) and

$$\mathrm{Vc} = A \times h \tag{2}$$

Where: A: area of the core sampler (cm^2) and h: height of the core (cm) .

Soil Field capacity (FC) and permanent wilting point (PWP)

To determine the soil moisture content at FC and PWP of chosen farmers' fields, undisturbed soil samples from each 30cm intervals for soil depth of 120cm were collected and taken to the laboratory for analysis. Pressure plate apparatus was utilized in the laboratory to determine the soil field capacity and permanent wilting point. After being saturated for a day, the soil sample was put under pressures of 1/3 bar (for FC) and 15 bar (for PWP) until there were no longer any changes in the soil's moisture content. After that, the soil sample was taken out and put in a container to be weighted. At each status, the soil moisture content was determined by drying it in an oven at 105°C for 24 hours. Finally, Total available water (TAW) for crop use in the root zone was calculated according to Allen *et al* (1998) by using equation(4).

Soil Moisture Determination

The gravimetric method was used to measure the soil moisture contents at soil depths ranging from 30 cm to 120 cm before and after irrigation. Soil moisture content on a volume basis for each sampled soil was computed by Kamara and Haque (1991).

$$\theta \mathrm{v} = \left(\frac{Ww - Wd}{Wd} \times 100\right) \times Bd \tag{3}$$

Where, θv:-Volumetric moisture content (%),
Ww:- Wet weight of the soil (g),
Wd:- Oven dry weight of the soil (g) and
Bd :- Bulk density of soil (g/cm^3)

Total Available Soil Water (TAW)

Total available water is the amount of water a crop can use from the soil for the sampled fields were calculated from the moisture content in volumetric content at field capacity and permanent wilting point according to Allen *et al* (1998):

$$\mathrm{TAW(mm)} = \sum_{i}^{4} 1000 \times (\theta_{FC} - \theta_{pwp}) \times \mathrm{D\,i} \tag{4}$$

Where, TAW:- Total Available Water at effective root zone (mm),

θ_{FC}:- Moisture at field capacity (cm^3/cm^3, %),

θ_{pwp}:-Moisture at permanent wilting capacity(cm^3/cm^3, %)

Di:- Depth of i^{th} soil layer (m), and

i:- Integer, 1 to 4, and n = 4 soil layers in the crop root zone.

Then, Readily available water (RAW) was determined using the equation of Allen *et al* (1998);

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

Where: RAW (mm) and P is the fraction for allowable soil moisture depletion for no stress.

Flow rate in the canal

The discharge in the canal was measured by using floating methods and it was calculated using the continuity equation (6).

$$Q = V \times A \quad (6)$$

Where, Q :- discharge(m^3/s),

V:- velocity of water in the canal (m/s) and

A(m^2) :- Average wetted cross-sectional area

The time it took to reach the known distance portion (10m) of the same canal for the three replications was recorded, and the average time was taken. Surface water velocity was determined by using Equation(7).

$$V_s = \frac{Known\ distance(L)(m)}{t(s)} \quad (7)$$

Where: Vs:- The surface velocity (m/s),

L:- Known distance (m) between two selected points(10m).

t:- Travel time in(sec) between selected points.

Finally, Surface water velocity was multiplied by correction factors 85% for rough or rocky bottoms by using Harrelson *et al* (1994).

$$V = 0.85 \times Vs \quad (8)$$

Where; V:- Average water velocity (m/s);

Vs:- Surface water velocity (m/s)

Amount of water delivered into the fields

A three-inch Parshall flume was used to measure the amount of water applied by the irrigators' fields at head, middle and tail of the irrigation event. Discharge(Q) from the field offtake to the fields was measured by using Gertrudys(2006):

$$Q = 0.1771 \times h_1^{1.55} \quad (9)$$

Where: Q :- flow rate in l/sec,

h_1:- upstream water flow depth in the converging inlet section(cm)

Depth of water applied (Da) was derived from discharge, cutoff time, and area irrigated by the irrigators using the equation(9):

$$Da = \frac{60 \times Q \times T_{app}}{A_f} \quad (10)$$

Where: Da :- Depth of water applied(mm),

Q :- Discharge rate (l/sec)

T_{app} :- Application time(minute) and

A_f :- Area of field (m^2).

Technical Performance Evaluation of Scheme

1) **Conveyance Efficiency(Ec)**

Average inflow (Qin) and outflow (Qou) of water at every 100m of canal segments were measured to determine conveyance efficiency and water losses at main and secondary canals using Equation(7).

The conveyance efficiency was estimated by using Michael (2009) equation(11).

$$E_C = \frac{Q_{outflow}}{Q_{inflow}} \times 100 \quad (11)$$

Where, Ec = Conveyance efficiency (%),

$Q_{outflow}$:- Water outflow (l/sec), and

Q_{inflow} :- Water inflow(l/sec).

The overall conveyance efficiency of the canal system was calculated by using FAO(1989).

$$E_c = E_m \times E_s \quad (12)$$

Where:- Ec :- Overall conveyance efficiency (%)
E_m:- Conveyance efficiency of the main canal (%)
E_s :- Conveyance efficiency of the secondary canal (%)

Determination of the water losses

The conveyance loss was determined by the water balance equation, which was calculated by using difference between flow of water entering and leaving each segment of the testing canal. It was calculated by using Michael (2009).

$$Ql = \frac{Qin - Qou}{L} \quad (13)$$

Where, Ql :- Water loss rate in the channel (l/s/100m)
Qin :- Inflow to the segment (l/sec),
Qou :- Outflow from the segment (l/sec) and
L :- Length of canal under testing (m).

2) Application Efficiency(Ea)

Application efficiency is the common measure for on-farm irrigation efficiency. It was calculated for each field by using Garg (2005).

$$E_a(\%) = \frac{D_s\ (mm)}{Da\ (mm)} \times 100 \quad (14)$$

Where: Ea(%):- Application efficiency,
Ds (mm) :- Depth of water stored and
Da (mm):- Depth of water applied.

The depth of water stored(Ds) in the soil profile of the root zone was calculated as Mishra and Ahmad (1990).

$$D_S = \sum_{i=1}^{4} \left(\frac{Wai - Wbi}{100}\right) \times Bdi \times Di \quad (15)$$

Where, Ds:- Depth of water stored in crop root zone (mm),
W_{ai}:- Moisture content of i^{th} soil layer after irrigation(g/g, %),
W_{bi}:- Moisture content of i^{th} soil layer before irrigation (g/g, %),
Bdi :- Bulk density of the i^{th} soil layer (g/cm^3),
Di :- Depth of i^{th} soil layer (mm),
i :- Integer, 1 to 4 and n = 4 soil layers in the crop root zone.

3) Water Storage Efficiency(Es)

It's a metric for determining whether or not irrigation is adequate. It was calculated by using Garg (2005).

$$E_s(\%) = \frac{Ds,(mm)}{Dreq(mm)} \times 100 \quad (16)$$

Where; Es(%) :- Storage efficiency,
Ds:- Depth of water stored (mm) and
Dreq:- Depth of water required prior to irrigation (mm).

The water required (Dreq) in the root zone prior to the irrigation event was calculated by using the equation Allen *et al* (1998).

$$D_{req} = \sum_{i=1}^{4} \left(\frac{\theta_{FC} - \theta_{Bi}}{100}\right) \times Di \quad (17)$$

Where; D_{req} :- Depth of water required in the root zone prior to irrigation (mm),
θ_{FC}:- moisture content at field capacity (cm^3/cm^3, %),
θ_{Bi}:- moisture content before irrigation (cm^3/cm^3, %),
Di :- Depth of soil profile (mm) in the root zone,
i :- Integer, 1 to 4 and n = 4 soil layers in the crop root zone

4) Distribution Uniformity (DU)

Distribution uniformity during an irrigation event describes how consistently water is applied over the entire field. The effective root depth of a crop was considered as a water distribution zone.

Three representative furrows (inlet, middle, and lower part of a field) were selected from each farmers' field, a furrow was subdivided into three regular intervals, and nine soil sampling points were selected. About, 216 soil samples were taken from the irrigation scheme using an auger at soil depths of 30cm intervals before and after the irrigation event. It was calculated using equation (18) and represents D1 to D9.

$D_1 = D_{1(0-30)} + D_{1(30-60)} + D_{1(60-90)} + D_{1(90-120)}$ (18)
$D_2 = D_{2(0-30)} + D_{2(30-60)} + D_{2(60-90)} + D_{2(90-120)}$, up to

$D_9 = D_{9(0\text{-}30)} + D_{9(30\text{-}60)} + D_{9(60\text{-}90)} + D_{9(90\text{-}120)}$

The averages of the least-water-stored quarter of the fields were obtained by arranging the depths of water stored at nine sampled places in descending order and calculated by Irmak *et al* (2011).

$$D_U(\%) = \frac{\text{DLq}}{\text{Dm}} \times 100 \quad (19)$$

Where: Du (%) :- Distribution uniformity

DLq:- Mean depth of least-quarter of water stored (mm)

Dm :-Mean depth of all water stored at nine sampled points (mm)

5) Deep Percolation Ratio (DPR)

As observed in the field, most farmers used closed-end furrow techniques in the study area. So that there was no runoff loss from the fields during irrigation events, and there was no evaporation from the soil due to the short duration of time. Only deep percolation losses had a significant role in application efficiency and were computed indirectly from application efficiency (Ea, %) and runoff ratio (RR=0) values(Feyen and Dawit,1999).

$$DPr = 100 - Ea - RR \quad (20)$$

Where, DPr = Deep percolation ratio (%).

6) Overall scheme efficiency

The overall irrigation efficiency measures the effectiveness of the complete physical infrastructure as well as operational decisions in delivering irrigation water from the diversion point to the targeted crop field. The overall scheme efficiency was calculated using a recommendation by Irmak *et al* (2011).

$$E_p = \frac{E_c \times E_a}{100} \quad (21)$$

Where: E_p :- Overall scheme efficiency (%),

E_c:- Overall conveyance efficiency (%) and

E_a:- Average application efficiency(%) of the scheme.

RESULTS AND DISCUSSION

Soil Physical Characteristics of Study scheme

All of the selected canal reaches' textural classes were found to be dominated by clay soil, except the head and middle canal reaches, where clay loam soil was discovered at depths of 90 to 120 cm. The findings revealed that over the whole command area, clay soil was the most common type of soil.

The bulk density were 1.21, 1.20, and 1.22 gm/cm^3 at the head, middle and tail reaches of the canal, respectively, with an average value of 1.22 g/cm^3 (Table 1). The investigation showed that soil bulk density increased along with soil depth. The results obtained are consistent with the value recommended by Miller and Donahue (1995), who suggested that clay soil should have a bulk density below 1.4 g/cm^3 for better plant growth. As a result, the scheme's bulk density was suitable for plant development.

Table 1: Soil Textural classes and Soil bulk density of the scheme

Canal location	Soil depth (cm)	Bulk density (g/cm^3)	Particle size distribution (%)			Textural class
			Sand	Clay	Silt	
Head	0-30	1.03	24	40	36	Clay
	30-60	1.14	26	52	22	Clay
	60-90	1.28	28	44	28	Clay
	90-120	1.39	34	34	32	Clay loam
	Mean	**1.21**				
Middle	0-30	1.09	26	44	30	Clay
	30-60	1.14	28	42	30	Clay
	60-90	1.29	24	52	24	Clay
	90-120	1.31	32	38	30	Clay loam
	Mean	**1.20**				
Tail	0-30	1.12	24	56	30	Clay
	30-60	1.18	24	40	36	Clay
	60-90	1.24	28	48	24	Clay
	90-120	1.35	22	46	32	Clay
	Mean	**1.22**				
Overall mean		1.21	23.83	43.5	32.67	Clay

Soil Moisture at FC and PWP

Volumetric moisture content at field capacity, permanent wilting point and total available water of the soil were varied from 31.2- 40.5 %, 19- 27 % and 102.1-151 mm/m with the average value were 36.72 %, 23.43 % and 133.18 mm/m, respectively(Table 2). The average water holding capacity of soil at scheme was low. In general, the values of FC, PWP and TAW of the soil were within the acceptable range, which was recommended by FAO(1989) for clay soil ranges from 320-400 mm/m, 200-240mm/m and 120-200 mm/m, respectively.

Table 2: Selected Soil FC, PWP and TAW at Soke scheme

Canal location	Soil depth (cm)	Soil physical properties (v/v) (%)		TAW (%)	TAW (mm)
		θ_{FC}	θ_{PWP}		
Head	0-30	37.1	22.0	15.1	45.3
	30-60	39.11	26.4	12.71	38.13
	60-90	38.2	24.6	13.6	40.8
	90-120	31.2	19.0	12.2	36.6
	Total				160.23
Middle	0-30	36.7	23.0	13.7	41.1
	30-60	37.3	23.4	13.9	41.7
	60-90	35.7	23.0	12.7	38.1
	90-120	33.5	20.0	13.5	40.5
	Total				161.4
Tail	0-30	34.62	24.41	10.21	30.63
	30-60	37.1	22.30	14.8	44.4
	60-90	40.0	27.0	13.0	39.0
	90-120	40.5	26.10	14.4	43.2
	Total				157.23
Overall mean					159.62

Soil Infiltration Rate

The measured value of the basic infiltration rates for testing fields' was 5.6 mm/hr at irrigation scheme. It was attained after time elapse of 176 minutes at 151 minutes at Soke irrigation scheme. The results obtained at scheme was slightly above the recommended value of Savva and Frenken (2002), which is basic infiltration rate for clay soil is 1-5mm/hr.

Technical Performance of Soke Irrigation scheme

Conveyance Efficiency(Ec,%) and water Losses

The result revealed that the main canal's average conveyance efficiency was 87.13% (Table 3). It indicates that, an average of 12.87% of the water in the main canal was lost before it entered the secondary canal. The secondary canals of the Soke scheme has a weighted average conveyance efficiency of 76.69%. The secondary canal experienced average water losses and flow rate losses of 23.31% and 3.07 l/s per 100 m of canal length, respectively. According to FAO(1989), the conveyance efficiency of earthen canals with a length of more than 2000 meters in clay soil should be at least 80%. This shows that secondary canals are operating inefficiently.

The quantity of water that was abstracted was transported to farm inlets with an average conveyance efficiency of 66.82%. This means that before it reached the command area, 33.18% of the water diverted at the irrigation scheme was lost. The result shows that the scheme's overall conveyance efficiency was relatively poor.

As the study done by Solomon (2016) on the Jari irrigation scheme revealed a nearly identical result, which is 66%. Unlike, Dinka (2017) reported conveyance efficiency which was 57.40% at Ketar scheme where canals built from both lined and unlined clay soil types. The major causes of the Soke Scheme's low conveyance efficiency in the lined and unlined canal sections include canal cracking, siltation, weed growth, and a rise in unauthorized users. The equality of water distribution across systems was impacted by the ineffective irrigation water delivery; in particular, the tail-end users did not receive their fair share within the allotted period of the irrigation scheme.

Table 3: Conveyance efficiencies and water losses at scheme

Canal section	Conveyance efficiency (%)	Water Loss(%)	Water losses (l/s)/100m
Main Canals	87.13	12.87	3.51
Secondary canals	76.69	23.31	3.07
Conveyance efficiency (%)	66.82		

Application Efficiency (Ea,%)

The application efficiencies were 56.11, 55.95, and 53.82 % at the head, middle, and tail canal reach, respectively(Table 4). The finding observed that scheme's average efficiency was 55.29%. The result reveals that it is within the permissible range set by Savva and Frenken (2002) for a for a properly designed furrow irrigation could range (50 -70%).

Nearly similar finding was reported by Dessalew *et al* (2016), which is 54.9% for clay loam soil types in Bedene Alemetan irrigation. A comparable finding of 56.1% for clay soil types in the Midhegdu irrigation scheme was also reported by Worku (2013). Furthermore, Israel (2018) reported a fairly similar finding which is 55% at the Ela irrigation system in the Wolaita zone.

This resulted due to farmers watering their fields excessively without taking the crop's needs into account. Additionally, there is no regular monitoring or technical assistance provided by extension agents or other specialists, and farmers lack expertise regarding the frequency and timing of irrigation.

Table 4: Application efficiency of irrigation scheme.

Field location	Applied depth (mm)	Stored water at root zone (mm)	Application efficiency (Ea,%)
Head	127.39	71.48	56.11
Middle	134.28	75.13	55.95
Tail	120.54	64.88	53.82
Scheme, Ea (%)			55.29

Storage Efficiency (Es,%)

The storage efficiencies varied from 92.1% at the middle to 87.22 % tail end with the average scheme storage efficiency being 89.60%(Table 5). Nearly similar result reported by Miniebel (2019), which is 91.6% for the Golda irrigation scheme for clay soil types. The current finding was in line with the UK's Natural Resource Conservation Service's recommendation of 87.5% for a homogeneous soil condition(Raghuwanshi and Wallender,1998). In general, the irrigation scheme adequately met the soil moisture required for the crops to be productive.

Table 5: Storage efficiencies at Soke scheme

Field location	Stored water at root zone (mm)	Required water (mm)	Storage efficiencies(Es, %)
Head	71.58	79.99	89.49
Middle	75.13	81.57	92.10
Tail	64.88	74.39	87.22
Scheme (Es, %)			89.60

Water Distribution Uniformity (DU, %)

The Soke irrigation scheme's average distribution uniformity was 91.39%(Table 6). In comparison to head field users, the distribution uniformity was higher for middle and tail field users. Similar finding reported by Worku (2013), which is 91.4% for clay soil types in the Midhegdu irrigation scheme. Also nearly similar result reported by Dessalew *et al* (2016),which is 90.23% at Bedene Alemetan small-scale irrigation. Unlikely, Dinka(2017) reported a lower uniformity of distribution, which was 61.60% of the clay soil types in the Ketar scheme.

According to Irmak *et al* (2011) state that a low value (<60%)DU suggests that irrigation water is applied unevenly, whilst a high value (>80%) DU shows that the application is fairly uniform all over the entire field. Therefore, Soke scheme provided uniform, appropriate irrigation water distribution across the entire farm land.

Table 6: Water distribution uniformity of the Soke scheme

Field Location	Mean stored water (mm)	Least quarter mean stored water (mm)	DU (%)
Head	60.97	54.65	89.64
Middle	55.17	50.8	92.07
Tail	56.31	52.06	92.45
Scheme DU(%)			91.39

Deep Percolation Ratio (DPR,%)

The average Soke scheme deep percolation loss was 44.71%. (Table 7). The results revealed that the tail field experienced the highest deep percolation loss, with 46.71%, relative to the head and middle field users, with 43.89 and 44.05%, respectively. It implies that most irrigators at tail users had low application efficiency because they applied too much water without taking the crop's water needs into account.

Table 7: Calculated deep percolation ratio at Soke scheme

Field location	Application efficiency (Ea, %)	Runoff ratio, RR (%)	Deep percolation ratio, DPR (%)
Head	56.11	0	43.89
Middle	55.95	0	44.05
Tail	53.82	0	46.18
Scheme average efficiency	55.29		44.71

Overall Efficiency of the Scheme

According to the study, the overall efficiency of the soke irrigation scheme was 36.94%(Table.8). It indicates that the scheme is performing with poor efficiency due to high deep percolation loss and a low-efficient conveyance at unlined sections of canals to be blamed. According to Savva and Frenken (2002) recommendation, the overall efficiency of the scheme was below acceptable limits (40–50%), which was reported in similar irrigation schemes in Africa. Nearly similar result was reported by Muhammedziyad *et al* (2019),which was 35.9% for Gemesha irrigation scheme.

Table 8: Overall efficiencies at Soke scheme

Internal indicators	Scheme Efficiency (%)
Conveyance efficiency	66.82
Application efficiency	55.29
Storage efficiency	89.60
Distribution Uniformity	91.39
Deep Percolation ratio	44.71
Overall efficiency of the scheme(%)	36.94

CONCLUSIONS AND RECOMMENDATIONS

According to performance evaluation, conveyance efficiency was relatively low due to poor water distribution, unauthorized turnout, leakages loss, and over-topping problems were observed in an unlined main and secondary canal. Water distribution uniformity and storage efficiency were performing in a good manner. The greater deep percolation loss was observed at tail field reach relative to the head and middle field users. High deep percolation loss, poor on-farm water management and a low-efficient conveyance at unlined section of the main and secondary canal were responsible for low overall efficiency of the scheme.

Based on above observation, improving measures to be required to boost the current status of scheme performance. Therefore, effort should be required to line the earthen canal section at the main and secondary canal, maintaining water distribution structure and frequent supervision and close monitoring should be practiced. Any concerned body should have to strengthen water users association, training and experience sharing to advance farmers' on-farm water management or conserve water. Moreover, regular canal cleaning and maintenance of canal infrastructures is needed to improve the overall efficiencies.

Conflict of Interests

The author declare that they have no competing interests.

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