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Performance Evaluation of Modern Spate Irrigation Schemes at Kobo Woreda, North Wollo, Ethiopia

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ABSTRACT

The main objectives of the study were to evaluating performances Gobu-I and II modern spate irrigation schemes. The Primary data collected includes measurement of canal and field discharge and the secondary data has been included total yields, farm gate price, area irrigated per crop, and climatic data. Discharges along the canals were measured by floating methods and the discharge applied in to the field inlets were measured by using rectangular weir methods. From the analysis of some selected comparative water supply indicators, the respective values of Gobu-I and II irrigation projects of conveyance efficiency, relative water supply, relative irrigation supply and water delivery capacity were 91.89%, 1.7, 0.9, 1.5 and 83.22%, 1.6, 1.03, 1.7 respectively. This implies that irrigation water is not restricted of water in the season. Output per cropped and planned area values for Gobu-I and Gobu-II were 51759.54, 48000, 47673.26 and 48000 Birr/ha while output per water consumed and irrigation supply values were 10.74, 8.83, 16.12 and 13.13 birr/m^3 respectively. This Indicates that Gobu-I was better in effective utilization of water to produce more yields. In mostly the main challenged problem occurs in the modern spate irrigation system is frequent damage of structures, sedimentation problems and water use management.

Key words: Comparative indicator, field water management, Gobu-I and II, Modern spate irrigation

1. INTRODUCTION

1.1 General

According to central Statistical Agency [1] total population of Ethiopia is now surpassing 100 million and is the second populous country in Africa next to Nigeria. Most of the population in Ethiopia lives in highland area, with 85 percent being rural and depend on agriculture with low level of productive [2]. Irrigation is highly expected to play a major role in the realization of Ethiopia food security and poverty alleviation strategy. It enhances agricultural production and improves the food supply, income of rural population and it's very important for poor countries especially for supporting national economy when it produce industrial crops (exportable crops). Irrigation is useful to transform the rain-fed agriculture system which depends on rainfall in to the combined rain fed and irrigation agriculture system. This is believed to be the most prominent way of sustainable development in the country [3].

The annual rainfall pattern of Ethiopia is characterized by spatial and temporal differences. The western part and the central highlands in particular, receive rainfall that is in normal years sufficient for crop production and animal husbandry. Much of the eastern, southern and northern parts of the country very often receive insufficient and/or unpredictable rain. However, considering the current situation with growing population pressure in the highland areas and a rapidly declining natural resource base has necessitated irrigated agriculture and in line with this irrigation is given prime attention on the country's development agenda [4].

Most farmers in drought prone lowland of Ethiopia produce only once a year. Among this kobo Woreda is one of the drought prone lowland areas of Ethiopia. A long dry spell or drought can lead to crop failures that exacerbate food shortage and poverty. The severity of such climate related crop failures increases with decrease altitude. Flood based farming (spate irrigation) is among the potential options in ensuring water availability for crop and livestock production in the arid and semiarid lowlands as access to other sources of water is limited either by physical availability or high costs [5].

In simple terms, spate irrigation is the diversion of flood flows in ephemeral rivers for irrigation. In reality, most irrigation schemes include some element of lower flows which may only be the recession of each flood event but can also be a base flow that may run continuously during the flood season. As such, there is no clear boundary between spate irrigation and a seasonal irrigation system where water is available continuously for several months of the year. Spate irrigation is practiced in many arid or semi-arid countries where floods arising from heavy rainfall represent much of the annual water resource. It is economically very important in countries such as Yemen, Pakistan, Eritrea and Ethiopia where agriculture is an important component of the economy [6].

Spate irrigation is on the increase in the arid parts of the Ethiopia Country: in East Tigray (Raya, Waji), Ormomiya (Bale, Arsi, West and East Haraghe), Dire Dawa Administrative region, in South Nations Nationalities and Peoples(SNNP) (Konso), Afar and Amhara (Kobo) region. In Southeast Ethiopia the word 'gelcha' is used translating as 'channeling' the flood to the farm and the Northern parts the word 'telefa' meaning 'diversion' is common [7]

Under the guise of 'modernization' extensive civil engineering investments have been made in the head works of spate irrigation systems in Yemen and to a lesser degree in Morocco, Pakistan, Eritrea and Ethiopia. Characteristically, traditional intakes were replaced by civil head works, typically a weir, an off-take gate and a sluice gate. In some cases a breaching bund was provided, to save on construction costs and to provide the means to handle very large floods. Also in some systems a sedimentation pond was part of the headworks, designed to avoid coarse sediments going into the command area. Because such modernized headworks are costly, in many cases, a traditional system with multiple off-takes from the river was replaced by a single diversion structures supplying a newly-built long flood channel [8].

In marginal rain fed areas (arid and semi-arid regions) the only water available for irrigation comes from seasonal spate flows in ephemeral rivers. Of the various strategies designed/planned to alleviate the prevailing poverty in Kobo woreda, specifically in the project area, is development of modernize spate irrigation scheme at the wadiGobu ephemeral river. This includes designing of modernize headwork and infrastructures, incorporating improved agronomic practices and implementation of spate irrigated crop production.

Poor management in modern spate irrigation water is one of the principal reasons for low water efficiency in irrigation systems. However due to water resource become scarce, more emphasis is given to efficiency use of irrigation water for maximum economic return and water resources sustainability. This requires measuring and evaluating how efficiently water is extracted from a water source to produce crop yield. The inadequate and often unreliable water deliveries in the main system causes farmers to face regular shortages in the flood supply, resulting reduce yields and income as well as in much smaller areas being irrigating than planned..

Besides the poor performance of the irrigations in the country, evaluation of spate irrigation systems is not common. Performance evaluation is the most practical tool to assess the success of any changes in irrigation management [9]. Evaluation of performance in terms of efficiency is prerequisite for proper use of irrigation water.

The coarser sediment fractions that are diverted from the catchments settle on the beds of the upstream reaches of weir/ or main canal and division boxes which will rise over time. Due to this the rises of sediment accumulation on the bed of the upstream reach of the weir or on the canal that affect the efficiency of the irrigation. Sedimentation has been a very serious problem in modern spate irrigation schemes due to the reason of most of the schemes are located at the foot of mountains characterized by high sediment yield [10].

In the study area of Gobu-I and Gobu-II Modern spate irrigation, these problems mentioned above and lack of awareness, poor irrigation water management and sedimentation in the canal affect the efficiency of water application, and which has impact on crop production

The most significant purpose of modern spate irrigation performance evaluation is to provide effective project performance through continuous information flow to project management at each stage. Continuous performance evaluation helps project management assess whether or not performance is sufficient, if not, it allows management to determine the required measures to reach desired performance levels. Performance evaluation providing a periodical information flow about the key indicators of an irrigation project is an effective management tool in monitoring irrigation schemes [11].

1.2 Performance Indicators

Performance can be simply defined as the level of achievement of desired objectives which are measured by Indicators. An indicator is some number that describes the level of actual achievement of the irrigation system in respect of one of the objective of irrigation system. Performance evaluation for any irrigation system is essential to assess how far the goals and objectives set forth at the time of project formulation of the system have been achieved [12].

Performance indicator includes both an actual value and a target value that enables the user to quickly assess the amount of deviation and standard that allows the manager to determine if the deviation is acceptable. A good indicator can be used in two distinct ways; such as it tells what current performance is in the system and in conjunction with other indicators may help to identify the correct course of action to improve the performance within the system. In this sense the same indicator over time is important because of it assists in identifying trends that may need to be reversed before the remedial measures to expensive or to complex [13].

A set of comparative performance indicators is defined, which relates outputs from irrigated agriculture to the major inputs of water, land, and finance. Nine indicators are presented by IWMI with the objective of providing a means of comparing performance across irrigation systems [14].

1.2.1 Irrigation Water Delivery (Water Supply) performance Indicators

Indicators address several aspects of this task: efficiency of conveying water from one location to other, the extent to which agencies maintain irrigation infrastructure to keep the system running efficiently, and the service aspects of water delivery which include such predictability and equity. Molden et al. (1998) define several supplies for comparative purposes. Four below characterize in individual irrigation system with respect to water supply (delivery) performance indicator.

Conveyance efficiency (Ec) = $\frac{\text{water flowing out of the system}}{\text{water flowing in to the system}}$ ----------------- (1.1)

Relative water supply (RWS) = $\frac{total\ water\ supply}{crop\ demand}$ ------------------------- (1.2)

Relative irrigation supply (RIS) = $\frac{\text{irrigation water supplied}}{\text{irrigation demnad}}$ -----------------------(1.3)

Water delivery capacity (%) = $\frac{\text{canal capacity to deliver water at system head}}{\text{peak consuptive demand}}$------ (1.4)

Where,
Total water supply= Surface diversions plus rainfall.
Crop demand= Potential crop ET
Irrigation supply= only the surface diversions and net groundwater draft for irrigation
Irrigation demand= the crop ET minus effective rainfall.

1.2.2 Irrigated Agricultural Output Performance Indicators

The four basic comparative performance indicators relate output to unit land and water. These indicators provide the basis for comparison of irrigated agriculture performance. Where water is a constraining resource, output per unit water may be more important, whereas if land is a constraint relative to water, output per unit land may be more important [14].

Output per cropped area(birr/ha) = $\frac{\text{production}}{\text{irrigated cropped area(Acroped)}}$ ------------------(1.5)

Output per unit command(birr/ha) = $\frac{\text{production}}{\text{Command area}}$ -------------------------------------(1.6)

Output per unit irrigation supply (birr/m^3) = $\frac{\text{production}}{\text{diverted irrigation supply}}$---------------(1.7)

Output per unit water consumed (birr/m^3) =$\frac{production}{volume\ of\ water\ consumed\ by\ ET(vconsumed)}$ -----------------(1.8)

Where,

- Production is the output of the irrigated area in terms of gross or net value of production measured at local or world prices
- Irrigated cropped area is the sum of the areas under crops during the time period of analysis,
- Command area is the nominal or design area to be irrigated
- Diverted irrigation supply is the volume of surface irrigation water diverted to the command area, plus net removals from groundwater
- Volume of water consumed by ET is the actual evapotranspiration of crops.

1.2.3 Limitation of the Indicators

First, the major difficulty of using the indicators is the uncertainty involved in many of the estimates. Two major types of uncertainties exist: uncertainties in the source of data and uncertainties in the estimates. Many of the data come from secondary sources, not directly measured by the researchers. There is a wide variety in the quality of data obtained from these sources. Second, means of estimating leads to errors. For example, there are large uncertainties in estimates of actual crop evapotranspiration and effective precipitation related to the methodology of estimating these values. The largest degree of uncertainty exists in the estimation of effective precipitation [14].

2. MATERIALS AND METHODS

2.1 General Description of the Study Area

2.1.1 Gobu-I modern spate irrigation scheme

Gobu-I spate irrigation project is situated in North Wollo Zone Kobo woreda along the border of Tigray region specifically in Amaya Kebele, 12 km from kobo town along with main road Kobo to Alamata having dry weather road to the head work site. Gobu-1 irrigation scheme also referred to by local community as "adinamilie", which means "lifesaving canal" .The geographical location of the site is located at longitude: 1352399.8040 UTM m, latitude: 559561.1430 UTM m and 1589.47 m Elevation. Even though Gobu-I spate irrigation is designed on no perennial river, the scheme is using both spate during Belg or spring time and supplementary irrigation in summer until the river flow ends after the main rainy season. Although the project area of this spate irrigation scheme is around kobo town the source of water is from upstream catchment flood flow (i.e., Gidanworeda peak highlands) which is shown in fig 3.1.

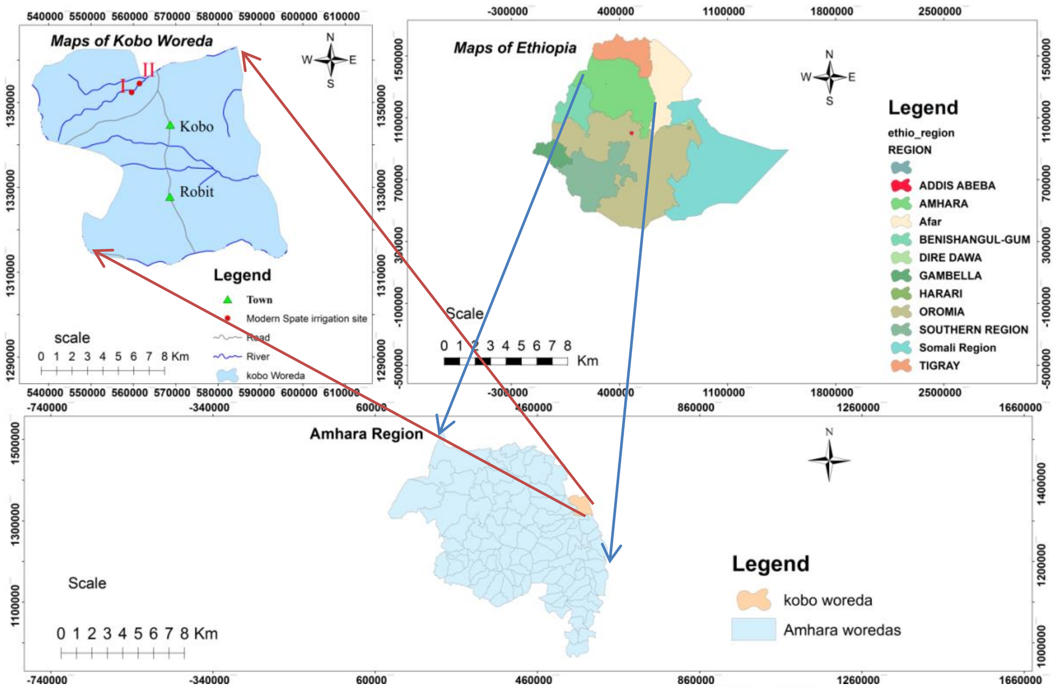

Figure 3.1 Location of Gobu-I and Gobu-II modern spate irrigation scheme

Topographically most of the cultivated lands of the project area are found in almost plain lands. In general, the command area lies from flat to gentle (0.5-3%) slopes. Hence, the slope of the command area has identified to be suitable for surface spate irrigation. The command area is also found inclined west to east position from the head work site and the elevation range is 1,579m.a.s.l at the top and 1,532.93m.a.s.l at the bottom of the command area. Most of the soil of the irrigated command area is clay loam. The crops cultivated in the area were sorghum, onion and teff. The climatic condition of the project area is dry kolla with annual rainfall 499.5mm and the annual mean minimum and maximum air temperature of the area is 15.2 and 30.7 ^{O}C, respectively which are taken from Addis Ababa meteorology agency of Kobo meteorology station.

2.1.2 Gobu-II Modern spate irrigation scheme

Gobu-II spate irrigation is located in the Amhara national regional state, North Wollo zone, kobo woreda, Amaya kebele. From main asphalt, road passing via Kobo town to Mekelle the projects can be accessed from kobo up to the Golehsa Bridge of the main road site is 15km all-weather roads and the remaining 5km is dry weather respectively. The headwork site is located at Latitude: 561408.005 UTM m, Longitude: 1354474.0394 UTM m and Altitude: 1531.37m. Gobu-1 irrigation scheme also referred to by local community as QiraroMelle.

The irrigated command area of this site is found on the right side of the river. Topographically most of the cultivated lands of the project area are found in almost plain lands. In general, the potential irrigable area is about 400ha and lies from flat to nearly flat (1-2%) slopes. Hence, the slope of the command area has identified to be suitable for surface spate irrigation. For this spate irrigation scheme the source of water is from upstream catchment flood flow (i.e., Gidanworeda peak highlands)

The command area is also found inclined West to East position from the head work site and the elevation ranges' 1,525.5m.a.s.l at the top and 1,465m.a.s.l at the bottom of the command area.

According to soil sample laboratory result, the textural class of the command area is clay loam.The crop cultivated in the area is only sorghum.

2.1.3 Crop production

Gobu-I: Different crops were grown on the command area of the project where farmers depending on climate condition of the project area, soil condition of the study area, adaptation of crops to the growing conditions of the study area, socio-economic condition of the study area and yield potential ,market potentials of crops. Among, teff, Sorghum and Onion were crops grown on the command area during the study. Sorghum and teff are the major staple food crops grown in the area. Teff and onion are also used for market as cash incomes. In the project area is found, onion is the leading crop having a land share of 38.4% followed by sorghum (31.4%), and teff (30.2%). In this command area spate water extend from September at the rain stop up to half of October, so that shallow root crops like onion and teff were grown.

Gobu-II: depend on the availability of spate water and soil type; sorghum is the only leading crop grows in the study area. In this area farmers use spate water in the first rainy season up to it stops at the beginning of September. After the flood water stops, the farmers not gain water for shallow root crops. The major crops sorghum (100% grown) complete their entire growth period (September to November) based on the soil moisture stored during the flood season from 20 July to end of August. Thus, the existence of a deep soil profile with a good water holding capacity and infiltration rate is an important element for the sustainability of the system to produce high yield of production. Due to this reason the farmers select sorghum grown to sustain soil moisture and to produce high yields potential.

2.1.4 Soil Types

As some book refers, the dominant parent material in the central plateau is basalt; the soil of the catchments is the result of the weathering process of this basalt. Based on field observation and based on the information extracted from 1:500,000 scale soils maps by GIS, two types of soils have been identified in the watershed (Gobu-I and Gobu-II) namely Eurticcambisols and Litosols. According to soil sample laboratory result, the textural class of the command area is clay loam and the depth to which plant roots can effectively exploit (effective soil depth) was measured during the field working days. Hence, the command area has deep soils with 1.5 meter depth.

2.2 General Data Collection

Data collection was started in the collaboration with DA of Gobu-I and Gobu-II modern spate irrigation projects assigned by kobo Woreda Agricultural Office. During the reconnaissance survey or data collection, Agricultural Offices, sponsor organizations, professional staff, DAs and some farmers were consulted about the general condition of the two modern spate irrigation project areas. The criteria for the selection of the area were availability of the secondary data, Proximity to Sirinka Agricultural Research Center (SARC) and availability of organizational set up and upon, nearness to weather station and upon conducting the research work.

2.2.1 Primary data collection

- Actual field observation and measures of the schemes at the sites is required to collect the necessary data to know the present conditions of the scheme. These primary data were collected from June to September includes daily field observations related to water delivery,.
- The flow discharges along the canals were measured with floating method and at the field inlets were measured with rectangular weir methods.

Discharge determination

The discharge of irrigation water diverted from Gobu-I and Gobu-II at the irrigation projects were determined by using floating method. After measuring the discharge at certain interval of canal, the average discharge was estimated and this discharge was used to estimate the amount of water diverted in the season. Mostly the season of Gobu-II irrigation cropping goes from July 20 to august end and for Gobu-I irrigation cropping goes from September to middle of October.

To calculate the total volume of water diverted from the river to the irrigated area within season, the total flow time of irrigation water in the main canal was recorded and multiplied by the respective discharges.

Total diverted volume of water = canal discharge*total day of irrigation season

Gobu-I total diverted volume of water = 0.289m^3/se*45day*24hr *60min *60sec=1,123,632m^3

Gobu-II total diverted volume of water = 0.376m^3/se*45day*24hr *60min *60sec=1,461,888 m^3

Therefore the total volume of water diverted to the irrigable land for the season was 1,123,632$m^3$and 1,461,888 m^3 for Gobu-I and Gobu-II.

2.2.2 Secondary data collection

The important secondary data were collected from the responsible bodies or officials at each spate irrigation projects, Woreda Agricultural offices, irrigation offices at regional and zonal levels as much as possible. Furthermore, Research center and NGOs of the agricultural sectors were visited periodically to gather further more information about each irrigation schemes. The secondary data included production cost per season, area irrigated per crop per season, area to be irrigated, crop type and cropping pattern. Climatic data of the irrigation scheme were collected from nearby meteorological station (kobo station).

2.3 Data Analysis Techniques

2.3.1 Determination of conveyance efficiency

Conveyance efficiency was measured on main canal by measuring discharge at upstream and downstream end of the canals. The discharges were calculated from the velocity of water flowing in the main canal by using floating materials. After measured the velocity at two different points and canal cross sectional area, the discharges were calculated by average velocity multiplied by the cross sectional area of the canal at upstream and downstream end of the main canal.

Conveyance efficiency is typically defined as the ratio between the water that reaches a farm or field and that diverted from the irrigation water (spate water) sources. One of the problems which decrease the conveyance efficiency includes including any canal spills (operational or accidental), sediment accumulation and evaporation that might results from management and losses resulting from the physical configuration or condition of irrigation system.

2.3.2 Comparative performance indicators

The comparative performance indicators rely on the availability of secondary data sources. Nine indicators are presented by IWMI with the objective of providing a means of comparing performance across irrigation systems but getting complete data required to calculate all the nine indicators for each irrigation project was difficult. Hence, to compare the two irrigation projects, minimum set of comparative indicators were applied with the availability of data gathered and comparative analysis were made within the spate irrigation projects.

Based on minimum set of comparative indicators developed by IWMI, Agricultural output performance and water delivery performance indicators were carried out in this study.

2.3.2.1 Determination of Water delivery performance indicators

This deals with the primary tasks of irrigation managers in the capture, allocation and conveyance of water from the source to field by management of irrigation facilities.

Indicators address several aspects of this task; efficiency of conveying water from one location to another, the extent to which agencies maintain irrigation infrastructure to keep the system running efficiently, and the service aspects of water delivery which include such concepts as predictability and equity [13]

According to Molden et al. (1998) define several supplies for comparative purposes. Four below characterize in individual irrigation system with respect to water supply/delivery/ performance indicators in order to compare the two selected spate irrigation schemes. Such as Conveyance Efficiency (Ec), relative water supply (RWS), Relative Irrigation Supply (RIS) and Water Delivery Capacity (WDC) were calculated by using the equation (1.1), (1.2), (1.3), and (1.4) respectively. These are meant to characterize the system with respect to water supply.

2.3.2.2 Determination of Irrigated Agricultural Output Performance indicators

These addresses the direct impacts of operational inputs in terms of such aspects as area actually irrigated and crop production, over which an irrigation manager may have some but not full responsibility [13].

In order to compare the two selected modern spate irrigation, the four basic comparative performance indicators relate output to unit land and water. These indicators provide the basis for comparison of irrigated agriculture performance [14]. The selected indicators used to evaluate irrigated agricultural performance were: output per cropped area, output per unit command, output per irrigation supply and output per unit water consumed which were estimated by using the equation (1.5), (1.6), (1.7) and (1.8) respectively.

3. RESULTS AND DISCUSSIONS

3.1 Crop water demand

Crop water requirement (CWR) and irrigation water requirement (IR) were computed from the climatic data which were used for the purpose of estimation of crop water productivity in terms of water consumed by crops. Crop water requirement or seasonal water demand for each crop was determined by using CROPWAT 8.0 computer program and summary presented in appendix-2. The calculation was made by taking the crop coefficient (Kc), crop stage, rooting depth, critical depletion (P), yield response (Ky) and crop height values of sorghum, onion and Teff. The results are presented below table 4.5.

For computed reference evapotranspiration (ETo) and effective rainfall, climatic data 2007 to 2016 from nearest station Kobo meteorological station were collected from Addis Ababa meteorological agency. These estimated (ETo and Peff see table 4.1 and 4.2) were used for crop water requirement calculation.

Crop water requirement (CWR) = K_c*ETo-Peff

Irrigation water Requirement (IR) = ETc-P_{eff}

Where k_c is the crop coefficient, ETo is reference evapotranspiration and P_{eff} is the effective rainfall determined by dependable rain (FAO/AGLW formula) by CROPWAT 8.0 computer program.

Then, total net crop water requirement (NCWR) and net irrigation requirement (NIR) are computed for each crop in the growing season.

Total net crop demand for season = $CWR_{sorghum}*(Area_{sorghum}/Area_{total}) + CWR_{onion}*(Area_{onion}/Area_{total}) + CWR_{Teff}*(Area_{Teff}/Area_{total})$

Where: CWR_{crop} is the water requirement of a crop which is taken from table 4.1, $Area_{crop}$ is irrigated areas of the respective crop in the season taken from the same table and the total irrigated area (350ha) for Gobu-I and 400ha for Gobu-II. In the same way total net irrigation requirement are computed on both irrigation schemes indicated in table 4.3.

Table 4.1: CWR and IR of Gobu-I modern spate irrigation project for each crop

Types of Crop	Area (ha)	Crop water requirement (mm/season)	Effective rainfall (mm/season)	Irrigation requirement (mm/season)
Sorghum	110	543.5	195	354.6
Onion	134.4	431.2	90.8	343.9
Teff	105.6	481.7	153.7	369.3
Total	350	1456.4	439.5	1067.8

Table 4.2 CWR and IR of Gobu-II modern spate irrigation

Types of Crop	Area (ha)	Crop water requirement (mm/season)	Effective rainfall (mm/season)	Irrigation requirement (mm/season)
Sorghum	400	543.5	195	354.6

Table 4.3 NCWR and NIR for both irrigation schemes

Irrigation project	Total Net crop water requirement(mm)	Total Net Irrigation Demand (mm)
Gobu-I	481.7	354.9
Gobu-II	543.5	354.6

3.2. Comparative performance indicators

Performance of the scheme was evaluated by using some selected comparative indicators, classified in to two groups, namely water delivery performance and agricultural output performance.

3.2.1 Water delivery performance evaluation

Water delivery performance considered as conveyance efficiency (Ec), annual relative water supply (ARWS), relative irrigation supply (RIS) and water delivery capacity (WDC) were applied as a parameter to evaluate water delivery (water supply) performance of the individual modern spate irrigation.

Conveyance efficiency (Ec): This is the total amount of water reached in to the irrigation scheme divided by the amount of water delivered from the water source in to the main canal system. It measures the efficiency of the conveyance system to convey water from turnout system to reach the irrigation scheme and shows the amount of water loss over a given travel distance from upstream to downstream of the conveyance system.

Irrigation project	Water flowing in to the system (l/s)	Water flowing out of the system (l/s)	Ec %
Gobu-I	288.72	265.32	91.89
Gobu-II	375.73	312.7	83.22

Conveyance efficiency underlies spatial variation based on the conditions of the canal, management system and sediment problems. These problems have observed in the Gobu-I and II modern spate irrigation schemes. During measurement, source of losses from lined canal were observed the canal filled by sediment load, leakage losses through seepage at different point of the canal and also mainly Gobu-I spate irrigation there have a problem of slope of canal, therefore huge amount of sediment were accumulated in the main canal and the required flood not reached to farmer's field. On Gobu-II spate irrigation there were leakage losses and the main canal almost filled by sedimentation problems, therefore management problems had arisen. The conveyance efficiency of Gobu-I and Gobu-II modern spate irrigation was 91.89% and 83.22% respectively. From the result above and figure 4.2, Gobu-I canal conveyance efficiency was better than Gobu-II modern spate irrigation conveyance or canal efficiency.

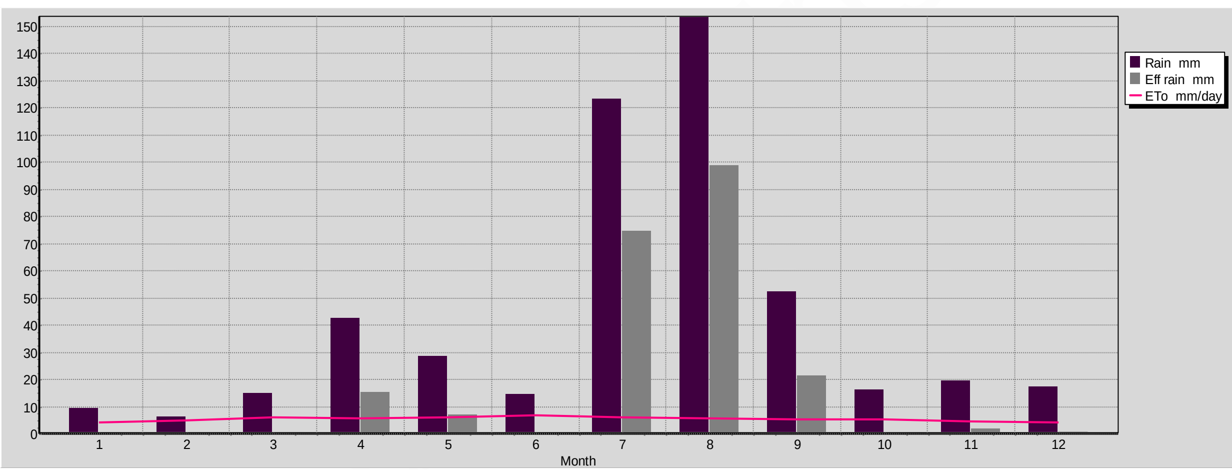

Figure 4.1 Climate/Eto/rain chart

Figure 4.2 Gobu-I and Gobu-II main canal sedimentation and canal leakage

From the computation of the CROPWAT 8.0 computer program model the peak irrigation requirement was occurred in the month of September and August and has values 0.55 l/s/ha for both Gobu-I and Gobu-II spate irrigation indicated in table 4.4.

To calculate water delivery capacity(%) of each scheme, from the field measurement the canal capacity at the system head(l/s) by using floating method were obtained and peak irrigation requirement(l/s/ha) was the output of CROPWAT model, the results above.

Therefore; Peak consumptive demand (l/s) = peak irrigation requirements (l/s/ha)*irrigated area (ha) at that season.

Scheme	Peak flow(l/s/ha)	area(ha)	Peak consumptive demand (l/s)	Canal capacity (l/s)	WDC	WDC (%)
Gobu-I	0.55	350	192.5	288.7	1.49974	149.974
Gobu-II	0.55	400	220	375.7	1.707727	170.7727

Relative water supply (RWS) and relative irrigation supply (RIS) is characterized or indicates the irrigation system performance with respect to whether there is an adequate/sufficient/ supply of water done or not to cover the crop water demand. According to Molden et al., (1998 Both RWS and RIS related supply to demand and give some indications of water abundance or scarcity, and how tightly supply and demand are matched. RWS indicates irrigation supply system includes rainfall (irrigation supply plus total rainfall) while RIS focus on irrigation supply water alone. RWS and RIS values were 1 or greater than 1 indicates an adequate supply of water while the values smaller than 1 indicates inadequate supply of irrigation.

Table 4.4 Results of net scheme irrigation requirement for each irrigation scheme in l/s/ha

Gobu-I

Net scheme irr.req.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
in mm/day	0	0	0	0	0	0.1	0.1	1	4.8	4.1	1.4	0
in mm/month	0	0	0	0	0	3.7	3	29.8	147.6	123.6	41.8	0
in l/s/ha	0	0	0	0	0	0.01	0.01	0.11	0.55	0.48	0.16	0

Gobu-II

Net scheme irr.req.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
in mm/day	0	0	0	0	0	0.4	0.3	4.7	4.1	2	0.1	0
in mm/month	0	0	0	0	0	11.9	8	141.8	128.1	61.7	2.7	0
in l/s/ha	0	0	0	0	0	0.05	0.03	0.55	0.48	0.23	0.01	0

Table 4.5 Result of water supply indicators

Irrigation scheme	Irrigation supply(mm)	Total water supply (mm)	Crop demand	Irrigation demand	Water supply indicators			
					Ec (%)	RWS	RIS	WDC
Gobu-I	321.04	820.54	481.7	354.9	91.89	1.7	0.9	1.5
Gobu-II	365.47	864.97	543.5	354.6	83.22	1.6	1.03	1.7

Table 4.6 Total yields and land coverage of Gobu-I & Gobu-II modern spate irrigation project for 2017/2018

Crops	**Gobu-I**			**Gobu-II**		
	Area(ha)	Production in Qt/ha	Total output in Birr	Area(ha)	Production in Qt	Total output in Birr
Sorghum	110	4,400	3,520,000	400	24000	19,200,000
Onion(red)	134.4	16,128	13,708,800			
Teff	105.6	844.8	887,040			
Total	**350**	**21,372.8**	**18,115,840**	**400**	**24000**	**19,200,000**

Table 4.7 Cropped area, irrigation water and yield of Gobu-I and Gobu-II irrigation projects

Irrigation scheme	Irrigated area (ha)	Command Area (ha)	Volume of Water consumed by ETc (m^3/season)	Irrigation supplied (m^3/season)	Production (Birr)
Gobu-I	350	380	1,685,950	1,123,632	18,115,840
Gobu-II	400	400	2,174,000	1,461,888	19,200,000

Table 4.8 Result of irrigated agricultural output indicators

Irrigation project	Output per irrigated area (Birr/ha)	Output per command area (Birr/ha)	Output per irrigation supplied (Birr/m^3)	Output per water consumed (Birr/m^3)
Gobu-I	51,759.54	47,673.26	16.12	10.74
Gobu-II	48,000	48,000	13.13	8.83

The values of RWS for Gobu-I and Gobu-II from table 4.5 were 1.7 and 1.6 respectively. The RWS values for both irrigation scheme were greater than 1 which means adequate supply of water were supplied to meet the crop water demand or the values implies that there is no constraining of water availability during the irrigation season. The values of RIS were 0.9 and 1.03 for Gobu-I and Gobu-II respectively. The RIS of Gobu-I is less than Gobu-II. From RIS values of Gobu-I and Gobu-II, Gobu-II RIS value is greater than 1 which indicates excess irrigation water was supplied to meet the crop water demand in the season than Gobu-I. The low value of Gobu-I RIS (0.9) may not represent a problem because of a value close to one is preferable, rather it may be provide an indication that farmer are practicing deficit irrigation a short water supply to maximize returns of water. For instance, RWS and RIS values alone this study indicates that the irrigation supply satisfies the water demand of crops in the scheme. According to Molden et al., (1998) it is better to have RIS close to 1 than a higher or lower value.

WDC is the ratio of an indicator that relates the amount of water delivered to the amount of water needed to delivered, i.e. the total water supplied to the scheme divided by gross irrigation water requirement. The water delivery capacity of Gobu-I and Gobu-II modern spate irrigation was 1.5 and 1.7 respectively. According to [14] values greater than 1 indicate that their capacity is not constraint to meeting crop water demands. Values close to one indicate that there may be difficulties meeting short-term peak demand. In both modern spate irrigation schemes WDC were greater than one, which indicates the canal capacity may not be a constraint to meet the maximum crop water demand.

3.2.2 Agricultural output performance evaluation

The final output of irrigated agriculture is crop production which can be expressed in terms of productivity, i.e. yield in quintal or its monetary values in Birr per unit land and water resource used [15].

Indicators of output per unit irrigated area, output per unit command area, output per unit irrigation supply and output per unit water consumed was used to evaluate irrigated agricultural output performance base on output to unit land and output to unit water

Base on the collected data from Kobo Agricultural and rural development office, annual report of the sites and planted and harvested date for the year 2017/2018, the agricultural outputs of each scheme are tabulated in table 4.1.

To calculate those output performance indicators, diverted irrigation supply has to be calculated in the below table 4.6 and volume of water consumed by ET has to be calculated as follow.

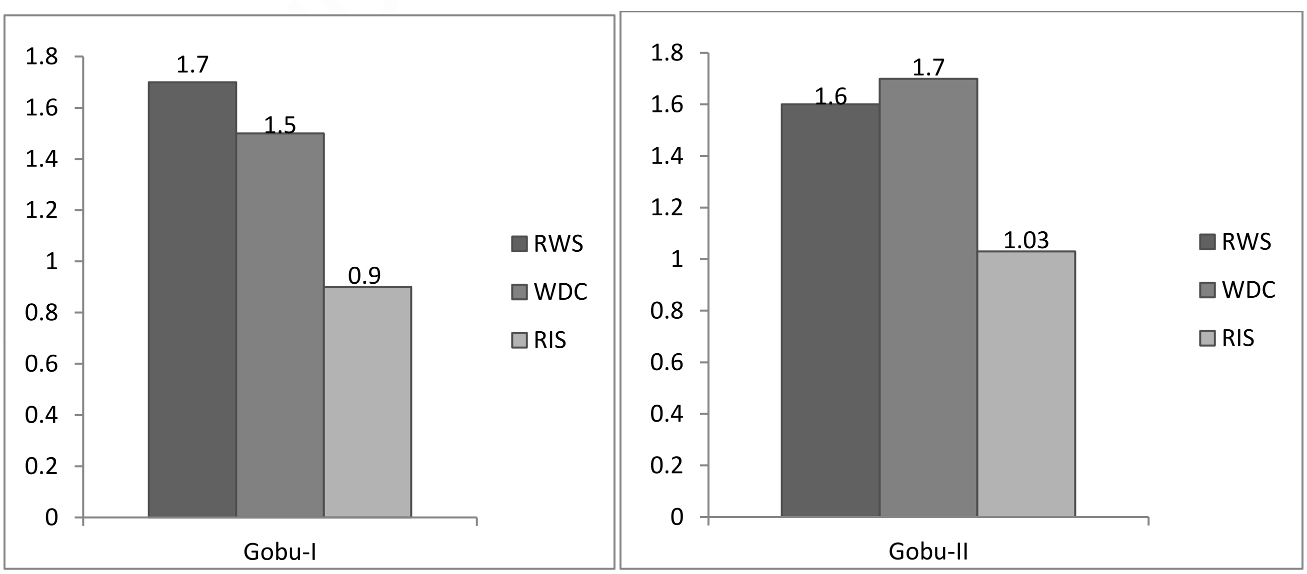

Figure 4.3 Diagram of water supply indicators

Volume of water consumed by ET is the actual evapotranspiration of crops = NCWR*Irrigated area

Gobu-I =481.7*350*10 = 1,685,950 m^3
Gobu-II = 543.5*400*10 = 2,174,000 m^3

As clearly seen in the table 4.7 and figure 4.4 Gobu-I modern spate irrigation has the higher value in output per unit cropped area (51759.54 Birr/ha). This higher value of output per cropped area is attained due to great attitude of farmers in producing market oriented crops like onion and teff and well experience of irrigation practice than Gobu-II.

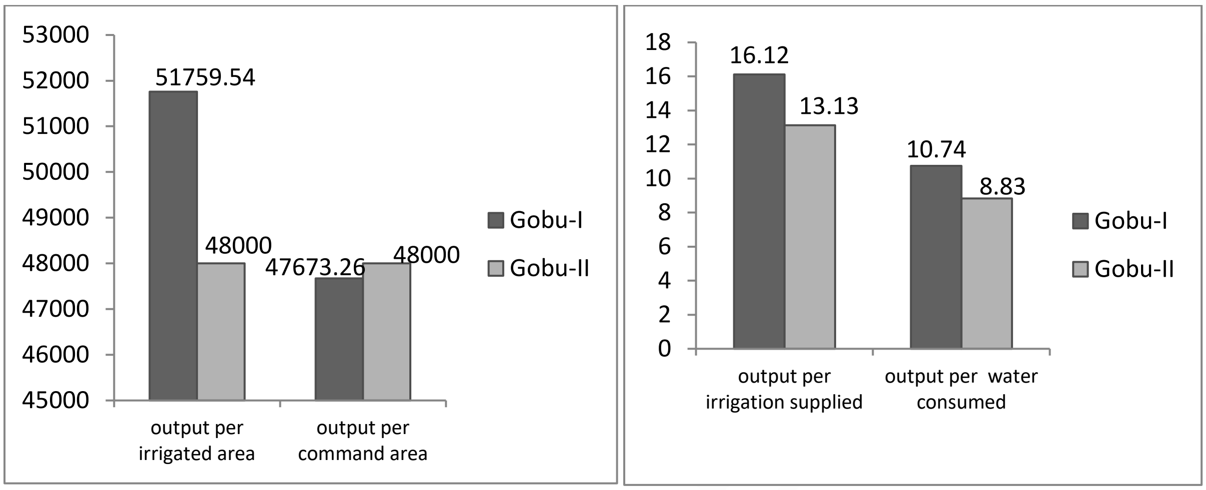

Figure 4.4 Diagram of irrigated output performance indicators

In the case of output per unit command area Gobu-II is higher than Gobu-I. This higher value attained due to irrigated the total designed area, but in Gobu-I spate irrigation there has 30 ha un- irrigated land. In this case higher land productivity values at Gobu-II than Gobu-I due to improved irrigation management in the scheme.

Again from the table 4.8 and diagram 4.4 the output relation to water supply for the cropping season output per water consumed values were 10.74 and 8.83 for Gobu-I and Gobu-II respectively. From the result Gobu-I modern spate irrigation has higher values (10.74) than Gobu-II. This indicated that Gobu-I was better in effective utilization of water, i.e. large amount of water was consumed by Gobu-II than Gobu-I as compared to its output.

In the case of output per irrigation supply Gobu-I has a higher value (16.12) than Gobu-II implying that Gobu-I was better in effective utilization of water. I.e. each volume of water diverted produced better yield in Gobu-I than Gobu-II and large amount of water (generous supply of water) was diverted at Gobu-II than Gobu-I. But as indicators are comparative can't say that Gobu-I achieved the required. It concludes that Gobu-I was better in land productivity by production per irrigated area and also shows better performance in water productivity.

When water is constraining resource, output per unit water may be more important, whereas if land is constraint relative to water, output per unit land may more important [14].

5. CONCLUSION

In the study area the values of RWS and RIS in Gobu-I and Gobu-II spate irrigation schemes were Greater than one and also close to one. This values indicates that there is not constraining water available situation during 2017/2018 irrigation season for total demand of both schemes or water demand of the crops in the schemes was satisfied. The WDC of Gobu-I and Gobu-II were greater than one. This result shows that Gobu-I and Gobu-II modern spate irrigation is not constraint to meet crop water demands.

Gobu-I modern spate irrigation has the higher value in output per unit cropped area than Gobu-II. This higher value of output per cropped area is attained due to great attitude of farmers in producing market oriented crops like onion and teff and well experience of irrigation practice than Gobu-II. In the case of output per unit designed area Gobu-II is higher than Gobu-I. This is higher value attained due to irrigated the total designed area, but in Gobu-I spate irrigation there has 30 ha un- irrigated land. In this case higher land productivity values at Gobu-II than Gobu-I due to improved irrigation management in the scheme. From the result output per water consumed and water supplied Gobu-I modern spate irrigation has higher value. Implies Gobu-I was better in effective utilization of water. I.e. each volume of water diverted produced better yield in Gobu-I than Gobu-II. Based on the assessment made to evaluate the performance of both modern spate irrigation schemes, the conveyance efficiency of both schemes Gobu-I modern spate irrigation was better than Gobu-II. This result shows that at Gobu-II modern spate irrigation scheme the canal was fully settled by sediment problems, therefore management problems on the scheme had arisen.

For Gobu-I and Gobu-II modern spate irrigation systems there were sediment problems in the main canal and takeoff. The repetition of O and M activities modern spate irrigation is high as compared to traditional one. So the objective of reliving farmers from repeated O and M activities by constructing permanent irrigation structures has not met its objectives.

The development of modern spate irrigation in the study area holds significant role to improve productivity and reduce poverty in any country, field survey with focus group discussion indicates that modern spate irrigation great benefit is accompanied with multi-dimensional problems. The major problems encountered in the modern spate irrigation in the study areas should be resolved before the projects are failed.

Recommendations

Based on the finding of this study the following recommendations are forwarded the resource utilizations.

- In the stud areas there is no attention given for the water works in relation to irrigation, simply the district experts and the administrator body talk about the presence of the structures, no one knows about its efficiency, failure, strength and productivity of the schemes except report from DA. Farmers irrigate their farm according to their experience from the late farmers no improvement is done from experts and development agent. According to the respective DA this is raised from lack of knowledge, training is given for district experts and they do not transfer it for concerned persons (DA). There for it is understood that the low performance of the modern spate irrigation to came up know how to irrigate flood to farm and when to irrigate it and how much to irrigate it. From this result it recommended that the district experts and administrative bodies should be giving the essential training to the users in order to establish the capacity to successfully carry out the farmers know how about the spate water management. Hence long term and short term training of experts is mandatory for the development of the sub sectors.
- The major problem observed in both modern spate irrigation schemes is sediment accumulation problem in the main canal, takeoff and on the diversion weir. In similar ways, the modern schemes are also underutilized due to miss management of the schemes and absence of proper openings for removing silt excluder. Therefore, remodeling sediment exclusion mechanism to improve the control over water on the conveyance by reduce silt accumulations in the main canal, minimize O and M losses and increased the quantity of flood water diverted to the farmers field to irrigate large area.
- Comparative performance indicators are the best indicators and estimators of the performance of irrigation projects as a whole but full, reliable and consistent documentation system is rather a must.
- Finally further more research doing and consultancy is recommended to assess and identify problems of the existed modern spate irrigation in Kobo woreda so that appropriate improvement design can be produced and successful improvement intervention works can be implemented.

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REFERENCE

1. CSA, Statistical Abstract of Ethiopia, Central Statistical Agency, Addis Ababa: Ethiopia. 2017.
2. Awulachew, S.B., et al., Water Resources and Irrigation Development in Ethiopia. International Water Management Institute (IWMI), 2007. paper 123.
3. Haile, G.G., Irrigation in Ethiopia, a Review. Journal of Environment and Earth Science, 2015. 5 (Irrigation and Water Management Research, Mekelle Agricultural Research Center, Tigray Agricultural Research Institute, Mekelle, Ethiopia): p. 141.
4. MoA, Small-scale irrigation capacity building strategy for ethiopia,Addis Ababa Ethiopia. 2011.
5. Hagos, F., et al., Spate Irrigation and Poverty in Ethiopia. 2013, International Water Management Institute, Nile Basin and East Africa Office, Addis Ababa
6. Ratsey, j., Technical Assistance for the Support to the Agricultural Sector / Food Security Programme in Eritrea, in Engineering Manual For Spate Irrigation. 2011.
7. Steenbergen, V.F., et al., Status and Potential of Spate Irrigation in Ethiopia. Springer Science+Business Media B.V. , 2011(Water Resour Manage).
8. FAO, Guidelines on spate irrigation Food,. Food And Agriculture Organization Of The United Nations(FAO) , 2010. paper 65, Rome.
9. Çakmak, B., et al., Evaluation of irrigation performance of asartepe irrigation association: A case study from turkey. Kayseri-Turkey, 2009(Department of Farm Structure and Irrigation, Faculty of Agriculture, University of Erciyes): p. 1-2.
10. Embaye, T.G., Analysis of Spate Irrigation Sedimentation and the Design of Settling Basinsin UNESCO-IHE Institute for Water Education. 2009, the Netherlands: Delft,.
11. Bos, M.G., Performance Assessment for Irrigation and Drainage. Kluwer Academic Publishers, Netherlands, 1997. (Irrigation and Drainage Systems).
12. Rani, S.Y.R., Dr. B. Venkateswa Rao, and Dr. S.Sreekanth, Modernization of an existing irrigation project by performance evaluation using performance indicators. International eJournal of Mathematics and Engineering, 2011.
13. Bos, M.G., et al., Methodologies for assessing performance of irriagtion and drainage management. Kluwer Academic Publisher, 1994(Irrigation and Drainage system 7: 231-261).
14. Molden, D., et al., Indicators for Comparing Performance of Irrigated Agricultural Systems, in research paper 20. 1998, International Water Management Institute(IWMI): Colombo, Sri Lanka.
15. Awulachew, S., Ayana,M.,, Performance of irrigation: An assessment at different scales in Ethiopia. International Water Management Institute (IWMI), Ethiopia, 2011. volume 47 (S1), : p. pp. 57-69