REPORT

ON

Community Based Irrigation Management in the Tekeze Basin: *Performance Evaluation*

A case study on three small-scale irrigation schemes (micro dams)

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ABSTRACT

Frequent monitoring of the performance of irrigation systems will assist to distinguish whether the targets and objectives are being met or not. It also provides system managers, farmers, policy makers a better understanding of how a system operates. It helps to identify the strengths and weaknesses, consequently alternatives that may be both effective and feasible in improving system performance to achieve maximum efficiency. The important resources in irrigated agriculture, land and water, are the one that should be considered and sustained in their productivity in order to meet the target.

The IWMI comparative indicators are used as a base for the performance evaluation of three schemes in Tekeze basin. The necessary data are collected from development agents based at the projects, the wereda's agricultural office and from the Tigray bureau of water resource development.

The result indicates that the schemes are performing differently in some of them the practice is well developed on the contrary there are aspects of irrigation water management that are lacking while practicing irrigation.

For the improved production as well as efficient utilization of water it is suggested that the introduction of very small water fees will help in enhancing the irrigation practice to the desired level. This also helps for sustainability of the practice if it is operated and maintained by the beneficiaries.

Improving the water utilization of the scheme, which requires improving the management skills of the users, is one challenge to be tackled to ensure the sustainability of the schemes.

1. INTRODUCTION

1.1 Background

The struggle to secure food in the country is highly assisted by increasing production using irrigation water from these small-scale irrigation schemes constructed in the basin. But the contribution towards this increment in production will vary from one to another, since it depends on the management of this water development. So, in order to identify the strength and the weakness of these schemes a comparative performance assessment is indispensable.

In the country water development for agriculture is a priority, but poorly designed and planned irrigation undermines efforts to improve livelihoods and exposes people and environment to risks. Recent estimates indicate that the total irrigable area in Ethiopia is 197,225 ha around 3 % of the irrigation potential (MOWR). Moreover, much of the increase in irrigated area had come because of expansion of small-scale irrigation. Yet, the existing irrigation development in Ethiopia, as compared to the resource the country has, is negligible.

The importance of irrigation in the Tekeze basin has been recognized many generations back according to members of the indigenous irrigation schemes. Field observations made in most part of the basin shows that almost all of the available perennial surface water resource is used for irrigation, except those found in deep gorges, as of many decade back. In Tigray alone, the total area irrigated by 2002 was 4773 ha or 0.44% of the total arable land (BOANR, 2003). The fluctuation in size of the irrigable area from one year to the other could be due to the drying of the water source following drought or shortage of rainfall.

To achieve sustainable production from irrigated agriculture it is obvious that the utilization of the important resources in irrigated agriculture, water and land, must be improved. The question- how is irrigated agriculture performing with limited water and land resources? Has not been satisfactorily answered. This is because that we are not able to compare irrigated land and water use to learn how irrigation systems are performing relative to each other and what the appropriate targets achievement are (Molden et al., 1998).

With many variables that influence performance of irrigated agriculture, including infrastructure design, management, climatic conditions, socio-economic settings, the task of comparing performance of systems is formidable. However, if we focus on the communalities of irrigated agriculture water, land, finance and crop production it should be possible to see, in gross sense, how irrigated agriculture is performing with various settings (Molden et al., 1998).

Now, IWMI has prepared different “comparative” indicators that are helpful for comparing irrigated agriculture between countries and regions, between different infrastructures and management types, and between different environments and for assessment over time of the trend in performance of specific project. The set of indicators is small, yet reveals sufficient information about the out put of the system.

The indicators have the following features:

- The indicators are based on relative comparison of absolute values, rather than being referenced to standards or target.
- The indicators relate the phenomena that are common to irrigation and irrigated agricultural systems.
- Data collection procedures are not too complicated or expensive.
- These set of indicators are designed to show gross relationship and trends and should be useful in indicating where more detailed study should take place, for example where a project has done extremely well, or where dramatic changes take place.

This research presents the Comparative performance of three irrigation schemes namely Haiba, Meala and Mainugus irrigation projects, which are serving for relatively longer period of time in the basin. The schemes are selected based on the following criteria.

i. Site accessibility,
ii. Availability of water in the reservoir, and
iii. Availability of compiled agronomic and engineering data.

The performance comparison is based on the production and management of 1996E.C (2003/2004) Irrigation production year. In the paper an attempt is also made to see the causes and effects of the variation in these schemes.

1.2 Problem Statement

Water Development by constructing small earthen dams in the region was believed to bring changes in the way of life of the local communities in the area. The major problem related with such kind of projects is that their negative impact on the environment and human health. Irrigation projects have the potential to degrade the land, the soil and waste the valuable resource- water if they are mismanaged. In recognition of both the benefit and hazards assessment and evaluation of irrigation schemes performance has now become a paramount importance not only to point out where the problem lies but also helps to identify alternatives that may be both effective and feasible in improving system performance.

Performance evaluation of irrigation projects is not common in the country. Lack of knowledge and tools used to assess the performance of projects adds to the problem. But now, IWMI has developed a set of comparative indicators that are used to assess hydrological, agronomic and financial performance of irrigation system, which are helpful to determine the conditions of the system and proper functioning of its elements.

1.3 Objective

In this research IWMI's comparative performance and internal process indicators are the criterion that will be used to evaluate the status of the existing three small-scale irrigation schemes in the basin. Thus the objectives of this research work are:

- To evaluate the performance of small scale irrigation schemes
- To test the comparative performance indicators in the basin
- To see the conveyance and application efficiency of the irrigation schemes
- To recommend appropriate strategies that will improve the performance of small-scale irrigation schemes.

2. MATERIALS AND METHODS

2.1 Description of study area

2.1.1 Location and physiography

Haiba

Haiba dam site is situated at Haiba plane in which most of the reservoir is grazing land. The scheme is located in southern zone of Tigray, Samre wereda, Addis Alem tabia, gonay daero kushet, particularly in the Haiba River, Which is 45 km from Mekelle along the main road to Samre and 2km branching to west. The geographical location is 13°19'North, 39°22'East with Altitude of 2300m.a.s.l. at dam crest.

Meila

Meila is found in Tigray region, Southern zone, Adigudom wereda and with in the Tabia Amdi Weyane, Which includes part of Haiba irrigation scheme. Meila dam site is found at 8.75km up stream and in series to Haiba dam site. The geographical location of Meila catchment lays between 13°16′- 13°18′ North 39°22′-39°25′East with Altitude range of 2340-3000m.a.s.l.

The catchment area that drains to Meila and Haiba dams are 14.4km^2 and 39.1km^2 (including Meila) respectively. To determine the water potential for Haiba dam site the difference is considered but for flood analysis the total area (i.e.39.1 km^2) is taken.

Ma'ynugus

The study area is found in the central zone of Tigray region, Laelay Maichew Wereda, Dura tabia, and Dura kushet. It lies between latitude of 14°07'00" and 14°09'20"N and 38°38'00" and 38°49'09"E longitude about 7km, west of Axum town. The elevation of the area ranges from 1650 to 2500m asl**.**

The topography of the area is not uniform. The catchment area of the study consists mountainous terrain and gentle slope, and considerably plain and hilly slopes. The mountainous portion is covered with scattered to good cover of bushes, while the gentle and hilly slope areas are mainly managed for agricultural lands and covered to some

The command area is a flat land with a slope range of 1 – 3%. Therefore, it is suitable for mechanization and farm developments. There are no gullies observed within this area except the main gully cut passing through it.

2.1.2 Climate

Haiba and Meila

The climate of these dam sites is almost the same since they are found in the same water shade one found just on the upstream of the other. The area has a mono-modal rainfall pattern that the main rainy season is during summer from June to August. The remaining months are dry. It has the mean annual rainfall of 428mm. It is found in the Dega agro ecological zone, with altitude range of 2300-3000m.a.s.l. The meteorological data for temperature and rainfall was collected from Mekelle, Samre, and Dengolat and extrapolated to the area of interest.

Ma'ynugus

The area has a mono-modal rainfall pattern that the main rainy season is during summer from June to August. The remaining months are dry. It has the mean annual rainfall of 662.7mm. It is found in the weynadega agro ecological zone. The meteorological data for temperature and rainfall was collected from different sources. The temperature data was collected from Seleklaka and the rainfall data from Axum.

2.1.3 Catchment and command areas

Haiba

The catchment area is characterized by flat terrain covering about 80% in proportion except the southeastern main mountaintop and hilly side the northern boundary of the catchment with small mountain features. Most of the flat area is cultivated and grazing land. The topographical features of most of the catchment area is uniform with flat topography of 0-5%.

The command area is found at the valley bottom surrounded by mountainous land formation. It is a plain with some irregularities (raised micro topography and gully formations). Though these can reduce the size (area) of the land to be irrigated and increase the cost of land levelling and construction of cross-structures they do not greatly limit the suitability of the land for irrigation practices, mechanization etc as they occupy only small area.

The scheme has a total design irrigable command area of 200ha and it varies from year to year based on the water collected during the rainy season. It is found about 2-2.5 kms away from the dam site. It is crossed by the Haiba river gully. Standing face towards the direction of the river flow the land in the left hand side of the gully is the main land to be commanded.

Meila

A mountainous terrain having a spectacular view of ruggedness characterizes the catchment area, and of course, there is remarkable area, which is under Agriculture practices on the hillsides. Other than these, a considerable area of plain lands, which can be said as agriculturally effectual, also characterizes the area. The altitudinal range of the catchment area is 2340-3000m above sea level.

The soil texture of the command area of the site is extended from heavy clay to loamy sand. Large part of the command area is covered with heavy clay texture.

Ma'ynugus

The catchment covers a total area of 13.05km^2. The dominant soil type in this area is light clay soil. The area starting from the lower right end of the catchment and up to the central periphery of it is dominated by clay loam, with a dominant soil depth of < 25cm and reddish dominant soil color. This has a scattered to good vegetation cover of bushes and to some extent agricultural lands.

The area starting from the upper central part of the catchment area including the upper right end has dominantly light clay soil with dominant soil depth of >150cm and < 25cm and having brown soil color. This part of the area is mainly put under agricultural practices and to some extent with dense grass cover.

The area which is found at the lower and upper central part of the catchment which continues up to the upper central end of the catchment has dominantly silt loam soil, with a soil depth of > 150cm and with a brown dominant soil color. This portion of the catchment is mainly put under agricultural practices and considerably under grazing land.

The area which is found starting from the left side of the reservoir, which continues following up the left periphery of the catchment to some distance following up the right side of the second main gully, and up to the upper left end of the catchment has dominantly light clay soil with a dominant soil depth of >150cm and < 25cm having a brown dominant soil color. This portion of the catchment is mainly put under agricultural practices and considerably covered with scattered bush land and degraded grazing land.

The command area of irrigation scheme is highly suitable with rational water management and agronomic practices. Since the ground water table is observed at about 1m depth where the land is frequently irrigated and rarely at about 2m depth on other farms, there may be water logging problem if there is no good management of irrigation water. The dam has a water storage capacity of 2.38 million m^3 and can irrigate 123.9ha. of land. But the area that can be irrigated depends on the amount of water harvested during summer season.

2.1.4 Major production constraints

The area is suffering from shortage of rainfall, which leads to water deficit for crop production. Even though, this constraint was minimized with construction of dam to collect summer rainfall, still the shortage of rainfall in some years leads to small storage of water in the dam. This situation is also happen this year and the past as well.

Farmers have lack of knowledge in using inputs such as fertilizers, seeds; chemicals, water and using natural manure. Weed infestation and crop diseases are one of the production constraints that decrease crop yield. Market problem and poor cropping pattern are also major problems in the study areas.

2.2 Methodology

2.2.1 Data collection

Primary data is collected from Respective sites. Likewise secondary data were also collected from Tigray region water resource development bureau, and the wereda's Agricultural office. Moreover, a participator approach discussions were held with beneficiary farmers and Wereda's Agricultural office development Agents.

2.2.2 Data analysis

The analysis is made based on the IWMI's comparative performance indicators and it is also attempted to see internal process indicators that is the efficiency of the schemes particularly the conveyance and application efficiency of the system.

Comparative Performance Indicators

To compute the total production of each scheme in all the crop types grown in the respective sites are described and an average yield per ha as well as an average price for each crop per quintal is provided for each site

The total infrastructure cost for each scheme is obtained from engineering design report of Co-SAERT, which was the responsible organization for the design and construction of the dams and now it evolves to Tigray region water resource development bureau.

The potential Evapotranspiration of the area is calculated using the penman-montine method in the CROPWAT model (FAO, 1992). The net crop water requirements and the net irrigation requirements are also calculated using the CROPWAT model. The effective rainfall is also calculated using the model. The results obtained on nine of the indicators are compared to one another. The results are presented in graphs.

The performance indicators used are:

$$\text{Out put per cropped area (birr/ha)} = \frac{\text{production}}{\text{Irrigated crop area}}$$

$$\text{Out put per unit command (birr/ha} = \frac{\text{production}}{\text{Command area}}$$

$$\text{Out put per unit irrigation supply (birr/m3)} = \frac{\text{production}}{\text{Diverted irrigation supply}}$$

$$\text{Out put per unit water consumed (birr/m3)} = \frac{\text{production}}{\text{Volume of water consumed by ET}}$$

$$\text{Relative water supply} = \frac{\text{total water supply}}{\text{Crop demand}}$$

$$\text{Relative irrigation supply} = \frac{\text{irrigation supply}}{\text{Irrigation demand}}$$

$$\text{Water delivery capacity} = \frac{\text{canal capacity at the system head}}{\text{Peak consumptive demand}}$$

$$\text{Gross return on investment (\%)} = \frac{\text{production}}{\text{Cost of infrastructure}}$$

$$\text{Financial self-sufficiency (\%)} = \frac{\text{revenue from irrigation}}{\text{Total O \& M expenditure}}$$

Performance evaluation analysis using The IWMI's performance indicators requires determination of standardized gross of production (SGVP). SGVP is defined as the output of irrigated area in terms of gross or net value of production measured at local or world prices. For this research maize is selected as predominant (base) crop and the equivalent production at world prices is taken as 128.33USD/tone (Source--)

$$SGVP = \left[\sum A_i Y_i \frac{P_i}{P_b}\right] p_{world}$$

Where, A_i is the area cropped with crop i,
Y_i is the yield of crop I,
P_i the local price of crop I,
P_b the local price of the base crop, and
P_{world} is the value of the base crop traded at world prices

Internal Process Indicators

The efficiencies of the schemes are computed by conducting field measurements and laboratory activities. To measure the conveyance efficiency of the schemes the discharge is measured at different points. The measurement starts just at down stream of the out let of the respective dams and the measurement continues at all points where the canals are Branching to field.

Similarly the application efficiency of the respective irrigation systems is done. The procedure starts by selecting a specific farm, there is no specific criterion but it is by random. The total irrigation water is measured and the farm owner determines the amount of water needed. What the researchers do are to take soil sample and to set the parshall flumes at appropriate position before the start of irrigation and record the reading at different time when the discharge is fluctuating and this continues until the farmer finishes watering. More over, soil sample is taken to know the moisture content of the soil. The sample is taken before the irrigation is started and again a day after the irrigation. The sample is taken at a depth of top 10 cm and 10-20cm and the samples are taken using soil core samplers. The depth is limited to this because the root of the crops at this growth stage is less likely to exceed this depth. The area of irrigated farm is also measured.

Finally the analysis is made using this field data after conducting laboratory works and the end out put is presented using the following concept.

1. Conveyance efficiency is analyzed by computing discharge at out let and the total sum of discharges joining to field canals.

$$\text{Conveyance efficiency\%} = \frac{\text{(Total sum of discharge to field canals)}}{\text{Discharge at outlet}} * 100\%$$

2. Application efficiency is computed as the ratio of moisture added to the soil profile due to irrigation to the total water supplied to the farm or the ratio of moisture retained due to irrigation with total water added to the field.

$$\text{Application efficiency\%} = \frac{\text{(Water retained in the soil due to irrigation)}}{\text{Total water added to the field}} * 100\%$$

Picture 1.Discharge measurements using current meter and Parshall flume

3. RESULTS AND DISCUSSION

The type of crops grown differs from scheme to scheme. However maize takes the highest percentage in all schemes. The production per unit hectare of land which is dependent on many factors differs significantly among the schemes. The detailed analysis carried out with reference to each scheme that will lead to IWMI's comparative assessment indicators are summarized in the following tables.

Table3.1 Crop type and yield for Meila Irrigation Project

Crop type	**Area (ha)**	**Yield Qt/ha**	**Yield Qt**	**Price (Qt/ha)**	**Revenue (Birr)**
(1)	(2)	(3)	(4)=(2)x(3)	(5)	(6)=(4)x(5)
Onion (local)	26.7	95	2536.5	225	570712.5
Onion	1.1	110	121	200	24200.0
Garlic	0.4	80	32	600	19200.0
Tomato	3.85	200	770	200	154000.0
Potato	3.35	180	603	150	90450.0
Pepper	3.3	70	231	500	115500.0
Carrot	0.1	40	4	150	600.0
Cabbage	0.1	160	16	100	1600.0
Lentil	1.0	30	30	350	10500.0
Maize	30.5	80	2440	190	463600.0
Chickpea	0.1	30	3	200	600.0
Total					1450962.5

Table 3.2 SVGP calculation for Meila Irrigation Project

Production in Tones of maize (tones)	P_{world} (USD/tones)	SGVP (USD)
763.66447	128.33	98003.61

Note: Base crop is maize

Table 3.3 Crop type and yield for Haiba Irrigation Project

Crop type	**Area (ha)**	**Yield Qt/ha**	**Yield Qt**	**Price (Qt/ha)**	**Revenue (Birr)**
(1)	(2)	(3)	(4)=(2)x(3)	(5)	(6)=(4)x(5)
Maize(AS11)	22	74	1628.0	190.0	309320.0
Maize (local)	51.3	70	3591.0	190.0	682290.0
Onion(exotic)	30.9	131	4047.9	200.0	809400.0
Onion(local)	14.5	60	870.0	225.0	195750.0
Tomato	4.9	155	759.5	200.0	151900.0
Potato	0.8	112	89.6	150.0	13440.0
Cabbage	0.4	120	48.0	100.0	4800.0
Abish	1.6	15	24.0	500.0	12000.0
Spices(white)	0.2	10	2.0	700.0	1400.0
Chickpea	3.5	25	87.5	200.0	17500.0
Wheat	1.8	32	57.6	250.0	14400.0
Garlic	6.1	60	366.0	500.0	183000.0
Lettuce	0.1	200	20.0	100.0	2000.0
Spices(black)	0.01	8	0.08	800.0	64.0
“Dimbilal”	0.01	8	0.08	800.0	64.0
Lentil	2.9	25	72.5	350.0	25375.0
“Gaya”	1.68	30	50.4	180.0	9072.0
Total					**2431775.0**

Table 3.4 SVGP calculation for Haiba Irrigation Project

Production in Tones of maize (tones)	P_{world} (USD/tones)	SGVP (USD)
1279.9479	128.33	164260.0

Note: Base crop is maize

Table 3.5 Crop type and yield for Mainugus Irrigation Project

Crop type	**Area (ha)**	**Yield Qt/ha**	**Yield Qt**	**Price (Qt/ha)**	**Revenue (Birr)**
(1)	(2)	(3)	(4)=(2)x(3)	(5)	(6)=(4)x(5)
Onion	9.0	119	1071.0	200.0	214200.00
Garlic	2.35	95.33	224.03	500.0	112016.67
Tomato	2.975	366.67	1090.83	200.0	218166.67
Potato	0.025	95.0	2.38	200.0	475.00
Pepper	8.15	80.33	654.72	300.0	196415.00
Carrot	0.175	316.67	55.42	150.0	8312.50
Cabbage	0.075	415.0	31.13	100.0	3112.50
Maize	25.8	67.5	1741.5	170.0	296055.00
Chickpea	0.55	68.75	37.81	250.0	9453.13
Abish	1.7	125.0	212.5	375.0	79687.50
Lettuce	0.175	336.67	58.92	50.0	2945.83
Total					**1140839.80**

Table 3.6 SVGP calculation for Mainugus Irrigation Project

Production in Tones of maize (tones)	P_{world} (USD/tones)	SGVP (USD)
671.08223	128.33	86122.22

Note: Base crop is maize

3.1 Irrigated Agriculture performance Indicators

This includes performance indicators, which are associated with the production and are presented as follows.

3.1.1 Out put per unit-cropped area

The output per cropped area shows the response of each cropped area on generating gross return.

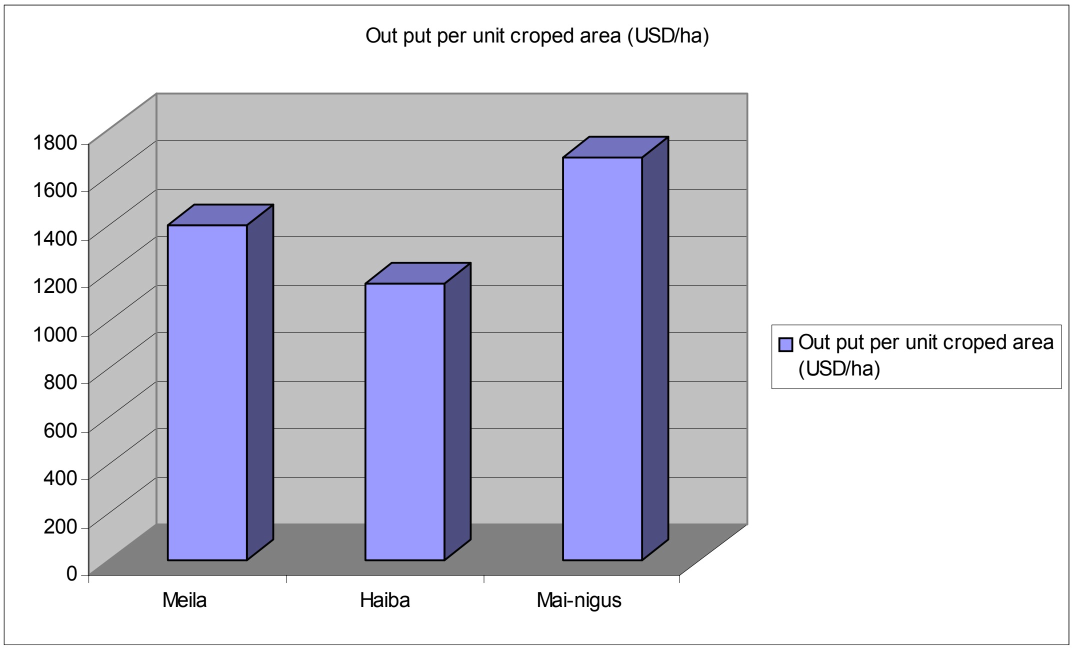

Fig.3.1 Out put per unit crop area

This parameter is giving clue about the management practice in every scheme. Based on this information as a datum it is possible to say that the response or income per cropped area in Ma'ynugus is best as compared to Meila and Haiba .And the return from Haiba is by far small as it is compared with Ma'ynugus. This is mainly due to the improved irrigation management in the scheme. This can be associated with the irrigation experience in the schemes. Ma'ynugus is one of the first constructed dams and irrigation is practiced for relatively longer period.

3.1.2 Out put per unit of command

This indicator expresses the average return of each design command and this is varying from scheme to scheme.

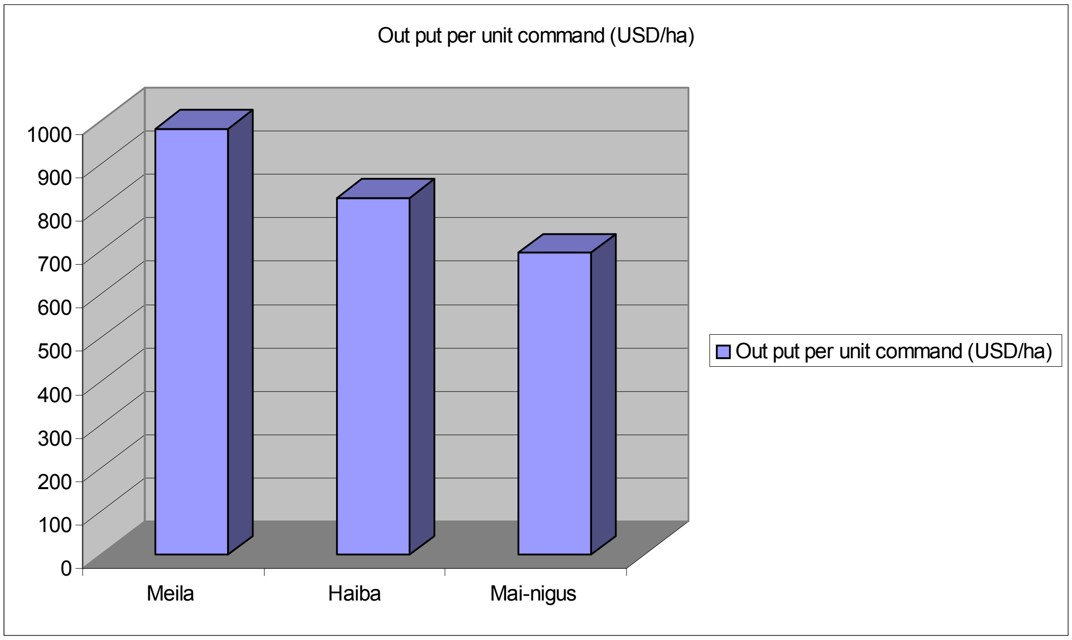

Fig.3.2 Out put per unit command

The out put per unit command of Meila irrigation scheme is high then followed by Haiba and the lowest is Ma'ynugus. The rainfall in this specific year was not good. Consequently the dams were not full and not irrigating the total designed command area of each scheme. The irrigated area for Meila was 70.05ha and that of Haiba and Ma'ynugus are 142.6ha and 51.2ha respectively. When this area is compared to each designed command, the one, which has large proportion of irrigated area over design, has large out put per unit command area and the trend goes in the same pattern.

3.1.3 Out put per unit water consumed

The output per unit water consumed is used to describe the return on water consumed.

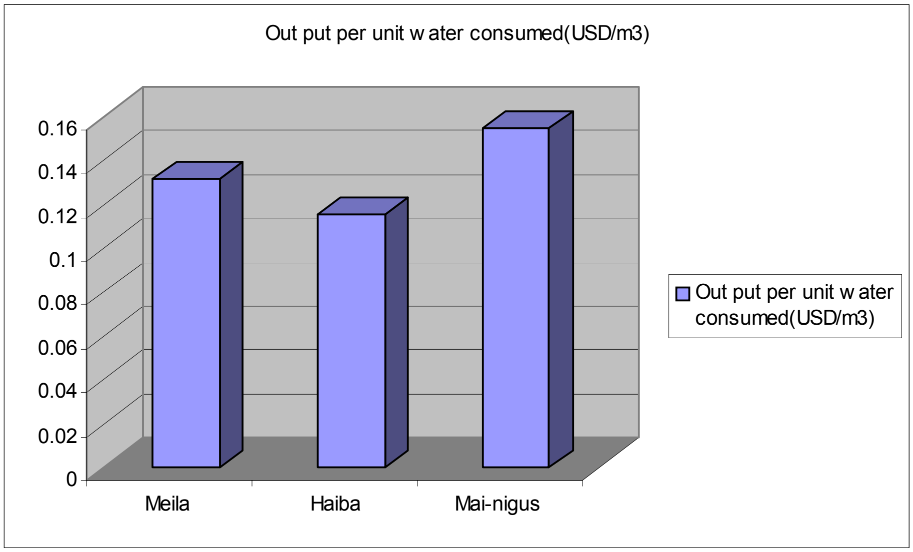

Fig.3.3 Out put per unit water consumed

The result of this out put is somewhat different as compared to the out put per unit command area. This is mainly gives due attention to the water consumed by each scheme and tells us how water is efficiently utilized by the scheme from economic point of view.

The out put per unit water consumed for Ma'ynugus is 0.1546USD/m^3, and 0.13189USD/m^3 and 0.115143USD/m^3 for Meila and Haiba respectively. This figure depicts that in Ma'ynugus the response of 1m^3 of water is high as compared to Meila and Haiba. This indicator shows that the crops grown in Ma'ynugus yield more compared to Meila and Haiba.

3.1.4 Out put per unit irrigation supply (USD/m³)

Out put per Irrigation supply shows the revenue of each meter cube of irrigation water in each scheme.

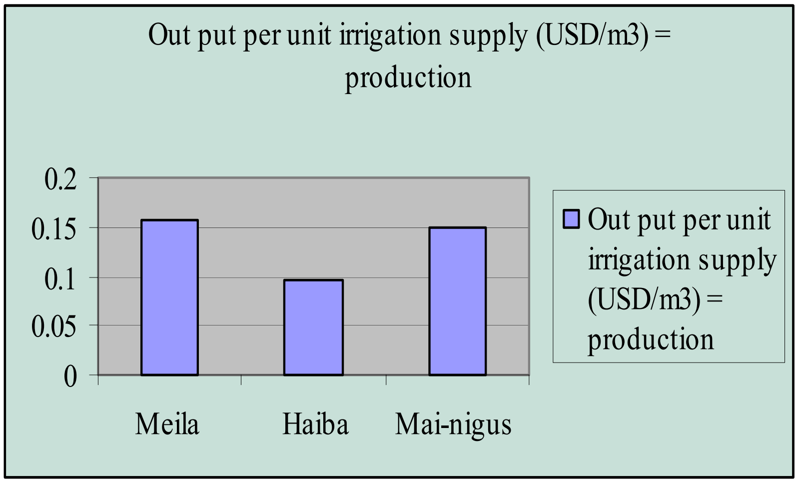

Fig.3.4 Out put per unit

As it is displayed in the graph in Meila it is about US$0.156 for one meter cube of irrigation water, US$ 0.096 and US$0.149 for Haiba and Ma'ynugus respectively.

3.2 Water use performance

3.2.1 Water delivery capacity (WDC)

The water delivery capacity of the irrigation scheme shows the capacity of the main canal to convey the maximum peak consumptive demand i.e the ratio of canal capacity at system head to maximum consumptive demand.

The canal capacity in each irrigation scheme system head is designed base on the maximum peak consumptive demand by considering reasonable freeboard. It is the same for all the schemes since all the dams are constructed for single purpose that is Irrigation.

3.2.2 Relative water supply (RWS)

Relative water supply depicts whether there is enough irrigation water supply or not.

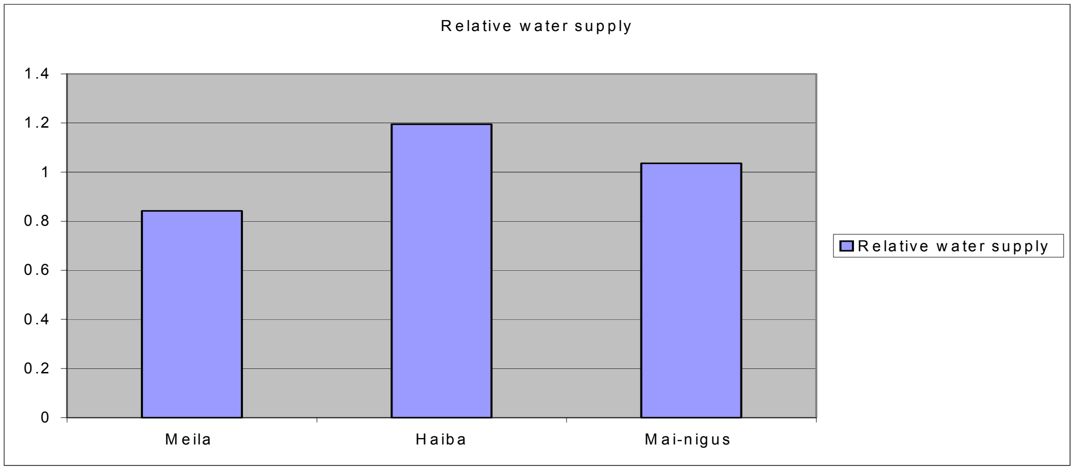

Fig 5.5 Relative water Supply

As it is displayed in the graph there is good water supply in Haiba and the water supply in Ma'ynugus is also enough but in Meila it is below a unit that is 0.84 .But this is not considered as a problem rather it is considered as producing by deficit irrigation with short water supply in order to maximize returns on water harvested.

3.2.3 Relative irrigation supply (RIS)

Relative irrigation supply shows whether the irrigation demand is satisfied or not. Since there was no rainfall in the area it is the same with the relative water supply.

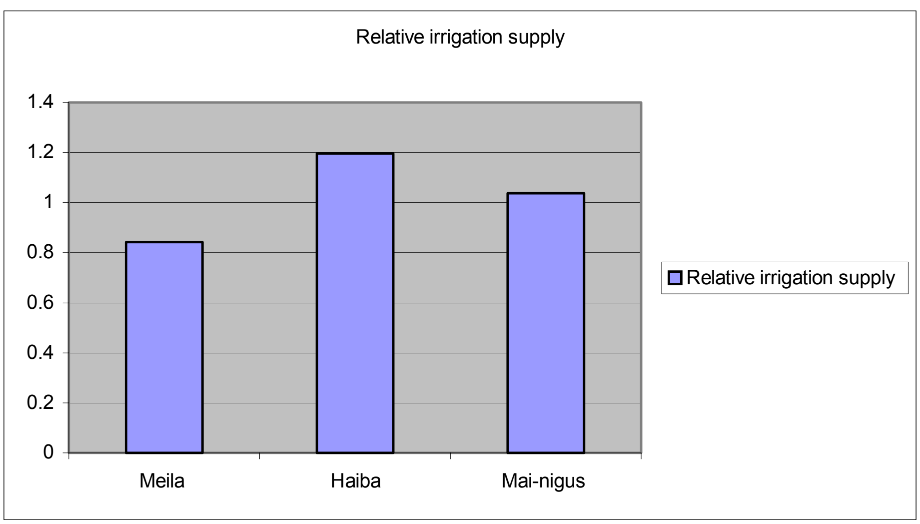

Fig.3.6 Relative irrigation supply

3.3 Financial performance

3.3.1 Gross return on investment

This indicator considers the production and the total cost of infrastructure for each scheme.

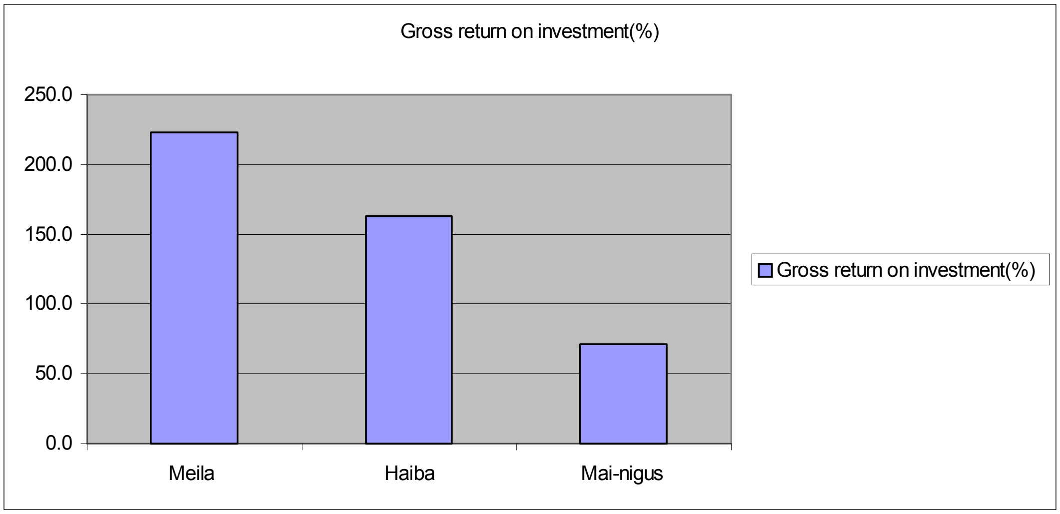

Fig.3.7 Gross return on investment

The graph shows that the gross return on investment of Meila is the best and for that of Ma'ynugus is the least. This is mainly associated with high infrastructure cost in Ma'ynugus. If we see the cost of infrastructure of Haiba and Ma'ynugus it is US$100959 and US$120947 respectively and the command area is 200ha and 123.9ha respectively. However the area irrigated in 1996 EC is about 71 % and 41% to their design potential for Haiba and Mainugus irrigation projects respectively. The cost of the infrastructure considered here is the total expenditure for constructing all infrastructures found in the in scheme excluding the cost of the headwork.

3.3.2 Financial self-sufficiency

Financial self-sufficiency indicates the revenue from the irrigation over the expenditure for operation and maintenance. The government covers the operation and maintenance of the schemes and it is considered as subsidy. Above and beyond, there is no fee for water it is for free. Therefore it is not possible to compare these schemes based on this indicator.

3.4 Internal Process indicators

In this part it is attempt to see the internal process indicators particularly the conveyance and application efficiency of the irrigation schemes. It is known that great amount of water is lost in unlined canal but it becomes considerable when the canals are not well designed and constructed appropriately.

More over, earthen canals are easily destructed when livestock and human beings are interfering and destructing the canal system and eventually result in huge water loss, which is the scarcest resource in the Agricultural production system of the region.

Fig.3.8 Livestock interference and overfilling of canals result in wastage of water and water logging

3.4.1 Conveyance efficiency

This is an efficiency, which indicates the amount of water lost during transportation of water from the reservoir or source to the field canal. Therefore the conveyance efficiency of Meila, Haiba, and Ma'ynugus are74.48%,53.2%, and 58.26%, respectively. It is also presented in the following graph.

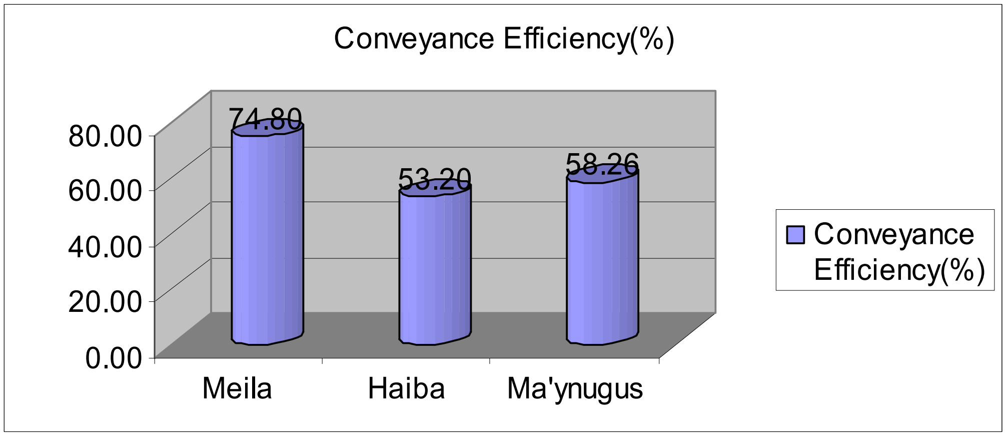

Fig.3.9 Conveyance Efficiency

As the graph indicates the conveyance efficiency of Meila is better than the rest two. This is probably associated with the quality of the canal works in Meila dam. In addition, the right secondary canal is crossing the marshy area and the losses may be compensated by the drains from the marshy area.

The fact also reveals that the canals in both Haiba and Ma'nugus are Ponding substantial water. This may be the most probable reason for this big water loss. You can see the following picture from the right secondary canal of Haiba dam.

Fig.3.10 Ponding water with very small speed in secondary canal, Haiba

Concisely, the main cause for these conveyance losses is the nature of the canal, which is unlined and result in huge water losses. Therefore, when we are saying

53.2% and 58.26% conveyance losses it means that the rest part i.e. 46.8% and 41.74% proportion of water is lost out of the total water harvested and stored in the reservoirs and it does mean something to water scares areas. And the investment in lining canal can be feasible until this cost is not exceeding the proportion equivalent to losses of the total investment of the irrigation schemes. In addition the farms found just at lower elevation of these canals have been suffering from poor drainage, which is a consequence of seepage water from the canals. This may hamper the motives to wards irrigation expansion.

3.4.2 Application efficiency

The application efficiency of a given irrigation scheme tell us whether the irrigation water is stored in the intended soil profile or lost as surface runoff or/and deep percolation. In this research it is also attempted to characterize the application efficiency of the stated irrigation schemes. The finding indicates that the application efficiency of Meila, Haiba, and Ma'ynugus are 72.84%, 64.7 % and 85.40% respectively.

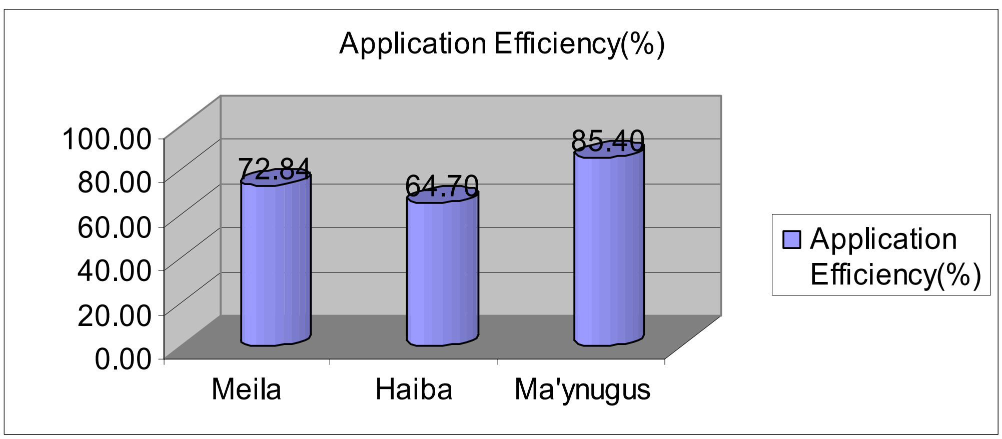

Fig 3.11 Application efficiency

Application efficiency is mainly related to the management of water at field level and it depicts that whether the water applied to the field is stored in the effective root zone of the soil profile or waste as runoff and deep percolation.

The finding indicates that the application efficiency of Ma'ynugus is best as compared to Meila and Haiba irrigation schemes. This may be associated with the experience they have in irrigation for several years and the strong bylaws practiced in the area.

In addition what is observed in the field is there is no responsible person who controls the amount of water applied to the field. There are responsible bodies called "Abo may" who control only persons belonging to water in that specific day and also controlling breaching of canals. But the amount of water needed to irrigate the farm decided by farm owner and the farm owners feel that they have to water more water assuming the next turn is long, actually the irrigation interval is not too long but their perception is different.

4. Conclusions and Recommendations

4.1 Conclusions

The utilization of water harvesting technique like small earth dams has a remarkable turn over in addressing the acute shortage of food production in the basin and in the country as well. This helps in providing food for the incremental population as a supplementary with rainfed agriculture, which is the dominant source of food production system in the country.

Despite the fact that every scheme has a contribution to wards food production, the degree of its contribution will vary from scheme to scheme since production is affected by many factors. So, the comparison of this irrigation schemes indicates the weaknesses and strengths of these irrigation schemes, which are helpful for managerial and technical practices.

The output per cropped area in Haiba is low as compared to Ma'ynugus, this means that the irrigation practice in Haiba is poor and in Ma'ynugus it is good. And the out put per unit command is high in Meila and low in Ma'ynugus this is mainly due to the absence of enough rainfall to fill the reservoir in that season. The return from one meter cube of irrigation water is high in Ma'ynugus and low in Haiba, this has an implication on the proper utilization of water, and therefore it is poor in Haiba. In addition the out put per irrigation supply of Haiba is very low as compared to Meila and Ma'ynugus, Meila is the highest this is due to practice of deficit irrigation. This was not deliberately done but due to wrong estimation of water in the reservoir. There was shortage of irrigation water at the end of the irrigation season.

The relative water supply is high (1.2) in Haiba and less in Meila, which is 0.8 but this is not considered as a problem rather it improves the return per irrigation water for the scheme. The relative irrigation supply of Meila is smaller than Haiba and Ma'ynugus.

The gross return on investment of Ma'ynugus is low, and high for Meila this variation is due to high infrastructure cost of Ma'ynugus.

There is no revenue collected for the operation and maintenance of the system. It is highly assisted by government. There are also beneficiaries' involvements in simple maintenance of canals and clearance of canals.

The conveyance losses in Meila, Haiba, and Ma’ynugus are 74.48%, 53.2%, and 58.26%, respectively and this is a big loss when we are considering the total investment cost for the development of these water-harvesting systems. And it is also good to lined the canals so that the total water harvested will be used to the intended purpose. Moreover, the farms at lower elevation than these canals suffering from seepage become safe and productive.

The application efficiency of Meila, Haiba, and Ma’ynugus are 72.84%, 64.7 % and 85.40% respectively. And the field management practice of Ma'ynugus farmers is better than farmers in both irrigation schemes.

There is no developed soil moisture characteristic curve for these irrigation schemes, which highly assists irrigation scheduling and finally contributes towards the improvement of application efficiency of the system.

4.2 Recommendations

- ✓ The comparison of the performance of irrigation systems will help to now the present status of these systems. Therefore for the improvement of the irrigation system management and the irrigation practice frequent performance evaluation is imperative.

- ✓ The output from cultivable area of Haiba is very poor. So it should improve its production by experience sharing from Ma'ynugus. Therefore farmers and development agents of these systems should share experience by visiting their sites one another. And this would be best if the government after identifying the weaknesses and strengths of each site by conducting subsequent performance evaluation assists it.

- ✓ The return from the water harvested in each scheme is varying and it is poor in that of Haiba. Therefore, to maximize the return from each drop of water a great effort should be carried out particularly in Haiba. This may be improved by implementing reasonable irrigation water fee than giving them for free because easy come easy go.

- ✓ The output per irrigation supply of Meila is high as compared to the rest of scheme. This is due to practice of deficit irrigation. Therefore, it is highly recommend practicing the same experience in other schemes as well.

- ✓ The introduction of cost sharing will help for operation and maintenance and other managerial activities of the irrigation systems. This should be started with very small rate per water consumed.

- ✓ Hydraulic flow metering structures should be constructed at deferent levels of the canals. This will assist to monitor the activities in relation to water utilization and irrigation efficiencies as well. Moreover this is a preliminary work for the introduction of fees in the system to make it based on the amount of water consumed.
- ✓ The conveyance loss is huge in the irrigation schemes. Therefore it is highly recommended to lined or construct by masonry the whole canal. Moreover the farmlands in lower elevation than canals become safe.
- ✓ The application efficiency of Haiba and Meila irrigation schemes are poor than the Ma'ynugus, therefore it is good to transform that experience to the rest dams. This can be done by giving subsequent training to the farmers.
- ✓ This paper also calls a proposal to develop a soil moisture characteristic curve of different irrigation schemes in the basin for the major soils.

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