An Assessment of the financial viability and income impact of small scale irrigation in Ethiopia

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Abstract

Recently, there has been very little irrigation development in sub-Saharan Africa. The main reasons cited for this lack of interest in developing irrigation in sub-Saharan Africa is that irrigation projects are expensive and perform poorly compared to projects from other regions. However, when classified into success and failure projects, the sub-Saharan Africa success projects' investment costs are not significantly higher than from other regions. African countries like Ethiopia, which has embarked on an agricultural led development program, aspire to use irrigation as a development strategy with small scale irrigation playing a key role in rural development. This study evaluates the financial performance of small scale irrigation using O & M and investment recovery, and the ability to replicate the investments. It is concluded that the systems are financially viable and provide a low cost development option for rural areas.

1. Introduction

Recently, there has been very little irrigation development in sub-Saharan Africa (SSA). The main reasons cited for this lack of interest in developing irrigation in SSA is that it was believed that irrigation projects in SSA are expensive and perform poorly compared to projects from other regions (Inocencio et al., 2007). In a study of 314 schemes of which 45 were from SSA, 51 from Middle East and North Africa, 41 from Latin America and the Caribbean, 91 from South Asia, 68 from South East Asia and 18 from East Asia, Innocencio et al (2007) showed that when average costs are considered, establishment costs for irrigation projects in SSA were significantly higher at an estimated USD14, 455 per ha compared to USD6, 590 for non-SSA projects. They further analyzed establishment costs by defining "Success" and "Failure" projects. In defining these they used 10 percent economic internal rate of return as a cut off point. Those projects that achieved less than 10 percent economic internal rate of return were classified as "Failure' projects. The justification for using 10 percent was that this is the cut off point used for evaluating public projects.

After applying this classification, they found that for the "Failure" projects in SSA the establishment costs averaged USD 23,184 compared to USD 10,624 for non-SSA projects, whereas for the SSA "Success" projects the average was USD 5,726 compared to USD 4,603 for non-SSA projects. This difference was not statistically significant showing that for "Success" projects, the SSA projects are not more expensive than their non SSA counterparts. Their analysis also shows that the performance of both non SSA and SSA projects has improved over time. Commenting on this performance improvement, they conclude that: "The degree and speed of improvements have been deeper and faster in SSA than in non-SSA, so that the difference in unit cost and project performance between SSA and non-SSA, which used to be significant in earlier decades, has been reduced to the extent that there is no significant difference in the latest decade". (Inocencio et al, 2007; pp 42)

Some countries in Africa, have a renewed interest and some like Ethiopia have recently become interested in the role that irrigation can play in the development process. Agriculture plays a major role in Ethiopia contributing more than 44 percent to GDP over the period 1996 to 2006 (Government of the Republic of Ethiopia, 2006_a). Most of agriculture's contribution is based on smallholders who produce cereals under rainfed production. This leaves the performance of the Ethiopian economy exposed to the vagaries of nature by depending on how good the rainfall season is (World Bank, 2006). The Ethiopian government, in its agricultural led development program, aspires to use irrigation as a major development component. Currently less than 5 percent of the potentially 3.5 million ha of irrigable land is developed. The government of Ethiopia aspires to develop about 430,061 ha within the planning period of the Plan for Accelerated and Sustained Development to End Poverty (PASDEP) which spans the years 2005/05 to 2009/10 (Government of the Republic of Ethiopia, 2006_b). This planning document aspires to strongly develop and support small scale irrigation (SSI).

Irrigation development in Ethiopia is classified using two systems. The first classification system uses the size of command area irrigated as follows:

1. Small scale irrigation systems <200ha
2. Medium scale irrigation systems (200-3000ha)
3. Large scale irrigation systems (>3000)

The second classification uses a mix of the history of establishment, time of establishment, management system and nature of the structures as follows:

1. Traditional schemes: These are SSI systems which usually use diversion weirs made from local material which need annual reconstruction or from small dams. The canals are usually earthen and the schemes are managed by the community. Many are constructed by local community effort and have been functional for very long periods of time, some were recently constructed with the aid of NGOs and government.
2. Modern schemes: These are SSI systems with more permanent diversion weirs made from concrete hence no need for annual reconstruction and small dams. The primary and sometimes secondary canals are made of concrete. They are community managed and have recently been constructed by government.
3. Public: These are large scale operations constructed and managed by government. Sometimes, public schemes have out growers whose operations are partially supported by the large scheme.
4. Private: These are privately owned systems that are usually highly intensive operations.

Given our interest in SSI, which is distinguished from large scale irrigation by the farm level scale of operation, we therefore prefer to identify SSI irrigation systems using the second classification system and we study the first and second categories of this classification. Werfring (2004) describes the typology of SSI in Ethiopia in detail.

Given the strong support envisaged for SSI development during the PASDEP planning period, it is important to provide insights into the viability of SSI investment in order to inform investment decisions.

2. Objectives

The main objective of the study is to provide a contribution that can be used to partially answer the question whether investment in SSI is a viable option for the proposed agricultural led industrialization development strategy by assessing the financial viability of existing SSI. Supplementary to the main objective we also estimate the importance of agriculture to rural smallholders by estimating how much income is derived from agriculture compared to off farm sources. PASDEP aspires to develop and support SSI but the current farm level contribution of irrigation to the rural households is not known. This paper also aims to estimate the income impact of irrigation to smallholder producers

3. Methodology

The methodology we use is partially based on that used by Huang et al (2006) to evaluate benefits and costs of irrigation systems in China. We use gross margin analysis to estimate agricultural income for irrigators and non irrigators. Based on the gross margins, we estimate the income contribution of agriculture in general and irrigation in particular to the household.

In order to assess the financial viability of SSI we define three indices;

1. O & M index = GMI / O & M.
2. Financial performance index = GMI / (I + O& M.).
3. Replicability index = GMI – (I + O & M) / (I + O & M).

Where: GMI = Gross margin from irrigated production, O & M = Operation and maintenance costs, I = annual replacement cost all on a per ha basis. Annual replacement cost is computed as initial investment divided by project lifetime. Project lifetime is assumed to be 30 years (Innocencio, 2007). Verdier (1992) gives estimates of O & M for earth work (canals, drains, feeder roads with no tarmac) as 2 percent of investment, and concrete structures (river diversion, weir and inlet) as 1 percent of initial investment. In this study O & M is assumed to be 10 percent of annual replacement cost.

The first index shows farm level ability to recover O & M costs. If farmers cannot recover O & M, it renders the scheme non-financially viable. The second index shows whether farmers recover both initial investment and operation and maintenance costs. Ideally, in a financially viable scheme, both investment and O & M should be recovered. The third index shows whether farmers can recover both initial investment and operation and maintenance costs and still have the potential financial capacity to reinvest in a similar SSI system, in other words, could the schemes potentially financially perpetuate themselves.

4. Data collection

Data were collected on the initial investment or establishment costs for the small scale irrigation systems. During the growing season May 2005 to March 2006, plot level data were collected from ten SSI schemes. Data were collected on cropping patterns, areas under crops, yields, marketed output, inputs, and input and output prices. Since farmers usually grow at least two crops, sometimes three on the irrigated plots, the cropped area is summed across seasons. On each of the schemes, a random sample of 50 farmers was selected. A random sample of 50 non irrigating farmers was also selected from each site as a control. Data were also collected on non-agricultural income so as to estimate the contribution of agriculture and irrigation to household income.

During the summer most of SSI systems grow cereals like teff, maize and barley under supplementary irrigation given that it rains during the summer. During the winter farmers grow a variety of vegetables including onions, tomatoes, and leafy green vegetables like spinach under full irrigation. Rainfed farmers' production is primarily based on the staple cereals teff, wheat, barley and sorghum. Both rainfed and irrigating farmers also grow perennial crops like mango, banana, sugar cane which are sometimes intercropped with seasonal crops. Data were collected on all crops grown on a sampled farm.

During data collection we took cognizance of the fact that most of the cereal production is kept for home consumption. The computation of gross margins was based on data collected on yields and the prices of marketed output. For instance, if a farmer sold half of the wheat yield, we assumed that the prices realized in the market would have also been realized by the farmer if the rest had been sold. Although it is possible that if more produce is put on the market, prices tend to reduce we also argue that the shadow price attached to the retained output by the farmer has to be higher than the market price, assuming a rational farmer would sell if their shadow price is lower than the market price.

Most farmers, both irrigating and rainfed mainly grow seasonal crops but some do grow perennial crops. Data on the input-output relationships of seasonal crops were easier to collect than those of perennial crops. For instance, there could be some perennial crops intercropped and spaced within a seasonal crop. The area was better estimated for the seasonal crop than for the perennial crop. Even though in some cases of modern irrigation schemes where most the area was under a perennial crop like banana, the input-output relationships were still much easier and accurate for seasonal crops since the operations on the perennials are not as regular and consistent as on the seasonal crops. Based on these two observations, this analysis only includes the sites with seasonal crops.

5. Challenges in data collection

During the process of collecting the data on establishment costs, we realized that the data on small scale irrigation systems is not systematically collected and kept in a central location. The data, if available, could be found for different schemes in different locations, for instance in different ministries. Sometimes data were found in one location, like a ministry, but different departments. Furthermore, some data is kept at federal level, whereas other data are kept at regional and sometimes district level. Some regional authorities pass information to the federal level, for instance to the Ministry of Water Resources, but some simply do not. If a donor is involved in the project establishment, sometimes the donor keeps the records, if at all. This made the process of collecting establishment costs for even a small sample of SSI systems quite an arduous and time consuming task. Given this, even though we started off with 10 schemes, three traditional and 7 modern, we could only collect accurate investment information on all the modern schemes and only one traditional system. The Hare modern scheme was excluded from the sample for the reason of perennial crops as mentioned earlier so the final sample, for the financial viability analysis, was made up of one traditional and six modern schemes. Even though the data is still not centralized for modern schemes, the likelihood that it exists and that it can be accessed is higher for modern schemes than for traditional ones since the modern schemes are usually built with some form of government involvement at regional or federal level. The data for most traditional schemes is very difficult to come by. Bruns (1991) notes that there is a serious lack on information on SSI.

6. Income levels and dependence on agriculture and irrigation

Table 2 summarizes the cropped area and incomes for the sample farmers. The average irrigated area for all the sample irrigated systems is 0.71 ha, but is slightly higher for modern schemes at 0.76 ha while it averages 0.58 ha for traditional systems. The highest irrigated area is at Endris modern irrigation system at 1.07 ha while the lowest is at Haiba modern irrigated

system at 0.35 ha. Average cropped area for the rainfed farmers is 1.41 ha.
Table 2 also shows the extent to which the sample households depend on agriculture for income. In table 1, total income is the sum of agricultural income, irrigated and non

Table 1. Income dependence on irrigation for sample schemes.[1]

Region	**Site name**	**Site type** (Irrigation/Rainfed)	**Area (ha)** Irrigated[2]	Rainfed	**Income** Total[3] (USD)	Agricultural income % of total Rainfed + irrigated	Irrigated
Oromia	Endris	Modern [n=42]	1.07 (1.20)	1.88 (1.46)	603 (975)	83	36
		Traditional [n=41]	0.65 (0.81)	1.40 (1.19)	471 (1198)	90	38
		Rainfed (n=55)	N/A	2.75 (1.47)	360 (288)	90	N/A
	Wedecha Belbella system	Modern [n=51]	0.46 (0.35)	1.13 (0.68)	771 (493)	92	44
		Traditional Filitino [n=52]	0.56 (0.41)	0.94 (0.47)	570 (404)	98	45
		Rainfed [n=57]	N/A	1.36 (0.59)	468 (315)	99	N/A
	Gologota	Modern [n=52]	0.96 (0.41)	N/A	713 (721)	88	86
		Rainfed [n=55]	N/A	1.39 (1.21)	304 (203)	71	N/A
Amhara	Zengeny	Modern [n=49]	0.85 (0.77)	0.76 (0.39)	552 (633)	91	58
		Rainfed [n=47]	N/A	0.81 (0.46)	261 (326)	90	N/A
	Tikurit	Traditional [n=55]	0.47 (0.49)	0.90 (0.86)	576 (639)	95	55
		Rainfed [n=42]	N/A	1.18 (0.76)	277 (164)	96	N/A
Tigray	Haiba	Modern [n=47]	0.35 (0.28)	0.73 (0.43)	346 (297)	82	34
		Rainfed [n=53]	N/A	0.72 (0.37)	240 (251)	80	N/A
	Golgol Raya (Kara Adishu)	Modern [n=26]	1.03 (0.60)	1.86 (1.15)	1100 (1071)	80	52
		Rainfed [n=22]	N/A	1.59 (0.89)	247 (320)	100	N/A
		All Modern [n=42]	0.76 (0.71)	1.16 (0.96)	650 (728)	87	53
		All Traditional [n=42]	0.58 (0.59)	1.09 (0.87)	536 (806)	95	45
		All Irrigated	0.71	1.13	616	89	50

[n=42]	(0.68)	(0.93)	(753)		
All rainfed	N/A	1.41	318	88	N/A
[n=42]		(1.12)	(278)		

1 ( ) = sdev; 2 = Gross irrigated area summed over the cropping seasons. 3= Total income (agricultural + non agricultural)

irrigated plus non agricultural income. Income from agriculture and that from irrigation is expressed as a percentage of total income to show the income dependence on agriculture and irrigation. For instance, the average annual income at Endris modern irrigation scheme is 603U SD. On average 83 percent of the 603 USD is derived from agriculture (irrigated and non-irrigated) and 36 percent of the 603 USD is derived from irrigated agriculture. Agricultural income at Endris modern irrigated system is about 500 USD and income from irrigated production is about 217 USD, meaning irrigated agriculture contributes slightly more than 43 percent of agricultural income, even though gross irrigated area is less than rainfed area. This makes agriculture a highly significant contributor to income for the smallholders, much more so than the dependence on agriculture depicted at national level. It also shows that irrigation, when made available, can play a significant role in contributing to the income of rural households particularly if we take into cognizance the small areas of irrigation developed per household.

For all irrigated systems, agricultural income constitutes about 90 percent of income, while it appears to contribute a slightly higher proportion on traditional irrigation systems. The lowest contribution of agricultural income is at Gologota rainfed system at 71 percent while it is highest for Golgol Raya rainfed farmers at 100 percent. This may be explained by the fact that Golgota is close to the capital city, several towns and public schemes which offer employment opportunities whereas Golgol Raya is several kilometers from the capital city and also has neither towns nor public schemes in its proximity, hence has limited off farm employment.

Irrigation contributes significantly to income at an average 50 percent for the whole irrigated sample while it appears to be slightly lower at traditional irrigated schemes at 45 percent. Given the significant contribution of irrigated agriculture to income, it is essential to establish if the systems are financially viable both in the long and short term.

One of the concerns raised by the World Bank (2006) is that, given the national dependence on rainfed agriculture, the performance of the economy is directly related to the quality of the rainfall season. We have demonstrated that this statement is even truer for rural smallholders whose incomes are a direct function of the quality of the rainfall season, given their high income dependence on agriculture. Irrigation, if it uses stored water, can be used to de-link the performance of the national economy, and more so the incomes of the rural poor smallholders from the quality of the rainfall season.

7. Investment levels for sample schemes

Table 2 summarizes the investment levels for the sample SSI schemes. Constant 2006 prices were used to make the figures comparable since the cropping data came from 2005/2006 growing season and the schemes were established at different times. The exchange rate of 1USD = 8.69 Birr which prevailed in 2006 (CIA, 2007) was used to convert the expenditures in Birr to USD. The average per ha initial investment cost is estimated at 2090 USD per ha. This estimate does not include possible contribution by the community on the form of labor and other materials. The data show that the systems are low financial investment irrigation projects as this is slightly under 40 percent of the figure quoted by Inocencio et al (2007) for success projects in SSA. Annual O & M costs were estimated as 10 percent of annual replacement costs.

Table 2. Investment levels for small scale irrigation schemes in constant 2006 prices

Region	Scheme name	Scheme type	Year established	Command area (ha)	Investment (USD/ha)		
					Initial Investment	Annual replacement	O& M
Oromia	Indris[1]	Modern	1980[4]	382	744.96[6]	24.83	2.48
	Gologota[1]	Modern	1962[4]	850	870.53[7]	29.02	2.90
	Wedecha	Modern	1990[5]	150	3436.89[8]	114.56	11.46
	Belbella system[2]	Traditional Filitino	1990[5]	85	2544.65[9]	84.82	8.48
Amhara	Zengeny[1]	Modern	1997[4]	270	1071.80[10]	35.73	3.57
Tigray	Haiba[2]	Modern	1997[4]	250	2087.52[11]	69.58	6.96
	Gol Gol Raya (Kara Adishu)[3]	Modern	2003[4]	104	3864.52[12]	128.82	12.88

Water source and delivery system: 1 River diversion and gravity, 2 Small dam and gravity, 3 Deep well and pressurized drip and sprinkler.

Year established: 4= actual, 5=based on feasibility study

Sources of Investment figures: 6. Indris Irrigation project. RID-OFFICE for C.Z. 1991. Porject proposal report. Information Brochure. Idris Irrigation Development project, 7. Average of sample modern schemes, 8. East Shoa Water Mineral and Energy Resources Department (1998). Goa Worka Small Scale irrigation Project Proposal Final Draft , 9. East Shoa Water Mineral and Energy Resources Department (1998). Filtino Small Scale irrigation Project Proposal Final Draft , 10. Personal communication Yenew Desalegn, Irrigation expert. Zengeny irrigation scheme, 11. Co-SAERT (1993).List of irrigation sites constructed by Co-SAERT from 1987-1992 E.C. Unpublished., 12. Raya Valley ground water Development report. Unpublished.

Note: Investment data for the traditional schemes at Endris and Tikurit t which are included in the income analysis, table 1, were not available.

Investment costs differ by site and region. It is beyond this paper to establish the reasons for the variations but this might partly depend on the water source and delivery system. The scheme with the highest establishment cost, Gol Gol Raya, has deep wells as water source and uses a pressurized drip and sprinkler system. We also note that for the two Wedecha Belbella systems, which are close to each other, the traditional system investment is lower, most likely reflecting less concrete infrastructure installed on the traditional system.

8. Assessing the financial viability of SSI

Table 3 summarizes the results of the financial viability analysis. Based on the

three indices defined above we get some insights into the financial viability of irrigated schemes. At the onset, we have to point out that this analysis only provides insights into the financial viability of these systems because it is based on one year's data. Given the variation of agricultural performance from year to year, ideally more than one year's data on gross margins would provide better insights. If more than one year's data is available, one could do many scenario analyses, one of which could be to use both the performance and replicability indices with a flow of gross margins and investment costs.

Table 3. Performance ratios for small scale irrigation systems

Region	Scheme name		Index Category	O & M	Financial	Replicability
			Distribution within Performance Indices (%)			
Oromia	Indris		<0	5	5	11
			GE 0 < 1	0	5	14
			GE 1	95	90	74
			Mean	111	10	9
	Gologota		<0	10	10	10
			GE 0 < 1	0	0	2
			GE 1	90	90	88
			Mean	245	22	21
	Wedecha Belbella system	Modern	<0	2	2	8
			GE 0 < 1	0	6	10
			GE 1	98	92	82
			Mean	70	6	10
		Traditional	<0	0	0	4
			GE 0 < 1	0	4	12
			GE 1	100	96	84
			Mean	68	6	5
Amhara	Zengeny		<0	0	0	0
			GE 0 < 1	0	0	2
			GE 1	100	100	98
			Mean	141	13	12
Tigray	Haiba		<0	0	0	17
			GE 0 < 1	2	17	23
			GE 1	98	83	60
			Mean	65	6	5
	Gol Gol Raya (Kara Adishu)		<0	0	0	19
			GE 0 < 1	4	19	19
			GE 1	96	81	62
			Mean	39	4	3
	All Modern		<0	3	3	10
			GE 0 < 1	1	7	11
			GE 1	96	90	79
			Mean	119	11	10
	All		<0	2	3	9
			GE 0 < 1	1	6	11
			GE 1	97	91	80
			Mean	111	10	9

that takes into account the time value of money for both costs and returns flows in computing either an Internal Rate of Return and or Net Present Value. Alternatively, instead of computing an internal rate of return, one could also assume that farmers could borrow money at a certain interest rate, for instance the rate at which the government borrows for development projects, annualize the cost flows by the interest rate and then evaluate whether the farmers earn a return higher than the interest rate. We do understand that such analyses would be more informative than the one done here. However, we believe that in the absence of data to achieve such, our analysis is informative, even though at best, it gives us the performance of the systems for one year, say emulating the first year of the project.

In our suite of indices, the first index shows whether the systems recover operation and maintenance costs. If it is negative, irrigated income is less than O & M, if it lies between 0 and 1, O & M is only partially recovered and if it is greater than 1 O & M is fully recovered. The same interpretation applies for the financial performance ratio where instead of O & M the sum of annual replacement cost and O & M is used to determine cost recovery. The means for these indices shown in table 3 show that most of the schemes recover O & M. It is possible that we may have underestimated O & M, at 10 percent of investment, however, the degree to which most of the schemes recover O & M leaves a lot of room for O & M to increase substantially but still being recovered. The lowest O & M index mean value is 39 for Golgol Raya and the highest is 245 for Gologota. The low O & M index at Gologol Raya can be explained by the fact that the deep well water source combination with drip and sprinklers requires more maintenance than the diversion weir and gravity flow used in the other systems.

Of importance is also the percentage distribution of farmers between the ratios across systems. For instance, at Endris modern irrigation scheme, 95 percent of farmers fully cover their O & M costs, and 90 percent cover both investment and O & M costs. In comparison at Golgol Raya 96 percent fully cover O & M costs while 81 percent cover investment plus O & M costs. In general, at all the schemes, 90 percent or more cover O & M costs while the lowest percentage covering investment costs is at Golgol Raya at 81 percent. This shows that farmers have the ability to pay for both O & M and investment costs.

The replicability index asks the question if farmers were to pay for the current scheme and to concurrently invest in a similar one, could they manage it, in other words, could the systems potentially financially perpetuate themselves. The answer to this question is yes they could manage. The lowest percentage of farmers with this ratio greater than one is at Haiba with 60 percent, followed by Golgol Raya with 62 percent. We do understand that this analysis evaluates what could happen; otherwise the income earned from irrigation is subject to many competing family needs which generally do not include reinvestment. This is just a simple way of evaluating financial viability. From this simple analysis, the SSI systems are financially viable and could also potentially financially perpetuate themselves. Adams (1990) notes that, if they can be viable, SSI provide a low cost, low technology alternative to development.

9. Conclusions

The financial analysis shows that SSI projects in Ethiopia are very low investment ventures. From the three indices we used, we conclude that the systems are financially viable. However, it is important to note that only one year’s data has been used in this analysis and therefore is missing the variability in returns that is characteristic of agricultural production. The financial viability performance is in line with the observations made by Inocencio et al (2007) of improved performance of recent irrigation projects in SSA. This makes investment in SSI a potentially viable low investment, development alternative.

We show the degree to which Ethiopian farmers depend on agricultural income, and specifically on irrigated income and how this varies by location. The analysis shows that SSI development has potential for improving the well being of the poor farmers through its significant impact on incomes.

It is important to note that all of the schemes evaluated in this study use diversion weirs, except one which uses underground water and another using a small dam, thus their performance dependends on the quality of the rainfall season. The schemes using diversion weirs although cheap to establish, cannot achieve one of the government's objectives of de-linking national economic performance and farmers' incomes from the quality of the rainfall season. The financial viability of these SSI systems however, provides insights into the fact that stored water could also be potentially used for SSI to de-link irrigation performance for the quality of the season. However, this needs to be evaluated against the investment costs for the stored water.

Finally, given the experience of collecting data on establishment costs for SSI, we conclude that data management and centralized systematic data collection of SSI investment and production data is definitely one area where there could be significant improvement in Ethiopia. Well organized data collection assists analyses that help inform decision making for policy makers.

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