Spate Irrigation and Poverty in Ethiopia

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Abstract

The study examined whether the use of spate irrigation in drought-prone areas of Ethiopia reduced poverty. Each of about 25 users of indigenous and modern spate irrigation schemes and an equal number of corresponding nonusers from the same peasant associations in Oromia and Tigray regional states were interviewed. The survey found that the poverty level of the spate irrigation users was significantly lower than that of the nonusers in terms incidence, depth and severity. Access to improved spate irrigation has led to reduced poverty, measured by all poverty indices, compared to traditional spate. Finally, the dominance test showed that the poverty comparison between users and nonusers was robust. From the study, it can be concluded that the use of spate irrigation in areas where access to other alternative water sources is limited, either by physical availability or by economic constraints, can significantly contribute to poverty reduction, and that modernizing the spate system strengthens the impact.

Key words: *Headcount ratio, poverty gap, severity of poverty, stochastic dominance test, Ethiopia, Africa*

Introduction

Most farmers in drought-prone lowlands of Ethiopia produce only once a year. A long dry spell or drought can lead to crop failure that exacerbates food shortage and poverty. The severity of such climate-related crop failures increases with decreasing altitude. The Ethiopian government is convinced that full or supplementary irrigation is required to minimize the risk of crop failure (FDRE 2010), depending on the availability of the water resources.

Flood-based farming including spate irrigation (SI) 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. SI is a unique form of water resources management that has been practiced in arid and semiarid regions where evapotranspiration greatly exceeds rainfall (FAO 2010). It is a form of water management involving the diversion of flashy floods running off from mountainous catchments, using simple deflectors of bunds constructed from sand, stones and brushwood on the beds of normally dry wadis (Lawrence and Steenbergen 2005).

Spate irrigation (SI) has been practiced by farmers in different parts of Ethiopia for many decades as a relatively low-cost and technically simple alternative. It was only recently that the government and other development partners began to pay attention to spate. According to Alemayehu (2008), SI is practiced in Tigray, Amhara and Oromia regional states. Since antiquity it has also been practiced at Konso in Southern Nations, Nationalities and People's Region (SNNPR) and in places like Aba'ala in Afar Region (Spate Project Technical Report 2012). SI is very common in Raya Azebo (Tigray), Kobo (in Amhara), Dedota and Arsi Negelle (Oromia) and Omorate (SNNPR). Recent estimates for the area under SI in Ethiopia are not available, but Alemayehu (2008) reported about 140,000 ha of land under SI system in 2008 with a very high annual increase anticipated. Over the last two to three decades, there has been an increased investment in improving the traditional schemes or development of new SI schemes in different parts of the country with the objectives of ensuring food security and poverty reduction.

SI schemes can be classified as traditional and modern diversions (for details see Erkossa et al. 2013). Traditional diversions consisting of deflecting spurs or, in flatter plains areas, bunds that are constructed across the flood channel and canals, are usually short and rarely include a secondary distribution system. Improved traditional systems are farmer-implemented, improved diversion structures and rejection spillways near canal heads, drop structures and flow diversion structures in main canals. In modernized and new systems, numerous traditional intakes are replaced with concrete diversion weirs with sediment sluices as well as steep canals and sediment management structures to minimize sedimentation (Erkossa et al. 2013). This study used only two typologies, traditional and improved, without modern improved SI systems.

Various studies indicated the positive impacts of permanent irrigation on productivity and people's livelihood as measured in marginal factor productivity, poverty (income and expenditure) and food security (Hanjra and Gichuki 2008; Hanjra et al. 2009; Namara et al. 2010; Hagos et al. 2012, 2013). As far as we could tell, however, there is no empirical evidence on the impact of SI on household poverty.

The study aims, therefore, to explore if SI has a significant impact at household level in improving livelihoods of smallholder farmers. It seeks to address the following research question: Does SI lead to significant reduction in household poverty? The study provides evidence on whether investing in SI has important implications on livelihoods (measured in terms of household poverty), which is important for the policy decision to promote this particular intervention.

Methodology

We estimated poverty following the money metric approach. Income or consumption could be used as the indicator of well-being. Most analysts argue that, provided the information on consumption obtained from a household survey is detailed enough, consumption is a better indicator than income for poverty measurement for many reasons (Coudouel et al. 2002). Hence, in this paper we estimated poverty profiles using expenditure adjusted for differences in household characteristics. The food and absolute poverty lines for 2010/11 were determined to be Birr 1,985 and 3,781, respectively (FDRE 2012). These values were used to calculate poverty indices.

We used the Foster-Greer-Thorbecke (FGT) class of poverty measures to calculate poverty indices (Foster et al. 1984). The FGT class of poverty measure is given as follows:

$$P_\alpha = \frac{1}{N}\sum_{1}^{N}\left(\frac{G_i}{z_i}\right)^{\alpha}, (\alpha \geq 0) \quad (1)$$

where, z denotes the poverty line, G_i Difference between expenditure per adult equivalent and poverty line for household *i* N = Total population (of the sample), and α is a nonnegative parameter indicating the degree of sensitivity of the poverty. It is usually referred to as the poverty aversion parameter. Higher values of the parameter indicate greater sensitivity of the poverty measure to inequality among the poor. The relevant values of α are 0, 1 and 2.

The FGT class of poverty measures have some desirable properties (such as additive decomposability), and they include some widely used poverty indices (such as the head-count ratio, poverty gap and severity of poverty measures). Following Duclos et al. (2006), the relevant values of *a* are 0, 1 and 2 where at $a = 0$ the equation measures poverty incidence or the headcount ratio, at $a = 1$ the equation measures depth of poverty (poverty gap) and at the equation measures poverty severity index or squared poverty gap. This takes into account not only the distance separating the poor from the poverty line (the poverty gap), but also the inequality among the poor.

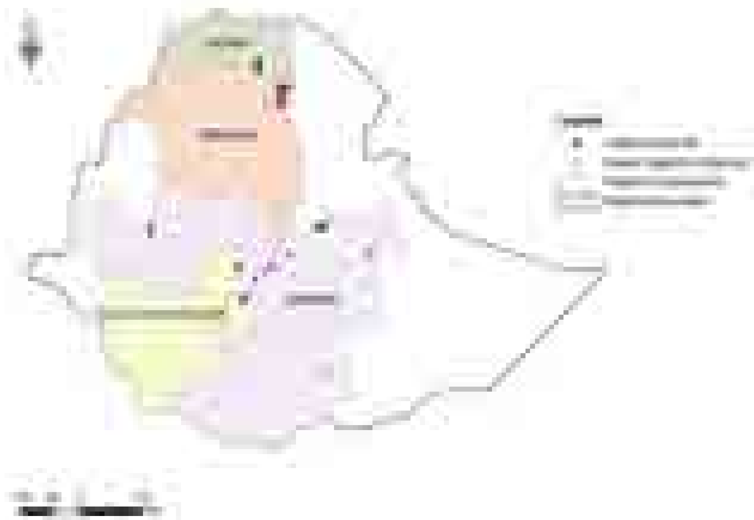
We calculated these indices using STATA 11.0 and tested for differences in poverty profiles between groups following approaches suggested by Kakwani (1993) and Davidson and Duclos (2000).

Poverty comparisons can, however, be sensitive to the choice of the poverty line. The important issue in poverty analysis is that the poverty line yields consistent comparisons (Ravallion 1994). Stochastic tests used to check the robustness of ordinal poverty comparisons prove to be useful in poverty analysis (Atkinson 1987). The idea of standard welfare dominance is to compare distributions of welfare indicators in order to make ordinal judgment on how poverty changes (between groups in this paper) for a class of poverty measures over a range of poverty lines (Ravallion 1994; Davidson and Duclos 2000). Hence, we conducted ordinal poverty comparisons using stochastic dominance tests and checked the robustness of the poverty orderings. This is to make ordinal judgments on how poverty changes for a wide class of poverty measures over a range of poverty lines.

Study sites and data sources

Two sites each in Tigray and Oromia were chosen for this study, with one traditional and one improved traditional. In Tigray, the sites included Fokisa (improved) and Gereb Heshewa (traditional). In Oromia, the sites were Dodota (improved) and Awadi (traditional). These sites were a subsample of samples (see Figure 3.1) used earlier in characterizing spate irrigation in Ethiopia (Erkosssa et al. 2013). From each site, 50 households were systematically selected for the purpose of this study, 25 users and 25 nonusers of spate irrigation. Each selected household was interviewed, using a pretested questionnaire, on access to services and infrastructure, demographic characteristics, access and use of spate irrigation, crop, livestock credit and off-farm income, food and nonfood expenditure, food security, and nutrition and health outcomes. Food and nonfood expenditures were used to assess the poverty impact of access to SI.

Figure 3.1. Location of the spate irrigation schemes and sites visited for this study.



Results and Discussion

Section 4 provides the results of summary statistics, poverty profiles and stochastic dominance tests, reported below.

Descriptive summary

The mean comparison tests indicate that users are better-off than nonusers, on average, in terms of several livelihood indicators (see Table 3.1), such as food expenditure, nonfood expenditure, completed primary education, etc. SI users have also a statistically higher livestock holding, family size (although insignificant in terms of female adults) compared to nonusers. This may imply that SI users are better-off compared to nonusers. But a mean comparison test does not consider the effect of other covariates in the calculation of mean value of a given variable and assessing the difference between groups. Thus we could not reach a final conclusion before we made a systematic analysis (by controlling other covariates) on whether access to SI has led to significant effects on household poverty.

Table 3.1. Mean comparison of spate users and nonusers.

Variable name	Mean of user of spate (n= 97)	Mean of nonusers of spate (n= 97)	t-test
Age of household head (in years)	43	42.1	0.445
Family size (in number)	5.361	4.814	-1.877*
Female adults (in number)	1.271	1.302	0.409
Male adults (in number)±	1.536	1.474	-0.411
Off-farm income (in ETB)	1490.88	1197.15	-0.568
Asset holding (in TLU)	1.845	1.281	-1.720*
Livestock income (in ETB)	783.21	1453.57	1.216
Credit income (in ETB)	740.38	753.51	0.075
Food expenditure during the last month (in ETB)	1951.46	1488.74	-2.330**
Nonfood expenditure during the last month (in ETB)	434.73	216.31	-2.625***
Total expenditure during the last month (in ETB)	2386.2	1705.057	-2.873*
Members' quantity, completer primary education	2.1237	1.659	-1.905**
Members' quantity, completer secondary education	0.773	0.659	-0.629

In some cases, observations (n) are not similar in number: ┼ = one observation is missing; ±= users 84 and nonusers = 78. *, **, *** significant at 10, 5, 1%, respectively.

Poverty indices

The study indicated that overall poverty in the study sites was lower compared to the national figures released in 2012 based on household income and expenditure survey (HICE) of 2010/11. The food poverty headcount index and food poverty gap index in the country are estimated at 33.6 and 10.5%, respectively, in 2010/11 while the national food poverty severity index stood at 4.6% (FDRE 2012). The incidence of food poverty of the overall sample is 5.5%, while depth and severity of food poverty are estimated at 0.4 and 0.05%, respectively. That is 5.5% of the individuals in the population were below the poverty line while the average distance from the poverty line is estimated at 0.4% (poverty gap) of the poverty line (or 794 Birr.month^{-1}.individual^{-1} that is required to bring the poor out of poverty) and about 0.05% severely affected by inequality.

On the other hand, as regards absolute poverty, 27% of the population are poor (headcount index) while poverty gap and severity of poverty are estimated at 6.7 and 2.2%, respectively (see Table 3.2). That is, about 27% of the individuals in the population in the study site were below the absolute poverty line (absolutely poor), considering both food and nonfood expenditures. The poverty gap, which is the average distance from the poverty line, is estimated at 6.7% of the poverty line amount (or Birr 2,646 month^{-1} individual^{-1} are required to bring the poor out of poverty). Finally, inequality is very severe for 2.2% of the individuals.

Table 3.2. Poverty indices of users and nonusers.

	Poverty indices		
Categories	P0	P1	P2
Food poverty of the overall sample (n = 577)	0.055 (0.009)	0.004 (0.001)	0.0005 (0.0002)
Absolute poverty of the overall sample (n = 577)	0.272 (0.018)	0.067 (0.005)	0.022 (0.002)
Food poverty SI users (n = 194)	0.031 (0 .012)	0.002 (0.0015)	0.0004 (0.0004)
Food poverty SI nonusers (n = 394)	0.068 (0.0127)	0.0046 (0.0012)	0.00063 (0 .0003)
z-statistics*	-44.562**	-27.534**	-15.886**
Absolute poverty SI users (n = 194)	0.186 (0.0279)	0.0373 (0.0073)	0.0116 (0.003)
Absolute poverty SI nonusers (n = 394)	0.319 (0.0235)	0.0817 (0.0073)	0.0278 (0.0031)
z-statistics	-99.928**	-91.728**	-74.865**

* The z-statistic is derived using Kakwani's (1993) and Davidson and Duclos' (2000) formulae to test for equality of poverty measures. The critical value for the test statistic is 1.96 (applicable for all tests in Tables 3.2 and 3.3) at 5% level of significance.

** Significant at 5% level of significance.

Access to SI significantly reduced household poverty. The headcount ratio of food poverty with and without access to SI is 3.1 and 6.8%, respectively. Similarly, the poverty gap of food poverty with and without access to SI is 0.2 and 4.6%, respectively. The severity of poverty of food poverty with and without access to SI is 0.4 and 0.6%, respectively. The corresponding ratios of incidence of poverty for absolute poverty with and without access to SI are 18 and 32%, respectively, while those of the poverty gap of absolute poverty with and without access to SI are 3.2 and 8.2%, respectively, and the severity of poverty of absolute poverty with and without access to SI is 1.1 and 2.8%, respectively. The poverty indices could be interpreted in a similar manner, as indicated above.

The use of improved SI resulted in a significant difference in household poverty levels as compared to the use of traditional SI schemes (see Table 3.3). The headcount ratio of food poverty with improved and traditional SI is 2 and 6%, respectively. The poverty gap of food poverty with improved and traditional SI is 0.3 and 0.5%, respectively. The severity of poverty of food poverty with improved and traditional SI is 0.1 and 01.1%, respectively.

Table 3.3. Poverty indices of users and nonusers.

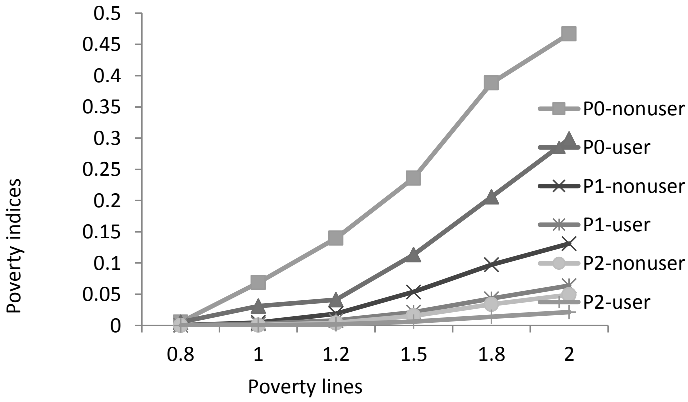
	Poverty indices					
Categories	P0		P1		P2	
Food poverty of improved SI (n = 246)	0.020	(0.009)	0.003	(0.001)	0.001	(0.0003)
Food poverty of traditional SI (n = 434)	0.060	(0.0114)	0.005	(0.0012)	0.0011	(0.0002)
z-statistics	-	53.362**	-	30.889**	-	19.249**
Absolute poverty of improved SI (n = 246)	0.219	(0.026)	0.0537	(0.007)	0.016	(0.003)
Absolute poverty of traditional SI (n = 434)	0.295	(0.022)	0.080	(0.007)	0.027	(0.003)
z-statistics	-	174.729**	-	100.411**	-	83.909**

** Significant at 5% level of significance.

Robustness of the ordinal measure

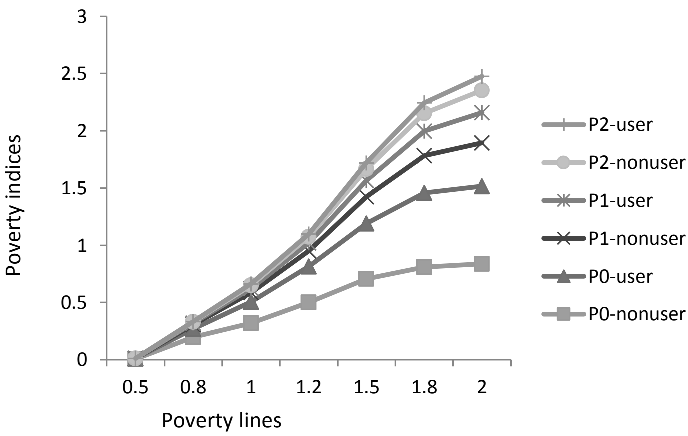
Whether poverty comparisons between the users and nonusers are robust could be examined using stochastic dominance tests. The test results indicated that the probability distributions of poverty indices (P0, P1 and P2) of users in food poverty are stochastically dominant than the distribution of poverty indices (P0, P1 and P2) of nonusers (see Figure 3.2).

Figure 3.2. Stochastic dominance test of food poverty of users and nonusers.



Likewise, the test results indicated that the probability distributions of poverty indices (P0, P1 and P2) of users in absolute poverty are stochastically dominant than the distribution of poverty indices (P0, P1 and P2) of nonusers (see Figure 3.3).

Figure 3.3. Stochastic dominance test of absolute poverty of users and nonusers.



The above result indicated that the poverty comparison between the users and nonusers is robust. In other words, regardless of changing the poverty line, the probability distribution of poverty indices of users is dominant than the probability distribution of poverty indices of nonusers, in both food and absolute poverty.

Conclusion and recommendations

The use of spate irrigation increased crop productivity, household income and reduced household poverty. Nonetheless, there was no empirical evidence so far that explores the welfare impact of spate irrigation. This paper provided evidence that may have important implications on policy decisions.

The study revealed that overall poverty in the study sites was lower compared to the national figures. The food poverty headcount index in the country was estimated at 33.6% in 2010/11, while the poverty gap index was estimated to be 10.5% and the poverty severity index stood at 4.6%. For the study area, however, the incidence of food poverty of overall sample is 5.5%, while depth of poverty is estimated at 0.4% and severity of poverty is estimated at 0.05%. Likewise, headcount is estimated at 27% while poverty gap and severity of poverty are estimated at 6.7 and 2.2%, respectively, of absolute poverty.

Regardless of the location or type of scheme (traditional or modern), access to spate irrigation significantly reduced poverty. When we compare households with and without access to spate irrigation, there is significant difference in poverty levels. Moreover, the difference in the level of household poverty was significantly affected by the type of spate irrigation scheme (improved or traditional) to which they have access to; those using the improved scheme are better off. Furthermore, the test results indicated that the probability distributions of poverty indices (P0, P1 and P2) of users in food and absolute poverty are stochastically dominant than the distribution of poverty indices (P0, P1 and P2) of nonusers.

The most important conclusion of this study is that SI has a significant impact on poverty reduction, even more so for improved schemes. Therefore, the study has an important policy implication: enhance access to SI in areas where access to other water resources is limited. In addition, improvement to the traditional SI schemes or development of new ones is also important (taking into account the design and construction factors noted in other papers here).

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Annex

Table A1. Nutrition (calorie) based equivalence scales.

Age in years	Men	Women
0 - 1	0.33	0.33
1 - 2	0.46	0.46
2 - 3	0.54	0.54
3 - 5	0.62	0.62
5 - 7	0.74	0.70
7 - 10	0.84	0.72
10 - 12	0.88	0.78
12 - 14	0.96	0.84
14 - 16	1.06	0.86
16 - 18	1.14	0.86
18 - 30	1.04	0.80
30 - 60	1.00	0.82
60 plus	0.84	0.74

Source: Dercon and Krishnan (1998).