Small Scale Irrigation Interventions for System Productivity and Natural Resource Management in Ethiopian Highlands: Benefits and Best-bets

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Abstract

Water scarcity became a common phenomenon in Ethiopia with drought frequency of at least once in three years while the country owns a large irrigation potential that should be exploited sustainably. Various national and international institutions are currently engaged in developing small scale irrigation (SSI) schemes for poverty alleviation. A monitoring and evaluation exercise was conducted in 2004 and in 2006 in four administrative regions of Ethiopia, namely Tigray, Southern regions, Oromia and Amhara, to assess the benefits and associated environmental effects of SSI investments of the International Fund for Agricultural Development (IFAD). A combination of participatory M&E tools namely, individual interviews, group discussions, key informants, review of relevant documents and field observations were used. The mission was supported by an in depth pre-mission socio-economic survey in three representative irrigation schemes. Data from the sites indicated that 50 % of the respondents had improved food security and higher income, while 26% of the respondents did not see any change on their livelihoods. Crop yield under irrigation was by 35% to 200% higher than under rain fed conditions, with much higher benefit obtained from high potential areas and in farms where external inputs (fertilizer, improved seeds and pesticides) are accessible. The positive effect was more visible with horticultural crops. There has been also a shift towards improved varieties with access to irrigation. Farmers replaced early maturing but low yielding varieties with high yielding varieties. Crop diversification increased significantly, in some sites from three to about 15 species, although this decision making process did not favour legumes. The apparent effect was on crop rotation, intercropping and land management with in the order of 79, 42 and 35%, respectively. On the other hand, there is a decline in number of livestock per household, but an increased number of draught oxen. The decline is associated with reduced grazing area due to conversion of dry season fallow to vegetable fields and an increase in area enclosure in the sloppy landscapes. The shift from cereal to vegetable-dominated cropping increased the competition for water between downstream and upstream users and between resource-rich and poor farmers. The impact of irrigation schemes should be evaluated better on long term benefits than short term fixes, as farmers initiated long term investments like planting perennial fruits, bought calves and other retail trade investments. The communities would benefit most from further integration of livestock into the schemes by adopting feed sourcing strategies for dairy and fattening. The paper also presented best-bets for improved irrigation management in Ethiopia.

Introduction

Water, land and finance are becoming the scarcest resources in the agricultural system of Ethiopia, scarcity being severe in regions where population pressure is high, access to market infrastructure is low and environmental calamities are frequent. Inefficient water management in the rainfed agriculture coupled with accelerated land degradation plays an important role in aggravating the recurrent food insecurity in the country. In the recent years, drought became a common phenomenon, happening in any part of the country at any time of the year, with a frequency of at least once in three years. Four different drought scenarios were identified in the mixed crop-livestock systems of Ethiopia namely, terminal drought, intermittent drought, foreseeable drought and definite drought (Amede, et al., 2004a). In situations where agricultural production is operating under these various drought scenarios, with annual rain fall variability of 40 to 50%, supplementary irrigation became a necessity for food production, particularly for intensifying systems through high yielding and input responsive varieties and breeds. Currently, the growth in food production in Ethiopia is primarily due to expansion of agricultural land while production pre unit of investment remained stagnant.

On the other hand, Ethiopia owns a wide range of irrigation opportunities with about 9.85 million ha of potentially irrigable arable land, while only 3 to 5% of the potential is currently under irrigation (WCD, 2000) accounting for approximately 3 per cent of total food crop production. Current yield from rain-fed land is only about 50% of the irrigated land, given all other inputs remain the same, thanks to the recurrent drought and limited adoption of water management practices. If the country is to achieve its stated aims of food self-sufficiency and food security, the current production shortfalls call for drastic measures to improve production efficiency of both irrigated and rain-fed agriculture. In response, the government of Ethiopia as stated in its Poverty Reduction Strategy Paper (PRSP) emphasized the importance of improved water resource development and its utilization to achieve food security through enhanced use of small scale irrigation. Since the early 1990s' the federal and regional governments of Ethiopia, with financial assistance from donors, have been attempting to upgrade traditional small scale schemes, built small scale dams, diversions and water harvesting ponds to respond to these environmental calamities. However, the performance of the irrigation systems has been poor. There exists a substantial yield gap in irrigated farms between achievable and actual yield both in terms of yield per unit of land but also yield per unit of water depleted.

Moreover, there exists conflicting reports regarding the agricultural benefits of small scale irrigation and its impact on natural resource management (Tafesse, 2003; IFAD, 2003; Kijne, FAO; Ersado, 2005). In some sites, small scale irrigation has significantly increased crop yield, and households using irrigation have higher agricultural production than non-intervention communities (Ersado, 2005). In others, small scale irrigation didn't bring significant increase in crop yield and livestock productivity directly but increased yield by about 26& by promoting increased use of improved seeds and fertilizer (Pender and Gebremedhin, 2004). These differences on impact of irrigation on agricultural productivity may have appeared because of the fact that small scale irrigation for food security is more than just technologies; but comprises production, marketing, credit, social, policy and institutional issues (Tafesse, 2003). It could be also because of differences in methodologies. In general, irrigation farming is expected to reduce farmers' exposure to variability in crop and livestock yields and therefore improve food insecurity, especially in the more remote, disadvantaged and poorer areas; to raise agricultural production and rural incomes where crop diversification and market-oriented agriculture can be promoted; and to enhance the capacity of communities to demand for better services but also to test, modify and adopt improved technologies.

The objectives of this paper are i) to quantify the negative and positive effects of small scale irrigation on small holder farmers and their systems and ; ii) to identify the biophysical and socio-economic factors affecting the performance of small scale irrigation schemes .

Materials and Methods

Sites and regions

Four major administrative regions of Ethiopia, namely Amhara, Oromia, Southern Regions and Tigray were considered for the study. These areas are characterized by food insecurity, drought prone and very high human and animal population. Based on altitude, annual rain fall and average temperature, these sites fall into two of the major traditional agroecological zones namely; i) Weinadega: mid highlands between 1 500 and 2 300 mts above sea level with wheat, teff, barley, maize, sorghum, faba beans and chickpeas as predominant crops while cattle, donekeys and small ruminants are the predominant animals and; ii) Dega: highlands between 2 300 and 3 200 meters with barely, wheat, oilseeds, and lentils as predominant crops and sheep and cattle being dominant livestock enterprises.

During the field work a total of 16 of the IFAD SCP II irrigation schemes, those established in 1988?? in Tigray, 5 in Oromia, and 2 in SNNPR were considered. In addition discussions were held in all four project regions, and with a total of 14 project woredas. Most of these woredas are considered by the Disaster Prevention and Protection Commission (DPPC) as food insecure (Fig 1). Since time did not permit visits to all 58 schemes of the project, a sampling approach was taken. A variety of scheme characteristics was identified (including distance from roads/markets; age; perceived performance), but nevertheless some compromises had to be made due to accessibility. In Oromia and SNNPR the opportunity was taken to visit older and new schemes while in Tigray schemes were selected covering a range of remoteness from Mekelle.

The studied schemes have been selected through a two-stage procedure. First a list was compiled of schemes constructed under SCP II and operated for at least three years (i.e. the more “mature” sites for impact assessment). Next one scheme in each of SNNPR, Oromia and Tigray has been extracted by simple random sampling.

Data Collection

The quantitative and qualitative date about the impact of small scale irrigation on system productivity and food security was collected in two rounds; between 13th September and 14th October 2004 and from 12 November to 2 December 2006, as part of an IFAD field evaluation mission. The study team started the mission by interviewing and discussing with IFAD stakeholders at different hierarchies starting from the federal ministry of water resources in Addis Ababa down to the scheme site team members. The data collection considers interviews of farmers, community leaders, extension agents, key informants, district subject matter specialists, bureau heads and federal authorities. We used PRA tools including transect walks, community group discussions, sample measurements and secondary data from actors at all levels. The mission was supported by a pre-mission socio-economic survey, which was carried out to obtain in-depth understanding of three small scale irrigation schemes (Hizaeti Afras in Tigrai, Nadhi Gelansedi in Oromia and Dobena in Southern regions) in the period June-September (IE Preliminary survey, 2004). Prior to the field trips a checklist was prepared considering relevant agronomic, natural resource management and livelihood indicators and considered during data collection from the respective sites, communities and stakeholders. The pre-mission survey also considered three information sources namely literature review, focus group discussion for communities and questionnaire for interviewing selected households. A PRA tool has been administered for focus group discussions with WUAs consisting of men and women. The focus group participants were 15-20, with 5-6 women per meeting. A prepared checklist was used as a guide for the exercise. A questionnaire was prepared for a household survey and 84 farmers in Dobena and 155 farmers in Nadhi Gelan Sadi and 136 farmers in Hizaeti Afras were interviewed. The interview was carried out by random walk from homestead to homestead: adult heads of household with irrigated land were interviewed. In the case of Dobena, all households were interviewed, as the scheme users were fewer than the planned sample (100 to 150 respondents per scheme).

During the main mission, a combination of five participatory M&E tools were used to assemble information and data namely, individual interviews, group discussions, key informant interviews, review of relevant documents and field observations. On site, the information gathering techniques included quantitative (through structured questionnaires) and qualitative (through semi-structured interviews) methods with both individual informants and groups, and observations combined with discussions. Secondary data and information from woreda, regional and federal institutions that have had a stake in respective projects were also carefully studied.

Results and Discussion

Scheme development

The project sites were identified for SSI development either because the respective communities contacted the woreda officials through their local representatives (e.g. Nazre in Tigrai) demanding the development of irrigation schemes. In other sites, the schemes were identified by irrigation engineers through a pilot survey in assessing various water resources, including perennials rivers. The need for upgrading the traditional irrigation schemes arose from the fact that traditional schemes were underperforming despite years of experience of communities in irrigation management. The results of the interviews indicated that the reasons why communities demanded for upgrading traditional schemes were 1) continual distraction of canals by erosion, siltation, animals and human activities; 2) extremely high labor demand to maintain and clean traditional irrigation canals; 3) considerable loss of irrigation water from the traditional canals due to seepage and easy destruction of canals by heavy rains; 4) the difficulties faced by the respective communities to build permanent crossovers over gullies to reach communities on the other sides of gullies and river sides, as it was observed in Mumicha in Oromia; 5) most of the traditional command areas were those on flat lands and valley bottoms, but it excluded fields even with very slight slopes and; 6) there was very limited institutional support in accessing marketable enterprises, technological innovations, and integrated extension services to crop, livestock, land and water management.

1. Impact on system productivity

The impact of irrigation schemes on system productivity could be seen from the perspective of its effect on crop, livestock and labour productivity in the respective sites. Though the time period was very short to evaluate the impact of irrigation on the productivity of some of the systems, as the schemes were 2 to 10 years old, there are variable results emerging from different sites and regions.

1.1 Crop yield

In average, crop yield under irrigation was at least by 35% higher compared to non-irrigated farms (Table 1), with benefits being much higher in high potential areas and in farms where external inputs (fertilizer, improved seeds and pesticides) were accessible. Maize was one of the most preferred crops farmers have been producing under irrigation across sites, accompanied by vegetables. Farmers have indicated a significant yield increase, particularly in drought sensitive crops like maize (Tables 1 and 2), which otherwise could completely fail if the terminal or intermittent drought coincides with the drought sensitive stage of the crop i.e. flowering period. Most farmers with market access produced green maize (about 20% of the area across Tigray) (COSART, 2001) with high stover quality for fodder. A case study in Tigray showed that in good years a farmer obtained about 6 and 3.5 tonnes ha-1 of maize under irrigated and rain-fed conditions, respectively, with about 60% yield advantage. A comparable amount of yield advantage was displayed by a farmer in Burka Woldiya, Oromia. Across sites, crop yield under irrigation was by 35% to 200% higher than under rain fed conditions (Tables 1 and 2), with much higher benefit in high potential areas and in farms where external inputs (fertilizer, improved seeds and pesticides) are accessible.

In drought prone sites, farmers replaced the early maturing but low yielding variety (e.g. Katumani) by a high yielding maize cultivar (e.g. Awassa 511) thanks to access to irrigation and obtained a 200% grain yield increase (BOA, Wukro Woreda, 09/2004). A similar trend was obtained with wheat and faba beans (Table 2). Farmers in Nazre (Tigray) indicated that they got up to 4x more onion yield today because of the combination of access to irrigation, good varieties, access to pesticides and better extension support. Crop yield increase was substantial particularly for horticultural crops not only because of improved access

to irrigation but also associated trainings and improved flow of information in pest management, organic manure application and improved water management skills. Moreover, the survey conducted in the three representative schemes indicated differences in crop yield among sites. For instance, in Dobena, the yield of tomato, potato cabbages and onions were 102, 94, 82 and 44 qt/ha while in Nadhi Gelan Sadi, it was 35, 37, 24 and 38 qt/ha, respectively (data not presented), which could be explained by difference in agricultural potential of the sites, particularly due to soil fertility and rain fall amount and distribution. In general, an increase in crop yield was accounted not only to improved access to irrigation but also to associated services in extension and input delivery. Moreover, the current distribution of water by water masters followed the principle of rotational irrigation for priority crops known to the majority and exceptionalities are established only after strong negotiation. For instance in Nazre, the order of priority for getting access to water was faba beans, tomato, pepper, onions, and spices. This form of bylaws may limit farmer innovation and responsiveness of individuals to market demands.

They consumed 71% of the cereals, pulses and oil seeds, 26% of the vegetables and about 2% of the fruits while they sold the rest to generate cash income. An economic analysis done with 10 representative heads of households indicated that their total gross earnings from the sales of these products was EB 22,602. Their net cash income per household after deducting costs was EB 1,141. In addition each household retained produce to a value of EB 1,181 which they used for home consumption (IFAD, 2004).

In few schemes (e.g. Belessa), irrigation had no significant effect on crop yield for various reasons. In some it was because of shortage of water at the critical crop stages, while in others it was because of poor agronomic practices related to very low population density, late weeding, lack of fertilizer application and absence of pest control.

1.2 Crop diversification

Traditionally, most of the sites were cereal growers, except for Chat in Harer and Onions and Pepper in few sites near to major roads. The primary cereal crops grown under supplementary irrigation were maize, wheat, and barley. With the development of irrigation schemes farmers have shifted towards growing diverse crop, in some sites up to 10 new marketable crops, predominantly vegetables. The bureau of agriculture played a key role in the introduction of new crops through establishing multiple demonstration plots in farmers' fields. Access to irrigation and opening up of new market opportunities encouraged farmers to systematically allocate their land to various enterprises, both in rain fed and irrigable fields. For instance in Lalay agula, Tigray, farmers allocate 30, 31, 25, 10 and 3% of their land to wheat, maize, pepper, barley, and teff, respectively under rainfed conditions, while under irrigation the land allocation was 35, 10, 50, 2 and 1.5% for pepper, onions, maize, tomato and cabbage, respectively (COSART, 2001). Besides, almost all varieties of crops grown in the sites at the time of the mission were improved varieties came along with the diversion schemes via the Woreda bureaus. For instance in Lalay agula, there has been a shift from the local maize variety Birhu to improved varieties, Katumani and Awassa 511 due to better access to irrigation water. Moreover, the diversion of the canals helped the extension to easily establish seed multiplication sites for non-traditional vegetables and spices, mainly onions, potato and tomato and hence it facilitated the growing of non-traditional crops in the area (data not presented).

Cropping Sequence and Management

Access to irrigation in most sites created an opportunity for double and in few cases for triple cropping. However, due to the decreasing water availability and an overwhelmingly increasing demand for water by downstream users, the possibility to expand irrigable land became unattainable, as it was the case in Dobena, Southern region. In the current rain-fed cropping systems cereals and legumes are grown in rotation, while in the irrigable fields with vegetables and fruit trees are grown primarily in rotation with cereals. This cropping practice limited the possibility of integrating nitrogen fixing, soil improving legumes like faba bean in the irrigation systems. It is partly because of the small land size of irrigable plots (about 0.20 ha per household) and partly due to market preference for selected crops. In situation where crop rotation was not practiced the risk to deplete the soil in a very short time and the possibility of pest incidence is obvious. For example, growing potato and tomato rotatively on the same land, without a break crop, may create a favorable ground for pests like potato late blight that would make it difficult to grow both crops next time. Hence, crop rotation as a component of integrated pest and soil fertility management should be sought as it was also a concern shared by practicing farmers across sites.

Despite the above mentioned concerns, interviewees indicated that irrigation brought in considerable changes on the farming system through improved crop rotation (cereals in the main rainy season and vegetable in the off season using irrigation), intercropping and improved land management (particularly terracing and use of organic manure) within the order of 79, 42 and 35%, respectively. In the three sample sites the farmers who practiced improved agronomic management of crops across the various practices after irrigation scheme was developed were 22.2, 41 and 36% in Dobena, Geland Sedi and Hizaeti Afras, respectively (Table 6).

Livestock systems

Feed shortage was apparent short before the main rains, between the months of April and June across sites. The decline in forage availability was associated partly to conversion of dry season fallow to vegetable fields and an increase in area enclosure of the traditional grazing areas in the sloppy landscapes, accompanied by frequent drought. Contrary to earlier reports, there is a decline in the number of livestock per household as a consequence of introduction of schemes across the regions regardless of agro ecology, but again there are also an increased number of draught oxen (data not presented). Other research findings also reported that increased irrigation was associated with a reduction in ownership of livestock but with increased adoption of technologies that enhanced productivity (Benin etal. 2003).With access to irrigation semi-pastoralist communities (e.g. Gedemmso, Oromia) have been converted to a crop-livestock system with significant reduction in stock.

In theory, the expansion of the irrigable area should have allowed farmers to produce more biomass all year round, partly as crop residues and grasses on strips, borders and hilly patches. However, the biomass produced from the vegetable fields was rarely used as feed source as the livestock rejected to it unless there were no other feed options in the system. Moreover, some farmers complained to the mission that the local authorities did not allow them to grow forages using irrigation as the current bylaws established by the water user associations gave priority mainly to food, fruit and vegetable crops. These bylaws may limit innovations in promoting livestock enterprises (e.g. Dairy and fattening). With increased vegetable production from irrigated plots and subsequent income some farmers, e.g. Amhara region, afforded to upgrade part of their stock with fewer but more productive breeds and in the process released part of their crop land for pasture development (Benin, et al., 2003).

Seed and fertilizer use

According to farmers view across the sites, decline in land productivity was strongly associated with soil fertility decline, prevalence of new pests and diseases in the system, excessive soil erosion and in some cases soil salinity.

The majority of farmers across the regions have been introduced to use of inorganic fertilizers only very recently, mainly through the extension systems. The potential effect of fertilizers on crop yield and farm income is much better understood than 10 years a go, though this capacity building process may not have been explicitly associated with the irrigation projects. However, only about 55% of the farmers across the sites 55% use fertilizers (mainly DAP), particularly for maize (data not presented). The government was their major input source for chemical fertilizer, mainly through credit arrangements. For instance, in Gereb koky, Tigray, the typical use of inorganic fertilizers in the irrigated fields was about 50 kg/ha, applied mainly to high value vegetables and green maize. On the other hand, perennial crops like coffee and chat did not receive any inorganic fertilizer across the visited sites, partly because they are commonly grown in fertile homesteads. The increased use of irrigation and fertilizer, however, did not attract much use of improved seeds because either they were unavailable or unaffordable to farmers. The local extension agents were multiplying seeds of only selected crops, mainly maize, potato and onions. Hence most farmers in the sites still use their own seed (Table 3). The source of seeds in three schemes was 55, 23 and 22% for own seeds, government sources and purchased, respectively (IE Preliminary survey, 2004). While seeds for cereal crops, vegetable and coffee are secured from multiple sources, seedlings for fruit trees are commonly purchased from the local market.

Similarly, recent reports from the region (G. Medhin etal. 2003) indicated that there is decreased use of chemical fertilizer with irrigation after the credit service for fertilizers was abandoned. Credit and financial services are not yet sufficiently addressing the needs of irrigation users to move into sizable market oriented enterprises. As an effect, there is a shift towards use and management of organic fertilizers namely manure, compost and crop byproducts in most sites, with an increasing number of practitioners adopting these practices (IE Preliminary survey, 2004) For instance in Burka Woldiyaa six out of seven randomly interviewed farmers practiced composting for the last two years. A farmer in Nazre, who conducted an informal experimentation described that on a 200 m^2 farm land he got a maize grain yield of 5, 4 and 1 qt from organic fertilizer, inorganic fertilizer and no fertilizer, respectively (personal communication).

Impact on household food security

The major effect of the irrigation projects on the communities was through the attitudinal change that they could produce for the market and could buy their food from the income they generate on farm. This is not yet a common knowledge in the rain-fed agricultural systems of Ethiopian Highlands.

Farmer interviews across the regions in the high potential areas (with at least 5 or more months long growing season) and low potential areas (with four or less months long growing season) (Engida, 2001), revealed that crop yield of cereals (e.g. maize) increased by about 70 and 20%, respectively, not only due to access to supplementary irrigation but also due to increased support of government institutions in extension and input delivery. In general, crop diversification has significantly increased, in some cases from only three crops before the construction of the scheme up to 15 crop species, encompassing various vegetable and high value crops (e.g. Gedemmso in Oromia). With access to irrigation, intercropping and relay cropping are also becoming common practices even in monocropping-dominated systems (Table 5). About 40% of the farmers produced more food than before the scheme was constructed, particularly apparent in the drought-prone environments (e.g. Amhara) and in areas where there was no access to irrigation earlier (Benin etal. 2003). Data from three sites also indicated that 34, 26 and 16% of the respondents had access to more food, no change or obtained increased income, respectively (IE Preliminary survey, 2004). In some cases, vegetables became part of the daily dish of farmers (e.g. Chelekot in Tigray). This should have a positive effect on household health, particularly through the integration of calorie, vitamin and micronutrient rich vegetables and fruit crops (Amede et al., 2004b). However, food security has not yet been fully achieved in almost all sites due to the small land holdings, low soil fertility status and other calamities. However, 83% of the interviewed farmers still consider lack of enough irrigation water responsible for low crop yield in irrigated crops (Table 4).

Impact on natural resource management

There were both negative and positive impacts of the irrigation projects on the environment. The major negative impact was done during the construction phase whereby new farm gullies were created and debris from the construction plots were placed on farmlands.

Soil Conservation and land rehabilitation

There are differences among regions, the longest physical structure being made in Tigray and the lowest in Oromia. In the selected sites between 21 and 54% of the households indicated that small scale irrigation attracted soil and water conservation practices (Table 5). The difference in performance was dictated by the historical view and understanding the status of land degradation in the regions and the subsequent regional policies. In situation where extensive soil conservation was made in the 1980s (e.g. Burke Woldiyaa and Mumicha in Oromia), erosion and runoff was considerably reduced with very limited active siltation seen on the valley bottoms and diversion canals (Personal communication, 2004). In some regions (e.g.

Tigray), a considerable amount of work in managing the upper slope of the schemes was done through the construction of soil conservation terraces and tree bund stabilizers, which was a necessity to sustain the future performance of the schemes. This was done by introducing regional policies since 1992, whereby an obligatory 20 days per year labour contribution by every resident in the region was adopted. This labour was mostly used to construct and rehabilitate terraces and landscapes. This type of policy could reverse land degradation especially if it is done in a participatory way. It could lead to community action with apparent economic and social benefits in terms of fodder, fuel wood, water and other resources.

However, although terraces are in place in most of the sites the effectiveness of these structures in reducing erosion, in improving water infiltration and in performing other environmental services was not assessed. Participatory impact assessment of the structures to display the positive and negative effects on the system could attract investors and the interest of communities to manage them sustainably. Moreover, integrating niche compatible trees on the soil bunds may reduce the pressure on cow dung, which is currently used as a cooking fuel, to be used for soil fertility restoration. Burning dung is one of the practices aggravating land degradation, particularly in the Amhara and Tigray regions, as it breaks the nutrient recycling in crop-livestock systems.

There is a huge land area which became under area enclosure in all regions though the size and management modalities differ from region to region. It was done particularly to protect schemes and upper slopes from producing silts but also to rehabilitate exhausted upper slopes. In most cases it was done in consultation and agreement with the local communities. In sites where area enclosure is practiced for at least two or more years, like in Gereb koky, with an area enclosure of 30ha, the vegetative cover of the system increased considerably. It was valued by the communities as a means to recharge the springs, as sources of bee forage, and also as a strategy to restore indigenous trees like *Dodonaea viscose* and *Olea africana*. In some cases farmers were allowed to graze their oxen in the protected areas during ploughing times. However, the sustainability of the enclosure would heavily depend on the immediate benefits communities and household will obtain and the strength of the local institutions.

Labor availability

In situation where the cropping season is doubled because of increasing access to irrigation during the dry seasons, the pressure on household labor was apparent. The shift in systems from less labor intensive cereals to labor intensive vegetables (Table 6) caused an increasing labor demand. When a vegetable farmer was compared to a cereal farmer the demand for labor was 1638 and 406 man days per ha, respectively, which was about 400 % higher, indicating that there could be a need for an additional labor through hiring, debo (local labour sharing arrangement among age groups) or any other arrangements. Farmers' interviews in Lalay agula revealed that lined canales and cemented diversions reduced the pressure on farm labor, about 5 to 8 man days per family per season, which otherwise used to be invested in cleaning and repairing furrows after the main rainy seasons. This has created a job opportunity for the land less youth across the regions.

Upstream and Downstream Relationships

The presence of very few perennial rivers aggravated by recurrent drought, and extensive awareness creation campaigns towards a shift to vegetable farming in almost all schemes incurred a considerable competition for water in the command areas and beyond across regions, and caused shortage of water for down stream users

(Table 4). Competition for irrigation water between upstream and downstream users, between vegetable growers and chat growers, between farmers with big irrigable plots and small plots, and between water users and water managers have been surfaced during the various formal and informal discussions. Farmers in two sites in Harer, Oromia indicated that there is less water for down stream communities than ever due to the need for frequent watering of the vegetables in the upstream fields. The traditional system, which has a considerable Chat farming, demanded watering only once in a month and used to release a considerable amount of water to downstream users. On the other hand, recently introduced vegetable crops like tomato require water once in a week, particularly in areas where the evapo-transpiration is very high. The consequence was that there was an emerging conflict between upstream and down steam users, and in some sites (e.g. in Burka Woldiyaa) the case is presented to the local court. Additionally, some farmers started to divert the water to non-traditional farms using motor pumps and gravity, commonly without asking for consent with the traditional water users. In some cases, these were people highly protected by local and regional authorities with very limited chance for the small farmers to maintain the statuesque.

In situations where there is an absolute water scarcity, it is only households residing on the source who could benefit from the limited water flows. Communities residing down stream tend to send their water master to negotiate with upstream communities in times of critical demand.

Lessons Learned

In areas where institutions and market incentives are in place (e.g. Ziwai in the Rift Valley of Ethiopia), farmers have doubled or tripled their incomes in a very short period of time. In other isolated, less accessible areas (e.g. Belessa in the Amhara region), there is no visible change on the income and livelihood of the people, even four years after the irrigation infrastructure is in place and being operational (personal observation).

In general, there are very few operational SSI schemes in the country that could be labeled as optimum because of the various difficulties facing them at different times and scales, ranging from shortage of technologies to imperfect markets. An innovation systems approach is required to enable the schemes bring the expected impact on the livelihoods of the people, including the identification of various challenges small scale irrigators are facing at farm, community, district and higher scales. There is also a need to look for success stories where combination of technological, policy, institutional and market interventions made some irrigation investment worth investing to make the respective rural communities food secured and keen to protect the environment. Table 7 displays interventions that made few irrigation schemes success story.

a. Access to irrigation and the associated institutional services given by governmental and non governmental institutions helped farmers to improve their income and enhanced their capacity to shift towards market-oriented agriculture. Unfortunately, priority was given only to the crop sector while livestock, particularly dairy and fattening, could have increased the benefits by much higher orders.

b. Although crop diversity is one key way of minimizing risk and exploiting opportunities, too much diversity in the farmers' fields may prevent them from more efficiently developing their production skills and creating functional market links with specialized traders and consumers. Too little diversity may again lead to deteriorated market prices during the peak season. Hence farmers' should be assisted to optimize the number and type of enterprises that are managing and minimize market trade-offs for better decision making.

c. Although there is a better use of land based resource under irrigation, farmers are still dependent on low input management, which may not bring the expected quantity and quality reflecting market demands. Hence there is a need for diversifying the inputs supply systems including credit opportunities.

d. Water is a very scarce resource, and the demand for irrigation water is on the rise. Hence irrigation investments should be supported by water saving agronomic and technical measures, including mulching, tie-ridging, minimum tillage, lining of canals and drip irrigation.

e. The current extension support on irrigation agronomy is far from responding to farmers' expectations. Participatory on-farm research on irrigation frequency, crop water demand, crop rotation, organic resource management, micro dose application of chemical fertilizers, management of perishable seeds and related issues should be promoted. The process should give farmers the chance to innovate.

f. It could be necessary to distribute demonstration fields to various farm niches and landscape positions to reflect field variability. Promoting the capacity of elite farmers 'like the Hirsha Cadre's in Tigray' will enhance the scaling-up process to reach more farmers and communities sustainably.

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Table 1. Comparison of yield of various food and vegetable crops of irrigated and non-irrigated farms in Lalay agula, Tigrai (SCPII scheme). N= 6

Crop type	Yield (qt/ha)		
	Non –irrigated farms	Irrigated farmers	% increase
Maize	25.75	43.75	69
Onions	102	172	68
Pepper	11	17.75	61
Tomato	200	300	50
Carrot	226	305.25	35
Potato	174.8	250	43
Cumin	4.25	7.50	76

Source: Woreda Bureau of Agriculture, Wukro, 09/2004.

Table 2. Crop yield before and after the irrigation project in Shoba, Oromia (SCPI scheme). n= 10, nd= not determined.

		Yield (Qt/ha)		
Crop type	Land area (ha)	Before the project	After the project	rease
Barley	Nd	10	12	20
Wheat	Nd	8	16	100
Maize	Nd	15	25	66
Faba bean	Nd	4	12	200

Source: Dessie, 2004

Table 3. Seed source for major crops in IFAD sites (Mean of 3 sites) SD

Seed source	No of sample	rce
Own seed	708	.
Government	294	)
Purchase	284	.
Total	1286	.0

Source: IE Preliminary Survey, 2004

Table 4. Experiences in access to irrigation water in three schemes of IFAD sites in Ethiopia.

Management practices	Irrigation site						Total	
	Dobena		N.GalanSadi		Hizaeti Afras			
	sample	% Users	ample	% users	ample	% users	ample	% users
Practice crop rotation	51	61.4	109	70.3	135	99.3	295	78.9
Mulching			68	43.9	7	5.1	75	20.1
Intercropping	52	62.7	106	68.4			158	42.2
Contour farming			46	29.7	12	8.8	58	15.5
Physical soil conservation	16	19.3	84	54.2	29	21.3	129	34.5
Biological soil conservation			9	5.8	5	3.7	14	3.7
Other change in farm	2	2.4	5	3.2	1	0.7	8	2.1

Table 5. Change in farming practice as an effect of the SSI schemes, n=374.

Experience in water supply	Irrigation site				*Total*			
	Dobena		N.GalanSadi		Hizaeti Afras			
	Count	Col %	Count	Col %	Count	Col %	Count	*Col %*
Sufficient water not available	73	90.1	125	82.2	106	80.3	304	*83.3*
Sufficient water available	5	6.2	27	17.8	25	18.9	57	*15.6*
Poor management of water	3	3.7	-	-	1	.8	4	*1.1*
Total	81	100.0	152	100.0	132	100.0	365	100.0

Table 6. Labor requirement of various vegetable and field crops (man days/ha) in irrigated farms of Northern Ethiopia.

Crop	Pre-planting operation	Cropping operation	Post harvest operation	Total
Onions	110	255	10	375
Potato	24	253	16	293
Carrot	50	235	15	300
Cabbage	110	235	10	355
Shallot	50	255	10	315
Maize	14	40	10	64
Wheat	22	60	10	92
Barley	22	60	10	92
Teff	18	68	12	98
Beans	18	34	8	60

Source: COSART, 2001

Table 7. Best bet interventions for small scale irrigation schemes; lessons identified from selected schemes and communities that work best.

Technology for SSI	Where does it fit best?
Irrigation water	Water-saving lines canals
	Multiple cross-over alignments
	Water reservoirs with closing lockers
	Furrow irrigation practiced
	More perennials than vegetables or cereals
	Market access is reliable
	Local institutions function
Vegetable farming	Close to town markets
	Reasonably good road network
	Rotational cropping practiced
	Water supply is adequate
	Managed by literate and young farmers
High yielding varieties	Water supply is adequate
	Better access to inorganic fertilizers
	Rotation with legumes possible
	Land shortage is not apparent
	Managed by resource-rich farmers
Inorganic fertilizer	Best used for maize
	Water supply adequate
	Is accompanied by compost and manure
	Higher Urea and less DAP
Organic fertilizer	Biomass is abundant
	Cow dung is not used for cooking
	Composting is practiced
	Preferably for fruit trees and vegetables
Pest management	Avoid growing potato and tomato together
	Uproot diseased plants
	Crop rotation practiced
	Field health sanitary practiced

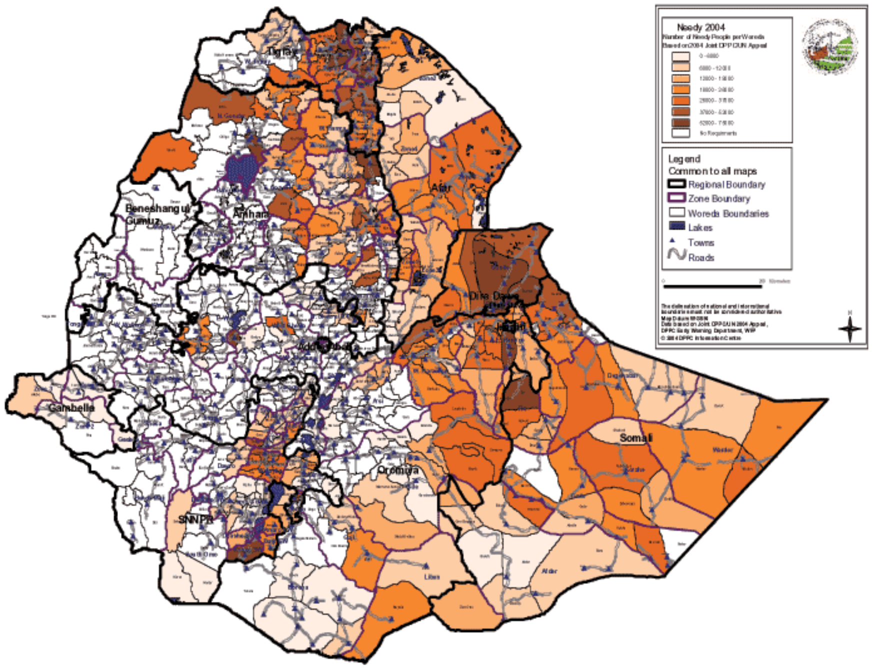

Fig. 1. Food insecure and secured Woredas in Ethiopia (DPPC, 2004)