

Shifting towards market-oriented irrigated crops development as an approach to improve the income of farmers: Evidence from northern Ethiopia



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Abstract

Rainfed crop production in the semi-arid areas is associated with high risk of rainfall variability which occasionally leads to complete crop failure. Most of the farmers in Atsbi-Womberta district of Eastern Tigray region, northern Ethiopia, have been classified as food insecure. To improve farmers' livelihoods in the district, interventions targeted at resource conservation and better use of conserved water for market-oriented irrigated crops development have been promoted.

This paper analyses the process and outcome of shifting towards market-oriented irrigated crops development and compares variation in income between beneficiary and non-beneficiary households. The transformation processes are based on market-oriented diversification into high value irrigated crops, based on a value chain approach, and demand driven, participatory and knowledge based extension. The paper also assesses the response of smallholder farmers to emerging opportunities and challenges, and the spectrum of transformation processes and strategies followed to bring changes in smallholder farmers' income. The changes associated with the interventions were systematically captured using household level surveys, specialized studies and key informant interviews.

Results show that farmers gradually shifted to non-cereal, more market-oriented irrigated crops, in which the share of market-oriented irrigated crops increased from 27% of the total irrigated land in 2004 to 89% in 2009. Similarly, the total irrigated area increased by about fourfold and the number of beneficiaries by about threefold due to improved use of conserved surface and groundwater, and investment in farmer skills and water lifting devices. Moreover, crop diversification and intensification of households increased in response to emerging opportunities and challenges. Annual cropping intensity shifted from mono-crop cereal to 2–3 high value diversified crop farming by some farmers. On aggregate, average income of beneficiary households increased by about ninefold compared to non-beneficiary households.

In the transformation, there have been continuous and interconnected processes and strategies in improving the effectiveness of adopting and using new skills and knowledge in harvesting and productive use of water, and responsive capacity of the extension system and partners. The lessons imply that investment in resources conservation could be enhanced if linked with short-term income generating activities through linkages with markets.

Key words: semi-arid, production risk, market-oriented diversification, resource conservation

1 Introduction

Rainfed crop production in Atsbi-Womberta district is associated with high risk of rainfall uncertainties which occasionally leads to partial or complete crop failure. There has also been continuous land cultivation and expansion to unsuitable steep sites, overgrazing, and pressure on natural resources mainly due to population growth (IPMS 2005). These practices reduce soil vegetation cover and subsequently aggravate the loss of the fertile topsoil mainly due to water erosion. This means finer soil particles that contain most of the plant nutrients and water holding capacity of the soil are reduced (Alt et al. 2009). The loss of the fertile topsoil and reduction in soil moisture retention leads to low yields of less than 500 kg/ha for most crops (SERA 2000; Assefa 2005). In worst cases, the result can be a complete crop failure, food shortages and dislocation of rural population. Thus, the farmers in Atsbi-Womberta district have been classified as food insecure for many years (SERA 2000).

Improving income of smallholder farmers in less favoured environments and with high rainfall variability in areas like Atsbi-Womberta district is a complex process. The transformation processes and strategies have been based essentially on the effectiveness of capturing and using skills and knowledge in managing extreme water variability. These include increasing water availability in the root zone and productive use of water (Koochafkan and Stewart 2008; Wani et al. 2009) integrated with improved soil fertility, pest management and choices of marketable high value crops (FAO 2001; Shepherd 2007; Nichols and Hilmi 2009). Thus, there have been continuous extension service supports in irrigated crops development to bring a meaningful difference in the income of smallholder farmers. This shift in thinking has emerged along with the change in government in Ethiopia, which focused on 'Agricultural Development Led Industrialization' strategy to support the food security of smallholder farmers since 1991. The shift in thinking identifies the management of natural resources as a key entry point for improved agricultural production.

The specific key entry points include investment to maximize rainfall infiltration and improve soil water-holding capacity, reducing land degradation while increasing the water availability in the soil for plant growth. Rainwater harvesting practices such as *in situ* conservation, construction of check dams, ponds, terraces and bands have been used (Belete 2009). Some of the conserved sites have been put under area enclosure and simultaneously cut-and-carry system of animal feeding has been introduced. Consequently, vegetation cover has improved, runoff and evaporation reduced, water infiltration increased and groundwater in the valley bottoms enriched and surface water

developed (Hailay 2008; Belete 2009). As a result, irrigated crops development has emerged in the downstream of the conserved watersheds (IPMS 2005). The emergence of crop production under irrigation is a major achievement of intensified resources conservation. Initially, farmers grew cereals under irrigation. However, irrigated crop production is relatively costly and needs external inputs such as water lifting devices, planting materials and fertilizers, and subsequent labour intensive operations. Furthermore, cultivation of traditional cereals such as wheat and barley under irrigation proved to be of limited potential to improve the income of smallholder rural farmers. Thus, integrated interventions on productive use of water and other associated inputs have been promoted for shifting towards more market-oriented high value irrigated crops.

In support of this strategy, interventions on capacity building of farmers, private and public extension service providers and researchers have been made collaboratively with partners along the commodity value chains. The capacity building interventions on high value irrigated crops development first assessed knowledge gaps in response to the dynamics of emerging opportunities and challenges based on the commodity value chain framework.

This paper specifically addresses the degree of shift towards market-oriented irrigated crops development and variation in income between beneficiary and non-beneficiary households, the institutional and farmer capacity to capture and use knowledge in response to emerging opportunities and challenges, and the spectrum of transformation processes and strategies followed to bring changes in the income of smallholder farmers in Atsbi-Womberta district.

The paper is organized in seven sections. The next section presents description of the intervention district (*woreda*). Section three deals with the diagnosis of the opportunities and challenges of irrigated crops development, while section four deals with actors involvement in the development of high value irrigated crops. Section five presents commodity value chain interventions, implementation and outcome monitoring. Key achievements are presented in section six, and the last section concludes the paper and presents implications.

2 Description of Atsbi-Womberta district

The study is conducted in Atsbi-Womberta district which is located in the Eastern zone of the regional state of Tigray, Northern Ethiopia (Figure 1). The district is characterized by extreme spatial and temporal rainfall variability. Altitude in the district ranges from about 900 to 3100 metres above sea level (masl). The pattern and distribution of rainfall and temperature spatially varies with the altitude gradient in the district (IPMS 2005). The main rainfall occurs between June–July with an annual average of about 668 mm. The district is classified into 16 rural administrative units known as peasant association (PA) and two urban peasant associations (Figure1). Total number of households in the district is about 23,400 with an average family size of 6. About 30% of the households are female-headed (IPMS 2005).

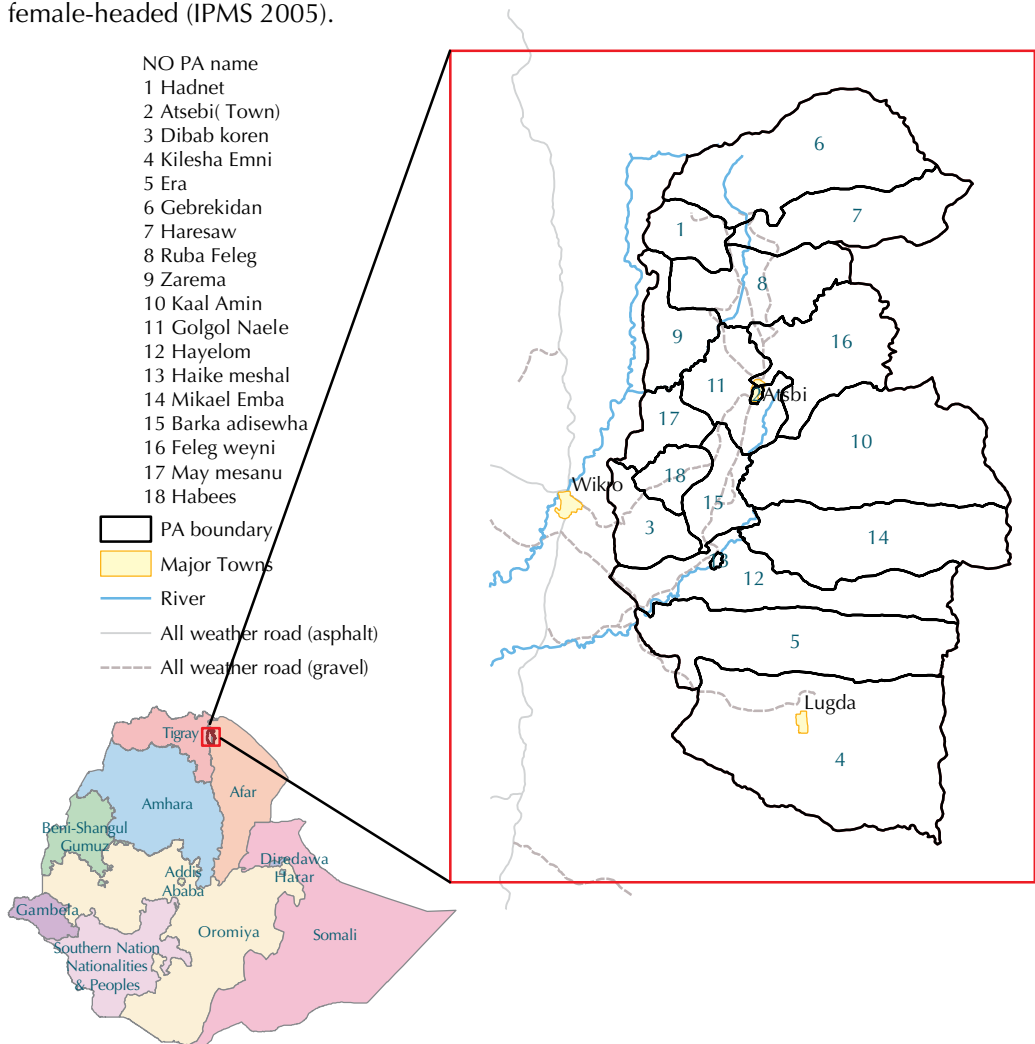


Figure 1. Map showing the location of Atsbi-Womberta district and its peasant associations in Northern Ethiopia.

Mixed crop–livestock system is the dominant farming practice in the district (Assefa 2005; IPMS 2005). Rural farmers manage crop and livestock in an integrated way to improve returns from the limited resources. Besides, farmers diversify sources of income to secure food for their family. Crop production traditionally focuses on highland cereals such as barley and wheat and highland pulses such as faba bean and field pea under rainfed conditions. More recently, market-oriented high value irrigated crops such as vegetables and spices have been introduced and cultivated mostly in the valley bottomlands or flood plains where water availability and soil fertility are relatively higher.

3 Diagnostic results of opportunities and challenges of the value-chains of irrigated crops in Atsbi-Womberta

To initiate market-oriented irrigated crop developments, the Improving Productivity and Market Success (IPMS) of Ethiopian Farmers project used a district level participatory market-oriented value chain diagnosis and planning approach aimed at identifying i) main farming systems, ii) potential marketable crop and livestock commodities at farming system level, iii) constraints and potentials for each value chain and its components, iv) value chain actors and their roles and linkages. Different value chain actors were involved and consulted in this planning exercise including farmers, community based organizations, research and development partners, community leaders, *woreda* decision-makers and NGOs such as the Relief Society of Tigray (REST), and World Vision Ethiopia (WV-E). Secondary biophysical and socio-economic data were collected, followed by open ended interviews with focus groups and key stakeholders. The results were presented in a stakeholder workshop in which priority marketable commodities were selected together with potential key interventions and partners.

Subsequently, two farming systems namely the pulse–livestock and apiculture–livestock were identified. In both farming systems, market-oriented irrigated horticultural crops were identified as potential market-oriented commodities that could contribute to improve the livelihood of smallholder rural farmers. The potentials, limitations and gaps in knowledge that warrant interventions were analysed along the value chain of irrigated crops (Table 1). The key gaps in capacity and knowledge that were identified include lack of marketing skills, access to market linkage and information, and lack of skills on product processing and grading. Furthermore, poor seedling and on farm irrigated crops management of the newly introduced crops such as vegetables; and limited skills in maintenance and operation of the newly introduced water lifting devices such as motor and treadle pumps, and drip irrigation were identified as gaps in skills (Table 1).

Table 1. Potentials and limitations in the value chain of high value irrigated crops in Atsbi-Womberta district

Value-chain stage	Potentials	Limitations
Marketing	Demand for high value irrigated crops mainly vegetable products exist in towns within 10–70 km radius with accessible all weather roads	Linkages of high value irrigated crops producers to markets and market information flow were weak Producers lack skills on market niche exploitation and crop choices in response to emerging market demand
Product processing	Premium price for high value quality crop products mainly vegetables existed in the nearby Mekele supermarkets and restaurants	Skill on value addition of high value irrigated crops such as grading, packing, transporting and improved temporary storage options were weak
Production technologies	Year round cultivation of market-oriented crops possible along the existing ecological gradients Improved vegetable varieties and technologies and unexploited surface and groundwater sources exist	Improved skills and knowledge on high value crops seedling handling; and on-farm water, nutrient, and pest management practices was low
Input and credit supply	Inputs for market-oriented irrigated crops such as water lifting devices and planting materials have been made accessible to farmers Establishment of private seedling supplies and other services was technically possible	Skills on private vegetable seedlings production and marketing; skills on maintenance and operation of water lifting devices were weak

4 Actor involvement in the development of high value irrigated crops

In the course of irrigated crops development phases, different actors played different roles (Tables 2 and 3). The districts OoARD supervised the interventions in irrigated crops development and organized the activities of different actors. The Tigray Agricultural Research Institute (TARI) and the Ethiopian Institute of Agricultural Research (EIAR) and their branch research centres supplied information on improved technologies for demonstration at the Farmers Training Centres (FTCs) and farmers fields. World Vision-Ethiopia and other NGOs supported irrigated crops developments mainly through input supply and credit. The IPMS project facilitated the identification, dissemination and use of knowledge among farmers, development agents (DAs), experts and others. The IPMS project also assisted in capacity development of farmers, private traders and extension service providers to respond to emerging opportunities and challenges as an input to improve the income of rural farmers. IPMS, Tigray Agricultural Marketing Promotion Agency (TAMPA) and the marketing unit of the OoARD facilitated access to market information and linkages, and marketing capacity of actors. IPMS led the documentation of lessons learned and scaling out of best practices.

Role and degree of involvement of actors also varied according to the transformation phases in the development of high value irrigated crops (Table 2). The number of actors and their degree of involvement in market-oriented high value irrigated crops development substantially increased compared to the phase of subsistence oriented crop husbandry. The involvement of some actors was important at specific phases of the transformation process. For instance, the involvement of IPMS–ILRI and TAMPA has been high during the market-oriented irrigated crops development phase and less during increase crop water availability and crop water uptake phases (Table 2).

Table 2. *Main actors and roles in development phases of market-oriented irrigated crops in Atsbi-Womberta district*

Transformation phases	Key actors and their roles
Increased crop water availability	<ul style="list-style-type: none"> – Community and community leaders, and decision-makers have been collaboratively mobilized and implemented natural resources conservation – Decision-makers provide guidelines and directions and close monitoring and evaluation – Public extension service providers and NGOs have been jointly providing technical support on resources conservation, construction of ponds, small dams, limited irrigation infrastructures and selection of biological planting materials suitable to the specific niche – NGOs also have been providing technical and financial support for resources conservation including food for work
Increased crop water uptake to improve yield	<ul style="list-style-type: none"> – The public extension service providers, community leaders’ services and NGOs intensified their support. The extension service providers have been strengthened with the establishment of core subject matter specialists to guide the on-farm management of irrigated crops development: water delivery, crop choices, watering schedules as supplemental and full irrigation, nutrient and pest management – The Tigray Agricultural Research Institute (TARI) and the Ethiopian Institute of Agricultural Research (EIAR) and their branch research centres generate new technologies and the Tigray Bureau of Agriculture and Rural Development (BoARD) and its office branches continuously supervise and implement the improved intervention at grassroots level aiming for the productive use of conserved water – NGOs support the productive use of water technically and financially. For instance, the Dedebit Credit and Saving Institution (DECSI) facilitated access to credit and saving services for farmers to use improved technological inputs such as water lifting devices, planting materials, fertilizer and others
Increased crop water uptake to improve income on investment	<p>In addition to the aforementioned roles, the input/output marketing and irrigated development units of the district OoARD have been strengthened with relatively qualified manpower at the district and peasant association (PA) levels. Irrigation Development Agents (DA) have been placed in PAs having meaningful irrigated lands. PA level cooperatives have been strengthened to facilitate input/output marketing. New actors such as IPMS–ILRI and TAMPA appeared at this stage. IPMS–ILRI facilitated the introduction of knowledge based market-oriented high value irrigated crop development to enhance the productive use of water by farmers. Community and community leaders closely and interactively implemented the improved interventions with partners. Decision-makers monitored the implementation of market-oriented irrigated crop development to enhance the sustainable and efficient use of resources and improve the income of farmers. Local NGOs such as TAMPA, in collaboration with partners, supported and promoted the market information and market linkage among producers, traders and consumers. The role and importance of Dedebit Credit and Saving Institution (DECSI) in facilitating access to credit and saving services for the farmers became very important when the need for water lifting devices has been increased to make better use of the available water for market-oriented crop development. The input supply and output marketing sector of the district OoARD and farmer cooperatives became better organized and strengthened. The district level OoARD also has strengthened its unit of irrigation development to support the design and construction of irrigation systems</p>

Table 3. Management approaches and key achievements in the processes of harvesting and productive use of water in relation to the transformation phases in Atsbi-Womberta district

Transformation phases	Management approaches	Results
Increased crop water availability	<p>Establishment of water harvesting systems including micro-dams, farm ponds, percolation dams, diversion and recharging structures</p> <p>Introduction of <i>in situ</i> soil and moisture conservation: bunds, ridges runoff strips, contour cultivation and trenches (Belete 2009)</p> <p>Agronomic practices: early dry planting and priming for early vigour growth and cover, increase vegetation cover and area closure</p>	<p>Surface and groundwater recharged and developed. Runoff and evaporation reduced, and infiltration increased (Hailay 2008)</p>
Increased crop water uptake to improve yield	<p>Selection of improved crops and varieties, early dry planting and priming</p> <p>Integrated water, nutrient and pest management (IPMS 2005)</p>	<p>Crop productivity and production improved, and technology uptake enhanced (IPMS 2005)</p>
Shift towards high value irrigated crops to increase income	<p>Introduction of context specific diversified choices of market-oriented crops and varieties</p> <p>Access to market information and linkages; access to input supply and credit, value addition</p> <p>Integrated water, nutrient and pest management</p> <p>Improvement in skills and knowledge, and capacity to innovate and use knowledge along the value chain of irrigated crops</p>	<p>Skill and knowledge, and the capacity to respond to emerging opportunities and challenges improved</p> <p>Scaling up of best practices started</p> <p>Income of households from market-oriented crops increased substantially and investment in resource conservation enhanced</p>

5 Value chain based irrigated crops development interventions, implementation, and outcome monitoring

Interventions such as productive use of conserved water, knowledge capturing, use and sharing of experiences and skills along the continuum of irrigated crop development were successfully implemented to bring changes in the income of smallholder farmers. The interventions have been applied through the support of the extension system. These include introduction and popularization of improved resources conservation and utilization of technologies, improved access to associated inputs, better market linkage and better access to credit and market information. Thus, the use of new skills and knowledge in irrigated crops development intensified or improved as smallholders shift from rainfed cereal dominated practice to market-oriented high value irrigated crops development in the Atsbi-Womberta district.

5.1 Interventions

5.1.1 Intervention on water harvesting and productive use

Technically, the transformation process from high risk rainfed agriculture to a market-oriented high value irrigated crops development has three interconnected development phases that vary in management approaches, harvesting and productive use of water (Table 3). These development phases were (1) increased crop water availability; (2) enhanced crop water uptake capacity to increase crop productivity and production, and (3) shift towards improved income of farmers through market-oriented and diversified high value crop choices.

Crop water availability increased through the introduction of water harvesting systems (Table 3). The commonly introduced water harvesting technologies include micro-dams, farm ponds, percolation ponds, diversions, recharging structures and limited irrigated channels (Belete 2009). *In situ* soil and water conservation practices include runoff strips, ridges and bunds. Consequently, surface and groundwater recharged and developed, and springs and river water flow amount and duration increased as a result of the first phase interventions (Hailay 2008). Besides, technologies and skills that increase crop water uptake capacity to improve crop productivity and production were also introduced and implemented (Table 3). Access to input supply, credit and extension support services available and comparatively improved in technical skills and timing. In the second phase

of the interventions, increased crop productivity and production were achieved under supplemental and full irrigation (Table 3).

5.1.2 Production, input supply and marketing interventions

Following the diagnosis and synthesis of the existing commodity potentials and limitations, new interventions were proposed for the value chain systems of market-oriented irrigated crops development (IPMS 2005). The proposed new interventions were identified together with research and development partners, farmers and local administrators under the facilitation of the IPMS project (Table 4). Besides, new knowledge was acquired and shared. Capacity development needs of actors on context specific irrigated crops such as vegetable and spices developments were assessed and need-based capacity development was provided.

Table 4. *Integrated interventions in the value chain of irrigated crops development in Atsbi-Womberta district*

Value-chain	Key interventions facilitated by OoARD, IPMS and other partners
Marketing	<p>Linkages among market-oriented crop producers, traders and consumers facilitated and communicated using telephone services available at each PA</p> <p>Trainings on marketing skills of farmers and traders were given</p> <p>Market information was made available from within the district and from nearby towns on biweekly basis, in addition to the Tigray regional state weekly supply of market information by radio</p>
Product processing	<p>Skills on quality based grading; packing, transporting and improved temporary storage options were developed</p>
Production technologies	<p>Improved skills and knowledge on high value irrigated crops such as seedling management for tomato, hot pepper and onion, and bulb seed supply of garlic and tuber seed of potato</p> <p>Skills on on-farm water, nutrient and pest management practices introduced and demonstrated</p> <p>Choices of dynamic market-oriented cropping patterns in response to nutrient mining, pest resurgence and frost facilitated</p>
Input and credit supply	<p>Private vegetable seedlings such as tomato, onion and hot pepper production and marketing strengthened</p> <p>Skills on maintenance and operation of water lifting devices such as drip, treadle and motor pumps facilitated</p> <p>Credit for purchase of high value crops inputs such as water lifting devices was available from credit facilitators such as DECSI, OoARD and NGOs</p>

5.2 Implementation of interventions for market-oriented irrigated crops development

Intervention implementation follows the structure of the extension service provision¹ (Table 5). Planning, implementation, and monitoring and evaluation of high value irrigated crops development has been conducted using the extension structure. Along the extension structure, various training approaches have been used to strengthen the capacity of farmers and extension service providers to respond to emerging opportunities and challenges. These included training of trainers; study tours; farmer to farmer exchange of information and farm visits; and knowledge sharing in agricultural exhibitions organized at PA,² district and regional levels. Before the decision to use a new technology or approach is made, improved agricultural technologies or approaches are first demonstrated to farmers at the FTC.

Table 5. *Level of the extension services and structures in Atsbi-Womberta district*

Level of services	Structure of the extension system and beneficiaries	Purpose of the intervention
Household	About 25–30 households grouped as development team per contact farmer	The development team shared and exchanged information on new technological innovations and skills with the facilitation of the contact farmer and DA The contact farmer shared the practical application of the new technology or approach in the field
Peasant association (PA)	Each PA has three DAs: one in crop production, one in animal production and a third in natural resources management. In PAs where the annual irrigated land coverage is above 50 ha, a DA has been assigned to assist the irrigated crops development	DAs provide extension service to households. Initially, new technologies demonstrated in the FTC and contact farmers and thereafter popularized to the development teams
Supervision sites/boundaries	Supervision sites are group of three to four adjacent PAs under one supervisor. Three supervision sites exist in the district	A supervisor supervises about 3–4 PAs. The weekly activities of each PA are monitored. The supervisor links the activities at PA level with the subject matter specialists (SMS) at district level
District/ <i>woreda</i>	SMS consist of various experts specialized in specific disciplines such as irrigated crops development	SMS monitor and give support across the PAs on the specific subject such as irrigation crops development

1. The extension service provision has been structured from the district down to the PAs and villages: district experts → supervisors of development agents → development agents (DAs) → contact farmers → farmers.

2. At PA level, there is a knowledge sharing and learning centre, known as FTC. The FTC is a technology demonstration and training centre for farmers particularly on market-oriented irrigated crop production such as vegetables and spices.

5.3 Outcome monitoring

To quantify the results from an individual or a combination of interventions, the project initially established a baseline data as a reference to measure and document changes. To establish baseline information, data from a formal baseline study and from some special diagnostic studies were used. The initial Participatory Rapid Appraisal (PRA) study also contributed to the quantitative and qualitative baseline information. The information collected included irrigated area coverage and the number of households involved in irrigated agriculture. This information was used to compile district level information on irrigated acreage (by crop) and households.

Several sources were used for regular documentation of changes and results, including six monthly progress reports, annual M&E reports, MSc theses, records kept by the OoARD, and personal observations. District OoARD staff also monitored changes in production and productivity on yearly basis. In 2009, the IPMS project staff conducted a household survey to systematically collect relevant information for commodities of intervention. The stakeholder meeting was organized to establish the evolution of the roles and linkages of the value chain actors.

The household survey conducted in 2009 obtained data from selected sample households in 12 PAs.³ The survey data consists of relevant production and marketing information on irrigated crops such as vegetables including area allocation, production costs and inputs use, level of production, and marketed surplus. In selecting the sample households, with the objective of getting some idea about the effect of the different interventions, a distinction was made between households which had adopted/benefited from the various interventions and households which had not. In both sample groups, both wealth and gender criteria were considered to get a representative distribution of sample households.

3. Hayelom, Barka Adi Sebha, Dibab Akorein, Michael Emba, Kal Amin, Habes, Golgol Naele, Ruba Feleg, Zarema, Haresaw, Gebrekidan and Hadnet.

6 Achievements

Various shifts and changes were observed in response to market-oriented irrigated crops development. Some of the key changes include a shift towards diversified high value crops, shifts in cropping intensity of irrigated crops, and changes directly associated with the management of value chain systems of irrigated crops. Shifts were also observed in increased capacity of beneficiaries to respond to emerging opportunities and challenges including incorporation of new commodities and rotation systems. Attitudinal changes towards natural resources management, and increased awareness about gender equity associated with market-oriented irrigated crops development were also observed.

6.1 Changes in irrigated areas, beneficiaries and share of market-oriented irrigated crops

The run-off to run-on surface ratio⁴ in the district is 9:1, indicating that runoff conservation is technically feasible in the district. Consequently, the various conservation measures significantly increased surface and groundwater mainly in the valley bottoms (Hailay 2008). To increase crop water availability, the communities in the district have been massively mobilized on runoff detention and retention since the early 1980s (Berhane Hailu, personal communication). At present, about 80% of the total district area is conserved by physical structures to reduce runoff and increase water infiltration (OoARD 2010). About 60% of the conserved area is also put under area closure (OoARD 2010). Besides, about 40% of the conserved area has been rehabilitated with biological conservation measures to stabilize the gullies and re-enforce the physical conservation structures. Both area closure and biological conservation interventions substantially increased ground cover (Hailay 2008; Belete 2009).

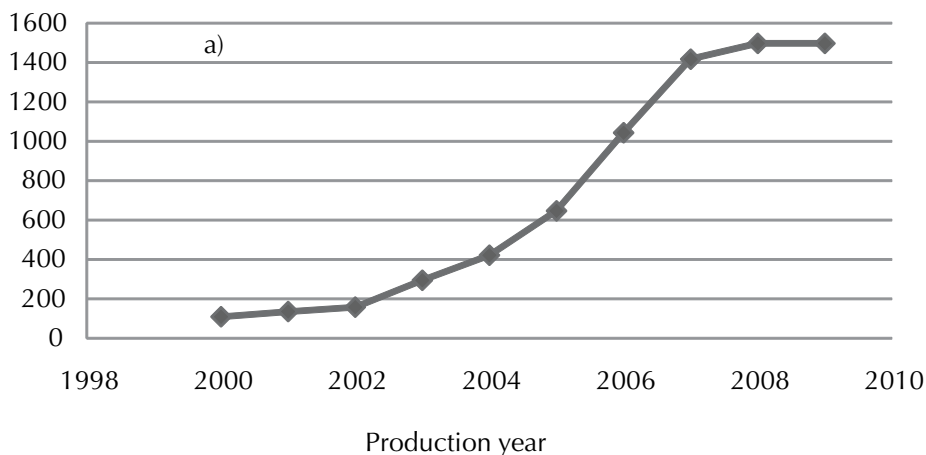
About four micro-dams are constructed along with distribution canals, and temporary water reservoirs. The supply of water lifting devices is arranged through credit facilities. Furthermore, access roads to most PAs are constructed largely through community labour with little donor or government support.

The increase in vegetation ground cover substantially reduces evaporation and increase water infiltration. The increased surface and groundwater has been instrumental in increasing the benefits of smallholder farmers. The effect of the various interventions in terms of irrigated area coverage, number of beneficiary households and trends in shifting towards market-oriented irrigated crops development were assessed at district

4. Run-off to run-on surface ratio is defined as the surface area of the run-off generating sites divided by the total surface area of to the run-on receiving sites.

level. OoARD statistics are used to indicate the trends in irrigated area and number of beneficiaries (Figure 2).

Irrigated area (ha)



Beneficiaries (households/Year)

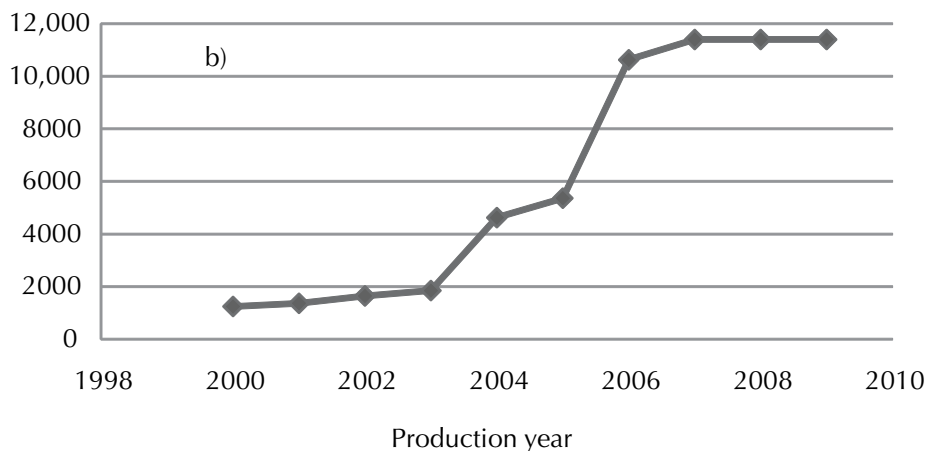


Figure 2. Changes in irrigated area (a) and the number of household beneficiaries (b) in Atsbi-Womberta district, 2000–2009.

The total irrigated area in the district increased by about fourfold and the number of beneficiaries by about threefold between 2004 and 2009 (Figures 2a and b). The increase in irrigated area and beneficiaries is largely attributed to (1) demand for high value irrigated crops products in the nearby market making irrigated crops profitable to growers, (2) access to irrigation input supplies such as water lifting devices and planting materials, (3) the increase in capacity and skill of growers and extension service providers on water harvesting and productive use of water for high value crops, (4) intensified

resources conservation interventions to increase crop water availability around runoff generating sites, and (5) continued community, government and donor investments in irrigation skills and infrastructures.

Better availability of water led to production of high value irrigated crops that resulted in better income to smallholders. This further triggered expanded use of available water in the run-on down streams and extra efforts to conserve more water resources in runoff generating sites in the district. For instance, the number of shallow wells in use in 2004 was 31, irrigating about 11 ha of land and benefiting about 121 households. In 2009, the number of shallow wells increased to 548, irrigating about 685 ha and benefiting 618 households as a result of coordinated government support and community involvement (OoARD 2009).

Similarly, new water harvesting mechanisms such as underground water reservoirs and percolation ponds have been introduced. Currently, there are about 649 water reservoirs and percolation ponds in the district as a result of coordinated government support and community participation. With increased water availability and emerging high value market-oriented irrigated crops products, the use of water lifting devices, planting materials, and better irrigated crops management and use expanded. For instance, the number of motor pumps was 47 in 2004 and increased to 392 in 2009 (OoARD 2009). Similarly, the number of treadle pumps increased from 29 to 748, and that of drip irrigation plots from 0 to 377 in the district. Besides, most of the planting materials of high value crops such as vegetables and spices were supplied locally. Women have been the major supplier of vegetable seedlings in the district (Ametemariam 2008). Credit services for inputs have been provided by credit institutions such as DECSI. Making use of the better availability of water, irrigated inputs, and better capacity in irrigation management, farmers have been able to take advantage of the demand for market-oriented high value crops products in the nearby market towns.

The increased benefits of smallholder farmers are associated with changes in cropping pattern in favour of market-oriented high value irrigated crops (Figure 3). Initially, irrigation water was used for cereals (wheat and barley). The shift from rainfed and irrigated cereal crops production (mainly barley and wheat) to high value irrigated crop production has been gradual. However, rapid shifts to diversified market-oriented high value irrigated crops such as vegetables and spices have been observed since 2005 (Figure 3). For instance in 2004, the share of irrigated cereals was about 73% (143.94 ha) of total irrigated land, with the remaining (52 ha) covered by high value market-oriented crops such as vegetables and spices. In 2009, the share of market-oriented high value irrigated crops mainly vegetables and spices raised to 89% (1331.9 ha) of total irrigated

land, with the remaining (165 ha) covered by cereals. The observed share of irrigated cereals in 2009 was largely attributed to the planting of short period maize aimed at breaking pest resurgence in the successive vegetables cultivation and to supplement the critical shortage of animal feed in June and July.

Share of high value crops (%)

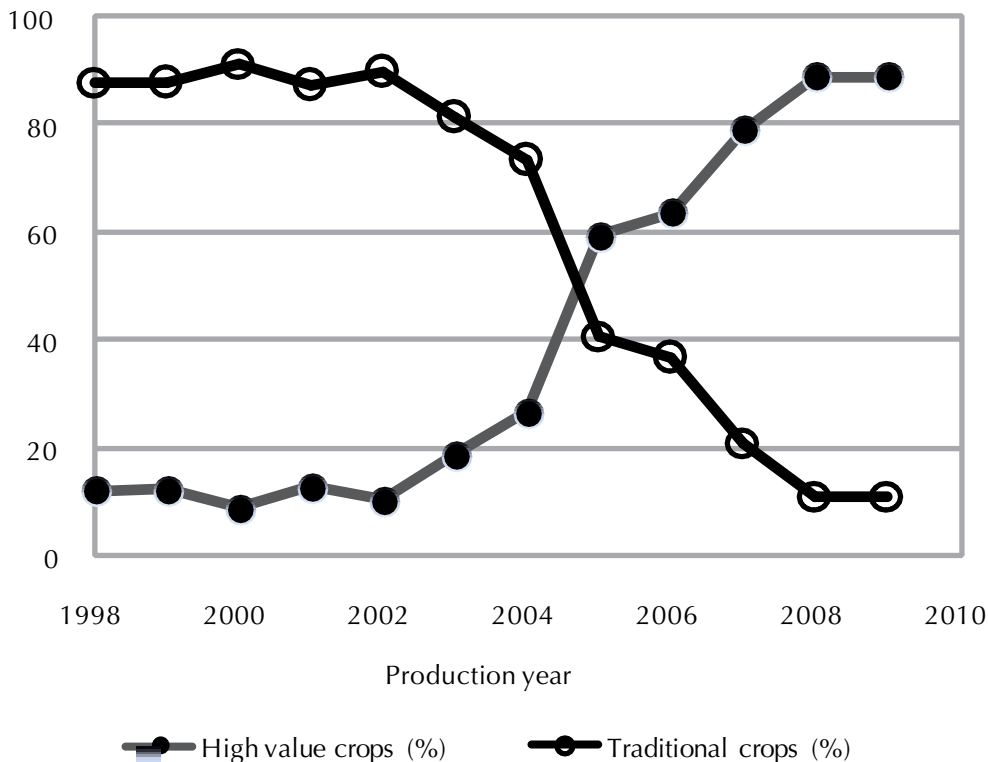


Figure 3. Shifts in irrigated crop choices towards market-oriented high value crops in Atsbi-Womberta district, 1998–2009.

The rapid shift from irrigated cereals to market-oriented high value crops might be attributed to the increased market demand in the nearby town, improved skills on the management of high value crops destined for market, and increased access to market information, credit and input supply. Farmers do have access to the locally made water lifting devices such as treadle pumps and drip irrigation as well as imported motor pumps. Furthermore, the improved skills of private vegetable seedlings produced enhanced the supply of locally produced seedlings and contributed to the shift into high value irrigated crops.

6.2 Changes in household income, cropping intensity and diversity

The resource conservation efforts of households and communities are translated into household income via market-oriented crop and animal production (Figure 4). Improved resource conservation avails more soil moisture for high value crops. Improved soil moisture also leads to improved feed availability for animal production. There also is an interaction between market-oriented crop and animal production.

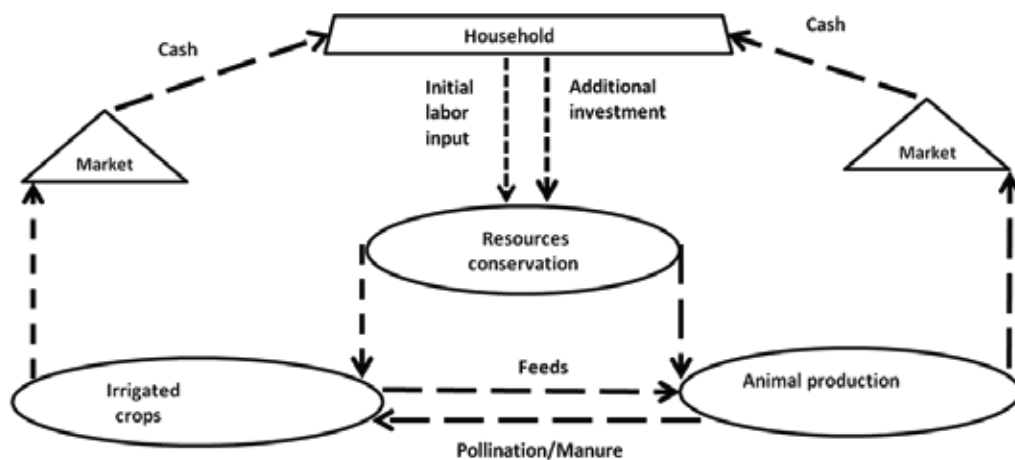


Figure 4. Schematic illustration on the relationships between natural resources conservation and market-oriented commodity development to enhance household income in Atsbi-Womberta district.

The household survey conducted in 2009, covering 2007/08 cropping seasons compared area covered, production, productivity, production cost, gross revenue and return to family labour for farmers who are beneficiaries of the IPMS interventions (adopters) and non-beneficiaries (non-adopters) based on three irrigated vegetables; onion, tomato and hot pepper (Table 6).

Table 6. Household production and income from vegetable production in Atsbi-Womberta district, 2007/08 season

Vegetable type	Farmer type	n	Average plot size (<i>timad</i>)	Average production (kg/household)	Average productivity (kg/ <i>timad</i>)	Average (ETB/kg) ^a	Average cost (cash outlay)	Average gross revenue	Average net return to family labour ^b
Onion	Adopters	28	0.190***	160.1***	2006.7	3.74	125.52***	791.34***	665.82**
	Non-adopters	28	0.022	23.3	2085.8	3.74	18.41	108.62	90.21
Tomato	Adopters	29	0.539**	2677.3***	3413.7	2.37	266.82	6345.11***	6078.29***
	Non-adopters	18	0.112	275.7	3269.3	2.37	89.45	653.46	564.01
Pepper	Adopters	8	0.109*	164**	420	11.87	27.59	1946.68**	1919.08**
	Non-adopters	11	0.015	27.2	275	11.87	7.51	322.86	315.35

ETB (Ethiopian birr). On 10 March 2011, USD 1 = ETB 16.6727.

Note: ***, **, and * are significantly different from the other group mean at 1, 5 and 10%, respectively.

a. Average price received by all households is considered (adopters and non-adopters).

b. Net return to family labour is the difference between gross revenue and cash outlays. A '*timad*' is about a quarter of a hectare.

The results demonstrated that on average, adopters cultivate significantly ($p < 0.01$) larger areas (0.19 *timad*/household) for all three vegetables (onion, tomato, and pepper) as compared to non-adopters (Table 6). Average productivity (production/unit area) was, however, not significantly different between adopters (420–3414 kg/*timad*) and non-adopters (275–3269 kg/*timad*) for the three vegetable types. On the other hand, the significant difference in income lies in the amount of annual cropping intensity. Adopters increased crop intensity by about two to three per year compared to only one crop harvest by non-adopters (Ametemariam 2008).

Analysis of aggregate income from the three vegetables is presented in Table 7. The average income from the three vegetables sales was about ninefold higher for adopters (ETB 4462/household) compared to non-adopters (ETB 501/household). Significant difference was also observed in labour use between adopters (42 man-days/household) and non-adopters (17 man-days/household). Sum of money outlay for the variable inputs of seed, fuel, fertilizer and pesticides used for the three irrigated vegetable crops was significantly higher for adopters (ETB 307/household) than non-adopters (ETB 85/household).

Table 7. *Irrigated vegetables, variable cost, labour use and income per household*

Farmer type	n	Average area (<i>timad</i>)	Variable costs ^a	Labour (AE)			Average income from vegetables sale ^b
				Own	Hired	Total	
Adopters	54	0.942***	306.65***	31.8***	9.7***	41.5***	4461.87***
Non-adopters	45	0.135	85.38	16.2	1.0	17.1	501.41

Note: a. Variable cost here is the sum of money outlay for seed, fuel, fertilizer and pesticides used for vegetable production per household.

b. Revenue could be calculated from total production but requires time to look for the price of each vegetable type to get a vegetable specific revenue to sum them up latter.

6.3 Changes in input supply and marketing services

Skills related to operation of water lifting devices and maintenance services relatively improved through practical training of the farmers and associated supporters (personal communication with farmers). Hence, most of the maintenance and repairing services of water lifting devices became available within the district. Prior to the intervention, farmers had to transport their devices to other towns for repair and maintenance services. There were also improvements in the management of seedling husbandry with the introduction of seedling handling based on the balanced growth of shoot to root ratio. Previously, vegetable seedlings of tomato, hot pepper and onion were raised in beds with good water and nutrient supply. Under such management, seedlings showed vigorous shoot growth with high canopy cover. The seedlings had disproportionate shoot to root ratio. This means, under ample supply of water and nutrients, vegetable seedlings develop 'crazy tops' at the expense of roots. After transplanting to the actual field, the roots were not able to supply the required water and nutrients to the shoots. Subsequently, the seedlings adjust to the new field by dropping the leaves and initiating re-growth of new leaves and roots in a balanced proportion. The consequence of shoot re-growth is that there was a delay by about 2–3 weeks to reach maturity or harvest. This delay mostly created mismatch of the vegetable market supply and demand mainly during the Ethiopian fasting months where vegetables market demand is very high. At present, most of the vegetable seedling supply is relatively well organized according to the planting date of the respective cultivars. The seedling supply is local and largely benefiting women with average annual income of about ETB 1000/head (Ametemariam 2008).

Before market interventions were introduced, vegetable prices in the main town of Mekele were about 2–3 times higher than the farm gate price (TAMPA 2008). After supply of market information and linkage interventions, the difference in vegetable price narrowed to 40–60% during peak production periods (OoARD 2008; TAMPA 2008). Vegetables product handlings including harvesting, grading, packing and transport equipment were also improved according to the market needs.

6.4 Response to emerging opportunities and challenges

The challenges and tested options in response to emerging opportunities and challenges as well as indicative results are summarized in Table 8. With continuous cultivation of high value crops such as vegetables, excessive nutrient mining, pest resurgence and frost have emerged as challenges (Table 8). Farmers also indicated that the introduction of cereals in rotation with vegetables reduced pest loads in their plots but nutrient mining continued, and the income obtained from cereals was much lower than that of market-oriented crops such as vegetables.

Table 8. *Tested options and associated indicative results in response to the emerging challenges in irrigated crops, 2005–2009, Atsbi-Womberta*

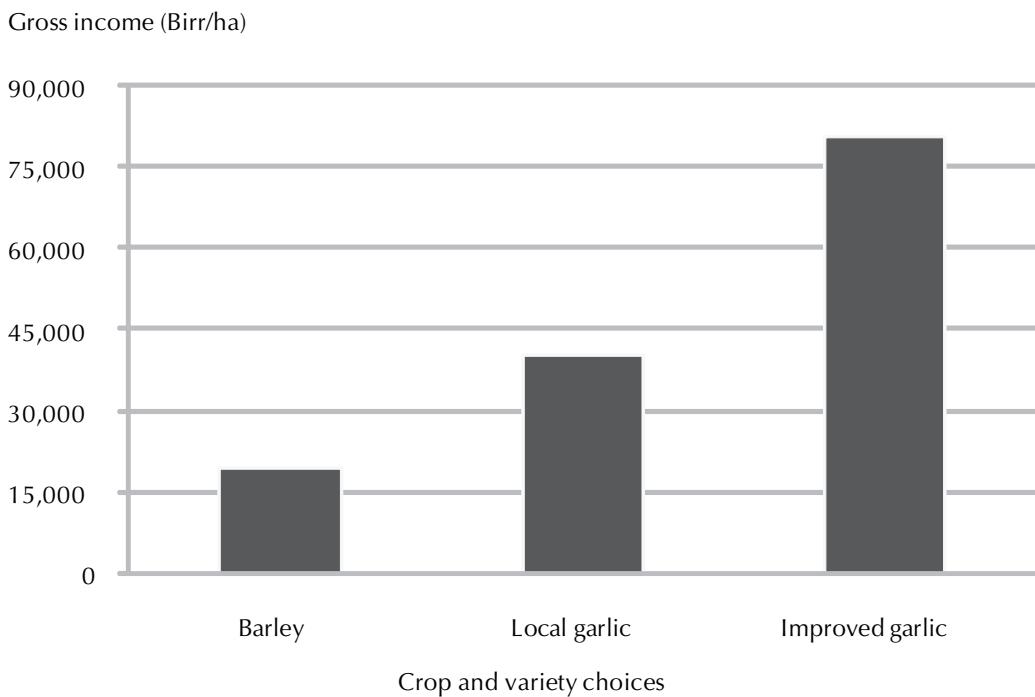
Challenges	Tested options	Indicative results
Nutrient mining and pest resurgence	Pesticide spray	Pest loads relatively reduced but substantial negative side effects to beekeeping sector noticed
	Re-introduction of cereals in rotation with vegetables	Pest load reduced but nutrient mining continued
	Introduction of leguminous pulses	Pest load reduced and soil fertility increased with improved vegetable yields
Frost	Local barley cultivation	Low return under irrigated conditions
	Introduction of local garlic	Gross income increased by about twofold compared to barley cultivation (based on farm input/output calculations). The barley straw also as sources of animal feed replaced by growing improved grasses around the buffer zones and irrigated channels
	Introduction of improved garlic varieties	Gross income increased by about twofold compared to local garlic variety (Tadesse 2009)

Furthermore, farmers mentioned that the use of pulses, namely field pea, faba bean, lentil and fenugreek, in rotation with vegetables, have reduced pest load, increased soil nutrient levels and results in reasonable income from beans. This observation is consistent with previous research findings that showed legumes such as faba bean and peas can fix about 165–240 kg N per hectare in western Europe with about 4–202 kg N per hectare remaining in the soil (Jensen 1986; Maidl et al. 2008).

In the highlands of Ethiopia, the total amount of nitrogen fixed by faba bean fields ranged from 139–210 kg N per hectare with about 12–58 kg N per hectare remaining in the soil (Amanuel et al. 2000). The net balance of the fixed nitrogen left after harvest was positive indicating that vegetables planted in rotation with pulses may benefit from the residual nitrogen in the soil. Most importantly, irrigated pulses were produced during the dry season when there are no other rainfed pulses. Irrigated beans produced during the dry

season fetch about ETB 650–850/100 kg compared to ETB 450–650/100 kg for rainfed beans harvested in December (TAMPA 2008). Furthermore, the harvesting period of irrigated beans coincides with the peak demand for beans by migrating labour working in the commercial sesame producing areas of Setit Humera, in northwestern Ethiopia. Thus, dry season harvested beans have a good market niche in the northwestern and western parts of Ethiopia.

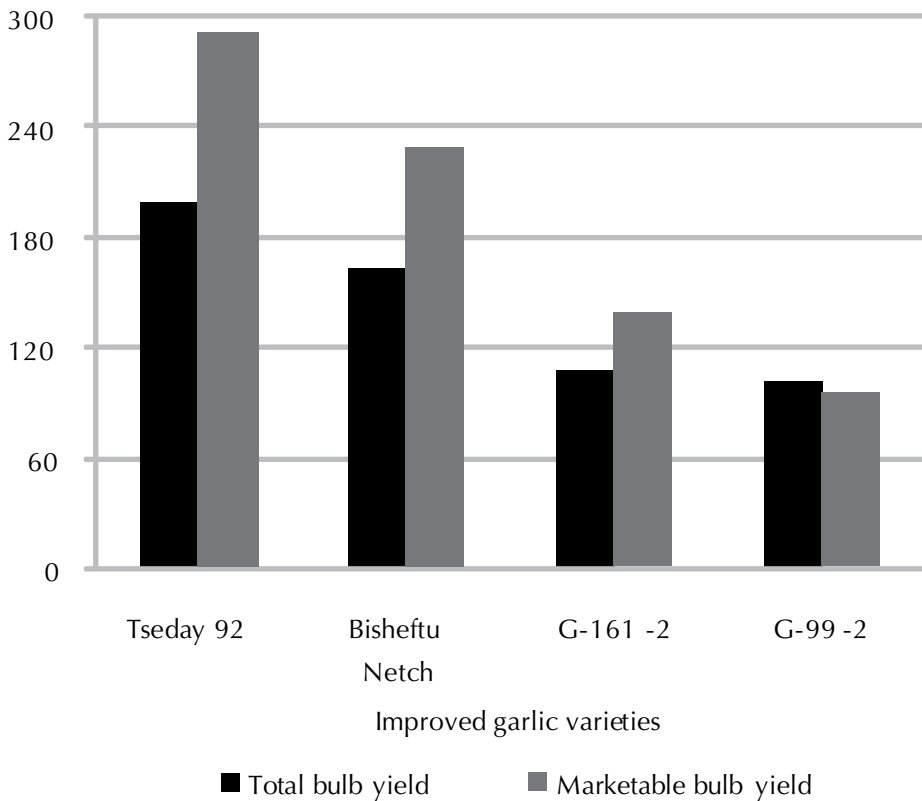
Extended frost period is a challenge to produce market-oriented irrigated crops. Garlic was introduced and tested as an alternative crop during frost seasons. The performance of the local garlic variety was promising and 10 of the farmers who tested garlic in small plots had achieved more than twofold income compared to cereals such as barley (Figure 5). Thereafter, four improved garlic varieties were introduced and tested. All the improved tested garlic varieties perform by about 95 to 290% higher in total and marketable bulb yield than the local garlic variety (Figure 6).



Source: Key informant interviews and Tadesse (2009).

Figure 5. Comparison of gross annual income (ETB/ha) among irrigated local barley and local garlic and improved garlic variety Tseday 92 in Atsbi-Womberta district, 2007.

Bulb yield increase over the local (%)



Source: Tadesse (2009).

Figure 6. Performance of improved garlic varieties over the local variety (%) in Atsbi-Womberta district, 2007.

Of the improved and tested varieties, the improved garlic variety, Tseday 92, gave about twofold total fresh bulb and threefold marketable fresh bulb yield over the local garlic variety (Figure 6). Moreover, techniques of garlic bulb seed production and storage were demonstrated to farmers (Tadesse 2009). At present, about 25 farmers are producing garlic during frost periods in three PAs namely Golgol Naele, Felegeweini and Ruba Feleg PAs and few have started supplying garlic bulb planting materials to others. The current price of fresh garlic bulb in the local market is about ETB 10–14/kg.

6.5 Environmental, wealth, gender and HIV/AIDS effects

6.5.1 Environment

Market-oriented high value irrigated crops such as pulses, vegetables, fruits, and spices are planted during the dry season (January–May), and flower in March and April when shortage of bee forage is critical. Beekeepers indicated that honey yield and bee colony strength improved following the introduction of irrigated crops during the dry season (Figure 4). Many researchers indicated that yield of horticultural crops and pulses such as faba bean increased due to honeybee pollination in many countries (e.g. McGregor 1976; Admassu and Nuru 2000; Somerville 2002; Musallam et al. 2004; Sabara et al. 2004).

Farmers in the district indicated that the use of the chemicals spray has negative side effect to the mushrooming beekeeping sector. The negative effects of using unsafe pesticide spray to honey beekeeping have been well established (e.g. Atkins et al. 1978). In Atsbi-Womberta district, the types of pesticide used and their toxicity level to non-target animals such as honeybees are not well known since most of the pesticides on use in irrigated crops are purchased from private dealers in the small towns (also see section 6.4 for farmer responses to this challenge).

Following the increased environmental benefits from market-oriented irrigated crops, farmers have started to put organized and intensified efforts to reduce runoff in steep slopes, construct detention ponds around farm lands and stabilized gullies. The efforts of reducing runoff showed a substantial change in groundwater enrichment, spring development and increased river flows (Hailay 2008; Belete 2009). For example, in a watershed known as Gergera in Hayelom PA, about 1.1 million m³ water per annum enriched the groundwater and is being used mainly for market-oriented irrigated crops development (Hailay 2008). In turn, farmers in the same PA mentioned that investment in resources conservation has intensified. Farmers mentioned that the watershed which was once environmentally degraded and devoid of vegetation has been rehabilitated. The same watershed has been serving as source of animal feed and runoff sources to be used as irrigated water in the downstream.

6.5.2 Wealth, gender and HIV/AIDS effects

In 2007, the wealth status of 108 household adopters and non-adopters of market-oriented irrigated crops from five PAs was compared using community based wealth

status classification⁵ as used by Assefa (2005) and SERA (2000). The five PAs were Felegeweini, Ruba Feleg, Adi Mesanu, Golgol Naele and Hayelom (Ametemariam 2008). The results indicated that about 17% of the adopter households were categorized as wealthy or rich, 64% as medium and 19% as poor (Figure 7). In contrast, about 60% of the non-adopter households were classified as poor, 36% as medium and 4% as rich. In this regard, about 81% of the adopters were relatively able to support their family compared to about 40% of the non-adopters. Interestingly, wealth status survey was conducted using similar wealth category on 650 households in five PAs⁶ of Atsbi-Womberta district in 2000 (SERA 2000). The survey indicated that about 50% of the households were categorized as poor, 33% as medium and 17% as wealthy indicating that there are no meaningful changes compared to the wealthy category of non-adopter households in 2007.

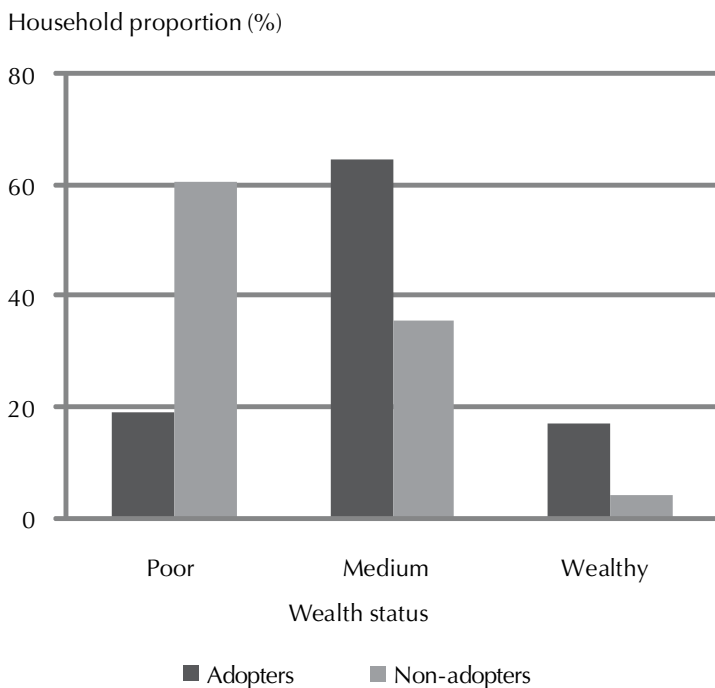


Figure 7. Wealth status households by adoption or non-adoption of market-oriented irrigated crop in Atsbi-Womberta district, 2007.

5. The criteria used were cultivated land and herd size, and the stock of seed/grain for planting and consumption. Farmers in rich group cultivated >1 ha land and possess ≥ 2 oxen, and ≥ 2 cows and had enough seed/grain in stock to cover the requirements for planting and consumption. The medium groups cultivate about 0.75–1 ha land, own one ox and one cow. The poor group cultivate < 0.75 ha land, and owned one or no ox, one or no cow, and few other animals and had insufficient seed or grain for planting and consumption.

6. Names of sample PAs: Felegeweini, Habes, Adi Mesanu, Michael Emba and Kelisha Emini.

There was also difference in wealth status between adopters and non-adopters of market-oriented irrigated crop development within the female-headed households (FHHs) in 2007 (Ametemariam 2008). About 7% of the adopters of FHHs were categorized as wealthy, 65% as medium and 28% as poor whereas about 71% of the non-adopter FHHs were categorized as poor and the rest (29%) as medium (Figure 8). This shows that the proportion of wealthy and medium households is higher in the adopters category than in the non-adopters FHHs category. The adopters are relatively better off to support their family compared to the non-adopter in FHHs. The wealth status of FHHs can be contrasted with that of the male-headed households (MHH) (Figure 8). About 90% of the MHH adopters were classified as rich and medium compared to 72% of the FHH adopters. This indicates that adopter FHHs are improving their livelihood in the same trend as adopter MHHs using market-oriented irrigated crops development. However, about 50% of the MHH non-adopters were classified as rich and medium compared to 29% of the FHH non-adopters. This indicates that the relative discrepancy in wealth status of MHHs and FHHs is higher in non-adopters than adopters.

Wealth status (%)

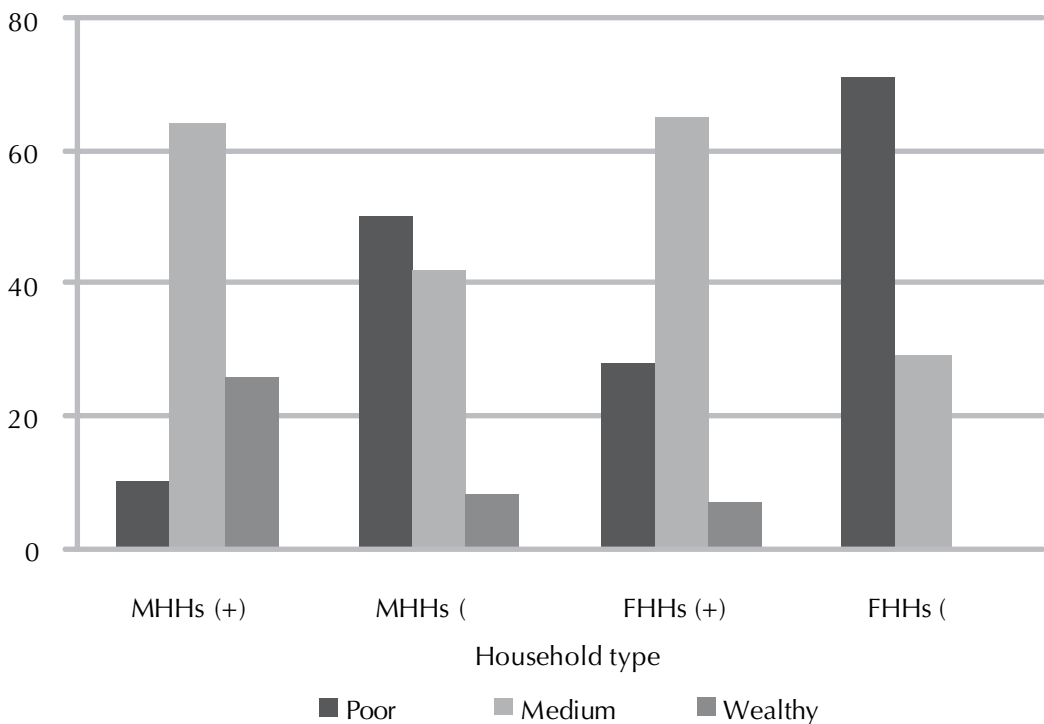


Figure 8. Wealth status of female-headed households (FHHs) and male-headed households (MHHs) adopters (+) and non-adopters (-) of market-oriented irrigated crops development in Atsbi-Womberta district, 2007.

Regarding attitude towards risk, survey results show that FHHs were less risk takers compared to MHHs (Ametemariam 2008). On the other hand, there was variation in access to training, skill and knowledge sharing among women in FHHs and MHHs. The knowledge, skills and decision-making power of FHHs was found to be much higher than the women in MHHs (Ametemariam 2008). Women in MHHs had relatively less access to training compared to women in FHHs. Furthermore, most of the husbands did not share the lessons and skills gained in training with their spouses at home (Ametemariam 2008). Hence, a wife and husband training in extension programs appeared to be useful as demonstrated in some of the IPMS pilot learning districts. Besides, survey results indicate that about 43% of the surveyed FHHs and 24% of the MHHs raise and sell seedlings of tomato, hot pepper and onion in the local market with an average income of ETB 1000/head in 2007 (Ametemariam 2008). Women also work as retailers and men as wholesalers of high value irrigated crops.

It is hypothesized that the income earned from market-oriented irrigated crops production and marketing may be associated with increased exposure of farmers to HIV/AIDS due to the increased human mobility arising from market interactions. In Atsbi-Womberta, there has been a substantial seasonal migration of the productive labour in search of work outside the district (SERA 2000). The seasonal migration of the productive labour could increase the risk of exposure to HIV/AIDS. On the other hand, diversification and intensification of irrigated crop production is labour intensive, with the implications that demand for hired labour also increases and could attract labourers into the district. Together with the development activities, IPMS facilitated awareness creation about HIV/AIDS through training, posters and brochures published in local languages. Skills related with repairing and maintenance of the water lifting devices have been strengthened within the district. These activities have been expected to reduce movement to the nearby towns. Linkages with traders are enhanced, and producers and traders are able to exchange market information using telephone services available at each PA. This should considerably reduce the number of days during which farmers stay out of their homes in search of buyers to sell their produce.

Farmers have been encouraged to bring positive changes in their saving and investment behaviour. In this regard there have been behavioural changes on the use of money by market-oriented commodity adopters. About 36% of MHHs and 30% of the FHHs have started saving the money obtained from high value crops in regular saving accounts (Ametemariam 2008). Others re-invest in irrigated crops or use the money to build houses in the nearby towns or send their children to school (Ametemariam 2008).

7 Conclusions and implications

The transformation from rainfed cereals to irrigated high value crops has taken place due to the use of new approaches and skills in resources conservation, and effective and organised market-oriented extension services to support smallholders. Through knowledge based interventions, conserved resources have been transformed into income of smallholder farmers through increased production and market linkages. Most importantly, this meaningful shift is the result of the learning of new skills and knowledge by doing and sharing experiences among partners or learning from change processes among smallholder farmers and partners.

Gradually knowledge and skill based productive use of water was successfully applied and integrated with other agronomic practices and this triggered the shift from rainfed to irrigated cereals and thereafter to the development of market-oriented high value irrigated crops. Having land under irrigation would mean having 2–3 diversified dependable crop harvests per year. Under rainfed conditions, farmers on average harvested two dependable crops over three years (SERA 2000). That means 2–3 dependable harvests per year using irrigation over a unit of irrigated land would give a much higher reliable income than three years harvest under rainfed conditions. This is because rainfed crops are mostly associated with high risks of crop failure under extreme rainfall variability and cereals fetch relatively lower price than the diversified high value crops such as vegetables and spices. Besides, the shift from rainfed cereal production to market-oriented high value irrigated crops increased average income of farmers by about ninefold. Hence, the transformation from rainfed cereal crops farming to market-oriented high value irrigated crops would bring a sustainable and meaningful difference in the income of smallholder farmers. This in turn triggers the community to re-invest in resources conservation to increase crop water availability.

Although high value market-oriented crop choices under irrigated sites are a key element to increase income of farmers in a sustainable way, so far about 46% of the potential irrigable land has been put under irrigation. This means that there is a need to put further efforts and investment to increase water availability through rainwater harvesting, retention and detention ponds to enrich surface and groundwater, and crop water uptake capacity through diversified and intensified crop management.

Furthermore, about 10% of the arable land is considered as most suitable for supplemental irrigation development. In this regard, the Atsbi-Womberta district has a huge sloping landmass with a 9:1 run-off generating to run-on sites. This potential topography is important to expand crop production under supplemental and full

irrigation and improve income of many smallholder farmers. There is a huge potential to develop intensified and diversified income generating high value irrigated crops development in the district. However, the uptake of new skills and knowledge by partners and farmers appeared to be time consuming. Hence, there is a need to intensify efforts to capacitate farmers and the public extension service with new skills and knowledge in the management of intensified and diversified income generating high value irrigated crops in the district and beyond.

To sustain market-oriented agricultural development, better private sector involvement is needed. The current supply of inputs is largely initiated and organized by government. The private sector could play critical role in agricultural input supply. The public extension service providers could thus be relieved and allowed to focus more on capacity building of farmers to respond to emerging opportunities and challenges. So far the gross income obtained from shifting from rainfed cereal farming to diversified and intensified high value irrigated crops development has been significant. However, the productivity of high value irrigated crops is still below the potential or achievable yield. There is a need to intensify irrigated research programs that integrate farm water management with high value crop choices, fertilizer use and pest control to increase crop productivity.

Undoubtedly targeting marketable commodities and interventions designed on the basis of knowledge gap analysis along the commodity value chain have made a significant contribution to the income of rural farmers. The responses are reflected in the changes in income and wealth status of high value irrigated crops growers, increased number of beneficiaries, improved farm gate price of high value crops, and attitudinal change of farmers to invest in resource conservation. The responses are also reflected in the capacity of the actors to manage high value irrigated crop production effectively in response to emerging opportunities and challenges. It can also be seen in the scaling out to neighbouring districts of the approaches and processes and innovative interventions in the value-chain of market-oriented high value irrigated crops.

The lessons from the spectrum of the interventions show that investment in resources conservation and irrigation infrastructure development should link with the income generating activities of the community. This linkage in turn stimulates community investment in resources conservation. These require shifting towards market-oriented crop production with improved skills and knowledge, and capacity to innovate and use knowledge along the value chain of the commodities to ensure better income to smallholder farmers.

A particular lesson from Atsbi-Womberta district is the involvement of the communities in the decisions to conserve and protect watersheds and croplands. A good entry

point to improve the income of rural farmers was the organization and mobilization of the communities using local resources to conserve soil and moisture. Furthermore, investment in natural resources was linked to benefits to the rural community. In that sense, the selection of moisture conservation sites with demonstrable potential to bring changes in the yield of crops was the first step to win the hearts and minds of the community. Besides, new introductions of high value crops were first tested at small scale and successful results were used as a learning site for others. Successful lessons have been scaled up with timely participatory evaluation and adapted by the communities and beyond. However, the traditional year round open grazing system is still exercised on about 40% of the district landmass. It is documented that overgrazing erodes the productive capacity of watersheds due to increased runoff, bare soil evaporation, and reduction in water infiltration and loss of valuable plant species (e.g. Abril and Bucher 1999; Rayburn 2000). Thus overgrazing is a challenge to the on-going resources conservation and development of irrigated agriculture. Besides, some farmers with large number of animals tend to choose and resort to open grazing system. Thus coordinated efforts are needed to promote controlled grazing, and cut-and-carry system of animal feeding.

Increased crop productivity and crop production per unit of land under irrigation is associated with high costs of inputs and labour. Therefore, the return from irrigated cereals was not very attractive to farmers. The shift has been towards production of market-oriented high value irrigated crops through the use of improved skills and knowledge, and the capacity to innovate along the value chain of irrigated crops. Hence, the experiences in Atsbi-Womberta district show that innovative, knowledge based, context specific, participatory and market-oriented high value irrigated crops interventions can bring successful changes in the income of smallholder farmers. It is important to scale out and up such successes to benefit more farmers in the district and beyond.

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