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Improving Productivity and Market Success of Ethiopian Farmers

Working Paper No. 21

Sustainable land management through market-oriented commodity development: Case studies from Ethiopia

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IPMS ETHIOPIA

This working paper series has been established to share knowledge generated through Improving Productivity and Market Success (IPMS) of Ethiopian Farmers project with members of the research and development community in Ethiopia and beyond.

IPMS is a five-year project funded by the Canadian International Development Agency (CIDA) and implemented by the International Livestock Research Institute (ILRI) on behalf of the Ethiopian Ministry of Agriculture and Rural Development (MoARD).

Following the Government of Ethiopia's rural development and food security strategy, the IPMS project aims at contributing to market-oriented agricultural progress, as a means for achieving improved and sustainable livelihoods for the rural population. The project will contribute to this long-term goal by strengthening the effectiveness of the Government's efforts to transform agricultural production and productivity, and rural development in Ethiopia.

IPMS employs an innovation system approach (ISA) as a guiding principle in its research and development activities. Within the context of a market-oriented agricultural development, this means bringing together the various public and private actors in the agricultural sector including producers, research, extension, education, agri-businesses, and service providers such as input suppliers and credit institutions. The objective is to increase access to relevant knowledge from multiple sources and use it for socio-economic progress. To enable this, the project is building innovative capacity of public and private partners in the process of planning, implementing and monitoring commodity-based research and development programs.

Most of the project's activities are taking place in selected Pilot Learning *Woredas* (PLWs). The smallholder farmers and pastoralists in the PLWs are expected to increase market-oriented production and productivity through the project's interventions during the project life. The project staff and partners will study this process through action research and learning. Some complementary focused studies are also undertaken by the project and its partners, which help to understand the context and determine key factors influencing the adoption and impact of the interventions. The results of all these studies and some important concepts, tools, methods and approaches developed will be published in the working paper series and will also be disseminated through other appropriate channels.

Intended users of the research outputs are government, non-governmental and private sector and donor organizations that are involved in market-oriented development. They may use these learnings in their efforts to scale out this development process to other *woredas* in the country. Some lessons learned are also expected to be relevant for possible use in market-orientated agricultural development efforts in similar contexts outside Ethiopia.

Sustainable land management through market-oriented commodity development: Case studies from Ethiopia

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Earlier version of the paper was presented at Tropentag 2009, 6–8 October 2009, Hamburg, Germany; and at sustainable land management workshop at the University of Gothenburg, Sweden, 14–15 April 2009

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Editing, design and layout—ILRI Editorial and Publishing Services, Addis Ababa, Ethiopia.

Correct citation: Berhanu Gebremedhin, Gebremedhin Woldewahid, Yigzaw Dessalegn, Tilahun Gebey and Worku Teka and. 2010. *Sustainable land management through market-oriented commodity development: Case studies from Ethiopia*. IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 21. ILRI (International Livestock Research Institute), Nairobi, Kenya. 42 pp.

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Abstract

Land degradation has been identified as severe environmental problem in Ethiopia, especially since the early 1970s. Because there is significant degradation on cultivated lands in Ethiopia, there is potentially high payoff to addressing degradation in the country. In this paper we focus mainly on the effect of short-term benefits to farmers and the explicit considerations of the linkages between natural resource management and market-oriented commodity development on the adoption and scaling out of sustainable land management practices. We hypothesize that linking natural resource management with market-oriented commodity development enhances sustainable land management by providing farmers with short-term benefits. We test this hypothesis with analysis of case studies of four districts in Ethiopia. Two of the case studies deal with the linkage between grazing land development and market-oriented livestock development, and the other two deal with the linkage between conservation agriculture and market-oriented crop production. Results indicate that, indeed, direct linkages of natural resource management with market-oriented commodity development that have profitable market opportunities can enhance sustainable land management. Results imply that participatory approaches to the appraisal of community resources, identification and prioritization of key constraints of commodity development, and implementation of interventions greatly facilitate adoption and scaling out of interventions.

1 Introduction

Ethiopia has been in continuous struggle to achieve the three objectives of increasing agricultural production, reducing poverty and ensuring sustainable use of the natural resources, especially since the early 1990s. Increasing population pressure on an already degrading land resource has rendered the struggle even tougher. Eicher (1994) lamented that increases in agricultural production need to come primarily from improvements in land productivity since the land frontier are shrinking. However, a significant increase in agricultural productivity cannot be attained if the land resource base continues to be degraded. Hence, ensuring sustainable land management is a matter of critical importance for agricultural growth in Ethiopia.

Land degradation has been identified as severe environmental problem in Ethiopia, especially since the early 1970s (Stahl 1993; Gebremedhin 1998). Because there is significant degradation on cultivated lands in Ethiopia, there is potentially high payoff to addressing degradation in the country. A number of programs and projects for sustainable land management (SLM) have been implemented in Ethiopia since the early 1970s, aimed at promoting private and collective efforts to conserve natural resources. While the interventions prior to 1990 were primarily technology-oriented and top–down with little participation of beneficiaries in decision-making, the interventions since the early 1990s have been relatively more participatory and institutional factors have received better attention.

Due to externalities and the public good nature of conservation services, neither private nor public efforts by themselves have been successful at preventing land degradation. Both are required in Ethiopia to curb soil erosion, restore and enhance soil fertility, maintain and improve soil structure and water holding capacity, and to ensure sustainable use of communal natural resources.

In designing policies, programs and projects for sustainable land management, it is of critical importance to make a distinction between the proximate (direct) and underlying (indirect) causes of land degradation (Fitsum et al. 2002). Proximate causes of land degradation are the factors that are directly related with the activities and practices that result in the degradation of the land resource, and include factors such as cultivation of steep slopes and erodible soils, low vegetation cover of the soil, burning of dung and crop residues, feeding crop residues, declining fallowing practice and fallow periods, erratic and erosive rainfall patterns, limited application of organic or inorganic fertilizers, deforestation and overgrazing.

The underlying causes include factors such as population pressure; poverty; high costs or limited access of farmers to fertilizers, fuel and animal feed; limited farmer knowledge on integrated soil and water management measures; limited or lack of farmer access to credit; underdeveloped markets; low profitability of agricultural production and conservation technologies; non-responsive extension services; high market and production risk; insecure land tenure; short planning horizon of farmers; information asymmetry; and lack of or inadequate short-term benefits to land users. Efforts for sustainable land management need to address the underlying causes primarily, as focusing on the proximate causes would mean to address the symptoms of the problem rather than the actual causes.

In this paper we focus mainly on the effect of short-term benefits to farmers and the explicit considerations of the linkages between natural resource management and market-oriented commodity development. We hypothesize that linking natural resource management with market-oriented commodity development enhances sustainable land management by providing farmers with short-term benefits.

We test this hypothesis with analysis of case studies of four districts in Ethiopia. Two of the case studies deal with the linkage between grazing land development and market-oriented livestock development, and the other two deal with the linkage between conservation agriculture and market-oriented crop production. Results indicate that indeed direct linkages of natural resource management with market-oriented commodity development that have profitable market opportunities can enhance sustainable land management.

The paper is organized as follows. The next section presents the research method. Section three presents the case study analysis results, while section four concludes the paper and draws implications for research and development.

2 Method

2.1 Study sites

The study is conducted in four districts of Ethiopia. Three of the districts located in the Amhara regional state (Bure, Fogera and Metema districts) and the fourth one is located in Tigray region (Atsbi-Womberta district) (Figure 1). Subsistence mixed crop–livestock agriculture is the dominant mode of production in all districts. Although there are differences in the severity of land degradation across the study sites, land degradation is an important factor of the decline of agricultural productivity in all. Atsbi-Womberta and Fogera are the case studies on the linkage between market-oriented livestock production and grazing land development, while Bure and Metema are the case studies on the linkage between market-oriented crop production and conservation tillage to curb soil erosion and soil fertility depletion, and improve soil moisture retention.

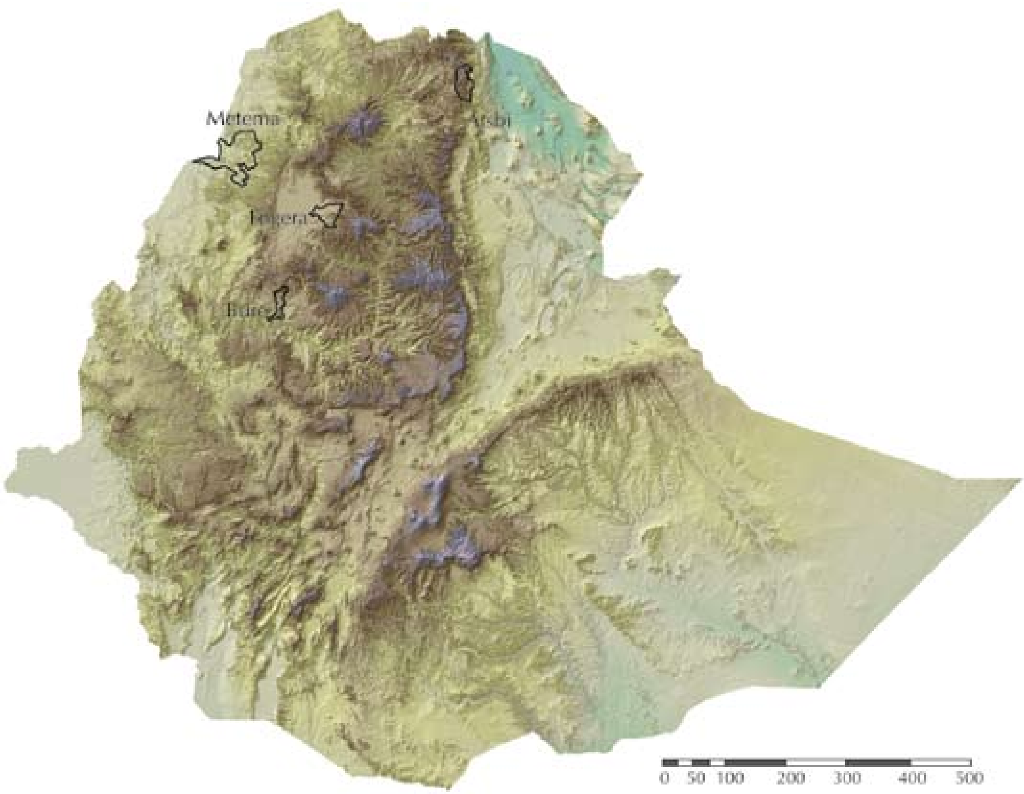

Figure 1. *Study sites.*

2.2 Data and analysis

Data for this analysis was collected using rapid appraisal techniques including focus group discussions, key informant interviews, and analysis of secondary data collected from the records of the district offices of agriculture and rural development. Personal observations of intervention areas supplemented the other PRA techniques. Primary data were also collected on key performance variables. Data were collected on process of the interventions, actors involved, challenges encountered, and results of the interventions in terms of the rehabilitation of the natural resources, improvements in productivity and household incomes. Results are based on qualitative analysis of group discussions and key informant interviews, and quantitative analysis of secondary and primary quantitative data.

3 Case study results

3.1 Grazing land development in Atsbi-Womberta district

3.1.1 Background

Atsbi-Womberta district is located in Tigray region about 80 km north of the regional capital, Mekelle. Due to more rugged topography and recurrent droughts, the Atsbi-Womberta district is the most severely degraded among the case study districts. Rainfall in Atsbi-Womberta is usually erratic, intense and short in duration, lasting for less than three months (June–August), with an annual average of about 668 mm. About 75% of the district landmass is located at an altitude of more than 2200 masl. The total land area of the district is about 122,300 ha, with about 13,050 ha cultivated land, 16,301 ha non-cultivable hillsides, and 8802 ha grazing land. Average land holding in the district is estimated at 1 ha per household. The district is known as an important supplier of highland sheep and high quality honey to the surrounding markets. Despite the historical importance of the district in these market-oriented commodities, shortage of fodder has reduced the supply of these commodities. Communal grazing lands and hillsides have been degraded for generations due to the uncontrolled and free grazing system that was prevalent in the area (Figure 2).

Figure 2. *A partial view of a degraded communal grazing land in Atsbi-Womberta used under free and uncontrolled grazing system.*

Governmental and non-governmental organizations in collaboration with local communities have put intensified efforts to rehabilitate degraded hillsides in the district since 1991. Initially, the interventions included construction of stone terraces and soil bunds, and area enclosures. Enrichment plantations on enclosures have also been widespread. Improvements in the vegetation cover of the hillsides and groundwater recharge have shown signs of spring development in the lower parts of the hillsides. Although there have been noticeable successes in the rehabilitation of the degraded landscapes, animal feed shortage had remained a critical limiting factor to advance market-oriented livestock developments in the district (SERA 2000; IPMS 2005a). Therefore, the IPMS project in collaboration with district and regional stakeholders (including regional bureau of agriculture and rural development, district office of agriculture and rural development, communities and the regional research institute) have promoted collective action to develop and manage degraded grazing lands and hillsides since 2005. The collective action has been explicitly linked with the objective of increasing the productivity and supply of the market-oriented livestock commodities in the district.

3.1.2 Processes

Problem diagnosis

In 2004, a participatory rapid appraisal (PRA) study conducted by the Improving Productivity and Market Success (IPMS) of Ethiopian farmers project revealed that feed was the most important critical constraint for market-oriented livestock and apiculture production in the district. The PRA results were presented at stakeholders' workshop for verification, where farmers and community leaders, extension service providers, NGOs, researchers and IPMS staff participated. The stakeholder workshop confirmed the findings of the PRA, and identified small ruminant fattening, apiculture and dairy as the most important market-oriented livestock enterprises that could be linked with the forage development.

Intervention planning

Following the diagnosis phase, a technical team consisting of experts on forage, animal production, forestry and agronomy was formed from the district office of agriculture and rural development, the regional bureau of agriculture and rural development, and IPMS. The team conducted discussion with the community and community leaders, and decision-makers on the possibilities of forage interventions. The team also assessed knowledge gaps in forage development, and visited various forage development sites in the region to gather experiences and draw lessons. The forage development sites visited included steep hillsides, bottom lands, backyards, and intensively managed irrigated forage sites. The experiences and lessons learned from the various field visits were shared with experts at the district office of agriculture and rural development, and communities and their leaders. Following these deliberations, work plans were drafted jointly with beneficiaries. The beneficiary farmers and extension service providers were given training on improved forage management and utilization.

Intervention implementation

Forage demonstration sites were identified in four land types: bottomland grazing areas locally known as *Sewhi*, heavily degraded grazing lands (lands unsuitable for crop cultivation and permanently allocated for grazing), irrigated lands, and backyards (Table 1). In the irrigated and backyards, farmers planted perennial legumes such as Tree Lucerne and *Sesbania sesban*, and annual grasses such as Napier and Phalaris around water points, water harvested ponds and structures. In the backyards, farmers developed legume shrubs under rainfed conditions and annual grasses mostly around ponds. In the irrigated sites, Napier grass and legume shrubs were demonstrated along the water ways, gullies and other water points. The technical support and supply of seedlings have been facilitated by the district office of agriculture and IPMS. For this reason, about 300 cuttings of Napier grass planting materials were introduced and established in the Farmers' Training Center (FTC) in Hayelom PA. Initially, the established Napier grass served as demonstration and training site on improved forage production and utilization for farmers. Later farmer demand for Napier grass planting materials increased. Consequently, the established Napier grass served as sources of planting materials for the surrounding farmers. There has also been continuous supply of Napier planting materials between farmers. The supply of legume shrub seedlings and Phalaris splits are facilitated from the forage nurseries located within the district.

In the bottom and heavily degraded grazing lands, forage development demonstration sites were selected in close consultation and discussion with the communities and their leaders. The community in Barka Adi Sebha agreed to enclose bottomland grazing land of about 69 ha of land for use under cut-and-carry system of animal feeding. In the heavily degraded grazing lands, the community in Golgol Naele PA agreed to put about 26 ha of land under enclosure for forage development. In both communities agreement was reached after repeated discussions with district agricultural experts and decision-makers, and community leaders on the details of the technical support services, input supply sources and role of each partner in the forage development. Consequently, communities set working bylaws and nominated individuals to enforce the bylaws with defined punishment for those who break the bylaws. Communities in both sites also agreed on the use right of the forages. In this regard, an important fact that contributed to the development of the communal grazing lands was the existence of traditional land demarcation in the communal grazing lands. Every farmer had a demarcated plot of land in the grazing land for his or her use right, and these rights are respected by all other users.

Table 1. *Forage development interventions and actors involved in Atsbi-Womberta district, 2005*

Site	Intervention area (ha) and location (PA)	Site condition prior to intervention	Interventions demonstrated	Actors involved
Bottom-land grazing areas	69 ha in Barka Adi-Sebha PA	Degraded and low vegetation cover Traditional land ownership demarcated Free and uncontrolled grazing system, with one season per year enclosure Little physical soil and water conservation structures constructed	Area enclosed from animals Cut-and-carry system of animal feeds introduced Community bylaws established	Community and community leaders, district decision-makers, extension service providers, NGOs, researchers and IPMS
Highly degraded grazing lands	26 ha in Gol-gol Naele PA	Heavily grazed and highly degraded Traditional land ownership demarcated Land under free and uncontrolled grazing system Various physical soil and water conservation techniques (stone and soil bunds, stone and soil fence bench terrace with trench) were in place	Area enclosed from animals Collective action organized to prepare grazing land for enrichment plantation of improved forage species Various improved forage species (*Phalaris aquatica*, Rhodes, *Sesbania sesban* and Tree Lucerne) selected, introduced and planted	Community and community leaders, district decision-makers, extension service providers, NGOs, researchers and IPMS
Irrigated lands and backyards	Farmer Training Center (FTC) demonstration, Hayelom PA	Hayelom FTC used as training and demonstration centre for innovative forage development Demonstration land available	300 cuttings of Napier grass planted in Hayelom FTC demonstration site Individual farmers collected Napier grass cuttings and established around their backyards and irrigated sites	Community and community leaders, extension service providers and IPMS

In the heavily degraded lands, the innovative and improved forage interventions implemented included cut-and-carry system of animal feeding and introduction of improved forage species and technologies. In the Golgol Naele PA, the community put up stone fences around the enclosed forage development site. The community also contributed labour and traction power for land preparation, planting of *Phalaris aquatic* (split and seeds), Rhodes (seeds), *Sesbania sesban* and Tree Lucerne seedlings (Figure 3). Moderate budgetary support, including for transporting planting materials, was provided by IPMS and district office of agriculture and rural development.

Figure 3. *Degraded grazing land (left), community participation in land preparation (middle) and forage planting (right) in Golgol Naele PA, Atsbi-Womberta district.*

3.1.3 Intervention outcomes

Forage development

During the first year, the performance of the introduced grasses, especially the split of *Phalaris aquatic* planted in the highly degraded grazing lands, as well as the performance of the Napier grass planted in the irrigated sites and backyards was quite satisfactory (Figure 4, Table 2). Cover abundance of natural vegetation substantially increased in both the bottom lands and steep grazing lands. In the bottom lands, farmers started to harvest forage three times per year (compared to once per year before enclosure).

Figure 4. *Forage development (from left to right) steep hillsides, bottom lands, irrigated sites and backyard, Atsbi-Womberta district.*

Table 2. *Indicative results observed in the forage development intervention during the first year of the interventions in Atsbi-Womberta, 2005*

Site	Results observed	Utilization
Bottomland grazing lands	Performance of the indigenous forage grasses and legumes was quite good Farmers started harvesting forage three times per year Availability of green quality feed relatively improved Availability of bee forage flowers increased during most part of the year particularly during the dry season Year round vegetation cover improved and the soil stayed moist with reduced runoff and evaporation, and increased infiltration	The green forage collected was used mainly for fattening sheep and for dairy cows Absconding of bee colonies during the dry season reduced, honey bee colony strength improved and frequency of honey harvest and amount increased Water availability for livestock and bee colony improved
Highly degraded grazing lands	*Phalaris aquatic* splits showed quite good performance Rhodes grass and natural vegetation also established very well with very good soil cover to reduce runoff and increase infiltration Among the legumes, Tree Lucerne performed well and started flowering Abundant flowering plants emerged which flower during the rainy and after few showers during the dry season	In the first year farmers decided not to cut-and-carry the forage biomass; rather they decided to collect seeds and plant them further for full rehabilitation of the area Nectar and pollen from the developed sites became important bee forage sources Farmers reported that there was an increase in honey production and reduction in colony absconding
Irrigated lands and backyards	The 300 cuttings of Napier grass introduced established well	Many farmers started collecting Napier cuttings from the FTC demonstration sites and planted them around their irrigated plots or back yards near water ponds or shallow wells

Green and higher quality forage biomass have been harvested or collected from the irrigated and bottomland improved forage sites frequently. About three times forage harvesting from the bottomland grazing lands resulted in about three times higher biomass per year compared with the situation before the intervention. In the irrigated sites, farmers have been able to harvest Napier grass green forage year round, usually at monthly or bimonthly intervals. The improved forage has been useful for fattening, dairy and beekeeping development and for better household income relative to the open grazing system.

Changes in botanical composition

Initially the number and type of vegetation observed in the open grazing fields was very low (less than 10 forage species identified). Within 2–3 years, about 45 different grass and legume species were recorded in the improved forage sites (Figure 5). Particularly the cover abundance of palatable legume species such as *Trifolium* spp., *Medicago* spp., and *Lolium* spp improved significantly.

Figure 5. *Changes in plant composition (upper and bottom middle and right) compared to the open grazing (upper and bottom left) in Atsbi-Womberta district.*

Changes in bee forage cover abundance

About 30–45% of the total plant compositions became valuable bee forage plants in the improved forage sites (Figure 6). Even on rocky sites, indigenous bee forage plants started to establish well. The major bee forage plants are usually perennial plants with deep root system and can extract moisture deep in the soil and stay bloom longer than annual plants. With increased moisture in the improved forage sites, the duration of bloom period of bee forage plants stayed longer than the none intervention sites. This might be one of the main reasons for the substantial increase in honey bee colony populations and honey production. In 2000, the bee colony population in the district was about 3731 mostly in traditional hives producing about 18,655 kg honey worth of ETB 373,100/year benefiting not more than 3000 households. In 2007, there were about 19,272 honey bee colonies (6012 colonies in modern and 13,260 in traditional hives) generating income of about ETB 18–21 million from honey and colony sales benefiting about 10,878 households (19% FHHs) (OoARD 2007).

Figure 6. *Improved cover abundance of major bee forage plants in rocky (left) and bottom lands (middle and right) in area enclosures, Atsbi-Womberta district.*

Environmental changes

Improved forage interventions slowed down runoff, increased water infiltration to the ground and helped to stabilize gullies (Table 2, Figure 7). Furthermore, groundwater table is enriched and springs started to develop down the sites. The groundwater is used for the production of high value irrigated vegetables and forage.

Figure 7. *Gully stabilization and spring development (middle and right) compared to the open grazing system (left) in Atsbi-Womberta district.*

Social changes

Usually male headed households own more animals than female headed households. Thus in the free and uncontrolled grazing system, female headed households were getting less proportion of benefit from the grazing lands. However, in the cut-and-carry systems, female headed households receive the same benefit as male headed households. Many of the female headed households either sell their forage in cash, or in exchange for traction power for ploughing and threshing. Cut-and-carry systems of animal feeding also freed children to attend school.

3.1.4 Popularization of experiences and lessons

Popularization of the forage development experiences have been conducted among the community and community leaders, extension service providers and decision-makers within and outside the district (Figure 8). Within the district, farmers, community leaders of all the 16 PAs, DAs, supervisors, experts and decision-makers visited the forage sites on different occasions, formally and informally. Outside the district, the regional BoARD, the southern and eastern zone of Tigray extension service providers and decision-makers visited the forage sites. Outside the Tigray region, decision-makers and extension service providers from Oromia and Amhara regions visited the forage sites on different occasions.

Figure 8. *Popularization of forage development experiences within the community (left) and beyond the district (middle and right).*

3.1.5 Scaling out of experiences within and outside the district

Within the district, forage development experiences have been scaled out to different sites (Table 3). The interventions in the highly degraded grazing lands expanded from 26 ha in one PA to 581 ha in 8 PAs by 2007 (within 2 years). Enclosures and cut-and-carry system introduced in the bottomland grazing lands also expanded from 69 ha in one PA to about 1746 ha in 13 PAs in 2007. More than 45,000 of cuttings of Napier grass were planted by farmers. Private backyard forage plantings also expanded.

Outside the district, improved forage management approaches have been expanded to many districts in the eastern zone of Tigray. Similarly, in Amhara region, Fogera district office of agriculture and rural development experts and farmers started to develop communal grazing lands in the district (see next section for more on this).

Table 3. *Scaling out of forage development experiences within the Atsbi-Womberta district, 2007*

Forage intervention sites	Initial intervention area (ha, PA, cuttings)	Scaled out coverage (ha, PAs or cuttings)	Utilization
Forage on degraded steep grazing lands	26 ha, 1 PA	581 ha in 8 PAs harvested once/year	Estimated biomass: more than 3 million kg biomass produced in 2007
Forage on bottom grazing lands: Year round cut-and-carry system of feeding	69 ha, 1 PA	1746 ha in 13 PAs harvested 3–4 times/year	Fattening utilization: Feed contributed to about 11,904 shoats and 2103 cattle fattened in 2007
Irrigated sites and gullies	300 cuttings introduced into an FTC	More than 45,000 cuttings	Dairy: Feed contributed to about 1700 dairy cows producing butter and some calf
Private/backyard forage development	Emerged by itself	10 PAs	Beneficiaries: More than 7800 households benefited
PAs fully transformed into cut-and-carry system of feeding	26 ha and 69 ha	4 PAs	Bee forage plants are sources of nectare and pollen to about 19,272 bee colonies

3.1.6 Lessons learnt

The experiences in Atsbi-Womberta district in forage development linked with market-oriented agricultural development generate the following lessons:

- The success in forage development in the Atsbi-Womberta district is primarily due to the explicit linkage of the forage development initiatives with the market-oriented livestock and honey commodities development. The coordinated efforts of actors that have stake in the development of the commodities facilitated implementation intervention.
- Collective action for communal resource management, organized and implemented on participatory approaches, and that ensures equity in benefit distribution, is likely to contribute to sustainable utilization and development of the resource.
- Communities can initially be sceptical about new interventions, as has been seen in the forage development case in Atsbi-Womberta in which the most degraded parts of the communal grazing lands was selected for testing leaving the better part for open grazing. The Atsbi-Womberta case also showed that upon realization of the benefits from the forage development interventions, even the most sceptics could turn leading champions of the intervention.
- The lack of experiences in actor coordination increases the time needed to reach at common understanding on the forage intervention technologies and approaches.
- Practical knowledge gap on how to introduce improved and new interventions needs to be addressed.
- Participatory appraisal of community resources and prioritization of interventions instil a strong sense of community ownership and facilitates the adoption and scaling out of interventions.

3.2 Grazing land development in Fogera district

3.2.1 Background

Unlike Atsbi-Womberta district, about 76% of the Fogera district is flat land. Most of the district is found at an altitude of less than 2000 masl. The total area of the district is about 117,404 ha, with about 51,472 ha of cultivated land, and 26,699 ha of grazing land (IPMS 2005b). Average land holding is about 1.4 ha per household. Average annual rainfall is about 1215 mm. Fogera district is one of the eight districts that border the Lake Tana, the mouth of the Blue Nile. The district is the origin of an important cattle breed, known as Fogera breed, which are characterized by bigger body framework, high traction power, and high milk yield.

Fogera district used to have vast productive grazing land that would usually be flooded during the rainy season by overflows from the local rivers of Gumara and Rib, and Lake Tana. After the rain season the flood sites recede and natural grasses grow on the residual moisture. These forage lands used to support large number of livestock both from the district and neighbouring districts during the dry season.

However, the area of the grazing land has been declining due to conversion into rice cultivation since 1987. According to Belete (2006), more than 17,937 ha of communal grazing land has been converted into rice and other crop production in 2004–2005. In addition to the declining size of communal grazing lands, the free and uncontrolled grazing system has resulted in severe degradation of the grazing lands. Moreover, a notorious weed, *Hygrophilla auriculata*, locally known as amikela, has invaded most of the remaining grazing lands. It is estimated that about 10,000 ha of communal grazing land is invaded by *H. auriculata* (Ashagre 2008). The weed suppresses underneath growth, and prevents animals from grazing due to its stingy thorns (Figure 9).

Figure 9. *Communal grazing land in Fogera invaded by* Hygrophilla auriculata *(amikela).*

As a result, feed shortage became a critical constraint of market-oriented livestock production in the district. Although the district was known as an important supplier of dairy products to the surrounding markets, feed scarcity has seriously reduced livestock productivity and marketable surplus. Hence, the IPMS project in collaboration with district and regional stakeholders has promoted collective action to develop and manage the grazing land with an explicit linkage to the objective of improving market-oriented dairy and beef production since 2007.

3.2.2 Processes

Problem diagnosis

A PRA study conducted by the IPMS in 2005 identified shortage of feed, due to shrinking of grazing land and expansion of the unpalatable thorny weed, as the most important constraint for market-oriented livestock production in the district. The PRA results were presented to stakeholders workshop for verification, where farmers and community leaders, extension service providers, researchers and IPMS staff participated. The stakeholders workshop confirmed the findings of the PRA, and identified cattle fattening and dairy as the most important market-oriented enterprises that could be linked with the forage development intervention.

Interventions planning

In order to alleviate the feed shortage and promote market-oriented livestock development, the IPMS project organized a meeting to deliberate on the possibilities of eradicating amikela and the development of the communal grazing lands. Participants of this meeting were representatives from the various district level government offices including the district administration and the district office of agriculture and rural development (OoARD). The meeting identified six peasant associations (PA) whose grazing lands were severely infested with the thorny weed for demonstration of the clearance of the weed. A study tour was also organized to gain lesson from the Atsbi-Womberta district in Tigray (see section 3.1). The study tour team members included farmers from four of the six peasant associations, DAs, OoARD experts and an expert from the district administration. Participants of the study tour presented their lesson to stakeholders in the district, and representatives of the four PAs in a one-day workshop. Finally, participatory action plan was prepared after consecutive discussions with community members of the PAs.

Intervention implementation

The OoARD of Fogera district dispatched official letters to officials of the six PAs and their DAs to mobilize the community for amikela clearance demonstration (Figures 10, and 11). In addition, the office assigned two experts for each PA to coordinate the one week amikela clearance demonstration. Motor-bikes and vehicles were allocated to facilitate transportation in all selected PAs at the same time. The IPMS project multiplied and distributed a leaflet entitled 'amikela as HIV/AIDS of grazing land' to raise the awareness of communities about the effect of amikela on the grazing lands. It also provided budgetary support to cover fuel and refreshment expenses.

Figure 10. *Amikela clearance in action.*

Figure 11. *Cleared amikela piled for burning.*

IPMS also documented the process in collaboration with the district office of information. After the clearance of amikela, community members from two of the six PAs (Kuhar

Michael and Shina) decided to enclose their cleared grazing lands for the first time. Community members in these PAs prepared bylaws for the management and use of the enclosures. The bylaw was distributed to concerned parties including the district justice office, administration, police, OoARD and IPMS to facilitate enforcement.

3.2.3 Intervention outcomes

Amikela clearance

Amikela clearance was conducted from February to March 2007. About 268 ha of grazing land was cleared in six highly infested PAs through one week community participation (Table 4). In this activity, about 7298 labour days was used, of which 78% were male and 22% were female labour.

Table 4. *Labour involved (person days) and area of grazing land cleared (ha) for amikela clearance in six PAs, Fogera district, 2007*

Name of PA	Labour involved/PA		Area cleared (ha)
	Male	Female	
Shaga	1200	350	75
Wagetera	436	98	67
Aboakokit	996	683	38.75
Kidist Hanna	923	143	42.75
Nabega	392	240	21
Shina	1742	95	23.75
Total	5689	1609	268.25

Forage development

Communities in the two PAs of Kuhar Michael and Shina which delineated and enclosed the grazing lands after amikela clearance in 2007 established community bylaws for the protection and utilisation of the forage. In the same year, communities in the Kuhar Michael PA harvested about 39 tonnes of dry weight biomass yield from 6 ha of grazing land in the first harvest on 5 August 2008. A second harvest was done on 27 December 2008 and about 63 tonnes of dry weight forage was harvested from the same area of grazing land (Table 5). The forage collected from the two harvests were distributed among 183 community members. Fifty of these community members started cattle fattening by tethering their animals using cut-and-carry system of feeding, which was the first experience in the district.

Table 5. *Forage dry weight biomass productivity (t/ha per year) and production (t/PA per year)*

PAs	Exclusion area (ha)		Forage productivity (t/ha)		Forage dry biomass (t/PA per year)	
	2008	2009	2008	2009	2008	2009
Shina	7.00	7.7	8.5	7.8	59.5	60.06
Kuhar Michael	6.00	11.4	10.7	10.48	64.2	119.47
Aba Kiros		38.5		6.99		269.12
Guramba		20		6.87		137.4
Menogzer		14		7.35		102.9
Total		91.6			123.7	705.04

Similarly, communities in the Shina PA harvested 60 t of dry weight forage from 7 ha of grazing land (Table 5) and was distributed among 126 community members in the first harvest. Eight of them were female headed households without livestock and earned income from sales of forage shares to other farmers in the village. This depicts the importance of grazing land development intervention to poor female headed households. In 2009, three additional PAs harvested forage from enclosed areas.

Species composition

Amikela clearance followed by enclosure contributed to the emergence and growth of different palatable forage species (Table 6). On the other hand, grazing lands cleared from amikela but not enclosed had little emergence and growth of palatable species. Non-enclosure also opens the possibility for re-emergence of amikela. This indicates the relevance of livestock exclusion to improve the productivity and development of the grazing lands.

Table 6. *Forage species composition and their coverage (%) in the cleared and enclosed grazing land in Kuhar Mikael PA, Fogera district, 2008*

No.	Species name	Local name	Composition (%)
1	*Pennistum* spp.	Tucha	27
2	*Trifolium* spp.	Wajima/Magete	11
3	*Echinochloa haploclada*	Gungurda	10
4	*Cynodon dactylon*	Serdo	13
5	*Panicum* spp.	Akerma	13
6	*Cyprus* spp.	Gicha	8
7	*Atraxon prionodies*	Yekok sar	9
8	*Andropogon* spp.	Gaja	2
9	*Hygrophilla auriculata*	Amikala	2
10	*Poa annua*	Yewf teff	2
11	Others		3

3.2.4 Promotion of experiences and lessons

Popularization of the forage development experiences have been conducted among the community and community leaders, extension service providers and decision-makers within and outside the district using field days, and by distributing leaflets (Figure 12). Within the district, farmers from 23 PAs, PA administrators, DAs, supervisors, experts and decision-makers of the district visited the forage site in September and December, 2008. In total about 229 people visited the sites. It is also expected that a large number of interested individuals may have visited the site on their own. Moreover, senior agricultural experts from the region, South Gondar zone and 12 districts of South Gondar zone visited the grazing land development intervention during the scaling up workshop held in Woreta, in February 2009. The Amhara region mass media agency aired programs on the grazing land development on radio and television.

Figure 12. *Field days organized for community representatives and experts.*

3.2.5 Scaling out

Community mobilization along with soil and water conservation development days are conducted during the slack farming activities in February and March every year in the district. Amikela clearance has been incorporated in the mobilization as of 2008 based on the previous amikela clearance experiences. Similarly area enclosure has expanded from 13 ha in 2008 to 92 ha in 2009, and the number of PAs with grazing land enclosures increased from two in 2008 to five in 2009. This expansion is attributed to various promotional efforts including field days and scaling up workshop.

3.2.6 Lessons learnt

The experience of amikela clearance and forage development linked with the development of market-oriented agricultural development in Fogera district provides the following lessons:

- Collective action for communal resource management, organized and implemented on participatory approaches, and that ensures equity in benefit distribution, is likely to contribute to sustainable utilization and development of the resource.
- Linking the development of communal resources with market-oriented commodity development enhances collective action for sustainable development and utilization of the resources.
- The experience in amikela clearance and enclosure helped farmers, DAs, experts and decision-makers to visualize the amount of feed lost due to amikela encroachment, and free and uncontrolled grazing system.
- The experience also showed the possibility of clearing amikela within a short period of time through community participation/collective action.
- An important lesson of these experience is also the fact that amikela clearance needs to be followed by enclosing the cleared area in order to maximize forage production and enhance the emergence and growth of palatable forage species, and depress the emergence of non-palatable ones. Therefore, adopting the cut-and-carry system helps to rehabilitate the grazing land quickly and in return to enhance the development of market-oriented livestock commodities.

3.3 Conservation tillage for market-oriented crop production

Multifaceted benefits of conservation tillage

Farmers in most parts of Ethiopia depend on crop–livestock mixed farming systems. The conventional crop production practice includes repeated farmland cultivation using ox-pulled ploughing tool, hand weeding, harvesting using sickle and threshing with animals. These activities require large amount of labour and draught power, consequently contributing to human and livestock population growth in the country. Overstocking of grazing land results in grazing land degradation. Population pressure coupled with low productivity leads to cropland expansion to marginal areas. Therefore, the traditional crop production practice may contribute to land degradation indirectly through human and livestock population growth. On the other hand, conservation tillage requires less labour and draught power for crop production, with potential to reduce land degradation.

Traditional farmland cultivation is characterized with frequent tillage. This results in impermeable hardpan development at a depth of 10–20 cm which impedes both rainwater and crop roots from entering the deeper layers of the soil profile. Consequently, the upper soil will rapidly be saturated during heavy rains and causes run-off and erosion problems. As a result, the soil will have low water holding capacity with rapid depletion of moisture for crop growth and exposes crops to transient moisture stress. Through this process the traditional tillage practice escalated the effect of low moisture stress on crop failure in Ethiopia. On the other hand, conservation tillage may improve water holding capacity of the soil and reduces run-off, consequently contributing to efficient utilization of the available rain water for crop production in arid areas of Ethiopia. Hence, conservation tillage helps to harvest reasonable crop yield even in cropping seasons with relatively moisture stress. The traditional tillage practice also causes siltation of water bodies (rivers, streams and lakes) in different parts of Ethiopia.

Conservation tillage would have remarkable economic benefit. Labour and draught power requirement of crop production using conservation tillage is low. Crop productivity may also be higher with conservation tillage, thus increasing the profitability of crop production through reducing cost of production and increasing farmland productivity. In addition, farmers can spend their time and labour on other activities which can bring additional income. Therefore, conservation tillage can contribute to achieving higher and diversified income.

Conservation tillage would also have several social benefits to Ethiopian farmers. For example, in Ethiopia ploughing is culturally a job of men farmers. Culturally women are not supposed to plough their land with ox-pulled ploughing tool. Consequently, female headed households are usually forced to rent their cropland for share cropping. Hence, the traditional cropland cultivation practice hinders female headed households from fully benefiting from their farmlands. The traditional farmland cultivation tool of Ethiopian farmers requires a pair of oxen. However, many of our farmers have one or no ox. This situation creates difficulties in the timely planting of crops for poor farmers. Conservation tillage allows to plant seeds with zero or one tillage. Hence, it can help female headed and poor farmers to plant their cropland on time and benefit from their farmlands.

3.4 Development of conservation tillage in Bure district

3.4.1 Background

Bure district is located in northwestern Ethiopia, in the Amhara region, about 400 km Northwest of Addis Ababa. It is one of the high potential and surplus grain producing districts in the country. Most of the district lies at an altitude range of 2000–2200 masl and has undulating plain topography. The total area of the district is 72,739 ha, with about 37,440 ha of cultivated land, about 5060 ha of communal grazing land, and about 6110 ha of forest land (IPMS 2007). Average land holding is about 1.6 ha per household. Average annual rainfall ranges from 1386 to 1757 mm and the rainy season extends from May to October. There are three soil types in the district, viz. Nitosol (63%), Cambisol (20%) and Vertisol (17%). Nitosol and Cambisol, the most erodible red soils cover about 83% of the land area.

Mixed crop–livestock farming system characterizes agricultural production in the district. Cereals are the dominant crops grown, which include maize, wheat, teff, finger millet and barley in that order of importance. On average, about 85% of the total cropland in the district is covered by cereals. The conventional crop production practice in the district, as is true in many parts of Ethiopia, includes repeated ploughing using ox-pulled traditional plough, locally known as *Maresha*, hand weeding, post-emergence herbicide application, harvesting using sickle and threshing with animals. Bure district has been known as an important supplier of wheat to the surrounding markets. However, the productivity of wheat has been declining mainly due to soil erosion, soil fertility depletion and weed infestation.

High and extended rainfall coupled with conventional cultivation practice and erodible soils has made soil erosion a critical problem of crop production in the district. Various soil and water conservation measures have been used by farmers to curb soil erosion. However, adoption of soil and water conservation measures has not been widespread for various reasons, including inconvenience in land preparation and planting and high labour requirements. Hence, the IPMS project in collaboration with the district and regional stakeholders has promoted conservation tillage with an explicit linkage with improving market-oriented wheat production since 2008. The project evaluated the environmental, social and economic benefits of conservation tillage in a participatory manner. Results are presented below.

3.4.2 Processes

Problem diagnosis

In 2007, a participatory rapid appraisal (PRA) study conducted by IPMS identified wheat as one of the most important marketable commodity in the district. However, wheat production is confronted with several challenges in the district. Wheat is planted at the middle of the rainy season (mid July) after ploughing the farmland for about six times starting from the on-set of the rainy season. This practice coupled with the torrential rainfall and erodible soils in the area results in severe soil erosion, fertility depletion and siltation of water bodies in the district (Figure 13). Moreover, wheat is a recently introduced but steadily expanding crop (5600 ha) in the district and farmers use post-emergence selective herbicides to control weeds. This practice is affecting beekeeping activity of the community. The PRA results were presented to stakeholders workshop for verification, where farmers and community leaders, extension service providers, researchers, wheat flour factory owners and IPMS staff participated. The stakeholder workshops confirmed the findings of the PRA and concluded that interventions are needed to promote market-oriented wheat production through conservation tillage.

Figure 13. *Soil erosion aggravated by conventional tillage.*

Intervention planning

Although conservation tillage has been under demonstration for maize production in the area since 2006 by SG2000, both farmers and agricultural extension experts did not try the technology for other crops production. IPMS project organized seminar to the district OoARD experts on the comparative advantage of wheat production using conservation tillage. As a result OoARD staff were convinced and decided to demonstrate the technology in the district. The project staff in collaboration with the OoARD experts, DAs and supervisors selected two major wheat growing PAs of the district to demonstrate the importance of this practice to farmers. Then five host farmers volunteered to test this new technology in collaboration with DAs of each PA. Finally, IPMS project in collaboration with OoARD organized theoretical and practical trainings to the selected farmers and development agents in order to promote the practice (Figure 14). Husband and wife were trained together to enhance the smooth implementation of the intervention and to facilitate the dissemination of this practice. This training was recorded with video camera in collaboration with the district Office of Information to be used as training material in the future.

Figure 14. *Practical training underway on conservation tillage.*

Intervention implementation

Wheat production using conservation tillage was demonstrated for the first time in 2008 by IPMS and the district OoARD. Since the conservation tillage was new to farmers and the pre-emergence herbicides were not available in the local market, IPMS purchased 10 litres Roundup for demonstration purposes. Farmers contributed land, seed, fertilizer and labour to demonstrate the practice. Each demonstration plot had an area of half a hectare. Half of the demonstration plot (0.25 ha) was planted with conventional tillage while the remaining part (0.25 ha) was planted with conservation tillage. Seed rate, fertilizer rate and planting date were uniform. Farmers ploughed six times to plant wheat using conventional tillage practice. On the other hand, to plant wheat using conservation tillage practice, farmers sprayed one litre Roundup two weeks before the planting date of wheat on the 0.25 ha of land. Within 14 days all the weeds died and farmers sow fertilizer and seed on the field and ploughed it to cover the seed and the fertilizer with soil. Farmers applied recommended rate of Urea on both plots when the wheat plant was at tillering stage. Farmers sprayed 2,4-D to control post-emergence weeds on plots planted with conventional tillage. The project evaluated the environmental, social and economic benefits of conservation tillage for wheat production in two PAs in a participatory manner.

3.4.3 Outcomes of the intervention

Results show that conservation tillage required significantly low labour and draught power compared to conventional tillage for wheat production. Therefore, it reduced the cost of production. In addition, it allowed farmers to plant large area of land on the recommended planting date. Conservation tillage also reduced runoff, soil erosion and fertility depletion. It also increased the productivity of land compared to conventional tillage especially if dry spell occurs during the cropping season. The economic benefit of wheat production through conservation tillage was superior compared to the conventional tillage (Table 7).

The length of wheat grain filling period grown with conservation tillage was much longer than those planted with conventional tillage. This could be because conservation tillage increases the water holding capacity of the soil or infiltration of rainwater. Tillers were also more in wheat grown with conservation tillage compared to conventional tillage, perhaps because conservation tillage reduces soil fertility loss through erosion. Conservation tillage did not require labour to control weeds. Therefore, it allowed farmers to be engaged in other income generating activities such as year round cattle and sheep fattening, poultry rearing, beekeeping and raising fruit seedlings for sale.

Table 7. *Cost of wheat production (Ethiopian birr*/ha) and relative profitability of traditional and conservation tillage technologies (ETB/ha) in Bure district in 2008*

Activity	Traditional tillage			Conservation tillage		
	Man days	Unit cost (ETB)	Total cost (ETB)	Man days	Unit cost (ETB)	Total cost (ETB)
a. Cost of production						
Ploughing cost for land preparation and sowing	24	70	1680	4	70	280
Hand weeding cost	2	22	44	0	0	0
Herbicide cost (2, 4-D)		50	50	0	0	0
Herbicide cost (Roundup 4 litres)		0	0		150	600
Spraying labour cost	4 hour	15	5	6 hour	15	7.50
Harvesting labour cost	16	20	320	16	20	320
Threshing labour cost	16	20	320	16	20	320
Total cost of production			2419			1527.50
b. Income	(qt/ha)	Price (ETB/qt)	Total income (ETB)	(qt/ha)	Price (ETB/qt)	Total income (ETB)
Grain yield (qt/ha)	32	360	11,520	32	360	11,520
Profit	9101			9992.50		

* Ethiopian birr (ETB). In June 2010, USD 1 = ETB 13.50.

Female and poor farmers normally rent their farmland, mainly due to lack of ploughing oxen and cultural barrier. Wheat production through conservation tillage requires only one ploughing to cover the seed and the fertilizer. Therefore, conservation tillage created an opportunity to poor farmers and female farmers in order to fully benefit from their own lands. Introduction of conservation tillage also increased the rental rate of land in the area due to higher return to land.

Farmers sprayed 2,4-D in September to control post-emergence weeds on wheat fields planted with conventional tillage. In September, most plants flower and honeybees collect nectar and pollen. This coincidence was affecting the beekeeping activity in Bure. Wheat production through conservation tillage did not require post-emergence herbicide application. Therefore, this activity demonstrated the harmony of wheat production through conservation tillage and beekeeping in the area.

3.4.4 Promotion of experiences and lessons

IPMS project organized field days to farmers, DAs, experts and decision-makers to popularize the performance of wheat grown using conservation tillage practice (Figure 15). IPMS also organized field days for higher officials of the district. In order to popularize the importance of conservation tillage for wheat production, the project prepared more than 4000 leaflets and distributed to participants of farmers festivals organized at district, zonal and regional levels. In addition, conservation tillage lessons were broadcast by the Amhara region television and radio programs. IPMS also prepared a training material recorded on DVD cassette for the promotion of wheat production using conservation tillage.

Figure 15. *Field day on conservation tillage organized for farmers, DAs, experts and decision-makers.*

3.4.5 Scaling-out of intervention

IPMS project and the district OoARD tried to scale-out the practice of wheat production using conservation tillage within and outside the district by distributing leaflets, organizing field days and scaling-out workshop. Both the conservation tillage practice promoted by the SG2000 and the IPMS project in collaboration with the OoARD was scaled out remarkably during 2008–2009. Conservation tillage practice was scaled out within the district from 9 PAs to 12 PAs, and from 119 ha of land to over 1500 ha of land, and from 283 farmers to over 3000 farmers (Table 8). Conservation tillage has also been scaled out to neighbouring districts such as Jabitehnan and Womberema. To expand the scaling out of conservation tillage practice, the IPMS project linked private chemical suppliers in the district with distributors from Addis Ababa to create adequate supply of Roundup for farmers within the district.

Currently, farmers are seeking advice from experts to grow several crops using conservation tillage. In addition, during 2006–2008, the district OoARD was the only supplier of Roundup to farmers. In 2009, two private Roundup suppliers and several multi-purpose cooperatives sold about 6000 litres Roundup to farmers (Table 8). Growing interest was seen among farmers to use Roundup before planting to kill weeds.

Table 8. *Conservation tillage expansion and input suppliers in Bure district*

Year	Amount of Roundup (litres/district per year)	Area planted (ha/district per year)	No of farmers/ district per year	No of PAs/ district per year	Crops grown	Roundup suppliers
2006	20	5	20	1	Maize	OoARD and SG2000
2007	56	14	56	3	Maize	OoARD and SG2000
2008	476	119	283	9	Maize, wheat and teff	OoARD and private input suppliers
2009	0ver 6000	Over 1500	Over 3000	12	Maize, wheat, teff and others	Private and multipurpose cooperatives

3.4.6 Lessons learnt

Several lessons emerge out of the promotion of conservation tillage in Bure district. The following stand out:

- Participatory appraisal of key constraints and the design of interventions for market-oriented commodity development, including aspects of natural resource management, is critical for a successful commodity development intervention.
- Careful consideration of key value chain components cannot be overemphasized to link NRM intervention with market-oriented commodity development.
- Conservation tillage can raise farm profitability through reduction of production costs and improving farm revenue.
- The results of the promotion of wheat production using conservation tillage in Bure district demonstrates the importance of the practice for increasing land productivity, reducing soil erosion and run-off, and improve soil fertility in the long run.
- The experience also showed that conservation tillage can enable poor and female farmers can benefit greatly from conservation tillage, thus contributing to poverty reduction.

3.5 Development of conservation tillage in Metema district

3.5.1 Background

Metema district is located at about 900 km northwest of Addis Ababa. The total area of Metema is about 440,085 ha, with about 103,908 ha cultivated land, 312,300 ha forest and grassland, and 23,877 ha uncultivated land. Average land holding size is about 5 ha, which is relatively higher as compared to the average landholding size in other parts of the country. The soils in the area are predominantly black Luvisol and Vertisol with good fertility status. The altitude in the district ranges from 550 to 1608 masl. Average annual rainfall ranges from 850 to 1100 mm, with uni-modal rainfall extending from June to September.

Farmers practice crop–livestock mixed farming system. Most of the cropland is covered with cash crops such as sesame and cotton. Soil fertility is relatively high and fertilizer application is very low. Due to high temperature and adequate rainfall, weed growth is very fast and causes substantial crop yield losses. According to Abraham et al. (2001) about 45 weed species (31 broadleaf, 13 grass weeds and 1 sedge) were recorded in cotton fields.[1] Recently, however, the proportion of grassy weeds per unit area is dominating as a result of repeated use of the post-emergence selective herbicide, 2,4-D.

Farmers in Metema use conventional tillage using oxen for ploughing and reduce weed infestation. However, the practice has several disadvantages. Repeated tillage of crop fields accelerates soil erosion and disturbs soil structure and reduces moisture retention capacity of the soil. Hence, in order to reduce the problems associated with conventional tillage and reduce yield loss due to weed infestation in the district, the IPMS project in collaboration with regional and district stakeholders has promoted conservation tillage practice in the district since 2005.

3.5.2 Processes

Problem diagnosis

In March 2005, IPMS organized and facilitated a multi-stakeholder meeting (farmers, OoARD staff, researchers, traders, PA leaders, and others) to identify major agricultural production constraints in Metema. The workshop was preceded by a participatory rural appraisal (PRA) in February, 2005. In both events, delayed planting, high cost of labour and oxen rent, weed infestation in crop fields were found to be the major problems of crop production in the district. In addition to being expensive, labour availability was also a problem confronting farmers in the district. High cost of production restricted the amount of land cultivated by farmers. Many farmers were using the post-emergence selective herbicide, 2,4-D, for weed control. However, this herbicide is used to control broad leaf weed species in sorghum fields only, since the other major crops grown, such as cotton and sesame, are themselves broad leaved species. Moreover, it has been observed that, repeated application of the selective herbicide has some negative consequences including shift of weed composition to grass weeds. Recently, the proportion of grassy weeds in Metema district is much higher than broad leaved weeds.

1. The study also identified that the level of weed complexity per unit area is higher in Metema as compared with similar and neighbouring places like Humera.

As a result, grassy weeds are becoming dominant in crop fields. Whenever a crop field is invaded by grassy weeds, farmers abandon the plot considering it as unproductive. However, farmers were not recognizing many of the disadvantages of the traditional way of land preparation and lack adequate knowledge on the advantages of conservation tillage practices over the conventional tillage practice.

Intervention planning

In its attempt to reduce some of the identified problems, the IPMS project staff in collaboration with the district OoARD introduced conservation tillage practice in the district. The conservation tillage intervention includes means to reduce ploughing during planting and weed infestation. To reduce weed infestation pre-emergence herbicides such as Roundup was introduced. To alleviate the shortage of ploughing oxen, different seed covering methods were introduced including covering crop seed by animal trampling or pulling dense thorny shrub branches for small seeded crops such as sesame. These practices were incorporated with the application of pre-emergence herbicides.

In 2005 MAKUBU demonstrated the technology in Metema and provided training to farmers and public sector staff (DAs, district experts) in collaboration with IPMS and OoARD (Figure 16). The training was given to 25 farmers, 5 DAs and 2 district level experts in August 2005. The training focused on the integrated use of pre-emergence herbicides with local minimum or zero-tillage practices. In addition, Roundup was sprayed on the district OoARD compound which was highly invaded by several weed species to convince the OoARD staff on the effectiveness of the herbicide. IPMS also facilitated the supply and linkage of per-emergence herbicides suppliers (Figure 17).

Figure 16. *Training for DAs and farmers on application of Roundup.*

Figure 17. *Rural input supply shop where Roundup is sold.*

Intervention implementation

Demonstration was conducted at Kokit PA near the main road where many farmers could observe the potency of the practice (Figure 18). Similar demonstrations were conducted in the PAs of Kumer, Agam-Woha, Shenfa, Gubay-Jajabit, Mender 6, Mender 7 and Mender 8 in 2005. Following the demonstration the demand for conservation tillage increased. In 2006, the private input suppliers supplied 525 litres of Roundup to the district. Information about the availability of Roundup and its prices was disseminated to farmers through DAs. All the supplied Roundup was sold to farmers at 85 ETB/litre. In 2007 the demand for conservation tillage further increased and about 1536 litres of Roundup were sold to farmers in and outside Metema district. The area under conservation tillage steadily increased and also the average Roundup purchase per household increased from 1 to 4 litres in 2007.

Figure 18. *Field with Roundup treated (left) and untreated (right) parts.*

In the process of implementation, several input suppliers started to supply various kinds of pre-emergence herbicides, to retailers in the lowland areas of North Gondar. The herbicides have similar effect and properties to that of Roundup. In January 2007, an agro-chemical supplier from Addis Ababa visited Gondar and Metema towns in order to assess market for a new brand herbicide known as Helosate. The Ambassel Trading House also started to supply Agro-set to retailers in Metema and other lowland districts in North Gondar. The Metema farmers cooperative union also introduced another pre-emergence herbicide known as Mamba in 2009. Hence, currently, four types of pre-emergence herbicides (Roundup, Mamba, Helosate and Agro-set) are supplied and used in Metema and the surrounding lowland districts.

3.5.3 Outcomes of interventions

The economic benefit of conservation tillage can be quantitatively measured through cost–benefit analysis. However, such data are not yet collected in Metema. Therefore, its importance was evaluated through analysing farmers' views, the volume of herbicide sold to farmers, area of land planted with this conservation tillage, number of beneficiaries, conservation tillage adopted outside the PLW and volume of the herbicide purchased by individuals.

During the dry period of December 2005 to May 2006, opinion survey on the importance of conservation tillage was conducted to collect data on farmers views about the technology. Data was collected from 131 farmers found in 5 PAs. The survey result revealed that out of the total interviewed farmers, 109 of them replied that conservation tillage was appropriate for the area since it greatly reduces labour costs for hand weeding and for oxen rent for ploughing. However, the respondents expressed their worry about the shortage of pre-emergence herbicides. On the other hand, 16 farmers replied that although the conservation tillage was important and reduced weed infestation, the herbicide was costly (75 ETB/litre). The rest of the interviewed farmers replied that it was too early to evaluate the importance of conservation tillage. In addition, all interviewed farmers reported that cotton and sorghum productivity improved significantly under conservation tillage perhaps due to the timely control of weeds, timely planting and soil fertility improvement.

Introduction of conservation tillage contributed to the introduction of new crop species in Metema. Prior to the intervention, crop plantation during August and September was very limited. After the introduction of conservation tillage, crops like teff (which is planted in August) and chickpea (which is planted in September) started to be grown widely. Conservation tillage triggered planting of teff and chickpea under black cottony soils which were left unproductive before the intervention. Production of teff and chickpea increased the annual income of farmers and also contributed as animal feed resource in the dry season. Moreover, the cultivated area in the district expanded due to reduced labour requirement and associated cost of weeding.

3.5.4 Promotion and popularization

In August 2005, a field visit was organized for farmers, DAs, and experts and decision-makers (members of the district cabinet) in Agamewoha PA. More than 58 farmers participated in the event. During the visit, a farmer who applied Roundup in his plot explained the processes that he followed during application and the outcomes of the conservation tillage. To reach a wider audience the demonstration work was video recorded and presented in many farmers' conferences and meetings. The conservation tillage was also popularized through farmers' own information networks.

3.5.5 Scaling out of intervention

Currently, conservation tillage is practised throughout all the PAs found in Metema and in some PAs of adjacent districts such as Quara and Armachoo. The input supply which began with a single private input supplier in Metema expanded quickly to involve many wholesale suppliers and traders, indicating the profitability of the business.

The volume of pre-emergence herbicides sold to farmers increased progressively during 2006–2009. Data collected from input suppliers based in Genda-Woha, Shenfa and Kokit indicate that the total volume of pre-emergence herbicides sold in 2006 was 525 litres while this volume increased to 7621 litres in 2009 (Table 9). The area under conservation tillage also increased from 596 in 2006 to 8637 in 2009.

Table 9. *Total sales of glyphosphate products and area covered in Metema and Quara districts, 2006–2009*

Year	Herbicide type	Herbicide volume sold (litres/year)	Area covered (ha/year)
2006	Roundup	525	596
2007	Roundup	1536	1740
2008	Roundup, Heloset, Mamba and Agro-set	1842	2983
2009	Roundup, Heloset, Mamba and Agro-set	7621	8637

3.5.6 Lessons learnt

The following lessons emerge from the introduction and promotion of conservation tillage in the largely cash crop farming system of Metema.

- Interventions based on felt needs and priority problems of farmers are likely to be adopted and scaled out quickly.
- Interventions need to address key value chain elements in order to ensure feasibility of technologies and ensure benefits to farmers.
- Partnership, information flows and skill and knowledge development are central to the successful adoption and expansion of interventions.
- The use of conservation tillage reduces the cost of production.
- Conservation tillage can play an important role for sustainable land management since it conserve soils from erosion and improves the workability and fertility of the soil.
- Introduction of conservation tillage can expand the crop choice opportunities of farmers by making it possible (and perhaps profitable) to grow new crops.

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