Market-oriented beekeeping development to improve smallholder income: Results of development experiences in Atsbi-Womberta district, northern Ethiopia

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Abstract

Beekeeping is an important income-generating activity in the Atsbi-Womberta district of Tigray. Beekeeping can also be easily integrated into the on-going natural resources conservation developments in the district. However, beekeeping has traditionally been considered as a supplementary enterprise and its potential as a source of smallholder income has never been fully utilized. The Improving Productivity and Market Success (IPMS) of Ethiopian Farmers Project, in collaboration with the district Office of Agriculture and Rural Development (OoARD), the regional Bureau of ARD and other partners have introduced, tested and promoted improved beekeeping development practices based on the value chains framework. This paper presents results of this experience. The core of the experience is the transformation of a largely traditional system towards a more knowledge based and market-oriented beekeeping. Major interventions include introduction, testing and promotion of learning platforms on improved use of hive equipment, improved apiary and colony management, bee forages, harvesting and postharvest handling practices, and facilitation of access to market information and linkages. Qualitative and quantitative studies were conducted to assess developmental changes made due to the interventions. Results show that the honey productivity of adopters increased by about threefold (32 kg honey/hive per year) compared to the non-adopters (10 kg honey/hive per year) in 2008 despite the variation in rainfall distribution and amount. Interestingly, the honey productivity of adopters increased by 52% in 2008 (32 kg honey/hive per year) compared to those adopters in 2004 (21 kg honey/hive per year). Market-oriented improved beekeeping adopters had a threefold higher income from the sale of honey (Ethiopian birr, ETB[1] 1820/household per year) than non-adopters (ETB 614/household per year). Moreover, the gross annual income of smallholder beekeepers in the district increased from about ETB 2.7 million in 2004 to ETB 19.5 million in 2008. Similarly, the number of honeybee colonies has increased by about fourfold and that of beneficiaries increased by about threefold. About 36% of the beekeepers adopted improved beekeeping management which contributed to about 75% of the district gross annual income of smallholder beekeepers in 2008. The basis of transformation towards market-oriented beekeeping has been capacity building of beekeepers to acquire, share and use improved skills. Results show that market-oriented improved beekeeping appears to be a more resilient income generating business under the uncertain and variable rainfall conditions.

Keywords: Beekeeping, market orientation, value chain, capacity building, resilient to rainfall variability

1. USD 1 is about ETB 10.125 in December 2008.

1 Introduction

The practice of beekeeping is deeply rooted within the Ethiopian farming community. The use of honey as food and medicine (Benjamin and McCallum 2008), and that of wax for candle lighting in churches has a long history in Ethiopia (Ayalew 2006). At present, beekeeping is largely an income generating activity that fits well into the concept of smallholder agricultural development. It can also be easily integrated into on-going resources conservation and rehabilitation developments in Tigray, northern Ethiopia. This is because honey is high value commodity and a non-perishable product if stored properly (Robinson 1980; Gentry 1982; MAAREC 2004; Somerville 2007). Furthermore, smallholder farmers usually consider honey as cash crop, rather than a subsistence commodity (IMPS 2005). These characteristics make honey an attractive product for commercially oriented smallholder beekeepers.

In Atsbi-Womberta district, there is a good potential for beekeeping development due to suitable weather conditions and availability of various natural bee forage resources (IPMS 2005). Beekeeping can especially be an attractive business for the landless and the poor because it needs a relatively small investment and does not have high land requirement. Beekeeping does not compete severely for resources with other farm enterprises (Gentry 1982; Adjare 1990; Bradbear 2004; MAAREC 2004). Beekeeping can also be supplementary to crop production by facilitating pollination (e.g. Wilson 2006).

However, beekeeping has been considered as a supplementary activity and traditionally managed, while its potential as source of smallholder income has been underutilized for many years (IPMS 2005; Melaku, et al. 2008; Kerealem et al. 2009). The supplementary role of beekeeping to household economy had even been declining in Atsbi-Womberta district (IPMS 2005). Reasons include increase in population pressure and subsequent increase in use of natural bee forage plants for fuel wood and house construction, and reduced diversity and cover abundance of bee forage plants due to overgrazing and continuous land cultivation for crop production (IPMS 2005; Ayalew 2006).

The emphasis on resource conservation and development in the district since 1991 started to provide favourable conditions for the development of improved beekeeping. However, interventions to develop improved beekeeping focused on the promotion of apiculture technologies with little emphasis on market linkages and the development of farmer skills and knowledge. Since 2005, the Improving Productivity and Market Success (IPMS) project in collaboration with the district Office of Agriculture and Rural Development (OoARD) has been promoting market-oriented apiculture that combined improved technologies, development of farmer knowledge and skills for apicultural management, and facilitating farmers' linkages with markets. This paper presents the results of this experience and draws lessons to scale up the achievements.

The paper is organized into five sections. The next section deals with description of the Atsbi-Womberta district. Section three looks at the steps in the market-oriented beekeeping development interventions. Section four presents results and discussions. The last section deals with lessons learnt for scaling out and up.

2 Description of the intervention district

The study area, Atsbi-Womberta district, is located in the eastern part of Tigray, northern Ethiopia (Figure 1). The district is mainly characterized by hilly and undulating terrain with altitude range of 918 to 3069 masl. Agricultural production has been severely affected by high spatial and temporal variability of rainfall (IPMS 2005). Although absolute amount of rainfall is usually not too low to support crop production (ranging from 541 to 68 mm/year), temporal distribution has been a critical constraint. A bimodal rainfall pattern consists of the small rainy season during March–May and the main rainy season during late June to early September. The district has about 13,050 ha of arable land and 8802 ha of grazing land. An estimated 16,301 ha are classified as unproductive land (degraded hillsides etc.) and about 89,185 ha are covered by forest (SERA 2000; OoARD 2008).

About 23,400 households inhabit the district with an average family size of six of which 30% of the households are female-headed households (IPMS 2005). Four major weekly market places operate in the district. The district is classified into two farming systems (IPMS 2005). The farming systems have important implications for apiculture (Table 1). The apiculture–livestock midland farming systems is more important for improved beekeeping and the pulse–livestock highland for honeybee colony.

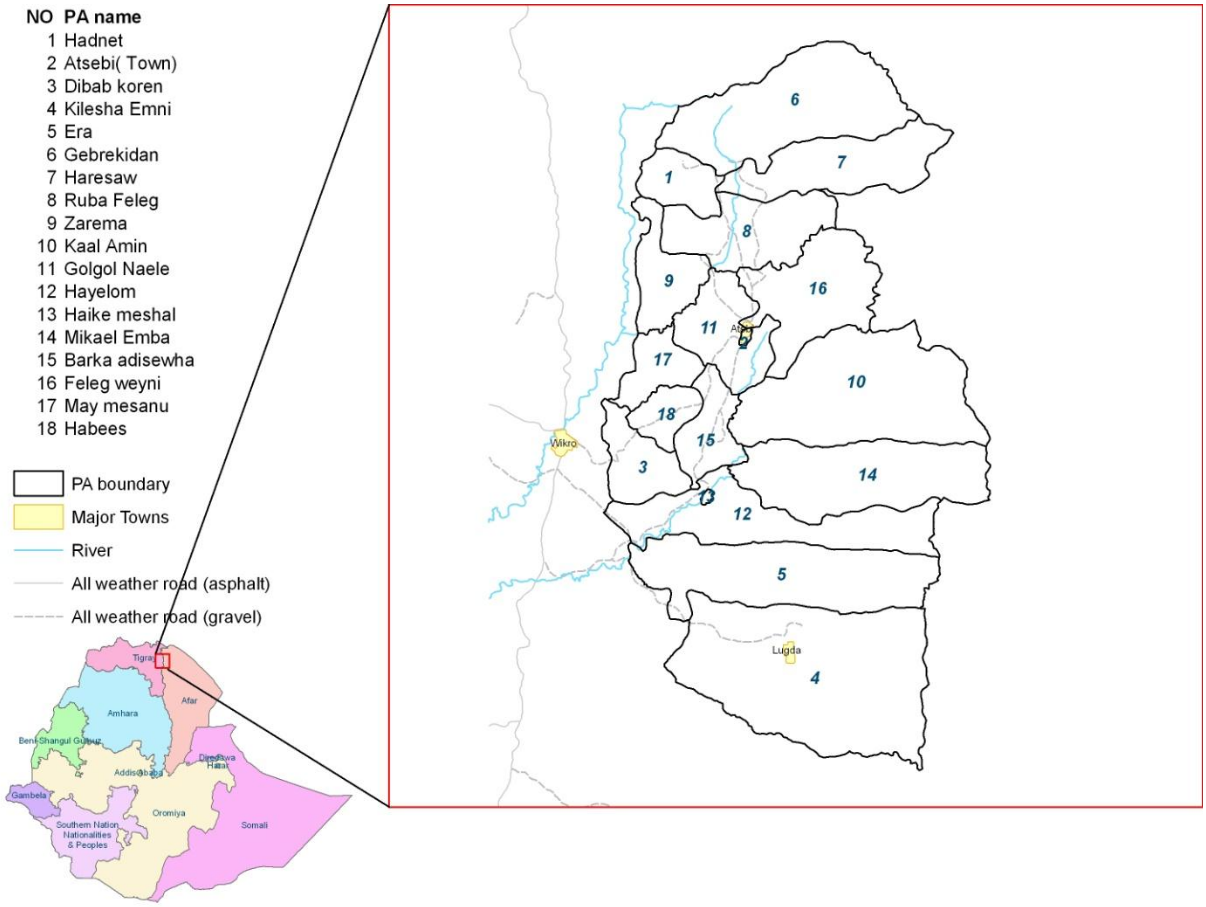


Figure 1. Map showing the location of Atsbi-Womberta district (left) and distribution of its peasant associations (PAs; right) within the district, northern Ethiopia.

Table 1. Characteristics of the apiculture–livestock midland and pulse–livestock highland farming systems in Atsbi-Womberta district

Variable	Farming system (FS) classes	
	Apiculture–livestock midland FS	Pulse–livestock highland FS
Altitude (m)	918–2600	2600–3069
Proportion of area coverage (%)	44	56
Household distribution (%)	37	63
Relative abundance of bee forage resources	Medium to high	Low to medium
Weather conditions	Extended daily sunshine hours and warm temperature during most of the year except in mild frost months and honeybees are able to forage actively during most of the year	Frost months are relatively very cool, and July to August is also cloudy and relatively less suitable for the honeybee colonies to forage actively
Relative suitability for beekeeping	High	Moderate
Traditional beekeeping specialty	Honey production	Honeybee colony capture before swarming
Temperature status	Relatively warm	Relatively cool

3 Market-oriented beekeeping development interventions

3.1 Transition into market-oriented beekeeping

Beekeeping development in the district can be classified into four phases (Table 2). The first phase is forest honey hunting, where honey was harvested from wild honeybee colonies in hive tree trunks, caves and tree branches. Some remnants of this practice still exist in the district. The second phase consists of honeybee colony management around homesteads using locally made hives (Ayalew 2006; Bradbear 2009). Production is subsistence oriented with low productivity (Ayalew 2006). The third phase, (which can also be called as the first improved beekeeping management phase), was implemented during 1996–2004. During this time, the extension service promoted improved beekeeping using modern hives, accessories and honey processing. Improved hives were initially distributed for free (Table 3). At the end of 2004, the total number of honeybee colonies in the district was about 6729, of which about 2000 honeybee colonies were relatively under improved beekeeping management using modern hives and the rest under traditional beekeeping using locally made mud hives (IPMS 2005). The fourth phase, market-oriented improved beekeeping has been promoted by the IPMS project in collaboration with the district OoARD and other partners including the regional Bureau of Agriculture and Rural Development (BoARD) and Dimma Beekeeping Development PLC. The principle in this phase was market-oriented beekeeping development based on knowledge, skill development, following the value chain development framework and the innovation systems perspective.

Table 2. Transition into market-oriented beekeeping development in Atsbi-Womberta district

Development stage	Beekeeping product-orientation	Level of skill, knowledge use and investment
Free honey harvests	Hunted beekeeping products used for home consumption as food and medicine. Wax used for candle making mostly in churches	No investment in the use of knowledge and other necessary beekeeping inputs. Honey search was based on intuitive knowledge of the hunters
Homestead beekeeping	Homesteads beekeeping adopted with some intervention of farmers. Beekeeping products were largely used for home consumption, churches and ceremonial occasions	Skills and experience of beekeeping management were local and gained through practical learning by doing
Food security oriented beekeeping: 1991–2004	Extension focused largely on increased beekeeping productivity and production with less emphasis on beekeeping product quality for market	Extension services started delivering skills and knowledge since 1998. Among the skills include testing and demonstration of improved beekeeping and popularization with the introduction of improved inputs such as modern hives, honey processor and ancillary equipment
Market-oriented beekeeping: 2005–2009	Market-oriented improved beekeeping management with products largely destined for market with key emphasis on product quality along the beekeeping value chain framework	Improved skills and knowledge on beekeeping promoted according to the assessed gaps in knowledge along the beekeeping value chain framework. Capacity of actors to innovate, use and share knowledge popularized. Access to market information and linkages established and are functional

Table 3. Promotion and implementation of improved beekeeping technologies in Atsbi-Womberta district, 1995–2004

Year	Implemented interventions	Number of honeybee colonies with improved hives	Number of beneficiary households
1995–1998	Ecological suitability for beekeeping assessed and beekeeping using modern hives introduced and promoted	18	9
1999	Improved beekeeping promoted	27	12
2000	Improved beekeeping management promoted	82	53
2001	Improved beekeeping management promoted	153	84
2003	Massive training of households conducted	820	275
2004	Massive training of households conducted	900	298

3.2 Participatory identification of market-oriented beekeeping interventions

Market-oriented beekeeping development interventions started with diagnosis of context-specific development opportunities and challenges using participatory rapid appraisal (PRA) methods. In the PRA process, various relevant actors including farmers, decision makers, public extension service providers and researchers, NGOs (World Vision-Ethiopia (WV-E), Relief Society of Tigray (REST) and Dedebit Credit and Saving Institute (DECSI) participated in 2004 (IPMS 2005). The PRA identified market-oriented smallholder beekeeping as one of the emerging marketable commodities that could contribute to increased income and improved livelihoods of rural farmers. Accordingly, the potentials, limitations and gaps in knowledge and skills of relevant value chain actors and stakeholders were assessed (IPMS 2005) (Table 4). Value chain based interventions were then promoted (Table 4). IPMS facilitated interventions on market-oriented beekeeping development starting 2005 with the lead actor being the district.

Table 4. Diagnosed potentials and limitations in the value chain of smallholder beekeeping in Atsbi-Womberta district, 2004

Value-chain stages	Potentials	Limitations	Key interventions facilitated by IPMS
Marketing	Existence of potential markets due to the undersupply of quality honey and honeybee colony products in and outside the district identified	Linkage of beekeepers to markets and market information flow were low. Skills on beekeeping products marketing in response to emerging market demand were weak	Linkages among market-oriented beekeepers, traders and consumers established and communication using the mobile and fixed telephone services facilitated at each peasant association (PA). Market information for beekeeping products in and out of the district has been available to growers biweekly. Organized access to market facilitated
Product processing	Potential for price premium for value added market-oriented beekeeping products exist in the nearby towns and supermarkets	Skill on value addition of beekeeping products such as grading, packing, transporting and improved storage options were low	Techniques on identification and harvesting of matured honey, grading and refining quality of honey using honey extractor, packing in suitable containers, transporting and improved storage options introduced, tested and promoted (see role of actors and service providers in Table 6)

Value-chain stages	Potentials	Limitations	Key interventions facilitated by IPMS
Production technologies	The rehabilitated and re-vegetated landscapes have been a source of bee forage plants and water. Traditional beekeepers with honeybee colonies and experience exist for the introduction of improved beekeeping technology. Potentials to use improved skills and knowledge on honeybee colony split, use of improved beekeeping equipment, apiary management available	Understanding on market-oriented beekeeping management was low among beekeepers. Transforming from traditional to market-oriented beekeeping may take some time	Improved skills and knowledge on beekeeping management such as honeybee colony transfer, inspection, swarm control and colony splitting introduced and demonstrated using modern hives and ancillary accessories. Beekeeping management based on the dynamics of nectar flow under extreme rainfall variability introduced, tested and promoted
Input and credit supply	Access to credit and improved beekeeping inputs such as honeybee colony, hand operated honey processing, modern hive and ancillary equipment available within reach of farmers	Weak linkages between private input suppliers of honeybee colonies, modern hives and ancillary equipment, and beekeepers exist	Private honeybee colony splitting services and skills on transfer, colony inspection and swarm control promoted. Credit for purchase of beekeeping inputs was available from credit facilitators and IPMS for landless youth

The value chain based interventions were related to the main beekeeping system components such as bee forage resources, honeybee colony supply, pests and diseases control, apiary management, access to credit, post-harvest management and marketing. The promotion included sale of liquid honey after extracting using centrifuge honey extractor, honey handling, grading, storage and packaging using 2–5 kg compact and see-through plastic containers.

3.3 Skill development and learning approaches

In response to the diagnosed limitations to market-oriented beekeeping development, the skill or knowledge needs and sources were assessed at the end of 2004 and subsequently revised annually (Table 3). The initial diagnosis did indicate that the components of the improved beekeeping knowledge exist among stakeholders (e.g., farmers, experts, consultants and private sector) in various forms in the district and beyond (IPMS 2005). Some beekeeping knowledge was gained through experience and some through training, observation, experience, and learning by reading text books and manuals. Few private beekeepers did have good experience captured from parents and knowledge gained through training and exposure and implemented improved beekeeping successfully (Box 1).

> Box 1. Originally Haleka Alem is a farmer from the surrounding of Wukro. At present he is one of the most experienced and knowledgeable beekeeper in the Tigray region. He accumulated beekeeping experience initially from his parents and grandparents. Thereafter, he has got lessons on improved beekeeping from experts in the district Office of Agriculture and Rural Development. He started beekeeping business with honeybee colonies using modern hives and management. Now he has established a big apiary site with more than 1000 honeybee colonies. Haleka Alem shares his rich practical beekeeping experiences and knowledge with the surrounding farmers. In this regard, Haleka Alem serves as a resource person during the various beekeeping training forums in Atsbi-Womberta. He also demonstrates colony splitting using modern hives to beekeepers in the district.

The assessment of the culture of knowledge flow and sharing among various beekeeping knowledge sources or stakeholders indicated that such culture was not developed well among the community (IPMS 2005). From 1998–2004, extension service providers were providing training on improved beekeeping to farmers focusing on technology adoption. The training on modern beekeeping was focused on adoption of improved beekeeping technology to increase productivity and reduce food insecurity. The training was loosely linked with market-oriented hive product development and value addition.

Since 2005, the IPMS project in collaboration with stakeholders mainly the district OoARD, facilitated market-oriented beekeeping skill and knowledge development for extension service providers (development agents (DAs), supervisors and experts) and farmers. In the skill and knowledge development interventions, farmers that are keen in market-oriented beekeeping development were included according to the specific hive product demand either for honeybee colony or honey, or both. The beekeeping skill development interventions included:

1. Primarily focused on capacity development of beekeeping management skill of farmers, extension service providers, researchers and private sectors to search, share and use knowledge in addition to technology adoption.

2. Improved beekeeping development linked with business skills and market orientations.

3. Strengthening learning forums through cross fertilization of experiences and skills. Skills and knowledge development approaches include establishment of knowledge sources, technology exhibitions, annual beekeeping learning forums/seminars, field visits and study tours, and training (Table 5).

Table 5. Skill and knowledge development of stakeholders using various approaches in Atsbi-Womberta district, 2005–2008

Knowledge sharing approach	Beekeeping issues addressed	Targeted beneficiaries
Study tours	About seven study tours related to beekeeping development integrated with watershed and irrigated development organized	Farmers, public extension service providers, decision makers, community leaders and community based organizations (CBOs)
Field days	About 13 field days on beekeeping development integrated with watershed interventions demonstrated	Farmers, public extension service providers and decision makers and landless youth
Technology exhibition	Value chain based beekeeping development shared at PA, district and regional levels since 2006	Farmers, public extension service providers, decision makers, community leaders and community based organizations (CBO), landless youth and experienced and non-experienced beekeepers
Access to knowledge sources	A WKC as a source of knowledge established in the district	Public extension staff experts, researchers and private sector
	Four FTCs as sources of knowledge and demonstration facilitated	Farmers and DAs
Beekeeping learning forum	Knowledge sharing among skilled, medium and less skilled farmers and subject matter experts	Farmers and experts, decision makers, community leaders, community based organizations and cabinet members
Trainings	Extension approach to enhance adoption	Experts as training of trainers
	Skill and capacity building of farmers	Farmers

Establishment of knowledge sources: The *woreda* knowledge centre (WKC) and farmer training centre (FTC) were established as sources of knowledge for experts and others on market- oriented commodities including beekeeping. The WKC were applied with some reference materials on beekeeping and offline copies of the Ethiopian Agricultural Portal (EAP), and CDs related to beekeeping development. The WKC were made to have internet connection. The main beneficiaries of the WKC facilities were extension service providers, researchers and students. At the FTC level, improved beekeeping technology was demonstrated to farmers and DAs. These include the use of improved beehive accessories (e.g., smoking can and bee veil), casting mould and honey processing. Besides, a live demonstration of improved beekeeping management combined with suitable bee forage has been established in some FTCs to share beekeeping knowledge with farmers. Moreover, some FTCs have been supplied with DVD player and flat screen TV monitor, computers and manuals to improve beekeeping knowledge sharing. FTCs were also connected to telephone services and electric power supply to facilitate knowledge acquisition and dissemination.

Technology exhibitions and market fair: Beekeeping knowledge capturing and experience sharing among farmers, DAs, experts and other members of the society were conducted at regional, district and PA levels using agricultural technology exhibitions on annual basis since 2006 (Table 5). The first national and regional knowledge sharing agricultural technology exhibition was conducted in March 2006 at Mekele.

Annual beekeeping learning forums: Since 2006, IPMS Atsbi-Womberta district has established various types of learning forums such as annual beekeeping experience sharing workshops and seminars (Table 5). The learning forum of beekeepers included experienced and non-experienced beekeepers in and outside the district.

Study tours and field visits: Study tours have been among the key methods to gain new experiences/ideas from others on improved beekeeping development. Since 2005, about 13 study tours have been organized to different sites for farmers, experts and decision makers of Atsbi-Womberta district. Many field days have been organized to demonstrate and share improved beekeeping development to beneficiaries and stakeholders (Table 5).

Trainings: Since 2006, many extension service providers have received training of trainers (ToT) in extension approaches (participatory extension, marketing extension, market assessment, gender, and knowledge management) in and outside the district. The ToT also included participatory beekeeping development planning, marketing, M&E, market information collection and dissemination and knowledge management.

3.4 Actors in market-oriented beekeeping development

Many actors played key roles in the development of knowledge based improved beekeeping along the beekeeping value chain framework (Table 6).

Table 6. Actors and their roles development of market-led beekeeping in Atsbi-Womberta district

Beekeeping value chain stage	Actors	Role of actors
Processing and marketing	OoARD, IPMS, Tigray Agricultural Market Promotion Agency (TAMPA) and Dimma Beekeeping Development PLC (DBD PLC)	Strengthening quality honey harvest, grading, processing and storage in quality containers. Create access to market information and linkage
Beekeeping production	OoARD, IPMS, WV-E, Irish project, REST, DBD PLC, GTZ, WFP and successful private beekeepers	Improved diversity and seasonal cover abundance of bee forage plants through resources conservation. Strengthening the capacity and skills of honeybee colony management, inspection, swarm control and colony splitting in relation to the seasonal nectar flow and colony strength
Input supply and credit	DECSI, WV-E, IPMS, OoARD, Cooperatives and DBD PLC	Facilitating the access to credit and input supply

The districts OoARD supervised and led the interventions in beekeeping. WV-E participated mainly in technology transfer and input supply. DECSI provided most of the credit and saving services. The OoARD, Irish project, GTZ, WFP and WV-E also played a key role in the rehabilitation of and re-vegetation of the degraded landscapes which became source of bee forage. Dimma Beekeeping Development PLC and private beekeepers in Wukro gave training to farmers on improved beekeeping management such as honeybee colony split, transfer and timely inspection for health. The Dimma Beekeeping Development PLC also supplied beekeeping inputs such as modern hives and honey extractor on credit to some landless youth. IPMS assisted in capacity development of farmers, private traders and extension service providers. IPMS also facilitated the documentation of lessons learned and scaling up of best bet lessons.

3.5 Monitoring changes

To monitor the results from individual or combination of interventions, the project initially established a baseline data as a reference to measure and document changes. To establish a baseline, data from a formal baseline study and data from some special diagnostic studies were used. The initial PRA study also contributed to quantitative and qualitative baseline information. Amongst others, the formal baseline study used PA level interviews and records from all PAs in the district. Several sources were used for regular documentation of change and results, including six monthly progress reports, annual M&E reports, thesis research, records kept by the OoARD, and personal observations. District OoARD staff also monitored changes in production and productivity on a yearly basis. A household survey was conducted in 2009 on 12 selected PAs. Specialized and focused studies on changes in relation to forage development/cover abundance and beekeeping performance were conducted and sampled in selected PAs along the various land uses (bottomlands, hilly sides, irrigated lands and backyards).

4 Results and discussion

The changes which are described below are the results of the interventions in the introduction, testing and promotion of learning platforms on the improved use of hive equipment, improved apiary and colony management, bee forages development, harvesting and post-harvest handling practices, and facilitation of access to market information and linkages.

4.1 Management of seasonal variability of honeybee forage

Seasonal bee forage availability. In Atsbi-Womberta, the bee forage availability varies seasonally with variation in rainfall pattern and monitoring the seasonal variation in forage availability is useful for beekeeping development. The variation in bee forage availability can be classified into four seasonal periods (Figure 2). These are ‘Dry period’ **(**February to mid March), ‘Transitional’ period (Mid March to June), ‘Nectar rich period’ (July to October) and ‘Frost period’ (November to January). Average figures for the 1999–2009 showed that about 85% of the annual rainfall fell in the ‘Nectar rich period’, 12% in the ‘transition period’ and about 3% in the ‘frost and dry periods’ (Gebremedhin et al. 2011). Bee forage availability is usually very high and consistent during the ‘Nectar rich period’. In the frost, dry and transitional periods, the bee forage availability is reported as low (Figure 2).

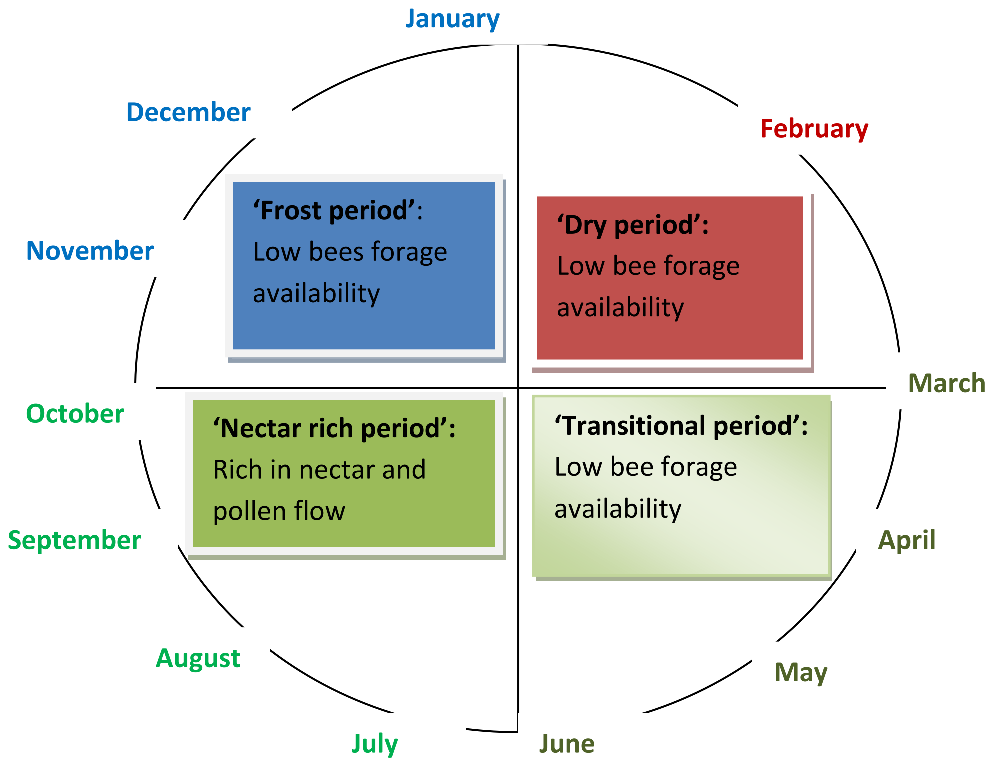


Figure 2. Seasonal variation in bee forages availability in Atsbi-Womberta district.

Following interventions in market-oriented beekeeping development, seasonal bee forage availability increased in most periods (Table 7). In the 'dry period', bee forage availability increased from low to medium around irrigated and closure grazing areas of the bottomlands and homesteads. In the 'frost period', bee forage availability also increased from low to medium around the closure grazing areas of the bottomlands and steep hilly sides. In the 'transitional period', bee forage availability increased from low to very high around the irrigated sites and high around the closure grazing areas of the bottomlands. During the 'Nectar rich period', availability of bee forage also increased particularly around the closure areas in the district. The results did show that seasonal bee forage availability increased in the forage shortage periods which could enhance market-oriented beekeeping productivity.

Table 7. Changes in seasonal bee forage availability in relation to various land uses in Atsbi-Womberta district. Seasonal bee forage availability scored on 0–4 scale points: 4 as very high, 3 as high, 2 as medium, 1 as low and 0 as absent

Land use type	Seasonal bee forage availability classes			
	Dry period (February to mid March)	Transitional period (Mid March–June)	Nectar rich period (July–October)	Frost period (November–January)
Irrigated lands	Medium	Very high	Very high	Low
Bottomlands: Area closure	Medium	High	Very high	Medium
Hilly side grazing lands: Area closure	Low	Medium	Very high	Medium
Arable lands and homesteads	Medium	Medium	Very high	Low

The reasons for the improved bee forage availability are attributed to the expansion in seasonal forage sources and increased cover-abundance of bee forage plants in the irrigated sites and area closures of the grazing bottomlands, hilly sides and homestead (Tables 8 and 9). Irrigated crops (vegetables, spices and pulses) expanded to more than 1500 ha of land in the district (OoARD 2008). The irrigated crops usually flower during the transitional period when abundance of bee forage is low particularly when there is no rain. Besides, most of the bottomlands and stabilized gullies, hilly sides and backyards have been put under area closure and cut and carry animal feeding system has been introduced and promoted (Table 8). Of the total grazing sites in the bottomland and associated gullies, about 71% (10542 ha) were put under cut- and- carry system of livestock feeding and became one of the major sources of bee forage. In the hilly side grazing lands, about 14646 ha of land were put under area closure and became the natural source of bee forage. Beekeepers around the area closures and irrigated sites indicated that the frequency of honey harvest has increased from single to 2–3 times/year (Mizan 2010). The community has put most of the steeply grazing lands under enclosure. These sites serve as bee forage resources mainly during the ‘Nectar rich period’ (Table 8). The relatively fertile bottomlands stay moist, green and natural bee forages plants flower alternatively in most of the months and the duration of flowering stays longer even in the absence of rainfall. Thus, there has been a clear shift in bee forage cover-abundance from mid- March to June, and relatively less meaningful changes in the frost periods because few plants flower during this period in enclosed and irrigated areas.

Table 8. Expansion and development of area closure (ha) as improved seasonal bee forage sources in Atsbi-Womberta district, 2008

Forage lands	Closure area (ha)	Main seasonal bee forage sources
Hilly side grazing lands	14646	Frost, transitional and nectar rich periods
Bottomlands and associated gullies	10542	Year round
Backyards	3617	Dry, transitional and nectar rich periods
Irrigated sites	1500	Year round

Seasonal cover-abundance of bee forage plants differ according to the sites of forage sources (Table 9). There has also been a substantial change in the cover-abundance and diversity of natural bee forage plants under different land uses (Table 9) combined with cut-and-carry system of animal feeding. For instance, the natural bee forage plants re-vegetated with increasing diversity and cover-abundance around enclosed areas. Based on our fields survey in 2008, the cover abundance of uniquely suitable bee forage plants locally known as ‘Gribiya’ (*Hypostus ariculata*) and ‘Tebeb’ (*Basium clandiforbium*) and ‘Swakerni’ (*Leucas abyssinica*) increased from 2–5% to about 25–50% around the steeply closure areas in Gergara watershed, Hayelom PA (Table 9); legumes and grasses around the bottomlands of Habes PA increased from 10–25% to 75–100% of which about 25–40% were valuable bee forage plants. In the irrigated area, natural plants, pulses such as faba bean and fenugreek, vegetables such as tomato have been flowering during the transitional period.

Table 9. Changes in cover-abundance and diversity of key bee forage plants as a function of land uses in Atsbi-Womberta. Bee forage cover-abundance scored on 0–4 scale points (4 as highly abundant, 3 as abundant, 2 as medium, 1 as low and 0 as absent), 2005–2008

Land use type	Cover-abundance of bee forage plants	Key bee forage plants	Main flowering habits outside the ‘‘Nectar rich period’’
Irrigated lands	Highly abundant	Many natural grasses and legumes grown around buffer zones and cultivated crops such as faba bean and tomato	Many plants flower during transitional and few during dry periods
Bottomland grazing sites: Area closures	Highly abundant	Many grasses (30 species identified), legumes and other herbs identified in the bottomlands	During transitional and dry periods and few plants during frost periods
Hilly side grazing lands: Area closure	Abundant	Many perennial bushes and shrubs mainly the key bee forage plants of *Tebeb*, *Sewakerni* and *Gerbiya*	During transitional period
Arable lands and homesteads	Low to Medium	Many cultivated crops and bushes and trees around homesteads including *Phytolacca dodecandra* (Endod), *Cordia Africana*, *Eucalyptus* spp., and cactus pear (*Opuntia ficus-indica*)	During the dry and transitional period

Quantity and quality of honey flow vs. seasonal bee forage availability. The seasonal quantity of honey flow varied significantly following the market-oriented beekeeping development interventions (Figure 3). Honey producers indicated that the trends in honey flow increased during the ‘nectar rich period’ similar to the bee forage cover-abundance seasonal trends (Alemtsehay 2011). Before the intervention, the maximum honey flow occurs from July to October. The rest of the months were characterized by inadequate honey flow. The honey flow between mid-March to June was highly variable due to the unpredicted and variable nature of the rainfall. March to June is relatively the most unpredictable season (Table 10) and the amount of honey can vary significantly. When there is enough rainfall to induce flowering, there could be adequate honey for harvest or support colony split (Table 10). In some seasons, when the amount of rainfall is sporadic, the honey flow is only adequate enough to maintain healthy and strong honeybee colonies. In the worst seasons when rainfall is low or absent, the honey flow is very low and unable to support survival of honeybee colonies. In the maximum honey flow period, the amount of honey produce is consistently above the honeybee colony requirement and the surplus is harvested for market supply (Table 10). In the lessor honey flow, bee flowers initially decline due to frost occurrence (usually November to January) and thereafter followed by dry spell months (mostly February to mid- March). The amount of honey usually declines below the colony requirement.

Table 10. Colony management interventions in relation to seasonal bee forage availability and degree of intervention successes (successful, partly, unsuccessful) in Atsbi-Womberta district

Season	Likelihood of forage predictability	Management interventions and colony management	Degree of intervention successes
'Dry period': February to mid-March	Predictable	Maintenance of bee colony with supplemental feeding and inspection to protect from bee enemies	Partly successful
'Transitional period': mid-March–June	Unpredictable	High forage availability: honey harvest and colony split possible Medium forage availability: Bees managed for colony strength Low forage availability: Colonies managed with supplemental feeding or move to forage sites	Partly successful
'Nectar rich period': July–September	Predictable	Honey harvest and inspection to avoid colony natural multiplication at the expense of honey production	Successful
Frost period: November–January	Predictable	Improved management of honey harvest and routine inspection and protect measures from natural enemies such as light smoking and cleaning	Partly successful

The seasonal honey flow increased after the intervention in market-oriented beekeeping development compared to before the intervention (Figure 3) due to the year-round enclosure of the forage sites and irrigated development. For instance, the honey flow increased around the homesteads, bottomlands and hilly side grazing lands during the 'frost period'. In the 'dry period', honey flow increased around irrigated sites and closure areas of the bottomlands, hilly sides and backyards. Honey flow also increased during the 'transition period' around the irrigated sites, bottomlands and backyards.

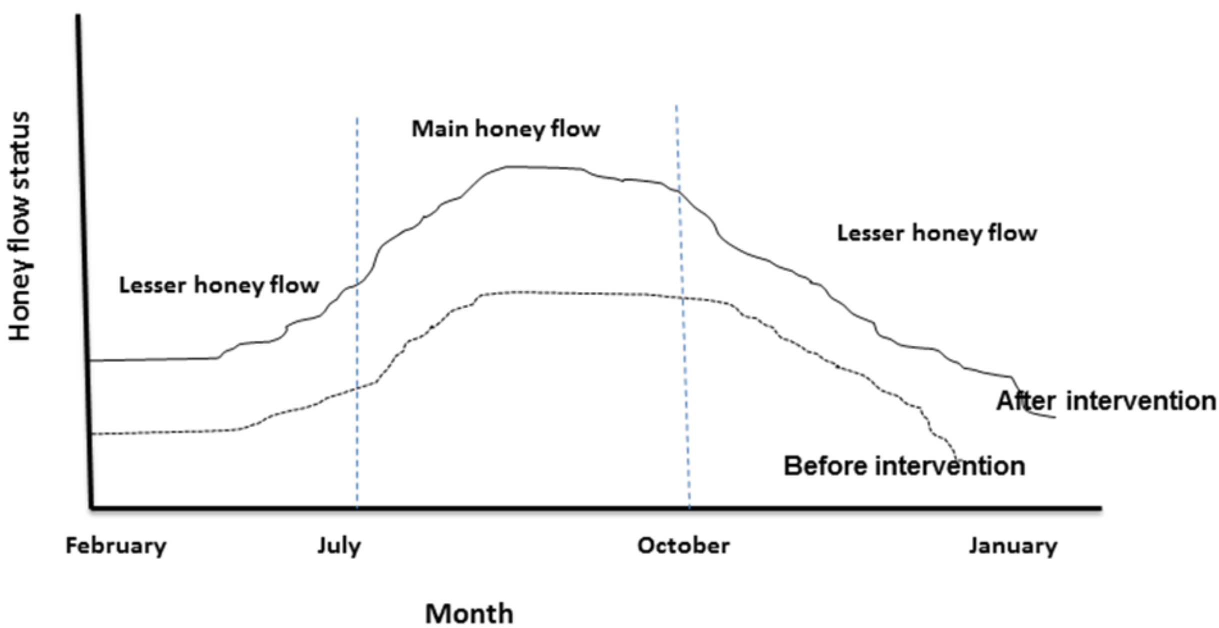


Figure 3. Illustration of seasonal variation in honey flow dynamics before (broken lines) and after (solid line) market-oriented beekeeping development interventions in Atsbi-Womberta district.

Although increased seasonal honey flow was observed around the closure and irrigated sites, the seasonal variation in honey quality needs due attention. This is because the quality and quantity of honey is related to the prevailing weather condition such as rainfall, temperature and sunlight (Gentry 1982). For example, excess rainfall during flowering stage of bee forages can alter the quality and quantity of honey. In this regard, Gentry (1982) indicated that for most plant species, the conditions promoting optimum honey flow are adequate rainfall before flowering and dry, sunny conditions during the flowering period. Thus, the timing and relative amount of rainy, dry and sunny days vary during flowering and hence the quality and quantity honey flow may vary accordingly. This could have implications on the quality and market price of honey (Alemtsehay 2011). For instance, the white honey of Atsbi is associated with the flowering time (August–October) of the key natural forage plants with sources of white nectar from plants locally known as ‘Gribiya’ (*Hypostus ariculata*) and ‘Tebeb’ (*Basium clandiforbium*) and ‘Swakerni’ (*Leucas abyssinica*). These forage species also flower during the dry, frost and transitional periods wherever there is moisture supply. Beekeepers indicated that honey harvested during these periods were relatively low in quality compared to the ‘nectar rich period’ (Alemtsehay 2011). The relatively low quality honey in other periods might indicate the changes in nectar quality.

4.2 Honeybee colony management

Difference in honeybee colony management in response to the seasonal variation in nectar flow and colony population dynamics were observed under market-oriented and traditional beekeeping (Figure 4; Table 10). When abundant pollen and nectar resources are available, the honeybee colony is stimulated to raise more brood and thus the colony population increases (Figure 4). When resources become low, brood-rearing decreases and colony population steadily declines. In local or traditional beekeeping, most beekeepers are less knowledgeable and experienced to apply knowledge-based beekeeping management following seasonal variation in nectar flow and honeybee population dynamics. In the ‘frost period’, for instance, most of the inexperienced or unqualified beekeepers harvest without retaining enough honey in the hive for honeybee colony maintenance. In this period, the colony population declines and becomes vulnerable to pests such as wax moth and rusts locally known as *Himodia*. The same holds true in traditional beekeeping management during the dry, transitional and nectar rich periods.

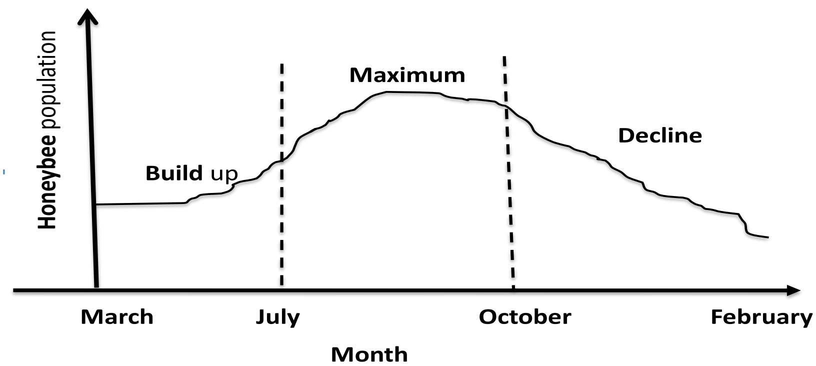


Figure 4. Illustration of seasonal variation in honeybee population dynamics in Atsbi-Womberta district.

In market-oriented beekeeping development, most of the beekeepers did apply a knowledge based beekeeping management following variation in seasonal nectar flow and colony population dynamics (Table 10). For instance, the ‘frost period’ is the most difficult season for beekeeping management and requires intensive skills and experiences to manage honeybee colonies, as they suffer from the cool night temperatures and frost. In the ‘frost period’, experienced beekeepers wisely manage honey harvest, some deliberately leaving honey in the hive as colony food reserve, and routinely inspect and protect colonies from natural enemies. Some beekeepers adjust hive locations and construct shelters, smoking and cleaning to minimize frost damage. In the ‘dry period’, beekeepers maintain honeybee colonies with supplemental feeds and water, and take extra inspection measures to protect the weak colony from natural enemies (Table 10). The key management element of colonies during the ‘frost and dry periods’ is to maintain healthy colonies and not production of honey or honeybee colony (Table 10).

On the other hand, most beekeepers apply different colony management during the ‘transitional period’ when bee forage cover-abundance varies from low to high (Table 10). This is the most unpredictable period in terms of bee forage availability and experienced and knowledgeable beekeepers did apply effective honeybee colony management in response to these changes under market-oriented beekeeping development (Table 10). Usually, whenever there is relatively good forage availability, beekeepers strive for manipulation of honey productivity for profitable income generation. When bee forage availability is relatively medium, beekeepers prefer to maintain strong colony in order to maximize honey harvest during the subsequent peak nectar flow period or 'Nectar rich period'. When bee forage availability is low, beekeepers management focuses on honeybee colony maintenance similar to the frost and dry periods. Hence, the focus of beekeepers during the transition period is partly to produce honey or colony and partly to strengthen or maintain the colony in response to the available bee forage resources.

The main market-oriented beekeeping management during 'nectar rich period' is to manage and inspect honeybee colonies to avoid natural multiplication of colonies at the expense of honey production and control swarm breeding through splitting (Table 10). This is because the 'nectar rich period' is associated with peak nectar flow and peak cover-abundance of bee forage plants and related with the maximum honey harvest (Table 7). This is the period with high bee forage abundance and, in relative terms, easily predictable. The amount of rain during this period is usually adequate to induce the flowering of perennial bee forage plants. The perennial plants are able to extract water deep from the soil and stay longer as sources of nectar and pollen. Under abundant bee forage supply, skilled and experienced beekeepers manage to obtain a large adult colony population or honey according to the market demand. On the other hand, colonies can also swarm under good bee forage abundance. Experienced beekeepers regularly inspect and manage the colony status to avoid swarm breeding. Farmers often avoid swarm breeding and swarming through colony splitting, increasing bee space or re-queening.

In general, the variation in honeybee colony management among beekeepers lies in the skills and knowledge applied to enhance profitable beekeeping development in response to the seasonal variation in bee forage availability. These skills and experiences are particularly important during pre- and post-frost and transitional periods. Usually, honeybee colonies can be exposed to bee forage shortages during the frost, dry and transitional periods. Experienced and knowledgeable beekeepers manage by moving the honeybee colonies to areas where there are bee forage plants around irrigated or moist gullies or bottomlands in order to maintain health colony. In this respect, repeated discussion with experienced beekeepers indicated that market-oriented beekeeping is relatively resilient to weather-induced changes and can be restored within the same year mainly during the 'nectar rich period' than the cultivation of rainfed crops. The management of market-oriented beekeeping needs time and requires year round inspection using various management approaches either to maintain a healthy colony or maximize productivity.

4.3 Market-oriented beekeeping extension

The extension approach in market-oriented beekeeping development has been participatory, demand-driven and knowledge-intensive based on the beekeeping value chain framework. The new market-oriented beekeeping extension approach was in part based on new knowledge on the improved beekeeping management including forage development and in part based on using a value chain concept which includes supply of inputs, marketing and processing. This also includes focus on market-oriented beekeeping development, knowledge capturing, use and sharing among beekeepers, synergy of experience based and newly introduced beekeeping skills and knowledge on integrated management of beekeeping along the beekeeping systems components.

For instance, shortage in supply of honeybee colony was identified as one of the limiting factors along the value chain. As an immediate intervention, credit services and honeybee colony supply was facilitated and honeybee colonies procured from other parts of Tigray to satisfy the colony demand of beekeepers. In 2005, about 144 honeybee colonies were distributed to landless youth from southern zone of Tigray. However, with the introduction of the honeybee colonies, there is a possibility of introducing devastating insect pests and diseases of honeybee into the district.

Alternatively, skill and knowledge private based honeybee colony multiplication using modern hives has been promoted and has evolved into private business where skilled beekeepers produce colony for market. Skills for honeybee colony supply were demanded because of the supply shortage. An experienced and successful beekeeper, Haleka Alem, helped train farmers in colony splitting using modern hives since 2006. In 2006, he gave practical training on honeybee colony splitting using modern hives to 77 farmers drawn from six PAs of the district. Subsequently, the trained beekeepers have been assisting their neighbours in bee colony splitting and also shared their skills with other farmers. For instance, about 153 farmers produced 172 honeybee colonies in the six PAs within the district in 2007. As a result, these farmers secured additional income from sales of honeybee colonies and became less dependent on external colony sources and reduced the risk of pests and diseases introduction. Moreover, they were able to select the desirable bee colony traits according to the interest and prior knowledge of the farmers. At present, honeybee colony splitting has grown into a private business where skilled farmers split colonies of their neighbours based on their agreed arrangements including reciprocal labour. The price of a colony ranges from ETB 400–800 depending on honeybee colony strength and type in 2008.

In the process of knowledge sharing, few innovative farmers emerged as the best innovators in understanding and practicing beekeeping as an art and science and have made meaningful difference in their household income. Knowledge and experience sharing forum among experienced and less experienced beekeepers and experts in and outside the district were established and promoted as part of the market-oriented beekeeping development. Innovative and best practices in market-oriented beekeeping development were shared among the beekeepers. For example, there was repeated absconding of hives by honeybee colonies when colonies were transferred from traditional to modern hives. The reason for honeybee absconding was not clear to beekeeping extension providers and other experts. During knowledge sharing meeting, a farmer from Era PA forwarded his experience on successful honeybee colony transfer from traditional to modern beehives (Box 2). Currently, it has become a habit to conduct beekeeping knowledge sharing forum among beekeepers and experts every year and to share newly tested skills in response to emerging problems. The sharing of knowledge has become popular among beekeepers within the district and sometimes outside the district. Some of the beekeepers have become best educators to surrounding beekeepers. Culturally, farmers show respect to skilful fellow farmers who made a meaningful difference in their income and lives. This is a partial shift in search of knowledge by private actors who understand, exercise and practice the art and science of beekeeping to generate better income.

Box 2. During knowledge sharing meeting, a farmer from Era PA forwarded his experience on successful honeybee colony transfer from traditional to modern beehives. He stated that he transfers all the contents of the traditional hive including wax, honey and propolis into the modern hive before transferring the colony. He positioned the hive content in the new hive similar to the way they were spatially placed in the traditional hive. In that case, the honeybee colonies feel as if they are in their original home with the same smell they are used to. This skill is essentially 'behaviour mediated honeybee colony management' that the experienced farmer applies in practice. This skill and experience on successful transfer of honeybee colony was shared and popularized among the beekeepers.

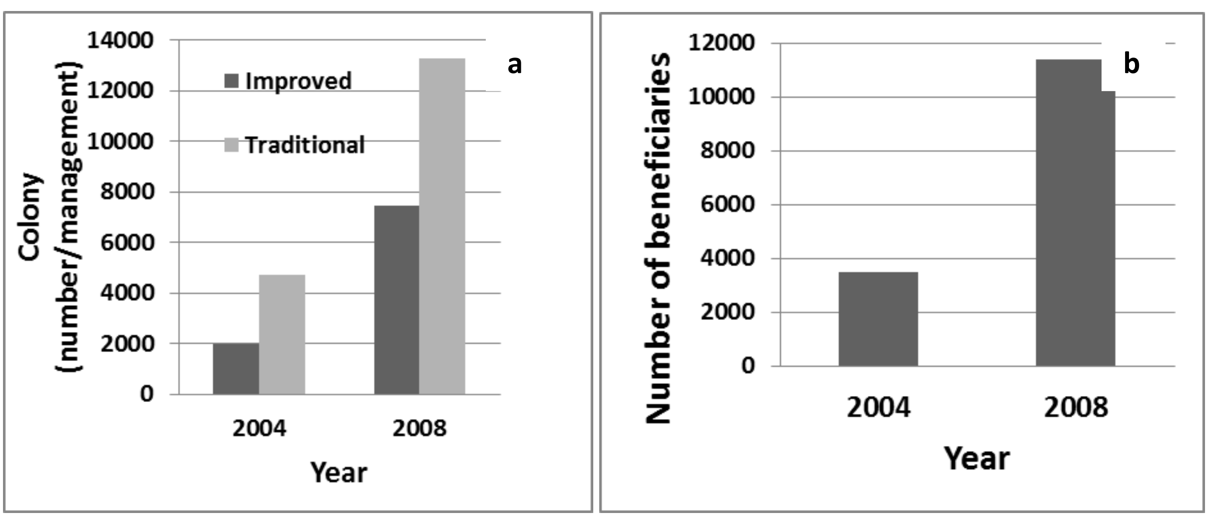
4.4 Management of honeybee maladies

In Atsbi-Womberta district, the presence of various honeybee maladies such as insect pests, predators, disease and pesticide poisoning were reported (Etsay and Ayalew 2001; Workneh 2007). Honeybee maladies can be classified into natural enemies (pests and predators) and pesticide spray. The damage due to honeybee natural enemies was less noticeable when the number of honeybee colonies was relatively low and scattered in the rural areas. The pest and predator load and the damage due to natural enemies increased as adoption of market-oriented beekeeping intensified (Workneh 2007). Based on the above information, beekeepers and extension service providers were capacitated with awareness creation, skill and knowledge on risks and reduction mechanism of honeybee enemies. However, beekeepers reported that the changes in reducing honeybee enemies were low.

The use of pesticide spray on high value irrigated crops, external livestock parasite and mosquitoes breeding sites particularly in the apiculture–livestock midland farming system of the district was also increased and awareness on the impact of pesticide spray to beekeeping promoted. The impact of pesticides on honeybee production was well documented (Sanford 2003; Teshome and Alemayehu 2005) and shared among the farming community. In principle, the communities have agreed to reduce pesticide use but implementation proved difficult. Thus, beekeepers indicated that damage due to honeybee maladies was increased with the promotion of market-oriented beekeeping development. In this regard, urgent measures need to be taken to reduce pest load and damage of honeybee maladies with the view to enhancing market-oriented beekeeping development.

4.5 Changes in improved beekeeping production

According to the information from the district OoARD, the total number of honeybee colonies in Atsbi-Womberta district increased by about threefold, from 6,729 in 2004 to 20,727 in 2008 (Figure 5a). Similarly, the number of beekeeping beneficiary households increased by about three fold (from 3432 to 11,398 households) (Figure 5b). Adoption of market-oriented beekeeping management is measured by the number of honeybee colonies in modern hives and use of improved knowledge to generate better income. In this case, the number of honeybee colonies under market-oriented beekeeping management increased by nearly fourfold from 2000 colonies in 2004 to 7467 in 2008 (Figure 5a). Similarly, honeybee colonies under traditional management increased by about threefold—from 4,729 in 2004 to 13,260 in 2008.



Source: OoARD (2008).

Figure 5. Changes in adoption of market-oriented improved beekeeping among households (a) and number of beneficiary households (b) in 2004 and 2008 in Atsbi-Womberta district.

Though there has been an increase in the absolute number of honeybee colonies, there was a variation in the adoption of market-oriented beekeeping innovations among beekeepers and PAs

(OoARD 2008). The variation in adoption of improved beekeeping appears to vary according to beekeeping products destined for market (either for honey or bee colonies), and types of forage sources. In this regard, the largest adoption of market-oriented improved honey production was found in the apiculture–livestock-midland farming system whereas the honeybee colony multiplication was prevalent in the pulse–livestock-highland farming system mostly based on traditional hives (OoARD 2008).

The number of honeybee colonies under traditional hives also increased by about threefold from 4729 in 2004 to 13,260 in 2008 despite efforts to transform them into improved hives to ease management. This is because most of the beekeepers targeted for bee colony multiplication prefer to keep their colonies in traditional hives particularly in highland farming systems. Beekeepers also hinted that the adoption of improved beekeeping innovations is linked to the type of bee forage availability. Based on our field survey in 2008, cultivated crops are the main sources of bee forage in the highland FS and natural forage plants in the midland FS. The main type of bee forage sources reflects the quality of the honey. In this regard, the best quality honey comes from the natural forage sources mainly in the midland FS. Thus, the highland FS is less competitive in market-oriented honey production compared to the midland FS. On the other hand, few farmers who develop natural forage around homesteads are able to produce quality honey in the highland FS. Thus, with improved natural forage cover-abundance in the closure areas of the bottomlands and steep degraded lands there is a possibility to enhance the adoption of improved beekeeping for honey production. Moreover, the initially high cost of improved beekeeping inputs such as modern hive and accessories as well as lack of skills often discourages beekeeping beginners to adopt improved beekeeping using modern hives.

New comers to beekeeping business indicated that they prefer to start with less risky and low cost traditional beekeeping using traditional hives and gradually move to improved beekeeping management using modern hives. Lack of skills and context-specific intervention approaches in skill and knowledge development perhaps needs special attention because the increase in use of beekeeping using traditional hives is associated mostly with beginners (personal field observation).

4.6 Changes in beekeeping productivity and income

Changes in hive productivity (honey and honeybee colony) of adopters and non-adopters of market-oriented beekeeping management were compared at hive, household and district levels (Figure 6). The hive honey productivity of adopters increased by about threefold (32 kg honey/hive per year) compared to the non-adopters (10 kg honey/hive per year) in 2008. Interestingly, hive honey productivity of adopters increased by 52% in 2008 (32 kg honey/hive per year) compared to those adopters in 2004 (21 kg honey/hive per year).

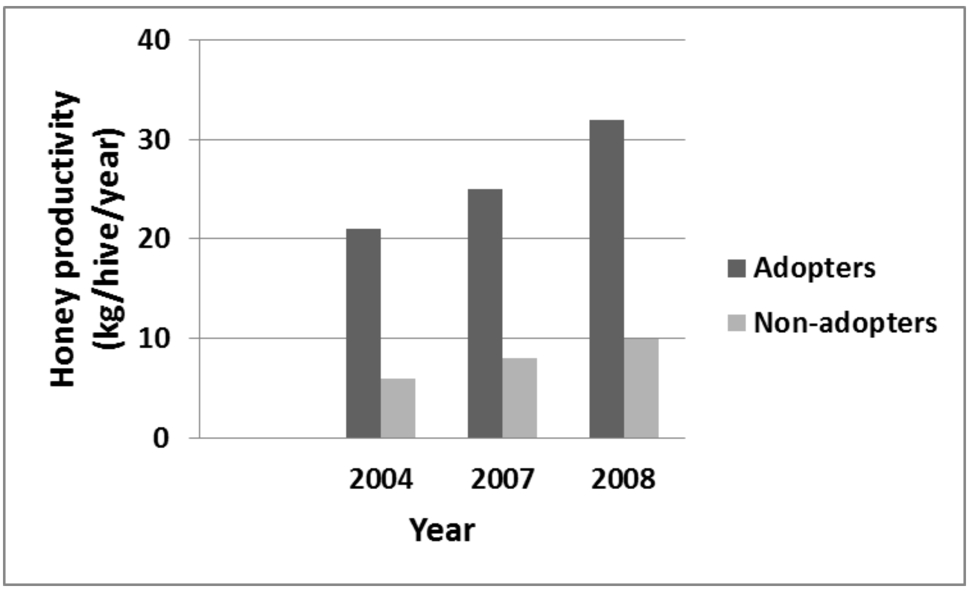


Figure 6. Comparison of hive honey productivity for adopters and non-adopters of improved beekeeping over the years 2004, 2007 and 2008, Atsbi-Womberta district.

Based on structured interviews with beekeepers and group discussion and key informant interviews across different land uses and PAs, hive productivity is largely a function of bee forage availability in the proximity of the apiary site (Table 11). Average hive honey productivity increased significantly in apiary sites around irrigated sites (40 kg honey/hive per year), closure areas of the bottomlands (36 kg honey/hive per year) and hilly sides (32 kg honey/hive per year) compared to the non-closure forage sites (20 kg honey/hive per year) in 2008 (Table 11). Similarly, honey productivity under traditional beekeeping management increased from 6 kg/hive per year in 2004 to 10 kg/hive per year in 2008. This could be due to increase in diversity of bee forage plants that can flower at various seasons of the year and serve as balanced sources of pollen and nectar. The increase in honey productivity is also attributed to increase in bee forage availability and cover abundance, improved skill and regular inspection by beekeepers in response to the dynamics of bee forage availability and colony population dynamics.

Table 11. Changes in average hive honey productivity (kg/hive per year) as function of land use in Atsbi-Womberta district in 2004 and 2008

Bee forage sources	2004		2008	
	Improved	Traditional	Improved	Traditional
Irrigated sites	30	7	40	12
Closure bottomlands and stabilized gullies	20	6	36	10
Closure-rehabilitated steeply lands	20	6	32	10
Arable and homestead lands	15	5	20	8
Average	21	6	32	10

Source: IPMS field survey (2009).

According to survey results, average multiplication of honeybee colonies using modern hives increased from one (using traditions methods) in 2004 to three colonies per hive per year in 2008 (Table 12). In the market-oriented beekeeping management, the number of honeybee colony splitting is managed according to the interest of beekeepers, colony strength and market signals. The multiplication of honeybee colonies in traditional beekeeping management remained unchanged, at an average of about two colonies per hive per year. Under traditional beekeeping management, the number of honeybee colony splitting is less manipulated and colony multiplication follows the natural course of reproduction.

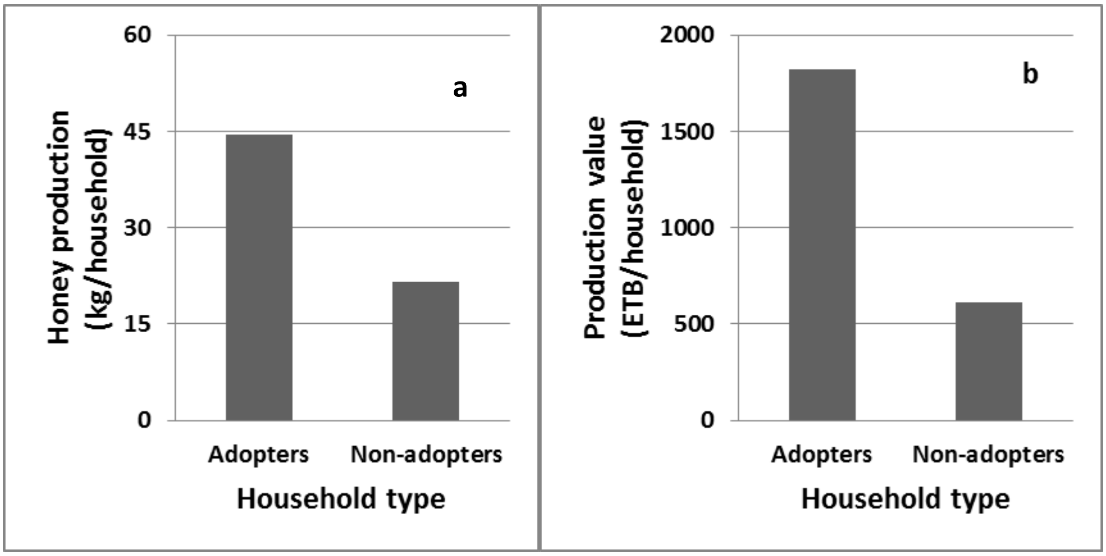
Table 12. Changes in average honeybee colony multiplication (number/hive per year) as function of land use in Atsbi-Womberta district, 2004 and 2008

Bee forage sources	2004		2008	
	Improved	Traditional	Improved	Traditional
Irrigated sites	1	2	4	2
Closure bottomlands and stabilized gullies	1	2	4	2
Closure-rehabilitated steeply lands	1	2	3	2
Arable and homestead lands	1	1	2	1
Average	1	2	3	2

The gross annual income of beneficiaries from the district increased to ETB 19.5 million compared to ETB 2.7 million in 2004 (IPMS 2005). Results of field survey in 2009 also showed that there was a significant difference in average honey production and value between improved beekeeping adopters and non-adopters households (Figures 7a and 7b). In 2007, average honey production for adopters of market-oriented beekeeping development was about twofold (46 kg honey/household per year) than non-adopters (22 kg honey/household per year) (Figure 7a). Market-oriented improved beekeeping adopters had a threefold higher profit from the sale of honey (ETB 1820/household per year) than non-adopters (ETB 614/household per year) in 2007 (Figure 7b). In Atsbi-Womberta district, the price of a honeybee colony ranges from ETB 400–800 in 2008. On the other hand, the farm gate price of a kg of honey from improved beekeeping is about ETB 70 and that of honey from traditional beekeeping is about ETB 24/kg in 2008. If we assume that about 50% of the traditionally managed honeybee colonies produce one colony each and 50% produce honey for the market annually, the gross annual income would be about ETB 4.96 million under the traditional beekeeping management system in 2008 (Figure 8; OoARD 2008).

Assuming that honey from improved market-oriented beekeeping is destined for market (Mizan 2010), then estimated gross annual income of the district would be about ETB 14.5 million in

2008 (Figure 8). Thus, the gross annual income of the beneficiaries in the district increased by about sevenfold in 2008 compared to the gross income of 2004 (IPMS 2005).



Source: IPMS field survey (2009).

Figure 7. Household level honey production (kg honey/household per year) (a); and value of honey (ETB/household) (b) for adopters and non-adopters of improved beekeeping in Atsbi-Womberta.

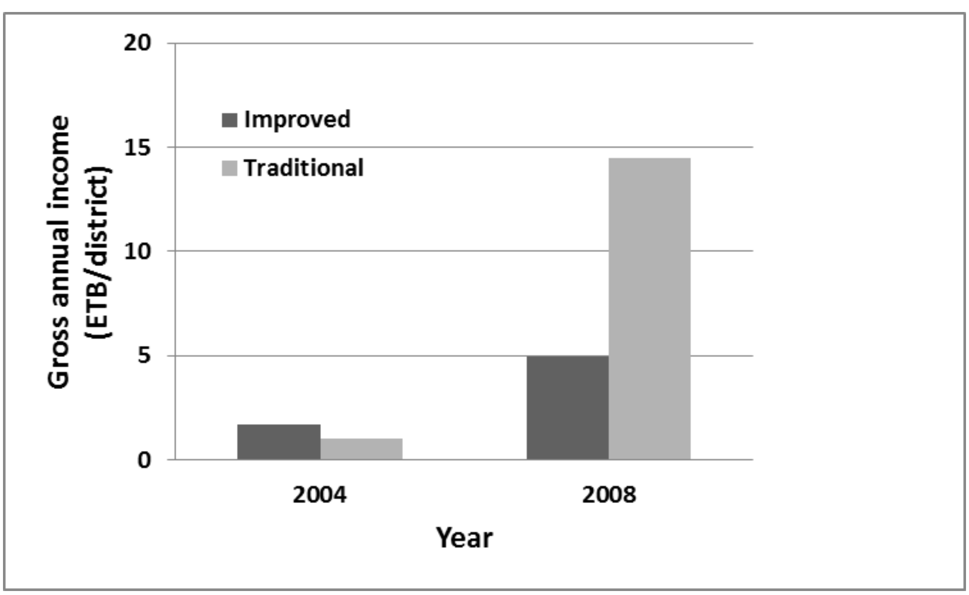


Figure 8. District level gross income estimate (ETB/district) from traditional and improved beekeeping in Atsbi-Womberta district, 2008.

Many beekeepers agreed that the increased productivity (honey and colony multiplication per year) is also a function of the genetic makeup of the honeybee colony. Genetically, honeybees in Atsbi-Womberta district belong to the African bee *Apis millifera* (Nuru 2002). Within the species, beekeepers differentiate honeybee colonies according to their performance, behaviour, colour and adaptation to drought and diseases. Accordingly, beekeepers identified about three major honeybee colony types: Red and black, and mixture of the two. The red honeybee colony type produces relatively higher yields, is less aggressive, but is susceptible to drought and pests compared to the black colony type and their mixes. The reverse applies to the black honeybee colonies. The above results indicated that genetically the existing honeybee colonies have adequate potential to produce honey under market-oriented beekeeping management with some farmers harvesting about 60–80 kg honey/hive per year around irrigated sites or in good seasons (OoARD 2008).

4.7 Quality of honey and honeybee colonies supplied

Knowledge and skills on the supply of quality honey has been promoted and meaningful changes have been observed in the supply of quality honey to the market. The quality of honey is at its best when it is kept in the beehive (Gentry 1982; Bradbear 2009). Honey quality could be reduced during honey harvesting, processing, storage and marketing. In traditional beekeeping, honey quality is reduced due to harvesting of unripe honey, excessive smoking during harvesting, mixing of honey with pollen, beeswax, broods and other hive products such as propolis. Honey was also stored in traditional containers such as clay pot, hide, gourd and tin. Previous research reports indicated that honey quality is reduced when stored in traditional containers (Nuru 1991; 1999). Lack of linkage and premium market price for quality honey also discourages beekeepers from producing and maintaining good quality honey.

In market-oriented beekeeping development, many beekeepers adopted the production and harvesting of quality honey in the district (Alemtsehay 2011). At harvest, beekeepers started checking for ripe honey, excessive use of smoking was reduced by using controlled smoker; ripe honey was harvested using clean ancillary equipment. About 36% of the honeybee colonies in the district were using frame hives (OoARD 2008) in 2008 and the honey in frames were easily extracted using centrifuge honey extractor and marketed as clean liquid honey.

In market-oriented beekeeping development, honey grading, storage and supply were significantly transformed in response to market demand. Beekeepers graded honey based on colour, consistency, aroma and flavour. These honey quality attributes were related to the type and pattern of nectar sources. This is further related to the 'foraging constancy' of honeybee behaviour whereby honeybees collect nectars from the same species as long as there is plenty of nectar (Amsalu 1991; Bradbear 2009). The colour of the honey therefore reflects the dynamics of flower pattern of the forage plants. Interviewed traders and beekeepers indicated that honey grading based on specific colour, aroma and flavour were useful to supply attractive and uniform quality honey to the market. At present, beekeepers stored honey in plastic buckets with tightly fitted lids. The quality honey has been sold using about 20–25 kg capacity plastic buckets to traders and 2–6 kg capacity plastic containers directly to consumers. Besides, preliminary honey quality taste with different consumers showed that consumers can grade the quality of honey effectively using taste. This indicates that the quality honey production warrants higher prices in the market.

Farmers mentioned that the honey from traditional hives was graded into three classes before marketing. The first class is 'watery white' honey, 2nd class-medium quality mixed with different honey colours, and third class is low quality honey-mixed with hive products such as pollen, honey and broods. The first class honey fetches about ETB 30–35/kg in 2008. The medium quality honey is usually marketed for the preparation of the local honey wines locally known as '*miyes* or *tej*' (equivalent to the mead drink or *mede* in the Netherlands) and fetches about ETB 20/kg in 2008. The third class low quality honey is usually used for household consumption and fetches about ETB 15–18/kg. Recently, the traditionally produced honey is often stored in plastic buckets and supplied to the market either as honey on the comb or liquid honey.

Field studies indicated that in market-oriented beekeeping development, beekeepers adopted the local multiplication and supply of honey colony based on desirable colonies attributes and strength using modern hives. Under traditional beekeeping, honeybee colonies multiplied naturally without knowledge and skill based intervention of the beekeepers. Beekeepers usually catch the splitted colony near the apiary before absconding or catch from other sources. When there is shortage of colony supply in the area, beekeepers buy from other sources. Thus there was no meaningful control on the desirable quality and strength of the honeybee colony. In market-oriented beekeeping development, colony producers indicated that the quality of a honeybee colony is usually assessed by the desirable traits acceptable to beekeepers and colony strength. The main desirable traits of a honeybee colony included high honey production and disease resistant; low tendency to swarm and abscond; and gentleness and calm on combs when colony is worked. Beekeepers also assessed the strength of the honeybee colony by the number of bees in a colony and honeybee colony activities such as whether a colony has an active queen or not. Under market-oriented improved beekeeping development, beekeepers have a skill to split or multiply honeybee colonies with desirable traits or make arrangement ahead of time to buy a honeybee colony with known desirable traits from their village. In this manner, beekeepers have been able to maintain and upgrade honeybee colonies with desirable traits in the village using modern hives.

4.8 Access to market information and linkages

The difference between the prices received by farmers and the retail prices has reduced from 50–60% in 2004 to 15–20% in 2008 (personal communication with traders and producers). As a result of the increased access to market information and linkage, honey price has increased significantly benefitting producers. Market price information of honey in the nearby markets is being posted in the PAs biweekly in addition to the information broadcasted by regional radio.

Honey market linkages between producers and traders from the nearby towns including Mekele were established through discussion forums in 2006 and honey marketing is facilitated by fixed telephone lines and cell phones. Recently, beekeepers started organizing honey outlet shops and traders can collect them easily. In these linkages, honey sellers have been discouraged from establishing relationships with traders without the consent of the farmers of honeybee colonies in the PA. This is because the farming community indicated that honey adulterations mostly take place by people who have no honeybee colonies and this measure discouraged adulterated honey marketers. As a result, the farm gate price of 1 kg of first grade white honey increased from about ETB 30–35 in 2004 to ETB 70–80 in 2008.

4.9 Effect on environment and gender

Honeybee colonies are essential for sustaining the environment by pollinating natural plants and increasing yields of crops. In harvesting pollen, honeybees pollinate million of wild plants including valuable herbs, shrubs and trees and high value cultivated crops such as spices and vegetables (McGregor 1976). The pollination of bees also helps for effective seed set and survival of the plants in the ecosystem (Benjamin and McCallum 2008; Bradbear 2009). Furthermore, beekeeping does not compete much for resources with other types of agricultural activities. The nectar and pollen of plants have no other use than for beekeeping. Because of the improved benefits from beekeeping products, the community maintains forage plants around their homesteads and in closure areas.

Although traditionally beekeeping is considered as a man’s job, about 11% of the producers in improved market-oriented beekeeping development and 22% under traditionally managed honeybee colonies were female-headed households in 2008 (OoARD 2008). The higher percentage of female-headed households in the traditional system could be due to lack of experiences and skills, and the relatively high costs of inputs in market-oriented beekeeping. Hence, provision of targeted and insured credit services for women interested in market-oriented beekeeping could enhance the adoption of improved beekeeping by female-headed households. In market-oriented beekeeping development, beekeeping is a flexible activity for both sexes of any age category in the household. In Atsbi-Womberta district, some women manage most of the beekeeping activities including construction of local hives, inspect and clean the apiary.

5. Opportunities, challenges and lessons learned for scaling out and up

5.1 Opportunities and challenges

Opportunities: In Atsbi-Womberta district, ample opportunities do exist to enhance market-oriented beekeeping development.

- Long tradition of beekeeping by the farming community, suitable agro-ecologies for honeybee colony and honey production, presence of some improved skills and experiences, and knowledge in beekeeping for improved productivity exist.
- Lack of quality honey, wax and honeybee colony exists in the local markets and beyond. The locally known self-branded 'Atsbi honey' fetches the highest price in the nearby markets. This advantage is expected to be sustainable because 'Atsbi honey' is not replacing the market of other honey sources from other locations.
- There is a large area of non-arable land suitable for beekeeping in the district. For instance, about 80% of Atsbi-Womberta district is non-arable. Most of the non-arable lands have been put under area enclosure. This has created opportunity for increased bee forage diversity and cover-abundance, and availability of water and suitable apiary sites for beekeeping development. At the same time, the areas under irrigation and year round closures in the bottomland have been increasing. These sites are potential sources of year-round bee forages and water. On the other hand, there are many landless youth, school dropouts and other jobless people in the district. There is a great opportunity to organize, capacitate, guide and engage them in beekeeping business on the available non-arable land in the district.
- Rainfall in Atsbi-Womberta district is very variable. In Atsbi-Womberta, shortage of rainfall is usually experienced during the reproductive or grain-filling period of crops due

to early withdrawal of rain. Sometimes there is delayed onset of rain or transient moisture stress at any development stage of the crops. Such variability substantially reduces grain production. However, the early withdrawal of rain enhances the production of quality nectar for quality honey production. Shower of rain that supports crop germination is adequate enough to initiate the flowering of perennial bee forage shrubs and trees. In the dry areas, a heavy rain or about two showers of rain at any part of the season may be good enough to trigger nectar producing flowers particularly in the bottomlands, gullies and conserved closure areas. In good seasons, the annual herbs are also good sources of bee forage plants. This shows that beekeeping development is adaptable, more resilient income-generating business than rainfed crops in the ecology of Atsbi-Womberta district.

- Perhaps the key and important opportunity for beekeeping is the presence of some skilful and experienced farmers with better understanding about the art and science of beekeeping in the district. Some innovative farmers understand well the behaviour of the honeybee races in relation to the nectar flow in their specific location. The shifts and changes in new technology have been fine tuned under this context. This skills and knowledge helps them to manage honeybee colonies in a productive way and enable them to make a difference in household income. Subsequently, few innovative farmers skilfully manage to produce about 60–80 kg honey/colony per year worth of ETB 6000–8000 under Atsbi-Womberta conditions in good seasons (OoARD 2008). These innovative farmers can be used as sources of practical knowledge to train and capacitate other less experiences farmers in the district.

Challenges: The challenges in market-oriented beekeeping development specifically related to knowledge and skills needs and development.

- Shortage of skilled manpower with ability to understand the existing beekeeping-human relationship and provide context-specific services to make a difference in the productivity and quality of marketable hive products.

- Lack of experienced and knowledgeable experts in the protection and control of honeybee pests such as predator mammals, birds, lizards, insects and diseases is a serious problem. Many arrays of honeybee maladies exist in the district and better alternative technologies have not yet been implemented in the district due to lack of know-how.

- There is a substantial difference in beekeeping management skills and knowledge among farmers. In this regard, how to improve and address the various knowledge and skills needs of beekeepers will continue as a challenge to the research and development service providers.

5.2 Key lessons learned for scaling out and up

- The key lesson drawn from the experience in market-oriented beekeeping in Atsbi-Womberta is the critical role of market-oriented participatory planning and implementation based on the value chain framework. This approach was found useful to enhance the adoption of market-oriented beekeeping development and should be used in smallholders' beekeeping development initiatives.

- The approaches of the implementation follow the existing structures of the public extension system. The intervention started with introduction and familiarization of the new approaches to the extension structures and other actors. The identified gaps in knowledge and proposed interventions were refined continuously in consultation with the farmers, extension staff and other development actors annually. This was to fine-tune the interventions into context. Market-oriented intervention approaches were institutionalized in the existing development structure.

- Linking knowledge sources with users in response to the identified gaps in knowledge along the beekeeping value chain was another key success element. The initial gaps in knowledge also were followed by new gaps as a result of action undertaken. The changes associated with the interventions were monitored and evaluated timely. Based on the results, the actors reflect, modify and propose new interventions. In this way, the role of IPMS has been to facilitate the sharing and use of knowledge among actors—translating the beekeeping knowledge embodied in the heads of the many actors into practice to generate income. Hence, what is new in our market-oriented approach is the focus on dynamic learning by doing, share and use the new knowledge, reflect and revise in an iterative process. The focus and emphasis on skill development to use and generate knowledge in response to emerging opportunities and challenges in addition to technology adoption is a new approach in the system which should be expanded.

- Creation and adoption of market-oriented beekeeping development approach is usually a slow process at the start. This is because improved beekeeping is an integration of good understanding of honeybee colony behaviour and timing of management operations in relation to good seasonal bee forage availability. To gain the skills and knowledge of the integrated understanding of improved beekeeping, beekeepers need to see and practice themselves and actual demonstration of improved beekeeping was found to be most effective teaching method and should be scaled out and up in other districts.

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