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Future of beekeeping in Northwestern Ethiopia: Scenarios, local adaptation measures and its implications for farmers' livelihoods

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Abstract. *Tassew A, Alemayehu G, Sölkner J, Wurzinger M. 2019. Future of beekeeping in Northwestern Ethiopia: Scenarios, local adaptation measures and its implications for farmers' livelihoods. Biodiversitas 20: 1633-1643.* For this study, a participatory scenario planning approach was used to understand the driving forces, generate the plausible future scenarios of beekeeping, explore local adaptation measures and its implications for farmers' livelihoods in Northwestern Ethiopia. Data were collected from three watersheds representing different agro-ecological zones. To identify the driving forces, different methods including key informant interviews, focus group discussions, workshops, researchers observations and literature search were applied. The data were analyzed by ranking followed by controllability, cross-impact and consistency analysis. The results show that nineteen driving forces were identified that are contributes to changes in beekeeping. Out of nineteen six most relevant and locally controllable driving forces (watershed development, deforestation, agrochemicals use, government emphasis for beekeeping development, technical support, and farmers' awareness) were selected to develop different plausible and contrasting scenarios. The three plausible and contrasting scenarios for beekeeping in 2025 are: ''repressive", ''beekeeping advance" and ''beekeeping on the margins". The results show that beekeeping significantly contributes to the livelihoods of farmers to 2025 under ''beekeeping advance" scenario. In the ''beekeeping on the margins" scenario, beekeeping has low contribution to the livelihoods of farmers. But the beekeeping is in a system of involution in ''repressive" scenario and has very low contribution to the livelihoods of farmers. The stakeholders were checked the plausibility of the scenarios and selected the ''repressive'' scenario as the worst, the ''beekeeping advance'' scenario as the best, and the ''beekeeping on the margins'' scenario as the business as usual and intervention strategies were developed to transform the current beekeeping into ''beekeeping advance" scenario. The study has shown that the participation of stakeholders in the scenario planning process provides knowledge relevant for understanding the dynamics and future scenarios of beekeeping. Hence, interventions to be made by concerned stakeholders to improve the beekeeping in the study areas need to focus on addressing the various and complex driving forces through a system wide and context-specific approach.

Keywords: Beekeeping, driving forces, Ethiopia, future scenarios, interventions

INTRODUCTION

Despite the long tradition of beekeeping in Ethiopia, having the highest honeybee colonies and being the leading honey producer as well as one of the largest beeswax exporting countries in Africa, the share of the sub-sector in the GDP has never been commensurate with the country's potentiality for beekeeping (Demisew 2016). The productivity of honeybee in the mixed farming system has been low due to many factors. The main reasons include low beekeeping technology adoption, changes in natural environments, pests and predators attack, and indiscriminate applications of agrochemicals (Ejigu et al. 2009; Gebey et al. 2010). Thus, the beekeepers in particular and the country, in general, haven't been benefiting from the growing demand for honeybee products in both domestic and export markets (Legesse 2014).

Until recently, beekeeping has received little attention from both practitioners and researchers in Ethiopia. For decades, only one beekeeping research center has been doing research at regional and national levels, and only recently regional research institutes have started beekeeping research (Ejigu et al. 2012). The few beekeeping development programs undertaken so far have been unsuccessful as only about 10% of the beekeepers are using improved beekeeping technologies (Demisew 2016). Among others, the failures of the development programs appear to be the lack of understanding the production systems, distribution of improved hives in isolation from other associated accessories, and lack of technical support (Girma et al. 2008; Gebremedhn and Estifanos 2013; Yehuala et al. 2013).

Farms in the mixed farming system are extremely diverse, complex and the changes have been driven by various driving forces and in this study, a driving force is "any influencing factor that directly or indirectly brings about change in the beekeeping". One farm usually incorporates a variety of agricultural practices; farmers keep different livestock species and honeybee colonies as livelihoods strategies. Indeed, beekeeping deliver different products and services and also highly complex. Progress in improving the productivity of these systems has been much more limited and is a significant research challenge (Hailu et al. 2011). Therefore, understanding context-specific through stakeholders' participation is important to understand the dynamics, to identify driving forces and thereby, to explore alternative future development paths.

However, there is scarce information available about how different stakeholders perceive changes in beekeeping and the reasons for changes to set up plausible futures development paths. In this context, research has to be designed in a way that will allow the participation of farmers and other stakeholders for understanding dynamic and complex systems. In this regard, different authors (Conroy 2005; Geerlings 2010; Pell et al. 2010) emphasize the involvement of stakeholders including local communities, development practitioners, researchers, and private sector actors for successful beekeeping development programs. Other scholars also highlight that research effort should focus on integrating knowledge from diverse disciplines and various stakeholders to solve real-world problems (Mcdonald et al. 2009; Bammer 2013).

Participatory scenario planning has been used as effective tool for understanding changes and futures development trajectories in social-ecological systems (Malinga et al. 2013). The use of participatory method becomes essential in the scenario planning process (Enfors et al. 2008; Malinga et al. 2013). Thus, the participatory technique applied in the scenario planning exercise encourages critical thinking and social learning processes about changes and the driving forces that drive the changes, the causal relationships and the different futures the driving forces may create (Swart et al. 2004; Reed et al. 2013). The participation of stakeholders in scenario planning process is also important for capacity-building, for ownership of the results, and to make decisions and actions (Reed et al. 2013; Bizikova et al. 2014). Therefore, this study was aimed at understanding the driving forces, generating plausible beekeeping future scenarios, exploring local adaptation measures and its implications for farmers' livelihoods in Northwestern Ethiopia.

MATERIALS AND METHODS

Description of the study areas

This study was conducted in three watersheds in Northwestern Ethiopia. A watershed is a topographically delineated area that is drained by a stream system or commonly defined as an area in which all water drains to a common point (Desta et al. 2005). A watershed is made up of the natural resources in a basin, especially water, soil, and vegetative factors. At the socio-economic level a watershed includes people, their farming systems (including livestock, beekeeping) and interactions with land resources, coping strategies, social and economic activities, and cultural aspects. It also has socio-political unit for planning and implementing resource management activities. The watershed approach was selected because nowadays the government of Ethiopia and NGOs has been supportive of community watershed programs to enhance rural livelihoods through managing natural resources (Desta et al. 2005). Hence, three watersheds were selected based on the size of the watersheds (area coverage), accessibility, agro-ecological representation, and years of experience in extension support by the government and ''Sustainable Natural Resource Management Program in North Gondar Zone (SRMP-NG)" project supported by Austrian Development Cooperation. The watersheds are named Wujraba, Godinge, and Mezega which are found in Chilga, Dabat, and Debark districts (Figure 1) and their surface area of the watershed is 560 ha, 330 ha and 316 ha for Wujraba, Godinge, and Mezega, respectively (Hailu et al. 2011). The watersheds are agro-ecologically distinct ranging from tepid moist (*''Weynadega''*) in Wujraba, cool moist (*''Dega''*) in Godinge and cold to very cold moist (*''Dega'' to ''Wurch''*) in Mezega. The watersheds are also distinct in rainfall, potential evapotranspiration, and temperature. Maximum annual average temperature of Wujraba, Godinge, and Mezega is 23.9°C, 18.8°C, and 19.9°C, while their average annual rainfall is 1,300 mm, 1,200 mm, and 1,450 mm, respectively. The topography of the watersheds is generally rugged mountains and undulating hills on the upper part of the watershed. Mixed crop-livestock farming is the mainstay of the livelihoods of households in all three watersheds. Farmers keep different livestock species and honeybee colonies. The principal crops grown include teff (*Eragrostis tef*), sorghum (*Sorghum bicolor*), and maize (*Zea mays*) in Wujraba, wheat (*Triticum aestivum L.*), barley (*Hordeum vulgare*), and triticale (*x-Ttriticosecale*) in Godinge and Mezega (Hailu et al. 2011).

The participatory scenario planning process

In this study, an exploratory scenario type was used (Kosow and Gaßner 2008). This approach was selected because the numbers of scenarios are not predetermined and are a result of the analysis. Hence, the purpose of the participatory scenario planning in this study is exploration and integration of stakeholders' knowledge in a qualitative design. The qualitative study was selected because the general issues in questions and the system that are being explored in this study become diverse and complex, and hence the use of mathematical models is not essential. Swart et al. (2004) noted that when perceptions, action, institutions, etc. are examined, they can best be embedded in qualitative scenarios. In this study, the research approach was not testing or developing theories but rather focusing on methodological alternatives for exploring the plausible alternative futures development pathways of beekeeping in the mixed farming system.

Data collection

Both secondary and primary data sources were used in this study. Secondary data were collected from office of agriculture, statistical office, research institutes, and non-governmental organizations. The primary data were collected using qualitative research methods (Silverman 2005) including key informant interviews, focus group discussions (FGDs), stakeholders' workshops and field observation. A purposive sampling technique was used to select the farmers for key informant interviews, FGDs, and workshops (Patton 1990).

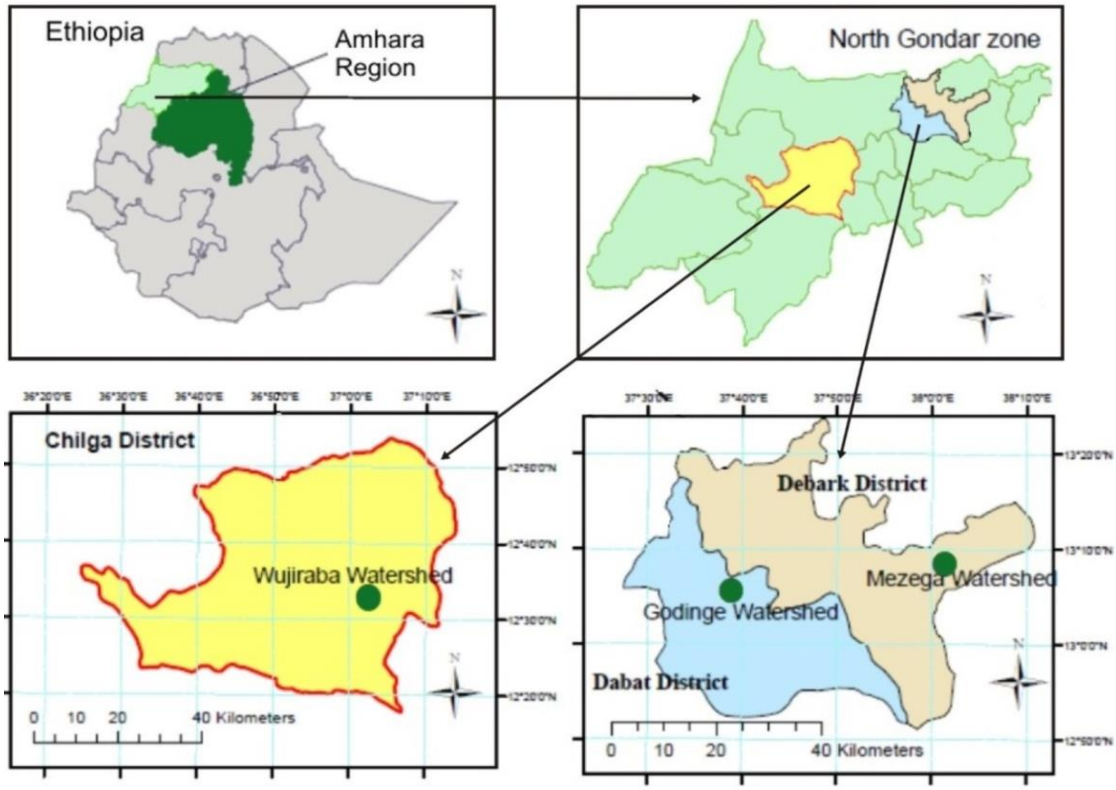

Figure 1. Map of the watersheds (Source: Authors based on 1994 Ethiopian Central Statistical Agency data)

Farmers were selected considering sex, age, wealth status, years of settlement (> 10 years), and experience in livestock farming. The selection was done by the involvement of the researcher, livestock development agents, and district SRMP-NG project focal persons. Thematic and institutional relevance was considered to select development agents, experts, researchers, and officials. In this study, the time frame considered was 10 years (from 2002 to 2012) to identify the driving forces of change and the scenarios developed as storylines of how the changes in beekeeping would be 2025. With regard time horizon, 10 years were set for this study so as to envisage the changes in beekeeping in the long run. A shorter timeframe was unnecessary as it would not address changes in beekeeping. A longer timeframe would have also been interesting, however, the beekeeping sub-sector developments for such longer time frame would be very hard to envisage by stakeholders such as farmers. Another justification is that Ethiopia has been going through enormous changes to achieve the growth and transformation plan (GTP) and its vision by 2025 of attaining the middle-income countries status. Thus, the scenario timeframe for this study falls under the category of a short term ranging from three up to ten years (van Notten et al. 2003).

Prior to the actual data collection, the researcher visited the specific research sites and several issues related to beekeeping were learned by observation and informal discussion with people. Transect walks created opportunities for observation and informal discussion with people. Issues that emerged from observation and informal discussion with people were used to guide key informant interviews, focus group discussions and stakeholders' workshops. In this study, a total of 24 (8 per watershed) key informant interviews and 9 FGDs (3 per watershed) with farmers were carried out. The FGDs participants comprised of 7 men and 3 women. Similarly, interviews were held with livestock development agents, and beekeeping development and research officials. FGDs were also held with beekeeping experts and researchers. Open-ended questionnaires were used for both the key informant interviews and FGDs and the discussion was done using the local language (‘‘Amharic’’) and their responses were recorded using a voice recorder. The researcher and his assistant moderated and recorded the discussion.

To identify the driving forces stakeholders’ workshops were held at each watershed with 16 participants including 10 farmers’ representatives (7 males and 3 females), the chairman of the peasant association, one livestock development agent, two district beekeeping experts, the head of district office of agriculture, and the head of district administration). In the workshops, first participants discussed and presented a list of driving forces that they considered important for changes in beekeeping in the past, present, and future. Then, the researcher added driving forces identified from preliminary assessment (key informant interviews and FGDs), and literature search. Finally, the driving forces obtained from different stakeholders were discussed together and agreed. The discussions were done using the local language (Amharic) and minutes were taken by the researcher and his assistant.

Data analysis

Ranking driving forces

Ranking driving forces is the first step in analyzing and filtering driving forces based on their relevance. Hence, all participants ranked the driving forces based on the degree of relevance. A direct ranking method was employed by displaying the driving forces written on the separate pieces of papers on a table for both experts and farmers. Literate farmers and experts have filled the ranking on prepared format by reading each driving force. The perceptions of the illiterate farmers filled with the support of the researcher and his assistant for reading each driving force. Hence, the ranking results collected from all participants were calculated using the median value. As the average (mean) can be significantly influenced by the values in the direct ranking and hence, decide to rank the driving forces based on median values. When the median value is similar for two or more driving forces, a five-scale Likert was established, ranging from 1 to 5 as follows: very low impact (i), low impact (ii), medium impact (iii), high impact (iv), and very high impact (v). However, the majorities of the DFs selected across watersheds were similar as well as the ranking results for the top-ranked DFs were also similar (Table 1) across all three watersheds. Then, it was decided to merge the ranking results of the three watersheds into overall ranking for the study areas.

Controllability analysis

Controllability analysis was conducted on the level of intervention at the state, region and local level. State represents the federal government while region represents from zone to region, and local means from district to watershed level. To understand the controllability of the key driving forces, all participant farmers had focus group discussions. Literate farmers and experts filled their perceptions on prepared format by reading, while the perceptions of the illiterate farmers were filled with the support of the researcher and his assistant after reading each driving forces for them.

At each watershed, the top-ranked driving forces were evaluated by each participant individually regarding how the different government levels (federal, regional, local) were intervening concerning the driving forces. Hence, as the focus of this study on local level, the DFs which can be intervened by individual, community, kebele and district levels are considered. Deforestation, multiplicity of benefits from beekeeping, technical support, and farmers' awareness are more controllable DFs, while climate variability, access to credit, and demand for honeybee products are less controllable DFs at local level.

Cross-impact analysis and interpretations

Cross-impact analysis (CIA) is a method to analyze the relationship or interaction effects of driving forces and thereby to identify the critical driving forces that are relevant to develop alternative and plausible scenarios (Vester 2002 as cited by Cole 2006). The CIA was conducted with the rates provided using the ordinal three scale ratings from 0 to 3, with hypothetical values assigned as: *0=if there is no influence*, *1= if there is limited influence, 2=if the influence is moderate* and *3=if there is strong influence*. The procedure followed with due consideration of the impact of each driving force in the left-hand row ("Active Sum", AS) against each driving force in the right-hand column ("Passive Sum", PS). Thus, AS indicates how strong that driving force affects other driving forces while the PS shows how strongly that factor is influenced by other driving forces.

Indeed, the CIA was done by district experts, scenario team and beekeeping researchers, but not done by farmers as the cross-impact matrix with three scale levels was difficult and complex to be understood by farmers. To understand the CIA of driving forces the participants had focus group discussions and then they filled their perceptions on the prepared format. Finally, the CIA results collected from the participants were calculated into active sum and passive sum mean values for each DF.

Then, the top-ranked driving forces were used to analyze their relationship or interaction effects between driving forces. But, the majority of driving forces used for CIA and the results of the CIA were almost similar across watersheds. Therefore, as done for ranking and controllability, the weighted mean of the active sum and passive sum of the three watersheds was calculated for the overall study areas (Table 2).

Typology of driving forces

The active sum and passive sum mean values from Table 2 were used to determine the factional character of the selected driving forces. The Absolute Numerical Difference (AND) = AS-PS was used to decide borderline cases while Quotient score = A/P and Multiplier score = A*P helped to understand the driving force's role in the system (Table 3). Technical support, land use change, access to credit, climate variability, farmers' awareness, and agrochemicals (a chemical used in agriculture including pesticides, fungicides, and herbicides) use are active (impacting) driving forces (Table 3). These driving forces are responsible for changes in beekeeping system with more influence on other driving forces. While, multiplicity of benefits from beekeeping, honeybee pests and predators, beekeeping technology, and demand for honeybee products are passive (more influenced) driving forces. Watershed development, deforestation and government emphasis for beekeeping development are critical driving forces. These driving forces are linked to other driving forces and have to be kept in focus. Farmers' cooperatives and water availability are buffer driving forces. These driving forces are hardly linked with other driving forces and can be considered rather isolated.

Scenario generation

In order to develop plausible and contrasting scenarios, a consistency analysis was applied in such a way that optional future development pathways of each driving force was checked pair-wise with all other driving forces optional future development pathways by applying a scale from -2 (totally inconsistent [are not compatible mutually]), -1 (partially inconsistent [are not compatible unilaterally]), 0 (neutral or independent [do not influence each other]), +1 (consistent [unilaterally reinforce each other]), +2 (strongly consistent [mutually reinforce each other]). Then, the driving forces that are active or critical as well as relevant and controllable at local level were selected for consistency analysis (Table 4). Due to complexity, the consistency analysis was done by the researcher and presented to experts to check for consistency. Finally, the storylines were developed using compatible driving forces.

Scenario transfer

The scenarios were presented to stakeholders in final workshops held in Feb 8, 2014. Accordingly, context-specific feedbacks were incorporated into the scenarios. Finally, the participants were asked to select the preferred scenario, and then to develop the local adaptation measures to transform the current beekeeping practices into rewarding scenario.

Table 1. Ranked driving forces

Driving forces	Wujraba	Godinge	Mezega	Overall*	Rank
Deforestation	4	3	3	3	1
Agrochemicals use	2	7	12	6	2
Multiplicity of benefits from beekeeping	4.5	5.5	6	6	3
Land use change	7	4.5	4	6	4
Technical support	6	7.5	6	7	5
Beekeeping technology	9.5	7.5	6	8	6
Farmers' awareness	8.5	9.5	4	8	7
Watershed development	8	9	8	8	8
Water availability	10	6	8	8	9
Government emphasis for beekeeping development	7.5	8	11	9	10
Honeybee pests and predators	10	11.5	8	10	11
Demand for honeybee products	9.5	13.5	12	12	12
Access to credit	11	13	11	12	13
Climate variability	12	14	10	12	14
Farmers' cooperatives	16	10.5	12	13	15
Adulteration	14	13.5	14	14	16
Access to market	15.5	16.5	14	15	17
Stakeholders support & integration	14	16	16	16	18
Access to transport	17.5	14.5	15	16	19

Note: * Weighted median

Table 2. The active sum and passive sum mean values of driving forces

Driving forces	Wujraba		Godinge		Mezega		Overall*	
	AS	PS	AS	PS	AS	PS	AS	PS
Farmers' awareness	24.10	21.70	22.8	20.8	22.1	18.9	23.00	20.47
Deforestation	19.90	19.80	19.7	17.6	22.21	19.71	20.60	19.04
Watershed development	20.40	20.10	19.1	18.4	20.1	21.7	19.87	20.07
Government emphasis for beekeeping development	25.60	23.60	24.79	23.21	25.1	23.1	25.16	23.30
Technical support	26.36	23.71	25.1	20.9	26.1	20.6	25.85	21.74
Water availability	14.60	17.90	13.6	16	18.7	18.2	15.63	17.37
Honeybee pests and predators	14.90	15.70	14.6	17.4	8.93	18.9	12.81	17.33
Demand for honeybee products	18.00	22.90	-	-	-	-	18.00	22.90
Beekeeping technology	20.60	24.40	19.1	25.4	21.1	24.8	20.27	24.87
Multiplicity of benefits from beekeeping	20.60	24.20	20.2	25.2	21.4	26.3	20.73	25.23
Land use change	23.10	19.10	21.6	12.8	18.8	19.7	21.17	17.20
Agrochemicals use	15.90	10.90	9.71	10.7	-	-	12.81	10.80
Farmers' cooperatives	-	-	12.6	14.6	-	-	12.6	14.6
Access to credit	-	-	-	-	13.6	9.71	13.6	9.71
Climate variability	-	-	-	-	22.9	19.4	22.9	19.4

Note: * Weighted mean

Table 3. Influence indices used to determine functional character of the driving forces

Driving forces	Active sum (AS)	Passive sum (PS)	AND* (AS-PS)	Quotient score (AS/PS)	Multiplier score (AS*PS)	Typology
Demand for honeybee products	18	22.9	4.9	0.79	412.2	Passive
Beekeeping technology	20.27	24.87	4.6	0.82	504.11	Passive
Honeybee pests and predators	12.81	17.33	4.52	0.74	222	Passive
Multiplicity of benefits from beekeeping	20.73	25.23	4.5	0.82	523.02	Passive
Farmers' cooperatives	12.6	14.6	2	0.86	183.96	Buffer
Water availability	15.63	17.37	1.74	0.9	271.49	Buffer
Watershed development	19.87	20.07	0.2	0.99	398.79	Critical
Deforestation	20.6	19.04	1.56	1.08	392.22	Critical
Government emphasis on beekeeping development	25.16	23.3	1.86	1.08	586.23	Critical
Agrochemicals use	12.81	10.8	2.01	1.19	138.35	Active
Farmers' awareness	23	20.47	2.53	1.12	470.81	Active
Climate variability	22.9	19.4	3.5	1.18	444.26	Active
Access to credit	13.6	9.71	3.89	1.4	132.06	Active
Land use change	21.17	17.2	3.97	1.23	364.12	Active
Technical support	25.85	21.74	4.11	1.19	561.98	Active

Note: * AND = Absolute Numeric Difference; AS*PS<300 as buffering, >400 as critical; AS/PS<0.8 as passive and >1.1 as active

Table 4. Consistency analysis for the selected driving forces

Driving forces (DFs)	Projections	DF	DF1			DF2			DF3			DF4			DF5			DF6		
		Projections	Integrated	Moderate	Fragmented	High	Moderate	Low	Increase	Moderate	Decrease	Strengthened	Moderate	Overlooked	Efficient	Moderate	Inefficient	High	Moderate	Low
		No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
DF1=Watershed development	Integrated	1																		
	Moderate	2																		
	Fragmented	3																		
DF2 = Deforestation	High	4	-1	-1	+1															
	Moderate	5	-1	+1	-1															
	Low	6	+1	-1	-1															
DF3 = Agrochemicals use	Increase	7	0	0	0	0	0	0												
	Moderate	8	0	0	0	0	0	0												
	Decrease	9	0	0	0	0	0	0												
DF4 = Government emphasis on beekeeping development	Strengthened	10	+1	-1	-1	-1	-1	+1	-1	-1	+2									
	Moderate	11	-1	+1	-1	-1	+1	-1	+1	+2	-1									
	Overlooked	12	-1	-1	+1	+1	-1	-1	+2	-1	-1									
DF5 = Technical support	Efficient	13	+1	-1	-1	-1	-1	+1	-1	-1	+2	+2	-1	-2						
	Moderate	14	-1	+1	-1	-1	+1	-1	+1	+2	-1	-1	+2	-1						
	Inefficient	15	-1	-1	+1	+1	-1	-1	+2	-1	-1	-2	-1	+2						
DF6 = Farmers' awareness	High	16	+2	-2	-2	-1	-1	+1	-1	-1	+2	+2	-1	-2	+2	-1	-1			
	Moderate	17	-1	+2	-1	-1	+1	-1	+1	+2	-1	-1	+1	-2	-1	+1	-1			
	Low	18	-2	-2	+2	+1	-1	-1	+2	-1	-1	-1	-1	+2	-1	-1	+2			

RESULTS AND DISCUSSION

Scenario storylines

Scenario I: Repressive

In this scenario, the support of local government for beekeeping has been overlooked. This has made the technical support and advice inefficient. The district livestock development office has not strengthened in terms of human power and budget. As a result, the beekeeping extension workers have not undergone refresher training in improved honeybee colony management practices and also highly involved in non-beekeeping development activities. Subsequently, farmers have not received up-to-date knowledge and skill from beekeeping extension workers. Farmers have also gotten difficulties in accessing credit, market and beekeeping technology. The coordination among stakeholders such as the local government, research centers, universities, and NGOs has been very weak. There has been no effort to encourage the public-private partnership investments in the beekeeping sector development. These have compromised the farmers' opportunities to have access to and use of beekeeping technology, and to improve honeybee colony management practices.

The availability of honeybee floral resources has decreased in this scenario, because there has been no integration of beekeeping with watershed development by stakeholders. There has been no effort of afforestation practices in the hillside that could provide nectar and pollen sources for honeybees. Deforestation rate has been high due to cutting of shrubs and trees for fuelwood and timber production. There has no use of improved stoves to reduce the wood needed for fuel. Important shrubs and herbs for honeybee floral resources have also disappeared due to the conversion of communal lands into crop production and settlements (Table 5).

In this scenario, the regional policymakers have not developed the enforcement guidelines regarding use of agrochemicals. Then, the use of the agrochemical has increased due to greater emphasis on crop production. The indiscriminate application of various agrochemicals has directly affected the health of honeybees and indirectly the availability of honeybee flora resources. Farmers' knowledge and skill of improved honeybee colony management practices have been low. As a result, there has been no prevention and/or control practice by beekeepers for honeybee pests and predators.

Thus, in this scenario the honeybee colony holding per household (HH) and population have decreased in 2025. The majority of farmers have not been keeping honeybees for livelihoods improvement. However, very few farmers have continued traditional beekeeping. Hence, beekeeping has eventually at risk with very unlikely options to contribute for livelihoods and food security of the majority of farmers. Honeybees have not also contributed to pollination work in different ecosystems.

Scenario II: Beekeeping advance

In this scenario, the support of local government for beekeeping has been improved. This has happened after the national government has prioritized for beekeeping sector development in the Growth Transformation Plan-II (GTP-II). Then, the regional government has taken initiatives in 2015 to transform the beekeeping sector. Thus, the support for beekeeping sector development has enabled beekeepers to have access to technical support and advice, credit, market and beekeeping technology. The beekeeping extension system has strengthened in terms of human power and budget; this, in turn, has encouraged the beekeeping extension workers to do more on the beekeeping technology transfer that could benefit beekeepers. There have been efforts to encourage the public-private partnership investments in the beekeeping sector development.

In this scenario, NGOs support has mobilized to supplement the local government in strengthening farmers' cooperatives/organizations through buying expensive beekeeping equipment such as honey extractor and casting mold and marketing. Moreover, the local government has continued its strong integration with research centers and universities. This integration has enabled farmers to have access to and use of improved beekeeping technology, and to improve honeybee colony management practices.

The availability of honeybee floral resources has increased due to the integration of beekeeping with watershed development and low deforestation rate. The local government and NGOs have made strong efforts to mobilize farmers to restore degraded lands. The involvement of farmers has promoted forest regeneration and conservation and has improved rural livelihoods through integrating with beekeeping. In this scenario, deforestation rate has been low. This is because; the local government and NGOs have been supporting farmers to use improved stoves. The use of improved stoves has reduced the amount of wood harvested for fuel. Farmers have also planted more *Eucalyptus* spp. around homestead for multipurpose uses; this has increased the availability of honeybee flora resources.

In this scenario, the regional policymakers have developed the enforcement guidelines regarding use of agrochemicals to improve crop yields. Accordingly, the local government has taken the initiatives to implement the legislation on the use and applications of agrochemicals through provision of training and awareness creation for farmers. On the other hand, awareness creation has resulted in no use of agrochemicals to destroy weeds from pasture lands and crop aftermath. As a result, the direct effects of agrochemicals on honeybees' health and indirectly on the availability of honeybee floral resources have minimized. Farmers' knowledge and skill of honeybee colony management practices have increased due to their indigenous knowledge and technical support; as a result, the beekeepers' prevention and/or control practices of honeybee pests and predators have been increased.

Table 5. Honeybee floral resources that have disappeared due to conversion of communal lands into crop production and settlements

Vernacular name	Botanical name	Nature of plant	Flowering season
Girar	*Acacia* spp.	Tree	Mar-Sep
Warka	*Ficus vasta*	Tree	Oct-Dec
Kosso	*Hagenia abyssinica*	Tree	Oct-Nov
Grawa	*Vernonia amygdalina*	Shrub	Dec-Feb
Agam	*Carissa edulis*	Shrub	May-Jun
Mech	*Guizotia scabra*	Herb	Aug-Sep
Maget	*Trifolium* spp.	Herb	Jul-Oct
Adey abeba	*Bidens macroptera*	Herb	Sep-Oct

Thus, in this scenario the honeybee colony holding per HH and population have increased. The uses of movable-frame and top-bar hives have increased. As a result, beekeeping has high contribution for livelihoods and food security of the majority of farmers. Moreover, landless rural households and youths have engaged more in beekeeping to improve their livelihoods. Honeybees have also significantly contributed to pollination work in different ecosystems.

Scenario III: Beekeeping on the margins

In this scenario, the support of local government for beekeeping has been inadequate. This, in turn, has affected farmers due to moderate access for technical support and advice, insufficient credit services, low market access, and less access to beekeeping technology. The beekeeping extension system has not been strengthened in terms of budget. As a result, the beekeeping extension workers have rarely undergone refresher training in improved honeybee colony management practices. Subsequently, farmers have received less up-to-date knowledge and skill from beekeeping extension workers. The coordination among stakeholders such as the local government, research centers, universities, and NGOs has been weak. There have been little efforts to encourage the public-private partnership investments in the beekeeping sector development. These have compromised the farmers' opportunities to have access to and use of beekeeping technology and to improve honeybee colony management practices.

The availability of honeybee floral resources has decreased due to the moderate integration of beekeeping with watershed development and moderate deforestation rate. However, NGOs have made efforts to mobilize farmers to restore degraded lands. The use of improved stoves has been less and has not reduced the amount of wood harvested for fuel. However, farmers have planted *Eucalyptus spp*. around homestead for multipurpose uses; in turn, the honeybees mainly depend on this tree species.

In this scenario, the regional policymakers have not developed the enforcement guidelines regarding use of agrochemicals. The crop farming has not been integrated with beekeeping; as a result, the use of agrochemicals has increased. The agrochemicals have directly affected the health of honeybees and indirectly the availability of honeybee floral resources. Farmers' knowledge and skill of improved beekeeping husbandry have been moderate. As a result, the beekeepers' prevention and/or control practices of honeybee pests and predators have not been increased.

Therefore, in this scenario the honeybee colony holding per HH and population have decreased in 2025. The beekeeping system is mainly based on uses of traditional hives with some model farmers using movable-frame hive. Thus, only few farmers have tried to continue beekeeping mainly based on their own knowledge and experience. As a result, beekeeping has low contribution for livelihoods and food security of the majority of farmers. Honeybees have also less contributed to pollination work in different ecosystems.

Scenarios plausibility and local adaptation measures

In the scenario transfer workshop, participants considered the three scenarios as plausible. Then, the participants have selected the ‘‘repressive" scenario as the worst, the ‘‘beekeeping advance" scenario as the best, and the ‘‘beekeeping on the margins" scenario as the business as usual. Following, they suggested the intervention strategies to transform the current beekeeping into ‘‘beekeeping advance" scenario. Thus, the suggested intervention strategies are presented below:

Improving the honeybee floral resources

The following are the major strategies that can be applied to improve honeybee floral resources: Multiplications and distribution of honeybee forage to beekeepers (i), Encouraging the community to plant and conserve multipurpose forage around home yard, farm boundaries and enclosed areas (ii). Integrating beekeeping with vegetable and fruits production (iii). Integrating scale-irrigation development with planting and multiplication of improved honeybee forage (iv). Awareness creation of farmers not to spray agrochemicals on crop aftermath and pasture lands (v).

Capacity building to beekeeping extension workers and beekeepers

It includes the importance of up-to-date and tailor-made training regarding improved honeybee colony management practices and beekeeping technology use to district beekeeping extension workers and livestock development agents. The training can be delivered by regional and zone beekeeping extension officers, researchers, academic staff from universities and other development partners. Then, the district beekeeping extension workers and livestock development agents provide on-farm training and demonstration to beekeeper farmers. The livestock development agents play a significant role in the continuous technical support to beekeeper farmers because they are assigned to work at kebele level.

Establishing and strengthening beekeepers’ cooperatives

It includes the establishment of new beekeepers' cooperatives and group marketing and strengthening the existing once. These are vital in handling and processing honeybee products such as honey and beeswax and in establishing sustainable linkages with the honey and beeswax processors in big cities.

Advance thinking about honeybees and beekeeping

At all levels (farmers, extension workers, local and regional government administrators, policy and decision makers) the thinking is that beekeeping is for honey and beeswax among others. But the role of honeybees for crop pollination is rarely considered. In this aspect, it is worthwhile to change the general ‘‘mindset" of stakeholders about honeybees, and to raise awareness about the importance of honeybees for crop pollination. Otherwise, the increased use of agrochemicals to improve crop yield endangers the life of honeybees.

Equip the working facilities for development agents

This includes equipping the hives, protective clothes and other beekeeping accessories for development agents at kebele level.

Honeybee colony multiplication

The honeybee colony multiplication could be done through splitting and grafting techniques using movable-frame and top-bar hives. To do so, livestock development agents could provide training and on-farm demonstration for farmers.

Increase access to credit

This could be achieved by changing the lending requirements as well as increasing the loan size. So that farmers can acquire the inputs needed for improved beekeeping.

Strengthen coordination among stakeholders

This could be through establishing effective local multi-stakeholder platforms to provide appropriate support to farmers. In this regard, the local government is responsible to provide appropriate guidance. Such coordination need not be on ad hoc basis and should be rather dynamics, revitalized, strengthened and nurtured in a way it can play more roles in focused beekeeping development interventions at local level.

Discussion

Driving forces of change

Nineteen driving forces were identified for the three watersheds system-wide analysis. Each driving force working alone and/ or in synergy with other driving forces has driven changes in beekeeping system. Studies reveal that various driving forces have the potential to drive changes in beekeeping at global, regional and local levels, for instance, habitat loss and fragmentation, pathologies, invasive species, pollution, and agricultural intensification (Shepherd et al. 2003; UNEP 2010). According to these authors, these driving forces are threats to beekeeping. On the contrary, the demand for honey and beeswax also increased in the developed countries (CIAFS 2012). This considered as opportunities for beekeepers.

After going through the ranking, controllability, and cross-impact analysis, 6 key driving forces were selected to develop plausible and contrasting future scenarios. The driving forces include watershed development, deforestation, agrochemicals use, government emphasis on beekeeping development, technical support, and farmers' awareness. These driving forces are attributes for changes in beekeeping which are most relevant at the present and cause changes in the system state over time. Thus, the participatory scenario exercise resulted in three plausible and contrasting scenarios called ‘‘repressive’’, ‘‘beekeeping advance’’ and ‘‘beekeeping on the margins’’.

Comparison of scenarios

In Table 6, the main differences between the scenarios compared according to the selected themes.

Table 6. Beekeeping scenarios contrast

Features	Scenarios		
	Repressive	**Beekeeping advance**	**Beekeeping on the margins**
Beekeeping importance	Beekeeping has very little importance to the livelihoods of farmers	Beekeeping has very high importance to the livelihoods of farmers; use of top-bar and movable-frame hives increases	Subsistence beekeeping based on use of traditional hives
Beekeeping technology use	Very low	High	Low
Honeybee flora availability	Decrease	Increase	Decrease
Honeybee colony losses	Very high	Low	High
Productivity	Very low	High	Low
Production orientation	Subsistence, without profit potential	Market-oriented, with high-profit potential	Subsistence, with some profit potential
Collective action (e.g., farmers groups) to support farmers	No	Strong	Weak
Crop-beekeeping-watershed development integration	Not good	Good	Moderate
Sustainability	Very low	High	Low
Role of actors	Local government neglects the beekeeping sector; no efforts by the national and regional governments for beekeeping investment; very little private sector and NGOs role; very weak linkage among stakeholders	Local government gives greater emphasis to improve the beekeeping sector; strong efforts by the national and regional governments for beekeeping investment; very good private sector and NGOs role; very strong linkage among stakeholders	Local government gives little efforts to improve the beekeeping sector; moderate efforts by the national and regional governments for beekeeping investment; little private sector and NGOs role; weak linkage among stakeholders

Implications of the future of beekeeping scenarios for farmers' livelihoods

From principle functions of beekeeping by livelihood strategy, the findings show that the three scenarios correspond with the typology of (Dorward 2009; Tittonell 2014), viz. ''Stepping up'', ''Hanging in'' and ''Stepping out''. Hence, the beekeeping system significantly contributes to the livelihoods of farmers to 2025 under ''beekeeping advance'' scenario. This scenario can be represented by ''Stepping up'' livelihood strategy, where the integration with crop production and watershed development and support schemes are made to improve the current beekeeping activities. While the ''beekeeping on the margins'' scenario follows the ''Hanging in'' livelihood strategy, where the beekeeping system has low contribution (subsistence) to the livelihoods of farmers.

The beekeeping is in a system of involution in ''repressive" scenario and has very low contribution to the livelihoods of farmers and this scenario follows the ''Stepping out" livelihood strategy. Hence, any collapse in the services would be detrimental effects to the livelihoods of smallholder farmers in the study areas, who also depend mainly on crop and livestock production for food security. For instance, beans, peas, soya beans, tomatoes, avocado, and mango are the important crops and these crops need honeybees for pollination services. This means that without honeybees, there would be a significant shortage of grains, vegetables, and fruits because of the lack of pollination services by honeybees. Study also reveals that the decline in honeybee population has a significant threat to food production in many parts of the world (Potts et al. 2010; Bianco et al. 2014). This is because of the strong dependence of a large of crop production on pollination by honeybees (Shepherd et al. 2003; Bradbear 2009.). Similarly, an important improved forage for livestock called alfalfa needs honeybees for pollination services. This means that without honeybees, the use of improved forage such as alfalfa would be difficult. Studies in other parts Ethiopia emphasize that the direct and indirect role of beekeeping for smallholder farmers as well as the country (Woldewahid et al. 2012; Gemeda 2014). Hence, the key message is that when honeybees flourish, farmers' livelihoods will improve.

In conclusion, the driving forces identified for changes in beekeeping are diverse and the analysis has shown that the driving forces are highly interrelated. The participatory scenario exercise resulted in three plausible and contrasting scenarios called ''repressive", ''beekeeping advance" and ''beekeeping on the margins". This study shows that beekeeping significantly contributes to the livelihoods of farmers to 2025 under ''beekeeping advance" scenario. In the ''beekeeping on the margins" scenario, beekeeping has low contribution to the livelihoods of farmers. But the beekeeping is in a system of involution in ''repressive" scenario and has very low contribution to the livelihoods of farmers. This study revealed that the participation of stakeholders in the participatory scenario planning process provides knowledge relevant for investigating the future scenarios of beekeeping and planning for local adaptation measures to ecological, technological, social, economic and political changes. Although the focus of this study was to show local scope of action, the study participants also highlighted that the regional, as well as national governments, still have a relevant role to play, e.g., to support the access to production-enhancing input (including services) and output markets by considering the availability of the resources during planning.

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