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Assessment of the Current Status, Utilization, Income Contribution and Marketing Constraints of Cactus Pear (*Opuntia* Spp.) in Bale Zone, South-Eastern, Ethiopia

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ABSTRACT

The cactus plant (Beles) grows profusely in Ethiopia and has adapted perfectly to the arid zones of the country characterized by droughty conditions, erratic rainfall, and poor soils subject to erosion. Cactus can be used for several purposes like sources of food, feed, as wind break, fence for crop and soil conservation for the people of the area. Although it is an important fruit and forage plant, there is no clear cut information about its current status, utilization, income contribution and marketing constraints in Bale Zone, South Eastern Ethiopia. To this end, the objective of this research was to assess the Current status, utilization, income contribution and marketing constraints of Cactus pear (Opuntia spp.) in selected districts of Bale Zone. In this study, three districts, namely, Sinana, Agarfa and Gasera were purposively selected based on their potential in cactus production and utilization. In addition, two kebeles from each district were selected purposefully based on their potential in cactus production. A total of 400 Cactus Grower and Non grower Households were selected to achieve the objectives of the study. Both qualitative and quantitative types of data were collected from sampled households. The quantitative type of data gathered from the respondents was analyzed using SPSS 20 versions whereas the data generated from group discussion and key informant interview were narrated and interpreted in the form of word. The descriptive result of the study indicated that Cactus feeding management includes the practices of cutting, scrubbing and chopping of young cladodes from branches of the stand for their animals and grazing. Regarding Cactus utilization in the study districts, farmers uses cactus pear for consumption (18.4%), live fence for crop field (13.7%), soil conservation (13.2%), and backyard live fence, (10.8%), for food security motive (9.9%), for forage (9.4%) and for wind break (8.5%) in the entire cactus growing areas of the study districts. Despite the fact that the vast majority of the respondents which accounts 61.3. % of the cactus growers reports they get unreasonable price from the sale of cactus due to lack access to potential market and low quality Cactus production, they obtained an average of 1007.9 Ethiopian Birr per annum. The study revealed that the income obtained from Cactus production was benefited 30.7% of farmers to cover their domestic consumables and purchase closes for their children. Also about 15.6% and 11.3% of the respondents were used the income obtained from the sale of cactus to cover costs of sending children to school and purchase improved crop varieties respectively. Regarding marketing constraints, the farmers indicated that Absence of Transportation facilities (20.3%), absence of market place (12.3%), low bargaining power (15.1%), perishability problem (17%), fluctuation of market price (9.4%) and availability of illegal brokers (14.2%) are the major problems they faces while selling their produce to the market. Regarding the income share of cactus grower and non grower Households it was found that the annual average income earned by cactus owner households were 13,910.6 birr whereas 12,371.3 birr for non cactus grower households with maximum earnings of up to Birr 30, 900 for non cactus grower and 35,960 for cactus grower households. Econometric result also reveals that the "average treatment effect on the treated" (ATT) for household income suggested, due to pure effect of cactus, the cactus owners obtain 1433.2049 birr of total income higher than non-owners; among which the mean difference of income between these two group is statistically significant at 5% probability level after matching. Considering the above mentioned fact, local government and other development partners should improve Access to market for cactus fruit so that farmers can get the best benefits from the cultivation of the crop.

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1. Introduction

Cactus Pear (Opuntia ficus- indica) was originated from central and southern Mexico. As cactus pear is a native to Mexico, the ancient Mexicans develop cactus from a wild plant, a source of fruit and tender cladodes, in to a semi domesticated resource for the family gardens to secure home consumption. Then urbanization pushed farmers to develop cactus pear in to a formal crop in less than six decades, adaptable to different environments and production system. (Flores *et al*., 1995).

Cactus Pear was introduced to Ethiopia between 1848 and 1920 (Neumann, 1997; Habtu, 2005). The plant is widely distributed in the arid and semi-arid regions of the country; especially in eastern and southern zones of Tigray Region of Ethiopia. According to Fesseha (2009), cactus was introduced to Tigray and broadly distributed in eastern and southern part of the region about 160 years ago. Over the last few decades interest in cactus pear as food and feed has increased due to its drought resistance, high biomass yield, high palatability and tolerance to salinity (Ben Salem *et al*., 1996). Stintzing and Carle (2005), described cactus pear as a miracle plant, dromedary of the vegetation world, and the bank of life as it can contribute to livelihoods of rural populations in dry areas. Cultivation of the plant may assume greater agricultural importance in dry areas since a larger part of the land is destined to become arid or semi-arid due to climate change (Snyman, 2006).

Cactus pear (*Opuntia ficus-indica*), locally known by the vernacular name "Beles" in Tigray Region and "Shoka" in Bale Zone" (study area) is in the genus *Opuntia* of the family Cactaceae (Nobel, 2002). Cactus pear and other plants in the family are of new world origin and are found in Africa and other parts of the world outside of Latin America. Spread to areas outside of its area of origin should have been aided by humans and partly by birds. Cactus pear has the ability to grow on marginal lands (Le Houerou and Corra, 1980) and hence its cultivation is likely to increase in the face of climate change. Cactus/"Beles'' is mainly used as fresh fruit in human consumption and the cladodes as animal fodder (Nefzaoui *et al*., 2010).

The importance of cactus is rising from time to time. Past research findings have indicated that cactus pear has become an integral part of the culture and economy of Northern Ethiopia, serving as a source of seasonal household food, income and employment, as livestock feed and other environmental benefits (Fitsum, 1997; Mitiku *et al*., 2002). Cactus is also playing an ever-increasing role in animal nutrition, especially since 1960s, when it served as the standing feed resource to enable animals survive critical periods of prolonged drought and dry seasons (Birhane, 1997).

Cactus pear has become the dominant plant in many part of Bale Zone. Despite being an alien plant, it is accepted now as an integral part of people's environment and source of income for the many households. However, there is hardly any information on the Status, utilization, income contribution and marketing constraints of Cactus Pear in Bale Zone in general and study districts in particular. Therefore, the overall objective of this study was to assess the Status, utilization, income contribution and marketing constraints of Cactus Pear in selected districts of Bale Zone. Consequently, the result of this research would be expected to fill a research gap on Cactus pear utilization in Bale Zone.

2. Methodology

2.1. Description of the Study Areas

Sinana district was located in the northern western part of Bale zone. It is bounded with Goro and Ginir in East, Dinsho in West, Agarfa and Gasera in North and Goba and Barbare district in the south. The total area of the district is about 163554 hectare which ranked as the third smallest district in Bale Zone. The lowest and highest altitude of the district is extended from 1500 to 2300m above sea level respectively. The annual average temperature is 21.5^{o}c whereas the minimum and maximum temperature is 18^{o}c and 25^{o}c respectively. The annual average rainfall is 1105mm whereas the minimum and maximum rainfall is 1060 and 1150mm respectively. (Source: Sinana district Agriculture and Rural Development office, 2014)

Agarfa Districts falls between Latitude 7^{0}17'N and Longitude 39^{0} 49'E. It found in the extreme North Western Corner of the zone, Agarfa District bounded by Shirka district of Arsi zone in the North, West Arsi zone in south West, Dinsho in south, Sinana in south East and Gasera in North East. The total area of the district is 1258km^{2} (125,800ha) which ranked the district 15th largest districts among the zonal district. The elevation of this portion of the district ranges between 2300m-2700m above sea level. The annual average temperature of the district is about 17.5 ^{o}c. In the lowland areas around Wabe Shebelle River the temperature is hot which reaches up to 25^{o}c.

Gasera district is one of the administrative territory of Bale zones which located 07^{0}22'293''North and 040^{0}11'535''East also bounder is at the North West Part of the zone. The district is bounded Agarfa by East, Sinana by north, and Ginir by southwest, Gololcha district by East and Arsi district by south. Gasera district total area is 1114 km^{2}covered from the Bale Zone.

2.2. Study Design

For the successful accomplishment of the study in three Districts, Cross-Sectional Research Design was implemented. A Onetime snapshoot of data were collected from target farmers.

2.3. Sampling technique

From 18 Districts of Bale Zone, three districts, namely, Sinana, Agarfa and Gasera were selected purposively for data collection based on their potential in cactus production and utilization. In addition to this, two kebeles from each district, namely, Hamida and Ilu sambitu, Dambal and illu Kerisha, Hambentu and Amanlama from Sinana, Gasara and Agarfa district respectively were purposefully selected based on their potential in cactus production. The total number of Households included in the study was determined by the data obtained from the Kebele administration office. This was assisted the researchers in developing the sampling frame by the help of development agents. Based on the sampling frame, household heads in sampled kebele were stratified into cactus-owners and non- owners. Hence, cactus-owners (212) and non- owners (188) were systematically drawn from each kebeles of the two stratums based on their respective number using proportional to population size technique. Finally a total of 400 Households were selected from six sampled kebeles to achieve the objectives of the study.

2.4. Sample size determination techniques

It is not feasible to study the entire population due to cost or time issues. Besides cost and time issues, it was not ethical to study the entire population if accurate enough results could be obtained by studying a subgroup of all people (Sarantakos, 1998).

For these reasons, 400 Households were selected so as to accomplish the study successfully by using the formula devised by Sarantakos (1998).

Table 1. Distribution of sampled HHs and peasant associations across sampled districts.

No	Districts	Total Household size	Sampled Household	Total PA	Sampled PA
1.	Agarfa	21452	127	19	2
2.	Gasera	17657	104	21	2
3.	Sinana	28520	169	20	2
Total		67629	400	60	6

$$n = \frac{N}{1+N(e)^2}$$

n = indicates sampling units, N = indicates total household, e = indicates the error which we can tolerate (which is, 0.05 in our case). The total household sizes in three study districts are 67629

Then, $n = \frac{67629}{1+67629\ (0.05)^2} \approx 400$ Households

2.5. Data Collection Methods

Both primary and secondary data were used for this study. Primary data related to personal, socioeconomic, institutional variables and other relevant variables were collected. Secondary information from published and unpublished documents was gathered to supplement primary data. Primary data were collected using quantitative approach by means of household survey. To have detail information about Cactus pear production in selected districts and drawing the right conclusions from the survey work, qualitative information were gathered from cactus owners and non-owner households. Collection of primary information were held using semi-structured interview schedule and managed through holding discussion with focused groups and key informant interviews using check list.

2.6. Data Analysis

The quantitative type of data gathered from the respondents was analyzed using the latest software version of SPSS 20. Appropriate techniques and procedures were used in the analysis of the status and utilization of cactus pear. Descriptive statistics like mean, standard deviation and percentage were used to provide a summary statistics related to variables of interest. Chi-square was used to identify variables that vary significantly across cactus owners and Non-Cactus Owner's categories. The data generated from group discussion and key informant interview were narrated and interpreted in the form of word.

3. Result and Discussion

3.1. Current status of Cactus pear

3.1.1. Collection methods, collection time and feeding systems of cactus

About 76.9% percent of the respondents in the study area allowed their animals to graze cactus in the wild and around their farm lands, while 23.1 % practiced cut and carry system of feeding their animals. On the other hand, 75.3%, 86.4% and 69.6% of the Households in Sinana, Agarfa and Gasera districts respectively allowed their animals to graze in the wild, whereas only 24.7%, 13.6% and 30.4% from the respective districts used the cut and carry system of feeding (Table 3). The feeding management in the study was cutting, scrubbing and chopping of young cladodes from branches of the stand for their animals and grazing.

Table 2. Distribution of sampled HHs across sampled kebeles.

No	Name of kebeles	Total number of HH	Sampled HH	Owner	Sampled owner	Non owner	Sampled non owner
1.	Illu sambitu	1445	113	665	52	780	61
2.	Hamida	712	56	572	45	140	11
3.	Amalama	630	45	617	44	13	1
4.	Ambentu	1130	82	207	15	923	67
5.	Denbel	515	46	200	18	315	28
6.	Ilu Kerisha	653	58	425	38	228	20
	Total	5085	400	2686	212	2399	188

Table 3. Collection methods, collection time and feeding systems of cactus cladodes in the three study districts.

Method used to feed cactus for livestock		district of the Household			Total	Pearson Chi- square
		Sinana	Agarfa	Gasera		
cut& carry	N	24	8	17	49	
	%	24.7	13.6	30.4	23.1	
free grazing	N	73	51	39	163	4.828836***
	%	75.3	86.4	69.6	76.9	(0.089)
Total	N	97	59	56	212	
	%	100.0	100.0	100.0	100.0	
Feeding system						
cactus alone	N	60	24	19	103	13.130876*
	%	61.9	40.7	33.9	48.6	(0.001)
mixing cactus with other feed type	N	37	35	37	109	
	%	38.1	59.3	66.1	51.4	
Total	97	59	56	212	97	
	100	100	100	100	100	
Feeding Time						
Morning	N	45	30	25	100	
	%	46.4	50.8	44.6	47.2	7.880921NS
Afternoon	N	28	13	11	52	(0.247)
	%	28.9	22.0	19.6	24.5	
Evening	N	15	10	7	32	
	%	15.5	16.9	12.5	15.1	
At any time	N	9	6	13	28	
	%	9.3	10.2	23.2	13.2	
Total	N	97	59	56	212	
	%	100	100	100	100	

Source: survey data, 2016/17

Table 4. Problem associated with cactus feeding for livestock.

Problem associated with cactus feeding for livestock		district of the Household			Total	Pearson Chi- square
		Sinana	Agarfa	Gasera		
Bloating	N	17	10	12	39	
	%	17.5	16.9	21.4	18.4	
Diarrhea	N	25	16	14	55	
	%	25.8	27.1	25	25.9	
sore mouth	N	22	14	10	46	1.37NS
	%	22.7	23.7	17.9	21.7	(0.995)
physical damage	N	20	12	11	43	
	%	20.6	20.3	19.6	20.3	
chocking of the throat	N	13	7	9	29	
	%	13.4	11.9	16.1	13.7	
Total	N	97	59	56	212	
	%	100	100	100	100	

Source: survey data, 2016/17

Table 5. Prevention practice of problem arise from cactus feeding.

Prevention practice of problem arise from cactus feeding		district of the Household			Total	Pearson Chi- square
		Sinana	Agarfa	Gasera		
restricting amount of cactus consumed	N	15	6	9	30	
	%	15.5	10.2	16.1	14.2	
feeding crop residue before & after cactus feeding	N	22	15	12	49	
	%	22.7	25.4	21.4	23.1	
wilting cladodes	N	20	13	11	44	2.52NS
	%	20.6	22.0	19.6	20.8	(0.961)
selection of Cladode	N	12	7	10	29	
	%	12.4%	11.9	17.9	13.7	
removing the spine and chopping of cladodes	N	28	18	14	60	
	%	28.9	30.5	25	28.3	
Total	N	97	59	56	212	
	%	100	100	100	100	

Source: survey data, 2016/17

Farmers in the study area had an experience of feeding cactus before or after feeding other feeds. About 48.6% of the respondents were used cactus alone and the remaining 51.4% fed it with other feeds. The former groups justified that since animals graze enough of cladodes no more additional feed was necessary and had no alternative feed better than cactus, especially during drier periods. But those that fed other feeds before or after cactus reported that cactus was not sufficient to provide important nutrients for the growth of animals so they add other forages before and after cactus feeding. The result of this study reveals that majority of the respondents which constitutes 47.2% were allowed their animals graze cactus freely within the morning time, while 24.5% responded that they feed their animal during afternoon.

3.1.3. Problems in cactus feeding and prevention practice

The extensive utilization of cactus for animal feed has negative health effects. These may range from physical injury such as blindness to death that arises due to acute diarrhea, Bloating and chocking of the throat

Problems in cactus feeding and prevention practices were assessed and the results showed that bloating, diarrhea, sore mouth, physical damage and chocking of the throat are the major problems (Table 4). Majority (25.9%) of the farmers in the study districts associated the severity of diarrhea with feeding cactus pear. The problem associated with diarrhea in feeding cactus for livestock were found to be almost similar across the three study districts which accounts 25.8%, 27.1% and 25% for Sinana, Agarfa and Gasera Districts respectively. The major cactus pear feeding problems reported from all the study areas were diarrhea followed by sore mouth and physical injuries (Table 4)

Table 5 shows prevention practices of feeding problems of cactus in the study districts.

Different prevention and practices against the feeding problems of cactus include restricting amount of cactus consumed, removing the spine and chopping of cladodes, wilting cladodes, selection of Cladode and feeding crop residue before & after cactus feeding. Among the total respondents of the study, majority (28.3%) of the Households believed that removing the spine and chopping of cladodes prevents problem associated with cactus feeding. During the survey, it was observed that only spiny type of cactus pear exists in the study areas. The second best alternatives preferred by respondents to prevent problems of cactus feeding was feeding crop residue before & after cactus feeding (23.1%).

3.1.4. Perception of farmers on animal response when fed cactus pear

Most respondents in the study districts believe that feeding cactus would result in increased milk production and growth rate of livestock (Table 5) with the response being similar among districts. Among the total respondents 48.1% of the household responded that feeding cactus can undoubtedly increase milk year whereas 36.8% of the households confirmed that feeding of cactus increases body weight gain by livestock. Conversely, about 15.1% of the respondents believe that cactus feeding results to no change in growth rate of animals. Generally, feeding cactus along with some supplemental feeds was reported to have positive effects on milk yield and body weight gain of animals.

3.1.5. Perception of farmers on the impact of cactus on natural vegetation

Cactus grower households who participated in the interview were cognizant of the impact of cactus on other vegetations (table 9). Cactus suppresses growth of field crops, while it inhibits growth of grasses at all. In other cases cactus

Table 6. Perception of respondents on animal response when they feed cactus pear.

Animal response when they feed cactus pear?		district of the Household			Total	Pearson Chi- square
		Sinana	Agarfa	Gasera		
increase milk yield	N	45	30	27	102	1.18 NS (0.880)
	%	46.4	50.8%	48.2	48.1	
increase body weight gain	N	39	20	19	78	
	%	40.2	33.9	33.9	36.8	
no change	N	13	9	10	32	
	%	13.4	15.3	17.9	15.1%	
Total	N	97	59	56	212	
	%	100	100	100	100.0%	

Source: survey data, 2016/17

Table 7. Household perception towards the impact of cactus on natural vegetation.

Cactus and its impact on natural vegetation		district of the Household			Total	Pearson chi-square
		Sinana	Agarfa	Gasera		
suppress growth	N	21	12	15	48	18.558** (0.0174)
	%	21.6	20.3	26.8	22.6	
inhibit growth	N	29	15	29	73	
	%	29.9	25.4	51.8	34.4	
occupies the space	N	31	23	8	62	
	%	32	39	14.3	29.2	
suffocate the plant	N	13	9	3	25	
	%	13.4	15.3	5.4	11.8	
Others	N	3	0	1	4	
	%	3.1	0	1.8	1.9	
Total	N	97	59	56	212	
	%	100	100	100	100	

Source: survey data, 2016/17

displaces other vegetation by taking the space. Respondents indicate that different types of vegetation used to cover the area now are under cactus. Apart from invasion by cactus, the vegetation was destroyed for various reasons including land clearing for arable land and for fuel wood. According to The result obtained from the survey 22.6% and 34.4% of the

Table 8. Household perception on ways of cactus pear in improving soil fertility.

Mechanism of soil ferity improvement		district of the Household			Total	Pearson Chi- square
		Sinana	Agarfa	Gasera		
cactus plant material decompose faster	N	26	10	13	49	4.364
	%	26.8	16.9	23.2	23.1	0.628
cactus conserve soil moisture	N	25	23	15	63	
	%	25.8	39.0	26.8	29.7	
the field is not plowed for long time	N	24	12	14	50	
	%	24.7	20.3	25	23.6	
root system	N	22	14	14	50	
	%	22.7	23.7	25	23.6	
Total	N	97	59	56	212	
	%	100	100	100	100	

Source: survey data, 2016/17

Table 9. Cactus Utilization in the three study districts.

Cactus utilization		district of the Household			Total	Chi square
		Sinana	Agarfa	Gasera		
Forage	N	11	4	5	20	19.205297NS (0.157)
	%	11.3	6.8	8.9	9.4	
fruit consumption	N	14	10	15	39	
	%	14.4	16.9	26.8	18.4	
backyard live fence	N	14	6	3	23	
	%	14.4	10.2	5.4	10.8	
live fence for crop field	N	13	10	6	29	
	%	13.4	16.9	10.7	13.7	
soil conservation	N	14	9	5	28	
	%	14.4	15.3	8.9	13.2	
for food security motive	N	11	5	5	21	
	%	11.3	8.5	8.9	9.9	
for wind break	N	12	3	3	18	
	%	12.4	5.1	5.4	8.5	
combination of all	N	8	12	14	34	
	%	8.2	20.3	25.0	16.0	
Total	N	97	59	56	212	
	%	100.0	100.0	100.0	100.0	

Source: survey data, 2016/17

respondents believes that cultivation of cactus have suppressive and inhibitive growth effect on natural vegetation whereas 29.2% of the respondents were confirmed that cactus cultivation occupies space.

3.1.6. Perception of Farmers on the Impact of Cactus on Soil Fertility

Farmer's response to the impact of cactus on soil fertility was similar across the study district. They indicated that cactus pear has a positive impact on soil fertility. This may be because the pads, roots, and fruits of cactus decompose and mineralize easily and enrich the fertility of the soil by releasing plant nutrients and improve the soil structure by increasing the organic matter contents of the soil. Among the total respondents about 29.7% of Farmers' also indicated that cactus enriches soil fertility by controlling erosion thereby conserving moisture. As shown in table 10, 56.36 % of the respondents respond that cactus enriches soil fertility through decomposition of the plant material. It is a common practice to clear cactus and utilize the land for crop production in the area. Cactus enriches soil fertility by decaying its roots and pads and mineralizing faster. In this research about 23.6% of the respondents replied that soil fertility could be improved through letting the field unplowed for long period of time. Furthermore since land under cactus is not plowed for long time, it may accumulate plant nutrients and develop better soil structure.

3.2. Cactus utilization in the study Districts

Farmers have been using cactus pear to satisfy their animals feed and water demands, for fence, for soil conservation and wind break all over the cactus growing areas of the study districts. However, there was no significant difference in the utilization of cactus pear among districts. According to 23.6% % of the respondents, cactus pear has a combination of all uses across the study districts. When we compare cactus pear utilization across the study districts, Gasera takes the largest share which accounts 25% for combined purpose of cactus and 26.8% for fruit consumption. The contribution of cactus within the study district was found to vary (for Sinana (11.3%) Agarfa (6.8%), and Gasera (8.9%). The data in table 9 clearly shows that Cactus feeding practice is a more familiar activity in Sinana than Agarfa and Gasera Districts. This could be mainly due to the fragmentation of the land leading to low crop residue yield and decreased volume of pasture from rangelands.

3.3. Marketing problems

Constraints to marketing of cactus, as indicated by the respondents, include absence of transportation facilities, absence of market place, low bargaining power, perishability problem, fluctuation of market price and availability of illegal brokers. About 20.3 % of the respondents which constitute the largest share mentioned that there were no transport facilities that can be used to carry the fruit to local market. The second most important problem indicated by 17.0% % of the respondents was the persishability of cactus fruit. Cactus pear is one of the most perishable fruit types. Unless the fruit is taken to the market or consumed without delay, it can easily be spoiled within a few days of picking. The third important constraint indicated by 15.1 % of the cactus grower's

Table 10. Marketing problems of Cactus pear across the three study districts.

Problem of marketing cactus		district of the Household			Total	Pearson Chi- square
		Sinana	Agarfa	Gasera		
transportation	N	21	13	9	43	
	%	21.6%	22.0%	16.1%	20.3%	
lack of nearby market place	N	14	8	4	26	11.774
	%	14.4%	13.6%	7.1%	12.3%	0.464
low bargaining power	N	16	10	6	32	
	%	16.6%	16.9%	10.7%	15.1%	
low price of cactus	N	10	5	10	25	
	%	10.3%	8.5%	17.9%	11.8%	
perishability problem	N	18	11	7	36	
	%	18.6%	18.6%	12.5%	17.0%	
price fluctuation	N	8	4	8	20	
	%	8.2%	6.8%	14.3%	9.4%	
availability of illegal brokers	N	10	8	12	30	
	%	10.3%	13.6%	21.4%	14.2%	
Total	N	97	59	56	212	
	%	100.0%	100.0%	100.0%	100.0%	

Source: survey data, 2016/17

Table 11. Household Expenditure of income earned from selling of cactus pear.

For what purpose do you use Income obtained from cactus?		district of the Household			Total
		Sinana	Agarfa	Gasera	
purchasing food during food deficit	N	1	3	5	9
	%	1.0%	5.1%	8.9%	4.2%
domestic consumable	N	26	17	22	65
	%	26.8%	28.8%	39.3%	30.7%
purchasing cloth for children	N	28	19	18	65
	%	28.9%	32.2%	32.1%	30.7%
cover costs of sending children to school	N	17	10	6	33
	%	17.5%	16.9%	10.7%	15.6%
purchasing improved seed	N	16	7	1	24
	%	16.5%	11.9%	1.8%	11.3%
Purchasing house construction material	N	0	0	3	3
	%	0.0%	0.0%	5.4%	1.4%
purchasing agricultural input	N	9	3	1	13
	%	9.3%	5.1%	1.8%	6.1%
Total	N	97	59	56	212
	%	100.0%	100.0%	100.0%	100.0%

Source: survey data, 2016/17

household was low bargaining power while fourth important marketing constraints were availability of illegal brokers. Lack of nearby market place, low price of cactus and price fluctuation were ranked by 12.3%, 11.8% and 9.4% respondents respectively

3.4. Expenditure and Income contribution of Cactus pear

3.4.1. Expenditure of income earned from selling of cactus pear

The respondents indicated that the income generated from the sale of cactus fruit was spent on purchasing of food in the case of food deficit households, for domestic consumables, clothing, to cover costs of sending children to school, for the purchase of improved seed and house construction materials The amount of money spent on the above items could vary from household to household. Nevertheless, the importance of the income generated from the cactus business to cover the costs of household consumables, clothing, and costs of sending children to school were indicated by 30.7%, 30.7% and 15.6% of the respondents respectively. The importance of cactus for covering costs of purchasing food ite ms was indicated by only 4.2% of the households. On the other hand, 6.1% of the respondents indicated that part of the income generated from the cactus business was spent on the purchase of improved seed.

3.4.2. Income portfolio of sampled Households

This section deals with the income dimensions of livelihood outcome that sample households depend on and earn from different income generating activities. Accordingly, the annual average total income earned by cactus owner respondents was 13,910.6 birr whereas 12,371.3 birr for non cactus grower households with maximum earnings of up to Birr 30, 900 for non owner and 35,960 for cactus grower households. The average total income for Sinana, Agarfa and Gasera districts households was Birr 12470 birr, 13910.6 birr, and 13915.75 birr respectively. The group statistical analysis showed that there is significant difference between mean incomes earned across the study districts at less than 1 percent probability level (Table 11).

In the study area, the major income sources for the sample households are crop (except cactus) sale, livestock and livestock product sale, sale of Cactus and income from off or nonfarm activities. Of these, the most important source of income for all households by its income share was found to be crop (6906.21birr) followed by livestock (3094.77%) and income from off/non -farm (2178.31%) in order of their importance (Table 11). Further examination of the data showed that within the two categories (grower and non grower) of households where each household has the same economic opportunities, there is a large variation in both the size of income and in the relative importance of different sources of income. Farming activities (crop production and livestock rearing) were found to be dominantly pursued by the two categories with increasing share by non cactus grower Household in crop production (7234.73 birr) and Cactus grower Household in Livestock production (3094.77 birr).

3.5. Econometric Results

This section presents the results of the logistic regression model which is used to estimate propensity scores for

Table 12. Average income of the HH across the study districts.

district of the Household		Income from crop production	Income from sells of Cactus pear	Income from livestock & its products	Income from off farm activities
Sinana	Mean	6319.05	820.94	3060.64	2269.63
	N	169	169	169	169
	Std. Deviation	5075.31	834.45	1588.952	2771.31
Agarfa	Mean	6623.45	959.27	3457.33	2504.56
	N	127	127	127	127
	Std. Deviation	4042.37	1152.92	2013.04	3513.92
Gasera	Mean	8205.64	1371.10	2707.50	1631.50
	N	104	104	104	104
	Std. Deviation	6022.01	1435.03	1454.04	2994.22
Total	Mean	6906.21	1007.90	3094.77	2178.31
	N	400	400	400	400
	Std. Deviation	5096.97819	1137.75	1723.35	3092.36

Source: survey data, 2016/17

Table 13. Logit results of cactus owners and non owner sampled household.

.psmatch2 CSTOFHH SEHH AGHH EDUHH HHS Farmexp HHMAST TLSZ Livest lu frexvis tesgea, logit

Logistic regression	Number of obs =400
	LR Chi2(10) = 344.72
	Prob> Chi^2 = 0.0000
Log likelihood = -29.303062	Pseudo R^2 = 0.8547

CSTOFHH	Coef.	Std. Err.	Z	p>|Z|	[95% Conf.	Interval]
SEHH	-1.403645	5.441506	-0.26	0.796	-12.0688	9.261511
AGHH	1.711557	.4679598	3.66	0.000	.7943721	2.628741
EDUHH	-.1942473	.7111389	-0.27	0.785	-1.588054	1.199559
HHS	-5.177805	1.302131	-3.98	0.000	-7.729935	-2.625675
Farmexp	.787057	.3701081	2.13	0.033	1.512456	.0616584
HHMAST	.5747152	2.674613	0.21	0.830	-4.667431	5.816861
TLSZ	.3678141	.3890429	0.95	0.344	-.394696	1.130324
Livest lu	.8152495	.480113	1.70	0.090	1.756254	.1257548
frexvis	-.3082691	.3110826	-0.99	0.322	-.9179797	.3014416
tesgea	.1955882	.2941154	0.67	0.506	-.3808674	.7720438
_cons	12.88014	8.989203	1.43	0.152	-4.738378	30.49865

Source: Own calculation based on household responses.

matching cactus owner households with non-owners households. The dependent variable in this model was a binary variable indicating whether the households are a cactus-owner or not.

The propensity score or the likelihood of being cactus owner for a given household was estimated using logit model where the dependent variable is cactus ownership and taking different covariates as independent variables.

Looking into the estimated coefficients, the result indicates that cactus ownership were significantly influenced by four explanatory variables including age of the household, family size, farm experience and TLU. As the regression in logit model shows it is likely to say that majority of households who are involved in cactus production has well farm experience, possess high land size, and livestock (in TLU).

3.5.1. Identify the Common Support Region

The common support region is where the values of propensity scores of both cactus owners and non-owner groups can be found. The basic criterion of this approach is to delete all observations whose propensity score is smaller than the minimum and larger than the maximum in the opposite group (Caliendo and Kopeinig, 2008).

The ATT are only determined in the region of common support. Hence, an important step is to check the overlap and the region of common support between cactus owners and non-owner groups.

As shown in Table bellow, the estimated propensity scores vary between .01604983 and 0.9999917 (mean =0.9435051) for cactus owners and between 1.29e-07and .9961066 (mean = .0545863) for Non- owners (control) households. Based on the minima and maxima criterion the common support region would then lie between .01604983 and .9961066. In other words, households with estimated propensity scores less than .01604983 and greater than 0.9961066 will not be considered for the matching exercise. As a result of this restriction, 180 households were discarded.

3.5.2. Testing the balance of propensity score and covariates

Balancing test in this context is a test conducted to know whether or not there is a statistical significant difference in the mean values of covariates for cactus owners and non-owners groups. Keeping other selection criterion, the balancing test indicates the quality of the matching algorithm implemented.

Table 14. Estimated mean of propensity scores matching.

```
. sum _pscore if  CSTOFHH==1

    Variable |       Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
      _pscore |       143    .9435051    .1604983   .0165846   .9999917

. sum _pscore if   CSTOFHH==0

    Variable |       Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
      _pscore |       148    .0545863    .1486152   1.29e-07   .9961066

. sum _pscore

    Variable |       Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
      _pscore |       291    .4914089    .4711431   1.29e-07   .9999917

.
```

Source: Own computation, 2017

It is evident that sample differences in the unmatched data significantly exceed those in the samples of matched cases. Unmatched sample size was 400 households but after matching it reduced to 220 households. T-values in Table below show that before matching seven of chosen variables exhibited statistically significant differences while after matching all of the covariates are balanced. There is no statistically significant difference among covariates. As shown in the table below the t-test found corresponding to _pscore tests whether there is significant difference on the mean value of the propensity scores between cactus owners and non-owners households. It shows that there was significant difference of six variables before matching but not after matching.

3.5.35. Estimating treatment effect on the treated (ATT)

The "average treatment effect on the treated" (ATT) measures the average difference on income between the matched cactus owners and non-owners.

As the estimation result presented in Table 15 shows, there is supportive evidence on the effect of cactus on

Table 15. Propensity score and covariate balance test.

Variables	Sample	Mean		%reduction		t-test	
		Treated	Control	%bias	bias	T	p>t
PSCORE	Unmatched	0.69497	0.30503	157.5		10.56	0.000
	Matched	0.64745	0.61254	14.1	91	1.01	0.313
SEHH	Unmatched	0.73333	0.82222	-21.4		-1.43	0.153
	Matched	0.76316	0.81243	-11.9	44.6	-0.74	0.461
AGHH	Unmatched	44.222	43.922	3.5		0.23	0.816
	Matched	43.763	44.128	-4.2	-21.6	-0.25	0.803
EDUHH	Unmatched	1.1444	1.8556	-34.6		-2.32	0.021
	Matched	1.3158	1.3749	-2.9	91.7	-0.19	0.846
HHS	Unmatched	6.7	6.7222	-1.7		-0.11	0.91
	Matched	6.7368	6.7354	0.1	93.6	0.01	0.995
TLSZ	Unmatched	0.39556	0.54111	-78		-5.23	0.000
	Matched	0.42138	0.42435	-1.6	98	-0.15	0.884
livestlu	Unmatched	1.9711	2.8237	-70.2		-4.71	0.000
	Matched	2.0873	2.0635	2	97.2	0.13	0.896
Farmexp	Unmatched	0.32222	0.53333	-43.4		-2.91	0.004
	Matched	0.32895	0.34698	-3.7	91.5	-0.23	0.816
frexvis	Unmatched	0.85556	0.86667	-3.2		-0.21	0.831
	Matched	0.85526	0.85089	1.3	60.6	0.08	0.94
HHMAST	Unmatched	0.41111	0.2	46.8		3.14	0.002
	Matched	0.38158	0.34634	7.8	83.3	0.45	0.654
Tesgea	Unmatched	0.73333	0.43333	63.5		4.26	0.000
	Matched	0.68421	0.61285	15.1	76.2	0.92	0.36

Source: Own calculation based on household responses

Table17. Average treatment effect on the treated for household income and asset building.

Variable	Sample	Treated	Controls	Difference	S.E.	T-value
HHtotinc	Unmatched	14793.5524	12283.9459	2509.6065	741.0488	3.39***
	ATT	13548.3478	12115.1429	1433.2049	2011.8645	1.21**

Source: Own calculation based on household responses

household income. It has been found that, on average, the cactus owners have higher income than non-owners. The mean difference of income between owners & non-owners households was statistically significant at 5% probability level after matching. This indicates that after matching the covariates are almost balanced.

These indicate that due to impact of cactus, the cactus owners obtain 1433.2049 birr of total income higher than non-owners.

Table 16. Chi-square test for the joint significance of variables.

Sample	Pseudo R^2	LR chi^2	p>chi^2
Unmatched	0.337	84.06	0.000
Matched	0.009	1.97	0.999

4. Summary, Conclusion and Recommendation

A study was conducted to assess the Current status, Utilization, Income contribution and Marketing constraints of Cactus Pear (Opuntia spp.) in the selected Districts of Bale Zone, South-Eastern, Ethiopia in 2017. In this study, three districts, namely, Sinana, Agarfa and Gasera were purposively selected based on their potential in cactus production and utilization. A total of 400 Cactus Grower and Non grower Households were selected to achieve the objectives of the study. Both qualitative and quantitative type data were collected from sampled Households.

The present study showed that the feeding management in the study area included the practices of cutting, scrubbing and chopping of young cladodes from branches of the stand for their animals and grazing. Respondents in the study area allowed their animals to graze cactus in the wild and around their farm lands and also they practiced cut and carry system of feeding their animals. Farmers in the study area had an experience of feeding cactus before or after feeding other feeds. Farmers used cactus alone in the drier months of the year where the other sources of feeds are scarce in the district. Bloating, diarrhea, sore mouth, physical damage and chocking of the throat were the major problems associated with feeding cactus. However, Feeding cactus along with some supplemental feeds was reported to have positive effects on milk yield and body weight gain of animals.

Currently cactus in the study districts were utilized for different purposes, as consumption live fence for crop field, soil conservation, backyard live fence, for food security motive forage and for wind break. Regarding Constraints to marketing of cactus, as indicated by the respondents, include lack of access to transportation, absence of market place, low bargaining power, and low price of cactus perishability problem, price fluctuation and availability of illegal brokers. Regarding the income share of cactus grower and non grower Households it was found that the annual average incomes earned by cactus owner households were 13,910.6 birr whereas 12,371.3 birr for non cactus grower. The result obtained from propensity score matching indicated that the "average treatment effect on the treated" (ATT) for household income suggested that due to pure effect of cactus, the cactus owners obtained 1433.2049 birr of total income higher than non-owners; among which the mean difference of income between these two group is statistically significant at 5% probability level after matching. It indicates that Growing Cactus would have a paramount importance in terms of stabilizing and improving the living standards of the farmers in the study districts.

Recommendations

Based on the results of our findings the following recommendations are forwarded:

- Access to market for cactus fruit has to be improved so that farmers can get the best benefits from the cultivation of the crop.
- Organizing the cactus growers into cooperatives could enhance their marketing power, create access to training facility and serve as a means of exchanging experience and knowledge on the cultivation and management of cactus that intern could help improve the productivity of cactus in the area
- Transformation of the existing traditional cultivation practice in to modern production and marketing system is an urgent issue for the study area. Provision of Extension services to promote the production and utilization of cactus pear has to be given special attention by the government. Modern management practices such as row planting, pruning, fruit thinning, irrigation (water harvesting technologies) should be introduced for cactus pear plantations for better yield and quality fruits
- NGO's and Government institutions are required to provide improved production and post harvest techniques to be able to penetrate the national market. Capacity building for different stakeholders (farmers' extension agents and merchants) on how to produce, harvest, package and transport would be of paramount importance to improve the existing quality of the produce. The community who live in such area needs to set sound land use systems to isolate cactus pear production and grazing area.
- Awareness should be created among the farmers on the current potential utilization of cactus pear, stressing their function as a biological barrier for reducing the impact of desertification, serve as backyard and crop fence, used as forage for livestock and food for human consumption.

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