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The effect of khat cultivation on rural households' income in Bahir Dar Zuria District, Northwest Ethiopia

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Abstract The study was conducted to evaluate the effect of khat cultivation on rural households' income in the Bahir Dar Zuria district using cross-sectional data collected from 180 randomly selected respondents, and supported by focus group discussions in two districts of northwest Ethiopia. The data were analyzed by simple descriptive statistics and beta regression. Results from descriptive statistics show that khat contributes the largest (51%) of farmers' income, followed by crop sale (33%), sale of livestock and their products (9%), and off-farm and non-farm activities (7%), Empirical findings from the Beta regression model also show that farming experience, education status, the proportion of land allocated for khat cultivation, total working capital of the household, the density of khat trees planted per hectare, and participation in off-farm and non-farm activity have a significant and positive effect on the proportion of khat income of the households. On the contrary, livestock holding, total asset ownership, and access to mobile phones have a significant and negative influence on the proportion of annual khat income of the households. Hence, the cultivation of khat can have a significant effect on the improvement of rural households' income and standard of living in the districts. However, increased khat production have also serious implications on the market, water resources, and human health. Thus, policymakers need to come up together to understand and devise proper running mechanisms for these controversies of khat production in association with economic, social, and health implications.

Keywords Khat cultivation · Khat income · Beta regression · Bahir Dar Zuria · Ethiopia

Introduction

Agriculture is the mainstay of the Ethiopian economy, which contributes to 32.7% of the gross domestic product (GDP), 81.4% of the export earnings, and about 70% of employment (NBE, 2020). The crop production that encompasses the cereal, pulse, and cash crops is widely produced in the country. Among the cultivated cash crops, khat is the one and Ethiopia is the leading khat producer in the World (Cafer, 2016). Khat grows in a wide range of agro-ecological

Khat is the name generally used for *Catha edulis*, a dicotyledonous evergreen shrub native to Ethiopia which is cultivated for the production of fresh leaves that are chewed for their euphoric properties or mental and physical stimulant (Dessie, 2013). Kebele is the lowest administrative level of Ethiopia, followed by woreda, zone, and region.

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zones between 1500 and 2700 m above sea level (m.a.s.l) and adapts to a range of well-drained soil and climatic conditions. It is mainly cultivated by smallholder farmers with an average land size of 0.1 ha (Dessie, 2013).

It is well known that the export of khat is banned in some countries. However, in Ethiopia, it is one of the major income earnings for the producers domestically and a means of foreign currency for the country (Terefe, 2020). As a result, the cultivation of khat in 2020 has rapidly increased in Ethiopia by 8.66%, out of which 21.8% was exported and 78.2% was consumed domestically (CSA, 2020; NBE, 2020). The main driving factors for the expansion of khat cultivation in Ethiopia include the low productivity of cereal crops due to the prevalence of degraded lands, drought resisting capacity of the plant, and low labor-demanding as compared to other cereal crops. Khat easily grows on degraded land but with a higher income return (Beyene et al., 2017; Kandari et al., 2014). Despite this, khat cultivation has reduced by 3.32% in the region as compared to the production in 2017 (CSA, 2020). This could be due to the recent ban implemented and practiced by the regional government as a result of covid-19 as well as the existence of war on the regional border. However, from the above-stated amount, about 3% of Ethiopian khat production originates from Bahir Dar Zuria District indicating that it is among the most commonly produced crops at Aba Gerima and other study *kebeles* of the district (Liyew et al., 2019). As noted by Cochrane and O'Regan (2016), the production of khat leaf is profitable as an alternative to other crops supplementing household income and bridging the lean season in the food calendar.

Despite several controversies that have continued in khat consumption, it has a substantial amount of revenue for the country as well as for those participants in the production and marketing process (Berhanu et al., 2014). The Ministry of Revenue (MoR) (2020) cited in the National Bank of Ethiopia (NBE) reported that the total export earnings from *khat* export (in million US dollars) in the years 2018, 2019, and 2020 were 263.5 (9.3%), 303.6 (11.4%) and 324.4 (10.9%), respectively. This makes it the third-largest export commodity of Ethiopia next to coffee (28.97%), and oilseed (13.63%), on average (Megeressa et al., 2014; NBE, 2020). Therefore, khat plays a considerable role in the national economy as a source of foreign exchange earnings, a major income source as well a means of livelihood for millions of farming households and traders who are directly or indirectly involved in harvesting, packing, transporting, loading and unloading the product that enables them to lead a better life (Feyisa & Aune, 2003; Habtamu, 2009).

A recent study conducted in the Aba Gerima watershed (Teneta-Laguna *Kebele*) pointed out that the income gained from khat cultivation is greater than the income from cereal crops by a factor of 1.5. Similarly, the economic returns and market opportunities for khat remained very high (Nigussie et al., 2017). The smaller the amount of available land means the more complicated it becomes for farmers to maintain their traditional cropping system. As a result, farmers are forced to prioritize crops that have high cash returns such as khat cultivation to access their foods and optimize benefits (Rahmato, 2009). A farming household that has below half a hectare of land may not produce sufficient food without the use of improved agricultural technologies, and credit. To overcome these, farmers cultivate khat to obtain a higher income from a smaller plot of land (Feyisa & Aune, 2003; Gebissa, 2010). Therefore, diversification into khat production as a strategy improves farmers' income and provides employment opportunities for khat-related activities (Njiru et al., 2013).

Different studies tried to see the reasons why the production of khat is increasing as time goes on. As noted by Kleina and Metaalb (2010), the reasons for the expansion of khat production include economic, agro-ecological, and land tenure systems-related reasons. Megeressa et al. (2014) also pointed out that some farmers prefer to cultivate khat over other crops because it is a cash crop that can give considerable revenues and also low susceptibility to drought with minimum demands of labor during production.

Most of the studies carried out focused on the contribution of khat to the household and regional economies (Gebissa, 2004), on khat and Ethiopian smallholder enterprises (Dessie, 2013), and the socio-economic contribution of khat (Kandari et al., 2014). However, these studies were carried out in the eastern part of the country. Lynn (2016) also examined the impact of khat production on household welfare in the Amhara region of Ethiopia, which is done at a regional level, and other empirical studies focused on the effects of khat production on rural households'

income in Kenya (Njiru et al., 2013). However, a review of empirical studies on khat cultivation revealed that there is no household-based study that addresses the effect of khat cultivation on rural household income around Bahir Dar Zuria District of Ethiopia. Therefore, this study was conducted with the objectives of assessing the contribution of khat cultivation to households' income and identifying factors that affect the proportion of annual khat income of households around Bahir Dar Zuria District.

Literature review

What is *Khat*?

Khat is a dicotyledonous evergreen shrub that has a slender trunk with smooth, thin bark. The leaves are faintly aromatic, with an astringent, slightly sweet taste (Al-Motarreb et al., 2002). Khat is a perennial tree crop native to Ethiopia. If properly handled, a healthy khat tree gives yield and lives up to 100 years which is propagated using suckers than seeds (Brooke, 1960; Gebissa, 2004; Peters, 1952; Kennedy, 1987 cited in Gyau & Muthuri, 2016). Khat is the most commonly used name for the stimulant stems and leaves of the shrub, which is found growing wild in the Middle East and is now cultivated intensively in Yemen, Ethiopia, Kenya, Uganda, and Northern Madagascar (Anderson et al., 2007). Khat can be cultivated by irrigation or rain-fed or in both conditions, which positively pools resource-poor farmers who have no access to irrigation. Under rain-fed conditions, it could be harvested up to two times a year, while it would be produced and harvested five times a year under irrigation. This substantially increases households' income, and also consistently brings a greater net return with a stable price than any other agricultural product in Ethiopia, including coffee (NBE, 2016 cited in Cafer, 2016).

Historical overview of khat cultivation

There is no uniformity in the literature regarding the origin and history of Khat cultivation in Ethiopia. Some literature shows that the production, cultivation, and use of khat in Ethiopia go back to the fourteenth century. However, its commercial production in the Eastern part of the country is a recent phenomenon that dates back 50 to 60 years (Woldu et al., 2015). The culture of khat consumption of communities in the Horn of Africa and the Arabian Peninsula combines two main purposes, i.e., religious and cultural purposes (Ong'ayo, 2007). Accordingly, Anderson and Carrier (2009) revealed that khat chewing in Ethiopia was linked with agricultural labor and associated with religious contemplation and meditation. Besides, the previous use of khat was observed frequently among Ethiopian Muslims who consumed it for praying and during the fasting period of the month of Ramadan, marriages, and religious festivals (Apps et al., 2011). The story of khat's role in development does not end in the main producer countries of Kenya and Ethiopia. It has expanded to Uganda and Madagascar as growing production regions. In describing the expansion of khat production in several regions of Uganda, Anderson makes similar points concerning the positive role that it plays in improving rural livelihoods (Anderson et al., 2007).

Contribution of khat cultivation to the income of households

As far as the contribution of khat cultivation to the household income is concerned, it has a substantial implication for the economy of Ethiopia by providing an alternative source of income for farmers and creating employment opportunities for those who involve in the supply chain of khat that links Ethiopia with the outside world. It has helped farmers to reduce their dependence on selling fuelwood by providing an alternative income for families. It is also one of the major cash crops for smallholder farmers (Cochrane & O'Regan, 2016).

The findings of Dessie (2013) indicated that income per ha from khat surpasses all major crops by several margins, i.e., 14.5, 17, 6, and 4 times more than cereals, pulses; oilseeds, and coffee, respectively. In addition, the finding of Gebissa (2010) confirmed that the benefit of producing khat is substantial and income from a half hectare of khat can be six times greater than Ethiopia's per capita income. Dessie (2013) also found that the livelihood contribution of khat in Ethiopia is not only for those who are directly involved in trades like khat transactions, khat sorting, packing, and khat transporting but also for those who are involved indirectly in retailing and marketing of khat and other activities like transportation services.

In addition, the consumption of khat has enhanced the production of groundnuts, bottled water, and cigarettes (as these items are usually taken while people chew Khat).

Another study conducted by Feyisa and Aune (2003) in Harar of Ethiopia shows that khat growers are better off in living standards than non-growers because khat growers have better houses, wear good clothes, have better household equipment, and are in a better position to send their children to school. Belwal and Teshome (2011) also revealed that farmers considered khat cultivation as a livelihood strategy to compensate for the declining household income from food crops and coffee. The Ethiopian government has encouraged the export market of khat, which has become a nationally important export product due to its contribution to securing foreign currency (Dessie, 2013).

Empirical review on determinants of khat and related cash crop cultivation

Nijiru et al. (2013) conducted research in Kenya and the result of logistic regression analysis on factors that influence the decision of farmers to participate in khat production indicated that contact with agricultural extension, agricultural land size, access to credit, number of school-going children, the main occupation of farmers and on-farm total income were found to be determinant variables which have a positive and significant influence. However, the age of the household head and distance from the main market had shown a negative relationship with the decision of farmers to participate in khat production. Nigussie et al. (2016) conducted a study in Ethiopia and identified the determinants of farmers' decisions on the allocation of land to tree planting. The result indicated that the sex of the household head, cultivated land, households' access to credit, the distance of farm plot from the main road, and possession of marginal land were found to have positive and significant influence. On the contrary, the age of the household head has a negative and significant influence on farmers' decisions on the allocation of land for tree planting. Another study by Ewnetu (2008) researched the determinants of smallholders' decision to grow trees and the extent of growing trees using the binary logistic regression model and Tobit regression model. On the one hand, the binary logistic regression results revealed that training, land size, number of plots, number of livestock in TLU, and additional land renting were found to be positive and statically significant in influencing the decision of farmers to grow trees in Basona district of Ethiopia. On the other hand, landholding size, and total annual output per ha were found to be positive and significant in influencing the decision of farmers in the Sodo Zuria district of Ethiopia. However, the sex of the household head, the number of years a farmer resided in the area, and access to training were found to be negative and statistically significant factors in influencing the decision of farmers to grow trees.

The adoption diffusion theory

The theoretical approach used to guide this study is drawn from the adoption diffusion theory (innovation-diffusion theory) which helps to determine what could be important (which factors) and how these factors influence decision making (Rogers, 2003). Rogers (2003) also outlines four major influences in the adoption process: the innovation itself, how information about the innovation is spread, time, and the characteristics of the society in which the innovation is introduced. Each of these influences speaks to the specific context of the time and place of introduction. However, Rogers' theory of perceived attributes outlines specific areas of potential resistance to the adoption of an innovation: (1) perceived relative advantage; (2) compatibility; (3) complexity; (4) trialability; (5) and observability.

The innovation-diffusion theory also provides the theoretical foundation for this study because the focus of the adoption analysis is on the demographic, socio-economic, and institutional characteristics of farm households which can be measured based on the adoption rate of agricultural technologies. Rogers (2003) defines diffusion as "the procedure in which an innovation is transferred through certain channels with time among members of a social system". While innovation is "an idea, practice, or object that is perceived as new by an individual", it may have been invented a long time ago by others (Roger, 2003).

Roger theory adequately determines factors that influence farmers to adopt agricultural technologies. The focus of the adoption analysis needs to be beyond the characteristics of farmers and plots of land, that is maximizing profit and utility. Moreover, access to

information on agricultural innovations is one of the most critically examined aspects of adoption and diffusion, especially in the developing world. This is because quality information and delivery are critical to the adoption process (Rogers, 2003; Simpson, 2015). The ability of farmers to see the innovation in action or the ability to try the technology or process before committing scarce resources and observing tangible benefits are important to the longstanding and organized adoption of the technology (Rogers, 2003).

Besides, Mendola (2007) and Davis et al. (2012) noted that the real barrier to the adoption level of smallholder farmers is resource constraint, which is particularly true for lack of capacity to purchase inputs such as fertilizer, or when some inputs such as labor and seed are in short supply. In addition, farmers may experience some market inefficiencies, which could make households unable to adopt or make adoption risky or unprofitable, and therefore makes it undesirable (Jack, 2013). In addition to resource limitation, literature shows mixed results on the characteristics of farms and farmers that decrease the barriers to adoption by building farmers' ability to absorb shocks including farm size, income, land tenure, education, and family size (Duflo et al., 2011).

Khat is considered a type of agricultural technology because growing the crop is not available to all due to access to irrigation, funds, knowledge, markets, and other factors. According to Jack (2011) cited in Cafer (2016), many of the poorest people around the world are farmers. Because of market instabilities, generating revenue from generous harvests is often uncertain and complicated, especially in underdeveloped areas. Therefore, the innovation-diffusion model for this particular study states that technology is passed on from its source to end-users through a medium of agents. The characteristics of farm and farm households are associated with the khat technologies that help in the design of farmers' demographic, socio-economic and institutional factors, which are expected to influence the proportion of annual khat income of households.

Research methods

Description of study area

The study was conducted in the Bahir Dar Zuria district in the West Gojam zone of Amhara National Regional State (ANRS), Ethiopia. It is located in North-west Ethiopia, about 565 km and 460 km away from the capital city, Addis Ababa via Bure and Motta, respectively (Fig. 2). Bahir Dar Zuria district is bounded by Lake Tana and North Gonder Zone on the North, Yelemana Densa district on the South, Dera district and Abay River on the East, and Mecha and Achefer districts on the West. The topography of the Bahir Dar Zuria district is estimated at 13% mountainous and hilly with many up and downs, 80% plain, and 7% gorges. It has one agro-climatic zone of *woyena Dega* (midland). Its altitude ranges from 1750 to 2300 m.a.s.l. with the mean annual rainfall ranging from 800 to 1250 mm, and the mean annual temperature ranging between 10 and 32 °C (WoA, 2016). The district is comprised of 32 rural *Kebele* administrations and has no urban *Kebeles*. The major soil type is 10% brown, 34% reddish, and 56% black. The land use pattern of the district includes 48,579 hectares of land for cultivation, 9410.69 hectares covered by forest, 27,629.42 hectares for grazing, 6532.25 hectares covered by bushes and shrubs, 5600.54 hectares by water bodies, 11,250.75 hectares for construction, 2105.06 hectares for roads and swampy areas, and 578 hectares have been kept without any use. From the cultivated area, around 5947 ha of farmland were covered by khat (WoA, 2016). Population in the study area are dependent on agriculture for their economy that practices a mixed farming system, i.e., crop along with livestock production to secure their family's food supply and income. The major crop cultivated in the area includes maize, millet, teff, and haricot bean. The livestock population size of the district includes cattle (201,524), sheep and goat (78,906), equines (23,616), bee colonies (18,845) and poultry (151,944) (WoA, 2016). The estimated population in the district is 208,933, out of which 106,378 (50.9%) of them are males and 102,555 (49.10%) are females (CSA, 2016).

Target population, survey design, sampling, and data collection method

The target populations for this particular study comprised khat producers, Development agents (DAs), Health Extension Workers (HEW), and representative farmers from various relevant positions at the *Kebele* level. A cross-sectional data collection design and multistage random sampling were employed for

this study. In the first stage, the Bahir Dar Zuria district was selected purposively due to the rapid expansion of khat crops in this area. Secondly, purposive sampling techniques were employed to come up with the four *kebeles* from 43 rural *kebeles* of the district, which have relatively high coverage of khat farms per hectare as well as a high number of farmers involved in khat cultivation (Tables 7 and 8). In the third stage, the farmers in each selected *kebeles* were stratified into male and female khat producers to take representative sample households from both sexes using proportion to population size and taken as the sampling frame. Finally, a total of 180 households were selected as respondents to collect primary data using random sampling techniques from the available list of households in the selected *kebeles* in the district. Besides, since the population size of the study area is finite, the researcher used Kothari's formula (2004, p. 179) to determine the total sample size and presented it as follows:

$$n = \frac{Z^2 pqN}{(N-1)e^2 + Z^2(pq)} \quad (1)$$

where N = size of household heads; p = Sample expected proportion of successes; q = 1-p; n = sample size ofthe study; z = the value of standard deviation at 95% confidence level; e = acceptable error (the precision). Thus, N = 4720, p = 0.5, z = 1.96. e = 0.075. Therefore, **n = 172.** Then, adding 5% non-response rate as a correction factor from the above sample size. So that the final sample size was: 172 + (0.05*172) = 180 (Table 7).

Both quantitative and qualitative types of data were collected from primary data was collected from sampled households who cultivate khat on their farm and focus group discussions (FGD) such as *Kebele* leaders, managers, representative farmers, elders, religious leaders, *Kebele* development agents, and health extension workers (HEW). Secondary data was collected from various published and unpublished documents of related surveys in khat cultivation such as different office reports, reviews of literature, journals, research reports, government publications and books, etc. which were related to the study topics.

For primary data collection, a semi-structured interview schedule was developed, and data related to demographic, socio-economic, institutional characteristics of households, and other related information were collected from sampled households. To enrich the findings of quantitative analysis, qualitative data were gathered through focus group discussions (FGD) from twelve participants in each sampled *Kebeles* which comprises primary and secondary sources, *Kebele* heads and deputy administrators, religious leaders, youths, female and male representative farmers, and community elders. A questionnaire was prepared for a face-to-face interview and FGD was prepared in the English language and translated to the local language (*Amharic*). Then, to determine the reliability and ensure the validity of the instruments, it was pilot-tested with a small representative sample of 8% or fifteen khat cultivators from non-sample *Kebele* households (Erobit and Gonbat). Thereafter, based on information gained from the pre-test, essential amendments were made for its validity, reliability, consistency, and clarity. Besides, relevant images were taken each time to enrich the information that was collected.

Statistical data analysis

The collected data were analyzed quantitatively by a combination of descriptive, ANOVA, and econometric analysis to address research objectives. The qualitative data were gathered through focus group discussions (FGD) and analyzed through narrating, summarizing, and discussing using thematic analysis. Parameters of the fractional outcome model (FOM) were estimated by a Beta regression which is based on the Bernoulli log-likelihood function as recommended by Papke and Wooldridge (1996).

The beta regression model

Beta regression models were used to analyze factors that affect the proportion of annual khat income of farmers computed as the share of khat income with the total annual household income of farmers in the year. Beta regression is widely used because of its flexibility for modelling variables between 0 and 1 and also its predictions are confined to the same range. However, beta regression models are not appropriate for dependent variables with some observations exactly equal to 0 or 1. It is rather appropriate for dependent variables strictly greater than 0 and strictly less than 1 because beta distribution has support only on the interval (0, 1) which was proposed

by Ferrari and Cribari-Neto (2004) and extended by Smithson and Verkuilen (2006). Beta regression is a model of the mean of dependent variable 'Y' conditional on covariates X, which is denoted by μ_x. A continuous dependent variable y in (0, 1), and independent variables (X). Then it fits a model for the mean of Y conditional on X:

$$E\left(Y_i/X_i\right) = \mu_x = g^{-1}\left(X_i\beta_i\right) \quad (2)$$

where *Yi* is the response variable indicating the proportion of annual khat income of a household from the total annual household income in that year; $g^{-1}(.)$ is the inverse function of g (.) and represents a known non-linear standard normal cumulative distribution function satisfying $0 < g\ (.) < 1$; X_i is $(1 \times k)$ vector of explanatory variables and β_i is $(k \times 1)$ vector of parameters to be estimated.

The set of independent variables determining the proportion of annual khat income incorporated in the model includes demographic, socio-economic as well as institutional variables (Fig. 1). Before taking the selected variables into the fractional outcome model of beta regression, selected variables were tested for the presence of multicollinearity and heteroscedasticity problems. The variance inflation factor (VIF) and contingency coefficient (CC) techniques were used to test the presence of multicollinearity for continuous and dummy independent variables, respectively. While Breusch-Pagan test was employed to check the presence of heteroscedasticity. Thereafter, only those variables that passed the multicollinearity tests were included in the Beta regression analysis (Fig. 2).

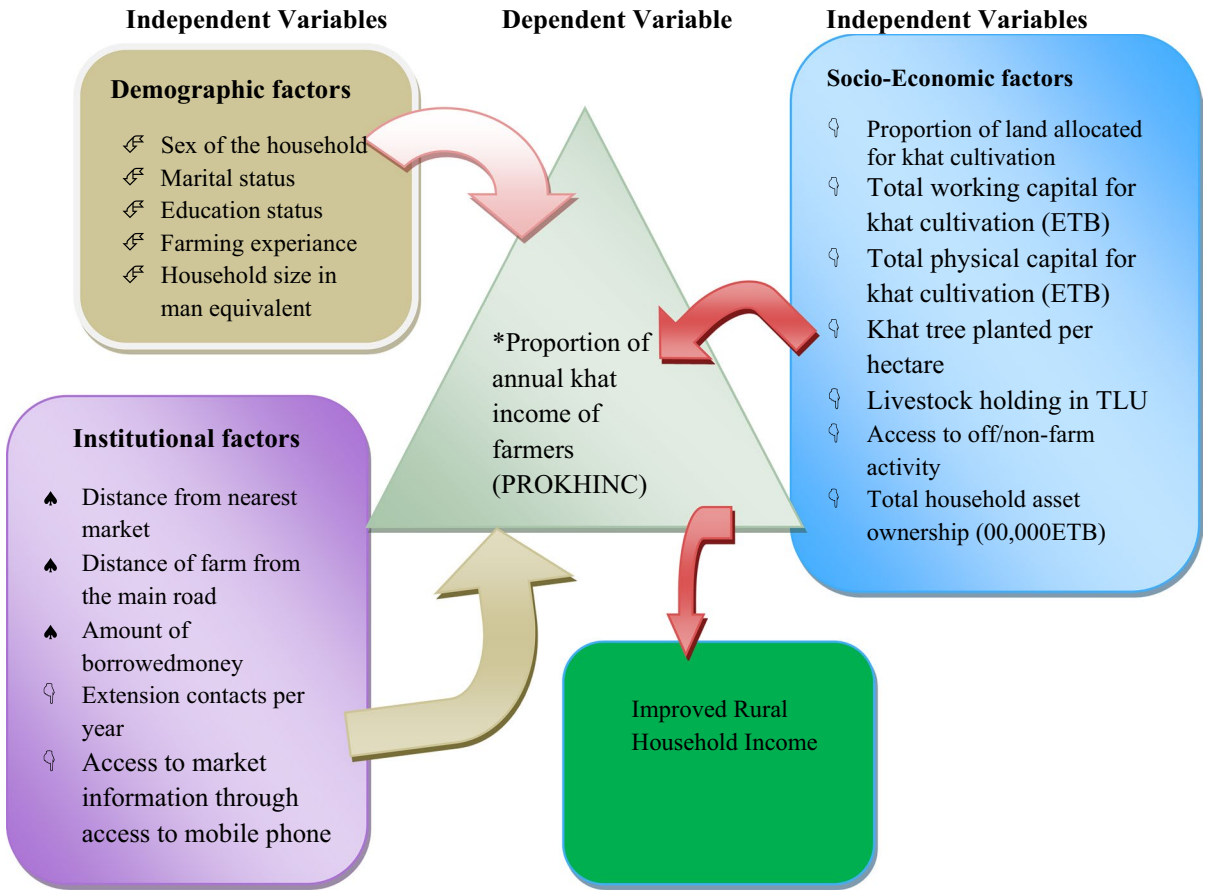

Fig. 1 Conceptual framework on effect of khat cultivation on rural household income in Bahir Dar zuria district, North West Ethiopia. *Source* Researchers own, 2017

Results and discussion

Socio-economic and institutional characteristics of the farmers

Results of the survey show that there were a significant number of khat growers in the region, with different degrees of cultivation intensities. The summary statistics of the variables included in the models are provided in Table 1. Most of the farmers (88.3%) were from male-headed households. The average age of the farmers was 44.18 years. The majority of the farmers (57.8%) had no formal education. The average available on-farm labor was 3.21 in man equivalent (Table 13 in Appendix) and the respondents have 11.13 years of khat farming experience, on average. The respondents owned an average of 1.71 ha of land and about 5.62 tropical livestock units (TLU) of livestock (Table 12 in Appendix). Out of their total land, growers allocated an average of 0.219 ha of land for khat cultivation (Table1).

Bullet contribution and share of khat cultivation to the households' income

As indicated in Table 2, on-farm, off-farm, and non-farm activities were the sources of income for the livelihood of households. The sources of on-farm incomes include the sale of cereals, livestock and livestock products, and khat leaves. Off-farm and non-farm income is derived from petty trades, horse-cart services, remittances, and working as daily laborers, guards, house servants, and drivers of three-wheeled motor vehicles.

The total annual mean income of households from all sources was 110,316.9 ETB. Out of this value, income gained from khat sales was the largest accounting for 56,112.84 ETB (50.90%) of the total annual household income followed by income from the sale of cereals, livestock, and products, off-farm and non-farm income sources, in order of their importance (Table 2). The finding is consistent with the findings of Lynn (2016) that reported the gross household income for khat growers was 50.2% higher than non-growers (i.e., 31,588.17 ETB for khat growers compared to 15,766.01 ETB for non-growers). Other findings such as Ministry of Finance and Economic Development of Ethiopia (MoFED) (2011), Rivera

Table 1 Description, units, and statistics for model variables (N = 180)

Variables	Units of measurement	H_0 sign	Mean	SD
SEX	1 = if male, 0 otherwise?	+	0.88	0.32
MRISTUTS	1 = if married, 0 otherwise?	+	2.18	0.52
EDUSTUTS	1 = if illiterate, 0 otherwise?	+	1.42	0.50
ACCMBL	1 = if yes, 0 otherwise?	+	1.28	0.90
ACOFNOFM	1 = if yes, 0 otherwise?	−	1.68	0.47
AGE	Years	−	44.18	9.11
FRMEXPOKH	Number	+	11.13	5.62
HHSZIMNEQT	Man equivalent	+	3.21	1.27
TOTLNDSZHH	Ha	+	1.71	0.90
PROLDALKH	Ratio	+	0.219	1.55
TOTWKGCPT	ETB	−	35,411.56	17,556.3
TOTPHYSCP	ETB	−	6381.21	4053.80
KHDSTYPRHA	Number	+	19,669	6767.6
LVSTCKHDG	TLU	−	5.61	2.42
TOTHHAST	00,000ETB	+	2.79	3.89
DSRESIMKT	Minute	−	40.97	23.48
DSFRMMRD	Minute	−	25.92	16.79
AMTBRDMNY	ETB	+	3.72	4.65
NoVisiPrYr	Number	+	6.58	4.75

Source Own survey result, 2017

ETB Ethiopian Birr, *TLU* total livestock unit

Table 2 Contribution and share of khat income to other sources of households' income in the year 2016/17 in ETB (N = 180)

No	Variables	Overall mean (ETB)	SD	The proportion of each to the total income (%)	The ratio of No. 1 with 2, 3, and 4
1	Total income gained from khat sale in ETB	56,112.8	28,836.5	50.87	
2	Total income gained from agricultural crop in ETB	36,758.24	27,081.2	33.11	7.59
3	Income from livestock and their product sale in ETB	10,278.6	12,003.1	9.32	5.46
4	Total income gained from off-farm and non-farm in ETB	7394.2	12,922.3	6.70	1.54
5	Annual household income gained in ETB	110,316.9	45,737.2	100	0.51

Source Own survey result, 2017

ETB Ethiopian Birr

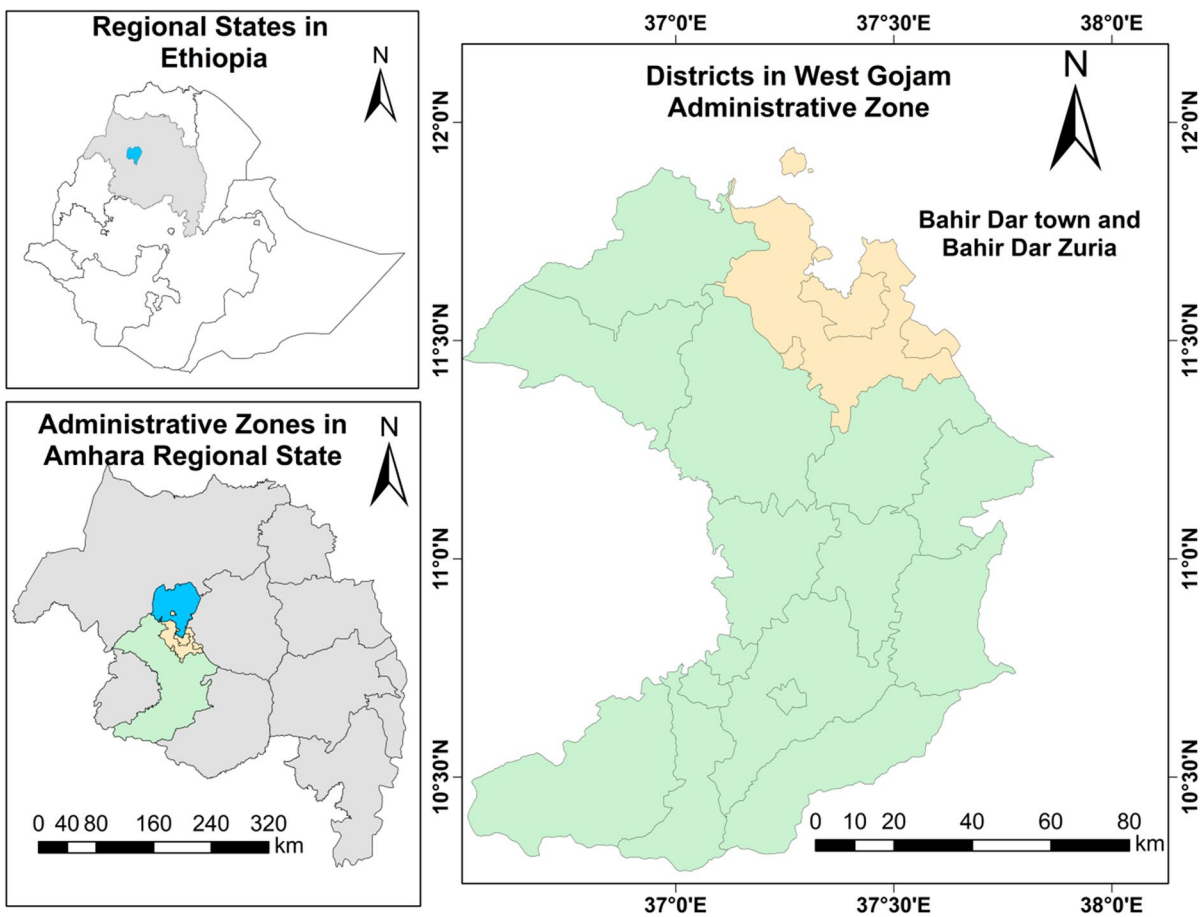

Fig. 2 Map of Ethiopia, Amhara region, West Gojam zone, Bahir Dar zuria woreda, and Bahir Dar City Administration. *Source* GIS Team of ANRS BoFED CSA map and used as a base map, 2017

(2012), Nijiru et al. (2013), Kandari et al. (2014), and Woldu et al. (2015) also confirmed the finding of the study. This implies that households in the study area generate their major income from the sale of khat. This evidence may suggest the increased expenditures of households on education and transport as a result of the excess income generated from khat. Thus, Khat cultivation has a positive contribution to the rural households' income. This could justify why most farmers in the study area are diversifying into khat production while abandoning the production of other food crops. Even though cereals are among the major crops produced in the study area, the market price of these crops is lower than the price of khat. As a result, most farmers are changing part of their farms into khat farms at an increasing rate. This, in turn, has reduced food crop production in the area and created a shortage of food crops. However, those farm households who are engaged in khat production do not suffer from food shortages as they get higher income from the sale of khat and can purchase food items from the market. The average income gained from the sale of khat was 7.59 times larger than income from off-farm and non-farm activity. It is also higher than the sale of livestock and livestock products, as well as cereal crops by 5.46 and 1.54 times, respectively. This result was consistent with the findings of Dessie and Kinlund (2008), who found that khat generates 25 times the income generated by maize and six times the income generated by sugar cane from 0.1 ha of land in Wondo Genet. Kandari et al. (2014) also found that the income return from maize mono-cropping is three times less than the intercropping of *Khat* with maize in the Hararghe highlands of Ethiopia.

The information generated from the FGD results revealed that khat producers were better-off compared to non-producers. As a result, khat growers have better houses, and farm equipment, wear better clothes and are in a better position to send their children to school than non-growers. In addition, khat growers also participate more in non-farm activities such as rendering transportation services and petty trades than non-growers. The finding is consistent with the results of Feyisa and Aune (2003) and Lynn (2016). Due to the lucrative income from khat, most farmers and even religious leaders in the study area have gained the motivation to be engaged in the cultivation of khat while abandoning the production of food crops.

The relative value of khat cultivation across food crops

The One-way ANOVA result revealed that there was a statistically significant mean difference between the income from khat, cereals, pulse as well as fruits and vegetables. However, in terms of area covered, total production, productivity, as well as landholding size per farmer, khat represents a lower share of other crops as indicated in Table 3. These results suggest that the relative economic advantage of khat per unit of land is higher than other crops produced in the study area, which is why most farmers in the study area are increasing the allocation of their farms for khat cultivation rather than crop production. This finding concurs with the findings of Kleina and Metaalb (2010), Woldu et al. (2015) and Gebrehiwot et al. (2016).It is also confirmed that the expansion of land used for khat production in the Amhara region has been a 252% increase from 2003/2004 to 2014/2015 (Cochrane & O'Regan, 2016). The focus group discussions during the fieldwork have also confirmed the advantage of producing khat over other crops as it provides income almost throughout the whole year, and improves the overall welfare of households.

Factors Affecting the Proportion of Annual Income from Khat production

Several factors influence the proportion of annual khat income of households. Ahead of moving to beta regression analysis in the fractional outcome model, problems associated with Ordinary Least Square (OLS) on hypothesized independent variables were tested for the presence of serious multicollinearity, heteroscedasticity, and specification error. Therefore, the mean VIF value was 2.17 indicating that there are no serious multicollinearity problems among the independent variables (Tables 9 and 10 in Appendix). Furthermore, the existence of heteroscedasticity was also tested by employing the Breusch-Pagan test. Hence, tests showed that there was no heteroscedasticity problem (Table 11 in Appendix). The value of the coefficient of determination (R^2) in multiple regressions is 0.7257 indicating that about 72.57% of the variation in the proportion of annual khat income of farmers is explained by independent variables showing that the independent variables

Table 3 Relative value of khat with regard to the area covered, production, and income of the sampled households across crops (N = 180)

Measures	Share of khat to			Total			
	Cereal	Pulse	Fru and veg	Khat	Cereal	Pulse	Frui. and veget
Area (ha)	0.31	9.12	1.76	55.9	181.9	6.13	31.8
Producer (farmers)	1.03	8.2	2.6	180	175	22	70
Production (Qt)	0.49	22.2	1.23	3261.9	6672	147	2648
Productivity (Qt/ha)	1.59	2.44	0.7	58.4	37	24	83.3
Gro.Inc (ETB/ha)	14.82	6.05	5.24	180,944	12,210	29,902	34,538
Anova: F (11,168)					49.13***	37.41***	3.05**
Sig					0.000	0.000	0.021
Cost (ETB/ha)	3.11	6.05	5.24	24,296	7726	5907	10,902
Net Inc (ETB/ha)	8.33	6.52	6.63	156,648	21,374	23,995	23,636

Source Own survey result, 2017

ETB Ethiopian Birr

** and *** significant at 5% and 1% significant level

explain the dependent variable well. Overall, the model fits the data well since the overall regression is significant at less than a 1% level of significance ($Prob > chi^2 = 0.0000$) (Table 4).

The Beta regression model results revealed that the proportion of annual khat income of the household in khat cultivation was responsive to farming experience, education status, the proportion of land allocated for khat cultivation, the total working capital, khat tree planting density per hectare, and access to off-farm and non-farm activity positively and significantly. On the contrary, livestock holding, the total value of asset ownership, and access to a mobile phone were found to affect the proportion of annual khat income of households negatively and significantly (Table 4).

Discussion

The farming experience of household heads has a positive and significant effect on the proportion of annual khat income of the farmers in khat cultivation, at less than1% significant level (Table 4). The positive sign of the marginal effect of beta regression analysis also indicates that the proportion of annual khat income of farmers increases, on average, by 0.26% as the farming experience of the household head increases by a year, ceteris paribus. This suggests that those households who have more years of farming experience might have also more knowledge of the newly introduced technologies in their area and thus have more information about the benefits of those technologies. As a result, they could accept and decide to engage themselves in more income-generating cultivation and thereby improve their living standards. The finding was in agreement with the findings of Girma (2017) who found that farming experience affects the output of haricot beans positively and significantly, at a 1% significant level. As opposed to this finding, Ewunetu (2008) in his findings from the Sodo Zuria district of Ethiopia confirmed that household heads that resided and farmed on their current landholding for a longer period were more likely to engage more in non-tree production activities as they perceive that they are less risky.

The education status of the household head had a positive and significant influence on the proportion of annual khat income of farmers at a 5% significant level, indicating that farmers who have better education status are more likely to generate more annual income from khat cultivation. This is because education enhances farmers' ability to process information (Table 4). The finding shows that a unit increase in the educational status of the household head would likely increase the proportion of annual khat income of households by 3.30%, holding all other factors constant. The result implies that the probability of recognizing the advantage of the new technology (khat cultivation) increases for households with a

Table 4 Results of beta regression model on the effect of explanatory variables on the proportion of annual khat income of the farmer (N = 180)

Beta regression					Number of obs = 180	
Wald chi2(15) = 2373.55					margins, dy dx(*)	
Prob > chi2 = 0.0000					Average marginal effects	
Link function: g(u) = log(u/(1 − u)) [Logit]					Model VCE: Robust	
Slink function: g(u) = log(u) [Log]					Expression: Conditional mean of PROKHINC, predict ()	
Log pseudo-likelihood = 163.91758						
PROKHINC	Coef	RobustSE	Z	P > z	dy/dx	Delt-methSE
SEXHH	.1345524	.2678399	0.50^{NS}	0.615	.0300254	.0598752
MRISTATUS	−-.0041499	.1371644	− 0.03 ^{NS}	0.976	− .000926	.0306123
FRMEXP	.0116675	.0037264	3.13***	0.002	.0026036	.0008355
HHSZIMNEQT	− .0485667	.0327051	− 1.48 ^{NS}	0.138	− .010838	.0073416
EDUSTUTS	.148056	.0753093	1.97**	0.049	.0330388	.0168191
PROLNALKH	3.569383	.5960876	5.99***	0.000	.7965094	.1267873
TOTWKGCPTL	8.77e−06	2.59e−06	3.39***	0.001	1.96e−06	5.82e−07
TOTPHYSCPTL	− 5.70e−06	.0000147	− 0.39 ^{NS}	0.698	− 1.27e−06	3.27e−06
KHDSTYPRHA	.016364	.0057536	2.84***	0.004	.0036516	.0012791
ACOFNOFMACTY	.3999634	.0744414	5.37***	0.000	.089252	.0165928
LVSTCKHDG	− .0440666	.015203	− 2.9***	0.004	− .009834	.0033997
TOTHHAST	− .0321847	.0107273	− 3.0***	0.003	− .007182	.0023859
DSRMKT	.0018522	.0019274	0.96^{NS}	0.337	.0004133	.0004316
DSFRMMRD	.0032883	.0026936	1.22^{NS}	0.222	.0007338	.0006005
AMBRDMNY	5.94e−06	7.69e−06	0.77 ^{NS}	0.440	1.32e−06	1.72e−06
ACCMBL	− .2099766	.1018902	− 2.06**	0.039	− .046856	.0226848
NoVisiPrYr	− .0109776	.0106268	− 1.03 ^{NS}	0.302	− .002450	.0023762
_cons	− 1.809746	.3503724	− 5.17	0.000		
_cons	3.083726	.2226201	13.85	0.000		

Source Own survey results, 2017

dy/dx for factor levels is the discrete change from the base level

NS not significant

** and *** significant at 5% and 1% level of significance

higher educational status. This is because education enhances farmers' ability to perceive, interpret, and respond to new technologies. This finding corroborates with the findings of Geberesilassie and Bekele (2015), who found that farmers with a higher level of formal education have also a higher probability of adopting new technology as they can analyze information earlier than the less educated ones.

The proportion of land allocated for khat cultivation had a positive and significant influence on the proportion of annual khat income of the households at a 1% significant level as hypothesized (Table 4). A unit increase in the proportion of land allocation for khat cultivation would increase the proportion of annual khat income of farmers by 79.65% all other factors being constant. This could be because farmers are providing more attention to khat production as they get a higher income from it. The result is consistent with the work of Ewnetu (2008) in the Basona Werena and Sodo Zuria districts. He found that landholding size had a positive and significant impact on the likelihood of growing trees. Tekelu et al. (2018) have also reported that the income potential of khat motivates smallholders to allocate more land to khat cultivation in southern Ethiopia. Similarly, Nigussie et al, (2016) found that the size of landholding has

a positive and significant effect on the proportion of land allocated for the Tanguay system of Acacia production decisions in the Fagita-Lekoma district of Ethiopia. Nyaga et al. (2015) also reported that farmers with better resource endowments are likely to allocate more land for growing trees on the homestead than those who had fewer resources.

Households' total working capital was found to influence the proportion of annual khat income of households positively and significantly at a 1% significant level (Table 4). The regression coefficient of this variable suggests that a unit increase in the total working capital of households for khat cultivation is likely to increase the proportion of annual khat income of households by 1.96 e−06, ceteris paribus. This could be because farmers would likely harvest more khat leaves for sale if they possess a higher working capital to manage their khat farm. This, in turn, leads to generating a higher proportion of annual income from khat and thereby improving the working capital of the household that further expanding khat cultivation.

Khat tree planting density per hectare was found to affect the proportion of annual khat income of farmers positively and significantly at a 1% significant level (Table 4). The possible justification might be that a unit increase in khat tree planting per hectare leads to an increase in the proportion of annual khat income of farmers by 0.37% keeping all other factors constant. As the household's plant one more khat seedling on their farm, the amount of khat yield for sale increases. This leads to generating more proportion of annual khat income for the khat-cultivating households and thereby contribute to improving their wealth status. The result corroborates with the findings of Ewunetu (2008) who found that the size of landholding was positively and significantly related to the number of trees grown per household in both Basona Werena and Sodo Zuria. In the same vein, Nigussie et al. (2016) confirmed that farmers with more land are more likely to plant Acacia decurrens at a greater planting density to increase their benefit from charcoal production.

Livestock holding in TLU also affects the proportion of annual khat income of farmers negatively and significantly (Table 4). This means that an increase in livestock holding of the households by one TLU will more likely decrease the proportion of annual khat income of the household by 0.98%, other factors held constant. This shows that farmers with larger sizes of livestock are not encouraged to cultivate khat; rather they use their livestock as a means of generating additional income through selling live animals and their products. Farmers with more TLU tend to specialize in livestock production and allocate more proportion of their land for pasture. Similarly, Kandari et al. (2014) reported the negative relationship between livestock holding and khat farm expansion indicating a decline in per capita herd size due to the replacement of major fodder crops by khat in the Harar region of eastern Ethiopia. In addition, Nigussie et al. (2018) found the same result in the Lay Gayenet district of Ethiopia. On the contrary, Ewunetu (2008) justified that livestock holding exerts a positive and significant influence on the likelihood of growing trees in Basona Werena. In the same line, khat cultivation affects livestock holding and grazing land negatively and strongly with Kendall's tau_b correlation coefficient of ($r\ (178) = -0.795$, $p < 0.001$). This implies that there is evidence that khat cultivation can affect livestock holding and grazing land with a significance value of 1% (Table 5). Accordingly, the result of the coefficient of determination (R^2) showed that 63.20% of the variation in livestock holding and grazing land was due to the cultivation of khat. The result of this study concurs with the findings of Dessie and Kinlund (2008) who found that plots of farmland in the Wondognet area of Ethiopia being used for the production of fruit trees, garden crops, and grazing land for the dairy farm are replaced by khat planation, contributing to declining of food production. Similarly, Tirusew et al. (2020) in the Laguna microwatershed of Bahir Dar Zuria district found that land for khat plantation has increased by 3.1%, whereas land for grazing declined by 2.6% in the last 59 years. This shows how khat production takes away the grazing land of farmers rapidly. As a result, farmers in the study area reduced the average number of livestock holding from 9.59 TLU before khat cultivation to 5.61TLU after khat cultivation within 11.13 years on average (Table 6). Khat cultivation is occupying additional areas at the expense of crop and grazing lands, which results in a reduction of crop residue as well as grazing land for livestock farming. Thus, cultivation and consequent expansion of khat in the study area leads to a tangible effect on the livestock holding of the rural households.

Participation in off-farm and non-farm activities serves as a livelihood diversification strategy,

Table 5 Influence of khat cultivation on different farming activities using Kendall's tau_b correlation coefficient

Description of variable Kendall's tau_b		Effect of khat cultivation on other farming	Effect of khat cultivation on crop farming	Effect on livestock and grazing land	Effects on private forest land	Effects on fruit and vegetable farming
Effect of khat cultivation on other farming	Corr. coeff	1.000	− .991**	− .795**	− .952**	− .879**
	Sig (2-tailed)		.000	.000	.000	.000
	R^2 (coff. detr)	100%	98.21%	63.20%	90.63%	77.26%
Effect of khat cultivation on crop farming	Corr. coeff	− .991**	1.000	.780**	.944**	.874**
	Sig.(2-tailed)	.000		.000	.000	.000
	R^2 (coff.detr)	98.21%	100%			
Effect on Livestock and grazing land	Corr. coeff	− .795**	.780**	1.000	.803**	.823**
	Sig. (2-tailed)	.000	.000		.000	.000
	R^2 (coff.detr)	63.20%		100%		
Effects on Private Forest land	Corr. coeff	− .952**	.944**	.803**	1.000	.884**
	Sig. (2-tailed)	.000	.000	.000		.000
	R^2 (coff. detr)	90.63%			100%	
Effects on fruit and vegetable farming	Corr. coeff	− .879**	.874**	.823**	.884**	1.000
	Sig. (2-tailed)	.000	.000	.000	.000	
	R^2 (coff. detr)	77.26%				100%

Source Own survey results, 2017

**Correlation is significant at the 0.01 level (2-tailed)

Table 6 Mean comparison on the effect of khat cultivation on livestock composition of the households (N = 180)

Variables	Overall Mean	Overall SD	Paired	Mean	SD	t-test
Number of livestock owned by the household before khat cultivation in TLU_1	9.59	4.11	TotLvstk Pair 1	3.98	2.93	18.22***
Number of livestock owned by the household after khat cultivation in TLU_2	5.61	2.42				
Number of oxen owned by the household before khat cultivation in TLU_1	3.24	1.12	Oxen Pair 2	1.32	0.74	23.76***
Number of oxen owned by the household after khat cultivation in TLU_2	1.93	0.89				
Number of cows owned by the household before khat cultivation in TLU_1	3.53	2.03	Cow Pair 3	1.58	1.62	13.07***
Number of cows owned by the household after khat cultivation in TLU_2	1.95	1.05				
Households number of years of khat cultivation experience in year	11.13	5.62				

Source Own survey results, 2017

***Significant at 1% level of significance

particularly in the case of income scarcity of households. As opposed to what is anticipated, the participation in off-farm and non-farm activities had a positive and significant influence on the proportion of annual khat income of the farmers at a 1% significant level (Table 4). The marginal effect in beta regression analysis indicated that the proportion of annual khat income gained in khat cultivation would increase by 8.93% if the households' participation in off-farm and non-farm activities increased by one unit, ceteris paribus. The finding suggests that those households who have access to off-farm and non-farm activities

Table 7 Distribution of selected sample households for the study

Selected *Kebeles*	Total households of *Kebele*	Sampling frame		Number of sampled households		
		Male	Female	Male	Female	Total
Sebatamit	1234	1083	151	44	6	50
Ten/lagun	753	647	106	27	3	30
Woramit	1063	960	103	39	4	43
Zenzelema	1670	1431	239	49	8	57
Total	4720	4121	599	159	21	180

Source Study area WoA and KoA (2016)

are more likely to generate a higher income from khat cultivation than those who have no access. This could be because khat growers can afford to buy additional farm inputs to enhance their khat farm since it can alleviate constraints of liquidity and working capital on farmers' decisions for khat cultivation. This could give a higher yield of khat per plot of land that leads to generating a higher proportion of annual khat income and thereby improving the livelihood status of households. This finding corroborates with the work of Nigussie et al. (2018) who states that income received from off-farm employment activities had a positive and significant effect on farmers' decision to plant a greater number of apple trees in the Lay Gayent district of Ethiopia. A survey study conducted by Woldu et al. (2015) and Beyene et al. (2017) in Ethiopia also concurs with this finding. The authors found that expanding income sources beyond on-farm activities could push farmers away from on-farm activities and hence improve their food access, household economies as well as livelihoods.

The total value of household asset ownership had negative and significant influences on the proportion of annual khat income of the households at a 1% significant level (Table 4). This finding opposes the work of Kedir (2017) who found that the number of assets owned by a farmer had a positive and significant impact on the level of adoption of improved soya beans by the farmers at a 1% significant level. The result of Nijiru et al. (2013) and Kuma et al. (2016) opposes this finding who found that coffee-growing households with a higher percentage of household income increased the probability of producing khat and securing their food. This implies that a unit increase in the total value of household asset ownership in ETB (as standardized by 100,000) would likely decrease the proportion of annual khat income of farmers by 0.72%, keeping all other factors constant. This shows that households who have more assets are less likely to generate income from khat cultivation; rather they generate their income from crops and other sources. Hence, households might look at other income-gaining activities rather than generating income from khat cultivation as the households' wealth status increases. This may be linked to the social as well as cultural values of the study area.

Table 8 Cultivated land size and khat farm size in hectare and its ratio in percent (N = 180)

No	Kebele name	Cultivated land in ha	Khat farmland in ha	The ratio of khat farm/cultivated farm*100 (%)
1	Zenzelema	1860	522	28.06
2	Woramit	2900.75	846.15	9.17
3	Tenta laguna	1514	618.50	40.85
4	Sebatamit	1889	849	44.94
	Total	8163.75	2255.5	27.63

Source Kebele and Woreda Agriculture office report (Basic data), 2017

Access to mobile phones was used as a proxy indicator for khat market information and surprisingly has a negative and significant influence on the proportion of annual khat income of farmers at a 1% significant level (Table 4). This finding is in agreement with the finding of Lynn (2016) who confirmed that owning an external communication device (mobile phone or radio) does not significantly predict the decision to grow khat. As opposed to this finding, Abera (2015) pointed out that access to communication facilities was positive and statistically significant with participation in the haricot bean marketing at a 5% significant level. The negative sign for the variable "access to mobile phones" implies that farmers were located very close to the khat market center, and the marketing situation of khat was very volatile

even within half a day. Due to this nature, the need for mobile phones for farmers as a tool for khat market information was very limited. Hence, a unit increase in households' access to mobile phones decreases the proportion of annual khat income of farmers by 4.69%, all other factors are constant.

Conclusion

This study has attempted to assess the effect of khat cultivation on rural households' income around the Bahir Dar Zuria district. The sources of income for the livelihood of sampled households include farm, off-farm, and non-farm income. Of these sources, the sale of khat contributes the largest share (51%) followed by the sale of cereals (33%), sale of livestock and their products (9%), and off-farm and non-farm activities (7%). This shows that the economic advantage of khat has been higher than all other crops cultivated since the average income per hectare from khat sale significantly surpasses the average income gained from other sources in the study area. As a result, the livelihood status of khat growers has been improved and they were able to secure their needs in terms of food and non-food items. This could also justify the reason why most farmers in the study area are diversifying into khat production at the expense of food crop production, private forest land, and grazing lands. Thus, if carefully managed, this change has the potential to contribute to sustainable rural livelihoods and as a poverty-reduction instrument in the short run. However, as confirmed by different literature and our data, khat cultivation could have a negative implication on the groundwater table due to high water demands of the plant, land allocated for food crop production, livestock size, grazing land, forest land, the honey colony as well as on the health of farmers as they spray pesticides on their khat farm without proper protection (Table 5).In addition, it can be concluded that households are more likely to gain a higher proportion of annual khat income if they have more experience in khat cultivation, better education status, allocate a higher proportion of land for khat, invest more working capital, plant a greater khat density in their farm and participate in off-farm and non-farm activities. As opposed to these, households are less likely to generate a higher proportion of annual khat income if they have more livestock holding, possess more assets, and have more access to mobile phones (Tables 7 and 8).

The results of the focus group discussions with the target groups were consistent with the statistical findings that increased khat production in the Amhara region of Ethiopia would improve the livelihoods of the producers. This, in turn, would improve the livelihoods of the other groups of people who are indirectly engaged in khat production, marketing, and distribution. The participants of the focus group discussion have inferred that Khat-producers' purchasing power has increased and thereby created a market for other commodities and services. However, the international markets are closing their doors to khat which would negatively affect the inflow of foreign exchange to the country. This implies that the Amhara region of Ethiopia should work on finding other agricultural and non-agricultural alternatives. The bureau of agriculture should encourage Khat producers to allocate their lands to other cash crops and high-value fruits and vegetables that could compensate for the income of farmers and increase the foreign exchange earnings of the country.

The results of the statistical findings as well as the observation by the researchers have confirmed that khat is one of the most water-intensive crops and has serious implications for natural resource management in the region. The results of the focus group discussion with the participants have implied that access to irrigation is important for increasing the market value of khat, and proper management of irrigation water through establishing a water user association would solve the shortage of supply of water to the khat production. This would help to produce khat during non-traditional harvest seasons. Moreover, the bureau of agriculture of the Amhara region and the ministry of agriculture at the federal level need to encourage the import of sprinklers and pumps (with reduced taxes) that could save the current usage of irrigation water, which is traditionally made by flooding the farmlands.

Field observation and review of the empirical literature (such as Al-Motarrebet al., 2002; Belwal & Teshome, 2011; Beyene et al., 2017; Cochrane & O'Regan, 2016; Kandari et al., 2014; Kleina & Metaalb, 2010; Megeressa et al., 2014) have shown that there is no serious health problem related to increasing khat production from the farmers' point of view. However, findings from FGDs and literature review show that khat consumers are exposed to

serious health problems such as cardiovascular diseases, diabetes, blood pressure, and a reduction in the number of sperm cells. Besides, consumers could also develop additional habits such as smoking cigarettes, drinking alcohol, and unprotected sexual intercourse after consuming khat, which could worsen the negative health outcomes. Therefore, regional and federal governments should enhance the awareness of the youth on the negative effects of khat consumption, create employment opportunities and healthy recreational centers/facilities for the youth, and discourage its consumption by restricting its access to open market and its affordability. Therefore, researchers, policymakers, scholars, and higher learning institutions operating in the study area need to come together to understand and devise proper running mechanisms for the controversies of khat production in a proper context in association with its economic, social, cultural, and health implications.

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Data availability Data is available for this research and will be submitted upon request.

Code availability Not applicable.

Declarations

Conflict of interest The authors declare no conflict of interest in publishing this paper.

Appendix

See Tables 9, 10, 11, 12, and 13.

Table 9 Multicollinearity checks of a continuous variable (estatvif)

Variables	Using Spss-22	Using Stata - 14		Remark
	Tolerance	VIF	1/VIF	
AGE	.213	4.60	0.217379	
HHSZIMEQT	.503	1.87	0.533954	
FRMEXP	.204	4.83	0.207142	
PROLNDALKH	.500	1.91	0.523955	
TOTWKGCPTL	.428	2.01	0.496640	
TOTPHYSCPTL	.512	1.92	0.520526	
LVSCKHDG	.625	1.50	0.664550	
TOTHHAST	.490	1.77	0.565405	
DSRESIMKT	.613	1.47	0.681656	
DSFRMMRD	.479	1.83	0.547120	
AMTBRDMNY	.819	1.22	0.821967	
NoVisiPrYr	.744	1.16	0.859175	
Mean VIF		2.17		

Source Own survey results, 2017

Table 10 Contingency coefficient for discrete variables (N = 180) Using Stata - 14

Variables	SEXH	MRISTA	Educst	ACOFNO ~	ACCMOB
SEXHH	1.00				
MRISTATUS	0.97	1.00			
Educstatus	0.20	0.18	1.00		
ACOFNOFRMA~Y	0.01	− 0.01	− 0.17	1.00	
ACCMBL	− 0.25	− 0.24	− 0.14	0.09	1.00

Source Own survey result, 2017

Table 11 Hetroskedasticity test (hottest)

Breusch–Pagan/Cook–Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of PROKHINC
chi2 (1) = 0.78
Prob > chi2 = 0.3760

Table 12 Conversion factors used to estimate size of livestock ownership in TLU

No	Type of livestock	Conversion factors	Remark
1	Oxen	1.00	In TLU
2	Cows	1.00	In TLU
3	Heifer	0.75	In TLU
4	Young bull	0.34	In TLU
5	Calf	0.25	In TLU
6	Sheep	0.13	In TLU
7	Goat	0.13	In TLU
8	Donkey	0.70	In TLU
9	Mule	1.10	In TLU
10	Horse	1.10	In TLU
11	Camel	1.25	In TLU
12	Chicken	0.013	In TLU

Source Ramakrishna and Demeke (2002), Storck et al. (1991) cited in Mikinary (2008)

Table 13 Conversion factors used to compute labor force in man equivalent

No	Age group	Male	Female
1	< 10 years	0	0
2	10–13 years	0.2	0.2
3	14–16 years	0.5	0.4
4	17–50 years	1	0.80
	> 50 years	0.70	0.50

Source Storcket al. (1991) cited in Samuel Gebreselassie and Kay Sharp (2008) and in Mikinary (2008)

References

Abera, S. (2015). Determinants of haricot bean market participation: The case of East Badawacho District, Hadiya Zone, Southern Nations Nationalities, and Peoples Regional State. M.Sc. Thesis, Haramaya University, Haramaya, Ethiopia. Unpublished

Ahmed, B. (2016). What factors contribute to the smallholder farmers' farm income differential? Evidence from East Hararghe, Oromia Ethiopia. *Journal of Asian Scientific Research, 6*(7), 112–119.

Al-Motarreb, A., Baker, K., & Broadley, K. J. (2002). Khat: Pharmacological and medical aspects and its social use in Yemen. *Phytother Research, 16*(5), 403–413.

Anderson, D. M., Beckerleg, S., Degol, H., & Klein, A. (2007). *The Khat controversy: Stimulating the debate on drugs*. Berg.

Andersson, D. M., & Carrier, N. (2009). Khat in colonial Kenya: A history of prohibition and control. *Journal of African History, 50*, 377–397.

Apps, A., Matloob, S., Dahdal, M. T., & Dubrey, S. W. (2011). Khat: an emerging threat to the heart in the UK. *Postgraduate Medical Journal, 87*(1028), 387–388.

Belwal, R., & Teshome, H. (2011). *Khat export and the Ethiopian economy*: Opportunities, dilemmas and constraints. *African Journal of Business Management, 5*(9), 3635–3648.

Berhanu, M., Aregash, E., & Ali, M. (2014). Socio-economic impact of *Khat* in Mansa District, Jimma Zone, South Western Ethiopia. *Discourse Journal of Agriculture and Food Sciences, 2*(2), 21–32.

Beyene, W., Jennifer, C., Anders, D., Leon, B., & Tefera, B. (2017). Khat production and consumption; its implication on land area used for crop production and crop variety production among rural household of Ethiopia. *Journal of Food Security, 5*(4), 148–154. https://doi.org/10.12691/jfs-5-4-5

Birhane, B. W. (2014). The effect of Khat (Catha edulis) chewing on blood pressure among male adult chewers, Bahir Dar, North West Ethiopia. *Science Journal of Public Health, 2*, 461–468.

Cafer, A. (2016). Tef, Khat, and community resilience: A mixed methods examination of smallholder adoption of sustainable intensification practices. Ph.D. Dissertation Presented to the Faculty of the Graduate School at the University of Missouri-Columbia.

Cochrane, L., & O'Regan, D. (2016). Legal harvest and illegal trade: Trends, challenges, and options in khat production in Ethiopia. *International Journal of Drug*

Policy, 30, 27–34. https://doi.org/10.1016/j.drugpo.2016.02.009

CSA (Central Statistical Agency) (2017). Agricultural sample survey 2016/2017 (2009E.C). Report on area and production of major crops (Private Peasant Holdings, Meher Season). Statistical Bulletin 584 (Vol. I). Addis Ababa, Ethiopia.

CSA (Central Statistical Agency). (2020). Agricultural sample survey 2019/20 (2012 E.C.) Report on area and production of major crops (Private Peasant Holdings, Meher Season). Statistical Bulletin 587 (Vol. I). Addis Ababa, Ethiopia.

CSA (Central Statistical Agency). (2016). Agricultural sample survey 2015/2016. Report on area and production of major crops (private peasant holdings, Meher Season). Statistical Bulletin 584 (Vol. IV). Addis Ababa, Ethiopia.

Davis, K., Nkonya, E., Kato, E., Mekonnen, D. A., Martins, O., Miiro, R., & Nkuba, J. (2012). Impact of Farmer field schools on agricultural productivity and poverty in East Africa. *World Development, 40*(2), 402–413.

Dessie, G. (2013). *Current African issues: Favoring a demonized plant: Khat and Ethiopian smallholder- enterprises*. Current African Issues No. 51. Nordiska Afrika Institutet.

Dessie, G., & Kinlund, P. (2008). Khat expansion and forest decline in Wondo Genet, Ethiopia. *GeografiskaAnnaler: Series b, Human Geography, 90*(2), 187–203.

Duflo, E., Kremer, M., & Robinson, J. (2011). Nudging farmers to use fertilizer: Theory and experimental evidence from Kenya. *American Economic Review, 101*(6), 2350–2390.

Ewnetu, Z. (2008). Smallholder farmers' decision making in farm tree growing in the highlands of Ethiopia. A Dissertation submitted to Oregon State University, Oregon. Unpublished.

Ferrari, S., & Cribari-Neto, F. (2004). Beta regression for modeling rates and proportions. *Journal of Applied Statistics, 31*(7), 799–815.

Feyisa, T., & Aune, J. (2003). Khat expansion in the Ethiopian highlands: Effects on the farming system in Habro District. *Agricultural University of Norway Mountain Research and Development, 23*(2), 185–189.

Gebissa, E. (2004). *Leaf of Allah: Khat and Agricultural transformation in Hararghe, Ethiopia, 1875–1991*. James Currey Publishers.

Gebissa, E. (2010). Khat in the Horn of Africa: Historical perspectives and current trends. *Journal of Ethnopharmacology, 132*(3), 607–614.

Gebrehiwot, M., Elbakidze, M., Lidestav, G., Sandewall, M., Angelstam, P., & Kassa, H. (2016). From self-subsistence farm production to khat: Driving forces of change in Ethiopian agro-forestry home-gardens. *Environmental Conservation, 43*(3), 263–272.

Gebresilassie, L., & Bekele, A. (2015). Factors determining the allocation of land for improved wheat variety by smallholder farmers of northern Ethiopia. *Journal of Development and Agricultural Economics, 7*(3), 105–112.

Girma, T. (2017). Determinants of Chickpea and Haricot Bean Production and its resource use efficiency in Damot Gale and Halaba Districts, Southern Ethiopia. M.Sc. Thesis, Hawassa University, Hawassa, Ethiopia. Unpublished.

Gujarati, N. D. (2004). *Basic econometrics*. 4th Front Matter Introduction. The McGraw-Hill Companies.

Gyau, A., & Muthuri, C. (2016). The socio-economic potential of under-utilized species to smallholder farmers: The case of Khat (*Catha edulis*) in Ethiopia. *African Journal of Business Management, 10*(11), 279–287.

Habtamu, E. (2009). Ethiopia's khat: opportunity or threat? Retrieved November 11, 2016, from http://www.Ezega.com

Hailemariam, M. (2008). Social networks and sex dimensions in use of irrigation by farmers in Alamata woreda, Southern Tigray, Ethiopia MSc thesis Haramaya University. Unpublished.

Jack, K. (2013). *Market inefficiencies and the adoption of agricultural technologies in developing countries*. Agricultural Technology Adoption Initiative J-PAL (MIT)-CEGA (Berkeley). Retrieved December 20, 2021, from https://www.povertractionalb.org/sites/default/files/publications/ATAI%20Review%20Paper%20May%202013.pdf

Kandari, L. S., Yadav, H. R., Thakur, A. K., & Kandari, T. (2014). Khat (*Catha edulis*): A socio-economic crop in Harar Region, Eastern Ethiopia. *Springer plus, 2014*(3), 579.

Kedir M. (2017). Adoption and Impact of Improved Soybean (*Belessa-95*) Variety among smallholder Farmers in Bambasi Woreda, Benishangul Gumuz regional state. M.Sc. Thesis, Haramaya University, Haramaya, Ethiopia. Unpublished

Kleina, A., & Metaalb, P. (2010). A good chew or good riddance—How to move forward in the regulation of khat consumption. *Journal of Ethnopharmacology, 132*, 584–589.

Kothari, C. R. (2004). *Research methodology Methods and techniques* (2nd ed.). New Age International Publisher.

Kuma, T., Dereje, M., Hirvonen, K., & Minten, B. (2016). Cash crops and food security: Evidence from Ethiopian smallholder coffee producers. *The Journal of Development Studies, 55*, 1267–1284.

Liyew, M., Tsunekawa, A., Haregeweyn, N., Tsegaye, D., Adgo, E., Tsubo, M., Masunagaf, T., Almaw, A., Sultan, D., & Yibeltal, M. (2019). Exploring land use/land cover changes, drivers and their implications in contrasting agro-ecological environments of Ethiopia. *Land Use Policy, 87*, 104052. https://doi.org/10.1016/j.landusepol.2019.104052

Lynn, H. (2016). Impact of khat production on household welfare in Amhara region of Ethiopia. MSc thesis in College of Agriculture, Department of Agricultural Economics, Kansas State University.

Megeressa, B., Aregash, E., & Ali, M. (2014). Socio-economic impact of *Khat* in Mana District, Jimma Zone, South Western Ethiopia. *Discourse Journal of Agriculture and Food Sciences, 2*(2), 21–32.

Mendola, M. (2007). Farm household production theories: A review of "Institutional" and "Behavioral" responses. *Asian Development Review, 24*(1), 49–68.

MoFED. (2011). P. 4. *Annual report on Macroeconomic development*.

Municipality office (Mo). (2016). Annual reports of Bahir Dar city Administration Municipality office.

NBE (National Bank of Ethiopia) and MoR (Ministry of Revenue). (2020). Annual report (2019–2020) on macro economic and social indicators of Ethiopia. Retrieved December 2021.

Nigussie, Z., Fisseha, G., Alemayehu, G., & Abele, S. (2018). *Smallholders' apple-based agroforestry systems in the Northwestern highlands of Ethiopia*. Springer.

Nigussie, Z., Tsunekawa, A., Haregeweyn, N., Adgo, E., Nohmi, M., Tsubo, M., Aklog, D., Tsegaye, D., & Abele, S. (2016). Factors affecting small-scale farmers' land allocation and tree density decisions in acacia decurrens-based taungya system in FagitaLekoma District, North-Western Ethiopia. *Small-Scale Forestry, 16*(2), 219–233.

Nigussie, Z., Tsunekawa, A., Haregeweyn, N., Adgo, E., Nohmi, M., Tsubo, M., Aklog, D., Tsegaye, D., & Abele, S. (2017). Factors influencing small-scale farmers' adoption of sustainable land management technologies in north-western Ethiopia. *Land Use Policy, 67*, 57–64.

Njiru, N., Muluvi, A., Owuor, G., & Langat, J. (2013). Effects of khat production on rural household's income in Gachoka Division Mbeere South District Kenya. *Journal of Economics and Sustainable Development, 4*(2), 54–63.

Nyaga, J., Barrios, E., Muthuri, C., Öborn, I., Matiru, V., & Sinclair, F. (2015). Evaluating factors influencing heterogeneity in agroforestry adoption and practices within smallholder farms in Rift Valley, Kenya. *Agriculture, Ecosystems & Environment, 212*, 106–118. https://doi.org/10.1016/j.agee.2015.06.013

Ong'ayo, A. O. (2007). Khat (*Catha edulis*).

Rahmato, D. (2009). *The peasant and the state. Studies in agrarian change in Ethiopia 1950s–2000s*. Addis Ababa University Press.

Rivera, R. (2012). Khat cultivation in Ethiopia fuels economy reduces deforestation. *Forest News*. http://blog.cifor.org/8059/khat-cultivation-in-ethiopia-fuels-economy-reduces-deforestation?fnl=en

Rogers, E. (2003). *Diffusion of innovations* (5th ed.). Free Press.

Simpson, B. (2015). Planning for scale: Using what we know about human behavior in the diffusion of agricultural innovation and the role of agricultural extension. USAID, MEAS.

Smithson, M., & Verkuilen, J. (2006). A better lemon squeezer? Maximum-likelihood regression with beta-distributed dependent variables. *Psychological Methods, 11*(1), 54–71.

Tekelu, B., Joe, H., de Ven, V., Giller, K., & Descheemaeker, K. (2018). Home garden system dynamics in Southern Ethiopia. *Agroforestry Systems, 92*, 1579–1595. https://doi.org/10.1007/s10457-017-0106-5

Terefe, P. (2020). Khat marketing and its export performance in the Ethiopian economy. *Science Research, 8*(4), 90–97. https://doi.org/10.11648/j.sr.20200804.11

Tirusew, A., Enyew, A., & Selomon, A. (2020). Trends of land use/cover change in Kecha-Laguna paired micro watersheds. *Northwestern Ethiopia, Cogent Environmental Science, 6*(1), 1801219. https://doi.org/10.1080/23311843.2020.1801219

Woldu, Z., Belew, D., & Benti, T. (2015). The coffee-khat interface in Eastern Ethiopia: A controversial land use and livelihood change scenario. *Journal of Agriculture, Science and Technology, 5*(2015), 149–169. https://doi.org/10.17265/2161-6264/2015.03.001

Woreda Office of Agriculture (WoA). (2016). Annual reports of Bahir Dar Zuria Woreda Agricultural office.