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From staple food to market-oriented crop: commercialization level of smallholder *teff* (*Eragrostis teff*) growers in Jamma District, Ethiopia

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Abstract

Introduction: In countries like Ethiopia where the selling of staple food crops is the common way of earning cash income; the concept of agricultural commercialization is never restricted to cash crops. Among the staple food crops, *teff* is becoming a market-oriented crop in Ethiopia. This paper investigated the challenges, opportunities, and intensity of *teff* commercialization in the study area.

Methods: Data were collected from 155 randomly selected *teff* growers, four focus group discussion participants encompassing both women and men farmers, and twelve key informant interviewees from the local leader, development agents, and head of the Woreda agriculture office. Data were analyzed by descriptive statistics, Value of *teff* sale, Crop Output Market Participation Index (COMPI), double hurdle model, and qualitative data analysis.

Results: The average *teff* commercialization in terms of the value of *teff* sale by sample households was 6005 ETB (Ethiopian Birr). The double hurdle model result revealed that sex of the household head, application of agricultural inputs, and row sowing technology positively affected the commercialization decision of farmers in the *teff* output whilst the size of land allocated to *teff*, chemical fertilizer, row sowing technology, and frequency of contact with extension agents positively influenced the intensity of *teff* commercialization. Adjunct to this high input price, lack of input availability, and frost were identified as major hinders to *teff* production in the study area.

Conclusions: The finding of this study showed that there is a direct relationship between agricultural inputs utilization for *teff* and farmers' decision to commercialize it and the level of its commercialization. Therefore, the timely provision of agricultural inputs and possible subsidization of these inputs will increase the productivity of *teff* since farmland expansion is unthinkable due to scarcity of land. Moreover, the District office of agriculture should collaboratively work with the nearby research centers to reduce the problem of frost by introducing a frost-resistant variety.

Keywords: Commercialization, Double hurdle, Jamma district, Smallholder farmers, *Teff*

Background

Even though agriculture is a key sector in many developing countries, including Ethiopia; smallholder farmers, who constitute the bulk of the rural poor in these countries have not fully benefited from agriculture's income generation function (Hazell et al. 2007). This is because they mainly focus on consumption-oriented

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agricultural practices which exclude them from the market system. Thus, the transition from subsistence agriculture to commercial-oriented one is important to improve the income, consumption, and nutritional setup of the farm households (Tadele et al. 2017). Recently there is a growing interest in developing countries to transform their subsistence agriculture into market-oriented one, and it is an indispensable pathway for poverty reduction and food security enhancement of the farm households (Tadele et al. 2017). Ethiopia has adopted the commercialization of smallholder agriculture as a strategy for economic transformation which is indicated in the Growth and Transformation Plan II (NPC 2016). It is believed to accelerate the economic growth and development of Ethiopia and pave out farmers from absolute poverty (Tesso 2016).

Though there is a common agreement about the importance of Agricultural commercialization; there is a misconception on the term agricultural commercialization itself. According to Strasberg et al. (1999) a farm household is assumed to be commercialized when they produced a cash crop and allocate a proportion of their resource to marketable commodities. However, Alemu et al. (2007) disagree with this kind of definition and for them; agricultural commercialization is not only restricted to cash crops since staple food crops can also be marketed. This definition is true in Ethiopia because the production and selling of staple crops is the most common way of living for the Ethiopian masses (Tefera 2013).

Still, scholars are debating whether smallholder commercialization should aim at increasing the productivity and marketed surplus of staple food crops or on high-value crops (cash crops). According to Pingali et al. (2005) and Gebre-ab (2006), the production of a marketable surplus of staple food over what is needed for owns consumption is initially the most common form of commercialization in peasant agriculture. They argued that staple food crops have been produced for a longer period under the subsistence system and hence smallholders have the technical know-how and experience in the production of these commodities. On the other hand, Dolan and Humphrey (2000) claim that, though high-value crops are riskier; the benefit gained from them is clearly higher than those staple foods and farmers should have to focus on cash crops like high-value crops. Other authors consider agricultural commercialization as the proportion of agricultural production that is marketed regardless of the types of the crop (Govereh et al. 1999; Pingali et al. 2005). This definition is adopted in our current study to measure the degree of *teff* commercialization by smallholder farmers.

From the above debate, it is possible to say that, smallholder farmers can commercialize either staple crops or high-value crops based on the situation. What matters should have to be the comparative advantage of their local area. Thus, issues like agro-ecological conditions, levels of production, resource endowments (land, labor, and capital), and market environments should have to be taken into consideration.

Commercialization of *teff* can be appreciated in Ethiopia in general and in the study area in particular as the agro-ecological condition is suitable for the production of this crop. Ethiopia is the center of origin of *teff* which has been cultivated for thousands of years in high land parts of this country (Demeke and Marcantonio 2013). *Teff* is becoming the essential source of income for Ethiopian farmers (Bachewe and Taffesse 2015). The income farmers generate from this crop has been increasing over the past decade due to a growing global interest in *teff* (Hager and Arendt 2013). This is because it's gluten-free which makes it the latest super food of the twenty-first century after "quinoa" (Collyns 2013). There is a possibility of *teff* to be the second gift of Ethiopia to the world after coffee (Amentae et al. 2016). This indicates the future of *teff* growers is bright. Apart from the international demand; the opportunities for market-oriented production of *teff* in Ethiopia are now opening up as modernized market segments such as processing industries and supermarkets are created. The following two aspects make this study unique. First, the previous researchers on *teff* commercialization such as Gebreselassie and Sharp (2008) and Tura et al. (2016) consider the proxy of degree of commercialization in terms of the amount of *teff* sale (volume of sale in kilogram or quintal). Farmers' commercialization behavior, however, could not be assessed solely on the basis of the amount of product they supplied to the market, but also on the basis of their price forecasting and market network capacity, which could better catch up by using the value of product sale as a proxy for commercialization. The current study used the value of *teff* sales as a proxy of the degree of *teff* commercialization in the study area. Second, the literature overlooks the prospects of *teff* commercialization which can be elaborated by addressing the issue of challenges and opportunities available to the farmers with regard to the *teff* crop.

In the study area, *teff* is a widely produced crop. According to a 2018 report from the Jamma Woreda office of agriculture, the area allotted to *teff*, its yield, and price have all increased substantially in the last five years. The report indicated that the price of *teff* has risen from 2200 ETB in 2014 to 3800 ETB in 2018. In 2014, the average *teff* yield was 12 quintals per hectare, but by 2018 it had risen to 20 quintals per hectare. Similarly, the average hectare of land allotted to *teff* increased from 0.25

hectares in 2014 to 0.57 hectares in 2018 (JDOA 2018). This trend clearly shows *teff* is quickly becoming a commercial-oriented crop in the study area. Hence, studying to what extent farmers are participating in the selling of this crop and identifying factors influencing *teff* producers in the commercialization of this crop is vital. The aim of this study was therefore to generate shreds of evidence in the study area to provide insights for the concerned body to enhance the benefits farmers reap from the crop. The study addressed the following specific objectives:

1. Calculate the level of *teff* commercialization by smallholder farmers in the study area.
2. Prospects of *teff* commercialization via identifying the main challenges and opportunities of *teff* commercialization in the study area.
3. Identify the determinants of farmers' *teff* commercialization decisions and the intensity of their participation in *teff* commercialization.

Research methodology

Description of the study area

Jamma district is located in the North-Eastern part of Amhara National Regional State, South Wollo Zone, Ethiopia lying between 10°23′0″ and 10°27′0″ N latitude, and between 39°07′0″ and 39°24′0″ E longitude. The district has 22 kebele (Kebele is the smallest administrative unit in Ethiopia) administrations. Compared to other districts of the Zone, Jamma district has a relatively moderate climate that is suitable for *teff* production and has an average annual temperature of 21 °C. The total land area under cultivation in the district is about 40,320 hectares, of which 17,210 hectares; 16,201 hectares, and 2000 hectares were covered by *teff*, wheat, and vetch production respectively in 2017/18 (JDOA 2018.

Sampling techniques and method of data collection

The study district was selected purposively due to its potential for *teff* production. A multi-stage sampling method was employed to draw sample respondents. At the first stage, ten major *teff*-producing Kebeles were identified with the help of Development Agents. In the second stage, four Kebeles (Faji, Debre-guracha, Elshama and Shil-afaf) were selected randomly. Finally, a total of 155 *teff*-producing households were selected randomly by probability proportional to the size of the Kebeles household number (Table 1). The sample size was determined using the Joskow and Yamane (1965) formula since the population is homogenous in terms of the production system. Even though the sample size used in this study was small (155), it could be representative because of the homogeneity of farmers' production system.

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

where, n is the sample size for the study, N = Total number of *teff* producers in the district (25,827).

Both quantitative and qualitative data were collected from primary and secondary sources. The primary data sources were sampled *teff* producers, key informants, and focus group discussants (FGD) while the secondary data related to *teff* production such as general socio-economic information, major types of crops produced in terms of area coverage, area, and topography were acquired from Jamma district office of agriculture. The household head level primary data such as demographic, socioeconomic, and institutional characteristics of respondents were mainly gathered using the structured interview schedule. In addition, four FGD (one FGD per study Kebeles) consisting of women and men farmer participants and twelve key informant interviews with the local leader and development agents of each selected Kebeles, and the head of the Woreda agriculture office) were also employed. The structured interview schedule was used to collect the quantitative data while the qualitative data were collected by FGD and key informant interviews.

Method of data analysis

COMPI (Crop Output Market Participation Index), the value of *teff* sold in ETB (calculated as the amount of *teff* sold in quintal by the household multiplied by the average price of *teff*), inferential statistics such as chi-square and t-test, econometric model, and qualitative data analysis techniques were used. A Chi-square test was used to see the significant relationship between the market participant and non-participants with respect to dummy variables whereas the t-test was used for continuous variables. The value of teff sold was used to describe the level of teff commercialization by the sampled households. COMPI was used to calculate the teff commercialization level of smallholder farmers which is represented mathematically as follows:

$$\text{COMPi} = \frac{\sum_{k=1}^{k} P_k S_{ik}}{\sum_{k=1}^{k} P_k Q_{ik}} * 100$$

where S_{ik} is the quantity of *teff* output k sold by household i evaluated at an average community level price (Pk), Q_{ik} is total quantity of *teff* output k produced by household i.

Table 1 Distribution of sample households in the sample Kebeles by PPS. Source: Own computation 2018

Sample kebeles	*Teff* producers			Sample drawn			The proportion of sampled household
	MHH	FHH	Total	MHH	FHH	Total	Respondents (%)
Debre-guracha	709	205	914	20	6	26	17
Faji	1496	676	2172	46	16	62	40
Elshama	730	423	1153	21	12	33	21
Shilafaf	963	235	1198	27	7	34	22
Total	3898	1539	5437	114	41	155	100

The qualitative data were interpreted, explained, and narrated to complement the quantitative data.

Econometric model specification

About 31% (48 sample farmers) did not participate in the *teff* output market. In such cases, the Ordinary Least Square (OLS) model cannot be used as it creates inconsistency (Wooldridge 2009). Tobit, Heckman, or the double hurdle model is appropriate in the existence of zeros/non-participants. The Tobit model has a limitation in that it assumes the decision to participate and the quantity of supply is decided by farmers simultaneously which is aberrant from the real situation. The Heckman model was used to correct the sample bias. However, Heckman's sample selection bias was checked and there was no sample selection problem in the data as the lambda value ($p=0.395$) of the Heckman model was insignificant. Thus, the Double hurdle model was chosen over Tobit and Heckman model. The model has two hurdles. The first hurdle equation is estimated by a binary probit model given below.

$$D_i* = \alpha' Z_i + \upsilon_i, \tag{1}$$

$$D_i = 1, \textit{ if } D* > 0 \textit{ and } 0, \textit{ if } D \leq 0,$$

where D^* is a latent variable that takes the value 1 if the farmer sells *teff* and zero otherwise; and α is a vector of parameters, Z is an explanatory variables and υ is error terms.

The formal model of the second hurdle or level of participation equation is given as:

$$\Upsilon_i* = \beta' \chi_i + \mu_i \tag{2}$$

$$\Upsilon i = \Upsilon_i*, \textit{ if } \Upsilon_i* > 0 \textit{ and } D_i* > 0$$

$\Upsilon i = 0$ otherwise, where Υ_i* and Yi are latent and observed levels of participation in *teff* output market respectively. β is a vector of parameters to be estimated and χ_i is explanatory variables (demographic, socioeconomic, and institutional factors) influencing the households' level of participation in *teff* output market, while μ is error terms.

Variables definition, measurement, and hypothesis

Dependent variable

There is no single universally accepted definition for the term agricultural commercialization. But in general smallholder commercialization in agriculture can be seen from three angles (Tesso 2016): (i) Type of crops grown by smallholder farmers, (ii) from the goals of smallholder farmers' agricultural production, and (iii) smallholders' participation in input and output markets. The first one is debatable as discussed in the introduction part. From the goal point of view, agricultural commercialization is attained when a household product choice and input use decisions are made based on the principles of maximizing profit. However, in developing countries like Ethiopia, where agriculture is still at the subsistence level, farmers are yet not reached the stage of agricultural production for profit maximization, and hence commercialization in terms of market participation makes sense. Generally, the concept of smallholder commercialization involves two steps (Boka and John 2017). The first step is participation in the input and or output market and the second step is the level of participation in the market. Following (Boka and John 2017), smallholder *teff* commercialization is measured in this study in terms of market participation and the degree of market participants from the output side. Based on this concept of commercialization, the current study had the following two dependent variables.

Market participation decision of Teff producers (MPD) It is the binary dependent variable for the Probit stage of the double-hurdle model and takes value 1 if the household sold *teff* in the 2017/18 production year and 0 otherwise.

Level of market participation (LMP) It is a continuous positive variable that represents the value of *teff* sold by the household in the 2017/18 production season (truncated regression model).

Explanatory (independent) variables

The independent variables of the study were those which are hypothesized to have an association with the decision to participate and the extent of participation in the *teff* output market. Based on the findings of past studies on households' commercialization, the existing theoretical explanations, and the researchers' preliminary knowledge of the farming systems of the study area, the following explanatory variables were selected (Table 2).

The two variables, tropical livestock unit (TLU) and farmer participation in off/non-farm activities, were given a positive/negative anticipated sign. This was due to inconsistent findings in the literature where some finding revealed a positive association between these variables and farmer commercialization. For example, Abdi (2016) observed that TLU influenced maize commercialization positively at a 5% significant level, but Tura et al. (2016) found a negative relationship between TLU and the extent of *teff* sale. Similarly, *teff* growers' non-and or off-farm participation had a beneficial impact on the volume of *teff* sold (Tura et al. 2016). However, Abu et al. (2014) revealed that non-farm and/or off-farm participation had a favorable impact on farmers' market participation while having a negative impact on the amount of maize sold. As a result, this variable was undefined.

Result and discussion

Socio-economic characteristics of the respondents

69 percent of the 155 sampled respondents were *teff* market participants, while the remaining 31% were non-participants. Male-headed households made up 95 percent of the overall market participants, while female-headed households made up just 5% of the total market participants. The nature of the crop, being a cash crop, is typically linked with men, and *teff* is one of the cash crops in the research area, as a result, this discrepancy could occur. At the 1% significance level, the chi-square test demonstrates that there is a significant percentage difference in sex between individuals who participated in the *teff* output market and those who did not. *Teff* market participants had an average age of 41.74 years, while non-participants had an average age of 48.47 years, showing that younger farmers were more *teff* market participants (Table 3). Through the implementation of agricultural technologies, younger farmers can harvest higher-quality products for the market than older farmers (Sulo et al. 2012). At a 1% level of significance, the t-test result ($t=3.36$) suggests that there is a significant mean difference between the ages of *teff* market participants and non-participant families.

Literate families are expected to have greater abilities and make better use of information on their crop output; hence education is vital for a household's engagement in crop commercialization. In the sample, about 67.70 percent of household heads were literate (able to read and write), whereas the remaining 32.30 percent were illiterate (Table 3). Only 27% of literate households were non-participants in the *teff* output market, whereas 86 percent of literate households were market participants. At the 1% significance level, the chi-square test shows a significant percentage difference in literacy status between *teff* market participants and non-participant families. Land is a critical production factor in rural areas. On average, 0.72 ha and 0.25 ha were allocated for *teff* production by *teff* market participants and non-participants respectively. This implies that land is

Table 2 Description of independent variables hypothesized for analysis

Variables	Descriptions	Sign
Sex of household head	1 if the household head is male and 0 otherwise	+
Age of household head	Measured in number of years	−
Household size	Measured in terms of adult equivalent	−
Improved *teff* seed	1if household used improved *teff* seed, 0 otherwise	+
Land allocated for *teff*	Hectares of land allotted to *teff*	+
Literacy status	1 if household head is literate and 0 otherwise	+
Total livestock owned	Measured in TLU (Tropical Livestock Unit)	±
Participation in off/non-farm	1 If household participate in off/non-farm 0 otherwise	±
Credit use	1 if the household used credit 0 otherwise	+
Frequency of extension contact	Measured numbers of days per year	+
Chemical fertilizer application	1 If a household applied chemical fertilizer 0 otherwise	+
Row sowing of *teff*	1 if the household sow *teff* in row 0 otherwise	+
Access to price related market information	1 if household has access to market price information 0 otherwise	+
Distance from market center	Measured in kilometer	−

a scarce resource in the study area and those who have a larger portion of land had the opportunity to cultivate more *teff* output via allocation of more land for this crop which led to their high participation in the *teff* market. The result from the t-test indicated the significant mean difference between land allotted to *teff* by *teff* market participants and non-participants at the 1% significance level.

Livestock supports the livelihoods of a larger proportion of rural households in Ethiopia by serving as draught power, transportation, and means of asset saving (an indicator of status/wealth) in rural areas in addition to serving as a source of food and cash income. Market participants' and non-participants' average livestock holding was 5.10 and 3.20 TLU respectively (Table 3). Statistical analysis of the t-test result ($t = -4.27$) indicated that there was a significant mean difference between livestock owned by *teff* market participants and non-participant households at a 1% level of significance.

Institutional characteristics of households

Farmers' market participation was thought to be influenced by their distance from the market center where they frequently sold their *teff* product. Households in close proximity to the market center have more opportunities to participate in the *teff* market. This is because the greater the distance from the market center, the higher the expense in terms of time spent versus the value earned from *teff* sales, discouraging farmers from attending the market. *Teff* market participants' dwellings are located closer to the Degolo (the town of Jamma Woreda) market center. *Teff* market participants were 5.10 km away from the market center on average, while non-market participants were 8.90 km away (Table 3). The t- statistical result showed that there was a significant mean difference in terms of distance traveled by those who participated in the *teff* market and who did not at the 1% significance level.

The use of improved *teff* seed is an important variable in analyzing smallholder farmers' *teff* commercialization as the use of improved seeds would enhance *teff* productivity. *Kuncho/Debre-zeyit* and DZ354 were the two *teff* variety widely used in the study area. Regarding the utilization, 60% of the respondents did not use improved *teff* seed during the 2016/17 production seasons. Out of these, almost half of them (49.5%) were not supplied their *teff* produce to the market while 97% of farmers who used

Table 3 Description of variables by market participation status of *teff* producers

Variables		Total (N = 155) 155	Participant (n = 107)	Nonparticipant (n = 48)	t/χ^2-value
Sex of household (%)	Male	73.5	95	25	84.24[a]
	Female	26.5	5	75	
Age of household (year)		43.83	41.74	48.47	3.36[a]
Household size (AE)		3.96	3.9	4.12	− 0.184(NS)
Literacy status (%)	Literate	67.7	86	27	52.60[a]
	Illiterate	32.3	14	73	
Land allocated for *teff* (ha)		0.6	0.72	0.25	− 8.23[a]
Total livestock owned (TLU)		4.5	5.1	3.2	− 4.27[a]
Off/non-farm participation (%)	Yes	67	80.6	19.4	7.38[a]
	No	88	60	40	
Access to market information (%)	Yes	58	96.7	3.3	76.66[a]
	No	42	31	69	
Credit use	Yes	38	88	12	16.26[a]
	No	62	57	43	
Distance from market (km) center(km)		6.28	5.1	8.9	7.43[a]
Frequency of extension contact		10	13	4	− 8.60[a]
Chemical fertilizer (%)	Yes	73	89	11	80.77[a]
	No	27	14	86	
Improved *teff* seed (%)	Yes	40	97	3	37.20[a]
	No	60	50.5	49.5	
Row sowing of *teff* (%)	Yes	22	98	2	26.24[a]
	No	78	56.5	49.5	

[a] Represents level of significance at the 1% level of significance

this input participated in the *teff* market. The chi-square result showed that there was a significant percentage difference between market participants and non-participants in applying improved *teff* seed at the 1% level of significance (Table 3).

Row planting of *teff* is one of the newly introduced technologies aimed at increasing *teff* productivity in Ethiopia (Giziew and Mebrate 2019). Hence, utilization of this technology can enhance smallholders' participation in *teff* commercialization. Among those who applied the row sowing method of *teff*, 98% of them were a participant in supplying their *teff* produce to the market while out of those who did not use row sowing techniques of *teff;* only 56.5% of them were involved in *teff* market. The chi-square test value ($\chi^2 = 26.24$) was significant at the 1% significance level, implying there was a significant percentage difference between *teff* market participants and non-participant households in terms of sowing their *teff* in a row.

Major types of crop produced and land allocated by farmers for each crops

Though other types of crop produced are not the objectives of the study; they are included here to compare them with *teff* in terms of land allocation by smallholders. Smallholders are said to be market-oriented if they produce commodities that are more marketable. But under semi-commercial farmers, where both market and home consumption are playing a central role in the production decision, all crops produced by a household may not be marketed in the same proportion (Gerbremedhin and Jatela 2010). Thus, households could differ in their market orientation depending on their resource allocation (land, labor, and capital) to the more marketable crops (Gerbremedhin and Jatela 2010). Hence, the allocation of more land to a specific commodity is one of the important indicators of farmers' market orientation. In the study area, a mixed farming system of both crops and livestock is widely practiced, where crop production plays a major role in household income. The major crops produced in the study area are *teff*, wheat, barley, vetch, and spices. On average, 0.57 hectares ranging from a minimum of 0.06 to a maximum of 1 hectare of land were allocated by farmers for *teff* production for the 2017/18 production seasons (Table 4).

The study observed that the average land allotted to *teff* production in the Jamma district is lower than what has been reported by (Gebremedhin and Hoekstra 2009). Their result showed that households allocated on average about 1.20 hectares of land for *teff* production. This difference might occur due to the farmers in their study area might have large cultivated land as compared to landholding by households in the current study. As indicated in Table 4, the mean area of land allotted for *teff* by sample households was higher than the land allotted for other crops. This is in agreement with what has been said by key informants and focus group discussants. They reported that the allocation of more land for *teff* production is common to the study area as farmers reap more income from *teff* due to its high market price; implying *teff* is the most marketed crop by farmers than other commodities.

Commercialization level of smallholder *teff* producers

The level of *teff* commercialization by smallholder farmer's answers to what extent smallholder *teff* producers supplied their *teff* produce to the market? It was measured using the Crop Output Market Participation Index. The index is measured as the ratio of the quantity of *teff* sold to the quantity of *teff* produced by farmers in the 2017/18 production season. The result of COMPI showed that, on average, farmers in the study area supplied 37% of their *teff* output to the market ranging from a minimum of 0 to a maximum of 90%, where 0 imply the households that have been operating in full subsistence level (those who consumed/used 100% of their *teff* product at home) while 90% indicates the highest level of *teff* commercialization.

After calculating this index, households were categorized into different groups based on their level of commercialization and this helped to classify farmers as subsistence, semi-commercial (medium), and high commercial. Previous researchers categorized farmers as low, medium, and high commercial farmers if farmers supplied less than or equal to 30%, between 31 and 64%, and greater than or equal to 65% of their *teff* product respectively (Gebreselassie and Sharp 2008). The authors of this article also followed the same procedure as the commodity is similar (*teff*). Based on this, smallholders' *teff* producers' level of commercialization in the study area is presented in Table 5.

Table 4 Major crops produced by sample households, area allocated and value sold. Source: Own survey computation 2018

Type of crops	Average land allotted(ha)	Average value of crop sold(ETB)
Teff	0.57	4894
Wheat	0.36	1059
Barley	0.03	137
Vetch	0.10	116
Spices	0.04	108

Descriptive analysis result of value of *teff* sold

The value of *teff* sold by the household was calculated using the study area's average *teff* price at the time of data collection. According to the descriptive analysis result of this study, there is a significant disparity in how much money *teff* growers make from the crop. Table 6 shows that the average value of *teff* sold by the sample household was 6004.5 ETB ranging from no sale at all to 36,000 ETB. This maximum income generated may not be due to the quantity of *teff* sold, but rather to the ability of some farmers to wait for a good market price of *teff* to occur in the market. During the summer, when the supply of *teff* is low, the price of *teff* is usually high.

Challenges, opportunities, and prospects of *teff* commercialization in the study area (qualitative data analysis)

Four focus group discussions were conducted in each selected Kebeles. Adjunct to this three key informant interviews encompassing model farmers, Kebele leaders, and development agents was also conducted. According to the group discussants and key informant interviews, the main problem that hinders smallholder farmers in teff commercialization is a natural disaster (frost) that significantly reduced smallholder farmers' teff production.

One of the FGD participants said that "I was very much delighted when I have seen the seedling of my teff but later on I harvested nothing because of the frost problem." Another difficulty farmers grumbled during the FGD was the interference of the government in fixing the price of teff. According to them, the government orders the buyers not to buy teff from farmers above the fixed price. This implies farmers are price takers. The discussants said that "the price of teff is low due to government interferences in the market but on the reverse, the prices of inputs are skyrocket." This discourages them from applying agricultural input to increase the productivity of teff. They also added that the problem is not only the high input price but also the lack of input availability. According to them, farmers prefer the DZ354 teff variety because of its good yield and high biomass it provides which is used for their livestock feed but the supply of this variety in the study area is still an unsolved puzzle. Furthermore, they also rose that there is a problem of weight cheating by teff merchants/collectors. The retailers who bought teff from farmers using local weighing (usually glass) use very large glass but refuse to buy farmers' glass.

Generally, it is possible to understand that due to the major problems raised above; teff producers in the study area are unable to reap the benefit from the comparative advantage of the area through the production and commercialization of teff. Though there are challenges in teff production and commercialization in the study area; there is also a good opportunity that can encourage the teff growers. The first and most important opportunity is the comparative advantage of the district that is suitable for the teff production. As a result of this farmers have long-term accumulated experience in producing this crop. The increased demand for teff products locally and internationally is also another optimistic for farmers in the study area. For instance, apart from the local and district demand, recently big organizations like Wollo University is started buying teff from Jamma district.

If the challenges that farmers raised will be mitigated and due attention is given to increasing the productivity of *teff*; smallholder farmers' *teff* commercialization in the study area will be increased. This will improve the livelihood condition of smallholder farmers.

Econometric model result

Determinants of households market participation decision in teff market

Before running the model, outliers were checked by a box plot graph so that there was no problem with an outlier. Multicollinearity was also checked by the variance of inflation factor (VIF) and contingency coefficient (CC) for continuous and dummy variables, respectively and the test indicated that the largest VIFs value is 2.30 (Table 9) and that of CC is 0.63 (Table 10) indicating

Table 6 Descriptive result of value of *teff* sold

Variable	Obs	Mean	Std. Dev.	Min.	Max.
Value *teff* sold	155	6004.516	7652.166	0	36,000

Table 5 Degree of smallholders' *teff* commercialization in the study area. Source: Own survey 2018

Teff supplied to market by the farmers	Frequency	Percentage	Level of commercialization
Sale none of their *Teff* product	48	31	Fully subsistence
Supply less than 30% their *Teff* output	21	13.5	Low
Supply 31–64% of their *Teff* product	43	27.7	Medium
Supply more than or = 65%	43	27.7	High
Total	155	100	

that there was no serious problem of multicollinearity. A Robust standard error method was employed to correct the problem of heteroscedasticity. The result of probit estimation shows that the likelihood of households' participation in a *teff* output market was highly influenced by the following variables.

There was a positive and significant association between the sex of the household head and *teff* commercialization decision at 1%. This implies that male-headed households were more likely to participate in the *teff* market by about 8.2% higher than their female counterparts (Table 7). This could be because female-headed households face resource constraints like information (input and output market information), farmland, and capital in the *teff* production. Regarding information access, the women focus group discussants witnessed that "*we women farmers did not receive information related to input and output market on time due to our limited social network outside the home*" "*All chores such as food preparation, house cleaning and child care consume much of our time and not allow us to have social interaction outside of our home.*" The result is closely related to the research output of (Aman et al. 2014). The author found out that male-headed households were more likely to participate in horticultural crops marketing than female-headed households due to better access to resources such as labor, capital, and skill.

There was a direct relationship between farm size allocated to *teff* and households' *teff* commercialization decision at the 5% level of significance. The result showed that an additional one hectare of land allotted to *teff* would increase the probability of a household's *teff* commercialization decision by 2.2% (Table 7). This result is consistent with what had been reported by (Tura et al. 2016) who found a positive and significant association between additional units of land allocated to *teff* and farmers' market participation likelihood in *teff* output.

It was hypothesized that chemical fertilizer could affect farmers' participation in the *teff* market positively. The result was consistent with the hypothesis and significantly affected a 1%. Those households who applied chemical fertilizer to the *teff* production were more likely to participate in the *teff* market by about 5.7% more than the non-users (Table 7). This implies that the utilization of chemical fertilizer increased *teff* yield. The result is similar to (Alelign et al. 2017) stating that high output is a pre-condition to make the initial output market participation and chemical fertilizer is believed as an important element in boosting productivity.

Row sowing technology can play an important role in increasing yield and can enhance the farmers' commercialization decisions. Despite this, previous researchers ignored this important variable in their analysis.

Table 7 Probit regression result of double hurdle model for market participation. Source: Own survey 2018

Variables	Marginal effect	t
Constant		2.19
Sex of household head	0.0824105[a]	3.37
Age of household head	8.56e−06	0.07
Household size	− 0.0021982	1.52
Use of improved *Teff* seed	0.0133895[c]	1.76
Land allocated for *Teff*	0.0219398[b]	2.15
Literacy status of household head	0.0079807[c]	1.65
Livestock ownership (TLU)	0.0008381	1.49
Participation in off/non-farm	0.0016685	0.65
Credit use	0.000482	0.17
Frequency of extension contact	0.0001788	0.44
Application of chemical fertilizer	0.0574449[a]	2.99
Row sowing of *Teff*	0.0055501[b]	2.89
Access to price information	0.0022619	0.75
Distance from market center	0.0002241	0.58

Number of observation = 155

log likelihood = − 15.26

Pseudo $R^2 = 0.72$

Prob > $chi^2 = 0.0001$

Wald $chi^2 = 43.14$

[a–c] Represents statistical significance at 1%, 5% and 10% significant level respectively

The result of this study showed that farmers who sowed *teff* in a row technology had a more probability of market participation by about 0.55% than those who did not apply (Table 7). However, in the study area, farmers lag in applying the technology due to they believe that it demands additional labor and fertilizer. But, (Vandercasteelen et al. 2014) finding of cost–benefit analysis shows that *teff* yield outweighs the cost of labor needed for applying this technology by 8% or more. The finding of this author also revealed that row planting of *teff* would increase *teff* production by 0.70 tons per hectare compared to traditional broadcasting, with all inputs (improved seed and fertilizer) being equal. Thus, Extension workers in the area should have to work more on creating awareness and persuading farmers about the merit of adopting the row planting of *teff*.

Determinants of level of farmers' *teff* commercialization

To achieve this objective the truncated regression model was employed. The model was statistically significant at the 1% level of significance, indicating the goodness of fit of the model that the hypothesized variables explain the dependent variable by at least one explanatory variable. In this regard, five variables significantly affected the level of farmers' *teff* commercialization at the 1% level of significance and are discussed as follows.

The age of the household head had a favorable and substantial impact on the household's *teff* sales value at the 10% level of significance. The model's marginal effect indicated that when the household's age increased by one year, the value of their *teff* sale increased by 104 ETB (Table 8). This can be explained by the fact that as the household's age increases, so does their experience with *teff* prices. The outcome is in line with what Endalew et al. (2020) has reported. They claimed that as farmers' experience (age) grows, so does their ability to estimate prices and network with market actors, resulting in increased wheat output and quantity delivered to the market.

The size of land allocated to *teff* positively affected the value of farmers' *teff* sale at the 1% level of significance. The result showed that; an additional hectare of land households allocate to the *teff* production would increase the value of *teff* sale by 13,633 ETB (Table 8). This implies that the land is a critical factor of production in areas where farmers are not intensively using inorganic fertilization due to various reasons. The result is in line with the study done by (Tura et al. 2016) who found a positive and significant association between the size of land allotted for *teff* and the volume of *teff* sold.

Extension advice is a necessary tool in building the managerial capability of farmers. The model result showed that as extension advice with farmers increased by one day, the households' *teff* sale increased by 341 ETB (Table 8). This is due to keeping all other things constant, an extension advice increases farmers' knowledge and skill in increasing *teff* productivity by linking them with agricultural inputs as well as ways of their application. Cognizant of this, extension advice could advance farmers information-seeking habits regarding *teff* price. The result is in line with Tekalign (2014) who stated that extension advice is important for farmers to commercial transformation.

The use of chemical fertilizer by smallholder farmers in the study area was found to be positive and significantly affected the value of *teff* sales at the 1% significance level. The result revealed that keeping all other factors constant, on average farmers who used chemical fertilizer sold an additional 17,931 ETB *teff* value than the non-users (Table 8). This is expected since fertilizer could increase *teff* productivity and hence farmers can have more *teff* products available for the market. The result is similar to the study reported by Alelign et al. (2017). They found that there was a significant and positive impact of the use of chemical fertilizer on the intensity of crop sales.

Table 8 Result of truncated regression for the level of market participation (value of *teff* sold)

Value of *Teff* sale	Coefficient/marginal effect/	z/t
Sex of household head	1813.803	0.50
Age of household head	104.2746*	1.67
Literacy status	4044.844	1.35
Household size	− 573.0693	− 1.39
Livestock ownership (TLU)	− 92.33967	− 0.31
participation in off/non-farm	− 309.1895	− 0.94
Use of improved *Teff* seed	− 71.25863	− 0.05
Frequency of extension contact	341.3838***	3.13
Land allocated for *Teff*	13,633.6***	8.32
Application of chemical fertilizer	17,931.61*	1.81
Use of improved *Teff* seed	2327.36	1.57
Row sowing of *Teff*	2620.083*	1.92
Access to price information	1700.799	0.76
Distance from market center	− 155.0722	− 0.56
_cons	− 33,632.04	− 2.78
/sigma	4711.027	10.51

Number of observation = 107

Prob > chi2 = 0.0000

Wald chi2 (14) = 152.31

Log likelihood = -1006.7867

Row sowing of *teff* technology, as reported in the descriptive section of this study, could boost *teff* production, hence increasing the value of *teff* sales. Elemineh et al. (2020) reported that row sowing technology adopters produced 26.89 quintals per hectare of *teff*, whilst non-adopters produced only 14.85 quintals per hectare with a significant difference between them at the 1% level of significance (Table 8).

Conclusion

Despite the *teff* production potential of the district, a significant number of households (31%) did not take part in the *teff* commercialization. The average level of *teff* commercialization by sampled households was also not high (only 37%). In terms of the value of *teff* sale, on average the sample households sold a 6005 ETB. This study has identified various challenges and household-level determinants that contributed to this low farmer's *teff* commercialization decision and the value of *teff* commercialization. The result of the study generally revealed that increasing the productivity of *teff* is very crucial to improving both commercialization decisions and the

level of farmers' *teff* commercialization. This is because production-related variables such as the application of chemical fertilizer, use of improved *teff* seeds, size of land allocated to *teff,* and row planting technology of *teff* positively and significantly influenced farmers in the *teff* commercialization. Thus, encouraging farmers to apply these inputs in their *teff* production is vital through expanding the access and timely provision of these inputs. Row sowing of *teff* also had a positive effect on the value of *teff* commercialization. Extension workers should give more emphasis and encourage farmers to apply this technology via training and demonstration. The size of land allocated to *teff* is another variable that encouraged farmers' value *teff* commercialization. The policy should improve farmers' access to land by encouraging farmers' participation in land lease markets by setting suitable rules and regulations since the lease of land can allow the transfer of land from less efficient farmers to better efficient farmers. On top of all, the recommended and advisable path regarding farmland in any agricultural production is increasing productivity per unit area of land through proper utilization of land resources and promoting technologies that would increase the productivity of land than farm area expansion. FGD and key informant interviewee participants strongly urged the problem of frost in the study area. Therefore, the District office of agriculture should collaboratively work with the nearby research centers to reduce the problem of frost that seriously reduces the *teff* output by introducing a frost-resistant *teff* variety.

Appendix

See Tables 9, 10, 11, 12, 13

Table 9 Variance of inflation factor (VIF) for continuous variables. Source: Own survey 2018

Variable	VIF	1/VIF
Farm allocated to *Teff*	2.30	0.406573
Frequency of extension contact	1.92	0.520866
Distance from market center	1.80	0.555668
Total livestock unit(TLU)	1.73	0.579079
Household size	1.25	0.798049
Age of household	1.32	0.755190
Mean VIF	1.77	

Table 10 Contingency coefficient test for dummy variables. Source: Own survey 2018

	SEX	LIT	OFARM	CRED	FERT	SEED	ROW	MKTINF
SEX	1.0000							
LIT	0.4310	1.0000						
OFARM	0.1985	0.1842	1.0000					
CRED	0.2593	0.2567	0.1206	1.0000				
FERT	0.6217	0.4177	0.1217	0.2089	1.0000			
SEED	0.4001	0.4507	0.1914	0.3906	0.3496	1.0000		
ROW	0.3638	0.3351	0.0194	0.3790	0.2759	0.4068	1.0000	
MKTINF	0.5871	0.5323	0.1609	0.2893	0.6291	0.4537	0.3615	1.0000

LIT literacy status of household head, *OFARM* farmers participation in off and/non-farm activity, *CRED* households received credit, *FERT* fertilizer application by sample households, *SEED* improved *teff* seed, *ROW* row sowing techniques of *teff*, *MKTINF* access to market information on price of *teff*

Table 11 AIC and BIC of truncated model

Model	N	ll(null)	ll(model)	df	AIC	BIC
	107		− 1006.787	16	2045.573	2088.339

estat ic, Akaike's information criterion and Bayesian information criterion

BIC uses N = number of observations; See [R] BIC note

Table 12 AIC and BIC of Tobit model

Model	N	ll(null)	ll(model)	df	AIC	BIC
	155	− 1179.315	− 1046.014	16	2124.029	2172.724

estat ic, Akaike's information criterion and Bayesian information criterion

BIC uses N = number of observations; See [R] BIC note

Table 13 Result of Tobit regression model

Value teff	Coef	Std. Err	t	P > t	[95% Conf	Interval]
SEX	3205.993	1457.665	2.20	0.029	324.2904	6087.696
AGE	43.64754	36.85989	1.18	0.238	− 29.22194	116.517
LITERACY	1289.453	1092.94	1.18	0.240	− 871.2141	3450.12
HHSZ	− 523.7654	255.2122	− 2.05	0.042	− 1028.302	− 19.2284
TLU	− 56.37077	177.6859	− 0.32	0.752	− 407.6435	294.902
NOFARMPART	− 235.527	196.0859	− 1.20	0.232	− 623.1754	152.1214
USECRED	− 34.40656	834.7558	-0.04	0.967	− 1684.662	1615.849
FRQEXT	254.6285	77.77902	3.27	0.001	100.8647	408.3923
FARMSZT	11,771.12	1137.524	10.35	0.000	9522.311	14,019.92
FERTAP	2787.223	1494.653	1.86	0.064	− 167.6033	5742.049
IMPVSEED	2087.689	898.0168	2.32	0.022	312.3716	3863.007
ROWSOW	1846.169	887.2629	2.08	0.039	92.11078	3600.227
ACMKTINF	560.2546	1066.651	0.53	0.600	− 1548.442	2668.951
DSTMKT	− 0.6759819	151.2716	− 0.00	0.996	− 299.7295	298.3775
_cons	− 10,664.16	2809.856	− 3.80	0.000	− 16,219.06	− 5109.271
var(e.Valueteff)	1.53e+07	2,079,934		1.17e+07	2.00e+07	

Number of obs = 155

Uncensored = 107

Limits: lower = 0 Left-censored = 48

upper = + inf

Right-censored = 0

LR chi2(14) = 266.60

Prob > chi2 = 0.0000

Log likelihood = − 1046.0145

Pseudo R2 = 0.113

Abbreviations

FGD: Focus group discussion; PPS: Probability proportional to sample size; MHH: Male-headed household; FHH: Female-headed household; COMPI: Crop output market participation index; VIF: Variance of inflation factor; CC: Contingency coefficient; ETB: Ethiopian birr; AIC: Akaike's information criteria; BIC: Bayesian information criteria.

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Author contributions

GEG initiate the title of the study and contributed data collection, analysis, and write-up of the paper. TLT involved data analysis; edition of the paper, and approved the final version of the manuscript. CSA actively participated in designing the research objectives, data analysis, and edition of the paper and approved the final version of the manuscript.

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Availability of data and materials
The authors want to declare that they can submit the data at any time based on the publisher's request. The datasets used and/or analyzed during the study will be available from the authors at reasonable request.

Declarations

Ethical approval and consent to participate
Ethical clearance letters were received from Haramaya University, Department of Rural Development, and Agricultural Extension for the sake of care for both the study participants and the researchers. During the data collection time, official letters were distributed to each District and kebeles and informed consent was obtained from each client. Furthermore, sample respondents were approached friendly during the data collection period.

Consent for publication
Not applicable.

Competing interests
The authors revealed that they have no competing interests.

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References

Abdi E. Smallholder agro-pastoralists commercialization of major crop smallholder agro-pastoralists commercialization of major crop (maize and onion) in Fentalle District: the Case of Boset-Fentalle Irrigation Scheme, Ethiopia. Age. 2016;2:31–4. https://doi.org/10.11648/j.ijae.20160102.12.

Abu B, Osei-Asare YB, Wayo S. Market participation of smallholder maize farmers in the upper west region of Ghana. Afr J Agric Res. 2014;31:2427–35. https://doi.org/10.5897/AJAR201485.45.

Ademe A, Legesse B, Haji J, Goshu D. Smallholder farmers' crop commercialization in The Highlands of eastern Ethiopia. RAAE. 2017;2:30–7. https://doi.org/10.15414/raae.2017.20.02.30-37.

Aman T, Adam B, Lemma Z. Determinants of smallholder commercialization of horticultural crops in Gemechis District, West Hararghe Zone, Ethiopia. Afr J Agric Res. 2014;3:310–9. https://doi.org/10.5897/AJAR2013.6935.

Amentae T, Tura EG, Gebresenbet G, Ljungberg D. Exploring value chain and post-harvest losses of *Teff* in Bacho and Dawo Districts of Central Ethiopia. J Stored Prod Postharvest Res. 2016;7:11–28. https://doi.org/10.5897/JSPPR2015.0195.

Dolan C, Humphrey J. Governance and trade in fresh vegetables: the impact of UK supermarkets on the African horticulture industry. J Dev Stud. 2000;2:147–76.

Gebremedhin B, Hoekstra D. Stable food crops turning into commercial crops: case studies of *Teff*, wheat and rice in Ethiopia. Ethiop J Econ. 2009;17(1):1–22.

Gebreselassie S, Sharp K. Commercialization Of smallholder agriculture in selected tef-growing areas of Ethiopia. Ethiop J Econ. 2008. https://doi.org/10.4314/eje.v16i1.39824.

Giziew A, Mebrate B. Determinants of the role of gender on the adoption of row planting of tef [Eragrostis tef (Zucc.) Trotter] in central Ethiopia. Ethiop J Sci Technol. 2019;12(1):19–43.

Hager A, Arendt EK. Influence of hydroxypropylmethylcellulose (HPMC), xanthan gum, and their combination on loaf specific volume, crumb hardness, and crumb grain characteristics of gluten-free breads based on rice, maize, teff and buckwheat. Food Hydrocolloids. 2013;32(1):195–203.

Hazell P, Poulton C, Wiggins S, Dorward A. The future of small farms for poverty reduction and growth. Washington, DC: International Food Policy Research Institute; 2007.

Joskow J, Yamene T. Statistics, an introductory analysis. J Am Stat Assoc. 1965;60(310):678.

Tadele M, Getahun W, Tesfaye A, Chebil A, Solomon T, Haw-Hassen A, Debele T, Assefa S. Analysis of Wheat Commercialization in Ethiopia: The Case of SARD-SC Wheat Project Innovation Platform Sites. Afr J Agric Res. 2017;12(10):841–9. https://doi.org/10.5897/AJAR2016.11889.

Tesso G. Commercialization of smallholder farmers in light of climate change and logistic challenges: evidence from central Ethiopia. Glob J Econ Bus. 2016;1:13.

Tura E, Goshu D, Demisie T, Kenea T. Determinants of market participation and intensity of marketed surplus of *teff* producers in Bacho and Dawo Districts of Oromia State, Ethiopia. J Agric Econ Dev. 2016;5(2):020–32.

Alemu D, E Gebre-Medhin, Dejene S. From farmer to market and market to farmer: characterizing smallholder commercialization in Ethiopia. In: paper submitted for ESSP Policy Conference on "bridging, balancing, and scaling up: advancing the rural growth agenda in Ethiopia. Addis Ababa, Ethiopia". 2006.

Bachewe F, Taffesse AS. Dynamic supply response of farm households in Ethiopia. Ethiopian Strategy Support Program (ESSP), Ethiopian Development Research Institute (EDRI) and International Food Policy Research Institute (IFRI), Working Paper 78. 2015.

Boka G, John C. Climate Change Challenges, Smallholder Commercialization, and Progress out Poverty in Ethiopia. Working Paper Series N° 253, African Development Bank, Abidjan, Côte d'Ivoire. (253). 2017.

Collyns D. Quinoa brings riches to the Andes: the guardian. 2013;3–6

Demeke M, Marcantonio D. Analysis of incentives and disincentives for tef in Ethiopia. MAFAP, SPAAA. 2013.

Elemineh DAH, H-E Merie, Kassa M. Prevalence and associated factors of agricultural technology adoption and *teff* productivity in Basso Liben District, East Gojjame Zone, North West Ethiopia. 2020.

Endalew B, M Aynalem, F Assefa, Z Ayalew. Determinants of wheat commercialization among smallholder farmers in Debre Elias Woreda, Ethiopia, Hindawi. 2020.

Gebre-ab N. Commercialization of smallholder agriculture in Ethiopia. Ethiopian Development Research Institute, Notes, and Papers Series No. 3. Addis Ababa, Ethiopia. 2006;3.

Gerbremedhin B, Jatela M. Commercialization of smallholders: is market participation enough? Contributed paper presented at the joint 3rd African Association of Agricultural Economists (AAAE) and 48th Agricultural Economists Association of South Africa (AEASA) Conference, Cape Town, South Africa, September 19–23. 2010.

Govereh J, Jayne TS, Nyoro J. Smallholder commercialization, interlinked markets, and food crop productivity: cross-country evidence in eastern and southern Africa. The Department of Agricultural Economics and the Department of Economics, Michigan State University (MSU). 1999.

JDOA (Jamma District Office of Agriculture). Description of Jamma district. 2018 (**Unpublished**).

NPC. Growth and Transformation Plan II. National Planning Commission I (Gtp Ii). 2016;236.

Pingali P, Khwaja Y, Meijer M. Commercializing small farms: reducing transaction costs ESA working paper no. 05–08 commercializing small farms : reducing transaction costs. 2005;2:42.

Strasberg PJ, et al. MSU international development working papers food crop input use and. Agric Econ. 1999.

Sulo T, Koech P, Chumo C, Chepng'eno W. Socioeconomic factors affecting the adoption of improved agricultural technologies among women in Marakwet County Kenya. J Emerg Trends Econ Manag Sci. 2012;3:0.

Tefera A. Ethiopia: grain and feed annual report. 2013;1:15.
Tekalign D. Determinants and welfare outcomes of commercialization of smallholders' farming: the case of Anchar Woreda, West Hararghe, Ethiopia. MSc Thesis, Haramaya University, Haramaya, Ethiopia. 2014.
Vandercasteelen J, Dereje M, Minten B, Taffesse A. Perceptions, impacts and rewards of row planting of *teff*, LICOS discussion paper, no. 350, Katholieke Universiteit Leuven, LICOS Centre for Institutions and Economic Performance, Leuven. 2014.
Wooldridge J. Hurdle and 'selection' models." Michigan State University BGSE/IZA Course in Microeconometrics. 2009;1:48.

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