Coffee production constraints and opportunities at major growing districts of southern Ethiopia

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Abstract: The study was conducted in four zones (Sidama, Gedeo, Gamo Goffa and Wolayta) of South Nation Nationalities and Peoples Region (SNNPR) with the objective to assess coffee production constraints and opportunities at major coffee growing districts (Wereda) of the region. Two districts from each zone and two peasant associations from each district were selected for the study using multistage sampling technique. Total sample sizes of 161 households were interviewed to generate both qualitative and quantitative data. Data were analyzed by using SPSS software and descriptive statistics were implemented. The study indicated that about 98.1% of the respondents produce coffee as a major crop followed by maize (75.2%) and "enset" (68.3%). Coffee was identified as a primary source of cash in all assessed areas except Gamo Goffa where banana ranked first among cash crops. The most important constraints identified in coffee production system were clustered in to two major categories as biotic and abiotic factors that can be considered as agronomic and environmental. Among the biotic factors diseases, insect pests, weed species and vertebrate animals were identified as the most important ones. Recurrent drought, frost, fluctuating rainfall pattern, high humidity, high temperature, low moisture, hail, storm, wind and reduced soil fertility were among abiotic factors affecting coffee production that could cause as much as 70% yield loss.

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PUBLIC INTEREST STATEMENT
Coffee consisted of 55% of the total expert earning and about 20% of the population depends on coffee for their lively hoods. But its production and productivity was affected by different factors: among which diseases, insect pests, weed species, recurrent drought, frost, fluctuating rainfall pattern, heavy rain, high humidity, high temperature, low moisture, hail, storm, wind and reduced soil fertility were identified as the most important ones. Despite the constraints immense opportunities were observed. The existence of all weather roads, convenient topography, land, relatively favorable weather, water irrigation and convenient government policy, and support from agricultural offices were some of the opportunities that can be used as an advantage for the improvement of coffee production. Thus it is possible to improve coffee production and productivity by solving the constraints and using possible opportunities in the study areas and locations with similar agro ecologies.
Immense opportunities for the production, marketing and processing of coffee in the studied areas were also identified. The existence of all weather road, convenient topography, fertile land, relatively good climatic condition, water bodies for irrigation, convenient government policy and support from agricultural offices were some of the opportunities discovered. Thus, based on the information obtained, it is possible for farmers (producers) to improve coffee production and productivity by solving the constraints and using possible opportunities in the study areas and locations with similar agroecologies.

**Subjects: Agriculture & Environmental Sciences; Botany; Entomology**

**Keywords: abiotic; biotic; policy; production; productivity; SNNPRS empirical**

1. **Introduction**

Ethiopia is the center of origin for highland *coffea* (*Coffea arabica* L), which is one of the most valuable cash crops in the country. It represents the major agricultural export crop, providing 20–25% of the foreign exchange earnings (ECFF, 2015). The coffee sector contributes about 4–5% to the country’s Gross Domestic Product (GDP) and creates hundreds of thousands of local job opportunities (EBI, 2014).

In Ethiopia, 764863.16 ha of land was allocated for coffee production and 494574.36 tones were obtained with average productivity of 0.64 tones ha⁻¹ in 2018/19 Meher Season from which 30% of the total production belongs to South Nation Nationalities and Peoples Regional State (SNNPR) (Central Statistical Agency [CSA], 2019). From top 25 coffee producing districts in Ethiopia, Oromia dominates with 18 coffee producing districts and the remaining top coffee producing districts are located in South Nations, Nationalities and Peoples Regional State (James et al., 2015).

Ethiopian coffee sector has bright prospects (Jose, 2012). The country has suitable altitude, optimum temperature, sufficient labor and fertile soil. It can sustainably produce and supply fine specialty coffee with potential of producing all coffee types of the various world coffee growing origins. Other opportunities of coffee production in Ethiopia are: high national and international demand for the product, increasing interest of private sector with high investment potential, high support by both regional and federal governments (Berhanu, 2017). Coffee, the backbone of Ethiopia’s economy, is the most important export commodity. During 2017/18 marketing year alone Ethiopia registered a record almost 917 million US dollars from coffee exports (United States Department of Agriculture [USDA], 2019).

In Ethiopia, coffee grows at various altitudes, ranging from 550 to 2,750 m above sea level. However, Arabica best thrives and produced between altitudes of 1,300 and 1,800 masl, annual rainfall amount ranging from 1,500 to 2,500 mm with ideal minimum and maximum air temperature of 15 and 30°C, respectively (MOA, 2013). Despite very high variability and large number of varieties released in the country most of the farmers still using their land races. Moreover, officially released varieties are also location specific. The average green coffee bean yield per hectare per year is 0.7 t ha⁻¹ which is bay far lower than the world average and the average of Brazil 0.8 and 1.3 t ha⁻¹, respectively (FAOStat, 2012). The total area coverage of coffee in Sidama, Gedeo, Wolayata and Gamo Goffa were 73030.04, 38487.25, 11913.82 and 5889.58 ha, respectively. The yield obtained per annum in Sidama, Gedeo, Wolayata and Gamo Goffa, respectively, were 50433.47, 21120.96, 5573.32 and 2634.27 tones with the average productivity of 0.64 t ha⁻¹, which is still lower than the world average (Central Statistical Agency [CSA], 2016). This might be attributed to different physical, biological and manmade factors; one of which is the lack of high yielding varieties at the farmers’ hand. Biological and institutional factors also play greater role in coffee production. Diseases, insect pest, poor access to market information, lack of physical
infrastructure, lack of improved coffee variety and poor extensions services were the major constraints of coffee production (Fekede & Gosa, 2015).

In addition, poor management practices, low soil fertility and poor pricing are considered as major constraints of coffee production. The changes in climatic conditions are also predicted to profoundly influence the population dynamics and the status of agricultural insect pests and diseases development. The increase in temperature has a strong and direct influence on insect development, reproduction and survival (Ward & Masters, 2007).

Coffee diseases cause considerable losses when not treated. According to Cerda et al. (2017), 57% yield loss was observed by the infection of disease causing organisms on coffee crop. Jima et al. (2017) also reported that the most economically important pathogenic coffee diseases are coffee berry disease (CBD), coffee wilt disease (CWD) and coffee leaf rust (CLR), and physiological disorder like coffee branch die back is caused by pseudomonas syringe and non-pathogenic agents. Similarly, CBD and branch dieback were causing high yield loss of coffee production. In the same way, insect pests such as Anthestia bug and coffee blotch miner are the major ones causing considerable damage. The assessment carried out in Eastern Ethiopia indicated that diseases and insect pests are causing considerable crop losses. CBD is major disease observed while CWD was considered as minor on few farmers’ coffee farms. Similarly, major insect pest that affects coffee production in Eastern Ethiopia were coffee stem borer and coffee berry borer. On the other hand, insect pests such as coffee trips, green scale and coffee cushion scale were reported as important coffee production constraints in the country (Fekede & Gosa, 2015).

A lot of coffee productions, processing and marketing problems assessments were made in Ethiopia. But they are not able to cover all coffee producing areas in the country in general and southern Ethiopia in particular. Thus this activity was carried out to cover untouched coffee producing areas of the southern Ethiopia and came up with possible solutions for the problems and recommendations for the opportunities. Hence agronomic, socio economical and environmental challenges and opportunity in coffee growing areas of Southern Regions of Ethiopia need to be studied, gap identified, documented for further utilization and recommendation of appropriate solutions. Thus this paper was aimed to compile the results obtained through the assessment of agronomic and social economic problems of coffee production at major growing districts of Sidama, Gedeo, Wolayta and Gamo Goffa Zones of SNNPR.

2. Materials and methods

2.1. Descriptions of the study area

Field survey was conducted in four zones of the region: Sidama, Gedeo, Wolayta and Gamo Goffa. Sidama, Gedeo, Wolata and Gamo Goffa are located 285, 365, 385 and 515 km, respectively. The zone centers are Hawassa, Dilla, Sodo and Arbaminch, respectively (Figure 1).

2.2. Sample size and sampling techniques

The study employed multi-stage sampling method. Districts and kebeles (PAs) were selected purposively in collaboration with zonal and district agricultural and natural resource management office based on coffee production potential. Accordingly, Dale and Loka Abaya from Sidama, Dilla Zuria and Wonago from Gedeo, Sodo Zuria and Humbo from Wolayata and Arbaminch Zuria and Mirab Abaya from Gamo Goffa were selected. The districts were selected from higher (1,800–2,000 masl) and lower altitude of coffee growing districts (1,200–1,800 masl). The kebeles (PAs) from each district selected purposively (Table 1). About 10 farmers from each PAs and a total of 161 households were selected from all districts by simple random sampling method.
2.3. Data sources, method of data collection and data analysis

2.3.1. Data source
The study utilized both primary and secondary data sources. Primary data was conducted by using structured questioner and GPS supported field observation in the form of survey.

2.3.2. Method of data collection
The questioner was pre tested and validated before the inception of actual work. The secondary data was collected from unpublished and published documents of zonal and district agricultural and natural resource management offices. General information of the respondents like sex, age, marital status, educational level, family size and number of family members engaged in agriculture; crops grown in the study area; coffee production system like varieties produced and experience of implementing improved practices, area covered by coffee crop, age of coffee trees own by individual farmers; coffee production problems like biotic factors such as disease, insect pests, vertebrate animals, common and invasive weeds, abiotic (environmental factors) such as drought, rainfall, soil fertility, wind, flooding, etc.; technical constraints and their management techniques were collected. Agro meteorological data was obtained from the nearby station of Ethiopian meteorological agency. Disease, insect pest identification and weed identification were made by collaborative work of farmers and experts from office of agriculture. Some data were collected from secondary sources to strengthening the observation.

2. Data analysis
Data were analyzed by using SPSS software version 12 developed by Morgan et al. (2004). Descriptive statistics such as mean, Mode, Median, frequency distribution and percentage were employed to understand socio-economic situation, constraints and opportunities of coffee production in the studied areas based on the data type.

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\text{Mean} = \frac{\text{Sum of observations}}{\text{Total number of observation}}
\]

Mode is the value that appears in the data more frequently.

Median is the most middle value when the data is arranged in descending or ascending order.
| Zone     | Woreda       | Kebele              | Altitude masl | Latitude            | Longitude        | Mean annual T (°C) | Mean annual rainfall (mm) |
|----------|--------------|---------------------|----------------|---------------------|------------------|--------------------|--------------------------|
| Sidama   | Loca Abaya   | Areda Gale          | 1,690          | 06°41’26.21" N     | 38°15’47.94" E   | 18.9               | 1235                     |
|          | Dessei       |                     | 1,633          | 06°43’34” N        | 038°18.440” E    |                    |                          |
|          | Dale         | Mato                | 1,798          | 06°47’21.1" N     | 38°25’59.7” E    |                    |                          |
|          |              | Bera Tedicho        | 1,814          | 06°42’36.0” N     | 38°24’36.5” E    |                    |                          |
| Gedeo    | Dilla Zuria  | Gollia              | 1,770          | 06°24’18.9” N     | 38°19’52.1” E    | 20.6               | 1129                     |
|          |              | Chichu              | 1,545          | 06°21’50.1” N     | 38°18’16.9” E    |                    |                          |
|          |              | Tumata cherecho     | 1,710          | 06°19’05.2” N     | 38°16’9” E       |                    |                          |
|          |              | Hasse Haro          | 1,770          | 06°24’18.9” N     | 38°19’52.1” E    |                    |                          |
| Wolayta  | Sodo Zuria   | Gilo Bisare         | 1,862          | 06°50’13.5” N     | 37°50’17.258” E  | 20.5               | 1263.9                   |
|          |              | Waje Kero           | 1,932          | 06°52’35.162” N   | 37°44’04.74” E   |                    |                          |
|          | Humbo        | Shochora Abala      | 1,708          | 06°40’34.7” N     | 37°44’24.40” E   |                    |                          |
|          |              | Kado Kanko          | 1,718          | 06°40’03.7” N     | 37°43’54.51” E   |                    |                          |
| Gamo Goffa| Mirab Abaya  | Mole                | 1,199          | 06°17’06.84” N    | 37°43’50.33” E   | 25.3               | 1485.9                   |
|          |              | Debo                | 1,229          | 06°17’33.63” N    | 37°45’35.7” E    |                    |                          |
|          | Arbaminch Zuria| Chanomile         | 1,194          | 06°06’54.55” N    | 37°36’40.60” E   |                    |                          |
|          |              | Ochola Lante        | 1,194          | 06°08’11.092” N   | 37°39’04.194” E  |                    |                          |

*Data obtained from Hawassa, Dikka, Sodo and Arbaminch meteorological stations.
Frequency is the number of times that each data appear in the observation.

Percent is the proportion of a given observation divided by a total number of observations and expressed in hundredth.

3. Results and discussion

3.1. General information of the respondents

3.1.1. Area studied

As shown in Table 1, the study was conducted in Sidama, Gedeo, Gamo Goffa and Wolayta Zones. In Southern Ethiopia, they are known in coffee production, processing and marketing. In Sidama, 73030.04 hectares of land was covered by coffee with the total production of 50454.44 tones of clean coffee and productivity of 0.89 t ha\(^{-1}\). Gedeo produces a total of 24121.0 t ha\(^{-1}\) clean coffee on 38473.3 hectares of land with the productivity of 0.63 t ha\(^{-1}\). Wolayta and Gamo Goffa allocated 11913.8 and 5889.6 hectares of land for coffee production, respectively. From these areas of land about 8207.6 tonnes of clean coffee with the average productivity of 0.46 t ha\(^{-1}\) was obtained (Central Statistical Agency [CSA], 2018).

3.1.2. Sex, age, marital status and educational level

About 95% of the responding farmers were male and most of them were married (97.5%). This value slightly varied with the location. In Sidama, Gedeo, Wolayta and Gamo Goffa, 95%, 97.6%, 92.5% and 95% of the respondents, respectively, were male. All the respondents in Sidama and Wolayta but 97.6% and 92.4% in Gedeo and Gamo Goffa, respectively, were married. The respondents were found with the age ranges 20–70 years. Nonetheless the higher proportion of the respondents was included in the age range of 30–40 years (Table 2), which is under the cluster of working age group (OECD, 2020). In the same way, about 95.7% of the respondents were educated. This indicated that majority of coffee producers in the study area were educated which in turn could help to boost production and productivity of coffee. The value of educational level varied with the location (Table 3) as Sidama and Wolayta zones comprised the highest proportion of educated person above grade 8 (37.5%) followed by Gedeo. This might be the contribution of construction and expansion of educational institutes in the region. Education is very important factor which helps farmers to understand and implement the information received from any direction (Jima et al., 2017).

3.1.3. Family size of the respondents

Family size of the respondents ranged from 7.2 to 9.1 with the higher family size in Sidama (9.1) followed by Gedeo (8.2). Gedeo and Wolayta had almost the same average family size of 8.2 and 8.1, respectively. The family size of Gamo Goffa was a bit lower than the other locations. On average the family size per family of coffee producing areas of Gamo Goffa was 7.2, which were by two units lower than Sidama and by one unit lower than Gedeo and Wolayta Zones (Table 4). These values are higher than the average household family size of the country, 4.6 persons per family (United nations [UN], 2017; Demographic and Health Survey [DHS], 2017). However, in the present finding the family size recorded is higher than the family sizes reported from Wolayta, 5–7 per family (Tesfatsion, 2016), and from Sidama the average household size of 5.87 per family (reported by Nigatu & Barbara, 2011). Similar study was conducted by Jima et al. (2017) in Oromia region of Aris Zone reported a family size of 2–18 with mean and standard deviation of 7.96 and 3.13, respectively (Jima et al., 2017).

3.1.4 Family members engaged in agriculture

In all assessed locations, all family member engaged in agricultural activity either as full time or as part time. In all locations, two of the family members were fully engaged on agricultural activity, which accounts for 55%, 58.5%, 50% and 70% for Sidama, Gedeo, Wolayta and Gamo Goffa zones, respectively. Whilst the rest of the family members with the exception of under aged kids (less
| Zone        | Sex of the respondents | Marital status | Age in years |
|------------|-------------------------|----------------|--------------|
|            | M | F | Mar | Sin | Wid | 1–20 | 20–30 | 30–40 | 40–50 | 50–60 | 60–70 | >70 |
| Sidama     | 95 | 5 | 100 | 0   | 0   | 0    | 15    | 35    | 30    | 15    | 0    | 5    |
| Gedeo      | 97.6 | 2.4 | 97.6 | 2.4 | 0   | 0    | 4.9   | 34.1  | 41.5  | 12.2  | 4.9  | 2.4  |
| Wolayta    | 92.5 | 7.5 | 100 | 0   | 0   | 0    | 12.5  | 45    | 27.5  | 15    | 2.5  | 0    |
| Gamo Goffa | 95 | 5 | 92.5 | 2.5 | 5   | 0    | 10    | 32.5  | 25    | 30    | 2.5  | 5    |
| Total (%)  | 95 | 5 | 97.5 | 1.25 | 1.25 | 0    | 10.6  | 36.6  | 31.1  | 18    | 2.5  | 3.1  |

Note: M = male, F = Female, Mar = Married, Wid = Widowed.
than 5 years old) engaged in agriculture as part time work. Under this cluster in Sidama, three of the family members (25%); in Gedeo, Wolayta and Gamo Goffa zones two of the family members with the proportion of 22%, 12.5% and 15% engaged in agricultural activities as a part time work (Table 5). This maximized the use of family labour in agricultural activity and reduces labour cost that perhaps would have encored employed with higher price which has great impact on coffee production. Susana (2006) reported that the comparative advantage of smallholder families for labour intensive production is unremunerated family labour and family labour is an important source of manpower in agriculture. While small coffee plantations are able to cope with the scarcity of agricultural labour by a substitution of family labour, medium and large coffee plantations are facing distinct problems to fetch manpower resources, putting the viability of the sector at stake (Akarsha & Hartmann, 2009).

3.2. Major crops grown in coffee-based farming system

A number of annual and perennial crops are produced for cash and family consumption in assessed areas. Among which, avocado, banana, bull heart (Annona escumous), cabbage, carrot, cassava, Chat, chick pea, common bean, Enset, ginger, kale, kororima, maize, mango, Papaya, peach, pepper, potato, sugar cane, sweet potato, taro, teff, tomato and yam are the most common ones produced in the assessed areas. Although the range of diversity of the crops produced varies with the agroecological condition, the farming system can be seen as diversified production

| Table 3. Educational level of the respondents across locations |
|-------------------------------------------------------------|
| Zone | Educational status | Illiterate | Read and write | 0–4 | 4–8 | 8–12 | > 12 | Others* |
|------|--------------------|-----------|----------------|-----|-----|------|------|---------|
| Sidama | | 0 | 15 | 7.5 | 40 | 32.5 | 5 | 0 |
| Gedeo | | 2.4 | 19.5 | 4.9 | 41.5 | 26.8 | 0 | 4.9 |
| Wolayta | | 0 | 10 | 25 | 25 | 30 | 7.5 | 2.5 |
| Gamo Goffa | | 15 | 15 | 32.5 | 22.5 | 7.5 | 2.5 | 5 |
| Total (%) | | 4.3 | 14.9 | 17.4 | 32.3 | 23.6 | 3.7 | 3.1 |

*Others = those trained TVT and 10 +.

| Table 4. Average family size of the respondents |
|-----------------------------------------------|
| Category | Sidama | Gedeo | Wolayta | Gamo Goffa | Average |
|---------|--------|-------|---------|------------|---------|
| Wives | 1.025(0.025)** | 1.024(0.04) | 1.18(0.07) | 0.98(0.03) | 1.05(0.02) |
| Husbands | 1(0) | 1.05(0.03) | 1(0) | 0.95(0.35) | 1(0.01) |
| Family size son | 3.05(0.24) | 2.68(0.2) | 3.2(0.25) | 2.55(0.2) | 2.87(0.11) |
| Family size daughter | 2.95(0.34) | 2.80(0.36) | 2.73(0.26) | 2.28(0.21) | 2.69(0.15) |
| Family size others* male | 0.68(0.19) | 0.49(0.13) | 0.05(0.35) | 0.18(0.08) | 0.35(0.06) |
| Family size others female | 0.48(0.18) | 0.44(0.12) | 0.13(0.08) | 0.25(0.18) | 0.32(0.07) |
| Family size male total | 4.7(0.29) | 4.1(0.23) | 4.18(0.26) | 3.55(0.21) | 4.13(0.13) |
| Family size female total | 4.4(0.37) | 4.15(0.37) | 3.95(0.34) | 3.63(0.23) | 4.03(0.17) |
| Total family size | 9.1(0.51) | 8.2(0.42) | 8.13(0.43) | 7.18(0.33) | 8.15(0.22) |

*Includes servants, son and daughters of relatives, brothers/sisters of wives/husbands. ** Values in the bracket refer standard error of means.
system (Table 6). Similar observation was made in Oromia which is the neighboring region of the study area where sampled respondents stated that coffee was intercropped with different annual crops such as Maize (69.8%), Sorghum (20.7%), Potato, Onion, Hot Pepper, Groundnut, Sweet Potato, Teff and Tomato were accounted for the remained percent (Jima et al., 2017). Fikadu et al. (2015) also indicated major crops produced intercropped with coffee in Sidama, Wolayta and Gamo Goffa zones. Most of the crops produced in the assessed areas were used for home consumption with very few exceptions. In Gamo Goffa, most of the farmers (60%) produced banana (Ba1) as a source of cash followed by coffee (Co1) (10%) from which they could earn about 7,200 birr per house hold (CSA, 2016, Alemu, 2017). Unlike Gamo Goffa, coffee stands the primary source of cash in, Sidama, Gedeo and Wolayta accounting for 80%, 92.7% and 57.5% of the total interviewed farmers respectively. Small proportion of farmers used khat (ch1), maize (Ma1), avocado (AV1), common bean (CB1), pigeon pea (Pp1), taro (Ta1), teff (Te1), cotton (Cot1), mango (Man1) and sweet potato (Sp1) as primary sources of cash (Figures 2–6). The finding also confirmed the report made by Worako et al. (2015) that 94.32% of household income of Sidama belongs to coffee. Wolassa (2013) who stated that coffee has been the major source of income for the rural households in the coffee producing regions of Sidama. Gurmu et al. (2015) reported that the primary source of income in Sidama, Wolayta and Gamo Goffa was crop production that accounts for 83.3% of the total production.

### 3.3. Coffee production

#### 3.3.1. Composition of coffee varieties and improved agronomic practices implemented

The assessment result indicated that about 95%, 53%, 100% and 70% of the respondents in Sidama, Gedeo, Wolayta and Gamo Goffa, respectively, produce improved coffee varieties. However, a great proportion (66%) of farmers was producing both improved and local varieties with the range of 40% in Gamo Goffa to 98% in Wolayta (Table 7). This might be due to the peculiar behavior of local varieties. The local coffee variety development strategy (Bayetta Belachew & Labouisse, 2006) identified coffee varieties that can be known by their natural resistance to major diseases, high yielding performance and peculiar quality and typicity (Desse

| No. | Sidama (Dale and Loka Abaya) | Gedeo (Dilla Zuria and Wonago) | Wolayta (Sodo Zuria and Humbo) | Gamo Goffa (Arbaminch Zuria and Mirab Abaya) |
|-----|-------------------------------|--------------------------------|-------------------------------|---------------------------------------------|
|     | Full time | Part time | Full time | Part time | Full time | Part time | Full time | Part time |
| 0   | 7.5       | 25.0      | 4.9       | 31.7      | 32.5       | 0         | 40.0       |
| 1   | 10.0      | 5.0       | 14.6      | 7.3       | 7.5        | 12.5      | 5.0        | 7.5 |
| 2   | 55.0      | 12.5      | 58.5      | 22.0      | 50.0       | 17.5      | 70.0       | 17.5 |
| 3   | 15.0      | 25.0      | 2.4       | 7.3       | 12.5       | 7.5       | 15.0       | 7.5 |
| 4   | 7.5       | 20.0      | 12.2      | 9.8       | 15.0       | 5.0       | 2.5        | 10.0 |
| 5   | 2.5       | 7.5       | 5.0       | 15.0      | 5.0        | 12.5      |            |      |
| 6   | 7.3       | 7.3       | 7.3       | 7.3       | 5.0        | 10.0      | 2.5        | 5.0 |
| 7   |            |           |           |           |            |           |            |      |
| 8   | 2.5       |           |           |           |            |           |            |      |
| 9   |            |           |           |           |            |           |            |      |
| 11  |            |           |           |           |            |           |            |      |
| 12  |            |           |           |           |            |           |            |      |
| 14  |            |           |           |           |            |           |            |      |
Table 6. Major crops produced in Sidama, Gedeo, Wolayta and Gamo Goffa zones

| Crops       | Sidama | Gedeo | Wolayta | Gamo Goffa | Average |
|-------------|--------|-------|---------|------------|---------|
| Coffee      | 100.0  | 100.0 | 97.5    | 95.0       | 98.1    |
| Maize       | 72.5   | 63.4  | 97.5    | 67.5       | 75.2    |
| Enset       | 38.0   | 97.6  | 75.0    | 5.0        | 68.3    |
| Common Bean | 40.0   | 56.1  | 97.5    | 27.5       | 58.4    |
| Banana      | 55.0   | 61.0  | 15.0    | 92.5       | 55.9    |
| Mango       | 32.5   | 31.7  | 22.5    | 92.5       | 44.7    |
| Teff        | 30.0   | 31.7  | 90.0    | 17.5       | 42.2    |
| Avocado     | 52.5   | 46.3  | 17.5    | 37.5       | 38.5    |
| Sweet potato| 3.5    | 31.7  | 72.5    | 10.0       | 37.3    |
| Taro        | 25.0   | 31.7  | 67.5    | 7.5        | 32.9    |
| Yarn        | 32.5   | 39.0  | 30.0    | 0.0        | 25.5    |
| Potato      | 2.5    | 9.8   | 40.0    | 5.0        | 14.3    |
| Chat        | 20.0   | 22.0  | 0.0     | 0.0        | 10.6    |
| Sugar Cane  | 12.5   | 22.0  | 7.5     | 0.0        | 10.6    |
| Others*     | 24.5   | 33.6  | 95.0    | 77.5       | 58.8    |

*Others include those crops that produced by less than 10% of the farmers in the interviewed zones (Pigeon pea, cassava, Moringa, pepper, Papaya, Bull, Chick, Barley, Cotton, Ginger, Tomato, cabbage, Carrot, kale, Onion, Ground nut, Kororima, Peach, Sorghum, Wheat and Spices).

Figure 2. Crops used as a primary source of cash in Sidama.

Figure 3. Crops used as a primary source of cash in Gedeo.

Figure 4. Crops used as a primary source of cash in Wolayta.
Lack of seed of improved varieties is one of the most important problems in coffee production. Unlike other crops, there is no any public and/or private sectors responsible to produce and market coffee seeds. Moreover, there is no national coffee seed standard and certification scheme (Taye, 2013).

Most frequently produced coffee varieties were 74,110 and 74,112 with the mean number of 612, 625 and 150 trees per household in Sidama, Gedeo and Wolayta, respectively (Figure 7). In Gamo Goffa, the name of improved varieties either expected to be changed to other local or the varieties were not introduced to the area. The mean number of trees of the so called improved varieties in Gamo Goffa was 52.5 head$^{-1}$. The bean yields improved varieties in average was 3.7, 4.48, 3.11 and 2.0 t ha$^{-1}$ in Sidama, Gedeo, Wolayta and Gamo Goffa, respectively (Table 8). Yield variation might be due to the difference in agroecological condition of respected locations and variation of the type of coffee varieties produced and management differences provided.

In line with this, all respondents confirmed that they were producing locally known coffee varieties in their farm lands. But the performance and the yield was completely lower than the yield obtained from improved varieties (Table 9). The number of trees of local varieties planted per head on average
was 590.8, 622.5, 89.1 and 41.37 in Sidama, Gedeo, Wolayta and Gamo Goffa, respectively. The average performance of local varieties in Sidama, Gedeo, Wolayta and Gamo Goffa, respectively, was 2.2, 3.42, 1.55 and 1.52 t ha$^{-1}$ (Table 9) which are significantly lower than improved varieties to the respective locations.

### 3.3.2. Implementing improved practices

The production and productivity of farmers' variety and cultivars can be improved by using improved agronomic and best management practices (Taye, 2014). Most of the farmers responded that they were using combination of improved practice such as compost preparation and application (Co), mulching (Mu), intercropping (Ic), pit preparation 2 months before transplanting (Pi), correct spacing (Sp), row planting (Rp), appropriate shade tree planting (Sh), stumping and on time weeding. But a great deal of farmers in Gedeo (26.8%), Wolayta (17.5%) and Gamo Goffa (62.5%) were not using improved practices for their coffee production (Table 10). This might be the lack of awareness creation works and information on improved practices that are employed to improve the production and productivities of coffee in the area. The opposite was observed in case of Sidama where combinations of practices were employed. Experience of Sidama farmers can widely be practices in the rest of coffee producing areas of the region.

The farmers developed 3–14 years of experience on implementation of improved practices. Among the improved practices intercropping with compatible crops is the most important one. Taye (2013) showed on his paper that coffee is intercropped with other companion crops or leguminous shade trees in complex agro forestry systems as low-cost production options to
Table 8. Improved varieties performance

| Variety   | No. of trees | Yield obtained (t/area) | Performance (t ha$^{-1}$) |
|-----------|--------------|-------------------------|---------------------------|
| CIP 1000 | 0.4          | 1.0                     | V1377 1000                |
|           |              |                         |                           |
| Jima      | 1216.7       | 2.3                     | 5.3                        |
|           |              |                         |                           |
| Kaffa     | 1200.0       | 2.0                     | 4.2                        |
|           |              |                         |                           |
| Project   | 200.0        | 0.4                     | 0.0                        |
|           |              |                         |                           |
| Wollega   | 100.0        | 0.1                     | 2.5                        |
|           |              |                         |                           |
| Total     | 6730.7       | 9.7                     | 40.6                       |

- Most of improved varieties planted recently and not started berry production.

Source: Tadesse et al., Cogent Food & Agriculture (2020), 6: 1741982
| Variety     | No. of trees | Yield obtained (t/area) | Performance (t ha⁻¹) | Variety     | No. of trees | Yield obtained (t/area) | Performance (t ha⁻¹) | Variety     | No. of trees | Yield obtained (t/area) | Performance (t ha⁻¹) | Variety     | No. of trees | Yield obtained (t/area) | Performance (t ha⁻¹) |
|-------------|--------------|-------------------------|----------------------|-------------|--------------|-------------------------|----------------------|-------------|--------------|-------------------------|----------------------|-------------|--------------|-------------------------|----------------------|
| Black coffee| 250          | 0.1367                  | 1.8                  | Badasa      | 1720         | 0.25                    | 5.71                 | Mike        | 129         | 0.07                    | 1.43                 | Kayra       | 102.5        | 0.251                   | 3.63                 |
| Enat Buna   | 1140         | 0.9200                  | 2.9                  | Cunsine     | 1750         | 0.19                    | 6.25                 | Sankara     | 38          | 0.02                    | 0.92                 | Mike        | 47.90        | 0.032                   | 1.44                 |
| Gotole      | 525          | 0.4000                  | 3.4                  | Dega        | 4334         | 0.51                    | 4.50                 | Tora Tuke   | 100         | 0.10                    | 2.31                 | Natra       | 2.00         | 0.001                   | 0.63                 |
| Limma       | 500          | 0.2000                  | 1.0                  | Enat Buna   | 1550         | 0.83                    | 1.66                 |             |             |                          |                      |             |              |                          |                      |
| Mike        | 1000         | 0.7000                  | 1.8                  | Hagere      | 4500         | 0.20                    | 1.11                 | Tora Tuke   | 100         | 0.005                   | 1.25                 |             |              |                          |                      |
| Organ       | 500          | 0.3000                  | 1.5                  | Kurume      | 554          | 0.51                    | 3.00                 | Unknown     | 35.83       | 0.012                   | 0.94                 |             |              |                          |                      |
| Red coffee  | 650          | 0.4500                  | 2.1                  | Unknown     | 1033         | 0.88                    | 1.60                 |             |             |                          |                      |             |              |                          |                      |
| Red coffee  | 200          | 0.2000                  | 2.5                  | Wolisho     | 6119         | 0.63                    | 3.56                 |             |             |                          |                      |             |              |                          |                      |
| Unknown     | 552          | 0.5245                  | 2.7                  |             |              |                          |                      |             |             |                          |                      |             |              |                          |                      |
| Total       | 5317         | 3.83                    | 19.6                 | Total       | 4980         | 4.00                    | 27.40                | Total       | 267         | 0.19                    | 4.65                 | Total       | 248.2        | 0.325                   | 9.12                 |
| Mean        | 591          | 0.43                    | 2.2                  | Mean        | 6225         | 0.50                    | 3.42                 | Mean        | 89.1        | 0.06                    | 1.55                 | Mean        | 41.37        | 0.054                   | 1.52                 |
Table 10. Proportion of farmers using improved practice in Sidama, Gedeo, Wolayta and Gamo Goffa

| Improved practices | Proportion (%) | Improved practices | Proportion (%) | Improved practices | Proportion (%) | Improved practices | Proportion (%) |
|--------------------|---------------|--------------------|---------------|--------------------|---------------|--------------------|---------------|
| CoIcPiSpWD         | 12.5          | CoMaMuWD           | 7.3           | CoPSp              | 2.5           | DtPsPi             | 2.5           |
| CoMuRspShSpStWD    | 7.5           | CoMuPiPr           | 4.9           | CuRptiWD           | 2.5           | DtSp               | 5.0           |
| CuDspRspShSpStWD   | 2.5           | CriCStWD           | 2.4           | DsRpsSpStTeWD      | 5.0           | No                 | 62.5          |
| DsPdPrRspSpStWD    | 7.5           | CuMuPiPrRpWD       | 9.8           | DtSpSt             | 17.5          | PsPsp              | 5.0           |
| IcPPrRspShSp       | 10.0          | MuPrSpWD           | 2.4           | IcPrrp             | 2.5           | RpPp               | 2.5           |
| PdPPrRspSpStWD     | 17.5          | MUPrSpWD           | 2.4           | MbSp               | 5.0           | RpSp               | 7.5           |
| PrPPrSp            | 10.0          | No                 | 26.8          | No                 | 17.5          | Sp                 | 10.0          |
| Rp                 | 2.5           | Pi                 | 2.4           | PrrPrRspSt         | 2.5           | SpSt               | 2.5           |
| RpSp               | 12.5          | PrrPrShSpWD        | 2.4           | PrrPrSt            | 5.0           |                   |               |
| Sp                 | 5.0           | PWD                | 2.4           | PrrPsSpSt          | 5.0           |                   |               |
| SpSt               | 7.3           | RgSpSt             | 2.5           |                   |               |                   |               |
| WD                 | 9.8           | SpStWD             | 2.5           |                   |               |                   |               |

Note: No stands for the proportion of farmers that did not practically applying improved production practices.
diversify food and cash security. In spite of the presence of improved technologies in the country, the lack of information restrains the farmers from using them. The assessment made in Uganda indicated that 30% of the farmers had no or little information with regard to improved coffee varieties (Mukadasi, 2019).

In the studied areas, the use of both organic and mineral fertilizers is either nil or very limited to some production systems (e.g., large commercial plantations). Evidence from decades of research in the country indicates that nutrient inputs (from both organic and inorganic sources) can boost productivity and quality of coffee if used in appropriate balance and rates (Solomon, 2014). However, in Gedeo, Wolayta and Gamo Goffa most of the time there was no tradition of application of inorganic fertilizers (Table 11).

In all the investigated zones, no one is using any pesticide except unknown doses of Diconyl and Octave, and unknown herbicide and fungicide provided by the then coffee improvement project (CIP) before 28 years in one of Sidama districts. Since then coffee disease and insect pests were

| Type of improved practices | Sidama       | Gedeo       | Wolayta     | Gamo Goffa | Over all     |
|----------------------------|--------------|-------------|-------------|------------|-------------|
| Composting                 | 7.5 ± 1      | 7.8 ± 2 (1) | 4.0 ± 0     | -          | 13.0 ± 1.1  |
| Crop rotation              | -            | 3 ± 0       | -           | -          | 3.0 ± 0     |
| Cultivation                | -            | 7.1 ± 1.4   | 10.0 ± 0    | -          | 7.5 ± 1.2   |
| Desuckering                | 12.8 ± 2.8   | -           | 8.0 ± 2.1   | -          | 13.0 ± 2.3  |
| Detopping                  | -            | -           | 7.0 ± 2.1   | 9.7 ± 0.6  | 8.6 ± 1     |
| Intercropping              | 8.9 ± 0.8    | 35 ± 0      | 4 ± 0       | -          | 13.9 ± 1.4  |
| Manuring                   | -            | 5 ± 0       | -           | -          | 5.0 ± 0     |
| Microbasin                 | -            | -           | 2.5 ± 0.8   | -          | 2.5 ± 0.8   |
| Mulching                   | 13.3 ± 2     | 9 ± 2 (1)   | -           | -          | 10.9 ± 1.4  |
| Pit preparation            | 9.4 ± 0.8    | 7.7 ± 1.3(1)| 7.2 ± 1.2   | 14.3 ± 2.1 | 9.6 ± 0.7   |
| Planting date              | 14.5(1) ± 1.5| 5.5 ± 1.9   | 5 ± 0       | 5.0 ± 0    | 10.6 ± 1.1  |
| Pruning                    | 6.0(1) ± 1   | 5.4 ± 1.2(1)| 7.0 ± 1.3   | -          | 6.2 ± 0.7   |
| Record keeping             | -            | -           | 3.0 ± 0     | -          | 3.0 ± 0     |
| Raised bed storage         | -            | -           | 4.0 ± 0     | -          | 4.0 ± 0     |
| Row planting               | 13.6(2) ± 0.8| 9.3 ± 1.6   | 10.4 ± 1    | 11.0 ± 2.3 | 4.0 ± 0     |
| Replacement                | -            | 4 ± 0       | -           | -          | 11.1 ± 0.6  |
| Selective harvesting       | -            | -           | 10.3 ± 2.9  | -          | 10.3 ± 2.9  |
| Shading                    | 11.7 ± 1.2   | 30.0 ± 0    | -           | -          | 16.0 ± 1.3  |
| Spacing                    | 14.8(2) ± 0.8| 7.6 ± 1.3   | 7.3 ± 0.7   | 11.0 ± 1   | 9.8 ± 0.5   |
| Stumping                   | 4.4 ± 0.9    | 3.7 ± 1     | 7.6 ± 0.7   | 20.0 ± 3.8 | 7.6 ± 0.7   |
| Uprooting                  | -            | 5.0 ± 0     | -           | -          | 3.0 ± 0     |
| Tie ridging                | -            | -           | 3.0 ± 0     | -          | 4.0 ± 1.2   |
| Trenching                  | -            | -           | 4.0 ± 1.2   | -          | 5.0 ± 0     |
| Weeding                    | 14.8(1) ± 0.9| 6.3 ± 1.1(1)| 12.0 ± 2.2  | -          | 9.0 ± 0.7   |
| Mean                       | 12.3 ± 0.3   | 7.6 ± 0.5   | 7.7 ± 0.4   | 11.8 ± 0.75| 9.9 ± 0.2   |

Note: The numbers in the parenthesis are respondents who do not know the number of years that they are using the corresponding improved technologies.
managed only by using cultural practices. This indicates Ethiopian coffee produced and delivered to the world market is organic as it’s free of any chemicals for disease, insect and weed management. Similar reports were made by Taye and Tesfaye (2002).

### 3.3.3. Irrigation, source of water and method of application

Proportion of farmers using both full and supplementary irrigation varies with location, source and availability of water, and rainfall pattern. In Sidama, no one was applying full irrigation for coffee production but about 25% of the farmers responded that they were using supplementary irrigation from rain water harvesting pond, flood and river for seedling development, stabilizing longer dry period and supplement younger trees which otherwise dried up due to low moisture stressed duration. Using watering can for irrigation was reported as the most common method of supplementary irrigation as it was frequently used in coffee nursery followed by flooding. Very few farmers (2.5%) were using water pump (Table 12). The use of supplementary and full irrigation most of the time depended on the source and sustainability of water sources. For example, Abiyot and Zemede (2014) reported that houses located close to perennial streams usually have their gardens situated at the back side and adjacent to the water way for ease of irrigation.

Similarly, supplementary irrigated coffee production system was implemented in Gedeo. Most of the farmers (87.8%) were rainfall dependent as the area receives about 1129 mm (mill meter) of rainfall per annum (https://en.climate-data.org) which is the optimum amount that coffee requires for normal growth and yield (Coste, 1992). However, 12.2% of the farmers were using supplementary irrigation sourced from rain water harvest and rivers. The water was applied by using can irrigation method, drip irrigation (plastic water bottle) and water pumping system for seedling development so as to supplement younger trees and coffee trees during very dry period (Table 12).

In Wolayta, unlike Sidama and Gedeo, only 7.5% and 47.5% of the respondents confirmed the implementation of both full and supplementary irrigation for coffee production, respectively. The common sources of water for irrigation were river and rain water harvesting ponds for seedling development, irrigating the whole field during longer dry period and supplementing younger trees (Table 12). In Gamo Goffa, 100% of the respondents confirmed that coffee crop was produced by using both full (62.5%) and supplementary (40%) irrigations. Most of the water was obtained from the nearby rivers and the crops were irrigated during seedling development by using flooding and motor pumping.

As a whole, in the investigated areas, practices of using irrigation for coffee production was lower which might be one of the most important causes for lower coffee yield (Table 13). If applied it could be possible to obtain higher yield as reported by united. The report stated that the development of drip irrigation and low-pressure pivots has made it possible to regularly achieve high crop yields (UN (United Nation), 2008).

In the presence of low moisture stress, some of moisture conservation methods like mulching, shading, terracing, trenching and micro basins either alone or in integrated way were implemented. Among which the most commonly used moisture conservation methods were combination of mulching and shading (47.5%) followed by mulching alone. But 7.5% of the respondents were not using any of the moisture conservation methods (Table 14). Applying intensive agronomic practices such as irrigation, pruning, mulching and maintenance of shade at optimum level alleviate the problem of low moisture stress (Belete, 2014)

As shown in Table 14, most of the farmers (47.5%) used to sell freshly harvested and dried beans. But only 2.5% of the farmers responded that they were selling dried coffee beans. Other 50% of the farmers used to sell freshly harvested, dried and pulped coffee depend on the urgency of the need of income. Harvesting was carried out by one by one hand picking of ripped beans (57%) followed by combination of hand picking, sweeping from branches and collecting from ground (20%). As far as processing and storage were concerned, about 77% of the respondents
| Location      | Type of irrigation | Proportion (%) | Source of water                      | Method of supply/irrigation | Mostly used                          |
|---------------|--------------------|----------------|--------------------------------------|----------------------------|--------------------------------------|
| Sidama        | Full               | 0              | 0                                    | 0                          | 0                                    |
|               | Supplementary irrigation | 25          | Flood (2.5%)                         | Can irrigation (15%)        | Seedling development                 |
|               |                    |                | Rain water harvesting (15%)          | Flooding (5%)               | Stabilize longer dry period          |
|               |                    |                | River (7.5%)                         | Furrow (2.5%)               | Supplement Younger trees             |
|               |                    |                |                                       | River (7.5%)                | Stabilize longer dry period          |
|               |                    |                | Rain water harvesting (15%)          | Flooding (5%)               | Stabilize longer dry period          |
|               |                    |                | River (7.5%)                         | Drip irrigation by using water bottle (2.4%) | Supplement Younger trees             |
| Gedeo         | Full               | 0              | 0                                    | 0                          | 0                                    |
|               | Supplementary irrigation | 12.2         | Rain water harvesting (7.3%)         | Can irrigation (4.9%)        | Seedling development                 |
|               |                    |                | River (4.9%)                         | Drip irrigation by using water bottle (2.4%) | Supplement Younger trees             |
|               |                    |                |                                       | Water pumping (4.9)         | Supplementation during dry period    |
| Wolayta       | Full               | 7.5            | River (7.5%)                         | Flooding                    | Irrigate the whole field during dry period |
|               | Supplementary irrigation | 47.5         | Pond (7.5)                           | Can irrigation (47.5%)       | Seedling development                 |
|               |                    |                | Rain water harvesting (15%)          | Supplementation Younger trees |
|               |                    |                | River (25%)                          | Irrigate the whole field during dry period |
| Gamo Goffa    | Full               | 62.5           | River (62.5%)                        | Flooding                    | Seedling development                 |
|               | Supplementary irrigation | 40           | River (40%)                          | Can irrigation (22%)         | Seedling development                 |
|               |                    |                | Pumping and flooding (2.4%)          | Irrigate the whole field during prolonged dry period |
|               |                    |                | Flooding (14.6%)                     | Irrigate the whole field during prolonged dry period |
were using raised bed lined with polyethylene sheet for drying coffee beans and store in Jute sack (62.5%) followed by bamboo basket (20.8%).

3.4. Coffee production problems

Coffee production problems are those factors that negatively affecting production and productivity of coffee. The problems could be seen as biotic, abiotic and technical in their very nature. Biotic factors included disease, insect pests, weeds and vertebrate animals. Abiotica factors were highly related to the agroclimatic condition such as recurrent drought, high rain, low moisture stress, high incidence of sun rise, frost and others. Those factors listed as technical challenges were lack of improved varieties, lack of remedies for coffee disease and insect pests, and weak linkage with the central market.

3.4.1. Biotic factors

3.4.1.1. Coffee diseases

Bacterial blight of coffee (BBC), CBD, CWD, coffee leaf blight (CLB), CLR, coffee stem drying disease (SD), leaf drier (LD) and leaf spot (LS) are most common diseases in the investigated areas. According to the respondent farmers, the most important coffee diseases challenging the production were CBD, CWD, BBC and stem drying diseases. They occur as a complex in combination or as a single incidence (Table 15). About 35% of the total farmers reacted that they were challenged by CBD followed by the CWD (17.6%) and complex occurrence of both CBD and CWD (10.9%). But 9.2% of the respondents were not suffering from any coffee diseases.

The distribution and effects of the diseases on the performance of coffee varied with the environments. Wider distribution and complex of coffee diseases were found in Sidama followed by Gedeo. In Wolayata, there was comparably higher CBD and CWD and their complex. Unlike other zones, coffee disease pressure was lower in Gamo Goffa as 73% the respondents confirmed that there is no any coffee disease problem. But about 13% of the farmers responded that presence of CBD and 14% confirmed the presence of CWD, CSC, DB, LS and their complex (Table 15). According to Teferi and Belachew (2018), these are common diseases in Sidama and Gedeo Zones. They indicated that coffee suffers from a range of diseases including CBD, CWD and CLR caused by Colletotrichum kahawae, Gibberella xylarioides and Hemileia vastatrix, respectively. BBC and coffee thread blight which is caused by Pseudomonas syringae pv garcae van Hall and Corticium koleroga, respectively, becomes an emerging constraint in Sidama and Gedeo Zones. Kumulachew et al. (2016) reported about 30% of national average crop losses to total harvestable coffee yield due to CBD. Similar report was also written by Holger and Omondi (2010) that CLR incidences in Ethiopia were present in all regions. CBD was presented mostly in Bonga (40.0%) and Yayu (26.3%), but less frequent in Harenna (18.6%) and Berhane-Kontir (6.0%).

| Type of irrigation | Proportion of farmers using irrigation (%) | Source of water | Method of irrigation | Mostly used |
|--------------------|------------------------------------------|----------------|---------------------|-------------|
| Full               | 17.4                                     | River (17.4%)  | Flooding by gravity (15.5%) | Irrigate during prolonged dry period |
| Supplementary irrigation | 31.1                                   | Pond (1.9%)  | Can irrigation (22.4%) | Seedling development Irrigate the whole field during prolonged dry period Supplement very younger trees  |
| Moisture conservation method (s) | Percent of respondents | Type of coffee sold | Percent of respondents | Harvesting method | Percent of respondents | Processing | Percent of respondents | Storage structures | Percent of respondents |
|---------------------------------|------------------------|---------------------|------------------------|-------------------|------------------------|------------|------------------------|---------------------|------------------------|
| Mu                              | 22.5                   | Db                  | 2.5                    | ON                | 57.5                   | DRB        | 77.5                   | Bamboo Basket        | 20.8                   |
| MuSh                            | 47.5                   | Fh                  | 15.0                   | ONSW              | 17.5                   | No         | 5.0                    | Beehives            | 12.5                   |
| MuShTe                          | 12.5                   | FhDb                | 47.5                   | ONSWCG            | 20.0                   | DG         | 12.5                   | Hipping             | 2.1                    |
| MuShTeMb                        | 2.5                    | FhDbPc              | 32.5                   | SW                | 2.5                    | DM         | 5.0                    | Jute sack           | 62.5                   |
| MuShTeMbTr                      | 5.0                    | FhPc                | 2.5                    | SWCG              | 2.5                    | Total      | 100.0                  | Nothing             | 2.1                    |
| MuTe                            | 2.5                    | Total               | 100.0                  |                   | 100.0                  |            | 100.0                  |                     | 100.0                  |
| No                              | 7.5                    |                      |                        |                   |                        |            |                        |                     |                        |
| Total                           | 100.0                  | 100.0               | 100.0                  |                   | 100.0                  |            |                       |                     | 100.0                  |

Note: Mu = mulching, Sh = Shading, Te = Terracing, Mb = Micro basin, Tr = Trench, Db = Dried beans, Fh = Fresh harvest, Pc = Pulped coffee, ON = one by one selective harvesting, SW = Sweeping, CG = Collecting from the ground, DRB = Drying on the raised bed, DG = Drying on the ground, DM = Drying on the mat.
## Table 15. Disease incidence and distribution across locations

| Sidama    | Proportion | Disease type/s | Proportion | Disease type/s | Proportion | Disease type/s | Proportion | Disease type/s | Proportion |
|-----------|------------|----------------|------------|----------------|------------|----------------|------------|----------------|------------|
| BBC       | 2.5        | BBCCBD         | 2.4        | CBD            | 12.5       | CBD            | 12.5       |
| BBCCBD    | 12.5       | BBCCBDCW       | 2.4        | CBDCWD         | 32.5       | CBDCSC         | 2.5        |
| BBCBDDB   | 2.5        | CBD            | 9.8        | CWD            | 27.5       | CBDCWD         | 2.5        |
| BLSDCBD   | 2.5        | CBD            | 2.4        | Db             | 7.5        | CWD            | 5.0        |
| CBD       | 20.0       | CBDCWD         | 56.1       | No             | 20.0       | Db             | 2.5        |
| CBDCWD    | 2.5        | CBDCWDL        | 2.4        | LS             | 2.5        | No             | 72.5       |
| CBDDB     | 2.5        | CBDDB          | 2.4        | No             | 4.9        |
| CBDDBLS   | 2.5        | CBDDB          | 4.9        |
| CBDDLSD   | 2.5        | CBDLSD         | 2.4        |
| CBDLSD    | 2.5        | CBDLSD         | 4.9        |
| CBDDSD    | 2.5        | CWD            | 7.3        |
| CWD       | 7.5        | No             | 2.4        |
| CWDDDB    | 2.5        | No             | 4.9        |
| DB        | 5.0        | No             | 72.5       |
| No*       | 25.0       | No             | 2.5        |

*No refers to the proportion of respondents that stated as there was no any disease attaching their coffee crop either in the field or at post harvest condition.
| Disease | Management options | Percent of respondents | Disease | Management options | Percent of respondents | Disease | Management options | Percent of respondents | Disease | Management options | Percent of respondents | Disease | Management options | Percent of respondents |
|---------|-------------------|-----------------------|---------|-------------------|-----------------------|---------|-------------------|-----------------------|---------|-------------------|-----------------------|---------|-------------------|-----------------------|
| CBD     | Ash               | 1.2                   | BBC     | CUBU              | 9.1                   | CWD     | ATSH              | 3.3                   | DB      | CUBU              | 14.3                   | Others | Co                | 100                   |
| Co      | D1                | 18.2                  | CUBU    | D1                | 4.9                   | Ma      | 4.8               | Mu                    | No      | No                | 70.0                   | Total   | 100.0             |                        |
| CUCoMu  | 9.3               | PRUNG                 | 9.1     | D1                | 4.9                   | Ma      | 4.8               | Mu                    | No      | No                | 70.0                   | Total   | 100.0             |                        |
| DI      | 2.3               | TC                    | 18.2    | No                | 24.6                  | Mu      | 4.8               | No                    | 19.0    | Total             | 100.0                   |                     |                   |                        |
| FS      | 3.5               | UPBU                  | 45.5    | SH                | 3.3                   | No      | 19.0              | Total                 | 100.0   |                   |                        |                     |                   |                        |
| FSRV    | 3.5               | UPBU                  | 55.7    | UPBU              | 42.9                  | UPBU    | 4.8               |                       |                     |                   |                        |                     |                   |                        |
| IFR     | 4.7               |                       |         |                   |                        |         |                   |                       |                     |                   |                        |                     |                   |                        |
| IRR     | 1.2               |                       |         |                   |                        |         |                   |                       |                     |                   |                        |                     |                   |                        |
| No      | 29.1              |                       |         |                   |                        |         |                   |                       |                     |                   |                        |                     |                   |                        |
| PRV     | 1.2               |                       |         |                   |                        |         |                   |                       |                     |                   |                        |                     |                   |                        |
| SH      | 1.2               |                       |         |                   |                        |         |                   |                       |                     |                   |                        |                     |                   |                        |
| UPBU    | 30.2              |                       |         |                   |                        |         |                   |                       |                     |                   |                        |                     |                   |                        |
| We      | 1.2               |                       |         |                   |                        |         |                   |                       |                     |                   |                        |                     |                   |                        |
| WeFS    | 1.2               |                       |         |                   |                        |         |                   |                       |                     |                   |                        |                     |                   |                        |
| WeMSH   | 1.2               |                       |         |                   |                        |         |                   |                       |                     |                   |                        |                     |                   |                        |
| WeMSHSP | 1.2               |                       |         |                   |                        |         |                   |                       |                     |                   |                        |                     |                   |                        |
| WePR    | 1.2               |                       |         |                   |                        |         |                   |                       |                     |                   |                        |                     |                   |                        |
| Total   | 100.0             |                       |         |                   |                        |         |                   |                       |                     |                   |                        |                     |                   |                        |

Note: Ash = Addition of wood ash, Co = composting, CUBU = cutting and burning infested tree, CUCoMu = cutting, composting and mulching, DI = Disinfestations of farm tools, FS = Field sanitation, FSRV = field sanitation and regular visit, IFR = infected fruits removal, IRR = irrigation, No = no any measure implemented, PRV = planting resistant varieties, SH = shading, UPBU = uprooting and burning, We = weeding, WeFS = weeding and field sanitation, WeMSH = Weeding and minimizing shade, WeMSHSP = Weeding, shade reduction, stumping and pruning branches, WePR = weeding and pruning.
3.4.1.1. Farmers’ disease management practices

Even if different integrated method could be used to control the disease, coffee production system in Ethiopia would not allow the use of chemical. So that farmers were using cultural methods to manage it and other diseases.

Among which application of ash, mulching, cutting infested tree and burning (CUBU), uprooting the infested tree and burning (UPBU), farm tools disinfection by fire, planting resistant varieties were frequently used methods. However, most of the farmers (24.1%) stated that they had no idea of managing CBD in their coffee field. Equal proportion of farmers was controlling by using uprooting infested tree and burning in a place away from coffee farm. But very few farmers were using combination of cultural practices to manage CBD (Table 16). In the same manner, BBC was said to be managed by using cultural methods like cutting and burning the infected trees/ tree parts, disinfecting farm tools, pruning infested branches, cleaning farm tools and uprooting infected trees followed by burning the uprooted trees. Among the management options most frequently uprooting and burning (45.5%) implemented to control/prevent BBC followed by farm tools disinfection and cleaning (18%) each. Uprooting and burning was still considered as the best method of managing CWD in Sidama, Gedeo, Wolayta and Gamo Goffa Zones according to 55.7% of the respondents of interviewed areas. But still 24.6% of the farmers had no idea of managing the disease. Dieback was also mentioned as one of the most important disease in Sidama, Gedeo, Gamo Goffa and Wolayta. According to the interviewed farmers, 42.9% of the farmers implemented UPBU and 14.3% were using CUBU to manage the disease.

Other diseases like LS, leaf rust (LR), leaf blight (LB), coffee stem canker (CSC) were considered as minor diseases that could easily be controlled by using mulching, composting and field sanitation. But most of the farmers had no knowhow of controlling the diseases (Table 16). It was reported that using resistant varieties for CBD (Gimase et al., 2019), disinfect machetes after cutting every diseased coffee tree, dig out all parts of diseased coffee tree and burn it at the spot (Zinabu et al., 2017).

3.4.1.2. Important insect and pests of coffee

The most common insect pests affixing coffee in investigated areas were anthestia bug, black ant, cut worm, leaf minor, fruit fly, mealy bug (white and black), red ant, spider, stem borer, termite, weevil and unknown insects. Among which stem borer was the most important and common insect pests in all investigated location with some exception as it was supper stated in Wolayta by termite. The distribution of insects varies with locations as anthestia bug was commonly found in Sidama, Gedeo and Wolayta; mealy bug was common for Sidama and Wolayta; and termite, black ant and weevil were common for Wolayta and Gamo Goffa zones. But most of the farmers (35.3% and 87.8%) in Sidama and Gedeo respectively reported that insect pest was no more a problem on
| Insect       | Percent | Insect       | Percent | Insect       | Percent | Insect       | Percent | Insect       | Percent | Insect       | Percent |
|--------------|---------|--------------|---------|--------------|---------|--------------|---------|--------------|---------|--------------|---------|
| Anthestia bug| 2.0     | Anthestia bug| 4.9     | Anthestia bug| 1.7     | Black ant    | 9.1     | Anthestia bug| 2.6     |              |         |
| Cut worm     | 13.7    | Leaf minor   | 2.4     | Black ant    | 1.7     | Midge        | 2.3     | Black ant    | 2.6     |              |         |
| Mealy bug    | 17.6    | No           | 87.8    | Fruit fly    | 1.7     | No           | 22.7    | Cut worm     | 3.6     |              |         |
| No           | 35.3    | Stem borer   | 4.9     | Mealy bug    | 8.6     | Stem borer   | 43.2    | Leaf minor   | 0.5     |              |         |
| Stem borer   | 29.4    |              |         | Midge        | 10.3    | Termite      | 11.4    | Fruit fly    | 0.5     |              |         |
| Unknown      | 2.0     |              |         |              |         | No           | 17.2    | Weevil       | 11.4    | Medly bug    | 7.2     |
|              |         | Red ant      | 1.7     | Midge        | 3.6     |              |         |              |         |              |         |
|              |         | Spider       | 15.5    |              |         | No           | 38.1    |              |         |              |         |
|              |         | Stem borer   | 19.0    | Red ant      | 0.5     |              |         |              |         |              |         |
|              |         | Termite      | 20.7    | Spider       | 4.6     |              |         |              |         |              |         |
|              |         | Weevil       | 1.7     | Stem borer   | 24.2    |              |         |              |         |              |         |
|              |         |              |         | Termite      | 8.8     |              |         |              |         |              |         |
|              |         |              |         | Unknown      | 0.5     |              |         |              |         |              |         |
|              |         |              |         | Weevil       | 3.1     |              |         |              |         |              |         |
Unlike Gedeo in Sidama, Stem borer was reported as the most devastating insect pest followed by Mealy bug (17.6%) and cut worm (13.7%). Similar results were reported by Fekadu et al. (2016) as coffee berry borer was found the leading pest examined during their study conducted Gedeo Zone. Even if they were not as devastating as coffee diseases, insect pest caused higher proportion of crop damage/yield loss (Table 17). On average about 14% of coffee yield loss was caused by the infestation of a crop by insect pests (Figure 8). Losses due to coffee pests are estimated to be 13% worldwide (Nyambo & Masaba, 1997) while in Ethiopia yield loss due to some insect pests such as Anthestia bug was reported to be 9% (Girma et al., 2008). Similarly, coffee blotch leaf minor was found to cause severe defoliation of coffee plant. However, Esayas and Chemeda (2007) reported that it never causes considerably yield loss.

3.4.1.3. Invasive and common weeds

3.4.1.3.1. Invasive weeds

No more invasive weeds were observed in the coffee fields of Sidama, Gedeo, Wolayta and Gamo Goffa Zones. But two devastating and widely spreading types of invasive weeds were found in the study areas: except parthenium and oxalis (Table 18). Among the respondents, 40.4% confirmed their existence while the rest replied that there was no any invasive weed in coffee production system. Parthenium weed was first reported from Ethiopia at Dire-Dawa, Harerge, eastern Ethiopia in 1988. A second major center of infestation was subsequently found near Dese, Welo, North Eastern Ethiopia. Parthenium weed seeds were believed to be imported from subtropical North America as a contaminant of grain food aid during the 1980s famine, and distributed with the grain (Matthew, 2015). Oxalis is a perennial ground cover which originated from Southern America and grows in both full sun and shade if the area receives adequate moisture. The plants themselves do not spread far by stolen or rhizomes, but seed of O. corniculata have evidently been carried long distances by human agency, either deliberately or accidentally. As a perennial weed and the presence of underground stolen made it difficult to manage in farm fields. In Ethiopia, it was found in the cereal fields, but currently the weed affects coffee farm lands too. It reduces crop vigour and yields, act as an alternative host to diseases rusts, compete for nutrients and light with crops and Labour intensive (Center for agriculture and biodiversity international [CABI], 2018).

3.4.1.3.2. Weeds

Weeds have great harmful impact on the production system, yield and quality of coffee. It was observed that most of the surveyed weeds disturb harvesting, suppress seedling growth, reduce yield, dry soil and harbor disease causing organisms and insect pests. But most of them can easily be managed by frequent cultivation, exposing seed bank to sun by implementing offseason ploughing, mowing and hand weeding. As shown in Table 19, some of common weeds in the coffee farm and their relative composition. The most important common weeds identified in the coffee farms of selected districts of Sidama, Gedeo, Wolayta and Gamo Goffa Zones were Cyperus spp (20%), Ajaratum (17%), Commelena (15%), Nicandira (11%) and others (36%). Nyabundi and Kimemia (1998) reported Digitaria abisinica (Couch grass), Commelina benghalensis (Wondering Jew), Cyperus rotundus L. (Nut grass), Cynodon dactylon (Stargrass), Pennisetum clandestinum (Kikuyu grass) as some of common weeds reducing production and productivities of coffee. Coffee Research Foundation (CRF, 2003) also stated that the yield losses due to weed effects can be over 50%. Thus they must be managed appropriately whenever they appear in the field.

| Response | Frequency | Percent | Proportion Parthenium (%) | Proportion Oxalis (%) |
|----------|-----------|---------|--------------------------|----------------------|
| No       | 96        | 59.6    | 88.1                     | 11.9                 |
| Yes      | 65        | 40.4    | 11.9                     | 88.1                 |
| Total    | 161       | 100.0   |                          |                      |

Table 18. Invasive weeds proportion in the study areas
Despite the presence of many options to manage coffee weeds, farmers were using common practices to control their negative effects. The most important management lists were frequent cultivation and hand weeding, exposing seed bank to open sun through hoeing and uprooting the weed and burring so as to minimize seed bank (Table 20). Habtamu (2015) has reported that the most commonly practiced weed control methods include manual, mechanical cultivation and use of herbicides or integrated weed management (IWM) depending on the availability and farming system.

### 3.4.1.4. Vertebrate pests on coffee

Vertebrate pests were not common on coffee production in selected areas of Sidama, Gedeo, Wolayata and Gamo Goffa with some exceptions. The pest type and devastation status varied with location. Among vertebrate pests coffee bean eating birds were the most important one in Gamo Goffa (52.5%) followed by Wolayta (22%) and Sidama (10%). In Gedeo, as the response of the

| Table 19. Common weed types in coffee farms combined over locations (Sidama, Gedeo, Wolayta and Gamo Goffa) |
|---------------------------------------------------------------|
| **Weed types**       | **Frequency** | **Percent** |
|----------------------|---------------|-------------|
| Amaranths spp        | 13            | 6.5         |
| Butter cup           | 2             | 1.0         |
| Ajaram int spp       | 34            | 17.0        |
| Climbing weed (Gigisha) | 6         | 3.0         |
| Commelena            | 31            | 15.5        |
| Datura               | 8             | 4.0         |
| Digitaria            | 18            | 9.0         |
| Datura               | 2             | 1.0         |
| Galinsoga            | 15            | 7.5         |
| Cyperusrotundus      | 40            | 20.0        |
| Nicandira            | 22            | 11.0        |
| Locus spp            | 2             | 1.0         |
| Silvia spp           | 1             | 0.5         |
| Solanum spp          | 1             | 0.5         |
| Tagatus              | 3             | 1.5         |
| Vermunda grass       | 2             | 1.0         |
| **Total**            | 200           | 100.0       |

| Table 20. Common weeds, their effect and management options |
|---------------------------------------------------------------|
| **Weed species**       | **Effect on coffee production** | **Management method** |
|------------------------|---------------------------------|-----------------------|
| Amaranths              | Interfere with harvesting, suppress seedling development, yield loss, reduce tree growth | Frequent cultivation and hand weeding, exposing seed bank to open sun through hoeing |
| Bides plosa            | Reduce tree growth, reduce yield and quality, Interfere with harvesting, make field management difficult and dry soil | Frequent cultivation and weeding |
| Climbing weeds (Convulvulus arvensis) | Kill the tree | Uprooting the weed and burring |
| Commolana              | Reduce tree growth, interfere with harvesting, reduce seedling growth, yield loss, make harvesting tedious, reduced berry size, suppress seedling development | Frequent cultivation and hand weeding |
farmers, the most important vertebrate pest was ape (16%) followed by monkey (8%) and Columbus monkey (8%). In Sidama, Gedeo, Wolayta and Gamo Goffa, 90%, 64%, 78%, 47.5% of the respondents, respectively, indicated that there was no any problem of vertebrate pests affecting the production of coffee (Table 21). Unlike other crops, the damage caused by vertebrate pests on the yield and performance of coffee can said to be very minimum. They are also can be managed easily by chasing them away (Table 21). Parvatha (2010) also has shown that birds viz. small green barbet and red whiskered Babul (pycnonotus jocosus) cause economic damage to coffee. These birds feed only on ripened coffee berries. They punctured the pericarp and siphoned sweet contents and dropped the husk and seeds on the ground. Monkeys also cause economic damage to coffee by feeding on sweet, succulent and palatable stem tissue of young plants. Both birds and monkeys can easily be scared by using trained dogs.

3.4.2. Abiotic factors affecting coffee production
The most important abiotic factors affecting the production and productivity of coffee at the surveyed areas were drought, reduced soil fertility, heavy rain, snow and frost which cause singly and/or in combination, great devastation such as flower abortion, fruit quality reduction, wilting, enhanced alternate bearing, aggravate berry disease and others (Table 22). Other abiotic problems like wind, high temperature, low moisture stress, moisture shortage especially at flowering stage were considered as important but cause minor effect on coffee production (Table 22). The same result was reported by Ngasoh et al. (2019). They indicated that abiotic stresses on plants like temperature, flooding, drought and salinity affect crop production heavily, as they cause stunted growth, affects plant metabolism and thus reducing crop yield by as much as 70%. But can be managed by using different methods like mulching, composting, providing irrigation, etc. (Table 22). The same result was reported by Arun-Chinnappa et al., 2017; Hassanuzzaman et al., 2010; Hassanuzzaman et al., 2013 ; Wahid et al., 2007. Abiotic stresses can be managed by genetically improving the genes and transcription factors, or by employing cultural practices which includes modification and adjustment of planting time and crop density in the field so as to contain the effect of these abiotic stresses. Another method is to apply phyto-hormones, signaling and trace elements, applying osmo-protectants (Wahid et al., 2007; Hassanuzzaman et al., 2010), modifying planting time and adjusting the compactness of plants cultivated to evade stress situations (Arun-Chinnappa et al., 2017; Mirza et al., 2013).

3.5. Intervention areas for further improvement of coffee production
Supply of improved, early maturing and disease resistant varieties were considered the critical point of intervention in which the farmers believe to improve coffee production and productivity followed by provision of technical trainings (Table 23). About 14.5% of the farmers considered the provision/on time supply of improved farm tools believed to improve coffee production in the interviewed areas. But few of the requested farmers (2.8%) needed chemicals for disease and insect pest control.

Despite the presence of different problems in the course of the production of coffee in the studied areas, there exist varieties of opportunities (Table 24). The presence of all weather road, convenient topography, fertile land, good climatic conditions, good government policy, support from agricultural office, irrigationannel, presence of market access, presence of NGOs for support, safe market, sufficient labour, sufficient land, sufficient rainfall, sufficient water for irrigation and village crossing rivers were mentioned as some of opportunities that can be used for further improvement of production and productivity of coffee in the studied areas. Jima et al. (2017) have conducted the same study in Arsi Zone, Oromia regional state and came up with the most important opportunities that can be utilize in the future so as to boost coffee productivity. The mentioned construction of rural road, proximate to Agricultural Research Center and availability of coffee plantation enterprise in the area were among major opportunities for coffee production. They also indicated that developing of improved coffee varieties, enhancing extension services to improve farmers’ skill and knowledge on coffee production system, improving coffee marketing condition, and enhancing infrastructural and institutional facilities were among important factors.
| Name of vertebrate pest       | Percent of respondents confirmed presence of the pest | All locations | Damage                                                                 | Management                                |
|------------------------------|------------------------------------------------------|---------------|------------------------------------------------------------------------|-------------------------------------------|
|                              | Sidama      | Gedeo     | Wolayta     | Gamo Goffa    | 21.1                      | Feed on mature fruits and drop them down, reduce yield, reduce quality | Chasing them away when ever seen                  |
| Coffee bean eating birds     | 10          | -         | 22          | 52.5         | 21.1                      |                                                                      |                                            |
| Ape                          | -           | 16        |             |              | 5.0                      | Eat fruits, break branches, drop berries                              | Scaring them using trained dogs               |
| Baboons                      | -           | 4         |             |              | 1.2                      |                                                                      |                                            |
| Columbus Monkey              | -           | 8         |             |              | 2.5                      |                                                                      |                                            |
| Monkey                       | -           | 8         |             |              | 2.5                      |                                                                      |                                            |
| Abiotic factor            | Proportion of respondents | Stage affected | Effect on coffee                                                                 | Copping mechanism                                                                 |
|--------------------------|---------------------------|----------------|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
|                          | Sidama       | Gedeo     | Wolayta | Gamo Goffa | All         | All | Wilting, drying, yield loss, wilting, defoliating leaves, prolonging flowering, reduce flowering, produce small berries in size | Irrigation (28.3), irrigation and mulching (3.3%), Mulching (32.1%), Mulching, water and soil conservation methods (1.9%), Mulching and shading (3.8%), Mulching, avoid moving in the field (1.9%), Shading (7.5%), Supplementary irrigation (5.7%), Unknown (15.1%) |
| Drought                  | 35.4         | 15.8      | 20.9    | 23         | 28.6        |     |                                                                                 |                                                                                 |
| Frost                    | 2.5          | 3.5       | 4.5     | 4.8        | All but seedlings |    | Aggravate berry disease, immature fruit drying, kill the tree, yield loss, defoliate fruits and leaves, | Nothing (70.6), replacing missed trees (5.9%), shade reduction (11.8%), shading (11.8%) |
| Fluctuating rainfall pattern | -            | 10.4      | 1       | 1.2        | Mother trees |    | Reduce flower, disturb growth                                                   | Shading (100)                                                                   |
| Heavy rain               | 24.1         | 7.0       | 10.4    | 2          | 13.1        |     | All especially flowering and mother trees                                      | Cannel opening and terracing (3.3%), Cannel opening (33.3%), Mulching (13.3%), Nothing (16.7%), Planting shade (13.3%), Terracing (6.7%), unknown (13.3%) |
| High hum                 |              |           | 4.5     | 1.2        | All         |     | immature defoliation of berries, aggravate berry disease,                      | Shade reduction (66.7%), Nothing (33.3%)                                        |
| High sun                 | 1.3          | 19.4      | 14      | 11.1       | All         |     | Burning, Wilting, Yield loss, drying tree, leaf yellowing/ promote leaf senescence, | applying compost (3.6%), irrigation (32.1%), Irrigation and Mulching (3.6%), Nothing (14.3), Shading and supplementary irrigation (3.6%), unknown (10.7%) |

(Continued)
| Abiotic factor          | Proportion of respondents | Stage affected | Effect on coffee                                                                 | Copping mechanism                                                                 |
|------------------------|---------------------------|----------------|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
|                        | Sidama | Gedeo | Wolayta | Gamo Goffa | All   |                        |                                                                 |                                                                                       |
| High temp              | 5.1    | 3.0   | 2       | 3.2       |       | Defoliate flowers, remove fruits, prolong flowering time, leaf defoliation, drying trees, wilting, yield loss and aggravate alternate bearing | Building water conservation structures (14.3%); irrigation and Mulching (14.3%); Mulching (14.3%); Nothing (14.3%); Shading (28.6%); Shading and opening cannel (14.3%) |
| Irrigation water shortage | 1      | 0.4   |          |           |       | Reduce flowering, wilting | Nothing                                                        |
| Low mois               | 6.3    | 1.8   | 9.0     | 6         | 7.9   | Wilting, Stem drying, Yield reduction, Yield loss, flower drop, Retard growth, flower abortion, aggravate alternate bearing, reduce flowering, burning trees | Composting (5.6%); irrigation (11.1%); irrigation and Mulching (5%); Mulching (22.2%); Nothing (11.1%); Shading (27.8%); unknown (11.1%); Water conservation (5.6%) |
| No                     | 15.2   | 45.6  | 3.0     |           | 15.9  |                        |                                                                      |
| Hail                   | 5.1    | 24.6  | 4.5     | 8.3       |       | Fruit drop off, tearing leaves, break branches, drop flowers, prevent fruiting, wounding | Nothing (66.7%); Shading (33.3%)                                               |
| Storm                  |         |       | 0.4     |           |       | Defoliation and dropping of fruits, breaking branches | Wind break                                                         |
| Wind                   | 5.1    | 1.5   | 4.0     |           |       | Breaking branches, leaf defoliation, disease transmission, drying | Fencing (9.1%); wind break (90.9%)                                             |
| Reduced soil fertility | -      | 1.8   |          |           |       | Yield loss,                        | FYM (33.33%); Composting (33.33%) and Shading (33.33%) |
### Table 23. Points for further improvement/intervention areas

| Points for further improvement                                | Frequency | Percent |
|---------------------------------------------------------------|-----------|---------|
| Additional coffee pulpery and processes sing plant            | 5.0       | 2.3     |
| Any remedy for disease problem                                | 6.0       | 2.8     |
| Chemicals for disease and pest control                        | 5.0       | 2.3     |
| Chemicals for disease control                                 | 6.0       | 2.8     |
| Farm tools                                                    | 31.0      | 14.5    |
| Harvesting machine                                            | 5.0       | 2.3     |
| Improved disease resistant varieties                           | 5.0       | 2.3     |
| Improved varieties                                            | 54.0      | 25.2    |
| Market information                                            | 5.0       | 2.3     |
| Motor pump                                                    | 10.0      | 4.7     |
| On time seed supply                                           | 5.0       | 2.3     |
| Training                                                      | 53.0      | 24.8    |
| Others                                                        | 24.0      | 11.2    |
| **Total**                                                     | 214       | 100.0   |

### Table 24. Opportunities of coffee production at the interviewed areas

| Opportunities                                              | Frequency | Percent |
|------------------------------------------------------------|-----------|---------|
| All weather road                                            | 12        | 7.23    |
| Convenient topography                                      | 1         | 0.60    |
| Fertile land                                                | 17        | 10.24   |
| Good climatic conditions                                   | 58        | 34.94   |
| Good government policy                                      | 3         | 1.81    |
| Good support from agricultural office                       | 5         | 3.01    |
| Irrigation cannel                                           | 1         | 0.60    |
| Nothing                                                     | 2         | 1.20    |
| Presence of market access                                   | 7         | 4.22    |
| Presence of NGOs for support                                | 1         | 0.60    |
| Safe market                                                 | 1         | 0.60    |
| Sufficient labour                                           | 12        | 7.23    |
| Sufficient land                                             | 6         | 3.61    |
| Sufficient rainfall                                         | 1         | 0.60    |
| Sufficient water for irrigation                             | 2         | 1.20    |
| Unknown                                                     | 9         | 5.42    |
| Village crossing river                                      | 28        | 16.87   |
| **Total**                                                   | 166       | 100.0   |
to improve coffee production and productivity, and thereby improving livelihoods of coffee producers in the study area.

4. Summary and conclusion
Lack of improved cultivars, unavailability of improved production technologies, physiological problems like die back and minimum or no use of agricultural inputs by small holder is also important factors for low coffee yield. Moreover, Ethiopian coffee is inferior in yield to other producers, which is mainly because of backward cultivation and harvesting system.

Effective supply of agricultural inputs, such as planting improved varieties, fertilizers, insecticides, at affordable prices, should be encouraged. However, the use of both organic and mineral fertilizers is either nil or very limited to some production systems (e.g., large commercial plantations). Evidence from decades of research in the country indicates that nutrient inputs (from both organic and inorganic sources) can boost productivity and quality of coffee if used in appropriate balance and rates.

CBD still cause significant crop losses on susceptible landraces although the magnitudes vary from place to place and from time to time. Thus phytosanitary measures such as regular field monitoring, uprooting and burning and/or burring infected plant should be taken seriously in to account as there was no any scientifically approved measures so as to manage most of coffee diseases. Strong efforts should continue to aware and sensitize and intensively train coffee farmers and extension workers about the diseases and their management through practical training.

It can be recommended that testing the adaptability of improved coffee verities that tolerate major disease and drought, generation of new varieties for the areas, enhancing extension services to improve farmers’ skill and knowledge on coffee production system and risk alleviating mechanisms, testing soil fertility and developing soil fertility mechanisms, establishment of market places in the vicinities of producers, strengthening and/or establishment seed producing institutions found to be vital to motivate coffee producers and increase coffee production and productivity in the study area and areas with similar situations.

In general solving biotic (disease, insect pest, weed and vertebrate animals), abiotic (drought, soil fertility reduction, frost, heavy rain, etc.) problems and by exploiting production, infrastructural and technical opportunities, the production and productivity of coffee can be improved alarmingly in the study areas and areas with similar agroecological conditions.

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I declare that the manuscript is mine and I am the principal investigator and one of the authors.

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