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Research Paper

Assessment of Farmers' Perception on Potato Farming Systems in North Western Ethiopia

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This study was proposed to investigate the overall perception of farmers' on potato (Solanum tuberosum L.) farming systems in north western Ethiopia where the largest production of potato in Ethiopia undertakes. From West Gojjam, East Gojjam, South Gondar and Awi Zones two Woredas and Kebeles were purposively selected during 2018/2019 growing season. Secondary and primary sources of data were collected. Smallholder farmers produced potato for food, seed, cash and to keep the soil fertility in all the districts. Only 9.8% of the surveyed farmers went through off farm activities as income source. They had an average potato production experience, livestock number and farm size of 36.81 years, 5.17 and 1.63ha, respectively. Such farmers used on average 0.47 ha (28.83%) of their land for potato production. The dominant potato growing season was the main season (65.1%) from June to September followed by irrigation system (25.7%) from February to May; the remaining (9.2%) was with residual moisture. From the totally produced potato (2.29 tones), 16.6% used as seed, 48.55% consumed and 25.73% sold in the near bye market with very low price (2.17 Birr/kg) that discouraged farmers from production. On average there were two commonly grown varieties per farmer. Some local varieties which had their quality had lost from their farming activities. On average farmers ploughed their land 3.34 times before planting potato and used 2.13 t/ha potato seeds at planting as seed rate. 14.4% used their own seeds, 73.5% purchased from the surrounding market, 10.2% from their neighbors and 1.9% from the agricultural offices including research centers as seed source. More than half of the surveyed farmers (91.1%) did not use separate plots for potato seed production. The cost and not on time availability made fertilizers unavailable, though most farmers (63.0%) used fertilization as traditional technique of soil fertility management. The farmers used crop rotation mainly with potato (35.1%) as a traditional technique of soil fertility management. Besides potato, faba bean, peas, lupine, wheat and barley were crops that best fit in crop rotation in the area. 1.9% of the surveyed farmers used terracing technique as a traditional means of keeping their soil fertility. Animal dungs were not used as a composting source as there was lack of animal dung. Lack of improved potato seeds (38.8%), diseases and insect pests (32.5%), lack of fertilizer (10.8%), land shortage (5.9%), lack of market access (4.7%), drought (4.1%), high cost of storage (0.6%), frost (0.3%) and lack of credit (2.3%) were the major constraints challenging potato production.

Key words: Potato, farming systems, soil fertility, crop rotation, potato seeds, constraints.

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INTRODUCTION

Food security is the top agenda of the government agricultural policy in Ethiopia. Among the different approaches that help the country to achieve food security is integration of root and tuber crops in the agricultural systems. Potato is one of these strategic crops that can be considered to ensure food security (EARO, 2000). Globally, potato (*Solanum tuberosum L.*) is the third most consumed crop behind rice and wheat (International Potato Center, 2013). Potato was introduced to Ethiopia in 1859by a German immigrant, Wilhelm Schimper. Howeverits adoption by Ethiopian farmers is like it did happen in other parts of Europe (CIP's World Potato Atlas, 2007).

Ethiopia is endowed with suitable climatic and prevalent conditions for potato production (Medhin *et al.,* 2001).Reports of different authors has pointed out that potato could be grown on about 70% of the arable land in Ethiopia (Medhin *et al*., 2001). Presently the total area of land allocated for potato production under the two major (Meher and Belg season) production system maximized from 0.3 million hectare in 2016 (CSA, 2016) to 70 million hectare in 2020 (CSA, 2020). The total volume of production has also grown from 3.65.to 29 million tons in over a period of time (CSA, 2016; 2020). In 2020, more than 10 million smallholders are engaged in potato production. This has resulted in a large increase compared to previous years. With the present area coverage, potato stands top among all other horticultural crops grown in Ethiopia next to red peppers (CSA, 2020). It accounted for 60% of the root crops and 28.5% of all horticultural crops added together. Likewise, potato accounted for 50.7% and 43.2% of the total production of root crops and all horticultural crops added together, respectively (Potato Strategic Plan, 2016). In the north western part of Ethiopia farmers produce potato at the end of rainy season immediately after harvesting of short season crops like barley with residual moisture. Potato can also be used in crop rotation system especially with cereals, pulses and/or potato.

The growth is expected to continue owing to the present rapid population increment. Besides this, availability of improved technologies, expansion of irrigation culture, increased market value, production systems diversification—rainy season, irrigation, short rains and recessed land (Gebremedhin *et al*., 2013). Potato is the fastest growing food crop in Sub-Saharan Africa with total production being doubled during the last 15 years in some countries. This is similar to the developments in Asia (China and India) where area and yield increased dramatically (Anton *et al.,* 2012). Moreover, Potato serves as a food security crop; provides high yield quality product per unit of input with a shorter crop cycle (Hirpa et al., 2010; generates income and employment opportunity for the poor (Abebe et al., 2017); contributes to the economic sustainability of agricultural systems in developing countries; relatively cheap but nutritionally rich (Sanginga and Mbabu, 2015); ideally suited to places where land is limited and labor is abundant due to its high harvest index (Muthoni and Nyamongo, 2009); and it serves as both food and cash income in the densely populated highlands of sub-Saharan Africa (Gildemacher et al., 2009).Potatoes are often grown in rotation with other crops such as maize, linseed, rapeseed, faba bean, or haricot bean (Anton *et al.,* 2012).

At present, Ethiopia is among the top potato producers in Africa (Bekele *et al.,* 2011). It accounts for 51% of the total potato harvested at national levels during 2016/17 cropping season.During this stated period,ANRS ranked 2nd in potato area coverage and production among the regional states of the country. The region puts 21,352.52 ha for potato production during this stated period. Among administrative zones of the region South Gondar, West Gojjam, East Gojjam and Awi zones contributed over 68% of the total area of potato production and the total yield harvested over these areas was about 118,913.89tons/ha which accounts 64% of the total yield harvested in the region (CSA, 2017). Due to different biotic and abiotic production constraints, the national/regional average productivity of potato is 14.2 t/ha in 2018/19 and 13.1 t/ha in 2019/20 (CSA, 2020), which is far below the World'sand East Africa average productivity (20.8 and 18 tons/ha, respectively) (CIP, 2018 and FAO, 2019, respectively), while the attainable yield with good crop management is well above 30 t/ha (Anton *et al.,* 2012).This may be due to lack of adaptable improved potato varieties, if available with high cost that farmers cannot afford it, unavailability of improved storage facilities, inappropriate agronomic practices, low price of the produced potato, etc as reported by Gebru *et al.,*(2017).

Farmers' in the highlands and undulated areas wherethe major potato growing belts in the country believe that potato can help to protect their soil from erosion owing to its early planting time unlike the late planted common staple cereals and pulse crops. Saida *et al.*(2016) reported substantial contribution of potato in reducing the amount of soil lost from the highland parts of the country. The other group argues that potato accelerates soil erosion owing to its morphological characteristics of shallow root systems requiring well prepared soil than other crops for better expansion of surface running fibrous root system and tuber development in one hand and also ease of harvesting after crop maturity that usually involves intensive soil tillage throughout the cropping period, which often leads to soil degradation, erosion and leaching of nutrients. During soil preparation, the entire topsoil is loosened particularly on sticky soils. The soil is also pulverized into small aggregates to avoid the formation of clods in the potato beds (International Year of the potato, 2008) which aggravates soil erosion. This is unlike other cereal/pulse crops requiring less number of cultivation before/after planting. Griffin *et al.* (2009) also reported that the amount of residue left after potato harvest is very small

unlike farmers perception in the country where by potato increase soil fertility by leaving all of its parts (except tubers) on the soil. Abebe *et al.* (2017) and Adamu (2013) found better barley yield after potato compared to plots planted following cereals.

Potato production is relatively sustainable since there is no known significant damage to human beings, animals, air, water, land, soil, forests, etc. Besides these, the contribution of potato as a precursor crop in improving productivity of proceeding crops was comparable to that of legume precursors. But, there is no area specific study on the overall role of potato in the farming systems. Therefore, this research was carried to assess the overall perception of farmers' on potato farming systems on north western Ethiopia.

METHODOLOGY

Description of the study area

The study was conducted in the western part of Amhara region, Ethiopia. The study areas/zones namely Awi, West Gojjam, East Gojjam, and South Gondar werepurposively selectedthat exhibit the desired production features which was the focus of the study(Figure 1). The sub-region is situated between 10.00-14.00° north latitude and 35.10-38.35° east longitude and characterized by the total annual rainfall ranging from 949 mm to 0 mm and the annual average maximum and minimum temperature of 34°C and 24°C, respectively. The last tenyears' (2009–2018) mean annual rainfall and temperature were 121.7 mm and 16.5°C, respectively, while the mean relative humidity of the area was as high as 56%. The rainfall pattern is mono-modal, extending from May to October (AppendixI). Western Amhara sub-region is characterized by different agroclimates with subsistence crop-livestock mixed farming systemsand highly heterogeneous soilsprovidingopportunities in terms of land use for the population.Much of Western Amhara has a potential to produce surplus agricultural produces.

"Cereals account for more than 80% of cultivated land and 85% of total crop production. The principal cereal crops in the Amhara Region are tef, barley, wheat, maize, sorghum and finger millet. Pulses and oil crops are the other major categories of field crops. About 27.9 percent of the livestock in Ethiopia, 30.7% of the poultry, and 18.5% of the beehives are found in the Amhara region. Most part of the region is on the highland plateau and is characterized by rugged mountains, hills, plateaus, valleys and gorges. Hence, the region has varied landscapes composed of steep escarpments and adjoining lowland plains in the east, nearly flat plateaus and mountains in the center, and eroded landforms in the north. Most of the western part is flat plain and extends into the Sudan lowlands. The topographical features represent diversified elevations ranging from 700 meters above sea level (m.a.s.l.) in the eastern edge to over 4600 m.a.s.l. in the northwest. A little over 50 percent of the total area of the Region is considered potentially arable for agricultural production activities" (Amhara National Regional State Food Security Research Assessment Report, 2000).

In the subregion, a large number of people are involved in the agricultural system (Lakew *et al.*, 2016).For the present study,multi stage sampling technique was used. Quarit and Yilmana Densa Woredas from West Gojjam zone, Sinan and Gozamin Woredas from East Gojjam zone, Farta and Lay Gayint from South Gondar zone, and Banja and Gaugusa-shikudad Woredas from Awi zone with two kebeles per each woreda purposively selected during the 2018/2019. The predominant farming system of the study area is a mixed farming system with the main food crops being tef, wheat, barley, faba bean and potato which were ideally grown in the distinct. Cattle, sheep, poultry, and donkey are the main livestock types.

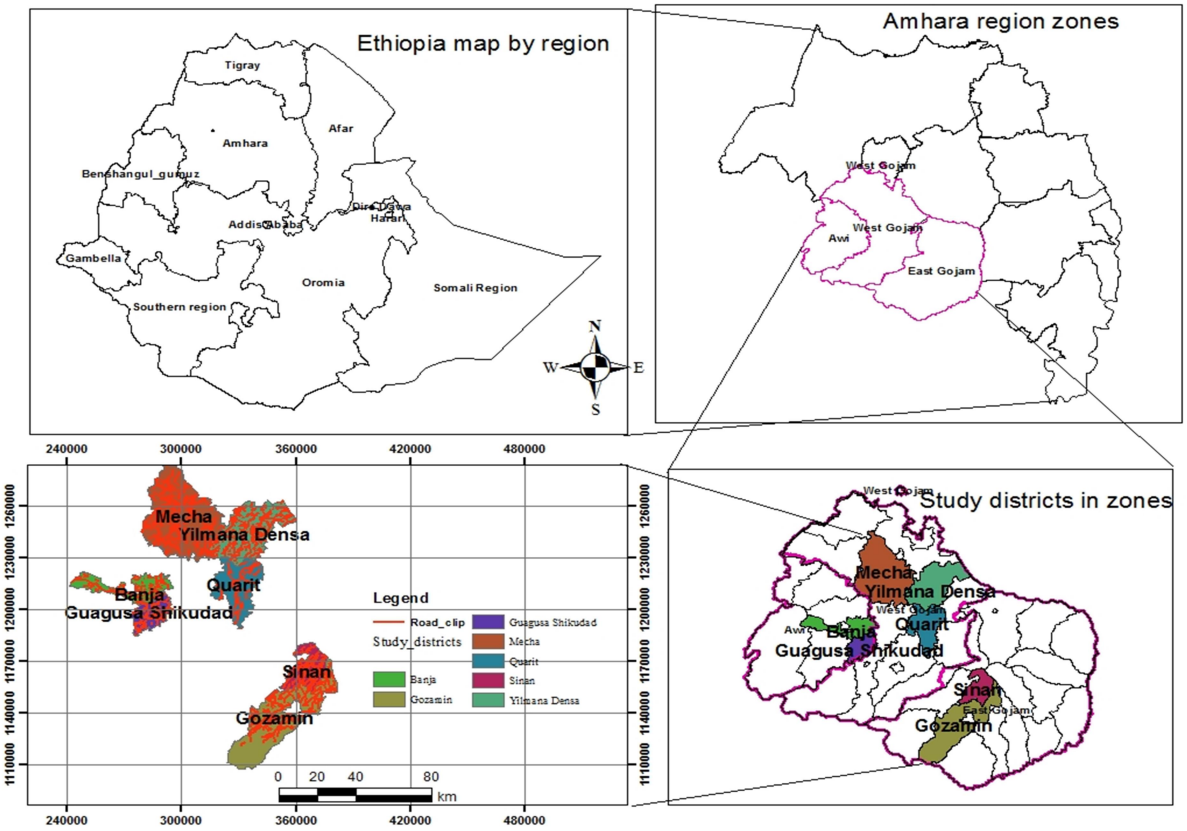

Figure 1.Map of the study area.

Sampling procedures and data collection

Elders (whose age is 30 and above) with different socioeconomic back grounds were used for this study. A proportional allocation formula was employed to select sample respondents from each*kebele* and each category by the formula of Yemane (1973):

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

Where *n* = sample size, *N* = population size, and *e* = level of precision (0.05).

Data was collected from both primary and secondary sources. Primary sources of data were collected using formal survey with a semi-structured questionnaire (Appendix II) that was administered to individual farmers. The questionnaire constituted open ended questions to allow full expression about the issue. Discussions were made with farmers, agricultural extension officers, researchers, and potato experts. Secondary source of data was obtained from the agricultural office of the district, from different books, journals and research articles. Both interviews in the questionnaires were filled.

Data analysis

All sets of data were subjected to Statistical Package for the Social Sciences (SPSS),Version 24 computer software (SPSS, 2010) and descriptive statistics such as mean, standard deviation and frequency were used to analyze the collected data.Major constraints in production practices of potato were summarized by multiple ranking methods using pie-charts. Class intervals were used to analyze descriptive statistics for age, education level and family size.

Results and Discussions

Demographic characteristics of Households

From the sampled population, about 91.5% of the sample households were maleheadedand 93.3% of the respondents were married (Table1). Average age of sample respondents was found to be 53.46 years (Appendix Table II). This showed more of the individuals taken for interview were aged. Aged people have less ability to take risk to become innovative. Moreover, the active labour force (15-64 years of age) of the sampled households was about 96.9%. 44.5% of the surveyed farmers had an age of more than 56 years (Table1).

Marriage is an integral part of life and related to identity and status in society (Ghimire and Samuels, 2013). Ploughing was men's duty. In other farm activities like land preparation, planting, cultivation and harvesting of the potato both male and female participated. Average family size of the area was 6.96which indicated that high population growth in the surveyed area (Appendix Table II). 64.2% of the sampled farmers had a family size of less than 7 (Table1). This decreases the farming land in general, and probably farmers' ability to allocate land to potato farming. In contrast, most of the potato agronomic practices require more labour. Therefore, it is possible that family members could help with these tasks during any stage of the crop growth as Gebru *et al.* (2017) stated. East Gojjam farmers had a higher family size (7.5) and more illiterate people (0.47 grades) (Appendix Table II). Okoye *et al*. (2008) reported large household size can provide more labour required for farm operations. Farm households having large family size of active labour force, have more chance to go for activities in their farming. But, large household size may not guarantee increased labour efficiency as a family may comprise children of school age.

Education helps farm households to acquire and interpret information on agricultural technologies. It is implemented to enhance the capabilities of adolescent girls (Ghimire and Samuels, 2013). 95.3% of the sampled farmers graded less than four (Table1). On average education level of sample households was 2.06 grades (Appendix Table II).This low education level could influence the sub-region farmers' ability to adopt new improved potato technologies. Okoye *et al.* (2008) revealed that educated farmers can deal with production problems and accept improved farming techniques than those who are less educated or without education. They also stated that farmers require production experience than education to increase productivity. But, education makeschildrenless available for farm activity.

From the surveyed farmers only 9.8% went through off farm jobs as an income source (Table 1). Ghimire and Samuels (2013) and Ghimire and Samuels (2013) reported most households derive their households from agriculture.In such areas where agriculture is at risk due to environmental factors, it is very important to create awareness on off farm employment activities to farmers. South Gondar farmers have a higher percentage of off-farm jobs than the other zones (Appendix Table II). This may be due to the fact that South Gondar farmers were more vulnerable to climate variability, drought, and soil degradation. Therefore, these farmers could leave their farming land, and move to big cities to look for other non-agricultural jobs.

Table 1. Mean demographic characteristics of the sample Households

Variable	Modality	Frequency of respondents (%)
Gender	Male	91.5
	Female	8.5
Marital status	Married	93.3
	Divorced	6.7
Age	35-54	55.5
	56-73	44.5
Educational background	0-4	95.3
	5-8	3.4
	9-12	1.3
Family size	3-7	64.2
	8-12	35.1
	>12	0.7
Potato production Experience	17-27	8.7
	28-37	44.8
	38-47	38.9
	48-58	7.6
Income source	Agriculture only	90.2
	Agri. with off farm activities	9.8

Production pattern and Production experience

Crop livestock mixed farming system is the basic feature of the district farmers. Potato production is the most important farm activity in this sub-region. The sampled farmers have an average potato production experience of 36.81 years (Appendix Table II). 38.9% of the sampled farmers had a potato production experience of more than 38 years (Table1). Theseindicated that farmers in the sub-region have ample experience on potatoproduction. In years to production experience Awi farmers were more experienced (39.71 years) than other zone farmers (Appendix TableII). This survey is supported by a report of Adet Agricultural Research Center (2011)potato production is an old practice in the North Western highlands.Similarly, Gebru *et al.* (2017)reported that farm experience of the farmersin Wolaita Zone, Ethiopiais more than 20 years.

Livestock number andFarm size

Livestock production is an integral part of the farming system in the sub-region. This type of farming system isreported by Waga*et al.*(2016). It can help a lot in the crop production; i.e. as draught power source, food, income source, organic manure, fuel source and transportation means. The sampled households had an average livestock number and farm size of 5.17 and 1.63ha, respectively (Table2). The largest livestock number and farm size were recorded in Awi Zone (5.87 and 2.17 ha, respectively) (Appendix TableII).Livestock and land is a very scarce resource and an important asset which is an indicator of wealth and perhaps a proxy for social status and influence within a community for farmers in Ethiopia. The average land holding of farmers in the present study was similar with the discursions by Yaze *et al.* (2017).Lakew *et al.* (2016) also reported the average land holding of farmers in the Amhara region was 1.7 ha. A survey by Mulugeta *et al.* (2020) revealed that total livestock number in north western Ethiopia was 4.3-6.5.

Table2. Mean Livestock number and land ownership of sampled households

Variables	Mean
Livestock Number (N)	5.17
Land holding (ha)	1.63
Potato production area coverage (ha)	0.47

Area allocation, productivity and production seasons of potato

Potato production in the highlands is an old aged practice but its production in the mid altitude and low altitude areas are limited. Adet Agricultural Research Center (2011) and FAO (2008) reported potato's production was widely expanding. The average land allocated for potato in the North Western part of Ethiopia was 0.47 ha (Table2). The maximum area allocated for potato was found in South Gondar zone (0.57 ha) followed by Awi Zone (0.53 ha)and West Gojjam (0.51 ha). The maximum potato production experience (39.71 years) was also in this zone (Appendix Table2). These three zones were also reported by Mulualem (2020) as the major suitable areas for potato production. Innovative farmers also rented in or outland in the study area for potato production. Mesfin *et al.* (2018) reported in Awi district potato covers 21% of the total land holding. As household landholdings shrink (Bekele *et al.,* 2011) and degraded, highly productive crops like potato became a good alternative to provide a cheap food source to the rapidly growing population in the area as well as in the country at large. Potato area coverage increased to 28.83% in 2019 (Table3).

Total amount of potato produced in the sub-region was 2.29 tons (Appendix Table II). The average amount of potato produced, reserved as seeds, consumed and sold are 2.29, 0.48 (16.6%), 1.26 (57.67%) and 0.80 tones (25.73%), respectively (Appendix Table II and Table3). The maximum amount of potato produced (3.01 t), consumed (1.34 t), conserved as seed (0.96 t) were in South Gondar Zone. The maximum amount of potato sold (1.26 t) was in West Gojjam Zone (Appendix Table II).The result was similar with the findings of Yaze *et al.* (2017). This result was also similar with the findings of Bezabih and Mengistu (2011) at Hulla. But, these authors also said that the largest amount of potato produced around Shashemene Atsibi Wonberta, and Saeesi Tsaeda Woredas was sold. This may be due to year and place difference.

The average price of potato in the sub-region was 2.06 Birr/kg (Appendix Table II). The maximum potato price (2.56 Birr/kg) was recorded in West Gojjam Zone (Appendix Table2). This may be due to market access of the zone than the other surveyed zones. Such low price was also recorded in SNNPRS and Tigray regions as Bezabih and Mengistu(2011) reported.

The trends of potato production were reported with the key informants during group discussions and individual farmers. The surveyed farmers had shown potato's production in all the three seasons: main season (65.1%) which is from June to September, irrigation systems (25.7%) from February to May and residual moisture (9.2%) (Table3). Potatoproduction with residual moisture was limited and restricted to the highlands of Gojjam where there is sufficient moisture in the off season. Thisresult contradicted with the report of Bezabih and Mengistu (2011) residual moisture supplemented with irrigation constitutes the bulk of potato production due to the low incidence of late blight and favourable market access. The reason behind this was the differences in the year and area.

Table 3. Area allocation and production seasons of potato

Variable	Modality	Frequency of respondents (%)
Area coverage	Potato area coverage	28.83
Production season	Main season	65.1
	Irrigation	25.7
	Residual Moisture	9.2
Potato amount produced	Potatoes reserved as seeds	16.6
	Potatoes consumed	57.67
	Potatoes sold	25.73
Potato price	Price/kg	2.17*

Where * indicates that the price was in Birr.

Commonly grown varieties and farmers' variety preference

Western Amhara farmers had hadtheir local varieties like Sabew (tolerant to late blight disease, high palatable and low yielder), Square (high palatable and low yielder) and Nech Dinch (high storage capacity). They used all these varieties in irrigation, in the main season and in crop rotation to improve soil health, optimize nutrients in the soil, and combat pest and weed pressure.For degraded lands, the surveyed farmers used Abalo/Agere local and Tolcha improved varieties. These varieties have high morphological growth characteristics in such degraded lands to ameliorate the soil's physicochemical properties. They did not use square local variety in such degraded lands as they have very weak morphological growth character.

The surveyed farmers are losing localpotato varieties like Abadamu and Abalo/Agerein their farming system as there is lack of storage facility on farmers' hand. These varieties had different quality attributesto be used in different breeding programmes and best fit to degraded lands (Abalo/Agere local variety). These lost varieties were discussed by Semagn *et al.* (2015) as they are locally cultivated.

There are two commonly grown improved varieties per farmeron average (Table4). This result is different from Yaze *et al.* (2017) as there is year difference. The surveyed farmers have maximum of four improved varieties namely Gudene, Belete, Jalene and Guassa. Most of the time,they get their seeds from their corporative or purchase from their neighbors or from the surrounding market. But as discussed by Waga *et al.* (2016) the use of improved varieties was predominantly governed by farmer's wealth, adoption and education levels and lack of access to improved varieties which was related to age and family sizes. To choose one variety for production, they rely on market access (Bezabih and Mengistu, 2011).

Farmers choose varieties in one of the following ways: yield potential (56.7%), marketability (13.6%), storage quality (11.0%), drought tolerance (6.5%), late blight resistance (3.5%), suitability for multiple harvesting (2.8%), early maturity (2.4%), adaptation to low soil fertility (2.2%) and palatable quality (1.2%) (Table4). Farmers in Ethiopia prefer varieties by their drought tolerance (Semagn *et al.* 2015);in Kenya owing totheir yield potential, market access and taste (Shimelis *et al.*, 2012), and inRwanda based onyield potential, disease tolerance and high dry matter content (Shimelis *et al.,*2012).

Table 4. Commonly grown varieties and farmers' variety preference

Variable	Modality	Frequency of respondents (%)
Potato varieties	Commonly grown potato varieties	2*
Farmers variety preference	Yield potential	56.7
	Marketability	13.6
	Storage quality	11.0
	Drought tolerance	6.5
	Late blight resistance	3.5
	Suitability for multiple harvesting	2.8
	Early maturity	2.4
	Adaptation to low soil fertility	2.2
	Palatability	1.2

Where * indicate d that commonly grown varieties was in number.

Management practices for production of potato

Average seed rate of potato was 2.13 t/ha (Table5). This result was in agreement with Gebru *et al*. (2017); and Yaze *et al*. (2017). All of the surveyed farmers used commercial fertilizers. The average amount of DAP and urea fertilizer for production of potato was 130.23 and 103.41 kg/ha (Table5).These rates were below the recommended rate. Similarresults were reported by Yaze *et al.* (2017). Similar studies in the southern part of Ethiopia revealed that farmers apply lower doses of fertilizers (Bezabih and Mengistu, 2011).

Animal dungs were not used as a composting source in north western Ethiopia as there was lack of animal dungs. But, animal manures are one of the main nutrient sources and the major component to keep the soil fertility. This result was also supported by Zelleke *et al.* (2010) who reported the extremely low use of manure in Ethiopia for soil fertility maintenance. Regarding composting, Gebru *et al.* (2017) reported that at Wolaita zone, Ethiopia farmers applied small amounts of organic fertilizers i.e. about 1.1 t/ha to their potato farms.

As potato seed source, 14.4% use their own seeds, 73.5% from the surrounding market, 10.2% from their neighbors, 1.9% from the agricultural offices including RCs (Table5). Biniam *et al.* (2014) also reported that majority potato growers in Eritrea buy seeds in the open market due to absence of formal seed supply system and limited supply from agricultural offices. Bezabih and Mengistu (2011) reported that seed potato producers in Tigray region mostly sell their seeds to farmers in their surroundings. According to the surveyed farmers', their seeds may be degenerated. They have informal potato seed systems as reported byZerihun *et al.* (2014); Bezabih and Mengistu (2011) and Gildemacher *et al.* (2009). These systems have a serious problem related with seed quality issues as a these systems supply inferior quality seeds (Bezabih and Mengistu, 2011); Gildemacher*et al.,* 2009) and Mulatu *et al.,* 2005) due toabsence of quarantine inspection systems during their production. The farmers of the surrounding had produced ware and seed potato both in the main and in irrigation seasons. 91.1% of the farmers did not use separate plots and management practices for seed potato. This result is in agreement with the report of Zerihun *et al.* (2014). This is due to lack of awareness and land shortage hence potatoes after production separated in to ware and seed potato after harvesting.

The potato area coverage was increasing from year to year (by 0.25 ha/year). This was due to increasingprice (15.4%); land shortage (7.1%);no other crops that can cover such degraded area (76.5%).Potato is an ideal food source for the area due to increasing awareness and population (1%) (Table5).

There is some extension effort that extends improved agricultural technologies. On average the extension agents contact the surrounding farmer one times/week.This low rate of extension contact is also reported by FAO (2008). Waga *et al.* (2016) also reported cash shortage is a major constraint in Ethiopia to implement extension packages for different crops. Knowledge, orientation and extension contact have a strong influence on farmers' productivity (Okoye *et al.,* 2008). Potato seed tubers (in some case), fertilizers and agronomic practices are delivered to the farmers through the extensionsystem in the study area.

On average, the surveyed farmers plough their land for potato production 3.34times (Table5). This result is similar with the findings of Waga *et al.* (2016). For the main and irrigation season potato production, ploughing starts at the end of February and August, respectively. Only 1.1% of the surveyed farmers use pesticides like Redomil (Table5). Hirpa *et al*. (2012)also reported lack of improved crop management practices such as pesticide application had larger effect on seed yield and quality.

Table 5. Management practices done on potato production

Variable	Modality	Frequency of respondents (%)
Seed rate		2.13*
Seed source	Their own seeds	14.4
	From the surrounding market	73.5
	From their neighbors	10.2
	From agricultural offices	1.9
Fertilizers used	DAP	130.23*
	Urea	103.41*
	Animal dung	0*
Increment of potato area coverage	Price is increasing	15.4
	Land shortage	7.1
	No other crop that can cover such degraded lands	76.5
	Potato is an ideal food source for the area	1
Ploughing	Number of ploughing	3.34*
Plots for seed potato	Separate plots for seed potato	8.9
Pesticide	Pesticide usage	1.1
Seed corporative member	Members of Potato seed corporative	15.2

Where * indicated that seed rate in kg, Fertilizers in kg/ha and number of ploughing was in numbers,

Seed corporative

There are some potato seed corporative in their surroundings. A good example is Lay Gayint from South Gondar. Though the Woreda is an ideal potato seed source especially for Amhara region, it has few seed corporative like Guna, Meseret, Agona, Alamaya and Tikdem which are located in few kebeles. They are not also efficient especially in potato seeds though they have gotten little support from some NGOs, Debre Tabor University and Adet Agricultural Research Center as reported by Mesfin *et al.* (2018).

Only 15.2% of the surveyed farmers are members of such corporative (Table5). Being a member, they get access to improved potato varieties if any, fertilizer on time, market access andincome source. Such seed corporative as a source of quality planting material should be strengthen for healthy and successful potato production venture (Mesfin *et al.*, 2018).

Potato storage systems

Farmers use different traditional potato storagesystems depending on the use of the produce (Ware and seed). 29.1% of the surveyed farmers use DLS for seed potato storage and 51.6% use wooden shelves.For ware potatoes, 25.2% of the surveyed farmers use wooden shelves, 30.9% use home floors, 33.9% use both wooden shelves and home floors, and 10.0% use production plots (Table6). This result was reported by Adet Agricultural Research Center (2011). Extended harvesting on the production plots are not effective for handling ware potato for long-term storage (Abebe, 2020). High cost of both seed and ware potato storage was considered as constraints (Fig2) for potato productivity in the surveyed area. Gebru *et al.* (2017) reported that postharvest problem had remained a serious constraint for agricultural

commodities in general and horticultural industry in the country. This gap was reported several times by Bezabih and Mengistu(2011). Hirpa *et al.* (2012) reported the low management practices like lack of storage methods had larger effect on yield and quality of potato. Poor postharvest management is a bottleneck to higher potato yields in in Africa in general as reported by VIB (2019).

Table 6. Potato storage systems

Variable	Modality	Frequency of respondents (%)
Seed potato storage	DLS	29.1
	Wooden shelves	51.6
	No seeds	19.3
Ware potato storage	Wooden shelves	25.2
	Home floors	30.9
	Wooden shelves & home floors	33.9
	Production plots	10.0

Where DLS = diffused light storage

Major constraints of potato production

Potato production was constrained in the Western Amhara sub-region by different factors like lack of improved potato seeds (38.8%), diseases and insect pests (32.5%), lack of fertilizer (very costy and not on time) (10.8%), land shortage (5.9%), lack of market access (4.7%) and drought (4.1%). Lack of credit (2.3%), high cost of storage (0.6%) and frost (0.3%)also considered as constraints for potato production in the surveyed areas (Fig2).

Dawit *et al.* (2020) alsoreportedunavailability of improved potato variety seeds, problems with pest and diseases, low soil fertility, poor agronomic practices and poor access to markets are the major constraints for the low productivity of potato at Farta Woreda. Lack of improved potato seeds is a major constraint of potato as reported by Waga *et al.* (2016). Hirpa *et al*. (2012) andMesfin *et al.* (2018) also reported lack of management practices like lack of appropriate fertilizer rate had larger effect on potato seed yield and quality. Only wealthy and educated farmers can get some improved potato seeds and can supply sufficient nutrients to grow these improved varieties. Land shortage was also a major constraint for potato production as reported by Waga*et al.*(2016) that can influence the adoption of potato technology as reportedby Belay(2003). To solve their land shortage some innovative farmers in the survey area hire land from other farmers who cannot afford to purchase inputs and weak due to age and other reasons. Waga *et al.* (2016) also reported such farmers must participate in other income generating activities that require less land.

Lack of market access was also a major constraint of potato production as reported by Waga *et al.* (2016). All farmers in the surveyed area harvest their potato at the same time and sell their produce in the nearby local market due to oversupply at a time. These farmers had low access for better price markets outside their area.In the area, markets were controlled by cartels which protect producers from receiving any market information from agricultural offices or distant merchants. Transport of potatoes to the nearby and distant markets was also very expensive due to poor road infrastructure and vehicles own to farmers. Lack of organized marketing channel also reported as a constraint for potato production in Kenya by Muthoni and Nyamongo (2009). Most of these farmers have a low financial and technical capacity to construct potato storage to store and sell their products when market prices become high. High cost of storage as a major constraint for potato production was reported by Zerihun *et al.* (2014), and many farmers use postponed harvesting. But, best management attribute levels like scientifically recommended storage methods, fertilizer rate, pesticide application, seed source, seed size, sprouting methods, tillage frequency, and planting dates have potentials to increase two times the seed yield quality (Hirpa *et al.,* 2012).

In almost all the surveyed environment especially in Awi and Gojjam, potato productivity was highly constrained by wilt disease. Bacterial wilt disease is making land out of production of potato. Cultural management practicessuch as rouging, crop rotation, etc and trainings farmers should be done to limit the further spread of this disease and sustain potato production in this sub-region.Wilting diseases as a major constraint for potato production was reported by Yaze *et al.* (2017); Mesfin *et al.*(2018) and late blight was reported by Bezabih and Mengistu (2011).

As indicated in the metrological data (Appendix Table I), erratic and unpredictable rain fall pattern and non-constant increment or decrease of the temperature makes the area to be sensitive to drought. Drought was also recorded as a

major constraint of potato in the surveyed area. Some credit service was provided to farmers from Amhara Credit and Saving Institute (ACCI). They used this credit for purchasing animals to fatten and then sell. This credit may only be used to purchase fertilizers for potato and other crops.

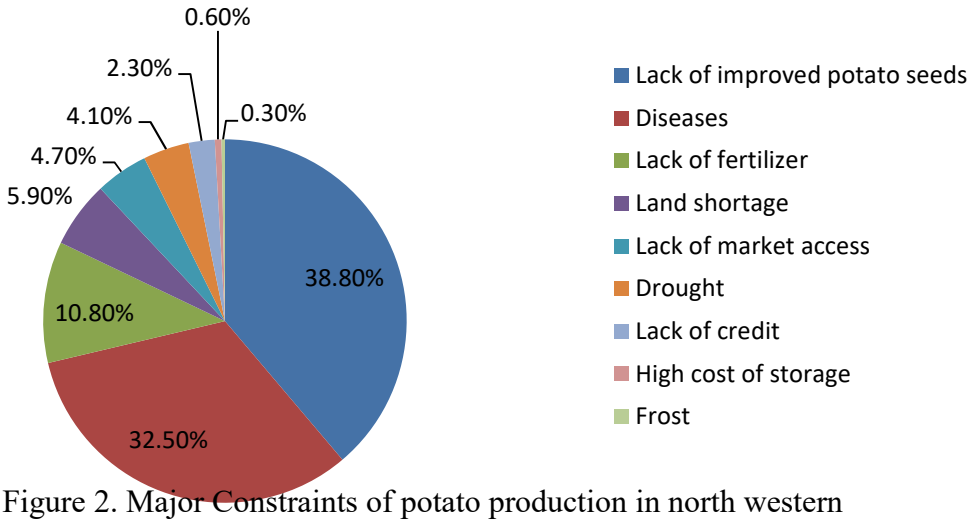

Figure 2. Major Constraints of potato production in north western Ethiopia

Traditional techniques for soil fertility maintenance

Traditionaltechniques for soil fertility maintenance includeterracing (1.9%), fertilization (63.0%), and crop rotation mainly with potato (35.1%)(Table7). Farmers in this environment used potato to keepthe fertility of the soil and conservation management practices. This was due to the significance amount of residue left after potato tuber production. Such practices with potato were reported by Anton *et al.* (2012). Josef *et al.* (2013) also reported potato planting early in the rainy season helps farmers to conserve their soil from erosion. Nyawade *et al.* (2019) reported that intercropping potatoes with any of the cover crops reduced nutrient and soil loss and runoff.The substantial contribution of potato in reducing the amount of soil lost from the highland areas was reported by Saida *et al.*(2016). But, the other group argues that cultivation practices done to plant potato before and after planting and ease of harvesting after crop maturity leads to soil degradation, erosion and leaching of nutrients (International Year of the potato, 2008 and Nyawade *et al.,* 2019). Griffin *et al.* (2009) also reported that the amount of residue left after potato harvest was very small as all residue decomposed before harvesting.

Though the surveyed farmers use fertilization as a traditional technique for soil fertility maintenance, the very costly and untimely supplied commercial fertilizeravailability were the major potato production constraint as discussed in Fig2. According to the surveyed farmers, crop rotation was used in pest control, soil fertility management and crop diversification. Crop rotation is one part of conservation agriculture. Anton *et al.* (2012) also reported potato is one among the crop rotation component crop as it has a significance amount of residue. Besides potato, faba bean, peas, lupine, wheat, barley and tef are crops that succeeding in crop rotation. The pre cursor of potato is lupine, wheat or barley while the succeeding crops are tef, barley and wheat. Potato is important in soil fertility management practices as the whole plant except the tubers will not be harvested like other cereals but decompose within the same field. The surveyed farmers had concluded that degraded land in which other crops cannot be produced is used for potato production though Chow *et al.* (2010) reported that potato production is a potential source of soil degradation. Saida *et al.* (2016) also reported substantial contribution of potato in reducing the amount of soil lost from the highlands. Farmers believe that potato can improve the fertility of the soil for the coming crops like the fallow land to the precursor crop. Unlike other crops, in which the whole plant part is harvested, the left over from potato will remain and contribute for soil fertility maintenance according to farmers view. In other crops the whole plant being harvested and there is no biomass

transfer to the land devoid of such practice. These are also reported by Abebe *et al.* (2017) and Adamu (2013). Karnata *et al.* (2019) also reported that highest amounts of organic carbon and organic matters were observed in potato leftovers.

Table 7. Traditional techniques for soil fertility maintenance

Variable	Modality	Frequency of respondents (%)
Traditional techniques	Fertilization	63.0
	Crop rotation mainly with potato	35.1
	Terracing	1.9

Source: Survey Result, 2019

CONCLUSIONS

Potato production in the highlands of Ethiopia is an old age practice. The survey revealed that farmers use Potato in soil fertility management, had their own local varieties, different variety preference, more than half of the surveyed farmers did not use separate plots and management practices for potato seed production and informal potato seed systems. Farmers used different storage systems for ware and seed potatoes. The study also revealed that there were traditional techniques of soil fertility management like terracing, fertilizationand crop rotation mainly with potato. Farmers in the surveyed area believed that potato can ameliorate the fertility of the soil and protect soils from erosion.Potato production was also constrained by lack of improved potato seeds, diseases, lack of fertilizer, land shortage, lack of market and credit access, drought, high cost of storage and frost, so we have to work for improvement of these factors through different interventions.

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REFERENCES

Abebe A. G., Bijman J., Ruben R., Omta O. and Admasu T. 2017. The role of seed/ware potato cooperatives in Ethiopia in improving quality and reducing transaction costs. Wageningen University. Netherlands.

Abebe C. D. 2020. Prospects and Challenges of Postharvest Losses of Potato (Solanum Tuberosum L.) in Ethiopia. Global Journal of Nutrition & Food Science Volume 2-Issue 5, P. 1-10.

Adamu M. 2013. Effect of double cropping and N fertilizer levels on cropping system and malt barley productivity in the highlands of North Shewa.Unpublished data.

Adet Agricultural Research Center (AARC). 2011. Research Achievements: A quarter century-long effort to lift the living standards of farmers. Pp117.

Amhara National Regional State Food Security Research Assessment Report. 2000. USAID Collaborative Research Support Programs Team. Addis Ababa. Ethiopia.

Anton H., Flip V., Huub S., Romke W. and Xiaoyong Z. 2012. Potato prospects for Ethiopia: on the road to value addition. Wageningen UR. The Netherlands.

Bekele B., Abate E., Asefa A. and Dickinson M. 2011. Incidence of potato viruses and bacteria wilt disease in the West Amhara sub-region of Ethiopia. Journal of Plant Pathology, 93 (1), 149-157.

Bezabih E. and Mengistu N. 2011. Potato Value Chain Analysis and Development in Ethiopia: Case of Tigray and SNNP Regions. International Potato Center (CIP-Ethiopia), Addis Ababa, Ethiopia.

Biniam M. G., Githiri M. S., Mehari T. and Kasili W. R. 2014. Potato Seed supply, Marketing and production constraints in Eritrea. American Journal of Plant science. Vol. (5):3684-3693.

CSA (Central Statistical Agency). 2009. Agricultural sample survey: Report on area and production of crops, Addis Ababa, Ethiopia. 126p

CSA (Central Statistical Agency of Ethiopia). 2016. Agricultural sample survey: Report on area and production of crops, Addis Ababa, Ethiopia.

CSA (Central Statistics Agency). 2017. Agricultural sample survey, volume III, report on farm management practices (private peasant holdings, meher season). Addis Ababa. Ethiopia.

CSA (Central Statistical Agency).2020. Agricultural Sample Survey, Volume I, Report on area and production of major crops. Addis Ababa. Ethiopia.

Food and Agriculture organization (FAO). 2019. FAOSTAT. Potato yield data 2017. Available at *http://www.fao.org/faostat/en/#data/QC*. Accessed 13-02-2019.

Gebru H., Ali M, Nigussie D. and Derbew B. 2017.Assessment of production practices of smallholder potato (*Solanum tuberosum* L.) farmers in Wolaita zone, southern Ethiopia. *Agric & Food Secur, 6:31,* DOI 10.1186/s40066-017-0106-8.

Ghimire A. and Samuels F. 2013.Change and continuity in social norms and practices around marriage and education in Nepal.Overseas Development Institute. London.

Gildemacher P.R., Kaguongo W., Ortiz O., Tesfaye A., Woldegiorgis G., Wagoire W.W., Kakuhenzire R., Kinyae P.M., Nyongesa M., Paul C. S., Leeuwis C. 2009. Improving potato production in Kenya, Uganda and Ethiopia: a system diagnosis. Potato Research, 52(2), 173-205.

Griffin S. T., Larkin P. R. and Honeycutt W. C. 2009.Delayed Tillage and Cover Crop Effects in Potato Systems**.**American Journal of Potato Research, Volume 86,Issue 2, pp 79–87.

Hirpa A., Meuwissen M. P., Lans V. D., Lommen M. J., Alfons J. G. M., Lansink O., Admasu T. and Paul C. S. 2012. Farmers' Opinion on Seed Potato Management Attributes in Ethiopia: A Conjoint Analysis. Agron. J. 104:1413–1424. doi:10.2134/agronj2012.0087.

International year of the potato. 2008. Potato and Soil Conservation. Available at.*www.potato2008.org.*

International Potato Center (CIP). 2018. CIP Annual Report 2017. Harnessing potato and sweet potato's power for food security, nutrition and climate resilience. Lima, Peru. International Potato Center, p. 47.

Lakew D., Menale K., Benin S. and Pender J. 2016. Land degradation and strategies for sustainable development in the Ethiopian highlands: Amhara Region. Socio-economics and Policy Research Working Paper 32. ILRI (International Livestock Research Institute), Nairobi, Kenya. 122 pp.

Mesfin F., Asmamaw B., Yonas W., Eshetu M., Biadige W. and Birhanu F. 2018.Pre-scaling up of Potato Technology Package in the High Land of Debark Woreda, North Gondar Zone, Amhara Region, Ethiopia. In Proceedings of the 9th Annual Amhara Region Agricultural Research Institute Conference on Completed Research Activities of Socio-Economics and Agricultural Extension Research.Ed. Yazie C., Daniel T. and Mulugeta A.9-20 March 2015, Bahir Dar, Ethiopia. Pp. 157-176.

Muthoni J. and Nyamongo O. D. 2009.A review of constraints of ware potatoes production in Kenya.Journal of Horticulture and Forestry. Vol. 1(7) PP 098-102.

Okoye B. C., Onyenweaku C. E. and Agwu A. E. 2008. Technical Efficiency of Small Holder Cocoyam Farmers in Anambra State, Nigeria: Implications for Agricultural Extension Policy**.** Journal of Agricultural Extension. Vol 12(1):107-116.

Saida A., Novita E. and Ilsan M. 2016.Sustainability Analysis of Potato Farming System at Sloping Land in Gowa Regency, South Sulawesi.Agriculture and Agricultural Science Procedia 9:4 – 12.

Shimelis H., Melis R. and Sibiya J. 2012.Participatory assessment of potato production constraints and trait preferences in potato cultivar development in Rwanda.International Journal of Development and Sustainability. ISSN: 2168-8662. Volume 1 Number 2.

Semagn A. K., Halseth D., Perry K., Jong D. W. Fentahun M. T. and Wolfe D. 2015. Identification of Farmer Priorities in Potato Production through Participatory Variety Selection.Am. J. Potato Res. 92:648–661. DOI 10.1007/s12230-015-9478-0

SPSS Inc. 2010.SPSS Statistics 18.0 SPSS Inc., Chicago, IL.

VIB. 2019. Potato in Africa. Fact Sheets. Available online at: http: //www.vib.be/VIBDocumentLibrary/VIB_Facts%20Series_Potato%20in% 20Africa%20LR.pdf (accessed June 6, 2019)

Waga M. D., Yenenesh T. G., Rogier P. O. S. and Paul C. S. 2016. The Analysis of Potato Farming Systems in Chencha, Ethiopia: Input, Output and Constraints. Am. J. Potato Res.93:436–447. DOI 10.1007/s12230-016-9521-9

Zelleke G., Agegnehu D. Abera S. and Rashid S. 2010. Fertilizer and Soil Fertility Potential in Ethiopia: Constraints and opportunities for enhancing the system. IFPRI working paper Soil Fertility Potential. 42p.

Zerihun N., Getachew A., Terefe D., Kibret N., Yoseph T. and Freyer B. 2014. Nature of local seed potato system in North Western Ethiopia. International Journal of Agricultural Research 9(2):74-86: ISSN 1816-4897?DOI:10.3923/ijar. 74.86.

APPENDIX Table I

Agro-climatic Data of Western Amhara which are suitable for potato production

Rainfall

Yilmana Densa

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009	0.0	10.9	17.9	32.6	8.0	100.7	277.7	281.5	126.1	80.3	7.3	15.0
2010	22.5	0.0	0.0	44.7	78.6	160.0	364.2	249.3	182.6	69.6	1.2	1.5
2011	Na	0.0	23.9	70.5	161.6	83.6	338.7	213.6	155.0	69.5	1.2	1.5
2012	Na	Na	Na	Na	35.0	177.6	116.2	297.2	137.9	27.0	76.5	13.8
2013	0.1	0.0	0.0	6.0	112.7	157.6	373.8	266.2	112.6	109.7	25.2	0.2
2014	0.0	3.5	114.2	85.6	188.3	130.6	210.8	200.2	151.8	108.5	21.7	0.0
2015	0.0	1.8	22.3	0.0	139.3	141.7	181.1	188.5	124.3	313.3	0.0	26.0
2016	0.0	0.0	73.8	21.4	176.2	161.2	294.8	146.3	98.7	85.4	0.2	0.0
2017	0.0	40.9	15.9	122.4	115.5	77.8	392.6	168.3	143.4	78.5	53.4	0.0
2018	0.0	0.0	37.9	15.8	107.3	159.9	307.8	244.6	224.6	154.2	172.5	7.2

Gozamin

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2009	11.7	21.1	43.0	23.0	17.0	115.2	283.2	620.3	106.9	103.0	10.9	16.8
2010	15.6	21.8	42.9	92.3	175.3	151.2	240.5	290.2	307.0	18.1	16.7	5.0
2011	0.0	3.1	110.4	68.9	237.8	143.0	231.1	288.3	282.9	37.9	97.3	11.5
2012	13.9	0.0	33.1	33.1	23.4	124.2	347.7	250.9	362.4	21.3	30.9	7.1
2013	3.6	4.7	16.4	11.8	125.0	168.3	288.8	291.4	202.8	147.3	34.2	0.0
2014	9.1	8.6	42.9	138.4	130.1	101.9	274.6	257.1	255.5	100.5	13.6	9.2
2015	6.0	14.6	45.5	20.1	244.1	119.1	149.7	237.2	129.4	12.7	65.0	16.0
2016	0.0	18.1	31.4	31.4	174.4	133.1	238.6	243.6	271.4	54.8	0.0	0.0
2017	0.0	25.1	62.3	79.8	274.9	107.9	278.7	236.9	198.5	60.5	21.4	0.0
2018	0.0	91.8	17.0	66.8	54.1	290.6	307.3	222.7	123.4	73.7	83.0	0.0

Farta

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2009	0.0	5.1	63.2	19.1	28.2	66.8	418.3	667.4	113.2	107.4	3.0	2.0
2010	13.1	0.0	33.3	52.1	65.3	151.2	499.3	527.9	203.0	41.4	21.1	9.7
2011	0.0	0.0	43.9	20.9	175.9	132.9	359.6	392.2	259.7	50.4	86.6	0.0
2012	0.0	0.0	33.8	0.0	57.2	277.7	389.3	447.7	214.0	24.4	41.3	4.0
2013	2.1	4.2	26.9	34.3	165.0	*	423.0	439.1	191.3	176.4	33.9	5.5
2014	5.4	4.3	151.5	63.7	206.3	165.2	340.8	453.6	222.2	86.1	50.8	0.0
2015	0.0	4.4	17.9	8.3	176.3	129.2	234.1	284.2	200.5	26.6	83.5	37.6
2016	0.0	0.0	16.6	16.6	193.0	162.3	375.6	398.8	168.4	27.9	1.5	0.0
2017	0.0	60.0	26.9	86.5	176.4	84.4	346.0	291.0	152.0	56.4	21.3	0.0
2018	0.0	10.0	2.0	4.8	55.8	304.0	440.2	422.7	211.3	97.1	50.9	10.7

Sinan

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	11.9	0.0	0.0	83.5	139.2	205.2	258.8	278.8	118.6	58.1	80.1	36.9
2009	4.5	38.1	82.4	0.0	0.0	128.9	348.7	0.0	68.2	0.0	0.0	73.3
2010	54.2	26.2	77.6	0.0	111.7	188.2	313.4	274.4	196.0	32.5	64.1	33.6
2011	16.6	2.0	54.0	93.3	114.2	120.0	221.0	152.2	221.5	10.8	94.2	16.0
2012	0.0	0.0	121.4	38.7	54.8	116.5	268.5	192.8	167.5	13.1	94.1	41.6
2013	2.7	16.8	67.4	23.4	172.3	209.7	323.8	270.3	97.2	85.9	61.7	0.0
2014	0.0	*	89.2	72.4	161.7	100.4	200.2	237.4	229.7	88.9	56.1	*
2015	NA	27.0	67.5	NA	NA	NA	227.5	NA	188.5	26.7	29.9	56.2
2016	na	Na	na	na	na	na	na	na	116.3	na	na	na
2017	0.0	87.1	48.9	73.8	160.1	142.8	300.5	344.8	289.5	na	na	na
2018	7.0	59.5	111.2	0.0	80.8	304.9	361.9	265.0	122.8	70.5	70.5	45.5

Banja

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016	0.0	0.0	63.1	61.6	196.1	349.4	0.0	0.0	346.4	175.0	20.5	0.0
2017	0.0	62.0	1.1	125.6	315.9	306.0	470.1	484.4	265.3	169.4	2.7	0.0
2018	0.0	24.1	14.2	52.5	169.3	330.3	445.0	506.0	314.4	149.1	94.4	52.5

Lay Gayint

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2007	0.0	0.0	45.8	76.1	0.0	161.9	396.0	331.1	115.6	4.8	20.9	0.0
2008	2.2	0.6	2.1	40.2	162.1	97.0	na	na	na	na	na	na
2009	na	Na	na	na	na	na	na	na	na	na	na	na
2010	12.3	3.5	0.0	66.4	91.9	16.7	393.1	407.4	161.5	13.4	34.6	20.2
2011	14.6	0.0	93.7	87.1	68.8	78.2	343.0	257.1	108.9	5.9	86.3	0.0
2012	0.0	*	90.6	36.6	23.0	101.2	310.8	294.2	112.8	11.4	31.2	7.7
2013	32.0	0.0	51.9	46.7	27.9	80.9	392.9	322.6	81.1	125.0	26.5	0.0
2014	32.1	9.9	57.9	51.5	191.1	27.0	219.9	213.9	153.9	40.9	72.8	12.2
2015	0.0	20.5	47.8	9.4	124.6	51.8	152.8	335.4	115.6	7.6	39.0	92.2
2016	34.0	4.7	51.6	42.8	157.4	96.8	422.7	249.4	87.1	23.8	0.0	0.0
2017	0.0	89.3	79.4	65.3	137.1	18.7	251.3	259.7	81.6	16.7	14.0	0.0
2018	0.0	14.7	3.9	66.0	17.5	128.1	408.1	348.9	99.0	41.6	92.1	36.6

Quarit

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2009	0.0	4.1	0.0	42.3	53.0	*	401.1	389.2	137.0	113.2	13.2	23.2
2010	10.8	0.0	21.3	0.0	98.9	369.3	260.0	265.8	165.8	56.8	78.1	0.0
2011	38.4	1.5	80.0	44.3	100.4	126.1	305.3	349.4	225.6	2.8	130.4	19.0
2012	0.0	2.0	7.4	1.0	21.2	86.8	268.9	0.0	167.5	13.1	43.4	0.0
2013	5.8	1.9	12.1	14.2	73.1	220.5	314.7	320.5	121.6	52.1	90.7	3.2
2014	6.3	2.5	85.9	108.1	226.8	112.6	257.7	310.0	183.3	125.8	19.4	4.5
2015	0.4	Na	35.8	7.8	192.8	224.2	164.9	253.1	155.4	50.7	53.9	69.5
2016	9.8	12.4	23.8	9.5	312.2	122.7	613.0	275.3	176.5	52.2	18.8	0.0
2017	0.0	71.6	94.9	94.6	128.2	213.1	373.3	457.9	189.5	112.2	28.3	0.0
2018	2.8	12.7	10.4	16.4	144.5	173.8	436.0	435.0	137.3	57.6	107.3	33.7

GuagusaShikudad

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2007	*	25.0	31.4	73.3	268.9	443.1	360.2	318.3	369.6	89.7	27.2	*
2008	16.9	0.0	0.0	165.9	297.6	*	*	329.0	246.4	120.9	54.2	2.6
2009	*	*	*	40.6	*	209.6	306.5	495.3	209.1	193.1	0.0	43.3
2010	21.5	0.0	22.2	0.0	131.0	168.8	*	367.0	460.8	106.7	*	*
2011	73.5	0.0	94.1	0.0	295.0	296.7	376.1	525.3	480.9	110.8	119.4	67.1
2012	0.0	0.0	20.9	0.1	135.4	326.4	524.1	345.0	475.2	26.0	63.0	37.0
2013	8.0	0.0	17.0	0.6	71.7	287.0	597.0	453.8	270.4	166.0	105.0	0.0
2014	0.0	7.0	98.0	289.5	*	448.0	542.5	503.0	465.0	507.0	269.0	*
2015	na	38.0	85.0	0.0	843.0	701.0	949.0	na	na	na	na	na
2016	0.0	0.0	174.0	426.0	322.0	452.0	423.0	583.0	583.0	373.0	405.0	0.0
2017	0.0	0.0	64.0	111.0	na	na	na	204.0	10.3	10.7	17.6	0.0

Relative Humidity

Yilmana Densa

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009	45	38	26	46	59	70	74	70	71	67	58	50
2010	38	43	39	38	43	57	70	77	69	66	52	54
2011	47	40	38	45	57	67	80	76	76	66	61	59
2012	*	38	48	39	54	70	79	80	72	66	61	59
2013	*	*	*	*	44	67	79	79	75	60	65	56
2014	49	39	38	38	27	68	82	84	74	71	64	58
2015	47	39	39	33	56	67	70	74	69	61	62	64
2016	50	43	41	40	67	67	88	77	72	65	49	40
2017	29	44	39	43	59	60	72	76	73	67	57	50
2018	29	27	22	29	39	61	68	65	60	51	51	46

Gozamin

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009	40	39	37	38	33	59	82	81	70	53	34	44
2010	35	34	33	41	63	71	80	78	71	43	38	35
2011	*	20	38	39	58	79	72	79	73	63	52	34
2012	26	17	29	30	31	61	80	79	73	40	43	33
2013	28	25	30	24	56	71	79	80	70	53	47	29
2014	37	32	36	39	56	63	77	75	72	52	50	42
2015	34	31	38	38	64	75	80	82	74	55	60	58
2016	45	40	52	52	74	78	86	86	79	63	46	46
2017	39	57	48	50	72	74	85	84	81	68	60	46
2018	37	40	38	42	56	79	81	82	71	64	64	60

Farta

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2009	42.6	49.1	27.7	39.2	0.0	59.4	77.5	225.1	67.5	66.0	50.3	49.8
2010	44.2	39.1	40.3	48.7	54.2	70.9	80.4	83.1	75.2	59.9	52.1	49.4
2011	*	30.4	41.0	37.4	58.7	67.0	77.8	81.8	78.7	55.2	57.2	50.0
2012	41.7	29.4	40.2	35.5	46.3	68.0	82.7	79.5	76.6	54.9	64.1	49.2
2013	40.9	33.7	34.8	41.5	57.5	na	76.6	83.5	72.3	76.6	58.7	45.7
2014	43.6	50.5	48.2	49.7	62.9	61.5	72.7	77.3	73.0	67.5	58.7	56.0
2015	42.6	41.2	42.0	37.8	63.3	71.3	78.0	80.9	75.1	62.2	61.2	66.2
2016	48.9	42.7	35.6	35.2	69.0	69.1	78.9	81.2	79.0	66.2	63.1	44.5
2017	29.0	45.6	38.1	48.4	68.1	68.5	80.7	85.3	74.1	68.0	54.6	39.9
2018	35.4	29.1	27.7	31.1	39.0	64.9	69.3	71.7	60.3	49.3	46.8	39.7

Lay Gayint

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009	na	Na	na	na	na	na	na	na	na	na	na	na
2010	na	Na	na	na	na	na	na	na	na	na	na	na
2011	na	Na	na	na	na	na	na	na	na	na	na	na
2012	na	Na	na	44	41	50	82	80	70	46	53	46
2013	38	31	40	42	44	57	82	86	65	62	59	47
2014	56	47	52	52	62	58	75	80	72	62	60	49
2015	45	37	40	39	54	54	65	79	68	52	57	na
2016	54	47	44	49	61	53	83	83	69	55	37	36
2017	24	53	44	45	65	51	78	84	70	61	55	40
2018	40	40	41	44	39	62	79	77	61	51	53	42

Temperature Maximum
Yilmana Densa

year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009	25.1	29.1	29.7	29.9	30.7	28.6	23.7	24.3	26.0	25.5	26.7	33.7
2010	27.3	28.9	29.7	29.8	27.9	26.4	23.4	25.0	25.2	26.0	26.5	25.9
2011	*	29.7	28.2	30.3	27.9	26.3	25.2	24.2	25.9	26.0	34.1	25.9
2012	*	*	*	*	30.1	27.0	24.1	23.5	23.7	25.5	25.4	26.7
2013	27.9	29.8	30.6	31.5	29.2	26.3	23.2	22.8	25.0	24.7	25.7	26.2
2014	27.8	29.3	29.0	29.0	27.1	26.3	24.1	23.3	24.1	25.3	25.7	25.8
2015	27.0	29.9	30.5	31.0	28.1	25.7	25.8	24.9	25.2	26.2	25.7	25.1
2016	27.0	30.5	31.6	30.9	27.5	26.7	24.8	24.5	24.9	21.8	26.2	26.4
2017	26.4	28.1	30.1	29.8	27.0	27.7	24.3	23.8	25.2	25.3	26.1	26.5
2018	26.5	28.7	29.3	27.9	28.2	23.3	22.8	22.6	23.8	24.8	23.7	25.0

Gozamin

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2009	*	26.5	24.3	26.4	24.3	21.2	20.5	19.6	20.8	26.5	23.0	16.1
2010	24.6	26.3	26.4	26.4	26.6	22.1	19.0	19.5	20.0	22.7	23.9	23.8
2011	25.2	26.9	26.8	27.8	24.2	21.1	18.7	18.7	20.6	21.4	22.9	23.2
2012	24.3	24.3	25.8	25.0	22.8	22.0	19.6	19.3	20.3	21.9	23.1	22.8
2013	25.2	26.9	26.8	27.8	24.2	21.1	18.7	18.7	20.6	21.4	22.9	23.2
2014	24.3	25.2	25.8	25.0	22.8	22.0	19.6	19.3	20.3	21.9	23.1	22.8
2015	24.1	25.9	26.2	26.8	24.3	21.6	20.8	20.4	21.7	23.9	23.6	23.5
2016	24.6	26.4	26.6	26.6	22.4	22.1	19.5	21.4	20.8	22.3	23.2	23.5
2017	24.4	25.1	26.4	25.9	22.7	22.0	19.7	19.6	21.0	22.2	22.7	23.4
2018	23.9	24.9	25.4	25.3	24.8	20.3	19.6	19.8	21.7	22.7	22.1	23.8

Farta

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2009	22.9	24.1	24.8	25.0	25.4	24.2	19.7	18.3	21.6	21.4	23.1	22.5
2010	22.5	24.4	24.7	24.7	23.8	21.6	18.9	19.2	20.5	21.9	22.2	21.6
2011	0.0	24.7	23.3	25.1	23.2	21.9	19.8	19.3	20.3	22.3	21.5	21.9
2012	23.1	25.0	25.7	25.8	25.6	23.4	21.2	20.1	21.1	23.4	23.1	24.1
2013	25.3	26.0	25.7	26.6	9.0	*	20.4	19.2	21.3	21.5	22.5	22.6
2014	23.3	25.2	24.7	25.4	24.2	23.9	21.9	20.0	21.1	21.3	22.1	22.0
2015	22.9	25.3	25.7	26.5	24.1	22.4	20.8	20.2	20.9	22.8	22.2	21.2
2016	22.5	24.9	26.0	25.9	22.6	22.2	19.3	19.5	20.5	20.8	22.6	22.7
2017	23.7	24.4	24.6	25.1	22.4	23.5	20.6	18.7	21.3	21.7	22.0	22.2
2018	22.4	24.3	24.9	24.7	25.5	21.0	20.2	19.5	21.5	22.0	21.7	22.4

Banja

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016	24.2	26.7	27.6	27.4	23.4	22.5	na	na	21.8	21.9	22.9	27.7
2017	25.4	24.9	26.9	26.2	23.4	24.0	21.6	21.3	22.8	21.8	23.3	24.3
2018	24.9	26.5	27.6	27.0	24.7	22.3	22.0	21.2	22.7	23.2	23.9	24.0

Lay Gayint

year	jan	Feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
2004	19.5	20.0	20.4	19.6	21.5	18.3	16.6	16.0	16.7	17.9	18.4	18.9
2005	18.9	22.0	20.8	21.4	20.1	20.7	16.6	17.8	*	*	*	*
2006	20.2	21.5	21.9	na	na	na	na	na	na	na	na	na
2007	33.5	36.1	na	na	na	na	na	na	na	na	na	na
2008	na	Na	na	na	na	na	na	na	na	na	na	na
2009	na	Na	na	na	na	na	na	na	na	na	na	na
2010	17.8	26.5	19.7	18.7	*	*	16.6	15.9	16.5	17.5	17.6	16.7
2011	17.3	19.9	18.6	20.0	19.4	18.9	16.4	15.3	16.1	17.3	17.1	17.7
2012	18.5	0.0	20.1	19.7	20.2	19.2	15.4	15.4	16.4	17.6	17.7	17.9
2013	18.9	20.7	20.4	21.6	20.8	19.4	15.6	14.9	16.9	17.1	17.8	17.4
2014	17.9	19.3	19.8	20.0	18.6	18.9	17.1	15.7	16.1	17.3	17.6	16.9
2015	18.4	20.8	21.0	21.8	20.2	19.7	18.9	na	17.7	19.6	19.0	17.6
2016	18.4	20.5	22.0	20.7	19.4	na	15.9	16.2	17.3	18.5	18.6	18.1
2017	19.1	19.0	19.9	21.0	19.2	20.1	17.3	16.1	17.5	18.4	18.5	18.8
2018	18.4	20.0	20.4	20.0	21.2	18.2	16.1	16.0	17.4	18.5	17.5	18.6

Temperature Minimum
Yilmana Densa

year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009	7.0	11.0	11.8	12.0	19.5	12.5	12.0	12.6	10.4	10.5	8.0	8.4
2010	8.6	10.3	11.3	14.1	13.9	12.9	12.5	12.0	12.2	10.7	9.5	12.8
2011	*	11.7	12.2	17.8	18.1	18.1	14.6	13.0	11.7	10.7	9.4	12.8
2012	*	*	*	*	12.8	12.8	13.6	13.3	11.8	9.9	10.6	8.5
2013	8.6	10.2	11.3	11.3	13.2	13.2	12.5	12.3	11.5	11.2	9.4	6.3
2014	7.5	7.7	11.4	12.9	13.3	13.0	13.2	12.0	11.4	11.2	9.5	7.7
2015	6.3	8.3	12.0	12.3	13.7	12.9	12.9	12.6	11.6	11.3	11.1	9.9
2016	7.3	9.8	12.7	12.4	16.0	12.5	12.7	12.4	11.8	10.9	7.1	6.6
2017	6.8	10.1	11.1	13.3	13.7	13.0	12.6	12.6	11.9	11.6	9.8	7.5
2018	7.2	10.2	10.0	11.5	12.8	12.8	12.8	12.3	10.8	11.2	9.4	8.7

Gozamin

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2009	9.2	11.4	11.9	12.5	12.5	11.3	11.6	11.5	10.1	10.3	8.3	9.7
2010	9.4	11.3	12.5	13.2	12.8	11.8	11.3	11.6	10.7	10.4	9.2	9.2
2011	0.0	10.0	11.7	12.4	15.4	11.3	10.9	11.3	10.7	12.1	9.5	8.5
2012	9.2	10.7	15.6	11.8	12.8	11.1	11.6	11.2	10.5	9.6	9.4	9.3
2013	9.6	10.9	12.6	12.5	12.6	11.6	11.3	10.9	10.7	10.8	9.4	6.9
2014	9.8	10.0	11.8	11.8	12.1	11.5	11.8	10.8	10.7	10.8	9.5	8.8
2015	8.9	10.9	12.8	12.8	12.3	11.9	11.2	11.3	10.9	10.9	10.3	10.0
2016	9.5	11.5	13.3	13.3	12.4	11.8	12.0	11.2	11.0	10.4	8.7	9.2
2017	8.1	11.8	12.8	13.2	12.2	11.2	12.1	12.2	10.9	11.1	9.2	8.1
2018	9.1	11.6	11.3	12.1	12.6	11.5	11.4	11.3	10.4	10.8	9.8	9.6

Farta

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2009	8.0	10.1	10.6	11.5	11.6	10.8	10.6	11.6	9.6	8.6	8.3	8.0
2010	8.3	9.6	8.7	6.7	5.2	11.8	10.0	9.3	9.3	9.0	8.4	8.0
2011	0.0	9.0	10.1	9.6	8.7	8.8	8.4	9.7	9.1	7.8	8.3	7.5
2012	7.9	9.1	10.4	11.2	11.6	10.1	9.8	9.7	9.2	7.9	8.1	6.9
2013	8.0	9.5	10.1	9.5	11.5	*	9.9	9.7	9.4	8.9	8.4	6.9
2014	8.2	8.9	10.5	10.5	10.8	10.2	10.6	10.2	9.5	9.3	8.3	7.9
2015	7.6	10.0	11.0	11.9	11.5	11.1	10.5	10.5	9.2	8.8	9.0	8.6
2016	7.2	9.1	12.5	12.5	11.4	10.9	9.6	10.3	9.6	9.2	7.8	7.6
2017	6.6	8.6	11.2	11.5	10.9	11.4	10.8	11.0	10.6	9.9	8.1	7.2
2018	7.3	9.9	9.8	11.0	11.3	10.1	9.8	9.8	9.1	9.2	8.3	8.0

Banja

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016	7.8	8.8	10.7	11.1	11.4	11.1	na	Na	9.6	9.8	7.3	11.6
2017	6.1	8.0	9.3	7.6	5.7	6.1	5.1	4.9	5.2	7.0	5.2	5.1
2018	5.1	6.6	9.2	9.4	10.0	9.8	8.9	8.5	8.1	8.4	7.3	7.3

Lay Gayint

year	jan	Feb	mar	apr	may	jun	jul	Aug	sep	oct	nov	dec
2004	7.8	7.2	8.0	8.7	9.0	8.0	6.9	7.1	6.9	5.6	6.1	6.0
2005	5.6	8.1	7.5	7.8	7.4	7.4	6.3	6.9	*	*	*	*
2006	6.1	6.9	6.5	na	na	na	na	Na	na	na	na	na
2007	11.3	13.0	na	na	na	na	na	Na	na	na	na	na
2008	na	Na	na	na	na	na	na	Na	na	na	na	na
2009	na	Na	na	na	na	na	na	Na	na	na	na	na
2010	7.8	9.8	9.2	10.0	10.8	10.3	8.4	7.9	8.6	7.8	7.2	7.2
2011	7.5	6.4	7.6	9.1	8.6	9.5	7.4	9.1	7.2	7.3	7.6	7.1
2012	7.4	Na	8.7	8.7	7.4	7.7	6.7	7.8	7.7	7.6	7.7	7.6
2013	8.2	9.2	9.5	10.1	10.2	9.4	7.9	8.0	8.1	7.4	7.9	7.0
2014	8.2	8.4	9.1	9.8	9.5	10.1	8.9	7.5	8.1	7.5	7.2	7.3
2015	7.5	9.4	9.5	9.7	9.9	10.2	9.6	8.3	9.1	8.6	8.6	8.3
2016	8.3	9.3	11.1	10.7	10.4	10.0	8.8	8.7	9.0	8.0	7.4	7.3
2017	7.3	9.0	9.2	9.5	9.7	10.4	9.1	8.5	9.0	8.6	7.6	7.3
2018	7.3	9.0	8.7	9.2	10.2	9.3	8.4	8.4	8.3	7.8	7.6	7.9

Quarit

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2013	11.0	11.8	12.1	12.4	13.6	13.6	13.0	12.8	11.8	11.4	10.7	8.5
2014	11.1	15.4	17.4	18.4	18.9	18.8	16.0	12.4	12.1	12.5	15.2	10.3
2015	10.6	Na	13.0	13.6	14.0	13.4	13.1	13.1	12.4	13.0	12.4	12.1
2016	10.3	12.4	13.7	14.5	62.3	13.1	13.4	10.1	11.5	12.3	10.3	10.5
2017	9.3	12.6	14.4	14.4	14.3	12.8	11.8	9.2	11.8	12.3	10.0	8.8
2018	9.4	12.0	12.4	12.8	14.0	13.3	12.3	8.5	11.3	12.5	11.3	11.2

Where na = non-available
(Source: North Western Metrological station, 2018)

APPENDIX II

Questionnaire for Informant Interview

Introduction:

My name is ***Momina Aragaw***, a PhD student from Hawassa University. The purpose of this informant interview is to get different aspects of potato production, helping me on my research with a title "**Assessment of potato (*Solanum tuberosum L.*) Farming systems and evaluation of potato' phosphorous use efficiency and its role in Soil Physicochemical Properties in crop production systems***"*. This project is a cooperation project between the school of plant and horticultural sciences at the Hawassa University and Adet ARC. The information I will get from you will be important for my research and for policy makers too.

Anything you tell me is confidential. Nothing you say will be personally attributed to you in any reports that result from this interview. This study will be written in a manner that no individual comment can be attributed to a particular person. The researcher is indebted to the kind cooperation of respondents and their sincerity of replies to the questionnaire.

Are you willing to answer my questions? Do you have any questions?

Code/Name of respondent:_____

1. Socio-Economic Characteristics of the Selected Household (Socio Demographic Data)

- Sex: **Female/Male**
- Head of the household: **Female/Male**
- Age _____
- Ethnic group:_____
- Religion:- _____
- Marital status: **Single/Married/ Divorced**
- Family number:_____
- Educational Background:- _____
- Income source:_____
- Production experience (in years): _____
- Livestock number _____
- Farm Size_____
- Total farm size _____

2. What are the most important crops in your area? _____,

Why? _____

Total potato area coverage _____

The dominant soil type of the area _____

3. What are the major constraints of potato production?

a. _____

b._____

c. _____

d. _____

e. _____

f. _____

g. _____

h. _____

4. What are the cultural practices done on potato production?

a. crop rotation

b. Irrigation

c. Intercropping

d. Fertilization

e. Pesticide application: Name the pesticides if any?

5. Are there any postharvest handling technologies of potato available in the area? If Yes

For Seed_____

For ware_____

6. Is there any extension system that extends potato technology? **Yes/No**

What is delivered from them? _____

(Seed tubers, recommended rate fertilizers (information/access), recommended agronomic practices, market information, and state if any other?

Frequency of extension contact: **twice/week, Once/week, once/two weeks, once/three week, once/month, state if any other?**

7. Are you producing potato in the main or in irrigation season?

Seed potato **main season/ irrigation season**

Ware potato **main season/irrigation season**

8. Is the potato coverage increasing or decreasing? **For seed?For Ware?** By how much you are increasing/decreasing your potato field? _____ Why?

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

9. Where do you get your seed tubers? _____

10. Is there any quarantine system in seed potato production systems? **Yes/No**

If yes, how it is done?_____

_____

11. How many times you plough the land before planting of seed tubers? _____ Where do you get planting materials? _____Do you get improved potato tuber seeds? **Yes/No** What are the varieties? _____

12. How many times you weed, cultivate, earthen up of your potato field?

Weeding _____

Cultivation _____

Earthen up _____

13. What is the importance of potato?

_____

(Source of food, employment, income, Component crop in crop rotation, in soil fertility management, state if other importance)

- How you evaluate these things? (Like in Birr, yield of the coming crop, soil fertility, food security)

_____

14. Gender role in potato farming

Who is the most responsible for potato farming?

- In land preparation? F/M
- In planting? F/M
- In weeding? F/M
- In Earthen up? F/M
- In cultivation? F/M
- In harvesting? F/M

15. Farmer's awareness about Local potato and improved Variety

- How many local varieties in your environment? _____ Name _____
- Improved potato varieties in your environment? _____
- Which variety is used mostly in crop rotation? _____
- Which variety is used in irrigation? _____
- Is there any lost potato variety? If Yes what is the name of these varieties? _____

16. Traditional Equipment's and farming systems for potato Farming, harvesting and storage

- Traditional equipment's in potato farming? _____
- Traditional storage structure _____

17. Utilization of potato

- Are you producing ware or seed potatoes?
- If you produce seed potato, is there any seed potato cooperative? **Yes/No**
- If yes, what is the name? _____
- Do you use separate plots for seed potato production? **Yes/No**
- Separate management (Fertilizer and cultivation) practices? **Yes/No**
- If no why? _____
- What type of seed systems in your environment? **(Formal/Informal/Commnumber y Based(Cooperatives))**
- Is there any quarantine for the seeds? **Yes/No**
- If yes, when is the quarantine take place? **(During Growing/at harvesting/during purchasing)**
- How many times? _____
- Is it enough? **Yes/no**
- For ware potato production, where you find your seed? How you store your potatoes for seeding? _____
- Is there any DLS in your environment? _____In number? ____

- Which variety is used for seeding? _____
- For what purpose you use the ware potatoes? _____
- What varieties used for ware potatoes? _____

18. Is there any potato cooperative in your environment? **Yes/no**

Are you a member of this cooperative? **Yes/no**

What is the advantage of being a member?

a. _____
b. _____
c. _____
d. _____
e. _____

19. Farmer's Traditional Knowledge on Crop Rotation with potato for Soil Fertility Improvement Practice

- Traditional techniques to improve soil fertility?
  a. _____
  b. _____
  c. _____
  d. _____
  e. _____
  f. _____
- Do you use crop rotation in your environment? _____
- If yes, what is the use of crop rotation in your thinking?
  a. _____
  b. _____
  c. _____
  d. _____
  e. _____
  f. _____
- What crops are best fit to crop rotation?
  a. _____
  b. _____
  c. _____
  d. _____
  e. _____
  f. _____

20. Do you use potato in crop rotation? **Yes/No** _____

- If yes, are all Varieties of potato can be used for crop rotation? **Yes/no**
- If no, what are the varieties that are used in crop rotation?
  a. _____
  b. _____
  c. _____

d. _____

e. _____

f. _____

- If yes, what are the pre and post cursors of potato?

  Pre cursor _____

  Post cursor _____

- Do you believe that potato is important in soil fertility management? **Yes/NO**How?

  a. _____

  b. _____

  c. _____

  d. _____

  e. _____

  f. _____

- How you keep potato farms soil fertility? _____

21. Fertilizers and manures used DAP**/Urea/TSP/Manure**

How much DAP/ha_____Urea/ha_____TSP/ha_____

Manures/ha _____

Where do you get this recommendation? **Adet ARC/BDU/DTU/AO**

22. Is the growing season and environment changed from time to time? **Yes/No**

If yes, explain how it is changed especially in terms of soil fertility, temperature and rain fall?

Soil fertility **Increasing/Decreasing**

Temperature **Increasing/Decreasing**

Rain Fall **Increasing/Decreasing**

Rain Fall **Normal/Abnormal frequency**

23. Important diseases and insect pests of potato

Insects

a. _____

b. _____

c. _____

d. _____

e. _____

Diseases

a. _____
b. _____
c. _____
d. _____
e. _____

How you control such pests? **Chemicals/ Cultural practices/ IPM or What if any other?**

If chemicals are used, name the chemical? _____

Where do you find the chemical? _____how many times you apply the chemical?

_____

24. How is the potato productivity in the last decade? _____By how much it's productivity minimized?_____

Possible reasons for this reduction?

a. _____
b. _____
c. _____
d. _____
e. _____

Solutions taken by you?

a._____

b. _____

c. _____

d. _____

e. _____

25. Distance to the nearest market from home_____

Is the price of potato you are going to sell is enough? **Yes/No**

Per kg price? _____

Do you get market information? **Yes/No**

If yes, where do you get this market information? _____

Is it important for you? **Yes/No**

If no, what should be done about the market?

a. _____
b. _____
c. _____
d. _____
e. _____
f. _____

26. Is there any credit service in your environment? **Yes/no**

If yes, where do you get the credit service?_____

How you can relate with the potato production?

_____

27. What should be done by

a. The government _____

_____

_____

b. Research Centres _____

_____

_____

c. Universities _____

_____

d. Extension Workers _____

_____

28. Do you have any comment? _____

Appendix Table II. Mean over all characteristics of the sampledHousehold

				Zone		
No.	**Variable**	**Mean**	**West Gojjam ± SE**	**East Gojjam ± SE**	**Awi ± SE**	**South Gondar ± SE**
1	Age, %	53.46	54.08 ± 0.544	52.34 ± 0.571	53.15 ± 0.671	54.13 ± 0.581
2	Educational background, %	2.06	1.19 ± 0.163	0.47 ± 0.103	1.55 ± 0.173	1. 23 ± 0.152
3	Family size, %	6.96	6.89 ± 0.176	7.50 ± 0.149	7.04 ± 0.170	6.41 ± 0.113
4	Potato production Experience, Year	36.81	38.87 ± 0.611	33.17 ± 0.518	39.71 ± 0.731	36.02 ± 0.647
5	Livestock Number (N)	5.17	5.49 ± 0.160	5.50 ± 0.174	5.87 ± 0.266	3.96 ± 0.084
6	Land holding (ha)	1.63	1.61 ± 0.061	1.83 ± 0.054	2.17 ± 0.075	1.09 ± 0.027
7	Potato area coverage (ha)	0.47	0.51 ± 0.051	0. 29 ± 0.014	0.53 ± 0.027	0.57 ± 0.030
8	Income source (AWOFA) (%)	-	1.12 ± 0. 27	1.04 ± 0.018	1.08 ± 0.032	1. 25 ± 0.034
9	Potato amount produced (t)	2.29	2.50 ± 0.016	2.00 ± 0.000	2.00 ± 0.000	3.01 ± 0.000
10	Potato consumed (t)	1.26	1. 21 ± 0.035	1.00 ± 0.000	1.15 ± 0.041	1.34 ± 0.045
11	Potato reserved for seeds (t)	0.48	0.51 ± 0.043	0.01 ± 0.000	0.01 ± 0.000	0.96 ± 0.018
12	Potato sold (t)	0.82	1. 26.± 0.095	0.01 ± 0.00	0.72 ± 0.094	0.58 ± 0.042
13	Potato price (Birr/kg)	2.06	2.56 ± 0.75	2.00 ± 0.000	2.00 ± 0.000	1.99 ± 0.009
14	Number of ploughing, N	3.34	3.31 ± 0.058	3.50 ± 0.700	3.04 ± 0.044	3. 42 ± 0.067
15	Seed rate (t)	2.13	2.00 ± 0.000	2.00 ± 0.00	2.00 ± 0.000	2.00 ± 0.000
16	Separate management practices for potato, %	-	8.92 ± 0.023	8.81 ± 0.037	8.95 ± 0.026	8.93 ± 0.023

Where SE = Standard errors, Means within a row followed by different superscripts differ (P<0.05), % = percent. AWOFA = Agriculture with off farm activities

Source: Survey Result, 2019