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# ASSESSMENT OF FARMERS' PERCEPTIONS CONCERNING POTATO FARMING SYSTEMS IN NORTH WESTERN ETHIOPIA

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## ABSTRACT

### Aim of the study
The main objective of the study here presented was to assess and investigate farmers' perceptions concerning potato (*Solanum tuberosum L.*) farming systems in North Western Ethiopia.

### Materials and methods
Secondary and primary sources of data were collated.

### Results and conclusions
It was determined that 9.8% of the farmers in the studied group were engaged in off farm activities. These farmers had an average potato production experience of 36.81 years, average livestock number of 5.17 head, and average farm size, of 1.63ha. On average, they allotted 0.47 ha (28.83%) of their land for potato production. The dominant potato growing season was the main season (65.1%), followed by irrigation season (25.7%), and the season with residual moisture (9.2%). 16.6% of the produced potato crops were used as seeds, 48.55% were used for household consumption and 25.73% were sold in the nearby market at a very low price (2.17 Birr/kg), as the source of income. On average, there were two commonly grown varieties per farmer. They were abandoning local potato varieties, which had different quality attributes that would make them suitable for various livestock breeding and agronomy programmes, and which would best fit the degraded lands. Farmers ploughed their land 3.34 times before planting the potatoes, and used 2.13 t/ha potato seeds at planting as seed rate. 14.4% of the farmers used their own seeds, 73.5% purchased seeds from the market nearby, 10.2% bought seeds from their neighbours, and 1.9% from the agricultural offices. Most farmers (63.0%) applied fertilization, crop rotation mainly with potato (35.1%), and used terracing technique (1.9%) as a traditional technique of soil fertility management. Generally, farmers in the surveyed area believed that potato improved soil fertility and protected their soils from erosion. Further studies should be conducted, in order to minimize the amount of ploughing in potato production. NGOs, GOs, and universities should take up the responsible task of multiplying and disseminating improved potato seeds, and preserving important local varieties. Training opportunities should also be given to farmers, instructing them on the production and usage of certified potato seeds in potato production.

**Keywords:** potato, farming systems, degraded lands, ploughing, crop rotation, soil fertility

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## INTRODUCTION

Food security is a priority agenda within the government agricultural policy in Ethiopia. Among the different approaches aimed at helping the country to achieve food security is the integration of root and tuber crops in the agricultural systems. Potato (*Solanum tuberosum* L.) is one of these strategic crops that can be considered a useful tool for ensuring food security. Globally, potato is the third most consumed crop, after rice and wheat (CIP, 2013).

Ethiopia enjoys suitable climatic and edaphic conditions for potato production. Reports by different authors indicated that potato could be grown on about 70% of the arable land throughout Ethiopia (Medhin et al., 2001). Recently, the total area of land allocated for potato production systems increased from 296,577.59 hectares in 2016 (CSA, 2016) to 335,362.48 hectares in 2020 (CSA, 2020). The total volume of production has also grown from 36,576,382.69 to 40,529,280.04 tons over the same period (CSA, 2016; 2020). In 2020, more than 10 million smallholders were engaged in potato production. This has resulted in a large increase in the output compared to previous years. With the present area coverage, potato is the most common of all horticultural crops grown in Ethiopia, right next to red peppers. It accounts for 60% of the root crops, and for 28.5% of all horticultural crops added together. Likewise, potato accounted for 50.7% of the total production of root crops, and 43.2% all horticultural crops together (CSA, 2020). In the North Western part of Ethiopia, farmers also produce potatoes at the end of the rainy season, immediately after harvesting of short-season crops such as barley with residual moisture.

The growth is expected to continue owing to the present rapid population increment. Besides this, other factors – availability of improved technologies, expansion of irrigation culture, increased market value, production systems diversification in income and productivity (rainy season, irrigation, short rains and recessed land) – also contribute to increasing the area of land to be planted with potato (Gebremedhin et al., 2013). Potato is the fastest growing food crop in Sub-Saharan Africa – in fact, in some countries, the total production of potato doubled over the last 15 years. This is similar to the developments in Asia (specifically, China and India) where area and yield increased dramatically (Anton et al., 2012). Moreover, potato serves as a food security crop; it provides high yield quality product per unit of input with a shorter crop cycle (Hirpa et al., 2012), and it generates income and employment opportunities for the poor (Abebe et al., 2017). It contributes to the economic sustainability of agricultural systems in developing countries, and it is relatively cheap but nutritionally rich (Sanginga and Mbabu, 2015). It is also ideally suited to places where land is limited and labour 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 accounted for 51% of the total potato harvested at national level during the 2016/17 cropping season. During that period, Amhara regional state ranked second in potato area coverage and production among the regional states of the country. The region devoted 21,352.52 ha to potato production during the stated period. Among administrative zones of the region, South Gondar, West Gojjam, East Gojjam and Awi zones contributed over 68% of the total area to potato production, and the total yield harvested over these areas was about 118,913.89 tons/ha, which accounts for 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 was 14.2 t/ha in 2018/19, and 13.1 t/ha in 2019/20 (CSA, 2020), which is far below the World's average productivity i.e. 20.8 tons/ha (CIP, 2018), and East Africa average productivity (18 tons/ha) (FAO, 2019), while the attainable yield with good crop management could be well above 30 t/ha (Anton et al., 2012). This discrepancy may be due to the lack of adaptable improved potato varieties – even if they are available, the cost is too high for the farmers to afford it as well as lack of availability of improved storage facilities, inappropriate agronomic practices, low price of the produced potato, among others, as reported by Gebru et al. (2017).

Farmers in the highlands and undulated areas of the country's major potato growing belts help to protect their soil from erosion owing to potato early planting time, early land cover by canopy, and application of ridge-furrow planting system serving as bunds – in contrast to late after-rain onset and flat-based planting system used for common staple cereals and pulse crops. Saida et al. (2016) also reported potato's substantial contribution to 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 – compared to other crops. The accelerated soil erosion is due, on the one hand, to the expansion of surface-running fibrous root system and tuber development ,and on the other hand, to the 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 cultivation before/after planting. Griffin et al. (2009) also reported that the amount of residue left after potato harvest is very low – unlike farmers perception, according to which potatoes increase soil fertility by leaving all of their leaves and stem parts (except the tubers) on the soil. Abebe et al. (2017) and Adamu (2013) found better barley yield when it followed potato compared to plots planted following cereals. Informal discussion with several farmers in the North Western and Central Shewa indicated that they believed potatoes had a similar impact on soil fertility as leguminous plants.

Potato production is relatively sustainable since there is no known significant damage that it would cause to human beings, animals, air, water, land, soil, forests, etc. Furthermore, the contribution of potato as a precursor crop in improving productivity of the crops that follow was comparable to that of legume precursors. This remains in contradiction to other report, which claim that there is no positive effect of potato on soil conservation, since firstly, the land is highly ploughed and harrowed, secondly, it is frequently cultivated to suit the fibrous root system of potato, and thirdly, it is heavy feeder crop owing to its high harvest index. However, there has not been a systematic study conducted to date in the area that would address the role of potato in the farming systems. This was the rationale behind the study here reported, aimed at assessing perceptions of farmers in North Western Ethiopia concerning the role of potato in the farming system.

## MATERIALS AND METHODS

### 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 – were deliberately selected, with the view to showcasing the desired production features that were the focus of the study (Fig. 1). The sub-region is situated between 10.00–14.00 °N latitude and 35.10–38.35 °E longitude and is characterized by the average annual rainfall of 1150 mm and the mean annual temperature between 16.9 °C and 26.0 °C. Over the last ten years' (2009–2018), the mean annual rainfall and temperature were 1250 mm and 16.5 °C, respectively, whereas the mean relative humidity of the area was as high as 56%. The rainfall pattern is mono-modal, extending from May to October, and it is highly unpredictable (Appendix, Figure I), which affects potato yield (Li and Zhang, 2020). Western Amhara sub-region is characterized by different agro climates with subsistence crop-livestock mixed farming systems and highly heterogeneous soils providing opportunities in terms of land use for the population.

Mixed farming system is predominant in these districts. Cattle, sheep, poultry, and donkey are the main livestock types. Cereals account for more than 80% of cultivated land, and they constitute 85% of total crop production. The principal cereal crops in the Amhara Region are teff, barley, wheat, maize, sorghum and finger millet. Pulses and oil crops are the other major categories of field crops. About 27.9% of the livestock in Ethiopia, 30.7% of the poultry, and 18.5% of the beehives are found in the Amhara region (Amhara National Regional State Food Security Research Assessment Report, 2000).

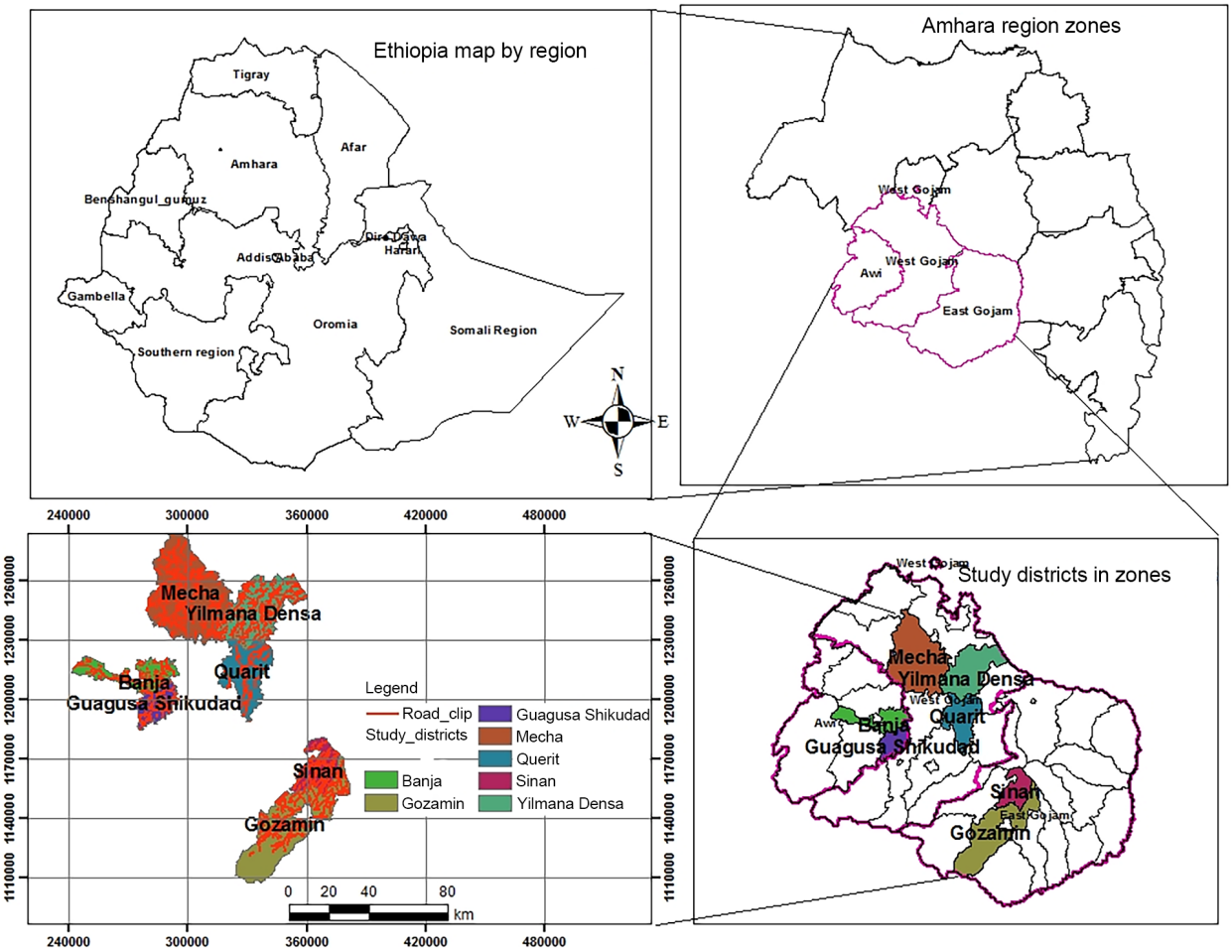


**Fig. 1.** Map of the study area (Source: Survey Results, 2019)

In this sub region, a large number of people are working in agriculture (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* (administrative units) were purposefully selected during the 2018/2019.

## Sampling procedures and data collection

Elders with different socioeconomic backgrounds, and with experience in potato production were consulted in this study. A proportional allocation formula was employed in order to select sample respondents from each *kebele* and each category, using the formula of Yamane (1973):

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

Where:

n – sample size,
$N$ – population size,
$e$ – level of precision (0.05).

Data was collected from both primary and secondary sources. Primary data were collected in a formal

survey, using a semi-structured questionnaire (Appendix II) that was administered to individual farmers. The questionnaire consisted of open-ended questions in order to allow full expression on the pertinent issues. Discussions were initiated with: farmers, agricultural development officers, researchers, and potato experts. Secondary data was obtained from the agricultural office of the district, as well as books, journals and unpublished research works.

### Data analysis

All sets of data were exported to Statistical Package for the Social Sciences (SPSS), Version 24 computer software (SPSS, 2010). Descriptive statistics such as mean, standard deviation and frequency were used in order to analyse the collected data. Class intervals were applied to analyse descriptive statistics for age, education level, family size, etc.

## RESULTS AND DISCUSSIONS

### Demographic characteristics of households

From the sampled population, about 91.5% of the sample households were male headed, and 93.3% of the respondents were married (Table 2). Average age of sample respondents was found to be 53.46 years (Table 1). This reveals that the majority of the individuals who took part in the interviews were aged. Aged people have less ability to take risks and innovate. Further, the active labour force proportion (15–64 years of age) of the sampled households was about 96.9%, of which 44.5% were above 56 (Table 2).

Marriage is an integral part of life and is related to identity and status in society (Ghimire and Samuels, 2013). Ploughing was men's duty. Both men and women participated in other farm activities – such as land preparation, planting, cultivation and harvesting of the potato. Average family size in the surveyed area was 6.96, which indicated high population growth (Table 1). 64.2% of the sampled farmers had a family size of < 7 (Table 2). On the one hand, this affects the availability of farming land, and thus probably also impacts farmers' ability to allocate land to potato farming. On the other hand, most of the potato agronomic practices require intensive labour. Therefore, it is possible that family members can help with these tasks at various stages 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) (Table 1). Okoye et al. (2008) indicated that large household size could provide more labour, which is required for farm operations. Farm households having large family size of active labour force, have more chance perform their farming activities effectively. However, large household size does not necessarily 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 also implemented to enhance the qualifications of adolescent girls (Ghimire and Samuels, 2013). 95.3% of the sampled farmers graded < 4 grades (Table 2). On average, education level of sample households was only 2.06 grades (Table 1). This low education level might be impacting the sub-region farmers' ability to adopt new improved potato technologies. Okoye et al. (2008) demonstrated that educated farmers were able to deal with production problems and accept improved farming techniques better than those who are less educated or without education. They also stated that farmers had more need of production experience than of education in the context of increasing productivity. Also, when engaged in educational activities, children became less available for farm work chores.

In the group of the surveyed farmers, only 9.8% had gone through off farm jobs as a source of income (Table 2). Ghimire and Samuels (2013) and Ghimire and Samuels (2013) reported that most households derived their earnings from agriculture. In such areas where agriculture is at risk due to environmental factors, it is very important to create farmers' awareness related to off-farm employment activities. South Gondar farmers have a higher percentage of off-farm jobs than in the other zones (Table 1). This may be due to the fact that South Gondar farmers were more vulnerable to climate variability, drought, unpredictable rainfall (Appendix, Figure I) and soil degradation. Therefore, these farmers would often leave their farmland, and move to big cities in order to look for other, non-agricultural jobs.

**Table 1.** Mean overall characteristics of the surveyed households (Source: Survey Results, 2019)

| | | | 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 | Experience in potato production, years | 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 | Source of income (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 amount consumed (t) | 1.26 | 1. 21 ± 0.035 | 1.00 ± 0.000 | 1.15 ± 0.041 | 1.34 ± 0.045 |
| 11 | Potato amount reserved for seeds (t) | 0.48 | 0.51 ± 0.043 | 0.01 ± 0.000 | 0.01 ± 0.000 | 0.96 ± 0.018 |
| 12 | Potato amount 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 ploughings, 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 error, Means within a row followed by different superscripts differ ($P < 0.05$), % = per cent. AWOFA = Agriculture with off-farm activities. Source: Survey results, 2019

## Production pattern and production experience

Crop-livestock mixed farming is the most prevalent system is the studied district, and potato production is the most important farm activity in this sub-region. The farmers in the study sample have an average experience in potato production of 36.81 years (Table 1). 38.9% of the surveyed farmers had a potato production experience of >38 years (Table 2). These results indicate that farmers in the sub-region have ample experience in potato production. In terms of years of production experience, Awi farmers were more experienced (39.71 years) than farmers from other zones (Table 1). This survey results are further supported by a report of Adet Agricultural Research Center (2011), which mentions that potato production is an old practice in the North Western highlands. Similarly, Gebru *et al.* (2017) reported that farm experience of the farmers in Wolaita zone, Ethiopia is more than 20 years.

**Table 2.** Mean demographic characteristics of the surveyed households (Source: Survey Results, 2019)

| Variable | Category | 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 |
| Experience in potato production | 17–27 | 8.7 |
| (years) | 28–37 | 44.8 |
| | 38–47 | 38.9 |
| | 48–58 | 7.6 |
| Source of income | Agriculture only | 90.2 |
| | Agri. with off-farm activities | 9.8 |

### Livestock number and farm size

Livestock production is an integral part of the farming system in the sub-region. This type of farming system is reported by Waga et al. (2016). It can help a lot in the crop production; i.e. as a power source during draught, as a source of food, of income, of organic manure, and of fuel, and also as a means of transportation. The surveyed households had an average livestock number and farm size of 5.17 and 1.63 ha, respectively (Table 3). The largest average livestock number and largest average farm size were recorded in Awi zone (5.87 and 2.17 ha, respectively) (Table 1). Livestock and land is an extremely scarce resource and an important asset, which is an indicator of wealth, and perhaps a proxy for social status and influence within the community of farmers in Ethiopia. The average land holding of farmers in the present study was deemed to be similar to the size reported by Yaze et al. (2017). Lakew et al. (2016) had also discussed that 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 within the 4.3–6.5 range.

**Table 3.** Mean livestock number and land ownership of the surveyed households (Source: Survey Results, 2019)

| 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 a long-standing practice, but in the mid altitude and low altitude areas, its production tends to be limited. As reported by Adet Agricultural Research Center (2011) and FAO (2008) potato's production was widely expanding. The average land allocated to potato in the North Western part of Ethiopia was 0.47 ha. The maximum area allocated to potato was found in South Gondar zone (0.57 ha) followed by Awi zone (0.53 ha) and West Gojjam zone (0.51 ha). Farmers' maximum experience in potato production (39.71 years) was also recorded in these zones (Table 1). The three zones were also discussed by Mulualem (2020) as the major suitable areas for potato production. Furthermore, innovative farmers rented land in the studied area, with the purpose of potato production. As discussed by Mesfin et al. (2018), in Awi district potato covers 21% of the total land holding. As household landholdings have shrunk (Bekele et al., 2011) and degraded, high-yield production crops such as potato became a good alternative for providing a cheap source of food 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 (Table 4).

Total amount of potato produced in the sub-region was 2.29 tons (Table 1). The average amount of potato produced, reserved as seeds, consumed, and sold, is 2.29, 0.48 (16.6%), 1.26 (57.67%) and 0.80 tons (25.73%), respectively (Table 1 and Table 4). The maximum amount of potato produced (3.01 t), consumed (1.34 t), and conserved as seed (0.96 t) was recorded in South Gondar zone. The maximum amount of potato sold (1.26 t) was recorded in West Gojjam zone (Table 1). These results were similar to the findings of Yaze et al. (2017), and also of Bezabih and Mengistu (2011) at Hulla. However, the latter authors also said that the largest amount of potato produced around Shashemene Atsibi Wonberta, and Saeesi Tsaeda Woredas was sold, which may be due to the year and place differences.

The average price of potato in the sub-region was 2.06 Birr/kg (Table 4). The maximum potato price (2.56 Birr/kg) was recorded in West Gojjam zone (Table 1). This may be due to the market access of the zone compared to the other surveyed zones. A similarly low price was also recorded in SNNPRS and Tigray regions, as Bezabih and Mengistu (2011) reported.

The trends in potato production were discussed with the key informants during group discussions, and with individual farmers in interviews. The surveyed farmers shed light on potato's production in all the three seasons: the main season (65.1%) that is from June to September; irrigated systems (25.7%) from February to May; and residual moisture (9.2%) (Table 4). Potato production with residual moisture was limited and restricted to the highlands of Gojjam where there is sufficient moisture in the off season. This result contradicted the report by Bezabih and Mengistu (2011) who claimed that residual moisture supplemented with irrigation constitutes the

**Table 4.** Area allocation and production seasons of potato (Source: Survey Results, 2019)

| 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 in Birr was applied.

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.

### Commonly grown varieties and farmers' variety preference

Western Amhara farmers have had their local varieties like Sabew (tolerant to late blight disease, high palatable, and low yielder), Square (high palatable and low yielder), Nech Dinch (high storage capacity), and Ayito. They used all these varieties in irrigation system, in the main season, and in crop rotation to improve soil health, to optimize nutrients in the soil, and to combat pest and weed pressure. Farmers use different varieties of potato including local varieties in their production systems. They did not use Square local variety in such degraded lands as it has very low morphological growth parameters. Varieties with high morphological growth parameters need be used in degraded lands instead. Farmers in the sub region were losing such local potato varieties as Abadamu and Abalo/Agere in their farming system due to the lack of storage facilities available to them. The aforementioned varieties had different quality attributes making them suitable for different breeding/agronomy programmes and best fit for degraded lands (particularly the Abalo/Agere local variety). These lost varieties were reported by Semagn et al. (2015) as locally cultivated in the year 2015. Potato seeds, which the farmers bought from their cooperative, their neighbours, or from the surrounding market, may be degenerated or diseased. But, as reported by Waga et al. (2016), the use of improved varieties was predominantly governed by farmer's wealth, adoption and educational level. Bezabih and Mengistu (2011) reported that the choice of one specific variety for production depends on market access. Unlike the surrounding farmers who choose varieties for their high yield potential, in other areas of Ethiopia farmers prefer choosing varieties for their drought tolerance, as reported by Semagn et al. (2015); Shimelis et al., (2012) also reported that in Kenya the selection criteria included the variety's yield potential, market access, and taste,and in Rwanda, yield potential, tolerance to diseases, and high dry matter content.

On average there are two commonly grown varieties per farmer (Table 5). This result is different from the one reported by Yaze et al. (2017) as there is year difference. The surveyed farmers use a maximum of four improved varieties, namely: Gudene, Belete, Jalene, and Guassa. Typically, they get their seeds from their cooperative or purchase seeds from their neighbours 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, whereas the lack of access to improved varieties was related to age and family size. To choose one variety for production, farmers rely on market access (Bezabih and Mengistu, 2011).

Farmers choose their 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%) (Table 5). Farmers in Ethiopia choose their varieties according to drought tolerance (Semagn et al., 2015); in Kenya, according to yield potential, market access, and taste (Shimelis et al., 2012); and in Rwanda, according to yield potential, disease tolerance, and high content of dry matter (Shimelis et al., 2012).

### Management practices for potato production

Average seed rate of potato was 2.13 t/ha (Table 6). 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 used in the production of potato was 130.23 and 103.41 kg/ha (Table 6). These rates were below the recommended rate. Similar results were also reported by Yaze et al. (2017), while Bezabih and Mengistu (2011) revealed that farmers apply lower doses of fertilizers in the southern part of Ethiopia.

Animal dung was not used as a composting source in North Western Ethiopia as this resource was lacking, although animal manures are one of the main nutrient sources and the major component in keeping the soil fertile. This result is also supported by the findings of 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 in Wolaita zone farmers applied small amounts of organic fertilizers i.e. about 1.1 t/ha to their potato farms.

**Table 5.** Commonly grown varieties and farmers' variety preference (Source: Survey Results, 2019)

| 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 |
| | Palatable quality | 1.2 |

Where * indicates that commonly grown varieties are included.

As potato seed source, 14.4% of the farmers use their own seeds, 73.5% use seeds from the surrounding market, 10.2% from their neighbours, and 1.9% from the agricultural agencies including research centers (Table 6). Biniam et al. (2014) also reported that the majority of 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' responses, their seeds are degenerated. They have informal potato seed systems, as reported by Zerihun et al. (2014); Bezabih and Mengistu (2011), and Gildemacher et al. (2009). These systems have a serious problem related with quality issues: they supply inferior quality seeds (Bezabih and Mengistu, 2011); Gildemacher et al., 2009) and Mulatu et al., 2005) due to absence of quarantine inspection systems during their production. The farmers of the surrounding area had produced ware and seed potato both in the main season 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 by Zerihun et al. (2014). The reasons behind this include lack of awareness and land shortage, hence potatoes produced is separated into ware potatoes and seed potatoes after harvesting.

The potato area coverage has been increasing from year to year (by 0.25 ha/year). This was due to increasing prices (15.4%), land shortage (7.1%), and the fact that no other crops exist that can cover such degraded area (76.5%). Potato is an ideal food source for the area due to increasing awareness and growing population (1%) (Table 6).

There are some extension efforts in place, aimed at disseminating improved agricultural technologies. On average, the extension agents contact the farmers from the surrounding area one time per week. This low rate of extension contact is also reported by FAO (2008). Waga et al. (2016) also reported that cash shortage is a major constraint in Ethiopia, preventing the implementation of 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 cases), fertilizers, and agronomic practices are delivered to the farmers through the extension system in the studied area.

On average, the surveyed farmers plough their land for potato production 3.34 times (Table 6). The surveyed farmers have no awareness as to whether or not this number of ploughing has detrimental effect to the soils and the nutrients in it. They only know that in order

**Table 6.** Management practices introduced in potato production (Source: Survey Results, 2019)

| Variable | Modality | Frequency of respondents (%) |
|---|---|---|
| Seed rate | | 2.13* |
| Seed source | Own seeds | 14.4 |
| | Seeds bought from the surrounding market | 73.5 |
| | Seeds bought from neighbours | 10.2 |
| | Seeds bought 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 ploughings | 3.34* |
| Plots for seed potato | Separate plots for seed potato | 8.9 |
| Pesticide | Pesticide usage | 1.1 |
| Seed cooperative member | Members of Potato Seed Cooperative | 15.2 |

Where * indicates average numbers of: seed rate in kg, fertilizers in kg/ha, and number of ploughings

to produce potato yield, frequent cultivation practices are required. However, Wischmeier and Smith (1987) and Bechmann and Bøe (2021) reported the frequency of ploughing has a major impact on erosion, soil, and nutrient loss. For the main season 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 (Table 6). Hirpa et al. (2012) also reported that lack of improved crop management practices – such as pesticide application – had a stronger impact on seed yield and quality.

### Traditional techniques for soil fertility maintenance

In North Western Ethiopia, traditional techniques for soil fertility maintenance include: terracing (1.9%), fertilization (63.0%), and crop rotation mainly with potato (35.1%) (Table 7). The surveyed farmers use potato in crop rotation and soil conservation practices. This is due to the significant amount of residue left after potato tuber production. Karnata et al. (2019) reported that highest amounts of organic carbon and organic matter were observed in potato leftovers. Crop rotation practices with potato were also reported by (Anton et al., 2012). 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 as well as reducing runoff. Also Saida et al. (2016) reported substantial contribution of potato to reducing the amount of soil lost from the highland areas. By contrast, CIP (2013) and Nyawade et al., (2019) argued that cultivation practices applied to potato plants before and after planting, combined with the ease of harvesting after crop maturity, lead to soil degradation, erosion, and leaching of nutrients. Griffin et al. (2009) also reported that the amount of residue left after potato harvest was very small as all residues decomposed before harvesting. Even though

**Table 7.** Traditional techniques for soil fertility maintenance (Source: Survey Results, 2019)

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

the surveyed farmers use fertilization as a traditional technique for soil fertility maintenance, the very costly commercial fertilizer and the untimely availability of its supply constituted the major potato production constraints. As the farmers reported, crop rotation was used in pest control, soil fertility management, conservation agriculture, and crop diversification. Hirpa et al. (2012) also reported that potato is one component of the crop rotation as it has a significance amount of residue. Besides potato, faba bean, peas, lupine, wheat, barley and teff are crops, which are also included in crop rotation system. The precursors of potato are lupine, wheat or barley, whereas the succeeding crops are teff, 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 instead it will be left to decompose within the same field. The farmers also concluded that degraded land in which other crops cannot be produced is used for potato production. Farmers believe that potato can improve the fertility of the soil for the coming crops when planed in the fallow land as a precursor crop. Unlike other crops, in which the whole plant is harvested, the leftover parts from potato will remain on that plot and contribute to soil fertility maintenance, according to the surveyed farmers' view. By contrast, in other crops, the whole plant is harvested, and there is no biomass transfer to the land devoid of such practice. Conclusions to that effect are also reported by Abebe et al. (2017) and Adamu (2013).

## CONCLUSIONS

Potato production in the highlands of Ethiopia is an age-old practice. Potato is produced for food, seed, income, and for the maintenance of soil fertility in all the studied districts. The survey also revealed that farmers use potato in soil fertility management, that they have their own local varieties, and differing variety preferences. The farmers are losing such local potato varieties, which had different quality attributes, suitable for different breeding/agronomy programmes, and offering the best fit for degraded lands. It is believed that a higher frequency of ploughing causes soil and nutrient erosion. The study also revealed that there were traditional techniques of soil fertility management applied, such as terracing, fertilization, and crop rotation mainly with potato. Farmers in the surveyed area believe that potato can ameliorate the fertility of the soil and protect soils from erosion. Further research should be conducted in order to minimize the number of ploughings in potato production. Trainings should be offered to farmers on the subject of production and usage of certified seeds in potato production. GOs, NGOs and universities should participate in preventing the loss of important local varieties.

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## CONFLICT OF INTEREST

All authors declare no conflict of interest in this paper.

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## OCENA SYSTEMÓW UPRAWY ZIEMNIAKÓW W PÓŁNOCNO-ZACHODNIEJ ETIOPII W PERCEPCJI LOKALNYCH ROLNIKÓW

### ABSTRAKT

**Cel pracy**

Głównym celem projektu było zbadanie, w jaki sposób rolnicy postrzegają uprawy ziemniaków (*Solanum tuberosum* L.) w systemach agrarnych północno-zachodniej Etiopii.

**Materiały i metody**

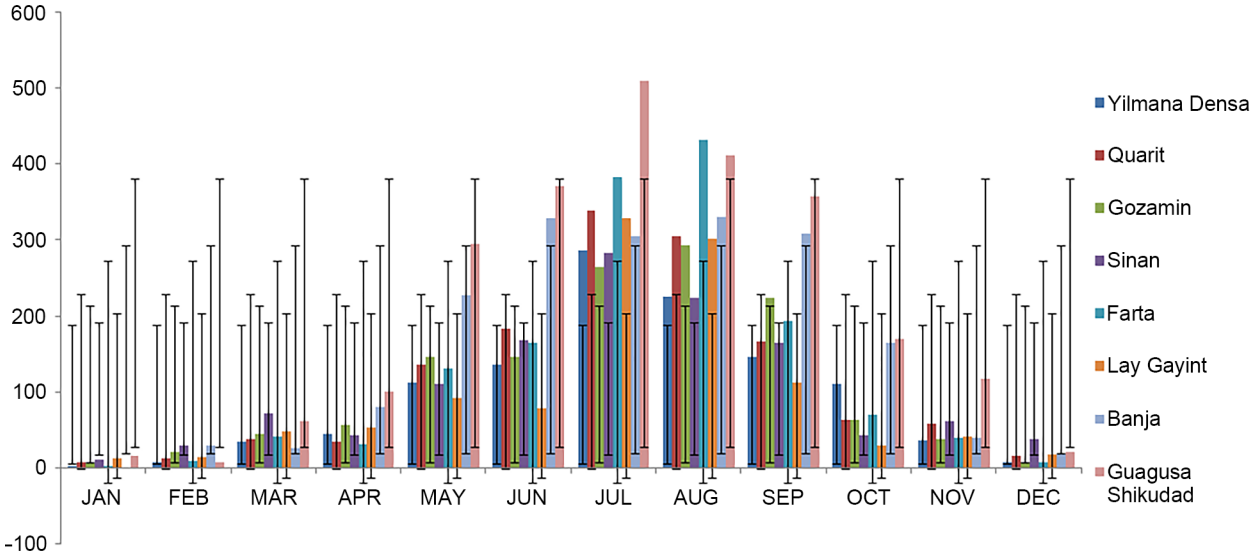
Dane zebrano ze źródeł wtórnych (literatura przedmiotu) i pierwotnych (bezpośrednie wywiady z respondentami).

**Wyniki i wnioski**

Ustalono, że 9,8% rolników zajmowało się wcześniej działalnością pozarolniczą. Średnie doświadczenie w produkcji ziemniaków wśród respondentów wynosiło 36,81 roku, średnia liczba posiadanych zwierząt gospodarskich 5,17, zaś średnia wielkość gospodarstwa 1,63 ha. Stwierdzono, że rolnicy przeznaczają średnio 0,47 ha (28,83%) swoich gruntów pod produkcję ziemniaków. Dominującym sezonem wegetacyjnym ziemniaków był sezon główny (65,1%), następnie okres nawadniania (25,7%) i okres wilgotności resztkowej (9,2%). Ustalono, że rolnicy wykorzystują 16,6% wyprodukowanych ziemniaków jako materiał siewny, 48,55% przeznaczają do spożycia w gospodarstwach domowych, zaś 25,73% sprzedają na pobliskim rynku po bardzo niskich cenach (2,17 birra/kg), co stanowi ich źródło dochodu. Średnio na rolnika przypadały dwie powszechnie uprawiane odmiany. Zanikały natomiast lokalne odmiany ziemniaka, o zróżnicowanych cechach jakościowych, czyniących je przydatnymi do wykorzystania w programach hodowlanych/rolniczych, a jednocześnie najlepiej dopasowane do uprawy na terenach zdegradowanych. Rolnicy orali ziemię średnio 3,34 raza przed sadzeniem ziemniaków i zużywali 2,13 t/ha nasion ziemniaka podczas sadzenia. Stwierdzono, że 14,4% rolników stosowało nasiona własne, 73,5% nasiona zakupione na okolicznym rynku, 10,2% nasiona zakupione od sąsiadów, a 1,9% nasiona zakupione w kooperatywach rolniczych. Większość rolników stosowała takie tradycyjne techniki zarządzania żyznością gleby, jak: nawożenie (63,0%), płodozmian z przewagą ziemniaków (35,1%) oraz technikę tarasowania (1,9%). Rolnicy na badanym obszarze są przekonani, że uprawianie ziemniaków poprawia żyzność gleby i chroni ją przed erozją. Należy prowadzić dalsze badania w celu zminimalizowania liczby orek w produkcji ziemniaków. Organizacje pozarządowe, rządowe i uniwersytety powinny wziąć na siebie odpowiedzialność za reprodukcję i rozpowszechnianie ulepszonych nasion ziemniaka oraz za ochronę ważnych lokalnych odmian tej rośliny. Należy również przeszkolić rolników w zakresie produkcji i stosowania kwalifikowanego materiału siewnego w produkcji ziemniaków.

**Słowa kluczowe:** ziemniak, systemy uprawy, grunty zdegradowane, orka, płodozmian, żyzność gleby

# APPENDICES




**Appendix, Figure I.** Rain fall pattern of Yilmana Densa, Quarit, Gozamin, Sinan, Farta, Lay Gayint, Banja and Guagusa Shikudad woredas (Vertical bars represent standard errors. Source: North Western Metrological Station, 2018)

## APPENDIX I

**Table. I.** Agro-climatic data of Western Amhara districts, which are suitable for potato production (Source: Survey Results, 2019)

**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 | n/a | 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 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 2010 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 2011 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 2012 | n/a | n/a | n/a | 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 | n/a |
| 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 |

**Maximum temperature**

**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 | n/a | n/a | 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 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 2007 | 33.5 | 36.1 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 2008 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 2009 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 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 | n/a | 17.7 | 19.6 | 19.0 | 17.6 |
| 2016 | 18.4 | 20.5 | 22.0 | 20.7 | 19.4 | n/a | 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 |

**Minimum temperature**

**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 | n/a | n/a | 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 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 2007 | 11.3 | 13.0 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 2008 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 2009 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 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 n/a = data not 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 look at different aspects of potato production, helping me in my research project titled "Assessment of potato (*Solanum tuberosum* L.) farming systems and evaluation of potato's phosphorous use efficiency and its role in soil physicochemical properties, in crop production systems". This is a collaboration 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 respondents for their kind cooperation and their sincerity of replies to the questionnaire.

Are you willing to answer my questions? Do you have any questions or queries before we start?
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:- _____
   - Source of income:_____
   - 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 to potato production?
   a. _____
   b. _____
   c. _____
   d. _____
   e. _____
   f. _____
   g. _____
   h. _____

4. What cultural practices are applied in 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, are they used:

   For seed_____

   For ware_____

6. Is there any extension system that improves potato-growing technology? **Yes/No**
   What do these extension systems deliver? _____
   – Seed tubers, recommended rate fertilizers (information/access), recommended agronomic practices, market information, other – please state what.
   Frequency of extension contact: **twice a week, once a week, once every two weeks, once every three weeks, once a month, other – please state how often** _____

7. Are you producing potato in the main season or in the 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 is it done?_____

    _____

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

12. How many times do you weed, cultivate, earthen up (cover) your potato field?

    Weeding _____

    Cultivation _____

    Covering _____

13. What is the importance of potato?

_____

(Source of food, employment, income, component crop in crop rotation, in soil fertility management, other – please state what)

- 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?
    - During land preparation? F/M
    - During planting? F/M
    - During weeding? F/M
    - During covering? F/M
    - During cultivation? F/M
    - During harvesting? F/M

15. Farmers' awareness about local potato varieties and improved potato varieties
    - How many local varieties are there in your area? _____ Name _____ _____
    - What are the improved potato varieties in your environment? _____
    - Which variety is used most frequently in crop rotation? _____
    - Which variety is used in irrigation? _____
    - Are there any lost potato varieties? If yes, what are the name of these varieties? _____

16. What is the traditional equipment, and farming systems used for potato Farming, harvesting and storage
    - Traditional equipment 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 of the cooperative? _____
    - Do you use separate plots for seed potato production? **Yes/No**
    - Are there separate management (fertilizer and cultivation) practices? **Yes/No**
    - If not, why? _____
    - What type of seed systems are there in your environment? (**Formal/Informal/ Cooperative**)
    - Is there any quarantine for the seeds? **Yes/No**
    - If yes, when does the quarantine take place? (**During growing/at harvesting/during purchasing**)
    - How many times is it applied? _____
    - Is it enough? **Yes/no**
    - For ware potato production, where do you find the seeds? How you store your potatoes for seeding? _____
    - Is there any DLS in your environment? _____In what number? ____
    - Which variety is used for seedling? _____
    - For what purpose(s) you use the ware potatoes? _____
    - What varieties do you use 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. Farmers' traditional knowledge of crop rotation, using potatoes for soil fertility improvement practice
    - What are the traditional techniques to improve soil fertility?
      a. _____
      b. _____
      c. _____
      d. _____
      e. _____
      f. _____
    - Do you use crop rotation in your environment? _____
    - If yes, what are the benefits of crop rotation in your thinking?
      a. _____
      b. _____
      c. _____
      d. _____
      e. _____
      f.a_____
    - What crops are best fit for crop rotation?
      a. _____
      b. _____
      c. _____
      d. _____
      e. _____
      f. _____

20. Do you use potato in crop rotation? **Yes/No** _____
    - If yes, can all varieties of potato be used for crop rotation? **Yes/no**
    - If not, what are the varieties that can be used in crop rotation?
      a. _____
      b. _____
      c. _____
      d. _____
      e. _____
      f. _____
    - If yes, what are the precursors and successors of potato?
      Precursors _____
      Successors _____

- Do you believe that potato is important for soil fertility management? **Yes/NO** In what way?
  a. _____
  b. _____
  c. _____
  d. _____
  e. _____
  f. _____
- How do you maintain soil fertility in potato farms? _____

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. Does the growing season and environment change from time to time? **Yes/No**
    If yes, explain how it changes, especially in terms of soil fertility, temperature, and rainfall?
    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 other (please state what)**
    If chemicals are used, please provide the name of the chemical compound _____
    _____
    Where do you find the chemical compound? _____How many times you apply the chemical compound?
    _____

24. How has the potato productivity been in the last decade? _____By how much did the productivity decrease?_____

    Possible reasons for this reduction?
    a. _____
    b. _____
    c. _____
    d. _____
    e. _____

    Solutions applied by you?
    a. _____
    b. _____
    c. _____
    d. _____
    e. _____

25. Distance from your home to the nearest market _____
    Is the price of potato you are going to sell at enough? **Yes/No**
    What is the price 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 not, 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 does it relate to potato production?
    _____

27. In your opinion, what actions should be taken by
    a. The government _____
    _____
    _____
    b. Research Centres _____
    _____
    _____
    c. Universities _____
    _____
    d. Extension Workers _____
    _____

28. Do you have any additional comments? _____

Source: Photo: Momina Aragaw

## APPENDIX III

**Table II.** Mean overall characteristics of the surveyed households (Source: Survey Results, 2019)

| | | | 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 | Experience in potato production, years | 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 | Source of income (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 amount consumed (t) | 1.26 | 1. 21 ± 0.035 | 1.00 ± 0.000 | 1.15 ± 0.041 | 1.34 ± 0.045 |
| 11 | Potato amount reserved for seeds (t) | 0.48 | 0.51 ± 0.043 | 0.01 ± 0.000 | 0.01 ± 0.000 | 0.96 ± 0.018 |
| 12 | Potato amount 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 ploughings, 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 error, Means within a row followed by different superscripts differ ($P < 0.05$), % = per cent. AWOFA = Agriculture with off farm activities