Promoting Drought and Heat Resilient Potato Genotypes in Eastern Ethiopia

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The Drylands Coordination Group (DCG) is an NGO-driven forum for exchange of practical experiences and knowledge on food security and natural resource management in the drylands of Africa. DCG facilitates this exchange of experiences between NGOs and research and policy-making institutions. The DCG activities, which are carried out by DCG members in Ethiopia, Eritrea, Mali and Sudan, aim to contribute to improved food security of vulnerable households and sustainable natural resource management in the drylands of Africa.

The founding DCG members consist of ADRA Norway, CARE Norway, Norwegian Church Aid, Norwegian People's Aid, Strømme Foundation and The Development Fund. The secretariat of DCG is located at the Environmental House (Miljøhuset Mariboes gate 8) in Oslo and acts as a facilitating and implementing body for the DCG. The DCG's activities are funded by NORAD (the Norwegian Agency for Development Cooperation).

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We would like to acknowledge Drylands Coordination Group (DCG) Ethiopia for its confidence to provide the financial support to implement the drought and heat resilient potato project which was carried out by Haramaya University. The planned project activities would not have been achievable without the technical guidance and support to develop the project proposal, as well as the financial support of the DCG project, which deserves special gratitude. We would also like to acknowledge a number of people and offices that played fundamental parts for the effective implementation of the activities at project sites. First, we would like to express our deepest gratitude and appreciation to the DCG Ethiopia project coordinator based in Addis Ababa for her technical guidance and timely budget administering. Secondly, we want to extend our appreciation to the farmers from target project sites, especially for their willingness to share information with us during the baseline survey, to thedistrict agricultural and natural resource offices, to Haramaya and Oda Bultum Universities ISSD project (based at Haramaya University), to research centers (Fedis and Holeta) and to the Afran Kallofarmers' cooperative union, all of whom directly or indirectly contributed to the success of this project. We would sincerely extend our appreciation.

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ACRONYMS AND ABBREVIATIONS

AARC	Adet Agricultural Research Center
BENEFIT	Bilateral Ethiopian Netherland Effort for Income and Trade
BoANR	Bureau of Agriculture and Natural Resource
DA	Development Agent
DCG	Drylands Coordination Group
DLS	Diffused Light Store
FARC	Fedis Agricultural Research Center
FTC	Farmers Training Center
HARC	Holeta Agricultural Research Center
HH	Households
HU	Haramaya University
ISSD	Integrated Seed Sector Development
McARC	Mechara Agricultural Research Center
MoU	Memorandum of Understating
NGO	Non-government Organization
PA	Peasant Association
PVS	Participatory Variety Selection
PWO	Pastoral Welfare Organization
Qt	Quintal, a unit equivalent to 100 kilo gram

EXCUTIVE SUMMARY

The project **"Enhancing Food Security Needs of Vulnerable Groups through Participatory Selection and Promotion of Drought and Heat Resilient Potato Genotypes in Eastern Ethiopia"** took place 2016-2017. It was implemented in a drought-prone area of Eastern Ethiopia, with the aim of scaling up the findings at national level through regional and national stakeholder's engagement. The project was implemented by Haramaya University (HU) with financing from Norad through the Drylands Coordination Group (DCG).

Prior to implementation of the project, early 2016,a stakeholder consultation workshop was held and a baseline survey was conducted. The main objective of the stakeholder consultation workshop was to create awareness among different partners, stakeholders and local community on the prevalence of climate change on agricultural production (especially with reference to potato) and the pathway to adaptation and popularization of drought and heat tolerant potato genotypes. Specifically, the stakeholder consultation workshop contributed to create linkages between stakeholders in future potato development; to share experiences among partners and stakeholders on cooperative based potato seed multiplication and a dissemination scheme, and to seek the way forward for potato research and extension in eastern Ethiopia. Diverse stakeholders and partners participated in the workshop, including representatives from farmers, zones and district Bureaus of Agriculture and Natural Resources (BoANR), regional and federal research institutions (Holeta Agricultural Research Center (HARC), Fedis Agricultural Research Center (FARC), Mechara Agricultural Research Center (McARC), Adet Agricultural Research Center (AARC)), Non-government Organizations (NGOs) (CARE-east Hararghe Field office), farmers' cooperative unions, DCG-Ethiopia, theIntegrated Seed Sector Development(ISSD) project, and Universities (Haramaya, Jigjiga, and Oda Bultum). The activities at the workshop included presentation, discussion, and sharing of different papers, and a discussion on the future direction in areas of intervention and collaboration on potato research. The outputs from the workshop synthesized into actions. A baseline survey was conducted to assess key existing challenges related to potato production, identify predominant potato cultivars under production at different districts, andunderstand why these cultivars were chosen. Here two issues were important: to assess specific characteristics (traits) of major local and improved potato varieties as perceived by farmers for production, and to prioritize future potato development interventions that need priority by researchers and extension workers in marginal areas.

Other key activities implemented by the project include:

- Awareness creation among different partners, stakeholders and local community on the prevalence of climate change on agricultural production (especially with reference to potato) and the pathway to adaptation;
- Capacity building (training) of smallholder farmers and partners (stakeholders) in participatory variety evaluation (PVE), improved potato agronomic practices, post-harvest ware and seed tuber management;

- Screening and selection of potato genotypes adaptable to the climate and environments in eastern Ethiopia and promote its production;
- Demonstrate and experience sharing of the value addition of potato through the processing into different products and recipe development,
- Demonstrated improved seed quality management using diffused light store (DLS);
- Facilitated market linkages for seed, ware and processed potato to potential customers.

By implementing these project activities the following outcomes were achieved:

- Key challenges affecting potato production, farmer's criteria forvariety selection and mitigation strategies to the changing climate were identified.
- Potato genotypes resilient to climate change and preferred by both male and female farmers were demonstrated and popularized. Farmers improved theirtechnical skills and knowledge about improved potato production, seed quality management, and methods for value addition relevant for potato crops.
- Farmers got the chance to see the real effects of climate-smart potato genotypes and quality seed on crop productivity and other attributes.
- The activities enabled farmers to enhance their crop diversity in order to adapt to their particular agro-ecology, and increase their knowledge about specific crops.
- The intervention helped farmers know how to practically apply technologies like improved agronomic practices, seed selection, management, and potato value addition
- Experience sharing and field days empowered farmers and stakeholders and enhanced the linkages between them. For instance, due to the improved linkage between farmers and potato value chain actors, farmer groups couldsell their seeds at premium price to seed users. Farmer groups, or the cooperative to which they were affiliated, were also able to create linkages with other processed potato product buyers such as the Pastoral Welfare Organization (PWO), and started supply of potato powder.
- The intervention improved access to potato varieties preferred by farmers, and this enabled farmers to switch from lower quality potato to the variety of their preference. In addition, the intervention also improved women farmers' capacity in potato value addition (processing of potato into different foods) to address problem of post-harvest losses and a decrease in nutritional value of the produce.
- Farmers groups at target sites got to know and implement a local method of seed storage and preservation that maintains the quality of the potato, through constructing of cost-effective diffused light stores (on either individual or group level).
- The collaborating partners such as Haramaya University and ISSD project have taken up the technologies and demonstrated them outside the project districts. They particularly targeted marginal areas where the crop had rarely been produced before. In addition, they carried out and value addition activities.
- Some district agriculture offices, such as the one in Doba district, showed interest in adopting the practice of demonstrating climate-smart potato genotypes. In collaboration with the ISSD project, the office evaluated 18 potato genotypes with farmers participated at a Farmer Training Center (FTC).In addition, the office mobilized farmers to evaluate the varieties, and organized experience sharing among stakeholders, as well as demonstrated improved seed storage technologies.

1. DROUGHT AND HEAT TOLERANT POTATO GENOTYPES: A STRATEGY FOR CLIMATE CHANGE ADAPTATION

Moisture stress as a result of erratic rainfall and recurrent drought is a major problem constraining agricultural production in a large part of Ethiopia. Moisture reliable highlands and lowlands of the country account for only 31 and 9.0% of the land, respectively, but are collectively inhabited by 71% of the population. Developing crop varieties, including potatoes tolerant to drought and heat, could be the priority research area in Ethiopia as a climate change adaptation strategy. With the current unpredictable annual rainfall and droughts once every five years with increasing temperatures, climate change presents challenges to feed Ethiopia.The potato is becoming a more important crop in Ethiopiawith the potential to feed much of Africa. Developing potato varieties tolerant to drought and heat would enable expanding the agro-ecology of the crop to the lowlands through makingthe crop resilient to moisture stress and heat and improving yields in order to attain targeted food requirements in 2050. For instance, eastern parts of Ethiopia are among the food insecure regions of the country characterized by fragmented small areas of agricultural land that are affected by recurrent drought. This requires availability of high yielding and locally adaptable crop varieties that maximize returns per unit area of land. Potatoes produce more food per litter of water than most grains, which has made the crop increasingly important in sub-Saharan Africa regions including Ethiopia. The crop is considered as one of the spearheads of agricultural policy in Ethiopia because of its multiple benefits for food security, income generation and export earnings. Lately, farmers in marginal and vulnerable areas have strived to domesticate and expand its production. Despite its short cropping cycle and high yield per unit area, average national yield of potato has remained constant in the country, ranging 8-11 t/ha in the last 20-30 years. In the same period, the area planted with potato cropshas also increased from 30,000 ha to about 164,146 ha (CIP, 2011). The reason is primarily due to lack of adaptable varieties for marginal ecology and use of low quality seed tubers for planting (Gildemacher *et al.,* 2009).

Potato is a cool season crop and sensitive to both moisture and heat stresses. The optimum temperature for potato production ranges between 18 to 30 degrees Celsius. If the temperature is higher than 30 degrees, the crop will not tuberize and will grow only vegetatively. The rainfall requirement for optimum yield of the crop ranges between 500 to 700 mm during the growing season. Therefore, the nationally released potato varieties and local cultivars are not productive in the mid- and lowlands of the country. Especially, drought (water deficit) and heat stress are the important environmental factors restricting growth and tuberization of the crop in many regions of the world, particularly when the two stresses occur simultaneously. The potato is a short season crop currently expanding to marginal areas of Hararghe zones for production by smallholder farmers. The crop is produced 2-3 times annually in Hararghe under both irrigated and rain fed cultivation. The crop also produces high yields and more kilocalories per unit area as compared to other cereals crops. Hence, for farmers in these particular zones where sorghum and maize is the dominant crop, integrating potato production to the farming systems is vital to ensure food and nutrition security and as a source of income. Farmers producing potato in Hararghe have approached market segments in Somalia, Dire Dawa, Hargessa, Yemen, Djibouti, and likes. The study

conducted by Hirpa et al. indicated that potato is the second most important income-generating cash crop next to khat, and able to improve food security and income of farmers largely producing cereal crops (Hirpa *et al*., 2010). Hence, involving smallholder farmers with fragmented drought-prone land, who have limited land holdings (less than 0.5 ha per household), would be beneficial. As the average family size per household is at least eight people, cultivating potatoes would contribute to improving the livelihood of rural households. However, a significant number of farmers do not take part in production of the crop due to limited availability of the potato varieties that are preferred by farmers because they meet their local demand despite the presence of challenging agro-ecologies.

The International Potato Center (CIP) in Lima, Peru has developed elite potato breeding clones tolerant to drought and/or heat-stress, and reported promising results for production in other parts of the world as well. Haramaya University research and extension office has introduced 34 low- land- potato- genotypes from CIP, Lima, Peru having three quality traits (drought tolerant, heat tolerant, virus resistant or a combination of these traits).The aim is toevaluate the genotypes with local and improved potato cultivars grown in Ethiopia for drought and heat tolerance. In a country with adominating agrarian economy like Ethiopia, alleviating food insecurity is one of the most important objectives to be attained by the agriculture system.

2. PROJECT SITES AND STAKEHOLDERS INVOLVEMENT

2.1 PROJECT SITES AND TARGET BENEFICIARIES

The project beneficiaries consisted of a group of potato growing farmers that was established from members of cooperatives (with legal recognition) from four districts (Fedis, Kersa, Chiro, and Gemechis). The farmers were selected from primary cooperatives namely Laga Hamaresa (Fedis), Haji Feji Irrigation User (Kersa), Jiru Jalela (Chiro) and Bilisa (Gemechis). In 2016 and 2017, the project consisted of 60 farmers (50% women farmers)from each primary cooperative (Table1). Their areas of involvement in the project included: training in agronomic and post-harvest potato production and seed quality management, a demonstration on potato processing into flour and different local food preparation from processed potato, experience- sharing and linkage with input and service providers, university and research. Farmers' access to good quality seed of drought and heat resilient potato genotypes was also supported. In addition, Participatory Variety Selection (PVS) was conducted with farmers at Farmers Training Center (FTC) and individual farmer plots in Kersa, Fedis, and Chiro where farmers were engaged in planting the trial and evaluation. The farmer's groups at each district have also constructed Diffused Light Store (DLS) through the financial support of other collaborating partners such as Haramaya University (HU), Fedis Agricultural Research Center (FARC), Oda Bultum University and the Integrated Seed Sector Development (ISSD) project.

Table 1: Summary of Target project beneficiaries disaggregated by location and gender (pooled value of 2016 and 2017)

Location *(By District-kebele)*	**Female**	**Male**	**Total**
Fedis-LagaHamaresa	30	30	60
Kersa-Burqa Watar	30	30	60
Chiro-Arbarakate	30	30	60
Gemechis-Wolensodefo	30	30	60
Total	**120**	**120**	**240**

2.2 STAKEHOLDERINVOLVEMENT AND PARTNERSHIP

Collaboration and participation of multi-discipline experts and stakeholders would enhance smooth implementation and ensure sustainability of the project. Haramaya University has implemented the project by engaging stakeholders at national and regional research centers, government offices and higher institutions. In line with this, different stakeholders and partners were involved in the project implementation at different levels. These collaborators include district BoANR offices, nongovernmental organizations, development partners, research centers, higher learning institutions and community-based organizations. The partners collaborated with the project in facilitation and organization of target farmers; demonstration and popularization of climate-smart potato genotypes; support in

infrastructure facilities like seed store and offices; organizing farmers field days; demonstration of different food products from potato; potato value addition, etc. (Table 2).

Table 2: List of stakeholders and partners involved in the implementation og project activities during 2016 and 2017

Stakeholders/partners	Areas of collaboration in the project
1. **Haramaya University Integrated seed sector development programme**	▪ Organizing farmers, supporting farmer-based seed production, providing infrastructure facilities (office, store, office equipment), facilitating market linkages for farm products ▪ Involvement in PVS and demonstration of climate resilient potato genotypes ▪ Documentation of success stories and sharing with target audiences through electronic and printed media
2. **Fedis Agricultural Research Center**	▪ Variety demonstration, strengthening of farmers capacity for quality- potato seed production, sharing experiences for scaling up
3. **Oda Bultum University**	▪ Demonstrating improved potato technologies, coaching and follow up for project activities implementation
4. **Haramaya University-potato breeding programme and food science department**	▪ Collaboration in training farmers and sharing experience on improved potato production technologies, seed production and post-harvest handling (store management), as well as demonstration of potato value addition (processing into powder) and different local food preparation methods from processed potato
5. **Fedis, Kersa, Chiro and Gemechis district BoANR offices**	▪ Mobilizing farmers for different activities, conducting technical follow up/coaching, and monitoring and evaluation of project activities
6. **Holeta Agricultural Research Center potato research programme**	▪ Sharing different experiences (manuals and protocols) for improved ware and seed potato production, food preparation, post-harvest management, developing guidelines (in local language) used by the farmers and stakeholders on different potato technologies
7. **Afran Kallo Farmers' Cooperative Union**	▪ Collaboration to facilitate experience-sharing for different stakeholders and farmers, involvement in demonstration of climate resilient potato genotypes as part of a varied menu of foods, supporting farmers group in access to markets
8. **Pastoral Welfare Organization**	▪ Involvement in the purchase of value-added potato (processed in to powder) from target DCG beneficiary farmers and demonstration of climate resilient potato genotypes at their intervention sites

3. ACTIVITIES IMPLEMENTED AND ACHIEVEMENTS OF THE PROJECT

3.1 ASSESSMENT OF BASELINE SURVEY

3.1.1 Rational and objectives of the baseline survey

Potato is a short season crop currently expanding to marginal areas of Hararghe zones for production by smallholder farmers. For farmers in these particular zones where sorghum and maize is the dominant crop, integrating potato production to the farming systems is vital to ensure food and nutrition security and source of income. As mentioned above, the potato is the second income-generating cash crop next to Catha *edulis* (khat) and represents a 759% increase in income when compared with sorghum (Hirpa *et al*., 2010). However, as previously mentioned, a large number of farmers are not engaged in production of potato despite the presence of suitable agro-ecologies. This is because there is a shortage of the varieties that are preferred by farmers because they meet the local demand. The nationally released potato varieties and local cultivars are less productive in the mid and lowlands of the country, where there are frequent moisture and heat stresses. Developing potato varieties tolerant to drought and heat would enable not only to sustainably produce the crop in the highlands but also to expand its agro-ecology to the lowlands of the country (Dandena *et al*., 2017). As a climate adaptation strategy, this would make the crop resilient to moisture stress and heat. This would improve yields and make it possible to meet targeted food requirements. Hence, selection and popularization of potato genotypes tolerant to drought and heat could provide an opportunity to expand the agro-ecology under which the crop could be cultivated profitably during periods of drought or moisture stress, particularly in the drier lowlands as well in the highlands. It would contribute significantly towards the national efforts to enhance household and national food security.

The main objectives of the baseline survey were: to assess predominant potato cultivars under production at different districts and the reasons why they were chosen; to assess specific characteristics (traits) of major local and improved potato varieties (as perceived by farmers for production); and to prioritize future potato development that needs priority interventions by researchers and extension workers in marginal areas.

3.1.2 Study sites and sampling

The baseline survey was undertaken at five selected districts (Haramaya, Kersa, Kombolcha, Chiro, and Gemechis) from east and west Hararghe zones. The districts were selected based on the criteria that:

- Potato is one of the dominant cash and food security crops for the farming community,
- Farmers were experienced in producing the crop,
- The ability of respondents to explain key challenges in potato production constraints, and mitigation strategies

The main socioeconomic activities of the studied districts are mixed farming i.e. both crop production and animal husbandry. The main crops grown in the area include maize, sorghum, groundnut, chat, coffee, haricot bean, sweet potato, potato, and pepper. Livestock husbandry includes cattle, sheep, goats, chicken, camel, and donkey.

A two-stage sampling procedure was used to select districts and kebeles[1] for the study. In the first stage, the five districts were purposively selected based on major potato producing areas and accessibility. From the selected districts, one kebele per district was selected in consultation with the district agriculture offices that is representing villages where farmers are producing potato either using irrigation or rainfed cultivation.

Data was collected from 150 respondents: 99 male and 21 women farmers (Table 3). For this study, both primary and secondary data were used. A structured questionnaire was used to collect primary data from sample households. The questionnaires were first pre-tested on selected respondents, and based on the results necessary modifications were made before carrying out the actual survey. The primary data were supplemented by secondary data whenever necessary. Descriptive and inferential statistics were used to analyze the data collected from the respondents using SPSS version 23. Descriptive statistics such as mean, standard deviation, percentage, frequency, and ratios were calculated

Table 3: List of districts and number of respondents considered for baseline assessment survey in 2016

District	Kebele	Male	Female	Total
Haramaya (east Hararghe)	Tinike and Finkile	20	10	30
Kersa (east Hararghe)	Burka watar	25	5	30
Kombolcha (east Hararghe)	Bilisuma	24	6	30
Chiro (west Hararghe)	Arbarakate	20	10	30
Gemechis (west Haraghe)	Walensodefo	25	5	30
Grand total	**5**	**114**	**36**	**150**

3.1.3 Output of the baseline survey

3.1.3.1. Socioeconomic characteristics of respondent households

Educational level, sex and marital status of the respondents is shown in Table 4. The results indicate that there is no significant difference among the respondents in relation to the level of education. About 45.22% of the respondents have primary education and 34.84% are illiterate. It is obvious that education level of the household is one of the primary factors affecting farmer's level of understanding in agricultural practices as educated farmers could be better access aware and use of improved agricultural technologies and associated inputs. Evidence from different sources depicted that there is a positive relationship between the educational levels of the household head and improved maize technology adoption (Alene et al., 2000; Abdissa et al., 2001; Habtermariam, 2004; Binod, 2010; Motuma, et al, 2010).

[1] *Is lower than district and the smallest administrative unit in Ethiopia*

Studies by Alene and Hassen (2006) also found evidence that education is positively related with production efficiency. Farmers with higher levels of education, therefore, are more likely to adopt improved maize technologies than those who do not.

Since there is no significant difference in educational level between the farmers, the educational level cannot explain the difference in level of potato production among the farmers across the districts. Similarly, there is no significant difference in marital status of the household among districts (X^2=10.29). More than 90% of the respondent households are married.

A significant difference in age and family size of the respondent households was observed (Table5). The respondents' average ages ranged from 32.26 at Kombolcha district to 41.00 at Kersa district. Respondents at Kersa district also have a larger average family size of 7.62 as compared to other districts. However, there was no significant difference in the total average land holding size (in ha) owned by respondents among the districts. The farmers have an average land holding size of 0.47 ha.

Table 4: Education level and marital status of respondent household (n=150)

	District						
	Haramaya	**Kombolcha**	**Kersa**	**Chiro**	**Gemechis**		
Education level (%)							
Illiterate	34.40	13.00	31.00	45.80	50.00	34.84	
Primary	43.80	60.90	44.80	45.80	30.80	**45.22**	14.041^{ns}
Secondary	21.80	26.10	20.80	8.40	19.20	19.26	
Tertiary	0.00	0.00	3.40	0.00	0.00	**0.68**	
Total	**100**	**100**	**100**	**100**	**100**	**100**	
Marital status (%)							
Single	3.10	13.00	3.40	0(0)	11.50	6.20	
Married	96.90	87.00	96.60	95.80	88.50	92.96	10.294^{ns}
Widowed	0.00	0.00	0.00	4.20	0.00	0.84	
Total	**100**	**100**	**100**	**100**	**100**	**100**	

ns= not significant

Source: Own survey data 2016.

Table 5: Age, family size and land size of respondent households (n=150)

Variable	**District**					**Mean**	**F-test**
	Haramaya	**Kombolcha**	**Kersa**	**Chiro**	**Gemechis**		
Age	36.16	32.26	41.00	36.29	37.27	36.57	2.06*
Family size	6.25	6.26	7.62	5.33	5.54	6.20	2.92**
Land size	0.48	0.42	0.49	0.45	0.59	0.47	1.29^{ns}

* and ** represents at 10% and 5% level of significance, respectively, ns=non significant at 10% level of significance

Source: Own survey data, 2016.

3.1.3.2 Major crops produced in the study area

The farmers in the study areas produce both food crops for their own consumption and cash crops (Table 6). The major crops produced are potatoes, pulses, cereals, other vegetables and Khat. However, there are significant differences among farmers across districts in terms of number of crops produced and farmland allocated for different crops (Table 6). Farmers allocate their land for production of different crops during the main season and as well as off-season. Farmers produce the crops using irrigation (as off-season production) and rain-fed cultivation. The study shows that only potato is produced during the main season and off-season using rainfed and irrigated cultivation, respectively. On average greater proportion of land during main season (0.2 ha) and off season (0.16 ha) was allocated to potato production as compared to other crops. This indicates that potato is the most important cash and food security crop for farmers in the study areas. Other crops were produced only once a year, such as cereals and pulse crops (rainfed), and vegetable cash crops (rainfed or irrigated). Khat is also produced as a perennial crop by the farmers at the study sites.

Table 6: Land holding size of different crops produced by respondent households in the study area (n=150)

Crop	District					Mean	F-test
	Haramaya	Kombolcha	Kersa	Chiro	Gemechis		
Potato (main season)	0.21	0.17	0.28	0.08	0.24	0.20	6.91***
Potato (off season)	0.16	0.15	0.24	0.16	0.09	0.16	4.43***
Cabbage	0.02	0.06	0.04	0.01	0.02	0.03	5.53***
Carrot	0.03	-	0.05	0.01	-	0.02	5.68***
Red root	0.03	-	0.02	-	-	0.01	3.06**
Onion	0.01	-	0.01	0.03	-	0.01	3.68***
Maize	0.14	0.12	0.17	0.14	0.13	0.14	0.68ns
Sorghum	0.13	0.09	0.08	0.09	0.16	0.11	1.54ns
Wheat	-	-	0.02	0.02	0.03	0.01	2.67*
Common bean	-	-	-	0.01	0.01	0.00	1.59ns
Khat	0.07	0.06	0.02	0.07	0.12	0.07	3.80***

*, ** and *** represents at 10%, 5% and 1% level of significance respectively, ns=non significant at 10% level of significance

Source: Own survey data, 2016.

3.1.3.3. Farmers experience in potato production

One way analysis of variance for comparison of the average potato farming experience of all the sites showed that there is statistically significant mean difference between the districts (Table 7). Farmers with more experience in potato production often appear to have more information and better knowledge and ability to evaluate the advantage of the technology.

Table 7: Mean experience of respondent households in potato production in years in the study area (n=150)

District	Mean	SD	Min	Max	F-test
Haramaya	14.12	6.73	2	31	
Kombolcha	10.20	6.56	2	25	
Kersa	18.01	8.98	5	35	**8.59*****
Chiro	8.25	6.12	2	20	
Gemechis	11.46	5.67	1	23	
Total	**12.81**	**7.73**	**1**	**35**	

*** represents 1 % significance level

Source: Own survey, 2016.

According to survey result, the most experienced farmer had 35 years of experience with potato production from Kersa district whereas the least experienced farmer had one year experience from Gemechis district. On average, farmers had 12.81 years of experience in potato cultivation. The average years of experience in potato cultivation for Haramaya, Kombolcha, Kersa, Chiro and Gemechis were 14.12, 10.20, 18.01, 8.25, and 11.46 respectively (Table 7).

3.1.3.4. Trends in potato production and area coverage the last 15 years in the study area

Both productivity and area coverage of potato production in the study areas have significantly increased during the last 15 years. About 76.1 % of the respondent households said/reported that potato productivity is increasing from year to year. Only 8.2% of the respondent households said that productivity is decreasing (the last 15 years) (Fig. 1). Similarly, the coverage of potato production has significantly changed and showed increasing trends as compared to 15 years back in the study areas (Fig.1). 59.7 % of the respondent households reported that the area coverage for potato is increasing, while 36.6% reported no change, and 3.7% said it is decreasing.

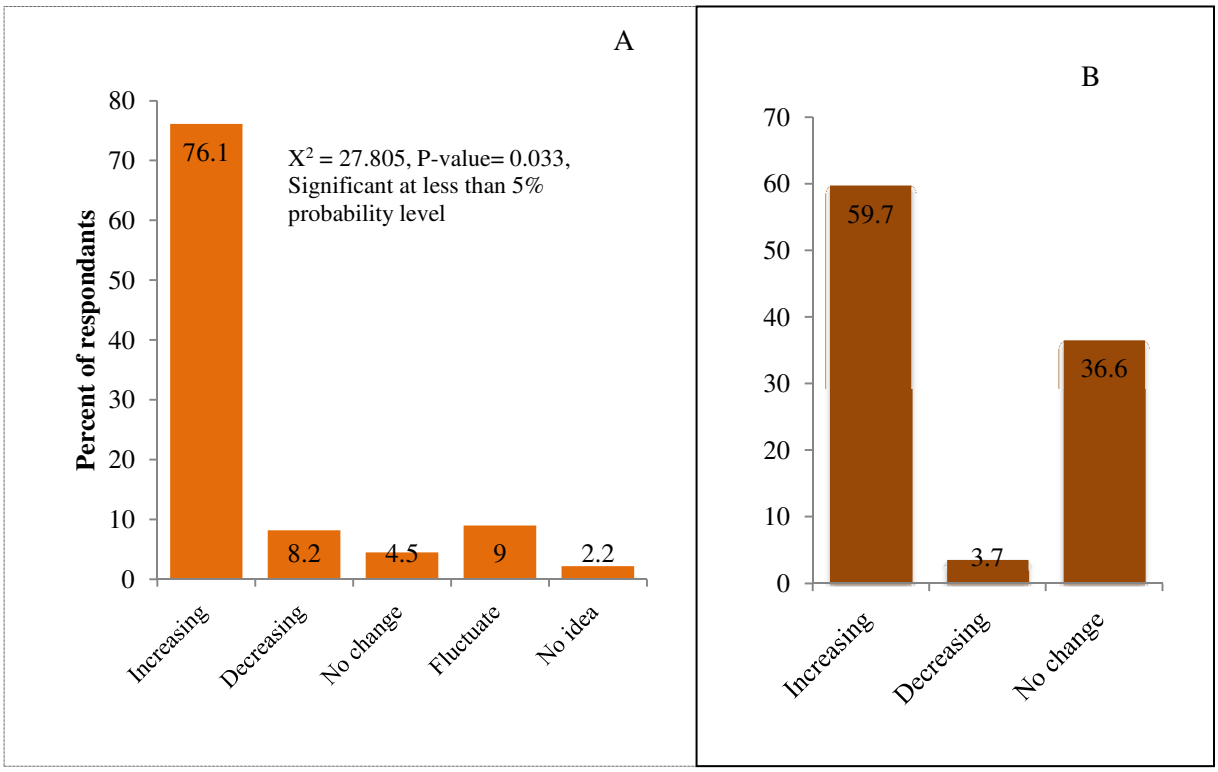

Figure 1: Trends of potato productivity for the last 15 years (A) and area coverage of potato production (B) in the study area (n=150)

Source: Own survey data, 2016.

The main factors contributing to increased productivity and area coverage of potato in the study area are: availability of improved and high quality seeds of potato tubers; improved production practices including proper land preparation; fertilization; cultivation; and post-harvest management. Other key factors are: the food and cash value of the crop; high yields per unit area; and multiple productions in the community (Table 8). The respondents indicated that increased market demand (49.3%), increased irrigation facilities (30.6%), source of income for households (35.8%), potential for high yield per unit area (32.1%) and improved access to extension services (32.7%) were additional important factors that contributed to increased productivity and area coverage of potato for the past 15 years.

The study done by Hirpa et al. (2010) shows that potato is regarded as a high-potential food security and stable food crop because of its ability to provide a high yield of high-quality product per unit input, with a shorter crop cycle (mostly <120 days) than major cereal crops like maize. According to Haverkort (2012), production of improved potato varieties recommended for highland areas are expanding to the lowland parts of the country due to their potential for production in a short period of time, high yield per unit area, and as a source of food and cash crops for a large number of food-insecure smallholder farmers and pastoralists in the country. According to the study by Haverkort (2012) the main production season for ware potato represents only 22% (34,000 ha), while the off-season production represent 78% (128,000 ha) in northern and central Ethiopia alone of the total area covered by potato annually. There is also a

current expansion of potato to lowland areas, where farmers use irrigation facilities for production during the remainder of the year after other staple crops are harvested. It was reported that potatoes are expanding to lowland areas where the farmers are increasingly cultivating potato as a winter crop from December to March (Haverkort, 2012).

Table 8: Factors contributed to increased potato production (volume) in the study area (n=150)

Production factors	Frequency	%of respondents
Increased market demand	74	49.30
Increased irrigation facilities	46	30.60
Become source of income for households	54	35.80
Become source of food crops for households	27	17.90
Used as a substitute of other harvested crops	18	11.90
Potential for high yield per unit area	48	32.10
Improved access to extension services	49	32.70
Access to improved variety	20	13.50
Improved used of good quality seed	50	33.40

Source: Own survey data, 2016.

3.1.3.5. Predominate potato varieties produced by farmers in the study area

A substantial number of potato varieties, both local and improved ones, are grown by farmers in eastern Ethiopia. More than 15 varieties were listed by the farmer respondents during survey work. However, the dominance of varieties varied across districts (Table 9). Only three improved varieties, namely Bubu, Gudanie and Jalanie, were used in the study area, and few households reported to use them. The local potato, Tulema, is the dominant variety produced in the study areas by a large number of households. About 50% of the respondents are producing local variety called Tulema. According to many farmers, improved varieties of potatoes released by research centers and Haramaya University are not widely popularized in eastern Ethiopia (Table 9). However, more than 20 potato varieties were released by research centers and higher learning institutions for production in Ethiopia. For instance, from five potato varieties released by HU, only Bubu is available to farmers for production in the study areas (Table 9). Shortage of basic seeds of improved potato varieties and prolonged dormancy are mentioned as the main drawbacks that hinder its production. Farmers mentioned that farmers' varieties have comparable yield potential and many more quality attributes compared to the improved varieties.

Short dormancy period for multiple season production, availability of seed tubers locally, high yield comparable to improved varieties and high market demand are the key reasons for the pre-dominance of farmers cultivars in the study areas. However, local varieties are susceptible to late blight disease and use of fungicides as a disease control mechanism is compulsory during the rainfed season. Improved varieties are resistant to late blight disease, they have high yields and good market value.

Table 9: List of predominate potato varieties produced by farmers (%) in the study area (n=150)

Variety	Breeding center	District					Total	Rank	χ^2-value
		Haramaya	Kombolcha	Kersa	Chiro	Gemechis			
Tulama	Local	0.0	8.7	100.0	87.5	57.7	50.0	1	90.81***
Bubu	HU	62.5	65.2	13.8	0.0	3.8	29.9	2	52.21***
Illili Dima	Local	75.0	52.2	3.4	0.0	7.7	29.1	3	63.48***
Dadafa	Local	81.2	30.4	0.0	0.0	3.8	25.4	4	77.46***
Chiro (Local)	Local	6.2	0.0	82.8	16.7	0.0	22.4	5	80.21***
Mokora	Local	0.0	8.7	3.4	41.7	38.5	17.2	6	30.06***
China	Local	0.0	0.0	6.9	12.5	65.4	16.4	7	58.42***
Shashamane	Local	9.4	13.0	17.2	25.0	11.5	14.9	8	3.12NS
Gudanie	HARC	43.8	21.7	0.0	0.0	0.0	14.2	9	37.13***
Jalanie	HARC	0.0	0.0	0.0	33.3	42.3	14.2	10	38.02***
Ashe	Local	0.0	65.2	0.0	0.0	0.0	11.2	11	81.52***
Bate	Local	21.9	30.4	0.0	0.0	0.0	10.4	12	23.51***
Samune	Local	0.0	4.3	3.4	16.7	3.8	5.2	13	8.43*
Amate	Local	0.0	0.0	0.0	0.0	26.9	5.2	14	30.68***
Dima	Local	9.4	0.0	0.0	0.0	0.0	2.2	15	9.78**

***, **, *; significant at 1%, 5% and 10% probability level, respectively; NS= not significant, HU=Haramaya University

Source: Own survey data 2016.

The choice of cultivating a modern variety versus farmers' cultivars for any one crop is driven by some quality traits that farmers and consumers prefer. In many cases, the modern varieties do not meet the production or consumption needs of farmers, particularly those in marginal areas (Dandena, 2015). The presence of diverse local potato varieties in the study areas generally revealed that farmers preferences were not so much considered in the breeding programme. Some local potato varieties are still the dominant varieties preferred by farmers (Fig. 2). The driving factors that determine production of a local variety over an improved variety, as identified by the respondents, were availability of seeds (Tulema and Dadefa), high market demand (Tulema and Jarso), short dormancy period (Tulema and Dadefa), and good cooking quality (Tulema and Jarso) (Fig. 2). Improved potato varieties that lack farmers preferred traits such as short dormancy period, disease resistance, high yield and market value in areas where irrigation based production is common. Hence, potato breeders should incorporate farmers preferred traits in the course of potato variety selection and breeding activities. Participatory variety evaluation should be also carried out using both the existing potato varieties preferred by farmers and newly released varieties adaptable to diverse agro-ecologies. There is also a need to focus on improving quality of local seed supply mechanisms for improved potato varieties. This is an area of intervention that seed value chain actors need to focus on.

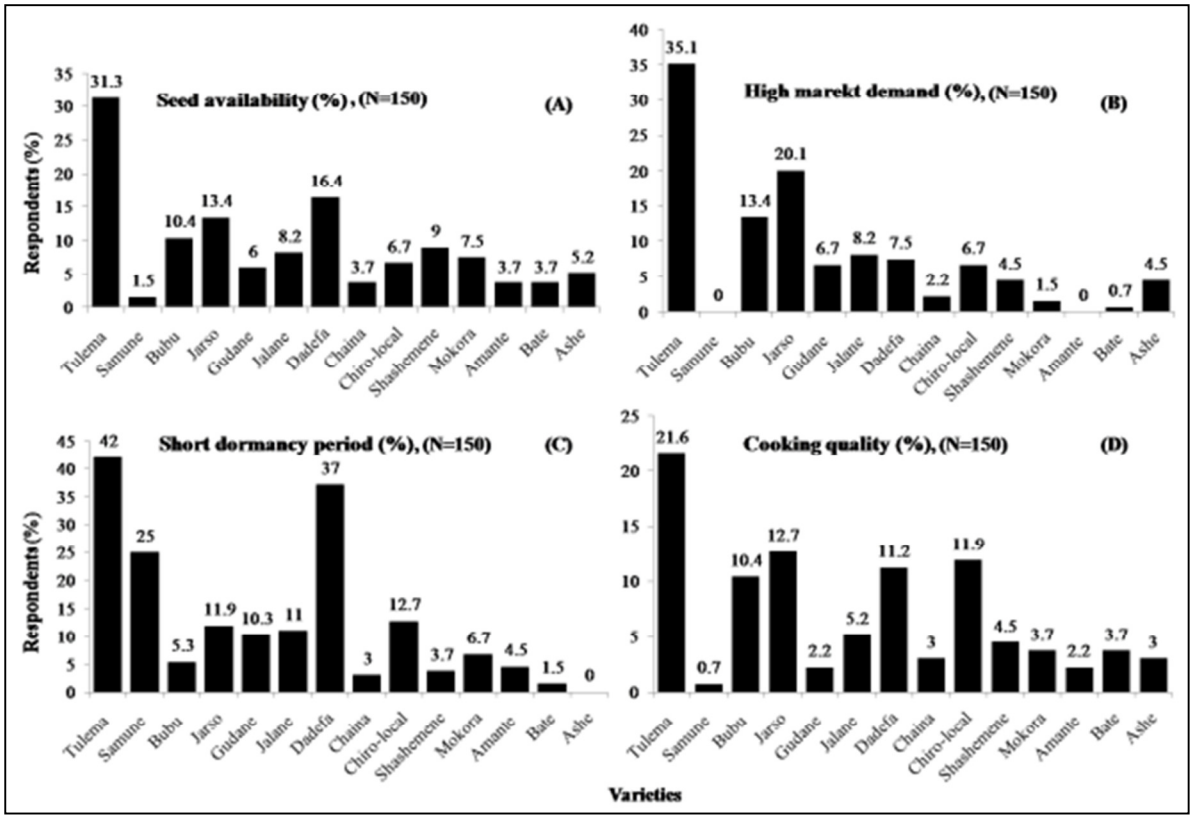

Figure 2: Predominant factors that determine production of different potato varieties in the study areas: seed availability (A), high market demand (B), short dormancy period (C) and cooking quality (D)

Source: Own survey data 2016.

3.1.3.6. Important potato traits preferred for potato production

The important potato traits preferred by farmers were revealed in the responses the households gave in the process of selecting varieties. The most important traits should be considered for future potato research and development programmes in the study areas. Traits such as improved yield and quality, improved seed availability, drought tolerance, biotic stress tolerance, disease management and better nutritional values were traits that received significantly higher ratings than others (Fig. 3). Varieties with long dormancy periods are disliked by farmers as this hinders multiple production of the crop using both rainfall and irrigation. Hence, future potato breeding programmes should focus on potato varieties with short dormancy periods besides the priority traits listed (Fig. 3) by farmers.

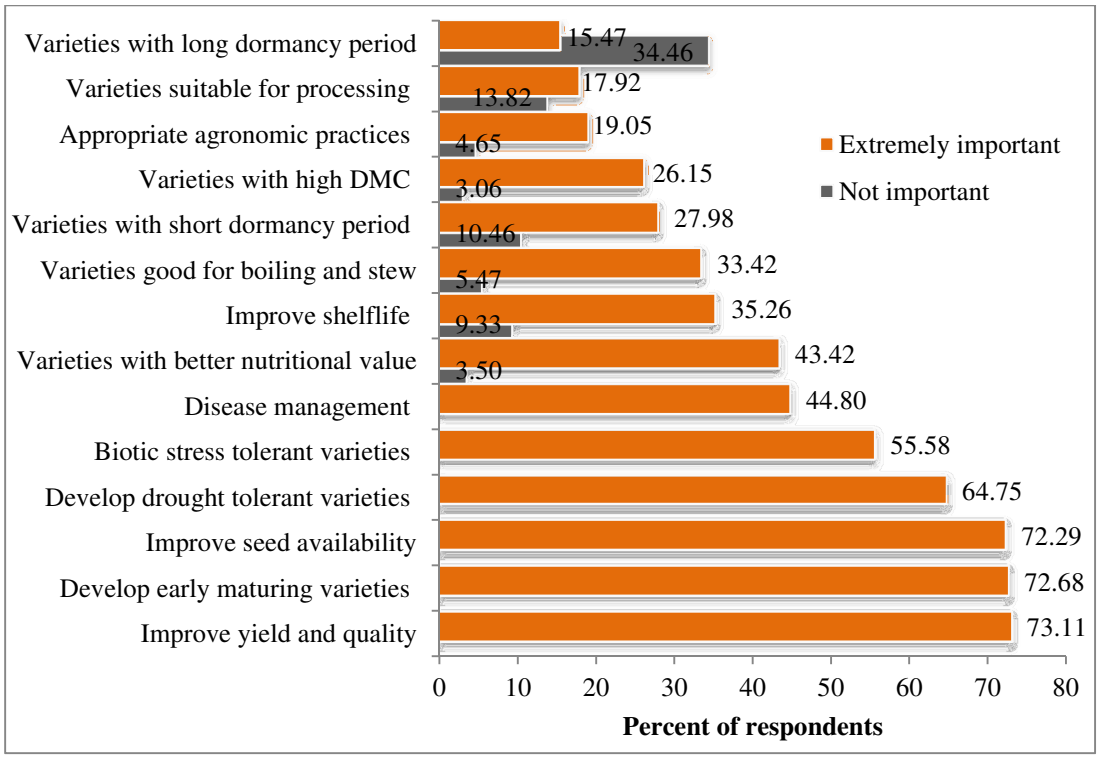

Figure 3: Important traits to be considered in future potato breeding programmes identified in the study area (using liker scale: 1=not important, 5=extremely important)

Source: Own data, 2016.

3.2 EVALUATION AND DISTRIBUTION OF POTATO GENOTYPES

3.2.1 Preliminary *in vitro* and on station evaluation

Primarily we conducted rapid *in vitro* screening of 43 potato genotypes (improved varieties, local cultivars grown by farmers and CIP clones) to identify osmotic stress tolerant genotypes for further field evaluations as part of PhD research carried out by Mr Dandena Gelmesa, project principal investigator. The experiment was conducted at Leibniz University of Hannover, Germany by inducing moisture stress using D-Sorbitol at three level of water potential (Ψ_w) of -0.8, -1.1 and -1.35 MPas in the culture media with the objective of elucidating the response of 43 potato genotypes to moisture stress under in vitro conditions. The genotypes were characterized using morphological drought related traits such as days to shoot and root initiation; shoot height; leaf number; shoot/root fresh and dry mass; root number and length, and biochemical analysis (proline content).

Using the *in vitro* screening experiment drought tolerant, moderately tolerant and susceptible genotypes to moisture stress of -1.35 MPa $\Psi_w$were identified. The promising moisture-stress- tolerant genotypes that best performed *in vitro* include Dadafa (from local or farmers' cultivar), Zemen and Belete (from improved varieties) and clones 20, 12, 13, 14, 17, 19, 2, 11 and 23 from CIP collections. These genotypes exhibited typical characteristics of early root

and shoot initiation, increased root number and length formation, increased shoot and root fresh and dry weight production as compared to drought susceptible genotypes (Fig. 4A-C). Jarso (local cultivar), Challa, Bubu, Chiro, Bule, Jalane and Gudanie (improved varieties) and clone 7, 21, 9 and 13 are poorly performed genotypes, especially at sever moisture stress of -1.35 MPa Ψ_w compared to control treatment (Fig.4 C-D). On top of that, osmotic adjustment of drought tolerant genotypes by early proline accumulation of 1.93-5.83 folds at mild moisture stress treatment of -1.1 MPa $\Psi_{w,}$ while drought susceptible genotypes accumulate the highest proline content at sever moisture stress of -1.35 MPa Ψ_w as adaptation strategy of plants to abiotic stress conditions.

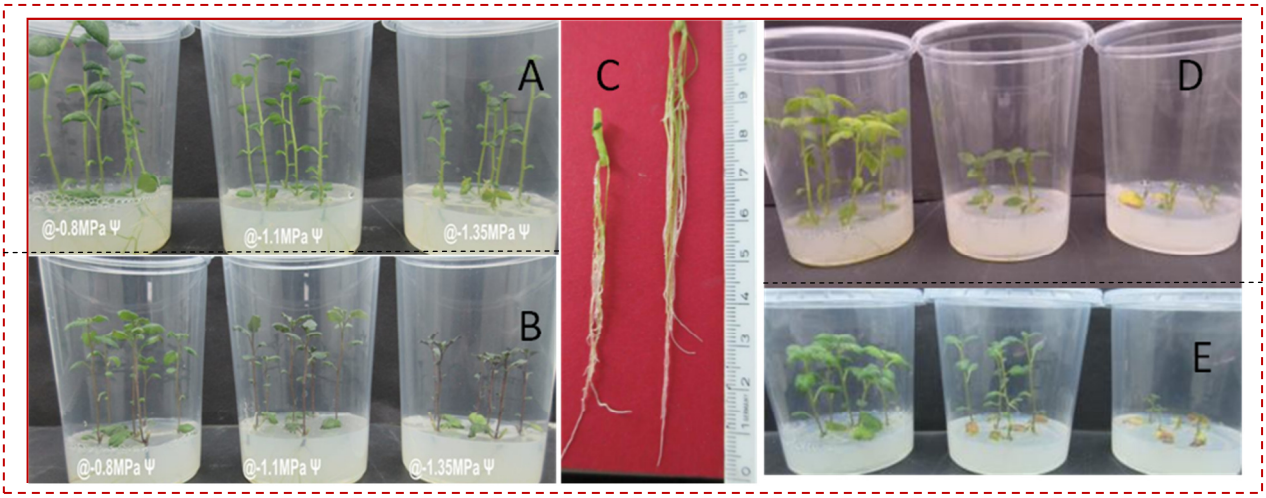

Figure 4: In vitro morphological growth performance of drought tolerant clone23 (A), clone20 (B), root growth of clone21 (C), and susceptible variety Bule (D) and Bate (E) grown in vitro at -0.8, -1.1 and -1.35 MPasΨ_w

Promising genotypes that performed well under *in vitro* testing, a subsequent field evaluation of the promising genotypes was being conducted by applying different irrigation regimes at Haramaya University research site. The first cycle of field evaluation indicated that some genotypes namely CIP clones-20, 10, 12, 14, 32 and 31 and Belete from the improved varieties performed better in terms of yield and yield related parameters (stem number, leaf area, leaf area index, tuber number, tuber weight and yield) (Fig. 5). Other features of these promising genotypes are early maturity (less than 90 days) and good tuber dry matter content.

Figure 5: Field evaluation of drought and heat tolerant potato genotypes at Haramaya University, 2016

3.2.2 Participatory on farm demonstration and evaluation

Ten selected promising potato genotypes seed tubers were multiplication for PVS trial at four districts. Gender responsive PVS trial for yield and quality attributes under abiotic stress conditions were conducted at Fedis, Kersa, Chiro and Doba districts to identify "best bet" potato varieties tolerant to drought for popularization in areas where moisture is limiting potato production (Fig. 6). The PVS trials were implemented in collaboration with farmers, district level experts, DAs and ISSD project of Haramaya University. Farmers were involved in planting, cultivation, field managements and evaluation of the genotypes. Different stakeholders including farmers, extension workers and researchers were invited to evaluate the genotypes at different growing stages to identify varieties preferred by farmers (superior yield, adaptable to their local agro-ecology and are marketable). More than 125 farmers, of which 21.6% are women, were involved in the PVS trials at all districts. Beyond the project sites in collaboration with PWO demonstration and evaluation of four potato genotypes were conducted at Erer Gota and promising genotypes for further multiplication and distribution identified.

Figure 6: PVS research on potato genotypes: Fedis and Chiro in 2016; Kersa and Doba in 2017

3.2.3 Multiplication and distribution of potato genotypes

Creating access to good quality seeds of improved potato varieties adaptable to abiotic stresses and technical capacity building of smallholder farmers is vital. The measures also led to a diversification of production in areas where the potato has not previously been grown, such as in low altitude and in areas of high temperatures. Multiplication and distribution of climate resilient potato varieties at four project implementation sites were conducted. About 194 qt of high yielding, disease tolerant and adaptable potato genotypes preferred for production were distributed as a starter seed to target beneficiaries at Kersa, Fedis, Chiro and Gemechis districts (Table 10). Every farmer (120 in total, and 50% were women), received at least one quintal of improved potato varieties and got technical support to plant as per the recommended practices and evaluated for yield and other quality traits.

Table 10: Potato tuber seeds distributed farmers in the intervention areas in 2016 and 2017

District	Quantity (qt)	Variety	Farmers accessed seed		
			Male	Female	Total
Fedis	34	Bubu and Belete	30	30	60
Chiro	80	Jalanie and Tulema,	30	30	60
Kersa	40	Gudanie, Belelte, CIP-clones #12, 14, 21 & 23	30	30	60
Gemechis	40	Jalanie and Dadefa	30	30	60
Grand Total	**194**	**11**	**120**	**120**	**240**

3.2.4 Outcome of PVS and dissemination of preferred potato genotypes

We realized that farmers not only consider tuber yield and disease resistance for potato selection, but other agronomic traits (stem number, stem thickness, tuber setting compactness, early maturity) and post-harvest quality (good for stew, boiling, local market, tuber shape, hard skin, short dormancy period, etc.). These were all important criteria for farmers. In line with this, we realized that the farmers 'cultivar "Dadefa" (selected in vitro for drought and heat tolerance) was still among the ones selected by farmers under field conditions through PVS. The results of this approach have demonstrated that it is possible to select potato genotypes for drought and heat tolerance through a participatory approach, which would lead to the development of high-yielding drought and heat tolerant potato varieties. The approach also improved technical capacity of farmers, gives recognition to the farmer's criteria for variety selection and built trust among farmers-extension workers-researchers. Both male and female farmers increased their ability to disregard non-preferred varieties based on their own preference traits and select more suitable varieties. The linkages and interventions also created an opportunity to expand potato varieties adaptable to diverse agro-ecologies that are preferred by both male and women farmers.

The farmers growing potato have got a high production on small plots of land compared to farmers growing other cereal crops. They sell the surplus on the local market. With this extra income they have been able to improve their housing situation through replacing their thatched roofs with corrugated iron sheet roofs and acquiring relevant furniture. They are

also able to send their children to schools while covering all related expenses, and some farmers started rearing cattle, sheep and goats. They are happier in participating in the project, and work together with researchers to conduct PVS to identify better drought tolerant and yielding varieties, which solves the problem of yield reduction and loss from frequent drought spells. Farmers supported by the project have developed assets, and have improved their household living conditions and ensured their food security. Monitoring and evaluation conducted by Freelance Consultant, Ato Behailu Alemayehu, in 2016 reported the following testimonials from project participant farmers.

"Mrs. Meyimuna Abdulahi and Mr. Abrahim Abdulahi are farmers in Fedis district at Ido Basi kebele, who started to grow a new potato variety on their plot of land for the first time. They practiced the skill and knowledge they acquired from training session at FARC by HU. They also taught this knowledge to others through practical experience at their plots, and shared their knowledge with their neighbours. Mrs. Meyimuna is among the female farmers who organized a potato farmers group, and they are now growing the improved potato variety named Bubu obtained from HU. The skills she got from training helped her to develop confidence to grow potato. She explained that she is lucky because she received potato tuber seeds while her group members did not get quality planting materials from other sources, due to shortage of planting materials. She is expecting more benefits from her farm plot by growing drought tolerant varieties and accessing irrigation water (from the new expansion irrigation structure in her village established through a government program).

Meyimuna explaining about her new potato cropping practices and part of irrigation expansion structure

Mrs. Muferia Bushra and Mrs. Derartu Shafi are female farmers organized in a potato farmers group within the Jelis Haji Faje Cooperative at Kersa. They explained that they got technical skills and improved agronomic practices on potato crop production; like land preparation, planting space, fertilizer application, disease management, harvesting and post-harvest management and potato tuber seed preparation. They also tought their husbands the skills and knowledge they acquired from training sessions that were arranged and facilitated by HU. Mr. Muzemil Kebira is in the same farmers group and he also got training this year. He constructed his own improved diffused light store (DLS) which has six quintals potato tuber seed storage capacity. He demonstrated this to his neighbours and motivated them to

Muzemil at his potato DLS

construct their own DLS. He explained the improved DLS has many advantages over traditional potato tuber seed preparation practices. With improved DLS, tubers are not spoiling; sprouts are strong and it minimizes sprout damages and initiates early sprouting.

Mr. Ahimed Muhamed is the chairperson of the farmers group at Arbarakate kebele, in Chiro district. He explained that only a few households are benefiting out of 1,100 household in the kebele members so far, and that there are many more that are looking for opportunities of accessing improved potato seeds with the ambition of improving their household livelihoods. He said, farmers in the area are frequently affected by drought related problems and this project is expected to solve the problems by identifying drought tolerant, early maturing and productive potato varieties. There is a shortage of potato tuber seeds in PA and the committee members are looking for possibilities of constructing a DLS with locally available materials. Mrs. Sadia Siraj said there is a shortage of surface irrigation water for growing potato during the dry season and requested for possibilities to support the development of access to underground water in their villages.

Mrs. ZemuAbrahim and her husband Mr. Bedru Ahimed live in Arbarakate kebele, in Chiro district of west Harerghe Zone. They are not members of a farmers' cooperative, but they learned from their neighbors and started to grow potato for the first time this season using rainfed agriculture withan improved potato variety obtained through the project. They expect a better harvest from their potato crop."

Pic: Zemu and her husband Mume at their potato plot

Pic: Obo Mume, village elder

3.3 CAPACITY STRENGTHENING, LINKAGESAMONG POTATO VALUE CHAIN ACTORS AND ADVOCACY

3.3.1 Training

Training on potato agronomic, post-harvest management and different food product preparation methods was provided to more than 150 farmers, of which 30% were women, and 10 were experts from partner organizations (Fedis agricultural research center, BENEFIT-ISSD project, district offices and Afran Kallo farmer's cooperative union) in 2016 and 2017. The objectives of the trainings were to improve the acute gap of knowledge and skills found at farmers levels during project implementation. There was a need for increased knowledge on general principles of community-based seed multiplication, potato production, post-harvest management and processing technologies as well as marketing strategies. The training methods adopted included visual pictures and power point presentations, group

discussions combined with reflections on farmer's practices, and videos. The training specifically covered the topics of seed production guidelines, agronomic practices (land preparation, planting, irrigation, weeding and off-type removal, protection (insecticide), harvesting, sorting and grading, seed tuber storage and food preparation.

3.3.2 Organizing farmers field days

Farmers field day were organized at Kersa (in 2016 and 2017) and at Chiro (in 2016) district project sites to share best experiences on the following items: demonstration of different potato genotypes tolerant to drought and heat; gender disaggregated variety evaluation and selection; diffused light potato storage management by informal group; and display of different locally prepared food from potato. In addition, one field day was organized in 2017 at Doba district, out of the project site, where drought and heat tolerant potato genotypes were demonstrated in collaboration with the ISSD project (Fig. 7). The objectives of these field days were to share experiences and best practices among farmers and other stakeholders on climate-smart potato genotypes PVS approaches, improved production and post-harvest seed quality management techniques and to ensure linkages among different actors operating in potato value chain activities.

Participants of the field day included farmers' representatives from nearby kebeles and other districts supported by the project, Development Agents (DAs) and expert representatives from different districts, Farmers cooperative union, BENEFIT-ISSD Project, research centers, seed producer cooperatives, West Hararghe zone BoANR and Haramaya University. More than 60 participants from zonal and district offices, researchers, academics, experts, farmers, unions, seed producer cooperatives etc. shared their best experiences (in a cluster approach) for quality potato seed production and store management, PVS, variety demonstration, and potato recipes for cooking (Table 11).

The participants of the field days (both in 2016 and 2017) shared experiences and discussed how to apply the skills and knowledge they had learned. Arranging field-days is one of the best tools for rapid adoption of best practices, creating linkages among different actors in the potato value chain, facilitating learning among farmers and enhancing availability of quality seeds locally.

Table 11: Summary of participants that participated in farmers field days, 2016 and 2017 (disaggregated by type and sex)

Participant type	Male	Female	Total
Farmers from project districts/sites	27	16	43
University (Haramaya)	3	2	5
Research Center (Fedis)	2	0	2
District experts and DAs	6	0	6
BENEFIT-ISSD Project	4	0	4
Farmer's cooperative union	2	0	2
Total	**44**	**18**	**62**

Field day for sharing experience at Doba district

New potato genotypes exhibition organized by Doba district, DCG and ISSD projects. From left to right the second person, Mr. Ahmed, is head of west Hararghe zone BoANR, the third, Dr. Mengistu Ketema, is director for research and extension office of Haramaya University

Farmers evaluating the yield potential of new potato genotypes at Doba district

Doba district agriculture office has demonstrated cost-effective improved seed storage methods

Figure 7: Different experiences in PVS, production, seed quality management and effective linkages discussed and shared with stakeholders and partners on the field day at Doba district, 2017

3.3.3 Experience sharing and demonstration of different potato processing and food preparation methods

The project activities of promoting climate resilient potato genotypes, demonstration of potato processing into powder (as a long term preservation method) and preparation of different food products to rural households led to improving income and nutritional status for farmers and different stakeholders. Farmer field days and experience sharing sessions were arranged to strengthen institutional linkages between farmers and different stakeholders. More than 10 different products and food types were prepared from potato and demonstrated to farmers and key partners. Women farmers were also involved in actual preparation of different food products during training and demonstration.

Products displayed and demonstrated on potato food product preparation

- Ready to use boiled and dried potato powder
- Ready to use chopped and dried potato powder
- Boiled and mashed potato product

- *Injera* prepared from potato
- Chapatti and bread prepared from potato
- Porridge prepared from potato
- Fried potato chips
- Doughnut (Bombolino) prepared from boiled potato
- Potato balls prepared from boiled and mashed potatoes
- Soup prepared from boiled potato flour
- *Sambusa* prepared from boiled potato stuffing inside wheat flour
- Potato *wot* served with chili spice (presented by farmers group)

Table 12: Summary of stakeholders participated in potato value addition activities, 2017

Participants type	Number of participants		
	Female	Male	Total
Farmers representatives	20	3	23
Afran Kallo Farmer's Cooperative Union	0	2	2
ISSD Project representatives	0	2	2
Fedis agricultural research center	0	2	2
District BoANR experts and DAs	0	8	8
Oda Bultum University representatives	0	1	1
Haramaya University representatives	2	0	2
Total	**22**	**18**	**40**

Besides potato processing and food demonstration activities, experience sharing on potato seed storage management and seed quality control was facilitated and conducted at Haramaya University potato breeding department. Participants involved in experience sharing and demonstration of food preparation activities were women farmer's representatives from four districts, district experts and DAs from four district project sites, participants from partners (Fedis research center, Haramaya University, the ISSD project, Oda Bultum University and Afran Kallo Union. Stakeholders and farmers who participated in value addition activities and improved seed quality storage methods are summarized in Tables 12 and 13.

Table 13: Summary of stakeholders that participated in improved seed quality management experience sharing events at Haramaya University, 2017

Participants type	Number of participants		
	Female	Male	Total
Farmers representatives	**8**	**0**	**8**
Afran Kallo Farmer's Cooperative Union	0	2	2
ISSD Project representatives	0	2	2
Fedis agricultural research center	0	2	2
District BoANR experts and DAs	0	8	8
Oda Bultum University representatives	0	1	1
Haramaya University representatives	2	0	2
Total	**10**	**15**	**25**

3.3.4 Facilitate market linkage for one farmers group producing potato powder

Linkage was also facilitated to supply potato powder by a farmers group in Kersa to the PWO. Haramaya University technically supported the farmers group to produce potato powder and supply to PWO through the signing of an agreement with Erer Gota Farm Development Cooperative Association. The farmers group agreed to supply 1kg of potato powder at a price of 45 ETB (4500 Birr per Qt) and signed a Memorandum of Understanding (MoU) with the union. The amount of potato powder requested by the union was 12.8 Qt. Unfortunately the farmers provided only 9.5 Qt of potato powder, because they experienced difficulties processing (chopping potato, dry and make powder) the sufficient amount of product within the given time frame. The farmers group would be happy to proceed in this business in the future if there is a market for potato powder, and they plan to acquire necessary materials and equipment for potato powder making (Fig. 8).

Figure 8: Haji Feji Farmers Group in the process of preparing potato powder to supply the product to Pastoral Welfare Organization

3.3.5 Seminar to share experience and lessons learned

Multi-stakeholder collaboration with participation of multi-discipline experts enhanced the smooth implementation and success of the project. For the implementation of the current

project, stakeholders and partners met for two days to discuss project achievements, future plans and to share experiences. The event was organized at Haramaya University and in Chiro town. The participants of the workshop included representatives from local level research centers, NGOs, district agricultural offices, and seed producer's cooperatives from selected districts of Hararghe zones. The aim of the event was to create awareness on the development of drought and heat tolerant potato genotypes as alternative strategies to overcome agricultural production challenges in a changing climate, and to discuss the roles and responsibilities of the different partners in collaboration during the project implementation.

Issues discussed in the workshop include: experience sharing and achievements in screening and popularization of climate-smart potato genotypes and different food preparation methods; mechanisms to strengthen linkages between local and regional partners for effective popularization and dissemination of climate resilient potato varieties to marginal and drought-prone areas; mechanisms to strengthen farmers' and stakeholders' access to basic seeds and cooperative based seed multiplication and dissemination; and seeking the way forward for potato research and extension in eastern Ethiopia. About 36 participants representing farmers, the district agricultural office, DAs, research centers and Haramaya University participated in the meeting (Table 14).

Table 14: List and number of participant from different organizations that participated in the seminar arranged to share experience on project activities

Participant type	No of participants		
	Male	Female	Total
Farmer representatives	10	2	12
District offices and DA representatives	10	2	12
Research and university representatives	6	2	8
BENEFIT-ISSD project representatives	2	0	2
Afran Kallo Farmers Coop. Union representatives	2	0	2
Total	**30**	**6**	**36**

3.3.6 Knowledge and information sharing

Numerous success stories registered by the project were documented and shared to different audiences through printed and electronic media. Some examples include: "**Breaking the Belief: Climate Smart Potato improvement, production and Future prospects in Ethiopia**" available online at http://www.haramaya.edu.et/breaking-the-belief-climate-smart-potato-improvement-production-and-future-prospects-in-ethiopia/; a documentary broadcasted in April 2016 by Ethiopian Broadcasting Corporation- "የስኬት ቁልፍ - በሃገራችን ችግር ፈቺ ጥናትና ምርምርን በተመለከተ የቀረበ ዶክመንተሪ"; display of the work during different events as posters and exhibitions; in the BENEFIT-ISSD project of Oromia east unit quarterly newsletter, and as a summary of DCG project activities that was published in Afaan Oromo, 2017.

4. SUMMARY AND CONCLUSIONS

Production of potato varieties recommended for highland areas is expanding to the lowland parts of the country due to its potential for production in a short period of time, high yield per unit area, and as a source of food and cash crops for a large number of food-insecure smallholder farmers and pastoralists in the country. However, the lack of suitable potato varieties adaptable to lowland drought prone/or high temperature areas deprives farmers of the opportunity of producing and using the crop. Potato may help feed Ethiopia in the era of climate change (http://phys.org/news/2013-05-potato-ethiopia-era-limate.html). While adapting to a warming world, the potato is becoming a more important crop in Ethiopia - with the potential to feed much of Africa. The current project activities implemented by HU led to the identification of genotypes that are adaptable to marginal areas. Through a participatory approach, potato genotypes tolerant to drought and heat were developed and popularized. Both farmers and other stakeholders participated in the project implementation at different levels.

It was concluded that, farmers were content with their participation in the project to adopt and start production and use of climate smart potato genotypes, as climate variability, resulting in terminal drought and erratic rainfall, had become the key challenge of the farmers in the area. By intervening through the project activities to support venerable rural farmers, the following achievements were realized:

- Farmers got the chance to see the real effects of climate smart potato genotypes and quality seed on crop productivity and other attributes. The activities enabled farmers to enhance their crop portfolios in their particular agro-ecology and change their attitudes towards specific crops. The intervention helped farmers know how to practically apply technologies like improved agronomic practices, seed selection and management, and potato value addition.
- Experience sharing and field days among farmers and others stakeholders were found to be the best approach that empowered farmers and stakeholders and enhanced the linkages between them. For example, due to an improved linkage between farmers and potato value chain actors, the farmers groups could sell their seeds at premium price to seed users, and a farmers group (or the cooperative to which they were affiliated) was able to create a linkage with other processed potato product buyers such as Pastoral Welfare Organization (PWO) and started to supply potato powder.
- The intervention has improved the access of women farmers to the potato varieties of their preference, and has therefore enabled them to stop producing less preferred varieties. In addition, the intervention has also improved the capacity of women farmers in potato value addition (processing of potato and preparation of different types of food using potato) to address the problem of post-harvest losses and to improve household nutrition. Farmers groups at target sites also got to know and started a local method of quality potato seed storage or preservation method both through construction of a cost-effective group or individual level diffused light store.
- The technologies and value addition activities have been taken up by collaborating partners such as Haramaya University and the ISSD project and demonstrated outside the

project districts. The popularization of climate smart potato varieties in marginal areas where the crop was rarely produced before is especially noteworthy.

- Some district agriculture offices, such as Doba district, were interested in adopting the practice of demonstrating climate smart potato genotypes. The office in collaboration with the ISSD project has evaluated 18 potato genotypes at Farmers Training Center (FTC) in participation with farmers. In addition, the office has mobilized farmers to evaluate the varieties, organized experience sharing among stakeholders, and demonstrated improved seed storage technologies.
- Numerous success stories registered by the project were documented and shared with different audiences through printed and electronic media.

Participation and/or consideration of traits important for the end users, and developing varieties adapted to specific agro-ecologies, like drought prone or hot dry regions, is fundamental to expand production of the crop in food insecure and lowland regions of Ethiopia. Collaboration and participation of multi-discipline experts and stakeholders enhanced the smooth implementation and ensured the success of the project. It is vital to expand these best practices and technologies to other potato producing areas, within the region and outside the region, in collaboration with key partners. Sharing of best practices through exchange visits among stakeholders and farmer groups may also enhance rapid diffusion of the practices. The collaborating project partners will continue to facilitate and scale up the practices and lessons learnt from this project in Eastern Ethiopia and beyond.

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6. ANNEXES

6.1 ANNEX 1: PHOTO GALLERY DEPICTING SOME PROJECT ACTIVITIES

Attached are some photos from implementation of different activities

Farmers and experts during training on agronomic and post-harvest seed quality management of potato, in Chiro town

Farmers and experts during training on agronomic and post-harvest seed quality management of potato, at FARC Harar

Happy farmer realizing the yield potential of a climate smart potato variety at Kersa, during the field day

Farmers and researchers realizing the effect of a new potato variety in increasing productivity, Kersa

Field day organized at Kersa, participants appreciating the performance of different varieties

Lunch was served from different foods prepared from potato for participants of the field day at Kersa

Participants sharing experience on potato seed storage management at Chiro district farmers groups

Participants sharing experience on potato seed storage management at Haramaya University

Boiled and dried potato for powder making demonstrated to farmers at Haramaya University

Potato powder ready to bake for different food during demonstration at Haramaya by Mrs. Birtukan Yimam

Women farmer participating in food demonstration training practicing Injera making from potato, at Haramaya University

Demonstration of different local food products prepared from potato to farmers and partners at Haramaya University

Demonstration of different local food products prepared from potato to farmers and partners at Chiro district

	
Field day with demonstration of climate resilient potato genotypes at Doba district	Evaluation of drought and heat tolerant potato genotypes with farmers at new sites in collaboration with the ISSD project

6.2 ANNEX 2: SURVEY QUESTIONNAIRES

Project: Enhancing Food Security Needs of Vulnerable Groups through Participatory Selection and Promotion of Drought and Heat Resilient Potato Genotypes in Eastern Ethiopia

1. General information

1. Zone _____ (District)_____
2. Village (PA) _____
3. Name of household head: _____
4. **Sex:** 1=Male [ ] 2=Female [ ]
5. Age of farmer (years) _____
6. Level of formal education of farmer:
   1=Illiterate [ ] 2=Primary [ ] 5=Other (specify) [ ]
   3=Secondary [ ] 4=Tertiary [ ]
7. Marital status of household head:
   1=Single [ ] 2=Married [ ]
   3=Divorced [ ] 4=Widowed [ ]
8. Household family size_____, Male_____, Female_____

2. Farmer's economic activities

1. Land size used for crop production_____ (Qindii/hectares)
2. Average land area currently under potato production
   a. _____ main season b. _____off season
3. Major crops regularly grown and hectares

(a) Food crops

i. _____hectare_____
ii. _____hectare_____
iii. _____hectare_____

(b) Cash crops

i. _____hectare_____
ii. _____hectare_____
iii. _____ hectare_____

Section 1. Potato variety selection and production practices

1. Are you producing potatoes? **Yes**[ ] **No**[ ]

a) If yes, when did you start production _____year
b) What does potato production trends (yield) looks like over for the past 15 years in your locality
   a. Increasing [ ] b. decreasing [ ] c. no change [ ] d. fluctuating [ ] e. no idea [ ]
c) If your answer to **Q1b** is increasing mention two important reasons contributing for yield increase
   1. _____
   2. _____
d) Is there a change in potato variety produced over the last 15 years? **Yes**[ ] **No**[ ]
e) If yes to **Q1d**, please mention the name of varieties you have been using

>15 years back	5 years back	Currently

f) Is there a varietal difference for production over different seasons **Yes**[ ] **No**[ ]
g) If yes to **Q1f**, please mention the name of potato varieties popularly grown by farmers over different seasons

Season	**Variety name**	**Variety type (local or impv'd)**	**Reason for preference**
Kiremt/Summer (June to August)			
Belg/Autumn (September to Nov)			
Bega/Winter (December to February)			
Tseday/Spring (March to May)			

2. **Is there a shift in potato production season in your opinion? <u>Yes</u>[ ] <u>No</u>[ ]**
3. **If your answer to Q2 is yes, which season is the major potato production currently (please rank the seasons)**

Seasons	**Rank (1^{st}, 2^{nd}, 3^{rd}, 4^{th})**
Kiremt/Summer (June to August)	
Belg/Autumn (September to Nov)	
Bega/Winter (December to February)	
Tseday/Spring (March to May)	

4. **What is the total area under potato production looks like in the last 5 years**
   1. decreasing b. increasing. c. no change d. no idea
5. **If your answer to <u>Q4 is increasing</u> what is the probable reason for area increase in potato production**
   a. increased market demand
   b. increased irrigation facilities
   c. become source of income for households
   d. become source of food crops for households
   e. used as a substitute of other harvested crops
   f. potential for high yield per unit area
   g. others……. (specify)

6. **What are the THREE most important <u>CHALLENGES</u> in the production of potato in your locality?**

>10 years back	**5 years back**
a. lack of good quality seed b. lack of adaptable varieties c. drought result in hard soil pan d. lack of irrigation facilities e. shortage of storage faculties f. lack of awareness g. poor soil fertility h. lack of capacity (finance and labor) i. lack of market linkage j. high cost of inputs (agro chemicals) k. disease and insect pests **l.** Other----------specify	a. lack of good quality seed b. lack of adaptable varieties c. drought result in hard soil pan d. lack of irrigation facilities e. shortage of storage faculties f. lack of awareness g. poor soil fertility h. lack of capacity (finance and labor) i. lack of market linkage j. high cost of inputs (agro chemicals) k. disease and insect pests Other----------specify
Currently	

a. lack of good quality seed b. lack of adaptable varieties c. drought result in hard soil pan d. lack of irrigation facilities e. shortage of storage faculties **f.** lack of awareness	g. poor soil fertility h. lack of capacity (finance and labor) i. lack of market linkage j. high cost of inputs (agro chemicals) k. disease and insect pests Other----------specify

7. What important traits do you perceive about different potato cultivars that are currently under production in your locality?

Variety	Seed easily	High market	High price	Good cooking	Storability	Early sprouti	High yield	Early maturin	Drought	Disease toleranc	Locally adaptab	Easy for	Uniform tuber	Good tuber

8. What top priority indices/traits do you recommend for researchers and extension personnel working on potato development? (5=extremely important, 4=moderately important, 3=important, 2=less important, 1=not important)

Attributes	Score
Improving yield and quality of potato	
Improving production and distribution of good quality seed	
Developing early maturing varieties	
Developing drought tolerant varieties (improve water use efficiency)	
Developing biotic stress tolerant varieties (late blight, inspect pests, bacterial wilt)	
Developing disease (late blight and pest) control and management techniques	
Developing appropriate agronomic practices (spacing, planting depth, fertilization, irrigation etc)	
Developing varieties with short dormancy period	
Developing varieties with long dormancy period	
Improving shelf life of potato	
Developing varieties suitable for processing	
Developing varieties good for boiling and stew	
Developing varieties having high dry matter content	
Developing varieties with better nutritional value	
Others ---------- (specify)	

Section 2. Perception of farmers to recurrent climate change

1. **What are the indicators you use to predict climate change?**
   a) increased drought incidences
   b) unpredictable wind movements
   c) change in seasonal temperature (very hot winter and very cold summer)
   d) prolonged winter seasons
   e) marked delays in the onset of rainy seasons
   f) disappearance of wetlands and decline water reservoirs
   g) other---------- (specify)
2. **What are your perceived main causes of climate change?**
   a) deforestation
   b) expansion of agricultural lands
   c) population pressure (increase)
   d) poor farming practices destroying soil and water resources
   e) the rise of industries, towns and cities
   f) lack of respect of traditional cultural values (e.g., cutting down of sacred trees
   g) unexplained natural forces
   h) others----------(specify)
3. **What are the major adaptation strategies you use in response to climate change (drought and high temperatures)?**
   a) planted early-maturing crop variety ……..
   b) planted new or drought/heat tolerant varieties…….
   c) applied moisture conservation strategies in the field----------
   d) planted early or late in the season……..
   e) shifting to crop based diversification----------
   f) shifting to other diversified income source----------
   g) practiced soil erosion protection methods----------
   h) abandoned plating a crop or variety------ (please name them)----------
   i) practice zero or no tillage----------
   j) increased use of small scale irrigation----------(**traditional/modern**)
   k) increased use of water harvesting technology----------
   l) involve in productive safety net programme----------
   m) sell of assets to purchase food ----------
   n) crop-livestock risk insurance----------
   o) reduce cultivated land area----------
   p) deep planting----------
   q) deep and repeated plowing----------
4. **What are the barriers to successful implementation of adaptation strategies to climate change (drought and high temperature effects?)**
   a) Lack of affordable and alternative technologies----------
   b) Small and fragmented land size----------
   c) Limited labor force----------
   d) High cost of agricultural inputs----------
   e) Unstable market price of agricultural products----------
   f) Lack of rural credit----------
   g) Lack of effective early warning system----------
   h) Others (specify) ----------

5. **Are there some potato varieties you prefer for production as drought or heat tolerant varieties?**
   Yes[ ] No[ ]
6. **If your answer to <u>No 5</u> is yes, please mention at least three varieties which you believe are drought/heat**
   a. _____ b. _____ c. _____
7. **What potato variety attributes do you think are contributing for drought or heat tolerance in potato production (mention at least three traits you think)**
   a. _____
   b. _____
   c. _____
   d. _____
8. **How might climate change affect potato production in the future (multiple response)**
   a. change in occurrence of new pests and diseases
   b. change in atmospheric temperature
   c. change in the availability of irrigation water
   d. change in the price of agricultural inputs
   e. change in the soil productivity
   f. change in rainfall occurrence (amount and distribution)
   g. others_____(specify)
9. **What might be your perception of climate change on the productivity of potatoes in the future**
   a. increase b. decrease c. no change d. no idea
10. **What do you think are the negative impacts of climate change on the livelihood of household? ((5=extremely high negative impact, 4=moderately high negative impact, 3=high negative impact, 2=less negative impact, 1=not impact)**

Factor	Score
Risk of hunger	
Food price	
Agricultural product market price	
Household income	
Access to resources (land, water etc)	
Volume of food available	
Quality of food (nutrition)	
Prevalence of health related diseases	
Others ….	

Thank you for your time!!