

Sub-theme 1: Animal Production and Health

Animal production and health sub-thematic research have eight research areas. These research areas are dealing on animals, on the environment where the animals are living, on animal products and interest of people on animals and animal products. All interested team members were invited to participate in the selection of research priority areas. Hot discussions were made and the priority research area was directed towards selecting individual research commodity. Considering the national research priority and Eastern Ethiopian condition in relation to Haramaya University research mandate area, four livestock research commodities have got priority and selected unanimously. These research commodities are selected to improve productivity in Eastern Ethiopia. The selected research focus areas based on their order of priority are briefly presented as follows:

1.1. Forage Production and Rangeland Management in Eastern Ethiopia

Though animal production is common and economically a lucrative business in Eastern Ethiopia, there is huge gap and scarcity in feed availability. Rangelands in Eastern Ethiopia are not well defined. Hence, this research focuses on:

- Develop forage production system, agronomic practice and different forage species;
- Improving forage biomass and palatability;
- Invention and adoption of technologies to improve feed availability;
- Improving feed resource and water availability of rangelands;
- Adopting and up-scaling feed treatment technologies.

1.2. Chicken Productivity Improvement in Eastern Ethiopia

Smallholder chicken is an integral component of the livelihoods of nearly all-poor rural households. However, germplasm resources are generally under-exploited and under-leveraged due to management problems, lack of effective capacity for testing, multiplication, and delivery to farmers, followed by continuous genetic improvement. Poultry diseases such as Newcastle disease, infectious bursal disease and infectious coryza are the most important hindrance to improved poultry industry. This research focus areas include:

- Selection of potential chicken ecotype and on station genetic performance and feed conversion evaluation under optimum management;
- Adoption and demonstration of tropical dual-purpose chicken breeds;
- Feeding different herbs to improve productivity of dual purpose chicken;
- Optimizing poultry feeds with different non-conventional feeds;

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- Development of synthetic breeds;
- Epidemiological study of ND, IBD and IFC and design control methods;
- Preparation and use of a local vaccine using local NDV, IBDV and IFC strains;
- Determination of a vaccination regime for indigenous village chicken and commercial small holders by vaccinating using imported and local vaccine strains;
- On-farm vaccination of indigenous village chickens and commercial chickens with ND, GD and IFC vaccine in selected smallholder farms.

1.3. Sheep and Goat Productivity Improvement in Eastern Ethiopia

There is limited selection and genetic improvement, and lower productivity of local sheep and goats; poor husbandry and high mortality rate of lambs and kids; lack of technologies to improve feeds and feeding methods; presence of serious infectious diseases (CCPP, PPR, etc.) are hampering export of small ruminants and meat from these species to prime meat markets with better economic return; lamb and kid morbidity and mortality are widespread in goat rearing areas of the country affecting growth and replacements; reproductive disorders resulting in abortion are common in local sheep and goats and parasitic diseases are among the most important causes of productivity loss in adult sheep and goats. Hence, the research focus of this research area includes:

- Study production system of goat and sheep;
- Different feed treatment technologies on performance of sheep and goat;
- Improvement of sheep and goat breeds through selection and cross breeding;
- Alternative starter feed formulation and housing management to reduce lamb and kid mortality;
- Epidemiological investigation on Causes and risk factors of young stock morbidity and mortality in sheep and goats in Eastern Ethiopia;
- Identification of causes and risk factors of reproductive disorders affecting performance of sheep and goats in Eastern Ethiopia;
- Investigation of internal parasites dynamics for application of strategic interventions in Eastern Ethiopia;
- Impact of PPR and CCPP in sheep and goats Eastern Ethiopia.

1.4. Camel Productivity Improvement in Eastern Ethiopia

Though camel production is well-known in Eastern Ethiopia, milk and meat productivity is very low. There is poor milk handling practice and high post-harvest loss; genetic and management

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problems that hampered camel productivity; camel Trypanosomosis (Surra) is a common cause of morbidity and mortality and there is an indiscriminate use of anti-trypanocidal drugs; camel calf morbidity and mortality are common; external parasites are highly prevalent and there is little or no information on vector borne diseases. This research area focuses on:

- Improving feed resource and water availability;
- Adopting and up-scaling feed treatment technologies;
- Studies on quantitative and qualitative genetic parameters on camel;
- Selection and evaluation of camels for economic traits;
- Post-harvest handling and improving the shelf life and quality of camel milk and milk products;
- Epidemiological study of Surra (vector and host range identification and also seasonal dynamics);
- Design and implement integrated control and prevention methods for Surra;
- Epidemiological study of external parasites (Tick and mange mites) and design and implement suitable control and prevention methods;
- The epidemiological investigation of camel calf morbidity and mortality and implementation of appropriate control and prevention methods;
- Select the best intervention methods for Surra, camel calf morbidity and mortality, and external parasites.

1.5. Apiculture in Eastern Ethiopia

Apiculture is well-known and economically viable farming activity in Eastern Ethiopia. However, honey production is very low. Moreover, there is poor honey handling practice and high post-harvest loss; genetic and management problems that hampered bee productivity and disease of bee.

The priority research focus includes

- Introducing and evaluating different species of bee;
- Improving feed resource and water availability for apiculture;
- Introduce different technologies for apiculture;
- Select the best intervention methods for disease of bee and beehive;

1.6. Dairy Productivity Improvement in Eastern Ethiopia

Diary production is an integral component of farming systems in Eastern Ethiopia. However, lower capacity of the local dairy cattle for milk production; limited selection and genetic improvement program for high milk production within indigenous cattle; the lower efficiency of reproductive

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technologies like AI and synchronization; poor calf and heifers husbandry limited future dairy replacement and expansion; higher mortality of calves; poor milk handling and post-harvest loss; poor technological intervention to improve the local available low quality feeds; shortage of feed and poor capacity to feed using scientific feeding system; mastitis and other diseases that cause reduced milk production are common in the area. Moreover, there are no clear control and prevention methods for clinical and subclinical mastitis in dairy farms; the problem of drug resistance among mastitis causing organisms is increasing; causes of calf morbidity and mortality are unknown, and there are no clear control and prevention strategies; the incidence and causes of reproductive disorders are unidentified. Hence, the following are identified as the research focus area:

- Genetic improvement of local dairy cattle through selection and breeding;
- Effect of feed treatment on milk production and milk quality;
- Evaluation of improved forage species for milk production and milk quality;
- Milk handling and reducing post-harvest loss, and the role of gender in urban dairy production;
- Assessment of calf and replacement heifers' husbandry practice;
- Evaluation of Estrous synchronization protocol and effectiveness of artificial insemination;
- Epidemiological study of mastitis and associated factors in Eastern Ethiopia;
- Design appropriate control and prevention method for mastitis;
- Perform drug sensitivity test and selection of effective groups of drugs;
- The epidemiological investigation of Calf morbidity and mortality;
- Design and implementation of appropriate control and prevention methods for calf morbidity and mortality;
- Investigation of the major causes of reproductive disorders, design and implementation of appropriate mitigation strategies.

1.7. Beef Productivity Improvement in Eastern Ethiopia

Beef production is very common among the smallholder farmers of eastern Ethiopia. Low productivity of the local cattle breeds; limited selection and genetic improvement program for beef production within indigenous cattle; ongoing Ogaden cattle breed improvement program show promising results but not yet finalized and need to be selected and distributed to the final beneficiaries; lack of comprehensive information on carcass quality and yield, only piecemeal approach research results are reported; there are identified potential cattle breeds (Ogaden, Babile, Boran) for beef production, but are not well characterized and evaluated in terms of beef

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productivity, meat quality and meat yield.; shortage of feed and poor capacity to feed using scientific feeding system; feedlot performance of breeds like Babile is lacking; and use of inappropriate animal for beef production (old and over-matured animals) that will produce tough and poor quality meat are among beef production and productivity challenges. Hence, the focus of this research area includes:

- Genetic improvement of local cattle breeds (particularly Ogaden, Babile and Boran) through selection and breeding
- Effect of different feeding regimens on performance, carcass yield and meat quality
- Evaluation of carcass yield, meat quality of local cattle breeds in the region
- Evaluation of meat processing technologies in the region and evaluation of its safety
- Epidemiological study of beef cattle diseases in the region

1.8. Hide and Skin Management in Eastern Ethiopia

Hide and skin production is known to generate a reasonable amount of foreign currency. However, low quality hides and skin; absence of market and market chain of hide and skin; absence of value addition and limited selection and genetic improvement program for improving hide and skin production within indigenous animal are among the many constraints of hide and skin production. Therefore, under this research area the following research priorities are identified:

- Genetic improvement of local animal breeds for hide and skin through selection and breeding;
- Effect of different feeding regimens on performance, and quality of hide and skin;
- Evaluation of marketing system for hide and skin;
- Introduction of hide and skin storing techniques;
- Establishing hide and skin marketing chains.

Sub-theme 2: Plant Production and Health (PPH)

Research on PPH has been conducted for several decades and encouraging results have been obtained both at regional and national scales. However, the crop production and productivity is constrained with many problems in Eastern Ethiopia. The climate change, erratic rainfall, recurrent drought and moisture stress in Eastern Ethiopia need to be addressed through technologies generated by researches. Researches may not address all the problems of crop production and productivity of the region in a short period of time and therefore problems that need urgent solution have been identified in each research area. Efforts have been made by research teams to address

the identified problems with research projects; and high priority research projects are selected. These projects are mainly focused on development of technologies for drought tolerant and moisture stress, farmers' participatory selection of technologies, development of technologies for multi- constraints and multi-cycle production, crop protection, germplasm enhancement and maintenance, quality seed multiplication, characterization and evaluation of fruit crops, neglected crops, plant species, indigenous trees and shrubs, as well as medicinal and aromatic plants. Thematic research approach has been attempted to apply in the process of identifying high priority research projects. The importance of professionals' participation from wide range of fields of specializations and the establishment of multidisciplinary teams in each research project should be considered for the success of the projects.

2.1. Field crops research area

2.1.1. Participatory Evaluation of Cultivars, Production Packages, and Integrated Pest Management of Sorghum in Eastern Ethiopia

Sorghum is the major crop produced in Eastern Ethiopia. However, the production and productivity of the crop is very low due to frequent drought, moisture stress and short growing season brought about by the global climate change. Disease and pest problems associated with the crop also need to be addressed. Promotion of production packages compatible with the production system are also among the major production constraints. Therefore, participatory evaluation of cultivars, production packages, and integrated pest management of sorghum are the research priorities in Eastern Ethiopia. The research components are:

- Participatory evaluation and development of improved sorghum varieties in eastern Ethiopia;
- Developing sorghum hybrid seed for different agro ecological areas of eastern Ethiopia;
- Development and evaluation of sorghum hybrids for Striga resistance in eastern Ethiopia;
- Participatory evaluation and identification of moisture stress tolerant and early maturing sorghum varieties for eastern Ethiopia;
- Development, Participatory Evaluation and Selection of Integrated Pest Management for Sorghum in Eastern Ethiopia.

2.1.2. Generation and Promotion of Maize Technologies in Eastern Ethiopia

In Eastern Ethiopia, the major problems in maize production and productivity are drought, moisture stress, disease and insect pest. There are also less fertilizer and integrated nutrient management package trials for this commodity which require due attention. The adaptability of

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maize varieties with enhanced nutritional qualities (protein quality, Pro Vitamin A and improved feed traits) in Eastern Ethiopia have not been tested at large and farmers have not participated in selection of maize technologies. The following research components are identified as high priority to address the problems within a short period of time. Components under this research area are:

- Development and maintenance of inbred lines and populations, and micro-seed multiplication of parents of commercial hybrids;
- Development of experimental hybrids and their evaluation (both non-QPM and QPM types)
- Evaluation of responses of maize to newly released blended fertilizers;
- Evaluation of the responses of maize to integrated nutrient management;
- Participatory evaluation and promotion of improved maize varieties at different agro-ecologies of eastern Ethiopia;
- Assessment of ecological distribution of parasitic- and non-parasitic weeds, maize stalk borer, fall armyworm, storage pests, rust, blight, maize lethal necrosis disease (MLND), ear rot diseases and development of integrated weed, disease and insect pest management in eastern Ethiopia; and
- Development of improved integrated agronomic management options for maize production in Eastern Ethiopia.

2.1.3. Development of Technologies for Small Cereals that fit to Eastern Ethiopia

The production of wheat, teff and barley is low and they have low contribution to the agriculture sector in Eastern Ethiopia. However, farmers' interest to produce these crops is increasing. This crop production in Eastern Ethiopia is mainly constrained by unavailability of crop varieties adaptable to the region, disease and pest, and abiotic stresses. Soil fertility problem is also among factors affecting the productivity of these small cereals. The following research components are believed to address the major problems. The research components under this are:

- Evaluation of responses of each small cereal crop to newly released blended fertilizers;
- Evaluation of the responses of each small cereal to integrated nutrient management;
- Identification of disease resistant, high yielding and wide adaptable wheat, teff and barley varieties in Eastern Ethiopia;
- Development of integrated weed, disease and insect pest management for wheat, teff and barley in Eastern Ethiopia;

- Development of improved agronomic practices for wheat, teff and barley and farmers' participatory evaluation of technologies in Eastern Ethiopia.

2.1.4. Integration of Technologies to Alleviate Multiple Constraints of Lowland Pulse Crops Production in Eastern Ethiopia

In Eastern Ethiopia, the production of lowland pulses has multiple advantages including the compatibility of crops to the existing intercropping crop production, enhancement of soil fertility, withstanding drought and moisture stress, providing protein rich food to the community and cash income as an export commodity. However, the production of these crops is constrained by multiple problems, and production agroecology shift is observed due to climate change that is not addressed by the University and National Project researches. The severity and frequency of drought also cannot be tackled with the existing lowland pulses species. The tackling of these problems requires identification of varieties to mid and high land altitudes, introducing drought tolerant species, alleviating disease and pest management problems, and demonstration of lowland pulses products.

Components are:

- Evaluation of the compatibility of recently released common bean and mung bean varieties in existing intercropping system in Eastern Ethiopia;
- Evaluation of seeded common bean populations in Eastern Ethiopia for food and nutrition security;
- Characterization and maintenance of common bean germplasm/landraces for agro-morphological traits;
- Maintenance of HU released common bean varieties and breeder seed multiplication;
- Introduction and evaluation of soybean genotypes for new production niches in Eastern Ethiopia;
- Screening of common bean germplasm for heat and/or drought tolerance in eastern Ethiopia;
- Survey on the prevalence of major insect pests and diseases of common bean and cowpea;
- Integrated management of major diseases (CBB, anthracnose, ALS), and insect pests (bean stem maggot) of common bean and mung bean in Eastern Ethiopia; and
- Identification of resistance sources for storage pests (bruchid) in common bean.

2.1.5. Integration of Technologies to Alleviate Multiple Constraints of Highland Pulse Crops Production in Eastern Ethiopia

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A number of faba bean, field pea, chick pea and lentil improved varieties have been developed and released nationally, combining diverse plant type with resistance or tolerance to several diseases, insect pests, and parasitic weeds and possessing other good agronomic traits. However, farmers in Ethiopia are reluctant to adopt them, with only 3-5% of the cultivated land covered with seeds of improved crop varieties. Shortage of seed of improved varieties, lack of attributes desired by farmers, low information exchange between farmers and researchers about the improved varieties, biotic and abiotic factors constrained production and farmers' uncertainty about the improved varieties or risk-aversion could be the major reasons for the low adoption rate of improved crop varieties. The production and productivity of grain legumes is constrained by several biotic and abiotic factors. Therefore, to enhance grain legumes productivity and utility, integrated and applied research should be give due attention in Eastern Ethiopia. Research components are:

- Evaluation of responses of selected highland pulse crops to newly released blended fertilizer;
- Participatory evaluation and selection of improved varieties and agronomic practices of fababean in Eastern Ethiopia;
- Participatory evaluation and selection of improved varieties and agronomic practices of field pea in Eastern Ethiopia;
- Participatory evaluation and selection of improved varieties and agronomic practices of chick pea in Eastern Ethiopia;
- Participatory evaluation and selection of improved varieties and agronomic Practices of lentil in Eastern Ethiopia;
- Survey, identification and integrated management of diseases, insect pests and weeds of faba bean in Eastern Ethiopia;
- Survey, identification and integrated management of diseases, insect pests and weeds of chick pea (*Cicer arietinum*) in Eastern Ethiopia;
- Promoting production and utilization of faba bean, chick pea, field pea and lentil for improved nutrition and health in Eastern Ethiopia.

2.1.6. Enhancing Groundnut and Linseed Productivity and Production in Eastern Ethiopia

Eastern Ethiopia is among the major groundnut producing regions in the country. The crop has a potential to alleviate food and nutrition security problems. It is also a high potential crop as export commodity that will be a good opportunity to generate additional income to poor farmers in moisture stress areas of lowland Ethiopia. However, the production and productivity of the crop is

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constrained as a result of either unavailability of technologies to farmers. In addition, Aflatoxin contamination limited export to international market. These problems have not been well addressed by the National Research Project in Eastern Ethiopia. Therefore, Haramaya University needs to take the responsibility in alleviating the problems. Though the alleviation of the problems requires a long-term research, the research team has identified the short-term research activities in this project. The research components are:

- Integrated management of Aflatoxin Contamination in groundnut;
- Scaling up of groundnut sheller in Eastern Hararghe;
- Scaling-up of improved groundnut varieties through Community based Small-Scale Seed Production Scheme in East Hararghe;
- Training on groundnut product development for enterprises and smallholder farmers;
- Trainings and preparation of aflatoxin management guideline;
- Pre-scaling up of groundnut technologies in major-growing areas of Eastern Hararghe;
- In-vitro selection of groundnut genotypes for resistance against *Apergillus* species (*Aspergillus flavus* and *Aspergillus parasiticus*);
- Development of disease resistant, high yielding and wide adaptable linseed varieties in eastern and western Hararghe;
- Development of improved agronomic practices for linseed production in eastern and western Hararghe;
- Popularization and seed multiplication of improved linseed varieties in eastern and western Hararghe.

2.2. Horticultural Crops Research Areas

2.2.1. Introduction, Evaluation and Generation of Technologies for High Value Vegetable Crops in eastern Ethiopia

Tomato and cabbage are produced in large areas of eastern Ethiopia, generating higher income for smallholder farmers and the crops are used for home consumption of farmers that contribute to food security and to tackle malnutrition. The egg-plant is available at vegetable markets of some cities in the region. The technologies demand for tomato, egg-plant and cabbage is increasing year after year in eastern Ethiopia. However, the improved technologies for these crops are not available in sufficient quantity and quality, particularly for egg-plant, there are no improved technologies recommended in the region in particular and in the country in general. Therefore, research projects

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are needed to be designed and executed to generate technologies for these crops focusing on the following major components.

- Evaluation and recommendation of tomato open pollinated and hybrid varieties for high yield and disease resistance, and development of methods for quality seed extraction of open pollinated varieties in eastern Ethiopia;
- Determination of fertilizer rates, spacing and weed management practices for tomato in eastern Ethiopia;
- Introduction, evaluation and recommendation of commercial egg plant varieties, determination of fertilizer rates, spacing, and weed management practices for high yield and fruit quality of egg plant varieties in eastern Ethiopia;
- Introduction, evaluation and recommendation of commercial cabbage varieties, determination of fertilizer rates, spacing, and weed management practices for high yield and head cabbage quality in eastern Ethiopia.

2.2.2. Evaluation, Development and Promotion of Technologies for Underutilized Vegetable Crops

Many reports of public health indicated that vitamin A and Fe deficiencies are severe public health problem and reaching at alarming levels especially in rural areas of eastern Ethiopia. Intervention of vegetable technologies is among the measures to tackle the malnutrition. The underutilized vegetable crops; Ethiopian mustard (*Yehabesha gomen*) and okra, and the newly introduced chaya (tree vegetable) are rich in vitamin A, Fe, Calcium and other micronutrients and can serve the purpose. Ethiopian mustard is a traditional home garden vegetable crop in the region and it is produced by farmers in small areas. Haramaya University has started research on okra and chaya, but promotion and adaptation of these crops has not been done in eastern Ethiopia. However, the success of the past efforts of the University to address the public health problem and to contribute to food security in the region is depend on the continuation of the research activities and to include research on Ethiopian mustard. Thus, research projects with major components are needed to be designed and executed to generate technologies for these crops. The research projects and major components are:

- Adaptation evaluation and recommendation of Ethiopian and exotic okra genotypes for tender fruits yield and fruits quality in eastern Ethiopia of suitable agroecologies for the crop;

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- Adaptation evaluation and recommendation of chaya for different agroecologies (localities) of Eastern Ethiopia, and
- Characterization and evaluation of Ethiopian mustard genotypes for leafy vegetable yield and nutrition contents of leaf in Eastern Ethiopia.

2.2.3. Development of Agronomic Practices and Packaging of Quality Seeds for *Improved Huruta Shallot* and *Haramaya I Carrot* Varieties

Production of carrot seeds in tropical areas without fulfilling the vernalization requirement is considered as the changing of the distinguishing characteristics of the crop. Seed production from shallot is also one of the most challenging tasks for researchers. However, the researchers of Haramaya University were capable to produce seeds from carrot without vernalization requirement and shallot seeds from vegetatively propagated variety and released as *Haramaya I* carrot and *Improved Huruta* shallot varieties, respectively, by National Variety Release Committee. The research efforts have been made to determine the agronomic practices and identify packaging of quality seeds of *Haramaya I* and *Improved Huruta* carrot and shallot varieties, respectively, to contribute for higher productivity and quality of root and bulb production in the country. However, the efforts of the University have not yet end with the required recommendations of agronomic practices and packaging of quality seeds to the two varieties. Therefore, research projects addressing the following major research components are required to be designed and executed.

- Identification and recommendation of planting time, suitable location(s), bulb quality and bulb handling, and quality seed packaging for *Improved Huruta* shallot variety, and
- Identification and recommendation of growing season(s) and treatment of roots and seeds for healthy seeds production and packaging of quality seeds for *Haramaya I* carrot variety.

2.2.4. Development of Agronomic Practices for High Bulb and Root Yields of *Improved Huruta Shallot* and *Haramaya I Carrot* Varieties

Haramaya University was capable to produce seeds from vegetatively propagated *Huruta* shallot variety and it was proposed released as essentially derived seed producing variety and named *Improved Huruta* shallot variety. The new shallot variety was also producing higher bulb yield than improved open pollinated and hybrid onion varieties. The *Haramaya I* carrot variety developed through mass selection using root to-seed production method. The released carrot variety was not only found to seed producing without vernalization requirement but it was superior in marketable and total root yields and other desirable traits to the commercial Nantes variety. However, recommendations have not made on the amount of fertilizers and plant population per hectare (unit

area) for high yield and quality bulbs and roots production in east Hararghe. Therefore, it is necessary to determine the rates of fertilizer and plant population for the two improved shallot and carrot varieties. Thus, the research projects with the following components are required to be planned and executed for the purpose.

- Determination and make recommendation on the rates of fertilizers, inter-and intra-row spacing for high bulb yield and quality bulbs of *Improved Huruta* shallot variety, and
- Determination and make recommendation on the rates of fertilizers, inter-and intra-row spacing for high root yield and quality roots rates of *Haramaya I* carrot variety.

2.2.5. Assessment of Fruit Crops Production Constraints and Development of Technologies to Enhance Fruit Production in eastern Ethiopia

In the current agriculture of eastern Ethiopia has not contributed much to the production of fruit crops. The region was known as one of fruit crops production regions in the country but this is now become a legend. The declining fruit production tragedy might be contributed by the low contribution of research to sorting out the production constraints and very low research efforts made to overcome the production constraints. It is known that fruit research requires decades and required huge amount of investment, but the University needs to address the critical fruit production problems before fruit production become nonexistent in the region. Thus, as priority of fruit crops research, the following research components are identified and research projects containing these components are required.

- Assessment of major fruit crops production and production constraints in eastern Ethiopia;
- Collection, establishment of fruit crops orchards, characterization and evaluation of fruit crops of importance to the region; and
- Evaluation the adaptation of improved varieties of major fruit crops (avocado, banana, mango, papaya, peach and passion fruit) in Eastern Ethiopia.

2.2.6. Characterization, Evaluation and Registration of Farmers Potato Cultivars for Short Tuber Dormancy, Tuber Quality and Tuber Yield under Irrigation

Potato is co-staple food, export commodity and the second economic crop next to of *Khat* in East Hararghe. The production is market driven and the region is known by multiple cycles (2 or more production) of potato production in a year. The improved varieties have long tuber dormancy period and have little time between growing seasons to permit adequate tuber sprouting to be used for multiple cycles' production in a year. The farmers used the cultivars having short tuber

dormancy (one month or less) during dry and *belg* seasons but cannot use these cultivars during main cropping season because the cultivars are susceptible to late blight. Neither Haramaya University nor National Potato Project developed varieties with short tuber dormancy, late blight disease resistant, high yield and quality tuber that satisfy the farmers of East Hararghe in particular and eastern Ethiopia in general. Besides the unavailability of improved potato varieties of farmers' interest, the research did not conduct systematic research to evaluate farmers' cultivars for yield and tuber quality under irrigation (dry and *belg* seasons production) and attempt has not been made to register the cultivars as varieties in eastern Ethiopia. Thus, research project containing the following research components is required to evaluate farmers' cultivars and register as varieties in eastern Ethiopia.

- Collection, characterization and evaluation of farmers' cultivars along with potato varieties for short tuber dormancy period, early maturity, high yield and tuber quality under irrigation, and
- Identify promising potato cultivars through farmers' participatory selection and submit the cultivars for registration as potato varieties in eastern Ethiopia.

2.2.7. Development of Potato Technologies for Sub-optimal Irrigation Production in Eastern Ethiopia

The farmers in Eastern Ethiopia are producing potato with two and three production cycles in a year using local cultivars with short dormancy period under sub-optimal irrigation. The region is drought prone area and the scarcity of water for potato production is becoming one of the major production constraints. The farmers are forced to produce potato under optimal irrigation water application and they obtain yield below the potential of the crop in the region and this is further interlinked and aggravated by climate change effects. This production problem is not to be tolerated anymore, therefore, the following research components are identified to address the problems and increase the production of potato in the region.

- Assessment of farmers' practices of water management in potato production and estimate tuber yield reduction due to sub-optimal irrigation water in East Hararghe, and
- Identification of potato cultivars, method for breaking dormancy of tubers, recommendation of irrigation water management and agronomic practices for high tuber yield and tuber quality fit to potato production system in the changing climate in Eastern Ethiopia.

2.2.8. Determination and Designing of Methods for Quality Processed Potato and Sweet Potato Products in eastern Ethiopia

Starting the introduction of potato, the crop was used for preparation of traditional foods such as “*dinchwoi*”, boiled potato etc. However, currently, tubers are processed to produce French fries, chips and others at small scale and flourishing in cities, towns and roadside villages. The roots of sweet potato with high dry matter also can be processed as French fries and chips, but no one tried to processed roots of sweet potato for these products. The East Hararghe is known for production of potato and sweet potato in the country; therefore, developing methods for proper processing of these products contribute to improvement of the livelihood of farmers and creates job opportunity for women and other interested people. However, if the processing of tubers and roots to French fries and chips not properly accomplished, the products are possible carcinogen due to accumulation of toxic compound known as Acrylamide. Therefore, it is necessary to design project focusing on the following research activities.

- Assessing the extent of chips/potato processed products, methods used to produce the products and estimate the toxic substances in the products in eastern Hararghe, and
- Designing easy method(s) for identification of tubers and roots for processing and make recommendations of method(s) for chips and other fried products from tubers of potato and roots of sweet potato to be used by small business people in eastern Hararghe.

2.2.9. Postharvest Handling Technologies of Horticultural Crops

High postharvest losses result in reduced food availability, lower quality foods, and lower nutritional value and/or food safety danger. Most of the past efforts in Ethiopia focused on development and dissemination of better yielding, disease resistant varieties for farmers along with production technology packages. But when production is boosted, prices will fall if there is no means to extend the shelf life via improved postharvest handling, cooling, cold storage or processing into more stable food products. But, the postharvest handling of most of the horticultural crops has not yet developed. The research priorities include:

- The effect of postharvest technologies on horticultural crops chemical compositions, physical quality, nutritional and sensory properties and acceptability by consumers;
- Postharvest loss determination and training on improved postharvest technologies and facilities for storing and handling fresh produce from the point of harvest to consumer markets;

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- Determining the efficacy of the appropriate postharvest technologies that can be used to extend product shelf-life for use in food processing industries (value-addition); and
- Awareness creation as well as transfer/dissemination of knowledge and skills on improved postharvest handling practices among the value chain actors (input suppliers, subsistent farmers, retailers, cottage and large-scale food processors) and experts working at grassroots levels on product storage best practices.

2.3. Crop Protection Research Area

Plant protection forms one of the major components of crop production, as yield is obviously far lower than the potential of the crops due to plant diseases, insect pests, plant-parasitic nematodes and weeds. Susceptible food crops could totally fail while some others bear substantial yield loss due to these pests. In addition to yield loss in the field, food crops are also lost in transport and storage unless properly handled and managed. Despite the remarkable progress made in increasing food production at the global level, approximately half of the population in the Third World still does not have access to adequate food supplies. Evidence suggests that food losses occurring in the postharvest and marketing system tend to be highest in these countries where the need for food is highest. Both quantitative and qualitative food losses of extremely variable magnitude occur at all stages in the post-harvest system from harvesting, through handling, storage, processing and marketing to final delivery to the consumer. Fruit, vegetables and root crops are much less hardy and are quickly perishable, if care is not taken in their harvesting, handling and transport, and they will soon decay and become unfit for human consumption. Postharvest rotting of cereal grains and of legumes is also quite common and the losses caused by it are quite significant. Such losses occur primarily at the large bins or warehouses of the growers, wholesalers, or manufacturers and are seldom observed by the general public. Storage losses are both in quality and quantity to the extent that it becomes detrimental to human health.

Some of the pests are imported from other countries, as the quarantine system of our country is also poor. Containment of such exotic pests requires regular survey and research to recommend proper policy measures. The success of plant protection programs depends on the ability to detect pests. Detection schemes can be designed in different forms of regular surveys. That is, because well designed survey program includes regular monitoring for insect pests, diseases, weeds, nutrient deficiencies, irrigation problems, sanitation, and much more. Early intervention is instituted as soon

as signs of damage are detected, rather than later when they are irreversible. Plants and pests are continuously confronted with each other during evolution in a battle for growth and survival. In this rivalry plants have evolved a stunning array of structural, chemical, and gene based defenses, designed to combat the pests of different nature and, so as the same pathogens by developing new races. Many plants both in nature and in agriculture are resistant to multiple diseases. Although much of the plant innate immunity system provides highly specific resistance to pest organisms, there is emerging evidence to support the hypothesis that some components of plant defense are relatively nonspecific, providing multiple resistances. Understanding multiple resistances is of fundamental and practical interest to plant biologists, entomologists, pathologists, and breeders to reduce loss levels to pests. The overall losses in food have been further aggravated by losses in feed and fodders of animals. Such losses could be due to mycotoxin contaminations that request for immediate solutions. Accordingly, the major research priority projects with major research components are identified by Crop Protection Research Area.

2.3.1. Assessment of Crops Yield Loss and Sustainable Management of Plant-Parasitic Nematodes in eastern Ethiopia

- Damage assessment, population dynamics and management of root-lesion nematodes (*Pratylenchus* spp.) in major cereals crops of Eastern Ethiopia;
- Sustainable management of plant-parasitic nematodes on tomato, pepper, potato and sweet potato crops in Eastern Ethiopia;
- Damage assessment, identification and characterization of cereal nematodes in Eastern Ethiopia;
- Investigating diseases complexes involving plant-parasitic nematodes and soil-borne fungal pathogens on root, tuber and vegetable crops;
- The potential of entomopathogenic nematodes to manage economically important insect pests of major crops in Eastern Ethiopia.

2.3.2. Assessment of Mycotoxin-Producing Fungi Distribution and Mycotoxin Contamination in Foods, Feeds and Fodders in Eastern Ethiopia

- Analyses of mycotoxin contamination in foods, feeds and fodders in Eastern Ethiopia;
- Importance and distribution of mycotoxin-producing fungi and their management in major Crops (especially focusing on legumes) in Eastern Ethiopia.

2.3.3. Assessment of Crops Yield Loss due to Insect Pests, identification and Management

of Emerging and Re-Emerging Diseases, Insect Pests and Invasive Weeds of Major Crops in Eastern Ethiopia

- Plant diseases, insect pests and parasitic weeds monitoring on major crops in Eastern Ethiopia (Regular Survey);
- Importance and distribution of emerging and Re-Emerging diseases, insect pests and invasive weeds of major crops in Eastern Ethiopia;
- Pinning out the association of production systems and disease epidemics and insect pest outbreaks on major crops in Eastern Ethiopia;
- White mango scale (*Aulacaspus tubercularis*), the newly emerging pest to Ethiopia;
- Sustainable management of American fall army worm the newly emerging pest of Maize in Ethiopia;
- Plant viral disease identification and management on major vegetable crops of Eastern Ethiopia.

2.4. Source of Nutrients for Sustainable and Eco-friendly Crop Production

2.4.1. Uses of Biofertilizers for pulse crops in small-scale production and Integrated Soil Fertility Management

Grain legumes are very important crops in the Ethiopia. They are exclusively important source of dietary protein and rank second as food after cereals and occupy more than 13% of the total cultivated areas, contributing about 18% of the total production, and provide food and income to more than 10 million households. Despite their immense contribution to household income, food security, and general livelihoods, the production and productivity of grain legumes in Ethiopia is below potential and this incidence of low crop productivity continues to be a challenge facing grain legume farmers in Ethiopia. This is mainly due to low soil fertility, limited input usage (fertilizers), limited availability of seed, and poor extension services. Therefore, low cost and sustainable solutions compatible with the socioeconomic conditions of smallholder farmers are needed to solve these soil fertility problems leading to poor yields of grain legumes.

A recognized approach by soil scientists and agronomists to dealing with soil health and fertility problems of smallholder farmers is the introduction of cost effective and yield rewarding soil fertility management technologies such as biofertilizers, organic fertilizers and an integrated approach [i.e. Integrated Soil Fertility Management (ISFM)]. Biofertilizers are considered to be an

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important component of integrated soil nutrient management, as they are cost effective and renewable source of plant nutrients that can supplement nutrients from other source (e.g. chemical fertilizers) in sustainable agricultural production systems.

Biofertilizers are selected strains of beneficial microorganisms' culture in laboratory and packed in a carrier, and either coated on legume seeds before planting or inoculated in to plant after planting to enhance the growth and yield legumes crops and provide nitrogen and organic carbon for subsequent or associated crops. The best known and most exploited symbiotic N₂-fixing biofertilizers are those belonging to the family Rhizobiaceae (Rhizobia) and include the following genera: *Rhizobium*, *Bradyrhizobium*, *Sinorhizobium*, *Azorhizobium*, *Mesorhizobium*, and *Allorhizobium*.

Despite the expected positive impact of biofertilizer adoption on yield and the environment, the availability of biofertilizers and farmers' decision and willingness to invest in biofertilizers is an important concern. Besides, the level of awareness about biofertilizers, farmers' socioeconomic situation such as educational level and income, access to extension services as well as farm size and farming experience, are expected to affect their perceptions about biofertilizers and their willingness to pay for them. Currently, there is limited empirical information on the use of biofertilizers in crop production and on farmers' willingness to pay for biofertilizers. Therefore, to enhance grain legumes productivity and utility, integrated and applied research on the use of biofertilizers should be given priority in Eastern Ethiopia. Research components to be considered include:

- Development of biofertilizers for different legume crops and application of the technology for legumes production under greenhouse and field condition;
- Integration of biofertilizers and inorganic fertilizers to enhance soil fertility and legume crops production: a sustainable approach of Integrated Soil Fertility Management (ISFM);
- Cross-inoculation of bioinoculants (biofertilizers) to evaluate their symbiotic efficiency and cross-infect or interchange between different legume groups;
- Utilizing the potential benefit of biofertilizers in legume-based cropping system especially intercropping and crop rotation with major cereal crops such as sorghum and maize;

- Scaling up the willingness and perception of small-scale farmers to utilize biofertilizers and an integrated approach with other fertilizers sources.

2.4.2. Promotion and Utilization of Biogas slurry as Organic Fertilizer for Better Crop Production

Decreasing soil productivity has become a global concern as soil fertility is diminishing gradually for many reasons including soil erosion, nutrient mining, loss of soils organic matter, improper fertilization, accumulation of salts and other toxic elements. Soil productivity is mainly affected by cropping systems and the crop management practices of tillage, synthetic fertilizer, and organic manure management. It has been reported that continuous and unbalanced use of synthetic fertilizer degrades the physicochemical and biological soil environment. In Ethiopia, yearly soil nutrient depletion resulted in serious deficiency of soil nutrients and reduction in total crop production. This necessitates growing search for many technologies such as adoption of appropriate and adequate fertilizer packages, involving the use of organic amendments and integrated nutrient managements.

As a result, the biogas technology which uses different biomass wastes become a popular in increasing production and productivity as well as overcoming prices of chemical fertilizers which our farmers find difficult to buy for their sustainable crop production. The use biogas slurry in crop production offer cheap, readily available and environmentally friendly system of crop production. Biogas slurry is a cheap source of plant nutrients and can offer extra benefits to soil fertility and crops quality and yield, and could also offer promising opportunity in preventing adverse environmental impacts of waste disposal. It could be used as an alternative, or complement or supplement to inorganic fertilizers

The use of biogas slurry as a soil amendment, thus, provide a sustainable way for agriculture, environment and farming communities and considered a high priority because of its positive effect on soil productivity and crop yield. Therefore, putting emphasis on locally available, low-cost and organic biogas slurry becomes an attractive option for selected major cereal, legume and vegetable crops production and its proper use can reduce the dependency of farmers on increasingly expensive chemical fertilizer. To substantiate this potential benefit of biogas slurry, a research component designed include:

- Evaluation of nutritive value of anaerobically digested biogas slurry for maintenance of soil fertility and increased crop production;

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- Evaluation different methods of utilization of biogas slurry for crop production;
- Assessment of the effect of biogas slurry on the growth, yield components, yield and quality of different crops;
- Investigation of the effect of sole and combined application of biogas slurry and chemical fertilizers on growth performance, yield and yield components of different crops;
- Determination of the appropriate rate of biogas slurry and fraction in its combinations with inorganic fertilizer for optimum and economic crop production;
- Promotion of the potential benefit of biogas slurry in crop production to enhance the awareness of farmers towards the technology.

2.5. Indigenous Trees/Shrubs, Aromatic and Medicinal Plants Research Area

The important role played by indigenous trees and shrubs in natural forest, wood land, and agroforestry system in east Hararghe and their benefit to the environment, livelihoods of the local communities and sustainable development is not well asessed and documented. Medicinal plant plays an important role in pharmacology and pharmaceutical chemistry because of its high essential oil content in its different parts in herbal medicine; they are used for their antiseptic properties against infectious diseases of fungal and bacterial origin. However, little information is available about the medicinal plants in eastern Ethiopia. Therefore, the research project need to be designed and executed focusing on evaluation of the status of indigenous trees, shrubs and analyses of chemical composition and antimicrobial effects of extracts from different parts of medicinal plants in Eastern Ethiopia.

2.5.1. Assessing the Status of Indigenous Trees and Shrubs, Determination of Medicinal Values of Herbs and Medicinal Plants in eastern Hararghe

- Status and future prospects of indigenous trees and shrubs in eastern Hararghe;
- Phytochemical and pharmacological investigations of extracts of different parts of selected herbs and medicinal plants in eastern Hararghe.

2.6. Germplasm Maintenance and Enhancement Research Area

2.6.1. Germplasm Maintenance and Enhancement of Crops and Seed Multiplication of Crop Varieties

Haramaya University has been contributing a lot to the country in developing crops varieties since

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its establishment as Agriculture College. The germplasm collected by the University has been the basis for the establishment of national gene bank and thousands of collections were conserved as world wealth at different gene banks. However, the University has failed to maintain its own varieties, collections and introduced crops genotypes. The seed production of crop varieties in the University is not under strict supervision of breeders. Therefore, the following activities are proposed to be implemented every year. Some of the activities related to this research area are:

- Maintenance of enhancement of potato and sweet potato collections and seed tubers and cutting multiplication of commercial varieties;
- Maintenance of inbred lines and old maize varieties, and seed multiplication of commercial varieties;
- Maintenance of cereal crops germplasm and seed multiplication of commercial varieties;
- Maintenance of common pulse crops collections and seed multiplication of commercial varieties;
- Maintenance of collections and seed multiplication of commercial varieties of oil crops.

2.7. Urban and Peri-urban Agriculture Research Areas

There will be high rate of urbanization in African countries in the coming twenty years. Many of the countries in which there are fast urban growths are least-developed nations. These countries are not capable enough to provide sufficient food demanded by the expanding urban population via imports from rural areas. This leads to increased food insecurity and prevalence of poverty in the urban areas. For instance, Ministry of Finance and Economic Development for Ethiopia (2006) reported that urban population of Ethiopia will increase in two folds by 2020, and urban poverty is currently becoming a growing concern especially in large cities of the country. Thus, cities may need to consider agricultural production in urban areas or urban fringe to reduce the food insecurity and prevalence of poverty. Urban agriculture in Africa was evolved as a response to scant sources of urban economic sustenance i.e. insufficient supply of staple food to cities coupled with declining purchasing power of city dwellers. Currently, millions of urban dwellers are reinforced to restore farming in urban areas throughout many African cities either to supplement their household income or because they cannot afford to meet their daily food needs.

Urban agriculture is not a phenomenon that is practiced only by urban people in African cities as

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their survival strategy. Deeltstra and Girardet (1999) have argued that it is also prominently being practiced in the developed world to supplement food imports. For instance, 40 % of agricultural production was obtained from urban farming in US in 1990, and there were 80,000 urban community gardeners in Berlin in 1999, as it was made evident by Deeltstra and Girardet (1999). Thus, understanding the role that urban agriculture plays in poor urban households is important for any following action to reduce urban food insecurity and improve income of the urban poor. Urban agriculture includes agricultural productions such as horticulture, floriculture, forestry, fishery, poultry and livestock mainly in public open spaces within cities and fringe of cities (Deelstra and Girardet, 2004 and Mougeot, 2000). It uses resources, products and services of the city area, and it provides the same. It is viable for efficient urban land use, poverty alleviation, economic development and environmental management as long as it is mainstreamed into urban livelihood policy strategies (Maxwell, 1999 and Mougeot, 2000).

Despite the fact that the growth and development of urban agriculture is an economically viable enterprise, official projects and programmes aimed at improving urban agriculture have been relatively rare. This is typically because urban agriculture has not been taken as an integral part of the urban planning process. As a result, no sufficient data are collected on urban agriculture nor does the activity have any identity or validation as a productive sector of the economy in countries like Ethiopia. Urban development planning has tended to neglect urban agriculture over the years. This has led to lack of supportive services to the sector. Urban agricultural practices are underdeveloped. They have not been developed to suit the changing demands for better technology. Urban agriculture has not been encouraged and given its rightful place in the economy. For example, there are no extension services available to the urban farmers. Presently there is no stated policy regarding urban agriculture in Ethiopia. The research components are:

- Evaluating the status of Urban and Peri-urban agriculture in Eastern Ethiopia
- Assessment of constraints of UA and PUA in Eastern Ethiopia
- Assessment of the farmers perception on the use of UA and PUA for the food security and urban and peri-urban food self-sufficiency
- Developing, demonstrating and adopting different technologies of Urban and Peri-urban agriculture to help achieve food security.

Sub-theme 3: Environment, Natural Resource and Climate Change

3.1. Natural Resource Analysis, Use and Management

Natural resources support the livelihoods of many poor people. However, there is scarcity of scientific knowledge to identify and addresses problems related to conservation and characterization of major natural resources such as soils, forests, biodiversity and others. Therefore, research project need to be designed and executed to understand the status of natural resources in eastern Ethiopia.

The major components of the research project are:

- Soil characterization, classification and mapping in Eastern Ethiopia;
- Assessing the extent and type of soil erosion in Eastern Ethiopia;
- Identification of local soil conservation approaches and their effectiveness in Eastern Ethiopia;
- Assessing the status of ecosystem and ecosystem services, and their contribution to poverty alleviation in Eastern Ethiopia;
- Modeling and predict future ecosystems and ecosystem services dynamic in relation to natural and anthropogenic impacts;
- Evaluation and analysis of range ecology and impacts on pastoralism and pastoralists livelihood;
- Study on governance for conservation and sustainable use of natural resource, in particular developing effective methods for conservation of natural resources across all related sectors and stakeholders;
- Exploring traditional customs, social institutions and innovation in natural resource management;
- Assessment of the status of vegetation and mapping vegetation resources in Eastern Ethiopia;
- Investigating the values of forest goods and services and their contribution to poverty alleviation in Eastern Ethiopia;
- Predict the future cause-effect relations between natural resource loss and their drivers.

3.2. Water Resources Assessment, Development, Utilization, and Management

The hydrology of eastern part of Ethiopia is based on river, wetland and lake systems. Water from these rivers, lakes and wetlands is becoming insufficient to meet the eastern Ethiopia's growing needs. Currently, eastern Ethiopia is facing serious water crisis in the form of water scarcity for

domestic, agricultural and industrial use. However, water resource of eastern Ethiopia is not well studied. They have been overexploited for different purposes without having knowledge on the occurrence, distribution, flows and quality of the groundwater systems. Therefore, detail hydrologic, hydro geologic, and water use and management investigations are needed in the region and the nation as a whole, for sustainable use of the waterresources.

- Assessing and mapping water resource potentials in Eastern Ethiopia;
- Identifying water harvesting practices and their effectiveness in Eastern Ethiopia;
- Identifying of local water conservation approaches and their effectiveness in Eastern Ethiopia;
- Examining water pollution in Eastern Ethiopia;
- Developing water use technologies;
- Examining current and future water management challenges and demands;
- Analyzing the cause and consequences of water use conflicts;
- Developing water Harvesting Systems/Technology Development.

3.3. Environmental Research, Development, and Management

Water pollution has become a growing concern in eastern Ethiopia over the last century as more and more waste is being disposed of in our rivers and lakes. This increase in pollution is harming our food supplies, drinking water and environment. Pollution of water sources from haphazard disposal of solid wastes, discharge of untreated or inadequately treated wastewater to water sources, lack of standard sanitary facilities and poor hygienic practices. A major concern of the presence of polluting elements in the aquatic environment is related to the negative health effects they may cause in humans, animals, and plants. Research components are:

- Assessing waste generation rate;
- Identification of waste management practices and their effectiveness in Eastern Ethiopia;
- Developing waste recycling technologies;
- Urban liquid waste treatment and management;
- Assessing environmental pollution;
- Estimation of pollution level and extent;
- Assessment of pollutant dynamics in the environment;
- Studying methods to reduce pollution of water resources.

3.4. Climate Change and its Management

Of all the places Ethiopia, eastern Ethiopia and its societies, ecosystems, and agricultural systems are one of the most vulnerable to the effects of climate change. Despite the urgent need to assess the effects of changing climate, current climate predictions, impact assessment and management approaches for eastern Ethiopia are uncertainties. To address this need, research is needed. Research components are:

- Evaluating landscape management practices for climate change adaptation, resilience, and mitigation;
- Examining carbon sequestration/emission/mitigation/soil quality/health potentials under different land uses;
- Identifying climate smart water resources management practices and their effectiveness;
- Examining impacts of climate change to agriculture, water, soil and ecosystem;
- Developing regional climate change models to for assessing the risk of climate change;
- Developing technologies for the production of bio-energy and other bio-products from agricultural and forest biomass.