Food and Agriculture Organization of the United Nations

National Agricultural Innovation System Assessment in Eritrea

Consolidated report

September 2021

In partnership with

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Abbreviations and acronyms

AED	Agricultural Extension Department
AfDB	African Development Bank
AIS	Agricultural Innovation System
ASARECA	The Association for Strengthening Agricultural Research in Eastern and Central Africa
AU	African Union
CGIAR	Consultative Group for International Agricultural Research
CIMMYT	International Wheat and Maize Center
DeSIRA	Development Smart Innovation through Research in Agriculture
ECLC	Eritrea Crop and Livestock Corporation
EDIB	Eritrean Development and Investment Bank
EIDP	Eritrea Ireland Development Partnership
ELISA	Enzyme-Linked immunosorbent assay
ErCS	Eritrean Catholic Secretariat
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FAS	Farmers Advisory Service
FGD	Focus Groups Discussion
FWA	Forestry and Wildlife Authority
GoSE	Government of the State of Eritrea
HAC	Hamelmalo Agriculture College
HRD	Human Resources Development
IAEA	International Atomic Energy Association
ICARDA	International Centre of Agricultural Development in the Dry Areas
ICRISAT	International Crops Research Institutes for Semi-Arid Tropics
IFAD	International Fund for Agricultural Development
ILRI	International Livestock Research Institute
KII	Key Informant Interview
MIHAP	Minimum Integrated Household for Agricultural Package
MoA	Ministry of Agriculture
MoE	Ministry of Education
MoEM	Ministry of Energy and Mines
MoF	Ministry of Finance
MoI	Ministry of Information
MoLG	Ministry of Local Government
MoLWE	Ministry of Land Water and Environment
MoND	Ministry of National Development
NAP	National Agriculture Programme
NAPHL	National Animal and Plant Health Laboratory
NARI	National Agricultural Research Institute
NGOs	Non-Governmental Organizations

NUEW	National Union of Eritrean Women
NUEYS	National Union of Eritrean Youth and Students
RSD	Regulatory Services Department
SDG	Sustainable Development Goal
SMCP	Saving and Micro-Credit Programme
SWC	Soil and Water Conservation
SWOT	Strength, Weakness, Opportunity and Threat
TAP	Tropical Agricultural Platform
TVET	Technical and Vocational Education and Training
UNDP	United Nation Development Programme
VDC	Village Development Committee

Key definitions

Agriculture Innovation (AI): The process whereby individuals or organizations bring existing or new products, processes and forms of organization into social and economic use to increase effectiveness, competitiveness, resilience to shocks or environmental sustainability, thereby contributing to food and nutritional security, economic development and sustainable natural resource management (TAP, 2016).

Agriculture Innovation System (AIS): A network of actors or organizations, and individuals, together with supporting institutions and policies in the agricultural and related sectors, that brings existing or new products, processes and forms of organization into social and economic use. Policies and institutions (formal and informal) shape the way that these actors interact, generate, share and use knowledge, as well as jointly learn (TAP, 2016).

Capacity Development (CD): The process whereby people, organizations and society as a whole unleash, strengthen, create, adapt and maintain capacity over time (TAP, 2016).

Functional Capacities (FC): Functional capacity is largely defined in the context of a sector or in a thematic context. Functional capacities include capacities relevant to individual and organizational effectiveness, such as management, leadership, budgeting, marketing, information and communication technology and strategic planning, in addition to soft skills such as communication and advocacy (FAO, 2012).

Organizational Capacities (OC): The organization's potential to perform – its ability to successfully apply its skills and resources toward the accomplishments of its goals and the satisfaction of its stakeholders' expectations (ECDPM, 2003).

Enabling Environment (EE): The context in which individuals and organizations put their competencies and capabilities into actions (TAP, 2016).

Executive summary

The Food and Agriculture Organization of the United Nations in Eritrea, in partnership with the Ministry of Agriculture is implementing the national component of a global project entitled *"Developing capacity in Agriculture Innovation System project: scaling up the Tropical Agriculture Platform Framework"* (GCP/GLO/017/EC). The project aims to strengthen capacities to innovate for climate resilient agriculture and food system.

One of the key activities of the project is the assessment of the Agricultural Innovation System (AIS) in Eritrea. The objectives of the assessment are to:

- identify critical gaps, needs, opportunities and good practices to formulate workable recommendations aiming at strengthening and making AIS more effective; and
- develop an understanding of AIS and how it functions and supports climate-relevant transformation of agriculture and food systems.

The assessment will also identify major bottlenecks and entry points for strengthening AIS in Eritrea as well as inform policy and decision makers on AIS performance and make recommendations for its improvement.

The assessment was done by using desk review from available sources, which included conference reports, proceedings, annual reports, current policy and strategies of the MoA. Focus Group Discussions (FDG) were used to complement qualitative and quantitative information of structural, functional, capacity and enabling environment from unit heads of research and extension. Key Informant Interviews (KII) were also conducted with department heads, project coordinators, programme leaders/experts from relevant government ministries and departments, farmers, farmers associations as well as from civil societies and private sectors. Three case studies were assessed in-depth using case study assessment checklists. All the data and information collected was summarised, compiled and analysed.

Over 35 stakeholders/actors who came from different departments, line ministries, farmers and farmers associations, international organizations and agencies were identified; their roles studied and a network map was prepared. The structural analysis, highlighted that the main driving forces for AIS initiation in the country, are climate change, poor yield in crop production, high incidence of pests and diseases, farmers request for better plant varieties and job creation for young people.

The creation of a platform is useful to promote interaction and networking among all actors involved and facilitate the generation and dissemination of innovation to farmers and agribusiness groups.

The development of agricultural research in Eritrea is outlined in generation I, where the linkages between researcher, extension and farmers are linear, directed by

researchers. The linear linkage does not include extension workers and farmers in research design, priority setting and innovation processes, and as a result, the adoption and use of the research is low. The research approach in generation I, is commodity-based and it does not include the production system that focuses both on crops as well as on national resource conservation and management.

The AIS assessment showed that there is a capacity gap in the technology generation. Most of the researchers are young and lack experience to be able to generate sound innovations to solve farmers needs. Besides this, there is a high staff turnover due to a lack of incentives, namely salary increment and promotion. On the other hand, the assessment showed that there are moderate infrastructures such as laboratories, equipment, seed cleaning machines, office buildings, storage buildings, etc. that enable researchers to accomplish their innovation processes. The assessment for capacity development and enabling environment showed that there are adequate skills, knowledge and attitudes; however, they are not put into practice. This could be caused by the lack of experiences of the human resources to generate appropriate technologies to solve farmers needs. Former Eritrean agricultural policies focused on enhancing productivity and ensuring food security, however, since independence in 1991, over 22 policies, proclamations, legal notes, regulatory, standards and guides have been issued for the advancement of agricultural development.

During the AIS assessment, it emerged that over 100 different technologies including cereals, vegetables, fruits, animal feeds, etc. have been released for production in the last 20-25 years. Most of these technologies were developed and released by NARI and disseminated by AED, Ministry of Local Government (MoLG), HAC, NARI and Village Development Committee (VDC)to farmers for production.

In conclusion, the assessment showed that there is an Agricultural Innovation System in place but there is no platform, hence, no interaction among the actors. The research development in generation I is based on a commodity approach. Besides, the linkage between actors is linear or top-down and the human resources have little experienced. The extension system is production-oriented rather than market-oriented. Many policies, proclamations, legal notes were developed and submitted to Ministry of Justice but still (to date) not been approved.

Recommendations are given in two distinct phases. Phase I should focus on creating linkages between research, extension and farmers whilst the research should centre its activity on farmer's needs and demands. The current commodity-research approach will be changed to a production system approach with more focus on crops, livestock and environmental conservation. The extension system will be market-oriented rather than production-oriented. In phase II, the main activities will include the development of an improved sustainable seed production system and human resources, as well as improving the extension infrastructure such as Information and Communication Technologies (ICT) and mobile for technology dissemination.

1. Introduction

The Food and Agriculture Organization of the United Nations in Eritrea, in partnership with the Ministry of Agriculture (MoA) is implementing the national component of a global project entitled "*Developing Capacity in Agriculture Innovation System Project: Scaling up the Tropical Agriculture Platform Framework"* (GCP/GLO/017/EC). The project aims to strengthen capacities to innovate for climate resilient agriculture and food system. It also targets at making Agricultural Innovation Systems (AIS) more efficient and sustainable in order to meet the demands of farmers, agribusiness and consumers, taking into account the different dimensions of Capacity Development (CD) (individuals, organizations, enabling environment) as well as its functional and technical capacities. The project is part of a large European Union initiative *"Development Smart Innovation through Research in Agriculture (DeSIRA): Towards climate relevant Agricultural and Knowledge Innovation System"*, which supports the implementation of the Tropical Agriculture Platform (TAP).

The Agricultural Innovation System (AIS) in Eritrea is based on the interaction of research extension and farmers. However, the technology generated by the research and education is hindered by many factors including human development and availability of equipment and infrastructure, and by low financial investment. Besides this, the interaction between the stakeholders such as input suppliers, farmers organization, market, land issues (land tenure system), policy issues and others is very poor. As a result, the production and productivity of the agricultural sector is scarce, which causes food insecurity and migration of the young to urban areas.

In the AIS approach, a paradigm shift takes place, diverting from linear and top-down model of technology transfer from research to extension to farmers, towards a system approach to agricultural innovation. Hence, assessing agricultural innovation systems is a precondition for identifying key areas requiring strategic interventions to strengthen their effectiveness and efficiency to meet the needs and demands of transformation in the agriculture sector.

The FAO-TAP has developed user-friendly tools to facilitate assessment of agricultural innovation practices and systems to gain a better understanding of enablers and disablers to generate evidence based findings for effective decision-making to strengthen and prompt transformations and achievement of the Sustainable Development Goals (SDGs). Generally, this project is nested within a broader macro policy of various countries National Agricultural Research Institutes (NARIs), which aims at reducing poverty and ensuring socioeconomic development of rural farming communities.

This AIS Assessment Report is easy to read and to understand. It is an overview of the national AIS (including drivers, actors, strength, capacities, gaps, challenges and opportunities); it identifies entry points for strengthening capacity of AIS (including

institutions, policy environment, collaboration, coordination and networking), with recommendations to strengthen capacity to innovate (individual, organizational and policy-functional and technical capacities).

The main objectives of AIS assessment are:

- to characterize and make a stocktaking of AIS and provide insights on factors that determine their capacity to foster and promote inclusive and responsible innovations;
- to identify critical gaps, needs, opportunities, good practices, etc.;
- to support the formulation of applicable recommendations aiming at strengthening and making AIS more effective;
- to develop an understanding of AIS and how it functions and supports climate-relevant transformation of agriculture and food systems;
- to identify major bottlenecks and identify entry points for strengthening AIS in Eritrea; and
- to inform policy and decision makers on performance of AIS and make recommendations for improvement.

A scoping study of agricultural innovations for climate relevant in Eritrea was conducted in August 2020. The study assessed the agricultural development in Eritrea, climate smart practices, key stakeholders, policies and strategies and challenges and opportunities of the agricultural situation of the country. The scoping study identified 25 innovations and conducted an in-depth analysis on 12 of these innovations. The findings and recommendations of the scoping study are considered in this country assessment report.

1.1. Research approach

The approach adopted while conducting the assessment mainly includes:

- Integrated analytical framework: structural, functional, capacity and policy environment analysis.
- Actors-centred: capacity development, joint discovery, learning by doing, strengthening linkages with policy.
- Formative: non-judgmental approach, conducive to learning, joint discovery and improvement.
- Engagement: involvement and engagement of relevant actors through multi-stakeholder participatory processes.
- Alignment with national goals and priorities for agricultural sector and rural development.

1.2. Research methodology

Capacity Development: Country team has been trained by the FAO Research and Extension Office of Innovation (OINR) on the basic principles of AIS assessment and customized tools to country situation. Ten days training process, through virtual communication with the trainers, was organized at FAO-Eritrea office. The sessions were AIS background and case studies.

Desk review and analysis of secondary data: Desk review and sourcing of information from available departments, which included meeting and conference proceedings, annual progress reports, MoA, Monitoring and Evaluation (M&E) databases and documents were collected and verified. There was also a review of current policy documents, guidelines, strategies and manuals of CDAIS project. Key issues were identified for further examination and consideration.

Focal Group Discussion: Qualitative and quantitative data were collected on the structural, functional, capacity and enabling environment and the interaction between these components. Focal group discussion were held with the senior innovation experts and carried out by using open-ended questionnaires. All relevant information has been recorded for analysis and reporting.

In-depth Key Informant Interview and discussions: The Key Informant Interviews (KIIs) were conducted with department heads, project coordinators and programme leaders/experts from relevant government ministries and departments, as well as from various international, national, community-based, civil societies and private sector organizations. The interviews were carried out in accordance with AIS guidelines using semi-structured questionnaires.

Case studies: The working team has identified innovations for further case studies; three case studies were assessed in depth using case study assessment checklist.

Analysis and reporting: All collected data and information using the above stated tools, were summarised, compiled and analysed, to understand how individuals, organizations and institutions are involved or are working on AIS capacity development. This has helped to understand which parties have a role in the implementation of actions in the country. During the analysis of the result or outcomes, the case studies were taken into consideration for further development. To assess the networking, the study team applied questionnaire and discussed it with key actors. Stakeholder analysis was used to analyse the structural assessment findings and the results are reported with detailed analysis of the actors, their characteristics and priorities.

1.3. Structure of the report

Section one – Introduction: defines the report objectives, scope, limitation and methodologies used to implement the AIS guidelines.

Section two – Country context: reviews the national sector policies and challenges, analysis of agricultural innovation, extension practices and education, as well as key institutional partners of innovations, innovation type and growth potential, vision for agriculture development, AIS role, contribution, challenges and constraints.

Section three – Results and discussion: presents the main findings of the assessment including structure, functions, capacity and enabling environment. It also describes the case studies, relevance of innovation, research and development institutions, linkages and networking, past and ongoing efforts in capacity development in AIS, setting the ASISD for AIS project operation, collaboration and funding, dissemination and adoption of the innovation, lessons and processes reflection and effects of innovations/outcomes of innovation.

Section four – Conclusion and recommendations: includes the major outcome of the study and gives recommendations for future implementation of the innovation system in the country.

Section five – Annex: presents the three case studies assessment findings.

2. Understanding the context

2.1. National development context

Eritrea is situated on the western shore of the Red Sea and has a coastline over 1 200 km and a total land area of 124 000 km^2. For several decades, Eritrea was diverted from its development path as a result of "no-war, no-peace situation" and ten years of international sanctions.

The situation normalised with the signing of the peace agreement between Eritrea and Ethiopia in July 2018 and the lifting of sanctions by the United Nations Security Council in November 2018. Since then, Eritrea has been gradually moving towards development and resilience-building, but in a context in which it remains highly vulnerable to economic, climate and exogenous shocks, including fluctuating commodity prices for its raw material exports, as reported in the African Economic Outlook 2021, African Development Bank (AfDB).

Eritrea's population is estimated to be 3.29 million, with an annual growth rate of 2.5 percent. About 70 percent of the population is under 35 years old as per Government estimates for 2012. Women constitute 55 percent of Eritrea's population (FAO 2016) of which 47.2 percent are household heads as reported in the Eritrea Population and Health Survey (EPHS), 2010. Cultural factors and unequal access to inputs and economic opportunities constrain women socio-economic empowerment in rural areas.

Malnutrition among children under five years old has led to a severe burden of stunting (50.3%), underweight (38.8%) and wasting (15.3%), EPHS, 2010. Causes include chronic under nutrition and micronutrient deficiency. Eritrea scored poorly (33.8%) on the Global Hunger Index in 2014 (International Food Policy Research Institute – IFPRI, 2018), being heavily dependent on food imports, Eritrea is also severely affected by variations in international food prices, which continue to have detrimental effects on rural net food buyers and other vulnerable people.

2.2. Agriculture sector review

Agriculture has been, in the past, the cornerstone of the Eritrean economy and is still the main source of income and food for more than 75 percent of the population. Eritrea has substantial and varied natural resources with modest land and water resources that can be developed to sustain socio-economic growth. According to FAO Country land use classification (1994), four percent is cultivated land, 49 percent is grazing and browsing land, one percent is forest and bush land, six percent is wood and shrub land, two percent is unproductive land and 33 percent is unusable land.

Eritrea has a potential 2.1 million hectares of arable land, of which an average of 500 000 hectares are currently cultivated under rain fed (mainly cereals) and about 600 000 hectares is potentially irrigable, out of which 60 000 hectares are irrigated with spate irrigation, being the most commonly used technique. Traditional rain fed farming accounts for more than 88 percent of the cropped land. Under general conditions of considerable climate variability (erratic rainfall) and recurrent drought spells, the areas that are suitable for rain fed crop production are limited to the central highlands, south-western lowlands and eastern lowlands. Overall, the country has a huge potential for expanding its agricultural area, including irrigated agriculture.

The main crops cultivated in the country are cereals [sorghum, maize, wheat, barley and taff (*Eragrostis teff*)], oil crops (sesame and linseed), pulses/grain legumes (faba bean, field pea, chickpea and lentil) and horticultural crops (vegetable: tomato, potato, pepper, onion leafy vegetables; fruit crops: orange, lemon, mandarin, mango, papaya and guava). Sorghum is the main and dominantly cultivated crop both in the highlands and lowlands, which cover over 48 percent (240 000 ha) of the cultivated land in the country, followed by pearl millet and barley with 16 and 15 percent, respectively. In the highlands and lowlands, chickpea is the dominant crop among pulses, as it is widely produced both for grain production and as crop rotation to increase soil fertility.

The crop production and productivity in the country is low due to erratic and poorly distributed rainfall and drought, a common phenomenon in the country that happens every three to five years. Besides, in most parts of the country, the land has been cultivated for centuries without fertilization, leading to low soil fertility. There is no fallowing land due to farmers' low land-holding rate, less than one hectare per household in the highlands and about two hectare per household in the lowlands. The other factor for poor soil fertility is due to the land tenure system of the country (diessa system)[1] which is a hindrance to farmers to implement long-term measures for soil and water conservation managements of farmlands.

Field crops (horticulture, cereals, pulses, etc.) are produced mainly for home consumption and for sale to pay taxes, health and social services and purchase of clothes. Farmers usually store their harvest to be used during the rest of the year, the stores are made of plant materials and cow dung that is not pest and rodent proof, hence harvest loss can, sometimes, reach 11 percent for cereals and over 30 percent for pulses.

To overcome these challenges, the government is putting emphasis on water harvesting, using different techniques such as construction of dams, intensive soil and

1 A form of communal village land ownership system in the highlands. The especial feature is that land is redistributed every five or seven years. https://land.igad.int/index.php/documents-1/countries/eritrea/gender-2/448-women-and-land-rights-in-eritrea/file

water conservation activities, divert rivers for spate irrigation, dug wells in different parts of the country to supplement irrigation in crop production.

Although Eritrea per capita holding of livestock is one of the highest in the world, livestock and dairy production have also largely remained traditional, characterized by low productivity, due to poor genetic makeup, exasperated by disease and inadequate feed. Animals serve as a source of food (meat, milk and milk products), manure and draft power and as a mean of wealth accumulation. Overgrazing is a common contributing factor to land degradation, loss of agrobiodiversity and desertification.

The Eritrean coastal water for fishing covers more than 52 000 Km^2 and is endowed with a large number of fish species. The annual sustainable fish yield ranges between 80 000-100 000 tons annually.

There is a big potential to develop the crop, livestock, fisheries and aquaculture sectors.

2.3. Agricultural research and extension

Research and the extension system in Eritrea were established during the colonial time in the early nineteenth century by the Italians. The Paradiso Agricultural Research Centre, the oldest research centre in Africa after Egypt and South Africa, was founded in 1905, was established to generate new technologies or innovations to improve the agricultural production system of the country. During that time there was very little investment in agriculture, which mainly focused on supporting the Italian settlers in the country. The centre continued to generate technologies during the British protectorate, until the aggression of Eritrea by Ethiopia. Likewise, the extension system in the country started in the early nineteenth century. As the war with Ethiopia aggravated, the activities of research and extension system in the country slowed down until 1991 when Eritrea became independent.

After independence in 1991, the Government of the State of Eritrea revitalized the agricultural development of the country by decreeing line ministries including the Ministry of Agriculture (MoA). The MoA is responsible for the development of agriculture in the country through the departments of extension, research, etc. In 1991, the Paradiso Agricultural Research Centre was transferred from Paradiso to Halhale, which is about 35 km from Asmara on the road to Mendefera. The newly transferred research centre focused on field crop improvement, livestock research and management of natural resources as its research priorities. To achieve its goals, research centres were also established at Shambiko, Goluj and Sheib with sub-centres at Hagaz and Akordate. The first six to eight years after its re-establishment, it was supported by FAO through the Italian fund for the development of its research activities, infrastructures and human resources.

Currently the research centre is well developed and has more than 85 research members and infrastructures facilities such as laboratories, equipment, seed cleaning, buildings, tractors and transport services. It maintains linkages with CGIAR and development agencies such as UNDP, EU and IFAD, etc.

Similarly, the extension division revived the development of research institute. Initially, the division focused on introducing farmers to improved crop production and farming methods by dissemination of inputs, soil rehabilitation, water conservation, water shade management, farmer training, demonstration of improved production system, etc. In the early 1900, the Training and Visit (T&V) extension approaches were used until the Farmers Advisory Service (FAS) system was adopted as the prevailing agricultural extension service approach supported by farmer field school. The approach was intended to be participatory, grass-rooted and focused on farmer demands, aiming to improve agricultural production at a low cost with appropriate technology. Since 2000, the FAS approach has been implemented by MoA with MoLG and contact farmers as main partners and supported by Danish International Development Agency (DANIDA). Currently the extension approach is farmer field schools.

3. Main findings of the assessment

Assessment of Agricultural Innovation System in Eritrea

The assessment of Agriculture Innovation System in Eritrea was carried out by using structural, functional, capacity development and enabling environment analysis tools. Details of the results of the three case studies are shown in Annexes 1-3.

3.1. Structural analysis

A. Actors of the innovation processes

In the structural study, the main objectives were to identify stakeholders and their roles, mapping of their network and study their interactions. During the key informant and focus group discussions, over 35 different stakeholders/actors that include international agencies and research organizations (i.e. CGIAR), line ministries, local farmers and traders, businesspeople, entrepreneurs, were identified and their roles and responsibilities were studied (see Table 1). The role of the international agencies and research partners were to provide funds, short- and long-term training, supply germplasm for research and technical assistance, while the role for most of the line ministries was to support the innovation process by assisting and participating in technology generation and transfer mechanisms. The American cereal and disease laboratory, Canada and Denmark rust laboratories participate in collection and identification of Eritrean wheat rust. Civil societies such as National Union of Eritrean Women (NUEW), National Union of Eritrean Youth and Students (NUEYS) and NGOs participate in the dissemination of technologies to end users and act as a bridge between researchers and farmers. Farmers and entrepreneurs participated in adoption of technologies, however, farmers' participation in the innovation process was very low and was mainly during on-farm trials and at various release stage. Whereas, farmers, traders and agribusinesses should participate in the innovation system starting at the innovation process of the project.

Table 1. Partners, their roles and responsibilities

Partners	Roles and responsibilities
International Partners	
EU	Provide funding, training and technical assistances for research activities of sweet potato, conservation agriculture, climate smart agriculture, community seed multiplication and others.
UNDP	Provide funding, Minimum Integrated Household Agricultural Package (MIHAP), funded improved stove mogogo through its small project grant/support.

Partners	Roles and responsibilities
IFAD	Provide funding, training and technical assistances for many projects in the country National Agriculture Programme (NAP).
AfDB	Provide funding and technical assistance.
AU	Provide funding for capacity building and technical assistances for promotion of quarantine and training.
FAO	Assist and funding, training, and technical assistances to NARI, AED and RSD, value chain in dairy, initiate AIS in Eritrea in collaboration with the MoA.
IAEA	Provide training, funding and technical assistance.
American cereal and disease lab	Provide wheat rust race analysis and identification.
Canada	Assist wheat rust laboratory analysis and identification.
Denmark	Provide wheat rust race analysis.
EIDP	Provide potato variety dissemination and capacity building.
Swiss Support Committee for Eritrea (SUKE)	Introduce grape variety seedling and provide capacity building.
Luke Finland	Provide material and equipment for NARI and AED.
CIMMYT	Supply germplasm of wheat and maize to NARI, funding technical capacity and training.
ICARDA	Supply germplasm of wheat, barley, chickpea, faba bean, funding, technical capacity and training to NARI.
ASARECA	Supply germplasm, provide funding and training.
International Centre of Insect Physiology and Ecology (ICIPE)	Push-pull for Fall Armyworm and *striga* management, insect identification, biological control of stem borer.
ICRISAT	Supply seed of sorghum and pearl millet for trials, fund, technical support and provision of staff training.
IDP	Provide capacity building, material supply, transport facility.
International treaty on plant genetic resource	Provide funding and staff training in genetic conservation and management.
National	
AED	Dissemination of varieties, input distribution, organize training to DAs, farmers and other technologies.
DeSIRA	EU initiative by to contribute to climate-relevant, productive and sustainable transformation of agriculture and food systems to HAC and AED and NARI.
Farmers	Participate in technology dissemination and adaption, provision of land to AED and NARI for on-farm trial and for conducting demonstration and technology evaluation.
HAC	Provide human resources, generate technologies and dissemination of technologies to users.
NARI	Generate technologies, provide training and dissemination

Partners	Roles and responsibilities
	technologies to users.
RSD	Contribute to food safety and quality and feed through quarantine, inspection of food (farmed and processed), feed, seeds, agrochemicals, forestry, wildlife, agricultural project, and issuing relevant permits and certificates. Provide performance evaluation and certification according to guidelines and proclamations.
Farmers association	Information sharing in innovation process and implementation/adoption, participate in technology evaluation.
TVET- MoE	Provide human resource-agricultural technicians.
Traders	Supply inputs: feed, fertilizer, pesticide, vegetable seeds, etc.
Red Sea Corporation	Provide seed, farm tools, equipment, veterinary medicine, pesticide, fertilizer, etc.
Asmara brewery	Malting barley user for beer industry in the country.
MoA	Policy development, technical support, project coordination, monitoring and evaluation.
MoF	Funding or approve budget.
MoH	Nutrition, control of zoonotic diseases.
MoLG	Bridge the gap between farmers and MoA and other development agencies.
MoI	Dissemination of innovation to farmers through radio, TV and newspaper.
MoND	Approval of funds (national development programmes).
MoLWE	Conservation of biodiversity, land tenure and land use, develop policy on environment.
Ministry of Marine Resource (MNMR)	Provide feeds, nutrition, both for human being and dairy production.
NUEW	Dissemination of innovations acting as a bridge between household and extension.
NUEYS	Dissemination of innovations acting as a bridge between household and extension.
Segen Construction Company	Construct dam, provide construction equipment and machines.
ECLC	Participate in dissemination of seed, irrigation and others.
ASISD	Coordination and guidance of AIS.
Science and Technology Commission	Approve technology.
Association of Eritrean in Agricultural Sciences	Platform for agricultural discussion.

B. *Source*: FAO

C. Interaction

The use of Innovation Platforms (IPs) is the result of the systemic thinking of the innovation with more emphasis on promoting positive interaction among stakeholders in the AIS. An IP is described as a forum established to foster interaction among a group of relevant stakeholders around a shared interest. Its effectiveness is enhanced by sustained interaction among the stakeholders through joint learning and sharing of ideas.

As the focus group assessment indicated, the main roles of stakeholders are to participate in policymaking, dissemination of information, inspection and generation of research results, training/education, funding, knowledge sharing, input supply and facilitation of marketing services (Table 2).

Table 2. Stakeholder interaction/ networking and collaboration

Actor	Interaction	Linkage/contribution
MoA (NARI, AED, RSD, HRD, ASISD)	Line Ministries (LM), farmers, farmers association, HAC, civil societies, International Agencies (IA), private sector	Fund raising, technology, trained labour force, participate in dissemination and provide input, equipment, regulation and inspection, variety evaluation, sharing of information.
Line Ministries (LM)	MoA, NGOs, private sector, HAC, farmers, farmers association, IA	Disseminate technologies, provide land, fund provision, sharing of information.
International Agencies (IA)/ partners	MoA, LM, NGOs, HAC, farmers	Provide funding, technical support, training, act as a bridge between research and farmers.
Educational Institutes (HAC, TVET)	Private sector, farmers, MoA, LM, Corp, IA	Train labour force supply, research, extension and fund provision.
Civil Societies (NUEW, NUEYS)	MoA, LM, IA, farmers, farmers association, corporation	Dissemination of technology.
Corporation (Red Sea, ECLC)	MoA, LM, civil society, HAC, farmers, farmers association	Purchase inputs, disseminate technology to farmers and sharing of information.
NGOs (ErCS, EIDP)	LM, MoA, private sector, farmers, farmers association, IA	Provide funding, technical support, dissemination of innovation to farmers like seed, veterinary medicine, improved breeds, etc.
Farmer, farmers association	MoA, Line ministries (LM), farmers association, HAC, civil societies, IA, NGOs, private sector, corporation	Fund, dissemination, input supply, land, adoption of technology, inspection, grant permits and certification, etc.
Private sector (traders, agribusiness, food and feed processors, etc.)	Farmers, NGOs, farmers association, HAC, corporation	Input supply, market access, value chain development sharing of information.

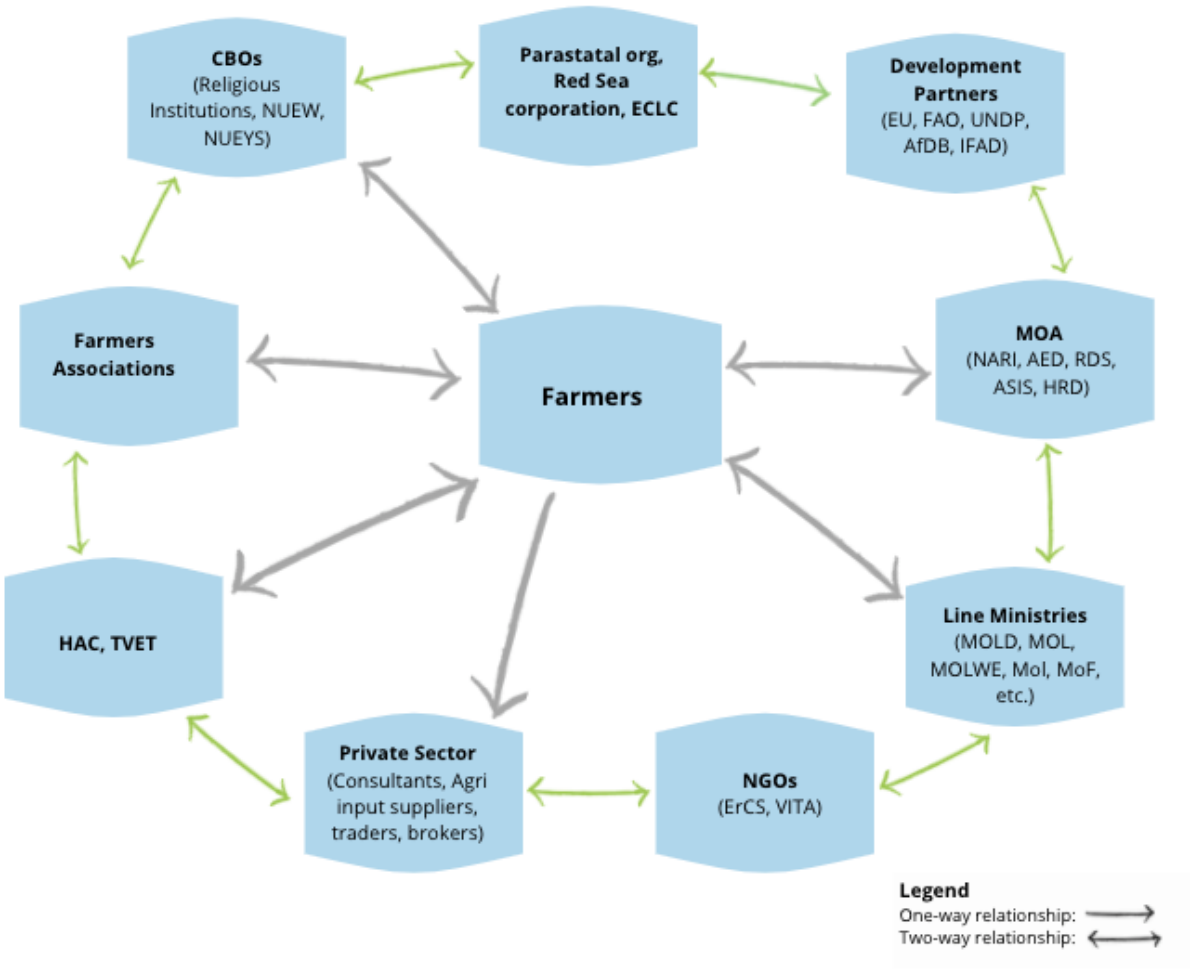
Source: FAO

D. Stakeholder network mapping

Stakeholder mapping was carried out through an intensive review of the collected information from MoA documents, FGD and KIIs. Networking and partnerships among stakeholders (private sectors, producer organizations, extension workers, education institutes and research organizations) is essential and represents a basis for sharing of ideas, participate in innovations development, processing, marketing in agricultural development.

- The main stakeholders in knowledge generation are NARI, HAC, NAPHL, CGIAR groups.
- Knowledge dissemination group include AED, MoLG, MoLWE, MoI, ErCS, EIDP, NUEW, RSD, NUEYS, crop livestock corporation.
- Funding is done by MoF, with the support of EU, UNDP, IFAD, AfDB, AU, FAO and IAEA.
- The groups in resource mobilization include development partners and MoF.
- Entrepreneurs include traders, small and medium agro-enterprises, Asmara brewery, vegetable and dairy farmers associations.
- Marketing, which is not yet well developed, is done by small traders and retailers.

The result of the network/mapping is shown in Figure 1.



Source: FAO

Figure 1. Stakeholders' network map

In all the three case studies (Annexes 1-3), FGD or key informant, the linkage between research, education, extension, farmers and others is linear or top-down directed by researchers. About 17 percent of the interviewed farmers reported that they do not have any linkage with research, 50 percent of the farmers reported their linkage with research is very poor, while 33 percent of the key informant farmers have moderate linkage with NARI.

E. Stakeholder importance and influence

During the study, four important and influencing stakeholder groups were identified as:

Group 1. Stakeholders that have **high importance and low influence** include EU, UNDP, IFAD, AfDB, FAO, AU, IAEA, CIGAR (ICARDA, ICRISAT, CIMMYT, and ILRI), ASARECA, Swiss Support Committee for Eritrea (SUKE), MoF and NAPHL. These groups are highly important as they provide funding and technical support and participate in technology generation. However, they have a low influence as they are not involved in dissemination of input and do not interact directly with farmers.

Group 2: Stakeholders that have **high importance and high influence** are AED, HAC, NARI, RSD, DeSIRA, ASIS, farmers, farmers association and MoLG. They are highly important because they are directly involved in innovation processes and they are highly influential due to their involvement in innovation dissemination.

Group 3. Actors/stakeholders that are involved with **low importance and low influence** are Asmara Brewery, MoE, NUEY, NUEW, Fishery and Segen Construction Company. These groups have low importance and low influences; they are not involved in technology generation nor in technology dissemination.

Group 4. Stakeholders that have **low importance but have high influence** are Traders, Red Sea Corporation, MoLWE, MoND, MoF and MoI. These groups have less importance because they have less participation in technology/innovation generation. However, the groups are highly influential as they are involved in dissemination of innovations.

Stakeholders importance and influence are represented in

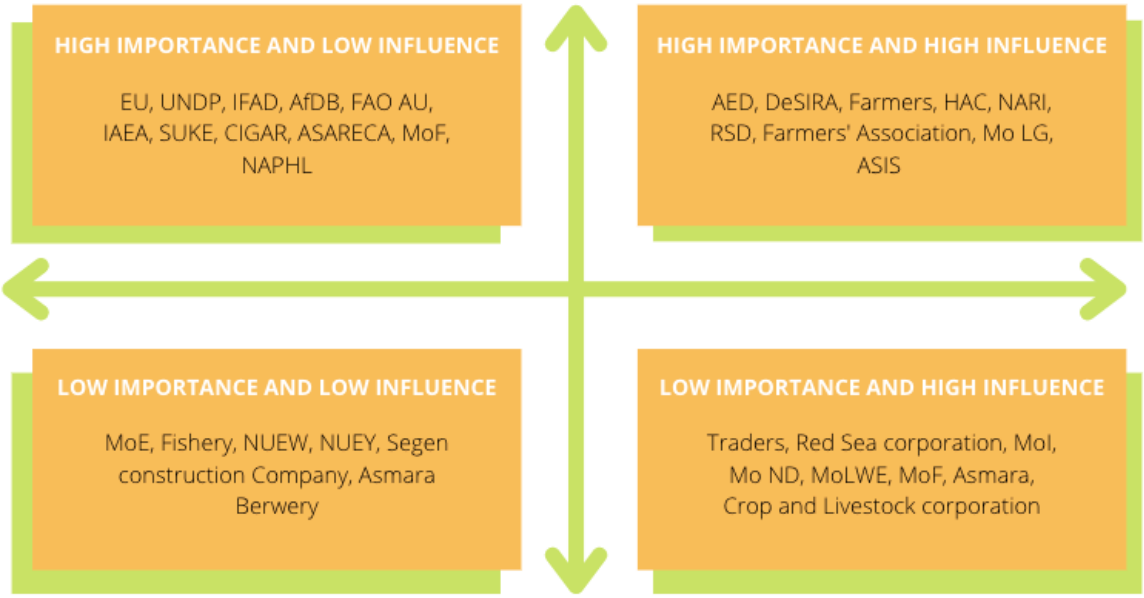


Figure 2.

Figure 2. Stakeholders importance and influence

F. Platform between research, education, extension, farmers and private sectors

The three case studies (Annexes 1-3), key informant and FGD study results, showed that about 94 percent of the participants reported they do not have an information and interaction exchange platform; only 6 percent of the respondents reported that they are part of a farmer association constituted of vegetable producers, dairy producers, bee producers and Eritrean women in agribusiness. In practice, these associations work in the same manner as a platform, by creating interactions with research, extension, traders and retailers. There are, however, opportunities to create platforms of vegetable producers, dairy producers, sesame producers, citrus producers, banana producers, fishery, urban agriculture, etc.

G. Formal and informal structures

In the country, there are formal and informal structures. The formal structure includes knowledge generation and dissemination, regulatory bodies or system coordinated platform and market development. The informal structures include the farmers and private sectors such as traders, processors and local farmers or social gatherings.

The main actors for the formal structures include NARI, HAC, ASISD, AED, MoLG, MoI and RSD, whilst for knowledge generation and dissemination the actors are: AED, TVET, MoI, ECLC, development organizations, NGOs, NUEW, RSD and MoLWE.

H. Mechanism for decision making in the innovation process

All decisions for innovation, strategic and annual plans, agreements (EU, UNDP) and management, are formally taken by the Government through the MoA and concerned organizations. Informal decisions are taken among farmers, traders, agribusiness and others suppliers of fertilizers, seeds, farm tools and chemicals.

I. Insights on underlying causes of AIS performance (Output 1)

According to case studies, FGD, key informants and scoping study, the main driving forces for agricultural innovation are: climate change, low crop production per unit area, farmers request to improve their production and production techniques, improve income, create jobs for young people and solve the major bottlenecks that affect production and development at large (Table 3).

Table 3. Driving/triggering forces and bottlenecks

Driving/triggering force	Bottlenecks
• **Develop smart climate agronomic practices to combat climate change.** • **Low crop production due to low use of inputs.** • **Farmers request to solve their problems.** • **Pests and diseases are major problems causing low crop production.** • **Develop early maturing and high yielding crop varieties.** • **Job creation.** • **Income generation for production of cash crop that has a high market demand.**	• Poor linkage among research, extension, farmers and educational institutions. • Poor resources mobilization - low fund, facilities, labour force, capacity building, procurement delay, etc. • Staff brain drain and staff turnover is high. • Most of the researchers are young and need further training. • Limited capacity in multiplication of innovation (seed, tools, etc.). • Low adoption and scaling up of new technologies. • Lack of staff training. • Shortage of skilled human resource. • Water problem for laboratory work and irrigation. • Logistics support - transport, budget, funding, storage problem, shortage of chemicals, infrastructure, spare parts/equipment, laboratory materials/equipment, etc. • Poor regulation capacity, weak inspection service. • Procurement delay because of long procedures.

Source: FAO

J. Opportunities for improving AIS performance (Output 2)

Opportunities for improving the AIS performance in Eritrea are very high due to the availability of modest laboratories for conducting research and infrastructures and building of offices. The other opportunities are conducive policy and strategies that enable the researchers to have research centres for conducting trials. Besides, the country has dedicated human resources for the provision of services at different levels and high farmer adoption capacity of new technologies.

3.2. Functional analysis

A. Existing agricultural innovations

The National Agricultural Research Institute is the main actor in innovation development and generation in the country through its multi centres located at potential production areas of the country. HAC conducts its research mainly in Zoba

Anseba, while NAPHL is responsible for animal diseases study/survey throughout the country. According to the key informants and FGD studies, there are over 160 innovations/technologies generated by the different units of NARI and HAC (Annex 4). Agronomy, natural resource, horticulture and animal science units are major generators of technologies. HAC, ASISD and NAPHL are involved in 16 innovation processes in total. In general, over 72 percent of the innovation processes are in crop or crop related activities and the remaining 28 percent of the innovations process belong to animal science and agricultural engineering units (Table 4). During the study, it was observed that there is no platform or interaction network to coordinate the different research institutes in the country. As a result of this, there is less interaction among the researchers that could have been useful to coordinate AIS and avoid duplication of work in the country.

Table 4. Agricultural innovation on processes

Department	Unit	Number of innovations/technologies	%
NARI		**145**	**90**
	Bio tech	9	6
	Horticulture	19	12
	Plant Protection	11	7
	Agronomy	42	26
	Natural Resources	24	15
	Plant Genetic Resources	7	4
	Animal Science	18	11
	Agri Engineering	15	9
HAC		**13**	**8**
	Agronomy	4	2
	Horticulture	4	2
	Plant Health	2	1
	Animal Science	1	1
	Natural Resources	2	1
ASISD		**2**	**1**
	Hydroponic	1	1
	Aquaponic	1	1
NAPHL		**1**	**1**
	Vaccine development	1	1
	Total	**161**	**100**

Source: FAO

B. Innovation/technologies released, their acceptance and impacts on the beneficiaries

During the FGD study, the participants reported that over 100 different technologies have been released for production and use in the last 20-25 years (Table 5). The agronomy unit released most of these innovations, their seeds are multiplied or increased on farmers fields under the close supervision of the researchers and senior extension workers. Similarly, many potato varieties have been also released and multiplied on farmers fields. All the technologies released/developed have been disseminated to farmers through different mechanisms such as demonstration, on-farm trials, field visit and leaflets/brochures. The major problems, for released varieties, are that the varieties get mixed and lose their purity after one to two years of release/production. During the study, some of the released innovations/technologies were not accepted due to different reasons (Table 5). To minimize the rejection of technologies, care should be taken to allow farmers to participate in the innovation processes, through platforms, from the beginning of the research plan to incorporate farmers needs, prioritize problems and views in technology generation; these will help for better adoption and to minimize the rejection of the technology at the end.

Table 5. Innovations outputs (released)

Group	Crop type	No. variety released
Cereals	Wheat	16
	Barley	7
	Sorghum	13
	Pearl millet	6
	Maize	3
Legume	Bean	2
Oil crop	Sunflower	1
Vegetables	Pepper	8
	Potato	11
	Onion	1
	Garlic	1
	Sweet potato	5
Fruit	Lemon	1
	Banana	3
	Date palm	5
	Papaya	1
	Citrus	6
Animal feed	Forage	4
Natural resource	Water conservation	2

Source: FAO

C. Relations with functional, structural and capacity analysis

The relationship with functional, structural and capacity analysis are clustered into six functions:

1. Knowledge generation
2. Dissemination
3. Institutional support
4. Involvement of entrepreneurs
5. Financial institutes
6. Commercializing input supply and socialization or collective action.

The first three cluster functions perform well in functional, structural and capacity analysis, while the remaining three cluster functions lack appropriate cohesive relationship due to the absence of platform, network and interaction formation in the agricultural development system. The last three cluster functions are not involved in the innovation processes; some of the generated technologies (improved stove) so far are not commercialized in the country due to the absence of input supplies (Table 6).

Table 6. Relations with functional, structural and capacity analysis

Functional analysis	Structural analysis	Capacity analysis
Cluster of functions identified	Who carries out the functions, Interrelations between them	Capacities needed to perform those functions Capacities exist at present
Knowledge generation	Org 1. NARI Org 2. HAC Org 3. NAPHL	**Exist**: NARI has Pearl millet breeders, Pearl millet pathologist HAC: has sorghum breeder, sorghum entomologist NAPHL has microbiologist **Need**: NARI needs breeder for many crops, agronomist, pathologist, entomologist HAC needs pathologist, soil expert, socio-economist for evaluation of technology NAPHL needs bacteriologist and virologist
Knowledge Dissemination	Org 1. AED, NUEW, HAC, NUEYS, ErCS, EIDP Org 2. MoI, MoLG Org 3. Farmers	**Exist**: AED, NUEW, NUEYS, MoI, MoLG, HAC, ErCS, EIDP involved in dissemination **Need**: trained extension workers at village level

Functional analysis	Structural analysis	Capacity analysis
Institutional support, funding agencies	Org 1. UN systems Org 2. MoF Org 3. MoND	**Exist:** EU, UNDP, IFAD, DeSIRA, MoF, CGIAR are funding organization, provide funding to NARI and HAC **Need:** Socio-economist to conduct on-farm trials
Entrepreneurs Finance institutions	Org 1. EDIB, SMCP, MoA Org 2. MoF Org 3. Private sector	**Exist:** EDIB, SMCP, MoA, MoF finance entrepreneurs **Need:** Credit, cooperatives
Commercialization, Input supply	Org 1. MoA, Traders Org 2. SMCP Org 3. Agribusiness	
Socializing change, collective action/social processes	Org 1. Farmers association Org 2. MoLG Org 3. Science and Tech Commission	**Exist:** Farmers association (vegetable and bee, EWWA and dairy producers) **Need:** Cooperatives, understanding process of micro, meso, macro; platform, interaction, involve Science and Technology Commission

Source: FAO

D. SWOT analysis

SWOT analysis was done to study the challenges and opportunities of the functions. The SWOT analysis showed that there are threats and weaknesses in knowledge generation, which need urgent action for appropriate technology generation in the country (Table 7).

Table 7. SWOT analysis to strengthen the key functions

Strengths	Weaknesses
• Availability of committed and dedicated human resources • Strategic plan is well prepared • Availability of Research Institutes (NARI and HAC and their research centres) • Availability of land at the different centres for conducting research • Availability of land race of different crops • Agro-ecological zone conducive for research work for screening or adaptation test • Availability of laboratory, equipment and infrastructure	• Lack of transport for survey work, station work or farmer field visit • AIS not implemented in the research system • No team approach in innovation process • Most of the researchers are very young with little research experience • Brain drains and high turnover of research staff
Opportunities	**Threats**
• Conducive policy and strategies, regulatory frameworks • Government allocated budget for agricultural research • High possibility to get national and international support (fund, technical, etc.) • There is a possibility to get quality water and land from nearby dam and government farm	• Budget shortage for field visit and on-farm trials • Disease and pests like wheat rust, *Tuta absoluta* • Low adaptation of innovations • No placement of research assistance • No networking, platform formed • Poor or no linkage among researchers • Linkage among research, extension and farmers is linear or top-down

Source: FAO

The function of stakeholders for the network mapping is shown in Table 8.

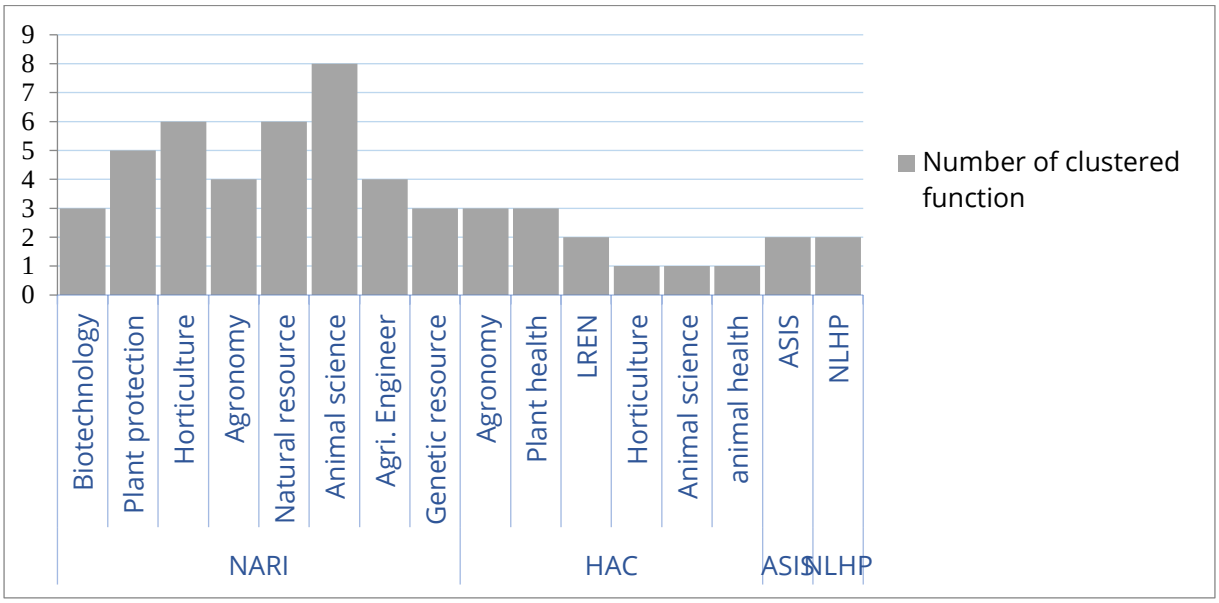
Table 8. Function of the stakeholders

Functions	Stakeholders
Knowledge generation	NARI, HAC, NAPHL, CGIAR groups
Knowledge dissemination	AED, MoLG, MoLWE, MoI, ErCS, EIDP, NUEW, NUEYS, Crop livestock corporation
Funding	EU, UNDP, IFAD, AfDB, AU, FAO, IAEA and MoF
Resource mobilization	MoF
Enterprise development	Traders, small and medium agro-enterprises, Asmara brewery, vegetable and dairy farmers associations

Source: FAO

E. Knowledge generation

Most of the time, agricultural knowledge in Eritrea is generated by researchers (NARI). During the FGD and key informant study, a total of 161 innovation processes were recorded mainly from NARI (145) followed by HAC (10), ASISD (2) and NAPHL (2). From the 161 innovations, 53 functions were clustered, of which 39 were from NARI, 10 from HAC and the remaining from ASISD and NAPHL. The highest cluster (8) is recoded from NARI animal research unit, this is due to the fact that innovations in animal science are quite different from each other hence it was difficult to cluster them. The same is true for natural resources. The agronomy unit, which has the highest number of innovations (42) has only four clusters. HAC has a total of ten clusters belonging to four departments, as shown in Figure 3.



Source: FAO

Figure 3. Institutes and innovation functions for knowledge generator

F. Knowledge dissemination

Knowledge generated is disseminated to farmers and users through AED, NUEW, MoLG, ErCS, HAC and MoI. The disseminations are performed through various mechanisms such as demonstrations, organized field days, field visits, training to farmers, distribution of leaflets, brochures and manuals. In Eritrea AED is the major disseminator of technology through its different units or subject matter specialists such as agronomist, horticulturalist, home science, animal production and others. In general, over 30 different technologies have been disseminated or demonstrated to farmers in the major production areas of the country. The MoI disseminates agricultural innovations through radio, TV and newspaper. HAC concentrates its technology transfer around Hamelmalo areas. MoLG acts as a bridge between research, extension and farmers in technology transfer through Zoba, sub-Zoba and village administration. ErCS

and NUEW participate in technology transfer in different parts of the country. The main technologies for dissemination are improved seeds, fertilizers, pesticides, forage technologies, vaccines, beehive, improved chickens, farm tools and energy saving stove (Annex 5).

G. Market development

At present the agricultural input supply is done through the credit and marketing unit of the MoA, which provides inputs like, fertilizers, seeds, pesticides, tools, AI and veterinary medicines. Most of these inputs are also supplied by traders but the prices are very high. Credit to farmers is also provided by Saving and Micro-Credit Programme (SMCP) and the Eritrean Development and Investment Bank (EDIB).

H. Entrepreneurial activity:

There are very few entrepreneurial activities in the dairy industry, horticultural production, beekeeping, milk processing and large-scale (5-20 ha) sorghum and sesame producers in the country. These entrepreneurs get credit from EDIB.

I. Resource mobilization

The main resources mobilized are budget, technical support, provision of inputs, and logistics that are provided by MoF and development partners such as UNDP, EU, IFAD and AfDB.

J. Infrastructure

Infrastructures includes laboratories, buildings, net house for different activities and irrigation structures that will help to pave an enabling environment for efficient research activities.

K. Preliminary entry points - for strengthening the key functions

- Strengthen the innovation processes through the participation of researchers, extension, education institutes, farmers, farmers associations, traders, processors etc.
- Establish platform for different agricultural production system that consists of researchers, extension workers, farmers, traders, processors and regulatory organizations.
- Create an interaction among actors or stakeholders in technology innovation processes and dissemination.
- Create and develop value chain processors in different agricultural production system.

- Transform the extension system from production in to market oriented production system.

3.3. Capacity analysis

Agricultural research in Eritrea is the responsibility of NARI and HAC. Both institutes have a total of 197 staff of which 89 belong to NARI. NAPHL has 40 and the remaining 68 belong to HAC. Although HAC has the highest number of qualified staff, the research activity within HAC is very low, mainly due to shortage of budget and transport. As a result, all the research activities are done by NARI in different agro-ecological zones of the country, despite it has a shortage of experienced personnel.

Table 9. Research human capacity

Research organization	PhD	MSc	BSc	Total
NARI	1 (1.1%)	15 (16.9%)	73 (82%)	89
HAC	23(33.8%)	33 (48.5%)	12(17.6%)	68
NAPHL		2	38	40
Total	**24**	**50**	**123**	**197**

Source: FAO

At present, the number of staff in the AED is quite high and it is composed of graduates with a Bachelor of Science degree (B.Sc.), diploma and certificate holders. The extension agencies are well spread up to the sub-Zoba level and in some Zobas like Zoba Maekel, they are placed up to village administration level. Village administration usually has 500-1 000 households and it is the lowest administration level in the country. All the extension workers usually get pre-work training and in-service training at intervals and they have a good technical capacity for technology dissemination to farmers through training, demonstration and distribution of manuals or leaflets.

A. Capacity assessment

Assessment was done to understand the gaps and needs of capacity. The main gaps are poor linkages between actors/stakeholders, shortage of experienced research staff (breeder, plant physiologist, molecular geneticist, pathologist, etc.), transport for fieldwork, lack of platform, etc. The capacity needs to include incentives such as staff promotion, salary increment and availability of internet for easy communication. Besides this, there is a need of equipment and chemicals for laboratory use. In places like Halhale, the water is saline which is not good for laboratory and irrigation use (Table 10).

Table 10. Capacity gaps and needs

Gaps	Needs
Lack of skilled personnel	Training to staff both short and long term
No platform - Poor linkage between relevant actors	Development of standard, accountable and sustainable platform
Budget for conducting on-farm trials, field visit, survey	Budget to cover operational costs
Shortage of facilities and equipment	Internet for references, information, virtual workshop, equipment, means of transportation, chemicals for laboratory research, quality water both for laboratory use and irrigation during off season, land for trial, basic seed multiplication, training for extension staff, etc.
No clear policy on AIS	Setting of AIS policy adopting the AIS approaches
Staff brain drain and high staff turnover	Training, incentives and benefits; staff promotion and salary increment
Weak regulatory service	Training and equipment for inspectors

Source: FAO

B. Capacity profile

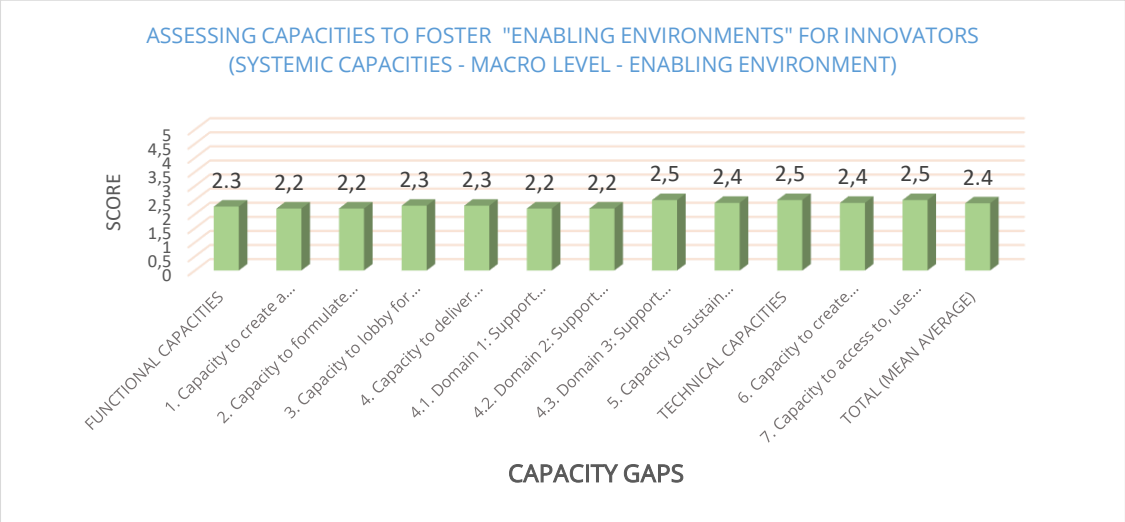
- **Type of organization:** Respondents belong to national research organization, extension/advisory services, regulatory services, and academia/education institute.
- **Experience in working in innovation fields:** Respondents have experience in working in innovation fields ≤ 5 years (0%), 5-10 years (30%), 10-15 years (10%), 15-20 years (30%) and ≥ 20 years (30%).
- **The main areas of experts/domain of innovation are:** agronomists, plant breeding, seed certification, entomologists, crop researchers, animal production, forage production, dairy development, agric. engineering, home science, extension.
- **Experiences with regard to AIS:** The number of participants reported: practical knowledge (40%), conceptual knowledge (40%), both practical and conceptual knowledge (15%) and none (5%).
- **Main outputs:** scientific papers (14%), policy papers (4%), project reports (27%), training manuals (24%), extension materials (16%), video (6%), database (4%) and others (6%).
- **Assessing capacities to foster enabling environments for innovators:** The result for the assessment for functional capacities to foster the enabling environment ranges between 2.2 to 2.5 with a mean score of 2.3 (Table 11). This showed that all the functional capacities are low in the ranges of skills, knowledge and attitudes, and even these, are not put into practice to create impacts/success. Similarly, the results of the technical capacity to create new products and

processes are in the range of 2.5 and 2.4 with a mean score of 2.5. Again, this result showed that knowledge and skill exist, but they are not in practice to generate innovations in the country. Table 11 and Figure 3.

Table 11. Assessment of capacities to foster "enabling environments" for innovators

Capacity Gaps	Score
Functional Capacities mean	**2.3**
1. Capacity to create a vision for improving innovators environment	2.2
2. Capacity to formulate comprehensive and inclusive innovation policies and instruments	2.2
3. Capacity to lobby for changes in the AIS toward more demand-led and interactive multi-actor innovation processes	2.3
4. Capacity to deliver demand-led innovation support services (in a responsive and coordinated manner)	2.3
4.1. Domain 1: Support services to Multifactor Innovation Partnerships (MIP)	2.2
4.2. Domain 2: Support services to Innovative Entrepreneurship (IE)	2.2
4.3. Domain 3: Support services to Technology Transfer (TT)	2.5
5. Capacity to sustain networking and broke raging among AIS actors	2.4
Technical Capacities	**2.5**
6. Capacity to create new technologies, products and processes	2.4
7. Capacity to access to, use and adapt existing technologies at competitive levels of cost and quality	2.5

Source: FAO



Source: FAO

Figure 4. Assessing capacities to foster "enabling environments" for innovators

C. Analysis of options for strengthening AIS

- **Main challenges related in capacity development:** the main challenges or constraints and opportunities to fulfil the functions include lack of skilled labour, shortage of chemicals, shortage of improved seeds and funding, while the opportunities are low awareness of farmers and limited services of AIS technology due to limited or no privatization in dissemination of innovations.
- **Capacity development activities in AIS**: there is a wide range of activities that include training, workshops and experience sharing visits. Moreover, important components for well-functioning of AIS are lacking, such as developing soft skills in innovation system management, knowledge management, stakeholder management, entrepreneurship fostering and training.
- **Main constraints related to capacity development:** Trained personnel, budget, spare parts/equipment, irrigation equipment, awareness, linkages between partners, construction policy, and fuel shortage for irrigation and transport respectively.
- **Main opportunities related to capacity development** include dedicated staff, initiative policy for research, trained personnel, high adaptation capacity, strategic plan and conducive working environment.

D. Entry points for capacities to perform a specific or group function

The capacity assessment provides insights on underlying causes of AIS performance and opportunities for improving performance. The entry points for capacity include:

- Innovation actors to:
    - introduce foundation seed multiplication;
    - improve individual/group capacity;
    - upgrade laboratories;
    - create institutional linkage and networking, infrastructure development;
    - set standards, norms, incentives, mindsets, etc.
- Innovation support service providers need to:
    - have adequate resources to deliver support services to Innovative Entrepreneurship (IE);
    - improve skills on Technology Transfer (TT); and
    - strengthen their skills and update their practices though training.
- Bridging actors' needs are to:
    - have knowledge and skills on how to facilitate innovation networks/platforms;
    - regularly strengthen the skills and update their practices on how to facilitate innovation dissemination,
    - have adequate new technologies for distribution to farmers; and
    - support the monitoring and evaluation activities.

3.4. Enabling environment analysis

Agricultural innovation policy analysis

Eritrea has no policy on AIS, instead it has an Agricultural Research Policy. According to the research policy, research is responsible for generating agricultural innovation in crop, livestock and other agricultural products that contribute to the food security of the country and create job for youths. The research policy allows NARI to have a national seed system, a mechanism for releasing agricultural innovations and establish relationships with regional and international organizations that can provide funds, genetic materials and trainings.

Research in agriculture has three generations depending on its development and outcome of the results and the participation of farmers or users. The agricultural generation in Eritrea is in generation I and the linkages between the actors are in linear model that privileges the adoption process. The research activities are more focused on a commodity approach and it does not involve farmers in research design and priorities. In addition, the level of incentives for agrifood firms' investments in R&D does not exist and the policy approach to innovation is not yet stable because the Agricultural Strategy and Policy is in a draft stage. The development of any agricultural research mostly depends on the policy of the country. In countries where the policy permits, or supports, the research programme, the development of the research activity is very fast. However, where the policy on the research is less prominent, the development of the research is poor due to lack of policy supports such as poor institutional support, insufficient or lack of infrastructure, poor capacity development and or little/no network formation.

After independence 1991, the Government of the State of Eritrea gave priority to the development of agriculture as well the agricultural research through the provision of infrastructure and capacity building. Agricultural research restarted at Halhale where the site has more land and water for conducting various research activities. Besides these, and to enhance the agricultural development, different policies, proclamations, regulations, programmes guidelines and legal notes were issued in the country. Most of these policies, proclamations, legal note and plans are enacted while some, like Agricultural Strategy and Policy, seed policy and pesticide proclamation, are not yet approved.

Table 12. Map of existing innovation policies, proclamations, regulatory and legal notes

Policy	Time	Proclamation	Time
Macro Policy, GoSE	1994	Fisheries Product Proclamation	1998
Land and Forest Tenure Policy 58/1994	1994	Forest and Wildlife Conservation and Development Proclamation No. 155/2006	2006
Interim-Poverty Reduction Strategy Paper (I-PRSP), GOE	2004	Plant Quarantine Proclamation No. 158/2006 enacted	2006
Food Security Strategy (FSS)	2005	Fishery proclamation 195/2007 enacted	2007
National Agriculture Development Strategy Policy Draft	2006	Seed proclamation not enacted	2002
National Agriculture development Strategy Policy Revised draft	2019	Pesticide proclamation not enacted	1997
Water Policy	2007	Animal health proclamation not enacted	2006
Land Use Policy	2007		
Programmes, Regulatory, Guidelines, etc.	Time	Legal Note	Time
National Environmental Management Plan	1995	Legal Notice No. 111/2006 - Regulation for the Issuance of Forestry Permit, enacted	2006
National Environmental Assessment Procedures and Guidelines	1999	Legal Notice No. 112/2006 - Regulation for the Issuance of Woodland permit enacted	2006
National Economic Policy Framework and Programme (NEPFP), GoE	1998-2000	Legal Notice No. 113/2006 - Regulations on the requirements of STDs for milk and milk products	2006
National Biodiversity Strategy and Action Plan (NBSAP) (1996, 2000, 2015)	2015	The Five Year Indicative Development Plan (FYIDP), GOE	2009
The Action Plan for Integrated Water Resources Management (IWRM) in Eritrea (2009-2016)	2009-2016	Ten Year Long-Term Indicative Perspective Development Plan (TYIPDP), GOE	2009
Eritrean Environmental, Protection Management and Rehabilitation Framework 179	2017		

Source: FAO

Timeline of policy and innovation events

Timeline of policies, proclamation and the evolution of the innovation events are given in Table 12. In the last 29 years over 100 innovations have been developed and released through the technology releasing committee. Most of the released innovations were varieties of cereals, vegetables, fruits, animal feeds, natural resource conservation methods (forest), climate smart agronomic practices, grain storage bins, irrigation techniques, etc. (Table 13).

Foundation seeds of the released varieties were multiplied in the different research centres and submitted to AED for multiplication and distribution to farmers. In the last ten years (2011-2020), for example over 1 702 quintals/170 tons of different foundation seeds were produced (Table 14). However, the distribution and adoption of these improved varieties is lacking because no adoption rates study was done in the country.

Table 13. Timeline policy evolutions and major innovations release period

Innovation			W*	W	T			W		S B P Dp Fe	P Pe Po	S Po Fe	P B W	P		S B W	Pe O Ci		O	S	W P	P	P W Mz Be	Fe	Po					Bn
Year	91	2	3	4	5	6	7	8	9	0	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
Policy				M												ASP	Wp LUP													
Proclamation				L	NE		L		EA			Se		PR SP	FS	Pes AH LG Pq									NB		EE			

Source: FAO

W*=wheat, B=barley, Be=beans, S=Sorghum, P=Pearl millet, Pe=Pepper, po=Potato, O=Onion, Mz=maize, Fe=Animal feed, Ci=Citrus, T=Taff, Dp=date palm, Bn=Banana.

M=macro policy, ASP=Agric. Strategy and Policy, Wp=Water policy, LUP=land use policy

PRSP=Interim-poverty Reduction, FS=food security, L=Land proclamation, AH=Animal Health proclamation, Se=Seed proclamation draft, pes=pesticide proclamation draft, Pq=Plant quarantine, LG=legal Note, NE=National Environment management plan, EA=National Environment Assessment procedure plan, NB=national Biodiversity Strategy and Action Plan, EE=Eritrean Environment project management and Rehabilitation framework.

Table 14 Foundation seed produced and distributed 2011-2020 in quintal

Year	Sorghum	Pearl Millet	Wheat	Barley	Legumes	Maize	Oil Crops	Total
2011	57.9	34.7	27.4	15	0	0	0	134.9
2012	31.6	26	22.8	39.6	14.2	5	0	139.2
2013	25	22.1	21.8	7.5	6.9	4.7	11	99.0
2014	38	12.5	77.5	6	21.5	9	6	170.5
2015	0	2.4	11. 2	0	0.4	2.0	0.6	16.4
2016	125	14.3	59.9	6.8	84	3.2	2.6	295.8
2017	3.4	0	17.1	23.1	59.6	9	2	114.1
2018	94.6	28.9	22.3	37.7	46.1	5.5	3.5	238.6
2019	48.3	28.8	77.6	40.1	21.2	0	8.2	224.2
2020	44	1.5	119.5	66	17.1	13	8.2	269.3
Total	**467.8**	**171.2**	**457.1**	**241.8**	**217.0**	**51.4**	**42.1**	**1702.0**

(1 quintal=100 kg)

Source: NARI Department of Agronomy.

Level of investment in public research

Investment in public research includes budget, training/ capacity building and infrastructure and these are the basis for the development of research and generation of technology.

Budget

The budget for the research decreased in the last five years from eight million to four-five millions. Most of the budget is used for staff salary. According to the FGD participant researchers, there is a problem of budget for field visits, on-farm trials and survey of pests and crop production study, as shown in Table 15.

Table 15. Budget of agricultural research for the last five years in Nakfa

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019
AED	13,062.3	13422.0	13,491.7	11,451.7	19,561.9	0.00	14,070.7	14,070.7	14,926.1
NARI	7,676.2	8,764.23	10,286.5	9,009.8	8,774.9	0.00	4,288.9	4,288.9	5,519.7

Source: MoA finance Office

Infrastructure

NARI has different infrastructures that include laboratory, equipment, building etc. which are mostly present at Halhale main centre. Some of the infrastructures are:

- Laboratories: soil, plant protection, biotechnology, agronomy, genetic resource, animal nutrition and animal health.

- All laboratories have essential equipment for running research activities.
- Offices: NARI has modest offices for its staff and administration.
- Stores, seed cleaning machine.
- Generators, solar, water pumps with their accessories, tractors with their accessories, vehicles and tracks.
- The institute has residential buildings in Sheib, Shambiko, and Goluj. It has land for conduction of trials in all the centres: Sheib, Shambiko, Goluji and Halahale, although Halhale has a water quality problem for laboratory use.

Training

AED and NARI periodically organize long and short-term training of their staff, both in the country and abroad, as in-services training to improve the knowledge of the staff and to introduce new technologies.

NARI provides long-term training (BSc and above) to its staff both within the country and abroad. However, the numbers of trainees and training sessions offered are very low (Table 16). This is the major bottleneck for development of skilled staff in the institute and the MoA in general. To improve the low skill capacity, NARI should provide more training in staff development. Likewise, the MoA and NARI also organize short-term training both in country and abroad. Each year over 100 research and extension staff are given short-term training on different subjects, Figure 5 and Figure 6.

Table 16. Long-term training for the period 2016-2020

Type	2016	2017	2018	2019	2020	TOTAL
MSc	-	1	--	1	3	5
PhD	-	1	--	--	--	1

Source: MoA HRD and NARI

Intellectual property: The concept of intellectual property is well understood in the country especially in the art (musicians) units. Its importance in the agricultural sector so far is low; however, it will become very important in the future as the number of innovations increase in the country.

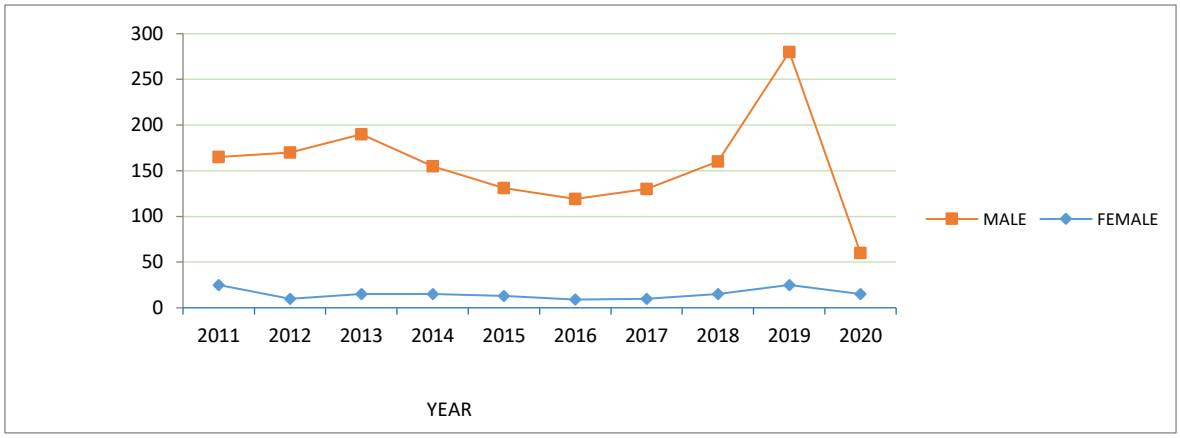


Figure 5. Short-term training to MoA staff *Source*: FAO

Figure 6. Beekeeping training to extension staff

Agricultural knowledge information system

The Agricultural Knowledge Information System (AKIS) is a base for development of innovation and dissemination. In Eritrea, different types of AKIS have been practiced such as FAS (Farmers Advisory Services) between 2002 and 2006, and after 2007 until today, Farmers Field Schools (FFS) are the tool for dissemination of innovations. This is a type of information exchange system from farmers-to-farmers that facilitates the participation of farmers to set research priorities.

Through the AKIS, the MoA also gives incentives to organizations such as HAC, Hagaz and Adi Halo by providing technical and material support, participating in development of curriculum and finally it employs the graduates from these institutes to work as extension workers or researchers. This system also allows to promote incentives to public-private partnerships with a number of agrifood firms such as dairy processors, vegetable, mushroom, rabbit and bee producers by creating market outlets, supply inputs, provide technical support such as beehives, production areas, training and others.

Systemic problems analysis

Systemic problems are a major factor for technology generation and dissemination as they hamper and delay the achievements of the innovation processes. The systemic problems include institutions, availability of infrastructures, development of skills and interactions. Assessments done on systemic problems such as network, capacities, and enabling policy analysis showed that the trend is good, but it still needs further strengthening.

Network analysis showed that the actors have low interactions both in development of technology and dissemination. There is also good networking among the actors, however, there is not an officially established platform and even if present, its functions are very poor and unsatisfactory for its members. Most of the associations give services to their members like fertilizers, seeds and veterinary medicines. Nevertheless, so far they are not involved in processing, marketing, organization of training for members, etc.

The capacity analysis demonstrated that there were both functional and technical capacities with low skills, knowledge attitude and even when these are present or exist, they are not put into practice. This indicates that the skills of the researchers are still low to generate acceptable innovations to solve farmers needs or problems.

In general, the enabling analysis demonstrates that there are some policies, institution, infrastructures, but they need to be strengthened especially in the development of human resource skills, establishment of cooperatives, network, platform formation, and encourage entrepreneurs, etc. (Table 17).

Table 17. Grid of generic categories of systemic problems and frequent examples in AIS in Eritrea

Categories	Subcategories	Examples
Institutional problems	Hard institutions	• Agricultural Strategy and policy not approved • Policy makers support technologies that contribute to solve farmers' problem • No subsidies, tax exemption, and venture capital to move technology from experimental phase towards scaling up phase
	Soft institutions	• No legitimacy of AIS governing actors
Capacities problems	Lack of functional capacities (knowledge, social and skills, inter-organizational capacities)	• Lack of innovators to formulate support needs • Lack of skilled/experienced staff to support innovators and innovation communities
Network Problems	Too weak interactions	• Lack of multiservice platforms • Lack of knowledge diffusion/interaction between actors
Infrastructural problems	Physical infrastructure	• Lack/weak Sciences-Technology infrastructures in the country • Weak internet access for researchers and actors • No prototype producer for new technologies
	Knowledge and Information infrastructure	• Low innovation support services to multi-actor innovation processes

Source: FAO

Policy instruments with innovation goals

The overall orientation showed that the instruments for the supply were low while the demand for the different instruments is moderate to high, this may be due to low funding, or because the policy did not allocate enough budget. The instrument support towards the creation of new knowledge and innovation ranges from low to moderate, due to financial problems. Likewise, the instruments for support of capabilities and skill for technology generation and dissemination is again low to moderate, whereas the instrument support for interaction among actors to enable learning process is moderate to high. The policy instrument focused on influencing demand for innovation is low to moderate. The policy instrument influencing the regulation and standardization is low to moderate (Table 18).

Table 18. Level of policy instruments with innovation goal of Eritrea

Policy Instruments	Overall orientation		Innovation Policy Goals						
	Supply	Demand	Increase R&D	Skills	Access to expertise	Improve systematic capability and complimentarily	Enhance demand for innovation	Improve framework	Improve discourse
Fiscal incentives for R&D	●●	●	●●	●●●	●●	●●●	●●●	●●●	
Direct support to firm R&D and innovations	●●●	●	●●	●●●		●●●	●●●	●●●	
Policies for training and skills	●●●	●●	●●	●●●	●●●	●●●			
Entrepreneurship policy	●●	●●	●	●●●	●●●	●●			
Technical services and advice	●●	●●	●●	●●	●●●	●●●			
Cluster policy	●●	●●●	●	●●	●●	●●●	●●●		
Policy to support collaboration	●●	●●	●	●●	●●	●●	●●●		
Innovation network policies	●●●	●●	●	●	●●●	●			
Private demand for innovation	●●	●●	●●	●●●	●●		●●	●●	
Public procurement policies	●●●	●	●●	●●	●●		●●	●●●	●●●
Pre-commercial procurement	●●●	●	●●	●●●	●●●		●●●	●●●	
Innovation inducement prizes	●●●	●●	●●	●●●	●●●		●●●	●●	●●
Standards	●●	●●●	●●	●●			●●	●●	●●●
Regulation	●●●	●	●●●	●●			●●	●	●●●
Technology foresight	●●●	●●	●●	●●			●	●●●	●●●

Source: FAO

Keys: Overall orientation and stated innovation policy goals of the listed innovation policy instruments: Major relevance (●); Moderate relevance (●●); Minor relevance (●●●)

Table 19. Matching matrix of policy in AIS of Eritrea

Objective	Policy instrument	Systemic problem mainly addressed	Type of firms likely to benefit from policy
Enhance the technological capability and productivity of Eritrean farmers	Clusters	Support services and networking	Farmers and farmers association and entrepreneurs
Increase the number and quality of researchers	Employee or train staff	S&T infrastructure and institutions	Subsistence farmers and farmers association. Entrepreneurs and crop livestock corporation
Strengthen grass-root initiatives and economies	Improve credit EDIB, SMPS, MoA (marketing unit)	Support services	Subsistence farmers and farmers associations, entrepreneurs and processors

Source: FAO

A. Governance

In Eritrea the AIS highlights that the farmers are in a situation where they are facing a very diverse soil fertility, poor rainfall and water aquifers, agricultural innovation and technology and agricultural production systems and agro-ecological situation that is still insufficiently documented and understood.

At the same time to satisfy the diverse range of farmer's needs and demands, an enabling environment should be created to enhance their production. This can be achieved through the involvement of the farmers and other concerned people to participate in the innovation processes. The AIS system involves all those bodies that are involved in agriculture and the generation of innovation will be a continuous process, as a result, the outcome of the research will be easily adopted by the participating partners.

B. Infrastructures

The government of Eritrea, particularly the MoA, has developed/constructed different infrastructures such as building of offices and laboratories, equipment, irrigation facilities, land for trial conduction and construct water facilities, for example:

- Water harvesting infrastructures (dams, ponds, diversions, wells, etc.)
- Irrigation systems (spate, furrow, drip, sprinkler)

- Modern farm machineries (tractors, planters, harvesters, threshers, etc.)
- Plant and animal laboratories
- Research centres and sub-centres representing the different agro-ecological zones
- Genetic resource conservation (gene bank)
- Seed cleaning facilities
- Regulatory services

C. Institutions

- There are limited norms and standards that lead and support the technology generation and dissemination.
- The innovation functions and process do not have a conducive environment i.e. limited transportation, laboratories and facilities, no clear platform and networks for interaction, approaches, incentives and partnership standards.
- The main actors of the innovation are governmental organizations with establishment through legal notices. NARI is responsible for innovation generation while AED deals with the dissemination of technologies.

D. Output 1 - Insights into problems in the AIS

- Although there are enablers for innovations, they need to be strengthened.
- The technology generated is limited in type, quality and quantity. The FGD participants reported that some of the released technologies are less accepted, like sweet potatoes and some Irish potatoes.
- Functions – knowledge generation and dissemination are low in pace, they need to be standardized and strengthened using the CDAIS guidelines. Meanwhile, functions – market development, entrepreneurial activity and innovation coordination, interaction, networking, platforming, etc. are almost non-existent.

E. Output 2 - Priorities for systems improvement

- Governance – AIS concepts, understanding needs to be institutionalized, systems and processes should be developed such as interaction network, platform and forum network among the different actors in the country.
- Institutions need capacity development in skilled or specialized fields like breeding, molecular genetics, citrus specialists with improved logistic and budget support.
- The linkages between the main actors such as research, extension, education, regulatory and farmers is very poor, this has to be strengthened and create a platform and network for interaction and participation in innovation processes needs to be created.

4. Conclusion and recommendations

4.1. Conclusions

There is a growing emphasis on innovation development in Eritrea. The reason is simply that, innovation underpins improvement in all socio-economic activities. Agriculture is the backbone of this country, hence, it is necessary to pay attention to the drivers of innovation taking place to improve the sector.

The study clearly demonstrates that Eritrea's researchers are involved in adaptive/commodity research with the aim of solving problems in the agricultural sector and in the nation as a whole. Although some domains such as crop variety improvement, received much attention, essentially relevant domains, such as development of cooperatives, marketing of agricultural products availability of credit, are less addressed. The study also showed that research activities on livestock improvement and animal health are minimal. The sector has numerous challenges, namely poor soil conditions, low and poor distribution of rainfall, disease and pest problems, lack or shortage of improved seed, limited appropriate technologies for processing and limited knowledge in post-harvest management.

The challenges identified can be classified into research, development-related challenges and the use of the innovations. The major challenge in the development and dissemination of the innovations is funding, which is either inadequate or delayed. Due to shortage of funding, extension workers and researchers are not able to conduct on-farm trials, field visits and demonstration in different sites/ecologies. A reliable funding source is required, for sustainable technology generation and dissemination. The other challenges are the shortage of skilled labour force, most of the staffs in research and extension are young and with little experience. In addition, there is high staff turnover (both researchers and extension workers) mostly due to lack of incentives and periodic promotion.

Most of the technologies in the country are developed by NARI followed by HAC. NARI is the foremost institution in Eritrea and its mandate is to carry out scientific and technological research for national development. The involvement of NARI in the generation and dissemination of the innovations is in line with its core mandate. NARI is involved in the generation of the technologies and innovations through its various units or sections like crop research, animal research, genetic resource and others. The involvement of HAC in research is limited due to its staff development.

In the last 20-25 years a number of technologies were developed and released to farmers for production, the impact of the technologies on the sector is not known, no study was made on the adoption rate of the technologies. This needs further work and the result will be useful for future decisions on the research direction.

Innovations such as Adhanet (improved stove), Green feed and Sorghum (Annexes 1-3) have been in the dissemination process. All these technologies have been adopted and are being applied in various ways. The dissemination of Adhanet, for example, was enabled by the support of EU, EIDP, ErCS, NUEW. The success of these innovations stemmed from the extensive support provided by the MoA and its supporting agencies. These findings clearly demonstrate that extensive collaboration among various stakeholders is necessary to convert research efforts into socio-economic developments.

During the study, it was observed that the number of private sector entities involved in input supply, wholesaler, retailers, entrepreneurs and agribusiness were very low, although their involvement or presence was essential for development of marketing and value chain agro-processing.

The AIS assessment showed that there was no official establishment of platforms in all the case studies conducted. Platforms are useful to create an interaction among the actors and are the basis for innovation processes. The assessment also showed that the linkage between farmers, researcher and extension workers is linear or top-down, technologies are simply passing from research to extension or farmers. There were no linkages or interaction among the research organization, although linkage among researchers is essential to avoid duplication of activities.

Despite these challenges, opportunities exist for the generation of useful innovations due to conducive environmental policies, availability of laboratories and infrastructures. NARI and HAC are well positioned to conduct research and develop technologies that will address Eritrea's socioeconomic challenges.

4.2. Recommendations

These recommendations are based on the analysis of the findings, review of case studies and the results of the interviews with key resource persons. The recommendations are given by phases.

Phase I-short term recommendations

1. The current linkage between research, extension and farmers is linear or top-down, non-participatory method where direction is given from researchers to farmers in technology generation and dissemination. Farmers should be part of the innovation process starting from the inception and design, up to the technology development stage. This will help to provide a mutual learning process and exchange of information between farmers, experts and scientists and could facilitate improved problem identification and technology development. Specifically, the linkage between extension and research needs to be improved so that farmers can receive

critical information and support in a timely manner and research efforts are effectively tied to farmer needs.

2. Establish an innovation platform as it is a basis for creation of interaction among stakeholders/actors and useful in technology generation and dissemination.
3. The extension method or projects should be more market oriented rather than production oriented to increase agricultural development. Usually knowledge, information and technology are generated and diffused through the private sector by forming cooperatives or marketing companies. Sustained growth in the agriculture sector would not be achieved if farmers are not integrated into the market.
4. The research activity in Eritrea has a commodity approach, whereas in the AIS system the research is more oriented towards a production system.
5. The improved stove-Adhanet dissemination is low, some of the reasons are high initial costs and availability of spare parts, such as chimney and gate, as well as lack of funds. Now is the right time to improve the structure of the stove in order to be accepted more by farmers. The MoA through its agricultural engineering unit should develop a modified stove at low cost. There is also a conflict over the ownership of the technology, this will affect the funding and smooth transfer of the stove. Adhanet was on dissemination for almost over ten years, it is good to have an assessment on the adoption rate to understand its status and to get feedback.

Phase II-medium term recommendations

6. Reduce the high extension and research staff turnover by creating a conducive environment, such as provision of transport, shelter, incentives, promotion, salary increment, organize periodic workshops or training including specialized courses like MSc or postgraduate diploma.
7. The capacity development within NARI is very low, most of the researchers are very young, with little experience and skills in breeding, molecular genetics, etc. essential for improvement or development of varieties or agronomic practice. To alleviate the capacity constraint, researchers must be trained on these subjects.
8. Improved seed is an important component for agricultural development. The multiplication of improved seed is uncertain as it is done through rainfall under farmers fields. In Eritrea, most of the time rainfall is not reliable, this can cause failure of the seed production. To avoid or minimize the risk of unpredictable rainfall, seed production should be done in areas where supplement irrigation could be available or produce the seed during the dry season under irrigation. However, the released varieties get mixed with local cultivars after one or two seasons of production; a method should be developed to minimize the mixture or develop a rehabilitation mechanism for the purity of the varieties.
9. Infrastructure roads, ICT and mobile phones access should be encouraged and established for easy of technology transfer. At present, the use of mobile phones by farmers is limited due to its high cost and availability, as the majority of the farmers cannot afford it. In countries such as Kenya, Ghana most of the extension activities are done via mobile phones or SMS, such conditions should be developed and encouraged in Eritrea to help to penetrate the grassroots (farmers) in the country.

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Annexes

In the FGD study, over 161 innovations have been identified, mostly from NARI and HAC, all innovations are at an early developmental stage or are in the process stage. To study the innovation processes, three case studies were selected based on their wider use, easy dissemination and adoption, contribution to food security, biodiversity with their value chains. The selected case studies were:

- Case study 1: Crop Improvement
- Case study 2: Green Feed
- Case study 3: Energy Saving Improved Stove

Annex 1. Case study – sorghum improvement

1. Introduction

Sorghum is the number one crop produced in Eritrea, it covers over 240 000 hectares of land each year and is cultivated in all agro-ecological zones of the country, but dominantly in the western lowlands and eastern part of the country. The crop is mainly produced for human food and for making local drinks. Its stalk is used for animal feed, fuel, house construction and for fences. It is mainly produced by subsistence farmers with a land holding of less than one hectare in the highlands and about two hectares in the lowlands. The production and productivity of sorghum in the country is very low, eight to ten quintal per hectare. The major sorghum production constraints are: rainfall, which is erratic and unreliable in most years, pests and diseases, soil fertility which is a major constraint in the mid and high altitude of the country where the soil depth is shallow due to over cultivation for centuries. Lack of power for land preparation, especially during planting time in June and July is also a bottleneck in the production of this crop. To alleviate these problems, sorghum improvement programme is undergoing in NARI and HAC. The improvement is done by breeding for higher yields, develop disease and pest resistance, and develop climate smart agronomic practices and others. So far, many varieties and climate smart agronomic practices have been developed and released for production.

2. Structural analysis

2.1. Actors role and responsibilities

Research on sorghum improvement in Eritrea is done by NARI and HAC with the aim to generate/produce high yielding varieties that are adaptable to different agro-ecologies. The research also aims at developing disease and pest resistant or tolerant cultivars, develop climate smart sorghum production practices and conduct on-farm trials. The

programme also produces foundation seed of the released varieties for further multiplication and distribution to farmers. It has different infrastructures like seed laboratory, office and field for trial conduction in different research centres and substations (Shambiko, Goluj, Shieb and Hagaz). The research is carried out in collaboration with different partners and international organization such as FAO, ICRISAT, ASARECA, etc. Table 1.

Table 1. Partners in sorghum improvement and their contribution

Partners	Role/contribution
ICRISAT	Supply germplasm for adaptation trial, provide funding, technical support and training to research and extension staff
ASARECA	Supply germplasm for adaptation trial, provide funding, technical support and training to research and extension staff
AED	Seed multiplication, participate in variety release and trial evaluation
RSD	Chair for variety release, trial evaluation and seed inspection
MoLG	Participate in variety evaluation, act as a bridge between researches and farmers in the evaluation and dissemination of technologies
NARI	Develop varieties of sorghum, develop climate smart sorghum practices, conduct on-farm trials, provide training to extension staff and farmers, etc.
HAC	Develop varieties of sorghum, develop climate smart sorghum practices, conduct on-farm trials, provide training to extension staff and farmers, etc.
Farmers	Participate in innovation process, evaluation of varieties, on-farm trial, seed multiplication adoption of improved technologies, etc.
EU, FAO, IFAD	Provide funding, technical assistance and training to researchers and extension staff

Source: FAO

2.2. Interaction

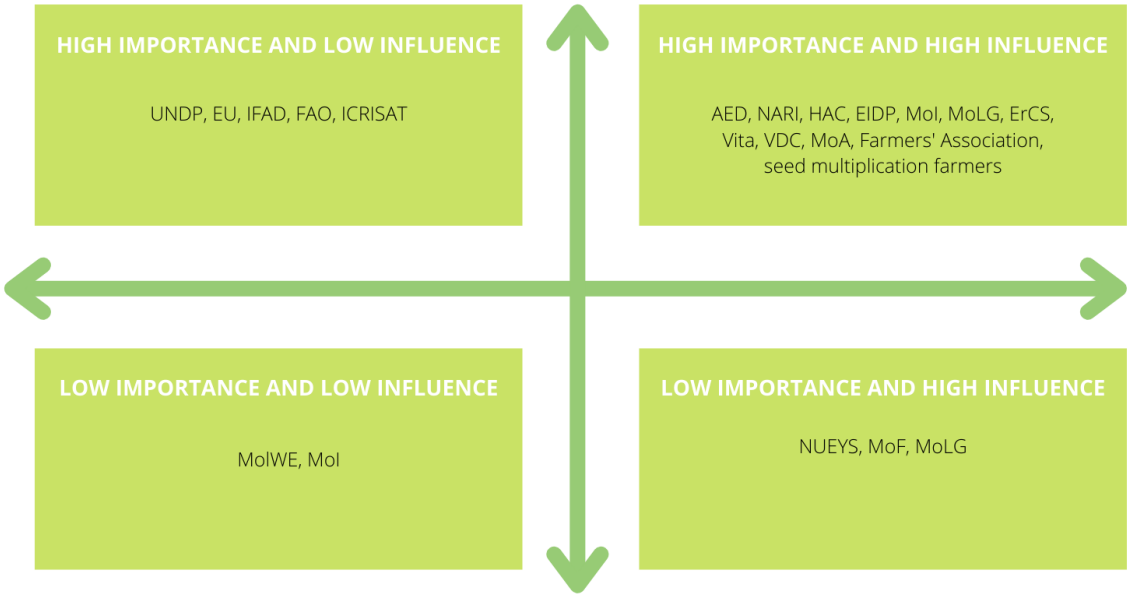
The interaction in this case study takes place at three levels: macro, meso and micro

Table 2. Interaction in sorghum improvement

Level	Actors	Interact with
Macro	Financial institute/dev. partners, line ministries: MoA, MolG, MoF, MoI, MoE, MoLWE	AED, NARI, HAC, VDC, provide funding, technical support and technical dissemination
Meso	NARI, HAC, AED, VDC, MoLG	Both interact with actors at micro and macro levels, innovation processes and dissemination
Micro	Farmers/Beneficiaries	Interact with actors at meso level, adopt technologies for production

Source: FAO

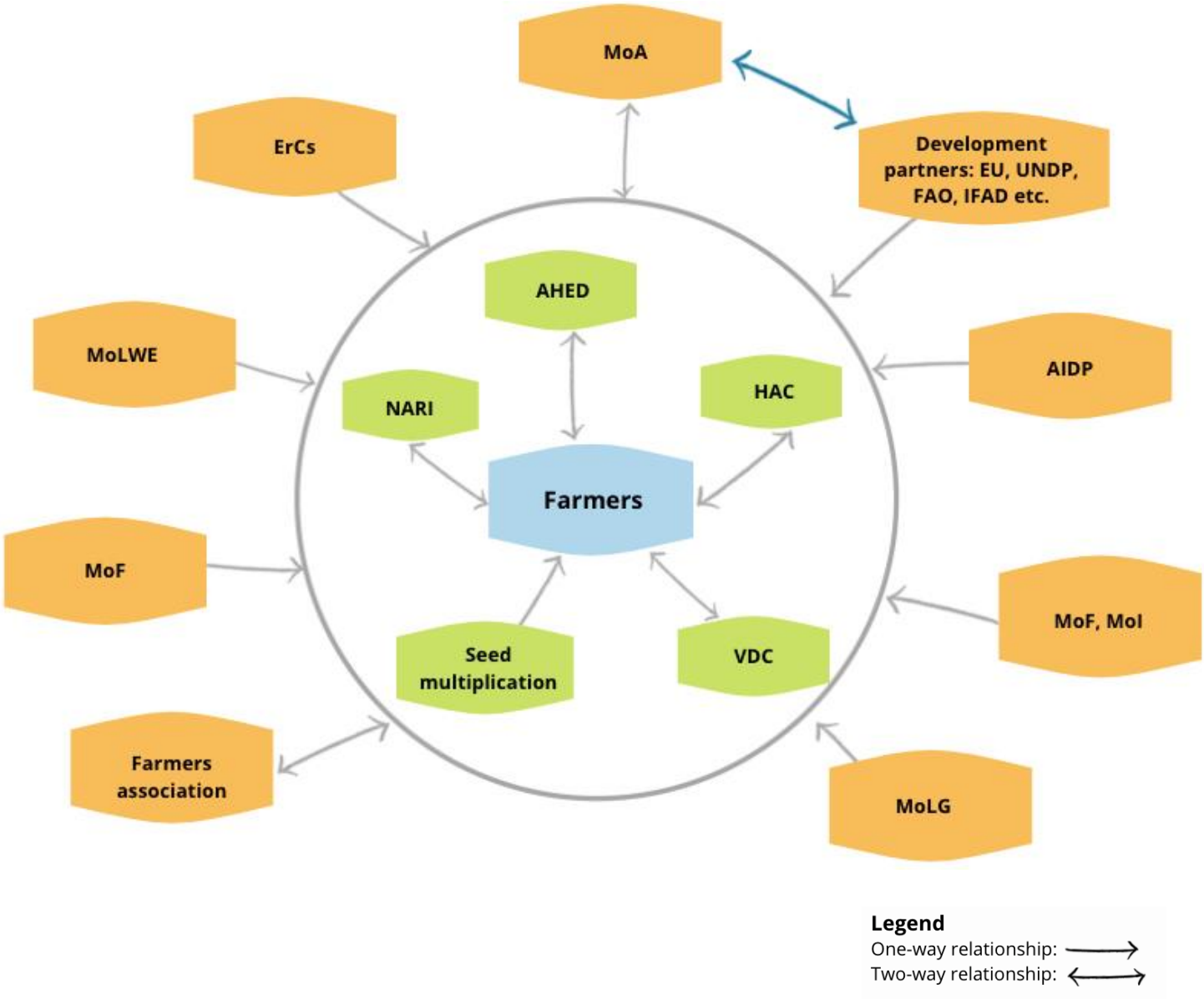
Various actors/stakeholders participate in technology generation and dissemination of sorghum innovations. Stakeholders such as UNDP, EU, FAO, IFAD and ICRISAT have high importance in innovation processes because they are involved in technology generation by providing funding, training and supply germplasm/genetic material for variety development, but they have low influence because they do not directly participate in result dissemination to farmers. Actors like AED, NARI, MoA, HAC, EIDP, ErCS, MoI, MoLG, VITA, farmers association, seed multiplication farmers and VDC have high importance and high influence, as they participate in innovation processes. They have high influence because they are directly involved in dissemination of final results to farmers. MoLWE and MoI have low importance and low influence because they are not involved in technology generation or in dissemination of technologies to farmers. Stakeholders such as NUEYS, MoF and MoLG, have low importance because they are not involved in innovation processes, but they are highly influential as they are directly involved in technology dissemination to end users/farmers, Table 2 and Figure 1 and Figure 2.



Source: FAO

Figure1. Stakeholder's importance and influence in sorghum production

2.3. Mapping and network



Source: FAO

Figure 2. Stakeholders network map – Sorghum improvement

During the sorghum case study assessment it was found that the farmers in Eritrea participate in the innovation processes very late during the on-farm trial or during field visits/ variety release time. However, for effective AIS, the actors, especially the farmers, AED staff, trader agribusinesses should participate right from the design of the innovation process and continue until the end of the innovation process. The extension staff, as well as the farmers, should feel that the work is their own and are included in the innovation process. The participation of the famers and other actors at early stage

will allow the users to accept the result of the innovation and will have a high adoption rate of the outcomes at the end.

3. Functional analysis

The functional analysis identified the following functions: knowledge generation, knowledge dissemination, marketing, entrepreneurship and resource mobilization.

3.1. Relations with functional, structural and capacity analysis in sorghum improvement

Relations with functional, structural and capacity analysis were done by identifying key functions and analysing the respective actors and capacity needs and existing capacities. Table 3.

Table 3. Relations with functional, structural and capacity analysis - sorghum

	Functional analysis	Structural analysis	Capacity analysis
Enabling environment analysis	**Cluster of functions identified**	**Who carries out those functions, interrelations between them**	**Capacities <u>needed</u> to perform those functions Capacities <u>exist</u> at present**
	Knowledge generation	Org 1. NARI Org 2. HAC	**<u>Need</u>**: NARI need sorghum breeder, plant pathologist, entomologist and soil expert HAC need agronomist, pathologist and soil expert **<u>Exist</u>**: NARI has pearl millet breeder and research assistance HAC has breeder, entomologist and technical assistances
	Knowledge Dissemination	Org 1. AED Org 2. MoI Org 3. MoLG	**<u>Need</u>**: AED Extension agencies who can work at grassroots level/village administration MoI trained agricultural journalist **<u>Exist</u>**: AED has extension workers at sub-Zoba level MoLG: VDC
	Institutional support, funding	Org 1. development partners (regional and	**<u>Need</u>**: EU, UNDP, IFAD, AfDB and FAO provide funds for

	agency	international) Org 2. MoF	innovation processes and technology dissemination MoF provide budget to NARI and HAC to generate variety, agronomic practices and salary to staff Exist: MoF provide budget for salary of extension staff and NARI, but low budget for travel, transport, etc. ICRISAT, MIHAP provide funding for variety development and dissemination to farmers
	Entrepreneurs Finance institutions	Org 1. Private sectors Org 2. SMCP, EDIB, Org 3. MoA	Need: Establish finance institutes to provide soft loan to entrepreneurs and farmers Exist: Some private traders provide loan in kind like seed, fertilizer, veterinary medicine to farmers SMCP, EDIB, provide finance to farmers, MoA provide credit in goods (fertilizer, etc.)
	Commercialization, Input supply	Org 1. Traders Org 2. MoA Org 3. Red Sea cooperation	Need: Create private sector and platform for supply of inputs Exist: MoA/AED, traders supply input (seed, fertilizer, veterinary medicine to farmers and farmers associations) Red Sea Trading Corporation did all the purchase for MoA
	Socializing change, collective action/ social processes	Org 1. MoLG Org 2. VDC Org 3 Farmers/farmers associations	Need: Create a socialization process Exist: MoLG, MoA and VDC organize farmers for social change or adoption of technologies. Farmers associations organize its members for change and adoption process.

Source: IFAD

Sorghum improvement procedures

The sorghum innovation processes include different breeding techniques and development of climate smart agronomic practices. The breeders collect both land races and germplasm from international organization, mainly ICRISAT, to have a preliminary selection for adaptation, disease resistance and desirable characteristics. Crossing of varieties or lines is also done to select resistance for different characters, mostly for yield. The crossed progeny is planted in single rows for selection of different factors such as yield and diseases. In both crossing and introduction of germplasm or land race screening, the best lines are advanced to preliminary trial to assess for yield and disease performance. Then the selected lines are planted as advance yield trial, from which the best performing lines are selected again for multisite test for one or two seasons. The best performing lines or varieties (two or three) will be studied under on-farm trial for one or two years, the best one or two varieties will be selected and planted in two to three major growing areas of the crop for variety release. At the same time, the breeder will increase the seed of the intended variety as basic/foundation seed to be given to AED for multiplication. In the case of Eritrea, the researchers do most of these activities, except in some cases farmers and extension workers are involved in the selection or evaluation of the on-farm trials. According to the AIS, the involvement of the farmers, extension, international organization and other people should start right from the designing of the trials all the way from germplasm selection up to variety release and seed multiplication. Such a method will encourage farmers to adopt the new variety easily. The variety release is done by committees that are composed of NARI, RSD, HAC, farmers association and farmers.

3.2. Sorghum improved technologies

So far, the sorghum improvement programme has released over 12 varieties that are adaptable to different agro-ecologies of the country. Today five of the improved varieties are out of production due to seed mixture during production and some of them have become susceptible to diseases. Almost all the released varieties are resistant to rust, *striga* (parasitic weed of sorghum) and are much high yielders than the local varieties (10-12 q/ha) with a yield range of 20-36 q/ha. All the improved varieties are also early maturing compared to the land race/local varieties. The grains of the improved varieties are white in grain colour which is mostly preferred by local people and has a high market demand due to its *ingera* (flat bread) which is also white, Table 4 and Figure 3. Climate smart agronomic practices have been also developed such as tide ridge for moisture conservation, early maturing and heat tolerant varieties. Farmers adopt all the improved varieties.

Figure 3. Sorghum improved varieties

Table 4. Sorghum released varieties and their characteristics

Variety	Year release	Variety Characteristics								
		Seed colour	Ecology	Rainfall	Soil type	Plant ht	Maturity	Yield/ ha	Rust resist	Striga resist
Seare	2006	White	CH-WL	300	SL	140	110	>20	yes	yes
Bushuka	2000	White	CH-WL	450	SL	180	116	>30	yes	yes
Shambiko	2000	White	CH-WL	350	SL	140	110	>20	yes	yes
Tebeldia	2010	White	CH-WL	300	SL	135	118	>20	yes	yes
Maeloba	2010	White	CH-WL	300	SL	140	115	>20	yes	yes
IESV 29029	2006	White	CH	350	SL	125		>20		
Hamelmalo	2009	White	Mid alt	300	SL	135	110	>25	yes	
Laba*	2000									
Sheib*	2000									
Shiketi*	2000									
Mocia*	2000									
Gedam Hamam*	2002									

Source: FAO

3.3. Dissemination of sorghum improved technologies

Dissemination of improved sorghum technologies are done mainly by AED, ErCS, MoI, MoLG and farmers. NARI and HAC also participate in dissemination of sorghum technologies to farmers around their respective centres by conducting demonstrations, on-farm trials and organizing training to extension workers. The international agencies such as EU, FAO, and ICRISAT also participate in the dissemination process by providing funding and technical assistance, such as delivering training for extension workers and farmers. Dissemination done by AED includes demonstrations on model or contact farmers field, organize farmers field visit, provide training to farmers, distribute leaflets and brochures to users/farmers. MoI disseminate innovations through mass media like radio, television and newspaper, ErCS disseminate seeds, chemicals, chicks, etc. to farmers. In general, the technology transfer is done in a linear way, from researcher to extension and then to farmers. Most of the released improved varieties are adopted and are under production both in the central highland and western lowlands.

3.4. Market development

Agricultural production consists mainly of grain production, in the country this is very low due to erratic and uneven rainfall distribution, as a result, sorghum grain is in high demand in most years. The grain is also processed in the form of flour, processed injera, as well as a local drink, and its stalk is valued as animal feed.

The marketing function is at its early stage. Meanwhile, the function is performed by MoA marketing and credit unit, traders, farmers associations to supply inputs and to market their outputs. Farmers are entitled to sell their product (grain and stove) to the market directly. The subsistence farmers sell their products after harvest (November-December) to the local market for purchase of household needs, pay taxes and other, while large farmers sell their products to traders, mostly late in the season after the prices of the grain increase in April-July.

In the current marketing situations, traders and brokers are the main actors. They provide the farmers credit service (cash for labour, fertilizers, tools, etc.), tractor services, pest control equipment and pesticides (herbicides). The MoA to Zoba and sub-Zoba offices also supply improved seeds and tractor services.

To improve the market situation there is a need to develop infrastructures such as transport, storage facilities, platform and establishment of marketing outlets.

3.5. Entrepreneurial activity

There are entrepreneurial activities in sorghum production in western lowlands between Goluj and Omhajer where there are semi commercial farms (10-20 ha/owners or entrepreneurs). Most of the semi commercial farms use inputs like tractor service for land preparation, sowing, harvesting and transportation, improved seed, herbicide spray for weed control, etc.

Subsistence and semi commercial farmers both use tractor services which are mostly provided by the government (90%) and very few by private services (10%). The rent for tractor services of the government is very low compared with private services due to high fuel and spare parts costs. Other inputs like fertilizers, pesticides, farm tools, etc. are also supplied both by the government and to a limited extent by the private sector.

To improve the sorghum production, there is a need for inputs, mainly machinery services (tractors and harvesters), transport, farm tools, herbicide sprayers for control of weed, postharvest storage and its management.

3.6. Resource mobilization

There is a good chance for resource mobilization for improved production of sorghum in the country. The majority of the commercial sorghum producers have a good understanding of crop production and adoption of new sorghum production techniques. Placement of extension personnel up to village administration level

facilitates easy dissemination and introduction of improved sorghum inputs to producers.

The government and development agencies and partners are committed, and they are financing the innovation process (NARI). The subsistence farmers can access credit through SMCP and MoA credit and marketing units. The semi commercial farms can access credit through the banks, both commercial bank and development banks, on collateral basis.

The access to rural finance should be strengthened and made operational at grassroots level (village administration and sub-Zoba), as most of sorghum producers are subsistence farmers. The access should include inputs supply, tools, tractor rent, pesticide spraying equipment and operational costs (labour and transportation of products).

3.7. Impact

According to the FGD discussions with farmers in Hamelmalo, the improved varieties are highly accepted and their production is very high 18-23 q/ha compared with the local varieties (8-12 q/ha), the stalk yield for improved varieties is also much higher than the local ones, which is important for animal feed during the dry season and for house construction. In addition to this, the improved varieties have a higher demand and price compared with the local varieties due to the colour of the grain, as well as the colour of injera which is white. However, for conclusive impact assessment it needs adoption rate studies of the varieties and agronomic practices.

4. Capacity analysis

4.1. Gaps and needs

The gaps and needs for sorghum improvement programme are given in Table 5. The main gaps are: shortage of improved seed, poor linkage between the researchers, extension workers and farmers, released varieties get mixed with local or other released varieties after one two years of production, shortage of skilled human resources, such as breeder or agronomist, and budgets for research running/working, especially for on-farm trials, field visits and for conducting surveys.

In order to have acceptable research results, there is a high demand and need to improve the current situation. This can be achieved through the provision of sufficient budget resources and transport, increased supply of improved seed to producers, improved skills of the researcher through further training, and creating sustainable quality water supply systems, Table 5. In general, the situation between the gaps and needs should be narrowed or decrease for successful research outcomes.

Table 5. Gaps and needs for sorghum improvement

Gaps	Needs
Shortage of improved seed to satisfy the demand of farmers	Increase seed multiplication site in more farmers fields and the site for seed multiplication should have access to irrigation in case of rainfall failure
Shortage and high price of input supply such as fertilizers, pesticides, veterinary medicines	Supply inputs with farmers, affordable prices
Improved seed get mixed very fast during production, it needs rehabilitation on time	Rehabilitate the mixed improved varieties as early as possible to get better yield and income
Poor quality and quantity of water for lab and for irrigation during dry season breeding or seed increase	Developed a sustainable water supply system
Lack of experienced research	Improve the internet service system so that researchers could have access to information
Lack of transport for conducting on-farm trials, field visit, etc.	Increase the budget situation to have access for transport, field work and for conducting surveys
Poor linkage between research, extension and farmers	Improve the current farmers, researchers and extension linkage for more discussion and adoption of technologies
Lack of training for young researchers	Most of the researchers are very young just coming from college; they need higher training to be good workers

Source: FAO

4.2. Capacity profile

- **Type of organization:** Respondents belong to Zoba Maekel beneficiaries, national research organization, extension/advisory services.
- **Experience in working in innovation fields:** Respondents experience in working in innovation fields ≤ 5 years (23%), 5-10 years (43%), 15-20 years (31%) and ≥ 20 years (13%).
- **The main areas of experts/domain of innovation are:** beneficiaries of green feed, soil and water, extension, research, agricultural engineering, natural resources management.
- **Experiences with regard to AIS:** practical knowledge (25%) and conceptual knowledge (23%), both (32%).
- **Main outputs:** innovation reports (50%), training manuals (23%), extension materials (12%), video (10%) and database (5%).

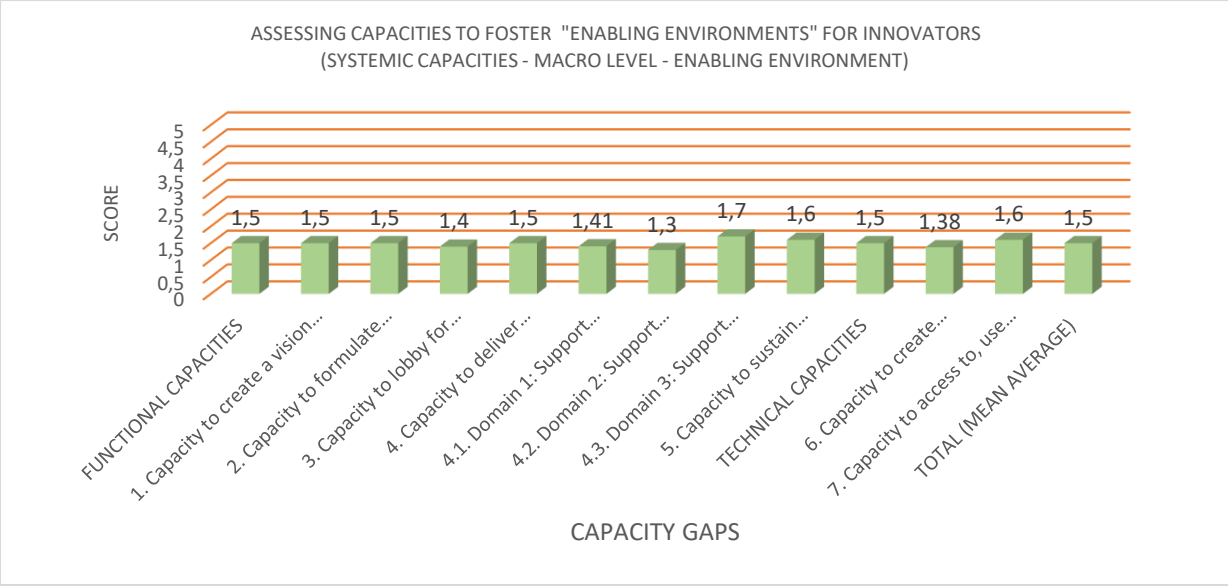
Table 6 showed that the functional capacity for sorghum improvement scores in the ranges of 1.3 to 1.7 with a mean of 1.5. Similarly, the technical capacity for the crop is in the range of 1.4 to 1.6 with a mean of 1.5. The study indicates that the capacity gap for the functional capacities in sorghum improvement lacks adequate skill, knowledge and

attitudes and even when skills, knowledge, and attitudes are present/exist they are not put into practice, Figure 4.

Table 6. Capacity gaps profile assessing to foster "enabling environments" sorghum improvement

CAPACITY GAPS	Score
FUNCTIONAL CAPACITIES	**1.5**
1. Capacity to create a vision for improving innovators' environment	1.5
2. Capacity to formulate comprehensive and inclusive innovation policies and instruments	1.5
3. Capacity to lobby for changes in the AIS toward more demand-led and interactive multi-actor innovation processes	1.4
4. Capacity to deliver demand-led innovation support services (in a responsive and coordinated manner)	1.5
4.1. Domain 1: Support services to Multi-actor Innovation Partnerships (MIP)	1.4
4.2. Domain 2: Support services to Innovative Entrepreneurship (IE)	1.3
4.3. Domain 3: Support services to Technology Transfer (TT)	1.7
5. Capacity to sustain networking and broke raging among AIS actors	1.6
TECHNICAL CAPACITIES	**1.5**
6. Capacity to create new technologies, products and processes	1.4
7. Capacity to access to, use and adapt existing technologies at competitive levels of cost and quality	1.6

Source: FAO



Source: FAO

Figure 4. Assessing capacities to foster "enabling environments" for sorghum

Keys for rating

0: no / none / never
1: adequate skills, knowledge, attitudes do not exist
2: skills, knowledge, attitudes exist, but not put into practice

3: adequate skills, knowledge, attitudes exist, but are too scared to create impacts/ limited success
4: skills, knowledge, attitudes exist and put into practice but with sufficient success
5: skills, knowledge, attitudes exist and put into practice with great success
N/A

5. Enabling analysis

5.1. Policy Environment

There is an agricultural research policy with the aim of producing improved technologies that will help to alleviate the production problems of farmers and contribute to food security through the production of high yielding and pest resistant varieties. The policy of the country also promotes research by providing budget, facilities, infrastructure, establishment of research centres, trained human resource, etc. The policy also facilitates the creation of collaboration and linkage with local, regional and international agencies for the advancement of the research.

The policy has an enabling environment in sorghum research since the crop is grown all over the country by most farmers, so the improvement of this crop will contribute to high sorghum production and thereby improve the food security of the country. Higher production means better yield and more income for producers.

5.2. Governance

The MoA, MoLG and village administrators implement all sorghum production activities in the country and as a result, the coordination and facilitation among the actors are performed well in most parts of the country. The main constraints, as explained earlier, are availability of inputs such as improved seeds, fertilizers and herbicides for control of weeds. The other problem is that the improved seeds get mixed after one or two seasons of production, which affects the purity of the released varieties.

Annex 2. Case study – Green feed

Introduction

The major livestock production system in Eritrea is based on the open rangeland, on an extensive system. In the highlands, the system is part of the mixed-crop livestock farming practice, while in the lowlands it is of the pastoral type, involving long distance movement of animals in search of feed and water. The intensive system is of limited scale, involving small-scale dairy farms operating in and around the main urban centres. The dairy farming system is of the intensive type and the key problems are shortage of feed supply and diseases (FMD, brucellosis, mastitis and tuberculosis).

Fodder and forage production are centred on two species namely: Alfalfa grass (*Medicago sativa)* and Napier grass *(Pennisetum purpureum)*, Figure 5*.* The production of these feeds depends on supplementary irrigation, manuring and limited use of mineral fertilizer, resulting in high yields. This system is the most cost-effective form of dairy farming as it provides the cheapest source of nutrients for livestock. Adequate quantities of good quality forage is produced to allow for sufficient livestock feeding and minimal reliance on expensive concentrate feeds by lowering total production costs. This high-quality forage will be sustainable for livestock maintenance and the production of seven to eight litres of milk per day. Concentrate feed will only be required for the production of additional milk above this amount. In Eritrea feed accounts for about 75 percent of the total cost of production per litre of milk (MoA, 2006).

2. Structural analysis

2.1. Actors and role of the partners

Partner organizations and institutes in green feed production and their roles are indicated in Table 7. NARI, AED and farmers are the main actors for the functions of the innovation to be performed.

Table 7. Actors' role and responsibilities - Green feed

Partners	Role of the partners
NARI	Develop new variety, agronomic practices, provision of seed and training
AED	Disseminate forage seed, inputs, organize training and collect feed back
RSD	Involved in regulation by issuing permits and conducting on-site and quarantine inspections
Farmers association	Participate in forage production and dissemination
MoLG	Act as a bridge between AED, NARI and farmers for adoption of green feed production and dissemination
MoLWE	Provision of land for feed production
ILRI	Provision of forage seed, fund and training extension and NARI staff
Australia	Provision of legume seed for animal feed, fund and organize training
EIDP	Provision of tools to be used in feed production
DeSIRA, EIDP	Provide seed, training, technical assistance both for innovation process and dissemination
EU, UNDP, FAO, IFAD	Provide funding, technical assistance both innovation process and dissemination of results to farmers

Source: FAO

Figure 5. Green feed Alfalfa (left), Napier grass (right)

2.2. Interactions

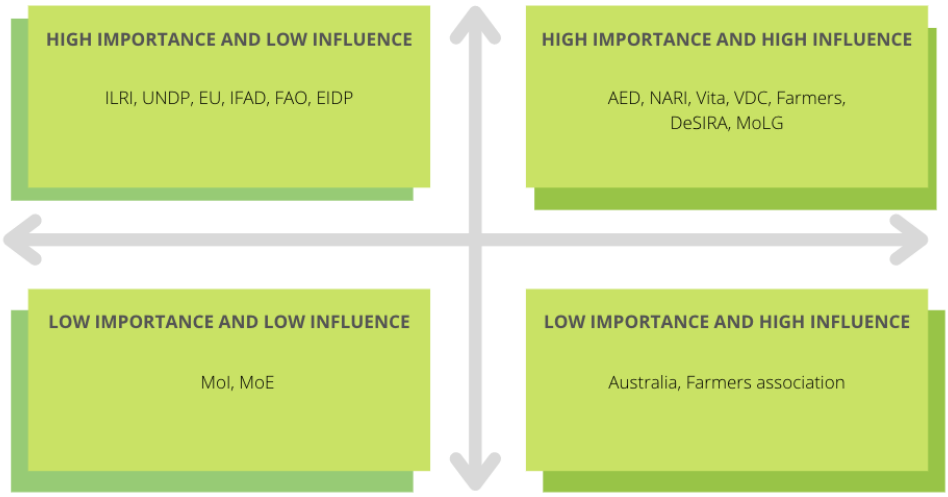
The interaction in green feed case study happened at three levels: macro, meso and micro.

Table 8: Interaction of actors in Green Feed production

Level	Actors	Interact with
Macro	Financial institute/dev. partners, MoA, MolG, MoF, MoI, MoE, MoLWE, HAC, DeSIRA	AED, NARI, VDC, farmers association, traders/input suppliers
Meso	NARI, AED, VDC, MoLG, farmers association, input suppliers	Both with actors at the Micro and Macro levels
Micro	Farmers/Beneficiaries	Interact with actors at meso level

Source: FAO

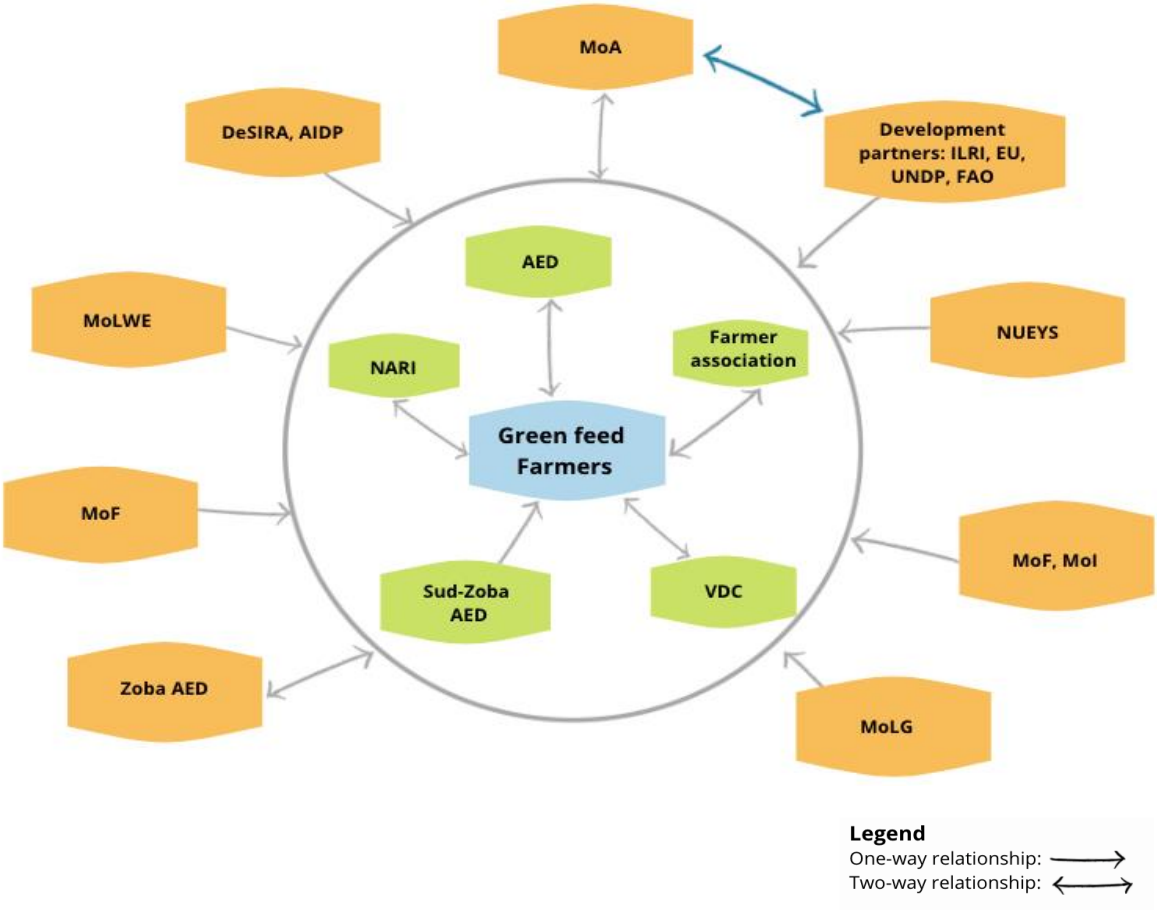
In green feed production, various actors and stakeholders play an important role in the innovation process, as well as in the dissemination of the technologies, and at the same time have different types of influences. AED, NARI, EIDP, DeSIRA, VDC, VITA, farmers and MoLG, are highly important in green feed innovation processes and at the same time have a high influence in green feed technology dissemination. NARI is the main actor in innovation processes, supported by AED and farmers associations. AED is responsible for dissemination of green feed technologies to farmers and farmers associations, whilst the MoLG acts as a bridge between extension workers and farmers in transfer of green feed innovations to users through VDC. EIDP disseminates seeds, veterinary medicine to dairy producers. ILRI, UNDP, EU, IFAD, EIDP and FAO have a very important role because they support NARI in innovation processes; however, they have little influence in interaction or involvement in the dissemination of the technology to users/farmers. EIDP is important in provision of credit to farmers and farmers associations. Stakeholders, such as MoI and MoE have low importance during the innovation process but have high influence in the dissemination of the technology through radio, TV and newspaper. Likewise, Australia (Source of forage seed) and farmers association has low importance and low influence due to its low involvement in innovation processes and since it is not directly involved with farmers, they also have a low influence in technology dissemination (Table 8, Figure 6 and Figure 7).



Source: FAO

Figure 6. Stakeholder's importance and influence of green feed actors' interaction

2.3. Networking



Source: FAO

Figure 7. Stakeholders network map – green feed

3. Functional analysis

Green feed production

During the FGD and key informant study, farmers reported that they produce green feed (Alfalfa grass, Napier grass, sweet potato and sometimes maize for silage) because concentrates are not easily available in the market, and even when available, the price is very high. The participants also reported that green feed provides the cheapest source of nutrients for dairy animals. Good quality green feed reduces reliance on concentrates, at the same time lowers the cost of production. Other farmers reported that the current good price of milk and its high demand pushes or invites farmers towards dairy business and green feed production. Farmers also reported that in dairy production, feed is the most important, because animals that are well fed produce more milk and earn better income. Some of the FGD participants also reported that they produce green feed because it fetches good price and income by selling it to dairy producers.

Forage production procedures

The main forage species used in Eritrea are Alfalfa and Napier grass, although other species are produced in limited area like in Elaberied. NARI conducts research on forage. The study of forage includes collection of germplasm from different sources mostly from ILRI/ILCA. The germplasms are tested for their adaptability, disease situation, and preliminary yield trial. The best lines among the germplasms are advanced to preliminary yield trial in replicated plots. Again, from the advanced line, five to ten lines are retested to study their performance and yield. From these lines, the best two – three varieties (lines) are selected and tested in three to five major Alfalfa growing areas of the country for two years; the selected variety is then recommended for release and production. The forage agronomists will provide about 50-100 kg of Alfalfa seed to AED for further multiplication. AED will conduct demonstrations at various forage producing areas of the country to show the released forage crop to farmers. Farmers will have a field day to observe the performance and stand of the new variety. Extension agencies and the forage researchers will frequently visit farmers field to give advice and guide on proper forage production management.

3.1. Relations with functional, structural and capacity analysis in green feed

The functional analysis highlighted the following functions: knowledge generation, knowledge dissemination, marketing conditions or development and resource mobilization (Table 9).

Table 9. Relations with functional, structural and capacity analysis in green feed

Functional analysis	Structural analysis	Capacity analysis
Cluster of functions identified	Who carries out the functions, interrelations between them	Capacities needed to perform those functions, Capacities exist at present
Knowledge generation	Org 1. NARI	**Exist:** Young graduates with little experience of work as forage agronomist **Need:** NARI need forage agronomist, technical assistances such as germplasm
Knowledge Dissemination	Org 1. AED, Org 2. MoI, MoLG, EIDP Org 3. Farmers	**Exist:** AED has forage technicians, MoLG organize farmers to adopt forage production; MoI disseminate forage technology through radio, TV and newspaper; Farmer adopt forage production method and disseminate to other farmers **Need:** AED need extension forage agronomist
Institutional support, funding agency	Org 1. DESIRA, EU Org 2. ILRI Org 3. MoF	**Exist:** DeSIRA EU, IFAD, provide funding for technology generation and dissemination; MoF provide budget salary for technician **Need:** ILRI provide funding, forage seed, and training to extension staff; MoF provide budget
Entrepreneurs Finance institutions	Org 1. EDIB, SMCP Org 2. MoA Org 3. Farmers associations, private sector	**Exist:** EDIB, SMCP provide finance support; MoA/AED credit and market unit provide **Need:** Farmers associations; private sector need finance support
Commercialization , Input supply	Org 1. Traders, MoA/AED Org 2. SMCP Org 3. Farmers association	**Exist:** MoA/AED, Traders supply input (seed, fertilizer, veterinary medicine to farmers and farmers associations **Need:** farmers associations and farmers supply inputs
Socializing change, collective action/ social processes	Org 1. Farmers association Org. 2. MoLG	**Exist:** Farmers association (vegetable and dairy producers) **Need:** Concept and understanding process of micro, meso and macro; 2. platforms, interaction and networking

Source: FAO

3.2. Source of inputs and supply

The major inputs used in the green feed production are forage seed (Alfalfa and Napier grass), fertilizer or manure, pesticide, fuel for irrigation, veterinary medicine, tools and carts for transport of harvested feeds. Farmers get seed from different sources such as AED, traders, farmers association and NARI. According to farmers, the seed obtained from NARI has a high germination rate and good stand. Pesticide, mostly used for control of aphid, is obtained from the market; tools and salt are obtained from traders at a high price. Most of the veterinary service is provided by the MoA, although sometimes farmers are forced to buy medicines from market at higher price.

3.3. Dissemination of green feed technologies

The MoA, through its Agricultural Extension Department (AED), raised the awareness of farmers on forage production through demonstration, organization of training, arranging field visits to model or contact farmers, and by distribution of leaflets, brochures, etc. The MoI also disseminates modern green feed production techniques through radio, television and newspaper. The major actors in dissemination process are AED, NARI, traders and MoLG with the support of development partners by providing funding for the development of the varieties and for dissemination of results to producers. The DeSIRA initiatives, through MoA, provide funding and technical support, such as fertilizer, seed and chemicals to dairy associations and green feed producers. Similarly, traders and agribusiness are involved in supply inputs such as seed, chemicals, etc. but the prices of the inputs in this case are very high compared with the MoA (Table 10). In general, NARI, AED, NGOs, development partners, farmers, farmers associations and private sectors interact in the innovation processes and dissemination of green feed technologies in the country.

Table 10. Actors/stakeholders in the dissemination of green feed

Actors/stakeholders	Roles in dissemination
AED	Disseminated seed, conduct demonstrations organize farmer training
NARI	Disseminated seed through the regional office of MoA, providing training, organize field day for farmers
HAC	Provide veterinary services, organize farmer training
MoLG	Act as a bridge between farmers and extension workers during the dissemination of the technologies
Farmers association	Organize farmers to attend training, field day, distribute leaflets and others
DeSIRA	Provision of fund and technical support like fertilizer, seed, chemical through AED and EIDP to farmers
IFAD, EU, FAO, ILRIEIDP	Provision of fund for training farmers and fund for dissemination

Source: FAO

3.4. Challenges and opportunities

The main challenges in forage/green feed production are shortage of land for feed production, lack of water for irrigation, shortage of fuel for water pumping and forage seeds. Land problem is critical as the area is highly populated and land is scarce, furthermore, land rental is very costly. The main opportunities are: dig water well on the downstream of dams, use of machinery for harvesting, cultivation and transport of feeds, improve the land tenure system for equal sharing of the land, and supply of seeds and other inputs through the DeSIRA project, Table 11.

Table 11. Challenges and opportunities in green feed production

Challenges	Opportunities
Shortage of land for green feed production	Improve the land tenure system
Lack of water for irrigation	Dig well on the downstream of dams
High cost of labour for cultivation of green feed	Use machine for cultivation, transport and harvesting
Fuel for pumping engines	MoA facilitate fuel supply to producers
Supply of inputs like seed, chemicals, etc.	DeSIRA project supply inputs

Source: FAO

3.5. Market demand

Green feed has a high market demand in all areas. Farmers who have land near water points produce Alfalfa and Napier grass as it fetches a higher price and is more profitable than crop production. The demand for forage is very high as there are many dairy producers in Dekemhare, Dibarwa, Mendefera and Keren. In these areas, the demand for milk is very high, farmers also have nearby milk processing, as a result the market situation for milk, as well as for forage, are sustainable all year round.

At present, there is no agricultural milk marketing system in the country. There are no private sectors or platforms for milk producers in the country. The MoA, through its extension department (marketing and credit unit) and small retailers in nearby towns, provide a marketing service (input supply mostly forage seed, fuel, tools, veterinary medicine, etc.) to green feed producers. Sometimes the farmers associations supply some inputs (concentrates, veterinary medicines, etc.) that are available in Tesseny from the Sudan.

Farmers sell their milk product directly to nearby towns like Dekemhare, Dibarwa, etc. During the fasting period, the farmers process the milk to produce butter that can be stored for a short period until the end of the fasting period.

In the current marketing situation, traders are the main actors who supply most of the inputs to green feed producers at very high prices. Traders also provide credit service mostly in kind (tools, veterinary medicines, seeds, etc.) and in cash (cash for labour cost). Green feed producers get tractor services for land preparation from the nearest MoA offices. Farmers around Dibarwa and Mendefera get seed directly from Halhale, NARI centre. Individual green feed producers sell their product to nearby dairy producers at about 3-5 kg per 5 Nakfa (1 Nakfa=0.07 USD). To improve the market situation there is a need to establish a platform, strengthening the dairy producers association who can organize and develop both milk and feed market outlets.

3.6. Entrepreneurial activity

The number of dairy entrepreneurs around the urban and semi-urban areas is increasing, more farmers are involved in the dairy industry, and the green feed production is also increasing to meet the demand for feed.

There are entrepreneurs of feed producers around the urban and semi-urban areas in Eritrea, mostly around Asmara, Dibarwa, Mendefera, Dekemhare, Keren and others where there are water sources. Most of the entrepreneurs use inputs such as AI, seeds, tools, tractor services for land preparation and labour for weeding, cultivation, irrigation, harvesting and transport. The entrepreneurs do not have platforms, instead, they have dairy producers associations. The main duty of those associations is to supply inputs.

It is very important to improve the capacity of feed production through the creation of a platform, construct reliable water source, tractor services, and transport of harvested feeds to the dairy farm or market, and input supplies on time and at reasonable costs.

3.7. Resource mobilization

The chance for resource mobilization for improved dairy and forage production in the country is very good. The majority of the dairy and forage producers have a good understanding of the production of green feed and adoption of new production techniques. Placement of extension staff at village level will help easy dissemination and introduction of improved green feed and dairy production in the country.

Most of small farmers and entrepreneurs use their own source of funding for establishing and running of the forage production, while some entrepreneurs get loans from EDIB or SMCP. The innovation process of feed is done by NARI using the government budget, and to some extent, from partner development agencies. Similarly, the source of funds for the extension is from the government budget and partners such as DeSIRA.

All the green feed innovation processes are done by NARI with government budget, although there could be some support from developing partners. According to the

FGDs, the subsistence farmers do all the activities with their own resources, as the plot sizes are very small. Similarly, most of the entrepreneurs, who have small plots, do all the forage production with their own resources, while those entrepreneurs who have larger plots get loans from SMCP.

Access to rural finance is needed to strengthen the farmers situation and it should be operational at grassroots level, as most of green feed producers are subsistence farmers. The access should include inputs supply, tools, seed, and pesticide spraying equipment and creating good marketing.

3.8. Impact

All the farmers, especially dairy producers, have accepted the green feed technology and are producing forage in all areas. Currently there is high milk production in Dekemhare, Dibarwa, Mendefera, Keren and Akordet. In these areas, the supply of milk and milk by products (value chain) have increased and at the same time, the price of milk decreased from 30 to 18-25 Nakfa per litre. This is especially true during the long fasting period of the Coptic religion followers, who they do not eat or consume meat and other animal products during fasting.

4. Capacity analysis

4.1. Capacity gaps profile/analysis

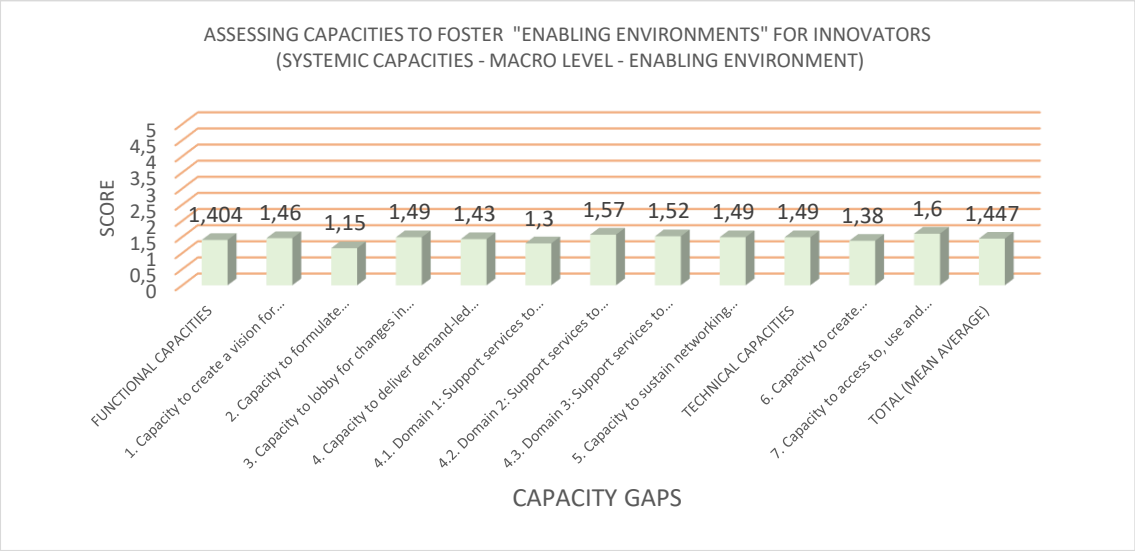
- **Type of organization:** Respondents belong to national research organization, and extension/advisory services.
- **Experience in working in innovation fields:** Respondents experience in working in innovation fields ≤ 5 years (0%), 5-10 years (0%), 10-15 years (33%), 15-20 years (0%) and ≥ 20 years (67%).
- **The main areas of experts/domain of innovation are:** animal production, forage production and dairy development.
- **Experiences with regard to AIS:** practical knowledge (33%) and conceptual knowledge (33%), both (34%) and none (0%).
- **Main outputs:** Scientific papers (14%), policy papers (0%), project reports (21%), training manuals (21%), extension materials (29%), video (14%), database (0%) and others (0%).

The capacity gaps and the enabling environment of the green feed situation showed that the functional capacity score/rate range from 1.2 to 1.6 with a mean of 1.4, likewise the technical capacity score ranges between 1.4 and 1.6 with a mean of 1.5. This indicates that the green feed technology lacks skill, knowledge and attitudes and even when they are present or exist, those are not put into use or practice, Table 12 and Figure 8.

Table 12. Capacity gaps profile assessing capacities to foster “enabling environments" for innovators green feed

CAPACITY GAPS	Score
FUNCTIONAL CAPACITIES	1.4
1. Capacity to create a vision for improving innovators' environment	1.5
2. Capacity to formulate comprehensive and inclusive innovation policies and instruments	1.2
3. Capacity to lobby for changes in the AIS toward more demand-led and interactive multi-actor innovation processes	1.5
4. Capacity to deliver demand-led innovation support services (in a responsive and coordinated manner)	1.4
4.1. Domain 1: Support services to Multi-actor Innovation Partnerships (MIP)	1.3
4.2. Domain 2: Support services to Innovative Entrepreneurship (IE)	1.6
4.3. Domain 3: Support services to Technology Transfer (TT)	1.5
5. Capacity to sustain networking and broke raging among AIS actors	1.5
TECHNICAL CAPACITIES	1.5
6. Capacity to create new technologies, products and processes	1.4
7. Capacity to access to, use and adapt existing technologies at competitive levels of cost and quality	1.6
TOTAL	1.4

Source: FAO



Source: FAO

Figure 8. Assessing capacities to foster “enabling environments" for innovators green feed

4. Enabling environment analysis

4.1. Policy environment

There is an enabling environment to promote dairy and green feed farmers in the country. The MoA provides seed, veterinary services, AI, medicine, organize periodic training on modern forage production and dairy management. In some areas like Situr in Keren, the government provided land for dairy and forage production, organized farmers to form dairy producer association and dug wells for forage irrigation.

The policy also influences forage and dairy producers by promoting good price and high demand of milk that pushes or invites them towards dairy business and green feed production. Farmers also reported that in dairy production, feed is most important because animals that are well fed, produce more milk and better income.

4.2. Institution

The MoA, MoLG and dairy association and village administration are the main institutes in the development and in the dissemination of green feed production.

4.3. Governance

All activities are implemented by MoA in collaboration with MoLG and village administrations. The linkage and collaboration among the actors/stakeholders work well, however, farmers reported that they lack inputs like fertilizer, seed, farm tools and fuel for irrigation. Farmers get these inputs from local market at very high prices.

Annex 3. Case study – Energy saving stove-Adhanet

1. Introduction

Fuel wood is becoming increasingly scarce, people are forced to travel long distance and they spend more time to fetch firewood. The price for firewood in Asmara and its surrounding has increased tremendously (800-900 Nakfa/100 kg) due to firewood shortage. To solve such problems, it was necessary to find an alternative source of energy. A study conducted from 2006-2008 in Asmara on energy, showed that the use of improved stove (for baking injera-flat bread) reduced the consumption of firewood by 50 percent when compared with the traditional Mogogo stove. The innovation so far has benefited over 400 000 households in the country. Thus, promotion of such work to a wider area is very important for the restoration of forest trees, vegetation, wildlife and the biodiversity at large.

2. Structural analysis

2.1. Actors role and responsibilities

Improved stove 'Adhanet' was designed and developed by the Ministry of Energy and Mining (MoEM) in collaboration with the Ministry of Agriculture (MoA). The stove was designed to use less firewood by about 50 percent and to improve the health of women from smoke pollution. During the development of the stove many line ministries, educational institutes, finance institutes, farmers and development agencies were involved and their contribution and roles are indicated in Table 13 and Figure 9.

Table 13. Actors/partners and their contribution-Adhanet stove

Partners/actors	Roles/contribution
Ministry of Energy and mines (MoEM)	Design and development of the stove, study power consumption and materials needed for construction of Adhanet
Ministry of Agriculture	Collaborate in development of the stove, involve in dissemination of the stove to users through its extension department
MoLWE	Participate in the innovation process
MoLG	Act as a bridge between extension agencies and rural areas in dissemination of the stove
NUEW	Provide funding, training to household, act as a bridge between MoA/AED and farmers, participate in dissemination
NGOs (ErCS, EIDP)	Provide funding, training and technical support to farmers and dissemination
Village community development, VDC	Participate in the innovation process, adopt the technology
Regional and international development agencies (AfDB, IFAD, EU, UNDP, FAO)	Provide funding, training, technical support during the innovation development and dissemination

Source: FAO

Figure 9: Improved stove Adhanet (top) - Traditional stove Mogogo (bottom)

2.2. Interactions

The interaction in the case study takes place on three levels: macro, meso and micro.

Table 14. Interaction in improved stove

Level	Actors	Interact with
Macro	Financial institutes, dev. partners, MoA, MoF, MoI, MoLWE	AED, VDC, MoEM, NUEW, MolG
Meso	AED, VDC, MoEM, NUEW	Both with actors at micro and macro levels
Micro	Household/Beneficiaries	Interact with actors at meso level

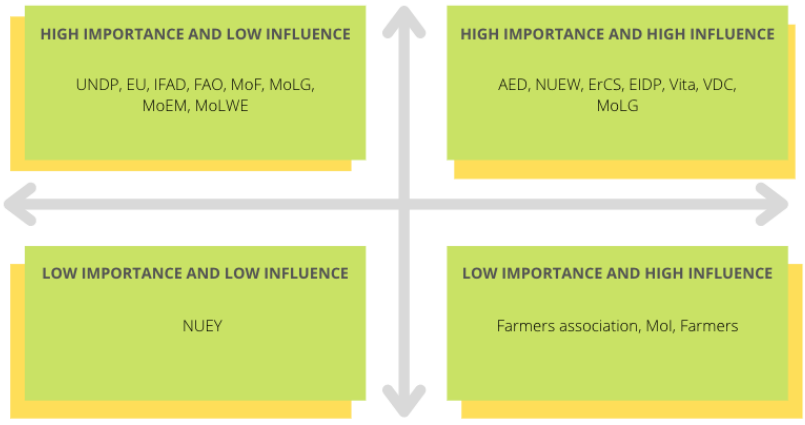
Source: FAO

Various actors/stakeholders interact in the innovation processes and have diverse influences on the technology generation and distribution. AED, NUEW, ErCS, EIDP, VDC, VITA and MoLG have high importance in technology generation, also they have high influence because they are directly involved in innovation dissemination to end users.

Actors/stakeholder such as MoLWE, MoEM, FAO, UNDP, EU, IFAD, MoLG, and MoF have high importance in the innovation processes by providing funding, organizing training, but have low influence in the dissemination of the technology because they do not have direct contact with farmers.

Actors such as NUEYS has low importance in technology generation and has low influence, as less involved in innovation disseminations.

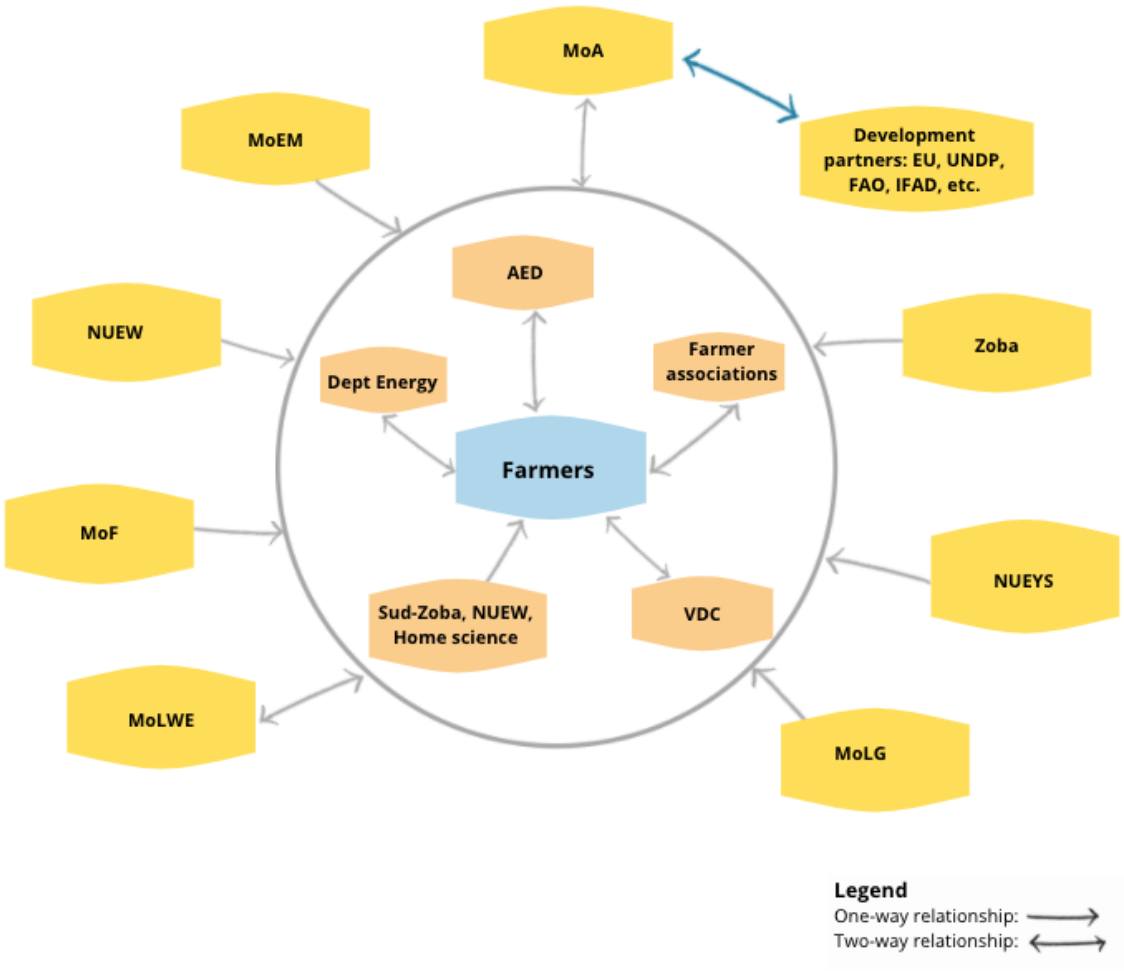
Stakeholders such as farmers, farmers association and MoI have low importance because they are not involved in technology generation, but they are highly influential since they are involved in innovation dissemination to users. Table 13, Figure 10 and Figure 11.



Source: FAO

Figure 10. Actors' importance and influence for improved stove

2.3 Mapping and networks



Source: FAO

Figure 11. Stakeholders network map – improved stove

3. Functional analysis

The functional analysis identified the following functions: knowledge generation, knowledge dissemination, marketing conditions or development, entrepreneurism development and resource mobilization.

3.1. Innovation procedures

The stove is well designed and made from bricks, mud, fire gates and chimney supplied by MoEM. The innovation is accepted by stakeholders due to its efficiency in conservation of energy, lower firewood consumption, no smoking and wood ash to be cleaned by women. In villages, local households can easily construct it. The innovation needs to increase the private sector involvement, by incubating entrepreneurs in the processes and needs marketing and financial supports. Resource mobilization is done by MoF with the collaboration of development partners such as UNDP.

3.2. Innovation team

The innovation team for generation and dissemination is composed of MoEM and MoA/home science, public health, women association, NARI/Agricultural Engineering. The team needs support for its sustainable continuity and to be strengthened through managerial support, back up of logistics and financial support. For commercialization and use of the innovation, as one of income generating means, there is a need to strengthen the Medeber workshop as a means of incubation of the innovation.

3.3. Relations with functional, structural and capacity analysis

The main functions are: knowledge generation and dissemination, institutional capacity building, entrepreneurship, commercialization and socialization of the innovation. These functions are performed mainly by MoEM, MoA/AED, MoLG, development partners. There is commitment and determination to reach the SDG targets in relation to sustainable use of resources and climate change. So far, the innovation has greatly contributed to the improvement of women health, and the use of firewood. The actors are actively promoting the development of the innovation and dissemination to each household. There is a need to establish platforms, develop entrepreneurial capacities and markets and mobilize resources to the level the innovation demands.

Relations with functional, structural and capacity analysis were done by clustering the partners according to knowledge generation, dissemination, financial institutes etc. that helped to perceive capacity needs and existing capacities. (Table 15).

Table 15. Relations with functional, structural and capacity analysis -Adhanet stove

	Functional analysis	Structural analysis	Capacity analysis
Enabling environment Analysis	Cluster of functions identified	Who carries out those functions, interrelations between them	Capacities needed to perform those functions Capacities exist at present
	Knowledge generation	Org 1. MoEM	**Need:** chimney and stove gate availability in local market; Budget for further dissemination **Exist**: Materials for new stove construction; only 162 000 stove disseminated
	Knowledge dissemination	Org 1. AED Org 2. MOI Org 3. MOLG-VCD	**Need**: AED, MoI need budget for dissemination; MoLG and VCD conduct adoption rate study; Ownership problem, form platform **Exist**: AED, ErCS and EIDP disseminate the stove
	Institutional support, funding agency	Org 1. development partners (EU, UNDP) Org 2. MOF	**Need**: EU, UNDP provide funding for further dissemination; MoF should continue on popularization; MoA form platform **Exist**: Low financial support
	Entrepreneurs finance institutions	Org 1. Private	**Need**: Private sector produce more spares of chimney and stove gate **Exist**: AED, ErCS and EIDP disseminate the stove
	Commercialization, input supply	Org 1. Traders Org 2. MOA	**Need**: MoA encourage private sector to produce spare part like chimney, gate; Traders should be encouraged to supply spare parts of Adhanet **Exist**: problem of chimney and stove gate

Enabl...	Functional analysis	Structural analysis	Capacity analysis
	Socializing change, collective action/social processes	Org 1. MOLG, VDC Org 2. NUEW	Need: MoLG and VDC encourage society to form platform Exist: AED, ErCS, NUEW and VDC socialize the innovation for more dissemination

Source: FAO

3.4. Triggers and bottlenecks

The major bottlenecks of Adhanet are availability of some parts of the technology, mainly chimney and gate. These parts are essential for conservation of energy and health of the family. Usually the MoA supply the two parts through its extension division. Currently, both chimney and gates are made in Medeber, Asmara, at reasonable price and many users of Adhanet buy the parts from Medeber. The other parts such as bricks, stone and others are easily made at local village level or by each household. Most of the development partners in Eritrea provide funding for dissemination of the stove to farmers (Table 16).

Table 16. Triggers and bottlenecks for development of Adhanet stove

Triggers	Bottlenecks
1. Reduce wood consumption for baking injera	1. No charcoal as by product of firewood use
2. Improve health of the family less smoke and clean house	2. Problem in availability of stove parts, mainly chimney and gate
3. Conserve forest or biodiversity that are cut for baking of injera	3. High initial cost over 2 200 Nakfa/stove which is a problem for poor farmers
4. Increase efficiency in conservation of energy	4. The need to break woods into small pieces, this requires labour to cut the wood into pieces

Source: FAO

3.5. Dissemination of improved mogogo

The following actors are involved in the dissemination of improved stove Table 17.

Table 17. Dissemination of improved Stove

Actors/stakeholders	Dissemination responsibility
AED, ErCS and EIDP	Disseminate improved stove by provision of construction materials, organize households training
EU, UNDP and IFAD, MoF	Provide funding for purchase of construction, support training for households and extension staff on construction of stove
MoLG and VDC	Act as a bridge between farmers and extension agencies in dissemination of stove
MoEM	Assist in training for extension agencies on construction of stove
MoI	Popularize the importance of improved stove to users through radio, TV and newspaper

Source: FAO

3.6. Challenges and opportunities

In general, the major challenges are numerous, initial cost over 2 200 Nakfa per stove, which is expensive for most households, some of the spare parts, like chimney and fire gate of the stove, are not easily available at local village level. In the highlands, where there is electric power, households do not use stoves, as the cost of electric is much lower than the cost of firewood. Similarly, the demand for the stove is low in the lowland where firewood is easily available and charcoal produce from the stove is low. Households use charcoal to fuel the Mogogo to boil coffee.

The main advantages of the stove are, reduced use of wood by more than 50 percent, improved family health, high energy conservation, time saving for women and children and contribution to the biodiversity by conserving natural vegetation (Table 18).

Table 18. Challenges and opportunities of improved stove

Challenges	Opportunities
Shortage of chimney and gate parts and their cost is high for some households	Reduce the use of firewood by 50 percent
Initial cost is high	Improve the health with no or less smoke
It is less accepted in the lowlands where wood is easily available, to get charcoal for coffee boiling	Adhanet has a high energy conserve ability compared with the traditional Mogogo
In some areas where ingera is less used its demand is low	More efficient energy use and time saving
Many households like to get charcoal from the stove, but this is not possible with Adhanet as it uses small branches that do not produce charcoal	Decrease destruction of vegetation, increased wildlife population and manures are used for soil fertility rather than used as biomass for energy use

Source: FAO

3.7. Impact

Over 400 000 improved stoves have been distributed to different households mostly in the highlands of Eritrea where firewood is very scarce and expensive. Mostly the MoA, followed by civil societies and NGOs with the cooperation of the MoLG, did the distribution of the stove. The distribution of the stove helps to reduce the consumption of firewood, improved household health in all the dissemination areas. To define conclusive impact of the stove and acceptance of the improved stove it is important to evaluate the adoption of the technology.

3.8. Market development

Adhanet is a simple technology that can be locally made once the training is given to women. It has many parts for its construction and for efficient use of the stove. Most of the parts are easily made at household level and are also available at village level. However, some parts like smoke chimney and gates are not available and these parts are made in Asmara at Medeber. The parts made in Medeber need to be produced in large number and be commercialized, where users can get them easily, with lower or reasonable price that could be afforded by farmers. In general, efficient dissemination and adoption of the technology needs value chain equipment.

3.9. Entrepreneurial activity

The possibility of developing entrepreneurial activity is very high, because skilled experts are available at Medeber in Asmara and there are farmers associations in most Zobas and sub-Zobas of the country who can make the technology available.

3.10. Resource mobilization

There is a good chance for mobilization of the technology in the country. The majority of extension workers are young with good will and ability to cope with new technologies and practices. Placement of extension staff up to village level will help for easy dissemination and introduction of the technologies to users.

3.11. Capacity gaps profile

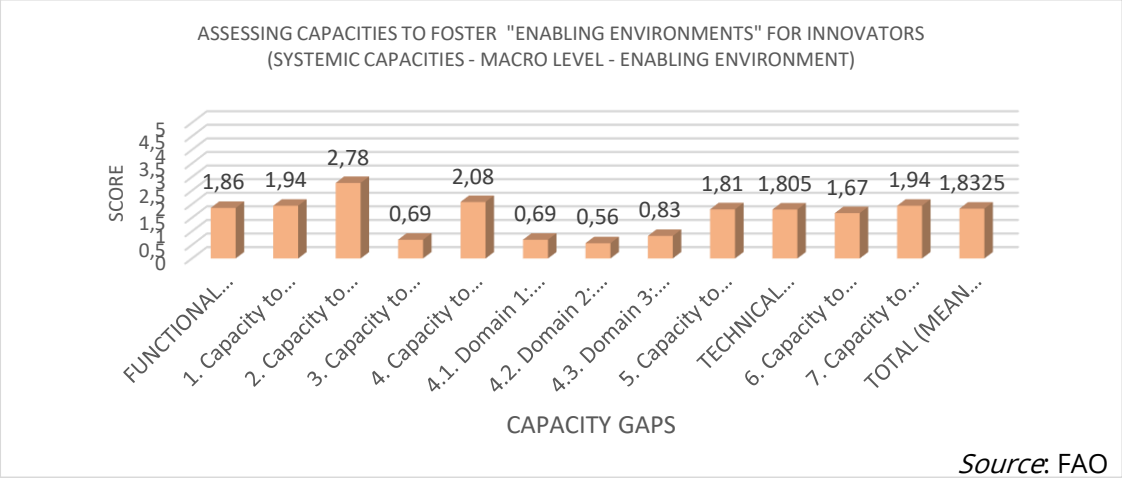
- **Type of organization:** Respondents belong to extension/advisory services, and regulatory services.
- **Experience in working in innovation fields:** Respondents experience in working in innovation fields ≤ 5 years (0%), 5-10 years (33%), 10-15 years (17%), 15-20 years (17%) and ≥ 20 years (33%).
- **The main areas of experts/domain of innovation are:** agricultural engineering, home science and extension.
- **Experiences with regard to AIS:** practical knowledge (33%) and conceptual knowledge (50%), both (17%) and none (0%).
- **Main outputs:** Scientific papers (14%), policy papers (0%), project reports (21%), training manuals (21%), extension materials (29%), video (14%), database (0%) and others (0%).

The functional capacity gaps to create a vision, capacity to lobby and the domain of MIP, IE and TT and capacity to sustain lacks skill, knowledge and attitudes. Functional capacity to formulate comprehensive innovation processes and capacity to deliver demands led innovation support to have skills, knowledge and attitudes do exist, but are not put into practice. In technical capacity, both creating new technology products or processes and capacity to access, lacks skill, knowledge and attitudes. In general, both the functional and technical capacity in the improved Adhanet stove still lacks skill, knowledge and attitudes for adoption of the technology Table 19 and Figure 12.

Table 19. Capacity gaps profile assessing capacities to foster "enabling environments" for innovators Adhanet stove

CAPACITY GAPS	SCORE
FUNCTIONAL CAPACITIES	1.9
1. Capacity to create a vision for improving innovators' environment	1.9
2. Capacity to formulate comprehensive and inclusive innovation policies and instruments	2.8
3. Capacity to lobby for changes in the AIS toward more demand-led	0.7
4. Capacity to deliver demand-led innovation support services (in a responsive and coordinated manner)	2.1
4.1. Domain 1: Support services to Multi-actor Innovation Partnerships (MIP)	0.7
4.2. Domain 2: Support services to Innovative Entrepreneurship (IE)	0.6
4.3. Domain 3: Support services to Technology Transfer (TT)	0.8
5. Capacity to sustain networking and broke raging among AIS actors	1.8
TECHNICAL CAPACITIES	1.8
6. Capacity to create new technologies, products and processes	*1.6*
7. Capacity to access to, use and adapt existing technologies at competitive levels of cost and quality	*1.9*
TOTAL	1.8

Source: FAO



Source: FAO

Figure 12. Assessing capacities to foster "enabling environments" for innovators of Adhanet stove

4. Enabling environment analysis

4.1. Policy environment

The FGD and key informant study on policy influence of the innovation is highly encouraging. The policy supports the households to accept and adopt the improved Adhanet stove through training, brochure distribution and exhibition of the technology to selected women. The technology is more economical in terms of firewood usage compared with the traditional stove and it improves the health of the household with less smoke pollution and time saving for women. It also has a positive impact on biodiversity in terms of forest and biodiversity regeneration, which is encouraging. This policy assists the availability of chimney and gates through the MoA and through the funding of the developing partners (UNDP, EU, and IFAD) in the country. In addition to these, the policy encourages the periodic provision of awareness training to farmers for further dissemination into new areas.

4.2. Regulatory framework

The regulatory work should be done by the RSD and science technology. At present most of the regulatory activity is done only by the RSD.

4.3. Governance

The innovation is administered by steering and technical committees at different levels with the strong support of MoLG, MoA and famers. The technical committee continuously supervise and assess the adoption and feedback of the technology. The MoA should encourage its staff to come up with simple modification of the stove.

4.4. Institutions

Various institutes including MoA, MoLG, NUEW, ErCS and EIDP do the implementation; this causes problems of coordination and ownership of the technology in a sustainable manner. There are no incentives for the innovators and people who are involved in the process.

4.5. Infrastructure

In Eritrea, except very few areas, the road infrastructure is available throughout the country, this has created a conducive environment for the dissemination of technologies. As stated earlier the only infrastructure problem, as far as Adhanet, is the availability of chimney and gate at village level.

5. Lessons learned from the case studies

Study on assessment of AIS was done using three cases studies of sorghum improvement, green feed production and dissemination of improved stove. The result

showed that the current innovation system of the three cases have some similarities to the general guide of the AIS in innovation processing, but not fully following up of the general guide of the AIS. Some of these differences are:

1. In the assessment processes, there were no innovation platforms established in any of the three case studies conducted.
2. The functional analysis of the three case studies showed that the present linkage between research extension and farmers is linear or top-down, while in the AIS, the linkage between research, extension and farmers is participatory, where the farmers and extension workers participate in the development of the innovation starting from the initiation of the innovation processes. This type of linkage encourages the extension workers and farmers to incorporate the farmer's priority problems and needs in the research programmes and in return, the farmers will easily adopt research results on time.
3. The research activity in Eritrea appears to favour the commodity approach, whereas in the AIS system, the research is more oriented towards a production system, as the production system gives greater opportunities for soil and water conservation or contributes to the safety of the environment.
4. The capacity gaps and the enabling environment for the three case studies showed that both the functional, as well as the technical capacity, score low or with no skill nor knowledge attitude, and even when skill, knowledge, attitudes are present/exist they are not put into use or practice. This happened because the research staff in NARI are young, with low training and lack experience to produce sound and acceptable research results. Some of the factors for low skilled personnel in the case of NARI and AED are high staff turnover (staff leave their job) due to lack of incentives such as salary increment and promotion.
5. The development of entrepreneurs in all the three cases is just at an infant stage, and its involvement in value chain for crops, as well as for animal product, is very low. There are very few entrepreneurs in dairy and sorghum producers. Commercialization of innovations has not yet started in the country, although this can be helpful for dissemination and sustainable use of certain innovation such as chimney and fire gates in case of the improved stove.

Annex 4. Research units and type of innovations

NARI FGD Unit	Innovations
Biotechnology	- Potato propagation through tissue culture - Banana propagation through tissue culture - Date palm propagation through tissue culture - Banana propagation meristem culture or short tip culture on artificial nutrient media - Potato virus testing through ELISA - In-vitro potato micro tube production - Mini-tuber production - Disseminate virus free potato variety - Tissue culture banana seedling distribution in Golugi and Aquardat - Establishment of molecular laboratory
Horticulture	
Vegetables	- Potato improvement - Tomato improvement - Tomato seed increase - Tomato variety observation - Onion variety observation - Hot pepper variety observation/ size of bulbs - Garlic variety observation - Spacing trial on onion - Pumpkin variety evaluation - Sweet potato evaluation
Fruits	- Banana variety trial and multiplication at Agordat - Citrus-germplasm collection and evaluation at Halhal - Papaya variety evaluation - Papaya gender determination - Papaya vegetative propagation - Grape-vine variety evaluation - Guava variety evaluation - Liquid fertilizer evaluation - Temperate fruit evaluation Apple peach Adi Keih
Plant Protection	- Screening wheat varieties for diseases and insect resistance - Race identification on stem rust, yellow and leaf rust (barley and wheat)

NARI FGD Unit	Innovations
	- Chickpea screening for pests and diseases - Push-pull management for fall armyworm - Insecticide screening on ABW - Insecticide trial on taff shoot fly - Insecticide screening for control blotch and rust on onion - Screening of sorghum lines against *striga* - Weed competition trial on barley and wheat - Botanical insecticides on fall armyworm - Survey of insect pests and diseases
Natural Resource	- Soil survey in Shambuko and Goluj and She'eb - Soil test in the lab - Fertilizer trial - Conservation agriculture -Crop residue -Zero tillage/Minimum tillage -Inter cropping -Crop rotation
Watershed	- Land problem for conducting trials at Halhal, Goluij and Shambuko - Adaptation trial for different water shade management using physical, biological techniques - Physical soil conservation that includes tide ridge and check dam - Different water harvesting techniques such as half-moon, V shape, etc. - Water harvesting at water shade and farm level - Use different crops to conserve water, using different conservation and use different varieties - Water shade level using different shrubs and trees to conserve soil and water - Use different grasses and bamboos for water conservation
Forestry	- Sericulture, nursery, tree seed - Sericulture – management of the trees - Tree measuring, diameter, height and volume of harvest - Tree improvement species elimination to identify the best tree

NARI FGD Unit	Innovations
	- Nursery different seedling rising - Conduct soil mixture trial - Frequency of watering - Tree seed collection - Germination test - Dispatch to Zobas - On-farm fodder bank trial - Home stead fruit and shrub production
Plant Genetic Resource	1. Conservation and sustainable use of plant genetic resource 1.1 Plant genetic resources 1.2 Forest genetic resource 1.3 Animal genetic resource
Plant genetic resource	- Explore for collection of genetic resource - All cereal crops, legumes/pulses and crops, fruit and vegetables, spice and medicinal plants, forage plants and their wild relatives
Forest Genetic Resource	- Collection of seeds of trees and shrubs most from endangered species - Seed collection and Leucaena characterization
Animal Genetic Resource	- Starting at Goluj - Characterization: phenotypic evaluation, regeneration, active and base distribution on Barka cattle
Livestock/Animal science	Main groups: Feeds and feeding Animal production Animal health
Feed and feeding/forage	- Feed conservation, strategy for dry season hay, silage and Leucaena - Sweet potato variety evaluation - Seed multiplication – Alfalfa grass, oat, *panicum maximum*, Napier grass - Establishment of Eritrean animal feed database - Forage production estimation to develop feed budgeting - Yield trial on Alfalfa and nutritive value at different stage
Animal Production	- Calf and heifer rearing strategy

NARI FGD Unit	Innovations
	- Community sheep improvement through distribution outstand cross breed rams - Determine cost of milk production in cattle at station and farm level - Supplementary effect of wheat bran on body weight of lamb - Phenotypic character of sheep Zoba Maekel and Debub - Effect silage supplant on milk production at Elabered - poultry improvement of local chicken through feed
Animal Health	- Breed improvement in AI - Identification of sheep breed to internal and external parasites - Dubarwa dairy pilot community project 2015 - Best heifer and management on farm and increase of milk production - Advice given by researchers on feed production, health and others
Agricultural Engineering	- Irrigation and soil and water conservation - Agricultural mechanization - Agro-production storage and processing - Physical farm structures
Irrigation of soil and water	- Soil and water conservation design and development of structures like contour, soil band and use of vertebra grass - Cut of ditches for water harvest - Bed furrow stretch - Spacing trial on Vertisol - Water resource development at NARI stations - She'eb spate irrigation demonstration model (gated water distribution) - Agro-meteorology and hydro-meteorological data collection and analysis - Pressurized irrigation, design and development - Pressurized irrigation water management
Agricultural mechanization	- Farm power and machinery testing and evaluation, calibration - Workshop development of tools - Seed cleaning machine follow up

NARI FGD Unit	Innovations
Agro-production storage and processing	- Post-harvest storage structure studies - Agro-production processing for tomatoes
Physical farm structures	- Design and development of dairy house and poultry house - Biogas structure

Source: FAO

Agronomy	Innovation
Legume - Chickpea - Faba bean - Lentil	- Selection - Adaptation trial - Variety maintenance - Multiplication breeder and foundation seed - Screening of varieties for diseases - Disseminating varieties - On-farm trial - Training extension staff and farmers
Barley - Malt barley - Food barley	- Adaptation trial - Training extension staff and farmers - Selection of varieties for disease resistance - Crossing of selected varieties - Varieties maintenance - Screening for yield - Multiplication breeder and foundation seed - Dissemination varieties - On-farm trial
Wheat - Bread wheat - Durum wheat	- Crossing - Selection - Varieties maintenance - Screening - Multiplication breeder and foundation seed - Dissemination varieties - Adaptation trials - On-farm trials - Training extension staff and farmers

Oil crop - Sunflower - Sesame - Niger seed - Rape seed	- Adaptation trial - Seed multiplication - Screening - Disseminating varieties
- Sorghum - Pearl millet	- Crossing - Selection - On-farm trial - Varieties maintenance - Training for extension staff and farmers - Multiplication breeder and foundation seed - Adaptation trial - Dissemination varieties
- Maize	- Crossing - Selection - Varieties maintenance - Multiplication breeder and foundation seed - Adaptation varieties - On-farm trial - Training for extension staff and farmers

Source: FAO

Annex 5. Knowledge dissemination functions identified and clustering

Institutions	Units	Number of Function clustered	Units	Number of function clustered
MoA/AED	Animal prod.	AI	Forage	Natural grass reseeding for regeneration of grazing areas
		Dairy cow dissemination MiHAP		Intro improved dairy feed production
		Organize farmer training		Crop residue use during dry season
		Small-scale milk production and processing		Provide training to farmers on forage
	Animal health	Provision of vaccine	Agronomy	Improved seed production in farmers field
		Disease surveillance		Intro climate smart agronomic practice
	Poultry	Improved check distribution	Protection	Intro integrated pest management
		Provision of vaccine of check		Pest surveillance
		Org. training on poultry to farmers		Migratory pest control
	Bee	Distribution of beehive to farmers		Organize farmer training
		Provision of honey processing	Horticulture	Produce tropical and temperate fruit seedling
		Org. training to farmers on bee		Vegetable seed distribution to farmers
	Home science	Distribution of Adhanet stove to households		Potatoes storage demonstration
		Nutrition education		Organize farmer training
RSD		Food processing	RSD	Training farmers on pesticides
		House management		Provide training on safe use of pesticides
HAC		Org. training of women	HAC	Basic seed production On-farm trial

Source: FAO

The TAP-AIS project

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MORE INFORMATION
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