AEAS / ESAPP / SLM Eritrea Joint Report

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Innovative Agricultural Approaches of Promoting Food Security in Eritrea: Trends, Challenges and Opportunities for Growth

Proceedings of the Workshop of the Association of Eritreans in Agricultural Sciences (AEAS)

2 – 3 March 2006
Asmara, Eritrea

Editors:
Bissrat Ghebru and Tadesse Mehari

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AEAS	Association of Eritreans in Agricultural Sciences
ADP	Asmara Dairy Plant
AKIS/RD	Agricultural Knowledge and Information Systems for Rural Development
AnGR	Animal Genetic Resources
ARD	Animal Resources Department
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ASMDFC	Asmara and Surrounding Modern Dairy Farmers Co-operative
CBD	Convention on Biological Diversity
CDE	Centre for Development and Environment
CFW	Cash for work
CHIHDP	Central Highland Irrigated Horticulture Development Projects
CPB	Cartagena Protocol on Biosafety
CTA	Technical Centre for Agriculture
DCG	Drylands Coordination Group
ECABIO	Eastern and Central Africa Biotechnology Forum
ECDF	Eritrean Community Development Fund
ELWDP	Eastern Lowlands Wadi Development Project
ESAPP	Eastern and Southern Africa Partnership Programme
FAnGR	Farm Animal Genetic Resources
FAO	Food and Agricultural Organisation
FAS	Farmers Advisory Services
FFS	Farmers' Field Schools
FFW	Food for work
GMOs	Genetically Modified Organisms
GoE	Government of Eritrea
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research institute
IPNM	Integrated Plant Nutrition Management
LMOs	Living Modified Organisms
MoA	Ministry of Agriculture
MoE	Ministry of Education
MoND	Ministry of National Development
NARI	National Agricultural Research Institute
NBF	National Biosafety Framework
NRSZ	Northern Red Sea Zone
NWFP	Non-Wood Forest Products
PWL	Percentage Weight Loss
RRA	Rapid Rural Appraisal
SIS	Spate Irrigation System
TSS	Total Soluble Solids
UNCED	United Nation's Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme

Acknowledgement

The Association of Eritreans in Agricultural Sciences (AEAS) would like to acknowledge the contributions made by various organisations to the success of this workshop and the publishing of its proceedings. AEAS would like to thank the United Nations Development Programme (UNDP) for the funds it provided for the workshop, the Eastern and Southern Africa Partnership Programme (ESAPP) for its financial support in printing the proceedings of the workshop and the Syngenta Foundation for Sustainable Agriculture, the Centre for Development and Environment (CDE) of the University of Berne and SLM Eritrea for their moral, logistic and financial support. The AEAS is also very grateful for the support given to it by the Ministry of Agriculture, the Drylands Coordination Group (DCG), University of Asmara, and Ram Farm.

In addition, AEAS wishes to thank the Organising Committee: Dr Bissrat Ghebru, Dr Tadesse Mehari, Teclu Ghebrehiwet, Yonathan Beyene and Netshti Abbay, for the commendable efforts they have made in organising the workshop. Special thanks go also to Dr Tadesse and Dr Bissrat for their tremendous job in compiling the papers presented in the workshop and editing this proceeding and Dr Micheal Kahsay for translating the abstracts to Tigrigna.

Finally, the AEAS wishes to express its gratitude to all the AEAS members and the participants for their valuable contribution and recognises all the contributions made by various institutions and individuals towards the success of the workshop.

AEAS Executive Board

Preface

This workshop on "Innovative Agricultural Approaches of Promoting Food Security in Eritrea: Trends, Challenges and Opportunities for growth" was held on March 2-3, 2006 in the National Confederation of Eritrean Workers Hall, Asmara, Eritrea. This is the third workshop the Association of Eritreans in Agricultural Sciences is organising, since its establishment. This workshop was organised by AEAS in collaboration with its partners: ESAPP, UNDP and SLM.

The aim of the workshop is to address the food security issues in the country by bringing together professionals in the various sectors of agriculture. The workshop also brings to the platform the policy makers and development partners who should play an important role in developing strategies and appropriate policies to implement the recommendations of the workshop.

The main objectives of the workshop include:

- Bring together experts in the various sub-sectors to exchange views and experiences on key issues affecting the development of the agricultural sector and its contribution to food security.
- Come-up with plausible recommendations that would enable end users to boost the productivity of their agricultural practices without adversely affecting the environment.
- Compile and present the outcome and recommendations of the workshop for appropriate action by policy makers and development partners.

Three keynote speeches, eleven selected papers and two posters related to food security were presented in the workshop and discussed thoroughly. Workshop participants were, at the end of the workshop, divided into five groups to discuss the relevant themes on food security and come up with recommendations. The five themes were:

1. The role of biotechnology in promoting food security
2. Enhancing crop production for food security
3. The role of extension and technology transfer in productivity
4. Integrated watershed management and productivity
5. Enhancing livestock production for food security

The crosscutting issue of gender in relation to food security was discussed in all themes. Excerpts of the workshop recommendations were then communicated to concerned ministries, policy makers and development partners for appropriate action.

The workshop was attended by close to 190 participants, who are directly or indirectly involved in promoting food security, from relevant public and private sector institutions both from within and outside the country.

The abstracts of the papers presented in the workshop were translated into Tigrigna and attached as annex at the end of the Workshop Proceedings for the benefit of the workshop participants and other stakeholders who cannot read English.

The Editors

Executive summary

Food security is achieved when a country is able to have food in sufficient quantity, in acceptable quality and should be accessible to all at an affordable price at any time and place in the country. In Eritrea there is considerable food insufficiency and hence insecurity that is primarily due to insufficient food production in the country. Agricultural productivity in Eritrea, which is an activity carried out by majority of the people, has declined very much in the last few decades and needs to be boosted. The current workshop aims at bringing together key stakeholders in food production and agricultural policy to discuss some of the innovative approaches that could be injected into the agricultural production sector to promote food security in Eritrea.

In line with this and in fulfilling one of its objectives, the Association of Eritreans in Agricultural Sciences, has been organising workshops in relevant, timely themes with the aim of suggesting pertinent recommendations that could enable the policy makers and development partners to tackle the problem at hand appropriately. The current workshop on "Innovative Agricultural Approaches of Promoting Food Security in Eritrea: Trends, Challenges and Opportunities for growth" has attracted 11 scientific papers on various fields related to the promotion of food security in the country. These papers were thoroughly discussed in the workshop and the participants were finally divided into five working groups to comprehensively discuss the issues and come up with appropriate recommendations on the various themes. The participants, therefore, discussed the roles of biotechnology, crop production, extension and technology transfer, livestock production and watershed management in promoting food security in Eritrea. The role of gender in food production and food security was recognised as a cross cutting issue and was discussed in all five themes.

Safe and appropriate use of biotechnology can enhance productivity and alleviate poverty. Hence, Eritrea should create an enabling environment for the implementation of this technology and at the same time institute mechanisms for the safe use and handling of biotech products. Creating awareness among the public, professionals and policy makers on issues related to biotechnology and biosafety, formulation of Biosafety Policy, establishing a capable government body responsible for handling biotechnology and biosafety issues further are some of the important concerns that need to be addressed before implementing biotechnological activities in the country.

Crop production in Eritrea, which is mainly traditional subsistence farming, has very low yield that is continuously declining. Although the total area under crop production has increased in the last few years and the construction of dams, reservoirs, and supplementary irrigation has increased the yield of cereals and horticultural crops, considerable improvement could not be achieved to cover the food requirement of the country and promote food security. Introducing water harvesting techniques for efficient utilisation of rainfall to supplement irrigation, exploiting available crop biodiversity to develop high yielding, drought tolerant and pest resistant crops, diversification of crop production into high value cash crops, and establishing feasible commercial farms that can boost production have been suggested to ameliorate the situation.

Currently the linkage between research, extension and farmers is very poor. However, there are a lot of opportunities available including the rich indigenous knowledge of farmers and the strong experience of farmers' advisory services that can be exploited to

improve the situation. Strengthening the research-extension-farmers interaction, establishing farmers' associations and ensuring a holistic or interdisciplinary approach to development (i.e. micro-finance, marketing, potable water, health, education, etc.) are some of the important steps that could be considered to improve the situation.

The accelerated degradation of the watershed areas that is increasing from time to time is threatening food production and contributes to the prevailing food insecurity in the country. This situation is further exacerbated by inappropriate land use planning, lack of sense of ownership of land by land users, lack of alternative sources of energy and inadequate awareness of watershed degradation at all levels. Thus, the possible solutions recommended to improve the situation are to: revise the existing land proclamation in a way that promotes investment on agriculture and secure tenure right on land, tree and other resources, develop proper land use planning policy, implement and enact drafted natural resources management laws, raise awareness and develop proper monitoring and evaluation system.

Livestock population is decreasing in the conventional system of production, whereas, the population is increasing in the intensive system of livestock production without showing much increase in productivity. The fact that the number of browsing animals is increasing and that of grazing animals is decreasing, could be attributed to the noticeable competition of land for crop production and the extensive reduction of rangeland and deforestation of potential forage trees and shrubs in the country. The existing livestock diversity and the availability of the local and export markets and the indigenous knowledge on livestock production, create a good opportunity for expanding livestock production in the country. Thus, proper attention should be given to the livestock sub-sector through the conservation of genetic resources and characterization of the existing breeds, introduction of modern commercial livestock farms and strengthening veterinary services throughout the country.

The role of gender in agricultural productivity and food security should be given utmost consideration because women play a significant role in the agricultural sector of the country contributing towards food security through their active participation in community development. Women play an active role in poultry and small ruminant production, herding of livestock and producing, processing and selling of animal products and in horticultural crop production especially in small-scale vegetable production.

Formulation of clear and unambiguous policies in the various sectors (especially the land use policy), creating and raising awareness among the public, policy makers and development partners and encouraging and empowering women to participate in all development activities are some of the important recommendations made by most presenters to promote food security in the country. There is also a need to institute gender friendly approaches in all decisions made, as 50 to 60% of households in the rural areas are female headed.

The workshop deliberations have addressed two of the three pillars of the national food security strategy: Promoting the contribution of agriculture towards increasing domestic food production and agricultural exports to earn foreign exchange. Food aid should only be imported during emergencies.

Opening of the workshop

Introductory remarks by the organising committee

Ato Hiruy Asghedom delegate of H.E. Ato Arefaine Berhe, Minister of Agriculture,
Dr. Mathewos Woldu, delegate of H.E. Dr. Wolday Futur, Minister of National Development,
Mr. Macleod Nyrongo, UN Resident/Humanitarian Coordinator and UNDP Representative (Eritrea)
Honourable guests, Dear AEAS members, Ladies and gentlemen,

On behalf of the workshop organising committee and myself I would like to welcome you all to this timely and important workshop on "**Innovative Agricultural Approaches of Promoting Food Security in Eritrea: Trends, Challenges and Opportunities for Growth.**" The Executive Board of the Association of Eritreans in Agricultural Sciences (AEAS) appointed the organising committee, consisting of Dr. Tadesse Mehari, Dr. Bissrat Ghebru, Ato Teklu Ghebrehiwet, Ato Yonathan Beyene and W/t Nitsihti Abay who have been working to this date to make the workshop a success.

On behalf of the association, the organising committee would like to inform participants that this workshop is intended to provide a forum of understanding and discussion that will enhance active participation and contribution from all participants. Thus, longer sessions have been given for discussion so that participants could adequately discuss timely issues of agricultural innovations and the direction towards which our agriculture should focus and be spearheaded to in order to promote food security. Hence, in the current deliberations, only 11 papers and two posters will be presented addressing different food security issues. In addition, there will be three keynote presentations from the Ministry of Agriculture (MoA), Ministry of National Development (MoND) and the UNDP. At the end of the presentations, we will form groups to discuss and make recommendations on how the various sectors of agriculture could contribute to attaining food security in the country.

The organising committee has compiled the abstracts of the papers for your easy follow up and we would like to inform you that the proceedings of the workshop will be published and will be made available to all participants. There are three rapporteurs Ato Hagos Yohannes, Ato Sirak Mehari and Ato Tedros Kibrom assigned for this workshop and they will be documenting all our deliberations and contributions.

The organising committee once again welcomes you all to the workshop and wishes a fruitful outcome of all our deliberations.

2 March 2006
Representative of the Organising Committee

Remarks by the AEAS chairperson

Ato Huruy Asghedom, delegate of H.E. Ato Arefaine Berhe, Minister, MoA,
Mr. Macleod Nyrongo, UN Resident/Humanitarian Coordinator and UNDP Representative (Eritrea)
Dr. Mathewos Woldu, delegate of H.E. Dr. Wolday Futur, Minister, MoND
Honourable participants, Ladies and gentlemen,

I am honoured, indeed, pleased to deliver this opening speech on behalf of the Executive Board of the AEAS. I would like to thank all of you for accepting our invitation to attend this meeting.

The theme of this workshop is 'Innovative Agricultural Approaches of Promoting Food Security in Eritrea: Trends, Challenges and Opportunities for Growth'. UNDP Eritrea has provided funds for this workshop and we would like to thank the UNDP country representative, Mr. Nyrongo for this contribution.

AEAS and the Dryland Coordination Group (DCG) have jointly organised this workshop. I would like to recognise the presence of Dr. Ingrid Nyborg of NORAGRIC, DCG Norway who is also going to share her experiences on the new paradigms in technology transfer. Finally yet importantly, our thanks go to the Sustainable Land Management Programme (SLM), which contributed to the success of the workshop. AEAS is also grateful for the support it receives from the MoA and the University of Asmara (UoA).

Dear participants,

AEAS is now more than 12 years since interested Eritreans working in various agricultural fields within and outside Eritrea established it. At the start, the association focused mainly in building up and strengthening its structures. Since 1998 however, it embarked on implementing some of the activities enlisted as its objectives. In line with this, it has organised three workshops so far:

1. In 1998, *'Soil and Water Conservation Management in Eritrea: current status and trends'* (in collaboration with the University of Berne).
2. In 2003, *'Irrigation Potential in Eritrea: Potentials and Constraints'* (in collaboration with the Sustainable Land Management (SLM) program and Syngenta Foundation).
3. The current workshop is the third.

In line with the Government of Eritrea's Macro-policy, the AEAS aspires to take part in the building-up and development of knowledge-based agriculture by creating platform for exchange of ideas and experiences among its members, constructively contribute towards refining agriculture related policy issues and the ongoing agricultural development strategies. As we know, hunger and food insecurity continue to affect millions of people globally and the majority of these live on agriculture for their livelihood and survival.

More than 70% of the Eritrean people depend on subsistence agricultural and the natural resource-base, which is characterised by low-input and low output. Land degradation, low and erratic rainfall, loss of biodiversity, war and conflicts have negatively affected the productivity of the managed and natural ecosystems. Consequently, the resilience of the local communities to shock has diminished. Food insecurity and poverty are still widespread in the rural farming and pastoral communities. In spite of all these hurdles, however, efforts are underway to improve the livelihoods of the people. As the problem is gigantic, it is not possible to solve it altogether at one time.

The environment, social and physical infrastructure for the development of the agricultural sector, has been subject to external stresses. Hence, its recovery, rehabilitation and transformation of the traditional practices applied to it require thorough analyses and understanding of its climatic variability, soils, flora and fauna and the current agricultural production systems. Knowledge-based sustainable innovative agricultural practises should be introduced to get out of these impasses. Our knowledge should be concomitant with the generation of innovative agricultural technologies and we should be ready for changes in the right directions.

As professionals, we have to recognise that agricultural technologies are evolving faster than our level of understanding. These changes are coming naturally in response to population pressure and changes in our demands. Theoretical and practical knowledge massed at colleges and universities is insufficient and should be periodically replenished with new and innovative ones. Hence, professionals should progress in tandem with these dynamic socio-economic, technological and ecological circumstances. Above all, we need to understand and appreciate our natural endowments and try to capitalise on them rather than looking outward.

AEAS recognises that linkage between research, extension and the producers is weak. Consequently, new innovative agricultural technologies and knowledge do not seem to reach producers. In some cases, research outputs are shelved in research and academic institutions. We should look for possible ways and means to pick up these innovations and share them with end users possibly through the creation of model farms. Mobilization of the critical mass of trained professionals should lay the foundation for the rational utilisation of our resources. Professionals should also synthesise and analyse complex technologies to make them easier and adaptable to our local situation. It is only through these means that we can ensure our professional ethics.

The workshop has the following general objectives:

1. Compile information related to food security and agriculture in Eritrea;
2. Encourage professionals working in the various agricultural sub-sectors with the aim of providing them a platform for exchange of experiences on key elements affecting the development of the sector;
3. Provide substantive inputs, by way of recommendations for policy review, relating to the development of the country;
4. Provide substantive advice to development programmes on priority areas for development;
5. Come-up with plausible recommendations that would boost the agricultural outputs without jeopardizing the environment.

The specific objectives are to:

i Discuss with focus on the agricultural sub-sectors and promote the skills and knowledge of professionals;

ii Promote and develop the interest of stakeholders in the development of agriculture;

iii Encourage innovative agricultural action oriented research outputs and studies;

iv Disseminate research findings and promote debates on agricultural development issues by means of proceedings, brochures, posters and other audio-visual materials towards enhancing the productivity of the farming, pastoral and fishing communities;

v Explore possibilities for the effective participation of women in food production and promote professionalism and participation of women in agricultural development; and

vi Organize group discussion, sensitise environmental issues and enhance government endeavours towards environmental protection and sustainable development.

With this brief remark I call upon Mr. Huruy Asghedom, Director General of Agricultural Promotion and Development, representing his Excellency Ato Arefaine Berhe, Minister Ministry of Agriculture to open the workshop officially.

Woldeselassie Ogbazghi (PhD),
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Opening speech

Distinguished members of the Association of Eritreans in Agricultural Sciences,
Ladies and Gentlemen

First of all, I would like to welcome you all for coming to our important professional meeting. As you all know about 80% of our population directly or indirectly depends on agriculture. However the productivity is below subsistence level.

The Association of Eritreans in Agricultural Sciences was established in 1994 and already twelve years have passed. We are the agricultural professional resources of the country but, so far, our practical participation in line with the agricultural national development programmes is very low. So it is time now to use our professional capabilities in a coordinated way in the name of the association to work for the achievement of food security at national and household levels.

We have to create models of agriculture with the involvement and harmonization of the diverse professionals available in the country. In Eritrea, we have only ephemeral rivers and uneven distribution of rain. Thus, taking our precarious situation into consideration, this house has to think again about practical participation in water and soil conservation projects, and in the application of appropriate irrigation and supplementary irrigation systems.

Last but not least, I wish our session will come out with concrete practical resolutions and recommendations that can pave the way to the achievement of food security in the nation.

Thank you for you patience.

Huruy Asghedom
DG, Agricultural Promotion and Development
Delegate of H.E. Ato Arefaine Berhe, Minister, MoA

Keynote speech 1: Key elements for achieving food security in Eritrea

What is food security?

"Food security is achieved when a nation is able to make food of sufficient quantity and acceptable quality, which can be accessible to all, at an affordable price at any time and place within the country."

With regard to food security, the government's long-term objective is: Ensuring food security for all its citizens, which is one of the primary long-term goals of our economic growth and poverty reduction strategies. Accordingly, achieving food security is at the top of our development agenda and the government is committed to it.

The Eritrean Food Assistance Program has four guiding principles. These principles stipulate that food assistance program should:

1. not disrupt the traditional family and community-based coping mechanisms;
2. not encourage dependency by undermining incentives of farmers to produce and market food;
3. be targeted assistance- at the poor and vulnerable;
4. be monetized and funds generated would finance food security projects.

Eritrea's food security strategy rests on three pillars:

a Enhancing production capacity in agriculture (through expansion and yield increases in rainfed agriculture and irrigation)

- Reorienting the extension and research system
- Promoting effective soil and water conservation
- Providing through the market critical agricultural inputs, credits, market and marketing
- Supporting rehabilitation of degraded catchments,
- Increasing access to land by poor farmers.

b Increasing our National foreign exchange earnings capacity to import food to fill the supply gap and to maintain strategic reserves:

- Increasing export of fruits and vegetables;
- Expansion of export of high value fisheries products;
- Revitalization of sectors to earn foreign exchange, i.e. industry, mining, tourism and services

c Enhancing the effective use of food assistance program to fill the supply gap, as a measure of last resort during emergencies.

Other critical factors to achieving food security include:

- Expanding modern infrastructure (roads, airports etc.),
- Expanding healthcare services and access to quality education, and
- Developing institutional capacity in planning, research, monitoring and implementation

In conclusion, our food security strategy can be achieved through a combination of: Maximum possible domestic food production; optimal commercial food imports and food assistance during emergencies. The workshop organized by the Association of Eritreans in Agricultural Sciences focuses on two of the pillars of Eritrea's National Food Security Strategy: Enhancing the contribution of agriculture towards increasing domestic food production and agricultural exports to earn foreign exchange. Hence it is timely and very relevant.

I wish you a productive workshop.

Thank you!

Dr. Mathewos Woldu,
Delegate of H.E. Dr Wolday Futur, Minister, MoND

Keynote speech 2: Address by UNDP Resident Representative

Mr. Chairman,
Members of the Association of Eritreans in Agricultural Sciences,
Government officials, Ladies and gentlemen,

I am very delighted to join you at this meeting. I consider my contact with the Association as one of the best discoveries in Eritrea. Two people have been instrumental for this: the first is Redaezghi with whom I share very similar views on agriculture and the environment. The second is a staff member of UNDP, Yoseph Admekom who is a member of this Association. The two did not have problems to get me attracted to the association because there is complete convergence of interest. We take pleasure in discussing farming without tilling the land; bee-farming is one of such practices.

But while I prefer to be considered as a member of this Association in my personal capacity, today I am here more as the representative of UNDP. UNDP cherishes its partnership with this Association. The Association is an asset that brings together Eritrean scientists with a wealth of experiences and knowledge about agricultural production systems, watershed management, research and extension and, above all, the spirit of determination to overcome obstacles which is characteristic of the Eritrean people. In its own right, UNDP is a knowledge based development agency, just as the Association is. I do not have to explain further why the partnership between the two is a natural one. We would like to help transform the knowledge into development action to eliminate poverty.

I note the range of research papers that are going to be presented and discussed here - eleven of them in different fields of agriculture including in integrated food production; non-food forest products; agricultural research; agricultural technologies, etc. I would like to advise the Association that this should not be the end of it. The Association should find ways of feeding into the high level Ministerial Food Security Committee: seek appointments with the Committee and brief them on the discussions so that the Association can influence national policies.

I really look forward to the outcome of the discussions. You can count on UNDP as your partner to take the decisions forward.

I thank you for your attention.

Macleod Nyirongo
UN Resident/Humanitarian Coordinator and UNDP Resident Representative (Eritrea)

Paper presentations

The role of biotechnology in promoting agricultural production and attaining food security

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Abstract

The current world population is about 6 billion and is expected to increase to more than 8 billion by the year 2025 at a rate of 80 million/year (95% of which will occur in the developing world). Currently approximately 0.8 billion of the global population are food insecure. Some 40,000 people die from hunger related causes every day. The situation in Africa is even grim. With the highest growth rate of 3.1%, Africa's population is 550 million today and is projected to increase to 1.3 billion in the next 25 years. Between 55-60% of the rural people in sub-Saharan Africa are absolutely poor, subsisting on less than US$ 1 per day. The global challenges today are: a) to prepare for the unprecedented levels of global population b) to ensure that this population has access to food at all times c) to produce this food in a sustainable manner. The last two components combined form the challenge of sustainable food security. To meet projected food demands by 2025 the average yield of all cereals must be doubled, from 2 to 4 billion metric tons/year. This increase must come primarily from increasing biological yields and not from area expansion and more irrigation, because land and water are becoming increasingly scarce as population increases. The response to these challenges is to harness all instruments of sustainable agricultural growth; and agricultural biotechnology is one such instrument. There is a growing realisation that agricultural biotechnology could make a valuable contribution toward solving the urgent problem of food supply, protecting the environment, and reducing poverty in developing countries. Many scientific studies have concluded that the promise of biotechnology as an instrument of development lies in its capacity to improve the quality and quantity of crops and livestock, swiftly and effectively. Since the last few decades, ever more precise techniques have evolved, permitting the genetic modification of most crops and food plants to the benefit of humans. Biotechnology tools are also increasingly being applied to crops and livestock-related needs of importance to developing countries. This paper will, therefore, discuss the adoption of relevant technologies that can benefit Eritrea to attain food security within a short period of time in a safe and sustainable manner.

Key words: Biotechnology, food security, GMOs, productivity, transgenic crops

Introduction

The current world population is estimated at about 6 billion and is expected to increase to more than 8 billion by the year 2025 at an annual increase of about 80 million. About 95% of the increase will occur in the developing world, especially in the cities, where urban population will more than triple (Serageldin, 1999). Currently approximately 0.8 billion of the global population of 6 billion (13.3%) are food insecure. They dwell among the 4.5 billion inhabitants of the developing countries in Asia (48%), Africa (35%), and Latin America (17%) (IFPRI, 1997). About 850 million people in the developing countries suffer from malnutrition and 1.3 billion are affected by poverty (James, 2003). Some 40,000 people die from hunger related causes every day. A sixth or more of the human family has, therefore, been marginalised (Serageldin, 1999).

The situation in Africa is even grim. At a 3.1% growth rate (the highest in the world), Africa's population was about 200 million 30 years ago; it is 550 million today and is projected to increase to 1.3 billion in the next 25 years (Ndiritu, 1999). Between 55-60% of the rural people in sub-Saharan Africa are absolutely poor, subsisting on less than US$ 1 per day. More than 200 million (over one-third of the African population) suffer chronic under nutrition.

As population increases the area of land available for food production declines. Some scientists calculate that "to meet projected food demands, by 2025 the average yield of all cereals must be doubled from 2 to 4 billion metric tons/year." These increases must come primarily from increasing biological yields and not from area expansion and more irrigation, because land and water are becoming increasingly scarce (Serageldin, 1999).

With increasing population, urbanisation and rising income, per capita consumption of meat, milk and eggs will rise by 2% (Delgado *et al.*, 1999). Global demand for meat will also increase by more than 55% of current consumption by 2020 with most of the increase occurring in developing countries (Rosegrant *et al.*, 2001). Thus, the demand for feed grain will increase by 3% per year in developing countries and 0.5% in developed countries.

The most important global challenges today are:

a to comprehend and prepare for the unprecedented levels of global population,
b to ensure that this population has access to food in adequate quantities at adequate prices, everywhere at all times and,
c to produce this food in a way that does not destroy the natural resources on which we all depend. The last two components combined form the challenge of sustainable food security.

The challenges we are facing today are both technological (requiring the development of new, high productivity, environmentally sustainable, production systems) and political (requiring policies that do not discriminate against rural areas). An essential aspect of the response to these challenges is to harness all instruments of sustainable agricultural growth; and agricultural biotechnology is one such instrument (Serageldin, 1999).

What is biotechnology?

Biotechnology is the use of living organisms or parts thereof, to provide useful products for the benefit of humans. In other words, it is the use of biological processes to achieve specific purposes. Biotechnology is not a new science; it is as old as humans. The processes of fermentation, brewing, food processing (bread and cheese making) and traditional vaccines were being practiced since the existence of humans. These are collectively classified as Traditional Biotechnology.

Modern or advanced biotechnology constitutes:

a Conventional biotechnology – which does not involve transformation of organisms or genetic manipulations. This includes tissue culture and micro-propagation, plant disease diagnostics, molecular breeding and marker assisted selection, animal production technologies, vaccine production, use of biopesticides, biofertilizers, bioherbicides, etc.

b Gene manipulation – modern biotechnology that involves transformation of plants, animals and microorganisms to produce improved crops and farm animals through genetic engineering. These transgenic varieties are known as Living Modified Organisms (LMOs), Genetically Modified Organisms (GMOs) or Genetically Improved Organisms (GIOs).

What are the benefits of biotechnology?

Safe and proper use of biotechnology can play an important role in:

a) Improving food production and hence attaining food security.
b) Improving economic growth and alleviating poverty.
c) Providing food with improved nutritional value (Improve human health).
d) Providing environmentally safe and sustainable agriculture.
e) Cleaning and safeguarding the environment (Bioremediation).

Biotechnology has been found to provide new opportunities for achieving productivity gains in agriculture. Many scientific studies have concluded that the promise of biotechnology as an instrument of development lies in its capacity to improve the quality and quantity of crops and livestock, swiftly and effectively. Report prepared by Kendall *et al.* (1997) stressed that the time required to identify and eliminate unfavourable traits through traditional crop breeding is greatly reduced by the use of genetic engineering techniques.

The application of biotechnology can create plants that are more resistant to drought and soil acidity and salinisation. These attributes are critical to the development of agriculture in the poorest areas where soils are poorly endowed. Additionally, plant characteristics can be genetically altered for earlier maturity, increased transportability, reduced post harvest losses, and improved nutritional quality. Vaccines against diseases afflicting livestock are already important products of biotechnological research (Morrison, 1999).

The role of biotechnology in attaining food security

Biotechnology can make a major contribution to food and feed security and to the alleviation of hunger and malnutrition, which claims tens of thousands of lives everyday in the developing countries of Asia, Africa and Latin America. Since the last few decades, Biotechnology tools are increasingly being applied to crops and livestock-related needs of importance to developing countries. They often provide the only or best 'tool of choice' for improving the genetic component of agricultural productivity.

GM crop commercialisation started in 1996 and in 10 years time (1996 to 2005), a total of about 475 million hectares of GM crops were planted globally which met the expectations of millions of small and large farmers in both industrial and developing countries (Table 1). GM crops delivered significant agronomic, environmental health and social benefits to farmers and to global society and contributed to a more sustainable agriculture. Most of the early products of agricultural biotechnology focus on crop protection. In 1998, transgenic crops that are herbicide tolerant covered about 19.8 million hectares. Use of herbicide tolerant varieties greatly facilitates weed control using certain types of herbicide and greatly reduces the amount of herbicide applied to the crop for effective weed control. This also enables farmers to employ soil conservation practices such as minimum tillage, which reduces soil erosion (Serageldin, 1999).

Table 1 Global area of biotech crops (Modified after: James, 2005)

Year	Hectares (million)
1996	1.7
1997	11.0
1998	27.8
1999	39.9
2000	44.2
2001	52.6
2002	58.7
2003	67.7
2004	81.0
2005	90.0
Total	474.6

Another focus of agricultural biotechnology research was on increased plant resistance to pests. According to Serageldin (1999), an estimated 7.7 million hectares were planted in 1998 to transgenic crops with introduced genes that produce substances toxic to target insect pests. The use of pesticides has dropped in areas using these crops (Figure 1), a positive impact not only on farm income but also on the environment. Since 1996, pesticide applications have been reduced by 172, 000 metric tons as a direct result of the use of biotech crops. The use of GM soybeans has been one of the largest contributors to reduce pesticide applications, accounting for cumulative reductions of 41, 000 metric tons (Monsanto, 2005). Australian farmers used 50% fewer pesticide applications on Bt cotton (Fitt, 2003).

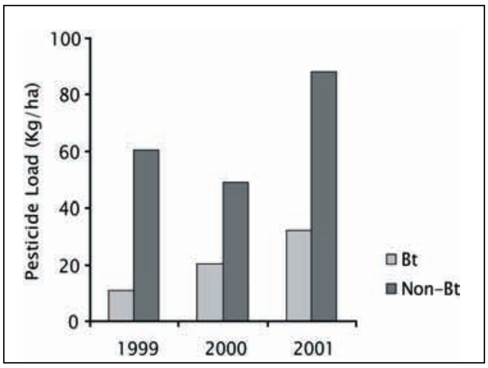

Figure 1 Pesticide usage, Bt and non-Bt cotton

Table 2 *Global status of biotech crops in 2005*

Country	Area (million ha)	%
USA	49.8	55.3
Argentina	17.1	19.0
Brazil	9.4	10.4
Canada	5.8	6.4
China	3.3	3.7
Paraguay	1.8	2.0
India	1.3	1.5
Others	1.5	1.7
Total	90.0	100%

In 2005, global area of biotech crops reached 90 million hectares, representing an increase of 11% from 2004 equivalent to 9 million hectares (Table 1). Remarkably, the global biotech crop area increased more than 50-fold in the first decade of commercialization. It is noteworthy that the top 5 countries include two industrial countries, USA and Canada and three developing countries, Argentina, Brazil and China (Table 2). A comparison of the global area of biotech crops for industrial and developing countries from 1996 to 2005 is given in Figure 2.

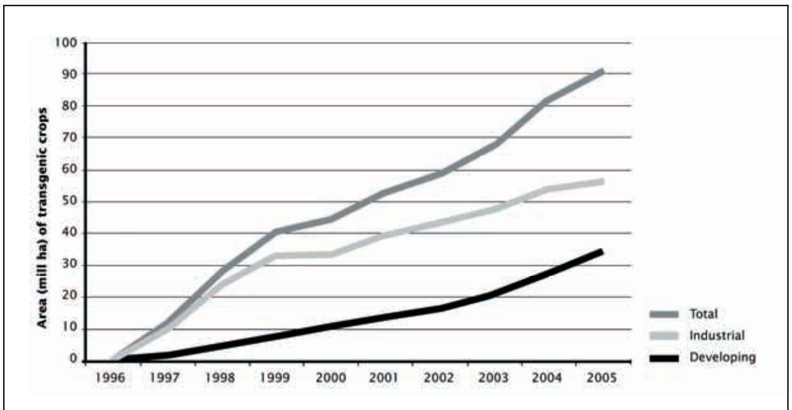

Figure 2 Global area (million hectares) of transgenic crops in industrial and developing countries, 1996 to 2005. (Source: James, 2005)

The global area of biotech crops grown by developing countries has increased every year from 14% in 1997 to 38% in 2005 (171% increase) (James, 2005). The main traits and attributes of commercial GM crops include herbicide tolerance (77%), insect resistance (15%) and herbicide tolerance and insect resistance, combined (8%) (James, 2005). The commodities that dominate the global biotech market are given in Table 3.

Table 3 *Commodities that dominate global biotech markets*

Commodity	Area (million ha)	%
Soybeans	54.4	60
Corn	21.2	24
Cotton	9.8	11
Canola	4.6	5

Public concerns about biotechnology

The advent of GMOs offers new options for meeting food and agricultural needs in developing countries. But we need to handle them very carefully as they may also affect biodiversity, natural ecosystems and human health if not used appropriately. Thus, the potential environmental risks and benefits need to be taken into account when making decisions about the use of GMOs. International trade and the unintentional transboundary spread of GMOs can also pose environmental risks depending on the national and regional contexts. The complex interaction that can occur between GMOs and the environment heighten the need to strengthen world wide scientific and technical capacity for assessing and managing environmental risks of GMOs (Hilbeck and Andow, 2004).

The use of conventional biotechnology such as tissue culture techniques, marker assisted selection, microbiology, animal production technologies, use of biopesticides, biofertilizers, bioherbicides, etc. do not pose any risks and can be applied safely. Opposition has only been mounted to the spread of transgenic crops or GMOs and protest movements have developed across the globe. Opposition to biotechnology and specifically to genetic engineering is derived from several viewpoints. They include fears of high-tech farming destroying the livelihood of smallholders, concerns about artificially created products competing with and destroying the marketability of 'natural' products, and the presumption of environmental threat. These concerns are genuine and cannot be ignored.

The fact that the genetic makeup of a particular variety of a plant is transformed through genetic transfer from another plant of the same species should not pose much of an ethical problem. This is because this process would simply be an accelerated way of achieving by biotechnological means what could be achieved through conventional breeding programs. This process of acceleration should not pose ethical or safety problems for anyone who does not oppose conventional breeding programs.

The next concern comes to the bioengineered product of a genetic transfer involving related but different species of plants such as wheat and barley, for instance. In this case we are already tinkering with nature, but the boundary to the conventional breeding system is so close, that for many that would also be acceptable. The possible result of such a gene transfer is unlikely to significantly modify or denature the plant. *Triticale* is such an interesting cross.

The more serious one is the design of new plant types, based on the assemblage of desirable traits collected from individual plant species or even from other organisms. This is pure manipulation of genes and tinkering with the natural order. Scientists, however, argue that this is not the first time humans are changing the natural order. Our very presence on this planet is prompting us to change the natural order of things, and that our increasing numbers, ever more powerful technology and insatiable appetites for consumption and pollution are indeed affecting nature, and mostly in negative and potentially dangerous ways. Global warming and biodiversity loss are but two examples. The matter, therefore, becomes a calculus of the potential benefits and potential risks associated with change, including the adoption of new technology (Serageldin, 1999). According to the author, any potential risk, no matter how remote, should not automatically veto the potential application of a technology. He in fact, compares this to a case much closer to our everyday life. We could ask if people would be willing to accept a technology that is contributing to global warming, kills about 50,000 persons per year and maims another

500,000 in the US alone, and is adding nothing vital to our lifestyles except the added convenience of personalized fast travel. Yet who would agree to ban the automobile?

Swaminathan (1999) also stresses that Mendel's Laws of Genetics were published in 1865, but were rediscovered in 1900, which means that it took 35 years for biologists to grasp the significance of the laws. Just as it took 35 years to understand the significance of Mendel's work, it may take a couple of decades more to understand fully the benefits and risks associated with genetically improved foods. It would therefore be prudent to apply scientific and precautionary principles in areas of human health and environmental safety.

FAO's Director General, Jacques Diouf, stated that on the one hand, we need to underline the different aspects of biotechnology, which do not raise great controversy and, on the other hand, GMOs which are very debatable and emotionally charged issues. *"... FAO recognizes that genetic engineering has the potential to help increase production and productivity in agriculture, forestry and fisheries. However, FAO is also aware of the concern about the potential risks to human and animal health and to the environment posed by GMOs. It therefore supports a science-based evaluation system that would objectively determine the benefits and risks of each individual biotechnology"* (FAO, 2005).

Biosafety mechanisms

Developing countries that are pursuing the safe and effective use of modern biotechnology recognize the need to have in place effective regulatory systems at national and institutional levels, compatible with international best practice. Biosafety refers to *"mechanisms aimed at ensuring careful design, transfer, handling and use of biotechnology and its products. It is a principle that tempers the adoption of a new technology with careful consideration of its potential effects on human health and the environment."* National Biosafety systems serve as mechanisms for ensuring the safe use of biotechnology and its products without imposing unacceptable risk to human health or the environment, or unintended constraints to technology transfer. International dialogue regarding concerns for the regulation and review of new agricultural products gave rise to the Cartagena Protocol on Biosafety (CPB) on 29 January 2000. The objective of the protocol is:

> *"to contribute to ensuring an adequate level of protection in the field of the safe transfer, handling and use of LMOs resulting from modern Biotechnology that may have adverse effects on the conservation and sustainable use of biological diversity, taking into account risks to human health, and specifically focusing on transboundary movements."*

For developing countries, functional biosafety systems are key to maximizing the benefits from biotechnology because they demonstrate to stakeholders and the public that attendant environmental and health issues are addressed by scientific risk assessments.

What are the implications of biotechnology to Eritrea?

Agricultural growth in Eritrea is severely constrained by rainfall shortages compounded by soil degradation, overgrazing and deforestation. We therefore need to develop crops and livestock breeds that are early maturing and adaptable to the harsh climatic conditions of the country. Moreover, as arable land becomes scarce with increasing population, harnessing all instruments of sustainable agricultural growth through the application of agricultural biotechnology is the best alternative to increase productivity and hence attain food and feed security in the country.

The tangible benefits of biotechnology that have so far been achieved in many developing countries of the world, which could safely be adopted to Eritrea, include the use of:

a Disease-free planting material (Micropropagation): a variety of tissue culture techniques are applied to propagate disease-free planting materials for many horticultural crops. In many African countries like Kenya, for example, the application of tissue culture technology has been initiated in different crops and has resulted in increased production of banana, pyrethrum, potato, coffee, cassava, sugarcane, date palm, flowers, etc. The demand for such materials is demonstrably high, and the changes at the household income levels of growers are becoming increasingly noticeable.

b Pest resistance: Biopesticides (Bacillus thuringensis and B. sphaericus) are being practiced widely to reduce the use of chemical pesticides and where cultural practices are not effective. Bacillus thuringensis (Bt) toxin is, for example, being used by farmers in China to combat cotton bollworm where the use of chemicals and other plant protection methods can no longer reliably control the pest. This genetically modified (GM) cotton provided smallholder farmers with significant economic as well as environmental benefits, by substantially reducing pesticide use without reducing output per hectare or quality of cotton (Pray *et al.*, 2000).

c Crop improvement/Transgenic plant varieties: This requires isolating genes that improve yield in some crops and inserting them in other crops using genetic modification technologies The principal benefits of transgenic crops include more flexibility in crop management, decreased dependence on conventional insecticides and herbicides and higher yields. Thus, crop improvement could be promoted through the production of genetically improved plants with superior properties in terms of resistance to diseases, insect pests and abiotic stresses. Many GM plant varieties, such as virus-resistant potatoes, tomatoes, cucurbits, Bt Cotton, Bt Corn, etc. are widely planted today in different parts of the world.

d Livestock improvement (New diagnostics and vaccines for livestock diseases): Traditional breeding practices have been too slow in Eritrea to meet national requirements of dairy products. Importing heifers and/or young quality-bred calves from abroad may be too costly and could also have adaptability problems. Cutting-edge technologies such as Marker Assisted Selection in animal biotechnology, artificial insemination, embryo transfer, in vitro fertilization, Successful gender pres-election in farm animals, etc. need to be carefully studied and introduced. Diagnostic tests and rDNA vaccines have been developed for rinderpest, cowdriosis (heart water), theilerosis (East Coast Fever) and foot and mouth diseases.

e Nutritional benefits: traditional breeding has been unsuccessful for increasing nutritional elements of many plant varieties, but recent progress in biotechnology has enabled scientists to enhance vitamin A content and elevated iron content in crops like rice (e.g. Golden Rice).

f Reduced environmental impact: through the use of Biofertilizers (Rhizobium, Azospirllum, Cyanobacteria, etc.), Biopesticides (Bacillus thuringensis) and Bioremediation (cleaning the environment using different microorganisms).

Biosafety mechanisms, however, need to be strengthened whenever such technologies are to be adopted.

Conclusion

Biotechnology has the potential to reduce input use, reduce risk to biotic and abiotic stress, increase yields and enhance quality – all traits which should enable the development of new crop varieties that are appropriate to poor producers and consumers. Biotechnology is only one tool, but a potentially important one, in the struggle to reduce poverty, improve food security, reduce malnutrition, and improve the livelihoods of the rural and urban poor (Morrison, 1999).

There is overwhelming evidence and knowledge that the needs and drive for biotechnology in Africa are quite different from those of industrial countries. Africa's agenda is based on the urgent needs for technological change to enhance food production and to alter the course of widespread poverty, hunger, and starvation. Industrial countries are driven by market and profit. These distinctions must be understood and appreciated at the national, regional, and global levels. This ongoing debate has created fear, mistrust, and general confusion to the public, and has failed to seek the views of African policymakers and stakeholders. Thus, the debate about biotechnology for Africa should not be whether or not the continent needs biotechnology, but how biotechnology can be promoted, supported, and applied in safe and sustainable ways that contribute to improved agriculture and to the social and economic welfare of the people of Africa.

According to McCalla and Brown (1999) biotechnology is one tool in our arsenal for feeding the world in the future. It is a solution not without problems, but it is one we cannot afford to ignore. We have fallen behind in educating consumers about the potential of biotechnology and in reassuring them about safety concerns. We could take some lessons from the pharmaceutical sector, where new drugs are introduced on a regular basis. No new drug is absent of all risk, but careful evaluation through extensive clinical trials indicates that the benefits outweigh the risks when taken under prescribed conditions. Likewise there is no such thing as 100% safe food in today's world, and no one would claim such. There were 6.5 million cases of food poisoning in the United States of America in 1992, resulting in 9,000 fatalities. We need to fully assess the risks and benefits of all "new" foods, and when the benefits far outweigh the risk we need to move ahead.

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Impact of integrated food security project implemented in Northern Red Sea Zone, Eritrea

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Abstract

The inhabitants of Northern Red Sea Zone are mainly nomadic agro-pastoralists who are relatively food insecure and have the highest malnutrition rate of about 23%. This is caused mainly due to the concurrent drought, prolonged war and inadequate agricultural inputs, knowledge in methods of production and utilization. The project aimed at improving the food insecurity situation of the target beneficiaries through vegetable production at household level. Vegetables were produced under small-scale irrigation schemes by constructing shallow hand dug wells, provision of pumps, pipes and training in methods of production and utilization. The project was implemented at 30 sites that extended from Karura through Gela'lo area whereby 616 nomadic households were made to depend on vegetable production for their food supplement and as part of their main source of income. Analysis of the impact of the project on beneficiary communities indeed confirmed that it is a sustainable and productive component of small-scale modality of addressing food security of our farmers in the long run.

Key words: Food security, impact, nutrition, sustainability, vegetable gardens, water wells

Introduction

Ensuring food security is one of the top national priorities and the cornerstone for sustainable economic growth and poverty reduction strategy in Eritrea (GoE, 2004a). To this effect, the Government of Eritrea completed national food security and poverty reduction strategies. In the former document, national and household level food security strategies have been formulated to alleviate the situation. At the household level, one of the strategies is to enhance the productive capacity of small-scale farmers by supporting the development of small-scale irrigation with high priority given to those that have high levels of community participation in planning, cost sharing in the construction (mainly in labour) and full operation and maintenance (GoE, 2004a). The strategy also encourages community participation to contribute some percent of investment costs, in cash or in kind. Moreover, it emphasizes introducing charges for water consumption for irrigation in order to recover operation and maintenance costs.

From this perspective, the implemented project becomes relevant and appropriate in addressing the household food insecurity status of the most vulnerable groups in the Northern Red Sea Zone (NRSZ). This zone was selected because it had relatively one of the highest malnutrition rates of about 23%, at that particular time, and had relatively the highest incidence of poverty (GoE, 2004b). Moreover, the area is semi-arid with low and highly variable rainfall and experienced four-year consecutive droughts (1997-2000). The population lacks knowledge and experience in methods of agricultural production and the necessary agricultural inputs to benefit from its natural resources. Despite all these limitations, there are potential arable land and underground water in some areas of the zone, which could be exploited for vegetable production to promote the drought copping mechanism of the community. The communities of the NRSZ are traditionally nomadic agro-pastoralists. The population is predominantly Muslim belonging to Tigre, Afar, Saho and few Tigrigna ethnic groups.

The project target areas were 30 sites in the sub-zones of Karura, Nakfa, Afaabet, Sheeb, Foro and Gela'lo (CARE, 2001). The strategy of the project was to address the food insecurity situation of the targeted populations through vegetable production under small-scale irrigation schemes. Initially, the project secured a reliable water supply and later on trained people in methods of vegetable production and utilization. In a sense, the project had three integrated components (water, vegetable production and nutrition) that were implemented sequentially. This approach was selected because, in the initial assessment, it was observed that in several locations vegetables were grown on a very small scale with irrigation water provided by shallow hand-dug wells and small-motorized water pumps. Moreover, during discussions with farmers, it was noted that even during the worst months of drought there was usually a limited amount of water available from the wells. Therefore, this project was developed and implemented by Vision Eritrea/CARE International in collaboration with the Ministry of Agriculture based on the needs assessment of the beneficiary communities and the potentials of the area.

Therefore, this study assessed the project as a small-scale modality to improve the food insecurity situation at household level. The main objectives of the study are:

- To assess the impact of the project on the livelihood of the beneficiary communities in the NRSZ.
- To assess the sustainability and multiplier effect of the project after the project phased out.
- To identify the challenges and lessons learned during the implementation of the project.

Materials and methods

This study is based on a baseline survey and periodic end line surveys, post project assessments and a terminal evaluation aimed at specifically analyzing and identifying the impact, sustainability and challenges encountered during the implementation of the project. At the start up of the project, a baseline survey was conducted on thirty targeted-sites and about 15-30 families were interviewed in each site. The baseline survey had three main sections each for the water, vegetable and nutrition components. In each component interrelated variables were incorporated that could be used as indicators to measure the impact of the project. In the water component, the main variables included type and number of water sources for human and animal consumption and vegetable production if any; distance to water source; safety and cleanness of water sources. In the vegetable component, the main variables were presence of vegetable gardens, type of vegetables grown, area of the vegetable garden, and purpose of the vegetable production. Similarly, in the nutritional component the variables include common diet of the community, type of vegetables consumed and their frequency. At the end of the project, an end line survey was conducted at randomly selected beneficiaries using similar and comparable variables stated in the baseline survey. Thus, it enabled the project to identify the specific outcomes and impacts with respect to the project activities. Moreover, one year after the implementation of the project, post assessment was done mainly focusing on the operational status, level of production and sustainability of the project. A terminal evaluation was also made through an independent body after the project phased out. On this evaluation, about 324 beneficiaries were interviewed and focus group discussions were made with different levels of stakeholders and informants.

Results and discussions

Over the period of the project (February 2002 to September 2004), thirty functional shallow hand-dug wells have been constructed and equipped with 17.7 hp pumps and pipes. The beneficiaries dug the shallow wells as their contribution and the project supplied all the necessary materials for the construction of the wells. Concurrently, water committees were established in each site and the members were trained on water management and maintenance of the water supply system. After the water sources were secured, about 616 households established small-scale vegetable gardens and the members were trained in methods of vegetable production and utilization (Table 4).

Impact of the project

One year after the termination of the project the impacts were assessed and the following short-term impacts became evident during the evaluation of the project as compared to the baseline survey.

a Water supply

Thirty water wells have been actively functioning for vegetable production and other domestic purposes. Statistically, more than 13,375 people have been using the wells for drinking purposes (Figure 3). In some areas, where there was no adequate safe and clean drinking water, the travel time was reduced to 45 min from the pervious 2 to 3 hours of walking distance. Moreover, the water wells have been used for more than 9,555 domestic animals within the project areas. Water harvesting and management skills have been increased tremendously in all the project sites since the implementation of the project.

Table 4 Number of project sites and the beneficiaries in 6 sub-zones of the NRSZ

Sub-zone	*Kebabi**	Population	Number of sites	Beneficiary families
Karura	*Mahmimet*	4,300	4	88
Nakfa	*Selselet*	1,200	1	22
	Nakfa town	5,000	1	12
	Muo	9,300	4	88
	Hiday	3,500	2	30
Afaabet	*Kamchewa*	5,500	3	64
	Afaabet town	3,500	1	14
	Kelhamet	6,600	3	61
Sheeb	*Ghedghed*	3,000	2	44
	Wekiro	4,420	5	110
Foro	*Wia*	875	3	66
Gela'lo	*Gela'lo town*	487	1	17
Total		47,682	30	616

* kebabi is the smallest level of administrative unit comprising of few villages/towns.

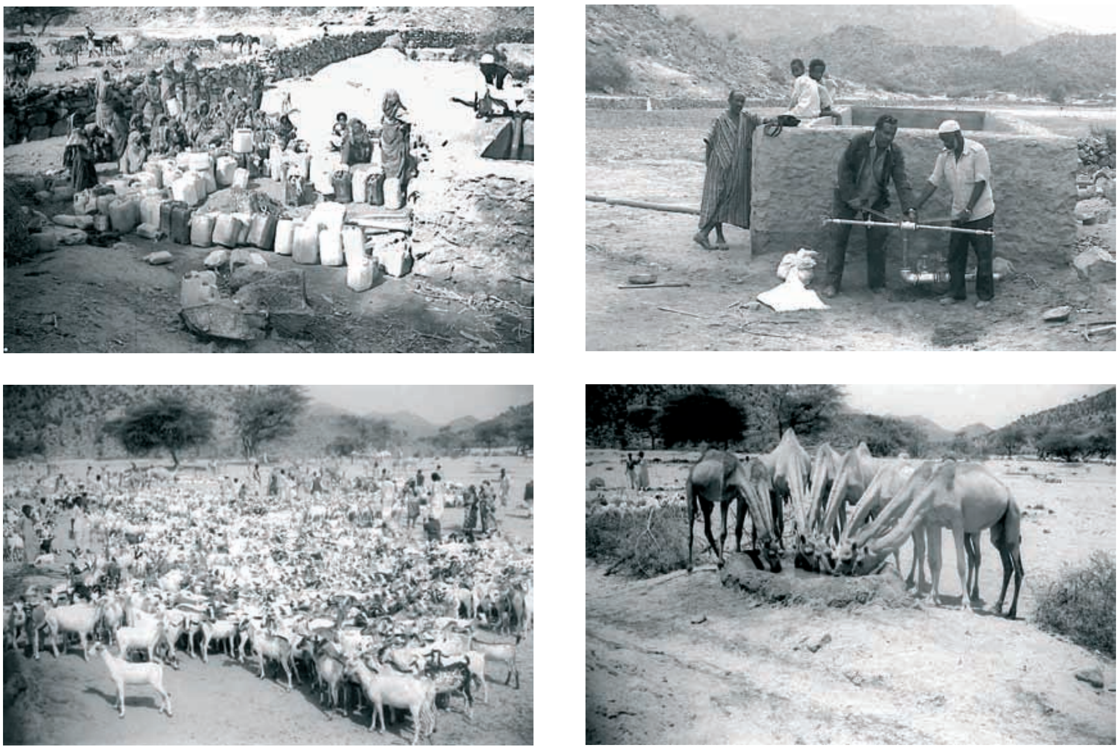

Figure 3 The wells have been used as a source of drinking water for human and domestic animals (Selselet, Nakfa sub-zone)

b Vegetable production

According to the baseline survey, only 16% of the farmers grow vegetables mainly (73%) for home consumption. About 10% of the farmers indicated that they grow tomatoes and onions and less than 9% grow vegetables like okra, hot pepper, pumpkin and watermelon. The farmers stated that the main reasons for not producing vegetables include lack of water supply, water pumps and inadequate knowledge and experience in methods of vegetable production. During the implementation of the project, 6 ha of land were cultivated for vegetable production but now 24 ha of land have been cultivated in all the project sites (CARE, 2005). This was mainly because the beneficiary farmers accepted the project and expanded their farmland for commercial purposes. At the moment, vegetable production has been adopted and considered as part of their main source of income in most of the project sites (Figure 4).

Initially, the gross income that one farmer could generate from around 100 m^2 of land over one growing season was estimated to be 434 Nakfa (Table 5). This was calculated based on representative field surveys made during the project implementation. The survey indicated that during the implementation of the project most of the vegetable production was used for home consumption. However, after the project phased out, most of the farmers expanded their farmland and started producing more vegetables, about 30% of which was used for home consumption and sold over 70% of their products. This way the beneficiaries were able to cover the expenses of fuel, maintenance, seed and other running costs. Thus, the net income that one beneficiary farmer could generate from 400 m^2 of land over one growing season (three months) reached approximately 3,027 Nakfa (Table 6). As a result, vegetable production in most of the project sites became the source of fresh vegetables for local markets at cheaper prices as compared to the nearby towns.

Table 5 *End line survey of vegetable production (in around 100 m^2) of a beneficiary farmer for one growing season (about three months)*

Vegetable types	Area (m^2)	Average production rate (kg/m^2)	Total vegetable Production (kg)	Vegetables consumed (kg)	Vegetable for commer-cial purpose (kg)	Unit price (Nakfa/ kg)	Total price (Nakfa)
Tomato	15	1.4	21.0	12.6	8.4	7	59
Onion	15	1.5	22.5	13.5	9.0	6	54
Swiss chard	15	5.0	75.0	15.0	60.0	4	240
Carrot	15	1.2	18.0	10.8	7.2	5	36
Okra	15	0.5	7.5	4.5	3.0	15	45
Gross income (Nakfa)							434

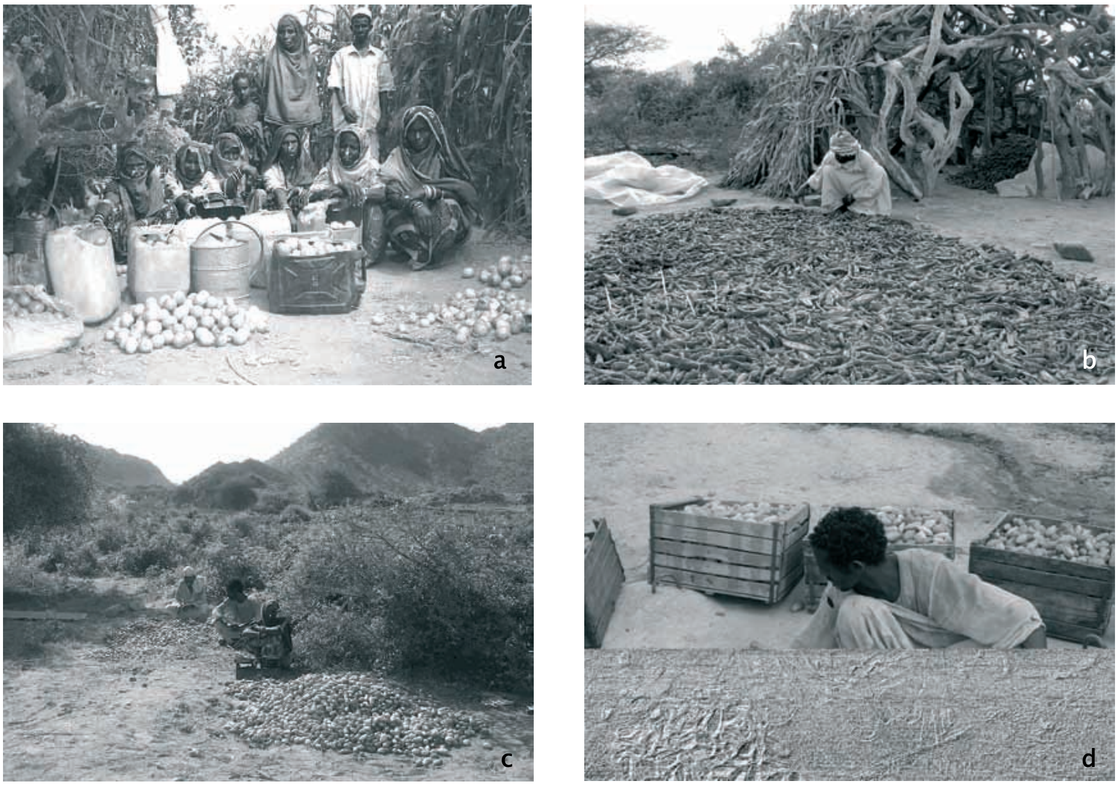

Figure 4 *Established vegetable gardens and harvested vegetables at different project sites and periods (a) Kamchewa, Afaabet sub-zone during the project period, (b) One year after the project phased out, (c) Hiday, Nakfa sub-zone during the project period and (d) One year after the project phased out*

Table 6 Post project assessment of vegetable production (in around 400 m²) of a beneficiary farmer for one growing season

Vegetable type	Cultivated Area (m²)	Average production rate (kg/ m²)	Total vegetable Production (kg)	Vegetables consumed	Vegetables for sold	Unit price (Nakfa/ kg)	Total price (Nakfa)
Tomato	100	1.4	140	21	119	11	1,309
Onion	120	1.5	180	18	162	6	972
Swiss chard	30	5.0	150	15	135	4	540
Carrot	75	1.2	90	9	81	6	486
Okra	65	0.5	33	7	26	20	520
Gross income (Nakfa)							3,827
Averaged total expenses (for fuel, seed, pesticide and maintenance)							800
Net income (Nakfa)							3,027

c Nutrition

In the baseline survey it was gathered that diets within the community mostly consisted of cereals in the form of porridge and meat. Although 72% of the families indicated that they eat vegetables, the consumption rate is very low. The types of vegetables consumed in their order of importance are: onions (72%), hot pepper (15%) and tomatoes (11%) (CARE, 2003). During the project implementation, 15 vegetable types have been introduced and 12 types have actually been adopted and cultivated by the beneficiary farmers. These vegetables include tomatoes, Swiss chard, okra, kale, cabbage, carrot, onion, hot pepper, beetroot, squash, '*rijla*' and '*molokia*'. Similarly, during the evaluation of the project it was noted that a remarkable change was underscored in the nutritional habit of the society (CARE, 2005).

Figure 5 Nutritional training using descriptive manuals and hands-on training in methods of food preparation and preservation

As a spin-off of the project outcome, the following impacts were observed in some of the project sites:

- Self-employment and hiring temporary workers has started to prevail over nomadic way of life. Some of the project sites have employed few guards and manual labourers to look after their vegetable gardens.
- Permanent villages were established in some project sites. For example, in *Deket* site (*Muo Lael Kebabi* and *Nakfa* Sub-zone) the project constructed four wells, which benefited 88 nomadic households. As a result, the beneficiaries started vegetable production as their supplementary means of livelihood and the local

government took this advantage and selected the area as the village site and started to establish some social services.

Sustainability and multiplier effect

The project became successful because it guaranteed its financial, technical and structural sustainability. The financial sustainability of the project was assured when the beneficiaries cultivated sufficient land to harvest enough vegetables to meet their family needs and sell some surplus to nearby markets to earn an additional income (Table 6). Technically, the beneficiaries took extensive training and hands on practices in matters of vegetable production, utilization and water management skills (Figure 5). Moreover, the structural sustainability of the project was ascertained because the project organized 20-22 neighbouring farmers as a group together to use one well. In addition, a water committee, responsible for the water management was set up. The farming households elected the committee members and developed water bylaws by which the committee was able to administrate the use of water. The responsibility of the water committee was to manage the water use, to collect fee to cover the costs of fuel, oil, and maintenance of the pump.

As a multiplier effect, some resourceful farmers who have observed the implementation of the project replicated it in their own farmland (For example, in *Shabielay* and *Afaabet* Sub-zone). The project could be replicable if farmers are able or have access to get some assistance to buy pumps and pipes and if they are trained in basic vegetable production and utilization by Ministry of Agriculture extension agents. Similarly, Vision Eritrea together with the Ministry of Agriculture replicated the project in Zoba Debub in seven sites in *Dekemhare*, *Adi Keih* and *Adi Quala* Sub-zones through funds from the European Commission (EC).

Challenges and lessons learned

The main challenges encountered to implement the project were:

- Salinity was a problem in some sites since the NRSZ is a semi-arid zone. Flashing the topsoil and selecting salt tolerant vegetables were recommended to solve the problem.
- Shortage of labour, especially, in digging water wells, as most of the beneficiaries are nomadic. This was solved by rescheduling the time of well digging when it was convenient for them.
- Lack of knowledge in methods of hand dug well construction in most of the targeted villages. This problem was solved through provision of hands on training to the masons available in the villages.

Similarly, the lessons learned from this project include:

- Active participation of the local community through out the project life is vital for the success of the project.
- Existing administrative structures at village level are important for the mobilization of the beneficiary communities. Moreover, in a traditional community, customary organizational structures should be respected to bring a breakthrough in such community-based projects.

- It has been proven that in certain areas of the NRSZ there is potential underground water at shallow depths, which can be used to produce vegetables in small-scale gardens at household level.

Conclusion and recommendation

Generally, this study has demonstrated that such small-scale project could benefit and address food security of a household in a long term. The project could be implemented in areas where there is potential underground water and cultivable land for vegetable production. In addition, to succeed in such projects, the beneficiary farmers and all stakeholders have to participate in all cycles of the project. Similarly, as vegetable production is labour intensive and full time activity there is a need for continuous assistance and follow-up until beneficiaries adopt the practice.

It is also recommendable and crucial that beneficiary farmers set up an efficient water committee to control the irrigation activities in general and water pumps in particular. Similarly, the contribution of certain amount of money per month by the beneficiaries is vital to cover the fuel and maintenance costs and for the overall sustainability of the project.

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The contribution of non-wood forest products to food security in Gash-Barka

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Abstract

The vegetation of Gash-Barka contains many useful trees and shrubs. These plants constitute an integral part of the rural household economy in providing wood and non-wood products and their contribution is significant towards food security. The main objective of this study is to evaluate the contribution of the non-wood forest products (plant species) with respect to their economic potential, productivity and sustainability to the rural household economy. In 2003-2004, study was carried out in the sub-zobas of Logo Anseba, *Agordat, Mogolo, Shambucco, Gonge, Haikota, Augaro, Goluj,* and *Barentu*. A total of 110 non-wood forest products-tree and shrub species have been documented. The non-wood forest products produced include: fodder, fruits, vegetables, roofing materials, edible gums, incenses, latex, tannin, dyes, medicine, nuts, seasonings, flavouring products, drinks, soup, oil, syrup, fibre medicine, insecticides, cosmetics, smoke bath, brooms, and toothbrushes. As a result of the expansion of irrigated and rainfed agriculture in riverine areas and beyond, these forest resources are found at the verge of local extinction. Participatory tools were used to evaluate the socio-economic conditions in which 92 households representing cultivators, agro-pastoralists and pastoralists participated. Ethno-botanical methods were employed to study the traditional plant use and management.

Excluding wood, the value of the non-wood forest products in comparison with crop, livestock products and off-farm activities showed that, it accounts for 14% of the total rural households' income. Mismanagement and unwise utilization of the forest resources are the major constraints for the sustainability of non-wood forest products. The study suggests that there are opportunities for conservation of forest resources, provided that the local communities are empowered so that they have the sense of ownership over the resources in their environment. Adequate efforts are required to inform policy makers on the values of the non-wood forest product producing plant species to enable them develop appropriate policies and strategies, as well as, promulgate laws pertinent to the conservation and sustainable utilization of these resources.

Key words: Gash-Barka, local communities, non-wood forest products, resources conservation, sustainability.

Background

A century ago, Eritrea had a forest cover of about 30% of the total land surface area. This figure dwindled to 11% in 1952 (NEMP-E, 1995; Bein *et al.*, 1996) and by 1960, it was estimated to be 5%. Today, the closed and open forest covers less than 1%, while bushland covers about 60% of the country. It is a well-established fact that the forest resources of Eritrea declined because of land clearing, overgrazing, increased consumption of wood fuel, construction of traditional houses, and recurrent droughts (NEMPE, 1995; Haile *et al.*, 1995; Bein, 1998).

The vegetation map of Africa includes 20 major regional centres of endemism out of which four regions namely the Afromontane, Sudanian, Somali-Masai, the Sahelian and the Sahara regional transitional zone are well represented in Eritrea (White, 1983; Friis, 1992). The Sahara regional transitional zone is found on isolated area along the south-eastern coast of the Red Sea. These regional centres give rise to distinct vegetation types rich in biodiversity, which deserve attention for conservation. There are nine mapping units, which represent nine vegetation types (Figure 6) (White, 1983; Ogbazghi, 2001).

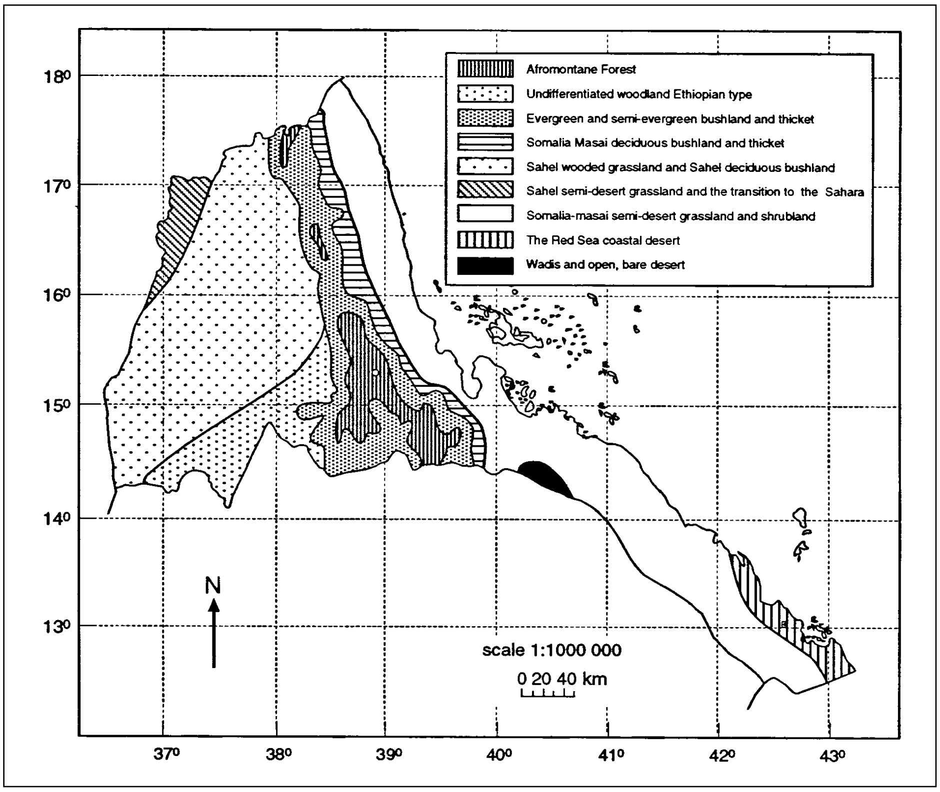

Figure 6 The vegetation map of Eritrea (White, 1983)

Geographically, the Gash-Barka administrative region extends from the Sudanian and Sahelian regional centres of endemism up to the Afromontane region. The Sudanian region is characterised by undifferentiated woodlands whereas the Sahelian region is mainly wooded grassland and deciduous bushland. The Afromontane is mainly undifferentiated montane vegetation. The riverine vegetation in the Gash-Barka is unique habitat with significant cover of doum palm and Tamarix *aphylla* species.

Justification and relevance of the study

Increased commercialisations of non-wood forest products (NWFP) have led to the depletion of plant resource base. In such event, there are two possibilities: domestication and integration of the species in question into the farming systems or face extinction. The risk of species extinction is exacerbated with increased population pressure, where even the non-destructive exploitation methods could possibly lead to the depletion of plant resources. To secure food, farmers in Eritrea increasingly apply agrochemicals or expand cultivable land and both strategies have detrimental effects on the natural resources. The consequences of such undertaking are not systematically documented i.e. there is inadequate knowledge on the economic potential of the commodities and their productivity to establish planned and appropriate non-wood forest products management system.

Standard exploitation techniques for the extraction of NWFP (e.g. tapping and chopping) processing, value addition, transportation and marketing are inexistent. Information on phenology, biology, management practices as well as husbandry of the naturally growing non-wood producing species is a prerequisite for sustainable exploitation of the resources. The land cover map of Eritrea shows that the arid and semi-arid climatic conditions dominate the vast area of the country and cannot be used for arable crop production without irrigation. The questions that remain to be answered are therefore: 'Are these areas useful and how could the vast woodlands be exploited and managed for food security on a sustainable basis? Do these areas support the rural population and contribute to the food security of the rural households? The ongoing development action plans to combat desertification and climate change as well as biodiversity conservation are outstanding instances in this respect.

Objectives of the study

The objectives of this research are to:

a Prepare a checklist of the major non-wood yielding plant species in Zoba Gash-Barka,

b Describe the utilisation of NWFP,

c Assess the contribution of the NWFP to food security, and

d Document the local knowledge regarding the management of the forest resources.

Methodology

The study was carried out in 2003-2004, in thirty-four villages of nine selected sub-zobas of the Gash-Barka region in Eritrea. The environmental setting is diverse in terms of altitude, amount of rainfall and agro-ecological distribution. Reconnaissance survey and Rapid Rural Appraisal (RRA) (Conway *et al.*, 1987) were carried out at zoba, sub-zoba and village levels. Checklist of plants was prepared and for each species, vernacular names, plant part used, season of harvest and uses were recorded (Martin, 1995; Martin, 2004). Indigenous management practices related with the exploitation was documented and analysed to understand the local people's perception on the status and values of NWFP. Questionnaire (in Tigrinya and Tigre languages) covering the use and commercialisation of the NWFP was used to depict detailed information on the demographic characteristics, number and types of trees used, number and types of livestock owned and income generated, off- farm activities, and the income generated from the NWFP. A household was taken as a sampling unit and 92 individuals representing cultivators, agro-pastoralists and pastoralists were interviewed. Gender, social status (married single, divorced or widowed) and other indicators were considered. The questions were pre-tested and validated outside the target villages. Plant resources use and management aspects were studied with emphasis on the quality and quantity of the resources over time and the possible reasons for the decline in the availability of the resources. Exploitation schedule elicited and fine-tuned the information on different socio-economic aspects of the respondents in view of the seasonality of harvest and the demands of the NWFP producing species. The results are represented in pictorial, qualitative description and the survey data is analysed using Excel version 2003.

Results and discussions

Description of the study area

The environmental setting where the study was conducted is shown in Table 7.

Table 7 Basic information on altitude and rainfall ranges in the study areas

Sub-zoba	Agro-ecological zone coverage	Altitude range (m)	Rainfall (mm)	No. of villages	No. of respon-dents
Agordat	arid lowlands	500-700	250-450	2	8
Barentu	moist lowlands	900-1100	500-700	1	7
Gogne	moist lowlands & arid lowlands	600-800	400-600	1	3
Goluj	moist lowlands	600-800	400-700	6	22
Haycota	moist lowlands arid lowlands	600-800	300-450	11	21
Logo-Anseba	moist highlands	1800-2200	400-500	6	6
Mogolo	moist lowlands	600-900	300-500	3	5
Shambucco	moist lowlands	900-1300	400-600	3	17
Laelay-Gash	moist lowlands	800-1300	400-700	1	3
Total				34	92

Socio-economic conditions

The study identified three major agricultural production systems: nomadic pastoralism, semi-nomadic and sedentary agriculture, which are slightly different from the figures provided by Cliffe (1988). Cultivation entirely depends on animal traction and the population is predominantly agro-pastoral, irrespective of household mobility (Table 8).

Besides the small Nigerian community, seven of the nine ethnic groups of Eritrea were consulted. Irrespective of their ethnicity, most of the respondents are engaged in farming, farming and herding, farming and tapping of gums and oleoresins. Few were purely pastoralists, who depend on livestock production only. Hence, 65% were agriculturalists followed by agro-pastoralists (31%), which is similar to the farming systems elsewhere in Eritrea (Haile *et al.*, 1995; Haile *et al.*, 1998). The age group of the respondents was in the range of 25-35 (7%), 36-46 (20%), 47-57 (45%), 58-68 (22%), 69-79 (5%) more than 80 years (2%) indicating that the information gathered represents the various age groups and the farming system patterns in the area.

Table 8 Relative proportion of the occupation of the respondents (%) of the various ethnic groups, in Gash-Barka

	Occupation				
Ethnic group	Agriculturalists	Agro-pastoralists	Tapping	Pastoralists	%
Bilen	2	–	1	–	3
Hidareb	3	2	–	–	5
Kunama	15	4	–	1	20
Nara	11	7	–	1	19
Saho	7	1	–	–	8
Tigre	18	10	–	1	29
Tigrinya	7	7	–	–	14
Other*	2	–	–	–	2
Total	65	31	1	3	100

*Includes community that has migrated from Nigeria long ago

Perceptions of the resources users and trends

With regard to the availability and abundance as well as the quality of the vegetation; respondents consistently indicated that the vegetation in their environs has declined over their lifetime. About 75% of them think that, nowadays, it is difficult or moderately difficult to get non-wood forest products for local consumption and for sale. Useful plant species disappeared or declined as the result of human induced factors which include the following:

- Shortage of community forest guards,
- Lack of proper land use system,
- Communal use of forest resources and lack of sense of ownership,
- Overgrazing, over-browsing and lopping by herders,
- Lack of awareness of local communities,
- Neglect of forest conservation norms and bylaws,
- Land clearing for rainfed and irrigated agriculture and resettlement of returnees and internally displaced people, and
- Excessive cutting of trees for firewood for local consumption and sale to urban settlements.

The remaining vegetation of Gash-Barka contains useful trees and shrubs, which are integral part of the rural household economy and contributions are significant to food security (Ogbazghi and Bein, 2006). Plants provide woods and non-wood products, and non-tangible services such as environmental and aesthetic values, which cannot be monetised. Other important commercial commodities and uses found in plants in the study area are: fodder, wild fruits, vegetables, thatch roofing, mats, gum, incenses, latex, tannin, dyes, human and veterinary medicine, nuts, seasoning and flavouring products, drinks, soup, oil, syrup, fibre (for making rope), insecticides, cosmetics, smoke bath, brooms, toothbrush, etc. (Table 9 and Appendix 1).

Most of the respondents (70%) indicated that the NWFP are sold to local customers; while others (21%) sell them to other regions of Eritrea and the remaining (9%) export them to the Sudan and other countries. The widely traded commodities are the leaves and fruits of Hyphaene thebaica (Doum palm locally known as Arkobkobai); the fruits of *Tamarindus indica (Humer), Ziziphus spina-christi (Gaba), Acacia nilotica (Gered)*; gum arabica, from *Acacia senegal* and *Acacia seyal* (*Akba*) and frankincense from *Boswellia papyrifera* (*Meker*). Gum Arabica and frankincense are export commodities.

Table 9 Proportion (%) of traditional uses of NFWP producing species and ranking (N=110)

Traditional use categories	% of the total (N)	Rank
Roofing materials and thatches shelter	100	1
Browse (fodder)	55	2
Bee forage	48	3
Medicinal (human and veterinary medicine)	29	4
Wild edible fruits	27	5
Smoke bath	22	6
Tannin and dyes	16	7
Toothbrush	11	8
Cosmetics, edible oils, soap and perfumes	8	9
Wild vegetables	6	10
Oils and edible gums	6	11
Rituals and sacred	6	12
Drnks, soup seasoning/flavouring	6	13
Fibre for making ropes, beds, chairs, sacks etc.	6	14
Gums and resins for domestic market and export	5	15
Jams and syrups	4	16
Insecticide (killer and repellent)	3	17

Most of the NWFP producing species flower and fruit during the dry season, when the farmers lack other sources of edible fruits to compensate deficiencies in their dietary needs including their vitamin needs (Ogbazghi and Bein, 2006). Locally, people consume wild fruits or sell them to the markets to generate cash and buy vegetables to supplement their vitamin needs. Medicinal plants are widely used by traditional healers to treat human and animal diseases. They remain as important sources of traditional medicine to compensate the lack of drugs in the area. Traditional herbal medicine is widespread and the knowledge is deeply rooted. The demand for herbal medicine is ever increasing despite the steady flow of many synthetic therapeutic substitutes because of lack of affordability, accessibility, and lack of confidence (Tadesse *et al.*, 1996).

Most acacia species produce leaves during the periods of the small rainy season, while others like *Ziziphus spp.*, *Balanites aegyptiaca*, *Hyphaene thebaica* and *Boscia spp.* are evergreen found in abundance in the dry wadi and are reliable sources of green browse throughout the year. *Faidherbia/Acacia albida* with reversed phenology is a reliable source of browse for livestock during the lean periods in which it produces succulent leaves and protein rich pods during the critical dry season. Bigger trees such as *Ficus vasta* (*Daero*), *Ficus sycomorus* (*Sagla*), *Balanites aegyptiaca* (*Mekea*), *Hyphanea thebaica* (Ar), *Adansonia digitata* (*Dma*), and *Faidherbia albida* (*Momona*), have ritual values and provide shade to humans and livestock. These trees are sources of inspiration, rituals or ceremonial services. Religious gatherings, and village assemblies gather under these trees to discuss issues pertaining to their daily life. Since pre-historic times, bigger trees have been subjects of legends, folklore, mythology and religion where some have been associated with military organisations wisdom, strength and reliability (Ciesla, 2002). Although all of the plants could be used as roofing materials, some, such as, the doum palm have unique qualities. Its leaves woven into special mats, locally known as '*Tenkobet*' are used as roofing material for sedentary and nomadic populations. The wood of the male tree, which is resistant to termites, is used as construction material.

Dyes are extracted from barks and leaves of some species. Plants and animal-based artefacts in the markets originate from tannins and dyes harvested from naturally growing plant species. Dyes, locally called, '*Subak*' are used to improve the appearance and add values to locally made materials such as hides, mats and baskets woven from the leaves of doum palm. The colourful products are sold at a reasonably higher price in the markets and may need further research and marketing to help farmers and pastoralists gain the desired level of benefits from their products.

Roots and young twigs of plants are harvested throughout the year as toothbrushes. Toothbrush is exploited both for household consumption and for sale. Roots and branches of selected species such as *Terminalia brownii* and *Dodonaea angustifolia* are also used as sources of smoke bath, which is widely practiced among the various ethnic groups. Smoke bath is most of the time used by women for medicinal and cosmetic uses for skin (smoothening and to have an attractive tint).

Acacia mellifera, *Acacia senegal*, *Adansonia digitata*, *Balanites aegyptiaca*, *Hyphanea thebaica* and *Ximenia americana* provide edible fruits and oil extracts. Gums extracted from the barks of several acacia species provide food to livestock. Plants and herbs and their extracts, infusions or their concoctions have traditionally served the rural households as important weapons against noxious insects. Species such as *Azadirachta indica* are repellent to mosquitoes, *Boscia senegalensis* is used in water purification. The concoction from the bark and leaves of Terminalia brownie is used to soak clothes to repel mosquitoes and extracts from the leaves, barks and wood are used as cosmetics and perfumes. The important ones are: *Acacia asak*, *Acacia seyal*, *Balanites aegyptiaca, Combretum fragrans* (perfume), *Hyphanea thebaica*, *Lawsonia inermis* (leaves for cosmetics), *Ziziphus spina-christi* (soap and antifungal effect), *Buddleia polystachya*, and *Phytolacca dodecandra* are used as soap. Drinks are extracted from the shoots of doum palm. The pulp and dried fruits of *Tamarindus indica* and *Adansonia digitata* (Baobab) are excellent sources of flavouring materials. Sources of fiber are *Acacia senegal*, *Acacia seyal*, *Acacia tortilis*, *Adansonia digitata*, *Capparis decidua* and *Hyphanea thebaica*. Fiber extracted from inner and outer barks of trees and fiber from leaves and Doum palm leaves are major commercial sources used locally and exported to the Sudan, where they are processed into mats, breadbaskets, baskets, fans etc.

Acacia senegal and *Boswellia papyrifera* are multipurpose gum yielding commercial species found in abundance. In spite of the exclusive right vested on the commercialisation of both species, rural communities get substantial benefits for household consumption and local trade. Due to over exploitation and inappropriate tapping techniques, these species are threatened to extinction. Domestication and introduction into the farming system would be feasible conservation strategies.

The western escarpment lying between 1500-2200 m altitudes (e.g. Logo-Anseba) is habitat for apiculture. Bees visit most of the flowering plant species during most parts of the year depending on the phenology of individual species. Besides, the sap of four species: *Balanites aegyptiaca*, *Hyphanea thebaica*, *Ziziphus spina-christi* and *Opuntia ficus indicia* is used as a source of jam and syrup. The ground fruits of *Balanites aegyptiaca* yield excellent source of drinks. The apical meristem of Doum palm shoots, when cut, drains delicious liquid, which upon fermentation is processed into local traditional alcoholic drink and is highly appreciated by the locals.

Management

Local forest management systems aimed at conserving and protecting forest resources exist but the respondents did not have the same level of understanding on the management practices of their environment. Most of the respondents (65%) indicated that, at the local village community level, NWFP producing species are managed by farmers and herders and the rest (16%) think by forest guards hired by Ministry of Agriculture (3.3%) branch offices, farmers (5.4%), nobody (5.4%), village council (4.4). This suggests that there is no clear division of responsibilities in the conservation and use of the natural plant resources between people and the local administration.

Table 10 Constraints and possible solutions to NWFP producing plants species in Gash-Barka region (n=92 households)

Constraints/ Problems		%	Possible solution to the problem
1	Land clearing for agriculture and resettlement	32	Government intervention in land use planning
2	Over-browsing and lopping	29	Conservation and introduction of forest laws
3	Lack of awareness and conservation norms	13	Conservation and reforestation activities
4	Shortage of community forest guards	9	Introduction of Agro-forestry systems
5	Communal use of forest resources	5	Community sensitisation
6	Excessive cutting of trees and shrubs for firewood	4	– Introduction of community-based forest management systems; – Adoption of community forest guards for conservation – Introduction of tree tenure – Train non-wood forest product users
7	Lack of proper land-use system	3	Charging for forest encroachment
8	Lack of forest bylaw	2	Controlled grazing and browsing
9	Overgrazing and lack of ownership	1	Introduction of energy saving systems at household levels

Constraints and opportunities

Table 10 depicts the main constraints and opportunities for sustainable management of NWFP. Various constraints negatively affect the distribution and abundance of the NWFP producing species. Influx of returnees from The Sudan and the internally displaced population as the result of the border war with Ethiopia (1998-2000) created additional burden to the resources base. The Adi Keshi environs are vivid evidence of the extent of damage on the woodlands. About 58% of the respondents suggest the enforcement of community-based forest management systems, which empowers farmers and pastoralists to have full control over the resource-base in their village areas.

The main sources of income for the rural households are crop cultivation (farming), livestock production, NWFP and off-faming activities. Farming contributes about 43% of the total income followed by livestock (34%). NWFP excluding the use of wood for domestic household energy and sale accounts for about 14% of the total household income. The average annual household income in the study area is estimated at 13,000 Nakfa (equivalent to about 1000 USD) (Table 11). Rainfed crop production consists of cereals (sorghum and pearl millet), and oil crops (sesame, groundnuts). The region is known for the local livestock breeds called '*Bgayt*' from which households sell live animals or livestock products such as milk and butter.

Table 11 Average annual income (in Nakfa) from sales of various farming and off-farm activities in Gash-Barka in 2003 and their contribution (%)

Income from	Farming	Farming & Herding	Farming & Tapping	Herding	Grand Mean (Total)	% contribution
N households	60	28	1	3	(92)	
Livestock						
Minimum	0.0	0.0		450.0	0.0	
Maximum	20,375.0	22,280.0		6,000.0	22,280.0	
Average	3,334.9	6721.8		2,600.0	4,305.5	34
Farming						
Minimum	0.0	0.0	18,000.0		0.0	
Maximum	26,000.0	16,000.0	18,000.0		26,000.0	
Average	4,704.0	6,746.8	18,000.0		5,316.8	43
Off-farm jobs						
Minimum	0.0	0.0			0.0	
Maximum	9,125.0	14,000.0			14,000.0	
Average	944.8	1,494.8			1,071.1	9
NWFP						
Minimum	0.0	0.0	6,150.0	0.0	0.0	
Maximum	12,831.9	34,266.7	6,150.0	2,773.3	34,266.7	
Average	1,554.8	2,031.4	6,150.0	1,143.5	1,736.4	14
Mean Income	10,598.5	17,022.8	24,151.0	37,46.5	12,521.8	

*1 USD in 2003 was equivalent to 13.50 Nakfa

Valuation of non-wood forest products

The main sources of the NWFP come from the exploitation of leaves of doum palm and the sales of various fruits and other minor products. The overall economic contribution of these products is lower than both crop and livestock production, which is lower than in the neighbouring countries and elsewhere in the world. Lemenih *et al.* (2004) reported that 31.9% of the annual subsistence household income in southern Ethiopia comes from gums and oleo-gums. In India, more than 50% of the forest revenue comes from NWFP (Shiva, 1993). Similarly, in Peru, Peters *et al.* (1989) indicated that the extraction of NWFP for local market was more profitable than timber harvest. Grimes *et al.* (1994) reported that revenue generated from NWFP products was significantly greater than returns from alternative land uses such as agriculture, timber and cattle ranching. The valuation excludes the income generated from the sales of wood used for domestic household consumption and sale. The non-tangible (environmental) values are not included in this study and require further investigation. Most of the vegetation cover has decreased in distribution and abundance where the total volume of the NWFP produced is low due to climatic and human induced factors. Some species have disappeared from most areas and others are on the verge of local extinction.

The sustainable extraction of NWFP advocated, as a strategy, to conserve biodiversity should include sustainable exploitation of the NWFP species (Boot, 1997). Under the Eritrean situation, the conservation and economic development strategies are hampered by lack of information. Thus, crucial information on biological sustainability, the impact of the different exploitation systems on the biological diversity and adequate knowledge on the role of non-wood forest products on the household economy is required for sustainable development. Under high population pressure, even, the non-destructive methods of exploitation (e.g. traditional harvesting techniques) could lead to, depletion of resources.

Conclusion and recommendations

The forest woodlands of Gash-Barka region, which have been significantly contributing to the livelihood of the rural people and ameliorating the environment, are under continuous shrinkage and fragmentation, mainly due to unwise human actions. To save the remaining forest resources before reaching irreversible level and thereby contribute to food security and poverty alleviation, we need to consider the following seriously.

a Promote community participation in the conservation and management of forest resources with clear benefits and responsibilities. We should develop strategies whereby the benefits from NWFP are shared equitably among the local communities without jeopardising the interests of the agro-pastoralists and pastoralists. Empower local communities to develop sense of belongingness on the natural resources and manage them responsibly. Avoid authoritative and destructive practices of forest management that have negative impact on the sustainability of these resources.

b Create market and charge systems for NWFP in view of their values, services and their scarcity, and encourage farmers and pastoralists to get the right benefits and hence have the justification to conserve and exploit them on a sustainable basis. Assess instruments such as loans and grants to raise seedlings, domesticate some of the NWFP trees and shrubs, and integrate them not only into the farming systems but also into the broader afforestation programs underway.

c Conduct careful resettlement and urban planning programmes prior to implementation in order to minimize the degradation of forest resources in general and the valuable NWFP producing species in particular.

d Encourage the implementation of pre and post investment environmental impact assessment on development projects. Develop management plans that demand developers to put aside some bonds or deposit in advance for mitigating the negative impacts that may arise during the implementation of projects.

e Promote value adding to the NWFP in order to increase the values of the commodities, which could increase the earnings of the users, as well as to encourage investors to re-look at them and invest an adequate amount of funds on the conservation and utilisation of these resources.

f As indigenous knowledge is gradually disappearing, it is important to document and frequently update the indigenous knowledge on the uses and management of the forest resources for future generations.

g Streamline the functions of extension workers towards conservation of forest and woodland resources, as now-a-days these agents do not pay balanced attention to the conservation and utilisation of the NWFP in the face of arable and irrigated crop production.

h Introduce collaborative riverine forest management along the riverbanks of Gash Barka and Setit and the flat-bottomed seasonally flooded valleys and Wadis with shared responsibilities of both the local communities and the government, as these habitats are useful from not only environmental point of view but also as sources of the NWFP producing species.

i Introduce policies and strategies, as well as, legally binding instruments on the conservation and sustainable management of the forests/woodlands.

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Additional Information

List of species used as sources of NWFP in the Gash Barka region of Eritrea

Species	Tn	Co	Dr	Br	Bf	Fr	Gu	Ins	Me	Oi	Sb	Tb	Ve	Fb/Ri
Acacia abyssinica				X										
Acacia asak	X	X		X	X				X					
Acacia etbaica	X			X	X				X					
Acacia laeta	X			X			X		X					
Acacia mellifera	X			X	X				X	X	X	X		
Acacia nilotica	X			X	X				X					
Acacia oerfota	X		X	X					X			X		
Acacia polyacantha				X	X									
Acacia senegal				X	X		X	X	X	X				
Acacia seyal	X	X		X	X			X	X		X			
Acacia tortilis				X	X			X	X					
Ackocanthera schimperi								X						
Adansonia digitata	X			X	X	X		X	X	X			X	Fb
Agave sisalana					X									
Albizia amara					X									
Albizia anthelmentica									X					
Aloe spp					X									
Anethum graveolens									X					
Anogeissus leiocarpus	X			X	X				X		X			
Arundo donax														
Azadirachta indica								X						
Balanites aegyptiaca		X		X		X			X	X	X	X	X	
Barleria eranthemoides					X				X					
Becium graniflorum					X									
Boscia angustifolia	X	X		X		X			X		X	X		
Boscia salicifolia				X					X					
Boscia senegalensis	X			X	X	X		X	X		X		X	
Boswellia papyrifera	X			X	X		X		X		X			
Budedleia polystachya		X												
Cadaba farinosa		X									X			
Cadaba rotundinfolia				X	X				X					
Calotropis procera				X	X				X					
Calpurnia awrea									X					
Capparis decidua				X	X	X		X	X		X	X		
Capparis tomentosa				X		X			X					
Carissa edulis				X		X					X			
Clerodendron myricoides									X					
Combretum aculeatum				X		X					X			
Combretum fragrans		X			X						X			
Combretum molle				X	X									
Commiphora erythraea					X									
Cordia africana				X	X	X								
Cordia monoica						X								
Croton macrostachyus					X									
Dalbergia melanoxylon				X	X						X			
Dichrostachys cinerea				X					X		X			
Diospiros abyssinica				X										
Diospiros mespiliformis				X		X						X		
Dobera glabra				X	X	X						X		

KEY: Tn= Tannins/Dyes, Co=Cosmetics, Dr= Drinks/seasoning materials, Br=Browse species, Bf= Bee fodder nectar/ pollen grains for bees Fr=Wild fruits: dry/fresh fruits or as jam, Gu= Gums/oleoresins, Ins=Insecticides: killers/ repellants, Me=Medicinal plants, Oi=Oils, Sb=Smoke bath, Tb= Tooth brush, Ve= Vegetables, Fb= Fiber, Ri=Rituals

Species	Tn	Co	Dr	Br	Bf	Fr	Gu	Ins	Me	Oi	Sb	Tb	Ve	Fb/Ri
Dodonaea angustifolia											X	X		
Eucalyptus spp					X				X					
Euclea schimperi				X		X					X			
Euphorbia abyssinica					X									
Euphorbia iricalli														
Faidherbia albida				X	X				X					Ri
Ficus carica						X								
Ficus glumosa				X		X								
Ficus sycomorus				X		X								Ri
Ficus vasta				X		X				X				RI
Grewia ferruginea				X		X			X					
Grewia flavescens				X		X								
Grewia tenax				X	X	X								
Grewia villosa				X	X	X			X					
Hyphaene thebaica				X	X	X		X	X	X		X	X	Fb
Juniperus procera								X						
Lawsonia inermis		X			X				X		X			
Maytenus sengalensis										X				
Meriandra bengalensis									X					
Mimusops kummel				X		X								
Nuxia congesta				X	X									
Ocimum chandiences				X										
Olea africana				X	X							X		
Opuntia ficus indica				X	X	X								
Ormocarpum pubescens											X			
Otostegia intgrifolia					X									
Phytolacca dodecandra		X								X				
Piliostigma thonningii						X								
Premna resinosa					X						X			
Prosopis chilensis				X										
Rhamnus staddo									X					
Rhus abyssinica					X									
Rhus natalensis				X										
Rumex nervosus											X			
Salvadora persica				X					X		X	X		
Schinus molle				X										
Sclerocarya birrea				X	X	X					X			
Senna alexandrina									X					
Senna siamea									X					
Senna singuana	X								X					
Shankuk				X									X	
Shelewi				X										
Sida schimperiana												X		
Steganotaenia areliacea									X					
Stereospermum kunthianum									X					
Syzygium guineense		X				X								
Tamarindus indica				X		X			X				X	
Teclea nobilis				X		X			X					
Terminalia brownii	X			X	X			X	X		X			Fb
Verbascum sinaticum									X					
Vernonia schimperi					X									
Ximenia americana	X			X		X			X	X				
Ziziphus abyssinica				X	X									
Ziziphus spina-christi	X	X		X	X	X			X		X		X	

KEY: Tn= Tannins/Dyes, Co=Cosmetics, Dr= Drinks/seasoning materials, Br=Browse species, Bf= Bee fodder nectar/ pollen grains for bees Fr=Wild fruits: dry/fresh fruits or as jam, Gu= Gums/oleoresins, Ins=Insecticides: killers/ repellants, Me=Medicinal plants, Oi=Oils, Sb=Smoke bath, Tb= Tooth brush, Ve= Vegetables, Fb= Fiber, Ri=Rituals

The case for animal genetic resource management plan in Eritrea

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Abstract

The world's domestic animal breeds represent an important resource for economic development and livelihood security. Extensive genetic diversity in these breeds allows the existence of livestock in all but the most extreme environments globally, providing a range of products and functions. Unfortunately, a large number of breeds have been lost and many are at risk. Further erosion of animal diversity might invite disaster as options for long term productivity and sustainability are lost. Hence, the imperative of conserving animal genetic diversity has gained global consensus and many countries have gone a long way in implementing animal resources management plan. Unfortunately Eritrea has been unable to take the necessary steps to manage its animal genetic resources despite the opportunities availed to it by international initiatives. This paper provides an overview of global initiatives, the Eritrean animal genetic resources, lessons learned in livestock development and the steps necessary to conserve and utilize these resources in a sustainable manner.

Key words: Genetic diversity, genetic resource, livestock, sustainable production

Introduction

Animal genetic resources (AnGR) are major underpinning of livestock production and the maintenance of their diversity is a necessary aspect of long-term productivity and sustainability. Indigenous livestock breeds often possess valuable traits such as disease resistance, high fertility, good maternal qualities, unique product qualities, longevity and adaptation to harsh conditions and poor quality feed, all desirable qualities for low input and sustainable agriculture. If maintained, the genetic diversity presently found in domestic animal breeds, allows farmers to select stocks or develop new breeds in response to changes in the environment, threats of disease, new knowledge of human nutrition, changing market conditions and societal needs, all of which are largely unpredictable (ILRI, 1999). Therefore, the conservation of our AnGR is crucial for long-term productivity and sustainability, which are the basis for food security.

Long-term food security as supported by livestock sector is dependent upon production systems, which are intensified in a sustainable manner. However, a requisite for the sustainable intensification is the utilization of the most appropriate animal genetic resources with the understanding of the limitations and opportunities of the production environment in which the animals will be maintained (FAO, 2001). This entails comprehensive understanding of the roles and values of locally adapted or exotic breeds and working to enhance their use and development. This paper presents an overview of global initiatives, Eritrean animal genetic resources, lessons learned from past livestock developments and the steps necessary to manage, develop, and use them to enhance their important role in food security.

Global initiatives for the management of farm animal genetic resources

Globally, the rate of decline of diversity of farm animal genetic resources (FAnGR) has been alarming. Based on a worldwide survey, 27 % of the existing 5,000 breeds are thought to be threatened or endangered (FAO/UNEP, 1995). In other words, it is estimated that about 50 breeds are lost per year, which is approximately one breed per week. The overwhelming consensus has been that this trend should be contained before it is too late. Various conventions and programmes have been initiated to this end.

Convention on Biological Diversity (CBD)

In 1992, the second United Nations Conference on Environment and Development in Rio de Janeiro recognized the importance of farm animal genetic resources in the CBD. Nearly all countries including Eritrea have signed this convention, which resulted in political and social awareness of the AnGR and activities to conserve them. The CBD, which came into force in December 1993, recognizes the sovereignty of each country over its genetic resources, which implies also the obligation to conserve these resources (UNCED, 1992b). Therefore, Eritrea has a responsibility to manage its AnGR under this convention.

Agenda 21

Agenda 21 is a comprehensive plan of action to be taken globally, nationally and locally by organizations of the United Nations system, Governments, and major groups in every area in which there are human impacts on the environment. This Agenda, which was a precursor to CBD, was also accepted during the Rio de Janeiro Earth Summit when the CBD was adopted (UNCED, 1992a). Eritrea is also a signatory to this agenda and as such has a responsibility to take measures to see its implementation in the context of its pursuit of food security and environmental protection objectives.

Agenda 21 in its conservation and management of resources for development section (Chapter 14 and 15) has set, interalia, the following objectives and activities for conservation of biological diversity (including AnGR) to which Eritrea is expected take practical actions:

- Develop national strategies for the conservation of biological diversity and the sustainable use of biological resources;
- Integrate strategies for the conservation of biological diversity and the sustainable use of biological resources into national development strategies and/or plans;
- Carry out country studies, as appropriate, on the conservation of biological diversity and the sustainable use of biological resources;
- Building capacity by strengthening existing institutions and/or establish new ones responsible for the conservation of biological diversity.

Global Programme for the Management of FAnGR

This special action programme was introduced in 1995 by FAO in recognition of the increasing international awareness to conserve and develop genetic resources for food and agriculture in a sustainable manner (FAO, 1998a). The technical programme aims at supporting effective management action at country level. This programme has, as its objectives, to establish practical mechanisms and set key actions by countries that aim, in particular, at:

- Developing and making better use of animal genetic resources adapted to the world's major medium-input and low-input production environments, so as to enable their agricultural systems to intensify sustainably; and
- Overcoming the serious threat of genetic erosion amongst the 5,000 or so remaining breed resources of the 14 main farm animal species.

The programme provides for a range of bilateral and multilateral assistance which could be in the form of both grants and loans, as well as in kind. In the context of livestock development programmes we are contemplating, it would be desirable and advantageous to enlist technical and technological help from international institutions such as FAO. Eritrea has failed to benefit from this very important programme for the lack of national body responsible to engage FAO.

State of world report on animal genetic resources

A global strategic AnGR assessment has been underway under the auspices of the Commission on Genetic Resources for Food and Agriculture, which is expected to report strategic priorities for action in AnGR conservation (FAO, 2000). Upon its planned adoption in 2007, countries will be expected to consider its implementation (FAO, 2005). The ultimate objective of this report is to develop national capacities and international cooperation to achieve the sustainable intensification of livestock production systems. Although Eritrea was duly invited and was keen to contribute to this report, it was unable to participate actively and effectively. It missed a wonderful opportunity to pinpoint its constraints. More than anything else, the exercise would have enabled the country to assess its state of national capacities and future capacity building requirements. Nevertheless, Eritrea should benefit from the global report to identify its national priorities in maintaining and enhancing the contribution of animal genetic resources to food and agriculture. But, it goes without saying that Eritrea needs to lay the groundwork to benefit from the recommendation of this report as the basis of international cooperation and assistance in global AnGR conservation.

Eritrean animal genetic resources

Diversity

Animal genetic resources include all species, breeds and strains of animals that are of economic, scientific, and cultural interest to agriculture, now and in the future. Most of the popularly domesticated species are present in Eritrea. The current estimate puts the combined population of livestock into 12 million, with small ruminant species forming by far the largest group (Table 12). There are also wildlife resources, which could potentially contribute to food and agriculture. Eritrea is probably rich in farm animal genetic resources despite its small geographical size. But, there is little understanding of the genetic diversity available.

Table 12 Livestock population size in Eritrea

Type	Population estimate
Cattle	1,928,000
Sheep	2,129,000
Goats	4,662,000
Camels	319,000
Equines	500,000
Poultry	2,500,000
Total	12,038,000

Source: MoA, 1997

There is a critical information gap about the Eritrean animal genetic resources. This is because no serious work has been done to systematically describe and characterize these genetic resources. The earliest description of Eritrean animal genetic resources was attempted during the colonial era (Table 13). Although the information was not collected using scientific method, this is the most useful information available by virtue of its timing as well as its comprehensive nature. What is needed now is to build on this information and implement a comprehensive characterization, *inter alia*, to identify the breeds and their genetic attributes, their population and status if any management plan is to be drawn to enhance their conservation and sustainable utilization.

Threats

There may be several threats to loss of AnGR diversity and according to FAO (1998b), the major global threats identified are the following:

- Introduction of exotic germplasm;
- Poor agricultural policies;
- Restriction of development to a few breeds;
- Changing market requirements;
- Degradation of ecosystems;
- Natural disasters (drought, disease); and
- Political unrest and instability.

All or any combination of these threats may be responsible for the loss of AnGR diversity in a country. Eritrea has suffered the ravages of a long war for independence and although there is no concrete information available to assess the damage to its AnGR, there are enough evidences to indicate the insidious and probably serious damage inflicted upon them during the war. The crossbreeding of Begait (Barka) with Dohein (exotic breed) is one good example. This action was presumably taken to utilize the fierce and flighty character of Dohein to evade capture by enemy soldiers. Similar cases of breed dilution are probably continuing to this day in cattle, sheep, goat, etc albeit the underlying reasons could be of economic nature this time around.

Table 13 Breeds of livestock popularly identified in Eritrea

Species	Breeds/strains	Distribution
Cattle	1. Barka/ Begait 2. Arado 3. Arab/Bahri/Aden/Berber 4. Nara variety	– Gash Barka (West and North West) – Highland, Sahel, Maria, Mensaea – Along the coast, Highland, Lowland – X bred of Begait & Scicurie
Sheep	1. Highland fat tail/Abyssinian 2. Arrit 3. Hemale/Deresh/ Hawitat 4. Barka (X bred of 2 &3) 5. Afar 6. Rashaida	– Highland – Maria, Mensae, Habab – Gash Barka (Barka Tahtai, Laelay) – Gash Barka (Barka Laelay) – Denkalia – Semhar
Goats	1. Barka 2. Tsaeda 3. Keih (red) 4. Tselim (Black) 5. Shicuria / Hassani 6. Others	– Barka, Senhit – Sahel – Ad Temariam, Habab, Maria – Ad Temariam, Habab, Maria – Gash Barka – Hamassien, Bilen, Assaurta, etc.
Swine	1. Black race 2. Wild Swine	– Italian origin – Semenawi Bahri
Dromedaries (camels)	1. Bishiari 2. Grain 3. Arho 4. Zebedi	– Bishari, Hidareb areas – Habab, Ad Temariam, Ad Moalem – Denkalia – Rashaida
Horses	1. Dongolaw (Junglai) 2. Galla	– Gash, Setit, Barka – Highland (Schimezana, Hamassien)
Donkeys	1. Abyssinian 2. Nubic/Kassala (Reef?) 3. Etbai	– All over the country – Gash Barka – Gash Barka
Mules	1. Mulletti (local) 2. Mules	– Highland – Exotic (Italian, Cyprus)
Fowls	1. Abyssinian 2. Guinea fowl (Zagra) 3. Turkey, etc	– Indigenous – Domesticated wild – Exotic

Source: Marchi, 1929

Deliberate dilution or replacement of indigenous genetic resources by external germ-plasm is one of the most important threats to AnGR diversity. During the 20th century many developing countries imported germplasm without careful thought for their ecological conditions. However, the low-input, low-output management system of the developing world has not been able to bring the desired change in productivity. What is worse is, it facilitated the destruction of indigenous AnGR diversity. This is where Eritrea needs to learn in its pursuit for food security to increase availability of milk, meat, etc. It is necessary to avoid independent and ad hoc breeding schemes, especially regarding exotic breeds. Any breeding scheme should be designed to fit the ecological condition on a sustainable manner, not the other way round and it should be supported by strong research evidence.

Sustainable livestock development in Eritrea

The basis of sustainable livestock development in Eritrea will necessarily have to depend on indigenous genetic resources not only because of their numbers and farmers' access to them, but more importantly, because of their adaptations to local environmental stresses including disease and heat tolerance. The only significant odd against the use of locally adapted indigenous breeds in increasing animal production is the fact that their absolute production figures are often low compared to exotic breeds (e.g. milk yield). However, when the production environment and the level of input are taken into consideration productivity itself is often remarkably high (FAO, 1998a). Moreover, there is a great scope of improvement of absolute production if sustainable production systems could be designed such that the utilization of available resources would be maximized without diminishing the future availability of those resources.

Much of Eritrea's animal agriculture will remain at low to medium input levels for the foreseeable future, as it is the case with other developing countries. In such an agricultural context, successful livestock development programme is assured through enhancement of productivity and maintenance of local adaptation (FAO, 1998b). However, the attainment of this objective presupposes the undertaking of true long-term economic valuation of animal genetic resources, particularly comparing locally adapted and/or exotic genotypes in the ecological condition of interest. Such studies are essential to guide livestock development programmes and to determine the most appropriate use and development of animal genetic resources. Without such information, policy makers and development agencies lack the basic information they need to ensure that their efforts are contributing to sustainable development. The critical lack of baseline information about our genetic resources is thus a major risk factor or impediment in our livestock development efforts.

Currently several livestock development undertakings are in progress in Eritrea, especially in Zoba Gash-Barka. Some well known sites such as Ad-Omar, Af-himbol, Fanco, etc., can be mentioned. An important question about these enterprises is the degree of their sustainability. When the breeds used are local genetic resources, the first condition of sustainable development is met. But, how about the second condition of enhancing productivity? What is the sustainable management system as stipulated by the ecological condition? (Is it medium-input, medium output or low-input, low output?). What could be the management improvement it takes to enhance productivity? These questions are some of the important aspects of research and development goals. Had there been a properly designed management plan for Eritrean animal genetic resources, some of the basic information required for policy makers and development agencies could have been collected from studies in such areas.

The following opportunities are available for improving animal economic efficiency using local AnGR in a sustainable manner (FAO, 1998b), if the required studies are undertaken:

a Determining the facts about economic performance
Key Question is "Has the economic value of the indigenous breed been underestimated?"

b Incorporation of the indigenous breed into a crossbreeding scheme
Key question is "Does the crossbred have better economic value than imported exotic or indigenous?"

c Selection within the indigenous breeds

Key question is "Will development by selection restore/improve profitability to the local breed?"

d Examining the potential of niche markets for quality high products
Key question is "Can the product be differentiated to make it command a higher market price?"

e Improving the management (nutrition, health, breeding, etc.)

Lessons learned from livestock development programmes

The world has learnt a lot from past livestock development programmes, which failed to understand the need for the synchronization of genetic resources and the ecological conditions. The following are some of the lessons learned about cross-breeding and genotype by management/environment interaction after close examination of case studies from several countries (FAO, 2001).

Myth – Crossbreeding

- There should not be an assumed benefit from crossbreeding locally adapted breeds with high input, high output exotic breeds, or replacement of locally adapted breeds with high input – high output breeds.
- Performance evaluation of breeds must occur within the local production environment on an experimental scale to ensure that the introduced or crossbred animals are suited to local conditions, both in terms of meeting their input requirements and their ability to perform in the local and often stressful environment.
- Modern breeding strategies and management practices can be integrated with traditional farming practices to improve the performance of locally adapted breed.

Myth – All production environments are alike

- Government policies may have unintended consequences and reduce sustainability of animal genetic improvement efforts if they are not carefully designed to consider genotype x environment interactions and farmers' capability to manage them;
- A broad participatory ecosystems approach in designing animal genetic resources development programmes is advisable to strengthen production systems. e.g. in terms of efficient nutrient cycling and energy use in the crop animal interaction on farm;
- Innovations in subsistence agriculture must be developed and tested to ensure that they produce sustainable benefits. Better methods for the economic valuation of animal genetic resources, including their social and environmental externalities, in local production environments will be of particular benefit.

Developing FAnGR management plan

The purpose of a FAnGR management plan includes identification, description and characterization of AnGR, its active utilization to increase food and other agricultural production, the conservation of endangered breeds for future use, access to AnGR and the monitoring and reporting elements. Each of these elements, large undertakings in their own right, require considerable organization and coordination of resources for their effective implementation. Most important though, charting the most appropriate strategy naturally presupposes the comprehensive assessment of various components important to the aim and goal of animal genetic resource management plan. Therefore, a systematic approach is highly required for developing the management plan. According to FAO (1998a), the recommended framework is as follows:

1. Developing a management capability

A focal point for management action needs to be established to provide the necessary leadership, communication and reporting. An essential element will be to establish a broad based network of technical and practical skills involving all those who have a contribution to make at national level. The focal point should consist of a co-ordinator and an advisory committee.

2. Assessment of needs

Inventory and characterization
The description of physical characteristics, production traits and information on its distribution, main uses, population numbers, etc., of each breed found in the country is essential. This should include wild relatives of domestic species as well.

Human and technical capacity
Resources should be identified for research, education, technology transfer, planning and policy development. The same is true of facilities for reproductive biology techniques, communication and data processing.

Livestock sector
For each species, all uses, main production environments and key factors influencing germplasm and accessibility should be identified. This includes identifying government policies, which affect animal genetic resources management and use.

The role of animal genetic resources
Potential contributions of indigenous and imported breeds to the nation's current and future needs for food and agriculture must be evaluated.

3. Developing a strategy for action

Based on the assessment of needs, goals and operational objectives must be determined. The objectives must be clearly defined and measurable so that progress can be assessed. Plans should be integrated with related national sustainable development and conservation initiatives. To ensure cooperation and maximum relevance of the strategy, a consensus among stakeholders should be obtained and their role in carrying out the plan established.

The main activities may include:

- Completing and expanding the inventory and characterization of breeds;
- Devising a comprehensive action plan for each important species;
- Training and capacity building.

Conclusion

Eritrea is committed to ensuring food security to its citizens and is currently engaged in some serious undertakings in crop agriculture. Similar serious undertakings should be expected in livestock agriculture if the food security objective is to be attained in a sustainable manner. The basis of sustainable food security as supported by livestock sector in Eritrea will be indigenous genetic resources not only because of their numbers and farmers' access to them, but more importantly, because of their adaptations to local environmental stresses including disease and heat tolerance. The challenge is to design and implement livestock development programmes, which sustainably intensify livestock production. Thus, if Eritrea is to undertake well-designed livestock development programmes, it needs to fill the critical gap in base line information about the performance of its genetic resources. In addition, it should make sure that appropriate management plans are drawn to prevent the loss of animal diversity. For these reasons, Eritrea needs to take up the management challenge for its animal genetic resources to achieve its cherished food security objective as well as meet its international obligations of agro-biodiversity conservation.

Addressing the management challenge for Eritrean animal genetic resource requires considerable institutional and technical arrangement. In its present situation, Eritrea might not be in a position to marshal all the resources required to manage its AnGR effectively. However, the important thing is to recognize the urgency of drawing animal genetic resources management plan and start creating capacity in a step-by-step approach. Definitely there are certain doable activities within the means and capacity of the country. For example, it is possible to physically characterize our AnGR through MSc research projects, or general research in enhancement of productivity or production system efficiency using the already deployed resource in large livestock development undertakings already underway. All that is required to implement such activities is a clear operational objective and a coordinating structure. Moreover, there are several international assistance mechanisms including the initiatives described in this paper, where Eritrea can deservedly enlist technical and financial help. But, this can only happen if Eritrea develops its strategy on how to manage its own animal genetic resources. Currently there is no mandated national body responsible for developing such a strategy. The immediate task is, thus, the establishment of a national body providing leadership for the management of AnGR in the country.

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Spate irrigation system: A boon to agricultural production and food security in Eritrea

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Abstract

A case study made in the *Sheeb* area by the author in 2001and other investigators formed the basis of this assessment. Spate irrigation is a system where seasonal rivers are diverted to irrigate adjacent fields prior to planting. This system has been successfully developed and operated in the eastern lowlands of Eritrea for more than 100 years. Spate irrigation in Eritrea has three comparative advantages. First, it is possible to grow crops (using spate irrigation) in arid lowlands of Eritrea that receive annual rainfall as low as 200 mm. Second, spate irrigation adds sediments (rich in nutrients) in the irrigable fields along with the flood water. Third, spate irrigation makes use of the otherwise lost flood-water, soil and nutrients to improve soil conditions and increase agricultural production. For example, the average water content of spate-irrigated soils is about 42% at field capacity, which is high. Moreover, the *Sheeb* spate irrigated area receives about 140 tonnes of fine sediments per ha per year that contain about 200 kg of total N, 100 kg of total P, and 1,400 kg of total K. This has increased sorghum yield (~2.0-2.5 tonnes ha^{-1}) by two to three times greater than the yield obtained under rainfed conditions. In 1997/78, a surplus of about 3,700 tonnes of food grain was produced in *Sheeb* area through spate irrigation, which in turn has increased the availability of crop residues for animal feed. Several studies have revealed that agricultural productivity and food security in Eritrea could be enhanced (i) by making the spate diversion structures more sustainable; (ii) by expanding the area under spate irrigated fields; (iii) by growing high value crops for export; and (iv) by improving rural infrastructures and social services. Such approaches could reduce the dependence on external food aid in the long term. This paper therefore presents the potential of spate irrigation system in Eritrea and its impact on agricultural production and food security.

Key words: Agricultural production, Eritrea, food security, *Sheeb*, spate irrigation system.

Introduction

Spate irrigation is a pre-planting system of irrigation where seasonal rivers (called wadis) are diverted by irrigation structures to irrigate land in the nearby fields (Peter, 1987; Tesfai and Stroosnijder, 2000). The seasonal rivers originate from adjacent highlands and mountainous catchments during the rainy season and flow towards the lowlands in the form of flash floods. Spate irrigation has been practised in arid and semi-arid regions of the world for millennia. It is largely applied in the Middle East, Yemen, Pakistan, North Africa, Somalia and Eritrea.

Table 14 Spate-irrigated areas and potential land in the Northern Red Sea Zone of Eritrea

Sub-zone	Cultivated land† (ha)	Potential land ‡ (ha)
Afabet	9,785	6,000 ‡
Sheeb	6,373	12,000
Foro	5,610	8,000
Karura	2,000	40,000
Massawa	1,200	8,000
Gela'lo	1,650	6,000
Ghindae	764	2,000 ‡
Nakfa	145	200 ‡
Total	**27,527**	**82,200**

Source: † = MoA, (2005), ‡ = IFAD, (1995)

Table 14 shows the current spate irrigated area and the potential land to develop spate irrigation in the Northern Red Sea (NRS) Zone of Eritrea. In total, about 28,000 ha of land are cultivated by spate irrigation in eight sub-zones. In these sub-zones, there are several spate irrigation schemes, which are all located along the Red Sea coastal plains. At least 82,000 ha of potential land are available for spate irrigation development in the NRS Zone. Nearly 50% of the potential land suitable for spate irrigation development is located in Karura sub-zone.

Why spate irrigation in Eritrea?

In large parts of the lowlands of Eritrea, the average annual rainfall is <300 mm. For instance, the mean annual rainfall in the eastern lowlands of Eritrea is <200 mm, out of which only <100 mm is received during the cropping season against an average annual evapo-transpiration (ETo) of <2,000 mm (Figure 7). This amount of rainfall is insufficient to meet the water demand of most crops grown in the area. Under such condition, crop production in the eastern lowlands of Eritrea is possible only by irrigation. But, what kind of irrigation system to adopt?

It is believed that a large part of the rainwater (that falls on the landmass of Eritrea) as well as millions of tonnes of soils and nutrients are lost by surface runoff and erosion annually. The construction of dams or large water reservoirs (in the lowlands of Eritrea) for irrigation purposes is often not feasible, as they would quickly become silted up. One notable example is the Foro dam in the eastern lowlands of Eritrea that was constructed in 1960 but then was completely silted after some years. However, one method that has been successfully developed to harvest some of the lost rainwater, soils, and nutrients for agricultural purposes is through the spate irrigation system.

This paper assesses the potential of Spate Irrigation System (SIS) and its impact on agricultural production and food security in Eritrea. A case study made in *Sheeb* area by Tesfai (2001) and other investigators formed the basis of the assessment for agricultural production and food security in Eritrea.

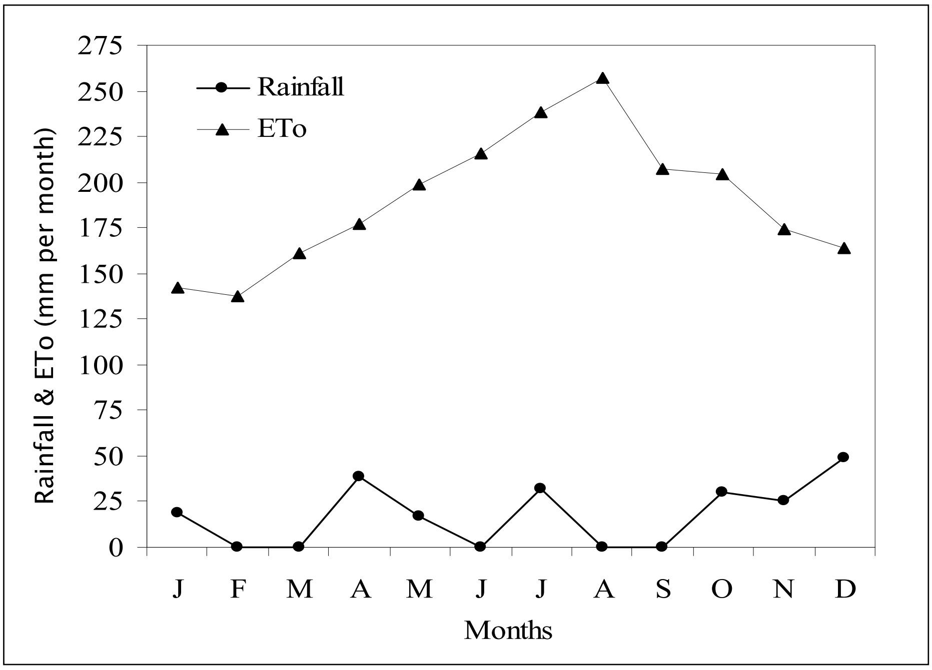

Figure 7 Mean monthly rainfall and ETo (mm) in Sheeb area (Tesfai, 2001)

Advantages of spate irrigation

Spate irrigation has three comparative advantages. These are: water, soil, and nutrient harvesting.

a Water harvesting

Spate irrigation is a floodwater harvesting system that makes use of heavy floods (flowing in short duration) for irrigation purposes. The floods, which emerge from the eastern highlands of Eritrea, are diverted to irrigate adjacent fields in the eastern lowlands, using diversion structures. The diverted floodwater soaks deep into the soil profile and provides residual moisture for crops to grow. However, several floods and soakings are necessary before a cumulative amount of 1,000 mm of water (~ the height of field bunds) has infiltrated into the soil. Under a spate irrigation system, the field bunds are flooded to saturation and all the macro- and micro-pores in the soil become completely filled with water.

Tesfai (2001) has reported that the water content of spate-irrigated soils varies from 40 to 44% at field capacity. With an average field capacity of 42%, the wetting depth of the soil profile could reach to about 2.4 m. Note that most of the roots of spate irrigated crops extend to a depth of 2 m. Hence, if the spate fields are flooded effectively three to four times, the moisture retained in the soil is sufficient to collect two or sometimes even three crop harvests.

b Sediment harvesting

Spate irrigation harvests not only floodwater but also sediments and/or soils that have been eroded from the highlands. The floods from the highlands carry various sizes of sediments that vary from big boulders and coarse sediments to fine soil particles. The coarser sediments and boulders usually deposit in the upper reaches of the wadis at the diversion and canal sites. Whereas, the fine soil particles are carried further down by the floodwater and often settle at the fields.

The soils inside the spate-irrigated fields are very deep which is evident from the depth of soil profiles along the *wadi* banks and from the elevation of the irrigated fields. The average soil depth in the spate-irrigated fields is about 3 meters. This is a result of sedimentation and deposition of soil particles in the spate fields.

Tesfai and Sterk (2002) have measured the sedimentation rate in spate-irrigated fields using sediment pins and found out that on average year, about 143 tonnes of sediment ha^{-1} is deposited on spate-irrigated fields in *Sheeb* area (Table 15). This equates to average annual increase (in depth) of 13 mm of soil layer in the fields. On volume basis, an average of 129 m3 of sediment ha^{-1} is harvested in the fields.

Table 15 Average values of mass, thickness and volume of sediments deposited on spate irrigated fields in Sheeb area (1998 and 1999) (Adapted from Tesfai and Sterk, 2002).

Sedimentation plots (1)	ρ_b^d	$\bar{S}$	SV	SM
	$t\ m^{-3}$ (2)	m (3)	$m^3\ ha^{-1}$ (4) = (3) × ($10^4 m^2$)	$t\ ha^{-1}$ (5) = (2) × (4)
Upstream plot	1.20	0.0199	199.0	238.8
Midstream plot	1.01	0.0120	120.0	121.2
Downstream plot	1.01	0.0069	69.0	69.7
Total mean	**1.13**	**0.0129**	**129.3**	**143.2**

ρ_b^d: soil bulk density, $\bar{S}$: average sediment layer thickness, SV: sediment volume and SM: sediment mass

c Nutrient harvesting

The spate irrigation system also enables farmers to harvest plant nutrients by depositing fertile soils on the irrigated fields. Tesfai (2001) has made soil analysis from inside and outside spate irrigated fields to investigate the effects of spate irrigation on nutrient harvesting.

Table 16 compares some of the soil chemical properties inside and outside spate-irrigated fields. The organic matter (OM), total N, and available P contents of soils inside the fields are almost two times greater than the soils outside fields. The difference is likely to be attributed by nutrient harvesting effects. In fact, the sedimentation in the spate-irrigated fields has enabled the farmers to harvest crops without application of fertilisers on the soils. The farmers in *Sheeb* area do not apply fertilisers to their soils. This is due to the fact that the sediments contain, among others, plant nutrients and OM that enrich the nutrient stocks of spate irrigated soils.

Table 16 Average soil properties in the top 0.25 m inside versus outside spate irrigated fields in Sheeb area (Adapted from Tesfai, 2001)

Property	Inside fields (n = 4)	Outside fields (n = 4)	Inside ÷outside
Sand, %	27.00	70.00	0.4
Silt, %	52.00	27.00	1.9
Clay, %	21.00	3.00	7.0
OM, %	1.55	0.86	1.8
N-total, %	0.14	0.10	1.4
P-Olsen, mg kg^{-1}	19.10	7.90	2.4
K-available, mg kg^{-1}	169.00	285.50	0.6
pH (H_2O)	7.93	7.93	1.0
ECe, d S m^{-1}	1.80	6.60	0.3

ECe: Electrical conductivity of a saturated extract of soil

Spate irrigation: A boon to agricultural production

As a result of harvesting water, sediments, and nutrients by spate irrigation, it is possible to grow crops and produce yield in arid lowlands of Eritrea. Spate irrigation is still seen as one of the main avenues to increasing crop production in Eritrea, and this, given the scale of imported food aid, is particularly important (IFAD, 2004). A wide range of food crops, cash crops and forages could be grown in spate-irrigated fields of Eritrea.

a Crop production

Spate irrigation provides water for one or more crops in arid areas of *Sheeb* where rainfed agriculture is totally unthinkable. The main crops grown in *Sheeb* area are sorghum (*Sorghum bicolor, (L) var.hijeri*) followed by maize, which is sown when there are enough floods. Other minor crops grown include pearl millet, cotton, sesame, groundnuts, and some vegetables, which are all grown using the residual moisture in the soil profiles.

When the spate-irrigated fields are flooded three to four times to the height of the bunds (0.5-1.0 m), sorghum can produce, after the main crop, a first ratoon crop with grain yield and even a second ratoon used for forage only. For instance in 1997/98, the average grain yield of sorghum was in the range of 1.2 to 1.5 tonnes ha^{-1} for the main crop and 0.7 to 1.0 tonnes ha^{-1} for the ratoon crop. The total yield of sorghum is two to three times greater than the yield obtained under rainfed conditions. According to farmers' opinion, shortage of water and pest infestations are the main constraints to crop production in the *Sheeb* area. The average yield of crop residues of sorghum (mainly straw) was 1.5 tonnes ha^{-1} in 1997/98. The straw of sorghum, maize and millet is mostly used for feeding livestock (Tesfai, 2001).

b Livestock production

Livestock is one of the integral components of the farm household in spate irrigation production system in the *Sheeb* area. The dominant types of livestock are oxen, cows, camels, goats, sheep, donkeys and chickens. The oxen are used for construction of the irrigation structures and for tilling the fields. The cows, goats, sheep and chickens are sources of food and income for the household. A household survey made by Tesfai (2001) has revealed that most farmers possess a small number of animals while a few of them own more than ten animals. The major constraint to increase livestock production in the *Sheeb* area is lack of feed followed by animal diseases. Livestock is tethered and fed by a cut-and-carry feeding system on green matter (from thinned sorghum plants and grasses) during the cropping season and on dry straw during the dry season.

In *Sheeb* area, the livestock products are mainly milk, butter, meat and eggs that often serve as a buffer against low crop yields. Some farmers sell their animals and others rent draught animals to buy food items when they encounter food shortages. Thus, the role of livestock in assuring food security at household level is significant.

Food security issues

a Food security: definition and concepts

Food security could be generally defined as access of all people to adequate nutritious food to lead a healthy and productive life at all times and at all places (FAO and WHO, 1992; GoE, 2004a). This means that food security, not only means adequate food supply but it also includes access by the population to a given food supply.

Conceptually, food security has two dimensions, i.e. national food security and household food security. National food security endeavours to make available food in market throughout out the country from domestic production, commercial imports, or food aid. Whereas, household food security makes sure that all household members have affordable access at all times and place to the food they need for a healthy life (GoE, 2004a).

b Spate irrigation for food security

One of the challenges for the people and the Government of Eritrea is to attain food security at household as well as at national levels. Since independence, the GoE is relentlessly working to assure food security and improve the living condition of its people by developing strategies and approaches that promote the development and growth of agriculture. Food security could not be achieved over night: it is a lengthy process. However, the opportunities to achieve food security (in the long term) via developing the agricultural sector are so great. "Spate irrigation is sometimes said to be a boon to food security" for those communities whose livelihood depends on this type of agriculture. At present, about 550,000 people (~15% of the population of Eritrea) make a livelihood on spate-irrigated agriculture. The spate irrigation system could play a greater role in enhancing food security by boosting up food production.

Table 17 Estimates of cereal food production and requirements in Sheeb area vs. national level (Adapted from Tesfai, 2001)

Food production/requirement (Tonnes)	*Sheeb* area		National level
	1996/97‡	*1997/98§*	1997/98¶
Food Production (FP)	2,246	6,700	472,193
Food Requirements (FR)	2,740	2,934	560,000
Deficit (–) or surplus (+)	–494	+3,766	–87,807
FP as % of FR	82	228	84

‡ bad year with estimated population ~ 17,564 and irrigated area ~ 2,246 ha (Daniel, 1997)
§ good year with estimated population ~ 18,810 and irrigated area ~ 2,680 ha (Daniel, 1997)
¶ good year, Ministry of Agriculture annual report (2000)

Table 17 shows the estimated food production and food requirements in *Sheeb* area vis-à-vis the national level. In 1996/97 in *Sheeb* area, the food production was lower than the basic food requirements of the population. As a result, there was food insecurity in *Sheeb* area, which was mainly caused by insufficient floods that were diverted to the fields. However, during this year of food deficit, the *Sheeb* area still produced 82% of its food requirements. The food requirement of *Sheeb* population is derived from the household survey made by Tesfai (2001). In this survey, on average, each person in *Sheeb* area consumes about 156 kg of cereal grains per year or 13 kg of grains per month, which is close to the World Bank (1994) estimate of 160 kg per year.

On the other hand, the food production in 1997/98 was better than in 1996/97 because of the high number of floods that were diverted to the fields. The production was then enough to feed the inhabitants of *Sheeb* area and to provide a surplus of about 3,766 tonnes of food grains to other parts of Eritrea where there was a food deficit. Hence, spate irrigation could enhance household food security during good years. Indeed, most farmers mentioned that during good harvest the crop production is enough for the whole year. However, during bad years the crop production could only satisfy food consumption for not more than 3 months (Tesfai, 2001). In such cases, the people will depend on food aid and/or use other coping mechanisms to combat food shortages.

At national level, even in a good harvest year (1997/98), food deficit of about 87,807 tonnes of cereals was shown in the country (Table 17). The food deficit was filled in largely by receiving food assistance and also by purchasing some food items from abroad. This implies that food insecurity remains a major threat to the economic development of Eritrea.

Strategies/approaches towards food security

a Local strategies

Table 18 presents some of the coping strategies developed by *Sheeb* spate irrigation farmers to combat food shortages during years of drought. Some farmers attempt to solve food shortage by taking food grains or cash (on a credit basis) from friends, relatives or local money lenders. Others tackle the food shortages by selling their animals; paticipating in food or cash for work; renting draught animals; remittance; wage labour; and a few farmers (4%) by involving in petty trade.

Table 18 Coping strategies to adjust to food shortage in Sheeb area (n =53)

Strategies	Contribution (%)
Food/cash on credit	23
Selling animals	21
Food /cash for work	18
Renting draught animals	15
Remittance	11
Wage labour	8
Petty trading	4
Total	100

Adapted from Tesfai, 2001

Apart from this, during the dry season (May to September) most of the Sheeb farmers (~80%) have developed a livelihood strategy of seasonal migration (transhumance system) to the highlands of Eritrea (where it rains) in search for food, water and grass. The transhumance system exploits the resources such as food, water, and grass that are available in the highlands, while these resources are scarce in the lowlands of Sheeb area during the dry season. In the highlands, some farmers also cultivate small farmlands inherited from their forefathers; others eat cactus fruits (Optunia ficus indica L.) as food supplements.

b Approaches towards food security

The critical elements in the agricultural policy of Eritrea towards food security entail, among others, increasing water availability for agriculture; increasing farm productivity; promoting production of high value crops; and expanding land under cultivation (GoE, 2004b).

To solve meaningfully problems related to food insecurity, the supply side (i.e. the provision of food or food supply) and the demand side plus the access side (i.e. the food requirements and making food available at reasonable and affordable price to consumers) must be well balanced. If food supply is smaller than the food demand, then food deficit will occur and food becomes insufficient and scarce in the country. Food shortages are common phenomena in large parts of Sub-Saharan African countries including Eritrea where the rate of population growth is about 3% (FAOSTAT, 1998), the highest in the world. In Eritrea, food security through spate irrigation could be prompted using the following approaches:

i) Making the spate irrigation system more sustainable

The potential of the SIS for agricultural production and its contribution to food security in Sheeb area is enormous and to the nation at large is not small. However, the spate irrigation system appears to be functioning below its potential due to several constraints. One of the major production constraints in SIS is water shortage, which is mainly caused by irregularity of the rainfall in the highlands and the breaching of traditional spate diversion structures (locally called Agim) by destructive big floods. The traditional diversion structures are made from dry acacia trees, stones and soils. These structures are not strong enough to divert big floods and thus often are breached and require repetitive maintenance.

To make the spate irrigation system more sustainable, the traditional diversion structures should be strong, i.e. reinforce the traditional structures with gabions or use other low-cost technologies. Such structures would have four advantages: they could withstand the force of heavy floods and divert part of the flood water effectively and thus make more water available in the fields; they would decrease the amount of trees to cut; they would reduce the cost of human and animal labour; and finally they would increase farmers' productivity.

ii) Increasing agricultural productivity

To meet the food demand of the Eritrean population, agricultural production should be increased either by expanding the area of cultivated land (i.e. extensifcation); increasing the yield per unit of individual crops (i.e. intensification) or increasing the number of crops grown in a particular area of land.

Extensifcation: According to IFAD (1995) and NRCE (1996) surveys, an estimated area of 60,000 to 90,000 ha of suitable land for spate irrigation is available in eastern lowlands of Eritrea. However, currently about 28,000 ha of land (25%) are developed by spate irrigation. This indicates that more than (75%) of potential land available for spate irrigation remains idle. Apart from this, there are also about 50,000 ha of potential land suitable for spate irrigation development in the western lowlands of Eritrea for example in Zoba Gash Barka (Abraham and Tesfai, 2005). Hence, by bringing more land under spate irrigation, there is a greater possibility of increasing agricultural production and assure national food security in the long term.

Intensification: increasing the yield of spate-irrigated crops per unit area (i.e. intensification) is also an alternative that enhances agricultural production. This will be achieved through application of agricultural inputs such as improved varieties, application of pesticides, fertilization and adoption of improved on-farm water management practises. Although, the main yield-limiting factor in spate irrigation is water shortage, other factors (such as inefficient soil moisture conservation, low OM and N) might also contribute to low crop yield. For example, chemical analysis of spate-irrigated soils by Tesfai (2001) has shown that most of the soils contain relatively low OM and total N (Table 16). Field experiments in spate irrigated soils in Yemen have shown that crop yields of sorghum were increased by 30-50% with the application of nitrogen fertilisers and other improved farming practises (UNDP/FAO, 1987).

iii) Growing high value crops

In spate-irrigated fields, a wide range of cash crops could be grown. However, the spate irrigation farmers use to grow staple crops like sorghum, maize or millet from year to year in the same field (i.e. monocropping). Diversification of crops i.e. growing high value crops (such as cotton, sesame, groundnuts and vegetables) in spate irrigated fields and exporting these crops will benefit not only the farmers but also the nation as a whole. The farmers' income will increase and concurrently national foreign exchange earnings will be raised. This will enhance the national capacity to import adequate quantity of food and make available food in the market at times of food shortages. Moreover, industrial crops like cotton could supply raw materials needed for local textile factories, which in turn save foreign currency used to import the raw materials.

iv) Improving rural infrastructures and social services

By and large, the GoE has made significant improvements in the rural areas by constructing roads, schools, and health centres since independence. One notable achievement is the construction of road from Gahtelai-Men-Sheeb-Wadi-Labka by the Eastern Lowlands Wadi Development Project (ELWDP). The construction of the road has facilitated transportation of agricultural products to distant markets and to bring external inputs.

Nonetheless, there is a need to improve social services such as establishment of safe and clean drinking water in the villages of Sheeb area, which was one of the components of ELWDP. Marketing facilities like creating market outlets and dissemination of market information to farmers are necessary to improve product sales so that household income increases. Moreover, there is a need to create an opportunity for the spate irrigation farmers to get access to credits, farm inputs and extension services.

Summary and recommendations

Food security in Eritrea remains a challenge. But, there are several opportunities to achieve food security in Eritrea in the long term. One of these opportunities is through developing spate irrigation systems in the eastern and western lowlands, where there is a significant potential of spate irrigation to increase agricultural production and enhance food security. To achieve this goal, however, planners and other development agencies working for spate irrigation development are advised to take into consideration the following points:

- The traditional spate diversion structures (Agim) should be strengthened by reinforcing the structures with gabions and other low-cost technologies in consultation with farmers in order to improve the productivity of SIS;
- Although, water shortage is the main yield-limiting factor in SIS, other factors might also contribute to low productivity of the system. In SIS, it is not the number of floods diverted to the fields that actually matter but how much water has been retained in the soil profile in each field is very crucial for crop growth and increasing productivity;
- Integration of cropping and livestock products is essential to increase the productivity of spate-irrigated soils. For example, use of manure and incorporation of crop residues into the soils will enhance fertility of spate-irrigated soils. However, alternative source of feeding for livestock should be sought. These may include activites like growing forage plants along the water courses; planting leguminous trees along the field bunds; or planting fast growing forage legumes between rows of cropped fields;
- There are many questions remaining unanswered and much more remains undiscovered in the field of spate irrigation. Demand-driven research for development of spate irrigation that will increase agricultural production and enhance food security must be contemplated in the spate irrigation schemes of Eritrea.

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Effect of growth regulators and waxing on the shelf life and quality attributes of Banana

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Abstract

Banana is one of the most common tropical climacteric fruits, which undergoes rapid deterioration after harvest. This limits extensive production and sales of this commodity in many countries. The effect of gibberellic acid (GA_3), indole butyric acid (IBA), and carnauba wax on the shelf life and selected quality attributes of banana (Musa AAA) cv. Williams were evaluated. Fruits were stored at three different temperatures (12, 15, and 22°C) for a maximum of 56 days. Percentage weight loss, firmness change, visual colour change, and respiration rate were measured weekly during the storage period. Total soluble solids and organic acid concentrations of the pulp were also determined at the beginning and at the end when fruits were fully ripe. Percentage weight loss, softening, colour change and respiration rate increased irrespective of treatments as the storage temperature and storage period increased. However, under all storage temperatures waxing, GA_3 and IBA applications significantly reduced ($\rho<0.001$) the parameters recorded as compared to control fruits resulting in an extended shelf life. Waxing was the most effective followed by GA_3. There was, however, no significant difference ($\rho<0.05$) among treatments for all the quality attributes after storage, which implies that these treatments not only extend shelf life but also preserve quality of the fruit. It is therefore concluded that waxing, GA_3, and IBA can be used as alternative methods to extend shelf life and maintain fruit quality, hence secure availability of the fruits for an extended period.

Keywords: GA_3, IBA, percentage weight loss, respiration rate, waxing.

Introduction

Banana is an important staple crop supplying up to 25% of carbohydrate for approximately 70 million people in the humid zone of Sub-Saharan Africa and Asia (Ferris, 1997; Gauhl, *et al.*, 1998). It is both food and cash crop for most producers and, as such, is key component of food security. Unfortunately, poor post harvest handling practices and lack of storage facilities resulted in substantial part of the harvested crop to become over-ripe by the time it reached its ultimate destination (Olorunda, 2000). In Eritrea, the crop is grown mainly in Zoba Gash Barka, which covers about 1000 ha of land. A survey conducted by the Ministry of Agriculture indicated that, poor post-harvest handling practice is a major banana production constraint (MoA, 2005). The study discovered that around 35% of the total production of banana in the country is spoiled or damaged mainly during harvesting and transportation. Hence, the fruit becomes available in quantity only for parts of the year. This indicates an urgent need to optimize storage conditions to secure and extend its availability. Although the situation is worsened in tropical environment under which the crop is grown, storage is not practiced due to lack of infrastructure facilities. A promising alternative is, therefore, to standardize optimum post harvest treatments, which are economically viable. Workers like George and Marriott (1985); Lebibet *et al.* (1995); Proft *et al.* (1998) and Olorunda, (2000) have tried to work on these aspects with little success. Fruit surface coating with Tal-prolong reduced ripening and extended shelf life up to eight (Olorunda and Aworh, 1984) or six days (Krishnamurthy and Kushalappa, 1985). Moreover, vapour guard and wax fruit coating retarded softening, water loss and colour development (Thompson, 2003). Ferris (1997) reported delayed ripening of banana by dipping the commodity in GA_3 under high atmospheric humidity conditions. Similarly, positive effects of plant growth regulators (PGRs) on shelf life extension of fruits have been reported by Babbitt *et al.* (1973); Khader (1992) and Purgatto *et al.* (2001). However, there is little information about the quality of the fruits after extended storage, although Krishnamurthy and Kushalappa (1985) reported that the quality of such fruits was inferior.

This study was undertaken to ascertain the possible role of some plant growth regulators and waxing on post harvest shelf life and quality attributes of banana fruits stored under different storage temperatures to secure their availability for an extended period.

Materials and methods

Plant material: Freshly harvested banana fruits from a uniform population at their green stage (physiologically mature) were used. On arrival, fruits were washed with tap water and dipped in a fungicide solution before they were randomized to the treatments which were: control (untreated), GA_3, waxing (carnauba 30%), or IBA. Six replications were used for each treatment. Fruits for GA_3 and IBA were dipped into aqueous solutions of 100 ppm GA_3 or IBA for 30 min. Waxing treatment was applied by lightly waxing fruits with a cloth dipped in the carnauba wax, and allowed to dry for 30 min. Fruits were then stored either at 12, 15 or 22°C in clean dark rooms.

Protocol

Percentage weight loss (PWL) was calculated using the formula PWL = $\{(I-A)/I\}*100$; where I= initial weight and A= actual weight. Firmness change was measured using the Densimeter, external colour change was scored numerically using a standard banana-ripening chart with colour plates ranging from 1-7 as described by von Loesecke (1949), and respiration rate was measured in terms of CO_2 release using an Infra Red Gas Analyzer (IRGA). Fruits were allowed to ripen naturally until the table ripe-stage von Loesecke (1949) and time taken to ripening was monitored in terms of days.

Total soluble solids (TSS): After fruits were fully ripe, a portion of fruit pulp was taken for further analysis of TSS and organic acids. Five-gram of finely ground fresh tissue was homogenized with 5 ml distilled water for 2 min. The pooled fraction was centrifuged for 10 min. The supernatant was decanted and TSS was measured using a calibrated hand held digital refractometer (ATAGO CO, Ltd, Japan).

Organic acids: Five-gram of fresh fruit weight was taken from a frozen sample and blended with 95% ethanol for 4 min at a maximum speed. The homogenate was centrifuged for 10 min and the residue was washed twice with 80% ethanol. The supernatants were combined and adjusted to 5 ml g^{-1} of fresh weight (FW) with 80% ethanol. For organic acid separation, 10 ml of sample was taken and evaporated in the dark for four to five hrs. The dry residue was redissolved in 1 ml of 0.2 NH_2SO_4 and 0.05% disodium ethylene diamine tetra acetate (EDTA). The sample was loaded onto a C_{18} Sep-Pak cartridge and eluted with up to 4 ml of the above solution. Finally it was filtered through a 0.45 μm nylon filter and injected into the high performance liquid chromatography (HPLC) for analysis. Concentrations were expressed as percentages of fresh weight.

All the data were subjected to analysis of variance (ANOVA) using GenStat 6th edition (2001). Treatments were compared for significance at $\rho < 0.05$ according to Fisher's protected LSD test.

Results and discussions

Percentage weight loss (PWL)

All fruits, irrespective of treatments, exhibited considerable PWL during the storage period, especially at high storage temperature. This was more pronounced as storage temperature and period increased. This is in agreement with results of Lebibet *et al.* (1995) who also found that higher storage temperature increased weight loss in banana. Despite this, waxing significantly ($\rho<0.001$) reduced PWL at all storage temperatures as compared to the other treatments, especially to control fruits (Figure 8).

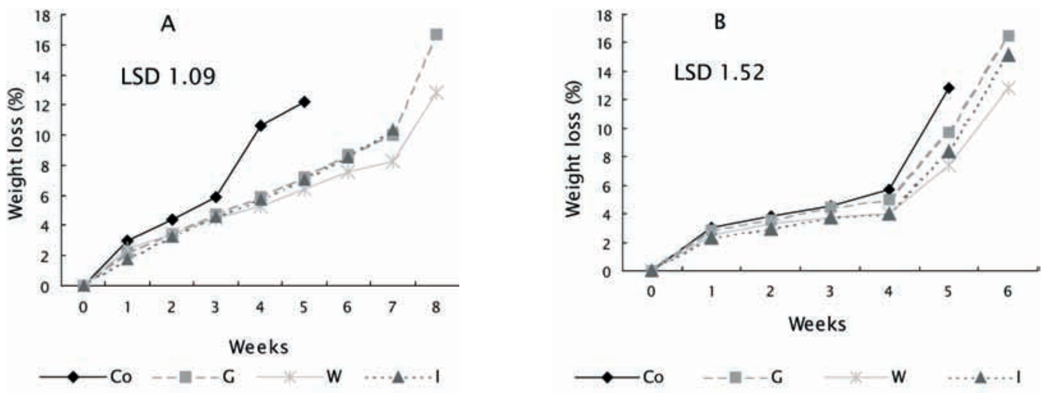

Figure 8 Percentage weight loss of banana fruits during storage as affected by storage conditions at 12°C (A) and at 15°C (B). Data points are means of six replicates. Co=control, G= GA3, W=waxing, I= IBA

As a result waxing extended the fruit shelf life up to maximum of 56 days at 12°C as compared to control, which was only 35 days (Table 19). This reduced weight loss by wax can be ascribed to the effect of wax covering gas exchange sites of the fruit, and modification of the atmosphere around the fruit. It has also been reported by Amarante and Banks (2001) and Banks *et al.* (1997) that edible surface coatings improved cosmetic features of fruits and reduced deterioration by suppressing water loss. Burdon *et al.* (1993) and Thompson (2003) also reported that the removal of epicuticular wax from the fruit surface increased the amount of water loss from the fruit. Waxing could, therefore, be an alternative means of preserving fruits for an extended time by reducing water loss.

Similarly, GA_3 and IBA resulted in reduced PWL. GA_3 at 12°C and IBA at 12 and 15°C exhibited significantly lower PWL ($\rho<0.001$) than control fruits and showed a trend of decreased rate at the other storage temperatures. Post harvest treatment of banana with GA_3 (Stover and Simmonds, 1987) and with auxin (Purgatto *et al.*, 2001) extended shelf life by decreasing senescence rate counteracting the effect of ethylene within the fruit tissue. Vendrell and Palomer (1997) similarly reported that both, GA_3 and IAA inhibited ripening in most climacteric fruits with similar effects. Modifying fruit atmosphere by waxing and post harvest application of GA_3 and IBA to retard ripening, therefore, became possible alternative methods of shelf life enhancement, especially in tropical environments to secure fruit availability for an extended period.

Table 19 *Average physio-chemical change of Banana fruit after storage and as affected by different treatments*

At 12°C

Treatments	Days to ripen	PWL (%)	Firmness (Scale)	Colour (Scale)	Respiration ($mLCO_2kg^{-1}hr^{-1}$)	TSS (°Brix)	Malic (%)	Citric (%)
Initial		0		1		1.53^{a}	0.021^{a}	0.016^{a}
Control	35	8.97^{c}	66.12^{a}	5.23^{c}	30.68^{c}	10.23^{b}	0.036^{b}	0.056^{b}
GA_3	50	7.29^{b}	72.06^{b}	3.62^{a}	2342^{ab}	10.60^{b}	0.04^{b}	0.053^{b}
Waxing	56	6.38^{a}	74.81^{c}	3.83^{a}	22.08^{a}	10.30^{b}	0.033^{ab}	0.057^{b}
IBA	48	7.25^{b}	70.23^{b}	4.27^{b}	26.87^{b}	10.80^{b}	0.037^{b}	0.052^{b}
LSD		0.38	2.03	0.27	3.48	0.81	0.013	0.01
ρ value		0.001	0.001	0.001	0.001	NS	0.007	0.008

At 15°C

Treatments	Days to ripen	PWL (%)	Firmness (Scale)	Colour (Scale)	Respiration ($mLCO_2kg^{-1}hr^{-1}$)	TSS (°Brix)	Malic (%)	Citric (%)
Initial		0		1		1.53^{a}	0.021^{a}	0.016^{a}
Control	35	7.42^{b}	72.41^{a}	4.41^{c}	36.67^{c}	10.97^{c}	0.053^{b}	0.054^{b}
GA_3	41	7.01^{b}	74.68^{b}	3.50^{a}	28.49^{b}	10.53^{bc}	0.048^{b}	0.052^{b}
Waxing	42	5.64^{a}	76.06^{c}	3.39^{a}	23.36^{a}	10.27^{bc}	0.041^{b}	0.055^{b}
IBA	38	6.08^{b}	71.94^{a}	3.80^{b}	29.29^{b}	10.03^{b}	0.040^{b}	0.046^{b}
LSD		0.62	1.02	0.24	1.78	0.81	0.013	0.01
ρ value		0.001	0.001	0.001	0.001	NS	0.007	0.008

At 22°C

Treatments	Days to ripen	PWL (%)	Firmness (Scale)	Colour (Scale)	Respiration ($mLCO_2kg^{-1}hr^{-1}$)	TSS (°Brix)	Malic (%)	Citric (%)
Initial		0		1		1.53^{a}	0.021^{a}	0.016^{a}
Control	14	10.95^{b}	59.5^{a}	5.61^{c}	39.42^{c}	9.90^{b}	0.038^{b}	0.032^{bc}
GA_3	22	10.79^{b}	70.2^{b}	3.65^{a}	22.72^{ab}	10.33^{bc}	0.029^{ab}	0.031^{b}
Waxing	24	7.57^{a}	75.4^{b}	3.65^{a}	19.47^{a}	10.33^{bc}	0.035^{b}	0.042^{cd}
IBA	21	10.86^{b}	72.1^{b}	4.29^{b}	28.72^{b}	10.97^{c}	0.057^{c}	0.048^{b}
LSD		0.84	7.57	0.46	7.11	0.81	0.013	0.010
ρ value		0.001	0.001	0.001	0.001	NS	0.007	0.008

Means in each column of all tables followed by the same letter are not significantly different at 5% level.
NS= Not Significant.

Firmness change

As fruits ripen they decrease in firmness, largely because the pectins (comprising of the middle lamella of cell walls) are solubilised (Wills *et al*., 1998). In this study, fruit firmness decreased during ripening regardless of the treatments. Fruits at higher storage temperature maintained acceptable condition only for a maximum period of three weeks (Figure 9-A). Despite the general decrease of firmness, waxing, GA_3 and IBA significantly ($\rho<0.001$) retarded fruit softening as compared to control fruits. Waxing yielded better results than the other treatments. This is in agreement with the previous report by Durand *et al.* (1984) and Drake (1997).

This phenomenon might be related to the effect of an increased endogenous CO_2 level, as the respired CO_2 couldn't escape easily through the openings when the fruits were waxed. According to Zagory (1998) the elevated CO_2 level suppressed plant tissue sensitivity to the effect of the ripening hormones. Similarly, GA_3 and IBA application exhibited promising results especially as compared to control fruits. This might be related to the effects of these growth regulators in retarding the ripening process. Delayed starch hydrolysis by IAA treatment in banana slices was also reported by Purgatto *et al.* (2001). Waxing and application of GA_3 and IBA might, therefore, be viable treatments in retarding fruit softening in particular and increasing fruit shelf life in general and hence their availability.

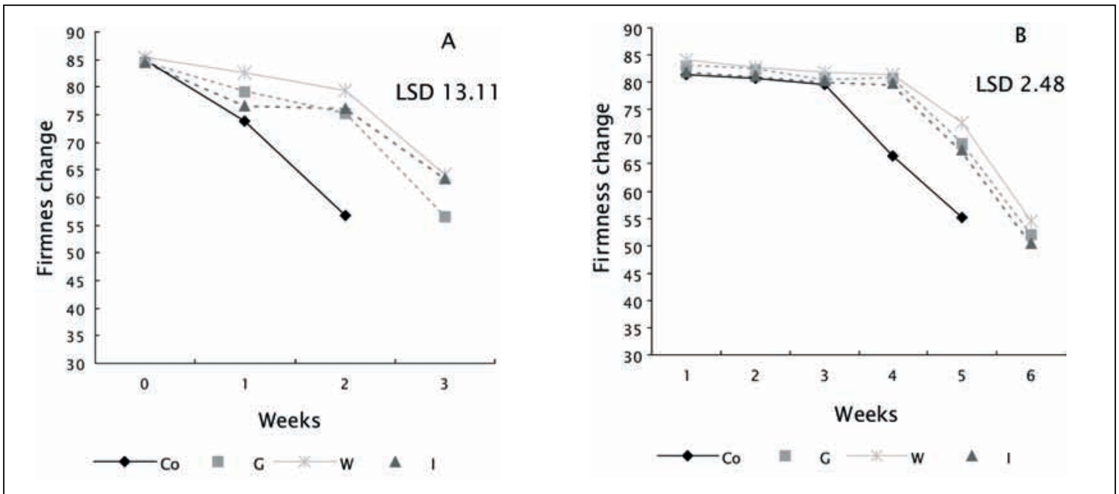

Figure 9 Firmness changes of banana fruits during storage as affected by storage conditions at 22 °C (A) and at 15°C (B). Data points are means of six replicates. Co=control, G= GA3, W=waxing, I= IBA

Skin colour change

Banana undergoes significant textural and colour transformation as the fruit ripens (Chen and Ramaswamy, 2002). In this experiment, increased fruit colour from the initial stage was evident in all fruits. Intense colour development was exhibited after 50 days at 12°C as compared to 40 and 20 days at 15 and 22°C, respectively. Report by Lebibet *et al.* (1995); Proft *et al.* (1998) and Chen and Ramaswamy (2002) suggested that rapid colour change in banana fruit was evident at higher temperature. Waxing, GA_3 and IBA application retarded colour development significantly ($\rho<0.001$) and the shelf life was extended considerably as compared to the control fruits at all storage temperatures (Figure 10). Similar results were reported by Banks (1984) and Vendrell and Palomer (1997). Colour scale 6 was reached after 35, 48, 50 and 56 days storage at 12°C for control, IBA, GA_3 and waxing respectively (Table 19). The effect of waxing may be related to the high build up of CO_2 within the fruit, which retarded fruit ripening and, hence, colour development. Retarded colour change was attributed to decreased chlorophylase activity after the application of GA_3 in mango by Khader (1992) and in tomato by Vendrell and Palomer (1997). Moreover, Vendrell and Palomer (1997) suggested that auxin suppressed the expression of genes responsible for colour development. Waxing, GA_3 and/or IBA proved to be promising techniques for retarding colour development during fruit ripening even at higher storage temperatures.

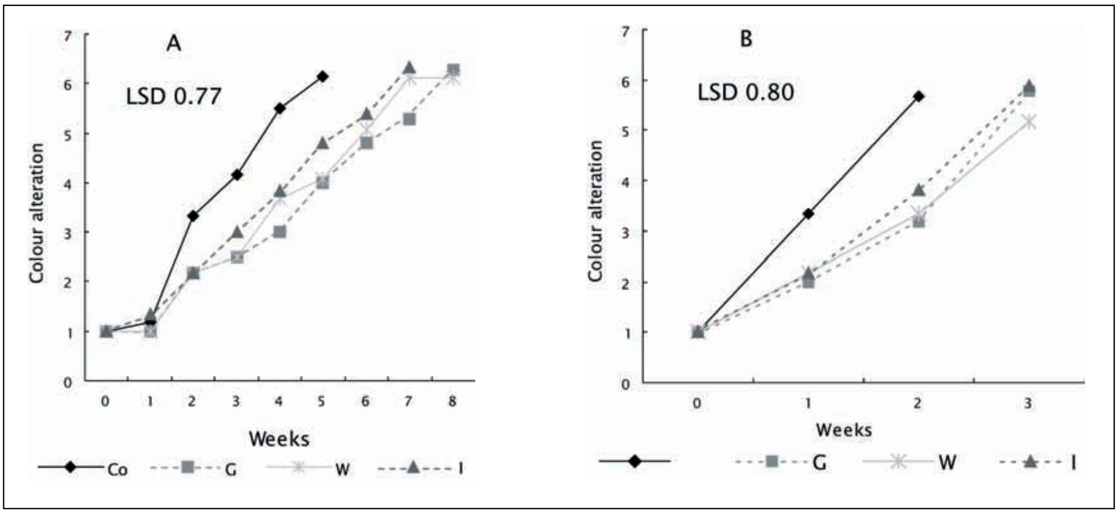

Figure 10 Colour changes of banana during storage as affected by storage conditions at 12°C (A) and at 22 °C (B). Co=control, G= GA3, W=waxing, I= IBA

Respiration rate

The storage temperatures significantly affected respiration rate and shelf life of the fruits. On average, fruits at 12°C exhibited a lower respiration rate during storage period as compared to the fruits stored at 15°C and 22°C. This may be ascribed to the effect of storage temperatures on the metabolic activity of the fruits. Similar results were reported by Proft *et al.* (1998) where storage temperature strongly stimulated high release of CO_2 from banana fruits. Irrespective of the effect of temperature, waxing, GA_3 and IBA significantly reduced ($\rho<0.001$) respiration rate, with waxing being the most effective. This was evident at all storage temperatures, especially at 15□C (Figure 11-A).

On the other hand, control fruits had significantly higher respiration rates at all the storage temperatures. This increased respiration rate of control fruits indicates the effect of temperature on fruits shelf life in the higher tropical environment. Decreased respiration rate due to waxing was previously reported in banana by John and Marchal (1995) and in avocado by Bender et al. (1993). This may be related principally to alterations in the permeability characteristics of the fruit skin. Wax coating formed an additional barrier through which the gas must permeate. According to John and Marchal (1995) coating extended the storage life of banana and plantain by slowing down gaseous exchange between fruits and the atmosphere thus delaying the onset of the climacteric phase. Previously, it was, reported by Babbitt et al. (1973) in tomato and Vendrell and Palomer (1997) in other climacteric fruits that GA3 and auxin retarded ripening mainly by acting antagonistically to the effect of ethylene. Recently Purgatto et al. (2001) reported that auxin overcame the effects of ethylene and as such IAA markedly retarded fruit respiration rate as compared to control. This implies that these treatments can be possible alternative treatments to extend shelf life of banana.

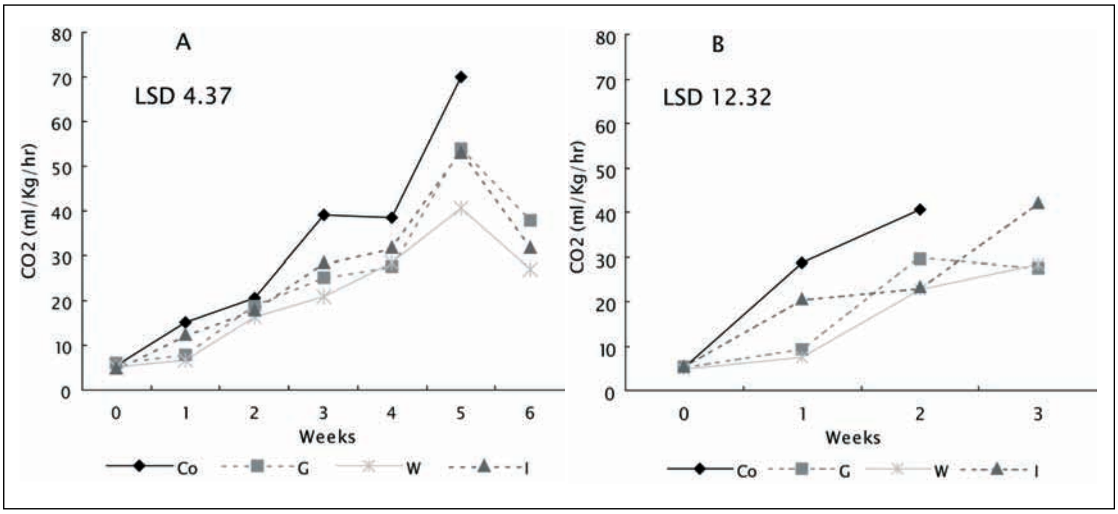

Figure 11 Respiration rate of banana fruits during storage as affected by storage conditions at 15°C (A) and at 22°C (B). Data points are means of six replicates. Co=control, G= GA3, W=waxing, I= IBA

Total soluble solid (TSS)

Fruit TSS has been routinely used to assess fruit quality. Starch-sugar conversion during ripening is one of the most striking changes in climacteric fruits such as banana (Chang and Hwang, 1990). In this experiment all the treatments applied were found to result in significantly ($\rho<0.05$) increased TSS as the fruit ripened (Table 19). This is in agreement with previous reports by Mustaffa *et al.* (1998) in banana. This increase in TSS level of fruits was related to the general physiochemical change of fruit concomitant to ripening. Control fruits at 15°C and IBA at 22°C exhibited significantly increased TSS. However, there were no significant differences between the rest of the treatments at all the storage temperatures. This clearly indicates that these treatments significantly extended the shelf life and preserved the quality attributes of banana.

Organic acids

Fruit sugar and acid concentration ratio has a marked influence on the sensory quality of fruits. Results from this experiment revealed that organic acids increased significantly ($\rho<0.001$) during fruit ripening irrespective of the treatments applied at all the storage temperatures (Table 19). Some workers reported similar increases in the organic acid contents during ripening of bananas (Inaba and Nakamura, 1988; John and Marchal, 1995). However, there was no appreciable difference among treatments and storage temperatures. These results confirmed that fruit quality is not affected by an extended storage period. Waxing, GA_3 and IBA appear to extend shelf life with no detrimental effect to the acid quality, even at higher storage temperatures.

Conclusion

Climacteric fruits like banana exhibit rapid respiration rate concomitant to ripening, which resulted in high fruit deterioration and perishability. Respiration rate, PWL, softening and colour change are some of the attributes routinely used to evaluate fruit quality and hence shelf life. This study showed an increased level of fruit PWL, colour development, respiration rate, TSS, and organic acids in all the fruits irrespective of treatments and/or storage temperatures. However, fruits treated with waxing and GA_3 exhibited relatively low rates of PWL, softening, colour change and respiration. This result reveals that these treatments can be alternative approaches to solve and/or minimize the excessive post-harvest loss of banana with low or no effect to the quality of the fruit. This further ensures availability of the fruit for an extended period to ensure food security, as the banana fruit is a common component of many household dishes. For this reason it is recommended that responsible government bodies should take an appropriate action to promote the adoption of the post-harvest treatments to reduce post-harvest losses. Training of farmers on improved handling and application of necessary treatment schemes to enable farmers to take better advantage of particular technologies to reduce losses is equally essential.

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Women, agriculture and food security: The Eritrean perspective

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Abstract

Food production in Eritrea, among others, suffers from frequent droughts, low technological inputs, land degradation, and improper cultural practices. The solution to these problems is not only technological intervention in food production alone but demands the full participation of the entire society, especially that of women in the areas of production, distribution and utilization of food. This being the case however, there is inadequate data that covers the role of women and their indigenous knowledge and innovations contributing to food production. This paper addresses some aspects of the role of women in food security: production, distribution, utilisation, access, domestication, and coping mechanisms. It synthesises and analyses relevant information in consultation with stakeholders. The findings indicate that women in Eritrea, irrespective of ethnic and religious dichotomy, play crucial role in the production, distribution and access of food at household, community and national levels. In order to enhance the participation of women and their contribution to household food security: favourable policies, appropriate technology, capacity building in food production and marketing should be in place and improved. This should be supported with a baseline study that will enable the prioritisation of actions and increase the effectiveness of the intervention.

Key words: Agriculture, food production, household food security, women

Introduction

Food security has been high on the agenda of the Government of Eritrea. In the Eritrean context, food security is defined as "the existence of a capacity and ability to make readily accessible food for all Eritreans which is of sufficient quantity and acceptable quality at an affordable price at any time and place within the country" (GoE, 1994). Eritrea's strategy for food security has the following salient features:

- i Enhancing and expanding agricultural production through various means including: improved soil and water management, use of improved crop varieties, diversification of cash crops and the shift towards irrigated agriculture. Moreover, encouraging income-generating activities such as handicrafts, poultry and small-scale horticultural production with emphasis on sustainable use and management of natural resources is also one of the strategies.
- ii Self-reliance and avoidance of the dependency on food-aid and the consequent monetization of food through the food-for-work (FFW) and cash-for-work (CFW) programmes;
- iii Increasing national foreign exchange earnings capacity to import food to fill the supply gap and to maintain strategic reserves by increasing the agricultural commodities and fisheries and the revitalization of sectors such as industry, mining, tourism and services to earn foreign exchange.

iv Promotion of training with emphasis on food and nutrition, child care, sanitation, domestic care, etc.

Food production in Eritrea

About 70-80% of the Eritrean population lives on subsistence agriculture, mainly on crop and livestock production, the majority of which are in low socio-economic status and are vulnerable to food insecurity. Agricultural production system in the country is composed of predominantly agro-pastoral (in which crop cultivation is mixed with livestock raising), agricultural (crop cultivators without livestock) and pastoral (livestock only) communities. A small proportion of the population depends on fisheries and the rest is composed of urban dwellers involved in daily labour, trade and employment in government or other institutions.

Food sources in Eritrea come from various activities that include: crop and livestock production, fisheries and collection of wild fruits and vegetables. The livestock sector of the country includes cattle, goats, sheep, poultry, camel and pack animals. These animals contribute significantly to the household income and nutrition thereby enhancing food security. Livestock are sources of draft power, milk, meat and generate income through sale of live animals or their products especially during adverse environmental conditions especially drought.

Crop production is essentially traditional, usually rainfed with no or little agricultural input to boost productivity. It includes rainfed cereal production, small-scale horticultural production and limited cash generating crops. Agricultural productivity is constrained by recurrent droughts and widely spread land degradation. Historical records show that cereal production has never satisfied the annual food requirement of the country. Moreover, a closer look at the population size versus annual cereal requirement, taking population estimates of 1943, 1952, 1964 and 1991 by various authors respectively (Longridge, 1974; Trevaskis, 1975; Tedla, 1964; World Bank, 1994) and calculating the deficit, shows that there is chronic food deficit in the country (Figure 12).

Despite the importance of collected fruits, vegetables and marine products in food security, there are no empirical data showing the extent of the contribution of these resources to the national food security. However, limited case studies show that they contribute substantially to the household economy and nutrition.

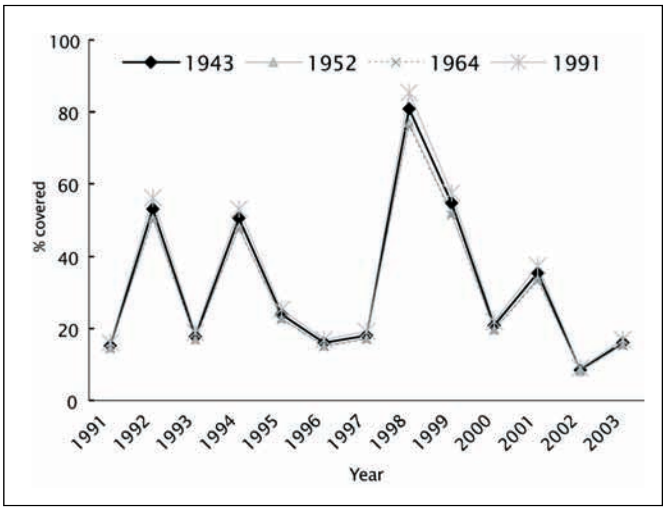

Figure 12 Annual cereal food deficits in Eritrea (1991-2003) NB: Food deficit was extrapolated based on the requirement of 145 kg of cereals per person per year (FAO, 1994)

Women: Food production and food security

Globally, women play a crucial role in the overall socio-economic life of all communities however their contribution is generally overlooked and even at times completely neglected. Women play a vital role in food production and utilisation. In Africa, women produce 78% of the continent's food including meta and staple grains on subsistence and small land holdings with very limited access to production resources (IFPRI, 2001). Quisumbing *et al.* (2004) reports that women in Africa provide the majority of agricultural labour.

Women, as transmitters of traditional knowledge, are involved in production and domestication of plants and animals. Women know seed selection, vegetative propagation and understand very well how plants and animals grow and reproduce. The contribution of women to food production and their involvement in agriculture is rarely seen as a positive action towards the insurance of food security.

Eritrean women participate in almost all activities related to food security at household and national levels. They are food producers, distributors and users of processed food products either as partners with their husbands or as household heads. The estimates of female-headed households in Eritrea range from 30% (GoE, 2004) to 47% (NSEO and ORC, 2003), which suggest that the involvement of women in ensuring food security at household level and thereby also at national level is massive.

Objective of the paper

The objectives of this paper are to:

- review the role of women in agriculture and food security in Eritrea,
- analyse the factors hindering the active participation of women in agriculture, and
- propose feasible alternatives for enhancing women's role in food security in the country.

Methodology

This study is a result of first hand observation and data collection across various ethnic groups and zobas (administrative regions) in the country. The primary data was enriched through literature review; consultations of relevant stakeholders and organisations engaged directly or indirectly in women development oriented activities. References were also made to some of the ongoing projects in which specific opportunities for women are identified.

The role of Eritrean women in household food security

Household food security (HFS) refers to the ability of a household to assure all its members sustained access to sufficient quantity and quality of food to live, active healthy lives. It is evident that if women can contribute and ensure their HFS, the collective amalgam of these in every household can impact the national food security in a country. Food security has three pillars/aspects- food production, access to food and utilisation (Figure 13). Eritrean women play a vital role as food producers, distributors and providers at least at the house-hold level, and take care of the family in particular and the community at large.

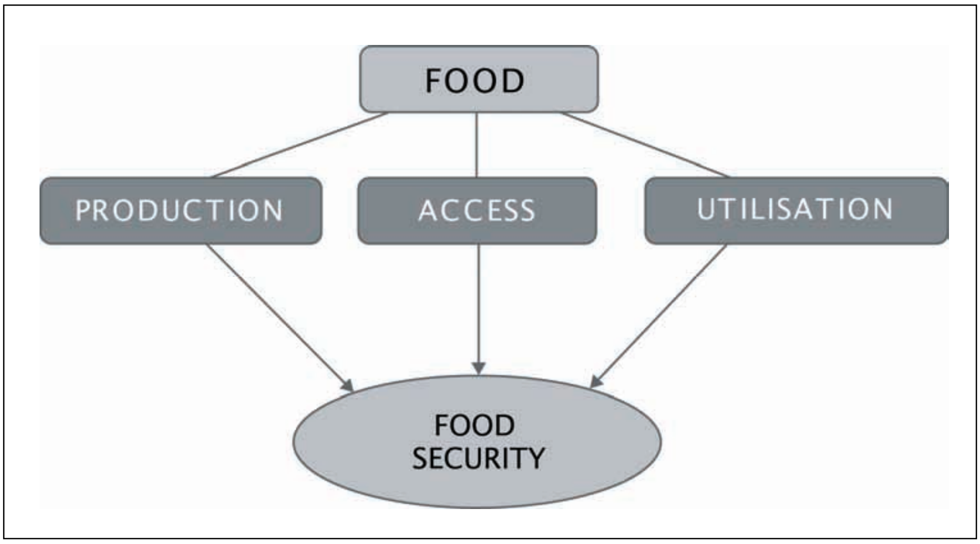

Figure 13 The components of food security where women are vital

Women as food producers

Although agricultural activities are perceived mainly as the responsibility of men, Eritrean women participate practically in all crop production activities except ploughing, which is predominantly considered as men's task. They participate in hoeing, weeding, harvesting, land preparation, threshing, transportation and storage. Herding is perceived as male's domain but women do participate in the livestock production aspect such as looking after the young, milking and processing livestock products (hides, cheese, butter, etc.). Similar information has also been documented in the surveys conducted in Zoba Maekel predominantly inhabited by the Christian, Tigrigna ethnic groups (Haile *et al.*, 1995) and in the coastal zone of the Northern Red Sea (Haile *et al.*, 2005). However, it should be recognized that there are differences in the degree of participation among ethnic and religious groups.

Many women in urban and semi-urban setting who have access to a small land where there is availability of water usually involve themselves or use the land for small scale horticultural production. The crops they focus on may be few and usually oriented for home consumption. In spite of this, this small harvest has great impact in improving the dietary/nutritional aspects of their family's everyday life. In terms of food security, this has cumulative effects and should be encouraged. Hence, they need small-scale production oriented extension services and food processing.

Currently, poultry is one of the highly growing activities that many women in rural and semi-urban areas are being engaged. This has changed the livelihoods of several households as evidenced in the market areas of the various towns and villages. This activity is currently threatened by the increasingly spreading bird flu around the world but had a great impact on many women who were actively engaged in this endeavour. Women are currently coping with this particular problem using their indigenous knowledge on poultry production systems including the selection of local breeds and interbreeding them with introduced breeds such as the Fayoumi and White Leghorns.

Women as food distributors

At household level once a family harvests or collects its food stock, the responsibility of distribution and allocation of the food lies entirely on women. Women ensure that the food stock lasts the family until the next harvest for instance by proper allocation of food during the daytime, by rationing, and self-discrimination. With regard to distribution, there is a fact that is usually neglected of the Eritrean women but perhaps of a wider occurrence as well. In poor families, women are generally low-fed since there is insufficient food. The priority of food distribution is first to the husband and then children. Mothers, usually eat leftovers. This coupled with the long working hours, which leaves the women mentally and physically exhausted, makes them vulnerable to diseases and malnutrition.

The challenge of women with regard to food distribution is seen particularly during the lean season. The coping strategies adopted by women vary from situation to situation, the economic status of the family and their marital status. They exchange high value crops for cereals or other commodities that can support their family for longer periods (for instance they exchange taff/chick pea for lower value crops such as sorghum). In addition, to meet the dietary requirement of the family and gain additional source of income, women practice mixed cropping. They mix legumes and cereals. Since the legume matures early, i.e. during the critical food deficit period, it helps in providing the family with food before harvest.

In adverse situations, such as drought, women and children are among the vulnerable group to low food intake. The condition is even worse in female-headed households. In such situations, women are engaged in off-farm activities: vegetable and animal sale. They also help in changing the diet and go to famine food collection. They collect various tuber plants: *Cyprus rotondus- 'kurta', Cyprus esculentus- 'kuinti'*, seeds of *Eleucine multiflora- 'adegela', Amaranthus spp.- 'hamli adgi/brnhayo'* and wild vegetables such as *Solanum nigrum -'hamli alem'/'hamli chegora'* and *Brassica spp. 'hamli gdebelu'*. In the eastern escarpment and the highlands, women collect the fruits of *Opuntia ficus indica- 'beles'* both for consumption, and for sale to earn cash.

Women and food use/processing

Eritrean women process many food products at household level. They make several types of preparations for the household use for instance, *'berbere'* (spiced, red hot pepper), *'shiro'* (chick pea paste), and *'injera'* (the daily pancake like bread from taff/sorghum). They make *'siwa/dge/mes'* (traditional drinks in various parts of the country).

Women process milk to various end- products including butter and cheese. To secure food, they process animal skin and hides to various end products. They process non-wood forest products- e.g. they use the leaves of doum palm for making baskets, mats and other items for sale. The task of women in the processing of these products, for instance, in the identification and collection of the right plants for dyeing and processing is time consuming and tedious.

Invariably therefore, women add value to the agricultural and non-wood forest products for household consumption or for sale to generate income for the family. Traditionally women play a vital role in human and livestock medicine. They either grow medicinal plants such as *'Shinfa'* (Lepidium sativum) or collect them from the wild in order to secure the family's well being (at least in their capacity).

The above mentioned involvement of women in the production, distribution and preparation of food vary depending on whether they are married, single, widowed, or with or without children. The biggest burden is on the female-headed households both in the rural and urban settings. In addition, the above mentioned activities and tasks of women are done on top of their day-to-day domestic duties including fetching firewood and water, grinding, and child care, generally taken for granted. MoA (1994) report indicates that on the average, the workload of Eritrean women exceeds 18 hours per day.

Women and community participation

In the rural areas, outside the household task, women constitute 60 % (MOA, 1994), 60-85 % (Fisseha, 1995) of the labour force in the rural development activities. Thus, they are engaged in soil and water conservation, afforestation, road construction and maintenance, and small dam and well construction. Besides, they are also involved in local public administrations- 'baitos'. In urban settings, women are involved in waged-labour, small-scale trade and handcraft to support their families.

Women and crop domestication

From ancient human history, women have played a leading role in crop domestication. This process started from wild fruit or grain collection and their subsequent domestication in the homestead. Nowadays this process is continuing, as women are the key crop selectors, distributors and end-use discoverers. In the Eritrean context, women regularly visit the fields and make note of the morphological and phenotypic variations of crop and select types that they consider will be of use for the next season. Besides, the adoption of new crops or varieties strictly passes through the scrutiny of women in which they check for the use, taste and storage aspects of the crops. Occasionally, they integrate wild plants into the agro-ecosystem.

Institutional set up, food security, and women

The Macro-policy of the Government of the State of Eritrea has recognized the decisive role played by women in the socio-economic and political transformation of the country. Thus, women have equal rights as men in education, economic activities and employment. The government also works towards improvement of the mother and child care services and the introduction of appropriate labour-saving technologies that reduce the drudgery of women in household and other activities.

In addition, the National Union of Eritrean Women (NUEW) is involved in various development projects that are targeted to improve the income of both rural and urban women. For instance, the NUEW organises women to make some crafts with local material and sell to the public. It also has established a number of skill development centres where women are trained for various skills to earn money. Since 1995, the NUEW has launched pilot projects aimed at improving the situation of female-headed households in various zones of Eritrea. The organization provides loans to women, who are engaged in small-scale horticultural production, animal fattening and poultry, and small-scale trade including teashops, vegetable sale, embroidery, tailoring, and water supply (NUEW, personal communication). Besides, NUEW is making efforts to reduce women's illiteracy, which is estimated to be about 90% (Fisseha, 1995). The strategy adopted involves three stages: eradication of illiteracy followed by skill development and grant schemes.

Conclusion and recommendations

The contribution of women to the food security of any country in general and to that of Eritrea in particular can be achieved through a concerted effort of empowerment. These efforts need to be geared towards the practical and strategic needs of women that could enable them to overcome their agricultural production problems. Some of the areas where our agricultural policies and development programs need to focus in relation to women so that their contribution to food security be augmented include:
Capacity building (training in areas that include small-scale farming, income generation, handcrafts, financial management, etc.),

- Enhancing women's participation in decision making at all levels to allow them to be part of the community/country development agenda and particularly in environmental conservation and resource utilisation,
- Increasing access to resources such as land and water as landless women may be vulnerable to food insecurity.
- Adopting technologies that are yield enhancing, energy saving, affordable, accessible, that reduce the burden of women and are environmentally friendly is vital. For instance, at farm level, women headed households need improved agricultural tools and equipment, water saving irrigation systems such as drip irrigation kits, and small pumps, which would allow them to save energy and boost their agricultural production.
- Funding women's activities: Most loan schemes cater for the farmers who are classified in the commercial scale and tend to marginalize women who would use the finances for small-scale production that focuses only to solve the family's nutritional needs.
- Encouraging women to start small-scale businesses, agricultural production such as poultry, backyard or field vegetables, flower production, apiculture, and handcrafts.

Agricultural development is a cornerstone to food security. However, it is not the sole means, and the concurrent development of other sectors such as industry and infrastructure is important. If the aspired level of food security by the nation is to be achieved, first, there is a need for smooth and effective information transfer between the different sectors of the economy. Secondly, there is a need to have supporting policies and finally, gender issues should be properly addressed with special emphasis to the contribution of women to food security in the wider perspective.

In addition, at grassroots level, action plans or development projects aimed at addressing food security should consider the multiple roles of women and need to have a holistic approach of action. Women themselves should be involved in decision-making in partnership with men. Since, policies and developmental activities that address both genders are likely to be more effective in improving food production and food security in the country.

Moreover, it is not enough to have a few “pro-women” policies, but the government and the society need to make a concerted effort to value women’s issues so that genuine change takes place. In conclusion, even good policies must have effective implementation, and that should be ensured.

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New paradigms in technology development: Exploring innovative approaches to linking agricultural research and practice

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Abstract

This paper looks at recent trends in agricultural technology transfer, and how researchers and practitioners might collaborate to develop innovative approaches to address the challenges of linking agricultural research results more closely with farmers. It looks at case studies from south East Asia, Tanzania, and Mali, where researchers and practitioners have tried to address this challenge, but have chosen different approaches sensitive to local contexts, constraints and possibilities. The paper then attempts to identify key principles, which have guided these approaches, and proposes a process for alternative systems of knowledge sharing in the Eritrean context using research conducted under the Drylands Coordination Group.

Key words: Action research, agricultural research paradigms, farmer field schools, local indigenous knowledge, participatory research, technology transfer.

Introduction

In the past 50 years, we have seen several shifts on how we perceive the development and spread of agricultural technology. Each broad paradigm has been based on certain assumptions on the nature of the challenges in agricultural production: who the actors are, what their roles are, what institutions are involved, and how they should function. Perhaps the most influential paradigm in recent decades has been the transfer of technology paradigm. This paradigm is best illustrated by the development of the *'Training and Visit System'*, through which the technologies developed by researchers under the Green Revolution were intended to be broadly spread to farmers by well-trained extensionists. While great strides were made in agricultural production under this conventional paradigm, it fell short in its ability to create technologies suited to the majority of poor farmers living under marginal and variable conditions.

Newer paradigms are thus emerging in which the focus in technology development has shifted from research stations to these vulnerable farmers. This paper looks at recent trends in agricultural technology transfer, and how researchers and practitioners are finding innovative ways to link agricultural research more closely with farmers. It looks at case studies from Tanzania, Mali and Sudan, where researchers and practitioners have addressed this challenge, but have chosen different approaches sensitive to local contexts, constraints and possibilities. The paper attempts to identify key principles, which have guided these approaches, and proposes a process for linking agricultural research and practice in the Eritrean context using research conducted under the Drylands Coordination Group as an example.

Conventional paradigms of technology transfer

What we refer to as the conventional paradigm in technology has its origins in the *Diffusion of Innovation Model* described by Roger (1962). Briefly, this is a linear model, where there is a clear distinction between research, education and farmers (Figure 14).

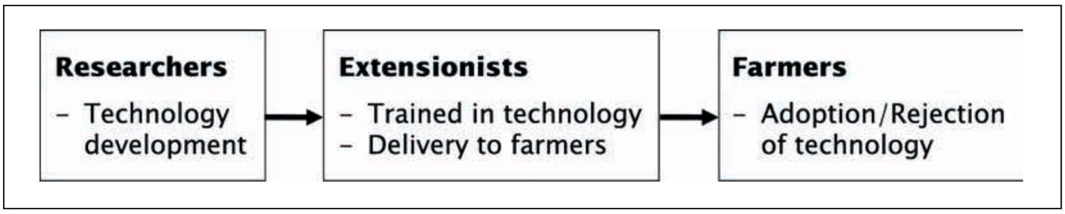

Figure 14 Linear model of technology transfer

In this model, the responsibility for the development of technology lies almost exclusively with the researcher. Research is performed mainly at public sector research stations, by researchers, on researcher-defined problems and evaluated according to researcher-defined criteria. The role of extensionists in this model is to disseminate technologies generated by public sector research organizations. Extensionists are trained in newly developed technologies, and are responsible for delivering them to farmers, often as set-packages combining technical and management recommendations. For example, a new seed variety may have been found to perform well on-station, and is then disseminated to farmers along with recommendations with respect to irrigation, fertilizer and pesticide requirements for optimum production. Farmers are mainly on the receiving end of technology, and their interest in or use of the technology is considered in terms of adoption or rejection.

Perhaps the best-known example of the linear model of technology in practice is the *'Training and Visit System'* (T and V system), promoted by the World Bank and implemented throughout the developing world from the 1970s through the early 1990s. The T and V system attempted to reform national agricultural extension services to enable them to more efficiently and effectively disseminate the emerging Green Revolution technologies, which were hoped to play a major role in relieving hunger and poverty throughout the developing world. The T and V system was basically a system of "message delivery". Extensionists visited "contact farmers" at regular intervals (every other week) and gave, at each visit, a simple seasonal instruction that had been designed by "subject matter specialists" in the research service. The T and V system, with its clear, hierarchical reporting lines, was well-suited for the rapid dissemination of pre-set agronomic practices, in areas with conditions comparable to those on the various research stations, and for farmers with access to inputs and irrigation. It failed, however, to respond to more location-specific, risk-prone, rainfed agriculture, where conditions differed significantly from agricultural stations on which the technologies were developed (Sharma, 2002) for more detailed critiques of the T and V System, see Biggs (1990), Roling (1994), and Ruttan (1996).

Underlying assumptions in the conventional paradigm

There are many variations in the way agricultural research and extension has been performed throughout the developing world (as well as the developed); for example, not all countries implemented the T and V system *per se*, and not all research has been conducted on-station. There have even been attempts to include farmers in research, for example, by inviting them to research stations to give their opinions on the varieties being developed. Despite these attempts, the approach remains linear, with researchers still responsible for research, extensionists for dissemination, and farmers for receiving the technology (Figure 15).

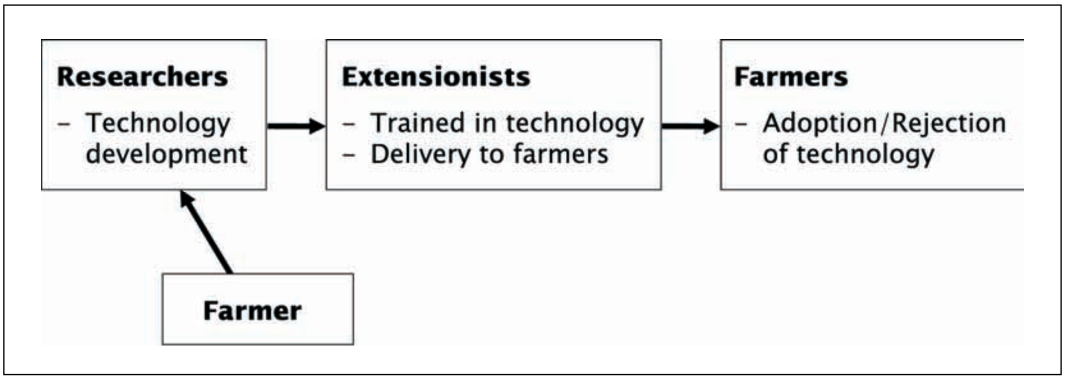

Figure 15 Linear model of technology transfer, with a 'touch' of farmer input

Nevertheless, several underlying assumptions common to the way agricultural technology generation and dissemination is viewed under this paradigm can be identified:

- Knowledge is situated with the researcher. It is therefore the researcher that develops new technologies, albeit with input from farmers in some cases.
- Farmers receive knowledge from elsewhere. There is limited acknowledgement of the value of local knowledge.
- Technology is either adopted or rejected; adaptation is seen as imperfect adoption.
- Non-adoption is due to poor communication of the technology between the extensionist and the farmers, or with the farmers themselves (i.e. cultural constraints).
- Technology from the research station is 'finished', to be disseminated to farmers.
- Technology is 'something' which can be transferred.

New paradigm: Farmer-focused

As a reaction to the conventional paradigm and its inability to address the needs of the majority of the world's poorer farmers experiencing variable conditions, an alternative paradigm has emerged. The approaches and models emerging within this paradigm vary as well, and are known by such names as Participatory Research, Action Research, Participatory Rural Learning, Agricultural Knowledge and Information Systems for Rural Development (AKIS/RD), to name a few. One of the main aspects these approaches have in common, however, is that they are all farmer focused: farmers are at the centre rather than at the receiving end of technology. In fact, the entire linear model of technology development, diffusion and transfer, which comprises the conventional paradigm, is rejected. Thus, the newer paradigm completely re-examines the way technology is conceptualized, as well as the process through which it is created, and the roles of the actors involved. Some examples of Farmer-Focused Paradigms in practice are provided below.

Farmers' field schools (FFS) in Southeast Asia

One particularly successful approach to farmer-focused technology development has been the Farmers' Field School (FFS). It was originally developed during the early 1990s to solve particular problems in crop protection in irrigated rice in Southeast Asia. The participatory method, however, has proved useful on a broad range of issues extending also to non-agricultural topics such as health education.

The development of FFS began with the problem of controlling a devastating insect pest, brown plant-hoppers (BPH) in rice. Farmers were using incredibly high amounts of pesticides, but the more they sprayed the worse was the pest problem. Finally a researcher found out that the BPH was a secondary pest - whose increasing population was actually caused by the insecticides. Farmers sprayed against stem-borers in the first place. But by doing so, they also killed spiders and predatory beetles that otherwise control the BPH. In the absence of those enemies, the BPH could quickly increase in numbers and reach levels at which they became a destructive pest. By spraying more to control the BPH farmers made things worse. The BPH-population virtually exploded once their natural enemies were eradicated. Desperate farmers ended up spraying with a concoction of pesticides at regular, down to weekly intervals.

But when researchers had found out of this, they also knew the solution. If farmers stop spraying the predators survive and the problem will go away. But how could they tell desperate farmers not to spray when they knew about all those pests? Nobody would risk following such advice. Farmers kept spraying and the extension service failed to bring home their message. It became clear that the approach of delivering messages to the farmers was not effective, and another approach was needed. Eventually FFS evolved. In the FFS, farmers learn by experimentation in the field, by observation, and by discussions within the participating group of farmers. Instructors are told not to answer questions; the farmers are supposed to both pose questions find the answer themselves, according to their own conditions.

One of the exercises in the FFS is to make what they call an “insect zoo”. They simply make a plastic tent over a crop plant and let in some spiders and pest insects. Then farmers can see through the plastic how the spiders are eating the insects. Then they make a spraying experiment and see how the dead spiders are floating in the irrigation water after the spray. In this way farmers learn and start discussing about pest-predator relationships and what harm insecticides could do.

Another experiment is defoliation trials on the crop (rice), where farmers cut leaves off the plant to see the effect. When that experiment is harvested, participants see, to their surprise, that an astonishing amount of leaves can be removed without significant reduction in grain yield. Through discussion they learned that they do not need to panic if they spot an insect in the field. An enormous number of them is required to make so much damage on the leaves that grain yield will be significantly reduced. This lesson, however, goes beyond decision making with respect to spraying needs. Farmers also learned about how a healthy plant can recover from damage through compensatory growth. If the plants are vigorous they can compensate for minor damages and it becomes less likely that protection by means of insecticides will be necessary.

But from there new questions arise. How do we grow a healthy plant? Farmers again begin to experiment. They are now in the process of developing a broad program studying optimal fertilizer rates and better crop husbandry. The FFS has proved to work. Farmers have become educated on key issues, learned to find solutions, and actually changed behavior. Surveys have shown that FFS-graduates spend much less money on insecticides and get higher crop yields compared with other farmers.

As said, this started with a specific insect problem in irrigated rice. The approach has been adapted for other pest problems, such as cotton. In Vietnam a youth group who had gone through the FFS (they also had women FFS groups) began discussing rats. The problem was severe and people bought excessive amounts of rat poison imported from China. Now both the rats and the rat poison were problems. The discussion went like this:

What are the natural enemies of rats? Snakes and cats.
What has happened with our snakes and our cats?
What are the habitats of snakes? etc.

From the FFS the youth knew the basic concept of pest-predator relationships and that to reduce pests one must protect the predators. They discussed practical issues and solutions and designed an action program in order to find better ways than to continue using the poison. In both cases, scientists and experts may be needed to provide new inputs and ideas, but actual change comes through farmers' direct involvement based on experiential learning.

Bean research in Tanzania

Another example of direct involvement of farmers in technology development can be seen from bean research conducted under the TARP II research program at Sokoine University of Agriculture, Tanzania. The Norwegian Embassy in DareSalaam funded this project. The focus of the entire program was to contribute to improve household food security and income, with a special focus on supporting women through conducting interdisciplinary, on-farm research. The bean research project thus started working directly with farmers, but rather than merely trying to introduce higher yielding varieties that were developed on-station, researchers and farmers tried to identify local and improved bean varieties which were drought-tolerant, and grew well in poor soils. This was because they knew from experience that improved varieties, which needed extensive inputs in order to produce well, were out of reach of the poorer farmers in the region.

The researchers and farmers, with the assistance of the extensionists, designed trials on farmers' fields. All follow-up was done by the farmers, who called upon researchers and extensionists when technical assistance was needed. The results after the first season were presented by the farmers to the researchers, and they were so successful in finding varieties that performed well under harsh conditions that the farmers informed that they were now going to start trials on maize varieties, and requested technical advice from researchers also in this endeavour. In this exercise, the farmers not only took part in the research, but in effect took charge of the research, and are now able to do further research on their own, and request assistance when they need it. The extensionists act then as a link between researchers at the research station, and farmers and extensionists are able to share this process with the surrounding villages, which are also now eager to start a similar process in their areas.

Another important aspect of this case is the manner in which the University, through this program, changed the incentive system at the University such that researchers would only get funding if they had interdisciplinary, on-farm research and were farmer-focused. This made it possible for researchers from different departments to join and move their focus from the University to farmers and their fields, where technology could be developed in the local context, under local social and environmental conditions. Although this represented a higher initial investment in that researchers visited the field more than usual, these costs reduced over time as farmers and extensionists took over the field trials.

Integrated Plant Nutrition Management (IPNM) in Mali

In many cases, research can start at the point where a promising technology already exists, maybe from another region, and the research focuses on exploring if this technology can also be useful in another area. In the conventional paradigm, this technology is considered finished, and the next step is merely transferring it to another area. In a farmer-focused paradigm, however, testing the technology in a new area with different farmers involves a new process of experimentation, where the technology is further developed according to local social, institutional and environmental conditions.

The objective of the IPNM project was to improve food security by building the competence of farmers and NGOs in soil fertility management. The project was implemented in Macina and Koro/Bankass in collaboration with CARE, in Bafaloubé in collaboration with AIDEB (Association pour le développement du cercle de Bafoulabé) and in Gossi in collaboration with OADS (Organisation d'Appui pour le Développement au Sahel). The project focused on four different technologies: microdosing of fertilizer, composting, zai method for water harvesting and urea treatment of straw to improve feed quality.

The approach

A diagnostic survey was initially undertaken to identify farmers' constraints related to agricultural development and to understand their priorities and solutions to the problems they are facing. A wealth ranking together with farmers classified them into different groups, which enabled the project to identify technologies suitable for the different wealth groups. An important component of the IPNM project has been the appointment of an IPNM committee in the villages where the project was undertaken. The farmers themselves appointed this committee. The farmers also appointed a responsible person for the project in each village.

The objectives of this committee were to:

- Introduce the technologies to other farmers in the village;
- Organize visits between the villages;
- Develop an approach for how to get access to inputs;
- Establish contact with suppliers of inputs; and
- Mobilize credit for inputs.

The farmers in consultation with NGOs and researchers selected the technologies that they thought might be appropriate for the sites. In some villages all the technologies were tested while in other villages farmers only chose to work on some of the technologies. The farmers themselves selected the farmers to take part in the test. Each of the selected farmers tested one technology. The test farmers had the responsibility to inform and share with the others their experiences. In the first year, only the test farmers took part, but in the following years many other farmers started using the technologies on their own initiative. Farmers from neighbouring villages were invited to see these tests, and thus the technologies spread to other areas.

At the end of each season, the IPNM committee identified the demand for fertilizer in the village and presented this to the NGO. As the project developed, however, the IPNM committee took the responsibility for purchasing and transporting the inputs to the village. Before initiating the on-farm testing of the technologies, the development agents of the NGOs involved also received training on how to use and present the different technologies to the farmers.

Several methods were used for scaling up the technologies. Inter-village visits and annual workshops were used to mobilize people and create interest for the project and to share experiences with other farmers. Radio programs were used in Macina to inform farmers in villages outside CARE's area of intervention. As a result, many villages approached the NGOs on their own initiative to join the project. A national workshop on the project was organized in 2002 to discuss the results of the project with other NGOs, public development agencies, Malian researchers and the commercial sector. The researchers have also presented the project to the leadership of the Institute of Rural Economy (Institut d'Economie Rurale), Permanent Secretary of the Ministry of Agriculture, Secretariat of the Desertification Convention and SASAKAWA GLOBAL 2000.

Results and discussion

The results of this farmer-focused research made it necessary to reconsider soil fertility management under Sahelian conditions. The study shows that it is possible to intensify millet and sorghum production in the Sahel using only minor investments in fertilizers. Sorghum and millet yield increased by 42 and 55% percent respectively when 0.3 g fertilizer was added together with the seeds to each planting pocket. This corresponds to about 7.5 kg fertilizer/ha and 3 kg fertilizer/ha for sorghum and millet, respectively. In sorghum, each money unit invested in fertilizer gave a return from 7 to 12 money units using this fertilizer application method. In millet, each money unit invested in fertilizer gave an average return of 5 money units. This technique is appealing to the farmers because of its low financial risk, the limited funds needed and the low workload. The method recommended by the International Crops Research Institute for the Semi-arid Tropics (ICRISAT) to apply 6 g fertilizer per pocket was not profitable for the farmers.

Composting has been well adopted in the town of Macina, but also in smaller villages. Women are using compost in gardening. Enriching the compost with Natural Phosphate from Telemsi (*Phosphate Naturel de Telemsi – PNT*) has further increased the quality of the compost. Composting in gardening is very likely to continue, but can be expanded to more villages.

Urea treatment of straw has been found to be interesting for improving feed quality for traction animals at the time of land preparation. Many farmers purchase cotton cake to feed the animals during this part of the season. However, urea treatment of straw is a cheaper alternative.

The zai method (earth depressions) has been found to be appropriate for rehabilitating degraded land. According to farmers' estimations, it takes about 40 man-days to treat one hectare. In sorghum, yields increased from 757 kg/ha in treatments without the *zai* to 1528 kg /ha in the *zai* method.

The success of the technologies can be best studied on the basis of what the farmers are actually doing. The IPNM committees registered a demand for 450 sacs of fertilizer in 2004, but access to fertilizer was very difficult because of the political crisis in Ivory Coast. Despite this, many farmers were able to get hold of fertilizer in small quantities and apply it on their farm.

This example, however, represents more than a successful development of technologies. Through the process of involving farmers in the design and implementation of the testing and sharing of results, new and sustainable institutions have been developed, and the competence of farmers in a large area has been raised through participatory research. It also allowed for an integrated approach, where several complementary technologies were introduced such that their combined impact could be discovered and evaluated.

Underlying assumptions in the farmer-focused paradigm

From these examples, we see that there are many ways to approach technology development, which is farmer-focused, and this can be done at different stages in the development of technologies. However we can, as in the case of the conventional paradigm, identify several underlying assumptions in this newer, farmer-focused paradigm:

- Local knowledge, previously underrated and undervalued, becomes central in understanding the complexity of farmers' context. It is not merely a matter of asking what farmers think, but taking their knowledge seriously in all stages of the research, from defining the problems, to designing the studies and the evaluation of the results. The bean research in Tanzania started with local knowledge of local varieties and soil conditions, and farmers used their knowledge and experience of local conditions throughout the entire research process.

- Farmer's adaptation of technologies is considered positive and desirable, and not a 'rejection' of technologies. In the IPNM research, for example, a conventional approach would have considered the farmers non-conformance to ICRISAT's fertilizer recommendations as a failure. The farmer-focused approach on the other hand applauded the development of local recommendations relevant to local economic and environmental conditions.

- Technologies from the research station are not finished, but are at the beginning of a process of adaptation and technology creation at the local level. This was particularly evident in Mali, where technologies developed elsewhere were the starting point of research, rather than the starting point of merely transfers or dissemination.

- Technology is not a 'thing', but a process of knowledge generation. It is a social process, where innovations emerge from and are being defined by specific cultural, political economic, institutional and historic contexts. Thus, the Farmers' Field Schools, although they have spread throughout Southeast Asia (and beyond), are not exactly alike – they deal with different problems and result in different institutions and local recommendations. The core principles, however, such as farmer experimentation and adaptation to local conditions, remain the same.

- There is a shift in focus from technology alone, to the process of innovation, and the emergence of new ways of producing and applying technology (Sulaiman and Hall, 2002). We see the development of different local institutions and partnerships in each case, and an emphasis on setting up different types of forums where research can be conducted and experiences can be shared. There is thus an acknowledgement that much more happens around the development of technology than merely the technology, and this opens for new ways of thinking of the impact of research on broader processes of social, economic, and institutional development.

In a newer paradigm, the linear model of technology transfer might be replaced with a model similar to that developed, for example, in AKIS/RD (Figure 16).

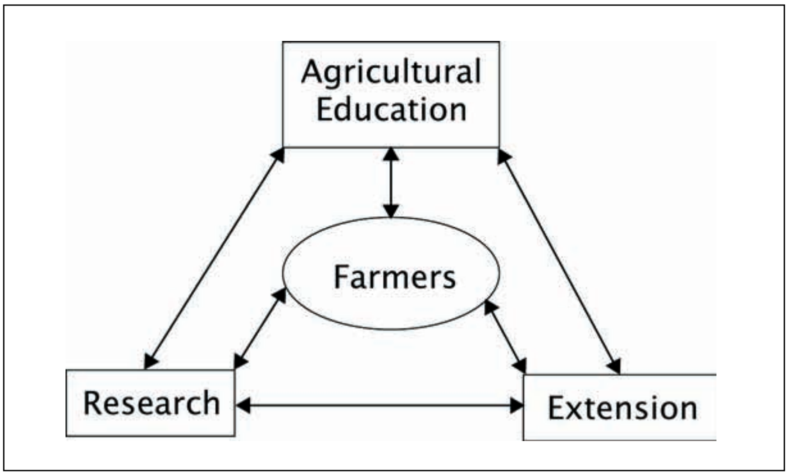

Figure 16 Conceptualizing technology generation in a farmer-focused paradigm (FAO/World Bank, 2002)

Knowledge in action – Activating research results in Eritrea

Using these principles and the lessons learned from these and other examples, is it also possible to find a way to activate the results of research already 'completed'? In Eritrea, the Dryland Coordination Group has sponsored a number of studies looking at agricultural and resource management issues, including:

- Assessment of non-wood forest products and their role in the livelihoods of rural communities in Eritrea
- Women and natural resource management: Kunama case study
- On-farm storage loss assessment and storage management
- Farmers' indigenous knowledge on maintenance of land races for in situ conservation and local seed supply system in Eritrea

What might be the next step? Conventional approaches might be to disseminate the results, presenting them to policymakers and possibly extension officials in a one-way communication. This might happen at a meeting or a workshop, where the results are presented and participants can ask questions or come with comments on what the results might mean in practice.

An alternative approach, however, one which lies more within a farmer-focused paradigm, would try to break away from a focus on dissemination – a term which lies squarely in the conventional paradigm, conjuring up visions of linear processes of top-down, one-way communication. Instead, there would be an attempt to create processes through which the results can be activated in a new setting, as the beginning of the creation of new knowledge. One way might be to visit a similar area as the one in which the original research was conducted, and to invite farmers, extensionists, representatives from local government, and NGOs to a field workshop, not for disseminating results, but to plan possible activities in their own area, inspired by discussions with those farmers and researchers where the original research was conducted. How this would happen in practice would depend on local participants and institutions and interest. The point is that, if the purpose of the field workshop is clearly to start a new process, then emphasis will most likely be put more on setting up good conditions for interaction and cooperation between actors, than on the mere delivery of messages. Responsibility for these processes will be placed locally, rather than centrally at a research institute or government office, but nevertheless with their support.

Conclusions

As we can see from the cases presented here, and many more, the emergence of a new paradigm of technology generation where farmers are at the center as active participants shows much promise in terms of addressing the variable conditions faced by the rural poor. It is important, however, that one reflects carefully over exactly how farmers will be involved, such that participation is not merely added on to a process that is essentially top-down or researcher defined. This is not necessarily an easy task, as most agricultural research and extension institutions remain embedded in the conventional paradigm of technology transfer. Shifting to a farmer-focused paradigm has far-reaching implications for how we view and conduct research, both in terms of the roles and responsibilities of the actors, as well as the institutions involved.

For researchers, attention needs to be given to not only the research itself, but how it is conducted; who is involved in what ways, in different contexts. It will also likely require researchers to develop new skills and qualities, allowing them to interact in new ways with farmers. It will also require adjustments in institutional incentive systems, in terms of what type of research gets funded and what kind of results are 'rewarded'. The Tanzanian case provides one example of an institution, which changed the incentive system to promote farmer-focused research.

It also will require the role of extensionists to be completely redefined. Rather than merely being trained in finished packages to be disseminated to farmers, they also become active participants in on-farm research, perhaps more as facilitators, linking farmers with resource people such as researchers, with a focus on creating good processes of communication. This will have implications for both the training and education of extensionists, as well as their field placement in relation to researchers and research stations (Sulaiman and Hall, 2002).

Finally, attempts to move towards a farmer-focused paradigm require that much of the terminology used in a more conventional paradigm is replaced with terms which better reflect the newer approach. The terms adoption, dissemination and technology transfer, for example, would give way to adaptation, knowledge sharing and technology generation. It might then be easier to ensure that all the actors involved share the same vision of how farmers, with the help of researchers and extensionists, move to the center of their own development.

Acknowledgement

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Rural institutions and food security in Eritrea: Preliminary findings from the central highlands and western lowlands

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Abstract

This paper examines the nature of external interventions from state, community, and private sector in the areas of inputs and outputs, and the extent to which households in the Central Highlands and Western Lowlands have benefited in terms of increased family incomes and food self-reliance. Our concern was to understand the systemic nature of production and marketing bottlenecks in these two ecological zones, and more importantly, to provide concrete suggestions as to the different policy options open to the Eritrean government in the area of sustainable food security. The findings suggest that inputs, training, and associational membership have not impacted on household production in any significant way. The paper concludes by suggesting ways in which policymakers can calibrate the balance among different institutional forms such that government interventions and community organization may better absorb and utilize basic technologies in the smallholder sector in order to enhance the efficacy of future development interventions.

Key words: Credit associations, irrigation, marketing, training, transaction costs

Introduction

The most important sector of the economy for Eritreans is agriculture, which despite a reduction in food production of some 40% over the period 1980-1990 still sustains 80% of the population. Yet, at present, agriculture and natural resources comprise only 22.6% of GDP. Two third of the population are unable to obtain sufficient calories and basic food needs, and food security remains a persistent problem. The Government of Eritrea (GoE) and technical experts alike have adumbrated interrelated structural constraints facing Eritrean agriculture: erratic rainfall and recurrent drought, small and fragmented farm size, extensive deforestation and soil erosion, lack of investment in land improvement, shrinkage of pasture land, the need to reform land tenure, the need to improve the quality of livestock, inaccessibility to markets, inadequate human capacity, poor physical rural infrastructure, labour shortages, weak agricultural extension services, inappropriate production technologies for smallholder farming, lack of credit access for smallholders (especially women), weak rural-urban industrial linkages, and an overall tenuous national food security situation (Tesfa, 1996; GoE, 2003).

The objective of this research project was to explore the relationship between food production and rural-based institutions in order to achieve greater understanding of the coping strategies of rural people. It sought to make a policy-level impact as well as a theoretical contribution to the food security question in Eritrea through an empirical investigation of case studies in two of Eritrea's major ecological zones: the Central Highland and the Western Lowland Zones. Striving to theoretically build upon technical studies and academic work, much of which is outdated since the mid-1990s, or is empirically weak (Gebrehiwet, 1993; Tesfa, 1996), we hypothesized that commercial and smallholder systems in both agro-ecological zones were coping with a host of productive and marketing bottlenecks, especially around food security, despite government and NGO interventions. In our subsequent investigations, and in light of the backgrounds and research interests, we further deepened our thinking on the technical and organizational nodal points that could be catalytic to a self-sustaining process of sustainable growth in smallholder rainfed agriculture.

Tentatively, we employed some key concepts as 'theoretical handles' by which to approach the data. In particular, we considered the role of institutions in economic development and the concept of transaction costs which may be defined as the costs of locating suppliers or customers and negotiating contracts with them, and the costs associated with imperfect market situations, for example, monopoly surcharges imposed by input suppliers, unreliable sources of supply, and restrictions on sales outlets (Pass and Lowes, 1993). The concept of transaction costs has been applied to the failure of pro-market reforms in contemporary African agriculture (Dorward, *et al.*, 2004). Through a simplified application of the concept of transaction costs we sought to explain why investment in physical infrastructure in smallholder agriculture is falling short of policy objectives.

Certainly 'establishing the basics' (roads, irrigation systems, research, extension, land reform) must take place in the context of extensive low productivity agriculture. However, the potential for profitable intensive technology up-take by smallholders may be constrained by weak financial and input/output markets. This institutional weakness would include not only high inputs like fertilizers, pesticides, new seeds, mechanical power, and irrigation systems, but even the diffusion of low input technologies such as organic manure (Ruttan, 1998). In Eritrea, where the private sector is weak and government capacity may be unable to match policy objectives, community organizations such as cooperatives and water user associations, are potentially pivotal in reducing the transaction costs of input supply, maintenance of infrastructure, government-to-farmer communication, and the general provision of public goods such as credit. This was a point made by Tesfa (1996) on the Eritrean context a decade ago. Elsewhere, Meinzen-Dick and Gulati (2002) quantitative research results in India indicate that water user associations are more likely to be formed based on factors such as larger irrigated areas, closeness to market towns, and a local leadership drawn from religious figures or educated youth. If institutional weakness is rendering production and technical investments in Eritrean smallholder agriculture ineffective then a complementary approach whereby government invests in social infrastructure (e.g. through technical and leadership training, provision of affordable inputs) may be the pathway to 'give a push' to smallholder agriculture.

Methodology

Study area

The field sites to be studied were tentatively selected by members of the team, in collaboration with the Ministry of Agriculture (MoA) staff. The research team then conducted a trial and error process of making contact visits to sub-zoba MoA offices in order to assess the on-the-ground status of outside interventions. Important for the study was a sample that reflected conditions in the Central Highland Zone and the Western Lowland Zone. Generally speaking, the Central Highland Zone is a high altitude cereal-producing zone with 500-700 mm of rainfall. Grain requirements are met partly through off-farm work (Watenbach, 2002). Salient ecological features of the Western Lowlands range include 300 mm of rainfall dominated by agricultural production systems centred on agro-pastoralism and irrigated commercial fruit and vegetable production (Tesfa, 1996). Studying two different agro-ecological zones offered comparative insights into the role of organizations across regions, which differed in rainfall patterns and land holding sizes. The team selected the villages based on the presence of development organizations, choosing three types: irrigation projects, horticulture associations, and marketing associations. Other sites visited but not selected included *Himbirti* (Central Region), *Haaylo* dam (Central Region) and *Hadish Adi* (Anseba Region), the reasoning being that project activity at these sites was either long defunct or not yet operational. The following three highland villages were finally selected: *Golagul* (close to *Adi Tekelezan* town), *Wara* (roughly 8 km from *Adi Tekelezan* town), both in Anseba Region; and *Kudofelasi* (roughly 5 km from Mendefera) in Southern Region. The lowland area selected was the town of *Hagaz* and its environs in Anseba Region.

Quantitative methodology

After the team selected the research sites, contact visits and group interviews were conducted from March to December 2004. The survey was subsequently administered from February to June 2005. The questionnaire developed for the purpose was tested at *Kudofelasi*. Then the questionnaire was slightly revised and the final version comprised of 39 questions, both structured and semi-structured, divided into four parts on topics covering general household profile, institutional support, household economy and farming system, and farmer perceptions. In total, 142 households were surveyed, out of which 57% represented the highland villages of *Golagul, Wara,* and *Kudofelasi,* and 43% represented the lowland *Hagaz* area. Facilitated by local MoA staff or the respective village chairman, survey interviewees were selected to include members of the association (if applicable), as well as those farmers involved in irrigation agriculture and those who were not involved. Methodological triangulation with the qualitative data reinforced the reliability of the survey data.

Survey results

Demographic structure

Mechanization is not common in the study areas. Although labour in the study areas could be acquired from different sources, the household was the primary labour source. In this regard, the analysis shows that the average household size comprises of six individuals. However, the villages show variation in their household demographic structure (Table 20). The numbers show the average age group distribution per household in each village. In *Golagul* on the average a household has 1.5 individuals who are below 14 years old. On average those between 15 and 40 are 2.8 and so on. Households thus differ from one village to the other in their average age group distribution.

The overall demographic structure of the study area shows that 50% of the population is less than 14 years old. This age group is mainly responsible for rearing small ruminant animals, collecting firewood, fetching water and undertaking light farm work. Though the youthful age of the household labour force may presently limit supply of the required quantity of labour for primary farm activities, this 'under 14' category will, within few years, keeping other variables constant, demographically dominate household and rural labour markets, thus alleviating current labour shortages. With many village youth in national service, land intensive practices, especially in relation to irrigation, such as at

Golagul, may have been difficult to do. Looking ahead, demobilized national service youth, with their organizational and technical skills, may potentially play leadership roles in spearheading the formation and running of community organizations.

Table 20 Average age group distribution per household from the four villages studied

	Age groups (Years)		
Village	<14	14-40	41-60
Golagul	1.5	2.8	0.6
Kudofelasi	2.7	2.0	0.8
Hagaz	4.2	1.9	1.0
Wara	2.5	1.3	0.9
Total	10.9	8.0	3.3

Agriculture

The dominant economic activity of all the villages is rainfed agriculture, with irrigation as a subsidiary activity in some households. The main rainfed crops in the highland villages of *Golagul, Wara* and *Kudofelasi*, are wheat, barley, maize, and beans while tomato, onion and potato predominate the irrigated production. Sorghum and pearl millet dominate rainfed cop production in *Hagaz* area. Farmland is acquired by different means where land title and sharecropping are common in the highland villages. These highland tenure arrangements also apply to the *Hagaz* area, in addition to the practice of land rent arrangements. Farm size differs from village to village. Overall average land entitlement per household is 1.33 ha in rainfed agriculture and 0.66 ha in irrigated agriculture. *Hagaz* has a relatively larger average farm size in both rainfed and irrigated agriculture, followed by *Kudofelasi* (Table 21). In addition, the average farm size acquired by sharecropping is bigger in *Hagaz* than in the rest. *Hagaz* and *Kudofelasi* villages performed better in irrigated agriculture compared to the others. At *Kudofelasi* there are also 20 commercial livestock producers, with their numbers growing, as well as a number of off-farm activities

The findings for *Hagaz* indicate greater agricultural productivity compared to the highland villages. Many of those interviewed at *Hagaz* were richer farmers possessing equipment, pumps, etc. As in the highland villages, there appears to be labour shortage for on-farm work. Though we did not directly interview female-headed households for cultural reasons, other studies suggest that the war has had a negative impact on productive activities such that 85% of respondents could not afford agricultural inputs whatsoever (MoE and RDE, 2000). There was also concern expressed by some informants at *Hagaz* that the extension services were paying more attention to the larger commercial farmers. An approach where there is a link between commercial and smallholder farmers (for example where the smallholders supply inputs, such as tomato and milk, to the commercial farmers) through contractual agreement is suggested to be an acceptable procedure. But in fact there appeared to be little in the way of economic interaction between the larger commercial farms and smallholders in *Hagaz* area.

Table 21 Average farm sizes per household

	Farm size (ha)	
Village	Rain-fed	Irrigated
Golagul	0.90	0.070
Kudofelasi	1.40	0.560
Hagaz	1.80	1.350
Wara	0.90	0.010

Generally speaking, farmers perceive that agriculture in the past ten years is either deteriorating or does not show any change. In this respect, the dominant proportion (77.5%) of the respondents perceived that it had deteriorated. This perception is supported by an earlier baseline survey (Asghedom and Fetsumberhan, 2003), which shows that in *Wara* the average yield of barley in a bad year (2002) was approximately 200kg/ha. Our survey result indicates that the average yield per ha for barley is approximately 177 kg in bad years (e.g. 2004), indicating a downward trend in cereal output. One factor in the decline of cereal output may, in part, be attributed to the ways in which the supply of international food aid depresses local cereal prices.

Household food self sufficiency

A World Bank (1994) study shows that grain consumption in Eritrea is 160 kg per year per person or 13.3 kg per month per person. This means that an average household, six, as defined by the World Bank should harvest at least 960 kg of grain per year for self-sufficiency. This study, however, shows that in 2004 the average yield of grains from rainfed agriculture was 302 kg, which means that households were in a deficit of 658 kg. The average yield recorded in 2004 would support an average household only for 3.7 months. This conclusion is substantiated by the responses of interviewees to a question on the number of months households can support themselves from their own harvest. According to the respondents, agriculture supports them differently as a function of rainfall. The study indicates that in bad rains, the dominant proportion (91.8%) of the respondents said they can support themselves for less than five months, and half of them (45.9%) cannot even support themselves for a month. On the other hand, during good rains, the dominant proportion (78%) of the respondents indicated that they could support themselves for five months or more, and 12.3% of the respondents said that they even have the capacity to support themselves for more than one year. Therefore, agriculture can hardly support households for more than five months for the dominant proportion of households in times of both good and bad rains (Table 22).

Table 22 Number of months and % of households that depend on own production in good rains

	Months			
Village	<5	5-8	9-12	>12
Golagul	59	30	7	4
Kudofelasi	31	38	23	8
Hagaz	2	17	53	28
Wara	17	50	33	0

Over 50% of the households in *Golagul* could support themselves only for less than five months, while *Wara* had only 17% of households in this category. *Golagul* and *Wara* are neighbours with common agro-ecological characteristics. They have the same average farm size for rainfed crop production while land for irrigation in *Wara* is 20% less than that of *Golagul*. However, irrigation land in *Golagul* is not under cultivation while *Wara* more fully utilizes the land. *Hagaz* and *Kudofelasi* have the highest proportion of households who support themselves from farming for more than five months. These villages undertake irrigation, which could be the reason for better support from farming. By the same token, average yield per household both from rainfed and irrigated crop production in 2003 and 2004 was better in those villages that practice irrigated farming (Table 23).

Table 23 Average yield (tons) per household both from rainfed and irrigated crop production

Village	2003	2004
Golagul	0.21	0.26
Kudofelasi	3.20	2.60
Hagaz	8.80	4.65
Wara	0.44	0.37

The overall trend indicates that the difference in households' food self sufficiency is mainly due to difference in the amount of rainfall and/or difference in irrigation water availability and management. This is evidenced by the difference in the length of time a household can support itself in good and bad rains as well as by a better level yield from irrigated agriculture, though the average land size is only 50% of the average farm size in rainfed agriculture. Moreover, 99% of the households believe that they would not have any problem of food self-sufficiency if the water issue was solved. Therefore, addressing the issue of water is among the key factors to transform traditional agriculture. However, this may pose an important question: Is solving the water problem a sufficient condition to improve household food self-sufficiency? To answer this question, hereafter, an attempt is made below to analyse the institutional support given.

Institutional support

1. Support for soil and water utilization

Significant capital outlay has been invested by the government towards maintaining and improving soil productivity by the construction of dams and irrigation works in *Golagul* and *Wara*. A survey was conducted to assess farmers' views regarding the external support to improve soil fertility and the results indicated that 39.8% of the respondents do not recognize the effort, while 13.6% considered that the effort did not help to improve soil fertility. On the other hand, 46.6% commended the effort in improving soil fertility. The study also shows that the implementation of one component is not a sufficient condition to improve agricultural productivity. Take the case of *Golagul*. There were extensive external support in setting up water pumps and irrigation canals over a wider area of the village fields for servicing 230 households. However, there was lack of technical support for water pump repair (three irrigation engines, both old and new, for downstream land were not functioning), that is, no orientation or training was given on how to run the irrigation technology after its installation; with no follow-up technical training on its maintenance (a point raised by the village elders on numerous occasions). Intra-village interest conflict complicates the technological bottlenecks. According to the *Golagul* elders, rich farmers were foot-dragging on resolving land managerial issues with the hope that the government would re-allocate the plots of the smaller farmers to those larger farmers with the means to profitably farm larger irrigated tracts of land. Hence, the infrastructure was used only in one season, in 1997, and has been idle since.

Kudofelasi presents a rather different picture. Horticultural production in the areas around Dekemhare and Mendefera has been recognized as economically important since the Italian colonial period. To stimulate horticultural production, the Government of Eritrea (GoE) poverty alleviation document cites the importance of credit for inputs like water pumps and the identification of foreign markets (GoE, 2003). Yet in *Kudofelasi*, despite the targeted intervention of an MoA-credit system for water pumps (which remain functional), tractor services, and inputs; plus training provided on crop production, soil conservation, animal husbandry, assisted by the Self-Help initiative, more energy was expended on the association than on the full utilization of technical inputs. Yet less attention was paid by the MoA to addressing the primary problem of the *Kudofelasi* horticultural association, which was the deterioration of ground water, used for irrigation. According to association spokesperson, water wells, the source of irrigation at *Kudofelasi*, have declined from 4-6 meters to 10-16 meters due to lack of rainfall.

Wara appeared to have stronger links with the MoA, and less internal village conflict in relation to upgrading its dam infrastructure. However farm size per household is very small (0.014 ha/household on average). And no intervention was undertaken in expanding irrigation land in order to increase farm size per household. Neither was significant intervention evident in the provision of high yielding and early maturing seed varieties, nor the provision of credit and inputs, that would have maximized productivity. Indeed a *Wara* elder stressed the need for improved seed and veterinary services for livestock, adding that *Wara* used to produce plentiful of potatoes during the Italian period. Thus the dam's contribution to household production was negligible. Shortage of male labour and increased reproductive pressures on women household members also have implications for the effectiveness of maintaining irrigation infrastructure. Other evidence from *Adi Tekelezan* in the environs of *Golagul* and *Wara* indicates that many households suffer from the increasing burden of trying to locate fuel resources like wood which, in case of long overnight distances, is also done by men (MoE, 2000).

Credit

Smallholder farmers lack financial capacity to purchase and apply modern inputs. To improve this capacity, micro-credit programmes have been introduced. To this end, the survey indicated that 35% of the respondents have received credit and 59% did not receive credit, while the remaining 6% did not respond. At the time of the survey, the main micro-credit institutions in the country were ACCORD, Eritrean Community Development Fund (ECDF), and Self-Help. Villages, however, differed in their access to credit, and not all sources of credit are available to all the villages (Table 24).

Table 24 Village access to credit

Village	% Respondents that had access to credit		
	yes	No credit	No response
Golagul	50	32	18
Kudofelasi	59	33	8
Hagaz	25	72	3
Wara	20	80	0

Kudofelasi had the highest proportion of respondents who received credit and comparatively speaking had a higher yield data (Table 23). *Golagul*, on the other hand, surpassed *Hagaz* and *Wara* in the proportion of farmers who had received credit. But yield wise *Golagul* recorded the lowest. Likewise, *Hagaz* had a low proportion of households who had received credit but it recorded the highest yield. In addition, farmers put forth their view on the contribution of credit to their farms. More than half (55.1%) of those who accessed credit indicated that the credit was very helpful while 24.5% responded that credit was partially helpful. Though farmers view credit favourably, the contribution of credit to agricultural output was limited by the absence of complementary inputs. Moreover, the end use of credit is what matters rather than the number of households who accessed credit. But the relationship between credit and agricultural production requires in-depth study aided by quantitative data. Wattenbach (2002) suggests that capital constraints can be addressed either through group credit schemes or expanded public credit schemes via the banking system.

Education and training

Villagers are well exposed to basic public education. Over all, 66% of the respondents are at least capable of reading and writing, a fact which may enhance technology transfer at the intersect of the extension agent and farmer. However, survey results concerning more specialized agronomic/animal husbandry training inputs show that the proportion of respondents who received training was less than 49%, while those who did not, stood at 51%. The distribution of training varies from village to village. *Hagaz* followed by *Golagul* had more than 50% of the respondents who received training, while *Wara* shows the lowest (27%) (Table 25). The lower percentage of training received by *Wara* villagers may be attributed to the fact that *Wara* is an off-road village as compared to the other three sites. The tendency then is that the more isolated a village is from the sub-region extension office, the less in the way of contact and training it will receive. *Golagul* and *Hagaz*, both near tarmac, received more training.

Table 25 Percent of the respondents who received training

Village	(%) of respondents	
	yes	no
Golagul	61	39
Kudofelasi	33	67
Hagaz	63	37
Wara	27	73

The dominant proportion (95%) of the farmers who received training indicated that the training was helpful, while only 5% of them had an opposite view. What remains unclear is the qualitative nature of the training, which makes an assessment difficult as to whether there is a positive relationship between training inputs and productivity output. Golagul, for instance, had 61% of its respondents trained. But the elders in the village continually reiterated that their main problem was not the amount of land but rather its administration: had land management issues been solved the dam would have helped in increasing productivity, even at half its capacity. Here the potential connection between training and output can be seen in one of the conflicts the *Golagul* elders related to the research team. Farmers with irrigated plots close to the source, which made irrigation relatively cheap and simple, ended up quarrelling over water usage with those farmers further downstream where irrigation was more difficult. These *Golagul* elders stressed that the existing traditional rules and regulations of land management are not effective; therefore solving their disagreements requires experts and intervention from the government. From the perspective of the research team, such conflicts over water use and plot allocation (cited earlier) may have been addressed via group dynamics and managerial training.

More seriously, contrasting a fully-installed and expensive irrigation network with its total inactivity over a number of years at *Golagul* raises some important questions about efforts to enhance food security. At this stage, we are only able to hypothesize what has gone wrong in *Golagul*. One obvious factor is the technocratic approach of the MoA, which should have also undertaken regular follow-up around land management, technical support, and dispute resolution. This pattern of top-down approaches by MoA is corroborated by a recent study on farmers in the areas of *Bultubyay, Areda, Falko* and *Mogoraib*, where run-off irrigation is practiced. The authors noted that farmers lack the technical know-how and skills of constructing and maintaining irrigation, and soil and water conservation structures. Lack of technical capacity is partly due to the fact that these farmers were not involved in the preparation, design, construction, and implementation of run-off structures. Consequently farmers come to depend on the government, rather than themselves, to maintain irrigation structures. As in the cases of *Golagul* and *Wara*, the fact that they were neither organized in irrigation committees, nor offered training, meant that the farmers lacked the local capacity to mobilize their resources for operation and maintenance. Consequently, the irrigation scheme suffered from poor output (Abraham and Tesfai, 2005). Another study on micro-dams in the central highland argues that many disputes can be traced to dams being initiated by outsiders without the full participation of end users. Consequently, unequal access to irrigation water and conflicts over the inequitable distribution of benefits between up/down stream villages result (Asghedom and Fetsumberhan, 2003).

Association membership

Agrarian associations in the study villages include a vegetable growers association in *Kudofelasi*, and three associations in Hagaz. There was no formal irrigation association as such in *Golagul* and *Wara*. 66% of the respondents are members of an association in their respective villages while 33% are not. In *Hagaz* and *Kudofelsi* 61% and 33% of the respondents are members of associations, respectively. Out of these, 74.4% indicated that their membership in such associations contributed to their agricultural activity. Especially in *Hagaz*, 83% of the respondents said that association membership was helpful. Regardless of the presence of the associations, the highest proportion (60.4%) of the respondents indicated that there was no support whatsoever towards improving marketing of inputs and outputs from any source, while 17% have shown that the issue of marketing is not relevant to them, as they do not produce any surplus for market. Some farmers (14%), however, have shown that the intervention on marketing was helpful and the remaining 9% indicated that the assistance was not helpful.

With regards to the *Hagaz* associations, the MoA officer said that there is credit for three associations – dairy, drip irrigation (50 families), and marketing. The initiative came from MoA, which promised to supply inputs such as fertilizer and insecticide to these associations. At the time of the survey, these inputs were not available. According to the marketing association staff, the dairy association has 845 cows: 185 cross-bred with the remaining local 'Barka' cows, organized by the MoA. The dairy association members meet 2-3 times per year, and have grown from 120 in 2000 to 165 members in 2004, with an entry fee of Nakfa 10/month. Another key function of the dairy association is to disseminate information. With regards to the drip irrigation association, the extent to which the ongoing water shortages in the area were impacting its activities, is not clear. The strongest of the three appeared to be the marketing association with its office in central *Hagaz* and officially called the 'Association of Vegetable and Fruit Producers'. This association markets various fruits and vegetables, and some grains, and involves several villages including *Hagaz*. Onion marketing is particularly a problem for the marketing association. Middlemen make Nakfa 7-9 per kg. as compared to the onion farmers who have no storage facilities of their own. And if they wish to market their produce off-season the only recourse for the association members is to fall back on private warehouses at a cost of Nakfa 5/kg of onion, which is very high. But if the marketing association had adequate storage facilities it could store onions for up to 4 months and therefore does not have to sell the onions at peak season when there is a surplus on the market. The members hope for the government or an NGO to construct a warehouse for them. This of course begs the question as to why this marketing association could not finance construction of a warehouse itself, especially when the majority of its members appear to be better-off farmers with highly capitalized farms, as noted earlier. Furthermore, this association is on a main trunk road with adequate rural infrastructure, power supply and market access to Keren and Asmara. The internal cohesion of these associations was unclear: there were no by-laws readily available, and one informant said that there was no structure as such, only a list of members based on the formation of the association two years ago.

Similar to that in *Hagaz,* the *Kudofelasi* association was formed by the MoA on the sub-zoba level, with individual members having joined from three different villages (*Kudofelasi*, *Embazareb*, and *Adi Ada*). It commenced with 300 members each with a contribution of Nakfa 300. Early on, however, the association was beset by problems of trust and awareness around management and institutional issues. For example, members did not put their produce in the association shop, and later the MoA replaced the weak leaders. Parallel to the *Golagul* experience, and perhaps *Hagaz* as well, there was insufficient follow-up by the MoA, as well as weak group dynamics due in part to lack of managerial and business training. Membership was voluntary and it elected managers twice. The main objective of the association was to sell outputs at a reasonable price and to make inputs available to the farmers at fair price. The association had been purchasing inputs such as fertilizers on a credit basis from MoA, but nothing was done on the output side. Currently, the association is under the Self-Help project of MoA, but in actuality it seems defunct.

To sum up, the results of the study show that the average farm size per household is 1.33 ha in rainfed agriculture and 0.66 ha in irrigated farming. While households mainly depend on agriculture, rainfed agriculture can only support households for less than four months on average. Villages with irrigated farming have better support from their agriculture where the dominant proportion of their households can depend on their farm for food for more than five months. The problems limiting agricultural productivity in irrigated farming vary from one village to another. In *Golagul*, the limiting factor is lack of institutional set up while in *Kudofelasi* it is the deteriorating ground water. In *Wara*, on the other hand, small farm land size is the main limiting factor while *Hagaz* has better farm size (> 1 ha/household). Lack of market access discourages farmers not to properly invest in their farms. Hence, one component may be satisfied in a village but complementary inputs might be lacking to supplement it. Consequently, the cumulative effect is low productivity in all villages. However, water and water related supports are key factors that should be practiced for agrarian transformation in rural Eritrea. But there is no common solution to all villages.

Discussion of results

In line with one of the themes of the AEAS 2006 workshop, which was to propose recommendations with regards to policy gaps around technology transfer, we assess our findings in light of the main GoE (2003) document currently available on poverty alleviation in order to make concrete recommendations on this topic. This document outlines a series of measures for smallholders of relevance to our case studies: creating practical cost-effective extension services to smallholder farmers for technology diffusion, expanding rural non-farm employment opportunities, provision of health care and clean water especially for female-headed households, rural electrification (including for the operation of tube wells to extract ground water), labour intensive public works, constructing rural markets to enable farmers to fetch better prices for their products, and facilitating rural financial markets including savings and credit associations. The document further emphasizes the need to rehabilitate large commercial farms to take advantage of global economic trends. What is not clear in the document is the proportion of financing that the smallholder and commercial sectors are to receive. There is no costing, only a general list of aspirations. Our tentative findings show that the smallholder sector is not maintaining household subsistence let alone a marketable surplus. And if agricultural growth occurs primarily in the commercial sector then this may lead to a form of dualism whereby a technically superior modern sector (with colonial period origins) co-exists with a low productivity smallholder sector, with few linkages between them. In such a scenario pro-poor rural growth may become ever more difficult to achieve.

One finding from our field data that merits repeating is that productivity is a function of interrelated factors of production where the presence of one cannot work in the absence of the other. Certainly there is much to commend on the national development efforts undertaken in the rural sector both at the micro- and at the macro-level, such as road building works, dams and other infrastructures, which we ourselves witnessed. Nonetheless, there are counter trends that have implications for the prospects of sustainable growth in the smallholder sector. For example, the GoE (2003) document says that in order to reduce distortions in the MoA's commercial activities, agricultural policy will seek to phase in an effective and efficient private marketing system for agricultural producers. An indicator of this trend can be found in fertilizer inputs where 'DAP', which used to be sold at a subsidized price of Nakfa 140/100 kg, with the recent removal of the subsidy,

has risen to Nakfa 496/100 kg. A free market supply system in inputs in a context of imperfect markets will most likely mean that only richer households or commercial enterprises will be able to afford this technology and thus enhance dualism. Whether a regulatory framework set up in conjunction with private distributors will cushion the impact of higher prices inputs remains to be seen (GoE, 2003). Promoting Foreign Direct Investment (FDI) in irrigation, based on
experience with concessions and smallholder irrigation, is also mentioned (GoE, 2003).

At the same time, the GoE document seeks to create a policy environment that addresses the input and credit needs of smallholders; further, it seeks to decentralize operational responsibility to *zobas*, synchronized with the MoA's devolution of commercial activities (GoE, 2003). The idea of devolution to the community sector should also be explored. For contemporary fiscal realities, and the experience of past retrenchments in the 1990s, requires a sober costing of the extension system and what it can realistically deliver in terms of quantity and quality to smallholder systems. The GoE (2003) calls for support to dairy co-operatives for the livestock sub-sector; and appropriate technology in irrigation: catchments rehabilitation, rainwater harvesting, ground water extraction, surface irrigation, and low-cost water saving irrigation methods. This would need greater co-management with communities, perhaps a discarding of the contact farmer model, and recognition of the vital role indigenous knowledge could play in spheres such as participatory technology acquisition. Such a policy thrust would mesh with some of the views expressed in the recent AEAS meeting of March 2006, where there was a feeling in the working group on *Extension* that an improved extension system should be more decentralized and participatory. Given that extension and research in Eritrea are in the same ministry, there is certainly opportunity for improvement.

Greater community self-organization would be more likely to reduce transaction costs such as stimulating a more accountable MoA extension service in terms of appropriate technology application, input delivery, support in the maintenance of dams, and assisting in the creation of more streamlined markets. Commercial suppliers would also be more likely to offer wholesale prices to organized groups of end-users. These are among the many economic benefits that could accrue to improving the efficacy of technical and productive inputs into the smallholder sector. But first and foremost this requires investment in social infrastructure. Embedding institutions in the community sector would ameliorate some of the problems encountered in this study such as lack of technical follow up, weak dispute settlement mechanisms, poor marketing facilities, inadequate water supplies, and non-existent irrigation management by-laws and so on.

Conclusion and recommendations

Based on the findings, the following recommendations are proposed for future project interventions in the smallholder sector.

- The specific problems facing any one village should be understood holistically and in all its facets prior to an outside intervention. Hence detailed data need to be collected on household and individual working patterns over time. Participatory research action approaches by line ministries could enhance greater awareness among outsiders and community-based end users alike about the challenges and opportunities facing local communities.

- Technical and educational support systems taken together could help expedite the solving of production and marketing bottlenecks for greater food security. In line with fiscal policy, front line ministries should nonetheless be financially bolstered in order to offer comprehensive and sustained training programmes. These could range from literacy training (especially for women's groups) and awareness dynamics, to technical and small-business certificate programmes.
- There needs to be firmer legal foundations for the various types of micro-organizations at the community level including marketing associations, autonomous cooperatives, and water user associations. Formal institutionalization would remove numerous uncertainties around the rules governing collective economic forms at the community level.

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Integrated watershed management: Socio-economic factors of water harvesting projects

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Abstract

The problem of water shortage in arid and semi-arid regions, like Eritrea, which is due to low rainfall and uneven distribution throughout the season, makes rainfed agriculture a risky enterprise. Extensive agricultural production, both crop and livestock, in these regions has been mostly achieved through supplemental irrigation. Water harvesting for dry land agriculture is a technology to ease future water scarcity in many arid and semi-arid regions of the world and maintain food security and is gaining new popularity these days. Nevertheless success of rainwater harvesting projects is not mainly on the technical aspects of rainwater harvesting systems, but in reality it takes more than engineering and agronomy to make the projects successful. Socio-economic factors such as, the acceptance by the beneficiaries, are particularly important. Among other socio economic factors, chances of acceptance of new technologies are much greater if new water harvesting techniques are developed with adequate involvement of beneficiaries, and effective management of the techniques. If the small-scale farmers are the beneficiaries then they must understand and be happy with the system that promotes food production. Thus, it is advisable to assess the economic viability and social acceptability of the farmers before water harvesting techniques and other new production technologies are transferred to them. The aim of this paper is therefore to address the importance of socio-economic factors (like people's priority, participation, adoption of the system, gender and equity, farming styles, and land tenure system) and the implications they may have on water harvesting projects in general and food security in particular.

Key words: Beneficiaries, Eritrea, food security, water harvesting projects, socio-economic factor

Introduction

Eritrea is located within arid and semi arid zones in Africa. These zones show ecological constraints with low and erratic rainfall, which set limits to nomadic pastoralism and rainfed agriculture. Local people in these areas have lived with these constraints for centuries. They have existed on local productivity and have used their traditional knowledge and technologies to device coping and adaptive strategies (Rowland, 1993).

Water harvesting for dry land agriculture is a strategy to ease water scarcity in many arid and semi-arid regions of the world and is gaining new popularity these days. Yet success of rainwater harvesting projects is not mainly on the technical aspects of water harvesting systems, but in reality it takes more than engineering and agronomy to make the projects successful. Lessons from many developing countries have shown that failure of many water-harvesting projects is due to less attention given by the developers to socio-economic factors that are particularly important. This paper therefore aims at addressing the importance of socio-economic factors and the implications they may have on water harvesting projects.

Methodology

This paper is based on literature reviews; secondary data sources such as Agricultural Knowledge and Information System (AKIS) study reports, model village situation analysis of sub-zoba *Emni Haili*; lessons from Eastern Lowlands Wadi Development Project (ELWDP), and Central Highland Irrigated Horticulture Development Projects (CHIHDP), personal observations and experiences, and discussion with various officers at different levels.

Results and discussion

The success of water harvesting projects in meeting the required objectives is bound to depend not only on technical and economic feasibility aspects but also on the socio economic factors of the beneficiaries and/or farmers themselves. Some of these socio-economic factors are: land tenure system, people's priorities and participation, local experiences with water harvesting techniques, adoption systems, farming systems and/or practices, and gender and equity.

Land tenure system

Land tenure issues can have a variety of influences on water harvesting projects and other soil and water conservation programs. Lack of land tenure means that farmers are unwilling to invest in water harvesting structures on land, which they do not formally own. In general, where land ownership and rights of using it is complex, it may be difficult to influence the farmer to improve land that someone else may use later. On the other hand, if land is owned privately, farmers like to construct any soil and water conservation structures that improve their land because it implies a more definite right of ownership. In case of common land, particularly where no well-defined management tradition exists, villagers are quite reluctant to treat areas, which are communally owned for fear of disputes.

In Eritrea, for instance, government owns the land in the rural and urban areas. In the highlands in particular, land to households is distributed through the '*Diesa*' system which is a communal form of land tenure: *people have the right to cultivate the land and enjoy the usufruct of that land, but do not privately own it*. Arable lands in highlands are distributed equally to households. The land is allocated to married men that head and manage a household. By implication, land is shared among them. A share is locally known as '*gibri*' and the villager as '*gebarai*' or '*gebar*' (literally meaning taxpayer). In the *Diesa* system, the village leader and a committee of elders selected by '*Baito*' (local village assembly) administer the land distribution. Another essential point of reference for the *Diesa* arrangement is that (re) allocation of land to households is done every seven years based on the quality of the land (i.e. the biophysical characteristics of the land e.g. the soil). One of the effects of such arrangements is that land holdings are fragmented and scattered around the village territory. Periodic or regular redistribution of land does not encourage long-term investments and hampers the management and quality of land. In such cases where the government and/or the community own the land, farmers hesitate to invest or improve the land that they do not formally own. For example, the socio-economic survey of 30 downstream horticultural developments done by the CHIHDP has shown that the size of the land holding (small size) and land ownership/land tenure system as the main problems hampering horticultural production under downstream irrigation schemes (Tewolde and Ghebreyohannes, 2003).

In other developing countries, it has been shown that the effect of tenure security on land investments and use of improved farming practices are important determinants of farmers' incentives to invest in land. Stability of tenure encourages investment in water harvesting and other soil and water conservation structures, while tenure insecurity detracts it. Perceived tenure security is associated with investment in water harvesting structures, tree plantation and soil bunds.

The potential role of government policy over land and the wishes and preferences of farmers regarding land tenure arrangements and land administration should be considered as important and crucial inputs into the design of future tenure arrangements in the country.

People's priorities

Priority means 'precedence in order or rank'. It should be realized that there are several dimensions to farmers' priorities. For instance, the aim of farming is to provide needed food for the family or cash to buy items or services not produced in the farm. Public services like research and ministries sometimes over-estimate the importance of technical priorities (increasing production) believing that farmers are likewise equally concerned.

In an Eritrean village, *Afelba*, a few years ago a group of students, doing their national campaign, terraced some land and planted trees. However, this area has not been managed and protected by the villagers. When asked, the farmers said that it was not their priority or plan to terrace that part of the hill. It is an important rangeland always used for grazing (Tekie *et al.*, 2001).

Similarly, in sub-zoba *Emni Haili* in the villages of *Hananit*, *Adi Namn* and *Kudozubo* preference ranking done by a team from Self Help Project with a group of men and women has shown that their priority was, in that order, water supply structures, construction of a clinic, road and kindergarten, and establishment of community shop (Tekie and Ghebreyohannes, 2003).

Farmers' priorities may not be in the best interest of the regional government. For example, farmers in a certain village may want to grow maize or sorghum for human and livestock use while the national government wants to grow cotton, which is a cash crop. Indeed, farmers' goals may not be favourable to long-term sustainable food production. So the question of how to integrate farmers' priorities with national government priorities can be openly discussed. The only route to matching priorities is to follow an interactive and participatory method that leads to a common understanding and interest (Roling and Jiggins, 1998).

If the objective of water harvesting projects is to assist resource-poor farmers to improve their production systems, it is important that farmers' priorities are addressed, at least partly; otherwise success is unlikely. If the local priority is drinking water supply or the construction of a clinic, for example, the response to water harvesting systems or structures for crop production will be poor.

Participation

The socio-economic conditions of a region or an area being considered for any water-harvesting scheme are very important for planning, designing and implementation. The chances for success are much greater if resource users and community groups are involved from early planning stage onwards. It is becoming more widely accepted that unless people are actively involved in the development projects, which are aimed to help them, the projects are meant to fail. It is important that the beneficiaries participate at every stage of the project. When the project is being planned, the people should be consulted, and their priorities and needs assessed. During the construction phase the people again should be involved in supplying labour and also in helping with field layouts after being trained with simple surveying instruments.

A mid-term evaluation report of ELWDP in Eritrea states that there was weakness in farmers' participation during the construction of the diversion. What was missing for a long time was a strategy for strengthening the farmers' organization and systematically and formally agreeing on the main issues in design and implementation. All these were important as farmers are expected to continue to manage the system. What should have taken place from the onset, in the words of one of the farmers interviewed was, work together with farmers on the design, and decide together. Before starting the work, ensure that an organization (and bylaws) of the beneficiaries is in place. Moreover, carry out consultations with farmers and their leaders who have indigenous knowledge of traditional structures. Be open to criticism, learn from farmers and teach farmers the advantages of modern technology (IFAD, 2004).

It is therefore helpful, throughout the course of the project to involve people in all phases of the project cycle (identification to monitoring and evaluation). By doing so the beneficiaries will feel sense of ownership of the project and the sustainability of project activities will be inevitable.

Local experiences with water harvesting technologies

Local experiences with water harvesting structures must be documented and appreciated, as they contribute to modern technology of water harvesting structures. Elsewhere in the world, the introduction of new technology of water harvesting structures has improved water provision in some places, in others, especially in remote regions of developing countries; it has often proved to be unsustainable. The reasons for project failures have always been because the technology and/or approach used for its implementation have been technically, economically, socially, or environmentally inappropriate. In many developing countries, past experience has shown that water harvesting or supply systems, which are dependent on external sources of fuel, spare parts, or expertise for maintenance and repair, are less likely to be sustainable as compared to those dependent only on local inputs, unless well-developed and reliable systems are in place for providing any external requirements.

There has been a tendency in many developing countries to equate improved water harvesting structures with modern technologies such as large concrete dams, motorized pumps, pipeline systems, which have often proved inappropriate particularly in poor rural areas. Many traditional technologies, in developing countries that have been tried and tested over the centuries that are sustainable and appropriate to the needs of the local community have been overlooked in favour of modern technologies and approaches.

Water harvesting systems have often been grouped into this same category of traditional technologies and have been unnoticed. In Eritrea, for example, a variety of traditional water harvesting structures are used. In the highlands of the country that receive average annual rainfall of around 500 mm, low earth ridges are built into basins, which trap the rain water and allow it to sink into the soil. People in these areas grow crops by capturing the runoff on nearby slopes by building contour bunds, and soil and stone bunds at farmlands. Where rainfall is below 200 mm, in the eastern escarpment of the country, floodwater harvesting from wadis (seasonal floods) that drain huge catchment areas of the highlands is used to grow crops by constructing embankments, diagonally across the riverbed. The water is trapped and spread across the area to be cultivated (spate irrigation). In the mountains, techniques like terracing and construction of stone lines across the slope is traditionally practiced. For example, *Adi Seldait* village in *Zoba Debub*, sub-zoba *Dibarwa* practices traditional water harvesting structures like bench terracing, check dams and contour bunds, which should be appreciated and documented.

Elsewhere in the world (e.g. in the Thar Desert in India), many communities depend on traditional rainwater harvesting technologies. These include tankas, simple clay lined reservoirs, *kundis*, covered tankas with compacted mud catchment areas and *khadins*, low walls diverting runoff from hillsides onto crops. While most of these *khadins* are still being used for runoff farming, many *tankas* and *kundis* have been abandoned since the arrival of modern piped water schemes. A study by the Centre for Science and the Environment (CSE) during the 1987 drought confirmed that while many on the new technology schemes based on tube well sources dried up, villages still depending on the traditional technologies still had water to drink (Agarwal and Narain, 1989). A return to the use of traditional rainwater harvesting technologies has subsequently been actively promoted by the CSE not only in the arid states of Rajistan and Gujarat but also throughout the country.

In summary, traditional water harvesting technologies have in most cases been able to meet the needs of local populations for many centuries and are sustainable. Ignoring this local knowledge and replacing traditional approaches entirely with new technologies, which are foreign to local communities, would seem unwise. Nonetheless, the traditional rainwater harvesting technologies can be upgraded and improved in order to provide affordable and sustainable supplies.

In general, strengths of building on traditional harvesting systems are that they are easy to understand and usually well adapted to the particular area in which they are practiced, and their efficiency can be improved by making simple adjustments.

Adoption systems

Adoption of a system in this context refers to the acceptance of the end-user of the new technology that fits to the areas in terms of the farming style, culture, demand of labour and practices. It is recommended that the new technologies of water harvesting are simple enough for the beneficiaries to implement, operate and maintain. Before a new technology is introduced into an area, motivation campaigns, demonstrations of the new technology within and outside the country and frequent training and orientation about the system is very useful. In order to encourage the acceptance of the new water harvesting structures, the beneficiaries should be supported by incentives.

The training sessions should be on local language supplemented by practice and written manuals for future reference. The impact assessment report of CHIHDP in Eritrea disclosed that 40% of the interviewed farmers reported that the training programs, though useful, lack practical sessions (e.g. Demonstrations) (Ghebreyohannes, 2005). The farmers thus recommended that in future, practical training should be incorporated in the training programs. Similarly, 70% of the interviewed farmers said that handouts were not given during training sessions and recommended that they should, in future, be provided with handouts for later references.

In general, since traditional harvesting systems are well adapted to a particular area by the local people, it is advisable to strengthen and build upon them by making simple modifications. By doing so the new water harvesting structures will be easily accepted by the local people and hence will be sustainable.

Farming systems

Farming systems are closely linked to livelihoods of farmers because agriculture remains the single most important component of most rural people's living and also plays an important role in the lives of many people in most developing countries including Eritrea. Each individual farm has its own specific characteristics, which arise from variations in resource endowments and family circumstances. The household, its resources, and the resource flow and interactions at the individual farm level, are together referred to as a farming system. A farming system is defined as a population of individual farm systems that have broadly similar resource bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate (FAO, 2001).

Water harvesting projects should have a picture of the livelihoods and farming system of the area before any intervention. The proposed new technology of water harvesting structures must not conflict in terms of labour demand with the existing farming activities, culture of the households, social values and the relationships and interdependencies of the farming communities. The human, social and financial capital of the farming community should also be taken into consideration. Diversion canals to capture water for crop production in *Badm* village, *Nakfa* area and *Adobha* area (in Nakfa) have been built by the Ministry of Agriculture. Nonetheless, farmers' response to use these diversions has been poor. Farmers in these areas are pastoralists and are more interested in raising livestock. Another example is the installation of complex drip irrigation system by Refugee Trust that covers 50 hectares in, *Gursub* village, sub-zoba *Haicota*. The beneficiaries of the area belong to the *Hidareb* ethnic group, which are pastoralists and raise livestock and the acceptance of the technology by the community was poor. In a nomadic farming system were the interest is to raise cattle, the response of the community to the construction of complex diversions to capture water for crop production or installation of a complex drip system will be poor.

Gender and equity

Gender and equity issues need to be taken into account before any intervention if water harvesting projects are planned to improve farmers' livelihoods. Gender refers to the social and psychological dimensions of the relationships between men and women, articulating how society and its history, norms, culture, institutions, education and socialization, economy, laws, and politics shape these relationships. Sexual identity is a reference towards our biological status as males and females.

Equity is an important parameter that should be taken into account in water harvesting projects. Equity refers to spatial uniformity or fairness in duties and benefits in water harvesting projects. During project design water harvesting projects should focus on fair advantages of both men and women, the role of the beneficiaries during construction, operation and maintenance and fair distribution in decision making, labour and profit.

In many developing countries, the issue of equity and gender in water harvesting structures is overlooked. For example, in Eritrea water harvesting activities like building of contour bunds, soil and stone bunds at farmlands, and terracing are often carried out by women. This increases their workload and leaves them less time for household activities and childcare.

Respecting the cultural values of the beneficiaries is very important. For instance, in some areas of Barka region (Eritrea), women and men do not mix in public. In such a case, one needs to organize separate workshops or discussion groups for men and women. And because generally in these areas men are the decision makers, train the men first and the women afterwards.

In general, success of water harvesting projects from equity and gender perspective, should take into account that both genders have equal access to water harvesting structures and benefit equally, both genders bear equal costs for using the structures, both genders participate equally in (paid and unpaid) water harvesting management and decision-making process.

Conclusion

The problem of water shortage in arid and semi-arid regions, like Eritrea, is one of low rainfall and uneven distribution through out the season, which makes rainfed agriculture a risky enterprise. Therefore, extensive agricultural production, both crop and livestock, in these regions has been mostly achieved through supplemental irrigation. Water harvesting for dry land agriculture is a technology to ease future water scarcity in these areas. Yet success of rainwater harvesting projects is not mainly on the technical aspects of rainwater harvesting systems, but in reality it takes more than engineering and agronomy to make a project successful. Socio-economic factors are particularly important.

In summary, when considering rainwater-harvesting projects in Eritrea, the following socio-economic factors need be taken into account:

- Land tenure should be secured to beneficiary farmers. Tenure or security of land is an important determinant socio-economic factor of farmers' incentives to invest in land on water harvesting structures and use improved farming practices. Stability of land tenure encourages investment in water harvesting and other soil and water conservation structures, while tenure insecurity detracts it.
- If the objective of rainwater harvesting projects is to assist poor farmers to improve their production systems, it is important that the farmers' priorities are fulfilled, at least partly.
- The beneficiary farmers should be involved in all phases of the project cycle (planning to monitoring and evaluation). By doing so, the beneficiaries will feel

sense of ownership of the project and sustainability of the project will be ensured.

- The proposed new technology of water harvesting structures should take into account the farming systems and/or farming practices of the beneficiaries. It must not conflict in terms of labor demand with the existing farming activities, culture of the households, social values and the relationships and interdependencies of the farming communities.
- Success of water harvesting projects from equity and gender perspective, should take into account that both genders have equal access to water harvesting structures and benefit equally, both genders bear equal costs for using the structures and participate equally in (paid and unpaid) water harvesting management and decision-making processes.
- Traditional experiences with water harvesting should be taken into account. It is advisable to strengthen and build upon them by making simple modifications.

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Dairy constraint analysis in Eritrea, with special emphasis on Asmara and surrounding dairy farms

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Abstract

The objective of the study is to analyse the historical background and identify constraints of the dairy sub-sector in Eritrea. The population of interest consisted of dairy farmers located in and around the capital, Asmara. Thirty dairy farmers were randomly selected and interviewed. Data on herd composition and breed, type and source of feed, type of mating, dairy housing, health, farmers' status, milk production and marketing, problems and constraints faced by dairy farmers were collected. Secondary data obtained from Asmara and Surrounding Modern Dairy Farmers Cooperatives were also subjected to cluster analysis to classify farmers according to their characteristic features (profile characteristics). Farmers with the same character were grouped. Interviewed farmers were characterised based on location, herd size, health, and farmers' status. Average herd size and lactation length were 15.4± 11 animals and 6-7 months, respectively. Common feed types used in the study area were cultivated forage, purchased forage, vegetable waste, grazing, hay/straw, industrial by-product, and compound feeds. Dairy farmers vary in their access to forage. A high proportion of peri-urban farmers have access to cultivated forage while high proportions of urban farmers have access to purchased forage. Usage of cultivated and purchased forage was associated with location ($p<0.05$). Natural, artificial insemination and combined systems of mating were used by 86.7%, 3.3%, and 10% of farmers, respectively. Both urban and peri-urban farmers use in-door system of housing. Foot and mouth disease, lumpy skin disease, nutritional disorders, mastitis, abortion, tuberculosis and digital problems were the most prevalent diseases. Dairying was considered by majority (73%) of the farmers as a primary means of income but by 27% as a part-time means of earning additional income. Three clusters (47.04%, 45.06% and 7.91%) of urban and (37.1%, 61.6% and 1.3%) of peri-urban farmers were identified. Clusters 1, 2, and 3, had 10± 0.6, 5± 0.5 and 23± 1.82 cows, respectively and produced 49.7± 3.45kg, 24.3± 3.02kg and 117± 10.73 kg of milk/farm/day. Shortage of land and feed, and lack of co-ordination were identified as major constraints facing dairy farmers. This study revealed that there is a need for dairy development in Eritrea. The existing potential could be exploited provided the identified constraints are solved. It was concluded that there is a need for further research.

Key words: Cluster, constraints, dairy sub-sector, Eritrea

Introduction

The commercial dairy farms in Eritrea are principally located in and around the main urban and peri-urban towns of Asmara, Mendefera, Dekemhare and Keren, and supply fresh milk to the urban centres. Modern dairy industry, since its introduction and until the mid 1970's, grew at a steady rate. Most dairy farms were located outside the main urban centres and animals were fed with cultivated forage. Land was available for forage cultivation in most of the farms. However, with the escalation of the war of liberation most dairy farms were relocated to the city centre where it was relatively safe. War destroyed infrastructures and caused dairy cattle to die of starvation. The nationalisation policy of the former Ethiopian socialist military regime also contributed to the decline of the dairy sub-sector.

Dairy cattle population and distribution are mostly related to milk market and feed availability. Majority of dairy farmers, which were relocated to urban centres, did not return to their former properties but had to depend entirely on industrial by-products to feed their cattle. The number of dairy cattle decreased as a result of feed shortage and improper housing. This led to decreased milk production, uneven distribution and unsustainable processing of milk and milk by-products. Due to the change in management system, direct sale of milk to immediate consumers in the locality became common.

Urban and peri-urban dairy has a positive and significant impact on food security and food production in Eritrea. It plays a vital role as a means of household income through the sale of milk and male calves, gives employment opportunity for the community and serves as a source of food for the households. According to Ehui *et al.* (1998), dairy production constitutes an important source of income through the sale of live animals and animal products. It also gives employment opportunity and is a source of food. Livestock ownership also impacts on farm productivity (through use of animal traction and manure as fertiliser or fuel) and hence cereal food production. Staal and Shapiro (1996) characterised urban and peri-urban dairy production systems among the many forms of dairy production systems in the tropics and sub-tropics, which involve the production, processing and marketing of milk and milk products that are channelled to consumers in urban centres. This makes it highly important for the livelihood of the rural, urban and peri-urban areas.

Although the dairy sub-sector in Eritrea started to revive gradually after independence. The major factors limiting dairy farming are not well identified. Hence, an assessment and investigation of the characteristic features of the existing production systems could help to identify the problems. Therefore, the objective of this study is to analyse anecdotal and current data (information) in order to identify dairy farming constraints in Eritrea.

Materials and methods

Data collection

The study was conducted in Zoba Maekel Administration located in the central highland ecological zone of Eritrea. The population of interest consisted of dairy farmers located in and around Asmara. A questionnaire surveying the qualitative and quantitative nature of the dairy farms was used to collect data. The instruments employed for data collection were interviews, formal and informal discussions, personal observations, and group survey. The study was conducted during January to mid March 2002.

Thirty dairy farmers from Asmara and surrounding areas were randomly selected from the list provided by the Asmara and surrounding Modern Dairy Farmers Co-operative (ASMDFC) office. The questionnaire encompassed information on herd composition and breed, type and source of feed, type of mating, dairy housing, health care and incidence of economically important dairy diseases, status of farmers (category), milk production and marketing channels. General farm condition and calf rearing practices, housing structure, location, manure management and disposal were all observed. Finally the major constraints faced by dairy farmers were assessed.

To get a clear view of the study, several discussions were also conducted with collaborative institutions such as the Ministry of Agriculture, Animal Resources Department (MoA-ARD), and private livestock consultants. Accordingly a time plan was prepared for conducting field survey and farm visits.

A group survey was conducted to identify the major constraints impeding dairy production. A one-day meeting was also conducted with 15 dairy farmers representing urban and peri-urban areas. Dialogue, brainstorming, and group discussions were used as guiding principles for the group survey. Open discussions were conducted among farmers themselves, with animal production experts and the advisor of the ASMDFC as facilitators of the meeting. Farmers listed down major on-farm production problems.

Data analysis

The main source of secondary data that was subjected for analysis comprises of 563 dairy farmers that included information on farm identification number, location, breed, herd structure (cows, calves, heifers, bulls), milk yield/farm/day and milk yield/cow/day. The data was obtained from ASMDFC.

Data were analysed using Statistical Analysis Systems (SAS version 1987). Correlations were calculated to observe the relationship between pairs of variables. Data of 563 dairy farms was subjected to cluster analysis and dairy farmers were classified according to their characteristic features (profile characteristics). This technique allows the grouping of individuals into clusters so that individuals in the same cluster are more similar to each other than individuals in another cluster. The validity of the clusters was established using canonical discriminant analysis on variables (bull/cow, calves, calves/100cows, heifers, milk yield/farm/day and milk yield/cow/day) not used in clustering. Chi-square test was used to determine the significance of, or the association between, locations and clusters.

Qualitative data obtained by survey were coded to make them suitable for statistical analysis. The aim of analysing the data obtained by survey was to describe dairy farmers according to their characteristic features.

Results

The results given below are for the primary data collected by interview and the secondary data set obtained from ASMDFC.

Correlations

Correlations between pairs of the following variables were calculated: cows, calves, heifers, bulls, herd size, milk yield/farm/day and milk yield/cow/day. Correlation results are given in Table 26.

Table 26 Correlation between pairs of variables

	Cows	Calves	Heifers	Bulls	Herd size	Milk yield /farm /day	Milk yield /cow/day
Cows	–	0.60**	0.65**	0.45**	0.97**	0.85**	-0.10*
Calves		–	0.44**	0.34**	0.72**	0.58**	-0.09*
Heifers			–	0.43**	0.78**	0.64**	-0.004
Bulls				–	0.53**	0.43**	-0.080
Herd size					–	0.86**	-0.09*
Milk yield/farm/day						–	-0.050
Milk yield/cow/day							–

*p<0.05 **p<0.001

All variables were positively correlated (p<0.01) to each other but negatively correlated to milk yield/cow/day. As expected, cows, calves, heifers are all highly correlated with herd size, and cows and herd size is also highly correlated with milk yield /farm/day.

Cluster analysis

Cluster analysis revealed three groups of dairy farmers in and around Asmara. In Table 27, mean values are presented together with Root Mean Square of Error (RMSE) and their respective significance levels for each cluster. Cluster 1, consisting of 41.6% of the dairy farmers, recorded medium numbers of cows and one bull. Cluster 2 consisting of 54.11% of dairy farmers, recorded the lowest numbers of cows and no bulls. Cluster 3, comprising of 4.3% of the dairy farmers, had the highest mean numbers of cows and bulls and the highest milk output per farm per day, but with relatively low milk yield per cow per day. A hypothesis can be stated that in cluster 2 dairy farmers with small number of cows must produce lower volume of milk/farm/day compared to cluster 3. Similarly for cluster 3 dairy farmers with the highest number of cows and bulls should have a higher number of calves and heifers as compared to clusters 1 and 2.

About 54% of the dairy farms are located in peri-urban areas. Farms in urban and peri-urban areas differ significantly in terms of number of cows and bulls (p<0.001), number of heifers, milk yield/farm/day and calves/100cows (p<0.05) (Table 28).

Table 27 Cluster means and significance of a three-cluster solution

	Cluster			RMSE[2]
Variables	1 (n= 233)	2 (n= 303)	3 (n= 24)	
Cows[1]	10.00	5.00	23.00	
Bulls[1]	1.00	0.00	2.00	
Calves	3.00	1.00	4.30	2.10 *
Heifers	3.00	1.00	7.00	2.30 *
Milk yield/day (kg)	49.70	24.30	117.50	37.20 *
Milk yield/cow/day (kg)	5.00	10.50	5.70	29.48 NS
Bull/cow	13.90	0.00	14.30	5.71 *
Calves/100	34.00	37.80	22.40	31.59 **

1 = cows and bulls are variables used for clustering 2 = root mean square of error

*= p<0.001 **= p<0.05 NS= not significant

Table 28 Summary of mean values of variables, root mean square and their respective probabilities in urban and peri-urban areas

	Location		RMSE2
Variables	Urban (n= 253)	Peri-urban (n= 307)	
Cows	9.30	6.30	7.30 **
Bulls	0.62	0.39	0.56 **
Calves	2.30	2.18	2.26 NS
Heifers	3.00	2.30	2.59
Milk yield/day (kg)	44.90	33.80	42.20
Milk yield/cow/day (kg)	6.33	9.50	29.53 NS
Bull/cow	7.00	5.90	9.01 NS
Calves/100 cows	30.00	40.00	31.34

*= p<0.001 **= p<0.05 NS= not significant 2 = root mean square of error

In order to check the validity of the proposed cluster, total canonical structures and their group means arising from discriminant analysis were used. According to Hair *et al.* (1992) variables with magnitudes of weights/loadings of greater than 0.3 are considered significant discriminants. Function1 of the discriminant analysis revealed that bull/cow, calves, heifers and milk yield/farm/day were the variables that make clear distinction between clusters. Group means suggest that this function differentiates between cluster 2 and cluster 3. Thus, mean values of heifers, farm milk yield/day, calves and bull/cow were higher in cluster 3 than in cluster 2.

For Function 2, heifers and milk yield/day have significant discriminant power. Group means suggest that it differentiated between cluster 1 and cluster 3. Indeed, cluster means and significance for a three-cluster solution show that the mean value of heifers and mean total farm milk yield/day in cluster 3 were higher than in cluster 1 (p<0.001).

Survey results

Based on location, the 30 dairy farmers were categorised into urban and peri-urban. The entire herd of the surveyed population had 224, 127, 89, 22 cows, heifers, calves and bulls, respectively. The average herd size was 15± 11animals and the range in lactation length was 6-7 months. Out of a total of 30 respondents 43.3% owned ≤10 and 56.7% owned >10 cattle. In the study area, the only breed used was the Holstein X Barka cross (local).

The common feed types used were green forage, vegetable waste, straw, hay, industrial by-products and compound feed. Green forage supply consisted mainly of green maize and/or barley at milk stage, spinach and other leafy vegetable wastes, and limited quantity of alfalfa and Napier grass. Green forage could be obtained either from irrigated land or purchased and as a result its usage varied between localities (Table 29). Farmers who cultivated vegetables for human consumption also sold vegetable waste to dairy farmers. In addition, vegetable waste is also purchased from the local market at a negotiable price. Industrial by-products are obtained from the flour mill factory at Asmara. In feeding animals, all available feeds are chopped and/or mixed (soaked) with water.

Table 29 shows that 52.9% of the dairy farmers with herd size of >10 cattle use cultivated forage as compared to 23.1% of farmers with herd size □10 cattle. Majority of peri-urban farmers and a few urban farmers use cultivated forage. On the other hand, majority of urban farmers and few peri-urban farmers use purchased forage. Both urban (93.33%) and peri-urban (86.67%) farmers had almost equal access to vegetable waste. Based on chi-square statistics, it would appear that usage of cultivated and purchased forage was related to dairy farm location ($p<0.05$) since access to cultivated forage depends on access to land for cultivation. Higher proportion (23%) of peri-urban farmers have access to land for forage cultivation as compared to (13.3%) of urban dairy farmers.

Table 29 Proportion of farmers within a herd category or within a location that use different roughages

Feed	Herd Category		X^2	Location		X^2
	≤10	>10		Urban	Peri-urban	
Cultivated Forage	23.10%	52.90%	2.73 NS	20.00%	60.00%	5.00 *
Purchased Forage	38.50%	35.30%	0.03 NS	66.67%	6.67%	11.60 *
Vegetable Waste	100.00%	82.35%	2.54 NS	93.33%	86.67%	0.37 NS

* = $p< 0.05$ NS = not significant

All farmers use one type of closed-tie indoor housing system. Approximately 73% and 27% of farms kept animals in own and rented barns, respectively. Of the urban farmers, 53% owned the barns and 47% rented, while in the peri-urban group, 93% owned barns and only 7% rented.

Methods of breeding were assessed during the interviews. Out of a total of 30 farmers interviewed, 86.7% used natural mating, 3.3% used Artificial Insemination (AI) and 10% used both methods. Of those who used natural mating, 57% used their own bull(s) and 43% hired bulls. Mating was conducted using Holstein-Friesian bulls and AI using imported Friesian semen.

About 60% and 40% of the farmers had full access and partial access to veterinary services, respectively. Economically important dairy diseases occurring or known to dairy farmers in both urban and peri-urban dairy farms were foot and mouth disease (FMD), lumpy skin disease, nutritional disorders, mastitis, abortion, tuberculosis, pneumonia, and digital problems. Since 1995, three outbreaks of FMD and about 321, 64, 560 and 200 cases of tuberculosis, brucellosis, mastitis and milk fever, respectively, were reported (MoA, 1997).

Dairying was considered by majority (73%) of farmers as a primary means of income but by few (27%) as a part time means of getting additional income. All farmers interviewed supply milk to the market. Of the total, 67% and 33% of the dairy farmers use formal and informal milk marketing outlets, respectively. Formal milk marketing is the supply of milk to the Asmara Dairy Plant (ADP) while informal milk marketing is direct supply of milk to consumers in the area. Milk is sold at a fixed price to the ADP but at a higher price in the direct (informal) market. Farmers sold milk informally or direct to consumers in order to compensate for or balance the loss incurred by selling their milk to the ADP at a lower and fixed price. Milk yield/cow/day was influenced by location but not by herd size, access to health service, and farmers' status (Table 30).

Table 30 The influence of location, herd size, health and farmers' status on milk yield

Variable	Level	Milk Yield/cow/day (kg)
Location	Urban (n=15) Peri-urban (n=15)	6.43** 7.63**
Herd Category	≤10 (n=13) >10 (n=17)	6.98 7.09
Health	Partial access[1] (n=12) Full access[2] (n=18)	6.86 7.21
Farmers' Status[3]	Full time (n=22) Full access2 (n=18)	6.53 7.54

** Significant difference Error mean square = 5.337
[1] = Where farmers get partial veterinary service [2] = Where farmers get full veterinary service
[3] = Category of farmers

Constraint analysis

Constraints to dairy production were determined using both informal (individual) and group based discussions. Feed shortage, farmers advisory service, land shortage, disease, inconsistent AI service, labour, breed, feed cost, low milk price, milk handling facility, and water shortage were constraints identified through individual discussions. Similar results were obtained by group-based discussions. The constraints were ranked according to their order of importance. Shortage of land, lack of co-ordination and feed shortage were identified as the major constraints in and around Asmara. The other constraints according to their rank of importance were lack of skilled human resources, disease and shortage of veterinary drugs, lack of know-how, inconsistent AI service, lack of extension package, and lack of milk cooling and transporting facilities. Constraint analysis revealed that all dairy farmers around Asmara face similar problems, which could have policy and technical implications.

The feeding systems used by farmers showed that there is shortage of feed resources. Basal and supplementary rations were not separated in feeding of dairy cattle. All available roughages and concentrates were mixed together and offered to the animals.

Dairy housing used by farmers was of poor design and location. Most urban dairies were concentrated in the residential areas. In most cases insufficient land space was available for separate calf pens, milking parlour, feed store and dung pit and other related services. The barns were poorly ventilated and poorly lit. Animals were not clean due to improper manure disposal. The accumulated manure also caused bad smell that could be of concern in the residential areas.

Discussion

The results of this study revealed that distinct groups of urban and peri-urban dairy farmers exist in and around Asmara. Urban dairy farms are those that are located inside Asmara. Dairy farms located outside Asmara are characterised as peri-urban dairies.

Clustering of dairy farms illustrated the existence of different groups. Farms with large herd size might face high competition for feed among the herds because feed is allocated according to the milk supplied to ADP. In addition, a reduced cost of bull management could spare additional feed for feeding cows. The majority of farmers with small herd size belong to the peri-urban area and have access to cultivated forage (Table 29) that could improve the nutritional status and milk production per animal.

Feed resources most commonly used by dairy farmers in the two localities are quite similar. Availability and variety of feeds dictate the feeding system in the dairy farms. The way farmers feed and manage their cattle could indicate the existence of problems related to feed and feeding. The most common system is zero-grazing where dairy cattle are housed in tie stalls. The farmers depend mostly on purchased feed resources. Traditional subsistence farmers supply dairy farms with barley and wheat straw but this also fluctuates with available rainfall. Although feeding has shifted from land resource based (grazing land) to a concentrate or by-product based system, farmers raise the problem of unequal distribution and general scarcity. To control the sale of unpasteurised milk to consumers, the Ministry of Agriculture introduced a feed distribution system where dairy farmers are able to obtain feed upon certification of milk supplied to the ADP. However, dairy farmers are not satisfied with the system because milk supplied to ADP fetches lower price, as compared to the direct sale of milk to consumers.

Due to inconsistent AI service majority of farmers might be obliged to use own or rented bulls. This could lead to high cost of bull keeping that lowers the income of dairy farmers. Breed improvement cannot be attained as required because of untested breeding bulls. Sharing of bulls or bull exchange could also result in the transmission of reproductive diseases. Bull testing, keeping breeding records and control of reproductive diseases could help to attain required breed improvement.

Dairy farmers in the study area were categorised as being market-oriented. The role played by dairying as a primary means of obtaining income and as a part-time means of obtaining additional income is similar to reports from Ethiopia and Zimbabwe (Hanyani-Mlambo *et al.*, 1998; Smith and Olaloku, 1998;Tegegne *et al.*, 2000) where cash income from sale of milk and/or breeding animals and utilization of available resources (land, feed, labour, capital) are the most important reasons for keeping dairy animals in urban and peri-urban dairy production systems.

The identified constraints could be grouped into policy, technical and institutional issues. Land is the only policy-related constraint whereas feed, disease and AI are technical constraints. Lack of coordination, lack of skilled human resources, lack of know-how and lack of extension package are institutional constraints. In contrast with this study, in South Africa animal theft was among the top agricultural constraints identified by farmers (Letty *et al.*, 1999; Letty *et al.*, 2000).

Land shortage is reported to be a serious problem affecting housing and forage cultivation (Zeggo, 1997; MoA, 1999; Teclu, 2001). Lack of land is suspected to be responsible for the shift of dairy systems from land resource based (grazing) to concentrate (by-product) based. Survey results also revealed that all dairy farmers feed their cattle on concentrates (industrial by-products). The issue of land ownership with respect to dairy production is particularly important in the urban and peri-urban areas. In addition to the land policy, the traditional land tenure system also does not encourage dairy farmers to establish perennial forages and build dairy barns on the allocated land. Farmers have users' rights, not owners' rights over the land they till. The effect of land as a major constraint of dairy production is reflected in feeding and housing systems.

Dairy farmers have developed their own feeding strategies hoping to overcome feed shortages. They mix and soak in water all available feed types to feed their animals. Farmers perceive that this system of soaking feed improves palatability. The impact of land problem on housing was observed during the study. In both urban and peri-urban farms dairy cattle were confined in houses not properly designed for dairy purposes. Dairy development is the result of organised and coordinated activity of different actors. However, lack of coordination was raised as one of the major dairy constraints. The role of research in dairy development has been defined clearly in the CTA (1996). Nonetheless, little or no research has been conducted to understand urban and peri-urban dairy. The research-farmer relationship can be bridged by education, general extension and consultation but no specialized dairy extension system exists. Shortage of qualified personnel was cited as the cause of poor extension services (MoA, 2000).

Conclusion

The results of the study revealed that there is a foundation for dairy development in Eritrea. This consists of dairy farmers with distinct characteristics. In addition the study has shown that dairying is a very significant source of income and food for urban and peri-urban households. Many of these farm households would not have been able to sustain their families without the benefits accumulated from dairying as a means of employment as well as income generating activity. Therefore, dairying has made a major contribution in Eritrea to food security and poverty alleviation. However, due to shortage of land, feed and lack of co-ordination, little or no progress has been achieved to date. Therefore, to alleviate the existing problems of land, co-ordination and feed, a holistic approach of problem identification involving all stakeholders should be done on aspects such as planning, policy revision and formulation. Furthermore, research on dairy systems targeting urban and peri-urban farms should be conducted.

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Recommendations of the working group discussions

The workshop participants were divided into five working groups on the following five themes identified for the workshop:

1. The role of biotechnology in promoting food security
2. Enhancing crop production for food security
3. The role of extension and technology transfer in productivity
4. Integrated watershed management and productivity
5. Enhancing livestock production for food security

The cross cutting issue of gender involvement in food production and food security was also discussed in all themes. The deliberations and the recommendations of the groups are summarised below.

1. The role of biotechnology in promoting food security

Biotechnology in Eritrea is at its initial stage and currently there is no institutional setup that can handle issues of biotechnology and biosafety. There is also lack of awareness regarding Biotechnology and biosafety at all levels.

Safe and appropriate use of Biotechnology can enhance productivity and alleviate poverty. Hence, Eritrea should create an enabling environment for the implementation of this technology. Moreover, biotech food products are already being imported and consumed in Eritrea and we cannot hinder the globalization effect of the technology. Eritrea is signatory to the Cartagena Protocol on Biosafety and has already established a National Biosafety Coordinating Committee in 2005. The Department of Environment (DoE), the focal point for biosafety, has recently started to develop the National Biosafety Framework (NBF) for Eritrea. In addition, Eritrea is a member of Codex Alimentarius Commission (on food safety). This will provide a good background so that the country becomes beneficiary of the new technology. In relation to Biotechnology, the main constraints and challenges are: Lack of awareness, inadequate human and infrastructural resources and finance.

The possible opportunities for Eritrea to develop its capacity in terms of Biotechnology include:

- a Membership in the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) and other regional biotechnology related organizations or institutions.
- b Eritrea can benefit from lessons learned from other countries with more experiences in terms of handling biotechnology issues.
- c The already drafted and/or implemented NBFs available for many countries can serve as starting templates for drafting the NBF for Eritrea.
- d Conventional biotechnology can be applied without any risk and hence can be adopted safely.
- e Eritrea can also benefit from potential skilled human resources in the Diaspora

Recommendations regarding the use of biotechnology in enhancing food security:

- Establish a capable government body responsible for handling biotechnology and biosafety issues and coordinating all the activities of stakeholders.
- Create awareness among the public, professionals and policy makers on issues related to biotechnology and biosafety.
- Introduce biotechnology courses as part of the curriculum in institutions of higher learning.
- Speed up the formulation of Biosafety Policy through responsible government bodies.
- Build human and institutional capacity in areas of biotechnology and biosafety.
- Have clearly delineated roles and responsibilities of all government bodies directly or indirectly involved in biotechnology.
- Implement conventional biotechnology using the necessary precautions.
- Create a network of Eritrean professionals in the Diaspora on biotechnology and biosafety.
- Establish linkages with regional and global biotech institutions such as ECABIO, ASARECA, UNEP/GEF, etc.
- Encourage the involvement of private institutions in biotechnology issues.
- Develop appropriate proposals on biotechnology for financial and technical support from development partners.
- Encourage development partners to play an important role in Policy formulation and establishment of a Biotechnology Research, institutes.

2. Enhancing crop production for food security

Crop production in Eritrea under farmers' management is very low and the yield is declining. The total area under crop production has increased in the last few years, but the total yield has not been able to cover the food requirement of the country. Although the construction of dams, reservoirs, and supplementary irrigation has increased the yield of cereals and horticultural crops, considerable improvement could not be achieved to promote food security at all levels in the country.

The main constraints for crop production in Eritrea include:

- Erratic and uneven distribution of rainfall causing recurrent drought.
- Weak linkage between research, extension and farmers resulting in poor transfer of technology to farmers.
- Shortage of labor force due to the deployment of active working force in the front line.
- Shortage of inputs and supplies such as better quality seeds and full information on integrated crop and pest management.
- The existing land tenure system.
- Poor marketing infrastructure such as roads and storage facilities; and lack of cooperatives.
- Shortage of cottage industries involved in food processing.

Opportunities

- Water harvesting techniques for efficient utilization of rainfall for supplementary irrigation.
- Participatory research approach in a multidisciplinary manner for identification and transfer of relevant technology (this has already started).
- Available crop biodiversity can be exploited to develop high yielding, drought tolerant and pest resistant crops.

Recommendations

- The Policy and legislative issues regarding seeds, quarantine, biodiversity, management and use of dams etc. should be ratified and/or implemented.
- Demand driven participatory approach should be used in the selection and transfer of technology and upgrading of skills.
- Adequate participation of zoba administration and relevant stakeholders should be available in all agricultural activities (e.g. during pest outbreak).
- Use of drought tolerant varieties and efficient water harvesting techniques for crop production should be encouraged.
- Increase feasible commercial farms with the potential to boost production.
- Diversification of crop production into high value crops (cash crops).

3. The role of extension and technology transfer in productivity

Currently the linkage between research, extension and farmers is very poor. The constraints and challenges in relation to extension are: a) The misconception and misunderstanding of the term 'extension' that exists and the role of the extension worker. This is reflected in the wrong practice of the science, and b) The existing organizational structure of the Extension Unit in the MoA has not been well defined. There are limited extension staff both in quality and quantity and therefore are unable to reach the farmer. There is no mechanism of monitoring and evaluation of activities and hence inadequate feed back.

The opportunities available and that can be exploited include:

- Rich local/indigenous knowledge of farmers.
- Formation of farmers' associations greatly reduces the need for contact farmers and provides larger interface between research/extension and farmers; thereby improving demand driven research.
- The strong experience of Farmers Advisory Services (FAS) needs to be emphasized and adopted widely.
- Draw from international and in country experiences.

The solutions and recommendations (agricultural policy/development) forwarded in this regard are:

- The new agricultural policy should be publicized and implemented.
- The existing extension structure in the MoA needs to be reviewed.
- Strengthen REF interaction.
- Establish/Strengthen farmers associations.
- Encourage the participation of women in extension activities and as farmers' representatives.
- Ensure a holistic or interdisciplinary approach to development (i.e. micro-finance, marketing, potable water, health, education, etc.).

4. Integrated watershed management and productivity

Currently the trend in the watershed areas and their management shows that there is a great deal of degradation of vegetation and biological diversity, accompanied by soil erosion and salinisation. In addition, there is degradation of water resources: siltation of water reservoirs, depletion of ground water, and water quality degradation (salinity and toxicity). The accelerated degradation that increases from time to time is therefore threatening food production and contributes to the prevailing food insecurity both at household and national levels.

The constraints in watershed areas that affect food security have been identified to be:

- Lack of sense of ownership of land by land users
- Inadequate coordination among institutions and stakeholders
- Inappropriate land use planning
- Lack of up-to-date information/data on natural resources
- Inadequate awareness of watershed degradation at all levels
- Lack of capacity for implementation
- Focus only on biophysical conservation and not on social factors
- Lack of alternative sources of energy
- Lack of monitoring and evaluation

The challenges ahead are:

- Watershed management is not linked to productivity and food security
- Watershed projects are more of donor driven and thus not sustainable
- Lack of implementation of action plans, policies and strategies
- Understanding the concept or system of watershed: Land, forest, livestock, crop, etc. and upstream and downstream linkages and management
- Bringing the responsibility of watershed management at household level

The possible opportunities in this area include:
At community level- it is possible to mobilise communities and build up on the local knowledge and experience of the farmers in order to use success stories as a learning process.

At institutional level- it is high time to implement the policy and strategies set, to follow participatory approach in designing, planning, implementing and monitoring and evaluation of watershed activities.

The solutions and recommendations on integrated water shed management are:

- Sector policy: Revise land proclamation No. 58/1994 in a way that promotes investment on agriculture and secure tenure right on land, tree and other resources.
- Develop proper land use policy and planning.
- Implement drafted agricultural policy.
- Implement and enact drafted natural resources management laws.
- Raise awareness on watershed degradation.
- Develop proper monitoring and evaluation system.
- Establish national information data center.

5. Enhancing livestock production for food security

The livestock population is decreasing in the conventional system of livestock production. In the intensive system, the livestock population is increasing whereas production is decreasing. Generally speaking, the number of browsing animals is increasing and the number of grazing animals is decreasing. Noticeable competition of land for crop production exists. There is extensive reduction of rangeland and deforestation of potential forage trees and shrubs and less attention is given to livestock feed deficit and only crop deficit seems of great importance at all levels. There is also a problem of skilled human resources in the livestock sector.

The constraints in livestock production include:

- Structural dismantling of the ARD, within the MoA (There is no institution at the moment which is responsible for livestock and rangeland development).
- Poor extension services in livestock sub-sector.
- Farmers are more interested in the number of animals than in the quality or productivity.
- Shortage of feed and watering points.
- Lack of proper land use planning.
- Lack of livestock information collection, documentation, and dissemination.
- Lack of pricing policy on animal products and animal feeds (forage and concentrate).
- Interference of people for settlement and land encroachment for horticulture and crop production.
- Deforestation for crop production and housing.
- Shortage of feed to livestock (poultry, dairy, honeybee, etc.).
- Animals are denied access to water and feed due to land clearing for crop and horticultural production.
- Lack of management of different livestock activities at institutional level.

The possible opportunities for livestock production in Eritrea are the existing livestock diversity, the market opportunity (local and export), the available human resources, proper rangeland management and development, and the available local/indigenous knowledge.

The possible solutions/recommendations include:

- Attention to the livestock sub-sector policy for instance, land use policy, drafting of pricing and marketing policy and animal breeding policy in addition to re-institutionalizing ARD.
- Livestock development should be given adequate attention and priority for instance the livestock industry has to be given equal opportunity with crop production.
- Scientific and modern commercial farms should be introduced.
- Proper breed identification (characterization) and conservation of genetic resources should be practiced.
- Livestock industry should be integrated with agro-industry and privatisation of livestock sector has to be encouraged.
- Trees and shrubs as animal feed and shelter should be conserved and identification and development of rangelands, enclosures and forage should be properly done.

- Veterinary services throughout the country need to be strengthened by establishing scientific breeding centers and a livestock early warning system.
- There should be proper monitoring of long and short term research activities for a better livestock production.

The role of gender in agricultural productivity and food security

Women are the major participants in the agricultural sector of the country contributing towards food security through many agricultural activities and through their active participation in community development. Women have an active role in poultry and small ruminant production, herding of livestock and producing, processing and selling of animal products and in horticultural crop production especially in small-scale vegetable production. However, the involvement of women in certain areas, for instance, as extension workers, is very limited. Nonetheless, in order to increase their contribution to food security, the following actions can be recommended:

- Decrease and share the burden of women in all activities related to crop production and assist them in the supply of inputs and facilities for crop production;
- Encourage the participation of women more in economic development programmes and decision making processes in the rural areas;
- Empower women socially and economically;
- Establish and practice gender friendly approaches as 50 to 60% of households are female headed;
- Draw extension workers, including women, from similar geographical and cultural settings as the farmers.

Annex 1 Workshop programme

Day 1: March 2, 2006

8:00–8:30	Registration of participants
	Chair: Dr. Bissrat Ghebru
8:30–8:35	Remarks by the Organizing Committee
8:35–8:40	Remarks by the AEAS Chairperson *Dr. Woldeselassie Ogbazghi*
8:40–8:50	Opening of workshop and keynote speech *H. E. Ato Arefaine Berhe, Minister, MoA*
8:50– 9:00	Keynote Speech 1 *H.E. Dr Wolday Futur, Minister, MoND*
9:00–9:10	Keynote Speech 2 *Mr Macleod Nyrongo, UNDP country REP*
9:10–9:40	The role of biotechnology in promoting agricultural production and attaining food security. *Tadesse Mehari, Dept. of Plant Sciences, UoA*
9:40–10:00	Discussion
10:00–10:30	**COFFEE/TEA BREAK**
	Chair: Dr. Teclemariam Zeggo
10:30–11:00	Impact of integrated food security project implemented in Northern Red Sea Zone, Eritrea *Mussie Fessehaye, Tesfalem Tekeste, Eyob Negusse, Aron Arefaine, and Tseggai Gherezghiher, Vision Eritrea*
11:00–11:30	The contribution of non-wood forest products to food security in Gash Barka *Woldeselassie Ogbazghi (UoA) and Estifanos Bein (MoA)*
11:30–12:00	The case for animal genetic resource management plan in Eritrea *Tecle Abraham, NARI, MoA*
12:00–12:20	Slide show, *Redaezghi Ghebremedhin, RAM Farm*
12:00–12:30	Discussion
12:30–2:00	*LUNCH BREAK*
	Chair: Dr. Woldeamlak Araia
2:00–2.30	Integrated watershed management: Socio-economic factors of water harvesting projects. *Fetsumberhan Ghebreyohannes, MoA*
2:30–3:00	Effect of growth regulators and waxing on the shelf life and quality attributes of Banana. *Biniam Mesfin, Dept. of Plant Sciences, UoA*
3:00–3:30	Women, agriculture and food security: The Eritrean perspective *Bissrat Ghebru and Woldeselassie Ogbazghi, UoA*
3:30–4:00	Discussion
4:00–4:30	**COFFEE/TEA BREAK**
	Chair: Ato Kidane Tsige
4:30–5:00	Rural institutions and food security in Eritrea: Preliminary findings from the central highlands and western lowlands *Sirak Mehari, Melake Tewolde, Kiflemariam Abraham, Greg Cameron*
5:20– 6:00	Discussions

Day 2: March 3, 2006

	Chair: Dr. Iyasu Ghebretatios
8:00–8:30	New paradigms in technology development: Exploring innovative approaches to linking agricultural research and practice *Ingrid Nyborg, Trygve Berg and Jens Aune, Norwegian University of Life Sciences*
8.30–9:00	Spate irrigation system: A boon to agricultural production and food security in Eritrea. *Mehreteab Tesfai, College of Agriculture, UoA.*
9:00–9:30	Dairy Constraint Analysis in Eritrea, with Special Emphasis on Asmara and Surrounding Dairy Farms *Ignatius Nsahlai and Alemseged Moges*
9:30–10:00	Discussion
10:00–10:30	**COFFEE/TEA BREAK**
10:30–12:00	Breaking into group sessions *Facilitators: Dr. Tadesse Mehari, Dr. Bissrat Ghebru, Teclu G/hiwet* Working group discussions
12:30–2:00	**LUNCH BREAK**
2:00 –2:30	Group discussions continue
	Chair: Ato Tecleab Misghina
2:30 –3:30	Working group presentations
3:30–4:30	Discussions
4:30–5:00	*COFFEE/TEA BREAK*
	Chair: Ato Semere Amlesom
5:00–5:30	Wrap up and discussion *Organizing committee*
5:30–5:45	Closing remarks, *Chairman of AEAS*

Workshop Rapporteurs: Hagos Yohannes, Tedros Kibrom, Sirak Mehari

Annex 2 List of participants

No	Name	Institution
1.	Abeba Tesfay	MoA
2.	Abrar Hassen	MLWE
3.	Abrha Garza	MoA, G/Barka
4.	Abrham Haile	Private
5.	Abrham Teklu	MoA, Debub
6.	Abubeker Osman	MoA, G/Barka
7.	Adugna Haile (Dr)	CA, UoA
8.	Alemseged Moges	MoA
9.	Alga Tewolde	MoA, Anseba
10.	Almaz Gezaie	MoA
11.	Almaz K/mariam	MoA
12.	Almaz Semere	MoA, RSD
13.	Amanuel G/tenseae	MoA, Debub
14.	Amnuel Negassi	MoA
15.	Andemicael Mesghina	CONCERN
16.	Andom Gebretnsae	MoA, NRS
17.	Andom K/mariam	MoTC
18.	Arefaine Berhe	MoA
19.	Asefaw Ghidey	MoA, Debub
20.	Asefaw Goitom	MoA, Anseba
21.	Asghedom Tewolde	MLWE
22.	Asmelash Asghedom	MoA, Debub
23.	Asmelash Wolday	NARI
24.	Asmerom Kidane	NARI
25.	Asmerom Mesfin	MoA, Maekel
26.	Asrat Haile	MoA, Maekel
27.	Aster Zerai	CA, UoA
28.	Ata Ibrahim Mohamed	Private
29.	Bahta Tedros	MoA, Debub
30.	Bereket Haileab	Private
31.	Bereket Tsehaye	Private
32.	Berhan Kiyar	HCA
33.	Berhane Habte	NARI
34.	Berketsehay Tiku (Dr)	Sawa Afhimbol
35.	Biniam Tsehaye	Private
36.	Bissrat Ghebru (Dr)	CA, UoA
37.	Btsuamlak Tsegai	MoA, Anseba
38.	Dagnew G/selassie (Dr)	CA, UoA
39.	Dagnew Kiflemariam	Private
40.	Dawit Giorgis	Private
41.	Dawit Solomon	HCA
42.	Eden Solomon	MoA, Maekel
43.	Efrem Araya	MoA
44.	Elyas Araya	CONCERN
45.	Ermias Asmelash	MoA
46.	Estifanos Bein	MoA, RSD
47.	Estifanos Seyum	MoA, SRS
48.	Fessehaye Tesfazion	MoA
49.	Fistum G/mariam	MoA, Debub
50.	Fisumberhan Desbele	MoA
51.	Fitsumberhan G/Yohanes	MoA
52.	Fithawi Mehari	CA, UoA

No.	Name	Institution
53.	Freyohannes Kidane	MoA, G/Barka
54.	G/Egziabhier H/michael	ATTI
55.	Geberemariam Hagos	MoA
56.	Gebrehiwet Haile	MoA, G/Barka
57.	Gebrehiwet Teame (Dr)	MoA
58.	Gebrekristos Mesmer	Private
59.	Gebremicael Habteab	MoA
60.	Ghebremiskel Hailu	Aligider
61.	Girmai Abraha (Dr)	MoND
62.	Goitom Asghedom (Dr)	CA, UoA
63.	Goitom Tekeste	MoA, G/Barka
64.	Greig Cameron (Dr)	CA, UoA
65.	Habte Gaym (Dr)	MoA, G/ Barka
66.	Habtemicael Tesfagaber	MoA, Anseba
67.	Haddish Moges	MoA, RSD
68.	Hagos Yohannes	MoA
69.	Haile Awalom	Maekel
70.	Haile Beraki	NARI
71.	Haileab G/Egziabihier	MoA, Maekel
72.	Haileab Kahsay	MoA
73.	Huruy Asghedom	MoA
74.	Ibrahim Mohmed Afendi	MoA
75.	Ibrahim Suleman (Dr)	
76.	Iyassu G/tatios (Dr)	NARI
77.	Iyassu Yohannes	MoA
78.	Iyob Berhane	Private
79.	Iyob Zerimaram	TICD, Tokor
80.	Jaber Ahmed	MoA, Anseba
81.	Jemal Siraj	Maekel
82.	Kesete G/giorgis	MoA, NRS
83.	Kibra Gebremeskel	MoA, Anseba
84.	Kidane G/Kidan	MoA
85.	Kidane Tekle	MoA, Anseba
86.	Kidane Tsige	MoND
87.	Kifle Negash	LWF
88.	Kiflemariam Abraha	NARI
89.	Leula Mekonnen	MoA, RSD
90.	Macloed Niyrongo (Mr)	UNDP
91.	Measho Tesfamariam	MoA, Debub
92.	Meaza Abraha	MoA
93.	Meaza Ghebremeskel	CAS
94.	Mebrahtom Asgodom	MoA, Anseba
95.	Mebrahtom Asgodom	MoA, Anseba
96.	Mebrahtom Hagos	MoA, RSD
97.	Mebrahtu Iyassu	MLWE
98.	Mebrahtu Solomon	Gov't Garage
99.	Mebrat Abraham	MoA, Maekel
100.	Mehari T/yohannes	MoA
101.	Mehreteab Tesfai (Dr).	CA, UoA
102.	Mengistu Rusom	HCA
103.	Mengsteab Debesay	MoA, SRS
104.	Mengsteab G/salassie	CA, UoA
105.	Mesfin Kidane	MoA, Debub
106.	Michael H/Mariam	MoF
107.	Michael Kassa	MoA, G/Barka
108.	Michael Tesfagaber	MoA, Debub

No.	Name	Institution
109.	Miraf Solomon	MoA, Maekel
110.	Mohamed Mahmud	MoA, G/Barka
111.	Nega Gedamu	MoA, Debub
112.	Nega Tesfamariam	MoA, Debub
113.	Negusse Abraha	NARI
114.	Netshti Abbay	NARI
115.	Nigisty Seyum (Dr)	MoA, RSD
116.	Nugusse Ogbamichael	MoA, Debub
117.	Ogbazgi Kifle (Dr)	MoA, Debub
118.	Ogbeab G/michael (Dr)	MoA, RSD
119.	Okbit Bahta	TICD, Tokor
120.	Osman Mohamed Ali	MoA, Anseba
121.	Redaezghi Ghebremedhin	RAM Farm
122.	Rezene Tewolde	MoA, Debub
123.	Rufael T/zion	MLWE
124.	Saba Ghebreselassie	Anseba
125.	Salah Egwali	MoA, G/Barka
126.	Saleh Mahumud Gulai	NARI
127.	Samson Andom	MoA, Anseba
128.	Samuel Asghedom	CA, UoA
129.	Samuel Haile	MoA, NRS
130.	Semere Amlesom	Hamelmalo, CA
131.	Semere Ghebrehiwet	MoA, RSD
132.	Semere Russom	Governor, Maekel
133.	Sirak Mehari	CA, UoA
134.	Solomon Fesseha	LWF
135.	Solomon Haile	MoA
136.	Stepane Halgand (Mr.)	EU
137.	Tadesse Kibreab (Dr)	MLWE
138.	Tadesse Mehari (Dr)	CA, UoA
139.	Teame Asfha	Park Semaetat
140.	Tedros Mekonen	MoA, Anseba
141.	Tekeste K/mariam	MoA, G/Barka
142.	Tekie G/Amlak	MoA, Anseba
143.	Tekle W/tensae	MoA, SRS
144.	Tekle Abraham	NARI
145.	Tekle Almseged	MoA, NRS
146.	Tekleab Mesgina	MoA, RSD
147.	T/haimanot G/Salassie (Dr)	NARI
148.	Teklemariam Berhane	NARI
149.	Teklemariam G/hiwet	MoA, SRS
150.	Teklezgi Tekie	MoA, G/Barka
151.	Teklu G/hiwet	Private
152.	Teklu Seyum	MoA, Debub
153.	Tesfai Fessehaye	MoA, Anseba
154.	Tesfai G/Mariam	MoA, Debub
155.	Tesfai Yosief	MoA, RSD
156.	Tesfalem Beraki	MoA, G/Barka
157.	Tesfalem T/giorgis (Dr)	MoA, RSD
158.	Tesfasalassie G/Mariam	MoA
159.	Tesfit G/egziabher	MoA, NRS
160.	Tiberh G/egziabher	MoA, Maekel
161. .	Tseggai Gherezghiher	Vision Eritrea

No.	Name	Institution
162.	Tsegai Tesfai (Dr)	NARI
163.	Tsegai Tewelde	MoA
164.	Tsehaye Woldemichael	CA, UoA
165.	Umer Jaber	HCA
166.	Wolday Futur (Dr)	MoND
167.	Woldeamlak Araya (Dr)	CA, UoA
168.	Woldegebriel Tareke	Private
169.	Woldemicael Abraha	MoA, G/Barka
170.	Woldesalassie Ogbazghi (Dr)	CA, UoA
171.	Woldu Mesfin	Private
172.	Woldu Tekle	MoA, G/Barka
173.	Yemane T/yohannes	NFIS
174.	Yergalem Solomon	Private
175.	Yohannes Beyene	MoA
176.	Yohannes K/mariam	MoA, Anseba
177.	Yonas Mengesteab	MoA, SRS
178.	Yonas Woldu	MoA, SRS
179.	Yonatan Beyene	NARI
180.	Yosief Admekom	UNDP
181.	Zekaria Abdelkerim (Dr)	COMSAT
182.	Zerabruk Abrhe	MoA, SRS
183.	Zerai Haile	Sawa Afhimbol
184.	Zerimariam G/Micael	NARI
185.	Zerit Tedros	TICD, Tokor
186.	Zimam Sebhatu	MoA
187.	Zufan Mekonnen	Private

Ministries and organisations which participated in the workshop

No	Organisation
1.	ACORD
2.	British Embassy
3.	CARE International
4.	CONCERN
5.	FAO – Food and Agriculture Organization
6.	ICCO – Interchurch Organisation for Development Co-operation
7.	Embassy of Israel
8.	Embassy of Italy
9.	LWF – Lutheran World Federation
10.	MoE – Ministry of Education
11.	MoI – Ministry of Information
12.	MoLWE – Ministry of Land, Water and Environment
13.	MoND – Ministry of National Development
14.	Office of National Security
15.	Royal Netherlands Embassy
16.	Royal Norwegian Embassy
17.	National Union of Eritrean Women
18.	National Union of Eritrean Youth and Students
19.	SLM (Sustainable Land Management Programme)
20.	TICD (Toker) Toker Integrated Community Development Programme
21.	UNDP – United Nations Development Programme
22.	Embassy of the United States
23.	Vision Eritrea

Annex 3 Tigrigna translation of abstracts

ጽሟቕ ናይ'ቶም ኣብ'ቲ

"መሃዝነታዊ ኣገባብ ንምርግጋጽ ውሕስነት መግቢ ኣብ ኤርትራ: ሓፈሻዊ ኣንፈት፡ ብጾሆታትን ተኽእሎታትን ንዕብየት"

ብዝብል ቴማ ካብ 2-3 መጋቢት 2006 ዝተጋብአ ዓውደ መጽናዕቲ ዝቐረቡ ጽሑፋት

ተራ ባዮቴክኖሎጂ ኣብ ምድንፋዕ ሕርሻዊ ምህርትን ምርግጋጽ ውሕስነት መግብን

ብታደሰ መሓሪ
ኮሌጅ ሕርሻ፡ ዩኒቨርሲቲ ኣስመራ፡ ቁ. ሳ. ጶ. 1220 ኣስመራ፡ ኤርትራ

ኣብዚ እዋን'ዚ መጠን ህዝቢ ዓለም ኣስታት ሽዱሽተ ቢልዮን ክምዝበጽሕ፡ 80 ሚልዮን ኣብ ዓመት እንዳወሰኸ ክኣ ኣብ 2025 ናብ ልዕሊ ሾሞንተ ቢልዮን ክብ ክምዝብል ይግመት። ካብ'ዚ ዝተጠቕሰ 95% ወሰኽ ህዝቢ ኣብተን ኣብ ምምዕባል ዝርከባ ሃገራት ከም ዝኸውን ይንገር። ኣብዚ እዋን ኣዚ ኣስታት 0.8 ቢልዮን (800 ሚልዮን) ህዝቢ ዓለም ውሕስነት መግቢ ዘይብሉ ክኸውን ከሎ፡ መዓልታዊ ክኣ 40,000 ሰባት ብጥምየትን ምስኡ ብዝተሕሓዘ ጠንቅታትን ይሞቱ።

ኣብ ኣፍሪቃ ዘሎ ኩነታት ከኣ እቲ ዝኸፍአ እዩ። ኣፍሪቃ ብ 3.1% መጠን ዕብየት ካብተን ዝበዝሐ ደረጃ ዕብየት ዘመዝግባ ኣህጉር ኮይና ኣብዚ እዋን'ዚ ብዝሒ ህዝባ 550 ሚልዮን ይበጽሕ። ድሕሪ 25 ዓመት ከኣ ናብ 1.3 ቢልዮን ክብ ክምዝብል ይግመት። ኣስታት 55-60% ኣብ ትሕተ ሳሃራ ኣፍሪቃ ኣብ ገጠር ካብ ዝነብሩ ህዝቢ መዓልታዊ መነባብሮኦም ብትሕቲ ሓደ ዶላር ኣሜሪካ ስለዝመርሑ ብድኽነት ኣዝዮም ዝተጠቕዑ እዮም። በዚ መሰረት'ዚ እምበኣርከስ ንዓለምና ኣንጸላልዮምዋ ካብ ዝርከቡ ቐንዲ ብድሆታት እዞም ዝስዕቡ እዮም፡

ሀ- ነቲ ብኣዝዩ ልዑል ናህሪ እናወሰኸ ዝኸይድ ዘሎ መጠን ህዝቢ ዓለም ክግበር ዘለዎ ምድላዋትን ምቅርራባትን፡

ለ- ውሕስነት መግቢ ናይ'ዚ ብልዑል ናህሪ ዝውስኽ ዘሎ ህዝቢ ዓለም ምርግጋጽ፡

ሐ- ውሑስን ቀጻልነት ዘለዎን ኣገባብ ተኸቲልካ ፍርያት ሕርሻ ምድንፋዕ፡

ኣብ 2025 ዓ.ም. ነቲ እናወሰኸ ዝኸይድ ዘሎ መጠን ህዝቢ ዓለም ዘድሊ ፍርያት እኽሊ ካብቲ ዘለዎ ዓመታዊ 2 ቢልዮን ሜትሪክ ቶን ናብ 4 ቢልዮን ክብ ክብል (ብዕጽፊ ክውስኽ) ከምዘለዎ'ዩ ዝእመት። እዚ ወሰኽ ሕርሻዊ ፍርያት'ዚ ከኣ መሬት ብምስፋሕን ልዑል መስኖኣዊ ማይ ብምጥቃምን ዘይኮነስ፡ ዝተመሓየሸ ምዕቡል ኣገባብ ሕርሻ ብምትእትታው ክኸውን ይግባእ። ምኽንያቱ ከኣ ቁጽሪ ህዝቢ ክብ ኣብ ዝብለሉ እዋን ትሕዝቶ መሬትን ማይን በብእዋኑ እናነከየ ስለዝኸይድ እዩ።

ተራ ባዮቴክኖሎጂ ኣብ ምርግጋጽ ውሕስነት መግቢን ምዕቃብ ኣከባብን ምንካይ ድኽነትን ኣዝዩ ሓጋዚ ምዃኑ ብስነ ፍልጠታዊ መጽናዕትታት ተረጋጊጹ'ዩ። ኣብ ሓጺር እዋን ዓይነትን ብዝሕን ፍርያት ሕርሻ ክብ ንምባል ዝሕግዝ ኣገባብ ብምዃኑ ከኣ ዓቢ ተስፋ ተነቢርሉ ዘሎ መሳርሒ ምዕባለ'ዩ። ካብ ዝሓለፉ ዓሰርተታት ዓመታት ጀሚሩ ከኣ ኣዝዮም ምዕቡላት ቴክኖሎጂታት (ጂን-ቴክኖሎጂ) ብምትእትታው ኣዝርእትን ካልእ ሕርሻዊ ምህርትን ብምምሕያሽ ኣብ ጥቕሚ

ደቂሰባት ከምዝውዕሉ ኣብ ርእሲ ምግባሩ፡ ነተን ኣብ ምምዕባል ዝርከባ ሃገራት'ውን ሕርሻዊ ኣቶተን ንኸደንፍዓ ሓጊዝወን'ዩ።

እዚ መጽናዕታዊ ጽሑፍ'ዚ ኣምበኣርከስ እቶም ንኤርትራ ጠቐምቲ'ዮም ዝብሃሉ ቴክኖሎጂታት ብኸመይ መገዲ ኣተኣታቲኻ ውሑስን ቀጻልነት ብዘለዎ መገዲን ኣብ ሓጺር እዋን ውሕስነት መግቢ ክረጋገጸሉ ዝኽእል ኣገባባት ክዝርዝር ክፍትን'ዩ።

ውሁድ ፕሮጀክት ውሕስነት መግብን ጽልውኡን ኣብ ዞባ ሰሜናዊ ቀይሕ ባሕሪ

ብሙሴ ፍስሃየ: ተስፋኣለም ተኸስተ: ኢዮብ ንጉሰ: ኣሮን ኣረፋይነን ጸጋይ ገብረእዝጊኣብሄርን

ቪዥን ኤርትራ: ቁ. ሳ. ጶ. 5571: ኣስመራ: ኤርትራ

ነበርቲ ዞባ ሰሜናዊ ቀይሕ ባሕሪ መነባብሮኦም ኣብ መጓሰን ሕርሻን ዝተሞርከሰ እዩ። ንውሕስነት መግቢ ብዝምልከት ምስ ካልኦት ዞባታት ኣነጻጺርካ ብተዛማዲ ኣብ ዝተሓተ ደረጃ ከም ዝርከቡን፡ ዝለዓለ መጠን ዋሕዲ መግቢ (ማለት 23%) ከምዘለዎምን ይፍለጥ።

ጠንቂ ናይ'ዚ ድማ ተደጋጋሚ ደርቂ፡ ዝተናወሐ ኵናት፡ ሰበኽ ሳግማዊ መነባብሮን ድሑር ልምዳዊ ማሕረስን እዮም። ስለዚ ቀንዲ ዕላማ ናይዚ ፕሮጀክትዚ ንተጠቀምቲ ምስ መሬቶም ዘለዎም ሌላ ብምሕያል፡ ብመገዲ ምፍራይ ኣሕምልቲ እቶቶም ክብ ኣቢልካ ውሕስነት መግቢ ብደረጃ ስድራቤት ንምርግጋጽ'ዩ። ኣገባብ ኣተገባብርኡ ድማ ሓጺር ዝዕምቆቶም ብኢድ ዝተኻዕቱ ዒላታት ብምህናጽ፡ ሞተር ማይ ምስ ሻምብቆታቱ (ቱቦታት) ብምዝርጋሕ፡ ግብራዊ ስልጠናታት ኣብ ምፍራይን ኣጠቓቕማን ኣሕምልቲ ብምሃብ፡ መጠነ ንኡስ መስኖኣዊ ሕርሻ ምምስራት እዩ። እዚ ፕሮጀክት'ዚ ካብ ንኡስ ዞባ ቃሮራ ክሳብ ንኡስ ዞባ ገልዓሎ ኣብ ዝዝርጋሕ 30 ነቑጣታት ዝነብሩ 629 ሰበኽ-ሳግም ስድራቤታት'ዩ ተተግቢሩ። ምፍራይ ኣሕምልቲ ድማ ከም መመላእታ ዕለታዊ መግቦምን ምንጪ ኣታዊኦምን ርእዮም ከምዝሰርሑሉ ተጌሩ። እምበኣርከስ እዚ መጽናዕቲ'ዚ ከም'ዚ ዝኣምሰለ መጠነ ንኡስ መስኖኣዊ ሕርሻ ኣተኣታቲኻ ቀጻልነት ዘለዎን ዝሓሸ ኣቶትን ብምኽዕባት ኣብ ነዊሕ ግዜ ውሕስነት መግቢ ምርግጋጽ ከምዝከኣል ይሕብር።

ኣበርክቶ ዘይ-ዕንጸይታዊ ውጽኢት ኣግራብ ኣብ ምርግጋጽ ውሕስነት መግቢ ኣብ ዞባ ጋሽ ባርካ

ብወልደስላሴ ዑቕባዝጊን[1] እስቲፋኖስ በይንን[2]
[1] ኮሌጅ ሕርሻ ዩኒቨርሲቲ ኣስመራ [2] ሚኒስትሪ ሕርሻ ኣስመራ

ኣብ ዞባ ጋሽ ባርካ ዝርከቡ እጽዋት ብዙሓት ኣገደስቲ ኣግራብን ቆጥቋጥን ኣለዎም። ካብ'ዞም እጽዋት ዝርከቡ ዘይ-ዕንጸይታዊ ውጽኢት ኣግራብ ቀንዲ ምንጪ ስድራቤታዊ ቁጠባ ኣብ ርእሲ ምዃኖም ኣብ ምርግጋጽ ውሕስነት መግቢ ኣበርክቶኦም ዕዙዝ እዩ። ቀንዲ ዕላማ ናይ'ዚ መጽናዕቲ'ዚ ምግምጋም ኣበርክቶ ዘይ-ዕንጸይታዊ ውጽኢት ኣግራብ ኣብ ገጠራት ብደረጃ ስድራቤት ብመንጽር እቶታውነት: ቁጠባዊ ዓቕምን ቀጻልነትን ምርግጋጽ እዩ። እዚ መጽናዕቲ'ዚ ኣብ ዓመተ 2003-2004 ኣብ ንኡሳን ዞባታት ሎጎ ዓንሰባ: ኣቑርደት: ሞጎሎ: ሻምብቆ: ጎኒ: ሃይኮታ: ኣውጋሮ: ጎሉጅን ባረንቱን ዝተኻየደ ኮይኑ 110 ዘይ-ዕንጸይታዊ ውጽኢት ኣግራብን ቆጥቋጥን ክልለዩን ክስነዱን ክኢሎም ኣለው። እዞም ዘይ-ዕንጸይታዊ ውጽኢት ኣግራብ ከኣ ከም መግቢ እንስሳ: ፍረታት: ኣሕምልቲ: መኸደኒ ናሕሲ: ብዕሪር: ዕጣን: ላተክስ: መለስለሲ ቆርበት (tannin): ሕብሪ: ዓካት: ካዕካዕ: ቀመም: መማቕርቲ: መስተ: መሕጸቢ: ዘይቲ: ፈውሲ: ጸረ ባልዕ: ጥሽ: መኽስተርን መወጽን የገልግሉ። ኣብ ከባቢ ገማግም ሩባታት ዝሰፍሕ ዘሎ ኣብ መስኖን ዝናብን ዝተሞርከሰ ሕርሻ፣ ምብራስ ናይ'ዞም ኣግራብ እዚኣቶም የስዕብ ኣሎ። እዚ መጽናዕቲ'ዚ ኩነታት ማሕበረ ቁጠባ ንምግምጋም ኣሳታፊ ዝኾነ ኣገባብ ብምኽታል ብማሕረስ: ብመጓሰ: ከምኡ'ውን ብማሕረስን ብመጓሰን (ኣጣሚሮም) መነባብርኦም ዝመርሑ 92 ተወከልቲ ስድራቤታት ተሳቲፎምዎ። ልምዳዊ ኣጠቓቕማን ምሕደራን ናይ'ዞም ኣግራብ ከኣ ብኤትኖ-ቦታኒካዊ ኣገባባት ተጸኒዖም።

ዘይ-ዕንጸይታዊ ውጽኢት ኣግራብ ምስ ምህርቲ እኽሊ: ውጽኢት እንስሳን ከምኡ'ውን ምስ ካብ ሕርሻዊ ንጥፈታት ወጻኢ ዝርከቡ እቶታት ክነጻጸር እንከሎ 14% ካብ ገጠራዊ ቁጠባ ስድራቤት ይሽፍን። ዘይምዕሩይ ምሕደራን ኣጠቓቕማን ጸጋታት ኣግራብ ንቐጻልነት ዘይ-ዕንጸይታዊ ውጽኢት ኣግራብ ቀንዲ ማሕንቖታት ኮይኖም ይርከቡ። ንነበርቲ ዓዲ ሓላፍነት ምሃብ ናይ ዋንነት ስሚዒት ከማዕብለሎም ስለዝኽእል ኣብ ምዕቃብ እዞም ኣግራብ ዝሓሸ ዕድል ከም ዝህሉ እዚ መጽናዕቲ'ዚ ይሕብር። ነዚ ንምርግጋጽ ከኣ ፖሊሲ ዝነድፉን ዝሕንጽጹን ኣካላት፣ ንምዕቃብን ኣጠቓቕማን ኣግራብ ዝሕግዝ መምርሒታት መታን ከውጽኡ ብዛዕባ ጥቕምን ኣድላይነትን ዘይ-ዕንጸይታዊ ውጽኢት ኣግራብ እኹል ሓበሬታ ክወሃቦም ይግባእ።

ውጥን ምሕደራ ተወርስኣዊ ሃብቲ (Genetic Resource) እንስሳታት ኣብ ኤርትራ

ብተኽለ ኣብራሃም
ሃገራዊ እኒስቲትዩት ምርምር ሕርሻ (NARI): **ቁ. ሳ. ጳ.** 4627 **ሓልሓለ: ኤርትራ**

ምርባሕ ዘቤታዊ እንስሳታት ሓደ ካብቶም ኣገደስቲ ጸጋታት ንቑጠባዊ ምዕባለን ውሕስነት መነባብሮን'ዩ። ሰፊሕ ሂወታዊ ብዙሕነት ናይዘን ዘቤታዊ እንስሳታት እዚኤን ንህላዊኤን ብዘይካ ኣብቲ ዘይምቹእ ከባቢታት ኣብ ርእሲ ምርግጋጹ ዝተፈላለየ ውጽኢታትው'ን ከም ዝህባ ገይሩወን'ዩ።

ኣብ'ዚ እዋን'ዚ ኣዝዮም ብዙሓት ዘቤታውያን እንስሳታት ጸኒቶም እቶም ዝተረፉ'ውን ናይ ምጽናት ሐደጋ የንጸላልዎም ኣሎ። ብተወሳኺ ምጽናት ተውርስኣዊ ሃብቲ እንስሳታት ኣብ ቀጻልነት ፍርያምነትን ምርግጋጽ ውሕስነት መግብን ሓደጋ ከስዕብ ተኽእሎታት ኣሎ። ስለዝኾነ ከኣ ነዚ እቓልቦ ዝሓትት ምዕቃብ ተውርስኣዊ ሃብቲ እንስሳታት ዓለማዊ ተቐባልነት ኣውሒሱ ጥራይ ዘይኮነስ ሓያሎ ሃገራት'ውን ኣብ ትግባረ ውጥን ሃብቲ እንስሳታት ኣተግቢረናኦን ነዊሕ ሰጕመንን ይርከባ። ብዓለምለኻዊ ተበግሶታት እቶም ዕድላት እንተተዘርግሑ'ኳ ኤርትራ ዘለዋ ተውርስኣዊ ሃብቲ እንስሳታት ንኽተማሓድር ክሳብ ሕጂ ኣድላዪ ስጉምትታት ክትወስድ ኣይክኣለትን።

እዚ መጽናዕታዊ ጽሑፍ'ዚ ሓፈሻዊ ስእሊ ዓለምለኻዊ ተበግሶ: ንብዙሑነት ተውርስኣዊ ሃብቲ እንስሳታት ኣብ ኤርትራን: ዝተቐስመ ትምህርቲ ንምዝርዛርን ከምኡውን እዞም ጸጋታት እዚኣቶም ቀጻልነት ብዘለዎ ኣገባብ ተዓቂቦም ኣብ ጥቕሚ ዝውዕልሉ መንገዲ ንምንዳይን ዝዓለመ'ዩ።

ስርዓተ-መስኖ ጀሪፍ: ዓበ ኣበርክቶ ንሕርሻዊ እቶትን ምርግጋጽ ውሕስነት መግብን ኣብ ኤርትራ

ብምሕረትኣብ ተስፋይ
ኮሌጅ ሕርሻ: ዩኒቨርሲቲ ኣስመራ ቁ. ሳ. ጳ. 1220 ኣስመራ: ኤርትራ

እዚ መጽናዕታዊ ጽሑፍ'ዚ ንተኽእሎን ጽልዋን ስርዓተ-መስኖ ጀሪፍ ኣብ ምዕባይ ምህርቲ ሕርሻን ምርግጋጽ ውሕስነት መግብን ኣብ ኤርትራ ዝምልከት እዩ። ቀንዲ መወከስን መበገስን ናይ'ዚ መጽናዕታዊ ጽሑፍ'ዚ ካብ 1997-2001 ብደራሲ ናይዚ ጹሑፍ'ዚን ብኻልኦት ተመራመርቲ ዝተኻየዱ መጽናዕትታት እዮም።

ስርዓተ-መስኖ ጀሪፍ ወቕቲ ሓልዮም ኣብ እዋን ክራማት ንዝውሕዙ ወሓዝቲ ኣሊኻ ኣብ ኣከባቢኦም ንዝርከቡ ግራውቲ ቅድሚ ምዝራኦም ማይ ንምስታይ ዝካየድ ኣገባብ መስኖ እዩ። ኣብ ኤርትራ መስኖ-ጀሪፍ ሰለስተ ተዛማዲ ረብሓታት ኣለዎ። ቀዳማይ፡ ውሑድ ዓቐን ዝናብ (ትሕቲ 200 ሚሜ ኣብ ዓመት) ዝረክብ ቆላታት ኤርትራ መስኖ ጀሪፍ ተጠቂሙ ዝተፈላለዩ ኣዝርእቲ ከብቁል ይኽእል። ካልኣይ፡ ሃብታም ሚነራላዊ ትሕዝቶ ዘለዎ ድበት (sediment) ካብ'ቲ ውሕጅ ተኣልዮ ትሕዝቶ ሚነራል ግራውቲ ይውስኽ። ሳልሳይ: እቲ ካብ በረኽቲ ቦታታት ተኢሒጊጉ (ተጸይሩ) ናብ ባሕሪ ዝፈስስ ዝነበረ ማይን ፍርያም ሓመድን ኣብ መዓላ ውዒሉ ሕርሻዊ እቶት ክብ ንምባልን ኩነታት ሓመድ ንምምሕያሽን ይሕግዝ። ትሕዝቶን ዓቐንን ማይ ኣብ ውሽጢ ሓመድ ናይ'ቲ ብመስኖ-ጀሪፍ ዝለምዕ መሬት ብገምጋም ናብ 42% ይበጽሕ። እዚ ዓቐን ማይ'ዚ ምስ'ቲ ብኻልእ ኣገባብ መስኖ ኣብ ግብሪ ዝውዕል ማይ ክነጻጸር እንከሎ ኣዝዩ ብዙሕ እዩ። ኣብ ሽዕብ: ብመስኖ-ጀሪፍ ዝለምዕ ሕርሻ ኣብ ዓመት 140 ቶን ኣብ ሓደ ሄክታር ዝተፈላለየ ትሕዝቶ ዘለዎ ልሙዕ ሓመድ ይእከብ። ሓፈሻዊ ማዕድናዊ ትሕዝቱኡ ድማ 200 ኪሎ ግራም ናይትሮጅን: 100 ኪሎግራም ፎስፎረስ: 1,400 ኪሎግራም ድማ ፖታሽዩም እዩ። በዚ መሰረት ድማ ንእቶት መሸላ ምስ ካብ ዝናብ ተጸቢኻ ዝለምዕ ሕርሻ ክነጻጸር እንከሎ ብክልተ ክሳብ ሰለስተ ዕጽፊ (2-2.5 ቶን/ሄክታር) ከም ዝውስኽ ይገብሮ። ንኣብነት ኣብ ዓመተ 1997/98 ኣብ ሽዕብ ብኣገባብ መስኖ-ጀሪፍ ካብ ዝለምዐ ሕርሻ 3,700 ቶን ዝያዳ እቶት እኽሊ ተሓፊሱ። እዚ ተወሳኺ እቶት'ዚ ከኣ ነቲ ካብ ተረፈ-ምህርቲ ሕርሻ ዝርከብ መግቢ እንስሳ ከብ ኣቢልዎ። ብዙሓት መጽናዕትታት ከምዝሕብርዎ፡ ኣብ ኤርትራ ሕርሻዊ ፍርያምነት ንምዕባይን ውሕስነት መግቢ ንምርግጋጽን ነዞም ዝስዕቡ ነጥብታት ምትግባር የድሊ:-

1. ንመእለዪ ወሓይዝ ዘገልግሉ ትሕተ ቅርጽታት ብቀጻልነት ክሰርሑን ኽተዓራረዩን፡
2. ዓቐን ናይ'ቲ ብመስኖ-ጀሪፍ ዝለምዕ ዘሎ መሬት ምስፋሕ፡
3. ንሰደድ ዝዓለሙ ልዑል ዋጋ ዘለዎም ኣዝርእቲ ምዝራእ፡
4. ትሕተ ቕርጽን ማሕበራዊ ኣገልግሎትን ገጠራት ከምዝመሓየሹ ምግባር።

እዚ ኣገባብ'ዚ ውሕስነት መግቢ ብምርግጋጽ ካብ ትጽቢት ረዲኤት ነጻ ኮይንና ብመግቢ ርእስና ንምኽኣል ሓጋዚ'ዩ።

ሳዕቤን ተቐጻጸርቲ ዕብየትን ምልካይ ስምዕን (wax) ኣብ ዕድመን ዓይነትን ባናና

ብቢንያም መስፍን
ኮሌጅ ሕርሻ: ዩኒቨርሲቲ ኣስመራ: ቁ. ሳ. ጶ. 1220 ኣስመራ: ኤርትራ

ባናና ሓደ ካብ'ቶም ቀንዲ ኣብ ቅናታዊ መሬት (ትሮፒክስ) ዝርከባ ሃገራት ዝፈርዩን ድሕሪ ምእታዎም (ምቐራጾም) ቀልጢፎም ዝበላሸውን ዓይነት ፍረታት'ዩ። እዚ ኩነታት'ዚ ድማ ንመጠን: ምህርትን መሸጣን ባናና ኣብ ዕዳጋ ይጸልዎ። ኣብዚ መጽናዕቲ'ዚ ጂበርሊክ ኣሲድ (GA_3)፡ ኢንዶል ቡትሪክ ኣሲድን (IBA) ካርኑባ ዋክስን ድሕሪ ምእታው (ምቑራጽ) ባናና ኣብ ዕድሚኡን ዓይነቱን ዝህልዎም ጽልዋ ተገምጊሙ። ባናና ን 56 መዓልትታት ኣብ ዝተፈላለየ መጠን ሙቐት (12ን 15ን 22ን ዲግሪ ስንቲግሬድ) ብምኽዛን መጠን ምጉዳል ክብደት: ለውጢ ሕብርን ትርን ከምኡ'ውን መጠነ-ምስትንፋስ ናይቲ ባናና ኣብ ነፍስ ወከፍ ሰሙን ተጸኒዑ። ከምኡ'ውን መጠን ናይ'ቶም ኣብ ፈርሲ ባናና ዝርከቡ ሓቖቕቲ ነገራትን ኦርጋኒክ ኣሲድን (Organic acids) ኣብ መጀመርታን ኣብ መወዳእታ ናይ ምኽዛን ግዜኦምን ተዓቂኑ። መጠን ምጉዳል ክብደት: ምልስላስን ዓቕሚ ምስትንፋስን ባናና ኣብ ዝተገብረሉ ክንክን ከይተሞርኮሰ ብመጠን ምውሳኽ ናይ ምኽዛን መዓልትታትን ሙቐትን ክብ ከምዝብል ተረጋጊጹ። እንተኾነ ግን ኣብ ኩለን መኽዘኒ ሙቐት: ምልካይ ስምዒ: ምጥቃም GA_3ን IBAን ነቲ ዝነበረ ረቛሒታት ብመንጽር እቶም ክንክን ዘይተገብረሎም ክነጻጸሩ እንከለው ኣዝዮም ($p<0.001$) ከምዝንክዩ ተገምጊሙ። ከም ውጽኢቱ ከኣ ነቲ ድሕሪ ምቑራጽ ዘሎ ዕድመ ባናና ኣናዊሓሞ። ስለዚ ምልካይ ስምዒ ኣዝዩ ውጽኢታዊ ክኸውን እንከሎ ምጥቃም GA_3 ከኣ ኣብ ካልኣይ ደረጃ ተሰሪዑ ይርከብ። ብተወሳኺ ኣብ ዓይነት ባናና ድሕሪ ምኽዛን ኽስዕቡ ንዝኽእሉ ለውጥታታ ምልላይ ኣብ ዝተወስዱ መዐቀኒታት ርኡይ ፍልልይ ($p<0.05$) ኣይተራእየን። ስለ'ዚ ድማ ውጽኢት ናይ'ዚ መጽናዕቲ'ዚ ኣገባብ ኣተሓሕዛ ፍረታት ድሕሪ ምቑራጾም ዕድሚኦም ዘናውሕ ጥራይ ዘይኮነስ ንብሉጽነቶም እውን ክዕቅቦ ከምዝኽእል ይሕብር። ስለ'ዚ ምልካይ ስምዒን GA_3ን IBAን ዕድመ ፍረታት ድሕሪ ምቑራጾም ንምንዋሕን መኣዛዊ ትሕዝትኦም ንምዕቃብን ከም ኣማራጺ ክገልግሉ ከምዝኽእሉ የረጋግጽ። እዚ ኣገባብ'ዚ ድማ እኹል ቀረብ ፍረታት ብቐጻሊ ኣብ ዕዳጋ ንኽህሉ ይሕግዝ።

ደቂኣንስትዮን፡ ሕርሻን ውሕስነት መግብን ኣብ ኤርትራ

ብብስራት ገብሩን ወልደስላሴ ዑቕባዝጊን
ኮሌጅ ሕርሻ: ዩኒቨርሲቲ ኣስመራ: ቁ. ሳ. ጶ.1220 ኣስመራ: ኤርትራ

እዚ መጽናዕቲ'ዚ ንተራ ደቂኣንስትዮ ኣብ ምድንፋዕ ሕርሻን ምርግጋጽ ውሕስነት መግብን ኣብ ኤርትራ ዝድህስስ እዩ። ኣብ ኤርትራ ብዘጋጥም ተደጋጋሚ ደርቂ፡ ሕማም እንስሳ፡ ዋሕዲ መግቢ እንስሳ ከምኡ'ውን ዘየድምዕ ያታዊ ኣገባብ ማሕረስን ድሩት ውጽኢት ቴክኖሎጂን ኣብ ፍርያት ሕርሻ ዓቢ ሃስያ ከም ዘስዕብ ይፍለጥ። ከም ፍታሕ ናይዞም ዝተጠቕሱ ሽግራት ከኣ ኣዝዮም

ዝማዕበሉ ሕርሻዊ ተክኖሎጂታት ምትእትታው ጥራይ ዘይኮነ፡ ተሳትፎ ኩሉ ህዝቢ ብፍላይ ድማ ተሳትፎ ደቂኣንስትዮ ኣብ ምድንፋዕ ሕርሻዊ እቶትን፡ ምዕሩይ ምክፍፋልን ምጥቃም መግቢን ምርግጋጽ እዩ። ይኹን ደኣ እምበር፡ ክሳብ ሕጂ ኣዕጋቢ ዝኾነ ስርዓተ-ሓበሬታ ብፍላይ ድማ ተራ ደቂ ኣንስትዮ ኣብ ሕርሻ፡ ያታዊ ፍልጠትን መሃዝነትን ደቂ ኣንስትዮ ኣብ ምድንፋዕ ኣቶት ሕርሻ ኣተኩሩ ዝድህስስ መጽናዕቲ የለን።

እዚ መጽናዕቲ'ዚ እምበኣር ተራ ደቂ ኣንስትዮ ኣብ ውሕስነት መግቢ ብፍላይ ድማ ኣብ እቶትን፡ ዝርጋሔን፡ ኣጠቓቕማን፡ ዘቤታውነት ኣእካልን እንስሳን ከምኡውን ኣገባብ ምብዳህ ሽግራትን የተኩር። ነዚ መጽናዕቲ'ዚ ንምክያድ፡ ዝተፈላለዩ ኣገባባትን ኣገዳስነት ዘለዎም ሓበሬታታትን ካብ ዝምልከቶም ኣካላት ምእካብን: ነቶም ዝተኣከቡ ሓበሬታታት ድማ ምጽናዕን ምስናድን ከምኡ'ውን ምስ መሻርኽቲ ኣካላት ምምያጥን ተገይሩ። ውጽኢት ናይ'ዚ መጽናዕቲ ከምዝሕብሮ፡ ኤርትራውያን ደቂኣንስትዮ ኩለን ብማዕረ ኣብ ምርግጋጽ ውሕስነት መግቢ ስድራቤትን ብደረጃ ሃገር ኣብ ዝካየድ ኣብ ምፍራይን ምክፍፋልን መግቢ ኣበርክቶኣን ወሳኒ እዩ። ስለዚ ብዝያዳ ተሳትፎኤን ክብ ንኽብላ ክሕግዛን ምእንቲ፡ ምቹእ ዝኾነ ፖሊሲ ምሕንጻጽ፡ ምስ ኩነታተን ዝሰማማዕ ተክኖሎጂ ምትእትታው፡ ከምኡ'ውን ኣብ ምፍራይ መግብን ዕዳግኡን (marketing) ቀጻሊ ስልጠና ክወሃብን ዓቢ ኣተኩሮ ክግበረሉን ይግባእ። ነቶም ቀዳምነት ክውሃቦም ዝግቦኦም ስጉምትታት ንምልላዮምን ንምስርያምን ድማ ብቐዳምነት መባእታዊ መጽናዕቲ ክግበር ይግባእ።

ሓደስቲ ኣገባባት ምስግጋር ቴክኖሎጂ፡ ድህሰሳ ምህዞኣዊ ኣገባባት ንምትእስሳር ሕርሻዊ ምርምርን ትግባረኡን (ልምድታት)

ብኢንጊሪድ ንይቦርግ: ትርይግቨ በርግን ጀንስ ኣውነን
ክፍሊ ኣህጉራዊ ኣከባብን መጽናዕቲን ምዕባለን፡ ኖር ኣግሪክ:
ኖርዌጂያዊ ዩኒቨርሲቲ ስነ ህይወት

እዚ መጽናዕቲ'ዚ እዋናዊ ምስግጋር ቴክኖሎጂ ሕርሻ ከምኡ'ውን ተመራመርትን ኣተግበርቲ መጽናዕትን ንምምዕባል ምህዞኣዊ ኣቀራርባ ተሓጋጊዞም ዝሰርሕሉ ኩነታት ብምሕንጻጽ ነቶም ዘለው ብድሆታት ኣለሊኻ ውጽኢት ሕርሻዊ-መጽናዕትታት ኣብ ሓረስቶት ንምንጽብራቕ ዝዓለመ'ዩ። ብተወሳኺ ንተሞክሮ ሃገራት ኣፍሪቃ: ታንዛንያ: ማሊን ሱዳንን ንምግጣም ብድሆታት ኣብ ኣቀራርባ'ቶም ዝተፈተኑ ተመክሮታት ብመንጽር ውሽጣዊ ኣተሓሕዛ ኣዝዮም ተነቀፍቲ ጉድለታት ዘለዎምን ዘካየድዎ ፈተነ ክውንነቶም ከም ዘየተኣማምንን ዝገልጽ'ዩ። እዚ መጽናዕቲ'ዚ ንቐንዲ መትከላት ናይ'ቶም ቕድሚ ሕጂ ዝተሰርሓሎም ኣገባባት ምርኩስ ብምግባር ንድፊ ናይ ዝተማሓየሸ ኣማራጺ ኣገባብ ከቕርብ ክፍትን'ዩ። ከም ኣብነት ኣብ ኣጻምእ መሬት ብጉጅለ ዝተገብሩ መጽናዕትታት ኣፍልጦ ናይ ምልውዋጥ ኣገባብ ኣብ ተመክሮ ኤርትራ ክብ ንምባል ክሕግዝ ይኽእል እዩ።

ትካላት ገጠርን ውሕስነት መግብን ኣብ ኤርትራ: መባእታዊ ውጽኢት መጽናዕቲ ማእከላይ ከበሳን ምዕራባዊ ቆላታትን ኤርትራ

ብሲራክ መሓሪ: መልኣከ ተወልደ: ክፍለማሪያም ኣብርሃምን ግሬግ ካሜሮንን
ዩኒቨርሲቲ ኣስመራ: ቁ. ሳ. ጳ. 1220 ኣስመራ: ኤርትራ

እዚ መጽናዕቲ'ዚ ነቶም ኣብ እትዋትን ውጽኢት ምህርቲ መግብን ዘጋጥሙ ብድሆታት ብመንጽር ምትእትታው መንግስታውያንን ኮማውን ብሕታውያንን ትካላት የጽንዕ። ከምኡ'ውን ኣብ ገጠራት ማእከላይ ከበሳን ምዕራባዊ ቆላን ኤርትራ ምትእትታው ናይ'ዘን ዝተፈላለያ ትካላት ኣብ ምውሳኽ እቶት ስድራቤታትን ብመግቢ ነብስኻ ምኽኣል ዘለዎ ተራን ንምርኣይ'ዩ። ቀንዲ ኣገዳስነት ናይ'ዚ መጽናዕቲ'ዚ ነቶም ኣብ'ዘን ክልተ ዝተፈላለያ ሕርሻዊ (ኢኮሎጂካዊ) ዞባታት ዘለው ኣገባብ መፍረን ማሕንቖታት ዕዳጋን ኣለሊኻ ውሕስነት መግቢ ንምርግጋጽ ብመንግስቲ ዝሕንጸጹ ፖሊሲታትን ንትግባሪኦም ዝሕግዙ ኣማራጺታትን ብጭቡጥ ምቕራብ'ዩ። ውጽኢት ናይ'ዚ መጽናዕቲ'ዚ ከምዘረጋገጾ ሕርሻዊ እትዋት: ስልጠና ከምኡ'ውን ኣባልነት ማሕበራት: ኣብ እቶት ስድራቤት ዝኾነ ይኹን ጽልዋ ኣይነበሮን። ስለዚ እዚ መጽናዕቲ'ዚ ከም መደምደምታ ኣብ ምሕንጻጽ ፖሊሲ ዝዋስኡ ኣካለት ንዝሓሸ ምዕባለ ምዕሩይ ዝኾነ ምትእትታው ቴክኖሎጂ ኣብ ዝተፈላለዩ ትካላት ንኽሰርጽ ክገብሩን ኣብ መስርሕ ምዕባለ ሕርሻዊ እቶታዊነት ከኣ እቶም ዝተፈላለዩ ክፋላት ሕብረተሰብ ተዋሃሂዶም ንኽሰርሑን ክሕግዝዎም ለበዋ የቕርብ።

ውሁድ ምሕደራ ማይ-ክፆታት፣ ማሕብረ-ቁጠባዊ ረቋሒታት ናይ ውህለላ ማይ ፕሮጀክትታት

ብፍጹምብርሃን ገብረዮውሃንስ
ሚኒስትሪ ሕርሻ: ቁ. ሳ. ጳ. 1048 ኣስመራ: ኤርትራ

ሕጽረት ማይ ኣብ ደረቕን ሓውሲ ደረቕን ዞባታት ኤርትራ ብምኽንያት ውሑድ ዓቐንን ዘይምዕሩይ ዝርግሐ ዝናብን ዝተበገሰ ምዃኑ ይፍለጥ። እዚ ሕጽረት ማይ'ዚ ኣብ ክራማት ዘጋጥም ብምዃኑ ንጽላት ሕርሻ ኣብ ሓደጋ የውድቖ። ስለዚ ኣብዚ ቦታ'ዚ እኽልን ዘቤታዊ እንስሳታትን ዘጠቓልለ ሰፊሕ ሕርሻዊ እቶት መስኖኣዊ ኣገባብ ክምተወሳኸ ብምጥቃም'ዩ ክዕመም ጸኒሑ። ምዕቃብ ማይ ንኣጻምእ ሕርሻዊ መሬት ኣብ ሓያሎ ድሩቕን ሓውሲ ድሩቕን ዞባታት ዓለም ኣብ መጻኢ ከጋጥም ንዝኽእል ሕጽረት ማይ ዘቃልልን ውሕስነት መግቢ ዘረጋግጽን ቴክኖሎጂ'ዩ። ውህለላ ማይ ልዑል ተቐባልነት እናረኸበ ዝመጽእ ዘሎ ቴክኖሎጂ ኮይኑ ፕሮጀክት ውህለላ ማይ ዝናብ ንኽዕወት ድማ ብቐንዱ ኣብ ተክኒካዊ መዳያት ጥራይ ዝሙርኮስ ዘይኮነስ ብጭብጢ ክርእ እንከሎ ክንየ ምህንድስናን ሕርሻዊ ክእለትን ብቕዓትን ዝኸይድ እዩ። ኣብ'ዚ መዳይ'ዚ ማሕበረ-ቁጠባዊ ረቋሒታት: ብፍላይ ከም ብሓረስቶትን ካልኦት ተጠቀምትን ተቐባልነት ምርካብ ኣገዳሲ'ዩ። ኣብ መንጎ ካልኦት ማሕበረ-ቁጠባዊ ረቋሒታት: ሓደስቲ ቴክኒካት ውህለላ ማይ ብብቑዕ ተሳትፎ ተጠቀምቲ ምስ ዝምዕብሉን ብኣድማዒ ምሕደራ ምስዝሰነዩን እዮም ተቐባልነት

ናይ ምርካብ ዕድሎም ክዓቢ ዝኽእል። ነዚ ዝተጠቕሰ ስርዓተ ውህለላ ማይ ትሑት ዝእቶቱ ሓረስታይ መታን ብግቡእ ክግንዘቦ ባዕሉ ብቐሊሉ ከማሕድሮ ክኽእል ኣለዎ። እዞም ሓደስቲ ኣገባባት ውህለላ ማይን ቴክኖሎጂታት እቶትን ናብ ሓረስቶት ቅድሚ ምስግጋሮም ከኣ ቁጠባዊ ውሕስነቶምን ማሕበራዊ ተቐባልነቶምን ምግምጋም ኣገዳሲ'ዩ።

እዚ መጽናዕታዊ ጽሑፍ'ዚ እምበኣር ገለ ማሕበረ-ቁጠባዊ ኩነታት: ከም ቀዳምነት ተሳትፎ ማሕበረ-ሰብ: ምርግጋጽ ማዕርነት ጾታ: ኣገባባት ማሕረስን ስርዓተ ዕደላ መሬትን ዝኣመሰሉ ረቋሒታት ኣብ ምሕደራ ውህለላ ማይ ካብ ዝናብ ብሓፈሻ: ውሕስነት መግቢ ኣብ ምርግጋጽ ከኣ ብፍላይ ክህልዎ ዝኽእል ተራ ክዝቲ ክፍትን'ዩ።

ውሁድ ኣገባብ ምርባሕ እንስሳ: ገምጋም ሕርሻ ኣፍረይቲ ጸባ ኣብ ኣስመራን ከባቢኣን

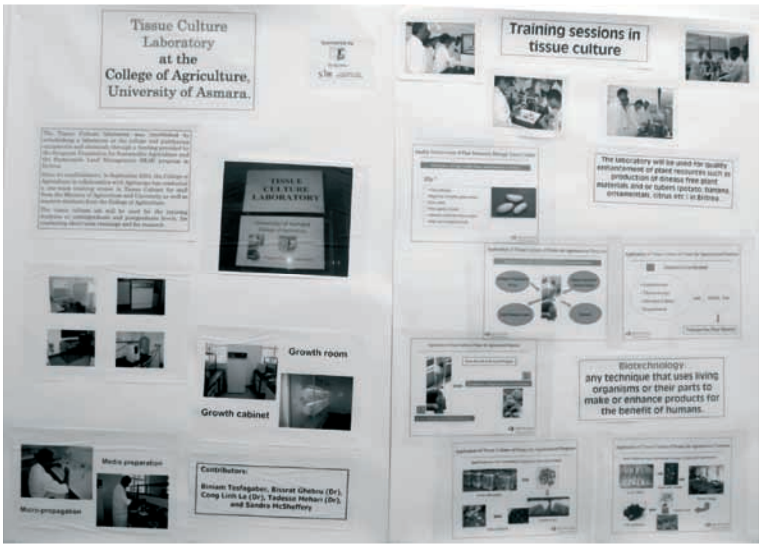
ብኢ.ግናቱስ ንሳህላይን ኣለምሰገድ ሞገስን
ሚኒስትሪ ሕርሻ: ቁ. ሳ. ጾ. 1048 ኣስመራ: ኤርትራ

ዕላማ ናይ'ዚ መጽናዕቲ'ዚ ታሪኻዊ ድሕረ-ባይታን መሓንቖታትን ናይተን ኣብ ኤርትራ ዘለዋ ሕርሻ መፍረ ጸባ ምጽናዕን ምልላይን ኮይኑ ኣብ ኣስመራን ከባቢኣን ዘተኮረ'ዩ። ሰላሳ ኣርባዕተ ከብቲ ሓረስቶት ብምምራጽ ድማ ቃለ-መሕትት ተኻይዱ። ዕላማኡ ከኣ ብዛዕባ ኣቃውማን ኩነታትን ጥሪት: ዓይነትን ምንጭን መግቢ እንስሳ: ኣገባብ ምርባሕ እንስሳ: ዓይነትን ኩነታትን መንበሪኦን: ኩነታት ጥዕንኦን: ፍርያትን ዕዳጋን ጸባ: ኩነታት መነባብሮ ሓረስታይ ከምኡ'ውን ኣብ መስርሕ ዘጋጥሙ ጸገማትን ማሕንቖታትን ንምልላይ እዩ። ካብ ማሕበር ኣፍረይቲ ጸባ ኣስመራን ከባቢኣን'ውን ኣድላዪ ሓበሬታ ተኣኪቡ። እቲ ዝተኣከበ ሓበሬታ ከኣ ንሓረስቶት ብመንጽር ሓፈሻዊ መነባብሮኦምን ካብ ጸባ ዝረኽብዎ እቶት ንምግምጋምን ሓጊዙ። እቶም ተመሳሳሊ ኩነታት መነባብሮን እቶትን ዘለዎም ሓረስቶት ከኣ ኣብ ሓደ ጉጅለ ተጠርኒፎም። ቃለ-መሕትት ዝተገብረሎም ሓረስቶት ብመሰረት ዝነብሩሉ ኣከባቢ: ብዝሒ ጥሪት: ጥዕና እንስሳን ኩነታት መነባብሮኦምን ተሰሪያም። ማእከላይ ገምጋም ብዝሒ ጥሪት 15.4 ኮይኑ: መጠን ንውሓት ሕልቦ (ምሕላብ) ከኣ ካብ 6 ክሳብ 7 ኣዋርሕ ይበጽሕ። ኣብ'ዘን መጽናዕቲ ዝተኻየደለን ከባቢታት ልሙድ ዓይነት መግቢ እንስሳ: ኣብ ሕርሻ ዝፈርዩ: ካብ ዕዳጋ ዝሽመቱ: ተረፍ-መረፍ ኣሕምልቲ: መጋሃጫ: ሓሰር (ድርቋ) ከምእ'ውን ተረፍ-ምህርቲ ፋብሪካታትን ዝተመጣጠነ መግቢ እንስሳን እዮም። ሓረስቶት መግቢ እንስሳ ንምርካብ ዘለዎም ተኽእሎ ይፈላለዩ፡ እብ ሓውሲ ከተማ ዝርከቡ ሓረስቶት ዝበዝሐ ክፋል መግቢ እንስሳ ኣብ ሕርሻኦም ዘፍርዩ ክኾኑ እንከለው: ኣብ ከተማ ዝርከቡ ሓረስቶት ከኣ ካብ ዕዳጋ ይሽምቱ። ስለዚ ኣጠቓቕማ መግቢ እንስሳን እቶም ሓረስቶት ዝነብርሉ ቦታን ክዛመድ ክኢሉ (p< 0.05)። እዚ መጽናዕቲ'ዚ ከምዘረጋገጾ ባህሪያዊ ኣገባብ መፍረ ዝጥቀሙ ሓረስቶት 86.7%: ሰብ-ሰርሖ ኣገባብ መፍረ ዝጥቀሙ 3.3% ክኾኑ እንከለው ንክልቲኡ ኣገባባት ኣጣሚሮም ዝጥቀሙ ሓረስቶት ከኣ 10% እዮም። ኣብ ከተማን ሓውሲ

ከተማን ዝርከቡ ሓረስቶት ነተን ናይ ጸባ ከብቲ ኣብ ገዛ ብምዕጻው ይምግብወን። ንሕማም እንስሳ ብዝምልከት ኣናሶ (ዕጭ ላም)፡ ሕማም ቆርበት (lumpy skin disease)፡ ጸገም ዘይ-ሙዕርይ ኣመጋግባ፡ ሕማም ጡብ፡ ምቑላዕን፡ ዓባይ ሰዓልን ካብቶም ብተደጋጋሚ ዝረኣዩ እዮም። መፍረ ጸባ ብመብዛሕትኦም ሓረስቶት (73%) ከም ቀንዲ ምንጪ እቶት ክጥቀስ እንከሎ 27% ሓረስቶት ከኣ ከም ተወሳኺ ምንጪ እቶቶም ምኳኑ ይገልጹ።

ኣብ'ዚ መጽናዕቲ'ዚ ሰለስተ ጉጅለ ማለት 47.04%: 45.06%: 7.91% ኣብ ከተማ ከምኡ'ውን 37.13%፡ 7.91%፡ 1.3% ኣብ ሓውሲ ከተማ ዝነብሩ ሓረስቶት ተለልዮም። ጉጅለ 1ን 2ን 3ን ብቕደም ተኸተል ብገምጋም 10: 5: 23 ናይ ጸባ ከብቲ ክውንኑ እንከለው ኣስታት 49: 24.3: 117 ኪሎ ግራም ጸባ ንመዓልቲ ከካብ ሕርሻኦም ከምዝረኽቡን ቀንዲ መሓንቖታት ከኣ ሕቶ መሬት: ዋሕዲ መግቢ እንስሳ ከምኡ'ውን ናይ ምውህሃድ ጸገማት ምኳኑ ተለል'ዩ። እዚ መጽናዕቲ'ዚ ኣብ ኤርትራ ሕርሻዊ ምዕባለ ንኣፍረይቲ ጸባ ኣገዳሲ ምኳኑ ብምሕብባር ንምእላይ'ቶም ዘጋጥሙ ጸገማት እንተተጻዊሩ ነቶም ዘለው ተኽእሎታት ብኣገባብ ክንጥቀምሎም ከምንኽእል የረጋግጽ። ብተወሳኺ ንመጻኢ ኣብ'ዚ መዳይ'ዚ ሰፊሕ መጽናዕቲ ንኽግበር ይላቦ።

Pictures from the workshop



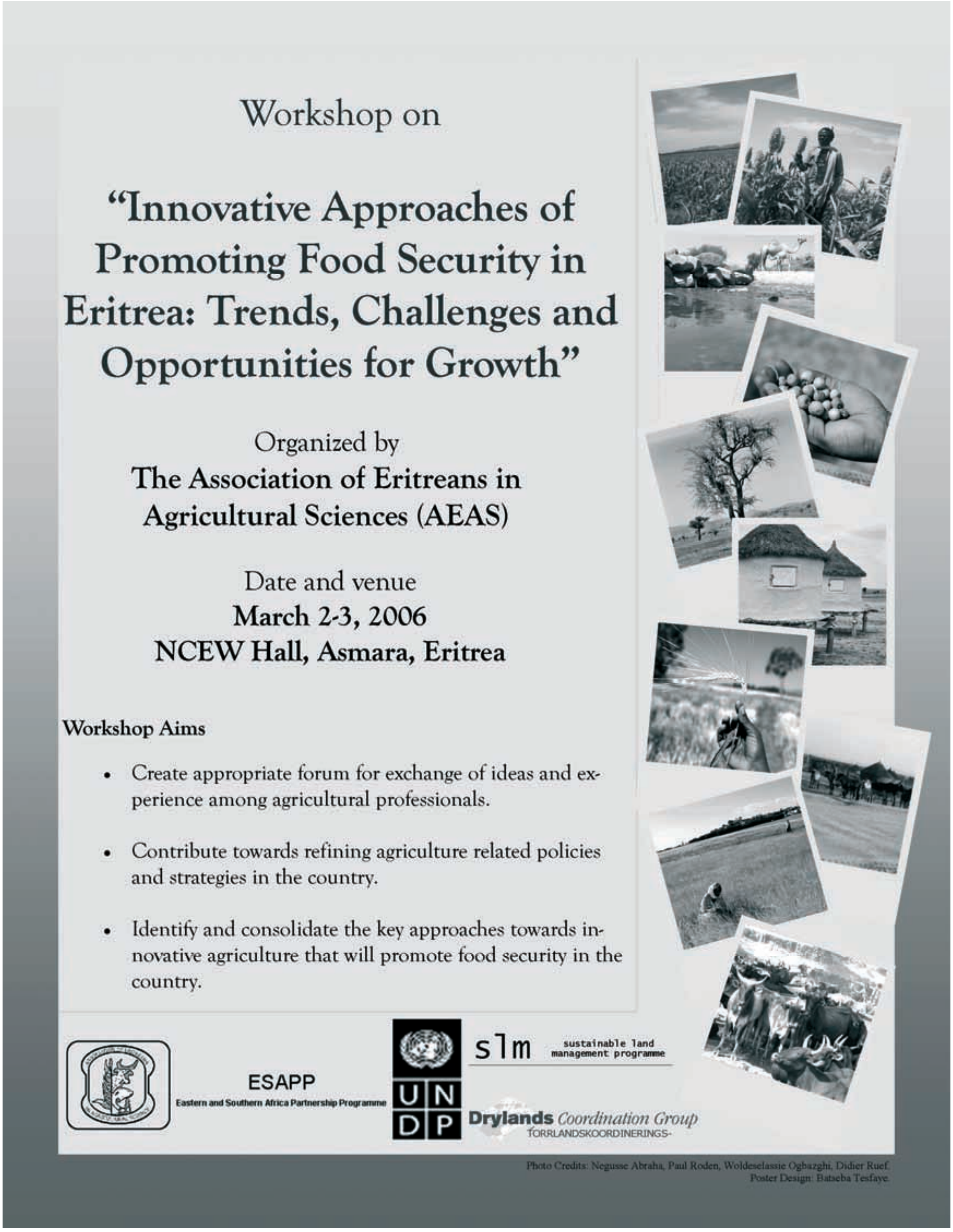
Tissue culture poster

Extension and technology transfer working group

Biotechnology working group

Crop and livestock working group

Watershed management working group



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