ISSUES AND CHALLENGES IN FOOD SECURITY

Proceedings of a National Workshop

Organized by The Biological Society of Ethiopia

Edited by
Abenet Girma
Dawit Abate (PhD)

February 5-6, 2009
Faculty of Science, Addis Ababa University
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ACKNOWLEDGEMENTS

The Executive Committee of the Biological Society of Ethiopia would like to extend their gratitude to the following sponsors of the 19th Annual Conference of the Society:

- Action Aid
- Save the Children/USA
- Horn of Africa Regional Environment Centre/Network
- World Food Programme
- Ministry of Science and Technology
- Catholic Relief Services
- Ethiopian Health and Nutrition Research Institute
- Ethiopian Institute of Agricultural Research
- Addis Ababa University
- Health Care Manufacturers

The organizers of the Conference would also like to extend their appreciation to the paper presenters and resource persons of the conference.
WELCOMING ADDRESS

Dear Dr. Abera Deressa, State Minister of Agriculture and Rural Development

Dear members of the Biological Society of Ethiopia

Distinguished guests

Ladies and gentlemen

The Biological Society of Ethiopia (BSE) is a professional society of biologists and allied scientists, educators and researchers. The society has about 1000 members engaged in biology teaching at secondary schools, higher education, research institutes, government and non-government organizations.

The society has been engaged in bringing together its members and the public at large to its annual conferences, workshops and panel discussions on different themes of particular importance during the last 18 years. The society publishes, Ethiopian Journal of Biological Sciences and disseminates research findings through the journal.

In this 19th Annual Conference, the Society has organized its activities around the theme ISSUES AND CHALLENGES IN FOOD SECURITY. It is very apparent to all of us that the global food crisis is prevailing and the challenges of food security are varied and require efforts by all stakeholders. The Executive Committee of the Society has thus identified the theme to be appropriate and timely for this conference and has selected and invited specialized and experienced individuals.

During the conference, papers by expert scientists and researchers as well as policy makers on ISSUES AND CHALLENGES IN FOOD SECURITY will be presented and discussed. It is my view that the recommendations made by experts and the outcomes of the discussion will help to guide the efforts made by government and non-government development agencies to tackle food insecurity in Ethiopia.

Besides presentations on Issues and Challenges in Food Security, research papers on various biological areas will be presented. Particular emphasis has been given to aspects of biodiversity and environment, food and agriculture, health and tropical diseases.

I would like to thank the Executive Committee Members of the Society for organizing the annual conference. I would like to appreciate the following organizations for rendering financial support: Addis Ababa University
Welcoming Address

Dawit Abate

(Associate Vice President's Office for Research and Graduate Studies, the Faculty of Science and the Department of Biology), Ministry of Science and Technology, Horn of Africa Regional Environment Centre/Network, Save the Children USA, Action Aid, Catholic Relief Services, Ethiopian Health and Nutrition Research Institute, Ethiopian Institute of Agricultural Research and Health Care Food Manufacturers.

Finally, I would like to welcome you to our two-day conference and express my sincere thanks to all presenters and participants of the conference.

Dawit Abate (Ph.D)

President, Biological Society of Ethiopia
Dear Members of the Biological Society of Ethiopia

Dear Invited Guests and Participants

Ladies and Gentlemen

I feel highly honoured to give a brief opening speech to the 19th Annual Conference of the Biological Society of Ethiopia. I appreciate that the society has chosen the theme ISSUES AND CHALLENGES IN FOOD SECURITY. It is both important and timely. Moreover, biologists play important roles in food production.

Food security has three aspects: food availability, food access and food adequacy. It means we would be food secure when each one of us is assured of access at all times to food required for a healthy life. When and how we could achieve food security essentially depends on our understanding of the underlying causes of poverty and the strategy we put in place to tackle the problem.

The major challenge to food security in Ethiopia is its underdeveloped agricultural sector that is characterized by over-reliance on primary agriculture, low soil fertility, limited use of farm inputs, environmental degradation, pre- and post-harvest crop loss, minimal value addition, product differentiation, and inadequate food storage capability. Most of our food is produced under rain-fed agriculture. Hence, food production is vulnerable to adverse weather conditions.

Our forest resources are vanishing at an alarming rate due to increased demand for fuel wood and land for crop production by the increasing population. Consequently, increased soil erosion and decreased soil fertility continue to affect agricultural productivity, thereby accelerating poverty.

Malnutrition has devastating effects on our population. It affects mortality and morbidity rates, reduces labour productivity and quality of life of all affected. Dietary diversification still remains the best way to provide nutritious diets from local sources to the sustainability of any population.

Biomass is the most important energy source in Ethiopia and practically the only source of energy in rural households. The development of alternative energy sources particularly biofuels is an opportunity in view of the suitability of agro-ecologies for cultivation of biofuel crops/plants. Biofuels
could gradually substitute fossil fuel (petroleum) products which deprive the country of most of its foreign exchange earnings.

Many continue to suggest that biotechnology has the potential to increase world food output and reduce food insecurity by improving crop yields and reducing crop loss. Genetically modified crops may provide opportunities provided that the potential anticipated risks are understood and controlled.

Ethiopia is endowed with diversified natural resources that potentially offer opportunities for agribusiness investment that creates employment and generates income.

I believe that this conference will discuss issues and challenges of food security in detail and help catalyse the activities and interventions we have to undertake for poverty alleviation and food security in Ethiopia.

Finally, on behalf of the Ministry of Agriculture and Rural Development, I would like to thank both the organizers and the organizations that supported the conference financially. I hereby declare the 19th Annual Conference of the Biological Society of Ethiopia officially open.
FOOD SECURITY IN THE DRY LANDS OF ETHIOPIA

Adrian Cullis

INTRODUCTION

In this paper the author outlines ways in which Save the Children/US (hereafter Save the Children) is re-positioning its food and livelihood security work in the dry lands of Ethiopia in response to seasonality, trends and shocks. Through this process, Save the Children seeks to better support communities living in the dry lands of southern Oromiya and Somali National Regional States to prepare for and respond to rising levels of uncertainty and risk, the result of more erratic weather patterns associated with global climate change.

Save the Children has adopted a broad-based stakeholder approach which recognizes the leadership role of customary and local (including woreda and regional) government institutions and leaders. In addition, Save the Children recognizes and works with other stakeholders including donors, other international humanitarian organizations, the private sector and research institutions. The author argues that working collectively it is not too late to make tangible progress towards the Millennium Development Goal of halving the number of people living in poverty by 2015, through accelerated economic development in Ethiopia’s dry lands.

Global and regional food insecurity

Since the 1960s, increasing world food production has more than kept pace with the rapid growth in population with food consumption increasing from 2,358 to 2,803 kilocalories per capita, despite a world population increase from 3 to 6.6 billion people (FAO, 2008). Whilst this is promising, it is also widely accepted that these global statistics do not accurately reflect regional differences between and within individual countries. For example, despite an improved global cereal supply, food prices in the Horn of Africa remain well above five year rolling averages. As a result, poor households are eating less and studies suggest that food consumption has fallen 20% within the last 12 months among the poorest households (FEWS NET, 2009).

According to FAO, the combined effects of below average rainfall, conflict, insecurity and higher than average food prices in the Horn of Africa have resulted in increasing the number of people confronting serious food

1 Food and Livelihoods Security Unit, Save the Children/USA, P.O. Box 387, Addis Ababa. E-mail: ACullis@Savechildren.org.et
insecurity to more than 17 million (USAID, 2009). In Ethiopia soaring cereal
prices compounded by poor seasonal rains and poor crop production have
resulted in 4.9 million beneficiaries requiring emergency assistance, over
and above the 7.2 million Productive Safety Net Program beneficiaries who
receive regular commodity transfers for up to 6 months each year. The
estimated cost of providing the required 450,000 metric tons of emergency
food aid for the half year to June 2009 alone is USD 390 million (UN-
OCHA, 2009).

Nutritional studies carried out in Ethiopia confirm that whilst progress is
being made, almost 50% of children living in the highlands are ‘stunted’
(Fig. 1), which is attributed to chronic household food insecurity.

![Trends in stunting by Region](image)

**Fig. 1** Trends in stunting by region (Save the Children/UK, 2008).

In the arid and semi-arid lowlands, rates of ‘stunting’ are significantly
reduced, because year round calorific intake is invariably higher. However,
similar nutritional studies in the lowlands confirm periodic high levels of
‘wasting’, the result of acute food insecurity (Fig. 2). Further studies confirm
that ‘wasting’ peaks in periods of drought.
Fig. 2 Trends in wasting by region (Save the Children/UK, 2008).

Devereux (2006) notes that ‘pastoral populations are sensitively attuned to conditions of low and variable rainfall ... and pastoral systems well adapted to drought’. He goes on to suggest that it is not drought alone that makes pastoral populations vulnerable to drought and by implication their children to ‘wasting’, but rather it is the result of changes in recent years that have compromised their highly-evolved drought response mechanisms. The changes identified by Devereux and others include: the loss of mobility, the loss of reciprocal grazing rights, land alienation (in particular the loss of ‘wet patches’ or ‘swamps’ which provide pastoralists with important pasture during times of drought to agriculture), and legal restrictions on trade. In order to fully understand these and other issues facing pastoralists, development actors need a comprehensive understanding of dry land ecosystems.

Dry land ecosystems

Although it is commonly recognized that the dry lands are characterized by high rainfall variability in both amounts and intensities and prolonged and recurrent drought, there is no single agreed definition for the dry lands. FAO and the United Nations Convention to Combat Desertification (UNCCD) have, however, developed accepted working definitions. FAO for
example defines dry lands as 'those areas with a length of growing period of 1 to 179 days' which includes regions which are climatically considered to be arid, semi-arid and dry sub-humid (FAO, 2000 in Koohafkan and Stewart, 2008). The UNCCD classification draws on the ratio between annual precipitation and potential evapo-transpiration. Globally the dry lands account for 40% of the land surface area and slightly more than 40% of Africa’s land surface area, excluding the hyper-arid Sahara zone (Koohafkan and Stewart, 2008).

In Ethiopia the term dry lands collectively describes the arid and semi-arid lowlands and the dry sub-humid highland regions, which account for an estimated 75% of the land surface area. In common with the rest of the Horn of Africa, the dry lands of Ethiopia are inhabited by some of the poorest and most marginalized communities in the world, with many living on less than USD 1 per day. Livelihood analysis of rural people living in Ethiopia's low dry lands identifies three broad livelihood groups as follows: rain-fed, smallholder farmers; agro-pastoralists; and pastoralists. Through livelihood profiling in Somali Region, these three groupings have been further sub-divided into 17 livelihood groups, which reflect different agro-ecological conditions and market opportunities (Save the Children UK and Disaster Prevention and Preparedness Agency, 2008). For example, pastoralists include the Moyale-Wayamo, Filtu-Dollo and Afdher Pastoral Livelihood Zones amongst others. These recently updated livelihood profiles offer food and livelihood security specialists valuable insights not only into local production and household economies, but also livelihood vulnerabilities and opportunities.

As a result of improvements in heath provision and other factors human populations continue to grow throughout the world and the same is true for Ethiopia. Rural populations in the low dry lands of Ethiopia, for example are estimated to be growing at an annual rate of 2.7% (Sandford and Yohannes Habtu, 2002). As a result of these increasing populations, the dry lands are under increasing pressure and some areas are showing signs of over-utilization, resulting in land degradation and mounting levels of vulnerability. For example, since 2000 there has been a sharp rise in the number of destitute pastoralists and ex-pastoralist communities can be found on the margins of almost all lowland trading centers and market towns. Having lost the majority of their livestock, ex-pastoralists are forced to eke out alternative livelihoods based on wage employment, the collection and sale of firewood, grass and water, and petty trade.

In addition to increasing pressure on and competition for access to and control over dry land resources, communities living in the dry lands are also seeking to come to terms with global climate change. Whilst experts continue to argue back and forth, communities living in the dry lands are unequivocal that global climate change is a reality: the incidence of drought
has increased and rainfall, both in terms of total annual rainfall and rainfall intensity, is more variable and erratic than at any time in living memory. Global climate change is set to have a profound impact on household food security, in particular among poorer households who simply do not have the economic clout to adapt.

**Approaches to improved food security**

In order to reduce levels of household food insecurity in the dry lands, food security strategies need to reflect the regional differences outlined above. For example, in highland regions the emphasis needs to be on increasing food production with view to tackling and reducing levels of chronic food insecurity and hence 'stunting'. This requires continued attention to soil and water conservation, crop rotations and use of inputs in order to increase cereal yields. In contrast, in the low dry lands increased emphasis needs to be given to drought preparedness and response in order to address 'wasting'.

However, despite all the evidence to the contrary, donors continue to provide massive support to conventional approaches to drought response, in particular in the form of food aid (Pantuliano and Wekesa, 2008), and relatively modest levels of investment are made available for timely livelihood-based interventions that have the potential to reduce the need for food aid, through averting humanitarian crisis. In Ethiopia for example, despite the fact that food prices rose by 300% between August 2007 and 2008 very little was done to stabilize food prices. Similarly, as livestock prices collapsed in the first half of 2008 with prices of all animal types falling between 50 and 80%, little was done to support destocking interventions. As a result, price distortions wreaked havoc on pastoral livelihoods with households forced to sell as many as six goats to purchase a 50 kg sack of grain where only 12 months earlier they had only been required to sell only one. Reluctant to decimate their herds, pastoralists had no alternative but to reduce the numbers and size of meals family members consumed daily. Not surprisingly after months of high prices, 'wasting' levels amongst children spiked and emergency nutritional programs were launched. Had it, however, been possible to address the terms of trade through the sale of cereals at more 'normal' prices, the humanitarian response may not have been necessary. Save the Children concurs with Sandford and Yohannes Habtu (2002) that 'if satisfactory ways can be found to increase and maintain pastoralists' cash income, there will be no separate food crisis'.

In order to help better protect and strengthen household food and livelihood security in the dry lands of southern Ethiopia, Save the Children is seeking to tailor interventions according to livelihood profiles. For example, in Somali Region, Save the Children is working in slightly different ways with Garre camel, sheep and goat pastoralists and with Dawa/Genale riverine
mixed farmers. In addition to working differently with different livelihood
groups, Save the Children has also found it necessary to improve the
flexibility of its programming in order that interventions more appropriately
support drought response, and has supported livelihood-based drought
response interventions in the droughts of January-April 2006, and January-
April and August-September, 2008.

Increased flexibility in programming in the dry lands has been strengthened
by the adoption of Oxfam Kenya's Drought Cycle Management Model in
2005. Developed in 1986 in Turkana, northern Kenya, the value of the
model (Fig. 3) is that while the timing of drought in unpredictable, it is
recurrent and as such can be planned for.

Fig. 3 The drought cycle management model.
The model is based on four 'phases', typically: 'normal', 'alert/alarm',
'emergency' and 'recovery' and for each phase different relief and
development interventions are prioritized. For example, in the 'normal'
phase, government and humanitarian actors are encouraged to support
infrastructure projects (schools, clinics, roads and communications),
improve natural resource management, and strengthen livestock services
(animal health and livestock marketing services). In contrast, during the
drought or 'emergency' phase, support is switched away from long-term
development to livestock relief interventions - commercial and slaughter
destocking, livestock feed supplementation, and emergency animal health - and food aid.

Save the Children also recognizes the work done by Wiggins (2008) on market-led agricultural development related to agro-ecology and location (Table 1). The value of Wiggins’ model is to remind us all that there are no ‘one size fits all’ approach, since market opportunities for micro-scale, high-value farming opportunities do not extend to ‘remote countryside’ semi-arid and arid lowlands, and that low production, subsistence systems will likely predominate for the foreseeable future. Save the Children draws on this model to inform its *Productive Safety Net Program – Pastoralist Area Pilot (PSNP-PAP)*, which is being implemented in Dollo Ado and Dollo Bay, Somali National Regional State and Arero, Oromiya National Regional State. For example, whilst Dollo is remote from Addis Ababa (almost 100 km), the Dawa and Genale river systems support relatively large populations, in particular in the three towns of Dollo Ado (Ethiopia), Dollow (Somalia) and Mandera (Kenya). Recognizing the market opportunities afforded by these urban populations, Save the Children is supporting small-scale irrigation schemes to produce a range of vegetables, fruit and fodder (for sale to peri-urban zero grazed milking cattle). In contrast in Arero, which is less than 500 km from Addis Ababa, there are fewer market-led opportunities as there are no major towns in the area and population density is relatively low. Thus, the program’s emphasis here is on improving access to basic services and to protecting and enhancing subsistence pastoral production systems through improved livestock and cereals marketing.

**Table 1 Market-led opportunities according to agro-ecology and location (Wiggins, 2008).**

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<th>Location</th>
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<tr>
<td></td>
<td>Sub-humid and semi-arid highlands</td>
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<td></td>
<td>Semi-arid and arid lowlands</td>
</tr>
<tr>
<td>Peri-urban</td>
<td>Micro-scale, high-value farming activities</td>
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<tr>
<td>Middle countryside</td>
<td>Specialized market-oriented arable farming and livestock</td>
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<tr>
<td></td>
<td>Extensive farming and livestock and only a limited non-farm economy</td>
</tr>
<tr>
<td>Remote countryside</td>
<td>Likely to remain in subsistence production</td>
</tr>
<tr>
<td></td>
<td>Low productivity subsistence farming, generating very small surpluses</td>
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**Getting food and livelihood security right**

If food and livelihood security programming is to achieve the planned high levels of impact in terms of poverty reduction and accelerated economic development, it is evident that increased recognition needs to be given to
Food Security in the Dry Lands of Ethiopia

Adrian Cullis

local specificities including local skills and knowledge, phase of the drought cycle, agro-ecology, land tenure arrangements, and market opportunities. Whilst good progress is being made to strengthen government extension services through the deployment of technical experts and Developmental Agents to the woreda and even kebele level, it appears that at least some of the experts deployed continue to think in terms of the delivery of standardized ‘agricultural extension packages’.

Therefore, rather than continuing to deploy technical experts according to administrative regions it may be more cost effective for the Extension Services to consider and possibly adopt a ‘preferred deployment approach’ whereby technical experts are deployed to those woredas and kebeles where there are real opportunities for agricultural-led development and in those areas where low productivity subsistence farming is unlikely to generate surpluses so that the focus will be on drought preparedness and response, with a view to protect livelihoods.

As a result of the re-positioning work carried out on food security within Save the Children, a twin-track approach has been adopted which focuses on protecting lives and livelihoods and strengthening lives and livelihoods. The following section aims to share how Save the Children has learned that working with a wide range of partners and stakeholders - including the customary institutions and leaders; local government staff, in particular technical officers; private sector including livestock and cereal traders, veterinarians and transporters; regional and federal level administrators and technical experts; donors (in particular USAID and ECHO); and other NGOs - it is possible to achieve real and sustainable benefits from livelihood-based interventions and responses as complementary to food aid and in some cases as an alternative.

Protecting lives and livelihoods

As noted above, Save the Children is implementing the PSNP-PAP in 5 woredas of Oromiya and Somali Regional States. In addition, however, Save the Children is also piloting and taking to scale a range of livelihood-based drought interventions which inject cash into drought-affected communities with a view to improving their purchasing power, in particular to improve access to grain. Examples of Save the Children supported interventions since 2006 include:

- A commercial destocking intervention which resulted in private livestock traders investing some USD 1 million in the purchase of 20,000 drought-affected livestock in southern Oromiya which were later exported to Egypt.
- A subsidized slaughter destocking intervention in areas where traders were not prepared to travel to increase the off-take of

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droughted livestock whilst at the same time offering pastoralists alternatives to depressed local markets. Under this initiative some 1,500 cattle and 720 sheep and goats were purchased at ETB 800 and 140, respectively, i.e., well above market prices. The intervention was favorably reviewed by an independent consultant who concluded that the 'program exceeded its food security and livelihood protection objectives'.

- A voucher scheme which assists drought (or flood) affected agro-pastoral and pastoral household to purchase livestock medicines from private veterinary pharmacies and in this way ensure that diseases are treated and parasite burdens are kept to a minimum so that animals better survive the drought, whilst at the same time strengthening private pharmacies and expanding their businesses. Under this initiative vouchers worth ETB 100 were distributed to some 7,000 households.

- A pilot voucher scheme which assists drought affected pastoral households to purchase fodder from riverine areas in Somali National Regional State in order to both maintain a core herd of breeding stocks and develop the market for irrigated fodder. Under this initiative ETB 750 supported 300 households to purchase fodder.

- Support to a network of community-managed grain banks, which seek to ensure that grain is both more widely available and that prices more accurately reflect 'real prices'. Since 2006 Save the Children has supported the establishment of 46 community-led cereal banks all of which are continuing to trade in cereals, though the volume of sales varies from group to group in which the cereal banks are mainly led by women. A recent internal review found that the women valued both the increased availability and access to cereals at a time of exceptionally high prices.

In addition to implementing livelihoods-based relief interventions, Save the Children is working closely with Tufts University and other research institutions to carry out impact assessments, which can be shared with policy makers to support federal and regional policy processes. As a result of several such impact assessments, Tufts University has confirmed that as much as 75% of the cash that has been injected into livelihood-based responses is spent locally on food, livestock support, clothing, paying off debts and supporting relatives (Dawit Abebe et al., 2008). Based on these studies, it appears that improved access to cash in lowland areas during times of drought plays a pivotal role in processing both lives and livelihoods.
Strengthening lives and livelihoods

In the more ‘normal’ phase of the drought cycle, Save the Children supports livelihood recovery and strengthening lives and livelihoods’ interventions. Whilst it does not have the resources to invest in large infrastructure projects, Save the Children actively supports woredas’ development plans to strengthen ‘physical capital assets’ including roads, health posts, veterinary posts, schools/ABE centers, warehouses/storage capacity and other rural infrastructure as part of the PSNP-PAP public works program.

In addition, Save the Children supports the following interventions:

- The privatization of veterinary pharmacies and the training of community-based animal health workers (CAHWs). To date Save the Children has supported the establishment of 8 private veterinary pharmacies and trained numerous CAHWs. Linked under a Save the Children initiative to help ensure that CAHWs are using only quality veterinary medicines, the private pharmacies and CAHWs have an annual turnover of thousands of Birr annually.

- Participatory rangeland management with a focus on mapping rangeland resources and supporting customary institutions to better prepare for drought through the development of a community action plan. As a result of this initiative, some 67 community action plans have been prepared, resulting in the establishment of more than 8,300 ha of drought reserves, the removal of private enclosures in the communal rangelands, improved livestock access to 87 water points (to improve human safety and reduce time taken for watering) and action research on the control and utilization of invasive woody species.

- Support to livestock marketing through the establishment of 46 livestock marketing groups, which achieved a combined annual off-take of 1,877 animals in 2008 which were sold for ETB 1,500, 250 (Informal estimates suggest that livestock marketing, much of it from the dry lands, generates USD 250 million annually in export earnings).

- Support to 65 women's income generating groups. Reviews of the women's groups confirm that in addition to the economic benefits, women are also able to access credit, support each other during times of crisis and that they have increased status in the community. Some 15 of the women's groups have organized literacy classes which the women confirm is important to help them develop their businesses.
New economic opportunities

In addition to working on immediate priorities, Save the Children is also funding small action research projects to explore and realize new economic opportunities. Together with SOS Sahel and CARE, Save the Children has recently funded a review of current practice associated with the collection, processing and sale of ‘non-woody rangeland products’ including aloes, gums, honey, incense and resins. Save the Children is currently in negotiation with an environmental consultancy group to research and develop a road-map for Save the Children’s next 5 years work on carbon sequestration in the rangelands of Ethiopia, with a view to securing carbon payments at some point in the future. Together, Save the Children estimates that rangeland products and carbon sequestration could annually generate millions of dollars which would reduce the need for international development assistance. In each of the above initiatives Save the Children plans to work closely with the relevant government body.

CONCLUDING REMARKS

At a time when food prices in developing countries remain well above 5 year rolling averages and as a result negatively affect food access for significant numbers of low income households, it is perhaps not surprising that global policy makers are largely negative about future trends in food and livelihood security in the dry lands, in particular the dry lands of the Horn of Africa. Whilst the challenges to arrest and reverse current trends are enormous, Save the Children’s work suggests that increased gains can be made to protect and improve the lives and livelihoods of communities in the dry lands if increased attention is given to researching appropriate interventions based on local specificities, including local agro-ecological conditions and market opportunities, different livelihood profiles and the different phases of the drought cycle.

The Biological Society of Ethiopia is well placed to play a central role in the process of providing policy makers with evidence-based information on dry land practice and policy objectives and in this way to renew hope that it is possible to make progress towards the Millennium Development Goals of halving levels of poverty by 2015. Not surprisingly, perhaps there is a caveat, however, the experience of Save the Children suggests that in order to achieve progress, academics, researchers and development experts need to forge new alliances beyond the comfort of their ‘ivory towers’ and Addis-based offices, and engage more with small-holder farmers, agro-pastoralists and pastoralists to define and implement collaborative action research agenda. Engaging with producers is inevitably ‘messy’ and at times frustrating; however the rewards are arguably much higher - healthy, well-fed and food secure households which are better able to survive and thrive in a time of global climate change.
REFERENCES


The paper addresses the debate on biofuels development versus food security in Ethiopia. The key issues are centered on prospects for utilizing the same land resources for production of biofuels and food crops. Biofuels are gaining prominence in both developed and developing countries for two main reasons. First, continued rises in the recent prices of oil products, although currently subsiding, have been used as a justification for seeking renewable energy sources to replace expensive and depleting fossil combustible fuels. In this regard, ethanol blended with benzene (e.g. 5%) has emerged as a viable option for fuel mixes. Use of biofuels as supplement energy sources for cooking purposes are further being advanced. Second, in order to mitigate climate changes due to greenhouse gas emissions from combustion of fossil fuels (mainly coal), biofuels have also been cited as possible substitutes. However, the need for guaranteeing food security has also been raised as an argument working against development of biofuels. An attempt is thus made in the presentation to broadly consider key pros and cons arguments for biofuel development in Ethiopia, a country with well-recognized food and energy deficiencies. The preliminary presentation is strictly done from the technological viewpoint for seeking viable alternatives to guarantee energy-food supply requirements. While more contributions will need to be sought from concerned natural scientists, an attempt is being made to provide a background for discussions and exchange of viewpoints. The role of biologists, chemists, physicists and agriculturalists are seen to be crucial in this regard. Similar efforts will also need to be contributed by knowledgeable environmentalists and economists, possibly supported by social scientists and development-oriented experts. Despite earlier misgivings about the benefits of biofuels in Ethiopia, it is still being contended that renewable energy sources could serve as catalysts for development in rural Ethiopia. This is because the main beneficiaries from use of biofuels will be the rising rural population of the nation as a whole. Without going into details, desirable management of resources (i.e. land

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deployments and water resource utilizations) are briefly touched upon. Wide research activities are also seen as being essential for determining the future of introducing biodiesels in semi-arid lands of the country. It is then stressed that development of biofuels in Ethiopia could serve as timely options in the national effort for enhancing poverty reduction and agro-industrial developments.

INTRODUCTION ON THE GOALS OF BIOFUELS DEVELOPMENT IN ETHIOPIA

The preliminary presentation on biofuels development and food security in Ethiopia broadly introduces and briefly considers prospects for utilizing land resources for production of both food crops and bio-energy sources for the country. In addition to producing adequate supplies of food sources, Ethiopia has actually been dependent for centuries on its biomass sources to meet its traditional energy requirements for domestic purposes and productive activities.

Concerns about both bio-energy sources and food supplies have in fact significantly contributed to development of socio-economic and cultural activities in the long history of the country. This has been so irrespective of the farming practices instituted in the settled highland areas or largely lowland pastoral regions of the country. While gradually there have also been trends towards using modern energy services and technologies, reliance on long-established living trends have largely remained unchanged. The key concerns, therefore, emerging are centered on availabilities and management of adequate food and energy supplies, as well as utilization of precious water resources. Henceforth, bringing together issues on biofuels development with concerns about food security is a timely area of study and necessitates detailed debate on management and availability of adequate food and biofuels.

Biofuels are defined as solid, liquid or gaseous fuels derived from relatively recently dead biological material and is distinguished from fossil fuels, which are derived from long dead biological material. Theoretically, biofuels can be produced from any (biological) carbon source although the most common sources are photosynthetic plants. Various plants and plant-derived materials are used for biofuel manufacturing. Globally, biofuels are most commonly used to power vehicles, heat homes and for cooking stoves. Agrofuels are biofuels which are produced from specific crops rather than from waste processes such as landfill off-gassing or recycled vegetable oil.

Further, biofuels are combination of traditional biomass and renewable energy sources comprising solid, liquid and gaseous fuels. Solid biofuels encompass fuel wood, charcoal, agricultural and dried cattle wastes. Liquid
Biofuels are ethanol, typically produced from molasses in sugar factories in Ethiopia, and biodiesels yet to be extracted from jatropha and other similar plants, as well as from oil seeds. Then biogas is produced mainly from cattle wastes through digestion and fermentation.

Like all food products, biofuels are dependent on the conversion of solar energy into useful chemical energy sources through the process of photosynthesis by combination of soil minerals and water. To start with, it is common knowledge that all food crops and biofuels are all plants; i.e. green plants, mixes of carbon, oxygen and water. Photosynthesis means “putting carbon dioxide together with light” to produce plants. The argument food versus biofuels is raised because of the background that the same land area (especially fertile land) could possibly be used either to meet a country’s food supply requirements or demands for fuels. Then the advantages and disadvantages of producing biofuels are to be considered not necessarily logically but by responding to market forces.

As given in the title, discussion will focus on prospects of biofuel development amidst on-going food security strategies being pursued in Ethiopia. Hopefully, Ethiopia will soon learn and adopt useful lessons from other sub-Saharan African countries for sustainable development of biofuels (Karekezi and Kithyoma, 2009). Then, possibly there could also be references to be made to the involvement of concerned international agencies like FAO (Food and Agriculture Organization) and the IAEA (International Atomic Energy Agency), as well as African countries which are being actively involved in the energy-food, or food-biofuels issues. Now, there are also trends to go to so-called second, third and fourth generation biofuels, but these are possibly not of interest to beneficiaries in Ethiopia.

The goals of the present discussion paper on biofuels and food security in Ethiopia is thus aimed at addressing the following interrelated issues:

- In Ethiopia, as energy and food issues, coupled with climate changes, are beginning to be seen as issues of utmost concern with a rising population, biofuels will need to be included in the on-going debates on increased food and energy production.

- While the industrialized countries are vigorously advocating for agrofuels, in sub-Saharan Africa there are apparently regional economic communities (RECs) that are either ready to promote or to undermine sustainable development of the biofuels industry.

- After the successful blending of 5% ethanol with gasoline from the national sugar industries, Ethiopia is in any case joining the trend towards blending oil with biofuels.
Advancement in the science and technology of biofuels (or agrofuels) are ultimately also going to be of direct interest to Ethiopia.

In terms of the energy and food requirements of the large rural population, biofuels could serve as catalysts for socio-economic developments.

KEY RATIONALE FOR BIOFUELS DEVELOPMENT

Why or how are biofuels becoming of active interest globally? What is the key rationale driving the powerful forces behind development of biofuels or agrofuels both in the industrialized and developing countries? Whatever the commercial and non-commercial reasons, it could be said that the two main driving forces are the global climate change on one hand, and the unpredictable increases in the price of oil due to the on-going economic turmoil. While the concerns about climate change are taking different directions, alternatives to gasoline and diesel fossils have been found in ethanol and bio-diesels have been sought to reduce greenhouse gas emissions, mostly comprising carbon dioxide, nitrogen and sulfur oxides.

As shown in Table 1 and also in Fig. 1, many oil importing African countries are particularly seen to need supplements for imported fossil fuels (i.e. oil). It is well known that a fuel is any material that is burned or altered in order to obtain energy and heat, or to move an object. In modern economies, modern fuels are fossil fuels mainly coal, oil, natural gas and fissionable nuclear materials, and renewable energy derived from the sun, directly and indirectly including biomass energy resources. The key drivers behind biofuels development have, therefore, been the oil imports of many African countries as summarized in Table 1. As oil is a perishable energy source, the remaining years of oil extraction are also indicated in Fig. 1 (Karekezi and Kithyoma, 2009).

Table 1 Biofuels - key drivers: Oil imports as a percentage of total imports in African countries.

<table>
<thead>
<tr>
<th>Category (in %)</th>
<th>Number of African oil importing countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 7.5</td>
<td>5</td>
</tr>
<tr>
<td>7.5 – 15</td>
<td>14</td>
</tr>
<tr>
<td>15 – 22.5</td>
<td>16</td>
</tr>
<tr>
<td>22.5 – 30</td>
<td>10</td>
</tr>
<tr>
<td>30 – 42.5</td>
<td>1</td>
</tr>
<tr>
<td>More than 42.5%</td>
<td>1</td>
</tr>
</tbody>
</table>
Fig.1 Biofuels - key drivers: Remaining years of oil extraction.

Henceforth, after extensive studies, Ethiopia has started its first blend of ethanol with gasoline. If the needed biodiesel sources are also planted and developed (e.g. like jatropha and soybeans), then bio-diesel blends could also be introduced soon.

LAND REQUIREMENTS AND COMPETITION FOR FOOD OR FUEL PRODUCTION

While regulatory frameworks are being developed by concerned bodies and agencies, the key question of setting land requirements for biofuels development in competition with crop production has to be addressed and resolved. Policy gaps and issues will also have to be addressed and recognized. Still, before going into the very sensitive issue of land competition, alternative paths could also be followed. Without going into debates, as a first measure, it can be proposed that pilot biofuel projects and research can be supported in the areas of agronomy, fuel and blending standards, production technology and processing, markets and consumer use. Then, it could be beneficial to inform the concerned stakeholders (e.g. small-scale farmers and interested investors) and create awareness among decision makers and the public. Once the directions of biofuels development are known, issues of land competition and directions of development can be seriously tackled.
Strictly seen from the energy-technology point of view, one is inclined to stress that there are both opportunities and challenges to simultaneously address the food and energy security requirements of the future generations of Ethiopia. The opportunities could easily include the benefits that can be obtained into moving towards modern energy services and technologies for the vast rural population of Ethiopia. The nearest modern energy devices are the small wick lamp and the kerosene stove, with the latter restricted to urban areas. Light output is weak and unreliable for reading or studying purposes. Besides, the kerosene stove is too expensive by the standards of rural communities. So two questions to be asked are: i) Can biofuels be considered as energy mixes to improve socio-economic conditions? ii) Can biofuels assist in moving away from traditional farming activities? Then the challenges are just too many to be enumerated. Can biofuels production assist crop production in any way? In trying to answer the above questions, ideas are proposed for discussion as follows:

Resolving the issue of land competition for biofuels and food security

Without resorting to the use of fertile lands and forest areas, thus not requiring new land, it is contended that biofuels development in Ethiopia could be restricted only to agro-industries (e.g. the sugar factories) and to semi-arid areas. Such a scheme will, however, need to be supported by research, development and demonstration. Besides, it is seen that intensive skill development could be initiated and promoted so as to benefit the rural and urban poor by conducting rigorous social and environmental impact assessments. Such measures could be enhanced by instituting evaluation systems, and revenue sharing to include small holder farmers. In the process, continued degradation of soil and lack of water conservation mechanisms in the semi-arid lands could be averted by minimizing losses of biodiversity and soil fertility. Furthermore, enforceable sustainability guidelines could be promoted so as to enable small-scale farmers in developing biofuels for electricity generation that could even be sold to the national grid.

Issues on land competitions for food crops versus energy crops

From a very cursory perspective, aside from environmental issues of concern, the most sensitive issues working against biofuels development are the interrelated concerns about reduced food production and increasing rise in food prices. Simply stated, there could be land competitions for either biofuels or food crop productions, especially in areas with high population densities. This is claimed to be more crucial in less developed economies, apparently posed by donor organizations (AU/UNIDO, 2007). The bases of the problem are as follows: on one side the need for high production of food crops and on another side the complex world of
food/energy commerce in which the key crops (e.g. maize and wheat) are also used as “feeds” for livestock animals. Therefore, what is being claimed is that “biofuels” are actually “agro-fuels” needed to be developed as commercial commodities by big investors as advised by their consultants or advisers, managers, marketing groups, and so on. Unfortunately, the same pattern of business development is also being extended to the less developed economies, as being attested by qualified researchers and investigators. From a very brief point of view, it is however difficult to firmly conclude that such lines of business thinking on “biofuels” or “agrofuels” could be applied in less developed economies, as in the case of Ethiopia.

Still, one can dare to conclude that the issue of land allocations (i.e. specifically as so many hectares for food crops and biofuels) cannot be easily quantified for a number of reasons. In the first place, the use of modern energy services in agricultural practices in Ethiopia is very recent, and being sustainably promoted to use fertilizers as major inputs for increased food production. Some limited modes of mechanized farming such as irrigation with pumping of surface running water (but not yet underground water!) are also being introduced. Otherwise, the importance of energy inputs into modern agricultural practices in Ethiopia are just being gradually promoted, subject though to lack of crucial investments.

The common objection stressed to biofuels development and to biomass energy production in general is that it could divert agricultural production away from food crops in a hungry world will need to be addressed directly. The claim being made is that this could lead to mass starvation, particularly in the developing countries. However, this view point can not be true in the case of Ethiopia, because it is an oversimplification of a complex issue involving the interests of small-scale and community farmers that are traditionally engaged in producing well known national food crops, oil seeds, soybeans and cash crops. So, can it be noted that there are many, many issues to be addressed and resolved beforehand before coming to the conclusion that there can be no adequate land allocations for both food crops and biofuels in Ethiopia? Besides, the major biofuels needed in Ethiopia will be derived from sugar plantations (i.e. for ethanol), while arid land is being recommended for jatropha (i.e. the main source of biodiesel). This is again a very cursory perspective being expressed by an energy technologist that will hopefully not be confronted by qualified agricultural, biological and environmental experts!!

Biofuels as catalysts for hastening rural development in rural Ethiopia?

As well known, it is now over 150 years in Ethiopia since serious attempts were made to try to introduce the benefits of modern technologies so as to improve socio-economic conditions and productive activities. Of course, as
well appreciated, modernization has come into the country in so many various forms and attributes. Still, not much has changed, or has not been changing in the rural areas of Ethiopia. Elsewhere in the world, during those same years, the laws of biology (e.g. plant selection), chemistry (e.g. analytical and organic), physics (e.g. electromagnetism and atomic theory) have been developed, refined, and extensively advanced, mainly outside sub-Saharan Africa. So applying the laws of electromagnetism, and energy-related physics, power plants have been built to provide electric light, motors and communication systems. Further applying the principles of modern physics, the electronic technology has been advancing in building what are termed as “analog” and “digital” worlds. Combinations of biochemistry have also produced the massive industrial products taken for granted as birthrights by consumers in the developed countries and in the advancing developed countries.

Unfortunately, socio-economic developments are not so successful in the less or least developed countries, including Ethiopia. At this early juncture of the 21st century, Ethiopia is mobilizing all available resources and energies to focus on sustainable development and poverty reduction. So, as part of the ongoing national Renaissance or Rebirth Movement in the country, can it be said that “Biofuels can serve as useful catalysts for hastening rural development?” It is to be recalled that a “catalyst” is to mean a “mechanism” for change and/or reaction. The answer to the question posed above is then that “development of biofuels” can do so for two main reasons. First, parallel to what our great athletes have reminded us, it is possible to overcome our tendency to downgrade or deride the importance of science and technology in our daily lives, provided we think hard and organize or manage our productive activities. Can our social scientists assist in this regard? The problem has been waiting for long to be resolved, and it needs to be recognized!! Second, our natural and applied scientists, as well as our economists, engineers and managers are able to assist in addressing the issues of managing our land and water resources for tomorrow and the future coming years.

The need for launching research activities on biofuels

Policy issues and strategies on biofuels development have been streamlined for approvals by Government policy-decision makers. So now we have the first “gasoline-ethanol” blend after the necessary preparations were completed. In the near future, there will definitely be more biofuel developments, provided the necessary scientific-technological outputs are also produced within the country. What is needed is however the research and consultancy outputs and services of scientists, technologists, economists and environmentalists on biofuels activities. Reference is being made here to needs for relevant and specific research outputs which can
be obtained with the latest experimental results supported by models using the latest and most appropriate information technologies (Wolde-Ghiorgis, 2009; Karekezi and Kithyoma, 2009).

From the point of view of safeguarding food security, it is important to stress that development of biofuels and of course food crops (recall the former green revolution) are being supplanted and supported by the new "green power generators". The basic question to be raised is of course "how can this be done?" And could such a direction require directives from higher concerned bodies? The simple answer is "of course", also with each professional group hopefully providing its services. At least in the immediate future, it cannot work any other way, and neither does the well-established practices and trends of focusing on food crops and cash crops for export be diminished. However, this so-called 'food versus fuel' controversy need not be exaggerated; as it is still not clearly known to the rural population engaged either in farming or pastoral activities. Even in the developed and advanced developing countries, the subject is far more complex than has generally been presented.

From what can be understood, this is because agricultural and export policy and the politics of food availability are factors of far greater importance which are largely under the control or influence of big business enterprises. So, if it can be argued that biofuels development can serve as catalysts for rural development in the case of Ethiopia, the point to be stressed is that there will be an increased awareness about food and energy (or fuel) requirements equally. The usual and traditional practice has been to grow and earn food crops, and also permanently rely on biomass energy resources that are (or were! in the past) freely available in the country side.

Preliminary notes on challenges on biofuels development with needed food security

As outlined above, both food production and biofuels development are of direct and immediate interest to Ethiopia. With a rising population, quality food products and accesses to modern energy services are urgently needed for sustainable development and poverty reduction. The ongoing development process is strategically being planned and pursued for both settled traditional farmers and pastoral communities, as well as for the rising urban population.

Irrespective of what has been said about Ethiopia's developments into the twentieth and now twenty-first centuries, the country has now definite aspirations for agro-industrial developments. Still, there are challenges to be faced and surmounted, including the negative effects of climate change and environmental concerns, and the still underdeveloped water management skills.
However, it is also being argued that Ethiopia definitely needs more food production as we have yet to overcome the food shortage problem that confronted us about 35 to 40 years ago. So, focusing on the issue of biofuels development without negatively affecting the progress towards food self-sufficiency, it is proposed that the preceding five steps need to be considered jointly. It is also recommended to align the biofuels development strategy with the National Food Development Strategy and Energy Policy as soon as possible. In essence, this will require aiming at knowledge and technology transfers about biofuels and biotechnologies from regional institutions or African universities. Then common strategies can be developed so as to share responsibilities in launching research activities in national research centers and universities. Further, it will be possible to arrange various workshops and seminars for knowledge transfers on biofuel development.

What needs to be done?

From what has been discussed, it is obvious that land uses in Ethiopia will need to be prioritized first for increasing food productions. It is also being contended that available or unused land could also be developed for producing biofuels as renewable energy sources. In the process, the country will be heading for a relatively complex and modern agro-industry system. The necessary national policies and strategies have already been established. In the case of biofuels, the appropriate sustainability guidelines have started to be implemented. These do not appear to conflict with food production strategies, they also ensure benefit sharing with the poor and/or small holder farmers.

- Enforcing mandatory blending ratios and targets – Once sustainability guidelines are in place, blending ratios and targets should be instituted; these should be realistic, home-grown and local, and promote incremental contribution of biofuels to energy supply.

- Implement appropriate institutional and fiscal framework – cross sectoral issue that requires selection, empowerment and funding of lead agencies that can coordinate concerned government agencies and encourage appropriate pricing and tax regime.

- From the Energy-Science-Technology view points, development of biofuels in Ethiopia will need to be strongly promoted, of course parallel with increased crop productions.

Despite the existing issues of debate on food versus biofuels, it has to be recognized and asserted that there are still strong arguments in favor of taking biofuels development in Ethiopia very seriously. First and foremost, the country has been dependent on the dwindling biomass resources for
cooking, lighting and cottage industries. It is also an oil importing country. Biomass uses have been continuing without any serious efforts to replace trees by planting, although fortunately this trend is beginning to take some momentum. Since quite some time, the deforestation pressure has been continuing to such an extent that there are now areas of desertification accompanied by soil erosion. Secondly, starting to think about growing food crops and plants for fuels could therefore greatly bring about changes in attitude on water management and usage, as well as opting for needs for improved cooking stoves and lighting lamps, and other energy devices. Without too much exaggeration, it can therefore be argued that there are sound scientific-technological justifications for biofuels development in Ethiopia. Could the benefits be supported by research results? This issue is a subject area for research.

CONCLUDING REMARKS

There are also agricultural products specifically grown for biofuel production including corn and soybeans primarily in the United States; rapeseed, wheat and sugar beet primarily in Europe; sugar cane in Brazil; palm oil in South-East Asia; sorghum and cassava in China; and jatropha in India and Mali. However, such methods or approaches for biofuel production are not of interest to Ethiopia. Biomass can come from waste plant material. The use of biomass fuels can, therefore, contribute to waste management as well as fuel security and help to prevent global warming, though alone they are not a comprehensive solution to these problems. Reduced global warming will contribute to regular seasonal and semi-seasonal rains, meaning sustainable grain production. In summary then, it is being contended that biofuel development and increased food production can both be increased in Ethiopia. It should be emphasized that the necessary studies will need to be undertaken for joint or parallel development in less fertile or semi-arid zones of the country for biofuels, thus leaving fertile lands for crop productions.

As set out in the abstract and introductory notes, it is obvious that biofuels will continue to be developed in all regions of the world be it developed, advanced (or nearly industrialized) developing countries, and less or least developed countries. Although not fully discussed, it has therefore been indicated that Ethiopia is in the right direction in opting for biofuels development. Still much remains to be contributed from research centers and academic institutions. Much remains to be done in the transfer of knowledge and technologies about biofuels, even by African standards. Besides, it is seen that support will need to be sought from donors. Still, it is hoped that the preliminary discussion paper will lead to more active participation by expert groups of researchers.
There are three common strategies of producing agrofuels that are not presently needed in Ethiopia. One is to grow crops purposely high in sugar (sugar cane, sugar beet, and sweet sorghum or starch (corn/maize), and then use yeast fermentation to produce ethyl alcohol/ethanol). The second is to grow plants that contain high amounts of vegetable oil such as oil palm, soybean, algae, or jatropha. When these oils are heated, their viscosity is reduced, and they can be burned directly in a diesel engine, or they can be chemically processed to produce fuels such as biodiesel. Thirdly, wood and its byproducts can also be converted into biofuels such as woodgas, methanol or ethanol fuel. It is also possible to make ethanol from non-edible plant parts, but this can be difficult to economically accomplish in Ethiopia. Sugar cane can, of course, be used both as a biofuel or food, but the main interest in Ethiopia is to produce the ethanol as a by-product of the sugar cane milling and juice extraction processes. Then hopefully, biodeisel can also be produced soon from jatropha plantations.

REFERENCES


THE GENDER DIMENSION OF FOOD SECURITY IN ETHIOPIA

Mulumebet Melaku¹

INTRODUCTION

Women in Ethiopia constitute half of the total population the majority of which live in the rural areas. Although it is not recognized and valued in economic terms, rural women have an important role to play in agriculture and ensuring food security. However, the fact that most of them are illiterate, their lack of access to productive resources and some social services limits their contribution to development and food security. Furthermore it curbs the benefits they should enjoy from economic, social and political development of the country.

The government recognizing the important role played by women for sustainable development and food security has enacted the National Policy on Ethiopian Women in 1993 to create an enabling environment for empowerment of women through integrated gender concerns in the design and implementation of development policies, programs and projects.

The Food Security Strategy also recognizes women’s great contribution for food security and gives due emphasis to the very disadvantaged position of women in the society (FSS, 2002).

At present most of the policies, development programs and projects in Ethiopia strongly stipulate women’s great role for sustainable economic and social development, but the implementation process is very slow due to a number of factors. This has led to the marginalization of women, as well as gradual erosion of sustainable development and food security. Food security is impossible if half of the population is deprived of the opportunity to contribute to sustainable development or enjoy benefits from the fruits of development. “No Security without Food Security and No Food Security without Gender Equality” (APRODEV, 2002).

This paper examines the gender dimension of food security in Ethiopia by scrutinizing the effect of the status of women as compared to men on various aspects of food security by primarily focusing on the following major questions: does women’s status matter for food security? What are the evidences that women’s status influence food security? It touches also some of the major constraints women are facing in promoting food security.

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at the household level. Furthermore, attempts are made to bring to light some of the efforts made to mitigate the problems.

CONCEPTS: GENDER AND FOOD SECURITY

Gender

The concept of gender is often confused with sex. Gender refers to women’s and men’s roles and relationships in a specific society or culture, whereas sex refers to universal biological characteristics of women and men. Sex is something we are born with while gender roles and relations are product of societies determined by the socio-cultural development of that given society. A person’s gender is not biological, rather it is socially constructed. A person’s gender affects the right to use and manage resources and determines his/her social status. The social status in turn determines the decision-making role and capacity.

Division of labor in most societies is based on sex where this classification is social not biological. The roles and responsibilities assigned to women and men are based on culture and tradition. The gender roles attributed to women and men vary among different societies and culture that changes over time in response to changes in ideas and behaviors. Some activities are assumed as a natural duty of one of the sexes, for example, child raising is classified as a female “natural” (sex) role, but it is a female gender role, because child raising could be done by both women and men. But child bearing is women’s sex role since men can not give birth to a child. In our societies household chores are completely left for women as if it is their ‘natural’ sex role, whereas in other societies men and women share household chores.

Gender equality is usually wrongly perceived as women and men to be the same. Naturally women and men are not the same; there are biological facts that differentiate them. Gender equality means that women and men experience equal conditions for realizing their human rights, and have an opportunity to contribute to and benefit from national, political, social, economic and cultural development. Gender equality will be realized when discrimination on the grounds of a person’s sex is eliminated and women and men enjoy equal opportunity in accessing all forms of resources such as land, education, credit, extension services, health care facilities, job opportunities, assuming decision-making positions. Gender equality means women and men assume the same status in the social, economic and political life of their society.

Ethiopian women in general hold unequal status in the society. This is apparent in the social, economic and political sphere. They have limited
ownership of resources, less access to education, health care and limited decision-making power and low political participation.

**Food security**

The central idea being similar, different institutions have defined food security in different ways. Food security as defined by the World Bank is "people's access at all times to sufficient, safe and nutritious food for enjoying an active and healthy life." Food and Agricultural Organization (FAO) defines food security not only in terms of access to and availability of food, but also in terms of resource distribution to produce food and the purchasing power to buy food where it is not produced (FAO, 2004).

Adequate food availability at the national level does not automatically translate into food security at the individual and household levels. Indeed, the issue is not only one of availability but also of access to food (Frankenberger and McCaston, 1998).

Food security is a multifaceted concept that encompasses a broad range of issues: population growth, control and mobility, resource distribution, consumption patterns, agricultural production, climate change, environmental degradation, socio-economic status, development, trade relations, land ownership rights, access to microfinance and to healthcare services. All of these issues are central to women, yet women's role in food security has remained practically invisible to many policy makers (www.paho.org).

Food insecurity exists when people lack sustainable physical or economic access to enough, safe, nutritious, and socially acceptable food for a healthy and productive life. Food insecurity may be chronic, seasonal, or temporary and it may occur at the household, regional, or national level.

The International Food Policy Research Institute disaggregates food security into three pillars: food production, food access and food utilization/nutrition security (http://www.ifpri.cgiar.org).

**Food production**

Sustainable production of food is the first pillar of food security (IFPRI, 1995). Women are active food producers. They play an important role in agricultural production as they participate in all activities. Women work on farms with men to produce grain and cash crops. At homesteads they plant vegetables and fruits for family consumption and for sale to earn additional income to ensure household food security.

Resources like land, farming tools, agricultural extension inputs, credit and market access are basics which Ethiopian women lack in most cases to produce enough food. In many parts of the developing world, gender
discrimination negatively affects production, household income, asset accumulation, food security, and nutrition. Yet women play an enormous role in crop and livestock production throughout the developing world. Researches have revealed that giving women the same access to physical and human resources as men increases agricultural productivity dramatically (Agnes and McClafferty, 2006).

In addition to their direct involvement in food production, women also contribute to food security in other significant ways such as natural resource conservation which is essential for sustainable food security. As the responsibility of providing food for the family rests on women, they always strive to fulfill this responsibility. This has given them the opportunity to develop special knowledge of the value and diverse use of plants for nutrition and health care. They preserve and grow those indigenous plants, thereby contributing to the conservation of natural resources, which, in turn, has an impact on food production and food security. Sustainable food production would be evident when there is a sustainable natural resource management in which women have a great role to play.

Food access

The second pillar of food security is access to food. Availability of food at the household level is a prime factor for food security, but this doesn’t mean that all members of the family have equitable and adequate access to food. Maxwell and Frankenberger (1992) have said that "it is misleading to assume that household members share common preferences with regard to (a) the allocation of resources for income generation and food acquisition or (b) the distribution of income and food with the household". The heads of the households, mostly men, have more power in determining the use of food resources.

Women are primarily responsible for preparing and ensuring availability of enough food for the family. They devote much of their time, energy and income to make food available for the family and ensure that each family member receives an adequate share of food. But usually they take the least share for themselves giving priority to their husbands and children.

Recent studies have shown that improvement in household’s welfare depends not only on the level of household income, but also on who earns that income. These studies disclosed that women, relative to men, tend to spend their income disproportionately on food for their family. Moreover, women expend their income on items associated with improvement in children’s health and nutritional status than men (IFPRI, 1995).
Food utilization/ nutrition security

Achievement of nutrition security is the third pillar of food security. By their gender role women take the responsibility of securing nutrition; they decide the type and amount of food to be served to the household members. Despite that most women are illiterate; they do not have the knowledge of labeling food items in their nutritional status in terms of energy, protein and minerals. Nutritional security also includes the availability of non-food resources such as health, child care, access to clean water and sanitation. The provision of “care” namely, paying adequate time and attention to meeting the physical, mental, and social needs of growing children and other household members is a crucial input to good nutrition.

Women also contribute to food security through reducing food losses. While women perform food processing and preservation work, they contribute to reduce food losses to ensure good nutrition for the family.

THE GENDER DIMENSION OF FOOD SECURITY

Looking at the gender dimension of food security is very important since both women and men have a role to play in food production and distribution. Both women and men have different but complementary roles in guaranteeing food security. Women often play a greater role in ensuring nutrition. Based on gender division of labor they are responsible for processing and preparing food for their family. “Food processing contributes to food security by assuring ongoing diversity of diet, minimizing waste and losses and improving marketability of foods, enabling women to participate in the trade of food products. Their marketing activities directly translate into improved family nutrition, as studies have shown that women tend to contribute a far greater percentage of their cash income to household food requirements than men do” (FAO, 1996).

Women have a major role in determining and guaranteeing food security as food producers, food providers and contributors to household nutrition. Rural women contribute over 65-70% of the labor for agricultural production. They actively participate in all aspects of agricultural production activities. They take part in land preparation; carry out most of the weeding, harvesting, transportation, threshing, processing and storage. They also perform most of the livestock management activities; feeding, cleaning, milking, processing dairy products and management of poultry. Furthermore at the household, all activities to secure nutrition for the family; food preparation, fetching water, gathering firewood, caring for children and elders is the responsibility of women.

Despite their immense contribution to the agricultural production and food security of the household, Ethiopian women suffer from the "invisibility" of their roles. This situation has been observed especially in lack of having
men. The revision of Family Law, Penal code, Civil Service Proclamation, Labor Law etc., are actions taken in recognition of the same.

Ministry of Women’s Affairs (MoWA), Bureau of Women’s Affairs (BoWA) at regional level and Women’s Affairs Departments (WAD) in sector ministries have been established to implement the National Policy on Ethiopian Women. These in fact are commendable steps taken to address issues of gender inequalities, which in turn can combat poverty, food insecurity and others.

Moreover, other policies and development strategies, including the Food Security Strategy recognizes women’s great contribution to sustainable economic and social development. However, due to various factors, the implementation is not as effective as expected.

**FOOD SECURITY PROGRAMS**

Ethiopia has been facing food insecurity problems for decades. Recognizing this fact, the government has developed the Food Security Strategy in 1996, which is under implementation since 2003, to mitigate these persisting problems in most parts of the country.

The strategy rests on three basic pillars:

- To increase the availability of food through increased domestic production;
- To ensure access to food for food-deficit households; and
- To strengthen emergency response capabilities.

Rural women in Ethiopia have a substantive productive role, such as in livestock maintenance, crop production, and the marketing of rural products, which has a significant contribution to economic development (FSS, 2002).

The Food Security Strategy clearly indicates that the existing gender disparity has an impact in achieving food security; “in light of new research, identifying female headed households as being more likely to become destitute, and old knowledge that development interventions are more likely to benefit male household members than females, it was felt that further efforts were needed to address the imbalance between male and female beneficiaries of development programs. This issue would be partially addressed if true community level participatory program design and planning methodologies are incorporated” (FSS, 2002).

The Food Security Strategy has three components: resettlement, Productive Safety Net Program (PSNP) and other food security programs.
Resettlement

The reasons for food insecurity are numerous, one of which is land degradation. In some parts of the country high population pressure has resulted in land degradation, thus a number of families in those areas face severe food shortage. In response to this the government has initiated resettlement programs, which give farmers access to fertile land.

'The main objective of the program is to enable up to 440,000 chronically food insecure households to attain food security through improved access to land/voluntary resettlement' (Voluntary Resettlement Program, 2003).

The resettlement program is framed for three years but with the intention of long-term effect on food security. The program involves all regions, which have to identify and ensure the availability of enough land for resettlement before mobilising settlers. The settlers should be targeted voluntarily. Those families who are not comfortable in the new area can return to their original homeland within three years. Their land use right for their holdings in their original homeland is preserved for three years and the household head has the right to move back individually or with family members in the beginning.

Although it is not yet confirmed by research, female headed households in most cases will not volunteer because of fear of labor shortage in the new area to meet the expected output. Women will also shoulder high responsibility of securing food for the family when their husbands go to resettlement areas.

Productive Safety Net Program

The Productive Safety Net Program (PSNP) is one of the Food Security Programs, which is aimed at preventing depletion of assets at the household level by providing employment opportunities and assets creation at the community level by engaging the PSNP beneficiaries in communal works.

The program has two components: Public Works (PWs) and Direct Support (DS). Households who have able-bodied laborers will be engaged in Public Works and those households who are labor-poor, mostly female-headed would be provided with resources through Direct Support program.

The Implementation Manual (PIM) recognizes a number of gendered aspects of the program. It encourages women’s participation in the Food Security Task Forces (FSTFs) at all levels; it notes that widows and other female household heads are more likely to need Direct Support and that pregnant women over 6 months and breastfeeding women up to 10 months should be exempted from the public works. It also allows for public works to
are respectful of the natural processes of the earth (environmentally sound and sustainable); (iv) the food itself is nutritionally adequate and personally and culturally acceptable; (v) the food is obtained in a manner that upholds human dignity; and (v) what is consumed must be safe and sustainable. The definition also entails the sustainability of production system to meet the food requirements (whether produced or purchased) of not just the current population but also of the future generation as well.

In conformity to the above definition forests have tremendous roles to play. They address all dimensions of food security which is summarized below. The contribution of forests to rural livelihoods is of particular significance in the developing world where most of the population dwell in rural settings and are heavily dependent on natural resources for livelihoods.

- Forests are sources of food. Forests harbor diverse plant and animal species that yield edible fruits, leaves and trophy;
- Forests are a source of cash income. Forests harbor wood and non-wood products such as lumber, wild coffee, herbal medicines, spices, resins/gums, bamboo, etc that can be sold to generate considerable income. Forests serve as a sector of the economy that generates considerable employment thus sustaining the livelihoods of thousands of households;
- Forests provide energy. They provide firewood to cook and light homes;
- Forests are apiary. Forests support apiculture as source of nectar, raw material for hive construction and to hang hives on. Indeed, one of the most important uses of the forest environment by the local people is honey production;
- Forest ecosystems are sources of rivers and springs used as drinking water for livestock and people; without forest there is no water and no life;
- Forests are shelters. They provide wood, climbers and other materials used for construction purposes and provision of safe and warm shelter;
- Forests are rangelands. They provide the largest forage and shade for livestock, particularly in dry seasons; and
- Forests are culture. Forests have significant socio-cultural values and are the pride and satisfaction of most traditional societies.

The objective of this paper is to present evidences that portray the multi-dimensional roles of forests in assisting individuals, households and a nation to achieve sustainable food security. The information presented is
THE ROLE OF FORESTS IN ACHIEVING FOOD SECURITY

Forests are excellent resources. They play tremendous roles in maintaining environmental quality and ecosystem integrity that uphold planetary systems. Forests affect the quality and quantity of most essential natural resources such as soil, water, biodiversity, climate and air on which human survival depends. Forests role in nutrient cycling principally in carbon, nitrogen and phosphorus as well as hydrological cycling are some of the most crucial natural phenomena without which global systems could collapse. Forests are storehouses of large quantities of territorial Carbon (C) pool and are playing a critical role as CO₂ sink to curb global climate change, while their destruction and release of C is a cause for global climate change. They also help to combat desertification. Forests provide scenic beauty and grace to a landscape that refreshes and revitalizes the human spirit. Forests are sources of subsistence and economic opportunities. The biotic resources of forest are used as food, medicine, fibre, energy and shelter. The host of bio-resources in the forests is human's insurance for food, medicine and overall survival. The roles of forests in food security are well depicted in Fig.1 and further analyses of these roles are presented in the succeeding sections by categorizing them into direct and indirect roles.

Direct roles of forests in food security

a) Forests as sources of food

Ethno-botanical literatures have documented the historical and current importance of an array of forest-derived resources consumed by communities living in and around the world's forests. From a wide range of ecosystems, some 7,000 of the earth's plant species have been documented as either gathered from the wild or grown for food (Wood et al., 2005). Some of these are already domesticated while larger numbers are still in the wild. From a nutritional perspective, natural ecosystems offer ample sources of animal protein and fat complemented by plant-derived carbohydrates from fruits and tubers and diverse options for obtaining a balance of essential vitamins and minerals from leafy vegetables, fruits, nuts and other plant parts. According to a report from 62 developing countries, people obtain more than 20% of their protein from wild meat and fish (Bennett and Robinson, 2000). For example, people in the Congo Basin alone consume more than 1 million tons of wild meat annually (equivalent to 4 million cattle) (Wilkie, 2001).
Fig. 1 Multiple roles of forests in food security of households.

In Ethiopia, more than 480 species of wild trees and shrubs have been recorded as important traditional or forest-food sources (Zemede Asfaw and Mesfin Tadesse, 2001). The majority of the species (i.e., ca. 72%) have fruits and/or seeds which are edible, while the remaining species...
possess vegetative parts, i.e., leaves, stems, and tubers/roots that are eaten. Some examples of these plants include *Moringa stenopetala* and *M. oleifera* that provides edible as well as nutrient- and vitamin-rich leaves and shoots, which also have medicinal values. Moringa is used as a source of food for households in Konso and Siomilral area at the end of the dry season when few other sources of green leafy vegetables are available (Mekonnen, 2007). Fruits of *Cordia africana*, *Balanites aegyptiaca*, *Dovyalis abyssinica*, *Ficus spp.*, *Carissa edulis* and *Rosa abyssinica* are commonly consumed in many parts of rural Ethiopia. Fruits of *Opuntia* (*Ficus indica*) and *Borassus aethiopum* are consumed and traded in the market for cash generation in Tigray and Afar.

Ethiopia also possesses a large potential in terms of wild animals. A number of fishes, mammals and bird species are hunted and consumed in the rural areas. Around 10-15 species of mammals, about 5% of birds, some fishes and few amphibians and reptiles are consumed as food. Some of the wild animals used as food sources include most antelopes such as bushbuck, reedbuck, kudu, duiker; monkeys and bush pigs. Francolin and doves are commonly used as food among birds.

**b) Forests as sources of income**

Forests play a significant role in alleviating poverty and thus supporting food security through provision of income. Globally 300 million people annually earn part or all of their livelihoods and food from forests (Pimentel et al., 1997). Forests provide income in formal and informal ways. Formally, forests provide considerable employment. For instance, in Ethiopia the meager forest resources available in the country are still proving reasonably high employment. According to the Central Statistical Agency, 169 public and private forest enterprises are currently employing 6% of the industrial work force of Ethiopia. Similarly, Addis Ababa Bureau of Trade and Tourism and Bureau of Agriculture reported that about 737 privately owned carpentry shops produce and sell furniture, building materials, coffins and wood sculptures in the capital employing a number of youngsters. The gum and incense sub-sector is reported to employ about 20,000-30,000 seasonal workers per year, while as many as 80,000 traditional healers are assumed to exist in the country, 9,000 of whom are officially organized and registered. There are also thousands of self employed atana (construction pole) sellers throughout the country (CSA. 2004).

The majority of forest-based income, however, originates from the informal production and marketing of forest products. Fuel wood collection and sale probably constitutes the single largest source of forestry employment in Ethiopia (Fig. 2). Sale of fuel wood is an important safety net for most rural households, particularly for those in marginal areas.
Annually the financial turnover from non-wood forest products alone in Ethiopia amounts to USD 2.305 billion. This is money that is mostly earned by small holder farmers and poor households that live near or in the forest and produce products such as forest coffee, bamboo, gums and resins, honey, herbal medicines, and the like. For instance, studies carried out in Bale region (Arsema Andargatchew, 2008; Neima, 2008) show that most of the household income is derived from non-timber forest products (NTFPs) principally honey, bamboo, coffee and firewood. Arsema Andargatchew (2008) revealed that on average 47% of the annual income of households is derived from the sale of bamboo in Shedem PA of Goba district in Bale. Similarly, Neima (2008) reported that NTFPs alone contributed to 54% of the total annual income of households on average, which was greater than the income from agriculture which contributed to only 38% of the total annual households' income. Over 90% of the forest coffee, honey and bamboo are taken to market for cash income generation that makes the NTFPs industry the pillar of cash income source for households in the eco-region.

Similarly, in Menagesha Suba forest area there are several NTFPs for home consumption and sale. On average 732 individuals per market day sell different NTFPs in four local markets around the forest (Aramede Fetene, 2006). The sale of NTFPs contributes to 27.4% of the annual income of households in the area. In Bench Maji 52% of annual cash income is obtained from NTFPs while it is about 41% in Sheka (Mohammed, 2007). The cash income generated is used for sustaining household food need as well as supplies of other necessities.

Herbal medicines not only play an important role in the Ethiopian healthcare system but also in terms of government expenditure savings.
For instance, the total value added to the economy from traditional medicine in the year 2005 was estimated at ETB 2 billion (Mender et al., 2006). The industry provides some 346,000 income earning opportunities. About 56,000 tons of medicinal plants are used per annum in Ethiopia, most of which are largely harvested from wild plant stocks. Some examples of herbal medicines and their prices are given in Table 1.

Besides, very large numbers of households generate some of their income from selling of woods from either natural or planted forests. Throughout rural Ethiopia, farmers practice small-scale tree planting and this tree planting practice is the largest source of non-agricultural income in rural Ethiopia (e.g. Turnbull, 1999; Jagger and Ponder, 2000; Mekonnen et al., 2007).

c) Forests as sources of energy

Food health and safety requirements are ensured in many ways. One of these is through proper cooking that requires energy. Fuel wood for cooking is one of the many important contributions of forests to food security in the developing world. The contribution of forest and tree resources to household energy supply is essential, particularly in Africa and will remain so for the foreseeable future. Africa has the highest per capita annual fuel wood consumption in the world (0.89 m³ per year). An estimated 623 million m³ are taken annually from forest and tree resources for energy purposes. Most of this is used for cooking food; thus, availability of fuel wood is important for household food security and nutrition.

Ethiopia is the largest user of fuel wood even by the standards of Africa. In Ethiopia forest biomass represents the bulk of energy sources and predominates both in rural and urban areas alike and this extraordinary dependence on biomass-based fuel has persisted in the country for long. While biomass fuel in general provides close to 95% of the total energy supply, 78% of this is derived from woody biomass obtained from forests and trees outside forests. In the 1990s, the demand was about 80 million m³ per year (FAO, 2002), while recent estimate for the year 2005 showed about 109 million m³ per year (FAO, 2005).

Woody biomass utilized for energy is obtained from the various forest/vegetation resources of the country such as natural forests, woodlands, bushlands, industrial forest plantations, peri-urban plantations, community woodlots, catchment and protection forests and farm forests. Overall, 68% of the households in the country use fuel wood collected from public vegetation resources. In urban centers, the predominant source is purchased fuel wood supplied by both rural and urban fuel wood carriers. Increasing urbanization and rising prices of commercial fuel is soaring the
demand for fuel wood, which in turn, is an emerging incentive for rural households to over harvest and sell fuel woods to generate cash income.

Table 1 Examples of medicinal plants used in Ethiopia and their prices (species in the first ten rows were surveyed in practitioners’ clinics).

<table>
<thead>
<tr>
<th>No.</th>
<th>Scientific Name</th>
<th>Type of Treatment</th>
<th>Part Used</th>
<th>Price per Treatment (ETB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Calendula officinal</td>
<td>Haemorrhoids</td>
<td>Leaf</td>
<td>150</td>
</tr>
<tr>
<td>2</td>
<td>Eucalyptus globulus</td>
<td>Skeletal muscular problems (also colds, respiration difficulties)</td>
<td>Leaf oil</td>
<td>250</td>
</tr>
<tr>
<td>3</td>
<td>Matricaria chamomile</td>
<td>Headache</td>
<td>Leaf</td>
<td>150</td>
</tr>
<tr>
<td>4</td>
<td>Rosmarinus officinal</td>
<td>Nerve manipulation when partially paralyzed</td>
<td>Whole plant</td>
<td>300</td>
</tr>
<tr>
<td>5</td>
<td>Datura stromnium</td>
<td>Chronic cough, asthma</td>
<td>Seed</td>
<td>150</td>
</tr>
<tr>
<td>6</td>
<td>Lactuca spp., Marubium vulgaris, Cynara scolymus</td>
<td>Hepatitis</td>
<td>Leaf</td>
<td>250</td>
</tr>
<tr>
<td>7</td>
<td>Verbascum</td>
<td>Haemorrhoids, eye diseases</td>
<td>Leaf, flower</td>
<td>250</td>
</tr>
<tr>
<td>8</td>
<td>Coriandrum sativum, Taraxacum officinal</td>
<td>Hepatitis</td>
<td>Fruit, leaf</td>
<td>250</td>
</tr>
<tr>
<td>9</td>
<td>Ricinus communis, Solanum giganteum</td>
<td>Skin diseases</td>
<td>Leaf, seed and fruit</td>
<td>100</td>
</tr>
<tr>
<td>10</td>
<td>Marubium vulgares</td>
<td>Chronic cough, colds</td>
<td>Leaf, bark</td>
<td>150</td>
</tr>
<tr>
<td>11</td>
<td>Hagenia abyssinica</td>
<td>Intestinal worms, tapeworm</td>
<td>Flower</td>
<td>Na</td>
</tr>
</tbody>
</table>

Source: Girma Defar (1998)

d) Forests as sources of fodder

Livestock rearing is an integral component of Ethiopian farming culture. While mixed farming system is the principal land use in Ethiopian highlands, pastoralism (in nomadic and semi-nomadic mode of life)
dominates the lowlands. Ethiopia owns the largest livestock population in Africa. There are about 35 million tropical livestock units (TLU) equivalent to about 70-80 million herds in Ethiopia. There are ca. 30 million cattle and over 42 million heads of sheep and goats and 7 million equines in the country (FAO, 2004). Cattle provides traction power for 95% of grain production; it also provides milk, meat, manure, cash income and serves as a hedge in times of drought and risks. They are also used as a means of asset accumulation. Livestock production in Ethiopia is purely traditional in nature. Pasturing is mostly free ranging in the forest, woodlands and grasslands. Forest grazing and browsing is a major source of feed for the vast population of livestock in the country. Specifically, in pastoral community areas in the lowlands where frequent drought and fodder failures often threaten their economy, the contribution of perennial vegetation resources to the fodder requirements of their livestock is considerable. Studies indicate that forests and woodlands provide 15% and 60% of feeds for the livestock during summer and winter, respectively. Indeed, forests are important contributors of sustained livestock production in the country.

Indirect roles of forests in food security

a) Forests and agricultural productivity

The provision of fertile and productive lands for crop production purposes is probably the most important role played by forests, and which will continue to be so. It is obvious that Ethiopia’s economy has been and is still dependent on subsistence agriculture. The sector employs over 85% of the population, who reside in rural or pre-urban settings. Agriculture is land-based and subsistence agriculture is more so since its sustained production relies on horizontal expansion into fertile natural ecosystems than intensification. In such a system it is not only a growing rural population that demands more and more cultivable land. Even at low population pressure rapid loss of soil fertility demands frequent clearing of fresh forest lands. Forestlands are the first target in the process of conversion and obtaining croplands because they are the most fertile to offer high yield return per area and labor. Forests of Ethiopia have been providing fertile croplands for millennia upon clearing.

Forest clearing in order to obtain fertile cropland is as old as crop culture and considerable parts of the country’s farmlands have been obtained through this process. In the past when population pressure was low, traditional management systems such as shifting cultivation have been used to utilize their positive impacts on soil fertility and maintenance of biodiversity. However, the traditional management practices have to change when demographic and economic pressures add further stress,
leading to permanent agriculture being practiced on deforested sites. Since forests are limited resources, the continued impact from horizontal expansion of croplands into forestlands is almost decimating the forest resources of the country (Mulugeta Lemenih et al., 2008). In fact, clearing forests for subsistent agriculture is the number one cause of deforestation in Ethiopia (FAO, 2007), in which clearing for agriculture and settlement results in the loss of 65,540 ha of high forests, 91,400 ha of woodlands and 76,400 ha of shrublands annually in Ethiopia (WBISPP, 2004).

It is obvious that 85% of Ethiopia's landmass falls within typical river basins. Given the steep and long slopes of these river basins, agricultural land uses could not have been sustained this far without the multiple ecosystem services provided by forests. These ecosystem services such as primary production, nutrient cycling, soil formation, soil conservation, crop pollination, water purification, climate regulation, disease regulation, watershed protection, etc. play a great role in ensuring food security. Forests are also used as fallow crops to rejuvenate degraded soils and put them back to production. Forests harbor many beneficial insects that assist crop pollination. Bees, butterflies, beetles, bats and other animals transport pollen, the male reproductive structures, from one plant to another with enormous benefits to humanity.

Forest ecosystems are also buffer stocks. They have been serving as a source of emergency relief for millions of food insecure citizens through formal and informal migration. For instance, from 2002 to 2005, nearly 400,000 households (2,200,000 million people) have been resettled from degraded, food insecure areas to the fertile and able to provide, food security forested areas in Ethiopia.

b) Forest biodiversity as security in a changing global food system

The term biodiversity refers to the variety of life on earth, including all animals, plants and micro-organisms, the genes they contain and the complex ecosystems they form (McNeely and Scherr, 2001). Biodiversity plays a crucial role for human nutrition through its influence on world food production as it ensures the sustainable productivity of soils and provides the genetic resources for all crops, livestock and marine species harvested for food (Hillel and Rosenzweig, 2002). It also supplies the genetic and biochemical resources that protect crops from pests and diseases as well as genetic materials that underpin crop improvement to allow us to adapt to global environmental changes and/or promote productivity. Our ability to sustain and increase crop productivity in the face of new pests, diseases, and other stresses on one hand and global population explosion on the other hand depends heavily on the transfer of genes to our crops from wild crop relatives that confer resistance and other qualities to these challenges.
Traditional food systems typically draw on local biodiversity and are based on local production and management of land and specific environments (Johns, 2006). As discussed in the preceding sections, ethno-botanical literatures have documented the historical and current importance of an array of resources consumed by communities living in and around the world’s forests. It also demonstrates the richness of the traditional knowledge of indigenous and local communities in relation to the gathering and hunting of plant and animal foods and the medicinal value of forest species. Forests are, therefore, important reservoirs of genetic resources which provide some foods at present and possess the potential to nourish a wider public in the future. The wild relatives of many common crops represent an important global heritage.

Biodiversity also supports tremendous ecosystem services such as nutrient cycling, crop pollination, hydrological cycling and climate regulation that contributes to sustainable food production. There is also a significant linkage between biodiversity and human and livestock health that ensures normal productive growth. Herbal medicine for human disease treatment secures vigor and productive citizens who can ensure food security. Today, over 80% of the Ethiopian population relies on herbal medicines extracted from forest biodiversity for their primary health care. Similarly, medicines used to treat livestock diseases ensure millions access to protein sources from livestock assets. In Ethiopia over 90% of livestock health is ensured by using herbal medicines obtained from wild plants.

**FORESTS, CLIMATE CHANGE AND FOOD SECURITY**

It is obvious that current global climate change is a real threat to food security by affecting weather conditions (droughts) and the overall increase in temperature that would affect crop performance. Climate change and forests are intrinsically linked. Forests and global climatic phenomenon are directly interrelated with respect to emission and sinks of CO₂, which is one of the greenhouse gases causing global climate change. On the one hand, deforestation is responsible for 20% of the world’s global warming. On the other side of the coin, forests and the woods they produce trap and store CO₂, playing a major role in mitigating climate change. Forest destruction (degradation and deforestation) is one of the significant causative factors for global climate change. Destruction of forests adds almost six billion tons of carbon dioxide into the atmosphere each year and preventing this stored carbon from escaping is important for the carbon balance and vital in conserving the environment. Indeed, to mitigate climate change, we need to stop deforestation and expand the land area covered by forests so that we can trap or sequester the excess CO₂ in the atmosphere. Similarly, we need to substitute fossil fuel usage with biofuels - like wood fuels from responsibly managed forests - in order to reduce carbon emissions.
If climate change has to be mitigated, forests are the real cost-effective mitigation measures known so far; this has already been stressed in Kyoto protocols and associated measures. Trees and forests help alleviate climate change by removing $\text{CO}_2$ from the atmosphere (by the process of photosynthesis) and converting it during photosynthesis to carbon, which they then store in the form of wood and vegetative parts, a process referred to as ‘carbon sequestration’. Trees are generally about 20% carbon by weight and, in addition to the trees themselves, the overall biomass of forests also acts as a ‘carbon sink.’ For instance, the organic matter in forest soils – such as the humus produced by the decomposition of dead plant material - also acts as a carbon store. As a result, forests store enormous amounts of carbon; totally the world’s forests and forest soils currently store more than one trillion tons of carbon - twice the amount found floating free in the atmosphere.

There is a new global initiative to address tropical deforestation known as REDD. REDD stands for reducing emissions from tropical deforestation and degradation in developing countries. It is a system of payment or policy that offers reward to developing countries for reducing their deforestation rates. Through REDD a huge amount of many can be transferred to countries willing to properly manage their forests and the money can be used for poverty alleviation and improving food security of forest dependent poor rural households.

Furthermore, forests are effective adaptation to climate change for many poor economies. They are resources to revert to during hard times caused by climatic anomalies such as droughts and floods. Poor people usually cut trees for sale and earn income and harvest wild food to survive. Existence of forests will also conserve moisture and thus, make crop productivity possible by way of irrigation. The water can be used for watering livestock, hence protecting people against the impact of climate change.

**FOREST DEGRADATION MEANS FOOD INSECURITY AND VULNERABILITY**

Food insecurity exists when people lack access to sufficient amounts of food and are, therefore, not consuming the food required for normal growth and development. This may be because of lack of access to food - because of unavailability, insufficient purchasing power, inappropriate distribution or inadequate utilization at the household level. One of the factors that can lead to general food insecurity is deforestation and forest degradation. Deforestation can lead to food insecurity directly and indirectly as well as in the short and long terms. The intricate relationships between forest resources and poverty (food insecurity) are summarized in Fig. 3.
The serious link between forest depletion and poverty in Ethiopia is in its indirect effect on agricultural sector productivity. Ethiopia is a country primarily based on agricultural economy. Nonetheless, general landscape, rugged topography, heavy deforestation, intensive rainfall and ill-practiced land management have resulted in heavy soil erosion and lowering of soil fertility leading to serious decline in national scale food production. Deforestation followed by improper land management on steep slopes are the major causes for soil erosion and loss of fertility, declining agricultural productivity and prevalence of poverty (food insufficiency) in Ethiopia. The interrelationships between deforestation, decline in soil productivity and the real impact they have on food insecurity in Ethiopia has been reported since the 1960s.

Fig. 3 Deforestation and poverty links in Ethiopia (Mulugeta Lemenih et al., 2008).

The decline in crop productivity of the soils due to erosion is still continuing today and poses a big challenge to the people and government of Ethiopia. Soil loss, caused by erosion resulted in an annual loss of grain production estimated between 57,000 and 128,000 tons, which could have been saved had forests covered steep slopes of the country's watersheds. The foregone production in the livestock sector resulting from soil erosion is estimated to be between 35,000-78,000 TLU (tropical livestock units)
annually. Furthermore, declining forest resources have turned animal dung and crop residues to be increasingly used in Ethiopia as fuel wood substitutes instead of being recycled on farmland to maintain soil fertility. Burning of dung and crop residues is estimated to represent additional annual loss in crop production of 700,000 tons of grain in Ethiopia (EFAP, 1994). Over all these losses represent a financial cost of 1.1% GDP or loss of food for nearly 5 million people each year. To the average farmer, the financial cost of grain and livestock production foregone represent about 12% of his/her income per annum (EFAP, 1994).

Water is another most important resource for agriculture. Due to deforestation and accelerated erosion, water resources in Ethiopia are severely affected by siltation and sedimentation. Several streams and lakes have already dried out and many others are drying. Deforestation also increases surface runoff and reduces the amount of rainfall infiltrating the soil and eventually percolating into groundwater aquifers. Low level of infiltration leads to low ground water recharge, which leads to low water availability during dry seasons affecting access of human and livestock to water throughout the year. This, in turn, leads to higher peak flows in streams and rivers causing greater flood damage during summer time. A good example in this regard is increasing siltation of hydroelectric dams and serious shortages of electric powers during dry seasons in the country. The impact of all these on agricultural productivity are yet to be grasped. The consequences of all these are poverty that is widespread in Ethiopia.

At the household level, loss of forest resources also leads to diminished income- and food-generating capacity for forest-dependent communities and thus food security. At the national level depletion/degradation of forests means depreciating national assets. Using depreciation approach, conservative estimate shows that nearly one-third of forestry's contribution to the GDP is lost each year due to depletion of forest resources (deforestation) in Ethiopia (EFAP, 1994). Unsustainable use of the forest resources in Ethiopia, therefore, significantly reduces forestry’s contribution to sustainable national income.

CONCLUSION

Food security/insecurity and forest resources have multi-dimensional linkage. Forests can provide food for consumption from arrays of bio-resources they host. They can provide cash income to empower individuals/households to purchase food and medicines for productive, healthy growth. Forest ecosystems also provide fertile lands for sustained crop production while forest grazing is supporting livestock production. Biomass from forests provides the energy needed to properly cook and consume safe food. Forests are a solution to global climate change that is threatening out future food production and health. They are effective
climate change mitigation strategy. Forest ecosystems provide multitudes of environmental services such as soil and water conservation in a watershed that significantly contributes to sustained food production. Thus, forest conservation and development measures ensure not only the food access of the present generation but also for generations to come.

REFERENCES


UNDERUTILIZED EDIBLE PLANTS AS A MEANS OF FOOD SOURCE DIVERSIFICATION IN ETHIOPIA

Getachew Addis¹, Zemede Asfaw² and Zerihun Woldu²

INTRODUCTION

Food security and nutritional status of the population are central concerns to governments in developing countries. In 1996, the World Food Summit (WFS) (FAO, 1996) adopted a definition which underlined that food security existed “when all people at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preference for an active and healthy life.” This concept embodies several dimensions consisting of food availability, accessibility and stability at individual, household, national and global levels. Food diversification has a direct bearing on the food security and balanced diet of people since broader presence of food variety at a particular point in time or over time would enhance food availability, accessibility, stability and the desired nutritional complements. Food diversification would also strengthen trade at different levels, leading to more income generation and greater access to food. The residual benefits of food diversification go as far as meeting the environmental objectives of conserving biodiversity in a sustainable way. Despite all these benefits, very little attention is directed to diversification of food sources. The main strategies followed by most countries to ameliorate food deficit has been increasing agricultural production and productivity of the elite cultivars. The most populated countries of the world (China and India), however, took a different approach to ensure household food security.

Countries like Ethiopia that are trying to get out of the food insecurity and malnutrition loop, have much to learn from the success stories of China and India. The course of actions that these highly populated nations went through is in diminutive terms being undertaken currently by local communities in Ethiopia. These communities use diverse food sources both from cultivated and wild origins. This observation can be likened to the idea promoted by the Asian FAO regional consultation group that suggested transforming the hitherto common concept of “green revolution” to a new

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concept of "ever-green revolution". This concept advocates the substitution of the commodity-centered approach by a farming systems approach to foster a sustainable agriculture and food security system. The farming systems approach is obviously ecologically, economically and socially sustainable. It is based on a fair play between traditional wisdoms and modern technologies. In the ever-green revolution therefore the ecological prudence of the past and the fruits of contemporary innovation can be harmonized. The pathway to an ever-green revolution on the farm is the adoption of integrated natural resource and gene management strategies (FAO Regional Technical Consultation, 1999). This new thinking is reminiscent of the traditional Ethiopian lifestyle that could be fitted with the polycultural farming and food systems of some communities and promoted to other communities.

Ethiopia has a large number of underutilized edible plants, most of them wild edibles, as discussed by various authors (Amare Getahun, 1974; Abbink, 1993; Mengistu Woube, 1995; Zemed Asfaw and Ayele Nigatu, 1995; Guinand and Dechasa Lemessa, 2001; Zemed Asfaw and Mesfin Tadesse, 2001; Getachew Addis et al., 2005; Tigist Wondimu et al., 2006; Zerihun Woldu et al., 2006). The ground is well set for Ethiopia in general and southern Ethiopia in particular to diversify food sources and contribute to household food security.

This paper presents the facts and the authors' collective viewpoints on how underutilized edible plant resources can contribute to achieve the goals of food security via food source diversification in a phase-by-phase adoption of promising underutilized edible plants to augment Ethiopia's food self sufficiency scheme.

Wild foods and their potentials in general

The entire population that rely on wild edible plants can hardly be accurately estimated; but it is generally thought that about 200-300 million people are partially or totally dependent on wild plants of the forests (Pimentel et al., 1997). The most populated countries on earth are substantially augmenting their livelihoods by the use of diverse floral and faunal resources. Chinese food is characterized by an assemblage of plants and animals that occur prosperously for a long time; and their ways of eating are characterized by "flexibility and adaptability" that developed through time and practice (Chang, 1977). Indian cuisine is influenced by Hindu religion that emphasizes on foods of plant origin avoiding animal products except milk due to ethical reasons. Chinese and Indian people went through different routes to achieve diversity of food sources but based on utilization of diverse mixes of wild floral and faunal resources. A food composition table consisting of the most common Indian foodstuffs of terrestrial and aquatic origin included 592 species (Gopalan et al., 1989).
The principal author has observed numerous edible plant parts sold in open
markets of Mysore town in India. Our field observations in southern
Ethiopia also show that some of these edibles or their close relatives are
part of the flora (Table 1), but are either underutilized or not used at all for
human consumption.

Research in different parts of Africa has also shown that wild plant and
animal species are quite extensively used at times of food abundance,
during the annual "hungry season", and in times of acute food shortage.
Ogle and Grivetti (1985a) reported that wild plants contributed a greater
share of the food for 39% of the Swaziland people than domestic cultivars,
and 18% reported an even balance between wild edible plants and food
crops, giving a good clue about the importance of wild plants in Africa's
food economy. Mostly, women and children routinely go out into the field
and forests to collect a variety of leaves, roots and tubers, seeds and fruits,
which are consumed either raw or cooked. At times of food availability,
these wild plants are usually eaten either as a side dish or relish
accompanying the main meals or as snacks in between meals (Lepofsky et
al., 1985; Ogle and Grivetti, 1985a; Zinyama et al., 1990).

Underutilized edible plant resources of Ethiopia

The category of underutilized edible plants includes plants that are
consumed by humans, but for which the level of use is not proportionate to
the potentials that exist. These plants are many in number both globally
and in Ethiopia. They can be categorized into two subgroups as wild edible
plants, comprising the bulk of the group and the underutilized food crops.
Ethiopia is rich in floral and faunal diversity that can be sustainably utilized
for food and other purposes.
Table 1 Some edible plant parts available in open market of Mysore town (India) but either not used or underutilized in Ethiopia (as observed by the principal author).

<table>
<thead>
<tr>
<th>Edible species</th>
<th>Family</th>
<th>Edibility in India</th>
<th>Status and related information in Ethiopia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mentha sp.</td>
<td>Lamiaceae</td>
<td>Aerial part</td>
<td>Flavouring (Medicinal and rarely used as flavouring)</td>
</tr>
<tr>
<td>Amaranthus gangeticus</td>
<td>Amaranthaceae</td>
<td>Tender aerial part</td>
<td>As leafy vegetable (Some Amaranths used in many areas as source of leafy vegetable and/or grain as well as medicine)</td>
</tr>
<tr>
<td>Amaranthus cruentus</td>
<td>Amaranthaceae</td>
<td>Tender aerial part</td>
<td>As leafy vegetable (source of leafy vegetable and/or grain as well as medicine)</td>
</tr>
<tr>
<td>Amaranthus sp.</td>
<td>Amaranthaceae</td>
<td>Tender aerial part</td>
<td>As leafy vegetable (source of leafy vegetable and/or grain as well as medicine)</td>
</tr>
<tr>
<td>Anethum sp.?/Foeniculum sp.?</td>
<td>Apiaceae</td>
<td>Leaf</td>
<td>Flavouring (Used as medicine, seed sometimes used for flavouring)</td>
</tr>
<tr>
<td>Solanum nigrum</td>
<td>Solanaceae</td>
<td>Tender aerial part</td>
<td>As leafy vegetable (Leaf sometimes used as vegetable)</td>
</tr>
<tr>
<td>Clausena sp.</td>
<td>Rutaceae</td>
<td>Leaf</td>
<td>Flavouring (Used as medicine)</td>
</tr>
<tr>
<td>Trigonella foenum-graecum</td>
<td>Fabaceae</td>
<td>Tender aerial part</td>
<td>As leafy vegetable (Seed used as spice)</td>
</tr>
<tr>
<td>Coriandrum sativum</td>
<td>Apiaceae</td>
<td>Tender aerial part</td>
<td>Flavouring (Seed used as spice and medicine)</td>
</tr>
<tr>
<td>Manihot esculenta</td>
<td>Euphorbiaceae</td>
<td>Root</td>
<td>NS (Root edible mostly in south but not north)</td>
</tr>
<tr>
<td>Centella sp.</td>
<td>Apiaceae</td>
<td>Leaf</td>
<td>As leafy vegetable (Centella asiatica used as medicine)</td>
</tr>
<tr>
<td>Pupalia sp.</td>
<td>Amaranthaceae</td>
<td>Leaf</td>
<td>As leafy vegetable (Leaf edible in some part of south Ethiopia)</td>
</tr>
<tr>
<td>Senna sp.</td>
<td>Fabaceae</td>
<td>Leaflet</td>
<td>As leafy vegetable (All senna spp. are medicinally used as laxative, sometimes S. occidentalis leaf used as vegetable and seed as coffee substitute)</td>
</tr>
<tr>
<td>Edible species</td>
<td>Family</td>
<td>Edibility in India</td>
<td>Status and related information in Ethiopia</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------</td>
<td>--------------------</td>
<td>----------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Moringa olifera</strong></td>
<td>Moringaceae</td>
<td>Young pod</td>
<td>As vegetable</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>M. stenopetala and rarely M. olifera leaflets are used as vegetable in south. No record on the edibility of pod. M. stenopetala used as medicine</td>
</tr>
<tr>
<td><strong>Musa x paradisiaca</strong></td>
<td>Musaceae</td>
<td>Flower head</td>
<td>As vegetable</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Only fruit edible</td>
</tr>
<tr>
<td><strong>Cucumis sp.</strong></td>
<td>Cucurbitaceae</td>
<td>Fruit</td>
<td>As vegetable</td>
</tr>
<tr>
<td><strong>Cajanus cajan</strong></td>
<td>Fabaceae</td>
<td>Young pod</td>
<td>As vegetable</td>
</tr>
<tr>
<td><strong>Coccinia grandis</strong></td>
<td>Cucurbitaceae</td>
<td>Fruit</td>
<td>As vegetable</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Only seed edible when matured</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Children consume ripe fruit and leaf boiled as vegetable in the south</td>
</tr>
<tr>
<td><strong>Tamarindus indica</strong></td>
<td>Fabaceae</td>
<td>Exocarp excluding cover</td>
<td>Exocarp excluding cover consumed and marketed for same in some southern parts</td>
</tr>
</tbody>
</table>

Note: Plant materials available in the market for sale were used for identification. Identification for some of the samples was therefore only possible at genera or higher level.
Wild edible plants

The use of wild plants in the Ethiopian diet has been underreported. However, observations and few studies undertaken in the last couple of decades on the field indicate that more than 300 wild plant species are consumed by rural and urban populations (Amare Getahun, 1974; Abbink, 1993; Mengistu Woube, 1995; Zemede Asfaw and Ayele Nigatu, 1995; Guinand and Dechasa Lemessa, 2001; Zemede Asfaw and Mesfin Tadesse, 2001; Getachew Addis et al., 2005; Kebu Baleme and Fassil Kebebew, 2006; Tigist Wondimu et al., 2006; Zerihun Woldu et al., 2006). The dry lands of Ethiopia alone host 287 species according to a recent compilation (Tigist Wondimu, 2007). The studies made so far on wild edible plants of Ethiopia give good indication that the country as a whole has a larger aggregation of herbs, trees, shrubs, climbers and creepers with edible fruits, leaves, seeds, tubers and other plant parts. The number known to date is just a portion of what exists, and focused and targeted ethno-botanical studies are expected to add more when noted against the fact that there are 800 species of traditional food plants in Kenya (Maundu et al., 1999) and 12,650 species consumed by humans globally (Kunkel, 1984).

All the wild edible plants are underutilized in the Ethiopian case because none of the species has ever been used to the limits of its potential. The knowledge, tradition, and opportunity of using wild plants by different communities as supplements to the dietary intake have been widely described. This extensive utilization of wild plants for food varied with respect to communities, age, sex, time of the day and season. Generally, youngsters (mostly male cow-herds) consume more wild fruits and vegetables than elders in times of food availability. There is an increase in number of species and plant parts consumed by all age and sex groups at times of famine or food shortage during war-time and dry season of a year when household food stock diminishes. The diverse flora of Ethiopia that is housing numerous underutilized edible plants, and the spectra of cultures for prospecting, using and managing the edibles deserve priority considerations in development initiatives.

Cultivated underutilized food plants

Ethiopia has more than 100 species of the conventional cultivated plants. Many of these (about 20 taxa) were domesticated in-house, many others were introduced from the Americas via various intermediary routes and many others came from Asia, Europe and the rest of Africa. The country is, thus, a megacentre of crop diversity that has donated important gifts to world agriculture in terms of crops and germplasm. There are more than 15 leguminous species and 13 species for each of the grass, labiates and the
cucurbits. The citrus and the solanaceous families also have 8 species each (Alemtsehay Teka, 2008). Many of the cultivated plants of Ethiopia, in particular the locally domesticated ones [e.g. ENSET (Ensete ventricosum), DAGUSA/finger millet (Eluesine coracana), DEQOQO/the Abyssinian variety of pea (Pisum sativum var abyssinicum), ANCHOTE (Coccinia abyssinica), MOKOTTA (Manihot esculenta)] and others can be considered underutilized since their research and productivity awaits further work.

Actual and potential use of underutilized edible plants in Ethiopia

The Southern Nations, Nationalities and Peoples Regional State of Ethiopia is characterized by having the highest number of ethnolinguistic communities (CSA, 1998). Data on consumption of plants that are less frequently used in food preparations are being added to the literature. In this regard, studies of the food plants of the Hamar and Xonso communities have brought up a large number of edible plants (more than 200 species) consumed in different forms with varying intensities (Guinand and Dechasa Lemessa, 2001; Zerihun Woldu et al., 2006; Getachew Addis et al., 2008). Homegardens, farmlands, bushlands and forest habitats are the main collection sites of the wild edibles while a considerable number of underutilized food plant species are cultivated. The Xonso people are eminent prospectors, users and managers of underutilized food sources; most of them being collected from wild lands. A good number of these species have been classified as semi-wild as they are managed in some form for their values as food, medicine, monetary income generation and other uses. One of the main coping strategies used by the Xonso to mitigate food deficiency is through the use of wild and semi-wild plants. Wild plants are copiously consumed when the usual food items are readily available. The trend towards increased consumption of more species and quantities of each has been observed at times of food scarcity (Guinand and Dechasa Lemessa, 2001; Zerihun Woldu et al., 2006; Getachew Addis et al., 2008). They use these plants as supplementary diets and as parts in regular dishes; further considering wild areas of their surroundings as normal places for gathering wild food items to evoke the extended farm concept discussed by Zerihun Woldu and co-workers (2006). If properly utilized, the wild and semi-wild flora can be used as insurance to food shortage, alleviating malnutrition, increasing options of the consumers in general and the vulnerable groups on account of the nutraceutical roles of some of the species and as sources of income.

Sustainable utilization of underutilized edible plants

In the past, traditional societies relied on the use of diverse flora and fauna to meet their food requirements. At present, the diversity of edibles is narrowing down to relatively fewer species. Of the thousands of species
known to be consumed worldwide only 150 are found in world commerce and 15 constitute the main sources of human food energy (Ogle and Grivetti, 1985c). Narrowing down of food base has basically twofold problems. Unlike food diversification, that assures balanced diet, limited number of edibles lead to malnutrition and enhanced effect of antinutrients. Secondly, as the gene pool of edibles gets narrower, coping mechanisms (alternative sources) of food shortage caused by natural calamites such as drought, pest and microbial pathogens on domesticated crops will similarly be limited.

Ethiopia has faced recurrent drought and famine over the years. Moreover, the segment of the population affected by malnutrition is significant. Food source diversification is, therefore, critical for Ethiopia in its efforts to overcome food insecurity, malnutrition and to set the stage for responding to the challenges of the impeding climate change. Improving access and raising the quantity and quality of food are key actions necessary to deal with food insecurity and malnutrition of the general population and improve rural livelihoods. Food diversification measures involve maximizing its availability through various options including promotion of mixed cropping and integrated farming, production of new crops and underutilized traditional food sources with proper storage and preservation mechanisms in place.

Among the diverse wild flora used for food, many (herbs in particular) have short life cycles. They germinate fast, grow under trace moisture and complete their life cycle within a relatively short duration. Although life span of the plant is short, edible parts are available at a time when the annual conventional food stock is found at its minimum level. The case in point is *Amaranthus hybridus*. It completes its life cycle within two months. During this period, fresh and tender leaves can be used as vegetable (before crop harvesting season/least crop stock in the year), and seeds harvested at the end of the cycle (personal observation by the principal author). The grains can be used immediately or easily stored for later use (as part of the meal during food availability or use as main dish during food deficiency). Amaranthus grains substitute nutrients that can be obtained from conventional cereals (Melaku Umeta and Kelbessa Urga, 2005) or can complement it. Similarly, the root of *Coccinia abyssinica* is a good source of carbohydrate (Habtamu Fufa and Kelbessa Urga, 1997), and the level of vitamins and minerals of the edible fruit is yet to be determined. Although the potential contribution of edibles from the wild is overlooked in food security and nutritional surveys, their dietary role may be extensive.

When viewed in terms of annual calendar, edibility of wild plants is distributed year round. Mostly edible wild herbs are available during rainy season and/or in moist areas. Many others are also available throughout the year and can be used to increase dietary variety in the form of
supplement or as a main dish. Table 2 shows nutritional composition of some edible wild and domesticated plant parts. Investigations show that the nutritive contribution of wild species compares well with domesticated edibles, and in some instances are superior to modern cultivars. Numerous wild edibles supply much, if not most, of the required vitamins (especially A, B and C), proteins, carbohydrates, macro-nutrients, trace minerals of nutritional importance, vitamins and fiber. While generally leafy vegetables (including the wild) are commonly known as source of minerals, they can also be compared favorably if not more in terms of quantity and quality protein in dry matter basis (Ogle and Grivetti, 1985b; Getachew Addis et al., 2008). Similar to pulses (unlike cereals), leafy vegetables are rich in the main limiting amino acid, lysine, but deficient in sulfur-containing amino acids (methionine and cysteine). For example, freshly dried (under shade) leaf of C. grandis (used as vegetable in Hamar and Xonso) contains 36% protein which is rich in lysine. Generally, cereals are staple foods in any society. Therefore, it can safely be assumed that consumption of the staple cereals complement the limiting amino acids. Although this may vary from one community to another, the protein obtained from the intake of pulses (small quantity), milk and other products may not meet daily lysine requirement set by FAO/WHO/UNU (1985). Use of freshly dried underutilized leafy vegetables can be taken as means of ameliorating the problem.

The facts about antinutritional factors in edible plants

Nature endowed plants with the capacity to synthesize a wide variety of chemical substances that are nutritious and beneficial in maintaining health while others are known to exert deleterious effect when ingested by humans and animals. It is a well known fact that a number of cultivated crops contain natural toxicants, which can vary in type and magnitude. For example, different parts of Lathyrus sativus contain ß-N-oxalyl-L-α, ß-diaminopropionic acid and cause irreversible paralysis of the lower limbs (Getachew Addis and Narayan, 1994; Binyam Kebede et al., 1995) if consumed in excess. Other antinutritional factors like phytic acid, trypsin inhibitor, tannin, oxalic acids and haemagglutinins are commonly found in different cereals, pulses and root/tuber crops. The presence of these antinutritional factors either reduces the bioavailability of nutrients, inhibit the activities of digestive enzymes, reduce food quality, or directly agglutinate erythrocytes of the consumer (Jaffé, 1980; Liener, 1989; Binyam Kebede et al., 1995). Even if these plant toxicants cause negative impact on the consumer, food processing of different kinds significantly reduces their concentration mostly below the tolerable limit. Had it not been for the presence of food processing methods and concomitant reduction in the antinutritional factors, rice, soybean, potato, cabbage, onion, kidney bean, etc. could have not been popular dietary crops in the world (Jaffé,
Underutilized Edible Plants for Food Source Diversification

Getachew Addis et al.

1980; Liener, 1994; Binyam Kebede et al., 1995). Above all, the most advocated pulse crop in the world (for its high quantity and quality protein), soybean, is so rich in these different antinutritional factors (Liener, 1994).

With regard to the level of antinutritional factors, wild edibles are not much different from domesticated food crops. Through years of experience, indigenous communities have either selected safe edible plants, possessing knowledge on detoxification methods to extremely reduce the toxic or antinutritional factors or understood the proper amount to be taken in the mixed diet similar to domesticated food crops. The Xonso experience of consuming “kurkufa” (staple diet prepared from mixes of cereals, pulses, roots and assorted vegetables including from the wild, possibly oil and meat) is more advantageous (nutritionally and health wise) than the experience of urban dwellers who consume few food items at a time. Under certain circumstances, the assumption of higher level of antinutritional factors of wild edibles compared with the domesticated crops explains ignorance on distribution of the same, proper processing and/or limiting the quantity of intake is simply a bias. Cuthbertson (1989) has provided a clear definition of healthy food as: "All foods can contribute to health, if used as part of a mixed diet; conversely, all foods can cause ill health if consumed unwisely."

Some examples on the antinutritional composition of wild edibles and domesticated crops are presented in Table 3. Mostly data obtained using different analytical techniques provide completely different results and the reader is advised to take values cautiously. Liener (1989) indicated that evidence which shows human health hazard due to food constituents are mere exaggeration. The reason behind is that most of the in vivo toxicity studies were conducted on small laboratory or farm animals. These organisms consume bulk quantity of a particular plant species that could affect their health over a long duration. With the exception of few cases (such as times of food shortage), this is not a normal eating pattern of humans. The presence of antinutritional factor(s) as a component of an ingredient in varied diet may not be harmful. However, it provides alert signal about the possible hazard that can be caused by consuming such foods. An example of such harsh experience is consumption of grass pea (Lathyrus sativus). Ingestion of grass pea during food shortage by some communities in different countries including Ethiopia caused neurolathyrism (irreversible paralysis of the lower limbs). Despite possible detrimental effect on bioavailability of nutritional factors and inflicting health problems, many of the so called "antinutritional factors" have health benefits some of which are explained by Thompson (1993).
Table 2 Comparison of nutrient-energy content of domesticated and wild edible plants (dry matter basis except moisture and mentioned).

<table>
<thead>
<tr>
<th>Plant</th>
<th>Moisture (%)</th>
<th>CHO (%)</th>
<th>Protein (%)</th>
<th>Fat (%)</th>
<th>Ash (%)</th>
<th>Energy (Kcal)</th>
<th>P (mg)</th>
<th>Ca (mg)</th>
<th>Fe (mg)</th>
<th>Zn (mg)</th>
<th>Vitamin C (mg)</th>
<th>β-carotene (µg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leafy vegetables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brassica carinata&lt;sup&gt;a&lt;/sup&gt;</td>
<td>NS</td>
<td>39.5</td>
<td>25.5</td>
<td>6.7</td>
<td>15.8</td>
<td>320.3</td>
<td>64.0</td>
<td>194.0</td>
<td>7.2</td>
<td>0.6</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Beta vulgaris&lt;sup&gt;a&lt;/sup&gt;</td>
<td>NS</td>
<td>31.8</td>
<td>25.9</td>
<td>4.7</td>
<td>24.7</td>
<td>273.1</td>
<td>68.0</td>
<td>417.5</td>
<td>5.6</td>
<td>0.4</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Moringa stenopetala&lt;sup&gt;a&lt;/sup&gt;</td>
<td>NS</td>
<td>51.8</td>
<td>9.0</td>
<td>5.8</td>
<td>12.6</td>
<td>295.4</td>
<td>65.6</td>
<td>792.8</td>
<td>3.1</td>
<td>0.5</td>
<td>28.1</td>
<td>160.0</td>
</tr>
<tr>
<td>Brassica oleracea&lt;sup&gt;b&lt;/sup&gt;</td>
<td>94.7</td>
<td>58.5</td>
<td>17.0</td>
<td>1.9</td>
<td>5.7</td>
<td>319.1</td>
<td>547.2</td>
<td>811.0</td>
<td>15.1</td>
<td>NS</td>
<td>169.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Brassica oleracea&lt;sup&gt;c&lt;/sup&gt;</td>
<td>91.4</td>
<td>NS</td>
<td>19.8</td>
<td>NS</td>
<td>9.3</td>
<td>302.3</td>
<td>465.1</td>
<td>546.5</td>
<td>8.1</td>
<td>NS</td>
<td>627.9</td>
<td>1200.00</td>
</tr>
<tr>
<td>Corchorus spp&lt;sup&gt;c&lt;/sup&gt;</td>
<td>79.3</td>
<td>NS</td>
<td>22.2</td>
<td>NS</td>
<td>12.1</td>
<td>280.2</td>
<td>589.4</td>
<td>1739.0</td>
<td>206.3</td>
<td>NS</td>
<td>386.0</td>
<td>30966.0</td>
</tr>
<tr>
<td>Amaranthus spp&lt;sup&gt;c&lt;/sup&gt;</td>
<td>88.3</td>
<td>NS</td>
<td>37.5</td>
<td>NS</td>
<td>20.4</td>
<td>359.0</td>
<td>876.6</td>
<td>1455.0</td>
<td>123.4</td>
<td>NS</td>
<td>544.7</td>
<td>47795.7</td>
</tr>
<tr>
<td>Portulaca oleracea&lt;sup&gt;c&lt;/sup&gt;</td>
<td>93.2</td>
<td>NS</td>
<td>31.5</td>
<td>NS</td>
<td>22.0</td>
<td>NS</td>
<td>NS</td>
<td>801.5</td>
<td>94.3</td>
<td>6.5</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Solanum nigrum&lt;sup&gt;c&lt;/sup&gt;</td>
<td>86.9</td>
<td>NS</td>
<td>35.9</td>
<td>NS</td>
<td>14.0</td>
<td>NS</td>
<td>NS</td>
<td>1219.3</td>
<td>186.0</td>
<td>10.2</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Seed</td>
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<td></td>
</tr>
<tr>
<td>Hordeum vulgare (black)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.1</td>
<td>83.1</td>
<td>11.0</td>
<td>1.8</td>
<td>1.4</td>
<td>392.6</td>
<td>315.6</td>
<td>30.5</td>
<td>10.4</td>
<td>NS</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Zea mays (white)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>10.0</td>
<td>81.1</td>
<td>10.0</td>
<td>5.1</td>
<td>1.3</td>
<td>410.3</td>
<td>320.0</td>
<td>21.1</td>
<td>7.8</td>
<td>NS</td>
<td>NS</td>
<td>0.0</td>
</tr>
<tr>
<td>Eragrostis tef (white)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>10.9</td>
<td>81.9</td>
<td>10.4</td>
<td>2.7</td>
<td>2.7</td>
<td>393.5</td>
<td>397.3</td>
<td>145.9</td>
<td>26.3</td>
<td>NS</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Eragrostis tef (red)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>10.8</td>
<td>78.9</td>
<td>10.1</td>
<td>3.0</td>
<td>4.3</td>
<td>383.0</td>
<td>3.3</td>
<td>3.0</td>
<td>168.2</td>
<td>NS</td>
<td>407.0</td>
<td></td>
</tr>
<tr>
<td>Amaranth (A. hybridus?)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
Underutilized Edible Plants for Food Source Diversification

<table>
<thead>
<tr>
<th>Table 2 continued</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maji (red)³</td>
</tr>
<tr>
<td>Goldiya (black)³</td>
</tr>
<tr>
<td>Goldiya (palewhite)³</td>
</tr>
</tbody>
</table>

**Root**

| Solanum tuberosum⁴ | 73.1 | 85.5 | 4.8 | 0.4 | 4.1 | 364.8 | 212.0 | 52.0 | 8.6 | NS | 52.0 | 0.0 |
| Amorphophallus galleensis⁶ | 84.5 | 83.5 | 5.8 | 0.4 | 6.0 | 360.8 | NS | 428.0 | 8.72 | 1.1 | NS | NS |

**Fruit/Fig**

| Citrus sinensis⁵ | 87.9 | 32.2 | 5.8 | 9.1 | 41.3 | 233.9 | 190.1 | 413.2 | 6.6 | NS | 314.0 | 2768.6 |
| Shola (Ficus carica??)*b | 88.1 | 61.3 | 6.7 | 2.5 | 6.7 | 294.5 | 142.9 | 848.7 | 7.6 | NS | 126.1 | 0.4 |
| Hyphaene thebaica*³b | 11.6 | 65.5 | 2.6 | 0.4 | 6.6 | 276.0 | 203.6 | 17.1 | 12.4 | NS | 9.0 | 0.5 |

Highest level of β-carotene (6075.9, dmb) recorded in *Psidium guajava* (zeyton).

Note: Plants in bold font are domesticated and normal are wild or semi-cultivated, NS is for not specified, highlighted β-carotene values should be taken cautiously due to deviation from normal values.

* Shola is mentioned as *Ficus carica*, most probably misidentified.
** Least in moisture content among fruits.

Ogle and Grivetti (1985b) indicated that vegetables are rich in lysine but poor in sulphur-containing amino acids (methionine and cysteine)

**References**

a-Cherinet Abuye *et al.* (2003), b-EHNRI (1997)
c-Ogle and Grivetti (1985b),
d-Melaku Umeta and Kelbessa Urga (2005)
e-Getachew Addis *et al.* (2008)
Table 3 Comparison of antinutritional factors between cultivated and wild edible plant parts (dry matter basis).

<table>
<thead>
<tr>
<th>Item</th>
<th>Part and processing state</th>
<th>TI (TIU/mg)</th>
<th>Phytic acid (mg/100g)</th>
<th>Polyphenols (mg/100g)</th>
<th>Tannins</th>
<th>Oxalic acid (mg/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sorghum bicolor</strong></td>
<td>Grain sieved (-60)</td>
<td>12.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cajanus cajan</strong></td>
<td>Grain (Ud) NS</td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grain (D)</td>
<td>18.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grain (Kilned, 105-110°C)</td>
<td>8.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Glycine max</strong></td>
<td>Grain (Ud) 122.0</td>
<td>1800</td>
<td>204*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grain (D) 16.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lathyrus sativus</strong></td>
<td>Grain (Ud) 23.2</td>
<td>467.3</td>
<td></td>
<td></td>
<td>670</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grain (D)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Solanum tuberosum</strong></td>
<td>Tuber</td>
<td>77.0**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Brassica oleracea</strong></td>
<td>Leaf</td>
<td>141.6**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Brassica carinata</strong></td>
<td>Leaf</td>
<td>79.3**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Coccinia abyssinica</strong></td>
<td>Tuber Nd 0.92</td>
<td>33.3**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.34</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Amorphophallus gallaensis</strong></td>
<td>Tuber 100</td>
<td>1064*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Coccinia grandis</strong></td>
<td>Leaf Trace 292</td>
<td>749</td>
<td>357*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Trigonella foenum-graecum</strong></td>
<td>Leaf Trace 286</td>
<td>729</td>
<td>504*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Solanum nigrum</strong></td>
<td>Leaf 160</td>
<td>70**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Oxalic acid estimation: * method of analysis was HPLC and ** using titrimetric.


+ = *L. sativus* has also ODAP (antinutritional factor); Nd- not detected
Grain (Ud)- grain undecorticated; Grain (D)- grain decorticated
The way forward

Ethiopia can take lessons from the path followed by highly populated countries for attaining food security, which involved boosting the production of conventional foods combined with promotion of underutilized food resources. Crop and livestock production need to increase in concurrence with serious programme on the lesser known underutilized edible plants and animals. Available information on sustainability, harvesting values, gastronomic properties, nutritional composition and safety, tolerance to adverse environmental conditions, multiplicity of uses and ease of production/collection reveal that promotion of underutilized edibles is a worthwhile venture.

Underutilized edible plants can be promoted in a step-by-step manner taking the elites in the first line and subsequently bringing the others. In this regard, priority action could be directed to underutilized edibles like *Moringa stenopetala*, *Solanum nigrum*, and *Amaranthus graecizens* as source of leafy vegetables and *Amaranthus hybridus* both as vegetable and grain. *M. stenopetala* is a common leafy vegetable in the south. It is either managed (North Omo) or distributed as wild (South Omo areas). Although detailed dietary survey is lacking, the investigator's unpublished document shows that it is one of the staple diets in Xonso. The other selected edible plant parts are also widely used in Ethiopia, the same or very close relatives are consumed in many parts of the world, extensive studies conducted and revealed that they are safe (no report on toxicity) and nutritious. Suggested priority edibles have also their own specific values. *M. stenopetala* is culturally highly acceptable, perennial (its edible part is available throughout the year) and medicinally important. All the remaining herbs are fast germinating and growing, naturally available during peak season of food deficit, preferred or acceptable by consumers for their taste and have medicinal importance (neutraceuticals). *A. hybridus* in particular has edible leaves (high harvesting value mainly in fertile soils) and seeds. Food technological studies on maintaining quality and upgrading sensory acceptability, studies on storage and preservation, seed germination and seedling establishment (domestication potentials and field trials), favorable ecological conditions for the selected edible plants are recommended to be conducted to upgrade the food value and expand consumption rates. It is also suggested to transfer the technology package to the community for appropriate action. Furthermore, early warning and information dissemination system should be well established so as to create awareness and take necessary preparation to use available opportunities or cope with the challenges.

Leafy vegetables such as *Leptadenia hastata*, *Portulaca quadrifida*, *Balanites aegyptica*, *Adenia ellenbekii*, *Coccinia grandis*, *Corchorus* spp. as
well as edible tubers like *Arisaema flavum* and *Amorphophallus galaensis* that are widely consumed in Xonso and environs also present themselves as candidates for food source diversification in the second line of promotion. The leafy vegetables are widely used for consumption in Ethiopia and many countries around the world. However, consumption (mainly during food scarcity) of the tubers is restricted to Ethiopia. An aroid, the very close relative of *A. galaensis* known locally as elephant foot yam (*A. campanulatus*) in particular is, however, an important crop in India (Gopalan et al., 1989). High harvesting value and carbohydrate level as well as ease of storage (on site or after powdering) makes *A. flavum* and *A. galaensis* important candidates in the second line of development. There are also meagre published and unpublished evidence that show nutritional composition of the vegetables and aroids which could sometimes be compared with domestic crops. However, some of these edibles are cited to have unwanted effect on the consumer and lack detailed nutritional and antinutritional composition (unpublished data by the investigators). Therefore, it is suggested to conduct toxicological and nutritional studies in addition to the study areas suggested for the first line (elite) edibles before recommending them for wider usage.

In the third line of promotion, underutilized edible plants of better agronomic yield and quality (in terms of nutritional, medicinal and safety benefits) values can be selected for promotion following rigorous study on the wider pool of the wild edibles. Table 4 shows the species of underutilized edible plants under three categories: those that can go straight to utilization in the first line of action, those that can be taken up after some work in the second line of action and those that have to go through more rigorous studies to test public acceptance, food values and other key tests. Furthermore, means of fetching bush meat and egg can be developed through controlling enemies and hunting (in sustainable manner) of culturally acceptable edible wild animals. In the long run, there is a need for cultural revolution and societal transformation to develop a food secured nation with its citizens having well versed feeding habit through adoption and nurturing of diverse and sustainable food sources, an experience worth learning from the Chinese. Ecosystem conservation, monitoring of underutilized edibles, enhancement of the roles of social groups, and positive practice of indigenous botanical knowledge are very critical actions. Success depends on the effectiveness of the transfer of information on production of diversified food sources being produced in healthy environments to serve the goals of poverty reduction, biodiversity conservation and preservation of bio-cultural heritages.
Underutilized Edible Plants for Food Source Diversification

Getachew Addis et al.

### Table 4 Promising frontline underutilized edible plant species presented under three categories (L=Leaf, F=Fruit, R=Root, S=Seed, A=Aerial part).

<table>
<thead>
<tr>
<th>Candidate underutilized edible plant species for the first phase/line of action (The elites)</th>
<th>Candidate underutilized edible plant species for the second phase/line of action (promising but some preliminary work needed)</th>
<th>Some of the candidate plant species for the third phase/line of action among the wider pool of underutilized food plants</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Amaranthus graecizens (L)</strong></td>
<td><strong>Adenia ellenbeckii (L)</strong></td>
<td><strong>Bosca salicifolia (L)</strong></td>
</tr>
<tr>
<td><strong>Amaranthus hybridus (L and S)</strong></td>
<td><strong>Amorphophallus gallaensis (R)</strong></td>
<td><strong>Canthium pseudosetiflorum (F)</strong></td>
</tr>
<tr>
<td><strong>Coccinia abyssinica (R)</strong></td>
<td><strong>Arisaema flavum (R)</strong></td>
<td><strong>Cordia africana (F)</strong></td>
</tr>
<tr>
<td><strong>Moringa stenopetala (L)</strong></td>
<td><strong>Asystacia gangetica (L)</strong></td>
<td><strong>G. arborea (F)</strong></td>
</tr>
<tr>
<td><strong>Opuntia ficus-indica (F)</strong></td>
<td><strong>Balanites aegyptiaca (L and F)</strong></td>
<td><strong>G. tenax (F)</strong></td>
</tr>
<tr>
<td><strong>Physalis peruviana (F)</strong></td>
<td><strong>B. rotundifolia (F and S)</strong></td>
<td><strong>G. vilossa (F)</strong></td>
</tr>
<tr>
<td><strong>Solanum nigrum (L)</strong></td>
<td><strong>Berchemia discolour (F)</strong></td>
<td><strong>Hoslunia opposita (F)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Celosia argentea (L)</strong></td>
<td><strong>Hyphaene thebiaca (F)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>C. trigyna (L)</strong></td>
<td><strong>Hyphaene thebiaca (F)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Carrisa spinarum (F)</strong></td>
<td><strong>Justicia flava (L)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Citruslanus (F)</strong></td>
<td><strong>Kedrostis foetidissima (L)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Cleome gynandra (L)</strong></td>
<td><strong>Kedrostis leloja (F)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Coccinia grandis (L &amp; F)</strong></td>
<td><strong>Kedrostis pseudogief (L)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Corchorus olitorius (L)</strong></td>
<td><strong>Launaea intybacea(L)</strong></td>
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<tr>
<td></td>
<td><strong>Corchorus tridens (L)</strong></td>
<td><strong>Maerua angolensis (L)</strong></td>
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<td></td>
<td><strong>Corchorus trilocularis (L)</strong></td>
<td><strong>Meyna tetraphylla (F)</strong></td>
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<td></td>
<td><strong>Digera muricata (L)</strong></td>
<td><strong>Oncoba spinosa (F)</strong></td>
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<td><strong>Ficus sur (F)</strong></td>
<td><strong>Pachycymbium laticoronum (A)</strong></td>
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<td></td>
<td><strong>Ficus sycomorus (F)</strong></td>
<td><strong>Rhus natalensis (F)</strong></td>
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<td></td>
<td><strong>Ficus thonningii (F)</strong></td>
<td><strong>Rhynchosia minima (L)</strong></td>
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<td><strong>Ficus vasta (F)</strong></td>
<td><strong>Salvadora persica (F)</strong></td>
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<td></td>
<td><strong>Leptadenia hastata (L)</strong></td>
<td><strong>Sclerocarya birrea (F)</strong></td>
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<td></td>
<td><strong>Mimusops kummel (F)</strong></td>
<td><strong>Sporobolus pyramidalis (S)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Portulacca oleracea (L)</strong></td>
<td><strong>Syzygium guineense (F)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>P. quadrifida (L)</strong></td>
<td><strong>Tamarindus indica (F)</strong></td>
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<tr>
<td></td>
<td><strong>Pentarrhumin insipidum (L)</strong></td>
<td><strong>Vangueria madagascarensis (F)</strong></td>
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<td></td>
<td><strong>Sterculia africana (S)</strong></td>
<td><strong>Ximenia americana</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Vangueria madagascarensis (L)</strong></td>
<td><strong>X. caffra (L)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Ziziphus spina-christi (F)</strong></td>
<td><strong>Z. mauritiana (F)</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Z. mucronata (F)</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Zanthoxylum chalybeum (F)</strong></td>
</tr>
</tbody>
</table>
REFERENCES


CONTRIBUTION OF TRADITIONAL AGROFORESTRY PRACTICES TO SUSTAINABILITY OF RURAL LIVELIHOOD IN ETHIOPIA

Zebene Asfaw

INTRODUCTION

Agroforestry systems make maximum use of the land. The tangible benefits of agroforestry include construction materials, food for humans and animals, fuels, fibers, and shade while service provision includes holding the soil against erosion and improving soil fertility (by fixing nitrogen or bringing minerals from deep in the soil and depositing them through leaf fall). Well-designed systems of agroforestry maximize beneficial interactions of the crop plants while minimizing unfavorable interactions. In a system with trees, pasture and foraging animals, the trees provide shade and/or forage while the animals provide manure. Exploitation of interactions between woody and non-woody (herbaceous or annual crop) components is the key to success of all agroforestry systems. The positive interactions between components of an agroforestry system are often complementary. These positive interactions are some of the major characteristics of traditional agroforestry practices such as agroforests, parkland agroforestry and scattered trees on cropland. The former is known for its economic and ecological sustainability, food diversification and risk aversion while the latter for its soil fertility improvement and shade provision as well as fodder production. This paper reports the contribution of traditional agroforestry to the livelihood of the rural community in Ethiopia.

AGROFORESTRY SYSTEMS AND LIVELIHOOD

In agriculture a system can be viewed as a type of land use that is specific to a locality and described in terms of its biological composition and management, level of technical management, or socio-economic features. In this context, agroforestry is a dynamic ecologically-based natural resource management system that diversifies and sustains production for increased social, economic and environmental benefits through integration of trees on farms and in the agricultural landscape (ICRAF, 1997).

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Agroforestry practice (AFP) is a specific land management activity of an agroforestry nature on a farm or other land management unit that consists of agroforestry components. It could be in the form of agricultural crops in combination with forest plantations, tree over crop cover, agroforests, trees and shrubs in pastures, and woody hedges (for fodder and browse, mulch, green manure and soil conservation) which are all agroforestry practices (Nair, 1993). Practices become systems when they are developed to form definite land utilization types in a specific area. Managing agroforestry components of the AFPs for positive interaction requires a good understanding of the net effects of component interaction. Component interaction refers to the influence of one component of an agroforestry practice or system on the performance of the other component as well as the system as a whole. These positive or negative effects can be either direct effects or result from the physical presence of the woody component in the system, which causes microclimate amelioration or nutrient additions via litter fall and root decay. Indirect effects may result from management practices connected with or necessitated by the presence of woody perennials, e.g. weeding, pruning, irrigation, or fertilization. In general, the success of agroforestry practices heavily relies on the exploitation of component interactions.

Contribution of AFPs to livelihood sustainability depends on positive interaction. Evidences from other part of the globe indicate that agroforestry practice contributes to sustain both food and wood security and biophysical sustainability (productivity, environmental services mainly maintenance of soil quality and microbial diversity). With regard to the latter, some of the advantages of the inclusion of compatible and desirable species of woody perennials on farmlands are: (i) increasing organic matter content of soil (e.g. Young, 1997; Rao et al., 1998), which in turn results in increased activity of micro-organisms in the root zone (Khanna, 1998); (ii) enhancing efficient nutrient cycling, hence maintaining soil fertility (Nair, 1993; Young, 1997); and (iii) control of soil erosion (Rocheleau et al., 1988). The positive effects of trees on soil and understorey vegetation are limited to certain sites and species combination, including both N-fixing and non-nitrogen fixing tree species (Ong and Leakey, 1999).

The increased consideration of traditional agroforestry land use practices and widening of the focus from the field to landscape scale in agroforestry science have made links between agroforestry and conservation of biodiversity more relevant and more obvious. According to Schroth et al. (2004), agroforestry contributes to biodiversity, *circa situ*, conservation on a landscape scale in three ways: (i) the provision of supplementary, secondary habitat for species that tolerate a certain level of disturbance; (ii) the reduction of rates of conversion of natural habitat in certain cases; and (iii) the creation of a more benign and permeable 'matrix' between habitat...
remnants compared with less tree-dominated land uses, which may support the integrity of these remnants and the conservation of their populations. In most agroforestry land use, a wide variety of crops are cultivated under a cover of mixed useful tree species that contribute to food diversification and risk aversion. Hence, it is an ecologically sustainable and economically better land use system that requires low input, and can be flexibly adapted to different basic conditions. For instance, coffee production from tree shade agroforestry contributes to 5% of GDP, 14% of agricultural revenue, 30% of government revenue and 60% of Ethiopia’s foreign currency earnings (Kassahun Bantte, 1993).

Best agroforestry practices

a. Agroforests

Agroforests are multipurpose agroforestry ecosystems in which trees are densely planted in blocks, which show different degrees of species diversity (trees, crops and animals), generally possess a multistrata structure and are managed by farmers. Agroforests are certainly amongst the most complex of all the agroforestry practices and are characterized by several ecological and economic interactions that contribute to making them some of the most sustainable practices. The multistrata canopy of an agroforest protects the soil from direct impact of rains, its dense mixed vegetation and ground cover reduces water run-off and the dense, multistrata root system contributes to soil conservation by checking soil erosion. The abundant litter and decaying roots increase the organic matter in the soil which can be further enhanced through the recycling of domestic waste and compost production, especially in homegardens. The deep and layered root system pumps deep-lying nutrients which are brought to the surface by the processes of litter and root decomposition. In general, it increases the productivity of farm unit.

In agroforests, there is a great diversity of species and hence known for *circa situm* conservation. Their multistrata nature enables them to make efficient use of light and they produce high yields of biomass. The biological performance of agroforests is akin to that of forests. These biological resources serve the farming household through the production of a varied and well distributed food supply (seasonal provision of wood, food and income diversification) and contribute to biodiversity. Diversity, mixed cropping, different biological cycles and absence of mass management are factors which reduce plant pathology risks in agroforests. Part of the biomass of agroforests consists of a rich harvest of highly nutritious (minerals, vitamins) food products whose harvest is well distributed in time, thus eliminating the risk for total crop loss which may affect monocropping or less diversified agricultural production systems. Other parts of this
Contribution of Traditional Agroforestry Practices

Zebene Asfaw

biomass are firewood and wild or cultivated medicinal plants. Their economic performance is also good since they require few inputs and yield high outputs, both in quantity, diversity and value. Their species diversity and the distribution of production throughout the year may also reduce marketing problems. The following examples are presented to show the importance of such agroforests in Ethiopia.

The Gedeo agroforest

This is one of the most sustainable innovative land use type in Ethiopia. It consists of food crops like enset (*Ensete ventricosum*), Boyna (*Dioscorea abisinica*), godere (*Colocasia esculenta*), leafy cabbage, green pepper, onion, shallot, various spices, avocado, papaya, banana, coffee and various native tree species. The characteristics of this agroforest is more of homegardens type and in some case of village-forest-garden. Their upper canopy is mainly dominated by *Millettia* which hosts both arbuscular mycorrhizal fungi and nitrogen-fixing bacteria known as biofertilizer, *Cordia africana* and *Albizia gummifera*. The former is the most preferred species both by men and women. Coffee is a cash crop which is sold as fresh just at harvest time while dried coffee is sold later from January to April. Farmers also sell enset, fruit trees and firewood mainly of *Millettia ferruginea* at a cost of ETB 35.00 for one horse load. As compared to other practices, this practice is ecologically sustainable. For example, the simplest indicators are absence of signs of erosion even at a range of 30-60% slope of land, presence of numerous springs, the amount of biomass that recycles during month of December to February, presence of diverse species and structural diversity resembling natural forest structure and high population density (more than 500 persons per km² in the zone but in some areas like Bula peasant association (PA) and Tumicha it is 1000 person per km²). Contribution of this agroforest to food security is enormous. Such type of agroforest also exists in some places in Sidama zone, known for high population density (Zebene Asfaw and Hulten, 2003; Tesfaye Abebe, 2005).

Homegarden agroforestry at Finote Selam

This agroforest is found in Gojam close to Finote Selam, Jabi Tahnan district, Menkusa Abdegoma PA as well as Bakel PA around Burie. It is characterized by multistrata. The upper layer is dominated by timber, shade and fruit trees, such as *Persea americana*, *Mangifera indica*, *Cordia africana*, *Albizia gummifera* and *Acacia lahais*. The middle layer is occupied by medium-sized plantation trees and agricultural crop species, such as *Sesbania sesban*, *Coffee arabica*, *Rhamnus prenoideis*, *Citrus sinensis*, *Citrus reticulate*, *Leucaena leucocephala*, *Prunus persica*, *Musa x
paradisiacal, *Carica papaya*, *Arundo donax* and *Saccharum officinarum*. The lower layer is occupied by vegetables and spices.

The effectiveness of the practice is mainly attributed to the multiple products obtained from a small piece of land. Various cash generating products from this practice are distributed over seasons and serve as risk aversion strategies. Unlike monocropping which aggravates the problem of soil erosion mainly on slopey land, this practice maintains soil erosion and fertility by maintaining vegetation cover and mulches. Similar fruit-based homegardens are found elsewhere e.g. Zegie, Kembata, Arba Minch, Wondo Genet and Ramis valley in Hararghie.

b. The Parkland agroforestry

Scattered or dispersed trees in cropland, often known as ‘parklands,’ are a widespread traditional practice in the semiarid tropics. The best known systems are those involving faidherbia (*Faidherbia albida*) prevalent throughout the rift valley and Hararghie (Poschen, 1986; Kamara and Haque, 1992). Trees generally occur in low density, 5–50 trees ha$^{-1}$ in the case of faidherbia (Depommier et al., 1992). Several studies have reported improved soil fertility in terms of soil organic matter, extractable P and exchangeable cations under trees compared with treeless open areas (Kamara and Haque, 1992). In four faidherbia parklands in Burkina Faso, the soils under trees had higher nutrient status than soils in open areas: 14% to 100% more organic C, 13% to 117% more organic N, 18% to 36% more extractable P, 2% to 67% more exchangeable Ca, and 60% to 100% more exchangeable K (Depommier et al., 1992). The fertility improvement was mostly noted in the topsoil (0–20 cm). Improvements are reflected through lower bulk density, lower surface resistance to penetration, increased porosity and greater aggregate stability (Campbell et al., 1994). These changes would lead to higher rain water infiltration into the soil and higher availability of water to crops.

Crop yield increases have been widespread under open and well-managed canopies of fully grown trees. As compared to open field, yield increase under canopy of faidherbia was 76% for maize and 36% for sorghum (Poschen, 1986). These yield increases under faidherbia (often referred to as the ‘albida effect’) are attributed to the combined effects of improved soil fertility, soil water and microclimate. Farmers in the central rift valley are very much benefitting from faidherbia as it sheds its leaves, as a reversed phenology, during teff growing season. Another important example of this category is the Muringa (cabbage tree) parkland agroforestry practices of Derchie and Konso in South Ethiopia.
Agroforestry as a tool to rehabilitate degraded forest sites and sustain livelihood in Sidama zone

a. A brief history of tree cultivation

Studies conducted in highland Sidama zone, Shebedino and Awassa Zurria have provided information on change of tree cultivation over periods (Zebene Asfaw and Hulten, 2003). A combination of influences such as socio-economic, stages of agricultural intensification and tenure system factors are found to be the main factors for changes in tree cultivation. On some farms large-scale expansion of exotic monoculture practice, such as *Eucalyptus camaldulensis* (red gum) and chat, is limited whereas a high abundance of native trees was observed. Although red gum planting started thirty years ago, chat monoculture has been increasingly expanding during the last twenty years and resulted in large-scale shift in production from coffee and/or maize fields to chat fields. Interviews with key informants and households (N=74) indicated that before 1974, it was difficult to plant trees on farms and obtain wood for any use. After 1974, over the years there was a progressive increase in the number of species and tree density. Self-sufficiency in households places particular requirements on fuel and construction wood, which were the prime objectives of expansion of tree planting.

Population pressure increased the necessity of land for crop cultivation and settlement and hence expansion of tree cultivation was limited to the immediate vicinity of houses. At the same time, expansion of settlement and crop cultivation decreased the size of communal grazing land to individual grazing fields. Population pressure also led to an increased need for self-sufficiency on farm resources leading to expansion of agroforests and multistorey homegardens with native trees. To supplement the role of native trees, exotic trees have been introduced during the last three decades. *Eucalyptus camaldulensis* (red gum) has become the predominant species in the entire land use. In addition to the above-mentioned driving forces for changes in tree cultivation, the need to earn income is the strongest incentive for widespread tree cultivation (mainly red gum and chat). Such farmers’ strategies are in agreement with the experience of Kenya where about 80% of households in Kakamega planted trees on their farmland to produce poles for sale (Arnold, 1987). At the study sites, farmers were motivated to cultivate fruit tree species such as avocado, mango, banana, guava and papaya for cash generation. As claimed by key informants, despite population growth, there has been a significant increase in trees over the last three decades which is in line with studies of de Biggelaar (1996) and Backes (2001).
b. Tree diversity arrangement strategies at field and farm level

The size of the land holding and its partitions (fields) has an important influence on rehabilitation, particularly on choice of species, arrangement and density as well as overall management (Table 1). In all studied farms, the fields used for growing trees were not specific. At a glance, the arrangement of red gum dominance seemed to be haphazard but a closer scrutiny would reveal that each assembly occupied a specific field/niche (Table 2). Higher land allocation to woodlot strategies of wealthier households was due, at least in part, to use the increased access to markets for higher red gum commercialization. The mean value of woody species richness at study sites, ca. 16 species per sampled farms is relatively high as compared with/to reports of Zemede Asfaw and Ayele Nigatu (1995). The highest number of woody species was at enset, boundary and front yard, respectively. The number of tree species on chat was found to be relatively low. As chat is a highly light demanding plant, farmers have to remove trees from the uppermost canopy or conduct intensive tree pruning. Differences in tree stem density between the different fields on farms of households of different wealth categories were noticeable (Table 3). The high stem density implied that farmers were self-sufficient either through direct use of tree products or indirectly through income generation from trees.

Table 1 Farm size, major field types and area distribution (%) within sample farms belonging to households of different wealth categories at the three sites.

<table>
<thead>
<tr>
<th>Status</th>
<th>Farm size (ha)</th>
<th>Field type and area distribution¹(%)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor</td>
<td>0.33</td>
<td>46.5</td>
<td>21.5</td>
<td>7.5</td>
<td>4.0</td>
<td>12.0</td>
<td>8.5</td>
<td>1)</td>
</tr>
<tr>
<td>Medium</td>
<td>0.62</td>
<td>49.0</td>
<td>16.5</td>
<td>9.0</td>
<td>6.5</td>
<td>10.5</td>
<td>8.5</td>
<td>-</td>
</tr>
<tr>
<td>Wealthy</td>
<td>1.31</td>
<td>28.5</td>
<td>15.5</td>
<td>7.5</td>
<td>7.5</td>
<td>18.5</td>
<td>22.5</td>
<td>-</td>
</tr>
</tbody>
</table>

Area distribution was calculated by dividing value of individual field area over mean farm: E = enset; FY = front yard; CH = chat; CO = coffee; M = maize; WL = woodlot; OT = others (grazing , sugar cane etc.)

¹) indicate fields without tree species or with too small number of trees to fit to one decimal place
Table 2 Mean number of tree species recorded on fields of sampled farms of households of different wealth categories at study sites.

<table>
<thead>
<tr>
<th>Status</th>
<th>Field type and number of species</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>E</td>
</tr>
<tr>
<td>Poor</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>14</td>
</tr>
<tr>
<td>Wealthy</td>
<td>20</td>
</tr>
</tbody>
</table>

B = boundary; E = enset; FY = front yard; CH = chat; CO = coffee; M = maize; WL = woodlot, OT = others

1) indicate fields without tree species or with too small number of trees to fit to one decimal place

Table 3 Mean number of stems and basal area ha⁻¹ and stem number distribution (%) on main field types on sampled farms of different wealth categories.

<table>
<thead>
<tr>
<th>Status</th>
<th>Basal Area ha⁻¹</th>
<th>Stem number (%) on main field types</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>E</td>
</tr>
<tr>
<td>Poor</td>
<td>5.2</td>
<td>2.043</td>
</tr>
<tr>
<td>Medium</td>
<td>5.9</td>
<td>1637</td>
</tr>
<tr>
<td>Wealthy</td>
<td>9.1</td>
<td>1785</td>
</tr>
</tbody>
</table>

B = boundary; E = enset; FY = front yard; CH = chat; CO = coffee; M = maize; WL = woodlot; OT = others

1) indicate fields without tree species or with too small number of trees to fit to one decimal place

The Sidama farmers plant or maintain trees to minimize their negative effects. They maintain trees according to their compatibility with enset, coffee, chat, vegetables, etc. on different fields. Various shade-tolerant fruit species like banana and enset are fitted in wherever some spaces are available. The major multipurpose species preferred for intercropping in homegardens (mainly enset and coffee fields) include Cordia africana, Millettia ferruginea, Persea americana, Carica papaya, Vernonia amygdalina, Erythrina spp. etc. The first two species are the most preferred by farmers, particularly on enset fields. The tree species locally known to negatively influence crops are fruit trees such as avocado, mango and guava; timber trees such as Eucalyptus spp., Cupressus lusitanica, Olea africana, Podocarpus falcatus, Juniperus excelsa and Albizia gummifera. The negative impact of red gum monoculture as claimed by farmers is in agreement with a report by Grewal et al. (1992), Michelsen et al. (1993) and Meertens et al. (1996). As part of *circa situ* conservation, it is important to mention the contribution of farmers in maintaining four of the first five officially declared endangered tree species on their fields. These
species are: *Cordia africana* predominantly produced in enset and coffee fields, *Podocarpus falcatus* and *Juniperus excelsa* in front yards and boundaries, and *Olea africana* in boundaries and front yards. Sidama farmers use trees for fuel wood, construction, to ensure food security, cash generation and maintenance of agricultural sustainability. In general, the diversity of uses of farm trees in Sidama as an insurance policy is a typical feature of the subsistence farming community in the tropics (Nair, 1993).

c. Topsoil chemical properties

As indicators of soil fertility pH, organic C, total N and available P were assessed (Zebene Asfaw and Agren, 2007). With regard to total N, no significant difference was observed (Table 4). The organic C content under Millettia was significantly different than values under Cordia, red gum and maize field. One of the most clearly observed effects of tree species is found for available P, which is more than twice as high under Cordia and Millettia as compared to that of red gum and maize fields. The higher concentration of nutrients under Cordia and Millettia than red gum and maize field is likely to be attributed to litterfall and roots of different plants and the low nutrient drain of the former two at harvest. Also the mechanism of soil improvement may involve maintenance or increase of soil organic matter, biological N₂ fixation, improved nutrient uptake through mycorrhizal associations, reduced loss of nutrients by prevention of erosion and leaching, increased water infiltration and storage, and improved biological activities (Young, 1997).

Available reports indicate that there is a considerable nutrient drain through harvesting of red gum. Harrison *et al.* (2000) reported removal (bolewood and bole bark) of red gum at an age of 41 months could be represent 29% of total P, whole tree 11.0 kg ha⁻¹ and 72% total P entire above-ground harvest. For a fertilised 9 year and 7 month old red gum stand, Fernandez *et al.* (2000) estimated an exportation of 48% of total P, representing 33 kg ha⁻¹ of P, through harvest of shoot and litter. Michelsen *et al.* (1993) reported lower soil nutrient status under Eucalyptus plantations than native tree species in central and south Ethiopia. In the present study, the organic C concentration under red gum was relatively high compared to the other species. Basu and Mandi (1987) indicated that organic carbon content under *Eucalyptus spp.*, particularly in the surface soil, had increased considerably with age. The pH was lower in the red gum woodlot soils, probably as a result of acidic substances in decomposing material. Basu and Mandi (1987) reported that Eucalyptus trees changed the soil to acidic, but Kushalapa (1987) claimed that Eucalyptus plantations do not turn the soil to acidic.
Contribution of Traditional Agroforestry Practices

Table 4 Mean value of topsoil chemical properties of major fields types originated from communal grazing land in Sidama, south Ethiopia.

<table>
<thead>
<tr>
<th>Variable description</th>
<th>Enset-coffee</th>
<th>Cordia</th>
<th>Woodlot red gum</th>
<th>Monocropping maize</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total N (%)</td>
<td>0.27</td>
<td>0.32</td>
<td>0.27</td>
<td>0.20</td>
</tr>
<tr>
<td>Organic C (%)</td>
<td>2.21a</td>
<td>3.11b</td>
<td>2.47b</td>
<td>1.32b</td>
</tr>
<tr>
<td>pH (H2O)</td>
<td>6.96</td>
<td>6.92</td>
<td>6.52</td>
<td>6.01</td>
</tr>
<tr>
<td>Available P (PPM)</td>
<td>17.79b</td>
<td>33.74a</td>
<td>7.45c</td>
<td>4.57b</td>
</tr>
</tbody>
</table>

CONCLUSION

From the review and research result presented, it is possible to conclude that there is a rich experience and knowledge that the scientific community and professionals in Ethiopia can learn from the traditional agroforestry management. The high number of species diversity and better soil fertility under agroforestry practices implies that contribution of biological and structural diversity to ecological sustainability is so high. In addition, high species diversity means better food diversification and risk aversion as compared to monoculture cropping. The Cordia and Milletia trees grown in enset-coffee crops are basically a multistorey system and have better nutrient concentrations as compared to both eucalyptus and maize monoculture. One possible explanation for sustaining high population both at Gedeo and Sidama zones could be due to the practice of agroforestry land use. Finally, why does Cordia africana become successfully established, grow fast, and have straight stems predominantly only on enset fields in Sidama? Could this be of help to overcome the unsuccessful story of Cordia plantations across the country, except in localized natural regeneration in the western Ethiopia?

REFERENCES


Contribution of Traditional Agroforestry Practices

Zebene Asfaw


OVERVIEW OF THE FISHERIES AND AQUACULTURE DEVELOPMENT STATUS – ITS CONTRIBUTION TO FOOD SECURITY AND PROTEIN SUPPLY IN THE DIET

Tetsaye Wudneh¹

ABSTRACT

A brief overview of the fisheries and aquaculture resources of the country is presented based on study reports, research papers and discussions with the concerned development officers in the Regional Governments. Ethiopia has substantial fish resources contained in the lakes, reservoirs and large rivers most of which are virtually untouched. Lake and reservoir fisheries rather than aquaculture have been the main focus of development for a long time. The riverine fish stocks have hardly been considered for development except for River Baro in Gambella which flows through a community with a strong fish eating culture, that make good use of the resource. Aquaculture has been practiced only to the extent of fish stocking in reservoirs and water bodies devoid of fish or for stock enhancement purposes. In spite of the high fish resources with estimated sustainable yield of over 50,000 tons/year, the supply from the lakes is already dwindling while the consumer demand is apparently increasing. Malnutrition from protein shortage in the diet of the community and associated health problems of children and women is often reported in nutrition studies, particularly among the rural poor. The constant reduction in fish supply from the lakes and the fast increase in price have apparently awakened the government to give more attention to the fishery sub-sector as indicated in the Poverty Reduction Strategy Paper (PRSP). Some recent programs of developing aquaculture are observed in this regard. Aquaculture possibilities have not been exploited yet although there is apparently high opportunity to develop and expand. Observations from recent activities in different research institutes and the growing graduate research programs, AAU (Zewai Fisheries Research Center, Sebeta BOMOSA program) are indicators for the changed attitude of the Government and its intension to enhance fish production and supply. The delay could be partly attributed to the shortage of technical manpower and lack of institutionalized concern, which seems to have substantially improved at the moment with the recent establishment of EFASA, a professional association. EFASA would be expected to speed up the research and development in this area. The paper intends to show the possibilities for expanding fish production in the

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Overview of the Fisheries and Aquaculture Development Status
Tafaye Wudneh

country, through concerted effort, to alleviate malnutrition due to protein shortage in the diet.

General

Ethiopia is endowed with a number of natural lakes, reservoirs and large rivers containing substantial quantities of fish stocks. The total area of the lakes and reservoirs stands at about 7,000 to 8,000 km$^2$ and the major perennial rivers stretch over 7,000 km in the country. Most of the lakes are located in the Rift Valley basin except Lake Tana, the largest lake in the country, which is found in the north-western plateau. Ethiopia is land locked and depends on these inland waters solely for the domestic supply of fish as a source of protein and as an alternative source of income for many of the rural community.

The overall potential annual sustainable fish yield of the country from the lakes, reservoirs and rivers combined is roughly estimated at about 50,000 - 60,000 tons (Table 1). This includes a potential yield of about 35,000 to 40,000 tons/year from the lakes/reservoirs and about 20,000 tons/year from the major rivers.

Table 1 Major rivers important for the fishery and their potential yield estimate.

<table>
<thead>
<tr>
<th>Name of basin</th>
<th>Basin Area (km$^2$)</th>
<th>Riv. channel Length km</th>
<th>Poten. Catch est. (ton/yr)</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Abbay</td>
<td>201,346</td>
<td>1206</td>
<td>4190</td>
<td>$(C = 0.03A^{0.37} - \text{empirical formula based on mainly African River systems that have been studied, } C=\text{potential catch; } A=\text{basin area})$</td>
</tr>
<tr>
<td>2 Awash</td>
<td>112,696</td>
<td>930</td>
<td>2380</td>
<td></td>
</tr>
<tr>
<td>3 Omo-Ghibie</td>
<td>70,213</td>
<td>750</td>
<td>1500</td>
<td></td>
</tr>
<tr>
<td>4 Genale-Dawa</td>
<td>171,042</td>
<td>1120</td>
<td>3575</td>
<td></td>
</tr>
<tr>
<td>5 Wabi Shebele</td>
<td>202697</td>
<td>1210</td>
<td>4215</td>
<td></td>
</tr>
<tr>
<td>6 Baro-Akobo</td>
<td>74102</td>
<td>770</td>
<td>1590</td>
<td></td>
</tr>
<tr>
<td>7 Tekeze</td>
<td>90000</td>
<td>840</td>
<td>1920</td>
<td></td>
</tr>
<tr>
<td>Total - main rivers</td>
<td>922,096</td>
<td>6826</td>
<td>19370</td>
<td>Estimated avg. yield of 50 kg/ha</td>
</tr>
<tr>
<td>Total - lakes and reservoirs</td>
<td>7,000</td>
<td></td>
<td>35,000</td>
<td></td>
</tr>
<tr>
<td>Overall potential yield</td>
<td>54,370</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fish species diversity

Most of the lakes are relatively poor in species composition compared to the riverine system, except for Lakes Abaya and Chamo in the southern Rift Valley Lakes Basin (RVLB), which contain more diverse fish communities. There are over one hundred fish species occurring in the
lakes and rivers of the country (Golubtsov and Mina, 2003; JERBE, 1998; JERBE, 1989). The overall fish species occurring in the Rift Valley Lakes is between 20 and 30 (Schroder, 1984). Lake Tana, outside the Rift Valley system, contains about 20 species with the Cyprinids, *Labeobarbus* sp. being dominant in composition (Nagelkerke et al., 1995; Nagelkerke, 1997; De Graaf, 2000; De Graaf et al., 2000; Eshete Dejen, 2003).

The most common fish species in the commercial catch are Nile tilapia, (*Oreochromis niloticus*), the African catfish (*Clarias gariepinus*), the Nile perch (*Latus niloticus*), *Bagrus* sp. *Labeo* sp. and *Barbus* sp. The common carp, *Cyprinus carpio*, is also important in Koka Reservoir and few other water bodies. Although there is a large stock of the species *Synodontis schall* in Lakes Abaya and Chamo, it is not popular in the market and is left for the fishermen’s own consumption. Other fish species such as the tiger fish, *Hydrocynus vitatus*, the elephant snout, *Mormyrus longirostris*, the Schilbid catfish, *Schilbae mystus* that have good stock size in Lakes Abaya and Chamo are not commercially exploited (Fishery Report RVLB studies, 2008).

Commercial catch in Lake Awasa mainly consists of *Oreochromis niloticus* and *Clarias gariepinus* in the commercial landing. *Barbus* sp. is landed in small quantities, but is not of economic importance. A similar species composition is observed at Lake Langano fishery with tilapia and catfish being important in the commercial catch. Lake Tana, which covers over 40% of the total lake area in the country, is currently the main supplier of *O. niloticus*, catfish and *Barbus* sp. for the fish market.

The riverine fish stocks

The riverine fish stocks, although more diverse in species composition with high market demand and value in some areas, are the least exploited hitherto. Several factors contribute to this retarded development. These include - the inherent problem, in riverine systems of difficult access to good fishing grounds from main roads the scattered nature of suitable fishing grounds and low awareness of the community on the nutritional and economic values of the fish resources. Apparently, this lack of proper awareness of the importance of the riverine fisheries is also observed among responsible government bodies. Thus, the focus of fisheries development has been mainly on the lacustrine fisheries as observed in the Lake Fisheries Development Project (LFDP) that contributed to the major changes in the fishery. Only limited attention was given to River Baro, Gambella since the main protein supply and livelihood of the local community is highly dependent on the riverine fishery (LFDP Technical Reports).
Aquaculture

Aquaculture or fish farm development in Ethiopia has been very limited and the practice mainly consisted of stocking of fish fingerlings into dams and small water bodies devoid of fish or to diversify species composition and enhance production. Fish fingerlings are usually collected from the natural wild stock or by keeping brood stocks in ponds. Intensive pond fish culture that require capital investment and technical input have not been seriously attempted for various reasons. Among these can be mentioned the lack of technical know-how, available cheap fish supply from the natural stocks, low demand for fish products, weak market network and infrastructure. Additionally, the existing policy has not been very encouraging in developing the aquaculture sector.

Thus, fisheries and aquaculture development in Ethiopia has been among the less attended sectors of the economy for a long time, with limited budget and manpower allocated to it. This is possibly linked to the low fish consumption culture of most of the population especially for inhabitants of areas far from the lakes. Traditionally fish is mostly consumed during the fasting period of the Orthodox Christians. The underdeveloped fish transportation, storage and distribution facilities and services have also played a role for making fish products unavailable for most people residing further away from the lakes.

Fish potential and the rate of exploitation

The development of commercial fisheries has been uneven among the different lakes with fish resources. With increased demand and improved road condition those lakes with easy access to the major market have been intensively exploited, to the extent of overfishing in some cases. Most of the Rift Valley Lakes are examples of this intensive fishing during the last decade that resulted in decline in fish landings in recent years as a result of overexploitation (Fig. 1).

In Lake Chamo, the Nile perch which fetches high value on the market has been selectively fished and the stock overexploited even though the lake is quite far from the central market in Addis Ababa. The close proximity to a large town and convenient road link to markets has been the cause for overfishing of tilapia in lakes Awasa and Zeway. With the current open access system the fishery in these lakes has created opportunity for the jobless people to make a living out of fishery with no legal restriction. The overfishing is, thus, caused by lack of proper control and monitoring on the resource use. Although the relevant fishery regulation and policy has been in place since 2003, (Procl. No. 315/2003), enforcement has not been realized either due to lack of institutional capacity or inadequate required guidelines for its enforcement.
On the other hand, there are some lakes which are not conveniently located near the market, and thus left underexploited. Such lakes/reservoirs like Beseka, Fincha, Melka Wakena, and the riverine fish resources provide wide opportunities to increase production and create job opportunities. The contribution to food security and protein supply in the diet of local community could also be greatly enhanced.

![Graph showing fish landings](image)

**Fig. 1 Trend of total fish landings from 5 major RVL – Chamo, Abaya, Awasa, Langano and Zeway.**

**Recent developments**

The situation has apparently changed in recent years and the consumption pattern has substantially changed. Several factors could be listed as causes for this change such as increased awareness of the food value of fish by the community, the economic benefit, the improved road communication, the economic capacity of the people and the contribution of the Lake fishery development project (LFDP). In connection with this, it appears that the fishery sector has recently attracted more attention from the government development sectors including the MoARD, MoWR and research institutions like EIAR, Addis Ababa University. The recent establishment of Ethiopian Fish and Aquatic Science Association (EFASA) could be a good indication of the increased attention to and awareness about the importance of the sector. Fisheries have been included in almost all the Integrated Master Plan Studies of all river basins (RBMPS reports, MoWR). The riverine fisheries have been and still are the least considered in the fisheries development programs by the MoARD projects.

Aquaculture programs, however, are getting more attention and several research programs have been conducted by different institutions. The AAU,
Biology Department is encouraging graduate students to carry out their M.Sc. thesis research in different areas of fish culture. The Sebeta national fish culture research center has established research link with international research institutions through the BOMOSA program it is currently implementing. The Oromia fisheries research center at Zeway has programs in aquaculture research that is supported by government budget.

Some investors are also approaching professional institutions for advice to initiate a commercial fish culture venture. These are new and encouraging initiatives that support the fisheries and aquaculture developments. However, such initiatives can be sustainable and beneficial if they are also supported by the government’s development policy. Fishery laws and regulations should be enforced and the awareness of the user community should be strengthened through strong and efficient extension service. Aquaculture development is very important to increase fish production and supply but it should not be seen as a solution for depleting fish stocks in natural water bodies through weak management.

REFERENCES


BIOTECHNOLOGY FOR FOOD SECURITY

Tileye Feyissa

INTRODUCTION

The political, economic and social world has changed significantly over the last 35 years. Several developments in different areas have been done in the past five decades than any time before in human history. The Green Revolution of 20th century contributed a lot in decreasing the number of malnourished people (Leisinger, 1999). However, more than 800 million people in developing countries are suffering from hunger and consequently different diseases. Recent skyrocketing food prices and sharing of agricultural land with bio-fuels with rising of world population indicate that there will be an era of food scarcity ahead which will be worse than any time before. All these problems will keep the hunger issue top on the agenda of human development. It is with these trends in mind that new technologies such as genetic engineering have to be judged. In the last 25 years, fast development of genetically engineered plants has been achieved. In the 10,000 years of history of agriculture, genetic modifications of crops have been done. In light of these genetic modifications of crops, the use of the term genetically modified organism (GMO) to designate genetically engineered (GE) crops is a definite misnomer since it implies that before GE there were no genetic modifications. Genetically engineered or transgenic would be more appropriate terms (Gepts, 2002).

Genetic engineering of plants is whereby genes from any organism are introduced into a genome of another organism. These methods include gene transfer by Agrobacterium tumefaciens, a pathogenic bacterium that naturally transfers DNA to plants by infecting the wound sites of most dicotyledonous plants. The strains of A. tumefaciens that are used in genetic engineering have been modified so that they are nonpathogenic. Other means of gene transfer in genetic engineering include particle gun bombardment where genes are shot into plant cells, and electroporation. Advances in gene technology and knowledge of DNA sequences of plants as well as of their parasites and symbionts are increasing dramatically. Due to these advancements and tremendous efforts done to produce new crop varieties, there is enormous potential to bring fast change, new prosperity and security of food supply in the whole world if applied properly. Considering these advantages, many countries have been adopting

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genetically engineered crops. Many regions are actively experimenting with these crops at a small scale. GE crops were planted on 114.3 million ha in 2007 globally showing a 12% increase over 2006 and increased to 125 million ha in 2008. The highly concentrated cultivation of the GM crops is in few countries with 90% in US, Argentina, Brazil and Canada (ISAAA, 2008).

![Global area of biotech crops: by year of production in million hectares (1996-2007).](image)

Fig. 1 Global area of biotech crops: by year of production in million hectares (1996-2007).

Genetic engineering is one of the few most debated technological issues (Altieri and Rosset, 1999; McGloughlin, 1999). Although the potential use of these genetically engineered plants is very high, they may also have potential risks and significant challenges to overcome. Therefore, the balance between benefits and risks should be weighed carefully with respect to risk assessment and management when the technology is adopted. Not only the risk of adopting the technology, but the risk of not adopting it should also be considered. On this paper the use of biotechnology for food security with emphasis on genetically engineered crop plants with respect to risk assessment and management will be discussed.
IMPACT OF BIOTECHNOLOGY ON FOOD SECURITY

Over the past few years a number of methodologies that contribute a lot to the advancement of research in the plant sciences have been developed. These advancements have been used to develop new crops. The first of these areas is plant tissue culture which is concerned with manipulation and subsequent growth of cells, tissues, organs and protoplasts on artificial media under aseptic conditions. The second area is genetic engineering or recombinant DNA technology. With genetic engineering, scientists have developed advanced methods for precise breeding of better crop varieties and livestock. This technology allows the detailed and precise manipulation of genes. These two areas of research, plant tissue culture and genetic engineering, have in recent years become associated with the general field of biotechnology and are potentially applicable to a wide variety of plant species. Recombinant DNA techniques in particular have already contributed much to the elucidation of basic mechanisms in plants at the molecular level.

Genetic engineering in fighting against hunger

The main objective of research and development for food security is to produce high yielding improved seed varieties at the same or lower tillage costs through qualities such as resistance to or tolerance of biotic and abiotic stresses. Equally important objectives are the transfer of genes with nitrogen-fixing capacity onto grains, and the improvement of food quality by overcoming vitamin or mineral deficiencies (Leisinger, 1999). The great advantage that genetic engineering has over conventional breeding is that the desired properties can be systematically sought, identified, and the DNA containing the gene(s) responsible for these properties can be extracted from almost any organism, and within a relatively short time transferred to a plant. Biotechnology, in general, has wide applications ranging from diagnostic aids for plant diseases to gene mapping.

Manipulation of disease resistance genes through molecular markers

The interaction between plants and potential pathogens can be characterized in detail by using molecular technique tools. This can be done at all stages from the earliest recognition events to the changes that occur during resistant and susceptible responses. The result of the interaction between plants and potential pathogens are determined by several genes that are involved during all the stages of interaction. However, the genetic variation observed in a specific plant-pathogen interaction is determined by one or a few loci (Michelmore, 1995).

Biotechnology has great potential for plant breeding as it speeds up the time taken to produce crop varieties with desirable characters. These days
it is possible to hasten the introgression of desirable genes among varieties and to transfer novel genes from related wild species with the use of molecular techniques. Analyses of polygenic characters using traditional plant breeding methods were previously very difficult. However, these polygenic characters can now be easily tagged using molecular markers. It would also be possible to establish genetic relationships between sexually incompatible crop plants (Mohan et al., 1997). Desirable characters can be selected by using Marker Assisted Selection (MAS).

**Abiotic stresses**

Losses to crop plants are caused by several abiotic stresses including drought or water surplus, cold and heat, salinity, and soil toxicities or nutrient deficiencies. The transfer of several genes that confer tolerance to different abiotic stress conditions have been carried out for several crop plants. However, further experiments must determine whether the improved stress tolerance is sufficient for agricultural applications (Klöti and Potrykus, 1999). Progress with production and commercialization of abiotic stress tolerant GE crops is expected in the near term.

**Biotic stresses**

Several biotic stresses cause enormous loss to crop production. The losses are at different degrees and their importance is different among countries, regions and ecosystems. Losses due to pests and diseases have been estimated at 37% of the agricultural production worldwide. The continuous and intensive planting of the high-yielding modern varieties has aggravated the problem. For example, the increased application of insecticides in cultivation of several crops including rice decimated natural enemies of pests of these crops and thereby led to secondary pest outbreaks (Woodburn, 1990).

*Bacterial disease resistance*: Bacterial diseases cause significant losses in production of crop plants. GE plants with antibacterial properties can be developed conferring the plant with inbuilt resistance.

*Fungal disease resistance*

Fungal diseases destroy 50 million tons of rice per year. Varieties resistant to fungi could be developed through the genetic transfer of proteins with antifungal properties.

*Viral disease resistance*

Viral diseases devastate 10 million tons of rice per year. Transgenes derived from the rice tungro spherical-virus genome allow the plant to develop defense systems. In cassava, the African cassava mosaic virus
causes immense damage. Transgenes interfering with the life cycle of the virus could lead to virus-resistant varieties.

**Insect resistance**

About 13% of losses of crop production are due to insects (Gatehouse et al., 1992). Insects cause a loss of 26 million tons of rice per year (Leisinger, 1999). In present days crops are mainly protected by using agrochemicals that pollute the environment and are risky to human and animal health. It is necessary to develop a more environmentally-friendly agriculture with low energy and chemicals inputs, and that do not generate harmful outputs such as pesticide residues. Therefore, development and production of plants with inbuilt resistance to pests and pathogens is necessary. Some successes have been achieved towards this aim using conventional plant breeding techniques and *in vitro* techniques (Jouanin, 1998). By using plant genetic engineering technology, it is possible to introduce resistance genes from any other species into crop plants.

The transfer and expression of toxin-encoding genes from *Bacillus thuringiensis* into plants to protect them against insects has attracted much attention. In such a system, the entire plant is protected, especially against insects such as borers that infect plant parts which sprays often cannot reach. The toxin affects the more susceptible early instar stages of the insect. In addition, since the product is retained within the plant tissues, the system is environmentally safe (Jouanin et al., 1998).

Plants synthesize the antimetabolic proteins constitutively in tissues that are particularly vulnerable to attacks and these proteins interfere with the digestive processes of insects. Plants use this defense strategy extensively. The synthesis of these proteins can also be induced by mechanical wounding, as it is the case when chewing insects feed on leaves. There are several evidences that show the defensive role that enzyme inhibitors play in protecting plants against insect pests (Ryan, 1990). Protease inhibitors from different plants have shown deleterious effects in *in vivo* artificial diet bioassays and in *in vitro* assays with insect gut proteases (Gatehouse et al., 1992). These protease inhibitors interfere with the growth and development of the larvae and in some cases cause the death of the insect.

**Transgenic plants for improvement of nutritional quality**

More than 100 million children and more than one billion women and children suffer from Vitamin A and iron deficiency, respectively. Transgenes will provide provitamin A and sufficient iron in the rice diet. Cassava contains toxic cyanogenic glycosides. The integration of transgenes could inhibit the synthesis of these toxic substances in cassava. Roots and tubers of several plants efficiently store starch but do not contain or contain little
protein. The transfer of genes for storage proteins into these plants would substantially improve their nutritional quality. The starch composition, fatty acid pattern and proteins of several plants can be modified to be used in food, industrial and pharmaceutical applications.

ACHIEVEMENTS IN PLANT GENETIC ENGINEERING

Over the past five decades, yield increases in the major food grains throughout the world have been substantial. Yield levels of maize, rice, and wheat nearly doubled from 1960 to 1994 mainly due to improved varieties, irrigation, fertilizers, and a range of improved crop and resource management technologies. Much of this has been part of the Green Revolution. In addition to increasing yield of crop plants, the Green Revolution has expanded farm and non-farm output, employment, and wages, thus, contributing to food security by reducing poverty. Higher productivity has also reduced the conversion of forests, grasslands, and swamp lands for cultivation of food crops, thus contributing to the preservation of biodiversity. New plant varieties have performed well even on less favorable lands and this has also raised food output (Leisinger, 1999). In general, due to high yield, the cost of food has been reduced and improved food security, particularly for vulnerable sections of the society.

Conventional breeding programs will remain important in the future. But they have a competitive disadvantage in that they are time consuming. If selection systems are developed by marker techniques, for example through characterization of genetic markers for certain properties, then research can be carried out with greater efficiency. Biotechnology has made marked concrete advances in the direction of higher food security, be it through resistance to fungal and viral diseases in major food crops or through improved plant properties. The development of new plant protection techniques by using genetic engineering technology has already led to interesting progress in terms of the environment and lessened dependence on chemical weapons (Commandeur and Komen, 1993).

Arable land is becoming scarce and the use of fertilizers and plant protection agents is reaching the ecologically tolerable limit. Biotechnology, by providing novel products and mechanisms of action, can help farmers to solve some agricultural problems which are either not solvable with traditional technologies or only with a far greater expenditure of time (Bunders, 1990).

It has been several years since GE has reached the commercial stage. New cultivars of several crops produced through genetic engineering are on the market in many countries. The crops include maize, soybean, cotton, papaya, etc. carrying additional genes conditioning traits as diverse as resistance to insects, viruses, and herbicides. These GE plants have
been adopted by farmers because they greatly facilitate the management of crops, provide a more effective alternative to current control methods, or offer the only viable possibility of disease control in the absence of any natural resistance within the crop gene pool.

Global status of commercialized biotech crops

The production of biotech crops and subsequent commercialization has been increasing dramatically since 1996. The proportion of the global area of biotech crops has increased consistently every year. In 2008, there were 14 biotech mega-countries with the USA being the top world ranking with 62.5 million ha followed by Argentina, Brazil, India, Canada and China (Table 1). The global biotech area reached 125 million ha in 2008 up from 114.3 million ha in 2007. The biotech crops have brought substantial economic and environmental benefits to farmers in both industrial countries and developing countries, where millions of poor farmers have also benefited from social and humanitarian benefits which have contributed to the poverty alleviation. The number of countries planting biotech crops increased to 25 among which 15 are developing countries and the remaining 10 are industrial countries. In 2006, 40% of the global biotech crop area, 49.9 million ha, was grown in developing countries. This percentage has grown to 43% in 2007 (ISAAA, 2008). The five principal developing countries that grow biotech crops are Argentina, Brazil, India, China and South Africa. These countries represent 2.6 billion people (40%) of the global population. This growth across all continents laid broad and stable foundation for future global growth of biotech crops. This very high adoption rate of biotech crops by farmers indicates that biotech crops have consistently performed well and delivered significant economic, environmental, health and social benefits to both small and large scale farmers in developing and industrial countries.

Biodiversity conservation

The fight against genetic engineering with the assumption that it makes superior varieties available to the small farmer in developing countries would be the wrong way to join the battle against the loss of biodiversity (Leisinger, 1999). Indeed, when the high-yielding resistant and tolerant varieties are available, they allow a substantial increase in yield. When the varieties are low-yielding, much more land is required for cultivation to produce the same yield as that is obtained by using resistant and tolerant varieties. To get additional land for cultivation, the last remaining forests are converted to cropland causing an ecological disaster. To reduce the loss of biodiversity, the main battlefield must be the preservation of tropical forests, mangroves and other wetlands, rivers, lakes, and coral reefs. The fact that inferior varieties are replaced by superior ones does not at all have to result
in an actual loss of biodiversity. Varieties that are feared to be substituted by high-yielding varieties can be preserved through *in vivo* or *in vitro* strategies.

**Poverty alleviation**

GE technology plays very important role in alleviation of poverty and hunger as 50% of the world's poorest are small and resource-poor farmers. About 20% are the rural landless dependent on agriculture for their livelihoods. Increasing income of small and resource-poor farmers contribute directly to the poverty alleviation of a large majority of the world's poorest people.

**Reducing the environmental damage caused by agriculture**

Progress in the first decade of production of biotech crops includes a significant reduction in pesticides, saving on fossil fuels and decreasing CO₂ emissions through no/less ploughing. Conserving soil and moisture by optimizing the practice of no till through application of herbicide tolerance, increasing efficiency of water usage, as 70% of global and 86% of fresh water in developing countries is used for agriculture.

**Mitigating climate change and reducing greenhouse gases**

Droughts, floods, and temperature changes are predicted to become more prevalent and more severe. There will be a need to produce crops that are well adapted to changing climate. Several biotech crop tools such as diagnostics, genomics, and marker assisted selection in biotech crops can be used to facilitate breeding and mitigate the effects of climate change.
Table 1 Global area of biotech crops in 2008 by country (million hectares).

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Area (million hectares)</th>
<th>Biotech Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>1*</td>
<td>USA*</td>
<td>62.5</td>
<td>Soybean, maize, cotton, canola, squash, papaya, alfalfa, sugarbeet</td>
</tr>
<tr>
<td>2*</td>
<td>Argentina*</td>
<td>21.0</td>
<td>Soybean, maize, cotton</td>
</tr>
<tr>
<td>3*</td>
<td>Brazil*</td>
<td>15.8</td>
<td>Soybean, maize, cotton</td>
</tr>
<tr>
<td>4*</td>
<td>India*</td>
<td>7.6</td>
<td>Cotton</td>
</tr>
<tr>
<td>5*</td>
<td>Canada*</td>
<td>7.6</td>
<td>Canola, maize, soybean, sugarbeet</td>
</tr>
<tr>
<td>6*</td>
<td>China*</td>
<td>3.8</td>
<td>Cotton, tomato, poplar, petunia, papaya, sweet pepper</td>
</tr>
<tr>
<td>7*</td>
<td>Paraguay*</td>
<td>2.7</td>
<td>Soybean</td>
</tr>
<tr>
<td>8*</td>
<td>South Africa*</td>
<td>1.8</td>
<td>Maize, soybean, cotton</td>
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<tr>
<td>9*</td>
<td>Uruguay*</td>
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<td>10*</td>
<td>Bolivia*</td>
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<td>Soybean</td>
</tr>
<tr>
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<td>Maize</td>
</tr>
<tr>
<td>12*</td>
<td>Australia*</td>
<td>0.2</td>
<td>Cotton, canola, carnation</td>
</tr>
<tr>
<td>13*</td>
<td>Mexico*</td>
<td>0.1</td>
<td>Cotton, soybean</td>
</tr>
<tr>
<td>14*</td>
<td>Spain*</td>
<td>0.1</td>
<td>Maize</td>
</tr>
<tr>
<td>15</td>
<td>Chile</td>
<td>&lt;0.1</td>
<td>Maize, soybean, canola</td>
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<tr>
<td>16</td>
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<td>Cotton, carnation</td>
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<td>Maize</td>
</tr>
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<td>Maize</td>
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<td>Maize</td>
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<tr>
<td>25</td>
<td>Egypt</td>
<td>&lt;0.1</td>
<td>Maize</td>
</tr>
</tbody>
</table>

* 14 biotech mega-countries growing 50,000 hectares, or more, of biotech crops
Source: Clive James, 2008.

PROBLEMS OF ADOPTING BIOTECH CROPS IN DEVELOPING COUNTRIES

There is no appropriate cost-effective and responsible regulation system in developing countries with respect to adoption, production and commercialization of GE crops. Many developing countries do not have any regulations. In those who have, the regulatory systems are unnecessarily cumbersome and in many cases impossible to implement. They are designed to meet the initial needs of industrial countries and with access to significant resources for regulation which developing countries simply do not have. It is important to design appropriate regulatory systems requiring only modest resources. Today, unnecessary and unjust stringent standards are denying the developing countries timely access to products such as golden rice whilst millions die unnecessarily in the interim. This is a moral dilemma, where the demands of regulatory systems have become "the end
and not the means" (Leisinger, 1999). On top of these regulatory problems, genetic engineering researches in developing countries are almost nonexistent and even those who started are stopping due to lack of funds. Most scientific researches in developing countries are funded by donors in western countries. Due to resistance against biotech crops by some developing countries, donor funding agencies are not willing to support biotech researches in developing countries. To make this even worse, most of the genes used in genetic engineering are patented although this has raised enormous debates. All these factors are leading genetic engineering researches to be confined only to developed countries.

**RISKS AND CONCERNS OF BIOTECH CROPS**

Despite high adoption rate and future promises, there are several concerns about the impact of GE crops on the human health and environment. Basically, GE involves the same modifications that have been taking place for 10,000 years and these are thought to be part of a long-term trend of genetic modifications about which few people have shown concerns. These genetic changes occurred without regulations or oversight. There was no regulation in the history of agriculture as stringent as the regulation of GE. The current regulation of GE is more than adequate. Regulatory systems are very important but can be different in different countries based on interests of the specific countries. For example, regulatory approaches in Europe and North America are essentially different. In the EU, it is based on the process of making GE crops whereas in the US it is based on the characteristics of the GE product. Many countries are establishing regulations based on EU or the US system or a mixture of both. Despite these differences, the information required for risk assessment is basically similar. Each risk assessment considers the possibility, probability and consequence of harm on a case-by-case basis. For GE crops, the impact of non-use should be added to this evaluation. It is important that the regulation of risk should not turn into the risk of regulation. When the risk assessment is done for GE crops, the best and most appropriate baseline for comparison is the impact of plants developed by traditional breeding. Plants developed by traditional breeding are an integral and accepted part of agriculture (Nap et al., 2003).

It is feared that the GE technology will harm people by undesired impacts on environment, health and/or the economic order at the expense of the poor. The public concern is becoming increasingly more vocal and sometimes violent. The coming years are very important in making decision for the commercial and economically viable application of GE crops in agriculture. Without the consent of society at large, biotech crops will fail in the marketplace. At the same time, the United Nations and other international organizations warn that the world is facing very serious
problems with global food and nutrition security that it cannot afford to turn away from GE crops (Schrope, 2001).

A common description of risk is ‘probability of harm’. When taking the magnitude of the potential harm into account, risk is expressed in a mathematical form as: Risk = probability u consequence = likelihood of event u (negative) impact of event (Conner et al., 2003). The negative or undesired impact of an event is commonly referred to as ‘hazard’. Risk can be expressed as rate of probability. The probabilistic interpretation of risk implies that managing probability or consequence or both can influence risk. These are difficult topics to master. Risk assessment tries to find answers on three questions for each individual case: what can go wrong? (the possibility of harm), how likely is that to happen (the probability of that harm occurring), and what are the consequences if it happens? (the consequence of that harm). The concept of risk is often implicitly taken as the possibility of harm, rather than the probability of harm (Conner et al., 2003).

Human health

One of the concerns of GE crops is allergenicity. There is no evidence that genetically engineered foods are more likely to cause allergic reactions than are conventional foods. Tests for several dozen transgenic foods for allergenicity have been done and only soybean that was never marketed and the now famous StarLink corn have shown the test. The allergenicity of the latter is highly debatable. Every year some people discover that they have developed an allergy to a common food such as wheat or eggs. Therefore, some people may develop allergies to transgenic food in the future as well.

Horizontal transfer and antibiotic resistance

Antibiotic resistant genes are often used as selectable marker gene during transformation experiments. There is concern that these genes may transfer to the normal flora of bacteria in human and turn them resistant to that particular antibiotic. Horizontal transfer of DNA occurs under natural circumstances and under laboratory conditions. It is probably quite rare in the acid environment of the human stomach.

Eating foreign DNA

Some people fear that it is dangerous to eat “foreign DNA”. We eat DNA every time we eat a meal. There is no evidence that DNA from transgenic crops is more dangerous to us than DNA from conventional crops, animals, and their attendant microorganisms that we have been eating all our lives.
Damage to the environment

The ecological probabilities of harm focuses on weediness, spread of the transgene by either vertical or horizontal gene flow, and the potential for any unintended, or pleiotropic effects. For example, one of the potential concerns raised about GE is escape of transgenes through pollen-mediated gene flow. Yet, gene flow is a feature of many crop plants whether transgenic or nontransgenic (Ellstrand et al., 1999). This raises a general concern about the effects of gene flow from crops whether transgenic or not to their wild relatives, for example on the genetic diversity of wild relatives. These effects have rarely been studied systematically. This situation raises the question whether cultivars developed by classical breeding should be subject to more stringent regulation, similar to that used for GE cultivars (Gepts, 2002).

One of the major uses of genetic engineering is that it introduces genes to a plant from any sexually incompatible organisms by crossing species barriers. The response of transgenes to environmental influences and the genetic background in which they operate has to be taken into account. These concerns are not limited to transgenes but any genes that are introgressed into crops within the same species or from other species, whether by classical breeding or GE.

The ecological risk assessment must have certain guidelines for regulatory systems and associated procedures. For this purpose, two general concepts, namely familiarity and the precautionary principle, have been proposed. The precautionary principle is part of the Cartagena Protocol on Biosafety (SCBD, 2000) and is now the basis of regulation in the EU. The concept of familiarity considers whether the GE phenotype is novel for the ecosystem under study. In general, the concept of familiarity seems too loosely defined to be very useful for risk assessments. Although the precautionary principle is recent, there are problems with respect to its full meaning and implications (Conner et al., 2003). In the recently adopted Cartagena Protocol on Biosafety, it reads:

"lack of scientific certainty due to insufficient scientific information and knowledge regarding the extent of the potential adverse effects of a living modified organism on the conservation and sustainable use of biological diversity..., taking also into account risks to human health, shall not prevent...from taking a decision, as appropriate, with regard to the import of the living modified organism in question..., in order to avoid or minimize such potential adverse effect". There is considerable controversy on the meaning, scope and application of this principle.

The fourth question of the risk assessment is: what are the consequences if we do NOT allow this GE crop? The consequence of non-use, tentatively defined as "the probability of harm of non-use v the impact of harm of non-
use’, may make cost/benefit analyses more transparent in assessments and discussions (Conner et al., 2003).

Botanical files are key indicators of the likelihood of a given species to hybridize with wild relatives and the impact this may have. Therefore, they should be used to assess the potential ecological impact of field or commercial releases of GE crops in a given region. Botanical files should be established for each region considered and such files are only applicable for that specific region. Botanical files consist of data on a particular plant and provide an index of the likelihood for dispersal of pollen, dispersal of reproductive plant parts, the distribution frequency of the wild relatives, description of the transgene, and description of the nutrition from the transgenic plant.

CONCLUSION AND RECOMMENDATIONS

GE crops have enormous potential for food security, poverty alleviation, biodiversity conservation, mitigating climate change and reducing greenhouse gases, and reducing the environmental footprint of agriculture. There are significant challenges to be overcome to adopt GE crops particularly in developing countries. There are concerns about the risk of the GE crops on human health and environment. Basically, GE involves the same modifications that have been taking place for 10,000 years and these are thought to be part of a long-term trend of genetic modifications about which few people have shown concerns. These genetic changes occurred without regulations or oversight and that current regulation of GE is more than adequate. Furthermore, genetic modification is nothing new and the latest round of genetic modifications, brought about by genetic engineering, should therefore evoke no extreme serious concern. However, the risk assessment and management must be worked on case-by-case basis. The balance between the risks and benefits must be analyzed carefully and decision must be made. No to GE by itself is a risk. Not using GE is not a solution to the potential risk that can be caused by using GE. The risk of non-use may be more than the risk of using. Unless important steps are taken in Africa in adopting gene technology with proper management, the Gene Revolution can fail in this continent as that of Green Revolution.

REFERENCES


McGloughlin, M. (1999). Ten reasons why biotechnology will be important to developing world. AgBioforum 2: 163-174


IPM: DEVELOPMENT AND ADOPTION FOR SUSTAINABLE FOOD SECURITY - AN OVERVIEW

Emiru Seyoum

INTRODUCTION

Although there are many variations in terms of defining Integrated Pest Management (IPM) by different entities the one used in this document is one that is used by Norris et al. (2002). IPM is defined as a pest management system that in the context of the associated environment and population dynamics of the pest species utilizes suitable techniques and methods in a compatible manner as much as possible and maintains the pest population below the level that would cause economic damages.

The history of pest management dates back to the beginning of agriculture which combines important events (discoveries and defining moments), influential people, institutions, organizations and governments in ways that have led to current advanced stages of IPM. IPM is described as a decision support system for the selection and use of pest control tactics (measures) singly or in a harmoniously coordinated strategy based on cost-benefit analyses that take into account the interests of and impacts on producers, society and the environment.

Integrated pest/vector management (IP/VM) nowadays addresses conscious ways to look at the problem in its entire coherence and practical approaches to the problem involving the study, experimentation and use of a proper technology. The principles, research and development and IPM-system need to be developed and applied on the basis of understanding imperative components (producers, society and environment) in order to be coherent, inclusive, sustainable and dynamic so as to meet man's needs in the fast changing environment.

Experience over the last 3-4 decades with regards to pests and pest management has shown scenes that involved sequences of vicious scenarios depicted below:

pest problem temporary solution more problem call for more complex solutions need for integration failure to integrate failure to solve farmers' problems increased farmer's family size versus decreased farm size increased food insecurity increased and sustained poverty (Dent, 1995). This can be best explained in relation to the complicated

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phenomena man has faced as a result of widespread and misuse of pesticides against pest organisms over 4-5 decades.

The rapid and widespread development of resistance by pest organisms to pesticides can be a good example of the above vicious phenomena. Any pest management tactic may act as a strong selection pressure which is biotic or abiotic stress that changes the survival and reproduction of individuals of a particular genotype relative to individuals of different genotypes within a species. Selection pressure in the form of repeated pesticide application will increase the frequency of genes within a population which confers resistance to that pesticide. Pesticide resistance is, thus, the naturally occurring inheritable ability of some pest biotypes within a given pest population to survive a pesticide treatment that should, under normal use conditions, effectively control that pest population.

When a new pesticide (product) is applied against a pest population, the population is controlled. Repeated (continuous) application of the same product will make the pest population resistant. Then increasing the dose of the product will make the pest more resistant. Applying more and at greater frequency will lead to a situation where the pest population is no longer controlled. The next option is to change the product (pesticide) but often resistance to one member of chemical family results in resistance to other members of the family that have the same mode of action. A white fly population which is resistant to DDT, an organochlorine insecticide, is also resistant to other organochlorine insecticides such as BHC, chlordane etc. This inevitably will lead to what is known as cross-resistance which is defined as “resistance of pests to two or more pesticides due to the same physiological mechanism of resistance”. Cross-resistance can confer single multiple genes. The other scenario is what is known as multiple resistance to pesticides by pest organisms. Under this situation, the pest possesses two or more different resistance mechanisms and is typically controlled by more than one gene (a multi-gene characteristic) that confers resistance to different modes of action or families of pesticides. A white fly population, for example, that is resistant to DDT and other organochlorine insecticides is also resistant to parathion and other organophosphate insecticides. The implications of cross-resistance and multiple resistance are very serious and the details of which are obviously far beyond the scope of this paper because in these cases resistance to one pesticide results in resistance to other pesticides to which the pest has never been exposed. This entails that there can be resistance to new chemical compounds even before they are released for use in the field (Mercalf and Luckman, 1975).

The scenes of resistance do not end at multiple resistance level; rather it leads to another phenomenon referred to as resurgence. The pest population is initially decreased by the action of the pesticide applied, but recovers to attain a higher population density than was present before the
application. Resurgence occurs as a consequence of several ecological processes that can be perturbed by the pesticide. These include reduced biological control (the pesticide kills beneficial organisms that normally regulate the size of the pest population), reduced competition (the pesticide could be differentially more effective against a competing organism, allowing the original pest to recover with lowered competition and hence attaining a higher population density), direct stimulation of the pest (physiological processes of the survivors are enhanced to make them more ecologically fit such as enhancing egg laying by insects) and improved crop plant growth (reduction in the surviving pests is effectively stimulated by the increased quality and quantity of host plant tissue, in effect decreasing intra-specific competition among pests). To sum it up, resurgence occurs when a pest population rapidly recovers from a pesticide application and subsequently increases to densities greater than pre-treatment.

The other challenging phenomenon in connection with resistance to pesticides by pest organisms is replacement. This occurs when pesticide treatment kills the target pest which is replaced by a different species that was formerly a minor pest. The minor pest then increases in number to utilize the resources no longer being used by the previous major pest. This results in the minor pest becoming a major pest - a more complex challenge to the farmer, crop production and subsequently food security. In general, the consequences of pest resistance to pesticides could be summarized as follows (Norris et al., 2002):

a) Increased pest damage due to inadequate control, leading to decreased availability of food and fiber as a result of increased crop loss;

b) Increased production costs for the agro-ecosystem manager if the new pesticide is more expensive, resulting in lower net revenue;

c) Environmental contamination if users are not familiar with a pesticide and simply increase application rates in an attempt to regain pest control;

d) Increased commodity cost for the consumer if the costs noted in item b are passed on or if commodity prices increase due to inadequate control;

e) If pest resistance becomes widespread, then an effective pest management tactic (the pesticide) has been lost;

f) Decreased sale of an ineffective pesticide with consequent loss of revenue to the manufacturer; and

g) Continual investment of time and effort in the development of alternative control tactic.

On the other hand, the immense challenge posed as a result of extensive and misuse of pesticides goes with that of the ubiquitous presence of pesticide residues in foods, feeds and organisms occupying every part of
the ecosystem which have caused widespread concerns among thoughtful citizens about the immense contamination and pollution effects on the environment at large.

The lesson we have now clearly learnt from decades is the fact that reliance on and widespread use of a single pesticide, vector management system would lead to far complicated problems rather than solving it. The most sustainable and feasible pest management approach is to devise a system that gives no or little chance for selection pressure by the pest to the control tactics deployed which can only be achieved through integration of control measures (tactics). Comprehensive pest management strategies nowadays evolve three fundamental approaches:

a) Manipulation of the pest organisms: Tactics that either directly influence the pest organism or alter its behaviour so that it no longer causes unacceptable losses. These tactics include: prevention (legislation and phyto-sanitary measures), pesticides (chemicals that have direct toxic influence on the pest) and non-pesticidal tactics (biological, behavioural and physical control).

b) Manipulation of the host plants: The tactics used here either increase crop tolerance to pest attack or change the crop so the pest no longer attacks it. The tactics employed affect the pest population indirectly through its food source and includes cultural and host plant resistance.

c) Manipulation of the environment: This can be achieved at two levels: i) Microhabitat - such as for instance, the humidity within the crop canopy which can be modified making the pest organism less able to develop (involving physiological process); and ii) Crop surroundings - which can be accomplished over larger geographic areas through alternation of habitats both within and surrounding the field (region).

IPM PROGRAM DEVELOPMENT AND IMPLEMENTATION

IPM program development

The complicated nature of IPM program necessitates the integration of teams of specialists in various disciplines such as agronomists, meteorologists, ecosystem ecologists, economists, etc. An IPM program should include key aspects in its developmental phase including i) identification of key pests, ii) pest biology and ecology, iii) characteristics of the regional crop production system, iv) cost-benefit information on control tactics, v) regional management components, v) reliable predictive models, vi) environmental and social constraints, and vii) record keeping.

Essential in developing an IPM program is also to plan ahead. An IPM program will anticipate pest problems rather than being a simple set of
reactions that occur once the pest is present (avoidance of last minute moves). Many mitigation tactics/strategies must be set prior to pest attacks.

**IPM program implementation**

In situations where the extension service and innovative (model) farmers have been involved right from the beginning in the design and development of the IPM program, the implementation process should not represent a major obstacle. An IPM development program should aim at improving farmer's innovation through a system where farmers are real actors (researchers). Farmers should also be in a position to make the final decision on how to pursue their own issues. Farmers' innovations could be further improved through collaborative initiatives with other stakeholders such as extension services (MoARD), research universities and national and regional research set ups, NGOs, volunteers etc. Innovative farmers are thus disseminators, members of research groups and of course, farmers.

**MODELS FOR FARMERS’ PARTICIPATION**

There are four approaches for farmers' participation in the development of an IPM program:

- **Non-participatory research - non-participatory implementation**: no farmer's input approach (e.g. classical biological control, quarantine)
- **Participatory research - non-participatory implementation**: uncommon (involves farmers initially, then "sit back" approach)
- **Non-participatory research - participatory implementation**: most common (top-down → scientists (basic/fundamental and applied/operational research scientists))
- **Participatory research - participatory implementation**: IPM systems for individual farmers readily fit into this system.

As an IPM system becomes more complex in design and implementation, the farmer in the development of the system becomes more critical and this places emphasis on participatory research-participatory implementation approach as the most appropriate model (Dent, 1995).

**ADOPTION OF IPM PROGRAMS**

The relative success of extension programs will be ultimately judged on the adoption rate of the IPM system/program and on the improvement in production associated with this. Adoption rates of IPM are a function of a number of aspects including:

1) the relative advantage of the IPM subsystem as perceived by the farmer;
b) the compatibility of IPM with the farming system;

c) its complexity;

d) the degree to which it can be subjected to simple, on-farm trials/FFS;

and

e) observability of the effect of the IPM developed (Dent, 1995).

IPM practitioners attempt to use the IPM approach that harmoniously fits within the farm operation and keeps that operation profitable. It is, however, almost universally recognized now that that successful producers (farmers) need to include not only the costs and benefits at the farm level in their budget analyses (overall planning) but also the long-term costs and benefits to the environment in order to be able to sustain productivity, ecosystem integrity and hence achieve sustainable food security.

**COMPONENTS OF AN IDEAL IPM PROGRAM/SYSTEM**

A sustainable and comprehensive IPM program constitutes fundamental components and their interrelationship as presented in Fig. 1.

The presence/inclusion of the major components and sub-components, related to society, ecosystem, economics, control technology and pests (Fig. 1) is now recognized as fundamental for the success of interdisciplinary IPM programs/systems.

**IPM AS OFFICIAL POLICY: EXAMPLES**

The growing concern among the general public for the health of the environment, particularly the impact of pesticides, has prompted governments in many parts of the world to formally and explicitly advocate the use of IPM as an environmentally friendly form of crop production. Table 1 shows a few examples of countries and the UN where IPM is recognized as a national policy for pest management.

**Table 1 Sample countries and the UN where IPM is a national policy.**

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Decision by</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>1985</td>
<td>Ministerial declaration</td>
</tr>
<tr>
<td>Malaysia</td>
<td>1985</td>
<td>Ministerial declaration</td>
</tr>
<tr>
<td>Germany</td>
<td>1986</td>
<td>Parliamentary decision</td>
</tr>
<tr>
<td>Indonesia</td>
<td>1986</td>
<td>Presidential decree</td>
</tr>
<tr>
<td>Philippines</td>
<td>1986</td>
<td>Presidential decree</td>
</tr>
<tr>
<td>Denmark</td>
<td>1987</td>
<td>Parliamentary decision</td>
</tr>
<tr>
<td>Sweden</td>
<td>1987</td>
<td>Parliamentary decision</td>
</tr>
<tr>
<td>Holland</td>
<td>1991</td>
<td>Cabinet decision</td>
</tr>
<tr>
<td>UN</td>
<td>1992</td>
<td>World heads of State,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Conference, Brazil</td>
</tr>
</tbody>
</table>

Source: Dent (1995)
Fig. 1 Various components of an ideal IPM program and their interrelationship (Source: Norris et al., 2002).

PROSPECTS OF IP/VM IN AFRICA

Many African countries such as Ghana, Senegal, Zimbabwe, South Africa, Botswana, Kenya etc have recognized and gone to great lengths in implementing IPM as a sound pest management option for the health of mankind and the environment and to maintain (enhance) biodiversity.
GAPS IN IPM IN ETHIOPIA

Although there are some fragmented initiatives such as the Pesticide Registration and Regulation Act, the Plant Quarantine decree (1971) and a Plant Quarantine regulation (1992), a draft bio-control regulation etc which have either been issued or initiated (Asferachew Abate et al., 2000), a team of experts from Dry lands Coordination Group (DCG) had carried out a survey on implementation aspects of IPM in Ethiopia (DCG, 2003). Accordingly, the survey revealed the absence of IPM Policy/Strategy and frame work gap in the country. It has also identified the effective coordination, collaboration and networking mechanism in IPM implementation. The other gap identified was low awareness of policy and decision makers on the relevance of IPM which has worsened the situation. The team has also indicated in its report that there exists insufficient infrastructure responsible for IPM implementation in the country and the least emphasis is given by GOs and NGOs towards IPM initiatives and implementation despite the unequivocal contribution of IPM to sustain the nation’s ecosystem (biodiversity) while sustaining/enhancing food security.

REFERENCES


THE NEED FOR FOOD SCIENCE AND TECHNOLOGY EDUCATION IN ETHIOPIA

Gulelat Desse¹

ABSTRACT

Ethiopia faces many historical, cultural, social and political obstacles that have restricted progress in Education for many centuries. Although the government achieved impressive improvements in primary, secondary and higher education, programs were offered only in the fields of engineering, natural science, agriculture, social sciences and medicine. Food Science and Technology Education has started only recently and shortage of trained manpower in the area in order to complement the Government’s efforts in Food Security strategy has been a serious problem. There is a remarkable increase in the rate of food production in recent years. However, it is below the increasing per-capita food need of the country. The Ethiopian food industry provides only primary products for final preparation in the home. The industries should respond to market demands for more refined, sophisticated, and convenient products (Urban Food). On the other hand, loss of food products due to improper handling, processing, packaging, preservation etc., is huge. Although, Food Safety has the same national and international requirements, less emphasis is given in the country and sub standard products are distributed in many instances. In addition, most Ethiopian children and families are chronically malnourished. Thus, highly trained scientists capable of understanding the complexity of food systems, technology and nutrition are highly required. The paper analyses the status of food industries, food science education and research in the country.

Higher education in Ethiopia

Ethiopia has a population of 73 million. However, the country’s higher education enrollment rate is low. Modern higher education began with the founding of the University College of Addis Ababa on March 20, 1950. The University College had less than 1,000 students and less than 50 teachers in the late 1950s. Most of the teachers were foreigners. The College of Agriculture and Mechanical Arts, College of Engineering in Addis Ababa, Institute of Building Technology, Gondar Public Health College, Theology College of Holy Trinity, Kotebe College of Teacher Education, and the

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Polytechnic Institute at Bahir Dar were opened in the 1960s. In 1961, most colleges in the country were reorganized under the Haile Selassie I University. With the beginning of a socialist revolution in 1974, the name of the university was changed to Addis Ababa University (AAU) (William, 2004).

Ethiopia has now embarked on a higher education expansion and reform program. The expansion has created twenty new public universities and higher enrollment rate. Currently there is an increased institutional autonomy, curriculum revisions and new programs are being launched.

**Universities offering Food Science and Technology in Ethiopia**

Among the twenty universities, only four have launched Food Science and Technology and related fields of study in the last five years. These include Addis Ababa University, Haramaya University, Bahir Dar and Hawassa University (Table 1) (MoE, 2007). Currently there are few first degree graduates from Hawassa and Haramaya Universities and around five graduates at a Masters level in Food Engineering from Addis Ababa University. Private Universities are not yet involved in the area.

**Table 1 Ethiopian institutions offering degrees in Food Science and related fields of study.**

<table>
<thead>
<tr>
<th>Name of the University</th>
<th>Location</th>
<th>Name of Program</th>
<th>Degree Offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Addis Ababa University</td>
<td>Addis Ababa</td>
<td>Food Science and Nutrition</td>
<td>Masters, Doctoral</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Food Engineering</td>
<td>Bachelor, Masters</td>
</tr>
<tr>
<td>Haramaya</td>
<td>Haramaya</td>
<td>Food Science and Postharvest Technology</td>
<td></td>
</tr>
<tr>
<td>Bahir Dar</td>
<td>Bahir Dar</td>
<td>Food Science and Technology</td>
<td></td>
</tr>
<tr>
<td>Hawassa</td>
<td>Awassa</td>
<td>Food Engineering</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Food and Biochemical Engineering</td>
<td>Bachelor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Food Science and Postharvest Technology</td>
<td>Masters</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Applied Human Nutrition</td>
<td></td>
</tr>
</tbody>
</table>

**Institutions involved in Food Science related research**

Improving and intensifying the application of food production technologies so as to increase the level of food production can solve problems related to food insecurity. Post-harvest technologies in critical areas such as food storage, processing, preparation, preservation and packaging must also play a significant role and need to be supported by research. There is no doubt that selective and intelligent borrowing of modern foreign technologies can help. Yet, a viable and efficient strategy calls for careful consideration of traditional technologies that have been or can be upgraded for wide application and broad-based benefit to the population. Indeed,
many modern technologies are either hard to acquire for economic or financial reasons or unsuitable to the socio-cultural context. Moreover, foreign technologies simply do not exist for solving some of the specific problems and thus meeting the whole spectrum of technological needs of the country. Technological development and application, relying in many instances on indigenous knowledge and technologies, is therefore an important part of any real solution to the problem of food insecurity in Ethiopia.

During the last two decades, science and technology policy experts have come to increasingly recognize that, in some areas of development, indigenous technologies provide the foundation for socio-economic progress. Food storage, processing, preservation and packaging are good examples of such areas, where technological development has generally been overlooked by policy-makers. Owing to the influence of training and research often acquired in industrialized countries, policies in most African countries have tended to systematically attach greater importance to new, attractive and imported technologies and less attention to indigenous technologies in general. Thus, the potential of indigenous food technologies for food security and sustainable development in Ethiopia require due research attention to allow indigenous food technologies to play a significant role in the development of the country. However, only six Government institutions are involved in the area (Table 2).

The Addis Ababa University (Science Faculty), Hawassa University, Jimma University and the Ethiopian Health and Nutrition Institute were involved on studies related to fermentation of some traditional products (Enset, Siljo, Borde, fermented milk products etc.) and nutrition while few publications related to food technology were made by Haramaya and Addis Ababa University. However, this is far from sufficient and not totally disseminated to the public.

Table 2 Ethiopian public institutions involved in food science related research.

<table>
<thead>
<tr>
<th>Name of Institution</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Addis Ababa University</td>
<td>Addis Ababa</td>
</tr>
<tr>
<td>Haramaya University</td>
<td>Haramaya</td>
</tr>
<tr>
<td>Bahir Dar University</td>
<td>Bahir Dar</td>
</tr>
<tr>
<td>Hawassa University</td>
<td>Awassa</td>
</tr>
<tr>
<td>Ethiopian Health and Nutrition Institute</td>
<td>Addis Ababa</td>
</tr>
<tr>
<td>Ethiopian Institute of Agricultural Research</td>
<td>Addis Ababa</td>
</tr>
</tbody>
</table>
Status of the Ethiopian food industry

Ethiopia has very limited resources at her disposal. However, the country is thriving to conserve and use its natural resources to provide the basic human necessities (food, shelter, education, clothing, energy etc). Accordingly, a number of food industries are emerging (Table 3). The industries are involved in production of flour, pasta, biscuits, bread, milk products, coffee, tea, sugar, honey, fruits, vegetables, spices and others. Most of the industries however, are backward in structure, employment, and technological content. Most of them even lack a single expert who can support the activities of the industry.

The Government has currently initiated the establishment of food-technology research centre, sugar research institutes and others. However, there is lack of appropriate human and material resources and effective management. This situation is again attributed to the lack of expertise in the area and failure to involve the already available scientists.

Table 3 Type and number of Ethiopian food industries.

<table>
<thead>
<tr>
<th>Type of the Industry</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food industries (flour, pasta, etc.)</td>
<td>35</td>
</tr>
<tr>
<td>Dairy industries</td>
<td>11</td>
</tr>
<tr>
<td>Coffee and tea processing</td>
<td>12</td>
</tr>
<tr>
<td>Beverage industries</td>
<td>9</td>
</tr>
<tr>
<td>Sugar and related products</td>
<td>11</td>
</tr>
<tr>
<td>Fruits and vegetables processing</td>
<td>5</td>
</tr>
<tr>
<td>Spices</td>
<td>3</td>
</tr>
<tr>
<td>Oil processing</td>
<td>29</td>
</tr>
</tbody>
</table>

Assessments of problems and needs

It is well known that food insecurity affects a large population in African nations. The problem is expected to get even worse in the years ahead in certain parts of the region, due to rapid population growth, limited additional land that can be brought under cultivation, and the degradation of the natural-resource base, including loss of soil fertility. In this context, increasing the productivity of the food and agriculture systems is not a mere matter of choice; it is an essential condition for long-term food security and sustainable development. And raising the level of development and application of appropriate technologies constitutes undoubtedly one of the fundamental elements of any strategy aiming at boosting and sustaining productivity in the food and agriculture sector.

The Ethiopian food industry is growing at an alarming rate and requires support from expertise in the area. However, Food science and Technology Education in Ethiopia is far from desirable. Food security had been critical
to the country’s development. This is mainly associated with poor technology, adverse changes in climate, soil degradation and problems in implementing programs. The National Food Security Strategy has identified two categories of food insecurity problems: Chronic and Acute. The Chronic food insecurity is a result of overwhelming poverty which is indicated by the lack of assets, while Acute food insecurity is seen as more of a transitory phenomenon which is related to man-made and unusual shocks like drought. The following are few among many reasons that are associated to the lack of food science and technology expertise:

1. Lack of scientific based food production systems to assist farmers to produce important commodities.
2. Inadequate knowledge with regard to processing, transportation, storage and overall handling of food products in the country.
3. Reliance on foreign sources of technology, instead of proper investigation and use and promoting indigenous/traditional technology.
4. Very little consideration given to the development and use of traditional food preservation techniques thereby enhancing postharvest loss.
5. Non-existence of a strategy to build managerial and administrative capability related to food science and technology
6. Lack of university programs and facilities for postgraduate research
7. Inadequate support services for the food industries with regard to dissemination, acquisition, or application of technologies
8. Failure in identifying, transferring, and adapting appropriate technology
9. Incapable engineering installations and consultancy services (consultancy services handled by non-professionals)
10. Ineffective coordination among universities, leading to the fragmentation of research and academic efforts
11. Food industries and consumers do not appreciate the importance of expertise in the area in relation to food standards

CONCLUSION

The country needs expertise to support and encourage studies and research and thereby raise the productivity of food crops and animal resources. This will help improve the means of production in kind, quantity, and quality by making it compatible with environmental protection and with the culture and traditions of Ethiopian society. Lack of Food Science and Technology professionals, professional associations (like consumers...
association), lack of adequate standard controlling bureaus has resulted in a major loss of food products and the distribution of sub-standard foods. Hence, basic and urgent problems of the people can be alleviated through making food science and technology education training as a priority as is being done in the other sectors (agriculture, natural resources and environmental protection, water resources, energy, industry, construction, education etc.).

REFERENCES

Ministry of Education. (2007). Ethiopian public universities

THE ROLE OF RESIDUE CONTROL IN AGRO-PRODUCTS AND FOODS FOR LOCAL AND INTERNATIONAL TRADE

Ghirma Moges¹

INTRODUCTION

Conformity to Technical Standards (Technical Barriers to Trade, TBT) and compliance with Sanitary and Phytosanitary (SPS) measures are technical non-tariff requirements by customers and countries which are trading partners to an exporting country. Both TBT and SPS requirements (WTO, 1994) are also the basis of technical aspects of these non-tariff trade barriers to which members of the World Trade Organization (WTO) have made agreements not to unjustifiably apply them to members for trade protections and unfair trade practices. The most important obligation under the two agreements is the requirement for adopting international standards as part of a national conformity assessment system which, among others, include the establishment of internationally accredited inspection, testing and calibration laboratories.

Ethiopia is not yet a member of the WTO but its export trade is mostly related to the WTO members (Europe, USA, Japan, China and the Middle East). This adversely affects the country's export trade by these technical non-tariff barriers more so than developing countries with current membership to the WTO, because, for the latter, there are provisions of negotiations, WTO arbitrations and technical support to improve their conformity assessment systems including the launching of accredited food testing laboratories.

An accredited conformity system including inspection and testing will support the implementation of Ethiopia's own food standards and regulations for effective control of the import sector more so than the export sector as the country imports much more diverse agro-products, foods and supplementary substances (e.g. pesticides, fertilizers, additives like colorants and preservatives) than it exports. A simple illustration in this regard is the hundreds of packed foods available in the supermarkets in Addis Ababa and in food shops in the major regional cities.

Below are international trade requirements with respect to SPS measures, attempts and successes in Ethiopia and regional countries as a way to illustrate the need for confirmatory assessment system with established

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quality assurance. This paper is abridged from a Consultancy Research by Ghirma Moges (2008).

The EU directive for residue monitoring plan

A good illustration of the stringent conditions regarding residues and contaminants in agro-products and foods by importing countries is the EU requirement for implementing the Residue Monitoring Plan (by trading EU member countries and) third countries (non-EU trade partners - e.g. Switzerland, Kenya) regarding imports into the EU member states of food-producing animals and foods derived from them. The Plan is to be annually prepared by the importing countries in accordance with Council Directive 96/23/EC (The EU, “Council Directive 96/23/EC – on measures to monitor certain substances and residues thereof in live animals and animal products, 1996), prior to being licensed for exporting live animals and animal products into the EU market.

Paragraph 2 of Directive 96/23/EC requires the implementation of the following:

(a) provide for detection of groups of residues or substances according to type of animal (Annex II of the Directive)

(b) specify the measures for detection of the presence of:

(i) substances referred to in (a) in the animals, in the drinking water of the animals and in all places where the animals are bred or kept;

(ii) residues of the aforementioned substances in live animals, their excrement and body fluids and in animal tissues and products such as meat, milk, eggs and honey

(c) comply with the sampling rules and schemes laid down in the Directive

The implementation of the plan is an aspect of SPS measures with respect to toxic chemicals for the stated commodities should they be exported to the EU market. The principal objective of the legislation is to detect illegal use of substances in animal production and the misuse of authorized veterinary medicinal products as well as to ensure the implementation of appropriate actions to minimize recurrence of all such residues and contaminants in foods of animal origin.

laboratory for official residue control with accreditation scheme in accordance with ISO/IEC 17025.

Consignment of foods will be rejected if they contain residues in excess of EU Maximum Residue Limits – MRLs – (for veterinary medicines and pesticides), Maximum Limits – MLs – (for contaminants e.g. heavy metals, toxins etc) or contain residues of veterinary drug substances prohibited for treating diseases (e.g. chloramphenicol) in food-producing animals.

This entails that testing chemical residues prior to exporting products such as meat, honey, fish, poultry, honey to the EU Member States, the most important requirement and a must operation for conducting national residue monitoring plans (RMPs), which are aspects of EU’s Sanitary and Phytosanitary (SPS) control regarding toxic chemicals and chemical contaminants. The RMP document for food commodities of animal origin must append valid test results, acceptable by the client country for many groups of substances categorized as residues and contaminants. The scopes of trace quantitative tests per commodity involve high-tech tests – Immunoanalysis, HPLC, GC, GC-MS, LC-MS and AAS for tens of thousands of substances -pesticides and veterinary drugs as well as contaminants like heavy metals and mycotoxins. The substance groups to be tested under the RMP, the level and frequency of product sampling and testing per commodity are an obvious challenge to Ethiopia, both economically and technically. Some substance groups in these commodities have attained zero tolerance for their residues (e.g. chloroamphenicol, nitrofurans) because their use at farm levels is completely prohibited by the importing EU Member State.

Residue monitoring plan for Ethiopian honey

The 1st Ethiopian Honey export to the EU market as at March 2008 is a good example of success in conducting the residues and contaminant tests which involved preparation of the RMP document and appending the test certificates. This has contributed to the income of its beekeepers, honey processors and exporters. The EU permit to import Ethiopian honey encouraged more honey processors and exporters who receive most of the honey from out-grower beekeeping farmers in the countryside. This is a good illustration of reducing poverty for thousands of farmer families mainly in Southern and North-western Ethiopia. Beekeeping is normally a side business to the farmer. The Residue Monitoring Plan has to be conducted annually and the 2nd plan for 2009 is underway involving more processors/exporters and with nearly four-fold increase (from 300 tons in 2008 to 1,100 ton in 2009) of honey planned for export to the EU market.). The success to receive such EU license is not without challenges. SNV-Ethiopia sponsored the processes of the Monitoring Plans from 2006 upto
now, including the cost of the residue tests conducted in an accredited laboratory in Uganda.

The lack of internationally accredited laboratories in Ethiopia for residue and contaminant control in agricultural products and foods has been the most important bottleneck which has been hard to achieve. Samples of honey collected (according to the EU regulations) for the 1st and 2nd plans have been exported to the laboratory of Chemiphar (U) Ltd in Uganda. The laboratory is recognized by the EU due to its international accreditation since 2001.

Ethiopian consumers as well will benefit from the process under the RMPs for honey as this will guarantee the safety of product (with respect to residues and contaminants) produced, processed and marketed by the local honey enterprises covered in the Plan.

Table 1 below refers to the substances and groups of substance to be annually monitored in honey by accredited laboratory testing prior to consideration for exporting honey to the EU Member States.

Table 1 Substances and substance groups to be monitored in honey in accordance with Annex I of the EU Directive 96/23/EC (E = Essential, HD = highly desired).

<table>
<thead>
<tr>
<th>Groups</th>
<th>Substances and group of substances to be monitored</th>
<th>No of Chemicals/Substance Groups</th>
<th>Honey</th>
</tr>
</thead>
<tbody>
<tr>
<td>A6</td>
<td>Compounds included in Annex IV to Council Regulation 2377/90/EEC Chloramphenicol Nitrofurans Nitroimidazoles</td>
<td>5 substances</td>
<td>E</td>
</tr>
<tr>
<td>B1</td>
<td>Antibacterial substances/groups</td>
<td>11 substances/groups</td>
<td>E</td>
</tr>
<tr>
<td>B2c</td>
<td>Carbamates and pyrethroids</td>
<td>22 substances</td>
<td>HD</td>
</tr>
<tr>
<td>B3a</td>
<td>Organochlorine compounds including PCBs</td>
<td>23 substances</td>
<td>HD</td>
</tr>
<tr>
<td>B3b</td>
<td>Organophosphorus compounds</td>
<td>11 substances</td>
<td>HD</td>
</tr>
<tr>
<td>B3c</td>
<td>Chemical elements</td>
<td>5 heavy metals</td>
<td>HD</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>77</td>
<td></td>
</tr>
</tbody>
</table>

**Developments after the East African Fish Ban by the EU in 1999**

The Lake Victoria fish export ban imposed on Kenya, Tanzania and Uganda for one year (1999/2000) was lifted by the EU only after proper Sanitary and Phytosanitary (SPS) measures had been taken by these countries. The loss in earning during the one year ban amounted to tens of...
millions of dollars. The income of fishermen and related occupations dwindled sharply. This is a negative example of consequence of SPS bans in trade that affected the livelihood of populations due to lack of acceptable regulatory standards and testing facilities which needed to implement the standards.

The Government of Uganda invested USD 180,000 for two years in a Monitoring Programme on Lake Victoria, and recruited 10 inspectors to supervise fish production at factories. The government solicited for support from UNIDO, which contributed greatly to the lifting of the EU ban, and hence, resumption of exports. It streamlined the fish inspection services and strengthened capacity of the concerned authority. Fishery policy has been formulated; inspectors trained; some equipment provided and a fish inspection manual produced. Uganda The swift action on national laboratory infrastructure had led to the accreditation of the UNBS Microbiology Laboratory and the establishment of a Belgium-based private laboratory –Chemiphar Uganda Ltd.

As a result of the developments, Uganda has gained access to fish markets; in addition to the USA which demanded approved Hazard Analysis Critical Control Points (HACCP) systems for the fish factories.

Uganda has attained a level of compliance with requirements of the EU and other countries, particularly relating to inspections on factory operations, fish testing and other measures of conformity assessment. Export-oriented fish processing has evolved to a rather substantial industry involving twelve companies. Exports exceeded USD100 million per year (USD120 million in 2005), providing income and employment directly or indirectly for hundreds of thousands of people (Jaffe et al., 2006).

Ugandan fish consumers as well benefited from the investment on the improved sanitary system for fish harvesting and processing.

By 2005, Uganda had already three main laboratories (Chemiphar, SGS and UNBS) to provide most of the laboratory services in Uganda. These laboratories have similar capacity and capabilities. All three have established QA achieved international recognition, provide similar services, and support a wide array of customers.

Chemiphar (U) Ltd., a private laboratory company, with a mother company with laboratories in Belgium started to establish its laboratory in Kampala and processed its international accreditation within 2 years. The Laboratory was established in 1999 and was accredited in 2001 by the Belgian accreditation body, BELAC. The Ugandan Laboratory was initially established to perform microbiological tests for fish freshness for export abroad including the European Union market.
The scope of the laboratory function was gradually expanded to chemical tests which included quality specifications, pesticide and veterinary drug residue as well as contaminant analyses in various foods and water. The Laboratory is internationally recognized through BELAC which signs Mutual Recognition Arrangement (MRA) with other national and regional accreditation bodies. Its tests results are also recognized buy the EU.

Today, as a result of this recognized product testing, Uganda enjoys the export of its agricultural produces to European and other international markets. In April 2005, for example, the EU approved the first Ugandan residue monitoring plan (RMP) for honey and included it in its EU third country listing in order for Uganda to gain access to the EU honey market. This would not have been possible without the analytical capacity of the Chemiphar Laboratory which did the quality, residue and contaminant analyses for honey.

The case of Uganda is therefore an excellent illustration of how a locally established accredited laboratory, as part of its conformity assessment infrastructure, facilitates local and international trade.

The need for Ethiopian food testing laboratories

It is not mainly because of the absence of equipment that many analyses cannot be conducted in Ethiopia. Many testing laboratories and Universities including the young Regional Universities (though the latter are not meant for routine testing services) are well equipped for testing quality specifications, residues and contaminants. Typical capital equipment usable for such quality and regulatory tests are available in these laboratories including Atomic Absorption and Emission Spectrophotometers (AAS, AES), High Performance Liquid Chromatographs (HPLC), High Performance Thin Layer Chromatographs (HPTLC), Gas Chromatographs (GC), GC-Mass Spectrometers (GC-MS), as well as an LC-MS. Some of them have even unnecessarily more than two or more of one of these testing equipment. Some recent survey has revealed that most are not operational due to lack of maintenance and operating technicians, spare parts and consumables. A significant percentage of the equipment have not even been commissioned for a number of years.

The inability to integrate the various locally available equipment and human resources to establish the measurement parameters required for valid test results have hampered the laboratory capacity of Ethiopian institutions. Apart from the weakness of organizing manpower, equipment and consumables there are four pillars of measurements (quality assurance/control, validation, measurement traceability and measurement uncertainty) which make laboratory testing valid to fulfill the universally
known motto "measured once, accepted everywhere". This deficiency in Ethiopian food-testing and other laboratories covers both chemical and biological measurements, the latter including microbiological tests and the toxins generated from them, e.g. mycotoxins.

There is no way to verify product conformity/compliance, without valid testing, against product certificates or label claims of the producer/supplier. Despite the stringent external trade requirements, the rigors of laboratories testing to monitor product quality parameters, residues and contaminants show very weak analytical capabilities in Ethiopia.

RECOMMENDATIONS

Effective control of residues and contaminants by regulatory bodies for Ethiopian agro-products, feed and food-stuff, drinking water as well as for imported food commodities can be maintained if the following measures are taken.

i. Harmonizing Regulations and Standards

- Finalize draft regulations for effective implementation by the assigned competent authorities.
- Amend the existing standards and regulations to harmonize with existing internationally acceptable SPS measures.
- Adopt or set new food quality and safety Standards and Regulations making sure that the SPS regulations are science-based or aligned with international standards
- Implement effectively the specification and regulatory standards by accredited inspection and testing as part of a strong conformity assessment infrastructure.

ii. Setting up accredited testing laboratories that include monitoring residues and contaminants

The recommended actions to set up accredited food testing laboratories, be it publicly or privately owned, will promote international trade. This will also be beneficial to the health of Ethiopian consumers since imported products and locally produced products, including drinking and bottled water, will be under effective control prior to distribution to the market.
REFERENCES


WTO Agreement on the Application of Sanitary and Phytosanitary Measures.
Feb. 5, 2009

Rapporteur: Ashenafi Assefa

After due presentations were made by respective resource persons, the following questions and/or comments were raised by the participants:

Session I (Morning)

Q. The discussion on biofuels/agrofuels and GMOs is important. However, risk minimization in adopting such technologies should not cause harm to anyone. The issue of introduction of GMOs to Ethiopia is being raised nowadays. I think we need to focus on the results obtained from adopting such technologies not just on the debate and/or promotion of adoption. There is a saying in Amharic ለሊ የሚ ከ-

Q. With regards to the issue of biofuels, I have a fear that Ethiopia might not be benefited due to the problems that may arise from implementation of the guidelines.

A. I believe you are referring to agrofuel not biofuel - the two have basic differences, the former interests business people and they need to do the work in Europe and US. We need biofuels which are also catalysts of development. I believe we need the involvement of everyone from all aspects of profession.

C. I would like to share my experience with you regarding the issue of biofuels. Farmers were encouraged to grow castor oil plants for use as biofuel in fertile lands of Wolaita (2.5 ha). The company for whom the farmers were producing the plants failed to pay the farmers due to sky rocketed price. This had negatively affected the community in my locality. And regarding the issue of biofuel production in marginal lands, I do not think that there is marginal land available as all types of land are used for agriculture purposes by the community. This is a point that the presenter and government representatives should be informed of. I believe it is better to focus on ecologically-friendly ways of living in the environment and that research is needed before implementation.
Q. What is our contribution to Carbon emission in terms of deforestation or land degradation? Why is it that we put the blame only on developed countries?

A. Our contribution to carbon emission is insignificant compared to that of the developed world. In mentioning causes of vulnerability there are some points to be raised like deforestation, degradation etc which can contribute to climate change as well. The point is we have not yet overcome the issue of starvation!

I am glad that we have started this debate. We can take lessons from other countries in sub-Saharan countries. As to the emission of carbon we need to have integrated data so that we can debate on the issue. The contribution of carbon emission from deforestation is small and actually negligible compared to the developed world. Still, there is lack of data on the issue. The responsible authority needs to collect and organize such data. Otherwise it would seem like that we are contributing. So far Ethiopia has clean energy however things are changing.

Enabling strategies and policies are helping the country to achieve steady growth during the last six years. The challenge is how we can continue this. There is a challenge for the generation to face in this respect.

Q. In spite of the predictions of the impact of climate change, there are some reports that predict tropical countries would benefit from the situation! Do you have any comment on this?

A. There is a need for focused and integrated study to answer this question. We might benefit from the phenomenon by increasing production and earning hard currency; policies can be amended based on the upcoming phenomenon. I suggest that ecologists may better comment on the details.

Q. With regards to disaster management, Ethiopia has been faced with repeated disasters related to food insecurity. What is the readiness of MoARD to shift its focus from disaster management to risk management? A great deal of money is spent by the Ethiopian Government on emergency. Why is it not possible to use it for environmental management?

A. Crisis versus risk management: In the past we have been managing crises and the amount of money spent for emergency response was around USD 400 million annually. The reason I brought up this data is to show that if a fraction of this money had been put into development, it would have made a difference. This is why the government wants to change its approach from crisis management to
risk management. Risk reduction approach means mitigation, preparedness and etc

Vulnerability profile include: Hazard risk, associated risk and vulnerability risk assessments

Drought - hazard associated risk enables identification of which population is vulnerable to a specific risk. From this one is able to know the underlying causes of vulnerability. Then one can design risk assessment intervention. All these are developments. Preparedness is part of early warning system; to do all this one needs to have skilled man power, budget and etc. Unlike the past, our mitigation system will be based on actions that are taken during or before a crisis.

If we devise the plan we hope to properly manage disasters. Disaster prevention includes mitigation, prevention, preparedness etc. For those interested MoARD is preparing a space on these issues.

C. Introduction of new GMOs to Ethiopia is a challenge. Our ignorance in accepting new technologies is one reason for our backwardness. The Department of Biology, Addis Ababa University has launched a graduate program in Biotechnology to introduce GMOs and other technologies and its application. I believe we should be open to transfer of technology and adaptation.

Session I (Afternoon)

Q. In the presentations about forest degradation, etc no one has mentioned private forests. Is this not a way out for our forest degradation?

A. Yes, forestry is a potential area for investment. There are a lot of lessons to be learnt. For example, in New Zealand sheep are reared in forests and referred to as organic. Investing on forests should be encouraged but forestry can also be combined with other industries like animal husbandry. The problem currently being faced is available land for forestry and investment. With regards to the issue of prices, it is not only food prices but wood prices as well that are increasing proportionally.

Q. Forests as a source of precipitation: is there any study which considers the impact of forest clearance in Southwest Ethiopia which may serve as a source for precipitation?

A. The results of data between forests and moisture are confusing. There is little evidence on the aggregation of rain and forests. But forests do help in infiltration, organic improvement of soil and the land sponge effect. Once water infiltrates it may finally discharge as a river,
the presence of water increases infiltration and thus enables year round water in an area.

Q. Investment on forests has taken place decades before harvesting of the trees. How would you encourage people to grow forests with the current escalating price?

Q. Most of the presentations were on subsistence agriculture and food security. Although of importance, I don’t think that subsistence agriculture of the Welaita, Sidama and Hammer experience is of great value. This is a challenge because we have to shift to the actual massive cultivation. I have not heard any suggestion on entrepreneurship on agro-forestry or related activities. Enterprising modern agriculture activities rather than searching for a bare land seem to be appropriate. It is better to encourage people with money to invest on massive agro activities rather than totally depending and competing for small pieces of land.

A. The income generated from agricultural production is attractive. For instance, in Sidama and Welaita, Eucalyptus is being cultivated for commercial purposes and the local people are benefiting from its cultivation.

Knowing how the existing system works is important. It is also significant to understand how small pieces of lands are managed by the local people in their area.

Q. The presenter on under utilized foods has emphasized on domestication. The burning issue should first be conservation, then we will come to domestication.

A. Food diversification includes underutilized wild and domesticated plants. There is a lot of experience to be learnt from India and China countries have challenged food insecurity by diversification.

Regarding domestication versus diversification, plant species should first be managed so as to be used in the future. Xonso is a highly populated locality but in all small plots one can find high diversity, an experience worth learning.

Q. Watershed management is one of the means to overcome food insecurity. Due to the current condition of pollution of many lakes do fisheries involve in watershed management?

A. Yes, it is the water and the nutrient that comes from it that determines the stock. We are attempting to convince the relevant government bodies towards this direction. Catchment management is needed but it must be integrated with other systems as well.
Q. Closing the gap in gender equality is critical. However, gender equality should start at a family level. Why is it limited to small number of females and few others in schools? Also in spite of the policy that is said to be in place, it is not being implemented.

Q. Gender definition: many of the current policies empower women. How many women are capable of standing for their right?

A. Nowadays, there is a move from policy makers, however, the gap still remains wide. The reason why this is so is also my question. I believe this is because of the attitudes and mind sets of individuals. In some cases, there is also resistance from policy makers. We need to be persons of practice. The attitudinal change must start from the family. Attempts are being made to achieve this by improving discussions amongst the family unit. Gender is not only the issue of women. The existing social structure has made us to accept women as inferior and men as superior. It is the responsibility of the community to address this. We all have to ask ourselves what we can do to address this in our families, work places etc.

Gender issues will be solved in the near future not by the legal system but through development and improvement of socio-economic conditions.

Session II (Afternoon)

Q. Any opportunity has a risk associated with it. For a country such as ours where we are constantly faced with food insecurity, why is it that we cannot seize the opportunity of adopting GMOs first so as to see to solving the problem?

A. When new technology comes there is a natural resistance because of controversies. Being food insecure, we need to compare the benefits and the disadvantages. Can we afford to stay starved and protect our biodiversity? GMOs are expensive and genes are patented. However, if we develop the technology the cost will be lowered. Most of the patents are for 20 years which is also another advantage and opportunity.

C. The issue of adoption of biotechnology and GMO is an expensive undertaking and important as well. Practical issues are another thing to consider. There is a global controversy of organic food stuffs. It is against all this baggage of attitude that we have to take into consideration. Additionally, we need to assess the condition in our context. The issue of sustainability is also a question to be raised. The burden is not easy. Our agricultural productivity has to be addressed so as not to lose our biodiversity.
A. Regarding the issue of organic food, the West and EU may advocate this because their farmers are subsidized not to produce surplus. Our case, however, is different. We are dying thinking about the issue of organic food.

Q. Biodiversity cannot be a prescribed plant: are you advocating that we need to import GMO or do we have to synthesize our GMOS? There is the saying in Amharic "አሸኔ ከር ከር ከሸኔ ከሸኔ". Is it possible to go back once we lose our biodiversity? Gene revolution is scary!

A. Agricultural imperialism: I do not want farmers to use GM seeds, it is becoming expensive. But we need to develop the technology in our context. This is possible as we have the potential for this.

I support the issue of regulation for safety but this should not be directly adopted from other countries.
Dear Invited Guests

Dear Members of the Society

Ladies and Gentlemen

It is a pleasure for me to deliver a brief closing remark for the 19th Annual Conference of The Biological Society of Ethiopia. From its inception about 18 years ago, the Society has always worked to bring its members together and create a platform to share experiences in biological research and biology teaching.

I believe the presentations made and the discussions that took place during last two days were fruitful. The theme ISSUES AND CHALLENGES IN FOOD SECURITY was a timely issue for the conference and the presenters were chosen to cover this wide and important issue of food security. I would like to thank the Executive Committee of the Society for the successful conference.

As former president of the society and Dean of the Faculty, I would like to mention a few points. The Society has continued to grow in the number of its members which is now more than 1,000. Young biologists particularly fresh Ph.D, M.Sc and B.Sc, graduates are joining the society. Efforts should be made to attract even more biologists to join the society. The society is now organizing itself ("I have been informed") for better communication with its members. The updated list of members of the society with complete addresses will be published and made available to all members soon.

The society's journal "ETHIOPIAN JOURNAL OF BIOLOGICAL SCIENCES" needs to be strengthened and shall continue to prove its reputability. The effort the editorial board is making is very crucial in this regard. Moreover, the cooperation of its members in submitting research findings to the journal and reviewing articles submitted will enhance its timely publication and reputability.

On behalf of myself and The Faculty of Science, I hereby declare that the 19th Conference of the Biological Society of Ethiopia is officially closed.
CLIMATE CHANGE AND ETHIOPIAN AGRICULTURE

Mathewos Hunde

The great majority of Ethiopia's population is dependent upon rural livelihoods and their output contributes significantly to the health of the nation's economy. Agriculture constitutes 90% of exports. Most of these outputs are produced by poor farmers working small plots of land and pastoralists fostering limited flocks and herds. In many ways, the fate of the country depends upon the fate of its rural work force. This presentation considers the implications of climate change on Ethiopian agriculture. Climate change impacts will be felt primarily in the form of rising temperatures and increased instability in rainfall patterns. Droughts and floods may become both more frequent and more severe, in addition to the already complex historical pattern of droughts and floods Ethiopia has experienced. Few areas of the country have escaped these disasters in recent decades. Data are presented to demonstrate the changing relationships between floods, droughts and the myriad of other hazards (human, livestock and crop diseases, malnutrition and livestock and crop pests, for example) that accompany these major climatic shocks. Increasing numbers of Ethiopian administrations and administrators are faced with the interlocking vulnerabilities arising from these disaster threats. Climatic shocks render an already vulnerable population susceptible to livelihoods crises, forcing millions of people to turn to the government for emergency assistance and safety net benefits each year to augment their own productive and coping strategies. The international donor, UN and NGO community has worked closely with the government to provide life-saving aid as well as support for the PSNP but has done so at great cost. In recent years, emergency food and non-food aid to Ethiopia has averaged $320 million/year, with some years costing considerably more. Despite sustained economic growth and increased domestic cereals production there has yet to be realized any substantial decrease in the size of the needy populations. The country has been spared the worst of climatic shocks since the major crisis of 2003 but is likely to face extreme weather events in the future. Although Ethiopia contributes very little to the global phenomena of climate change, it will pay a high price for the excessive consumption of the industrialized world. Combined, these realities signal the need for reform of the way the nation manages its disaster risks and related vulnerabilities. The Disaster Management and Food Security Sector

1 Early Warning and Response Directorate, Disaster Management and Food Security Sector, Ministry of Agriculture and Rural Development, Addis Ababa
(DMFSS) of the Ministry of Agriculture and Rural Development is leading the implementation of the newly reoriented disaster management system, which, unlike in the past, focuses on disaster risk management. The vulnerability profile-based approach is an integral part of the new direction that forms a basis for designing and implementing disaster risk reduction interventions as well as strengthening preparedness (i.e. hazard monitoring, risk forecasting, early warning and standby capacities) for providing timely and appropriate responses before, during or after a disaster. The DMFSS, in collaboration with Government partners, is working to build the capacities of the myriad of woreda and regional authorities who are on the first line of implementing the redirected disaster management system, disaster risk reduction approach which is believed to be fundamental for adopting and mitigating climatic change induced disaster risks.
The interference of human beings on the environment since the industrial revolution has resulted in increase in the concentration of greenhouse gases in the atmosphere. Its consequence, global warming/climate change, become an international issue since the 1980's. Governments responded to the problem of climate change by adopting the United Nations Framework Convention on Climate Change (UNFCCC) at UNCED in 1992 held in Rio de Janeiro. The ultimate objective of the UNFCCC is to stabilize the concentration of greenhouse gases in the atmosphere at a safe level (i.e. to avoid dangerous interference with the climate system). The Kyoto Protocol which commits developed country parties to reduce on average 5.2% of their 1990 greenhouse gas emission level by 2010 was also adopted in 1997.

Ethiopia as a least developed country is more vulnerable to the adverse impacts of climate variability and change. Food security and ecosystems are among the sectors that will be adversely affected by climate change. Hence, most of the projects prioritized in the National Adaptation Plan of Action (NAPA) are related to the food security and ecosystem.

In this paper an attempt is made to highlight the cause of climate change and its effect on Food security and ecosystems at global, regional and national level based on assessments carried out by the Intergovernmental Panel on Climate Change (IPCC) and other relevant bodies. Observed rainfall and temperature variability and trends over Ethiopia and future climate projections as well as the possible effect on food security and ecosystems are also discussed. Besides, activities achieved so far and in the near future as well as recommendations for further action are to be discussed.

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## Program

**Thursday 5 February 2009**

**Rapporteur: Ashenafi Assefa**

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<th>Chairperson</th>
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<tr>
<td></td>
<td>8:15-9:00</td>
<td>Registration</td>
<td>Dr. Dawit Abate, President BSE</td>
<td>Dr. Dawit Abate, Dept. of Biology, AAU</td>
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<tr>
<td></td>
<td>9:00-9:05</td>
<td>Welcoming speech</td>
<td>His Excellency, Dr. Abera Deressa, State Minister, MoARD</td>
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<td></td>
<td>9:05-9:15</td>
<td>Opening speech</td>
<td>Ato Mathewos Hunde DMFSS, MoARD</td>
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<td></td>
<td>9:15-9:45</td>
<td>Climate change and Ethiopian agriculture</td>
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<td></td>
<td>9:45-10:15</td>
<td>Food security in the drylands</td>
<td>Mr. Adrian Cullis, Save the Children USA, Addis Ababa</td>
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<td><strong>Session II</strong></td>
<td>10:15-10:45</td>
<td>Coffee/tea break</td>
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<td></td>
<td>10:45-11:15</td>
<td>Biofuels development and food security in Ethiopia</td>
<td>Prof. Wolde-Ghiorgis, Dept. of Electrical &amp; Computer Engineering, AAU</td>
<td>Dr. Fassil Assefa, Dept. of Biology, AAU</td>
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<td></td>
<td>11:15-11:45</td>
<td>The gender dimension of food security in Ethiopia</td>
<td>W/o Mulumebet Melaku, Women's Affairs, MoARD</td>
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<td></td>
<td>11:45-12:15</td>
<td>Food security, ecosystems and climate change</td>
<td>Ato Gebru Jember, MWR/National Meteorological Agency</td>
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<td>12:15-12:35</td>
<td>Discussion</td>
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<td>12:35-13:35</td>
<td>Lunch</td>
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<td><strong>Session III</strong></td>
<td>13:35-14:05</td>
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<td>13:35-14:05</td>
<td>Not by grain alone: The role of forests and wild biodiversity to food security in Ethiopia</td>
<td>Dr. Mulugeta Lemenih, Wondo Genet College of Forestry and Natural Resources</td>
<td>Dr. Brook Lemma, Associate vice President Office for Research and Graduate Programs</td>
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<td>14:05-14:35</td>
<td>Underutilized edible plants as a means of food source diversification in Ethiopia</td>
<td>Dr. Zemede Asfaw, Dept. of Biology, AAU</td>
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<td></td>
<td>14:35-15:05</td>
<td>Agroforestry and its contribution to sustainability of rural livelihoods in Ethiopia</td>
<td>Dr. Zebene Asfaw, Wondo Genet College of Forestry and Natural Resources</td>
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<td>Time</td>
<td>Session IV</td>
<td>Overview of the fisheries and aquaculture development status – its contribution to food security and protein supply in the diet</td>
<td>Dr. Tesfaye Wudneh</td>
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<td>Biotechnology and GMO for food security</td>
<td>Dr. Tileye Feyissa</td>
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<td>Development, implementation and adoption of IPM for food security</td>
<td>Dr. Emiru Seyoum</td>
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<td>The need for food science and technology education in Ethiopia</td>
<td>Dr. Gulelat Desse</td>
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Friday 6 February 2009
Parallel Session I (Hall B5)

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<th>Session I</th>
<th>Time</th>
<th>The anti-diuretic hormone, vasopressin, mediates the effect of increased dietary salinity on the reproductive status of male spiny mice, Acomys rufus</th>
<th>Tilaye Wube, Dept. of Biology, AAU</th>
<th>Dr. Habte Teke, Dept. of Biology, AAU</th>
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<tbody>
<tr>
<td>9:00-9:20</td>
<td>The anti-diuretic hormone, vasopressin, mediates the effect of increased dietary salinity on the reproductive status of male spiny mice, Acomys rufus</td>
<td>Tilaye Wube, Dept. of Biology, AAU</td>
<td>Dr. Habte Teke, Dept. of Biology, AAU</td>
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<td>9:20-9:35</td>
<td>Evaluation of extracts of Schinus molle for larvicidal and growth regulatory activities against Anopheles mosquitoes</td>
<td>Getnet Atiafu, Dept. of Biology, Debre Markos University</td>
<td>Dr. Habte Teke, Dept. of Biology, AAU</td>
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<td>9:35-9:50</td>
<td>Variation in body shape of European seabass larvae (Dicentrarchus labrax) reared under xenic and axenic conditions</td>
<td>Eayasu Shumbulo, Dept. of Biology, Arba Minch University</td>
<td>Dr. Habte Teke, Dept. of Biology, AAU</td>
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<tr>
<td>9:50-10:05</td>
<td>A preliminary study of helminths of the Ethiopian wolf (Canis simensis Rüppell 1840, Canidae)</td>
<td>Hable Jebessa, Dept. of Biology Education, AAU</td>
<td>Dr. Habte Teke, Dept. of Biology, AAU</td>
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<tr>
<td>10:05-10:20</td>
<td>Discussion</td>
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<tr>
<td>10:20-10:50</td>
<td>Coffee/tea break</td>
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Session II

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<tr>
<th>Time</th>
<th>The role of valid testing agro-products and processed foods - avenue to food security and poverty reduction</th>
<th>Ghirma Moges, ChemTest Consulting, Addis Ababa</th>
<th>Dr. Seyoum Mengisto</th>
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<tbody>
<tr>
<td>10:50-11:10</td>
<td>The role of valid testing agro-products and processed foods - avenue to food security and poverty reduction</td>
<td>Ghirma Moges, ChemTest Consulting, Addis Ababa</td>
<td>Dr. Seyoum Mengisto</td>
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<tr>
<td>11:10-11:25</td>
<td>Socioeconomic determinants of infant and child mortality in rural Ethiopia</td>
<td>Fitaum Zewdu, First Consult, Addis Ababa</td>
<td>Dr. Seyoum Mengisto</td>
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<td>Time</td>
<td>Session IV</td>
<td>Presenters</td>
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<td>4:00-4:20</td>
<td>Comparative evaluation of FACScalibur Vs FACScount on the enumeration of CD4 cells from HIV positive patients</td>
<td>Lishan Admasu, International Clinical Laboratory, Dr. Mekuria Lakew, Dept. of Biology, AAU</td>
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<tr>
<td>4:20-4:35</td>
<td>Malaria/Intestinal helminth co-infections and anaemia in Antsokia-Gemza district, Ethiopia</td>
<td>Daniel Woldeyes, Dept. of Biology Education, Arba Minch University</td>
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<td>4:35-4:450</td>
<td>Effect of extracts from <em>Withania somnifera</em> and <em>Capparis tomentosa</em> on isolated smooth muscle tissue <em>in vitro</em></td>
<td>Workneh Sima, Wolaita Sodo University</td>
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<td>4:50-5:10</td>
<td>Discussion</td>
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</table>
| Session I | 9:00-9:20 | Genetic variation of *Juniperus procera* Hochst ex endl. populations in Ethiopia assessed by using microsatellite (SSR) markers | Demissew Sertse, Holetta Agricultural Research Center  
Dr. Kifle Dagne, Dept. of Biology, AAU |
|----------|---------|-------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
|          | 9:20-9:35 | The floristic composition and diversity of wetland vegetation in Telo Woreda, Southwest Ethiopia | Dikaso Unbushe, Dept. of Biology, Arba Minch University  
Mohammed Worku, Dept. of Crop Sciences, Jimma University |
|          | 9:35-9:50 | Survey of *Parthenium hysterophorus* L. weed prevalence and distribution in Sheka zone, Southwestern Ethiopia | Mohammed Worku, Dept. of Crop Sciences, Jimma University  
Kumelachew Yeshitela |
|          | 9:50-10:05 | Diversity of foliofolous lichens in Godere forest, Southwestern Ethiopia | Kumelachew Yeshitela |
|          | 10:05-10:20 | Discussion | |
|          | 10:20-10:50 | Coffee/tea break | |
| Session II | 10:50-11:10 | Genetic diversity of chloroplast haplotypes of *Hagenia abyssinica* (Bruce) J.F. Gmel in Ethiopia | Taye Bekele, Institute of Biodiversity Conservation  
Dr. Tileye Feyissa, Dept. of Biology, AAU |
|          | 11:10-11:25 | Genetic divergence among wild rice populations and cultivated rice (*Oryza* spp.) in Ethiopia | Gezahegn Girma, Ethiopian Coffee Forest Forum  
Dagnachew Lule, Bako Agricultural Research Center |
|          | 11:25-11:40 | Variability, heritability and genetic advance in quantitative traits of teff; implication for genetic conservation and improvement strategies | Dagnachew Lule, Bako Agricultural Research Center  
Tafisse Alemu, Dept. of Biology, AAU |
|          | 11:40-12:05 | *In vitro* evaluation of antagonistic potential activity and assay of culture filtrates of *Trichoderma harzianum* and *T. viride* against coffee wilt disease (*Fusarium xylarioides*) isolates | Tesfaye Alemu, Dept. of Biology, AAU  
Shiferaw Abate, Dept. of Biology, Arba Minch University |
|          | 12:05-12:20 | Discussion | |
|          | 12:20-2:30 | Lunch | |
| Session III | 2:30-2:50 | *In vitro*, somaclonal variation and field performance of pineapple (*Ananas comosus* (L.) cv smooth cayenne in Ethiopia | Zenihun Abebe, Jimma University, College of Agriculture and Veterinary Medicine  
Dr. Tamrat Bekele, Dept. of Biology, AAU |
|          | 2:50-3:05 | Micropropagation of *Prunus africana* (Hook. f.) Kalkman from seedling | Shiferaw Abate, Dept. of Biology, Arba Minch University  
Shiferaw Abate, Dept. of Biology, Arba Minch University |
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<tr>
<th>Time</th>
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<th>Speaker(s)</th>
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<tbody>
<tr>
<td>3:05-3:20</td>
<td>Optimizing the productivity of cereal/pulse mixed intercropping system in Ethiopian highlands</td>
<td>Getachew Agegnehu, Holetta Research Center</td>
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<tr>
<td>3:20-3:35</td>
<td>Prevalence of <em>Listeria</em> spp. in retail meat and milk products in Addis Ababa, Ethiopia</td>
<td>Roman Yilma, Faculty of Veterinary Medicine, AAU</td>
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<td>3:35-4:00</td>
<td>Coffee/tea break</td>
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<td></td>
<td><strong>Session IV</strong></td>
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<tr>
<td>4:00-4:20</td>
<td>Nutrition method to assess proximate content and diversity of barley landraces</td>
<td>Tesfaye Messele, Institute of Biodiversity Conservation</td>
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<tr>
<td>4:20-4:35</td>
<td>Role of plant-growth-promoting rhizobacteria (PGPR) on growth and yield performance of tef (<em>Eragrostis tef</em> (Zucc.))</td>
<td>Delelegn Woyessa, Dept. of Biology, Dire Dawa University</td>
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<tr>
<td>4:35-4:50</td>
<td>Post-harvest handling and major defects of mango (<em>Mangifera indica</em> L.) in Jimma area</td>
<td>Yetnayet Bekele, Jimma University</td>
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<td>4:50-5:10</td>
<td>Discussion</td>
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**Closing session**

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<tr>
<td>5:00-5:20</td>
<td>Closing remarks (Hall B5)</td>
<td>Guest of Honour</td>
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<tr>
<td>6:00-8:00</td>
<td>Dinner reception</td>
<td>AAU Restaurant</td>
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**Poster Session**

1. *In vivo* therapeutic efficacy of Artemether-Lumefantrine (Coartem) against *Plasmodium falciparum* in Kersa, South west Ethiopia, Ashenafi Assefa, Moges Kassa, Gemechu Tadesse, Hussen Mohamed, Tesfayae Mengesha, Abebe Animut, Adugna Woyessa

2. *Acacia senegal* (L) willd: A promising multipurpose tree species with diverse socioeconomic and ecological benefits in arid and semi-arid areas of Ethiopia, Asmamaw Alemu and Getachew Desalegn