Environmental Sustainability and Coffee Diversity in Africa

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Summary

Africa is known as the centre of origin and genetic diversity for all coffee species produced worldwide. It is also one of the most vulnerable regions to global climate change. In most African countries, natural forest ecosystems with high levels of biodiversity are under serious threat, largely due to increasing population pressures and subsequent deforestation and land degradation. The destruction of natural coffee habitats coupled with changes in weather patterns can adversely affect coffee genetic resources and the livelihoods of millions of people in Africa and elsewhere. This paper deals with environmental preservation and coffee diversity in Africa, and takes into account opportunities and challenges in the face of global climate change and financial crisis. Sustainability includes environmental, social, and economical components, which are linked with importance and risks to the use of natural resources for development and human well-being. Special attention is given to the sustainable use and conservation of native coffee habitats and genetic resources for the future development and competitiveness of the coffee sector in Africa and globally. The diversity in coffee genes, species and ecosystems, traditional farming practices and technological innovations such as mitigation and adaptation strategies to climate change need to be exploited in the African continent to produce superior quality coffee types and remain competitive in the world market. The wild or cultivated coffee species/cultivars have specific ecological and input requirements to adapt and thrive in their places of origin and thus preserve diversity in Africa or in other coffee producing countries. This presentation provides a brief insight into the huge opportunities and challenges facing the environment and conservation of coffee generic resources in Africa, and includes an overview of coffee research and conservation experiences in Ethiopia, the birthplace for Arabica coffee. It draws conclusions about the need for urgent implementation of sound conservation measures to warrant the sustainability of healthy ecosystem services, development of the coffee sector and improving the living standards of people worldwide and in the African continent in particular.

Introduction

Coffee belongs to the genus *Coffea*, in the Rubiaceae family. There are about 103 species of genus *Coffea*, all exclusively restricted to the tropical forests of Africa, Madagascar and islands of the Indian Ocean (Mascarene Islands). Of all the species, only two (*Coffea arabica* L.) and *Coffea canephora* Pierre ex Froehn) have commercial value in the world coffee industry. *Coffea arabica* is the only species occurring in Ethiopia and is geographically isolated from the rest of the *Coffea* species. It is naturally restricted to two isolated mountain forests on the western and eastern sides of the Great Rift Valley in southern Ethiopia. It is the most popular and widely cultivated coffee species in the world, dominating 70% of total coffee production and over 90% of the market. The remaining proportions come from Robusta coffee, which originates from the equatorial lowland forest of west and central Africa. Arabica and Robusta coffees have been adapted and thrive best in the tropical highland and lowland areas of coffee producing countries, respectively. There may also be several other coffee species in the natural forests of Africa that may be used by indigenous and local communities for different purposes but these remain for future studies.

Coffee is of exceptional importance to the livelihoods of millions of people, particularly in developing countries. It is produced in most African countries and plays a central role in the national economies of

Ethiopia, Côte d'Ivoire, Uganda, Zimbabwe, the Democratic Republic of Congo, Angola, Rwanda, Tanzania, Cameroon, Burundi and others (ICO, 2009). Despite its importance, the value of coffee exported from Africa has declined considerably over the years due to various reasons, particularly inefficient policy frameworks, lack of sustainability and competitiveness in the coffee sector, inadequate access to improved technologies, deficient services, poor market access and lack of incentives.

In Africa, coffee is grown predominantly on small-scale farms with limited and fragmented land holdings, little access to inputs and low prices. It is produced in various production systems, predominantly mixed plantings with other crops and shade trees. Crop diversification is practiced largely to ensure family food and cash security for smallholder coffee producers. In other words, coffee-based traditional agroforestry systems are commonly practiced that promote conservation and organic coffee farming, helping to maintain ideal environments and maximum biodiversity. This also enables sustainable use of natural resources and continuing provision of free ecosystem services and high biodiversity levels including, *inter alia*, coffee diversity. Nevertheless, agricultural production and productivity remain low and make sustainability issues questionable, given the high population growth rate in Africa. There is often a trade-off between maximum biodiversity and food insecurity, consequently threatening crop diversity in developing countries. The additional stresses from climate change, the financial crisis and increased demand for high quality coffees are among the reasons for the ever increasing costs of coffee production and processing, which are beyond the reach of most coffee farmers in Africa. Moreover, the coffee market system and share of benefits do not reach poor communities in developing countries to the extent that is desirable, making the practical contributions of fair-trade and sustainability initiatives questionable.

The varied landscapes and predominantly conservation-oriented coffee production systems in African countries have helped to maintain sustainable ecosystems with a range of social, economic and environmental services. However, the concept of ecosystem services can raise a number of new issues and has the potential to create a new 'paradigm' in relation to environmental and biodiversity issues. This requires extraordinary adaptation to tackle the changing status of ecosystem services and understand the techniques for maintaining and restoring resilient biological and social systems. According to the Secretariat of Crop Biodiversity Conservation (2009), connecting the local community with the natural environment and understanding the implications of losing precious natural resources and biodiversity should be the concern of every country and citizen of our planet to engage in a global alliance to protect life on earth. IIDS (2009) also reported that agriculture and forestry are part of the solutions to the problems to mitigate climate change and feed nine billion people by 2050.

In the centers of origin and diversity in Africa, coffee species are, however, under a severe threat of genetic erosion and irreversible loss largely due to increasing population, expansion of large farms, crop replacement, the coffee crisis and climate change, among others. The additional stresses imposed by climate change can also aggravate these problems as they can disrupt the ecosystem. The impact of climate change on degradation of farm lands and natural resources can contribute to reduced agricultural productivity and food insecurity in developing countries. Intensive coffee production, on the other hand, can hamper efforts to protect, maintain, and enhance habitats and species. Hence, unless appropriate global initiatives are urgently realized, the present green Africa can be easily converted into deserts with profound and damaging consequences for natural resource bases, biodiversity, economies and livelihoods.

It should thus be the special concern of international partners in the world coffee sector to provide new technologies, technical and financial support and delivery of farm inputs to ensure environmental sustainability and coffee diversity in Africa. In this regard, provision of incentive mechanisms and equitable benefit sharing to improve the livelihoods of indigenous and local communities are crucial elements for the conservation of forest areas and coffee genetic diversity, while enhancing household incomes of smallholder coffee farmers through a sustainable increase in productivity, quality and trade in African coffees. This would ensure climate services provided by carbon sequestration from the world's

natural forest habitats. In this connection, Lee (2009) described a new conservation paradigm resistance to climate change which will ensure the integrity of climate services provided by carbon sequestration from the world's natural habitats. An internationally coordinated response and implementation of a global system is needed very soon to adapt and mitigate the effects of climate change on species and ecosystems.

Overview of coffee research and conservation in Ethiopia

There are still natural coffee forests in southwest and southeast Ethiopia with rich biodiversity including the wild *Coffea arabica* populations. The major coffee production systems include forest, semi-forest, garden and plantations. The forest ecosystem, which includes coffee forest and semi-coffee forest production systems, occupies nearly 33% of land used for coffee production and contributes 25% of national coffee production. Coffee is intercropped with other companion crops or leguminous shade trees as low-cost production options to diversify food and cash security. Thus, the majority of coffee production (90%) comes from the smallholders while the rest is produced by large-scale producers (state farms and investors). Ethiopian coffee is processed and exported in two processing techniques, namely, natural sun-dried (70%) and washed (30%) coffees. The diversity of coffee, soil and climate, among others, enable the country to produce and supply the *de facto* organic coffees. Taye and Tesfaye (2002) described the traditional organic coffee production system as the only viable option to remain competitive in the world market and the only hope for smallholder coffee producers in Ethiopia. However, it requires accreditation and certification to enhance coffee quality and premium prices, and thus improve the living standards of rural coffee producers.

In Ethiopia, coffee is mainly produced in the southwest (former Kaffa, Illubabor and Wollega), southeast (Bale and Arsi), south (former Sidamo), south east (Harerge) parts of the country. In these areas are found the famous coffee types known internationally by the names Limmu, Gimbi, Yirgacheffe, Harar, etc.; coffee types which fetch a premium price. The total area of land devoted to coffee production is estimated at 662,000 hectares, of which 496,000 hectares are estimated to be productive. There are different arabica coffee cultivars and landraces with desirable traits (yield, quality, disease resistance, drought stress tolerance, etc). The local coffee landraces are known by vernacular names and growth characteristics in the different localities. According to Yacob et al. (1996), they are broadly grouped into three canopy classes of open, intermediate and compact types. These arabica coffee species could be bourbon or typical cultivars as they are quite different in shoot and root growth systems as well as adaptation to specific site and respond to management inputs. They also vary in frequency of occurrence along rainfall gradients and soil profile depths (Taye et al., 2004), indicating the existing variability among the cultivated coffee landraces in their adaptation strategies under specific environments. Arabica coffee cultivars with open and compact crown habits were found to escape soil moisture stress through deeper and shallow root distribution as well as leaf shedding and rolling, respectively. Moreover, research findings (Kufa 2006; Beining 2008) also reveal the presence of significant diversity in drought adaptation and avoidance mechanisms among the wild coffee populations in Ethiopia.

The local communities living in and around the forest mainly derive their livelihoods from coffee forests which are the source of timber and non-timber forest products like honey, spices, wild food, medicine etc (Senbeta 2006). Human-induced forest losses are still the major threats to forest resources. Originally, about 34% of the country was covered by dense natural forest, but this figure had declined to about 2.7% by 1989 (Rogers 1992). The main driving forces behind deforestation are the expansion of agricultural land, uncontrolled exploitation of forest resources, overgrazing, seasonal fires, non-forestry investment, mining and establishment of new settlements in forested areas (Gole, 2003). Currently, Afromontane rainforest with wild coffee populations is the major remaining forest in the country. However, the management of coffee forests has affected and will continue to affect the diversity, composition and structure of the forests. Beekeeping has also the potential to influence the diversity of forest species as the traditional beehives are usually made up of limited tree species because of their easy workability, light

weight and good odor for bees (Senbeta 2006). However, as coffee management continues, the coffee forest could be changed to coffee farms with a few shade trees.

The Jimma Research Center has released 26 coffee varieties (23 pure lines and 3 hybrids), which are high yielding, resistant to diseases, and possess unique inherent quality attributes of each locality. Recently, 12 pure line specialty coffee varieties (Wellega = 4, Sidamo/Yirgacheffe = 3, and Harar = 5) have been identified and proposed respectively from Gimbi, Yirgacheffe/Sidamo and Harar coffee populations, which make a total of 38 improved coffee varieties in the country. The multiplication and distribution of these and other promising specialty coffees are aggressively underway at their respective locations. The research findings depict the significant interactions between coffee genotypes and environment, demonstrating the need for local coffee landrace development programme (Belachew and Labouisse, 2006). Coffee specialization, research and development interventions focus on the use of local landraces at each locality, and also *in-situ* conservation promoting market-oriented and specialty coffee production systems. This breeding strategy would broaden the genetic bases of coffee populations for future works in the country. The available coffee research and development achievements and future priority areas are synthesized and documented from the various presentations at a national coffee workshop in Ethiopia (Girma et al., 2008).

Nowadays, it is not uncommon to observe new coffee tree drying symptoms due to climate changes that have resulted in physiological disorders between vegetative and reproductive growths. This is associated with continuous flowering and heavy crop loads as a result of changes in weather patterns with erratic rainfalls. The situation is aggravated by the outbreak of insect pests and diseases, requiring new corrective strategies to revive Arabica gene pools from possible fast and irreversible losses.

With regard to experiences in conservation of coffee genetic resources, two major conservation approaches, *in-situ* (in their natural habitats) and *ex-situ* (outside their areas of origin) are used in a complementary manner. Financial support from the EU through the framework of the Coffee Improvement Programme (CIP) has played a significant role in the collection and conservation of coffee gene pools. It supports coffee conservation, research, extension (nursery and field management) and marketing components and has greatly contributed to the overall development of the coffee sub-sector in Ethiopia. The financial support from the EU and the project on the Conservation and use of Wild Populations of *Coffea arabica* in the Montane Rainforests of Ethiopia (CoCE) has enabled the identification of potential coffee forest areas for *in-situ* conservations. Based on the interdisciplinary research findings and recommendations of the CoCE project (www.coffee.uni-bonn.de) two sites were identified by the Government of Ethiopia as UNESCO Biosphere Reserves, i.e., the Yayu Coffee Forest Biosphere Reserve and the Kafa Biosphere Reserve (Tadesse et al. 2009 unpub).

A cost-benefit analysis comparing the use of wild coffee forests as compared to their conversion into agricultural land revealed that, because of the high time preference rates, poverty, inappropriate institutions and lack of income alternatives, the conversion of forest land is more beneficial for individual farmers, whereas conservation would be beneficial to the entire society (Rojahn, 2006). The value of coffee genetic resources was also estimated on the basis of assessing three breeding programs using genetic information to breed improved coffee cultivars. The three breeding programs concern breeding for resistance to coffee berry disease and coffee leaf rust, low caffeine contents, and increased yields. The resulting economic value of the wild coffee genetic resources amounts to around US$1.5 billion at a 5% discount rate (Hein and Gatzweiler, 2005).

According to Dullo et al. (1998) and Belachew and Labouisse (2006) there are about 21,407 coffee germplasms (Arabica = 10,573, Robusta = 8,000, Mascaro *coffea* accessions = 1,282 and arabica or robusta in Cameroon = 1,552) in the different field genebanks of some African countries, of which around

89.85% is found in Ethiopia. This corroborates with Surendra (2008) who reported that Ethiopia alone possesses around 99.8% of total Arabica genetic diversity. Up to now, a total of around 11,691 arabica coffee germplasm accessions have been collected from the different areas and *ex situ* conserved on research plots of the Jimma Research Center and its sub-centers (5,960 accessions) and field genebanks of the Institute of Biodiversity Conservation (5,731 accessions) in Ethiopia. The potential, constraints and recommendations for the conservation of Ethiopian coffee genetic resources are presented in a coffee book (Girma et al., 2009). Cognizant of the importance of coffee, its high genetic erosion in the centers of origin and minimal conservation efforts, Belachew and Sacko (2009) emphasized the need for immediate conservation measures to safeguard the sustainability of the global coffee industry. To this effect, multi-site *in situ* conservation approaches seem advisable for sustainable conservation and use of coffee genetic resources, although they require high costs, community mobilization, proper incentives and compensation mechanisms to provide the basic necessities and thus improve the living standards of the local population.

Conclusion

Coffee is indigenous to tropical Africa and is produced in most countries in the continent. It is largely produced by smallholders who are the most vulnerable to market and climate associated risks. Consequently, if producers are forced to neglect their farms because of inadequate market access and low prices, native coffee habitats and supply of quality coffee to the coffee industry in consuming countries are jeopardized. Moreover, increasing population pressure, deforestation, expansion of large-scale farms, competition from other crops, settlement programmes, financial crisis and climate change, among others, are threatening coffee forest areas and coffee genetic diversity in the continent. Coffee is an evergreen and perennial tree crop suitable for agriculture and forestry practices in different agroforestry systems. Its production needs to be fully embedded into any climate agreement and compensated for its multiple eco-services such as carbon sinks in each country and production system. To this effect, smallholder producers should be organized and have enough power to take on their responsibilities in each organizational structure and value chain process. Above all, the negative impacts of climate change on coffee production and its ecology call for an urgent reaction to maintain quality environments and coffee diversity through minimizing deforestation and forest degradation. This would enhance coffee quality, raise the income of smallholders and contribute to poverty reduction in Africa. Cognizant of existing opportunities, African counties can excel at the sustainable supply of superior quality coffees to global consumers only if funding is sought from multilateral donors and with appropriate collaboration to achieve set development goals in the African continent.

It can be concluded that immediate measures are required to identify and design ways of implementing relevant conservation strategies against the possible threats from climate change to coffee ecology and production in Africa. To this end, implementation of global coffee genetic resources conservation initiatives proposed by Belachew and Sacko (2009) and other relevant projects could be among the top priority actions to maintain quality environments, conserve and benefit from the unique coffee germplasm base in Africa. Identification of options to deliver incentive mechanisms and equitable benefit sharing from the ecosystem services and from the use of forest genetic resources; and premium prices for quality coffees are critical issues for the sustainable development of the coffee sector and human well-being in developed and developing countries. More systematic studies on the possible impact of global climate changes on social, cultural and economic issues and identifying the best adaptation and mitigation strategies call for further work on the implementation of best options for conserving coffee genetic diversity and its forest ecology for global benefit. Therefore, strong coffee partnerships in both coffee producing and importing countries are required to coordinate and facilitate sustainability initiatives for the future development of the coffee economy in Africa and globally.

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