Preserving diversity for speciality coffees. A focus on production systems and genetic resources of arabica coffee in Ethiopia

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Ethiopia holds a unique position in the world as *Coffea arabica* L. has its primary centre of diversity[1] in the south-western highlands of the country (figure 1). That fact is strongly validated by observations of travelers and scientists; and more recently by several studies using DNA-based genetic markers.

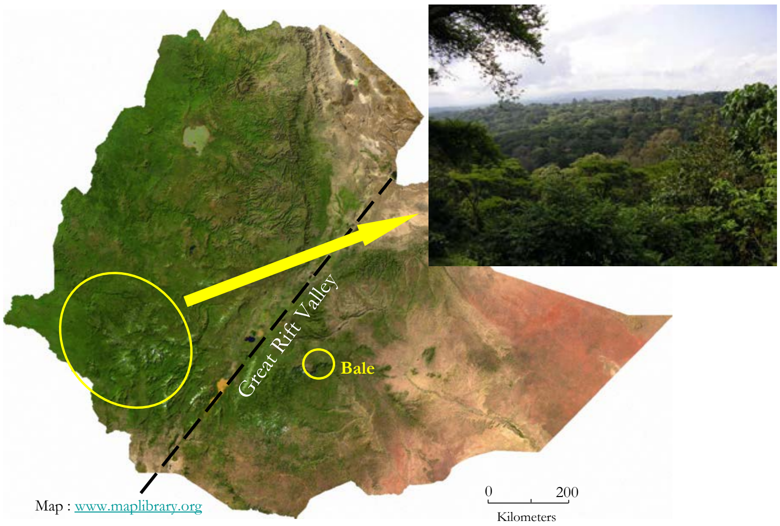


Figure 1: Rainforests in south-western highlands, and possibly Harenna forest in Bale on the eastern side of the Great Rift Valley, are the natural habitat of *Coffea arabica*.

Four major coffee production systems spread over diverse ecological zones are commonly distinguished, along with intermediate or mixed situations: Forest coffee, Semi-forest coffee, Garden coffee and Plantation coffee systems.

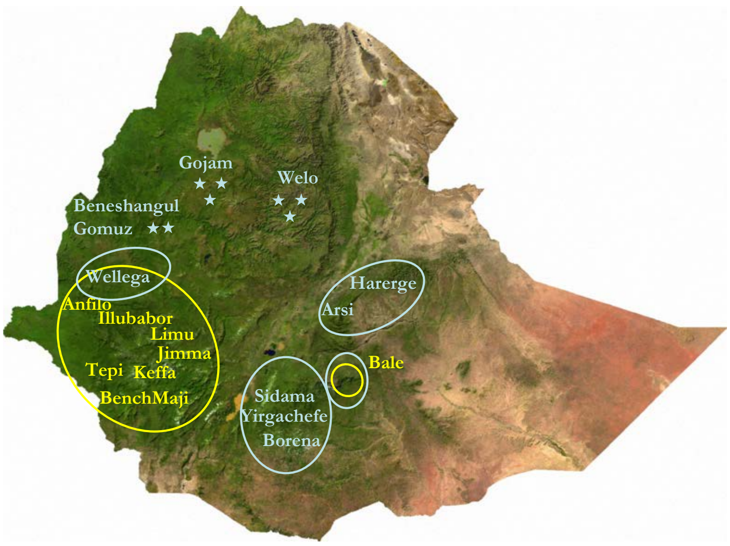


Figure 2: Main coffee areas**.** Coffee is found in its natural habitat (yellow circles) where it is picked in more or less managed forests as well as cultivated in gardens (blue circles and stars).

[1] see glossary at the end of the handout

The four major coffee production systems

Figure 3: Forest coffee in Yayu (Illubabor). Coffee trees are simply protected and tended for convenient picking.

In Forest coffee (figure 3) and Semi-forest coffee (figure 4) systems, the commonly called **'wild coffee'** is directly derived from spontaneous coffee trees of the forest. Forest and Semi-forest coffee systems predominate in south-western Ethiopia and in Bale. They account for 5% (forest) and 35% (semi-forest) of national coffee production.

Figure 4: Semi-forest coffee in Limu Kosa (Limu).
Farmers slash weeds, lianas and competing shrubs, thin forest trees and fill open spaces with local seedlings.

Figure 5: Garden coffee in East Harerge. Coffee is grown on smallholdings, combined with other crops in open sunlight or under a few shade trees.

In Garden cultivation system, coffee is combined with other crops in open sunlight or under a few shade trees (figure 5). In these gardens it is commonly referred to as coffee **'landraces'**. This system predominates in smallholdings of the South (Sidamo, Yirga Chefe), in the West (Wellega) and in the East (Harerge and Arsi). Very small-scale coffee growing in the marginal zones of northern Ethiopia such as Gojam and Wello can be included under this category. Garden coffee accounts for 40 to 50% of national production.

In Plantation system, coffee is cultivated in order to maximize the productivity. Planting material can be landraces but most of the time consists of a limited number of **'improved coffee cultivars'** selected by the Jimma Agricultural Research Center (JARC) for their productivity and resistance to diseases (coffee berry disease and coffee leaf rust). This sector includes a few large private and state farms (figure 6) located in the South-West, as well as smallholder plantations spread all over most of coffee growing areas. It accounts for 10 to 20% of national production.

Figure 6: Young coffee trees in Teppi State Farm. Coffee is grown under a few shade trees after land clearing and soil preparation.

Contributing factors to genetic erosion of Ethiopian coffee genetic resources

1. Partial reduction of production in some areas for economic, climatic or agronomic reasons: low prices, especially during the 'price crisis' between 1999 and 2004 and competition from the more lucrative khat; prolonged periods of drought in some marginal areas; low yields particularly in forest and semi-forest coffee systems and in the coffee berry disease-prone areas (figure 7) - especially affected Harerge; impact of coffee wilt disease or tracheomycosis that destroys coffee trees.

Figure 7: Coffee berry disease decreases yield, particularly at high elevation. It is presently limited to African countries.

2. Deforestation due to Population pressure in the major coffee growing zones

Given the current demography (77.4 million inhabitants and a population growth rate of 2.4%) with population and cattle migrations from drought prone zones, land pressure is increasing from time to time in areas best suited to coffee production. In south-west Ethiopia, approximately 38% of the highland plateau was covered by 1,158,000 hectares of closed high forest at the beginning of the 1970s, and, by 1997, only 556,700 hectares were left making a loss of 52% in less than 30 years.

Figure 8: Deforestation by new settlers in the south-western Ethiopia near Teppi.

3. Replacement of local landraces by few improved varieties with a narrower genetic base

The search for greater profitability at all levels in the supply chain is encouraging few varieties with better yields and qualities. Twenty three pure lines and three hybrids are currently proposed and disseminated to farmers by the coffee research. This trend is amplified by the current move by investors into more intense and selective garden and plantation cultivation methods, mainly in the south-west.

It is interesting to note that the partial reduction in some coffee areas highlighted in 1 above has not detracted the overall increase in national production, which has expanded since 2004 from 240,000 tonnes to an estimate of 344,000 tonnes in 2007, making Ethiopia the largest coffee producer, consumer and exporter in Africa, and the third world producer of arabica after Brazil and Colombia.

Ex situ conservation in Ethiopia

In Ethiopia, it was only after the creation of the Jimma Research Station (now the Jimma Agricultural Research Centre or JARC) in 1967 that organized coffee research and germplasm collection started at the national level. Currently the conservation of genetic resources is ensured in the form of living *ex-situ* collections (figure 9) at the main JARC centre near Jimma and at 9 other sub-centres or testing sites, which are located in the main coffee producing zones under different agro-ecological conditions.

Figure 9: A field genebank in a station of JARC near Agaro (Limu).

In December 2006, the total number of accessions conserved at JARC was about 4,780. The JARC genebank is of prime value in that the number of accessions is large, the morphological diversity observed is high, and the diversity of the geographical origins from where the collections are made is fairly large and representative.

In addition to ex situ conservation by JARC, there is also a field genebank established and managed at Choche near Jimma by the Institute of Biodiversity Conservation (IBC) with 5,196 randomly chosen accessions conserved. Some of these are from JARC.

Complementary conservation methods

In situ conservation of genetic resources is acknowledged as being complementary to *ex situ* conservation and its implementation in Ethiopia has long been considered as a national urgency. For the time being, emphasis is placed on the conservation and controlled exploitation of a few, more or less degraded, remnants of forest areas, under research or development projects funded by international agencies (e.g. EU-CIP, ZEF-University of Bonn in SW Ethiopia, Norad-Irish Aid by Farm Africa in Bale). In general, the sustainability of such *in situ* conservation initiatives can be assured only if the farmers earn large enough benefits from the agro-forestry system as a whole.

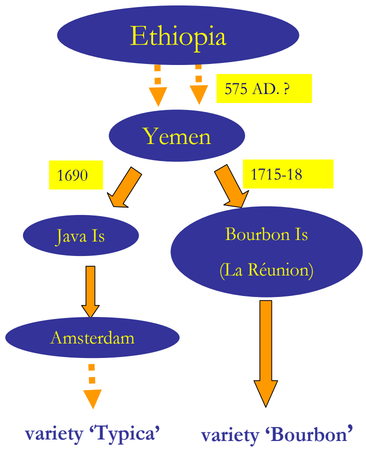
Improvement of forest coffee qualities, currently rather mediocre, is a prerequisite to achieve premium export prices. Enhanced post harvest systems can realise the known full potential. Only then can marketing strategies such as product labelling (e.g. environmental certification, Protected Designation of Origin, etc.) increase the market value of forest coffees.

Figure 10: Beehives in a forest near Bonga (Keffa). Non timber products as honey, spices, nuts and fruits complement the incomes obtained from forest coffee.

At the same time as preserving forests, it also seems important to develop some *in situ* conservation methods for coffee-based garden systems that are known to represent an important reservoir of diversity although to a lesser extent than coffee that is currently in forests.

Arabica coffee genetic resources out of Ethiopia

Outside Ethiopia, world arabica coffee production is largely based on using a small number of cultivars: **'Typica'; 'Bourbon';** and mutants (e.g. '**Caturra'**) or hybrids of those two varieties (e.g. '**Mondo Novo'**).



Source: Anthony *et al.* (2001) Euphytica 118:53-65

Figure 11: Yemen is the primary centre of dispersion from which a very small number of seeds were at the origin of the world coffee industry.

The low genetic diversity observed within those cultivars makes coffee crops particularly vulnerable to diseases and environmental hazards. Therefore in recognition of Ethiopian diversity plant material surveys and collections were undertaken in Ethiopia from the beginning of the 20th century. Those operations led to the establishment of valuable genebanks at several international research centres in Africa, Asia and America. This material constitutes the commonly called '**Ethiopian coffee genepool'**.

Two interesting 'Ethiopian' varieties are '**Geisha'** and '**Java'.** Both are vigorous, productive and moderately resistant to coffee leaf rust, and have a good to excellent cup. 'Java' showed resistance to coffee berry disease in Cameroon.

History of 'Geisha'

A batch of seeds was collected in Ge(i)sha, south-western Ethiopia in 1931, and sent by the British Consulate in Ethiopia to Kitale, Kenya. In 1936, several progenies of those plants were sent to Lyamungu, Tanzania where a tree (VC496) was selected for its resistance to coffee leaf rust. Later, in 1953, seeds of this tree were sent to Turrialba, Costa Rica from which 'Geisha' variety was disseminated to other countries in the world.

Presently, the largest collections of Ethiopian coffee outside Ethiopia were those carried out under the aegis of the FAO[2] in 1964-65 and by ORSTOM[3] in 1966, representing a total number of 682 distinct accessions collected mainly in forests and semi-forests of Ethiopia. In 2000, Silvarolla *et al.* found a large variability (0.42 to 2.90%) in the caffeine content of 99 progenies of FAO collection and in 2004 three caffeine-free coffee plants. This Ethiopian genepool has also been used for traits of agronomic interest (resistance to diseases or nematodes), or to improve yield and quality by crossing with 'Bourbon' or 'Typica'-derived varieties as in Central America where the hybrid variety 'Centroamerica' will be commercialized for the first time on a large scale in 2008.

However, these Ethiopian collections are not yet fully evaluated and it is expected that other plants with interesting quality characteristics such as original aroma, distinctive fragrances or naturally low caffeine content will be found in the near future.

[2] Food and Agriculture Organization of the United Nations
[3] Office de la Recherche Scientifique et Technique Outre Mer, France (now IRD, Institut de Recherche pour le Développement)

Conclusion

From the point of view of a plant breeder, the Ethiopian coffee genetic diversity is high compared to commercial varieties but is yet to be properly assessed. With the exception of selection for resistance to coffee berry disease, the diversity of the Ethiopian coffee germplasm has only been very partially exploited in Ethiopia, while the genetic resources continue to dwindle at an alarming rate. There is no doubt that urgent measures are necessary to slow down the process of forest degradation. However, improving our knowledge of the genetic structure of Ethiopian forest and garden coffee tree populations is a prerequisite for justifying and planning a global conservation strategy for the future. Much also remains to be done to assess the diversity and thus the value of the collections currently conserved *ex situ* by JARC and IBC.

Ethiopia stands out through the diversity of its *terroirs* and the uniqueness of its forest production system. The existence of a varied range of Ethiopian origin coffees on the world market is only a partial reflection of that diversity. Nine denominations are recognized in international trade, namely Limu, Jimma (commercially Djimma), G(h)imbi and Lekempti, Sidamo, Yirgachefe, Illubabor, Harar, Tepi and Bebeka. With the marketing trend of differentiating to add value to products, roasters and food groups use these names also for speciality coffees. There is also a substantial growth of exports of certified coffee (Fairtrade, organic, Rainforest alliance, etc.). Recent discoveries have revealed the specificity of coffees from Amaro, Amhara, Arsi, Balé forest, Borena, Guji, Kaffa forest, Omo, and many other areas.

There is therefore a huge potential in Ethiopia for diversifying the types of coffee because of the wide variety of ecological niches and farmers practices. With improvement and care in the growing and more in the post harvest practices, it is possible to have a much larger share of the Ethiopian production with differentiated natural range of tastes to be in the speciality coffees category.

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Glossary

Accession. A distinct sample of germplasm which is maintained in a genebank for conservation and use.

Center of diversity. The geographic region in which the greatest variability of a crop occurs. A primary center of diversity is the region of presumed origin and secondary centers are regions of high diversity, which have developed as a result of the subsequent spread of a crop.

DNA-based genetic markers. A unique DNA sequence, occurring in proximity to the gene or locus of interest, can be identified by a range of molecular techniques such as RFLPs, RAPDs, AFLP, DAF, SCARs, microsatellites etc.

***Ex situ* conservation.** Conservation of a plant outside of its original or natural habitat, *e.g.* in a genebank.

Genebank. Facility where germplasm is stored in the form of seeds, pollen or *in vitro* culture, or in the case of a field genebank, as plants growing in the field.

Genetic erosion. Loss of genetic diversity between and within populations of the same species over time or reduction of the genetic base of a species due to human intervention, environmental changes and other causes.

Genetic resources. Genetic material of plants, animals and other organisms which is of value as a resource for present and future generations of people.

Germplasm. The genetic material responsible for a plant's characteristics.

***In situ* conservation.** Conservation of plants or animals where they developed their distinctive properties *i.e.* in the wild or in farmers fields.

Khat. Khat is a shrub that shows a better resistance to drought than coffee tree. The fresh young leaves and tender shoots of khat are chewed for their stimulant effect. The World Health Organization classifies khat as a drug of abuse that can produce moderate psychic dependence.

Landraces. Farmer developed varieties of crop plants that are adapted to local environmental conditions.

Terroirs: French word commonly applied to vineyards, a terroir is characterized by a physical environment, cultural practices, harvesting and processing methods that contribute to the originality of its production and give a unique character to its product.

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