

1 INTRODUCTION

1.1 Background and problem statement

Ethiopia is the homeland and center of genetic diversity of Arabica coffee (*Coffea arabica* L., Rubiaceae) (Vavilov 1951). The original habitat of coffee is the shaded understory of montane rainforests in southwestern and southeastern Ethiopia between 1,000 and 2,000 m asl. Indigenous communities have been utilizing wild coffee for centuries, and the art of preparing coffee is a central part of the Ethiopian culture. Until today, Ethiopian coffee is mainly produced in traditional coffee production systems. This means wild coffee is simply picked inside the forest, or managed inside the forest by removing competing undergrowth vegetation and some canopy trees (Demel Teketay 1999).

Arabica coffee started its triumphal procession around the world from Ethiopia in the 10th century, when coffee plants were taken to Yemen by Persian invaders. Later, coffee beans were shipped to Europe from the famous port of Mocca. Linnaeus, ignorant of the true origin of the coffee plant, hence named it *Coffea arabica* L. (Richard 1847; Demel Teketay 1999). In the 17th and 18th century, European merchants introduced coffee to India, Java, and finally to Latin America (Demel Teketay 1999). Today, Arabica coffee is cultivated in over 70 countries and is one of the most important raw goods on the world market (DKV 2004). For many developing countries, coffee is the main source of foreign currency. Ethiopia is the seventh largest coffee producer worldwide and ranks ninth in coffee export (EEA 2001). Coffee is its most important export crop contributing decisively to the country's foreign currency income with 41 % (FAO and WFP 2006).

International coffee breeding currently aims at increasing coffee productivity and the plant's resistance towards pests and diseases. Furthermore, there is an international demand for coffee cultivars adapted to sub-optimal environmental conditions, e.g., to drought or cold (ZEF and EARO 2002). The genetic base of the world's coffee plantations is very narrow, though, because the spread of Arabica coffee around the globe was based on a small number of trees (Tewolde Berhan 1990; Demel Teketay 1999). Plantation coffee therefore has a limited potential for the breeding of new varieties (Meyer 1965; Hein and Gatzweiler in press).

Wild Ethiopian coffee populations can play a crucial part in international coffee breeding. Owing to natural selection processes in their original forest habitat, genetically diverse coffee varieties have developed, which vary, for example, in drought resistance, light requirements, disease tolerance, coffee bean size and taste (Hindorf et al. 2004; Kassahun

Tesfaye 2006; Taye Kufa 2006; Beining in prep.). These coffee genetic resources constitute a tremendously valuable asset to Ethiopia (Hein and Gatzweiler in press). The discovery of three naturally decaffeinated coffee varieties underlines this great potential (Coghlan 2004).

Genetic information from wild varieties of cultivated species is, however, being lost at an alarming rate, in particular for tropical crops like *Coffea arabica* (Lovejoy 1995; Hein and Gatzweiler in press). The kryo-conservation of coffee seeds in gene banks is not yet developed to a satisfactory level. Hence, the genetic diversity of wild coffee populations can only be conserved through *ex situ* conservation in field gene banks or *in situ* conservation in their natural environment. *In situ* conservation is the preferable solution, because it sustains the mechanisms of natural selection and adaptation to changing site and environmental conditions (Charrier and Berthaud 1990; Tewolde Berhan 1990; DFSC and IPGRI 2001b; Tadesse Woldemariam 2003; Meilleur and Hodgkin 2004).

In the past three decades, large parts of the Ethiopian forest areas with wild coffee have been modified or destroyed by new settlements, agricultural activities and timber extraction (Reusing 1998; Million Bekele 2002). The population pressure on the remaining forests continues to grow and will cause further deforestation and fragmentation. This destruction of the original habitat of *Coffea arabica* will eventually lead to the loss of the wild coffee genetic resources.

The Ethiopian rainforests have special conservation value not only because of the presence of wild coffee, but also because of high numbers of endemic species and high floristic diversity. This great biodiversity coupled with the extreme threat caused by habitat destruction makes them part of the Eastern Afromontane biodiversity hotspot (Gil et al. 2004).

Ethiopia thus faces the challenge to conserve its last montane rainforests and the wild coffee genetic resources in a densely populated area. The livelihoods of local communities heavily depend on forest resources, and wild coffee production is the main source of income (Tadesse Woldemariam 2003; Urich 2005; Stellmacher in prep.). Conservation concepts therefore need to integrate protection and traditional uses of the forests. They also have to create incentives for the local population to participate in conservation measures and should guarantee the fair and equitable sharing of the benefits from the use of genetic resources as postulated by the internationally ratified Convention on Biological Diversity (CBD 2005).

Such comprehensive conservation concepts require accurate knowledge on the ecological and socio-economic situation in the region of concern. For this reason, the

Ethiopian Institute of Agricultural Research (EIAR) in Addis Ababa, Ethiopia, and the Center for Development Research (ZEF) in Bonn, Germany, jointly initiated the interdisciplinary research project “Conservation and use of wild populations of Coffea arabica in the montane rainforests of Ethiopia (CoCE)” (CoCE 2006). The project is divided into six interdisciplinary sub-projects covering issues on forest diversity, genetics, ecophysiology, pathology, socio-economy and institutions. The present thesis is written within the sub-project on forest diversity.

1.2 Objectives

This study has the objective to investigate the impact of selected environmental parameters and coffee management on the Afromontane rainforest with wild coffee in the Bonga region (southwestern Ethiopia). The forest in the study region is highly fragmented and the forest patches differ in size, altitude and degree of coffee management intensity. The ultimate goal of the study is the identification of the forest areas that are most crucial for the protection of wild coffee as well as for the conservation of the original plant diversity of the region. To meet this goal, it is necessary:

- (1) to study the distribution of wild coffee in relation to environmental factors, and to examine the impact of coffee management on forest structure and on the wild coffee populations (Chapter 5),
- (2) to investigate the effects of environmental parameters and coffee management on plant species diversity, floristic composition and vegetation structure of the forest (Chapter 6), and
- (3) to identify the influence of human activities on abundance and distribution of canopy tree species (Chapter 7).

The results are used to develop a conservation concept for the Bonga region (Chapter 8).

2 WILD *COFFEA ARABICA* IN SOUTHWESTERN ETHIOPIA

2.1 Ecological requirements of *Coffea arabica*

Coffea arabica L. (Rubiaceae) grows naturally as bush or small tree in the shaded understory of montane rainforests in southwestern and southeastern Ethiopia (Figure 2.1). It occurs at altitudes between 1,000 and 2,000 m asl with the most suitable range being 1,500 – 1,800 m asl. Coffee tolerates annual rainfall between 900 and 1,300 mm yr⁻¹, but most appropriate are conditions above 1,300 mm yr⁻¹ with an optimum at 1,600 – 1,800 mm yr⁻¹ (Alemayehu Mamo 1992). The optimum average annual temperature for coffee is 18 – 24 °C with contrasting seasons.

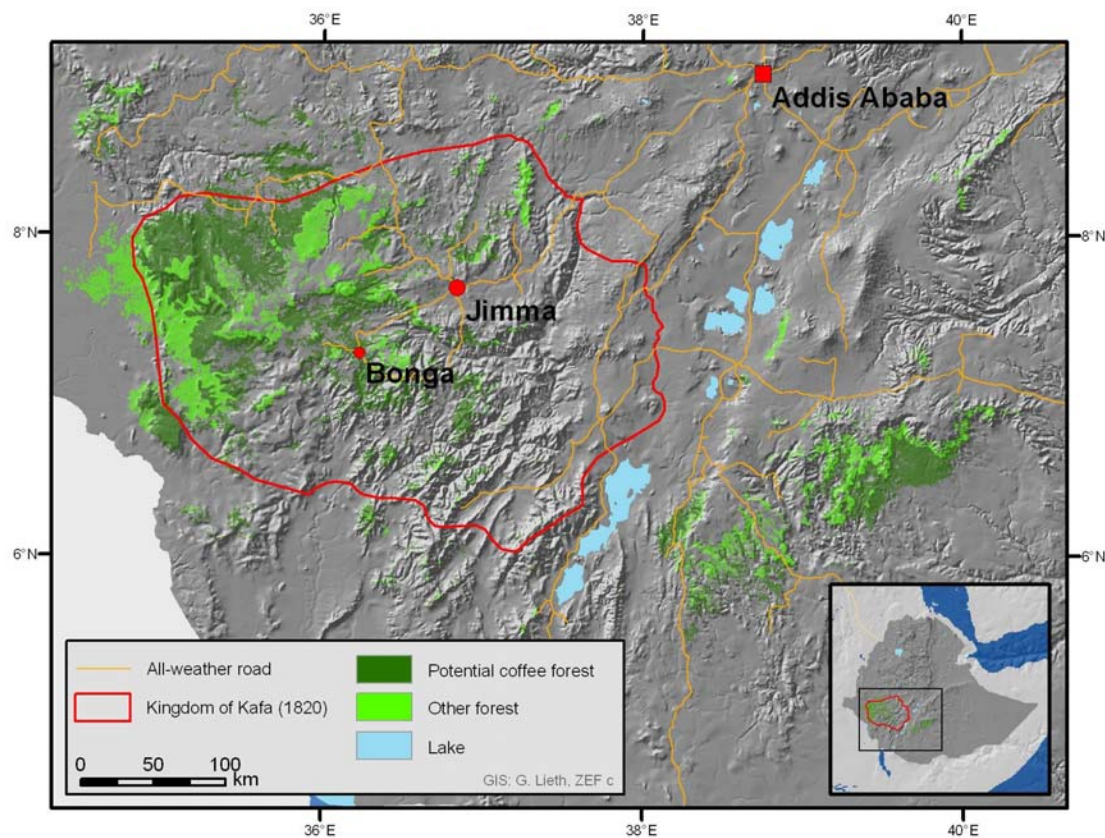


Figure 2.1 Forest cover in southwestern and southeastern Ethiopia with ecologically suitable areas for wild coffee growth (potential coffee forest) (Georg Lieth, unpubl. 2005) and the borders of the kingdom of Kafa in 1820 (Bieber 1923)

Coffee grown in plantations tolerates much wider altitude and rainfall ranges than coffee grown in its original habitat. Coffee plantations occur from sea level up to 2,800 m asl. Annual rainfall can be as low as 500 mm yr⁻¹ if coffee is irrigated as, for example, in Harar (eastern Ethiopia) (Demel Teketay 1999).

Coffee grows on soils with varying acidity. Slightly acid soils, as present under montane forest in southwestern Ethiopia, are the most suitable (Krug and De Poerck 1968). Since coffee is an evergreen plant, it requires sub-soil water at all times. Thus, deep soils with good water-holding capacity are the most suitable environment for coffee growth. The soil structure must also allow good drainage because the surface feeding roots need a drier period for part of the year to slow down growth, ripen the wood and initiate flower buds (Demel Teketay 1999). In high rainfall areas such as southwestern Ethiopia, where the dry season is short and cloud cover is frequent, coffee grows successfully in shallow clay soils of 15 – 20 cm depth. Yields, however, can be remarkably reduced in years with excessive rainfall or an unusually long dry season (Alemayehu Mamo 1992).

Coffee is self-fertilizing, but fertilization by bees increases the yield substantially (Roubik 2002). Monkeys, birds and rodents relish the sweet pulp of ripe coffee fruits and disseminate the coffee seeds inside the forest (Sylvain 1955; Meyer 1968).

2.2 Traditional management and processing practices

Forest coffee is traditionally managed in forest coffee (FC) and semi-forest coffee (SFC) systems (Demel Teketay 1999). They constitute 14 % and 54 % of the total coffee production area in Ethiopia, respectively. In FC systems, only some competing undergrowth is removed. In SFC systems, most undergrowth is removed and some emergent trees are cut. In semi-forest plantations (17 % of the total coffee production area) farmers keep only few shade trees and plant additional coffee seedlings collected in adjacent areas as well as improved coffee varieties distributed by government extension workers and non-governmental organizations (NGOs). Home-garden coffee (9 %) and modern type plantations (6 %) only constitute small parts of the total coffee production area.

Coffee fruits consist of endosperm (beans) coated by testa (silverskin) and endocarp (parchment) surrounded by fleshy mesocarp (pulp). During wet coffee processing, the mesocarp is removed with water (pulping), and the remaining fruit is fermented and dried. Endocarp and testa are then removed mechanically (hulling) (Cannel 1983).

Traditionally, farmers harvest forest coffee by strip harvesting or by shaking trees and collecting the fruits from the ground. They thus obtain a mixture of ripe and immature fruits. These are dried on the soil or sometimes on mats (dry processing). Thereafter, pulp, parchment and silverskin are removed manually.

The quality of traditionally processed coffee beans is good enough for home consumption, but does not meet export standards. Foreign coffee experts have long

complained that forest coffee should be harvested perfectly ripe, but not from the ground, should be mechanically pulped and hulled (wet processing), or dried on stools to avoid the smell of earth (Cecchi 1888; Branzanti 1942; Sylvain 1958; Fee 1961).

2.3 History of coffee production and trade in Kafa

Kingdom of Kafa

The ancient kingdom of Kafa is said to be the homeland of *Coffea arabica*. During its heyday in the 19th century, it comprised large parts of southwestern Ethiopia (Figure 2.1). The origins of the kingdom of Kafa can be traced back to the 14th century (Bieber 1920; Bieber 1923; Bahru Zewde 2002). Its history, though, is only poorly known, because the Kafa do not have a written language and travel reports by outsiders are scarce. In fact, the entry into southern Ethiopia, anytime from the beginning of the 17th century to the beginning of the 20th century was virtually impossible for Europeans (Meyer 1965). As a consequence, *Coffea arabica* growing concealed in the montane rainforests of Kafa kingdom was neither collected nor described from its place of origin until quite recently.

The Kafa kingdom was highly organized and closed its borders almost hermetically against the surrounding provinces of the Ethiopian empire. Its citizens and affiliated kingdoms had to pay taxes and tributes, such as ivory, civet oil, leopard skins, gold, musk, animal hides, honey and butter, which the king used in his external trade relations. For a long time, though, the most important items of export were slaves taken from tribes south of the kingdom (Assefa Gebremariam, pers. comm. 2005). In return, the king expected salt bars, glass, beads, cloth, ironware, and firearms.

The goods were transported along trade routes that had already been established during medieval times. Bonga, close to where the Kafa king had his residence, is considered as the starting point for trade routes to Massawa (Eritrea), Matamma (Sudan), Zeila and Berbera (Somalia) (Bahru Zewde 2002).

In the early Kafa kingdom, coffee was an important product for home consumption as well as for ceremonial and medicinal purposes. It was probably cultivated in home gardens and forest coffee systems (Beshir Abdella, pers. comm. 2004; Assefa Gebremariam, pers. comm. 2005). Even though coffee was only a minor trading commodity, slaves and merchants played an important role in disseminating the plant from Kafa to other provinces (Wrigley 1988; Berhanu Abebe 1998).

The trade activities of the Kafa kingdom reached their peak in the 19th century (Bahru Zewde 2002). Stimulated by international demand, coffee finally became a major

product in the trade business in the second half of the 19th century (Berhanu Abebe 1998). In other parts of Ethiopia, e.g., Harar, coffee export goes back earlier than 1810.

One of the first scientific missions to southwestern Ethiopia carried out by a French team during the years 1839 – 1842 observed that *Coffea arabica* grew spontaneously throughout the whole Changalla region (i.e., southwestern Ethiopia) and was cultivated widely in the provinces of Énarrea (i.e., around the town of Jimma) and Caffa (Richard 1847). Most coffee from these provinces was taken to Massawa by caravans, shipped to Mokka and sold as Arabian coffee from there.

At the end of the 19th century, the Kafa kingdom was attacked by Emperor Menelik II and his allies. When Menelik II finally managed to overthrow the Kafa king after 12 years of war in 1897, the country was largely depopulated, because 60 % of the Kafa people had been killed or displaced (Bieber 1923; Strengé 1956; Meyer 1968). The wars of 1897 also eliminated the coffee trade and led to an abandonment of coffee cultivation (Di Fulvio and Chapman 1947).

Feudal Ethiopia

Under Menelik II (1889 - 1913), Kafa became a province of Ethiopia with Jimma as its administrative center. The emperor expropriated the Kafa nobility and distributed fertile land and forests to his own allies, mainly Amhara people. These feudal landlords had the right to impose taxes and to demand the workforce of the local peasants. In return, the landlords had the obligation to pay coffee as a tribute to the emperor. This obligation, coupled with a revival of the coffee trade business and the free workforce, led to an increase in coffee management. The feudal landlords established semi-forest coffee systems and transplanted coffee seedlings inside the forest as well as in home gardens (Assefa Gebremariam, pers. comm. 2005).

Transportation, however, made access to the international market difficult for the coffee producers of southwestern Ethiopia. Merchants needed 35 – 40 days to transport dried coffee on mule back to Addis Ababa (Southard 1918). In 1916, only 16 tons of coffee reached the international market via Addis Ababa and Djibouti. The establishment of a customs and trading station at Gambela was expected to clear the way for larger coffee exports from southern Ethiopia, which could be transported from Gambela via Khartoum to Port Sudan (Southard 1918). The route via Gambela did not gain any greater importance, though, because despite the low cost, it was apparently too long and dangerous (Spaletta 1917).

The building of the Addis Ababa - Djibouti railway in 1917 as well as the construction of the Jimma - Addis Ababa road in 1933 decreased transportation costs and contributed to the development of the coffee market. Starting from the 1920s, coffee exploitation became one of the main sources of income in the region. Even tenants who before collected coffee only for their landlords and for home consumption struggled for the right to trade coffee for their own profit on the market (Philippe 2003).

Jimma was the uncontested coffee trading center for exchanges between northern and southern Ethiopia as well as with the Arab world and Europe (Meyer 1965; Philippe 2003). While until 1923 almost all coffee exported from Ethiopia came from the Harar plateau, in 1933 the export of coffee derived from wild plants in southwestern Ethiopia reached the level of Harar coffee, and even overtook it in the later years up to the Italian war (Di Fulvio and Chapman 1947).

The coffee business attracted foreign merchants and investors to the southwestern of Ethiopia, e.g. Arabs, Armenians, Greeks, Italians, Swedish and Dutch, who were the first to establish small coffee plantations (van Doren, pers. comm. 2004). Modern coffee plantations were only established in the late 1950s (Krug and De Poerck 1968), for example in Agaro (Meyer 1965) and Wushwush (Fee 1961). At that time, 20,000 tons of forest coffee were harvested annually in Kafa, and especially Bonga was well known for its coffee production (Fee 1961). In the 1960s, Kafa contributed 27 % of the export coffee, i.e., more than any other province in Ethiopia (Krug and De Poerck 1968).

Since the Derg regime

In 1974, Emperor Haile Selassie was overthrown by the military, and the socialist-inspired Military Coordinating Committee known as the Derg assumed power. The Derg announced a land reform program, which destroyed the feudal system and proclaimed the nationalization of all the lands of Ethiopia. Peasant associations were put in charge of the land distribution (Philippe 2003). Foreign coffee plantations and coffee areas owned by feudal landlords were confiscated by the regime or redistributed amongst local peasants (Assefa Gebremariam, pers. comm. 2004).

Commercial coffee exploitation was one of the objectives of the new government. The peasant associations had the task to stimulate coffee production by disseminating modern management and marketing practices and by distributing seedlings of improved coffee varieties and fertilizer to farmers. In many parts of Kafa, however, farmers were not motivated or did not have the capacity to tend to the coffee plantations and semi-forest coffee

systems as intensively as their former landlords. Thus, the general management intensity of forest coffee decreased (Assefa Gebremariam, pers. comm. 2004). This trend was emphasized by the decline in world coffee prices, which began in 1987. Paradoxically, at the same time, farmers started to be increasingly dependent on coffee economically, as it was becoming the major cash crop and the only income generating activity (Philippe 2003).

The Ethiopian Peoples Revolutionary Democratic Front (EPRDF) overthrew the Derg regime in 1991 and established a new administrative system in Ethiopia. The Kafa province was transformed into the Kafa zone within the Southern Nations National Peoples Regional State (SNNPRS). Governmental and non-governmental organizations (NGOs) continue to distribute improved coffee varieties and fertilizers to farmers in southwestern Ethiopia. Enthused by an increasing demand for wild coffee on the international market, in 2004 the Kafa Forest Coffee Farmers Cooperative Union gained the license to trade directly with foreign business partners. Farmers have thus profited from better prices and the intensity of forest coffee management is increasing again.