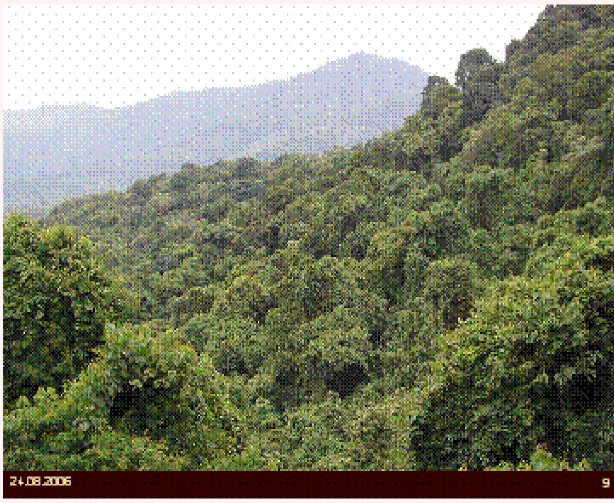
Admasu Shibru Keraga

Economic Analysis of Conserving Wild Coffee Genetic Resource in Southwestern Ethiopia



Zentrum für Entwicklungsforschung
Center for Development Research
University of Bonn

ZEF Bonn

Cuvillier Verlag Göttingen

Economic Analysis of Conserving Wild Coffee Genetic Resource in Southwestern Ethiopia

---

Inaugural-Disseratation

Zur

Erlangung des Grades

Doktor der Agrarwissenschaften

(Dr. agr.)

der

Hohen Landwirtschaftlichen Fakultät

der

Rheinischen Friedrich-Wilhelms-Universität

Zu Bonn

Vorgelegt am 24.08.2006

Von

Admasu Shibru Keraga

BSc. in Agricultural Economics from Alemaya University of Agriculture (Ethiopia)

MSc. in Agricultural Economics from Alemaya University of Agriculture (Ethiopia)

aus

Äthiopien

Bibliografische Information Der Deutschen Bibliothek
Die Deutsche Bibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über http://dnb.ddb.de abrufbar.
1. Aufl. - Göttingen : Cuvillier, 2006
Zugl.: Bonn, Univ., Diss., 2006
ISBN 3-86727-009-0

Referent: Prof. Dr. Klaus Frohberg
Korreferent: Prof. Dr. Karin Holm-Müller
Tag der Promotion: 24.08.2006

Nonnenstieg 8, 37075 Göttingen
Telefon: 0551-54724-0
Telefax: 0551-54724-21
www.cuvillier.de

1. Auflage, 2006
Gedruckt auf säurefreiem Papier

ISBN 3-86727-009-0

This Piece of Work is dedicated to all Species and Organisms threatened by Manmade and Natural Factors!

Kurzfassung

Die vorliegende Studie erfasst den Wert des Erhalts der wilden Kaffee genetischen Ressource aus der Sicht der Kaffeebauern, in dem ihre Zahlungsbereitschaft für verbessertes Pflanzmaterial erfasst wird und die Produktionseffekte von verbesserten Sorten berechnet wird. Des weiteren wird der Frage nachgegangen wie viel und warum die Bauern Wildkaffeewälder umwandeln und anderweitig landwirtschaftlich nutzen und welche Opportunitätskosten mit dem in-situ Schutz der Wildkaffeewälder verbunden sind. Die Forschungsgebiete sind Geba-Dogi und Berhan-Kontir und Gomma district in Jimma im Südwesten von Äthiopien.

Die Wildkaffeepopulationen der Kaffeewälder sind die Hauptquelle für Pflanzmaterial, insbesondere in Berhan-Kontir wo sie 85% des jährlich gepflanzten Materials ausmachen. Ungefähr 15 Kafeesorten, die gegen die Kaffeekirschkrankheit (Coffee Berry Disease) resistent sind und einen durchschnittlichen Ertrag von 820kg/ha hervorbringen können (nationaler Durchschnitt sind 471 kg/ha), wurden aus den Sammlungen ausgewählt. Über die letzten drei Jahrzehnte, erbracheten diese Selektionen einen Ertragsgewinn, dessen Wert höher ist als die Kosten der Sammlung, der Selektion und Dissemination der Sorten.

Eine Umfrage im Rahmen einer Zahlungsbereitschaftsanalyse kam zu dem Ergebnis, dass die befragten Bauern bereit sind für ertragssteigerndes und krankheitsresistentes Pflanzmaterial zu zahlen. Die Bauern, welche in der Nähe von Wildkaffeestandorten wirtschafteten, waren bereit weniger zu zahlen als solche Bauern, die weiter von den Kaffeewäldern entfernt wohnten. Der Beitrag der Wildkaffeepopulationen zum Wert des verbesserten (selektierten) Pflanzmaterials wird abgeleitet von der Bereitschaft der Bauern in verschiedenen Standorten für verbessertes Pflanzmaterial zu zahlen. Es wird errechnet indem man die ungefähren Kosten des Züchtens und der Verbreitung des pflanzmaterial von der Mittel Zahlungsbereitschaft für das verbesserte Pflanzmaterial zu zahlen abzieht.

Eine Waldnutzungsanalyse zeigt auf das die Waldgebiete zurückgehen und von Kaffeewaldnutzungssystem ersetzt werden. Diese Wandlung der Waldnutzung bringt die Einführung neuer lokaler aber auch verbesserter Sorten mit sich. Der Anbau von verbesserten Kaffeesorten und von Getreidearten ist in beiden Untersuchungsgebieten angestiegen. Die Größe der von Haushalten bewirtschafteten Waldkaffeestandorte steht in einem positiven Zusammenhang mit Faktoren wie: Grössere Mais und Kaffeeflächen, Nahrungssicherheit, Entfernung zu Distriktzentrum und Waldgebieten, und kleinerer Anbaugebiete von verbessertem Kaffeepflanzmaterial.

Erfahrungsgemäß ist es vernünftig wenn die Bauern ihre Wildkaffeestandorte zu intensiver bewirtschafteten Landnutzungsformen umwandeln. Die auf Kaffee basierenden Bewirtschaftungssysteme warfen dabei höhere Erträge ab als die Getreidestandorte (Preise von 2001). Der Wert eines 40.000 ha großen Wildkaffeewaldes (über 30 Jahre diskontierter Schattenpreis) ist viel niedriger als der nationale Wert der wilden Kaffee genetischen Ressource. Das kann teilweise den Anreiz erklären die Wildkaffeepopulationen zu schützen.

Höhere Preise für Wildkaffee könnten die Bauern dazu bewegen die Wildkaffeestandorte zu erhalten. Eine Pauschalzahlung pro Flächeneinheit Wildkaffeewald könnte die Bauern ebenfalls dazu motivieren den Kaffeewald zu erhalten. Diese Pauschalzahlung müsste die Bauern für die Verluste kompensieren, die ihnen durch das Verbot der Umwandlung in landwirtschaftliche Nutzfläche entsteht. Ein Preis von 4 ETB pro kg trockene Waldkaffeekirschen könnte die Bauern dazu motivieren den Wildkaffee zu erhalten. Auf der Basis von Preisen im Jahr 2003 kann ein zusätzlicher Verlust von 323 ETB erwartet werden, wenn 0,25 ha Waldkaffee erhalten werden. 300 ETB können dahingegen gewonnen werden wenn die gleiche Fläche mit verbesserten Kaffeesorten oder Getreidesorten angebaut wird.

Abstract

The study assesses the value of conserving the wild coffee genetic resource for the local coffee producing farmers in terms of their willingness to pay (WTP) for improvements in the coffee planting material and the production effects of improved coffee cultivars. Moreover, the question of how much and why the farmers are maintaining or converting the wild coffee plots into other systems are addressed. In addition, the opportunity cost of in situ conservation of the wild coffee populations (WCP) is estimated. The study sites are the Geba-Dogi and Berhan-Kontir forest communities and the Gomma district of Jimma zone in southwest Ethiopia.

The WCP are used as the major source of coffee seedlings, especially in Berhan-Kontir where they account for about 85% of the seedlings planted annually. About 15 coffee cultivars that are resistant to the coffee berry disease (CBD), with an average yield potential of 820 kg/ha (national average 471 kg/ha) are selected among the collections of wild coffee germplasms. These cultivars brought a yield gain whose value is higher than the costs associated with the collection of the germplasm, selection and dissemination of the cultivars over the last three decades. Additionally, estimate of the farmers' WTP for improved coffee planting material indicates that they are willing to pay for such material, especially with regard to the yield limiting factors, including CBD, coffee wilt disease (CWD), rust, and vigor nature of the coffee trees. Furthermore, those farmers surrounding the WCP are willing to pay less than those located far from the forest coffee sites. The contribution of the WCP to the value of the improved planting material is derived from the estimates of farmers' WTP for the improved material in the different places. It is calculated by deducting the approximate cost of breeding and dissemination of the planting material from the mean willingness to pay for the improved planting material.

Information on factors associated with the change in forest land use can help to determine the priority subjects of intervention in order to shape the dynamic process. Analysis of the forest land use indicates that the area of such forest land has been diminishing and mainly replaced by a forest coffee system that incorporates the introduction of certain local and improved cultivars. The cultivation area of improved coffee cultivars and cereal crops has also increased in both forest communities. Factors like larger area of maize and coffee cultivation, food security,

distance from district center and distance from forest sites, and smaller area of improved coffee cultivation are positively associated with the area of wild coffee plots at the household level.

Empirically, it is rational for the farmers to convert their wild coffee plots into a managed form of coffee production, or maize farms since the returns per unit area can be improved, as it is the case at 2002 and 2003 prices. However, the coffee-based farming system gave higher marginal returns than the cereal-based system at 2001 prices. A 30-year discounted value of the shadow prices of the forest land with WCP in southwestern Ethiopia with a total area of about 44,000 ha, based on commonly observed crop prices as in 2001 and 2002, is much lower than the nationally aggregated value of the wild coffee genetic resource. This can partly justify the incentive to conserve the WCP.

A discriminated coffee pricing, i.e., a higher price for coffee harvested from wild and forest coffee system than the coffee produced conventionally from semi-forest and improved coffee systems could influence the farmers' decision to maintain the wild or forest coffee farm types. A lump sum payment per unit area of forest coffee farm types could also motivate them to maintain the forest system by compensating them for the losses they would face if they were not allowed to establish other farming systems that would replace the forest coffee system. A price level of about Birr 4.00/kg dry cherry for forest coffee could motivate the farmers to preserve the forest coffee type based on the relative crop price levels in 2003. Based on 2003 prices, a marginal loss of about Birr 323.00 is expected due to maintenance of 0.25 ha forest coffee farm type, while about Birr 300.00 is expected to be gained due to the same unit expansion of improved coffee or cereal crops cultivation.

Acknowledgements

In the Name of the Father, the Son, and the Holy Spirit, One God, Amen!

First of all, many thanks is directed to our Lord Jesus Christ, the Almighty God, the everlasting father, and the prince of peace and love. Beyond his care in all the micro seconds in life, he endows us with wisdom to uncover all the necessary mystery of nature.

A special thank is to my supervisor Professor Dr. Klaus Frohberg for a continuous and profound comments and encouragements I have got throughout my study period. I would not have been able to complete this study to its standard without his guidance. My co-supervisor, Prof. Dr. Karin Holm-Muller is also greatly appreciated for her advice and cooperation. I am also highly indebted to Dr. Franz Gatzweiler for his valuable comments. Moreover, I would like to thank to Dr. Daniel Tsegai for his time to read my thesis comprehensively and his personal motivation and encouragements and to Dr. Assefa Admassie for his constructive comments and advise throughout my work. I also would like to thank Dr. Detlef Virchow who contributed a lot in the design of the research objectives.

I am very grateful to the Germany Government in general and the Federal Ministry for Education and Research in particular due to the scholarship for my stay in Germany and finance my field work. The coordinators at ZEF, center for development research, university of Bonn, namely, Dr. Günther Manske, and his assistants Ms Rosemarie Zabel and Ms. Hana Peters, and ZEFb secretaries especially Mrs. Ritter Pilger, Gelisa and Mrs. Sandra Tobbe, and Mr. Ludger Hammer are also acknowledged for the facilities and home feeling cares through out my stay at ZEF.

I also acknowledge the COCE Project directors and coordinators namely, Prof. Dr. Paul Vlek, Dr. Manfred Denich, Dr. Franz Gatzweiler, Dr. Taddesee W/Mariam and Mr. Million Abebe due to different ideas exchanged during a number of meetings and field trips, in addition to the well-timed facilities provided to conduct the field work.

I would also like to express my thankfulness to the researchers in the COCE project, namely Ms.Christine Schmitt and Dr. Feyera Senbeta who conducted the ecological aspects, Mr. Kassahun Tesfaye who conducted on the genetic aspect, Ms. Alice Being and Mr. Taye Kufa who did on the physiological aspect, Mr. Till Stellmacker and Mr. Teklu Tesfaye, who conducted the institutional aspect, Mrs. Anke Rojahn who conducted on the economic aspects, and Mr. George Lieth, the geographer, for exchange of ideas and information related to the coffee project. Moreover, sincere thanks for Ms. Margaret Jend for her assistance in editing the thesis for language, and the staff member of ZEF especially, Dr. Maja Micevska, Prof. Stefani Engel and Marc Muller for their technical assistances.

I would also like to thank different offices in Ethiopia including the Coffee and Tea development Authority (CTA), Ministry of Agriculture (MOA), Institute of Biodiversity Conservation (IBC), Coffee Liquoring Unit (CLU), Sidama and Oromia Farmers' Cooperative offices, Oxfam office, Farm Africa, GTZ head office, Environmental Protection Authority (EPA), the regional, zonal and district level agricultural development departments of the Oromia and Southern Ethiopia regions, and particularly the Illubabor zone and the Yayu district, the Bench-Maji zone and the Sheko district, and the Jimma zone and the Gomma district agricultural development departments. Particular thanks go to socioeconomics research division staff, Mr. Tsegai Gidey and Mr. Zekarias Shumeta, and staff members of the breeding research division of the Jimma Agricultural Research Center, Mr. Tolossa Ararsa and Mr. Ketema in Illubabor zone, Mr. Getinet Belay and Mr. Hamza Shifa in Bench-Maji zone. Moreover, remarkable thanks also extended to CTA staff members including Mr. Assefa Tigineh, Dr. Workaffess W., Mr. Kassu K., Mr. Birhanu, Mr. Tessema, Mr. Yehasab, and Mr. Alemayuhu, CLU staff members especially Mr. Abrham, Mr. Dessie and Mr. Endalle.

A very exceptional thank goes to my wife Yeshihareg Wolde and my son Senay Admasu, who tolerated loneliness during the time when Ethiopia fall under an intense political turmoil where by families were demanding to stay in unison. Many thanks for their motivation and encouragements and helped me to grow up to this standard to my senior brother Mureja Shibru and Mr. Amare Lemma. I must also extend special thanks to Father Wolde Egnet, Mr. Gebre Egnet, and Ms. Hirut Wolde and her family who had taken their precious time to take care my family during my stay in Germany. I would also like to extend thankfulness to my parents (Shibru Keraga and Wembechy Dibaba), brothers and sisters, friends especially Mr. Mulugeta Tekle, Dr. Samson Ashine, and Mr. Behailu W/Senbet, ZEF students especially Mr. Sed Nuru, Mr. Franklin Simtowe, Mr. Sayan Chakrabarty, Dr. Lulseged Tamene and Dr. Degnet Abebaw for their home feeling friendship and the Cologne church community, which with the benevolence of God kept me healthy to perform my duties.

Wishing all a Holy Blessings from Jesus Christ and be considered in his eternal Government.

Table of Contents

List of Tables

List of Figures

List of Tables in the Appendix

List of Abbreviations and Acronyms

ADD Agricultural Development Department
CBA Cost Benefit Analysis
CBD Coffee Berry Disease
CIP Coffee Improvement Program
CLR Coffee Leaf Rust
CM Choice Modeling
COCE Conservation and Use of Wild Populations of Coffee Arabica in the Montane Rain Forests of Ethiopia
CPI Consumers' Price Index
CSA Central Statistical Authority
CTA Coffee and Tea Authority
EV Equivalent Variation
CVM Contingent Valuation Method
CWD Coffee Wilt Disease
EARO Ethiopian Agricultural Research Organization
EEA Ethiopian Export Earning Authority
EPRDF Ethiopian People Revolutionary and Democratic Federation
EU European Union
EV Equivalent Variation
FAO Food and Agricultural Organization
FCU Forest Coffee Unit
GMO Genetically Modified Food
Ha Hectare
IAR Institute of Agricultural Research
IBC Institute of Biodiversity Conservation
ICO International Coffee Organization
ITC International Trade Center
JARC Jimma Agricultural Research Center
KAT Kembata- Alaba Timbaro Zone in Southern Ethiopia
Kg Kilogram
LDCs Less Developed Countries
LP Linear Programming
Masl Meters above Sea Level
MCTD Ministry of Coffee and Tea Development
MOA Ministry of Agriculture
MoFED Ministry of Economic Development and Cooperation
NGO Non-Government Organization
NPV Net Present Value
PA Peasant Association
SNNPRS Southern Nation, Nationalities and Peoples Regional State
UK United Kingdom
UNEP United Nations Environment Program

USA United States of America
USAID United Stares Aid for Development
USD United States Dollar
WCP Wild Coffee Populations
WTA Willingness to Accept
WTP Willingness to Pay

1. General introduction

1.1 General background

Plant genetic resources include the wild types found in their natural setting, landraces that are found on farmers' fields as a result of a continual selection process or improved material developed in the process of breeding (Evenson et al., 1998). That means plant genetic resources are a product of the natural system in their wild form and the result of human activities with respect to selection and improvement.

Wild crop genetic resources are basically the source of domestication and have been used as inputs for crop genetic improvements. Crop genetic diversity determines the opportunity of developing planting material that can adapt to environmental conditions and cope with uncertainties like pests, diseases and drought (Almekinders and Boef, 2000; Pearce and Moran, 1994; National Research Council, 1993). In addition to the possibility of improving the yields of crops per unit area in production, genetic improvements create opportunities to develop varieties that have required nutritional constituents that are dynamic and change over time. Wild genetic resources, as the basic source of genetic diversity, can secure a continuous production of crops and improve agricultural productivity.

The diverse natural and physical setting of Ethiopia[1] with 18 different major and 49 minor agro-ecological zones[2] and with a topography ranging from 110 m below sea level at the Kobar sink

[1] Ethiopia is located at the horn of Africa and covers a total area of about 12.5 million km^2. The population was about 53.5 million in the 1994 census with an estimated growth rate of about 3% per annum leading to a current population of more than 70 million. It is one of the poorest countries in the world with about 50% of the population living the below poverty line in 2003 and 2004 (CIA, 2005). The agricultural sector accounted for about 43% of the national domestic product in 1999/2000; however, this share is declining (Befekadu et al., 2001).

[2] Agro-ecology of Ethiopia is classified into 18 major and 49 sub-agro-ecological zones (MOA, 2000; FAO, 2003). They are grouped into six major categories: arid zone (31.5% of the country), semi-arid (3.5 %) sub-moist (19.7 %), moist vegetation covers (25 %), sub-humid (15.5 %) and humid (4 %), and per-humid (1%). The sub-humid and humid zones provide the most stable and ideal conditions for annual and perennial crops, and it is here that the remaining natural forest with its high biological diversity to be found.

in the Afar depression to a peak of 4,620 m above sea level at Ras Dashen give rise to diverse species and genetic resources. About 6500 to 7000 higher plant species are estimated to exist in Ethiopia out of which about 10 to 12% are estimated to be endemic (TewoldeBerhan, 1991). Information on the genetic diversity and presence of the wild coffee populations (WCP) [3] in the natural forest lends credence to the generalization that Ethiopia is the center of origin of Arabica coffee. Moreover, Ethiopia is known to have a rich Arabica coffee gene pool (Antoni and Lashermes, 2002, Demil, 1999).

Coffee supports about 100 million people in the world and it is one of the most important agricultural commodities with an annual value of about US$ 11 billion in the world market (ICO, 1999). About 70% of world coffee is produced by about 25 million smallholder farmers. Coffee production in Brazil, Colombia, Ivory Coast, Mexico, Angola, Uganda, Indonesia, El Salvador and Guatemala is based on few Arabica coffee material originated from Ethiopia, which has been distributed since the 13th century (Haarer, 1962). Coffee is the major source of foreign exchange for many developing countries (about 80% for Burundi, 55% for Uganda, 43% for Rwanda, 30% for Nicaragua, etc., in 1998: Oxfam, 2001).

According to Krug and Poerck (1968), Arabica coffee was introduced into Arabia prior to the 15th century. It was first planted in Java in 1690, and in the early 18th century it was carried to Surinam, Martinique, and Jamaica. Cultivation of coffee soon spread throughout the West Indies, Central America and favorable regions of South America. Later, it reached India and Sri Lanka. On average, about 90% of the world coffee supply is Arabica coffee (Morton, 1977). This indicates that Arabica coffee plays a significant economic and social role in many developing countries, accounting for about 70% of world market supply.

---

[3] The *wild coffee populations* refer to undomesticated Arabica coffee trees that are thought to be diverse in terms of different attributes. As they are not planted by human, the local people call them 'wef zerash', which means bird sown. Wild-coffee forest refers to a forest system where we find naturally regenerated wild coffee populations under the forest. And, the wild coffee and the forest coffee refers to the coffee growing systems with a totally wild nature in the former case and a semi-managed wild coffee system in the later, both representing wild coffee populations.

In Ethiopia, Arabica coffee is one of the most important crops and has a high social, cultural, and economic significance. It contributes to about 67% of the export earnings, and about 25% of the population depends directly or indirectly on coffee for its livelihood (Oxfam, 2001; Cousin, 1997). This shows that any shock on the coffee sector can have a significant influence both on the economy of the country in general and on the livelihood of the population in particular. As Ethiopia is known to have a long tradition of producing coffee. Coffee production is not only deemed for market but also for consumption, as about 50 % of the production is consumed domestically. Coffee is currently produced on more than 400,000 ha of land, mainly in Oromo and southern Ethiopia regions (MOA, 2003).

In spite of the importance of Arabica coffee in Ethiopia, its genetic diversity is not being protected adequately. Its diversity is threatened by factors such as the loss of natural habitats through deforestation and the introduction of improved varieties (Taddesse, 2003). Despite the ecological contribution of coffee species, as long as a better substitute for coffee is not found for coffee producers or consumers, coffee will remain as an important commodity. Conservation of the wild types of the Arabica coffee is necessary to ensure the genetic diversity of Arabica as a supply of coffee planting material for the producers. However, conservation of the wild Arabica coffee populations in in-situ is a difficult task, as the forest lands in question are used by the local farmers mainly for agricultural purpose.

In order to develop useful concepts for conservation and utilization of the resource, a research project, namely "Conservation and use of wild populations of Coffee Arabica in the montane rainforests of Ethiopia (CoCE)[4]" has been implemented in Ethiopia. Decisions to develop a successful conservation and use strategy demand comprehensive information on the value of the resource, and the trend and nature of interactions of the involved stakeholders with resource. A successful conservation and use program calls for a strategy that is economically viable, socially

[4] CoCE is an interdisciplinary research project involving ecology, biological science, economics and social sciences, which was designed to develop concepts for conservation and use of the wild Arabic coffee populations in particular and the forest resource in general. It is implemented in collaboration between different partners, mainly the University of Bonn and the Ethiopian Agricultural Research Organization (EARO). It is financed by the German Federal Ministry for Education and Research.

acceptable and environmentally sound. Among others, assessment of the economic value of the resources and the costs of conservation are crucial to justify conservation of natural resources (Artuso, 1998; Gollin, undated). The importance of economic assessments of conserving the wild genetic resource is important especially when competitive uses of the forest land by the surrounding farmers exists, and when capital resources are required for conservation. Capital resources are very scarce in a country as poor as Ethiopia. Accordingly, estimation of the economic values of the montane rainforests and the costs of conservation are part of the CoCE project objectives. This particular study focuses on the assessment of the economic values of conserving the wild coffee genetic resource and the opportunity cost of in-situ conservation of the resource in its natural habitat, taking the local coffee producing farmers in to consideration. Information on the benefits and costs associated with the conservation of the resource for the local coffee producers and the nation at large will support the development of conservation strategies and facilitate the decision making process.

1.2 Problem statement

The WCP and the coffee landraces that are evolved through active farmer inter-generational selection are the basis for further development and improvement of the coffee planting material by agricultural research centers and commercial breeders. Wild or naturally regenerated coffee populations are known to exist in the natural forests in different parts Ethiopia, especially in the south western and eastern parts.

In this study, the main focus is on the wild populations of the Arabica coffee and less on the landraces. This is based on the fact that wild crop genetic resources generally have a high diversity, which can help to develop improved planting material through breeding (Brush and Meng, 1998). As it is natural for farmers to continuously select higher yielding and more disease-resistant cultivars, the genetic diversity of crops at farm level can be lower than that in wild populations. This can be attributed to the introduction of improved varieties, which can decrease crop genetic diversity (Swanson, 1995). Due to the occurrence of the coffee berry disease (CBD) in Ethiopia in the past three decades, the farmers favor disease-resistant cultivars.

The government has been involved in the development of resistant material and dissemination of such planting material to the coffee producers in the country.

Studies assessing the wild Arabica coffee collections have shown that the wild Arabica populations in Ethiopia have diverse attributes such as disease resistance, varieties with different bean size and cup quality (Paulos and Demil, 2000). In a national coffee breeding program led by the Jimma agricultural research center, about 15 CBD-resistant selections were identified. These cultivars have yields about 110% (Appendix 2) higher than the national average yield, which was about 471 kg ha^{-1}.

Several Arabica coffee cultivars originated from the WCP of Ethiopia have been identified as resistant to nematodes and other diseases found in Brazil. Moreover, recent findings show that certain coffee germplasm among Ethiopian collections is naturally caffeine-free (Planet ARK, 2004). This is an opportunity in that consumers can obtain a naturally caffeine-free coffee and possible to avoid the costs of decaffeination. A research team in the Tropical Agronomy Center for Research and Teaching (CATIE)[5] found that particular coffee germplasms among the Ethiopian wild Arabica coffee collections of the mid 1960ies are extremely resistant to nematodes and diseases such as red blight and coffee anthracnose (IPS, 1997).

The coffee breeding activities in Ethiopia that has been undertaken since 1978 was primarily aimed at developing improved cultivars with better yield potential and more resistant to CBD than the local landraces. Currently, the national coffee breeding program focuses on the development of improved varieties that have the potential to resist other yield limiting factors like coffee wilt disease (CWD), coffee leaf rust (CLR), pests and drought, and that have a better cup quality. The IBC and JARC collect coffee germplasm from wild mother trees in different areas to increase the coffee genetic diversity reserve in ex-situ field gene banks. In addition to its benefit for maintaining the genetic diversity of Arabica coffee, conservation of the forest land

[5] CATIE is an organization formed by the Central American countries, the Dominican Republic, Mexico, Colombia and Venezuela.

with the WCP is also of ecological importance with respect to conservation of soils, wildlife species and ecosystem diversity.

Recognizing the benefits of the WCP, both national and international institutions have been collecting the wild coffee germplasm in response to concerns regarding the loss of the genetic diversity and for the purpose of developing disease resistant material[6]. Although the collections can help to develop certain material, they could not substitute conservation of the WCP per se. In general, conservation of genetic resources can be launched ex situ on a new plantation field or in the laboratory, in situ in their natural habitat or on farmers' fields[7]. Since coffee seeds cannot be stored for long in laboratories as opposed to other crops (Eirea et al., 1999; Black et al., 2000), the in-situ conservation method is suggested for conserving the coffee genetic resources in their natural habitat. Furthermore, it is not possible to collect all the diverse genetic material of a species in the wild for conservation at ex situ on fields. The in-situ conservation method also has advantage in that the genetic resources are subjected to changing environmental conditions, which supports adaptation of the species to different environments.

The importance of conserving the resource could be explained as there has not been such conservation activity in Ethiopia (Taddese et al., 2001), which may be due to factors like

---

[6] Coffee germplasm collection dates back to the 1960ies. The FAO Coffee Mission, 'François de recherché scientifique pour le development en coopération' (ORSTOM) and Ethiopia's Institute of Agricultural Research (IAR) are involved in these collections (Dullo et al., 2001; Taddese et al., 2002). The FAO coffee mission led by Dr. F.G. Meyer based in Washington National Arboretum collected about 600 samples of Arabica coffee seeds. The coffee collections were distributed to the leading coffee research centers in the world including centers in India, Costa Rica, Tanzania, Peru and USA (Krug and Poerck, 1968). In Ethiopia, collection and conservation of coffee accessions has been undertaken by the Ethiopian Agricultural Research Organization/Jimma Agricultural Research Center (EARO/JARC) in collaboration with the Institute of Biodiversity Conservation (IBC). To date, more than 5000 coffee accessions have been collected and conserved by EARO/JARC and the IBC center *Choche* in the Gomma district of the Jimma zone (Taddese, 2003).

[7] In-situ conservation refers to the conservation of a genetic resource within the natural ecosystem in which it occurs; ex-situ conservation refers to the maintenance of the resources in botanical gardens, field gene banks or storage facilities outside of their original habitat (FAO, 1993). On-farm conservation is the preservation of the resource by using the cultivars or land races on farms or in outdoor agricultural museums, of agriculture which exist due mainly to the active and continuous contribution of the farming community.

inadequate knowledge of the potential benefits from the resource, the poor economic status of the country[8], etc. Moreover, certain form of conservation of the resource need to be made as the threats to the resource could be so serious that certain genetic resources could be lost forever, as far as the cost of doing it is manageable.

It is generally reported that the areas with the WCP that are found only in some parts of the forests in Ethiopia have been continuously decreasing. This is due to the expansion of agricultural land[9], which has resulted in conversion of the natural habitat of the WCP and substitution of the wild coffee trees by genetically more uniform cultivars or by other crops that yield higher incomes. The pressure on the forest land in terms of agricultural land expansion is associated both to farmers' resettlement programs[10] and the local farmers' practice of forest clearing. This is also related to the high population growth especially in rural areas, estimated at about 3.2% per annum that can put serious pressure on the forest. This has resulted in deforestation of about 10,000 ha per year in the coffee growing areas (Taddese et al., 2002; Asres, 1996). Farmers prefer high yielding varieties that can resist diseases in order to improve the productivity of their farmland. Therefore, the very low yield from the wild coffee plots and the better income opportunities from alternative crops cultivation contribute to the conversion of the wild coffee plots into alternative land-use systems.

A discouragingly low coffee price is another factor that can reduce farmers' coffee management activities, such as weeding, and can lead to replacement of coffee plots by other crops such as Chat (Catha edulis) in eastern and southern Ethiopia and maize in the western part of the country (Demil, 1999; Taddese and Demil, 2001), which in turn can reduce the genetic diversity of

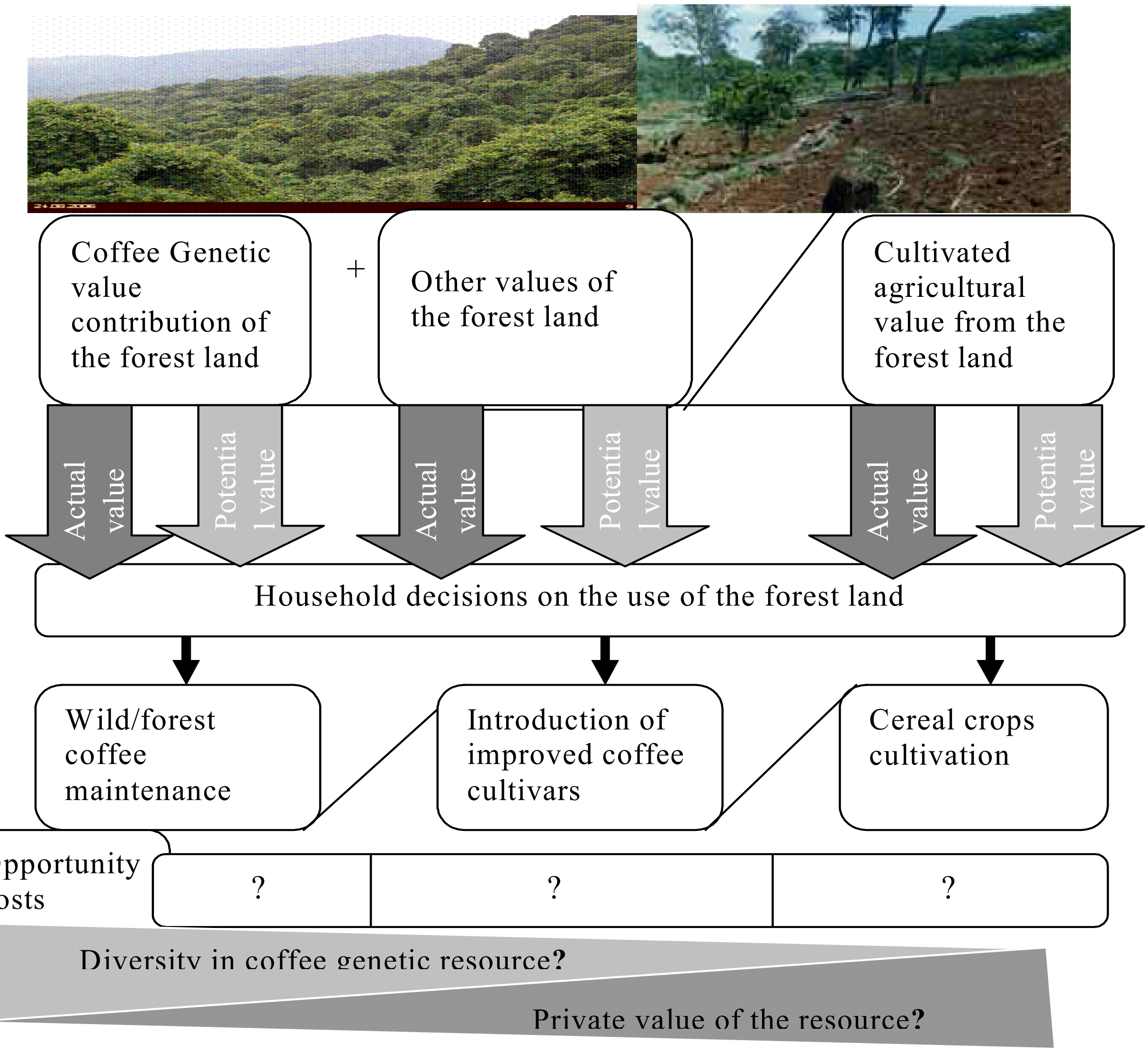
[8] This could also be related to the instability of the political system in the country with frequent government changes, which hinders the planning and implementation of a long-term development strategy that is based on sustainable use and conservation of natural resources.

[9] In Ethiopia, land is the property of the government, and there is no official market for land transaction. Farmers pay annual land-use taxes.

[10] In the settlement program of the Derg regime (1974 to 1991), people were moved from the northern part of the country with its distinct culture and farming system into different pocket areas in the south and southwestern part of the country with different farming systems.

coffee. These current threats will lead to further losses in the Arabica coffee genetic pool unless effective conservation measures are taken. These interacting situation and the resultant resource use systems is depicted in Figure 1.1.

Figure 1.1. The values of the forest land resources and farmers' utilization system



The actual and potential benefits that can be obtained from the resource by different stakeholders at local and global levels could be the basis for conservation decisions. In cases when the importance of coffee as a commodity to the local people or to the nation is lower, conservation of the resource may nevertheless be necessary due to its value at the global level. The objective of this dissertation is specific to the analysis of the valuation of conserving the wild coffee populations with respect to their local level agricultural contributions and the threat of the genetic resource depletion. At local level, the information on the benefits and the costs associated to conservation of the WCP that determine the decision to switch the scarce capital resource for conservation are, however, lacking.

The value associated with the coffee genetic resource as the most direct usable product in the forest needs to be estimated to single out its contribution as incentive to conserve the forest. The value of the genetic resource for domestic coffee production can be a vital indicator of the forest resource value, and the farmers' value perception of alternative coffee planting material would be a basis for the valuation process. The perception of the farmers to potential and actual benefits from alternative forest land use systems and their respective costs are important elements in the households' land-use decisions. The costs could be of either direct costs, transaction costs or opportunity costs associated to the respective land use system. Factors that affect the economic contribution of coffee to the livelihood of the people and the nation in general, such as a decline in coffee prices that could force the farmers to replace the coffee plots with other crops, can have a negative influence on the potential value of the genetic diversity at a local level.

The study areas include the forest sites with the WCP,[11] namely the Geba-Dogi and the Berhan-Kontir forest communities in southwestern Ethiopia, and the Gomma district in Jimma Zone. The Geba-Dogi and the Berhan-Kontir forest communities are two of the three sites that are selected as National Forest Priority Areas (NFPA) especially with reference to the presence of WCP in the forest. The site selection also assumed to supplement other studies in the area whose outputs can be integrated for development of strategic concepts for managing the forest resources. These include the social, institutional and biological studies in the CoCE project. The Gomma district as a reference coffee producing area in the country, where we do not find WCP, is considered to

[11] These three sites are the Geba-Dogi forest (located between $35^{0}45'$ - $36^{0}05'$ east and $08^{0}15'$ - $08^{0}37'$ north) in the Yayu district in the Illubabor zone, the Berhan-Kontir forest (located between $35^{0}15'$ - $35^{0}30'$ east and $06^{0}55'$ - $07^{0}05'$ north) in the Sheko district of the Bench-Maji zone and the Boginda-Yeba forest (located between 36^{0} 00' – 36^{0}17' east and 07^{0}21' – 07^{0}34' north) in the Bonga zone. An area of about 18600 ha, 20,000 ha and 5500 ha of forest land that is known to have the WCP is delineated for forest coffee conservation in the respective sites (Paulos and Demil, 2000).

compare farmers' value perception of their local coffee genetic resource in areas with and with out the WCP, and thus help to aggregate the genetic value of the WCP. All the study areas are characterized by the coffee-based farming system. The coffee growing systems in the two forest communities are yet a typical of WCP. The detail description of the study areas is presented in chapter 3.

1.3 Objectives of the study and research questions

1.3.1. General objective

Information on the values associated with the genetic, species and ecosystem diversity in the forest coffee system and the estimate of the direct and indirect costs associated with conservation of the resource are necessary to make appropriate decision on conservation of the montane rain forests. The general objective of this study is to assess the extent to which conservation of the forest system is justifiable based on potential values of the coffee genetic resource from a domestic point of view. This is related to the demand for improved coffee planting material that can be developed out of diverse coffee genetic material. It is also related to the potential threats to coffee production, which requires improved planting material as a substitute to the local planting material. As development of valuable planting material out of the wild coffee germplasm is supplemented by the local farmers' knowledge of utilizing the resources (Hardon et al., 2002), it is also necessary to investigate what special characteristics of the WCP the local farmers might have observed in addition to the direct value of the resource.

The issue of conservation also raises the question of whether the forest land with the WCP can be preserved while maintaining the existing farming system in the area. As the forest lands with the WCP are both held by private smallholder farmers and publicly owned, it is necessary to understand how much and why the farmers are maintaining the resource or converting into other land-use systems. It is important to reveal how serious the conversion of the forest coffee lands into other systems is, and what factors are contributing to the future position of the resource in terms of scarcity. Since there is strong relationship between smallholder farm households' characteristics like poverty and natural resource degradation (Cattaneo, 2002), analysis of the effect of household and farm characteristics on the preservation of the forest land is important.

Moreover, it is vital to assess the opportunity cost for the farmers due to conservation measures. The opportunity cost refers to the value forgone in alternative land uses, for example, the value that farmers may sacrifice due to measures like restriction of expanding cultivation of improved coffee material or cultivation of other crops. Information on the comparative contribution of the coffee-based system and that based on alternative cereal crops (like maize, sorghum) to the livelihood of the farmers will indicate the relative incentive levels that motivate farmers to maintain certain production systems, and the potential pressure on forest in general and to the WCP in particular. Such information can help to determine the level of incentive that may motivate farmers to contribute to conservation of the forest resource and identify alternative conservation methods.

1.3.2. Specific Objectives

The specific objectives of the study are as follows:

1. To assess the economic value of the wild coffee genetic resource to the coffee farming community and the nation at large.
2. To analyze the future area of the forest land with the WCP, identify opportunities for preserving the system under the existing agricultural system, and identify the associated factors.
3. To estimate the opportunity cost of conserving the WCP in situ.

1.3.3. Research questions

Analysis and description of the benefits and opportunity costs of conserving the WCP and analysis of the farmers' interaction with the forest land are crucial in designing appropriate conservation measures. The major research questions related to the study objectives are:

1. Related to the major factors limiting coffee production in Ethiopia, how high is the willingness to pay for improved coffee planting material, and then the potential values of the wild coffee genetic resource for the producers?
2. How much and why are the farmers maintaining or replacing the wild coffee plots into other systems?

3. What factors determine the variability in replacing the wild coffee plots among households?
4. How much is the household level opportunity cost of conserving the WCP in the montane rain forest areas and the incentive levels that motivate the farmers to replace their wild coffee plots into other systems?

1.4 Outline of the dissertation

The dissertation is organized into seven chapters. In Chapter 2, an overview of the economics of genetic resources conservation is given. Specifically, the economic value concepts of genetic resources and different theories behind the concept of genetic resource conservation are discussed. Moreover, the methods of assessing the economic values of natural resources and the concept of discounting the future values of natural resources are discussed.

In Chapter 3, the study areas and the survey procedure are presented. Moreover, descriptive information on the different coffee growing systems and a summary of socioeconomic descriptions of the study areas, major factors related to the forest land-use systems and the uses of wild coffee germplasm collections are presented. Chapter 4 presents the description of factors limiting coffee yield and the farmers' demand for improved coffee planting material in terms of their willingness to pay for such material, and the aggregate monetary values due to the adoption of coffee berry disease-resistant planting material in the past three decades.

In Chapter 5, conversion or maintenance of the forest land with WCP is analyzed on a household level as a central force that determines the conservation of the wild coffee genetic resources against an assumed conversion of the forest lands with WCP in the study areas. In Chapter 6, the opportunity costs of maintaining the WCP are estimated in reference to the alternative use system of the forest land by the local farmers. In Chapter 7, the dissertation concludes with a summary of the main findings, policy implications and suggested researchable topics whose output could contribute to a more effective conservation strategy. In the appendix part, glossary of some terms used in the dissertation is attached in addition to supportive information for the respective chapter.

2. Economics of genetic resource conservation

2.1 Introduction

Genetic resources have different value dimensions. They range from private to public values; from local to global values; from current to future value; and from gene-specific to species and ecosystem level contributions. Sustainable use of such resources needs to be considered, since societies attach certain normative values to such resources. Due to the scarcity of capital resource, sustainable supply (maintenance or production) of the resource needs to consider cost effectiveness. To this regard, economics of genetic resources conservation helps to better understand the economic contribution of the resources by assessing the actual and potential values of the resources, supporting the assessment of priorities through the identification of cost-effective measures that might be taken to conserve the genetic diversity, and assisting the design of economic incentives and institutional arrangements to promote conservation of the resources by individual farmers or communities (Drucker, 2004).

As the genetic resources are at risk of attrition, a certain form of conservation is rational as long as the associated costs do not outweigh the expected benefits. In the following sections, the different value aspects of genetic resource conservation and methods of assessing their economic values are discussed.

2.2 Economic value of genetic resources

The importance of wild genetic resources is evident in the field of agriculture, as the agricultural commodities of the world including modern varieties are basically domesticated from wild resources. Furthermore, sustainable supply of agricultural products depends, among others, on the presence of genetic diversity as a source of planting material that can resolve producers' seed problems and satisfy consumer interests. Improvements in the crop genetic make-up in many countries have been successful due to the diverse nature of genetic resources. For example, in the USA, about 50% of the cereal yield increments in the last 60 years are due to improvements in planting material (Fuglie et al., 1996; Rubenstein et al., 2005). Thirtle (1985) estimated that biological improvements in crops have contributed to about 50% yield increment for corn, 85% for soybean, 75% for wheat and 24% for cotton in the USA. It is also a common phenomenon that biological improvements in crops have shown significant yield effects in other countries (Byerlee, 1996; Evenson and Gollin, 1997). The need for genetic resources[12] is continuous with an increasing demand (Virchow and Anishetty, 2003; Knudson, 1999; FAO, 1997), which is aimed at a sustainable supply of planting material in such dynamic conditions where agricultural productivity is threatened by diseases, pests, and drought.

A partial view of people's perception of the value of the genetic resources and the presence of components like the public nature of such resources (Brown, 1987; Simpson and Sedjo, 1992; Rubenstein et al., 2005) are mentioned as factors behind the limited reserve of wild genetic resources. People's perception on the value of such resources depends on the level of information available about the use values of the resources and the nature of constraints faced by the beneficiaries that can be addressed by using the resource, among other things.

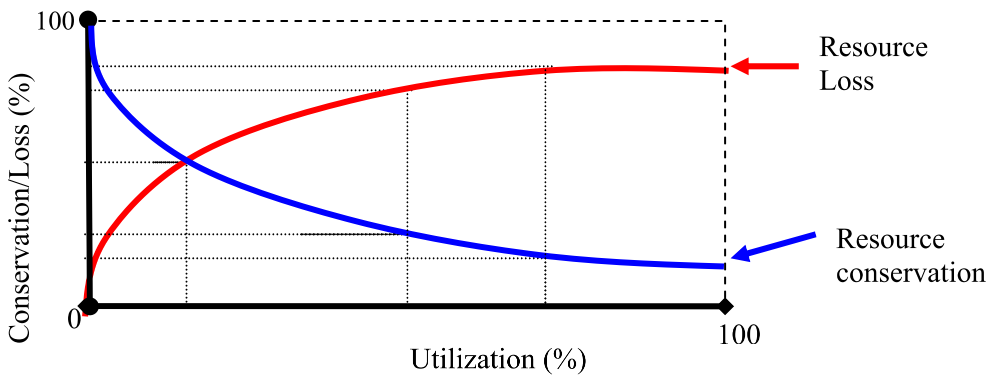
The potential beneficiaries may perceive such resources differently by attaching dissimilar importance to the various value aspects of the resource, which can result in an inconsistent repercussion on the sustainable use of the resources. For instance, the current or future values of the resource, and the private or public nature of the resource may render a tradeoff between utilization and conservation of the resource. Individuals usually choose an alternative that maximizes their private satisfaction.

Utilization of a resource instead of conserving it assumes some behavioral decisions. The economic decision to utilize a resource, instead of conserving it, is made when the value forgone

[12] Although it may be possible to expect a continual existence of a species in a natural system if the seed of the species is maintained, as is the case with renewable resources, a genetic resource becomes non-renewable when its species becomes extinct. The changes in the landscapes or forest covers that disturb the habitats of wild genetic resources can cause extinction of certain species that are found at a limited diversity.

in the alternative system is lower. The issues of concern at the individual level are the private and current value aspects of the resource. As shown in Figure 2.1, utilization of a forest land resource brings about a loss of the public nature of the resource, which could have been enjoyed in terms of genetic, ecologic, and landscape values, etc. The level of resource loss, which may be viewed with respect to time, can not be expected to be 100%, since a certain level of the resource can still remain unutilized.

Figure 2.1 Relationship between utilization and loss of a forest land resources



Source: Own depiction

In the case of the forest lands with WCP, it may be possible to maintain the coffee genetic diversity through utilization of the land for forest coffee production, as long as the WCP are not destroyed or replaced. Human intervention at any level, however, could result in a loss of certain varieties and species. Development of a balance between the two forces is the task that needs to be tackled for.

Beyond the private values, genetic resources have values of a public nature. The farmer level private values of in-situ conservation of a genetic resource include its value as an insurance against environmental and socioeconomic changes and the reduction in the demand for chemical inputs like pesticides, due to the opportunity for developing improved planting material, the benefits of soil conservation, etc. Although genetic resources are not "purely" public goods, since they are potentially exclusive when certain groups could be prevented from using the resource, and are non-rival, as the use of a genetic resource does not reduce the quantity or quality of the resource available to others (Swanson and Barbier, 1992). The public nature of the resource conservation includes reduction in pollution caused by use of chemicals in production process, insurance against environmental changes, disease and pests, empowerment of local communities and food security due to their contribution for a continual production of the crops or improvements in the quality or productivity of the planting material for the benefit of the public at large (Labiberte et al., 2000).

Assessment of the local value of such resources in view of the local people, who depend largely on the resource to address their basic requirements, is a vital aspect. In such a case where conservation of the WCP is to be conducted in-situ on farm fields, the farmers' perception of the resource value and its contribution to the local production are very important.

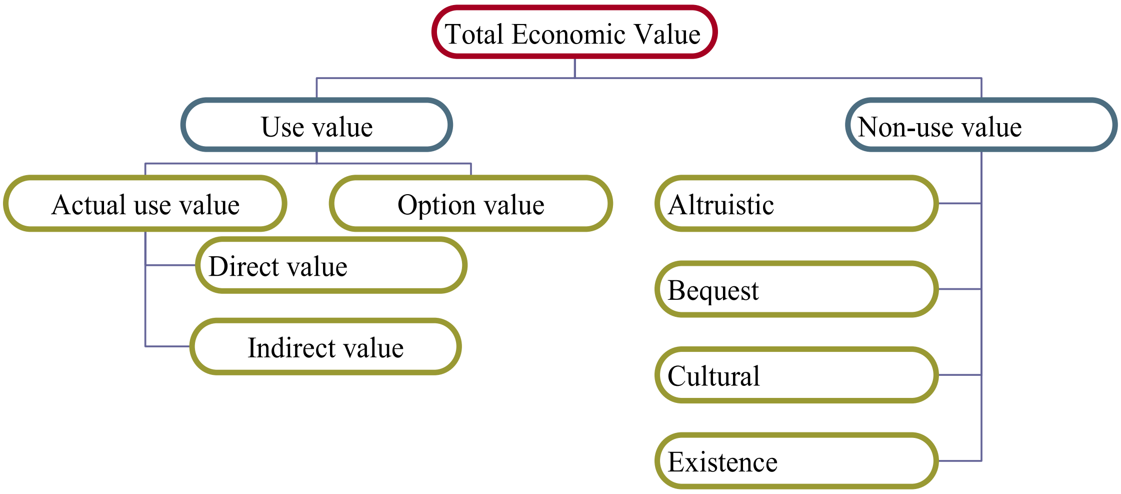
Moreover, the future and public value aspects of such resources, which are relatively overlooked in the day to day activities of private individuals at the local level, are vital elements to be considered. Since value perceptions at different levels in the vertical dimension from the local to the international level have a different influence on the sustainability of conserving the resource, it is important to assess the different value aspects of the resource considered by the stakeholders at the local, national or global levels. The higher the benefits expected by the beneficiaries, the greater will be their potential responsibility to conserve the resource.

Moreover, as Gatzweiler (2003) described, a resource valuation process needs to consider the changing nature of the social, cultural and technological factors that govern the value in addition to the different aspects of the resource use. The attitude of producers regarding the resource value changes due to the occurrence of diseases, pests or draught, which demand resistant planting material. Changes in the preference of products, e.g., due to consumer health factors calls for a higher quality product that may only be obtained through the use of improved varieties. These different elements of values, and the dynamic nature of the goods and their demand have not adequately been accounted for by traditional economics. Modern economics however give special attention to the assessment to the potential future and ecological values of natural resources (Rolf et al., 2000). The economics of genetic resources has increasingly been recognized for its contribution in the assessment of the resource values as determined by the perception of the people involved.

Generally, the economic values of genetic resource conservation can be viewed as a net benefit after deducting the costs of conservation. The total economic value of a plant genetic resource can be disaggregated into use and non-use values as in the general economic concept of biodiversity conservation (Figure 2.2). In agricultural biodiversity, the direct use value refers to the value from consuming the good, which can be the quality or the quantity of consumables or the cash income it generates, the productivity gains from crop genetic improvement, and amenity values associated with agricultural landscapes. Indirect use values include production effects such as resistance to biotic and abiotic stress, functions such as ecosystem productivity, soil or water quality, and habitat protection for other components of the biodiversity. The option value refers to the future values that can be used to combat as yet unknown adverse conditions (insurance value) or to exploit undiscovered sources of information (exploration value).

Those benefits which do not imply a contact between the consumers and the goods or services are termed non-use values. Non-use values include altruistic values, referring the value useful to other individuals, and bequest values referring the value that future generation will have the opportunity to enjoy. Values of WCP can be reflected as: a direct value of coffee beans collected in the forest, the observed and contingent value of coffee planting material that is developed by using wild coffee germplasm in terms of different attributes demanded by producers or consumers, and the heritable and existence values of the resource. The hedonic values of the wild coffee germplasms for breeding purposes with respect to different attributes reflect the genetic resource value.

Figure 2.2 Components of total economic values of agricultural biodiversity



Source: Birol (2002)

Although generations and decades have passed without adequate attention to the importance of genetic diversity, conservation concepts have been well developed and become a global concern due to better understanding on the importance of such wild genetic resources with respect to uncertain production and consumption requirements. Drucker (2004) also argues that it is important to invest in preserving natural resources due to the value aspects, which, however, are not addressed by the prevailing market system, and not well recognized by the local farmers. The presence of inter-generational benefits of genetic resources, and access and global sharing of benefits from such resources can facilitate efforts of governments to conserve natural resources.

Due to the serious threat to the resources, a precautionary principle[13] has been recommended at the global level to secure such resources before they are lost for ever (Raffensperger and Barrett, 2001). There is also a strong argument that all genetic resources could potentially be valuable, and thus they need to be conserved based on ecocentric or anthropocentric value paradigms[14],

[13] The precautionary principle or approach is a recently adopted strategy of deciding to conserve and protect the environment when there are threats of irreversible damage prior to scientific certainty of the damage or the value (Principle 15 of the Rio Declaration on Environment and Development, 1992.

[14] The ecocentric paradigm of conservation emanates from the intrinsic value that all living organisms may have potential relevance in the future, and the anthropocentric paradigm suggests that biological

and the future values of such resources are difficult to assess[15]. If the benefits from the forest resources are to be significant, protection according to IUCN protected area category[16] can be justified. However, it is necessary to identify and quantify the potential social benefits of the resources in order to improve the resource use system.

2.3 Methodological framework of valuation of genetic resources

Efficiency of resource allocation can be improved with the help of information on the associated benefits and costs of alternative systems (Haab and McConnell, 2002). Economic valuation of the associated benefits and costs, therefore, helps to guide decision makers to make use of the resources in the best way possible. The quality of assessments of the benefits and costs of a system is determined by the nature of the goods or services involved and the competence of the estimation model in reflecting realities of the system.

Environmental goods and services can not usually be valued perfectly due to the effects of market failures, policy failures or combination of them. This is because when there is no market for a good or service, there is no market price that reveals individuals' willingness to pay as a monetary value for the good or service. Failures in the market could be caused because of externalities, public nature of the goods, lack of property rights, and limited knowledge on the resources and shortsighted development planning. Externality occurs when an economic activity affects the activity of a third party out of the target consumers or producers. Public nature of the goods refers to the low excludability and rivalry natures. Property rights, which mean the rights to own, lease or use resources, allow to create markets for such goods and externalities.

---

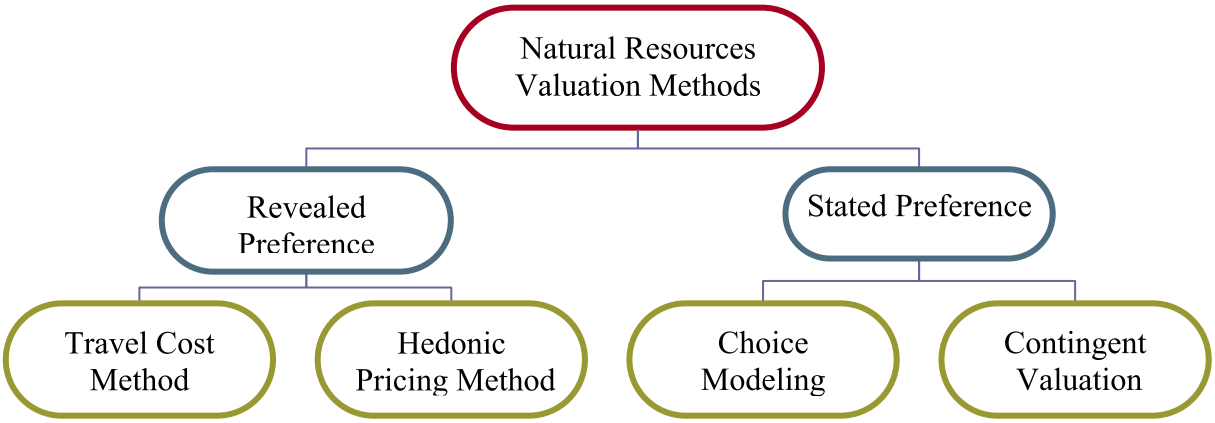
resources as a collection of goods and services have use values that support the maintenance of human life (Grimble and Laidlaw, 2002; McNeely et al., 1990).

[15] Such option values of genetic materials make value estimation stochastic, since they are potentially used in subsequent breeding processes; thus the decision to conserve such genetic resource may be justifiable even with costs higher than the expected benefits (Artuso, 1998; Gollin, undated).

[16] International Union for Conservation of Nature and Natural Resources (IUCN) (1985) specified seven categories of protected areas, namely, nature reserve, wilderness area, national park, natural monument, habitat/species management area, protected landscapes and managed resource reserve. http://rainforests.mongabay.com/10iucn_categories.htm

The two main approaches (Figure 2.3) used to measure welfare changes are the revealed preference (RP) market based methods, where the analyst recovers the value from the actual behavior of the consumers' preferences and the stated preference (SP) methods, where the analyst uses the information that is stated by the consumers when directly asked to express their value judgment. There are different forms of the RP methods, the main ones being the hedonic (implicit) pricing and travel cost methods. Both of these RP methods assess the use values of the resource. The hedonic pricing method uses statistical techniques to single out the partial values of the resource attributed to the qualitative characteristics that define the resource based on observed information about the resource and the prices. It has been used in a selection of residential locations with respect to different spatial characteristics. The travel cost method has been used to study the willingness of tourists to pay for visits to recreation sites.

Figure 2.3 Techniques of natural resource valuation



Recently, the importance of the SP method has become well recognized as it can produce data that are consistent to economic theory, and the estimations are indistinguishable from their RP method counterparts (Haab and McConnell, 2002; Louviere et al., 2000). Reasons for the development of the stated preference methods are: 1) the need to estimate demand for new products with new attributes or features that are not perfectly revealed at market level; 2) explanatory variables for the products have little variability in market places; 3) new variables that qualify the products are being introduced frequently whose value is reflected by choices; and 4) the fact that some products are not traded in the real markets at all. Finally, observational data collection is time consuming and expensive (Louviere et al., 2000).

The SP methods are used mostly in the absence of markets, where the valuation is based on estimating the Willingness to Pay (WTP) or Willingness to Accept (WTA) for provision of goods or services, and reduction in the level of the goods or services respectively (Riley, 2002; Hanley et al., 2001; Scarpa et al., 2001a). WTP and WTA are monetary measures of welfare, where the WTP is the maximum amount of income a person will pay in exchange for an improvement in circumstances or the maximum amount a person will pay to avoid a decline in the circumstances. WTA is the minimum amount of income a person will accept for a decline in circumstances or to forego an improvement in circumstances. These stated preference methods have been recognized as powerful methods of estimating the monetary values of non-traded goods and services and have been applied in different fields including environmental policy and forest planning in the UK (Hanley, 2001), in the fields of environmental valuation and resource damage assessments in the USA (Hanley et al., 2003), and in transportation and health economics.

Choice Modeling (CM) or choice experiments and Contingent Valuation Method (CVM) have both been used to estimate the use and non-use values of goods and services by assessing the WTP or WTA for a provision or loss of certain quantity or quality levels (Birol, 2002; Gollin, undated; Scarpa et al., 2001a). The CVM has been applied by different institutions, e.g., the World Bank, the United States Agency for International Development (USAID) and other donor agencies (FAO, 2000; Cicia and Scarpa, 2000). Fields of application include the assessment of the demand for sanitation services, willingness to pay for improvements in the water supply, benefits of establishing national parks, and costs/benefits of restricting land use to reduce tropical deforestation in developing countries, etc. Despite the critics attributed to its dependence on asking people rather than observing their actual behavior, CVM has frequently formed the basis for policymaking. However, the design should be well structured and care taken in the implementation process (Romano, 1999; Whittington, 2002).

The choice model has been used to compare the values of Creole pigs' attributes to those of more productive exotic breeds in Mexico (Scarpa et al., 2001a), to value attributes of countrysides in the USA, and in a Scottish agro-environmental scheme offering payments to farmers in return for adoption of conservation practices. It was also employed to investigate consumer preferences of genetically modified foods and to estimate the social benefits of reducing genetically modified contents in food by Kontoleon et al. (2002) as noted in Birol (2002).

Depending on how much detailed information is required on the contribution of the characteristics of a resource, selection can be made between the CVM and CM. CM is preferable and used in this study to estimate the values of improvements in the quality of coffee planting materials. The advantage of the CM method over the CVM is based on the fact that it can value the resource disaggregated into individual attributes and compare a number of alternative products (Riley, 2002; Scarpa et al., 2001b). Moreover, CM can avoid some of the response difficulties that can be found in contingent valuation like 'yea-saying' in dichotomous questions (Riley, 2002). The detailed empirical estimation procedure of the CM model is described in chapter 4.

The choice model is here employed to estimate the potential values of improvements in the quality of the coffee planting material owing to the advantages of the choice model. The valuation of natural resources conservation considers not only of the values to the current generation. The valuation process should also consider people's willingness to pay for making available the resource for the next generations. Therefore, the valuation also depend on the level of discounting due to the long term benefits, the concept of discounting and its importance for valuation of natural resources is discussed in the following section.

2.4 Discounting future values of resources

Discounting future values of natural resources has been one of the most disputed issues in ecological economics. Discounting is a procedure of computing the present values of future financial flows of benefits or costs that are associated with a project. Discounting is in general desirable to compare summaries of the benefits with the costs that accrue at future times with today's equivalent values.

Discounting is justified both due to the productive nature of an economy and individuals' or societies' impatience about the future, thinking that something worth more now than later. The risks that either the item may not be available later or that some personal or institutional factors may hinder to enjoy the product or service later are also considered implicitly. Discounting can be defined as the rate of change in the marginal value of consumption, when 'consumption' is considered as a numaraire, or the rate of change in the marginal value of investment when 'investment' is considered as a numaraire (Berlage and Renard, 1985)[17]. It is also described as the rate at the equilibrium level that approximates the rate (marginal) of return on capital that is determined on the inter-temporal production possibility function and the rate (marginal) of time preference that is determined on the inter-temporal indifference function (Layard and Glaister, 1994).

---

[17] The first definition has been widely used as an argument of the *Social welfare function*, while the second definition was proposed by Little and Mirrlees (1968, 1974). The social time preference discount rate, $i_t = -\Delta U_{ct}/U_{ct}$. If the investment is considered to be socially sub-optimal and if the consumption can not be restrained in favor of the investment, the discount rate must then be combined with the shadow price of the investment which rations the scarce investment funds. As described in UNIDO (1972) and Berlage and Renard (1985), the formula for the discount rate, i_t, can be derived from the shadow price of the investment as:

$$p_t = \sum_{u=t+1}^{\infty} \frac{(1-s_u)q_u \prod_{m=t+1}^{u-1} D_m}{\prod_{m=t+1}^{u} (1+i_m)}$$

where p_t is the shadow price of the investment, which is defined as the present value of the future consumption stream from a dollar invested in the current year, q_t is the marginal productivity of capital in period t, s_t is the fraction of q_t which is reinvested, and $D_m = 1+s_m q_m$. By considering the result at time T of investing one dollar at time t<T the formula can be decomposed as:

$$p_t = \sum_{u=t+1}^{T} \frac{(1-s_u)q_u \prod_{m=t+1}^{u-1} D_m}{\prod_{m=t+1}^{u} (1+i_m)} + p_T \prod_{m=t+1}^{T} \frac{D_m}{(1+i_m)}$$

The second term in this function measures the present value of the capital stock in period T that is accumulated through reinvestment. With the assumptions that *q* and *i*, are constant and *s*=0, the shadow price of the investment at any time is the ratio of the initial levels of the marginal productivity of capital to the discount rate, i.e., $p_t = q_o/i_o$.

Specifically, the discount rate is associated with the opportunity cost of the forgone benefits or the pure time preferences (or impatience). The concept of the social opportunity cost is based on the productivity of the capital resource in general (Berlage and Renard, 1985). The assumption here is that the investments of today, although they involve sacrifices in today's consumption, generate larger quantity of the resources available for the future consumption. Thus, the opportunity cost of relinquishing the present consumption is reflected by the discount interest rate. The discount rate that is derived from the pure time preference prinCIPle, which is also called the social time preference rate (Berlage and Renard, 1985), is also related to the assumption that the economy will grow positively in the long-term, i.e., a dollar will be valued less in the future.

In conditions without market failure, risk and tax, the relationship among the rate of return on investment (*i)*, the social rate of time preference (*r*), the pure time preference (*ρ)*, the absolute value of the income elasticity of marginal utility of money (*Θ)* and the per-capita growth rate (*g)* is presented according to Philibert (2003) as: $i = r = \rho + \theta . g$. Most economists, however, agree in that the society's preferences provide weaker justifications for discounting than the social opportunity costs, as the preferences are not absolute in nature and are changing over time (Farber and Hemmersbaugh, 1993).

With an assumption that the future generations will be richer than the present generation, discounting may help to decide on the more effective investments that could contribute more to the wealth of the future generation. However, as Rabl (1996) suggested, the rate of return on marginal investment should not be higher than the growth rate of an economy on long term basis since the compound interest of values over a long period give unrealistic results. It can also be argued that the current rate of return on investment need not be used for any investments in the future as not all capital of an economy could be invested and reinvested at a time. As a result, it is suggested that the discount rates in the long term economic growth, say after 30 years, need to approach the growth rate of the economy, and to use conventional rates for the short periods (Rabl, 1996). In the intra-generation context, the social discount rates should not be zero as the people in the generation could also have dynamic temporal preferences. Moreover, setting the discount rate at zero level results in a discrepancy that such a rate means lower than the rates of return in a risk free investment like government bonds (Farber and Hemmersbaugh, 1993).

The assumption of positive growth rates of economies is also controversial. According to Weitzman (1999), the constraint on the rate of economic growth due to the physical limits of the nature could be relaxed as an economy grows through technical improvements as technologies replace them with alternatives. However, this assumption may not necessarily hold true in the future as different factors like scarcity of certain basic resources and war can limit a continuous growth and development process. Future damages on the natural resources could result in a slow down of economic growth (Faure and Skogh, 2003; Rabl, 1996; Lazoda, 1993; Philibert, 2003). Sterner (1994) also suggested that an economic growth trend follows a logistic curve leading to a steady state. The reasons that can push growth rates down result in a negative real discount rate.

Valuation of environmental goods and services in monetary terms assumes that the environmental and other values are substitutable. The assumption of substitutability is however difficult when the natural resource is limited in supply. Therefore, this calls for the application of a very low discount rate to prevent underestimation of their future values due to the less substitutable nature of the resources. For example, it is impossible or very difficult to compensate for the exact value forgone due to extinction of a species or a variety through technical advancement. The future value of fuel wood could increase if its substitutable goods like electricity or oil energy become scarcer, which implies that the value of a forest resource could be higher in the future than today. Batie and Shugart (1989) also strongly argued against discounting and advocate for an approach that ensures the survival of species, habitats, and ecosystems as far as the costs of doing so are not "unacceptably" large.

The level of the discount rate for a project should also be evaluated with respect to the impact of the investment on conservation of natural resources and the demand for the natural resources as inputs to the productive investment (Fisher and Krutilla, 1975; Farzin, 1982; Lozada, 1993). This is argued as depletion of natural resources could be enhanced with low discount rates when the natural resources are necessary as inputs for such investment projects. Such paradoxical effect of a low level discount rate is called “the conservationist’s dilemma” in the literature of environmental economics.

It has been argued by many economists that the pure time preference or utility discounting would be difficult to assume at intergenerational context (Cline, 1992; Lazoda, 1993; Philbert, 2003). With increase in the world population through time, natural resources are expected to be more competitive and could be valued more in future than at present. In order to mitigate the effects of challenges like damages of basic natural resources that the next generations could face, it may be more reasonable to argue giving more weight to future benefits than discounting.

The argument on the intergenerational effects of discounting is also related to the rights of the future generation and the obligations of the current generation to the future (Farber and Hemmersbaugh, 1993). It is argued whether it is the ‘responsibility’ or the ‘obligation’ of the current generation to save environmental resources for the future generations. However, it is possible to assume that a society is responsible and willing to pay for such bequest values of natural resources. On the ethical level of society’s responsibility, some writers suggest that it is adequate for a generation to consider only the next generation (Farber and Hemmersbaugh, 1993), and not the following generations. This contention was based on the idea that a society may not be willing to make sacrifices for more generations, and if the right of the next generation is adequately recognized by a generation, then, the same could be assumed for the successive generations. Therefore, it could be acceptable to limit the duration of a project accordingly. Nonetheless, shifts in the demand of the society against the expected service out of the project or development of competing products and the physical and economic life of the capital investment need to be considered, as these can affect the life time of a project (Prest and Turvey, 1965; Curry and Weiss, 1999).

Due to the various aspects that influence the interest rate, there is no agreement on the level of the rate to be used in the analysis of long-term projects. Although many development projects, for example, in the World Bank, were using a rate of 10 % on the ground that the investments should be expected to yield higher returns, much lower rates such as 6 % or 3 % have been proposed to protect the future benefits from further discounting (Young, 1998). As the level of the discount rate determines the final conclusions of cost-benefit analysis, policy makers need to make a deliberate bias especially for such projects that are related to the conservation of natural resources.

Use of declining rates are also suggested as alternative to the use of a constant discounting rate that implies a geometric function of converging values in terms of present values. The use of declining rates of discounting prevents the present values of the future benefits from falling (Newell and Pizar, 2003) and result in a hyperbolic function of the present values. According to many economists, for example, Farber and Hemmersbaugh (1993) and Philibert (2003), although there is no agreed model of deriving appropriate discount rates, the discount rate should not significantly exceed the expected long-term rate of the economic growth.

The issue of discounting may also be perceived differently between developing and developed countries, as their economies are different in terms of strength and returns from investments. As poor people are usually shortsighted, they relatively discount future values more than the people in the developed countries, in general. May this imply whether the justification of discounting with respect to the level of economic growth that is argued in the intergenerational context works for the inter-country context? In other words, should a country with lower rate of economic growth use a lower discount rate than a country with higher rate of economic growth? For the time preferences of the people in the societies, both the level of the economy and the rate of economic growth could have influence, although the rate of growth is more important as it is directly reflected through the returns from future investments. Philibert (2003) noted that investments on climatic change mitigation need to employ higher discount rates in developing countries, and lower rates in developed countries due to the relative scarcity of capital in the countries. However, on top of the absence of material goods transfer to next generations in developing countries, the current generation should not exploit the natural resources using higher discount rates. To this effect the use of certain level of discounting can be considered ethical as a motivation or incentive for the people to cooperate and invest on conservation of such natural resources.

How do the rates of discounting be determined for projects whose benefits and costs are shared by two or more countries? Such projects can be apparent especially related to environmental and climatic damage preventions, which require the cooperation and the integration of the countries. Development of the discount rates that consider the socio-economic situations of different countries is important for projects whose costs and benefits could spread beyond national boundaries. A compromise need to be made on the difference in the pure time preferences of the people in the different countries to fix appropriate discount rate for such projects.

2.5 Summary and conclusion

Conservation of genetic resources should be viewed as naturally important process so that both current and future generations can make use of the resources. Diversity of crops genetic resources have helped to generate improved varieties that have contributed for about 50% of the yield improvements in the field of crop production. Therefore, contribution of genetic resources for agricultural improvement as direct values of the genetic resources needs to be revealed for all crops and appropriate management strategies needs to be designed for a sustainable use.

As the value attributes of genetic resources are more of a public nature, the care given to such resources by private individuals is not enough to permit an efficient and sustainable use of the resources, as individuals are more interested in the private value aspect of the resources. Therefore, public action is important to improve the efficiency of allocating the resources for a sustainable use, which is based on a compromise between the private and public, and current and future values of the resources. In order to design the level of investment by a society necessary for a sustainable use of the resources, e.g., for a conservation program, the actual and potential benefits and costs associated to the process need to be assessed. The total economic value of a resource comprises the sum of its use and non-use values, which can benefit the producers and consumers. Economic valuation techniques help to reveal the values of the resources and the associated costs of conservation, so that decisions to conserve and efficiently use of the resources can be facilitated. Moreover, it is important to consider the contribution of potential stakeholders to the conservation of the wild genetic resources.

The RP methods have been used for a long time to value resources based on observation data. Since natural resources have option values and other non-use values that are not reflected in the markets, the SP methods are developed as alternative economic valuation techniques to assess the values of the resources using hypothetical markets. Methods such as choice modeling as a kind of SP methods have been acknowledged to better approximate the values of natural resources.

In order to decide on investments for conservation of natural resources, the sum of the expected values of the benefits that accrue over a series of years need to be compared with that of the expected costs that are associated with the process of conservation. Cost-benefit analysis is the most common method of doing such analyses. As both the benefits and the costs usually involve time factor that integrate the preferences of individuals at different times and generations, the issue of discounting also determines the final conclusions of the analysis. Although using a very low discount rate could imply more sacrifices from the present generations that may weaken people's motivation to conserve, it is worthy to consider the rates of returns on investments or long-term growth rates of the concerned economies at large.

As one aspect of the benefit stream in the conservation of the forest system, the value of conserving wild coffee genetic resource in Ethiopia is assessed in this dissertation. As an incentive to conserve the WCP, the expected values of the wild coffee genetic resource is compared with the opportunity cost of the forest land using different levels of discounting rates. The following chapter gives the description of the study area, the data collection methods and descriptions of the coffee growing systems in the study areas with major emphasis on the variables related to conservation and use of the wild coffee genetic resource.

3. Data and Methods of data collection

3.1 Introduction

Both primary and secondary data were collected using a combination of survey techniques, including formal survey and a case study. The formal survey was conducted to collect household level cross-sectional data that aids statistical inferences. A choice experiment, which was aimed at estimating farmers' willingness to pay for coffee planting material, was also combined with the formal survey. On the other hand, a case study was made to collect a detailed farm management data on a group of households at a coffee- and cereal-based farming systems in the forest communities. The surveys were conducted after a pretest of the questionnaires. The study also employed informal techniques of gathering and cross checking certain qualitative information through discussions with district and zonal level agricultural experts, in addition to interviews with key informants and group discussions in the forest communities.

As the study focuses on the conservation of the forest with the WCP, detail information is gathered in the forest communities. In this chapter, description of the questionnaire, the sampling procedure, the location and description of the study areas are presented. Descriptive information on the coffee growing systems, the household land-use system and utilization of the WCP resource is also presented.

3.2 Description of the questionnaire

The primary data were collected at the farm household level using a structured questionnaire. The questionnaire includes household characteristics; farmland availability, access and utilization; the coffee production systems and trends; utilization of the wild coffee; criteria for selection of coffee planting material and comparative quality of planting material produced from the different coffee systems; use of wild coffee seedlings; and the coffee marketing situation at the smallholder level.

The farm management data also includes detailed information on household resource availability, actual household land use plan, input uses and production of the existing enterprises, household consumption and selling balances, monthly labor requirements for each activity in farm operations, and household expenditures.

Secondary data on district and national level acreage and number of coffee growers, government activities regarding the use of wild coffee, coffee breeding and dissemination of improved coffee planting material, and yields and prices of different crops, etc were also collected. These data were collected from different institutions like the Central Statistics Authority (CSA), Coffee and Tea Authority (CTA), District Agriculture Development Department (ADD), etc.

3.3 Sampling procedure

The study populations in the forest communities were selected among the peasant associations surrounding the forest areas with the WCP. As the total population of the households is very large, the sample size was not determined statistically based on the total population. Due to the cost of time and finance, an alternative technique of sampling was employed to specify the sample size that can represent the population with respect to the focus of the research. The unit of analysis is a household. The study population was approached using stratified random sampling technique to consider vital variability in the communities, i.e., the level of the threats to the WCP and distance from the forest site, to improve the representative ness of the particular population.

Accordingly, in each of the Geba-Dogi and Berhan-Kontir communities 120 sample households were randomly selected out of the sampling-frame of membership lists of peasant associations[18]. In the Gomma district, a random sample of 64 households is considered for the choice experiment in addition to those selected in the forest communities. For the choice

[18] ‘Peasant associations’ are the smallest official administrative structure within a ‘district’ (or Wereda), where about 200 to 500 farm households exist per peasant association. A number of districts or weredas form a ‘zone’ and a number of zones form a regional government’.

experiment, as is presented in Chapter 4, taking 100 households in Geba-Dogi, 88 in Berhan-Kontir and 64 in Gomma, each multiplied by 15 scenarios gave 1500 observations for Geba-Dogi, 1320 for Berhan-Kontir, and 810 observations for Gomma district. The data for Gomma is divided into 510 and 300 observations respectively for the highland and mid-altitude areas to see the effect of altitude in the area. In addition to these, samples of 30 households in the Geba-Dogi community are considered for detailed farm management information at the coffee- and cereal-based farming systems.

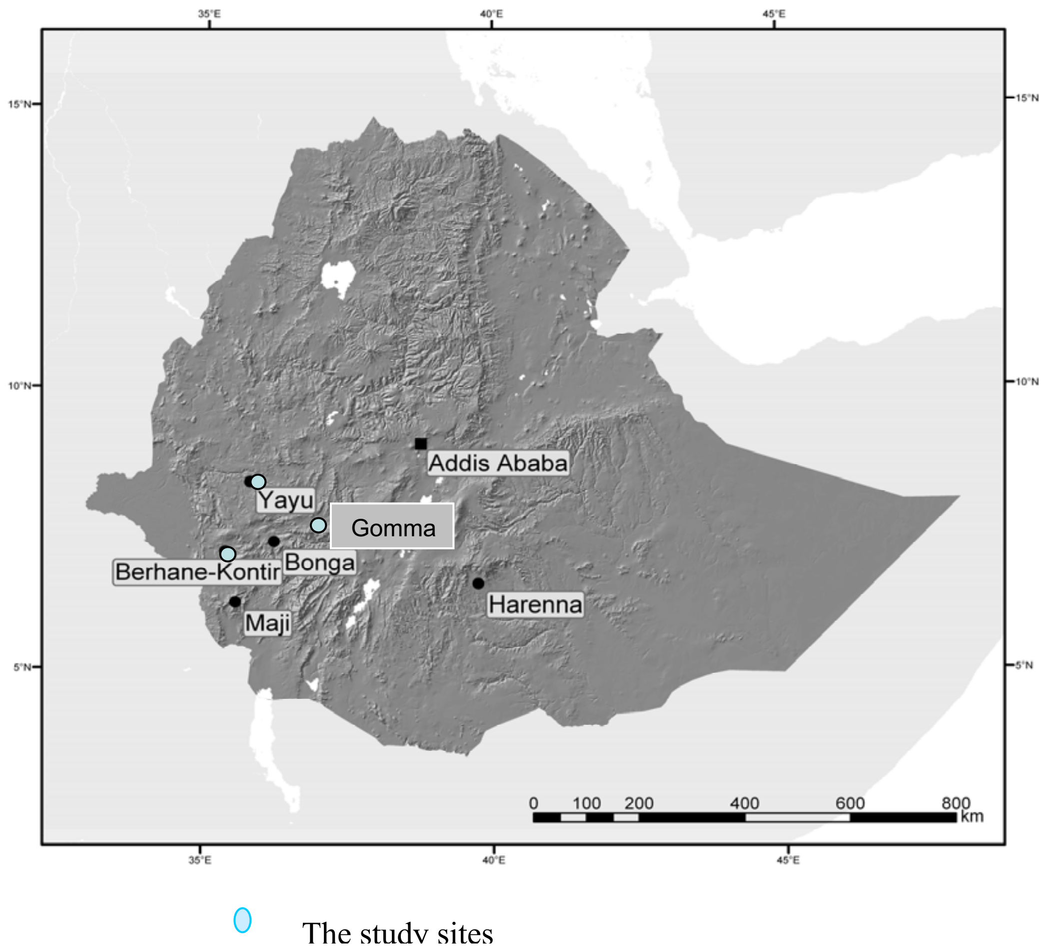
A face-to-face interview technique was employed to get the responses of the respondents after the enumerators were trained with the questionnaire and translations of the questions into local languages. The enumerators were the experts in research centers and agricultural development department, who have experience in such survey interviews.

After a sample respondent is politely picked among a group (if any), smoothening of the interview conditions was insured through convenience of seats followed by a respective greetings and introduction by name and affiliation, introducing the objective of the questionnaire and summarizing the contents. Then, the respondents are informed as the aim of the survey was purely for research purposes and asked for patience and honest response based on their real history and exact feelings as it determines the final conclusions of the whole work.

3.4 Location of the study area

The study areas, namely the Geba-Dogi and the Behan-Kontir forest communities, and the Gomma district are located in the southwestern Ethiopia. The Geba-Dogi forest is located between $35^0$45' - $36^0$05' east and $08^0$15' - $08^0$37' north along the two sides of the Geba and Dogi rivers in the Yayu district of the Illubabor zone about 562 from Addis Ababa. The Berhan-Kontir forest is located adjacent to the Gez-Meriet peasant association in the Sheko district in the Bench maji zone between $35^0$15' - $35^0$30' east and $06^0$55' - $07^0$05' north about 595 km from Addis Ababa. The Gomma district is located 390 km from Addis Ababa in the Jimma zone. See Figure 3.1 for exact location of the study sites.

Figure 3.1 Locations of the Study Areas



The study sites

3.5 Descriptive information of the study area

3.5.1 Background information

Similar to most places in Ethiopia, the population in the study areas is composed of both Christian and Muslim religions and diverse ethnic groups as shown in Table 3.1. On average, a household has a family size of about 6.3 and 6.6 with a male to female ratio of 1.0:0.9 in the Geba-Dogi and Berhan-Kontir communities, respectively. Education services frequently do not reach the farmers and about 38% of household heads in Geba-Dogi and 20% in Berhan-Kontir cannot read or write with a period of education of 3.2 and 2.7 years, respectively. However, the majority of the children attend schools.

Table 3.1 Description of some vital socio-economic variables in the study areas

Variables	Geba-Dogi Community (N=120)	Berhan-Kontir Community (N=119)	t-value
Ethnic composition	Oromo (67.5%), Amhara (25%), Tigre (7.5%)	Amhara (45%), Bench (19%), Keffa (11%), Mezenger (7%), Others (17%)	
Religion	Christian (60%) and Muslim (40%)	Christian (75.5%) and Muslim (24.5%)	
Major agricultural enterprises	Coffee, maize, sorghum, apiculture,	Coffee, maize, sorghum, apiculture	
Male to female ratio	1: 0.937	1: 0.941	
Mean comparison of vital variables			
Family size	6.33 (2..2)	6.66(1.9)	1.23
Farm size (ha)	2.76 (1.5)	3.84 (1.9)	4.93**
Area of coffee (ha)	1.7 (1.0)	2.8 (1.5)	7.00**
The current area wild coffee	0.15 (0.23)	0.43 (0.5)	5.5**
Area wild coffee five years ago (ha)	0.21 (0.31)	0.52 (0.5)	5.8**
Area of maize (ha)	0.75 (0.56)	0.89 (0.58)	1.89*
Area of sorghum (ha)	0.22 (0.36)	0.01 (0.05)	6.5**
Livestock(mean/household)			
Cows	1.04 (1.3)	0.9 (1.1)	1.02
Oxen	1.12 (1.3)	0.53(0.8)	4.3**

The values in bracket are standard deviations.
** Significant at 0.01 level, * significant at 0.05 level.
Source: Own survey results

As indicated in Table 3.1 farmers in Berhan-Kontir community have larger farm size. Selected socio-economic characteristics and the current land-use system of the study sites are indicated in Table 3.1. Both forest communities are known to receive in-migrants from different parts of the country. About 63% of the households in Geba-Dogi and 91% in Berhan-Kontir are in-migrants, while there is no significant out migration out of the communities. The in-migration into these areas is due mainly to pulling forces in the community such as the presence of 'free' public forest land (as stated by 25% of the households in Geba-Dogi and 73% in Berhan-Kontir), and calls made by the incumbent relatives (as stated by 34% of the households in Geba-Dogi and 20% in Berhan-Kontir), and parents and partly by the government resettlement programs (as stated by 34% of the households in Geba-Dogi and 6% in Berhan-Kontir).

Most of the households derive their basic food needs and cash requirements from agriculture, while off-farm activities are very limited. Only 8% of the households earn additional income from petty trading, 11.5% from wage labor, 4% from handcraft, 2.5 % from pottery and 2.5% as traditional healers in Geba-Dogi, while in Berhan-Kontir only 6.7% of the farmers earn some income by selling their labor. Farm size per household has been decreasing, since the households share their farmland with the maturing young boys. The average farm size per household is 2.8 and 3.8 ha in the Geba-Dogi and Berhan-Kontir communities, respectively. Of the current holdings of the households, in the Geba-Dogi about 85.9% obtained through government provision, 12.5% from parental transfer, 1.5% through purchase from other farmers, and 0.038% through clearing of adjacent forest lands. In Berhan-Kontir, about 88% obtained through government provision, 11% through purchase from other farmers and 1% through parental transfer. Shortage of farmland in the areas was also observed, as about 80% households in Geba-Dogi and 72% in Berhan-Kontir stated that the size of their farm was inadequate for their family.

Agriculture in the study areas is mainly a coffee-based cropping system followed by maize and sorghum crops with a small share of other crops like Teff, wheat, enset (or false banana), fruit crops like banana, mango, orange and papaya. In the Berhan-Kontir forest community, spice crops like ginger, turmeric, long pepper and cardamom are grown. Coffee is the major crop, covering about 62 and 73% of the farm land in the Geba-Dogi and Berhan-Kontir forest communities, respectively, while the remaining fields are mainly used for maize. Domestic animals, namely cows, sheep and goats, equines and poultry are only a secondary importance to cropping system (Table 3.1). Related to the agricultural tradition of the area and suitability of the forest system to grow coffee better than cereal crops, farmers prefer to produce coffee. As a result, the area under coffee cultivation has been increasing in the last years.

The agricultural production system is labor intensive and very traditional. For instance, farmers produce maize and sorghum by tilling the soil manually with a hand hoe as there is a shortage of oxen-labor in the Berhan-Kontir forest community. Crop diseases, weed infestation, destruction of crops by wild animals and poor harvesting practices are the major factors limiting cereal crop yields. However, introduction of improved varieties of coffee and maize, and use of chemical inputs like fertilizer have contributed to improved productivity of food crop cultivation.

Wild animals, especially bush pigs, warthogs and monkeys cause to damage to the crops, especially to maize, sorghum, Teff and coffee, and threatening domestic animals. Such damage by the wild animals has been increasing, especially in the Geba-Dogi community. Maize production in the area is highly threatened by wild animals, and therefore farmers minimize the risk by cultivating maize near their home or next to the maize plots of another household. Farm plots that are far away from the households are usually used for coffee since coffee is less threatened by wild animals than cereal crops. Animal diseases like trypanosomiasis, anthrax (or Aba-Senga in local language), black-leg (Aba-Gorba), pasteurellosis (Gororsa), and internal and external parasites limit cattle farming seriously in both study areas.

3.5.2 Coffee growing and production systems

The coffee production area in Ethiopia was first estimated and documented by the International Coffee Organization (ICO) in 1965/66. According to the estimate made by Central Statistical Authority (CSA), the area of coffee held by smallholder farmers in Ethiopia during 2001/02 was about 256,545 ha (CSA, 2003). Currently, about 500,000 to 550,000 ha of coffee nationwide including the area owned by large-scale farmers are estimated (MOA, 2003) [19].

There are different coffee growing and production systems in Ethiopia mainly due to varying level of forest trees associated with coffee, the nature of coffee tree regeneration and the resource level of growers. On a national level, the systems have been categorized in different ways, but mainly based on the relative level of human intervention in the coffee system. The categories are: forest coffee system, semi-forest coffee system, garden coffee system and plantation coffee system (Demil, 1999). The relative share of the different coffee production

[19] The estimate of the MOA is based on data collected on coffee acreage from each peasant association through the agriculture development departments (ADD) in all districts, zones and regions of the country.

systems has been changing through time, as the share of plantation coffee, which is covered by Coffee Berry Disease (CBD) resistant cultivars, and the garden coffee has been increasing.

The current coffee production system in the study areas can be classified based on management level and nature of coffee tree regeneration. In terms of coffee tree regeneration, the coffee systems can be categorized into: *wild coffee system*, *fores*t (semi-domesticated) *coffee system*, *semi-forest system,* and system with *improved coffee cultivars*. These systems can be described as follows. The previously categorized 'forest coffee system' (Demil, 1999; Paulos and Demil, 2000) is divided into wild coffee system and forest coffee system in the case of the forest communities with the WCP in order to identify the land-use change in the relatively undisturbed areas of the WCP at the household level. These terms are adopted hereafter accordingly.

Wild coffee system: The wild coffee system is found in natural forest where the coffee trees regenerate naturally and spontaneously with unsystematic spacing. The coffee trees grow in a complex ecosystem together with many plant and animal species. These systems are owned either by the smallholder farmers near the forest or are public. There are no agricultural activities in this system. There may be a path to the coffee trees and space created around individual coffee trees by slashing. The coffee beans either drop from the trees or are harvested by the owner of the plot or by anybody in the community. The wild coffee system is not recognized as a production system because of the poor yielding capacity of the coffee trees as a result of high competition with other species for light, nutrients and water. According to the survey data, about 44% of the households surrounding the Geba-Dogi forest owned about 0.15 ha area of such unmanaged wild coffee plots, while about 61% of the households surrounding the Berhan-Kontir forest owned an area of about 0.43 ha.

Figure 3.2 Typical forest coffee system, Berhan-Kontir forest

Forest coffee production system: The forest coffee system is the domesticated form of the naturally regenerated WCP. Here, larger trees that are thought to reduce coffee yields are thinned out, the underground grassy species is cleared off, and local coffee seedlings are occasionally planted on available free spaces (Figure 3.2). These areas are found surrounding the remnants of the WCP. The forest coffee population may approach the wild coffee system in terms of coffee population diversity, since the coffee populations are naturally regenerated and remain in the system. However, the forest coffee populations have higher coffee yields than the wild coffee system, since they grow in a relatively open area, grow vigorously with less competition with other species, and are relatively better managed.

Nationally, the area of the wild and forest coffee systems is estimated to be about 40,000 ha i.e. about 10% of the total national coffee acreage (Paulos and Demil, 2000; Workaffess and Kassu, 2000; Demil, 1999). The average yield of coffee in the wild coffee system is minimal, not exceeding 200 kg per hectare as estimated in Yayu in the years from 2001 to 2003, while the yield increases up to 410 kg per hectare in the managed form of forest coffee as estimated in the Geba-Dogi forest community.

Semi-forest coffee production system: In the semi-forest coffee system, local coffee cultivars are planted under natural forest using local seedlings obtained from self-raising or wild coffee seedlings growing naturally under old coffee trees. The only agricultural practices in the forest and semi-forest coffee systems by most smallholder farmers are weeding and light pruning. Frequency of weeding in the majority of the systems is once or twice (Appendix 3 Table 1).

Average yield in the semi-forest coffee is 441 kg per hectare, which ranges from 407 to 500kg per hectare per year, according to the estimate for 2001 to 2003 in the Geba-Dogi forest community. The total area of semi-forest coffee in Ethiopia is estimated to be about 34% of the total national coffee production area (Workaffess and Kassu, 2000).

Improved coffee production system: Coffee plantations comprise relatively uniform coffee populations. The cultivar seeds are developed at research stations, give higher yields and are more resistant to the major coffee diseases, namely CBD and rust, than the local coffee. Cultivation of these cultivars have been established in Ethiopia since the beginning of 1970's following the incidence of CBD by the Coffee Improvement Program (CIP) of the Ministry of Coffee and Tea Development (MCTD) and Coffee and Tea Authority (CTA). Intensity of weeding in the improved coffee system is significantly higher than other coffee types (Appendix 3 Table 1). The yield of improved coffee cultivars is also higher than the other coffee cultivars and estimated to be about 675 kg per hectare per year in the 2001-2003 production years in Yayu. Around the Geba-Dogi forest, about 88.3% of the households own such plots, while this is only 13% of the farmers around the Berhan-Kontir forest.

At the national level, improved coffee plantations are estimated to cover about 20% of the total coffee acreage. Modern coffee plantations that are mainly based on improved coffee cultivars with more intensive management practices including repeated weeding and application of fertilizer and herbicides is held by large scale coffee farm types. Such large-scale coffee production systems, which are located in southwestern Ethiopia, add up to 20,198 ha, accounting for about 5% of the national coffee acreage. An additional 22,000 ha of privately owned large-scale coffee farms have been established since 1992 following the privatization policy of the current government. The large-scale coffee farms are managed relatively well.

The wild coffee system is the natural genetically diverse system, while the improved or modern coffee plantation system is the other extreme where the coffee system in the later case has a low genetic diversity. Some farmers claimed to have a plot of land in the potential conservation sites of the WCP. The draft rule of the preliminary conservation projects forbids the farmers both to plant coffee and to slash the plot, and they are only allowed to pick coffee beans in the buffer area and forbidden to go into the central area. Since some farmers have given up larger areas while some other farmers only have to give up a smaller area, arrangements are required by the government to address the problems of the farmers.

3.5.3 Forest coffee land use

Fifty years ago, most parts of southwestern Ethiopia were completely covered by forest. Gradually, the forest land has been converted into agricultural land mainly to a coffee based farming system. Along a transect, away from the remaining forest system with the WCP, the area of coffee land decreases and that of cereal crops increases both at household and community levels, and ends up with a cereal based farming system.

The areas of the different coffee systems have changed in the past. The wild coffee area has been diminishing and replaced mainly by the managed form of forest coffee farm as indicated by about 95% of the farmers in Geba-Dogi and 97% in Berhan-Kontir. Out of the farmers who have wild coffee areas (47% of the sample in Geba-Dogi and 64% of the sample in Berhan-Kontir), about 52% in the Geba-Dogi and 84% in the Berhan-Kontir wanted to convert the remaining forest land with the WCP, while 27% of them in the Geba-Dogi and 15% in the Berhan-Kontir wanted to leave the areas unmanaged.

The area covered by the improved coffee and forest coffee systems are increasing which is mainly at the cost of reducing the area of wild coffee system in both locations (Table 3.2). About 55% of the farmers in Geba-Dogi and 15% in Berhan-Kontir plan to increase the area of improved coffee cultivation.

Table 3.2 Farmers' plan to change the area of the different coffee systems (% response of the sample farmers)

The coffee systems	Geba-Dogi		Berhan-Kontir	
	To increase	To keep the current status	To increase	To keep the current status
Forest coffee	30	70	81	19
Semi-forest coffee	41	59	-	-
Improved coffee	55	44	15	74

Source: Own survey data

Improved coffee cultivars are planted not only in the improved coffee plots, but also in the forest coffee plots (as stated by 28% of the sample farmers) and in the semi-forest coffee plots (as stated by 24% of the sample farmers) in Geba-Dogi. In Berhan-Kontir, about 31% of the farmers stated that they had started to plant improved coffee cultivars in their forest coffee plots.

3.5.4 Wild coffee utilization

Farmers used to collect different products and services from the forest including coffee beans, wild coffee seedlings, and other timber and non-timber products to be used as construction material, medicine, farm implements, beehive construction material, etc.

Farmers especially those with less farmland and youngsters collect coffee in the wild forest. Such collection of coffee is locally called *Kote* (local term at Yayu). However, not all the coffee beans that are found in the wild forest are collected (Table 3.3). The major reasons for not collecting the wild coffee beans include the dense nature of the forest, lack of roads in the forest, labor requirements and the very small amount of coffee available in the wild forest (Table 3.4).

The number of farmers who increased their reliance on wild coffee is higher than those who reduced their reliance (as 31% over 17%, respectively, in Geba-Dogi). The reasons for an increased reliance on wild coffee collections include increased demand for cash income by the family, which rises with increase in the family size.

Table 3.3 Collection of wild coffee beans in the public and private forest land holdings (% responses)

	Geba-Dogi		Berhan-Kontir	
	Public Forest	Private Holdings	Public Forest	Private Holdings
Not harvested	2	8.5	0	3
Partly harvested	48	19	44.5	90.4
All harvested	10	72.5	0	6
Do not know	40	0	55.5	0

Source: Own survey data

Table 3.4. Major reasons for not collecting the wild coffee in the public and private holdings (% response)

	Geba-Dogi		Berhan-Kontir	
	Public forest	Private holdings	Public holdings	Private holdings
Restrictive law	20	0	37	0
Inaccessibility	56	33	51	34
Very distant location	19	7	0	0
Lack of labor	4	33	4.5	60
Inconsiderable coffee amount	0	20	7.5	2

Source: Own survey data

About 99% of the farmers in Geba-Dogi and 98% in Berhan-Kontir perceived the significance of the forest for climatic reasons, and most farmers had a certain concern that the forest resource should be maintained for the coming generation. About 73% of the farmers in Geba-Dogi and 98% in Berhan-Kontir were aware of the value of the forest, and the remaining 27% of the farmers in Geba-Dogi and 2% in Berhan-Kontir overlooked the value of the forest for the next generations. About 57% of the farmers in Geba-Dogi and 13% in Berhan-Kontir wanted the public forest in the community to be preserved, although only 38% and 11% of them were willing to contribute to conservation with labor in Geba-Dogi and Berhan-Kontir, respectively.

The farmers in both communities, as is common in all parts of the country, consume considerable amount of coffee. It is drunk by persons of all ages including children above three years old in most rural areas. In a household, coffee is mostly prepared two times per day (in the morning and at night). The drink is deemed for different purposes including for welcoming guests, for enjoyment, as a food value, to motivate workers on farm and in public gatherings, to entertain people during times of sickness and grieve, and as an addiction.

The coffee drink is made from both the beans and the leaves. Although the use of coffee leaves for making coffee has been abandoned in recent times in many parts, it is still common in some places, especially in Sheko. Such a drink is called *Chemo*. The *Chemo* common in Sheko is a special type of coffee drink. Its preparation is as follows: the coffee leaves, especially the shoot of the plant including the young branches, are picked, roasted, ground or crushed, and cooked for some 30 to 40 minutes with different spices including ginger, garlic, chilli, sacred basil (locally called Beso-Bila) and salt. It is drunk alone or together with bread, taro, cassava, etc., and it is common to feed babies of more than 6 months in Sheko. It is more used by the following ethnic groups: Sheko, Messenger, Kaffa, and Bench. Collection of such leaves is free in the wild forest area irrespective of the owner of the plot. Due to its effect on the yield of coffee, the owners of the plots have begun to complain, as the number of consumers of Chemo is increasing in the Berhan-Kontir community.

In the following chapters, the contribution of the wild coffee genetic resource to the local coffee producers as a source of coffee planting material is assessed and estimated. The diversity in the wild coffee genetic resource is considered as the source of development of the improved coffee planting material used by the coffee producers. The aggregate value is compared with the opportunity costs of preserving areas of WCP in order to identify the benefits of conserving WCP in situ.

4. Agricultural values of the wild/forest coffee populations

4.1 Introduction

In-situ conservation of wild coffee genetic resources as one option for conserving genetic diversity is aimed at maintaining the conditions that create and maintain the diversity at the natural setting where the wild genetic resources are found. The assumption behind conservation of the wild Arabica forest coffee in Ethiopia is primarily based on the assertion that the wild Arabica coffee populations are genetically diverse (Demil, 1999; Taddese, 2003; Pawlos and Demil, 2000; Bayetta and Mesfin, 1986) as compared to other coffee growing systems like the garden or semi-forest coffee populations, which are used for selection of coffee cultivars that have potential resistance to different coffee diseases and pests.

The economic value of genetic resources is best explained as the value of the genetic information (Virchow, 1999) or the attributes (Puppe, 2002) embodied within the resource. The value of a genetic resource is based on its ability to address production impediments like diseases, pest and drought, or other attributes like yield or nutritional qualities that address consumer interests.

In addition to the direct earnings through the coffee harvest from the wild or forest coffee plots, the genetic value of the WCP is important, as it can benefit the society as a whole. Since there is a trade-off between the direct use values of the forest land, as returns from cultivation of the wild coffee or forest coffee, and the genetic value that could be obtained while keeping all diverse coffee populations, it is vital to assess the relative weights attached to these value aspects by the respective stakeholders.

The responsiveness of the beneficiaries of the genetic resource towards conservation of the resource or the value they attach to the resource relates to their level of dependency on the resource and their livelihood opportunities. The value attached by the local coffee producers is very important, as these are the direct users of the genetic resource, who basically depend on the forest land to derive their basic needs and are spatially linked to the forest. As coffee is their major enterprise and they are generally poorer as compared to other beneficiaries like coffee marketers (urban settlers) (MoFED, 2002), the importance of the genetic resource may be more stringent to them, and the valuation could better be reflected in this view of analysis.

It is difficult, however, to measure an exact value of genetic resources that includes both the current and future values, since the demand for such material is associated with the dynamic nature of the coffee production system. Therefore, any valuation depends on the perceptions of the people based on the observed trend and current knowledge of circumstances. The ability and willingness to pay for improved planting material by the local farmers is an approach of valuation, as it could reflect both the current and potential value of the genetic resource for coffee producers.

The importance of the genetic resource to the producers is associated to the production impediments that limit the yield of coffee. This is because improved coffee planting material or selections, whose availability is secured through conservation of the coffee genetic diversity, is used as an alternative panacea to address the coffee production impediments. Therefore, the value of the coffee genetic resource to the farmers is assumed to be reflected as the value they attach to the improved nature of coffee planting material with respect to the coffee production constraints they are facing. In this Chapter, such agricultural value of the coffee genetic resource is assessed and analyzed in terms of farmers' potential demand for improved coffee planting material, and the production effect of adopting CBD resistant coffee varieties in the past.

4.2 Coffee production constraints and the need for improved planting material

Coffee production in Ethiopia has been affected by diseases like coffee berry disease (CBD), coffee wilt disease (CWD), coffee leaf rust (CLR), and drought, etc., especially in the last three decades in most coffee producing areas in Ethiopia, although the severity has varied from place to place. Furthermore, cultivation practices are very traditional. This has all led to the low level of coffee production, which is estimated nationally to be about 471 kg clean beans per hectare (MOA, 2003).

The coffee berry disease, which is caused by the fungus *Colletotrichum kahawae,* attacks the green or ripening coffee berries. In Ethiopia it was first identified in 1971 and then spread over most coffee producing areas in the country. It is estimated to reduce coffee yields by 25 to 30% at the national level (Alemu and Sokar, 2000). Yield loss varies from year to year and from region to region, and was observed to be over 40% at Gera (a typical highland coffee growing area in the Jimma zone) on average between 1987 and 1991 (Eshetu and Girma, 1992), and up to 100% in some places, especially in the highlands when rainfall is high (Van der Graaf, 1984; Tefestewold, 1986). The severity of CBD is less or nil in lowland areas in Ethiopia. The occurrence of CBD has forced farmers to practice intercropping or to convert coffee farms into cereal farms in eastern and southern Ethiopia (Negash and Abate, 2000) where about 40 % of the sampled coffee farms were attacked by the disease in 1998.

Minor coffee diseases like coffee tree death, coffee leaf rust, coffee leaf blight, brown eye spot and thread blight are also found in Ethiopia. Coffee wilt disease (*Jibberella xylarioides*) is the most common pathological cause of coffee tree death (Figure 4.1), which is common in most coffee growing areas in Ethiopia.

Figure 4.1 Coffee trees suffering from coffee wilting disease

The disease attacks the vascular system of the plant and thereby inhibits the transport system and finally results in the death of the coffee tree. It has been observed in Ethiopia since 1957, and it became a very threatening disease curbing coffee productivity, especially in the last five years with an incidence rate of about 28% at the national level (Million et al., 2003). The other pathogenic cause of coffee tree death is root-rot disease which is caused by *Armillaria mellea* (Eshetu et al., 2000).

Coffee leaf rust is observed to attack coffee trees in some lowland areas such as Tepi and Bebeka in the southwest part of the country and Harerghe coffee in eastern Ethiopia, although it is not a serious problem (Eshetu et al., 2000). Over 45 species of arthropods are known to attack coffee plants in Ethiopia, where Antestia (*Antestiopsis intricata*) and Bloch Leaf Minor (*Leucoptera caffeina*) are the main insects, which are found mostly in low and medium altitude coffee growing areas, particularly in the large-scale coffee farms in Tepi and Bebeka (Million, 2000). They ultimately damage the coffee beans, which then drop to the ground.

The strategies adopted to reduce the yield losses especially due to CBD in Ethiopia were the use of chemical spray as a short-term strategy and development and dissemination of resistant cultivars that are adaptable to different coffee growing agro-ecologies as a long-term strategy. Since CBD has been the most important factor limiting coffee yield in Ethiopia in the last three decades, much of the national coffee breeding effort has been in the development of coffee planting material that is resistant to CBD. Since the termination of smallholder agricultural input subsidies in 1994, the use of chemical spray became an unprofitable operation because of increasing price of the chemical (Jirrata and Assefa, 2000; Yilma et al., 2000). Therefore, the long-term strategy for controlling the disease called for development and use of disease-resistant planting material.

Coffee breeding in Ethiopia has been undertaken by the Ethiopian Agricultural Research Organization (EARO) at the Jimma Agricultural Research Center (JARC), which was established in 1967 mainly to address the CBD problem. The coffee breeding activity is targeted to improve planting material that can cope with different production impediments and satisfy consumer quality parameters. To this end, use of WCP and collection of coffee germplasm will be a continuous process. In a selection program initiated in 1973, 1303 CBD resistant mother trees were identified, and 276 were identified to be promising, and finally 15 effective CBD resistant cultivars with satisfactory yield potential were approved and released to users (Bayetta et al., 2000). These improved coffee selections now cover about 20% of the coffee farms in Ethiopia (Bayetta et al., 2000). There are only two hybrids of coffee cultivars that have been developed to date that are not yet disseminated to the users.

The success in the breeding process is due to the presence of certain wild coffee trees that are naturally resistant to CBD. Coffee research experience at JARC confirmed the presence of diverse coffee genetic resources in Ethiopia that can help to develop cultivars with desirable traits like yield, quality and CBD resistance (Bayetta and Mesfin, 1986; Bayetta et al., 2000). It is important to note that most or all of the CBD-resistant mother trees were collected from the WCP in the southern and southwestern part of the country (Appendix 4A Table 1).

As the coffee cultivars that are developed at the research center are location specific and are observed to be poor performing when planted out of their recommended agro-ecology (Negash and Abate, 2000) together with the occurrence of other coffee diseases like CWD and the demand for better quality coffee by consumers, the use of wild coffee germplasm will be inevitable. Assessment of these value indicators is focused here to show the magnitude of the benefits and thus the implications for sustainable use and conservation of the resources.

4.3 Methodological framework

Separating the exact contribution of germplasm to a particular modern variety is not a simple task for different reasons: first, the genetic resources are seldom traded, especially in developing countries (Pearce and Moran, 1994; Cromwell, 1999; Gollin, undated). Second, the embodied or future value of the resource is unknown or unobserved (Kaplan, 1998). However, it is possible to value such resource using methods focusing on the value of genetic enhancements or on the value arising from both the genetic material and its use by breeders (Thirtle, 1985; Evenson and Gollin 1997; Rubenstein et al., 2005). Yield gains are then a result of contributions from conservation, collection and exchange of wild material, and public and private investments in a breeding process (Frisvold, 1999). The potential for developing improved planting material out of the WCP can be substantiated by the already observed valuable coffee selections and the presence of genetic diversity in the wild Arabica coffee populations (Shiferaw et al., 1989; Demil, 1999; Pawlos and Demil, 2000).

The value of the wild coffee genetic resource can be viewed, first in terms of the value of the wild coffee planting material used by the local community (Guinand and Dechassa, 2001; Deginet, 2005), and second as the yield gains due to adoption of improved coffee selections selected from the wild coffee germplasms, which have been disseminated in the past. The first method estimates the potential values of the wild coffee genetic resource through estimating farmers' willingness to pay for the improved coffee planting material in the different communities with and with out the WCP.

The willingness to pay for the improved coffee planting material as the potential value of such non-traded goods as genetic resources is approached using the stated preference method that approach the monetary value of the resource through the attributes that explain the resource (Birol, 2002). It assumes that the respondants have full information on the resources. Accordingly, the estimation here follows both estimation of the local coffee producers' willingness to pay for improved planting material and assessing the yield increments due to adoption of improved coffee planting material. Choice modeling, as the most common method of the stated preference methods, is employed to estimate the ability and willingness to pay for such valuable products by the local coffee producers both in the forest communities and in a typical coffee producing area where there is no forest land with the WCP.

Choice modeling:

Choice modeling is one of the stated preference methods of valuation that encompasses a range of approaches. The general model of choice is based on the assumption of the rational behavior of individuals that render to choose among alternatives the one that maximizes their utility function (Alkerov and Monjardet, 2002; Bentham, 1970). It is conducted by assessing the willingness to pay for the provision of alternative goods or services (Birol, 2002; Relay, 2002). The modeling is based on the Lancaster's theory of demand where consumers have preferences for goods and services, and derive utility from the underlying attributes characterizing them rather than the commodity per se. Choice modeling assumes non-separation of taste and preference from components defining the goods or services, random components that are serially uncorrelated, fixed utility parameters, and unobserved heterogeneity (Lovouire et al., 2000; Lancaster, 1991). It also assumes that the goods or the services are easily understandable (FAO, 2000).

The model relates the probability of a choice outcome to the utility associated with alternatives, and the utility of each alternative to a set of attributes that determine the utility of alternative choices (Lovouire et al., 2000). The procedure of valuation is such that compensating or equivalent variation of both the individual attributes and the goods in question are derived from the choice data set that is ultimately used as the demand function for the commodity in question.

The origin of choice modeling is in the field of marketing. It was initially applied in the field of transport and subsequently applied in environment and health economics. Scarpa et al. (2001) used choice modeling to compare the value of different breeds of pigs in Mexico based on attributes that characterize them. Ruto (2005) also used the method to assess the value of an indigenous breed of cattle in Kenya to support decisions on conservation of the genetic resource. It was also used to develop farmer payment systems in a Scottish agro-environmental scheme in return for adoption of conservation practices, to investigate consumer preferences of genetically modified foods and to estimate social benefits of reducing GMO contents in food by Kontoleon et al. (2002) as noted in Birol (2002). Moreover, in environmental economics, choice modeling has been used to estimate willingness to pay or accept wetlands protection in Australia (Morrison et al., 1998), deer hunting in Scotland (Bullock et al., 1998), rock-climbing in Scotland (Hanley et al., 2002), and river water quality improvements in England (Georgiou et al., 2000).

The major limitations of choice modeling, which are mainly due to the stated or contingent nature of the technique, include the possibility for respondents to be biased in relation to their relative understanding of the goods and services or their deliberate valuation with respect to what they wish, rather than a utilitarian approach, and the challenge of providing respondents with complex information in a manageable format, and biases in selecting respondents (Lancsar, 2002).

The estimation procedure of the WTP is such that assuming a random utility theory, the unobservable utility of household i for good j, U_{ij} is decomposed into a deterministic component V_{ij} , which is an indirect utility function of the choice attributes as well as the decision maker's characteristics, and a random error component, ε_{ij} (Lancsar, 2001), as in Equation 4.1.

$$U_{ij} = V_{ij} + \varepsilon_{ij} \quad .... \quad .... \quad .... \quad (4.1)$$

Based on the equivalent variation (EV) theory, the WTP is defined as the amount that has to be taken away from the person's income for a change in the level of a good or service while keeping his utility constant. Its mathematical presentation is as in Equation 4.2 below.

$$V\left(Y - WTP, P, q_1 ; Z\right) = V\left(Y, P, q_0 ; Z\right) \quad .... \quad (4.2)$$

where V denotes the indirect utility function, Y is the vector of individual income, P is vector of prices faced by the individual, and q_o and q_1 are the initial and improved levels of the good or quality indexes (with $q_1>q_o$,) (FAO, 2000). Assuming a linear functional form, the systematic representation of the indirect utility function, V_{ij}, can be presented as in Equation 4.3.

$$V_{ij} = \beta^{\tau} X_{ij}^{\tau} + \gamma^{\psi} Z_i^{\psi} \quad .... \quad .... \quad (4.3)$$

where X_{ij} is the vector of attributes of the product, Z_i a vector of the personal characteristics of the individuals, and β and Υ are the respective coefficients of choice attributes (τ) and personal characteristics (ψ).

Although the fixed nature of individual specific variables across choices precludes their direct inclusion in the model, recent studies have shown flexibility of choice modeling to incorporate such variables by interacting with choice attributes or generic variables (Greene, 2003). Using a conditional logit specification as the best representation of the distribution of the choice probability, the probability that household i choose good ℓ, $\Pi_{i\ell}$

is specified as in Equation 4.4.

$$\Pi_{i\ell} = \frac{\exp(V_{i\ell})}{\sum_{j=1}^{n}\exp(V_{ij})}, \quad j, choices = 1,2,.., \ell, ..., n \; .... \; ... (4.4)$$

Then, the equivalent variation (EV) due to the change in the quality of the choice alternative can be derived from the logit function as in Equation 4.5 below.

$$EV = \frac{1}{\lambda}\left[\ln \sum_{j=1}^{n} e^{v_j^0} - \ln \sum_{j=1}^{n} e^{v_j^1}\right] \; .... \; .... \; .... \; .... \; .....(4.5)$$

where, λ is marginal utility of income or money derived as a negative of the price coefficient in the logit model, and $\ln \sum_{i=1}^{n} e^{v_j}$ is the inclusive value or the expected value of the maximum utility of alternative choice j; the compensating variation considers the change from the initial condition V_j^0 to the new condition of the good V_j^1 (Louviere et al., 2000). Accordingly, the method is used here to estimate the value of improvements in coffee planting materials.

The choice experiment:

In Ethiopia, there has not been a market for coffee planting material, as the government was undertaking the supply of the material to the producers. The improved coffee cultivars that were developed in research centers have been distributed predominantly by the Ministry of Agriculture (MOA). Since 2000, the system has changed in that private individuals or groups have been involved in multiplication and distribution of coffee planting material as they have obtained the coffee seeds from the research center. Yet, there is no regular supply of such material, neither from the government nor from the private seedling distributing agents. The government used to supply the planting material at a value of Birr 0.16 to 0.25 per a coffee seedling, on a credit basis, although majority of the farmers just did not pay at all or the material was provided as a subsidy. Currently, the system cannot supply sufficient planting material to the farmers. The unit price of the planting material supplied by private individuals reached 0.50 to 1.00 Birr, especially in the major coffee producing region.

The experiment was carried out in the Geba-Dogi and Berhan-Kontir forest coffee communities, and in the Gomma district in the Jimma zone. The first two sites represent areas with WCP, while the latter represents typical coffee producing communities in the country in terms of both production constraints and significance of coffee to smallholder farmers. The sites were selected to represent the ranges of values at areas with and without the WCP and areas with different levels of coffee production constraints.

The experiment began with preliminary information on important attributes of coffee planting material. The information was obtained from secondary sources and exploratory surveys as these methods are commonly used to specify important attributes and their levels (Adamowicz et al., 1998b). Preliminary information on vital attributes of coffee planting material that are considered by the coffee producers and ranges of the farmers' ability and willingness to pay for improved coffee planting material was collected through group discussions. Although a number of coffee planting material attributes for selecting planting material can be mentioned like yield, disease resistance, yield stability, environmental adaptability, marketability, fertilizer requirements (Edilegnaw, 2004), the most important attributes are those factors that determine the yield levels. The marketability and fertilizer requirement attributes are less important as the coffee marketing is not discriminated by variety types, and application of fertilizer is not a basic practice for coffee farmers in Ethiopia, which again is not necessarily variety specific. Accordingly, resistance to CBD and CWD, vigor nature and price were found to be the most important attributes in Geba-Dogi and Gomma, while resistance to CBD was replaced by resistance to rust in Berhan-Kontir (Table 4.1), since CBD is relatively less important in that area. All the attributes except the price have two levels, i.e., whether the product is resistant or not to the diseases and whether it is vigorous or not.

The price attribute is set to have three levels in the different sites as indicated in Table 4.1. Due to differences in the nature of the local alternative coffee planting material and severity of coffee production threats, farmers in the different communities stated different levels of willingness to pay for improved coffee planting material. In each community, the three levels of the price attribute are set in such a way to include the possible ranges of farmers' willingness to pay.

Accordingly, the levels are set as the maximum amount a farmer is willing to pay for planting material with all attributes having the required level, an average willingness to pay for improvements in one or more of the attributes, and a minimum amount a farmer is willing to pay for improvements in one of the attributes.

Table 4.1 Attributes of the coffee planting material

Attribute	Level	Description
Resistance to CBD	2	Resistant to CBD, or not resistant to CBD
Resistance to CWD	2	Resistant to CWD, or not resistant to CWD
Resistance to rust	2	Resistant to rust, or not resistant to rust
Vigor	2	Vigorous, or not vigorous
Price	3	100, 250 and 400 cents for highland Gomma, 50, 100 and 250 cents for mid-altitude Gomma, and free, 15 and 25 cents for Geba-Dogi and Berhan-Kontir

Fractional factorial design is used to minimize the number of profiles. Based on this, 15 scenarios were selected out of 24[20] that can be obtained by combination of the three attributes with two levels each and the price attribute with three levels. Although there is no consensus as to the number of profiles (Louviere et al., 2000) in general, the experiment here was limited to a two-choice form comparing the profiles representing improved planting material and the local planting material. A random selection of 100 farmers in the Geba-Dogi community, 88 farmers in Berhan-Kontir and 54 farmers in Gomma were considered for the analysis, which made the total number of observations to be 1500, 1320 and 810, respectively, for the three sites. In order to see the effect of variation in Gomma due to variations in terms of altitude, the sample is divided into 510 and 300 observations, respectively, for the higher and lower altitude area.

After rearranging the scenarios in a manageable format such that the presentation was understandable and ensured a consistent response, the respondents were asked to choose between the planting material presented in the scenarios, which had certain positive quality

[20] The total number of combinations out of the three attributes with two levels each and one attribute with three levels is determined as: 2^3*3^1, i.e., 24.

improvements, and the local alternative coffee planting material that the producers can obtain freely. Information on how the farmers perceived the alternative coffee planting material in terms of the quality of attributes is considered. The local alternative coffee planting material refers to the coffee seedlings that are grown and developed under old coffee trees or local coffee seedlings transplanted or raised by the farmers. The experience of the coffee farmers in using coffee cultivars developed by research centers and the fact that the farmers have been producing more coffee than any other crops in the area facilitated understanding of the nature of the scenarios in the experiment.

The willingness to pay for improved material is expected to be positively associated with the probability of having positive disease resistance qualities and vigorous nature, since these attributes are associated to the fruit bearing ability of the coffee tree. The price attribute, however, is expected to associate negatively with the probability of choices as the law of demand suggests. In addition to the choice-specific variables, some variables that vary from individual to individual, namely age (in years), education level (in years of schooling), area of improved coffee and area of maize farm, are considered.

4.4 Results and discussion

4.4.1 Farmers' use of wild coffee planting material

Coffee is the most important crop and forms the livelihood of the households in the study areas, accounting for about 74%, 61% and 55% of households' farmland areas, respectively, in the Berhan-Kontir and Geba-Dogi forest communities, and the Gomma district. In addition to the wild coffee harvest, farmers living near the forest use the WCP as a source of coffee seedlings. About 85% and 22% of the coffee seedlings planted in the last three years around Berhan-Kontir and Geba-Dogi forest communities, respectively, were wild coffee seedlings (Figure 4.2).

Coffee planting is a continuous activity where coffee farmers replace dead trees, periodically replace old coffee trees by new ones, or expand their coffee farms. On average, farmers plant about 255 to 600 coffee seedlings each year (Appendix 4BTable 1).

Figure 4.2 Wild coffee seedlings

Since the coffee production system is constrained by different threats, the coffee planting material must have certain attributes. Especially resistance to CBD, CWD, rust and drought, the vigorous nature of the coffee tree, years of bearing, survival rate of seedlings and cup quality are important, although farmers weigh each attribute differently (Table 4.2). The importance of resistance to CBD and CWD is reflected more by farmers in Gomma than farmers in the forest communities, as they are the most important attributes with respect to selection of coffee planting material.

Table 4.2. Importance of different coffee seedling attributes in selecting planting material (in % of total responses)

Attribute	Gomma		Geba-Dogi		Berhan-Kontir	
	Important	Not important	Important	Not important	Important	Not important
CBD resistance	96.7	1.6	72	28	54	37
CWD resistance	85.4	13	41	59	77	18
Rust resistance	14.5	82.3	12	88	89	7
Drought resistance	64.5	34	45	56	98	2
Vigor	85.5	13	85	15	100	0
Years of bearing	82	16	49	51	100	0
Survival rate	75.8	22.6	52	48	98	1
Cup quality	58	40.3	33	68	92	8

Note: The difference between the summations of percentages from 100 refers to the ‘don’t know’ option.

According to the farmers' perception, the quality of coffee seedlings developed at research centers and the locally grown seedlings are different in terms of their quality attribute as indicated in Table 4.3. While local planting material is observed to be better in terms of -

Table 4.3. Farmers' response about different coffee seedlings for resistance to diseases and content of acceptable quality attributes (in % of total responses for each attributes)

Site	Gomma		Geba-Dogi		Berhan-Kontir	
Attribute	Seedlings from research**	Local seedlings	Seedlings from research	Local seedlings	Seedlings from research	Local seedlings
CBD/Rust resistance*	79	14.5	77	29	1	1
CWD resistance	24.2	25.8	8	33	2	3
Drought resistance	19.4	72.6	6	59	14	26
Years of bearing	14.5	95.2	2	81	9	30
Vigor	51.6	72.6	23	81	16	26

* Rust refers only to Berhan-Kontir site

** Seedlings from research station refer to the coffee selections developed by JARC

drought resistance, vigor and long years of bearing, the seedlings distributed by research centers are better in terms of CBD resistance. For example, about 79% of the farmers in the Gomma district respond that the coffee seedlings from the research center are resistant to CBD, while the rest 21% respond against resistance. Farmers' preference of the seedlings among alternative types considers the fulfillment of the vital attributes with respect to the most important yield limiting factors, especially the CBD.

4.4.2 Regression results of the choice model

The regression results of the conditional logit model are presented in Table 4.4. The dependent variable in all cases is the probability of choosing the improved planting material over the local alternative. The model was employed in its relaxed form to consider individual specific variables that can explain the probability of choice. The individual specific variables were incorporated by interacting with an alternative specific constant referring to the choice of improved material. The diagnostic measures of the regressions are significant as reported in Table 4.4.

The model depicts the relative importance of the choice-specific attributes in the probability of making choices. The results indicate that all four choice-specific attributes are significantly important for preference except the attribute vigor nature in the Gomma mid-altitude case. The direction of the effect of these attributes on choice probability is also as it was expected, where the probability of choosing the improved material is inversely related with the price attribute and positively related to improvements in material quality with respect to resistance to CBD, CWD, and rust or to the vigor nature of the planting material.

Table 4.4 Determinants of the choice probability for improved coffee planting material

Attribute	Gomma high-altitude		Gomma mid-altitude		Geba-Dogi forest community		Berhan-Kontir forest community	
	Coefficient	Prob	Coefficient	Prob	Coeficient	Prob	Coefficient	Prob
Vigor	1.66	.000	.370	.114	.110	.019	.724	.000
CWD	1.60	.000	.888	.000	.297	.060	2.61	.000
CBD	4.67	.000	2.272	.000	1.221	.000	-	-
Rust	-	-	-	-	-	-	2.34	.000
Price	-.008	.000	-.0144	.000	-.069	.000	-0.116	.000
Education level (years)	.088	.070	-	-	-	-	0.105	.000
Age	-.023	.020	-	-	-	-	-	-
Area of Maize farm	-	-	-.548	.040	-	-	-	-
Area of Coffee farm	-	-	-.446	.140	-	-	-	-
Native ness of household	-	-	-	-	-.221	.100	-	-
Area of improved coffee	-	-	-	-	.344	.000	1.34	.000
Constant	-2.07	.002	-.671	.210	-.445	.007	-3.66	.000
No. Observation	510		300		1500		1320	
CHI_SQ(6);Prob[Chi.Squ>Value]	253.89; Prob=.000		79.56; Prob=0.000		267.88;Prob=.000		510.9; Prob=.000	
LL	-192.6		-145.95		-831.53		-553.41	
Adj.R^2	.45		.28		.20		.39	
Overall Correct Prediction percent	76		68		63		73	

Note: The dash symbols indicate that the respective variables are excluded in the analysis because of their insignificant nature

Source: Own estimation

Among the explanatory variables, resistance to CBD is the most significant attribute, as it is the most important coffee yield limiting factor in the study areas. Resistance to CWD is the second most important attribute, as the disease has become very severe in all coffee growing areas, while it is the most important attribute that determines the choice probability in the Berhan-Kontir forest communities (Table 4.4).

The analysis of the choice model across locations indicates that, based on the contribution of the different attributes to the utility, farmers outside the forest-based coffee systems, i.e., in Gomma district, are less sensitive to price since the coefficient of the price attribute is less in both the highland and the mid-altitude areas as compared to that of the forest communities, which can imply a higher demand for the improved planting material in the former cases that can be associated to the severity of the coffee production threats that the farmers are facing.

Household-specific factors determining the choice probability

The probability of choosing the improved planting material, and then of its willingness to pay varied among the sample farmers in different locations and among farmers in the same community. Results of the choice model indicate that farmers in the highlands areas were willing to pay more than those in the lowlands. Information on the conditions or attributes of households or their farm characteristics can be indicative of the variations in their willingness to pay and helps to understand the conditions that force them to pay a high or low price. The factors may be temporary or long-term attributes, which may be attached to the location, the farming system or demographic factors. The effect of such variables could thus influence the values of the genetic resource in terms of the extent or scale of value estimates, and thus needs to be conceptualized in the design of conservation strategies. These important variables are discussed as follows:

1) Cultivation area of improved coffee selections

The cultivation area of improved coffee farm land at the household level is significantly associated to the probability of choice of improved planting material as indicated in the model results (Table 4.4) for the Geba-Dogi and Berhan-Kontir communities. The percent coverage of improved coffee cultivars in these two sites is 34% and 3.5% out of their total coffee farm respectively. Farmers who have a larger area of the CBD resistance cultivars are willing to pay more than those with smaller areas.

Since coffee is the major crop on which most farmers depend for their livelihoods, with a share of 74%, 61% and 55% of the household farm size for the Berhan-Kontir, Geba-Dogi and Gomma sites, respectively, food insecurity is more associated with the ups and downs in the returns from coffee production. Coffee productivity in Ethiopia in general is very low as compared to the world average and can be attributed partly to diseases and the low input production (Yilma et al., 2000) leading to a national average of 471 kg per hectare, while the world average ranges from 500 to 600 kg per hectare (Kemal et al., 2000). As in the Gomma areas, due to the lower productivity of the local coffee coupled with the scarcity of farm land, most coffee farmers are interested in keeping a high yielding coffee farm and look for a quality planting material to maximize coffee returns.

2) Maize farm size: The area of the maize farm at the household level is found to be negatively associated to the choice or probability of improved material as was the case in mid-altitude Gomma (Table 4.4). Those farmers who allocated a larger area for maize cultivation attached less value to the improved coffee planting material. This could partly be explained by the fact that the farmers considered maize cultivation as an alternative means of addressing the household food problem, and such farmers tended to reduce their investment on technologies for improving coffee yield. Households with a larger area of maize cultivation are relatively more secure in terms of food when the prices for agricultural products fall, since maize is the staple food item in the study areas and is less affected by diseases when compared to coffee.

3) Education and age: The education level of the household head is found to be positively and significantly associated to the WTP for the improved material (Table 4.4). The effect of age level of the household head is such that younger household heads are willing to pay more than older heads, which may be due to the higher value they attach to the future, i.e., they expect more returns in the future, or to the relatively higher education levels that the younger household heads have[21].

---

[21] Results of simple Pearson correlation coefficient tests indicate that age (in years) and education level of the household head (in years) are significantly and negatively associated with -.43 and -.45 statistics, both significant at 0.01 levels, respectively, in the Berhan-Kontir and Geba-Dogi communities.

Elasticity of the probabilities due to change in the levels of the variables can be used as a supplement for comparing coefficients in the different models (Adamowicz et al., 1998b). Accordingly, at it is shown in Table 4.5, elasticity of the probability of choosing the improved product due to 10% change in the levels of CBD attribute is about 17% in the Gomma highlands and 9% in Gomma mid-altitude, while it is about 5% in the Geba-Dogi forest community, which indicates that the importance of resistance to the CBD attribute decreases moving from the less forest based system (Gomma) to the forest-based coffee system (Geba-Dogi).

Table 4.5. Elasticity of attributes on the probability of choosing the improved material due to a 1% change in the level of the attributes

Attributes	Gomma highland	Gomma mid-altitude	Geba-Dogi	Berhan-Kontir
Vigor	0.56	0.14	0.04	0.27
CWD resistance	0.68	0.39	0.13	1.19
CBD resistance	1.69	0.91	0.49	-
Rust resistance	-	-	-	0.85
Price	-1.31	-0.95	-0.61	-1.12

Source: Own calculation

Results of the marginal rate of substitution of choice-specific attributes over the price attribute indicate that the farmers' willingness to pay in terms of the attributes of improved products is higher in the area without the WCP than in that with the WCP (Table 4.6). The willingness to pay of the farmers in the Geba-Dogi community is lower, which is associated with the lower severity of coffee diseases, and/or the local planting material, which is better in terms of quality. The level of the three vital attributes of the local alternatives is indeed better in the forest-based coffee populations (Appendix 4B Table 3). The marginal willingness to pay[22] for the CBD

[22] The marginal rate of substitution between one attribute and the price attribute is interpreted as the marginal willingness to pay. Marginal willingness to pay is calculated as the ratio of the coefficient of an attribute to that of the price attribute. That is the ratio of $\frac{\partial V_{ij}}{\partial X_j^{\tau}}$ to $\frac{\partial V_{ij}}{\partial X_j^{p}}$, which is equivalent to the absolute value of the ratio of the coefficients of attribute τ to that of the price attribute, where V_{ij} is the indirect utility function, X_j^{τ} refers to attribute τ of choice j and P refers to the price attribute.

attribute is highest in the Gomma highland with 5.75 cents and lowest in Geba-Dogi with 0.17 cents (Table 4.6).

The farmers in all the study areas were willing to pay more for CBD resistance than for CWD resistance or the vigor nature. This is consistent with the fact that CBD is still the most important disease constraining coffee production in most coffee growing areas in Ethiopia. Resistance to CWD is the second most important attribute followed by the vigor nature of the coffee trees, which is associated to the yielding potential of the coffee tree.

Table 4.6. Marginal willingness to pay (in cents) for the attributes

Attributes	Gomma highland	Gomma mid-altitude	Geba-Dogi	Berhan-Kontir
Vigor	2.04	0.26	0.016	0.062
CWD resistance	1.96	0.61	0.043	0.226
CBD resistance	5.74	1.58	0.176	0.203

Source: Own estimation

The most important result of the conditional choice model estimation is the mean welfare effect due to the improvements in the quality of the planting material with the possible price levels attached to them. It is estimated as the overall mean value of farmers' willingness to pay for the improved nature of the planting material, as shown in Table 4.7.

Table 4.7. Magnitude of the willingness to pay (cents) due to improvements in the quality of the planting material in the different places

Scenario	Gomma highland	Gomma mid-altitude	Geba-Dogi	Berhan-Kontir
Overall mean value[23]	303	90	15.85	7.38
Accepted level of improvements over average local *	606	163	11.45	38.5

Source: Own estimation/calculation

* Derivation is based on the levels of the chosen improved alternatives. The change in the equivalent variation, ΔEV due to improvements in the quality of attributes is calculated as in Rolf et al. (2000) as: $\Delta EV=(-1/\beta p)(\Delta Ai * \beta i)$, where βp refers to the coefficient of the price attribute in the choice model; ΔAi, the change in the quality levels of attribute i.

The mean value due to improvements in planting material on average is 303 cents for the Gomma highland, 90 cents for the Gomma mid-altitude 15.87 cents for the Geba-Dogi and 7.38 for the Berhan-Kontir sites (Table 4.7). This refers to the mean willingness to pay for average levels of improvements in quality of the attributes as presented to the farmers determined with their respective choice probabilities. Most farmers in the forest communities, i.e. the Geba-Dogi and the Berhan-Kontir sites, preferred the local alternatives, while the farmers in the Gomma district preferred the improved alternatives.

The values 303, 90, 15.87 and 7.38 cents are the sum of the contribution of the wild materials, the experts' value in selection or breeding process and dissemination of the materials to the users. These aggregate values projected for certain time horizons at the national level indicate the level of investment that can be made for conservation of the wild material and the supply of improved planting material. In addition, although it is not easy to perfectly determine the contribution of the wild populations to the improvements in the planting material, the approximate cost of breeding and dissemination of the coffee planting material is deducted from the total value attached to a planting material to derive the contribution of the wild material. The lower willingness to pay for the improved planting material by the farmers in the areas with the WCP than the areas with out the WCP indicates that the local freely available planting material in the former case has certain levels of the vital attributes over those in areas with out the WCP.

[23] The average willingness to pay due to the improved nature of the planting material is estimated based on Equation 4.5, as the equivalent variation due to the change in the quality of the improved planting material over the local alternative planting material.

The mean WTP for the improved products with an acceptable level of attributes could be as high as 606, 179, 11.45 and 38.5 cents, respectively, for the Gomma highland, the Gomma mid-altitude, the Geba-Dogi and the Berhan-Kontir sites. In this case, the value is higher, because the valuation is made only for those products that are acceptable to the farmers.

It can therefore be assumed that the coffee producers are the primary victims of the loss of diversity in the coffee genetic resource, as this can be used as a source of improvements in the quality of the vital coffee planting material attributes. As long as the coffee producing farmers in Ethiopia do not have resistant planting material on their own farm, they will continue relying on the development of improved cultivars. This raises the issue of the level of investments on conservation of the diverse coffee genetic resources and breeding activities. Aggregate values due to improvements in the quality of the vital attributes is therefore a vital aspect to be considered in the decision to conserve the resource at least because of the agricultural values that can be expected from the genetic resource of the WCP.

Aggregate values of improvements in the genetic content of coffee planting material

Aggregating the value of such natural resource could give certain motivation to the decision process of conservation and use strategies. The aggregate value of improved coffee planting material in terms of smallholder coffee producers' willingness to pay for such improvements in Ethiopia can provide insight into the projected value of the resource on a domestic level.

The household demand for coffee planting material is estimated using the 3-year average of the observed number of coffee planting material used by the coffee producers who have already established coffee farms (Appendix 4B Table 1). Out of more than 950,000 coffee producing smallholder farmers in Ethiopia (Kohli, 1981), 825,669 of them are in the main coffee producing regions (Oromia region, SNNPR and Gambella region (MOA, 2003). The required annual number of coffee planting material, i.e., the coffee seedlings, in these regions is more than 247 million, which are planted for replacing the coffee trees that have died due to drought, disease or other factors, and for new plantations, as a household on average used to plant more than 300 seedlings per year.

The yearly demand for planting material is assumed to be homogeneous, as the sample farmers have always been typical coffee producers. The demand for coffee planting material is expected to be less as the improved nature of the material can reduce the risks of wilting that demand certain number of seedlings for replanting (Appendix 4BTable 2). This is adjusted with respect to the percentage of the wilting rate of the improved planting material over that of the local material. The mean value of the improved planting material is multiplied by the adjusted number of coffee seedlings needed per year, and then nationally aggregated by multiplying the results with an estimated number of coffee producing households.

Based on the mean value of a coffee planting material, a coffee farmer is willing to pay about Birr 458.80 or € 41.70[24] per year for coffee seedlings. This value is the contribution of the genetic resource and the costs of breeding and dissemination of the improved planting material to the users. The aggregate value of this total sum for the total coffee producing households in the country indicates the potential value attached by the coffee producers for the conservation of wild coffee genetic resource, breeding and dissemination of improved coffee plangent material. The discounted net present value of such an aggregate value for the 825,669 coffee producing households in Ethiopia in thirty rears period amounts to about Birr 7425 million or € 675 at 3% discount rate, Birr 5823.70 or € 529.40 at 5% discount rate, and Birr 3571.30 or € 324.60 at 10% discount rate.

The contribution of the wild coffee genetic resource per unit planting material is calculated by deducting the approximate cost of breeding and dissemination per planting material. Based on 29 years data on the plantation of improved coffee (See Appendix 4c Table 6 and 7), which is estimated to cover about 76147 ha with about 338397268 plants, the cost in real terms of breeding and dissemination per seedling is about Birr 1.50. This cost is considered as a

[24] In Ethiopia the exchange rate is determined through foreign exchange auction held weekly by the central bank. According to the case in 2005/2006 an exchange rate of Birr 11.00 per unit Euro is considered in this analysis.

maximum since it carries certain fixed costs like infrastructural expenditures and because of the possibility to multiply the improved cultivars in the future. The most common spacing of coffee planting, i.e., 1.5 meters by 1.5 meters dimension that gives out 4444 plants per ha is considered to determine the density of the coffee plants. Accordingly, it is estimated that farmers in the Gomma highland area are willing to pay about Birr 153 cents over the costs of breeding and dissemination (Table 4.8).

Table 4.8. Aggregate values (in cents) of improved coffee planting material

Sites		Gomma high land	Gomma mid-altitude	Geba Dogi	Berhan Kontir
1. Total annual coffee planting material required per Household					
	Improved coffee	175	118	26	26
a) Replanting	Local coffee	52	35	33	33
	Correction factor	0.24	0.16	0.20	0.20
	Adjusted number of seedlings	55	25	12	12
b) New plantation		188	125	33	33
c) Total annual coffee planting material required per household		416	236	229	229
2. Estimate of the WTP based on average level of improvements in the quality of the material					
a) WTP (cents per unit planting material)		303	90	15.8	7.38
b) Annual value per household (cents)		126048	21240	3634	1690
c) Average annual value per household in the major coffee growing areas*(cents)		45884			
3. Contribution of the WCP as the difference between the value in 2a above and the cost of breeding and dissemination per seedling**					
a) Value per planting material (cents)		153	0	0	0
b) Annual value per household (cents)		63648			
c) Average annual value per household in the major coffee growing areas*(cents)		14639			

* The average value per household is derived for the major coffee growing regions by giving weights for the location groups referring the proportions of the different coffee systems in the country. A proportion of 10% is considered for the forest coffee systems as it is the same at national level, that of the highland type is considered to be 23%, and the rest 67% is considered to be a mid altitude system.

** Based on the past 29 years data, the average cost of breeding and dissemination per seedling is about Birr 1.50.

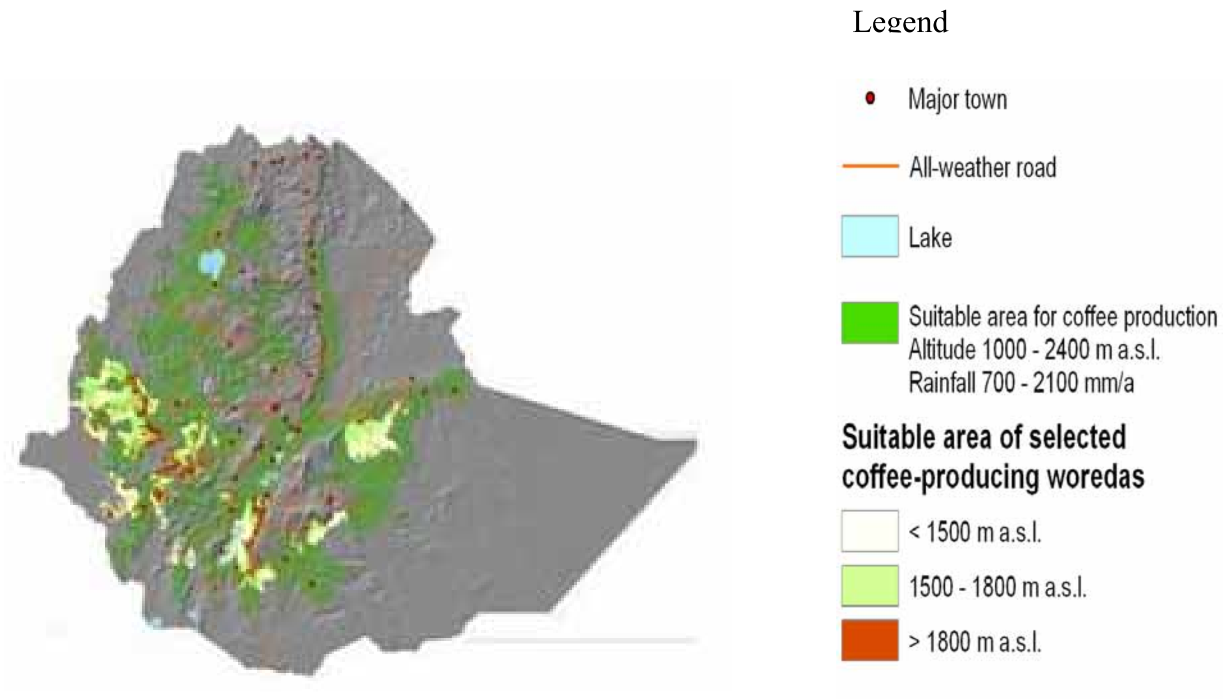
The estimate for the contribution of the WCP per coffee producing household is about Birr 146.40 (or about € 13.30 based on the current exchange rate). The nominal annual aggregate value for the major coffee growing regions in Ethiopia is about Birr 120 million. This equals Birr 2,369 million (€ 215.36 million) based on a discount rate of 3% in thirty years, Birr 1858 million (€ 168.90 million) based on a discount rate of 5%, and Birr 1139 million (€ 103.55 million) at a discount rate of 10% in thirty years.

Although the level of the discount rate significantly influences the value, a 5% discount rate may be more appropriate[25]. In the end of chapter six, this value of the wild coffee genetic resource, which may be obtained with the maintenance of the diverse coffee populations in southwestern Ethiopia montane rain forest land, is compared with the value of agricultural return from cultivation of the forest land that contains the WCP, as the alternative land use system at the local level. This forms the opportunity cost of preserving the wild coffee populations in situ.

According to the categorization based on suitability for production, Ethiopian coffee producing regions are categorized such that about 23% of the area is found to be above 1800 meters above sea level (masl); about 41.45%, between 1500 and 1800 masl, and the rest 35.6% in lowlands below 1500 masl (Figure 4.3).

[25] The economy of the country is growing at rates from 3 to 7% in the last few years. And the cost of capital is also reduced to about 7.5% from 10.5% that has stayed for about ten years.

Figure 4.3. Suitability of the areas for coffee production in Ethiopia

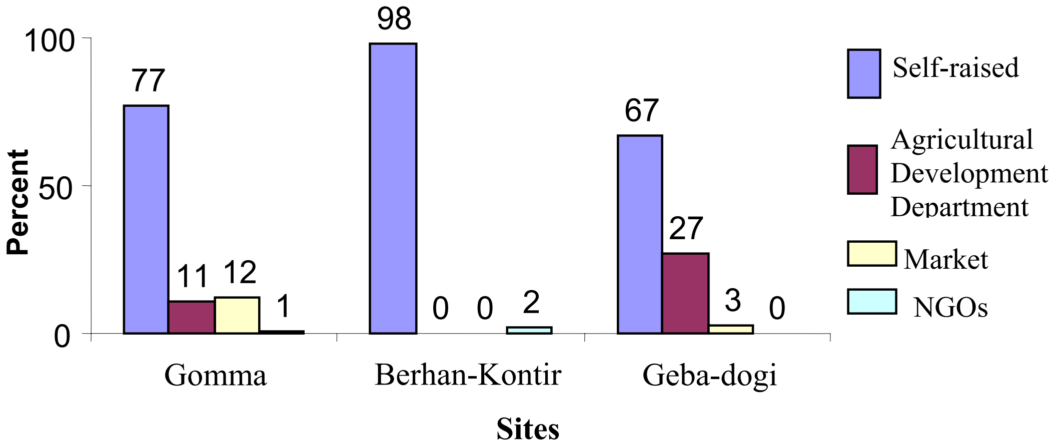


4.4.3 Value of the CBD-resistant cultivars in the past

The coffee berry disease has been the major disease in the coffee production system. The chemical spray method of controlling CBD is no longer applied in Ethiopia due to the cost of the chemical that make coffee production unprofitable relative to other crops like maize (Yilma et al., 2000). However, it was considered in Ethiopia as a short-term strategy and used intensively especially in the first half of the 1990's. Although about 74% and 37% of the sample farmers in the Gomma and Geba-Dogi forest communities, respectively, had experience with the chemicals, this type of CDB control is no longer practiced as the subsidy scheme ended in 1994. As a result, about 97% of the farmers in the Gomma and 99% in the Geba-Dogi forest community did not apply any CBD control chemicals between 1999 and 2003. Farmers in the area around the Berhan-Kontir community had no experience with the chemicals at all. However, the use of chemical inputs is in general not encouraged by the coffee development program, as it is assumed that better prices can be obtained on the world coffee market for chemical-free coffee produce.

As a long-term strategy, the use of CBD-resistant cultivars has been an important activity in the last three decades, and as a result a considerable area (more than 20% of the coffee acreage) is covered with these cultivars under the coffee improvement program (CIP[26]) of the Coffee and Tea Authority (CTA) and the former Ministry of Coffee and Tea Development (MCTD). Although self-raised seedlings are still the major source of coffee seedlings, especially in the Berhan-Kontir and Geba-Dogi forest communities, (Figure 4.4), about 74% of the seedlings in 2001 to 2003 in the Gomma district are improved seeds which are produced by research stations.

Figure 4.4. Share of the different sources of coffee seedling based on data over the period from 2001 to 2003



Most farmers in Gomma and the surrounding Geba-Dogi forest areas plan to increase the area of CBD-resistant cultivars (Table 4.9). The use of CBD-resistant cultivars has been increasing more than that of the local alternatives in Gomma, a typical coffee producing region in the country (Appendix 4BTable 1). Since coffee production is threatened by the disease in most parts of

[26] The coffee improvement program has been ongoing in four phases since 1977 and covers most of the activities for improving the coffee production systems in the country. The major financing body is the European Union.

Ethiopia, such disease-resistant cultivars are of great importance to the national economy and the livelihood of the coffee producers.

Table 4.9. Percent response on farmers' intent to change cultivation area of CBD-resistant cultivars

	Gomma	Geba-Dogi	Berhan-Kontir
To increase	78.7	55	15
To decrease	3.3	1	11
To keep as it is	16.4	44	74

Source: own survey

The adoption of the CBD-resistant cultivars benefited both households and the nation at large. The yielding potential of these cultivars has protected coffee farms from conversion into other crops, as was the case in the central and southern parts of the country. Since coffee is the major cash crop in most coffee growing areas, improvement in yields and thus income at the household level contributes to household food security and allows to higher expenditure on production inputs, education, health, etc. With the increase in the scale of coffee production, it is natural to expect employment of more people in the different pre- and post-harvest activities. The contribution of the exportable equivalent of coffee could also be a considerable source of foreign exchange in Ethiopia.

The production effect of these cultivars over the associated costs is estimated here for the period from 1977 to 2001, i.e., since the beginning of introducing the cultivars into the production system until the end of the first three CIP phases. The costs of collecting the parent material, selection and dissemination of the cultivars to the farmers are considered. It is a partial analysis of the observed yield gains due to adoption of the CBD-resistant cultivars until 2001, although the yield gains could also continue in the future. Detailed information on the costs and the benefit streams is given in Appendix 4C.

Development of the CBD resistant cultivars began with a crash program to develop such material in the shortest time possible in order to lessen the effects of the disease. The program had a budget of Birr 100,000 annually from 1973 to 1976, and Birr 3.6 million from 1997 for collections and research activities (Van der Graaf, 1984). An evaluation of the mother trees and re-evaluation by planting them at research stations were made to screen for their resistance against the disease and for other attributes like yield and quality. In the process, 15 CBD-resistant cultivars were identified and disseminated to different parts of the country beginning in 1977 (Appendix 4C Table 1). Until 2004/2005, about 88,053 kg of improved coffee seeds were disseminated, expected to cover about 97,600 hectares. The breeding process has been continuing at JARC to screen the cultivars further for other diseases, pests and qualities. The continuous evaluation, selection and maintenance of the coffee collections has also incurred costs, i.e., for the maintenance of over 4643 accessions on 15.78 ha in different research stations under the JARC. The cost details based a 6-year average in an ongoing research experiment on a 2.21 ha plot are given in Appendix 4C Table 2.

After 1979, activities for improving the coffee production sector took place in the coffee improvement program (CIP) of the MCTD until 1994 and thereafter the institution is reorganized as the Coffee and Tea Authority (CTA) that operated from 1995 to 2004 in collaboration with the IAR (JARC) and Ministry of Agriculture. The CIP budget included infrastructure development in the coffee growing districts, promotion of coffee production through expansion of disease-resistant cultivars and improved management of coffee farms, recurrent budgets for the coffee and tea development departments, equipment, training of managers, technical staff and farmers, etc. While the costs of the collection of the germplasm and the costs during the selection or research process are all considered, only part of the extension budget is associated to the CBD resistant selections. Based on information from coffee experts especially at district and zonal levels, a proportion of about 35% of the CIP expenditures approximates the share for the expansion of the improved cultivars. As the cultivars cover a small proportion of the coffee acreage (i.e., 20%), most of the investments made by the CIP had implications on the management of the coffee production system as a whole, and other agricultural activities in the CIP districts, as the MCTD was responsible to perform all agricultural activities in the respective target districts. The expenses incurred for different purposes including infrastructure, farmer and expert training, nursery establishments, equipment costs and running costs is given (Appendix 4C Table 3).

Since the experts at both zonal and district levels perform different activities in addition to expansion of the improved cultivars, about 20 to 30% of their labor time is assumed to be associated with the activities of disseminating the improved cultivars (Appendix 4C Table 4). The implementation of the CIP activities was hindered by a repeated change in the structure of the administrative regions due to the change in the regime and changes in the structure of the implementing institutions, i.e., the establishment of the CTA as a result of the restructuring of the MCTD in 1998, which led to additional costs.

Although the on-farm average yield of the CBD-resistant cultivars (i.e., 824 kg per hectare; Appendix 4C Table 5) with improved management that includes the application of fertilizer is 75% higher than the national average coffee yield (471 kg per hectare), a yield of 675 kg per hectare, which is the estimated yield of the cultivars based on average farmers' management levels in the Yayu district, is used to calculate the marginal yield increments due to the CBD-resistant cultivars. The difference between the yield of the farmers and that of the researchers is mainly due to different weeding intensity. Assuming homogeneous yields over the years, the marginal yield increments are calculated based on the data of the annual expansion of the improved coffee farm type (Appendix 4C Table 1). The area of coffee covered by the distributed seeds is calculated based on a norm of 110.7542 ha per 100 kg of seed (Bayetta et al., 2000).

The streams of the costs and the marginal returns are corrected for inflation using a constant dollar value using time series information on the consumer price index (CPI). The CPI is used as there is no record for producers' price index at national level. The details of the costs and the benefits are presented in Appendix 4C table 6 and 7. Accordingly, in 29 years until the end of 2001, a compounded value using a real interest rate[27] of about Birr 2,297.7 million or about € 208.8 million is estimated to be obtained due to the increase in yield as a result of the use of improved cultivars (Table 4.10).

[27] The price level of year 2001 is used as a base to calculate the constant dollar value of the streams. The real interest rate is calculated by deducting the inflation rate from the nominal interest rate, which is used as a long-term interest rate, i.e. about 12%.

Table 4.10. Summary of the cost and benefit streams (in Birr)

R. no. (n)	Year	CPI at 2001base price	Inflat-ion rate (CPI_i-CPI_0/CPI_0)%	Real interest rate (R)	Nominal values of the costs	Nominal values of the benefit	Net Nominal Value (NV)	Real values at constant dollar value, at 2001base price (RV_i) ($RV_i=NV_i*CPI_0/CPI_i$)	Compounded value in the end of 2001(P_n) $P_n=P_0(1+R)^{29-n}$
1	1973	15.4	0.94	11.1	100,000	0	-100,000	-647,821.2	-12,217,912.7
2	1974	17.1	10.7	1.3	100,000	0	-100,000	-585,304.7	-833,749.9
3	1975	17.9	4.7	7.3	100,000	0	-100,000	-559,226.8	-3,524,126.2
4	1976	21.3	18.9	0	100,000	0	-100,000	-470,192.8	-470,192.8
5	1977	25.9	21.9	0	3,600,000	0	-3,600,000	-13,891,367.1	-13,891,367.1
6	1978	30.7	18.6	0	18,550,633	0	-18,550,633	-60,368,755.8	-60,368,755.8
7	1979	34.7	12.9	0	18550,633	44,485.06	-18,506,148	-53,329,725.4	-53,329,725.4
8	1980	39.1	12.5	0	18,550,633	1,048,378	-17,502,255	-44,819,985.9	-44,819,985.9
9	1981	39.8	1.9	10.1	18,550,633	3,078,382	-15,472,251	-38,872,496.4	-265,012,927
10	1982	42.7	7.3	4.7	18,818,293	8,123,197	-10695096	-2,504,6054	-60,117,257.7
11	1983	44.3	3.8	8.2	18,818,293	12,483,378	-6334915	-14,287,322.1	-58681155.1
12	1984	44.2	-0.2	12.2	7,766,427	17,787,168	10,020,741	22,656,617.2	161,560,164
13	1985	52.4	18.4	0	7,766,427	24,248,945	16,482,518	31,484,731.4	31,484,731.4
14	1986	54.8	4.6	7.4	7,766,427	40,745,844	32,979,417	60,209,794.8	174,972,395.8
15	1987	49.6	-9.5	21.5	7,766,427	27,140,761	19,374,334	39,064,682.8	593,713,773.3
16	1988	50.7	2.2	9.8	7,766,427	34,544,496	26,778,069	52,849,146.7	178,940,345.2
17	1989	55.5	9.6	2.4	7,766,427	36,387,712	28,621,285	51,545,154.2	68,617,734.8
18	1990	58.4	5.2	6.8	9,214,247	29,025,253	19,811,006	33,927,262.1	70,235,720.5
19	1991	70.6	20.9	0	9,214,247	30,476,661	21,262,414	30,117,663.7	30,117,663.7
20	1992	85.4	21.0	0	9,214,247	34,806,161	25,591,914	29,962,021.8	29,962,021.8
21	1993	93.9	10.0	2.0	9,214,247	61,000,322	51,786,075	55,123,234.1	64,644,739.8
22	1994	95.0	1.2	10.8	9,214,247	80,912,449	71,698,202	75,438,847.1	154,990,100.8
23	1995	107.7	13.4	0	12,493,182	163,227,095	150,733,913	139,913,554	139,913,553.9
24	1996	108.7	0.9	11.1	12,493,182	122,588,040	110,094,858	101,255,741	171,203,607.6
25	1997	101.7	-6.4	18.4	12,493,182	164,151,537	151,658,355	149,054,121	293,136,375.6
26	1998	102.2	0.4	11.6	6,482,021	188,487,757	182,005,736	178,160,544	247,603,593.4
27	1999	108.0	5.7	6.3	6,482,021	166,380,236	159,898,215	148,031,363	167,162,586.4
28	2000	108.6	0.6	11.4	6,482,021	149,563,008	143,080,987	131,710,312	146763,635.3
29	2001	100.0	-7.9	19.9	6,482,021	152,402,677	145,920,656	145,920,656	145,920,655.7
								Sum in Birr	2,297,676,243
								Sum in Euro	208,879,658
								Birr per hectare	2364
								Euro per hectare	215

More benefit can then be expected in the following years, as the program has already recovered the investment costs incurred in the past. Based on the 29 years information, a net value of about Birr 2364.00 or € 215.00 is estimated to be obtained per hectare of the improved coffee farm per year. Accordingly, a net amount of about Birr 2054 or € 186.70 can be expected every year per hectare as the case in 2001 even without additional expansion of the improved cultivars.

Improvements in the attributes of the coffee planting material are important since the effect of coffee yield limiting factors is still considerable (Table 4.11; Appendix 4C Table 8 - 10). Furthering the coffee breeding and selection program is not only due to the CBD, but also to find resistant material against the CWD, rust and drought, and to identify material with attributes required by producers like vigor nature and by consumers like cup quality. According to the farmers, certain coffee trees that were thought to be CBD-resistant failed to be so especially in the Gomma district (Table 4.11). This may be due to the use of the planting material outside its recommended domain or due to the deteriorating capability of the selections to resist the disease.

Table 4.11. Percentage response of the trend in the severity of CBD on the different coffee types.

	Gomma		Geba-Dogi	
	CBD resistant cultivars	Semi forest coffee	CBD resistant cultivars	Forest coffee
Increasing	36.2	68.3	7.5	27
Decreasing	12.8	20	16	19

Source: Own survey

4.5 Summary and conclusion

Coffee is the most important crop for the livelihood of the households in the study areas, accounting for about 74% of the farmland in Berhan-Kontir, 61% in Geba-Dogi and 55% in Gomma. In addition to the wild coffee harvest, farmers near the forest use the WCP as a source of coffee seedlings. About 85% and 22% of the coffee seedlings planted in the last three years in the Berhan-Kontir and Geba-Dogi forest communities, respectively, were wild coffee seedlings. It is important to consider the importance of the local value of such resources, so that the contribution of the local population to conservation of the resource can be promoted. In effect of coffee production threats like CBD, CWD, CLR, and drought, most farmers living outside the forest lands with the WCP are willing to pay more for improved planting material, which is disease resistant and of a more vigorous nature and has higher yielding potential.

Farmers around the Geba-Dogi and Berhan-Kontir forests attached higher value to local coffee planting material as a substitute for improved coffee planting material, while the farmers outside the forest lands, where there is no WCP, are willing to pay more for improvements in the coffee planting material than those in the forest communities. Since CBD and CWD are constraining the coffee production more in these areas, the farmers are willing to pay more for the improved material. Since improved coffee planting material can directly contribute to higher yields, the WCP that are important for developing such material could be considered as the natural protection of the coffee production system against production threats like diseases.

A coffee producing farmer in Gomma district is willing to pay annually about Birr 242.60 (Table 4.8) more than a coffee producing farmer in the communities with the WCP for coffee planting material. This indicates the need for improvements in the coffee planting material in Ethiopia (as Gomma district is a typical coffee producing area in the country) Furthermore, the aggregate value of the values of the genetic resource as estimated for the major coffee growing regions, which is estimated for thirty years to be about Birr 2,369 million or € 197.4 million based on a discount rate of 3%, and Birr 1,858 million or € 155 million based on a discount rate of 5%. These values indicate the benefit of conserving the wild coffee genetic resource.

The contribution of the wild coffee genetic resource is also viewed as the yield effects of the 15 CBD-resistant cultivars that are known to be selections among the wild coffee germplasms, and have prevented high losses in the last three decades. The marginal values of adopting the CBD resistant cultivars in the last three decades indicate that the investment cost is already recovered, and resulted in a positive net present values, corrected for inflation and time value of money.

The decision to conserve the WCP, however, should not only depend on the estimated value of the resource at a point in time, but also on the continuous importance of the coffee commodity, the abundance of the WCP and the threats to the forest resource in general. This is based on the theory that values of such resources change with the changing nature of different elements in the system (Gatzweiler, 2003). The expected level of availability of the resource depends on the potential human pressure, the forces that motivate the people to erode the resource and the opportunity costs of keeping a certain area of forest land with the WCP at the household level, which are equally vital for development of conservation concepts. This is explained in the following two chapters.

5. Farmers' practice of replacing the wild coffee growing systems by alternative cultivation systems

5.1 Introduction

Land-use change and deforestation is a very common phenomenon in the tropics and an annual deforestation of about 15.4 million ha of tropical forest area was estimated during the 1980's and about 12.7 million ha in the first half of the 1990's (FAO, 1997). The situation in Ethiopia is also serious, where deforestation of about 10,000 ha of forest land is estimated to occur annually (Tadesse and Denich, 2001). The farm land-use system at the household level is usually associated with expected returns from alternative use systems, nature of the land tenure and effectiveness of land-use plans. Land-use system here refers to the purpose for which the forest land is used, how the wild coffee system has changed in the past and the direction of future use by the local population.

In the remaining forest areas in southwest Ethiopia, the wild Arabica coffee populations are threatened by deforestation. Deforestation in this part of the country is a great threat to the WCP, as the region is recognized to be the center of origin and diversity of the Arabica coffee genetic resource (Demil, 1999; Antoni and Lashermes, 2002; Tadesse, 2003). The diversity in the coffee genetic nature is inferred from the high number of identified coffee cultivars and the presence of un-domesticated wild coffee trees growing in the natural forests in the region especially in the Bench Maji, Illubabor and Kaffa zones. The WCP are recognized to have valuable attributes that can resist diseases like the coffee berry disease (Bayetta et al., 2000).

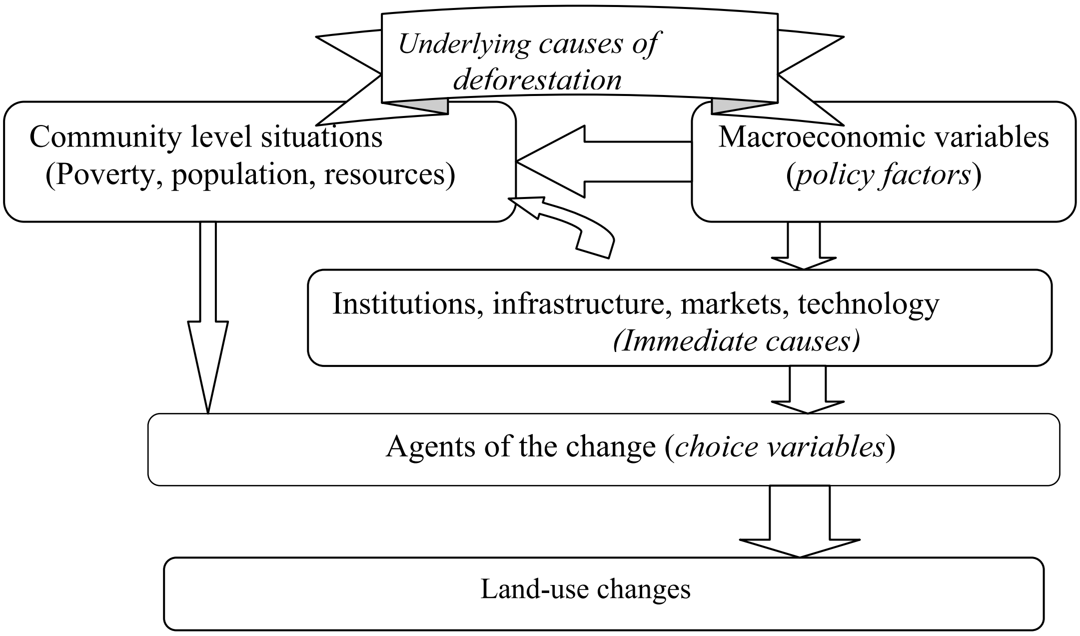
Although landscape change is a natural phenomenon, monitoring is necessary so that those activities that are threatening the sustainable use of natural resources can be controlled. Conservation of genetic resources requires information not only on the values of the resources, but also on the degree of threats to the genetic diversity and information on what conditions and factors motivate farmers to preserve the genetic diversity (Brush, 1992). Moreover, effectiveness of in-situ conservation of crop genetic resources depends on how the local people are using the resource (Tapper and Hamilton, 1994) and their degree of dependency upon the resource for livelihood. The focus of this chapter is to describe and analyze changes in the land use in the coffee growing systems, to discuss factors determining the changes and maintenance of the WCP at the household level. The coffee growing system here comprises areas where coffee trees grow naturally and are unmanaged, or coffee trees planted on an established farm with a certain level of management.

5.2 Methodological framework

Land-use change in agricultural systems takes the form of either a complete conversion of the habitat as an extensive growth model of agriculture that exhibits changes in the structure of the farm, or agricultural intensification. In either case, the causes can be attributed to different factors existing at different levels, i.e., household, regional and national levels. A schematic framework of the change process (as in Figure 5.1) shows that there are underlying causes, which can be macroeconomic (or policy forces), natural or community level factors related to population density and poverty level, immediate causes like institutions, infrastructure and markets, and characteristics of the individual households that are agents in the change process (Angelson and Kaimowitz, 1999).

The effect of the macroeconomic factors, although different in different countries and ambiguous in certain cases (Angelson and Kaimowitz, 1999), plays a vital role in controlling deforestation through its influence on variables like population growth, poverty reduction or development policies, and institutional and infrastructure settings that in turn can influence the change agents, i.e., the people living around the forest. Certain agricultural development policies can lead to land-use changes, for instance through promoting agricultural intensification (Jongman and Bunce, 2000). Land use changes can also result in response to certain pricing policies (Tuner et al., 1993). An ineffective land tenure system that cannot control free riding in the forests also enhances conversion of forest lands.

Figure 5.1 Interacting factors in the process of deforestation



Source: Angelson and Kaimowitz (1999), with own modification

The effects of community level conditions such as the poverty level of the people and population growth are also important factors contributing to the deforestation process. Although the reasoning is different, conversion of forest land can be practiced both by smallholder and large-scale farmers. The effect of poverty on the deforestation process is not always unidirectional. The most conventional hypothesis about poverty-environment interaction is that poorer families are likely to clear forests to meet their basic need requirements either for agriculture (more in cases where there is a shortage of farmland) or fuel wood collection (WECD, 1987). This can be associated to the presumption that poor farmers used to discount future values of resources (Perrings, 1989). This is logical in that it is natural to address basic and current needs primarily before reservation or saving resources for future use. A study on the relationship on time preference, poverty and conservation made in Indonesia, Zambia and Ethiopia also showed that the rate of time preference amongst rural households is generally high and increases with poverty (Holden, Shiferaw and Wik, 1998). Poorer families may also not be able to expand their farm by clearing forests because of a shortage of investment capital (Rudel, 1993). However, recent studies reveal that the relationship between deforestation and per capita income is an inverted U-shape type, as described in the Environment-Kuznet's curve (Panayotou, 1995; Antle and

Heidebrink, 1995). It implies that up to a certain level of income in a development process, deforestation rate increases, while after a certain level of growth, the rate decreases and then compensation begins to appear, e.g., afforestation programs. The compensation process may not, however, permit reversion of some of the irreversible resources that were lost in the first phase of development. This, therefore, suggests a need to address conservation and sustainable use of resources at all stages of development. However, the natural resources need not be substituted totally for such temporal economic growth purposes.

According to results of different studies on land-use changes, it is difficult to clearly generalize the direction and magnitude of the effects of variables like poverty, income level, tenure security, prices and technology on land-use changes (Angelson and Kaimowitz, 1999). This is mainly because of variations in the mix of the factors and their interactions in different countries. The decision by a household to change his farm land-use system is associated with the combined effect of pushing factors like the institutional, infrastructure and market, or household and community level factors. Therefore, it is necessary to understand the special nature of the relationships of such factors in the study sites because of possible site specific variability.

Designing effective conservation of forest resources requires information about interactions among the major elements in the system, which includes mainly forest, people, technological, institutional or policy related factors. Since the smallholder farmers are the major change agents, detailed understanding of their decision making process with respect to the utilization system of the forest lands with the WCP is necessary. This information can indicate the effect of household and farm characteristics, and the responsiveness to the upper level forces. The analysis here is a description of the change process and a microeconomic level analysis of the nature of the agents to identify factors that force them to change their land-use system.

Microeconomic models explain how individuals allocate their resources with respect to variables such as individual preferences, institutional and infrastructural set up. The two variables under consideration here are the explanation for the complete conversion of wild coffee plots[28] and the

[28] The wild coffee plots that were intact 10 years before (1993-2003)

variation in the area of wild coffee plots maintained by smallholder farmers near by the forest sites. Most of the farmers in the community are known to have previously owned wild coffee plots.

The empirical model

The analysis was performed using a micro-econometric estimation of the binary variable model, which can be constructed as an observed binary outcome associated to a continuous latent variable with a measurement model[29]. The observed binary variable Y reflects whether a household has maintained a certain area of wild coffee or converted the whole wild coffee plot that was intact ten years before, while the latent variable Y* reflects the underlying continuum area of wild coffee plot households have. The relationship between the two variables is of the form:

$$Y = 1 \ \text{if} \ Y^{*} > 0, \ \wedge \ Y = 0 \ \text{if} \ Y^{*} \leq 0 \quad \text{.........} \quad (5.1)$$

where, $Y^* = X'\beta + U$, where, X represents a matrix of explanatory variables with β coefficients and U refers to the independently distributed error term that is assumed to be normal with mean zero and constant variance. Then, for a given value of the explanatory variable Xi, the distribution of the individuals with the binary outcome y, is:

$$P(Y = 1 / X) = P(Y^{*} > 0 / X) \quad \text{..........} \ . \quad (5.2)$$

Using a standard logit expression, the probability of a household having certain area of wild coffee plot with associated characteristics, X, is specified as:

$$P(Y = 1 / X) = \frac{e^{X'B}}{1 + e^{X'B}} \quad \text{.........} \quad (5.3)$$

For the analysis of the intensity or variation in the area of the wild coffee plot maintained by household i, Yi is approached using a censored Tobit model, which is a mixture of discrete and continuous parts (Greene, 2003). Mathematically, the model can be expressed as in Equation 5.1 above. The density of the censored random variable is given by:

[29] Binary models can be obtained in three ways: first when the binary outcome is observed to be associated to a latent variable with a measurement model, second, when the binary model can be constructed as a probability model, and third, with a random utility or discrete choice model (Long, 2001).

$f\left(Y^* \mid Y^* > a\right) = \dfrac{f(Y^*)}{\Pr ob(Y^* > a)}$ .... (5.4), then, in the assumption of normally distributed Y* with mean μ and standard deviation σ,

$\Pr ob(Y^* > a) = 1 - \Phi\left(\dfrac{a-\mu}{\sigma}\right) = 1 - \Phi(\alpha),\ \ where\ \ \alpha = {}^{a-\mu}\!/_{\sigma}\ \ and\ \ \Phi(.) is\ normal\ cdf, ...$ (5.5), *and*

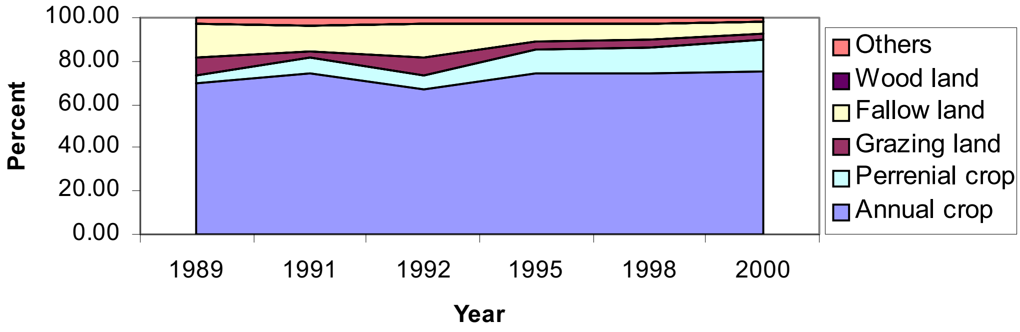
$$f\left(Y^* \mid Y^* > a\right) = \frac{f(Y^*)}{1-\Phi(\alpha)} = \frac{\frac{1}{\sigma}\phi\left(\frac{Y^*-\mu}{\delta}\right)}{1-\Phi(\alpha)},\ where\ \ \phi(.)\ is\ \ normal\ \ pdf. ..... (5.6)$$

The censoring is made at zero from left in the analysis of the intensity of the area of wild coffee plot maintained by the households. Ordinary least square estimates are inconsistent in such censored model, and thus maximum likelihood estimates are employed. A change in an explanatory variable has effects on the conditional mean of Y^* in the positive part of the distribution, and again on the probability that the observation will fall in that part of the distribution. The expected value of the whole observation is the product of the expected value conditional to being above the limit and the probability of being above the limit (McDonald and Moffitt, 1980).

5.3 Changes in the forest land-use

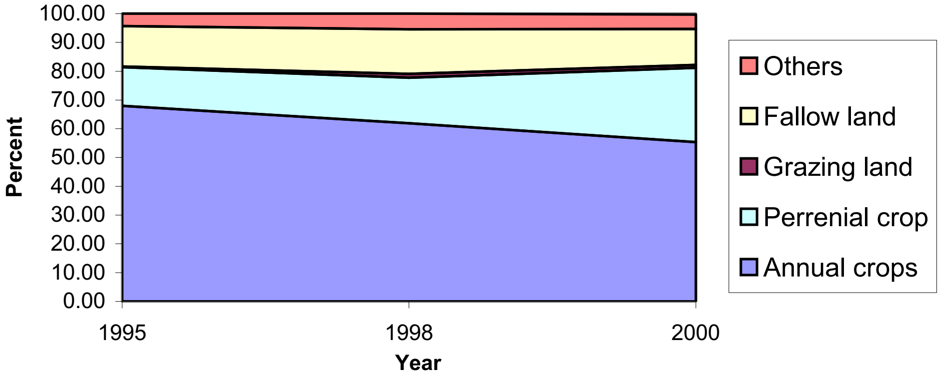
Fifty years ago, most of the area in south and south-western Ethiopia was covered by dense natural vegetation and was not inhabited by people, except in some places on the edge of forests where a few individuals settled (Chekun et al., 1996). During the 1950s and 1960s, landlords from both within Ethiopia and abroad established large-scale commercial coffee farms in the southwest of the country, having been attracted by the growing opportunity to export coffee during the imperial era (Kholi, 1981). Following the establishment of large-scale coffee farms, people who came for wage labour into these farms used to settle at the edges of the forests and converted the forest into agriculture land to make their livelihood (Kholi, 1981). Through time, the area of agricultural land increased through the conversion of forest or grasslands. Figures 5.2 and 5.3 show the increasing trend of agricultural land expansion at the zonal level in the study areas, while the area of grass, fallow and wood lands decreased according to household level data collected by the national Central Statistical Authority (CSA). Agricultural land is still being expanded near both forest coffee sites.

Figure 5.2. Trend in the household level land-use change in Illubabor (in % of holdings)



Source: Central Statistical Authority (CSA) (1993, 1995a, 1995b, 1995c, 1996, 1998, 2000)

Figure 5.3. Trends in the household level land-use change in Bench-Maji (in % of holdings)

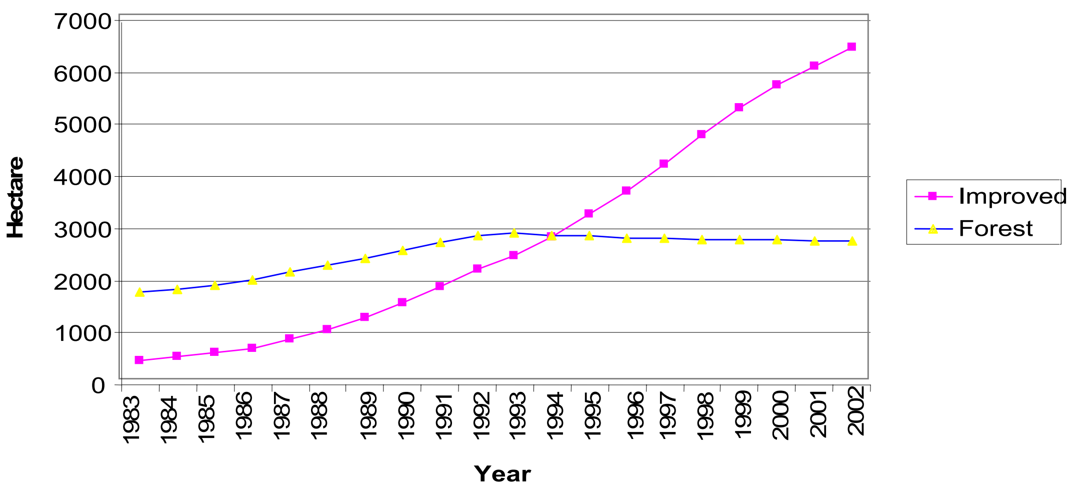


Source: Central Statistical Authority (CSA) (1996, 1998, 2000)

In the Illubabor zone, about 90% of the available land was used for agriculture in 2000 while it was about 73.5% in 1998, i.e., a total increase of about 16.5%. Out of the total increase, about 10.5% was an increase in permanent crops, mainly coffee, and the remaining 6% were annual food crops. The remaining land was allocated for house construction, fallow land, woodland and grazing land.

Although coffee has been replaced by maize in southwestern and by Chat *(Cata edulis)* in the southern and eastern parts of the country especially in the mid 1980s, the area with coffee at the national level in Ethiopia has not decreased in the last two decades. New plantation of coffee was also promoted by the MCTD and then the CTA, which was accomplished mainly in the Coffee Improvement Project (CIP).

Figure 5.4 Trend in the area of forest coffee and CBD-resistant coffee cultivars (in Hectare) in Yayu district



Source: Yayu district Agricultural Development Department, The Planning Section

District level information also indicates that planting of CBD-resistant cultivars has been increasing especially in the Yayu district according to annual plantation data (Figure 5.4). The MOA and research institutions have estimated that the CBD-resistant coffee covers about 20% of the total national coffee acreage based on the data on the yearly disseminated coffee seeds or seedlings.

In both study sites, coffee is the dominant crop. In the Geba-Dogi community, coffee accounts for about 62% of the farmland and the farmers intend to allocate about 65% of their farmland to coffee. Although the topography of the landscape and presence of *wild* animals do not encourage production of cereal crops like maize and sorghum, the area of land allocated to such crops is increasing through time as they are the staple food crops in the area**.** In the Berhan-Kontir community, the land-use system is such that coffee accounts for about 72.8% of the farmers' holdings, while on average farmers plan to cover 76% of their farmland with coffee within the existing agricultural system. At the district level in Sheko, the area of land allocated to maize increased by 42% from 1998 to 1999 (Table 5.1), although it decreased thereafter because of the lower price of maize and increased prices of inputs, i.e., fertilizer and seed. The area of grassland is decreasing due to competition for land for crop production such that traditional rearing of cattle with open grazing is becoming difficult because of the shortage of grasslands. Fallowing is also almost no longer practiced in both study areas.

Table 5.1. Trend in maize area cultivation in Sheko district from 1998 to 2002 in hectare

	1998	1999	2000	2001	2002
Sheko	2676	3812	3467	2880	2398
Rate of change	-	42,5%	-9,1%	-16,9%	-16,7%

Source: Sheko district Agricultural Development Department

Table 5.2. Relative land share of different coffee systems at household level around Geba-Dogi and Berhan-Kontir forest communities

<table>
<tr><th></th><th></th><th>Improved coffee</th><th>Semi-forest coffee</th><th>Forest coffee</th><th>Wild coffee</th></tr>
<tr><td rowspan="2">Geba-Dogi forest community</td><td>Current share</td><td>34%</td><td>15%</td><td>42.4%</td><td>9%</td></tr>
<tr><td>Farmers' interest to maintain</td><td>41%</td><td>11%</td><td>45%</td><td>3%</td></tr>
<tr><td rowspan="2">Berhan-Kontir forest community</td><td>Current share</td><td>3.5%</td><td colspan="2">81.2%</td><td>15.3%</td></tr>
<tr><td>Farmers' interest to maintain</td><td>9%</td><td colspan="2">86%</td><td>6.3%</td></tr>
</table>

Source: Own Survey

According to the data on the smallholder farmers' use of their private holding in the two forest communities, forest coffee accounts for the highest share out of both the current coffee holding and the farmers' future plans for coffee acreage (Table 5.2). Considering farmers' cultivation practices in the last ten years in the Geba-Dogi community, the area of forest coffee, semi-forest coffee and improved coffee increased annually by 4%, 11% and 21%, respectively, while that of the wild coffee area decreased annually by 6%. Privately owned wild coffee plots are usually replaced by forest coffee types as stated by 90% of the respondents, while 10% of the respondents also replaced the wild coffee plots by improved coffee cultivars in the Geba-Dogi community. In the Berhan-Kontir forest community, expansion of a managed type of forest coffee had been increased at an annual rate of 10%, and improved cultivars increased at a rate of 17% annually, while the area of wild coffee plot decreased at a rate of 7% annually (Figure 5.6). Conversion of the wild coffee plot to the more yielding forms is common with most farmers because of the higher yields. The area of wild coffee plot that is accessed by the farmers has been diminishing (Figure 5.5 and Figure 5.6) as stated by 97% and 53% of the sample farmers in the Berhan-Kontir and Geba-Dogi communities, respectively.

Figure 5.5. Sizes of different coffee types at different time horizons in the Geba-Dogi forest community at household level

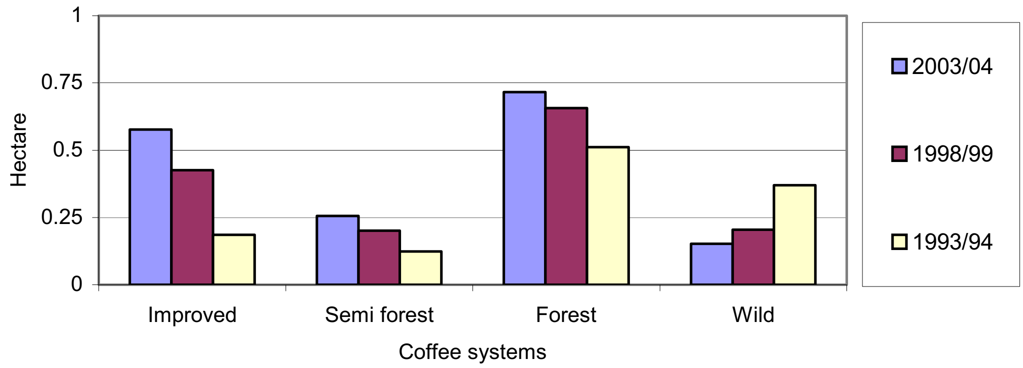
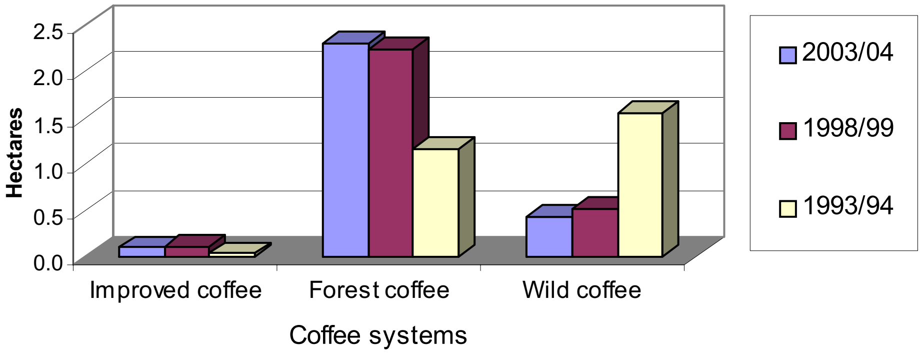


Figure 5.6. Size of different coffee types at different time horizon in Berhan-Kontir forest community at household level



5.4 Regression results

Although the households in each study sites share common institutions like markets, infrastructure, and tenure arrangements, there is variability among them in terms of owning the area of coffee in general, wild or forest coffee in particular. Putting it in another way, the conversion rate of the privately owned wild coffee plots varies in relation to household or farm-specific characteristics. The following tables show the results of the logistic regression (Table 5.3 and 5.4)[30] of factors explaining the maintenance or complete conversion of the wild coffee plots and a Tobit analysis (Table 5.5 and 5.6)[31] of associated factors for variations in the area of wild coffee plots maintained at the household level. The estimation is based on robust standard

[30] In the logistic regressions, the β coefficients indicate the change in the logit or log of odds of maintaining certain area of wild coffee for a unit change in the explanatory variables, holding other variables constant. The probability level (P>/z/) indicates the significance level of the explanatory variables using the Z statistics. The odds ratio (the Exp (β)) indicates the change in the odds by a factor of Exp (β) due to a unit change in the explanatory variable. The marginal effects column in the tables shows the marginal change in the probability (ƏP(Y=1/X)/ƏX) due to a unit change in the explanatory variables, while it is a discrete change for the dummy independent variables.

[31] In the tobit regressions, the effect of change in the explanatory variable (X) on the expected value of the dependent variable (Y*) i.e. $\partial EY^*/\partial X_i$ is the sum of the change in Y* of those above the limit, weighted by the probability of being above the limit; and the change in the probability of being above the limit, weighted by the expected value of Y* if above (McDonald and Moffitt, 1980). The disaggregated effects of the explanatory variables that are of interest are displayed in the last two columns in Table 5.5 and 5.6. The beta coefficient, βstdXY, which is calculated based on the standard scores of the variables that indicate the relative importance of the explanatory variables in explaining the dependent variable, is also indicated. The higher the absolute value of this coefficient, the more important the variable is.

errors and the models adequately fitted as the measures reported in the tables are significant. Independence of the explanatory variables is also checked using the variance inflation factor. For descriptive statistics of the variables see Appendix 5 - Table 1 and 2.

Table 5.3. Determinants of household level probability of maintaining wild coffee plot at the Geba-Dogi community

Variable	β	P>/z/	Exp(β)	Marginal effect
Food shortage (1=shortage; 0=no shortage)	-1.492*	0.063	0.225	-0.2562
Distance from district town	0.004	0.935	1.004	0.0006
House type (1=corrugated iron; 0=thatched house)	0.346	0.644	1.413	0.0552
Nativity to the area (1=local; 0=others)	1.223*	0.090	3.397	0.2082
Maize size proportion	0.042*	0.116	1.043	0.0063
Proportion of forest coffee	-0.083***	0.000	0.920	-0.0127
Improved coffee	-1.932	0.150	0.145	-0.2951
Distance from forest	0.519**	0.040	1.681	0.0793
Size of wild coffee 5 years ago	3.452*	0.065	31.552	0.5273
Household size square	-0.0006	0.951	0.999	-0.0001
Constant	1.946	0.425		

Observations=69
Wald chi2(10)=29.45, Prob > chi2 = 0.0011
Log -likelihood = -24.332454
Pseudo R square=0.4142
Prediction Probability= 81.18%

*** Significant at .0.01; ** significant at 0.05; and * significant at 0.1 level;
Source: Own estimation

Table 5.4. Determinants of household level probability of maintaining wild coffee plot at the Berhan-Kontir community

Variable	β	P>/z/	Exp(β)	Marginal effect
Distance from district town	0.585***	0.000	1.795	0.0816
House type(1=corrugated iron; 0=thatched house)	-2.258***	0.004	0.105	-0.2622
Nativity to the area (1=local; 0=others)	1.470***	0.016	4.351	0.1781
Size of maize farm	0.933*	0.121	2.543	0.1301
Size of forest coffee farm	0.846***	0.019	2.329	0.1179
Improved coffee	-4.557***	0.010	0.010	-0.6356
Distance from forest	0.309*	0.114	1.362	0.0431
Size of wild coffee 5 years ago	3.443***	0.002	31.282	0.4802
Size of wild coffee ten years ago	0.463	0.385	1.589	0.0646
Constant	-13.488***	0.000		

Observations = 112
Wald chi2(9) = 33.05 Prob > chi2 = 0.0001
Log -likelihood = -35.96317
Pseudo Rsquare = 0.5146
Prediction Probability = 83.25%

*** Significant at 0.01; ** significant at 0.05; and * significant at 0.10 level.

Source: Own estimation

Table 5.5. Determinants of the intensity of holding wild coffee plot at Geba-Dogi community

Variable	β	P>/z/	βstdXY	Marginal effect	
				E(y/ y*>0)	Pr (y* >0)
Proportion of forest coffee (%)	-0.009***	0.000	-0.0271	-0.0047	-0.0115
Improved coffee(ha)	-0.039	0.477	-0.1202	-0.0212	-0.0509
Maize size(ha)	0.057	0.357	0.1748	0.0308	0.0741
House type(1=corrugated iron; 0=thatched house)	0.103	0.183	0.3167	0.0533	0.1420
Native ness to the area(1=local; 0=others)	0.144**	0.013	0.4450	0.0749	0.1988
Claim land (1=yes;0=no)	-0.090	0.435	-0.2789	-0.0525	-0.1073
Food shortage(1=shortage; 0=no shortage)	-0.169**	0.022	-0.5215	-0.0876	-0.2329
Asset value	-0.0001***	0.003	-0.0002	-0.00003	-0.00008
Distance to forest zone	0.054***	0.003	0.1672	0.0295	0.07092
Distance to district town	0.006	0.143	0.0180	0.0032	0.0076
Household size	0.012	0.380	0.0359	0.0063	0.0152
Age square	0.00002	0.511	0.0000	8.65e-06	0.00002
Constant	0.246	0.292			
/lnsigma	-1.441***	0.000			

Observations= 69; 49 uncensored and 20 left-censored
Wald chi2 (12) =49.26, Prob >chi2 =0.0000
Log -likelihood = -11.901466

*** Significant at 0.01; ** significant at 0.05; and * significant at 0.10 level.

Source: Own estimation

Table 5.6. Determinants of the intensity of holding wild coffee plot at the Berhan-Kontir community

Variable	B	P>/z/	βstdXY	Marginal effect	
				E(y/ y*>0)	Pr (y* >0)
Forest coffee (ha)	0.186***	0.002	0.299	.0849	.1169
Improved coffee (ha)	-1.515***	0.000	-2.440	-.6918	-.9519
Maize size (ha)	0.446***	0.000	0.718	.2036	.2802
House type(1=corrugated iron; 0=thatched house)	-0.433**	0.019	-0.697	-.2113	-.2545
Native ness to the area(1=local; 0=others)	0.211	0.205	0.340	.0998	.1291
Claim land	0.213*	0.076	0.343	.0932	.1369
Food shortage(1=shortage; 0=no shortage)	0.045	0.809	0.072	.0208	.0279
Asset value	0.00005	0.449	0.0001	.00002	.00003
Distance to forest zone	-0.012	0.794	-0.020	-.0057	-.0078
Distance to district town	0.043**	0.035	0.070	.0198	.0273
Household size	-0.051	0.187	-0.082	-.0232	-.0319
Age square	-0.00004	0.470	-0.0001	-.00002	-.000025
Constant	-0.747	0.121		-.3409	-.4692
/lnsigma	-0.529***	0.000			

Observations=112; 70 uncensored and 42 left-censored
Wald chi2(12) = 61.72, Prob >chi2 = 0.0000
Log -likelihood = -90.345

*** Significant at 0.01; ** significant at 0.05; and * significant at 0.1 level.
Source: Own estimation

Maintenance of wild coffee plot is associated with different factors but mainly with farm size, food self-sufficiency, cultivation area under coffee or maize, distance of residence from forest area, and settlement history.

Farm size: Shortage of farm land is one of the constraints that farmers are facing according to 72.3% and 80% of the farmers in the Berhan-Kontir and Geba-Dogi forest communities, respectively. According to the regression results, sizes of maize plot and forest coffee plots are vital determinants in explaining both the magnitude and the complete conversion of wild coffee plots in Berhan-Kontir. Since maize is the major food crop, those farmers who faced food shortage have already converted most of their wild coffee plot and maintained a smaller area of wild coffee plot than those who did not face food shortage, which is the case in the Geba-Dogi forest community. Similarly, those farmers who cultivated a relatively larger area of coffee had not converted their wild coffee plots. Conversion of wild coffee plots was assumed as a means of relaxing the shortage of farmland in order to support family demands of maize or coffee. Introduction of improved coffee cultivars, however, is negatively associated both with the probability of keeping the wild forest coffee plot unconverted (as is mostly the case in Geba-Dogi) and with the area of such unconverted wild forest coffee plots (as it is the case most in Berhan-Kontir) according to the regression results. The availability of wild forest coffee plots is also negatively associated with a higher family size.

The number of landless farmers is considerable in both areas. However, farmers in these forest sites have relatively larger farms compared to the district level average. About 66% and 79% of the farmers in Geba-Dogi and Berhan-Kontir, respectively, have greater than 2 ha, while only 12% and 2% have 1 ha or less in the respective sites. About 32% and 5% of the households are landless or have les than 0.5 ha in the Sheko and Yayu districts, respectively (Table 5.7). Such households are either supported by their family or live as sharecroppers.

Table 5.7. Distribution of households by farmland size in Yayu and Sheko districts

Farm size	Landless	<0.5ha	0.5-1ha	1-2ha	2-5ha	>5ha
Yayu	2.5%	2%	48.6%	20.6%	23.2%	3.1%
Sheko	20,4%	12,0%	19,7%	28,5%	18,1%	1,2%

Source: District level agriculture development department offices

Landlessness and shortage of land in agriculture-based societies can be an indicator of poverty (Sinha, 1984). For the farmers in the study areas, where crop production is the dominant enterprise, ownership or access to farmland is necessary. In both forest sites, redistribution of farmlands to youngsters is common. The number of landless farmers is increasing through time, as more than 90% of the youngsters are known to stay in the community. Redistribution of the fixed farmland per household will result in a decreasing ratio of land to labor in the production process, which can be a pushing factor for farmers to look for additional farmland. About 80% of the households were looking for additional farmland in the Geba-Dogi forest community, while only about 20% stated having an adequate farmland area. In the Berhan-Kontir forest community, about 72% of the households were looking for additional land while about 28%

stated having an adequate area. Yet, about 28% of these households stated that there was no means of getting additional farmland.

Potential means of getting additional farmland according to the perception of the farmers were: clearing adjacent forest land nearby their farmland, buying, or renting land according to 14%, 11.6%, and 2.3% of the respondents, respectively, while about 71% were looking for the "goodwill" of the government in Geba-Dogi. For the Berhan-Kontir community, the potential means of getting additional land were clearing adjacent forest land for 70.4% and buying for 26% of the households.

Location: Location of households from the main district town and from the center of the forest sites are also of importance. According to the regression results, households located farthest from the district town are less motivated to convert forest land and have a larger area of wild coffee plot in the Berhan-Kontir community, while households in the Geba-Dogi forest community located far away from the forest coffee area have a larger area of wild coffee plots than those located near the forest. This result is consistent to the result of Edilegnaw (2004) who also found that farmers who are located farthest from market centers, roads and extension services allocate more farmland on local varieties.

Conversion of the wild coffee system into the managed form is usually done by a labor cooperation called Dado (local term) in the community, where each member works in turn at the other member's plots. It does not demand a large amount of capital, as the value of major assets is not significant in the explanation of the conversion in the regression analysis. However, the type of house is significant in that those households in Berhan-Kontir forest community with a higher house value (for example, houses made of corrugated iron sheets) have left less wild coffee plots.

Settlement history: Households whose heads are native to the community (i.e., the Oromo in Geba-Dogi, the Mejengir, the Sheko, and the Bench in the Berhan-Kontir community) have a significantly higher area of wild coffee plots in both sites, which can be seen in all the regression analyses (Table 5.3 - Table 5.6). This could be associated with the traditions of tese communities, where especially the Mejengir in Sheko are used to utilizing forests, as they are more interested in forest products like honey than in crop production. It is argued that at both study sites the farmers convert the wild forest coffee into a managed system partly with the intention of facilitating formalization of an ownership right on that particular plot. The resettlement program of the Derg regime, which brought people from the north especially from Wollo and Tigray, greately contributed to the conversion of forests at both sites. In addition to such a formal settlement program, people from the north used to come as wage workers during coffee harvesting and/or were invited by their relatives, who had settled in the area.

Although there is a rule that forbids illegal holding of farmland, some farmers have settled inside forest areas (Figure 5.7), where they have illegally gained official recognition by corrupt peasant association officials.

Figure 5.7. Views of Berhan-Kontir forest

Conversion of the 'wild' coffee plots into a managed system of coffee farm is associated to a higher expected yield from an intensive cultivation of the coffee or cereal crops production. The average yield of coffee in Yayu is, 160 kg per ha for the wild coffee, 440 kg for the forest/semi-forest and 675 kg for the improved coffee production systems.

Related to the perennial nature of coffee that requires long term investments, farmers do not automatically change their farm plan due to factors like a fall in the coffee price, although land-use change is associated with the expected income generating potential of the farm land. Since the coffee farmers mainly depend on coffee for most cash requirements, the price of coffee influences the farmers' decision regarding the area of land allocated to coffee. About 40% of the sample farmers stated that they decreased the level of coffee management with falling coffee prices, while close to 25% waited about three years for better prices before decreasing the level of coffee management. About 35% of the farmers in Berhan-Kontir forest communities stated that they intended only to improve the level of coffee management as a compensatory measure. However, the ultimate effect of a persistent fall in the relative price of coffee to other crop prices is the conversion of the coffee farms into other cropping systems with better returns. The first crop opted to substitute for coffee is maize according to 96% of the sample farmers. An increase in the price of coffee is an incentive for farmers to produce more coffee. Its effect on the wild coffee system is such that most farmers are motivated to improve coffee management, i.e., by slashing and replanting more coffee seedlings in the free spaces in the forest.

Production of cereal crops like maize and sorghum has been increasing, especially after the resettlement program of the Derg regime as these cereals are the staple food crops. The agricultural development strategy that has been promoting intensification of cereal crops production and encouraging farmers to adopt improved maize seed and fertilizer in the last decade has contributed to the changes in the land-use and land cover. Absence of effective land-use planning and sustainable rural development strategies that have resulted in uncontrolled settlement and an increasing number of poor smallholder farmers have been the underlying factors for the changes in land use. There is still no public activity that controls or monitors land-use changes in the area.

The existence of the wild coffee system in the area is also associated with the historic setting of the traditional agricultural system, among other things. Coffee production was the first traditional agricultural practice in the area. Most of the agricultural operations are manual, and there is no real improvement in the production techniques.

The declaration that states land as the property of the Government and prohibits private confiscation of free land has also played a fundamental role in the existence of the remaining forests. However, the increasing population and thus of higher demand for farmland in rural areas have been a threat to the wild coffee system.

5.5 Summary and conclusion

In the study areas, the WCP regenerate naturally in the forest. However, the wild coffee system is threatened due to changes in the land-use system. Although the forest coffee system is still dominant at both sites, the area of wild coffee plots has been decreasing while that of improved coffee or cereal crops, especially maize, has been increasing through time. In general, conversion of wild coffee plots into more productive systems by the smallholder farmers seems to be a means of improving the household food supply.

The price of coffee and other crops in the area can also influence the land-use. For conservation of the wild coffee populations, a policy supplemented management of coffee prices needs to be made at least locally, as a persistent fall in the coffee price forces the farmers to allocate more land for food crops. Although an increase in the coffee price encourages farmers to convert wild coffee plots into the managed form of forest coffee, strategies that can improve the food security situation, for example, improving yields per unit area, can reduce the burden on the forest as those farmers who are not facing food shortages maintain a larger area of wild coffee plots. This also applies to those farmers with a larger area of forest coffee and maize.

Due to the fact that majority of the wild coffee plots that are held by private households are being converted into the managed form of coffee production, the decreasing trend in the area of wild coffee plots and the increasing area of improved coffee and other crops cultivation are leading to a loss in the wild coffee genetic diversity.

Considering the conversion of the wild coffee plots, the role of the government is vital in the design of appropriate resource utilization systems. It could support through implementation of a more effective land-use system, establish responsible institutions and support the people with appropriate technology, infrastructure and marketing structures, which help alleviate poverty in general. This would lower farmers' pressure on the forest and lead to sustainable use and conservation of the coffee genetic resource. In the expectation of the value in terms of the wild coffee genetic resource or ecological values of the forest, incentives for the farmers that cover production risks associated with a typical wild/forest coffee system could be one aspect of a conservation strategy. In order to have an effect on the maintenance of the forest-based coffee, the reference value for the incentive should be the value that the farmers could obtain by cultivating other crops. A quantitative estimation of the opportunity cost of maintaining typical wild coffee and forest coffee plots at the household level is made in the next chapter.

6. Opportunity cost of conserving the wild coffee populations

6.1. Introduction

The costs of conserving the genetic resources are important aspects to be considered in the design of appropriate resource conservation and utilization systems. Effectiveness of in-situ conservation of crop genetic resources depends, among other things, on how the local people, as typical customers of the resource, are using the resource (Tapper and Hamilton, 1994) with distinct opportunity costs, and their degree of dependency upon the resource for their livelihood.

The interaction between the farming community and the forest resources surrounding the coffee genetic resource conservation sites that could have negative impacts on conservation of the resource is a concern to be balanced, since the farmers are also assumed to threaten the resource for their private interests. The use of the forest land to preserve the wild genetic populations is less valued by individual farmers as compared to alternatives such as clearing for agricultural purposes, and thus land conversion can occur because of the discrepancy in the observed private and public values of the resource. Reduction in land owners' earning capacity due to maintaining the forest coffee land for conservation of the genetic resource forms an opportunity cost of the conservation program (Rubenstein et al., 2005). Edilegnaw (2004) identified the importance of compensation for farmers to enrich on-farm crop diversity for the opportunity costs associated to maintaining the diverse varieties as alternative to keeping the more yielding varieties. He approached the opportunity cost maintaining local crop diversity as the difference in the gross margins between the improved varieties and farmers' varieties. Opportunity costs of in-situ conservation of genetic resources require thinking more than just partial estimation of gross margins on top of the problem of generating cross-sectional data on gross margins of production activities at household level in developing countries like Ethiopia.

Farmers' use of the forest land for intensive agriculture or cereal crops production brings about a loss in the coffee genetic resource. As described in the previous chapter, farmers in the forest community used to reallocate their farmland to different crops or production techniques. This is usually a unidirectional change from the wild coffee system to a managed system with improved coffee cultivars or cultivation of food crops like maize and sorghum. The activities of smallholder farmers are direct reflections of household requirements, which include mainly food self-sufficiency and reduction of risks associated with fulfilling family food requirements.

The objectives of farmers, which are related to the physical and socioeconomic circumstances of the system, vary in different farming systems and types, and in different levels of development that range from a very subsistence to commercial and profit-oriented system. A rational producer or consumer behaves in such a way as to maximize his satisfaction with the limited resources and technology. The *propensity to resource depletion* per household for the purpose of basic requirements in terms of available resources (labor and land), i.e., the cost of acquiring basic needs, is high in poor societies. Associated to the unskilled nature of their labor and low productivity of the land resource which is characterized by low external input rain-fed agriculture, such people may tend to sacrifice much of these resources especially under conditions where they are short of fulfilling their immediate basic needs. This argument is in line with Rung's findings (1994) such that a very high value is attached to food in developing countries while environmental quality is more important in developed countries.

It may, therefore, be difficult to secure the livelihood or in particular address the food demand of an increasing population with a traditional agricultural system that is characterized by limited technological improvements (Ruthenberg, 1985) in production and marketing systems. It could also be difficult to maintain natural resources in such a community for inter-generational use with the assumed pressure exerted onto the natural resource by the people, especially when the established agricultural system or farmland can not supply the basic requirements.

The farmers' preference of alternative use of the forest land resources could be explained by the comparative expected returns from the alternatives. Farmers in the study areas allocate their farm land both for coffee and food crops. As coffee is a cash crop, the trend and level of the coffee price plays a significant role in its cultivation preference. For example, with a fall in the coffee price, farmers intend to convert their coffee plots into maize in Jimma (Kassahun et al., 1990) and to chat (*cata edulis*) in the eastern and southern parts of the country (Tesfaye and Sindu, 2000). Farmers do not convert coffee forest lands into cereal crops cultivation automatically when the coffee price falls due to the perennial nature of the coffee crop. Nevertheless, the forest land has apparently been converted into a managed form of coffee or into cereal crops in the study areas in the past. In this chapter, an economic estimation of the households' farmland allocation is made to assess the level of incentive or disincentive that force the farmers to maintain or convert certain areas of forest coffee land. The analysis refers to the coffee- and cereal-based farming systems surrounding the Geba-Dogi forest coffee conservation site. Since the proposed conservation sites of the WCP are located both on publicly owned forest land and privately held smallholder farmers land, the potential pressure on the forest is influenced by the activities of the surrounding community and needs to be considered in the design of appropriate conservation or utilization strategies. Related to the opportunity cost of conserving the Arabica coffee genetic resource, questions such as how much could a farm household lose when maintaining his wild/forest coffee plots against the introduction of improved cultivars or other crops, and what level of incentive encourages farmers to convert their forest coffee plots into cereal crops cultivation or into improved coffee systems are the major issues addressed in this chapter.

6.2. Methodological framework

6.2.1 Farm land valuation

Local level opportunity costs of conserving WCP in situ in the forest system or incentives for converting a typical land-use system relates to the value of forest land based on alternative use of this land. Estimation of land values is based on the expected returns from the land and the potential changes in the land use (Duffy and Holste, 2005). A common approach for valuing land is the current value of a discounted sum of net incomes or economic rents that the land is expected to yield over time (Elad et al., 1994) calculated as:

$$V = \sum_{i=1}^{n} \left(\frac{a_i}{(1+r)^i} \right) \qquad .....(6.1)$$

where, V is current value of the land per unit area, a_i is the expected annual rent, r is the annual interest rate, and n is the number of years. The expected annual rent of the farmland can vary depending on physical and climatic factors, quality of the land, market system, purpose and efficiency of using it, among other things. The expected annual value can be estimated as net income from production by considering the time value of investments (Duffy and Holste, 2005) or can be approached by using a hedonic pricing method when there is a market for land (Elad et al., 1994).

Alternatively, a mathematical programming model can be used to estimate the value of land as a resource in a production system. Shadow prices of resources that can be derived from optimization models can be used to reflect the values of resources used in a production process (Freeman, 2003; Southgate, 2000). Mathematical programming models as optimization models determine optimum allocation of resources in production activities (Heckelei and Wolff, 2001; Hazell, 1986; Sankhayan and Cheema, 1991; Bezabih and Storck, 1992).

There are two broad approaches for conceptualizing farmers' behavior with respect to management of their resources. The first one is the normative method, which aims at prescribing how a farmer should behave in order to maximize his objective function. This method follows the application of programming models. The second is the positive approach, which explains how the farmer is behaving with respect to observed circumstances in the system. This method begins with a model that portrays the existing system. In situations where a land-use system has not yet become stable, the existing system cannot reflect the expected short-term reality let alone the long-term reality. Irrespective of external factors, the farmers in the study areas are assumed to make changes to their resource use system based on their household and local factors. Therefore, the normative method is considered here for the purpose of estimating the shadow prices of the major resources.

A mathematical programming model has the advantage in that it is open for flexibility as dictated by the purpose of the investigation and modifications in the production system. It is more appropriate than a partial enterprise analysis, as it can solve system problems by simultaneously subjecting the objective function, which may be expressed by multiple activities, to the limited resources. It is more suitable for modeling farm-level activities in developing countries, since it depends on farm budget data, which are more reliable than the data required in econometric methods. Moreover, analysis of the effects of changes in the economic structure or the size distribution of farms that take place due to the introduction of new crop varieties or land reform is simpler with programming models than with econometric methods (Hazell, 1986). Maximization functions using Linear Programming (LP) models have been widely used in different systems (Hardaker, 1978).

The assumptions adopted in the LP model are the static, linear, continuous and deterministic natures of technical relationships. Both the objective and the constraint functions are linear in the coefficients and the variables. The value of the objective function is the sum of the contributions of various activities. Similarly, the contribution of a constraint equals the sum of its contributions in various activities, and the contribution of a decision variable to the objective function is independent of the level of other decision variables. This assumption is related to the assumption of proportionality that signifies constant returns to scale whereby multiplication of the level of any activity by a constant factor changes the contribution of that activity to the objective function by a multiple of the same constant factor (Winston et al., 1997).

As a result of the development of the LP method and electronic computers, LP has become a useful tool for identifying the optimal organization of farm businesses (Beneke and Winterboer, 1973). Its importance is more remarkable in cases where a number of resources with a multiple of uses exist and where the relationship among production, consumption, resource availability, and social or cultural constraints is strong as it is the case in smallholder agriculture (Low, 1978). The importance of LP is also reflected in its ability to facilitate determination of the marginal values in effect of either exclusion or reduction in the level of the activities. It also provides information on the marginal value product of scarce resources in an optimal plan, which indicates the binding nature of resources. This makes LP highly reliable for solving such interrelated economic problems, i.e., valuation and optimal resource allocation as primal and dual functions (Dorfman et al., 1958).

6.2.2 Structure of the linear programming model

Most optimization models consider profit maximization as an objective function. This assumes separability of production and consumption decisions, which is hard to assume in developing countries where production decisions are not independent of the consumption or labor supply decisions. This is because most markets in such countries are either imperfect or missing. Agricultural households in developing countries are usually aimed at maximizing a utility function where consumption being the major objective variable. As markets in such countries are assumed to be imperfect, most agricultural household models assume that utility maximization is constrained by a minimum level of consumption (Thorner et al., 1986). Therefore, in developing policy scenarios on the existing conditions of the farmers circumstances, it is appropriate to assume that households maximize utility from consumption of own production, market goods and leisure, expressed as a quasi-concave function. This implies that the utility is essentially a function of own production of crops, whose proceeds are used to finance the purchase of other essential commodities not produced on the farm.

The LP model is used here to describe the effect on the farmers' objective value of changes in the land-use system or due to certain activities in a conservation program. The LP model is structured in the form of maximizing the gross margin of crop production activities subjected to production constraints including land, seasonal labor, working capital, yield balances of the crops, and minimum consumption requirements. The model is specified as:

$$Max.\ F, \quad F = \sum_j \sum_k P_j Y_{jk} - \sum_i \sum_j P_i X_{ij},$$

$$S.T \quad \sum_j a_{ij} Y_j \le b_i, \ \forall i \quad and$$

$$\forall j, i, Y_j, X_i \ge 0 \qquad ....\ ....\ ....(6.2)$$

wh

Y_{jk} is the amount (in kg) of product out put j of type k

P_i is the price (in Birr) per unit of variable input i

X_{ij} is the quantity of input (in kg) vi for the production of product j

a_{ij} refers to the coefficients of input-out, that is the amount of resource i required to produce one unit of product j,

b_i refers to resources like land, labor, capital and drought animal, and other constraints including consumption requirements and yield levels, with b_i resource limits, and

Y_j, $X_i > 0$ refers to the non-negativity restrictions.

A sample of thirty representative farmers was taken in the area around Geba-Dogi forest community for a detailed enumeration of quantitative farm management data on resource levels, production, selling and consumption. Data was collected on the source and magnitude of available resources: land, labor and capital, crops grown and alternative methods of production, current allocation of farm land, unit requirements of different resources for each farming activity, average yield levels of different crops with different production techniques on-farm and at the research station, average prices of the crops during the time of data collection and their levels in the past years. In addition, data on crop prices, yields and land-use in the area was collected from the Yayu district agricultural development department. The data was checked for consistency at the community level during group discussions with a representative group of farmers, who were assumed to know about the agricultural systems in the area.

Farmers' objectives

The objectives of smallholder farmers, which are related to the physical and socioeconomic circumstances of the system, vary in different farming systems and types, and in different levels of development. Farmers in the study area rely on the forest and the farmland for their basic needs. Cropping system is the dominant farming system with less attention being given to livestock resources. The nature of farmers' objective function, therefore, influences assessment of the level of connectedness of the people with the forest and explore the opportunities of wild coffee genetic resource conservation.

Based on the classification by FAO (1997), the system in the Geba-Dogi area is a semi-subsistence farm type with limited resource producing food crops for household consumption and for sale to obtain cash to meet household requirements such as purchase of inputs, medical expenses, and tax payments and also for the purchase of food items. Farmers consider the effectiveness of these objectives based on the implicit process of maximizing the productivity of their resources, especially land and capital. In other words, farmers are always trying to adjust and modify their farm plan with respect to their objectives against the changing conditions such as yields and other constraints they are facing. When farmers in the surrounding forest community suffer from food insecurity, they exploit their land to cultivate crops. In cases of unfavorable institutional arrangements that lead to a lower coffee price, farmers prefer to produce food crops, which mean a loss of biodiversity in the forest areas.

Constraints

The production system of the smallholder farmers is constrained by different factors like land and capital. The farmers also face seasonal labor shortages due to the occurrence of labor competing activities.

Land

The average farm size in the coffee- and cereal- based systems surrounding Geba-Dogi forest community is 2.2 and 2.03 ha. Due to the smallness of the farm size and of the plots with different crops, the unit of analysis considered here is in terms of quarter of a hectare, which is locally called Fechassa. The allocation of farmland for major crops is given in Appendix 6A Table 1. All farmers in the study area allocated certain area for coffee and food crops, mainly maize, sorghum and Teff. The major improved production techniques include use of improved maize[32] and coffee seeds. An area of about 0.4 ha is left for grass and fallowing in cereal based system.

Labor

The potential labor resource at the household level is a function of the size, age and sex composition of the family members. There is division of labor among the family members for different activities, although some activities are done irrespective of sex. The average household size in the coffee- and cereal-based farming systems is 6.7 and 6.0 persons, respectively, and the sum of the labor resource is categorized by Period 1 (from September to June) and Period 2 (July and August) based on the inclusion of labors of students for household or agricultural activities in the Period 2 (Table 6.1). Conversion into the adult equivalent is made taking into account the particular capacity of each member. The adult equivalent is a standardized unit in relation to the working capacity of an adult male. Adult woman labor is considered as 70% of that of an adult male, that of a woman from 66 to 75 years as 35%, of a man aged 66 to 75 years as 50%, and the

[32] A maize package is always combined with fertilizer and has been introduced extensively since the beginning of 1990's (Howard et al., 1999). The recommended rate of improved maize seed and fertilizer per 0.5 ha plot is 50 kg of Di-ammonium Phosphate fertilizer (DAP), 50 kg of urea, and 12.5 kg of maize seed. Both the fertilizer and the seed are provided on a credit basis to be paid after the harvest.

youth of both sexes aged 14 to 18 years as 50% of an adult equivalent. This follows various studies such as Collinson (1983) and Cleave (1974).

Among the numerous constraints in the coffee-based system, the binding constraints are farmland, December labor during the peak of coffee harvesting, May and June labor at the peak of weeding, and working capital. In the cereal-based system, these are farmland, September to October labor at the time of maize harvesting and coffee weeding, November and December labor during coffee harvesting, and June and July labor during maize weeding. Farmers around the forest areas cultivate both coffee and cereal crops. Such combination of coffee and other crops puts an additional burden on household labor because of competing activities in the two production systems.

Table 6.1 Average adult equivalent size per household in the Geba-Dogi forest community

Age		14-18		18 to 65		66 to75		Total	
System		Period 1	Period 2	Period 1	Period 2	Period 1	Period 2	Period 1	Period 2
Coffee based	Per day	0.206	0.63	1.49	2.21	0.03	0.03	1.726	2.87
	Per month	4.12	12.6	29.8	44.2	0.6	0.6	34.52	57.4
Cereal based	Per day	0.1416	0.708	1.584	2.104	2.03	2.03	1.7256	2.812
	Per month	2.832	14.16	31.68	42.08	40.6	40.6	34.512	56.24

Note: Period 1 refers to from September to June, while Period 2 refers to the period of July and August
Source: Own survey

Most of the agricultural activities are undertaken by the family members. Because of different household chores and child care activities, mothers are assumed to spend 25% of their time in agricultural activities. The number of working days is limited to a maximum of 20 days per month due to different social, religious and administrative purposes that demand about 10 days in a month. The rural administrative bodies of peasant associations also call for public meetings and community business about two days per month.

Working capital

The level of available working capital that is to be spent on the agricultural activities in a year is based on information on the amount of cash income that households spend on the activities. The source is either from household income or credit[33]. Thus, a household has about Birr 327.00 and 421.00 in the coffee-based and cereal-based farming systems, respectively, based on 2003 crop season data.

Coefficient determination

Objective function coefficients: the returns and the variable costs of the activities enter the objective function row in the model. The sales price of the products is based on the average prices recorded for 2003 (Table 6.2).

Table 6.2 Average prices (in Birr per kg) of the major crops

	Coffee (dry cherry*)	Maize	Sorghum	Teff	Wheat
2003	2.50	1.20	1.00	1.85	1.35
2002	1.00	0.65	0.65	1.45	
2001	4.80	0.32	0.46	1.25	

*The measure of clean bean coffee is about 48% of the weight of dry coffee cherry

Source: Yayu district agricultural development department

Grain yield coefficients

A crop-cut estimate of yields made by the Yayu district agricultural development department for coffee based on different production techniques is considered. For other crops, the yields are based on the farmers' estimate, which are averaged considering recent poor and good yield levels. A sensitivity analysis is performed with respect to the yield estimates of possible improved production techniques developed by researchers. Table 6.3 shows a 3 year yields (2001

[33] Credit is common for farmers, who adopt improved maize production package to access seed and fertilizer. On average, a credit of about Birr 96 is given for maize package unit per household.

to 2003) for coffee based on different production techniques and Table 6.4 displays the yield level of cereal crops on farmer and research station levels.

Table 6.3 Yield of coffee (clean bean) at different farm types

	Improved coffee at research station level	Improved coffee on farm	Forest coffee	Wild coffee
Yield (kg/ha)	1220-2380	600-725	400-500	125-200

Source: JARC, Breeding Section; Yayu District Agricultural Development Department

Table 6.4 Yield of major crops with different methods of production

Crops	Technology level	Yield in kilogram per hectare	
		Coffee-based	Cereal-based
Maize	Improved varieties research station	35-70	35-70
	Improved variety and fertilizer on farm	35.7	35.7
	Local seed without fertilizer	18.1	13.24
	Local seed with fertilizer	-	22.84
Sorghum	Local seed without fertilizer	15.1	10.5
Teff	Local seed without fertilizer	4.68	6.2
	Local seed with fertilizer	-	8.0
Wheat	Local seed without fertilizer	-	12.7

Source: Own survey

Minimum food requirements

The minimum food requirements of households are determined based on the average amounts of the products consumed or not sold but kept for home consumption. About 102 kg of coffee, 483 kg of maize, 166 kg of sorghum, and 195 kg of Teff are required per household in the coffee producing areas, while, in the cereal-based system the average minimum consumption requirement of coffee, maize, sorghum, Teff and Wheat is about 91.8 kg, 435 kg, 149 kg, 175 kg and 84 kg, respectively. The activities of selling or purchasing the crops from market are assumed to incur no costs to the households as the market days are Sundays and the market is usually located at village level especially for coffee. Purchasing activities are considered following to the situation of the coffee producing farmers where the proceeds from the coffee is used to purchase necessary items including different home use items and some food crops that are not produced at home, although minimum amount of maize, as the dominant staple food crop, is specified in the model.

Human and oxen labor requirements

The labor requirements are set on a monthly basis, as the average can best reflect the allocation of the monthly labor to the different activities. Appendix 6A Table 2 and Appendix 6A Table 3 depict the labor requirements per Fechassa (0.25ha) of the different activities. The model specification considered the restriction of certain operations to be performed by unique labor types like adult labor for draught power, and the periods of major activities including weeding and harvesting are relaxed according to their usual time of operation, which usually is a period of more than a month.

Owing to the potential for improving returns per unit area in the system by adopting yield improving production techniques, the system of land use is assumed to be changing through time, i.e., the existing household allocation of farm land may not remain as it is. As a result, the validity of the estimation procedure is based on the consideration of the possible basic conditions defining the system including the objective function, the production techniques of the enterprises and the resource limits. As the major interest here is to estimate the opportunity costs of conserving the wild or forest coffee system, the estimation is determined with respect to the alternative dominant enterprises existing in the system. Moreover, comparing the estimated shadow prices of the crops under cultivation to their observed levels indicates perfect co-linearity, without any discrepancy.

6.3 Crop production techniques

The yield of the major crops is very low in the area, which is associated with the very traditional nature of the production methods, which use very little or no external inputs (Table 6.3 and 6.4). The yield level of coffee varies in different subsystems as a result of different levels of weeding and the nature of the cultivars in terms of resistance to the diseases like the coffee berry disease.

The forest coffee is the better yielding coffee farm type next to the systems using improved coffee cultivars, while the wild coffee system gives the lowest yields due to higher shade level and weed competition (see also level of weeding in the different coffee systems in Appendix 3 Table 1).

On-farm yields per hectare for maize, sorghum, Teff and wheat are very much lower than the levels obtained in the research station. In the study area, yield of maize has improved significantly especially in the last decade due to improved maize varieties and fertilizers. Adoption of the improved maize production technique was, however, hampered by an increase in price of fertilizers and/or decrease in the price of maize[34].

There are different options for improving the yield level of the crops. Practices such as the use of more improved varieties, improving cultural practices especially weeding, use of external inputs namely, fertilizer, pesticides and herbicides can improve yield levels. In addition, improving harvesting techniques that reduce harvest losses and quality impairment especially for coffee can also be mentioned.

Fertilizer has been used since the first half of the 20th century and its significant contribution to yield is recognized. At research stations, high yielding varieties of hybrid maize types (BH-660 and BH-670) that can yield about 9000 to 12000 kg per hectare, and composite types (Gibe comp-1) that can yield about 5000 to 7000 kg per hectare have been developed and disseminated in many parts of the country including the study areas. On-farm yields of maize are estimated to be about 6000 to 8000 kg per hectare for the hybrid[35] and about 3500 to 4500 kg per hectare for

[34] From 1996/97 onwards, the grain to fertilizer price ratio has been decreasing throughout the country, where the price of Di-ammonium Phosphate fertilizer (DAP) increased from Birr 143.00 and 131.00 in 1996 to Birr 223.3 and 208.3 per 100 kg in 1999 (EEA, 2000/2001). The price of maize was as low as Birr 30 per 100 kg in 2000, while prices ranging from Birr 60 to 100 per 100 kg were observed both before and after 2000.

[35] The hybrid nature of the improved maize seed forces the farmers to purchase seeds every year. This, according to the farmers, is costly, and as a result they prefer to use better yielding composite varieties so that they can reuse the harvest as a source of seeds for the next production season.

composite types. Research on sorghum has been successful and a number of varieties have been developed and disseminated, among which the early maturing and disease-resistant variety Aba-Melko, which was developed in 2000 at JARC and yields about 6000 to 8000 kg at the research station, and 4000 to 5000 kg on farmers' fields, is well recognized and is under expansion in the Jimma and Illubabor zones.

Large areas of maize and all of the sorghum, Teff and wheat areas in the study areas are cultivated with local seeds and without fertilizer. Weeds are one of the most serious factors behind the lower yield levels. The farmers' agricultural management system can not control the repeated weed infestations that severely hamper crop development.

The price trends of the cereal crops are in general dynamic in response to changes in the domestic supply levels. Farmers usually make decisions on allocation of their farmland to the crops with insufficient information about the expected price developments. Furthermore, farmers decide to cultivate a minimum area of food crops especially due to uncertainties in the price of coffee, which is mainly determined by the world market. The area of coffee cultivation is not automatically affected when the coffee price falls. The results of the farm plans are as follows based on the activities and constraints (Appendix 6A Table 4 and 5).

6.4. Results and discussion

6.4.1 Returns in the coffee-based farming system

Farmers decide to reallocate their farmland when they expect higher returns based on intuitive judgment of the best use of resources. Reallocation of farmland continues to exist as long as returns from different alternatives change due to factors like yield and factor/product prices. In the short term, coffee producing farmers are willing to accept certain losses in coffee production, since they do not automatically reduce the coffee area when yields or prices drop due to the perennial nature of the crop. That is, coffee yields high at one year and lower in the next year. However, as far as the relative price of coffee is not so lower, cultivation of improved coffee cultivar is the most profitable enterprise due to its higher yield potential.

The comparison of farm returns per unit area in the coffee-based and cereal-based systems is made based on the returns of the crops that are produced in the area. Table 6.5 shows average returns per household in the systems with different price conditions. The average gross margin that is subjected to the minimum consumption requirement restrictions per unit area is higher in the cereal-based system than in the forest coffee-based system based on 2002 and 2003 price levels that encourage to cultivate more cereal crops than coffee. Any package that can increase cereal crop prices or improve productivity encourages the farmers to replace the forest-based system by a cereal based farming system. Conversely, packages that improve the productivity of coffee or increase the price of coffee encourage the farmers to maintain the coffee-based system. When the relative price of coffee is higher, as in the level observed in 2001, the average earning per household or per unit of land is higher in the coffee-based system. A difference of about Birr 246.00 and Birr 465.00 per household with equivalent farm size is estimated between the cereal and coffee based systems based on 2002 and 2003 price levels (Table 6.5). The level of activities is presented in Appendix 6A Table 6. The farm land allocation is between maize and coffee as the cropping system in the area is dominated by these two major crops.

Table 6.5 Average returns (in Birr) per household in the coffee- and cereal-based systems

Scenario*	Coffee based system		Cereal Based system
	Actual farm size (8.8 Fechassa)	With a farm size of 8.13 Fechassa	(8.13 Fechassa)
Base model 2003 prices	6451	5871	6117
2002 prices	2183	1981	2446
2001 prices	13926	13022	9004
2002 price, but, Birr1.00/kg for maize and sorghum	2718	2555	3588

* See the price levels of the crops in Table 6.2
Source: Own estimation

Based on the 2003 prices, the marginal value of farm land in the cereal-based system is higher than that of the coffee-based system. The higher returns that can be expected from the cereal based system (Table 6.5 and Table 6.6) can explain why the farmers would allocate a larger area to cereal crops based on the 2002 and 2003 price levels. This indicates the long-term effects that can be expected when, for example, the coffee price remains low for more than three years. The analysis provides the expected private values of the forest land and also approximates the opportunity costs of alternative production systems in the community. As indicated in Table 6.6, production of wild and forest coffee are not profitable due to their low level of yield, and are excluded in the model. It may be possible to preserve these coffee systems by motivating the producers with higher prices given to the coffee produced in such systems that make the enterprises comparatively profitable. Accordingly, a price level of about Birr 11.7 and Birr 1.40 must be added more than that of the conventional coffee produced in other systems like garden, semi-forest or improves coffee systems.

Table 6.6. Results of sensitivity analysis based on 2003 prices

		Coffee-based system		Cereal-based system (8.13 Fechassa)
		Actual farm size (8.8 Fechassa)	With a farm size of 8.13 Fechassa	
1. Minimum increase in price per kg for the crops to be planted (in Birr)	Wild coffee	11.70	11.70	-
	Forest coffee	1.40	1.40	-
2. Shadow Prices of Land (in Birr)		865	865	890

Source: Own estimation

Currently, production of specialty[36] coffee is promoted, e.g., forest coffee, shade coffee, organic coffee, which can obtain better prices for the farmers. In order that the farmers can reserve such wild or forest coffee plots, a minimum level of incentive is called for to protect them from losses that can be expected in the systems as compared to the alternative systems.

The marginal value of the farm land is higher than the amount that farmers are willing to pay for additional units of farmland based on local land rents. In the forest communities, farmers rent out

[36] Specialty coffee is a recently recognized coffee marketing code, which gets a premium price for the producers due to the associated services of the system, including opportunities for preservation of biodiversity, encouraging biological cycles and conservation of soils (ITC, 2002). El Salvador uses a coffee product code called '*biodiversity friendly'* (Science/Nature 1999). '*Bird friendly'* is another product type that was promoted with additional 5% premium price for the typical coffee produced in a system that encourages species diversity. In the USA about 10% of the coffee market includes biodiversity-friendly coffee, which specifically focuses on migratory birds.

their coffee plot, in return for 50% of the produce, where the activity of slashing is performed by the person who rent in the plot. After performing the slashing (or weeding) activities, the forest coffee plot is usually rented out in return for about 66% of the harvest, which means harvesting activity shares about one-third of the total harvest. This practice is common in the coffee area. In terms of money, the common rental value per 0.25 ha ranges from Birr 100.00 to 200.00 per year, which varies with the stand of the coffee farm and price expectations.

6.4.2 Opportunity cost of improved coffee selections and cereal crops cultivation

Wild coffee and forest coffee plots are the first to be converted into an improved coffee or maize system. Due to their resistance to disease and the yield advantage, improved coffee selections are preferred to the local alternative material in most coffee growing areas. The expected future scenario of farmland use in the Geba-Dogi forest community is, however, determined by yield levels and prices of the crops and inputs such as fertilizer.

Some of the farmers surrounding the demarcated coffee conservation sites in the Geba-Dogi and Berhan-Kontir forest communities complained that they lost certain area of wild or forest coffee, included in the conserved site. Moreover, restriction of improved coffee or cereal crops expansion in the forest coffee-based farming system in order to conserve genetic and species diversity assumes certain cost for the farmers. Information on such expected losses indicate both the importance of such economic forces that can motivate farmers to intensify the cultivation techniques, and the level of costs that need to be considered as the opportunity costs of allocating the forest land for conservation of the genetic resource. Different scenarios with different price levels of the crops are considered to see the change in the marginal values of the resources and the activities as indicated in Table 6.7. Specifically, the extreme price levels for the major crops that were observed in the last ten years were considered. Accordingly, the price levels of 2003, as scenario 1, 2002 as scenario 2, and 2001 as scenario 4. Additional ranges of price levels of the major crops are also considered as indicated in the Table 6.7. The last two scenarios are added for Table 6.9 to see more ranges of changes in the shadow prices due to the price relative changes.

Table 6.7 Scenario specification for the sensitivity analysis based on price of the major crops

Scenario	Prices (Birr per kg)			
	Coffee	Maize	Sorghum	Teff
1	2.50	1.20	1.00	1.85
2	1.00	0.65	0.65	1.85
3	1.00	1.00	1.00	1.85
4	4.80	0.32	0.46	1.25
5	4.50	1.20	1.00	1.85
6	2.00	1.00	1.00	1.85

Note: Coffee prices are presented in terms of dried cherry

Based on the model constrained by the production of minimum amount of maize, restriction of 0.25 ha of forest coffee reduces the return per Fechassa about Birr 323.00 and Birr 783.00 at 2003 and 2001 price levels, respectively (Table 6.8). As the yield level directs not to allocate a farm land for the forest coffee, a household could lose a return equal to the product of the marginal value per Fechassa and the average area of the forest coffee plots per household that is 2.23 Fechassa. Accordingly, a household may loss about Birr 721.00 and Birr 1747.00 at price levels of 2003 (i.e. scenario 1) and 2001 (i.e. scenario 4) respectively due to restriction of the existing area of forest coffee. Correspondingly, restricting further expansion of both the area of improved coffee and cereal crops cultivation to allow conservation of the existing forest coffee system as indicated in Table 6.8 (column B and C), results in a shadow price of Birr 301.00 and 716.00 for improved coffee plots at the price levels of 2003 and 2001, respectively. Based on price levels of 2003 and 2001, expansion of cereal crops cultivation is less profitable than improved coffee cultivation. The loss associated with one unit of forest coffee approximately equals the potential gain that can be obtained by adding a unit area with improved coffee cultivars. The shadow price of the improved coffee farm type is higher than that of cereal crops cultivation, except when the price is Birr 1.00 per kg for dry cherry coffee, maize and sorghum, i.e., when the relative price of coffee is lower.

Table 6.8. Shadow prices per 0.25ha of forest coffee plot, improved coffee plot and cereal crops cultivation at different scenario of price levels in the coffee-based farming system

Scenario	Forest coffee	Improved coffee	Cereal crops
1.	-323.40	301.00	0
2.	-118.00	114.00	56.00
3.	-104.00	103.00	210.00
4.	-783.00	716.00	0

Source: Own estimation

The shadow prices of farmland mainly determined by the most profitable enterprises, in this case, primarily the improved coffee and maize enterprises. Therefore, the shadow price of land is the same between two cases where the minimum consumption requirement of the major staple food, i.e. maize is subjected to be produced at home or permitted to be purchased from market with in certain range of prices. As the relative price of coffee rises, as it is the case in 2001, the shadow price of land increases (Appendix 6A Table 7). As the aim here is to estimate the opportunity cost of conserving the forest in situ, different scenarios with the possible ranges of prices are considered.

It is more informative to compare the return from cultivation of the forest land, as an opportunity cost of conserving the wild coffee populations, and the estimated genetic value of the wild coffee populations at local levels. The conservation program, which is tentatively considered in the three forest sites in southwestern Ethiopia, is indeed expected to bear a value more than the opportunity cost of the forest land based on the conventional agricultural cultivation system. Table 6.9 shows the comparison of thirty year discounted values of the shadow price of the forest land and the value of the wild coffee genetic resource, which was estimated based on coffee producers' willingness to pay in chapter 4. Although it is commonly accepted to consider discounting of the future values at lower rates, the comparison is made at three levels of interest rate.

Table 6.9. Comparison of the values of the shadow prices of the forest land and the value of wild coffee genetic resource, values given in Birr (the values in bracket are in Euro)

1		Scenarios					
		1	2	3	4	5	6
2	Shadow prices per Fechassa/year	865	301	244	146	930	681
3	Shadow prices per hectare/year	3,460	1,204	976	584	3,720	2,724
4	Nominal shadow prices for the forest areas with 44100ha[1]	152,586,000	53,096,400	43,041,600	25,754,400	164,052,000	120,128,400
5	Nominal value of the wild coffee genetic resource per year[2]	120,870,015	120,870,015	120,870,015	120,870,015	120870,015	120,870,015
6	Annual net nominal value (5-4)	-31,715,985	67,773,615	77,828,415	95,115,615	-43,181,984	741,615
7	NPV for 30 years discounted at 3%	-621,647,289 (-51,803,941)	1,328,392,746 (110,699,395)	1,525,471,260 (127,122,605)	1,864,308,003 (155,359,000)	-846,385,945 (-70,532,162)	14,535,984 (1,211,332)
8	NPV for 30 years discounted at 5%	-487,552,423 (-40,629,369)	1,041,846,580 (86,820,548)	1,196,413,501 (99,701,125)	1,462,160,136 (121,846,678)	-663812946 (-55317745)	11400443 (950036)
9	NPV for 30 years discounted at 10%	-298,983,876 (-24,915,323)	638,896,073 (53,241,339)	733,681,813 (61,140,151)	896,646,768 (74,720,564)	-407,072,877 (-33,922,739)	6,991,142 (582,595)

[1] The three sites refer to the Geba-Dogi forest with an area of 18600 ha, the Boginda-Yeba forest site with an area of about 5500 ha, and the Berhan-Kontir forest site with area of about 20000 ha.
[2] This value is calculated from Table 4.8

The comparison indicates the greater value of the wild coffee genetic resource over the shadow prices of the forest land in the area at most of the scenarios discussed. As shown in the table, it would not be costly to conserve majority of the area in the three target conservation sites for the WCP (about 44,100 ha) that is found in southwestern Ethiopia, at the different scenarios of relative crop prices. If we assume a zero direct costs of conserving the wild coffee populations other than the shadow prices of the forestland, as may be the case by dividing such costs by many potential beneficiaries, the genetic value of the wild populations could cover the shadow price of the forest land area of about 35,000ha, 100,400ha, 123,800ha, 206,970ha, 32,500ha, and 44,370ha respectively in the six scenarios. At the first and fifth scenarios, where the crop prices are higher and gave higher values of the shadow prices of the forest land, the genetic value of the wild coffee populations is little shortfall to cover the shadow prices of the forestland as the opportunity costs of conservation. As it is a reality to have more benefits than that of the coffee genetic resource from conserving the forest land, the analysis could not be considered as the comprehensive cost benefit analysis of conserving the forest land.

Coffee Price as an instrument for conservation of the wild coffee populations: The returns from wild or forest coffee farms are lower than from other enterprises like improved coffee or maize at the 2003 or 2002 price levels and, therefore, do not appear as basic variables in the coffee-based farm model. The model shows that it is advantageous for the farmers to allocate more area for improved coffee cultivars at a coffee price of Birr 2.5/kg of dry cherry and maize price of Birr 1.20/kg, or at a coffee or maize price of Birr 1.00/kg or at a coffee price of Birr 1.00 and maize price of Birr 0.65/kg (Appendix 6A Table 6).

Interventions that improve coffee price or yield levels could influence the land-use change dynamics. Based on the model results, discriminated price levels for coffee produced in the different systems, e.g., a higher price for coffee produced in wild and forest coffee systems, could keep the introduction of improved coffee under control. Keeping other variables in the system constant, according to 2003 price levels, it would be profitable to maintain certain area of forest coffee plots if forest coffee is priced at Birr 4.00/kg dry cherry, while the conventional price for coffee is Birr 2.50/kg. Similarly, keeping unmanaged wild coffee plots with a yield level of about 125 kg/ha beans would also be profitable with a dry cherry coffee price of Birr 14.20/kg.

A price level of Birr 4.00/kg of dry cherry is not uncommon in the system. While the coffee prices in Ethiopia rose up to Birr 6.00/kg in the mid 1990s, they have dropped to less than Birr 1.5/kg of dry cherry especially in the last five years (see Appendix 6B), and the coffee producers have thus suffered from inadequate income (Oxfam, 2002a; Oxfam, 2002b). The fall in coffee prices is basically due to an increasing supply of coffee on the world market, power imbalances in the market and the low quality of coffee (Oxfam, 2002a). It is, however, important to recognize the share that the farmers may get out of the total marketing margin in order to improve their advantage in producing coffee in general and wild coffee in particular. Since the coffee price is determined on the world market through a few roasting companies, an integrated stakeholder role at the world market level that can administer the coffee pricing system is necessary to support a sustainable maintenance and production of forest coffee in order to exploit its service as a habitat for the WCP. The practice of the International Coffee Organization (ICO), which coordinates different stakeholder cooperation for integrating the aspects of food security, environment and trade (ICO, 1999), could be an instrument to address the pricing element to motivate smallholder farmers to contribute to conservation of the forest coffee system. For example, the forest coffee production system in countries like Mexico is currently being promoted by premium prices for the forest coffee related to its service for conservation of the natural forest environments for coffee production (Gimble et al., 2001).

The 'coffee campaign' undertaken by Oxfam[37] making public the farmers' coffee price shocks may contribute towards an advantage in coffee production over production of other crops like

[37] Oxfam International, a non-governmental organization has been involved in making the coffee trade a fair one so that the smallholder coffee producers who supply about 70% of coffee for the world market shall benefit from the commodity. The coffee price has fallen about 70% since 1997 and is reported to seriously affect the life of many farmers in different countries and is again seriously threatening the cultivation of the crop (Oxfam 2002c). The Oxfam coffee campaign also reflected the margin the coffee producers are taking as one cup of coffee is priced at about USD 1.00 to 2.50 in the west, while 1 kg of clean beans could make 100 cups of coffee is sold at USD 0.50 at the farm gate level, which is about 0.2 to 0.5% of the final price (Oxfam 2002b).

maize (See Appendix 6C for the resolutions made by the First International Coffee Conference that was organized by the Oxfam Coffee Campaign). Local level practices like improving the quality of the coffee through harvesting and processing activities and improvement of the yield levels with appropriate management levels can improve the benefits of coffee production. Moreover, it could also be possible to improve the farmers' marketing share through promotion of farmers' cooperative marketing strategies, which allow the farmers to enjoy the values added in the marketing process.

6.5 Summary and conclusion

This chapter focuses on the empirical justification of forest coffee land conversion into cereal crops production or replacement by improved coffee cultivars at the household level in the Geba-Dogi forest community.

Farmers consider farmland as their major resource value from the forest land for cultivation of crops. It was identified that farmers intend to use their wild coffee plots in a well managed form or convert it into cereal crops cultivation. The decision to convert certain area of forest land is a function of the expected returns from the alternative utilization systems. Farmers follow the experiences of successful farmers in the community in terms of adopting certain methods for improving their cultivation. Based on the situation in the last few years, cultivation in the cereal crop-based system seems more yielding than that in the coffee based system. The lower yield of wild or forest coffee system and the lower price of coffee led to a higher return in the cereal-based cultivation system.

It is questionable to expect the maintenance of the coffee-based system on the 2003 price level of 2.50, 1.20 and 1.00 Birr/kg for coffee (dry cherry), maize and sorghum, respectively; on a price per kg of Birr 1.00 for coffee, maize and sorghum; or on a coffee price of Birr 1.00/kg and Birr 0.65/kg of maize and sorghum. With these price levels, farmers in the cereal-based system could obtain higher marginal and average values per unit area of farmland. However, the farmers in the coffee-based system could obtain higher marginal values than those in the in the cereal based system at price level of Birr 4.5, Birr 0.32 and Birr 0.46 per kg for coffee, maize and sorghum, respectively, which was the case in 2001. Therefore, in-situ conservation of the wild coffee populations on farmer's field assumes certain costs for the local farmers if they are to conserve the wild coffee land instead of using it for more profitable systems such as with improved crop varieties. If the wild forest coffee is to be conserved in situ in the farming community, a certain form of protection needs to be provided with respect to the farmers' livelihood to control or lessen the pressure on the forest.

The need to conserve the WCP could be justified as the estimate of the potential genetic value of the WCP, as it is estimated in Chapter 4, is much higher than the value that can be obtained in the alternative forest land use system. Conservation of the wild coffee genetic resource on farmers' fields could take a form of coffee pricing arrangements that motivates farmers to maintain the wild and/or the forest coffee, or per unit area of the forest land consideration of compensations that vary with respect to the relative prices of other crops grown in the area. A price level of about Birr 4.00/kg of dry cherries for forest coffee (with a yield level of 441.00 kg clean beans per hectare), or Birr 14.20/kg of dry cherries for wild coffee (with a yield level of about 125.00 kg of clean beans per hectare) could be comparable to the returns from alternative enterprises, and may lead to preserve the typical forest coffee types, according to the relative price in 2003. Based on 2003 prices, a marginal loss of about 323 Birr/Fechassa is expected due to a restricted maintenance of existing forest coffee plot (0.25 ha) while about Birr 300 is expected to be gained due to the same unit area expansion of improved coffee or cereal crops. Based on 2001 prices, the expected loss due to a restricted maintenance of the existing forest coffee (0.25 ha) is Birr 783/Fechassa, while the gain due to expansion of improved coffee or cereal crops is about Birr 716.00/Fechassa. A strategy of sustainable use and conservation of the wild coffee populations needs to consider the disincentives at the household level associated with maintaining forest coffee land. To this end, a higher premium price for forest coffee than that for improved coffee or an area based lump sum compensation could help to address both the conservation and farmers' food security issues.

7. Summary, conclusions and policy implications

7.1 Introduction

Coffee, as the second most tradable product in the world market with an annual account of about USD 11 billion supports for the livelihood of about 100 million people in the world (ICO, 1999). Most of the beneficiaries from the commodity are smallholder coffee producing households (about 25 million) in about 80 developing countries, who supply about 70% of the world market coffee. In Ethiopia, coffee contributes to the national socio-economy to a great extent as a source of export earning, which accounts for more than 50% of the total, and is the main income source for about 25% of the population. The sustainable production of coffee, however, demands conservation of the wild coffee genetic diversity to help generate coffee planting material that can address different yield limiting factors like diseases, pests and drought.

Due to the lack of knowledge on the value of biodiversity resources, the lack of adequate capacities for conservation and other political and poverty reduction activities, there has been almost no conservation of environmental and genetic resources like the wild coffee genetic resource in Ethiopia. Thanks to the initiatives by individuals and institutions both in the country and abroad, a research project has been undertaken to explain the biodiversity and the utilization system of the forest system that contain the WCP, and to develop conservation and use strategies. This project, i.e., conservation and use of Arabica coffee populations in the montane rain forest of southwestern Ethiopia (CoCE), is conducted in collaboration with the University of Bonn (Germany) and the Ethiopian Agricultural Research Organization (EARO), and is financed by the Germany Federal Ministry for Education and Research.

Numerous experts have emphasized the importance of conserving the greatest possible biological diversity because of the potential values that can be enjoyed by the present and future generations (Wilson, 1998; McNeely et al., 1990). The researches on economics of natural resources and their management especially since the beginning of 1970s have revealed substantial knowledge on the natural resources and then influence on the management of the resources, although much attention was given to general prinCIPles such as *sustainable* *development*, *polluter-pays principle*, *precautionary principle* that consider ethical or political concerns (Faure and Skogh, 2003).

In order to assess the benefits of conserving the resource and contribute to the decision making process, the values of the genetic resource need to be determined. Conserving the WCP in situ brings about opportunity costs for the farmers in the community, as the system hinders the introduction of improved varieties or the expansion of other crops. Other questions like how the value of the wild coffee genetic resource justifies conservation of the forest resource, how do the farmers interact with the resource, and what is the expected future level of the forest resource in the area are some of the vital concerns related to conservation of the resource. In countries like Ethiopia, where there is only little capital for investing in conservation projects where the benefit is to accrue over a long period of time, empirical justification of the values of the resource and the possible costs of its conservation are important.

This dissertation is focused on providing information on the economic aspects of conserving the coffee genetic resource in-situ in its natural forest habitat, where the farmers cultivate the surrounding land. Specifically, it assesses the observed and potential value of the coffee genetic resource domestically in terms of the value of improved coffee planting material as viewed by the coffee producers. Since the value of the genetic resource is associated with the existence of the wild coffee system, analysis of the change in the wild coffee plots is made at the household level. The wild coffee system here refers to a natural forest with naturally regenerated coffee trees, which is not managed by farmers. Forest coffee refers to a managed form of wild coffee where the forest populations are thinned and the undergrowth slashed to allow the naturally regenerated coffee trees to grow freely with less competition from other species. Moreover, the opportunity cost of conserving the resource to the farmers is estimated. Furthermore, the potential value of such genetic resource is assessed using the stated-preference technique, which will motivate the responsible agencies to consider such values in developing appropriate use and conservation strategies.

The study was conducted in the Geba-Dogi and Berhan-Kontir forest communities in southwest Ethiopia where the WCP exist. A household survey with a sample of 120 farmers from each site was taken. In addition, the Gomma district, as a typical coffee producing area in the Jimma zone, was considered to determine the possible ranges of the willingness to pay for improved coffee planting material. In addition to the survey data, secondary data and local level group discussions to help qualify the collected information were used. After explaining the problems related to the threat and importance of conserving the genetic resource in Chapter 1, the theoretical and empirical framework of the value of genetic resource conservation and valuation techniques and an overview of the study areas are discussed in the second and third chapters. In Chapter 4, the value of the WCP is assessed in terms of the potential values of improved coffee planting material and the value of coffee berry disease-resistant cultivars among the wild coffee germplasm collections. Since the value of the genetic resource is assumed with the maintenance of the wild coffee populations, the farmers' tendency of maintaining the wild coffee plots or converting into other forms of land use is explained in Chapter 5. The farmers' interaction with the forest resource is explained in relation to what characteristics of the household and the farm make them convert the wild coffee plots into alternative crops or cultivation systems. In Chapter 6, a quantitative description of the incentives that lead farmers to replace the forest coffee plots by alternative use systems is given. Explicitly, an estimate of the farmers' potential loss due to maintaining the forest coffee plots and limiting further expansion of improved coffee or other crops is made. Furthermore, a comparative evaluation of the value of the wild coffee genetic resource and the opportunity cost of conserving the WCP in situ is made based on a 30 year time horizon.

The following sections summarize the results and provide policy implications for conservation of the natural forest resource in general. Moreover, potential gaps that would give more information for developing a more effective conservation and use strategy are identified and indicated at the end of the chapter.

7.2. Summary and conclusions

7.2.1 Genetic value of the wild coffee populations

The results of this study indicate that the WCP are used as the major source of coffee seedlings for the surrounding farmers. About 85% (in Berhan-Kontir) and 22% (in Geba-Dogi) of coffee seedlings that were planted in three years (2001-2003) were wild seedlings that are naturally regenerated under the wild coffee trees.

The contribution of 15 cultivars that are resistant to the coffee berry disease (CBD), which have been planted on about 20% of the coffee acreage in Ethiopia in the last 30 years, is another value aspect of the WCP. This is because the CBD-resistant cultivars are direct selections among the wild coffee germplasm collections without any hybridization process. The CBD-resistant cultivars have shown an annual yield potential of about 820 kg and 1850 kg clean beans per hectare on farmers' fields and research stations, respectively, while the national average yield is about 471 kg per hectare. As the improved seedlings were supplied by the governments free of charge, the value of the cultivars is estimated in terms of the marginal value due to their yield effects. This empirical study indicates that the CBD-resistant cultivars helped to save a considerable amount of money against the loss due to the disease. The loss due to CBD was estimated to be about 30% nationally (Alemu and Sokar, 2000). The value due to the marginal yield effects of these cultivars obtained in the last 30 years is much higher than the costs associated with the collection of the wild germplasm, selection and dissemination of the improved cultivars.

Wild coffee genetic diversity is becoming increasingly important as there is a growing demand for improved coffee planting material in most of the coffee producing areas. The developed CBD-resistant cultivars are location specific and are not effective in many localities. In addition, the coffee production system in Ethiopia has faced other important diseases like the coffee wilt disease (CWD) and coffee leaf rust, and varieties that are resistant to drought and have a good cup quality are indispensable.

The potential value of improved coffee planting material that could be developed out of genetically diverse wild coffee germplasm was estimated using the choice experiment. Econometric results of the choice experiment indicate that farmers are willing to pay for improved coffee varieties that have vital attributes, especially resistance to CBD, CWD and rust, and vigor nature of the trees. Among these attributes, the resistance to CBD and CWD are of greatest importance, as they are the two most serious coffee diseases in Ethiopia. Furthermore, those farmers in areas surrounding the forest with the wild coffee populations (i.e., in the Geba-Dogi and Berhan-Kontir communities) are not prepared to pay as much as those located far from the forest coffee sites (i.e., in the Gomma district). This is related to the lesser severity of coffee disease problems in the forest communities with the WCP as compared to the areas without the WCP. This inference is due to the fact that farmers in the forest communities obtain advantages from the wild coffee material associated to the qualities in terms of resistance to diseases and vigor nature. Since most of the coffee producing areas in Ethiopia are seriously affected by diseases like CBD, CWD, and rust, it is in the interest of most coffee producers to look for improved planting material as is the case in the Gomma district of the Jimma zone. The contribution of the WCP to the value of the genetic enhancement is estimated by the difference in the willingness to pay for the improved planting material estimated for farmers in typical coffee producing areas over the estimated cost of developing an improved planting material at research stations and the cost of dissemination.

7.2.2 Conversion and intensification of the wild coffee lands

Analysis of the forest land use indicates that the forest lands surrounding both forest communities have been changing such that the area of wild coffee system has been diminishing and replaced mainly by a managed form of coffee farm with introduction of local or improved coffee cultivars. The cultivation area of improved coffee and cereal crops has increased through time at both sites. Although all farmers surrounding the sites have forest coffee plots, only few of them have some area of unmanaged wild coffee plots. On top of institutional factors like increase in coffee price, different household and farm characteristics are also associated with the farmers' motivation regarding conversion of their privately owned wild coffee plots. Most importantly, a larger area under maize and coffee, food security, distance from district center, greater distance from forest sites to residence, and smaller area of improved coffee are positively associated with the area of wild coffee plots maintained at household level. As most farmers at both sites are looking for additional farmland (80% in Geba-Dogi and 72% in Berhan-Kontir), the wild coffee system is threatened due to the demand of farmland for cultivation purposes.

Information on the factors that are associated to the land-use change process can help to identify important intervention measures in such a way to shape the dynamic process towards a sustainable use of the resource. Otherwise, the potential value of the resource can not be explored in reality, if some form of intervention is not made to conserve these last patches of the WCP.

7.2.3 Opportunity cost of conserving the wild coffee genetic resource on farmers' fields

Since the wild coffee system at both study sites are surrounded by farmers who are using the forest land for cultivation purposes, the remaining forest land is threatened by conversion for cultivation purposes. Such inference is the most likely case since it is a normal practice for farmers to adopt a more yielding improved varieties or shifting to a more profitable enterprise.

Conservation of wild or forest coffee lands existing de facto on farmers' fields assumes certain cost for the owners of the land, which amount to the difference value over what can be obtained from an alternative utilization system. Empirically, it is rational for the farmers in the study areas to convert their wild coffee plots into either a managed form of coffee production or substitute them by improved coffee or maize, since the return per unit area is lower than that of the alternative enterprises based on the price levels of 2002 and 2003[38]. The price/yield levels of these different enterprises determine the motivations.

A continued existence of the coffee-based system in the Geba-Dogi area with prices as in 2002 and 2003, and at price levels of Birr 1.00 per kg for coffee, maize and sorghum is not to be expected. With such prices, farmers in the cereal-based system can make more marginal and average returns per unit area. However, the farmers in the coffee-based system could get higher

[38] In the Geba-dogi community, the coffee price was Birr 2.50 per kg dry cherries, Birr 1.20 for maize and Birr 1.00 for sorghum per kg in 2003. In 2002, it was Birr 1.00 for coffee cherries and Birr 0.65 per kg of maize and sorghum.

marginal return than in the cereal based system at a price level of Birr 4.50, Birr 0.32 and Birr 0.46 per kilogram of coffee, maize and sorghum, respectively, which was the case in 2001.

It is more informative to compare the discounted values of the shadow prices of the forest land as the value that can be expected in the next best alternative with the potential genetic value of the WCP to justify the need to conserve the forest system with the WCP for the sake of the coffee genetic resource. Accordingly, a 30 year discounted potential value of the genetic resource, using different rates of discounting, implies the contention to conserve majority or all the forest areas with the WCP, i.e., 44,100ha at different crop price scenarios observed during the period from 2001 to 2003 in the area.

Based on these results, management of the in-situ conservation of the coffee genetic resource on farmers' fields could be approached in terms of either a differentiated pricing system or a lumpsum compensation per unit area of forest land for the owners. The former approach is in order of administering the coffee prices such that higher price can be given to coffee that is produced in the wild or forest coffee systems than the coffee produced conventionally in improved or garden systems. The latter approach refers to a compensation for the loss an owner of wild coffee or forest coffee plots could face as compared to the amount that can be obtained in the next best alternative production system.

A price level of about Birr 4.00/kg of dry cherry for forest coffee or Birr 14.20/kg for wild coffee could motivate farmers to conserve such forest coffee types, according to 2003 price levels. Based on 2003 prices, a marginal loss of about 323.00 Birr/Fechassa is expected for forest coffee, while about Birr 300.00 is expected to be gained due to expansion of improved coffee or cereal crops plots by one Fechassa (i.e., 0.25 ha). Based on 2001 prices, the expected loss due to a restricted maintenance of forest coffee plot is Birr 783.00/Fechassa, while the gain due to expansion of improved coffee or cereal crops is about Birr 716.00/Fechassa. A strategy of sustainable use and conservation of the wild coffee populations needs to consider such disincentives at the household level associated with maintaining certain areas of forest coffee land. To this end, a higher premium price for forest coffee over that of improved coffee could support policies concerning both the conservation and farmers' food security issues.

7.3 Policy implications

Destruction of a natural resource that can be used by humans for generations seems to neglect the future uses of the resource. Conservation of natural resources needs to be treated like any long-term investment program, which can also benefit future generations, in addition to the benefits for the present generation. There is a need to conserve at least the seeds of such genetic resources before they become extinct and loss their renewable nature. This demands an inter-temporal concept of benefit transfer. Theories suggest the need to conserve such natural resources mainly for their future values. Conservation of the wild Arabica coffee genetic resource can also be viewed with respect to the potential benefit to the coffee producers and consumers in the world, as Ethiopia is known to be the center of origin and diversity of Arabica coffee.

However, the aggregate genetic value of the WCP, which is higher than the corresponding opportunity cost of conserving the existing forest lands, can justify the need to conserve the resource, especially as the forest lands with wild coffee populations are being converted into other agricultural production systems as the farmers consider primarily the private value of the resource. Therefore, policy measures are vital for conservation and sustainable utilization of the resource. The farmers as the major actors in the change process have been using the resource for their private interest and have been overlooking the issue of conserving the public resource. This costly way of addressing local problems that involve intensive use of natural resources need to be considered in the national and international development agendas. Moreover, such policy incentives demand social, cultural, economic and legal frameworks (Edilegnaw, 2004).

Accordingly, the following aspects are vital in the policy framework of the regional or national government.

1. Conservation of the wild coffee populations should be strengthened, and coffee breeding activities need to be promoted to collect, select, and develop cultivars with attributes like resistance to diseases like wilt, berry disease, rust, and with vigorous nature.

2. Measures that can improve the yield of forest coffee without affecting the coffee genetic diversity and yield of other crops, which can help improve the food security status of the farmers should be implemented in order to lessen farmers' pressure on the forest. In addition, more needs to be done to search for opportunities that can raise farm-gate coffee prices in general, improving harvesting and handling of coffee, (i.e., transport, storage and processing), and opportunities that can improve the marketing power of smallholder farmers through the formation of farmer cooperatives.

3. Land settlement/resettlement practices need to be checked such that people are not allowed to settle in the forest, and that the administrative structure at the peasant association level is strengthened in such a way that all the members of the community have equal rights (as opposed to a small number of leading members in the peasant association) and responsibilities. Moreover, since the current state of the art is that most of the maturing youngsters in the communities are runing their life through farming in the communities, additional mechanisms that can limit the density of people depending on the forest lands could help reducing the pressure onto the forest.

4. Special coffee marketing arrangements need to be made to include compensating mechanisms like discriminated pricing, i.e., a higher price for coffee harvested from wild or forest coffee than for conventional coffee, as this could influence the farmers' decision to maintain the wild or forest coffee farm types. A lump sum payment per unit area of forest coffee plots owned by the farmers could be made, which could be adjusted according to the changing crop prices. This may be done by creating a forest coffee fund in the coffee sector in order to motivate those farmers who maintain diverse coffee populations. Moreover, a global coffee trading system needs to consider conservation of the genetic resources to support a sustainable supply of coffee.

7.4 Suggestions for future research

The results of this work as such cannot provide all the required information to design an effective conservation and use strategy for the resource. The following research topics are important in order to gain more information for sustainable use of the forest resource.

1. Comparative analysis of the performance of different coffee marketing strategies and their impact on conservation of WCP. It is especially important to generate information that can help guide the coffee marketing systems to protect the coffee producers from such risks as fall in coffee price, and motivate them for more cooperation in the conservation program.

Relevance

One of the major reasons for farmers to keep on producing coffee is the relative income generating potential of coffee farming enterprise. The income generating potential is determined by the efficiency of operations at different levels in the production and marketing processes, among other things. Currently there are different strategies and channels of coffee marketing in Ethiopia. The conventional and the niche marketing strategies are the major classifications. The latter one deals with arrangements of coffee supply as special coffee product forms like 'biodiversity friendly coffee', 'Bird friendly', 'Organic coffee', 'Sustainable coffee' and 'Shade coffee' that are related to the nature of the coffee production systems and interactions with other environmental attributes, while the former strategy is the system with an indiscriminate supply of coffee from different locations and production systems. By analyzing the structure, conduct and performance of the different marketing strategies, it is possible to identify inefficient practices that are at odds with farmers' net income and their relative importance for conservation of the WCP.

2. Assessing the value of Arabica coffee genetic resources in other producing countries. The objective is to assess the willingness to pay for conserving wild Arabica coffee populations with respect to different production limiting factors that coffee producers might have been facing in different coffee producing countries.

Relevance

Diversity in the coffee genetic resource with a potential of developing more productive planting material could be a benefit to most coffee producing countries. Such benefits of the genetic resource to other countries in the world could also be a justification to conserve the WCP. Even if the local community could undervalue the wild resource, external funding could compensate the costs of conserving the resource if the wild resources have certain value to other parts of the world. The information could also be a basis for designing benefit transfer policy arrangements that can support the conservation and utilization of the resources.

3. Assessment of coffee quality grade levels by location and estimating losses due to improper harvesting and processing.

Relevance

Improvements in the return from the coffee commodity could be one of the justifications for the need to conserve the genetic resources. Arabica coffee that is being produced in certain parts of Ethiopia like Harerghe (eastern Ethiopia) and Yirgacheffe (southern Ethiopia) are known to have superior cup quality. The cup quality of coffee could be associated with the quality of practices during harvesting and processing; the natural characteristics of the coffee cultivars, or location specific characteristic of the production area. Improvements in the quality of coffee by improving certain activities can increase the return from coffee. Assessing and comparing the observed coffee quality/grade levels by location and coffee processing types and the real quality/grade levels of the coffee that is being produced from different locations with a possible proper level of harvesting and processing can indicate the marginal loss due to the existing harvesting and processing types.

4. Analysis of the economic importance of wild animals as opportunities and threats in the community.

Relevance:

The wild animals that are found in the forest are thought to be valuable for the ecosystem sustainability. However, there is still a conflicting interest between the animals and the surrounding people in the forest communities. The interaction between the people and the animals in turn is hypothesized to have potential impact on the interaction between the people and the forest, which needs to be specified and develop a compromising concept for the conservation program.

References

Adamowicz, W., Boxall, P., Williams, M., Louviere, J. 1998a. "Stated Preference Approaches for Measuring Passive Use Values: Choice Experiments and Contingent Valuation." American Journal of Agricultural Economics 80: 64-75

Adamowicz, W., Louviere, J. and Swait, J. 1998b. Introduction to Attribute-Based State Choice Methods. Report to National Oceanic and Atmospheric Administration US Department of Commerce (NOAA), Resource Valuation Branch and Damage Assessment Center.

Agricultural Information System, Ministry of Agriculture and livestock – Ecuador. 2001. Expansion of Ecuador's Export Commodities, Product Profile - Special Coffee, World Bank Project. (http://www.sica.gov.ec/ingles/agro%20oportunidades/docs/business_op/CORPEI/cafe_%20especial.pdf)

Agrisystems Limited. 2001. Coffee Support Project: Ethiopia. Formulation Report, July 2001, United Kingdom.

Alemu, T. and Sokar, I. 2000. Status of CBD in Minor Coffee Growing Regions. Proceedings of the Workshop on Control of Coffee Berry Disease (CBD) in Ethiopia, Addis Ababa (Ghion Hotel), 13-15 August 1999, Addis Ababa, Ethiopia.

Almekinders, C. and Boef, W.D. 2000. Discouraging or Encouraging Diversity. In: C. Almekinders and W.D. Boef (eds.): Encouraging Diversity. Intermediate Technology Publications Ltd. London.

Angeleson, A. and Kaimowitz, D. *1999.* Rethinking the Causes of Deforestation: Lessons from Economic Models. The International Bank for Reconstruction and Development / THE WORLD BANK, *The World Bank Research Observer, vol. 14, no. 1* pp. 73–98.

Angerov, F. and Monjardet, B. 2002. Utility Maximization, Choice and Preference. Studies in Economic Theory No. 16 Springer-Verlag, Berlin

Antoni, F. and Lashermes, P. 2002. Genetic History of Coffee Domestication Traced through Chromosomes. Scientific Bulletin No. 161, Institut De Recherché Pour Le Development (http://www.ird.fr/us/actualites/fiches/2002/161.htm)

Anzueto, F., Bertrand, B., Sarah, J.L., Eskes, A.B. and Decazy, B. 2001. Resistance to *Meloidogyne incognita* in Ethiopian *Coffee Arabica* Accessions. *Euphytica* 118: 1–8, *Kluwer Academic Publishers. The Netherlands.*

Artuso, A. 1998. Creating Linkages between Valuation, Conservation and Sustainable Development of Genetic Resources. In: R.E. Evenson, D. Gollin, and V. Santaniello (eds.): Agricultural Values of Plant Genetic Resources. CABI Publishing, U.K.

Asres, T. 1996. Agroecological Zones of Southwest Ethiopia. Matreialien Zur Ostafrica-Forschung, Heft 13.

Batie, S. S., and Shugart, H. H. 1989. The Biological Consequences of Climate Change: An Ecological and economic assessment, in N.J. Rosenberg, W. E. Easterling, III, P.R. Crosson, J. Darmstadter (Eds.), Greenhouse Warming: Abetment and Adaptation, Resources for the Future, Washington.

Bayetta B. and Mesfin A. 1986. Variations among National Coffee Collections for some Agronomic Characteristics. First Ethiopian Coffee symposium. Aug. 1986, IAR Addis Ababa (Unpublished).

Bayetta B., Behailu A. and Gebramu T. 1998. Description and Production Recommendations for New Cultivars of Arabica coffee. Research Report No. 34. IAR Addis Ababa

Bayetta B., Behailu A., and Fekadu T. 2000. Breeding for Resistance to Coffee Berry Disease in Arabica coffee: Progress since 1973. Proceedings of the Workshop on Control of Coffee Berry Disease (CBD) in Ethiopia, Addis Ababa (Ghion Hotel), 13-15 August 1999 Addis Ababa, Ethiopia.

Befekadu D., Berhanu N. and Getahun T. (eds.). 2000/2001. Second Annual Report in Ethiopian economy. Ethiopian Economic Association (EEA) Vol.2, Addis Ababa.

Beneke, R.R. and Winterboer, R. (1973). Linear Programming Applications to Agriculture. Iowa State University Press, Ames, Iowa

Bentham, J. 1970. An Introduction to the PrinCIPles of Moral and Legislations. Athlone Press, London.

Berlage, L. and Renard, R. 1985. The Discount Rate in Cost-Benefit Analysis and the Choice of a Numeraire. Oxford Economic Papers, No. 37, Pp. 691-699.

Bezabih E. and Storck, H. 1992. Improvement Strategies for Farming Systems in the Eastern Highlands of Ethiopia. Agricultural Economics; Vol.8. Elsevier Science Publishers B.V. Amsterdam.

Birol, E. 2002. Applying Environmental Valuation Methods to Support the Conservation of Agricultural Biodiversity In: M. Smale, I. Mar, and D. I. Jarvis (eds.): The Economics of

Conserving Agricultural Biodiversity On-farm. Proceedings of a Workshop Hosted by the IPGRI, Italy. May 13-16, 2002.

Black, M. J., Bradford, K. J. and Vázquez-Ramos, J. (Eds.). 2000. Seed Biology: Advances and Applications. CABI Publishing

Brown, G. 1987.Valuation of Genetic Resources: The Preservation and Valuation of Biological Resources, G. Brown, W. Kunin, J. Sweirzbinski (eds.).Seattle. WA: University of Washington Press.

Brown, G. Jr. 1990. Valuation of Genetic Resources. In: Orians, G.H., Brown, G.M. Jr, Kunin, W.E. and Swierzbinski, J.E. (eds.). The preservation and valuation of biological resources. University of Washington Press, Seattle, USA.

Brush, S.B. and Meng, E. 1998. The Value of Wheat Genetic Resources to Farmers in Turkey In: R.E. Evenson, D. Gollin, and V. Santaniello (eds.): Agricultural Values of Plant Genetic Resources. CABI Publishing, U.K.

Brush, Stephen B. 1992. Farmers' Rights and Genetic Conservation in Traditional Farming Systems. World Development 20:1617-1630.

Bullock, C.H., Elston, D.A., Chalmers, N.A. 1998. "An Application of Economic Choice Experiments To A Traditional Land Use - Deer Hunting And Landscape Change In The Scottish Highlands." Journal of Environmental Management 52, 335-351.

Byerlee, D. 1996. Modern Varieties, Productivity and Sustainability: Recent Experience and Emerging Challenges. World Development, 24, 697-718

Casley, D.J. and Lury, D. 1982. Monitoring and Evaluation of Agriculture and Rural Development Projects. A World Bank Publication. John Hopkins University Press. Baltimore.

Cattaneo, A. 2002. Balancing Agricultural Development and Deforestation in the Brazilian Amazon Research Report 129 International Food Policy Research Institute Washington, D.C.

Central Intelligence Agency (CIA). 2005. The World Fact Book. (http://www.odci.gov/cia/ publications/factbook/docs/ contributor_copyright.html).

Central Statistical Authority (CSA). 1993. Ethiopian Agricultural Sample Survey, 1988/89: Report On Crop Land Utilization (Private Holdings) Statistical Bulletin No. 118, Addis Ababa, Ethiopia

Central Statistical Authority (CSA). 1995a. Ethiopian Agricultural Sample Survey, 1991/92: Report On Land Utilization (Private Holdings) Statistical Bulletin No. 134, Addis Ababa, Ethiopia

Central Statistical Authority (CSA). 1995b. Ethiopian Agricultural Sample Survey, 1994/95: Report On Land Utilization (Private Holdings) Statistical Bulletin, Vol. 4, No. 132, Addis Ababa, Ethiopia

Central Statistical Authority (CSA). 1995c. Ethiopian Agricultural Sample Survey, 1990/91: Report on Land Utilization (Private Holdings) Statistical Bulletin No. 131, Addis Ababa, Ethiopia

Central Statistical Authority (CSA). 1996. Ethiopian Agricultural Sample Survey, 1995/96: Report on Crop Land Utilization (Private Holdings). Statistical Bulletin Vol.4, No. 152, Addis Ababa, Ethiopia

Central Statistical Authority (CSA). 1998. Ethiopian Agricultural Sample Survey, 1997/98: Report on Land Utilization (Private Holdings) Statistical Bulletin, Vol. 4, No. 193, Addis Ababa, Ethiopia

Central Statistical Authority (CSA). 2000. Ethiopian Agricultural Sample Survey, 1999/2000: Report on Land Utilization (Private Holdings) Statistical Bulletin No. 227, Addis Ababa, Ethiopia

Central Statistical Authority (CSA). 2003. Ethiopian Agricultural Sample Enumeration, 2001/2002: Results at Country Level (Part II), Addis Ababa, Ethiopia

Central Statistical Authority (CSA). 2003. Land Use: Results for Oromia Region. Ethiopian Agricultural Sample Enumeration, 2001/2002, Addis Ababa, Ethiopia

Chekun T., Geremew G. and Teshome A. 1996. Problems and constraints of coffee production in southern Nations, Nationalities and Peoples State (SNNPRS): A case study of four years

Cleave, J.H. 1974. African Farms: Labor use in the Development of Smallholder Agriculture. Praeger Publishers, New York

Cline, W.R. 1992. The Economics of Global Warming, Institute of International Affairs, Washington D. C.

Collinson, M. 1983. Farm Management in Peasant Agriculture. West View Press, Boulder, Colorado

Cousin, T.L. 1997. Ethiopia, Coffee and Trade. Case number: 397, CASE MNEMONIC: COFFETH (http://www.american.edu/TED/ethcoff.htm)

Curry, S. and Weiss, J. 1999. Project Analysis in Developing Countries. Secon Edition. Palgrave McMillan

Deginet A. 2005. The Economics of Smallholder Coffee Farming Risk and its Influence on Household Use of Forests in Southwestern Ethiopia. Cuvillier Verlag, Göttingen, Germany.

Demil T. 1999. History, Botany and Ecological Requirements of Coffee. Journal of The Ethiopian Wildlife And Natural History Society No 20, Addis Ababa, Ethiopia.

Dorfman, R., Samuelson, P.A., and Solow, R.M. 1958. Linear Programming and Economic Analysis. Mc Graw-Hill Book Company, New York

Drucker, Adam G. 2004.The Economics of Farm Animal Genetic Resource Conservation and Sustainable Use: Why Is It Important and What Have We Learned? Commission on Genetic Resources for Food and Agriculture. FAO - Background Study Paper No. 2

Duffy, M. And Holste, A. 2005. Estimated Returns to Iowa Farmland. Journal of the ASFMRA Vol. 68

Dulloo, D. E., Charrier, A., Dussert, S., Anthony, F., Tesfaye, S., Rakotomalala, J. J., Agwanda, C., Legnate, N. 2001. Conservation of Coffee Genetic Resources: Constraints and Opportunities. 19th International Scientific Colloquium on Coffee. ASIC (Accessed on January 24, 2005) Http://Www.Asic-Cafe.Org/Pdf/Abstract/B208.Pdf

Edilegnaw W. 2004. The Economics of On-Farm Conservation of Crop Diversity in Ethiopia: Incentives, Attribute Preferences and Opportunity Costs of Maintaining Local Varieties of Crops. Development Economics and Policy Series, Vol.45. Peter Lang, Berlin, Germany.

Eirea, M.T.S., Walters, C., Calidas, L.S. 1999. Water Sorption Properties in Coffea Spp. Seeds and Embryos. Seed Science Research, CABI Publishing, Vol. 9, No.4.

Elad, R.L, Clifton, I.D.and Epperson, J.E. 1994. Hedonic Estimation applied to the Farmland Market I n Georgia. Journal of Agriculture and Applied Economics, 26 (2): 351-366

Eshetu D. and Girma A. 1992. Determining levels of CBD Resistance on Progenies of 1982 Selections using Detached Berry Test. Addis Ababa, Ethiopia.

Eshetu D., Teame G. and Girma A. 2000. Significance of Minor Diseases of Coffee Arabica in Ethiopia: A Review. Proceedings of the Workshop on Control of Coffee Berry Disease (CBD) In Ethiopia, Addis Ababa (Ghion Hotel), 13-15 August 1999 Addis Ababa, Ethiopia.

Evenson, R. And Gollin, D. 1997. Genetic Resources, International Organizations and Improvements in Rice Varieties. Economic Development and Cultural Change, 45, 471-500.

Evenson, R.E., Gollin, D. and Santaniello, V. 1998. Introduction and Overview: Agricultural Values of Plant Genetic Resources. In: Evenson, R.E., Gollin, D. and Santaniello (Eds.) Agricultural Values of Plant Genetic Resources CABI Publishing, Wallingford, UK.

FAO. 1997. Report on the State of the World's Plant Genetic Resources. Rome.

FAO. 1993. Conservation of Genetic Resources in Tropical Forest Management. FAO Forestry Paper 107, Rome, Italy.

FAO. 1997. Farm Management for Asia: A Systems Approach. FAO Farm Systems Management Series – 13.

FAO. 2000. Application Applications of the Contingent Valuation Method in Developing Countries: A Survey. FAO Economic and Social Development Paper 146, Rome.

FAO. 2003. Integrated Natural Resources Management to Enhance Food Security: The Case for Community-Based Approaches in Ethiopia, Environment and Natural Resources Working Paper No. 16

FAO. 1997. Status of the World's Forests. Rome, Italy.

FAO/UN. 1996. Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture & the Leipzig Declaration. Adopted by the International Technical Conference on Plant Genetic Resources Leipzig, Germany 17-23 June 1996 Rome FAO.

Farber, Daniel A. and Hemmersbaugh, Paul A.1993. The Shadow of the Future: Discount Rates, Later Generations, and the Environment. Vanderbilt Law Review 46: 267-304.

Farzin, Y.H. 1982. The Effect of Discount Rate and Substitute Technology on Depletion of Exhaustible Resources. World Bank Staff Working Papers Number 516, The World Bank, Washington D.C.

Faure, M. and Skogh, G. 2003. The Economic Analysis of Environmental Policy and Law: An introduction. Edward Elgar Publishing.

Fisher, A. and Krutilla, J. V. 1975. Resource Conservation, Environmental Preservation and Rate of Discount. The Quarterly Journal of Economics, Vol. 89, No. 3, Pp. 358-370.

Freeman, A.M. 2003. The Measurement of Environmental and Resource Values: Theory and Methods. Second Edition. Resources for the Future, Washington D.C.

Frisvold, G., Sullivan, J. and Raneses, A. 1999. Who Gains From Global Improvements In US Crops? The Journal of Agrobiotechnology Management Economics, Vol.2, No.3 & 4, Article 15.

Fuglie, K., Ballenger, N., Day, K., Klotz, C., Ollinger, M., Reilley, J., Vasavoda, U., and Yee, J. 1996. Agricultural Research and Development: Public and Private Investments under Alternative Markets and Institutions, Agricultural Economic Report No.735. Washington D.C.: Economic Research Service, US Department of Agriculture.

Gatzweiler, F. 2003. The Changing Nature of Economic Value: Indigenous Forest Garden Values in Kalimantan, Indonesia. Institutional Change in Agriculture and Natural Resources, Volume 16. Shaker Verlag, Germany.

Gimble, C., Behrbaum, M., Anderson, J. W. 2001. Shade Grown Mexico Coffee Steps in to the Spotlight. SEATTLE Conservation International and Starbucks.

Golley, F. 2000. Analysis of the Concept of Landscape Change In: U. Mander and R.H.G. Jongman (Eds.): Consequences of Land Use Changes WIT Press, Boston

Gollin, D. Undated. Valuing Ex-Situ Collections of Plant Genetic Resources: Conceptual Framework and Empirical Approaches. Biodiversidade: Perspectivas E Oportunidades Tecnologicas (Http://Www.Bdt.Fat.Org.Br/Publicacoes/Padct/Bio/ Cap6/)

Greene, W. H. 2003. Econometric Analysis. Fifth Edition. Pearson Education International, USA.

Grimble, R. and Laidlaw, M. 2002. Biological Resource Management: Integrating Biodiversity Concerns in Rural Development Projects and Programs Biodiversity Series No 85, NRI.

Guinand, Yves and Dechassa, Lemessa 2001. Wild-Food Plants in Ethiopia: UN-Emergencies Unit For Ethiopia Reflections on The Role Of 'Wild-Foods' and 'Famine-Foods' at a Time of Drought. UNDP, Emergency Unit for Ethiopia (Http://Www.Africa.Upenn.Edu/Faminefood/Downloadable/Famine%20Food%20Article.Doc).

Haab, T.C. and McConnell, K.E. 2002. Valuing Environmental and Natural Resources: The Econometrics of Non-Market Valuation. New Horizons in Environmental Economics, UK.

Haarer, A.E. 1962 Modern Coffee Production, Second edition. Leonard Hill, London.

Hajacowicz, S. A. and Young, M.D. (Eds.). 2002. Value of Returns to Land and Water and Costs of Degradation: A Consultancy Report to the National Land and Resource Audit by the Policy and Economic Research Unit of CSIRO Land and Water, Canberra.

Hamon, S., Anthony, F., Barre, P., Berthaud, J., Boursot, M., Chabrillange, N., Chin-Long Ky, and Marie-Christine. 1998. Biotechnology for Coffee Breeding and Genetic Resource Enhancement. Cahiers D'études Et De Recherches Francophones / Agricultures. Volume 6, No. 7, 480, Réseaux Transnationaux D'amélioration Des Plants Utilisant Les Biotechnologies.

Hanley, N. 2001. "Cost-Benefit Analysis and Environmental Policy Making", Environment and Planning C: Government and Policy, Vol. 19, 103-118.

Hanley, N., Mourato, S and Wright, R. 2001. "Choice Modeling: A Superior Alternative for Environmental Valuation?" Journal of Economic Surveys, 15, 435-462.

Hanley, N., Ryan, M. And Wright, R. 2003. Estimating the Monetary Values of Health Care: Lessens From Environmental Economics. Health Economics, Vol. 12, Pp. 3-16.

Hanley, N., Wright, R. And Koop, G. 2000. Modeling Recreation Demand Using Choice Experiments: Rock Climbing in Scotland. Discussion Paper 2000-11, Department of Economics, University of Glasgow.

Hardaker, J.B. 1978. A Review of Some Farm Management Research Methods for Small Farm Development in LDCs, Journal of Agricultural Economics, Vol.30, NO.2 Pp315-332.

Hardon, J., Duvick, D. and Visser, B. 2002. Genetic Diversity, Conservation and Development. In: C. Almekinders and W.D. Boef (Eds.). Encouraging Diversity. Intermediate Technology Publications Ltd. London.

Hausman, J. A., K. L., Gregory and McFadden, D. 1993. "Assessing Use Value Losses Caused By Natural Resource Injury," In: Hausman, James A. (Ed.). Contingent Valuation: A Critical Assessment, Pp. 341-359. Amsterdam: North-Holland.

Hazell, P.B.R. 1986. Mathematical Programming for Economic Analysis in Agriculture. McMillan Publishing Company, New York.

Heckelei, Thomas and Wolff, H. 2001. A Methodological Note on the Estimation of Programming Models. Institute of Agricultural Policy, Market Research and Economic Sociology, University of Bonn, Germany.

Holden S.T., Shiferaw B. and Wik M. 1998. Poverty, Market Imperfections and Time Preferences: of Relevance for Environmental Policy? Environment and Development Economics 3(L): 105-130.

Howard, J. Kelly, Valerie, Demeke, Mulat, Maredia, Mywish, and Stepanek, Julie 1999. Green Revolution Technology Takes Roots in Africa: The Promise and Challenges of The Ministry of Agriculture/SG2000 Experiment With Improved Cereals Technology In Ethiopia MSU Agricultural Economics, Policy Synthesis Number 42. Michigan State University.

Http://News.Bbc.Co.Uk/1/Hi/Sci/Tech/Specials/Sheffield_99/450243.Stm

IAR/Jimma (Institute of Agricultural Research/Jimma). 1996. Recommended Production Technologies for Coffee And Associated Crops. IAR, Addis Ababa

International Coffee Organization (ICO). 1999. Framework for Four Studies on Coffee and Environment.

International Trade Center (ITC). 2002. Coffee: An Exporter’s Guide. Geneva, Switzerland

International Union for Conservation of Nature and Natural Resources (IUCN). 1985. United Nations list of National Parks and Protected Areas. IUCN, Gland.

IPS (Inter Pres Service) 1997. Agriculture: Improved Coffee Cultivation in Central America Http://Www.Ips.Fi/Koulut/199747/5.htm.

Jongman, R.H.G. And Bunce, R.G.H. 2000. Landscape Classification, Scales and Biodiversity in Europe. In: U. Mander and R.H.G. Jongman (Eds.): Consequences of Land Use Changes. WIT Press, Boston.

Kaplan, J. 1998. Conserving the World Plants. Agricultural Research. Vol.46, No.9. Pp.4-9.

Kassahun S., Hailu T. and Steven, F. 1990. The Profitability of Coffee and Maize among Smallholders: A Case of Limu Awraja, Illubabor Region, Research Report No. 10, Institute of Agricultural Research.

Kemal, N., Geremew, G., and Abebe, B. 2000. Socioeconomic and Farming Systems Study, Consultancy Report Prepared for Coffee Improvement Program III CTA, Addis Ababa.

Kholi, D.R. 1981. Report on Sample Census of Coffee Farms (1974/75-197/77). MCTD, Planning and Programming Department, Ethiopia

King, D.M., M. Mazzotta, and K.J. Markowitz. (Undated): "Ecosystem Valuation". Web Site (Http://Www.Ecosystemvaluation.Org).

Knudson, M. 1999. Agricultural Diversity: Do We Have The Resources to Meet Future Needs? In: Frisvold, G. and Kuhn, K. (Eds.). Global Environmental Change: Assessing the Impacts (Pp.43-86). Alders Hot: Edward Edgar Publishing.

Krug, C.A. and Poerck, R.A.D. 1968. World Coffee Survey. FAO Agricultural Studies No. 76 FAO/UN.

Lancsar, E. 2002. Deriving Welfare Measures From Stated Preference Discrete Choice Modeling Experiments. Discussion Paper 48 University of Technology, Sydney City Campus, Haymarket

Layard, R. and Glaister, S. (Eds.) 1994. Cost Benefit Analysis. 2nd Edition. Cambridge University Press, U.K.

Lazoda, G. A. 1993. The conservationist dilemma. International Economic Review, Vol. 34, No. 3

Long, J.Scott and Freese, Jerremy .2001. Regression Models for Categorical Dependent Variables Using STATA. STATA Corporation Texas, USA

Louviere, J.J., D.A. Hensher, and J.D. Swait 2000. Stated Choice Methods: Analysis And Application. Cambridge University Press, UK.

Low, A.R.C. 1978. Linear Programming and the Study of Peasant Farming Situations. Journal of Agricultural Economics: Vol.29, No.1-3 Pp 199-200

Maddala, G.S. 1983. Limited Dependent and Qualitative Variables in Econometrics. Cambridge, UK: Cambridge University Press.

McDonald, F. and Moffitt, R.A. 1980. The Use of Tobit Analysis. The Review of Economics and Statistics, Vol.62, No.2.

Melaku J. and Samuel A. 2000. Status of CBD in Oromia Region. Proceedings of the Workshop on Control of Coffee Berry Disease (CBD) In Ethiopia, Addis Ababa (Ghion Hotel), 13-15 August 1999 Addis Ababa, Ethiopia.

Million A. 2000. Significance of Arthropod Pests of Coffee in Ethiopia. Proceedings of the Workshop on Control of Coffee Berry Disease (CBD) in Ethiopia, Addis Ababa (Ghion Hotel), 13-15 August 1999 Addis Ababa, Ethiopia.

Million A., Arega, Z. and Sisay, T. 2003. Coffee Wilt Disease: Cause, Effect and Management. Jimma Agricultural Research Center, Crop Protection Division (unpublished)

Ministry of Agriculture (MOA). 2000. Agro-Ecological Zones of Ethiopia. Natural Resource Management and Regulatory Department, Addis Ababa.

Ministry of Agriculture (MOA). 2003. Coffee Development and Marketing Comprehensive Plan. Ministry of Agriculture. Addis Ababa, Ethiopia

Ministry of Coffee and Tea Development (MCTD). 1989. Report on Yield Assessment Survey (1988 or 1980/81). Addis Ababa, Ethiopia

Ministry of Finance and Economic Development (MoFED). 2002. Ethiopia: Sustainable Development and Poverty Reduction Program Federal Democratic Republic of Ethiopia (FDRE) Addis Ababa Ethiopia

Morrison M, Bennett J, Blamey R and Louviere J. 1998. Choice Modelling and Tests of Benefits Transfer. Choice Modelling Research Report 8, University of New South Wales, Canberra.

Morton, J.F. 1977. Major Medicinal Plants. C.C. Thomas, Springfield, IL.

National Research Council (NRC). 1993. Managing Global Genetic Resources: Agricultural Crop Issues and Policies. Committee on Managing Global Genetic Resources: Agricultural Imperatives, Board on Agriculture, National Research Council. Washington, DC: National Academy Press.

Nestle. 2004. Faces of Coffee. A Public Affaire. Switzerland

Newell, R. G. and Pizar, W. A. 2003. Discounting the Distant Future: How much do uncertain rates increase valuations? Journal of Environmental Economics and Management, No. 46, Pp. 52-71.

Oxfam 2001. Bitter Coffee: How the Poor are Paying for the Slump in Coffee Prices. Oxfam International, London.

Oxfam. 2002. The Crisis in Coffee. Oxfam International, London.

Oxfam. 2002a. Mugged Poverty in Your Coffee Cup. Oxfam: Make Trade Faire. Http://Www.Maketradefair.Com/Assets/English/Mugged.Pdf)

Oxfam. 2002b. Crisis in the Birth Place of Coffee. Oxfam International Coffee Campaign Report. Abera Tola (Ed.). Oxfam: Make Trade Faire. Artistic Printing Enterprise, Addis Ababa

Oxfam. 2002c. Rigged Rules and Double Standards: Trade, Globalization and the Fight against Poverty. Oxfam: Make Trade Faire. (Http://Www.Maketradefair.Com/Assets/English/Report_English.Pdf)

Palo, M., Siiriainen, A. and Mery, G. 1990. A Research Project on Deforestation and Development in the Third World. In: Palo, Matti and Mery. Gerardo (Eds.): De*forest*ation and Development in the Third World, Vol.III, Helsinki

Paulos D. and Demil T. 2000. Some Ecological Parameters Occurring in the Major Coffee Growing Areas of Southwestern and Southern Ethiopia. Proceedings of the Workshop on Control of Coffee Berry Disease (CBD). August 13-15, 1999, Addis Ababa, Ethiopia.

Pearce, D. and Moran, D. 1994. The Economic Value of Biodiversity IUCN – The World Conservation Union Earth Scans Publications Ltd., London

Pender, J. L. 1996. Discount Rates and Credit Markets: Theory and Evidence from Rural India. Journal of Development Economics 50: 157-196.

Perrings, C. 1989. An Optimal Path to Extinction? Poverty and Resource Degradation in the Open Agrarian Economy. Journal of Development Economics, 30, 1-24

Perrings, C. Undated. The Economics of Biodiversity Loss and Agricultural Development in Low Income Countries. Environment and Department, University of York Heslington York YO I 5DD (Accessed On 30th Oct. 2004 – (Http://Www.Worldbank.Org/Devforum/Files/Agriculture.Pdf).

Philbert, C. 2003. Discounting the Future. International Society for Ecological Economics, Internet Encyclopedia of Ecological Economics, International Energy Agency, Energy and Environment Division

Planet ARK, 2004. Scientist Calls Decaf Coffee Row Tempest in Teacup Http://Www.Planetark.Com/Dailynewsstory.Cfm/Newsid/26014/Story.Htm, REUTERS NEWS SERVICE July 14, 2004 Paulo Mazzafera

Prest, A. R. and Turvey, R. 1965. Cost Benefit Analysis: A Survey. The Economic Journal Vol. 75, No. 300, Pp. 683-735

Puppe, C. and Nehrings, K. 2002. A Theory of Diversity. Econometrica 70:1155-1198

Rabl, A. 1996.Discounting of long term costs: What would future generations prefer us to do? Ecological Economics, Vol. 17

Raffensperger, C., Barrett, K. 2001. In Defense of the Precautionary PrinCIPle. Nature Biotechnology, Volume 19. Nature Publishing Group: Http://Biotech.Nature.Com

Riley, C. 2002. Economic Valuation with Stated Preference Techniques: Summary Guide, Department for Transport, Local Government and the Regions

Roebeling, Peter C., H. Jansen, R. Schipper, F. Enz. E. Castro, R. Ruben, H.Hengsdijk and B. Bouman. 2000. Farm Modeling For Policy Analysis on the Farm and Regional Level. PP (171-198). Tools for Land Use Analysis on Different Scales: With Case Studies from Costa Rica, Kluwer Academic Publishers.

Rolf, J., Bennett, J., and Louviere, J. 2000. Choice Modeling and Its Potential Application to Tropical Rainforest Preservation. Ecological Economics, No.35, PP: 289-302.

Romano, D. 1999. Genetic Resource Valuation Methodologies, Their Strengths and Weaknesses in Application: The Contingent Valuation Method In: Rege J.E.O. (Ed). Economic Valuation of Animal Genetic Resources. Proceedings of an FAO/ILRI Workshop Held at FAO Headquarters, Rome, Italy, 15–17 March 1999. ILRI (International Livestock Research Institute), Nairobi, Kenya.

Rubenstein, K.D., Heisey, P., Shoemaker, R., Sullivan, J. and Frisvold, G. 2005. Crop Genetic Resources: An Economic Appraisal. Economic Information Bulletin Number 2, United States Department Of Agriculture (USDA).

Rudel, Thomas K. 1993. Tropical Deforestation: Small Farmers and Local Clearing in the Ecuadorian Amazon. New York: Columbia University Press.

Runge, C.F. 1994. A Policy Perspective on Sustainability of Production Environment: Towards a Land Theory of Value, Center for International Food and Agricultural Policy, Department Of Agriculture and Applied Economics, Working Paper P92-2

Ruthenberg, H. 1985. Innovation Policy for Small Farmers in the Tropics. Clarendon Press, Oxford.

Ruto, E. 2005. Valuing Animal Genetic Resources: A Choice Modeling Application to Indigenous Cattle in Kenya. Center for Rural Economy University Of New Castle, UK.

Sankhayan, P.L. and Cheema, H.S. 1991. Using Linear Programming Models For Generating Optimum Farm Plans: An Expository Analysis. Indian Journal of Agricultural Economics Vol. 46 No. 4

Scarpa, R., Drucker, A., Anderson, S., Ferrae, N., Gomez, V., Risopatron, C.R., and Rubio-Leonle, O. 2001. Valuing Animal Genetic Resources in Peasant Economies: The Case of Box Keken Cycle Pig in Yucatan.

Scarpa, Riccardo, Kristjanson, P., Drucker, A., Radeny, M., Ruto1,E.S.K, And Rege, J.E.O. 2001b. Valuing Indigenous Cattle Breeds In Kenya: An Empirical Comparison of Stated and Revealed Preference Value Estimates Fondazione Eni Enrico Mattei NOTA DI LAVORO 104.2001 SUST – Sustainability Indicators and Environmental Evaluation Http://Www.Feem.It/Web/Activ/_Activ.Html

Science/Nature 1999. Biodiversity-Friendly Coffee to help El Salvador. Broadcasting on Friday, 17th September, 1999. UK.

Shiferaw A., Fekade M., Enyew M. and Biratu T. 1989. Coffee Area Specialization. Ministry of Coffee and Tea Development, Addis Ababa

Sorby, K. 2002. What is a Sustainable Coffee? Background Paper to World Bank Agricultural Technology Note 30, "Toward More Sustainable Coffee. World Bank.

Southgate, D. 1990. The Causes of Land Degradation along "Spontaneously" Expanding Agricultural Frontiers in the Third World. Land Economics 66(1): 93-101.

Southgate, Douglas 2000. Estimating Irrigation Benefits: A Methodological Overview Department of Agricultural Economics, Ohio State University, USA.

Sterner, T. 1994. Discounting in a world of limited growth, Environmental and Resource Economics, Vol. 4.

Swanson, T. M. and Barbier, E.B. 1992. Economics for the wilds: wildlife, diversity and development. ISLAND Press. USA, Washington, D.C.

Swanson, Timothy, M. 1995. The Economics and ecology of Biodiversity Decline: The Forces Driving Global Change, chapter Uniformity in Development and the Decline of Biological Diversity, pages 41{55. Cambridge University Press.

Taddese Woldemariam Gole and Denich, M. 2001. Subsistence in a mountain forest ecosystem: the case of southwest Ethiopia. In Proceedings of the World Mountain Symposium 2001, 30 September - 4 October 2001, Interlaken, Switzerland.

Taddese Woldemariam G. 2003.Vegetation of the Yayu forest in Southwestern Ethiopia: impacts of human use and implications for in situ Conservation of Wild Coffee Arabica L. Populations. Ecology and Development Series No.10. Cuvillier Varlag, Göttingen, Germany.

Taddese Woldemariam G. and Demil, T. 2001. The Forest Coffee Ecosystems: Ongoing Crisis, Problems and Opportunities for Coffee Gene Conservation and Sustainable Utilization. Pp. 131-142. In: Imperative Problems Associated With Forestry in Ethiopia (Ed. BSE). Biological Society of Ethiopia, Addis Ababa.

Taddese Woldemariam G., Denich, M., Demil, T. and Vlek, P.L.G. 2001. Human Impacts on Coffee Arabica Genetic Pools in Ethiopia and the Need for Its In Situ Conservation. In: Engels J., Ramanatha Rao V., Brown, A.H.D., Jackson, M. (Eds.): Managing Plant Genetic Diversity. CAB International and IPGRI. Http://Www.Cabi-Publishing.Org/Bookshop/Readingroom/0851995225/0851995225Ch23.PDF

Tefestewold B. 1986. Survey of CBD in Harerghe Administrative Region. MSc thesis, Alemaya University of Agriculture

Tefestewold B. 1995. Studies of Colletotrichum Population of Coffee Arabica L. in Ethiopia and Evaluation of the Reactions of Coffee Germplasm. PhD Dissertation, University of Bonn.

Tesfaye N. and Sinidu A. 2000. Status of CBD in SNNPRS. Proceedings of the Workshop on Control of Coffee Berry Disease (CBD) In Ethiopia, Addis Ababa (Ghion Hotel), 13-15 August 1999 Addis Ababa, Ethiopia.

Tewode Birhan G. E. 1991. Diversity of the Ethiopian Flora. In: Engels J.M.M., Hawkes J.G. and Melaku Worede (Eds.). Plant Genetic Resources of Ethiopia. Cambridge University Press.

Thirtle G.G. 1985. Technological Change and The Productivity Slowdown in Field Crops: United States, 1993-78," Southern Journal of Agricultural Economics, 17 (Dec.) Pp.33-42

Thorner D., B. Kerblay and R.E.F. Smith. 1986. A.V. Chayanov on the Theory of Peasant Economy. University of Wisconsin Press, Madison, USA.

Turner, B.L., Moss, R.H., and Skole, D.L. (Eds.). 1993. Relating Land Use and Global Land Cover Changes: A Proposal for an IGBP-HDP *Core Project.* Report from the IGBP-HDP Working Group on Land-Use/Land-Cover Change. Stockholm: Royal Swedish Academy of Sciences.

UNEP (United Nations Environment Program). 1994. Intergovernmental Committee on the Convention on Biological Diversity, Second Session, Nairobi, 20th of June to 1st of July, 1994: Farmers' Rights and Rights of Similar Groups. The Rights of Indigenous and Local Communities Embodying Traditional Lifestyles: Experience and Potential for Implementation of Article 8 (J) of The Convention on Biological Diversity, Note by The Interim Secretariat, Doc. UNEP/CBD/IC/2/14 Of 20 May 1994.

United Nations Industrial Development Organization (UNIDO). 1972. Guidelines for Project Evaluation.

Van Der Graaf, N.A. 1984. Resistance to Coffee Berry Disease in Ethiopia: The CBD Program from 1972 to 1979. PP.145-166. In: Proceeding of The First Regional Workshop on Coffee Berry Disease. 19-23 July, 1982, Addis Ababa, Ethiopia

Virchow, D. 1999. Economic Value of Genetic Resources: An Age for Research. Review Article. Agbiotechnet Vol.1 ABN 009

Virchow, D. and Anishetty, M. 2003. Regional Collaboration to conserve Crop genetic Resources. In: Virchow, D. (ed.), Efficient Conservation of Crop Genetic Diversity: Theoretical Approaches and Empirical Studies. Springer, Germany.

Vogel, Josef H. Undated. From The "Tragedy of Commons" to the "Tragedy of Common Place": Analysis and Synthesis through the Lens of Neoclassical Economic Theory. Department of Economics, University of Puerto Rico. San Juan, PR 00930-3345

Weitzman, M. L. 1999. Just Keeping Discounting, But … in Portney P.R., Weyant J.P. (Eds), Discounting and Intergenerational Equity, Resources for the future, Washington D.C.

Winston, W.L., Albright, S.C., and Broadie, M. (1997). Practical Management Science: Spreadsheet Modeling and Applications. Duxbury Press, International Thomson Publishing GMBH, Bonn, Germany

Workaffess W. and Kassu K. 2000. Coffee Production Systems in Ethiopia. Proceedings of the Workshop on Control of Coffee Berry Disease (CBD). August 13-15, 1999, Addis Ababa, Ethiopia.

World Commission on Environment and Development. 1987. Our Common Future Oxford University Press, Oxford.

Yilma, T., Olana, G. and Zegeye, T. 2000. Socioeconomic Issues Related to Fungicide Use Against CBD in Ethiopia. Proceedings of the Workshop on Control of Coffee Berry Disease (CBD) in Ethiopia, Addis Ababa (Ghion Hotel), 13-15 August 1999 Addis Ababa, Ethiopia.

Young, A. 1998. Land Resources: Now and for the Future. Cambridge University Press, U.K.

Appendices

Appendix 1. Glossary of some terms that are used in the dissertation

1. *Biological diversity*: refers to the number, variety and variability among plants, animals and microorganism species and the ecological systems in which they live. It can be defined in three levels: genetic diversity referring the different genes and variations with in a species; species diversity referring the variety and abundance of different species; and ecosystem diversity refers to the variety of habitats such as wetlands, grasslands or forest lands occurring in a region.
2. *Coffee Selection*: A process of developing improved coffee planting material by direct selecting among collected germplasm with certain scientific screening method through evaluations without any crossing or hybridization techniques. The selected materials through such a method are called selections.
3. *Direct use values of genetic resources*: refers to their values to produce food or to help create new varieties.
4. *Forest coffee system:* is the domesticated form of the naturally regenerated wild coffee system by thinning some of the larger trees that are thought to deter coffee yield, clearing the underground grassy species, and planting some local coffee seedlings on available free spaces
5. *Improved coffee planting material*: a coffee planting material containing one or more traits of interest developed through the coffee selection procedures or crossing.
6. *Improved coffee system*: a coffee production system established by using improved coffee planting material that is developed in research stations.
7. *Land use system*: here refers to the purpose for which the forest land has been used, how the wild coffee system changed in the past and the direction of future use by local users.
8. *Landraces*: are varieties improved and selected by farmers over generations without the use of modern breeding techniques.
9. *Local coffee planting material:* a coffee planting material that farmers obtain either under the old coffee trees, regenerated naturally or self raised seedlings using local seed.
10. *Propensity to resource depletion:* refers to the amount of resources (labour and land resources) sacrificed for a unit amount of basic needs, in this case food, which is

supposed to be higher for poor smallholder farmers because of the unskilled nature of their labour and lower productivity of land resources.

11. *Polluter-pays prinCIPle*: states that the company that causes pollution should pay for the cost of removing it, or provide compensation to those who have been affected by it.
12. *Public goods:* are commodities or services that once produced can be supplied to other users without affecting the supply for the original users. Pure public goods are characterized by both attribute of non-rival and non-exclusiveness. Non-rival nature implies that consumption of the good/service by one does not reduce the quality or quantity of the goods/services available to other consumers; and the non-exclusiveness implies that there is no way to prevent others from making use of the goods/services.
13. *Option values of genetic resources:* refers to the potential values that may be observed in the future when they become important like for pharmaceutical, ecological or industrial applications
14. S*ustainable development*: Sustainable development recognizes the interdependence of environmental, social and economic systems and promotes equality and justice through people empowerment and a sense of global citizenship. The guiding prinCIPle of sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (http://www.ace.mmu.ac.uk/esd/PrinCIPles/prinCIPles.html).
15. *Wild coffee populations:* refers to undomesticated Arabica coffee trees that are thought to be diverse in terms of different attributes. As they are not planted by human, the local people call them ‘wef zerash’, which means bird sown.

Appendix 2. Average yield of the CBD resistant selections on-farm and on research station

Appendix 2. Table 1. Average yield of CBD resistant selections on-farm and on research station

Selection	% share of seeds in improved coffee plantation	On-farm Yield (100kg)	Average contribution to on-farm yield	Average yield on research station(100kg)
741	19.4	6.5	1.26129	12.2
74110	12.7	9.5	1.20945	19.1
75227	9.34	8.5	0.79415	17.9
74148	8.73	6.5	0.56725	18
74158	8.73	9.5	0.82906	19.1
744	8.01	8.5	0.6807	16.6
7440	6.06	8.5	0.51489	16.2
754	5.95	7.5	0.44661	14.8
74140	5.24	9.5	0.49743	19.7
7454	4.21	8.5	0.3578	18.3
74112	4.21	9.5	0.3999	18.1
74165	4.21	8.5	0.3578	17.3
7487	2.77	9.5	0.26335	23.8
Dessu	0.41	14	0.05749	18.2
Ababuna	0	15.5	0	23.8
Mch2	0	14	0	24
CatJ19	0	10.5	0	16.6
CatJ21	0	14	0	19.4
Sum	100	178.5 (with mean 9.92)	8.23717	333.1 (with mean 18.5)

Appendix 3. Land use system and description of management levels of cultural practices on the different coffee systems in the study areas

Appendix 3. Table 1. Levels of weeding practice on the different coffee production systems in the Geba-Dogi forest community (in % of the total area)

Coffee types	Un-weeded	Once weeding	Twice weeding	Three times weeding
Wild	100	0	0	0
Forest	8	70	20.6	0.6
Semi-forest	3.5	58	33.3	5.2
Improved	3.77	42.3	45.42	8.54

Appendix 4A. Background information of the CBD resistant selections

Appendix 4A. Table 1. Background information of CBD resistant selections

No.	Cultivar	Origin		Year released	Yield (100KGs Clean-bean per hectare)		Canopy nature	Recommended areas		
		Location	Altitude (m		On station	On farm		High Alt	Mid Alt	Low Alt
1	741	Gera,Keffa	1900	1977/78	12.2	6-7	Open	S	S	US
2	744	Washi,Keffa	1700	1979/80	16.6	8-9	Open	S	HS	S
3	7440	Washi,Keffa	1700	1979/80	16.2	8-9	More Open	S	S	S
4	7454	Washi,Keffa	1700	1980/81	18.3	8-9	More Open	S	S	S
5	7487	Washi,Keffa	1700	1980/81	23.8	9-10	More Open	HS	S	US
6	74110	Mettu,Illubabor	1710	1978/79	19.1	9-10	Compact	HS	S	US
7	74112	Mettu,Illubabor	1710	1978/79	18.1	9-10	Compact	HS	S	US
8	74140	Mettu,Illubabor	1710	1978/79	19.7	9-10	Compact	HS	HS	US
9	74148	Mettu,Illubabor	1710	1979/80	18.0	6-7	Compact	HS	HS	US
10	74158	Mettu,Illubabor	1710	1978/79	19.1	9-10	Compact	HS	HS	US
11	74165	Mettu,Illubabor	1710	1978/79	17.3	8-9	Compact	HS	S	US
12	754	Wushwush,Keff	1920	1980/81	14.8	7-8	Open	S	HS	US
13	75227	Gerra, Keffa	1900	1980/81	17.9	8-9	Open	HS	S	US
14	Dessu	Bonga, Keffa	1650	1996/97	18.2	13-15	More Open	US	HS	HS
15	Aba-Buna	Gera-Bonga	-	1996/97	23.8	15-16	More Open	US	HS	S
16	Melko-CH2	Gerra-Yayu	-	1996/97	24.0	13-15	More Open	US	HS	S
17	Catimor-J19	Portugal	-	1996/97	16.6	9-12	Compact	US	US	HS
18	Catimor-J21	Portugal	-	1996/97	19.4	13-15	Compact	US	US	HS

Note: High Alt=1750-2100 masl; Mid Alt= 1550-1750masl, and Low Alt=1550-1000masl.
HS=Highly suitable; S=Suitable; and US=Unsuitable

Source: IAR/Jimma (1996) and Bayetta et al. (1998)

Appendix 4B. Coffee planting material demand and qualities their quality levels

Appendix 4B.Table 1. Number of coffee seedlings planted by type of the seedlings

	Gomma			Geba-Dogi			Berhan-Kontir		
	CBD resistant selections	Local seedlings	sum	CBD resistant selections	local seedlings	sum	CBD resistant selections	local seedlings	sum
2001	157	79	236	205	92	297	134	469	603
2002	277	62	339	200	63	263	72	501	573
2003	404	110	514	153	51	204	49	525	574
Mean	279	84	363	186	69	255	85	498	583

Appendix 4B.Table 2. Average number of planting material demanded by farmers per year (average of the period from 2001 to 2003)

	Gomma highland	Gomma mid altitude	Geba-Dogi
New plantation	228	111	196
Replanting	227	153	59
Total	456	264	255

Appendix 4B. Table 3. Quality of attributes (ranged from 0 to 1) for improved planting material that farmers have chosen. (The values in brackets are that of the local alternatives)

Attributes	Gomma high land	Gomma mid altitude	Geba-Dogi	Berhan-Kontir
Vigor	0.607(0.676)	0.609(0.749)	0.554 (0.795)	0.65(0.46)
CWD	0.828(0.294)	0.880(0.251)	0.791 (0.380)	0.94(0.18)
CBD	0.982(0.059)	0.935 (0.151)	0.890 (0.341)	0.79(0.10)

Appendix 4C. Costs and benefits of the CBD resistant selections

Appendix 4C. Table 1. Quantity of improved coffee seed disseminated by year

Year	Quantity of improved coffee seed (in kg)
1977	50
1978	948
1979	3124
1980	5719
1981	6417
1982	4939
1983	6906
1984	2655
1985	3940
1986	3392
1987	4194
1988	2801
1989	1977
1990	1055
1991	661
1992	468
1993	1003
1994	4305
1995	3497
1996	2362
1997	1495
1998	1295
1999	1200
2000	2350
2001	2000
2002	6000
2003	8200
2004	5200
Total	88153

Source: JARC, Research-extension division; Bayetta et al. (2000)

Appendix 4C. Table 2. Amount of cost (in Birr) by cost particulars at the experimental plot (2.21 ha) of coffee cultivars evaluation: the case of Harerge coffee collections

Year	Permanent Labor	Lab. Casual	Lab. Researcher	Fertilizer	Herbicide	Tractor Labor	Nursery Materials	Total
1	825	892	2347.5	0	0	600	12366	17030.5
2	1905.12	6887	2347.5	764.16	825	6203.1	0	18931.88
3	5628.75	5681	2347.5	1886.86	255	288.3	0	16087.41
4	2402.75	6840.5	2347.5	2085.28	765.45	780	0	15221.48
5	5207	9474	2347.5	1574.14	1260	130	0	19992.64
6	2408.7	6783	2347.5	1574	1395	0	0	14508.2
Average	3062.88	6092.92	2347.5	1314.07	750.07	1333.57	2061	16962.02

Source: JARC, Coffee Breeding and Genetics Research Division

Appendix 4C. Table 3. Expenditure of the coffee improvement project (CIP) phases*

CIP phase	No. of districts considered	Duration of implementation	Expenditure in Birr: From the Government account	Expenditure in Birr: From the EEC	Expenditure in Birr: total
I	8	1978-1983	32500000	277600000	310100000
II	15	1984-1989	68800000	46240000	115040000
III-1	18	1990-1994	96400000	18150000	114550000
III-2	18	1995-1997	0	96835160	96835160
III-3	18	1998-2001	0	60414569	60414569
IV**	77	2002 onwards	18745000	52728037	71473037

Source: CTA, Accounts Division

Note: * The cost figures that are obtained at the project phase level are divided for the project phase years equally.

** Phase IV started in 2002 and is planned for 7 years

Appendix 4C. Table 4. Share of experts' labor time and their values at different levels

Extension Cost	Zonal head	Zonal experts	District head	District Team leaders	District Experts (3)	Develop-ment agents (15)	Sum
Share of labor for the improved coffee promotion	5	30	5	20	20	30	
Monthly salary	1850	1530	1530	1150	980	600	
Monthly Value	92.5	459	76.5	230	196	180	
Monthly total value per district	92.5	1377	76.5	230	588	2700	5358
Annual value per district	1110	16524	918	2760	7056	32400	64296
Total value for 8 districts	5550	82620	7344	22080	56448	259200	461466
Total value for 18 districts	5550	82620	16524	49680	127008	583200	928086
Total value for 15 districts	5550	82620	13770	41400	105840	486000	788100
Total value for 77 districts	17760	264384	70686	212520	543312	2494800	3875118

Note: All the values are given in terms of Eth. Birr.

Appendix 4C. Table 5. Percentage share of the disseminated coffee cultivars and their yield estimates on farm and on research station

Code of the selection	Percent share	Yield on-farm	Yield at research station
741	19.40452	6.5	12.2
74110	12.73101	9.5	19.1
75227	9.342916	8.5	17.9
74148	8.726899	6.5	18
74158	8.726899	9.5	19.1
744	8.008214	8.5	16.6
7440	6.057495	8.5	16.2
754	5.954825	7.5	14.8
74140	5.23614	9.5	19.7
7454	4.209446	8.5	18.3
74112	4.209446	9.5	18.1
74165	4.209446	8.5	17.3
7487	2.772074	9.5	23.8
Dessu	0.410678	14	18.2
Mean		8.237166	17.80714

Source: Source: Bayetta et al. (2000)

Appendix 4C. Table 6. Area covered by improved coffee cultivars and the marginal return due to the cultivars by year

Year	Amt seed, (in '00kg)	Area cover by coffee (ha)	Cumulative area of mature coffee (ha)	Change in yield on farm (in kg)	Net market value per kg* (in Birr)	Total summary of benefit (in Birr)
1977	0.5	55.37712				
1978	9.48	1049.95				
1979	31.24	3459.962	55.37712	11296.93	3.9378	44485.059
1980	57.19	6334.035	1105.327	225486.8	4.6494	1048378.2
1981	64.17	7107.099	4565.29	931319.1	3.3054	3078382.1
1982	49.39	5470.152	10899.32	2223462	3.6534	8123196.7
1983	69.06	7648.688	18006.42	3673310	3.3984	12483378
1984	26.55	2940.525	23476.58	4789221	3.714	17787168
1985	39.4	4363.717	31125.26	6349554	3.819	24248945
1986	33.92	3756.784	34065.79	6949421	5.8632	40745844
1987	41.94	4645.033	38429.5	7839619	3.462	27140761
1988	28.01	3102.226	42186.29	8606003	4.014	34544496
1989	19.77	2189.611	46831.32	9553590	3.8088	36387712
1990	10.55	1168.457	49933.55	10186444	2.8494	29025253
1991	6.61	732.0855	52123.16	10633124	2.8662	30476661
1992	4.68	518.3298	53291.62	10871490	3.2016	34806161
1993	10.03	1110.865	54023.7	11020835	5.535	61000322
1994	43.05	4767.97	54542.03	11126574	7.272	80912449
1995	34.97	3873.076	55652.9	11353191	14.3772	163227095
1996	23.62	2616.015	60420.87	12325857	9.9456	122588040
1997	14.95	1655.776	64293.94	13115964	12.5154	164151537
1998	12.95	1434.267	66909.96	13649631	13.809	188487757
1999	12	1329.051	68565.73	13987409	11.895	166380236
2000	23.5	2602.725	70000	14280000	10.4736	149563008
2001	20	2215.085	71329.05	14551126	10.4736	152402677

* refers that 40% of the market value is the share of all marketing costs

Appendix 4C. Table 7. Cost summary of the extension, salary, re-evaluation and multiplication activities (in Birr)

CIP Phase	Year	Collection of germplasms, cost of the crash selection program and annual extension related costs	Staff salary	Cost of maintenance and multiplication of seeds	Summary of costs
Collection of germplasms and selection of cultivars	1973	100,000	0	0	100,000
	1974	100,000	0	0	100,000
	1975	100,000	0	0	100,000
	1976	100,000	0	0	100,000
	1977	3,600,000	0	0	3,600,000
I	1978	18,089,166.67	461,466	0	18,550,633
I	1979	18,089,166.67	461,466	0	18,550,633
I	1980	18,089,166.67	461,466	0	18,550,633
I	1981	18,089,166.67	461,466	0	18,550,633
I	1982	18,089,166.67	461,466	267,660.6	18,818,293
I	1983	18,089,166.67	461,466	267,660.6	18,818,293
II	1984	6,710,666.67	788,100	267,660.6	7,766,427
II	1985	6,710,666.67	788,100	267,660.6	7,766,427
II	1986	6,710,666.67	788,100	267,660.6	7,766,427
II	1987	6,710,666.67	788,100	267,660.6	7,766,427
II	1988	6,710,666.67	788,100	267,660.6	7,766,427
II	1989	6,710,666.67	788,100	267,660.6	7,766,427
III	1990	8,018,500	928,086	267,660.6	9,214,247
III	1991	8,018,500	928,086	267,660.6	9,214,247
III	1992	8,018,500	928,086	267,660.6	9,214,247
III	1993	8,018,500	928,086	267,660.6	9,214,247
III	1994	8,018,500	928,086	267,660.6	9,214,247
Modified III	1995	11,297,435.33	928,086	267,660.6	12,493,182
Modified III	1996	11,297,435.33	928,086	267,660.6	12,493,182
Modified III	1997	11,297,435.33	928,086	267,660.6	12,493,182
Modified III	1998	5,286,274.788	928,086	267,660.6	6,482,021
Modified III	1999	5,286,274.788	928,086	267,660.6	6,482,021
Modified III	2000	5,286,274.788	928,086	267,660.6	6,482,021
Modified III	2001	5,286,274.788	928,086	267,660.6	6,482,021

Appendix 4C. Table 8. Farmers' response of the trend in the severity of CWD on the different coffee types (in % of sample farmers).

	Gomma		Geba-Dogi	
	CBD resistant selections	Semi forest coffee	CBD resistant selections	Forest coffee
Increasing	72	92.6	56	34
Decreasing	2	2	4	4

Appendix 4C. Table 9. Faremrs' response of the trend in the severity of drought on the different coffee types (in % of sample farmers)

	Gomma		Geba-Dogi	
	CBD resistant selections	Semi Forest coffee	CBD resistant selections	Forest coffee
Increasing	26.7	47	25	8
Decreasing	0	0	10	3

Appendix 4C Table 10. Farmers' response of the trend in the severity of coffee leaf rust on the different coffee types (in % of sample farmers)

	Gomma		Geba-Dogi	
	CBD resistant selections	Semi forest coffee	CBD resistant selections	Forest coffee
Increasing	72	9	8	3
Decreasing	2	9	4	3

Appendix 5. Descriptive statistics of variables explaining conversion of forest land at household level in the Geba-Dogi forest and Berhan-Kontir communities

Appendix 5. Table 1. Description of some variables at the Geba-Dogi forest site

Variables	Without wild coffee	With wild coffee	t-test (prob.)
Farm size (ha)	2.79	2.98	-0.04(0.9)
Coffee farm size (ha)	1.84	1.85	-0.05(0.9)
Maize farm size (ha)	0.61	0.8	-1.3(0.2)
Proportion of maize farm	20.5	27.5	-1.95(0.05)
Forest coffee farm size (ha)	0.93	0.64	2.36(0.02)
Proportion of forest coffee	55	39	2.8(0.005)
Improved coffee farm size (ha)	0.67	0.55	0.85(0.39)
Wild coffee farm size before 5 years (ha)	0.18	0.4	-2.8(0.006)
Household family size (squared)	45.9	43.5	0.39(0.7)
Age (squared)	2312	2446	-0.36(0.7)
Distance from the forest site (km)	2.7	3.1	-0.9(0.36)
Distance from district town (km)	16.59	18.54	-0.88(0.3)
	Chi-square (prob.)		
Food shortage	0.58 (0.4)		
House type	0.45(0.49)		
Native ness of the household head	0.0 (1)		

Appendix 5 Table 2. Description of some variables at the Berhan-Kontir forest site

Variables	Without wild coffee	With wild coffee	t-test (prob.)
Farm size (ha)	3.32	4.3	-2.7(0.006)
Coffee farm size (ha)	2.36	3.22	-3.06(0.002)
Improved coffee farm size (ha)	0.18	0.05	2.3(0.02)
Maize farm size (ha)	0.81	0.97	-1.4(0.1)
Wild coffee farm size before 5 years (ha)	0.19	0.72	-6.14(0.000)
Distance from Forest (km)	2.09	2.12	-0.11(0.9)
Distance from district town (km)	16.05	17.7	-3.2(0.001)
Household family size (squared)	47.7	48.7	-0.19(0.8)
Age (squared)	2525	2212	1.36(0.1)
	Chi-square (prob.)		
Food shortage	.85(0.35)		
House type	5.06(0.02)		
Native ness of the household head	3.4(0.06)		

Appendix 6A. Input out put coefficients, activities and constraints, and farm plans

Appendix 6A. Table 1. Farmland allocation for the different crops in Geba-Dogi

Cereal based farming system		coffee based farming system	
Crop types	Actual area in hectares	Crop types	Actual area in hectares
Farm size (in Fechassa)	8.13	Farm size	8.8
Improved coffee	0.4	Improved coffee	1.50
Maize (Fertilized and Improved seed)	0.668	Semi forest coffee	1.17
Maize (Fertilized and local seed)	0.233	Forest coffee	2.23
Maize (Local seed)	1.168	Wild coffee	0.15
Sorghum (local seed)	1.468	Maize (fertilized and improved seed)	0.80
Teff (Fertilized and local seed)	0.4	Maize (local seed)	2.25
Teff (Local seed)	1.868	Sorghum (Local seed)	0.3
Wheat (Local seed)l	0.568	Teff (Local seed)	0.27
Other crops	1.35	Other crops	0.28

Appendix 6A Table 2. Human and oxen labor requirements of the different crop production activities per Fechassa at the coffee based system

Activities	Production of Wild Coffee	Production of Forest Coffee	Production of Improved Coffee	Production of Improved Maize	Production of Local Maize	Production of Sorghum	Production of Teff
Sept. labor	0	0	0	0	0.00	0	6.54
Oct. lab	0	0	0	0	0	0	6.54
Nov. lab	0	0	0	0.00	0.00	4.32	0.00
Dec. lab	0	0	0	0.00	0.00	4.32	0.99
Jan. lab	0	0	0	0.00	0.00	0.00	0.99
Feb. lab	0	0.00	0.00	1.17	1.48	0.00	0.00
Mar. Lab	0	0.00	0.00	1.85	1.51	3.00	0.00
Apr. Lab	0	0.00	0.00	3.70	3.02	3.00	0.00
May. Lab	0	0.00	0.00	5.55	4.54	1.85	4.80
Jun Lab	0	0.00	0.00	7.39	6.05	3.69	4.80
Jul. Lab	1	1.14	1.32	5.55	4.54	3.69	4.80
Aug. Lab	0	0	0	3.70	3.02	1.85	6.54
coffee first weeding (July Aug)	4	3.415418	3.971911	0	0	0	0
coffee second weeding (Sept-Oct)	3	3.415418	3.971911	0	0	0	0
coffee harvest (Nov-Jan)	6	13.17552	12.042	0	0	0	0
Maize harvesting (Oct-Dec)	0	0	0	7.37	9.38	0	0
Feb. Ox lab	0	0	0	0	0	1.39	0.00
Mar. Ox Lab	0	0.00	0	0.88	1.11	2.78	0.00
Apr. Ox Lab	0	0.00	0	1.75	2.22	1.39	0.00
May. Ox Lab	0	0.00	0	1.75	2.22	0.00	2.17
Jun Ox Lab	0	0.00	0	0.88	1.11	0.00	4.33
Jul. ox Lab	0	0.00	0	0.00	0.00	0.00	2.17
Feb Draft. Lab	0	0.00	0	0.00	0.00	1.39	0.00
Mar. Draft. Lab	0	0.00	0	0.88	1.11	2.78	0.00
Apr. Draft. lab	0	0.00	0	1.75	2.22	1.39	0.00
May draft. Lab	0	0.00	0	1.75	2.22	0.00	2.17
Jun draft. Lab	0	0.00	0	0.88	1.11	0.00	4.33
Jul. Draft. lab	0	0.00	0	0.00	0.00	0.00	2.17

Appendix 6A Table 3. Human and oxen labor requirements of the different crop production activities per Fechassa at the cereal based system

Activities	Production of Improved Coffee	Production of Improved Maize	Local Maize Fertilized	Production of Local Maze	Production of Sorghum	Production of Fertilized Teff	Production of Teff	Production of Wheat
Sept. labor	0	0.6	0	0.00	1.05	1	3.75	2.76
Oct. lab	0	0	0	0	0.00	0	5.54	1.41
Nov. lab	0	0	0	0	2.43	6.67	0.00	6.71
Dec. lab	0	0	0	0	3.41	0.00	2.50	2.35
Jan. lab	0	1.4	0.00	0.46	1.64	3.33	2.00	3.06
Feb. lab	0	1.2	0.00	3.23	3.86	0.00	1.00	0.00
Mar. Lab	0	4.9	1.43	2.46	4.18	0.67	0.00	0.00
Apr. Lab	0	1.7	3.43	5.57	3.25	1.33	1.21	0.00
May. Lab	0	5.8	8.86	2.97	1.30	3.50	4.25	0.94
Jun Lab	2.5	0.00	0.00	0.00	3.61	3.67	3.93	2.94
Jul. Lab	0.00	0.00	0.00	0.00	0.50	1.67	6.48	4.71
Aug. Lab	0.00	1.2	0.00	0.00	0.55	0.167	1.54	2.94
Maize weeding (Jun, Jul.)	0.00	11.2	4.57	3.14	0.00	0.00	0	0
Coffee first weed(July Aug)	2.50	0	0	0	0	0	0	0
Coffee second weed (Sept-Oct)	9	0	0	0	0	0	0	0
Coffee harvesting (Nov-Jan)	18.25	0	0	0	0	0	0	0
Maize harvesting (Oct-Dec)	0	7.2	6.57	5.11	0	0	0	0
Feb. Ox lab	0	0.2	0.00	1.66	2.36	0.00	0.00	0.00
Mar. Ox Lab	0	3.1	1.14	2.17	2.05	0.00	0.00	0.00
Apr. Ox Lab	0	1.7	2.86	2.29	0.45	1.33	0.14	0.00
May. Ox Lab	0	1.4	1.43	0.06	0.18	3.33	2.43	0.00
Jun Ox Lab	0	0.8	0.29	0.34	0.45	1.67	3.50	2.35
Jul. ox Lab	0	0.2	0.00	0.00	0.14	0.67	1.86	2.71
Feb Draft. Lab	0	0.2	0.00	1.66	2.36	0.00	0.00	0.00
Mar. Draft. Lab	0	3.1	1.14	2.17	2.05	0.00	0.00	0.00
Apr. Draft. lab	0	1.7	2.86	2.29	0.45	1.33	0.14	0.00
May draft. Lab	0	1.4	1.43	0.06	0.18	3.33	2.43	0.00
Jun draft. Lab	0	0.8	0.29	0.34	0.45	1.67	3.50	2.35
Jul. Draft. Lab	0	0.2	0.00	0.00	0.14	0.67	1.86	2.71

Appendix 6A. Table 4. Constraints in the typical farm model

	Constraints
1	Farm size
2	Sept labor
3	Oct lab
4	November lab
5	December lab
6	January. Lab
7	February lab
8	March lab
9	April lab
10	May lab
11	Jun lab
12	July lab
13	August lab
14	Coffweed1(July Aug)
15	Cofweed2 (Sept-Oct)
16	Coffee harvest Nov-Jan
17	Maize harvesting Oct-Dec
18	February Ox lab
19	March ox lab
20	April ox lab
21	May ox lab
22	Jun ox lab
23	Jul. Ox Lab
24	Feb draft. Lab
25	Mar. Draft. Lab
26	Apr. Draft. Lab
27	May draft. Lab
28	Jun draft. Lab
29	Jul. Draft. Lab
30	Work capital
31	Credit
32	Wild coffee Yield balance
33	Forest coffee Yield balance
34	Improved coffee Yield balance
35	Improved maize. Yield balance
36	Local maize yield balance
37	Sorghum yield balance
38	Teff yield balance
39	Subsistence coffee consumption
40	Subsistence maize consumption
41	Subsistence sorghum consumption
42	Subsistence Teff consumption
43	Maximum improved coffee
44	Maximum area of cereal crops

Appendix 6A Table 5 Activities in the typical farm model

	Activities
1	Land allocated to the production of wild coffee in Fechassa
2	Land allocated to the production of forest coffee in Fechassa
3	Land allocated to the production of improved coffee in Fechassa
4	Land allocated to the production of improved maize in Fechassa
5	Land allocated to the production f local maize in Fechassa
6	Land allocated to the production of sorghum in Fechassa
7	Land allocated to the production of Teff in Fechassa
8	Sale of wild coffee (kg)
9	Sale of forest coffee (kg)
10	Sale of improved coffee (kg)
11	Sale of improved maize (kg)
12	Sale of local maize (kg)
13	Sale of sorghum (kg)
14	Sale of Teff (kg)
15	Labor transfer in February
16	Labor transfer in March
17	Labor transfer in April
18	Labor transfer in May
19	Labor transfer in June
20	Labor transfer in July
21	Consumption of wild coffee in kg
22	Consumption of forest coffee in kg
23	Consumption of improved coffee in kg
24	Consumption of improved maize in kg
25	Consumption of local maize in kg
26	Consumption of Sorghum in kg
27	Consumption of Teff in kg
28	Transfer credit
29	Coffee first weeding Aug trans
30	Coffee first weeding July trans
31	Coffee harvesting Nov lab transfer
32	Coffee harvesting Dec lab transfer
33	Coffee harvesting Jan lab transfer
34	Maize harvesting Dec transfer
35	Maize harvesting Nov transfer
36	Maize harvesting Oct transfer
37	Coffee second weeding Oct transfer
38	Coffee second weeding Sept transfer
39	Teff purchase alternative for home consumption
40	Maize purchase alternative for home consumption
41	Sorghum purchase alternative for home consumption

Appendix 6A.Table 6. Level of major activities at different crops prices (in Fechassa)

	Coffee based system		Cereal based system (8.13 Fechassa)
	Actual farm size (8.8 Fechassa)	A farm size of 8.13 Fechassa	
Amount of optimum level of activities based on 2003 prices (in Fechassa)			
a. Improved coffee	7.5	6.6	3.8
b. Improved maize	1.2	1.5	4.3
Amount of optimum level of activities based on prices (1.00 Birr per kg of coffee, maize and sorghum) (in Fechassa)			
a. Improved coffee	4.13	3.5	1.0
b. Improved maize	1.43	1.6	4.3
Amount of optimum level of activities based on 2001 prices (in Fechassa)			
a. Improved coffee	8.7	8.13	5.2
b. Improved maize	0.08	0	0

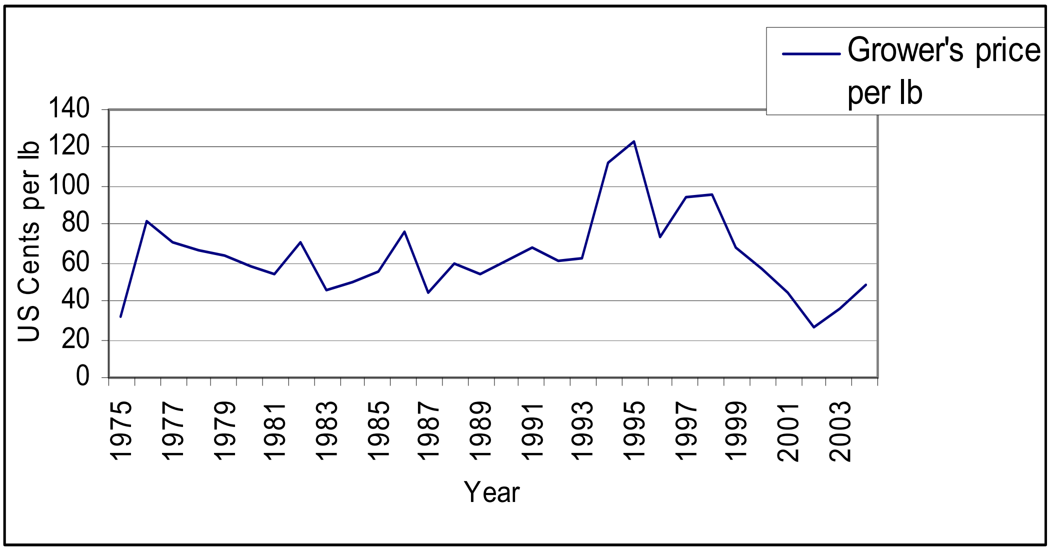
Source: Own estimation

Appendix 6A. Table 7. Shadow prices of the forest land at different price scenarios and model constraints[1]

Scenario	Constrained model	Unconstrained model
1	865.00	865.00
2	301.00	301.00
3	244.00	244.00
4	1719.00	146.00
5	1610.00	930.00
6	681.00	681.00

Note: 1 In the constrained model, the maize as the dominant staple food is subjected to be totally produced at home, while in the other case it is permitted to purchase from market

Appendix 6B. Trend of coffee price paid to Ethiopian coffee growers



Source: International Coffee Organization: Historic data (http://www.ico.org/asp/display7.asp)

Appendix 6C. Proclamation of the International coffee conference conducted on September 23, 2002UNECA Hall Addis Ababa.

Recognizing the fact that the smallholder coffee producers get less than 1% of the value of a cup of coffee sold and its implication on the economy at large,

- ❖ applauds the Ethiopian government for:

1. Improve marketing networks to pass profits onto the farmers;
2. Encourage cooperatives to export directly,
3. Brand and certify organic coffee,
4. Work with fair trade certifying process to guarantee the best price for farmers
5. Tax exemption and sales tax reduction,
6. Relax price controls.

- ❖ Calls on corporations national and international to look beyond profits and act in asocial responsible manner,
- ❖ Calls governments of the south to cooperate to bring about fair trade to benefit all their constituencies,

- Endorses the Oxfam International Coffee Rescue Plan which calls for action from all stakeholders of the coffee sector under the auspices of the ICO, should result in:

  - Roaster companies paying farmers a decent price so that they can send their children to school, afford medical expenses and have enough food, increasing the prices to farmers by reducing supply and stocks of coffee on the market through:

  1. roaster companies trading only in coffee that meets basic quality standards as proposed by ICO;
  2. The destruction of at least 5 million bags of coffee stocks, funded by rich-country governments and roster companies.
  3. The creation of a fund to help poor farmers shift to alternative livelihoods, making them less reliant on coffee.
  4. Roaster companies committing to increase the amount of coffee they buy under fair trade conditions to two percent of their volumes.

- Endorses the production of organic coffee and the preservation of improvement in Ethiopian coffee quality
- Endorses idea of a safety net to respond to humanitarian crisis.
- Endorses the concept of greater partiCIPation of farmers in determining prices in ways like having the farmers represented at the ICO to express the farmers' needs.