HIV/AIDS, Labor Organization and Agrobiodiversity

The Case of Farm Households in Southwest Ethiopia

Kidist Gebreselassie

PROPOSITIONS (Stellingen)

1. Where households value diversity, a higher degree of substitutability between products from the field and the home garden enhances crop species diversity in the home garden in response to a decline in productivity in the field (*this thesis*).

2. For farm households affected by adult male morbidity and mortality, sharecropping-out fields is more feasible than owner-operating them (*this thesis*).

3. As long as it generates a better-off society, voting one's caste is as good as casting one's vote.

4. It is a misconception to think of an inevitable trade-off between the principles of majority rules and minority rights. It is not a misconception to think that in democratic governance the principle of majority rules does not necessarily violate the principle of minority rights.

5. The apparently overriding attitude that misdeeds are always performed by others is uncivilized and obsolete for a global village society.

6. Continue on 'othering', hushing, stigmatizing and discriminating HIV/AIDS affected people and you will loose the fight against the pandemic.

Stellingen behorende bij het proefschrift

HIV/AIDS, Labor Organization and Agrobiodiversity

The Case of Farm Households in Southwest Ethiopia

Wageningen, 14 januari 2009, 13:30

Kidist Gebreselassie

HIV/AIDS, Labor Organization and Agrobiodiversity

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HIV/AIDS, Labor Organization and Agrobiodiversity

The Case of Farm Households in Southwest Ethiopia

Kidist Gebreselassie Gebremariam

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To my son Nazrawi

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ABSTRACT

Farm households affected by HIV/AIDS reallocate their resources which has implications for crop diversity. Previous research shows that agrobiodiversity contributes to reducing the negative effects of HIV/AIDS through improving household nutrition and thereby delaying the progression of HIV into AIDS. The nutrition and health improvement effect of crop diversity is influenced by the extent to which the pressure of the epidemic causes the households to divert more resources towards some crops or activities than to others, such as through constraining labor availability. The thesis aims at analyzing to what extent, if, HIV/AIDS affects agrobiodiversity in the home garden of farm households where labor is allocated to the field and the home garden and sharecropping is an option.

The study employs a farm household model where transaction costs in the labor market is taken into account and where adult male morbidity and mortality is assumed to cause a differential productivity effect between labor allocated to the home garden and fields. It contributes to the literature by paying attention to how HIV/AIDS-driven household resource reallocation affects agrobiodiversity and how the effect might change with the availability of sharecropping possibility and varying role of plots. The analysis was carried out both theoretically and empirically. The theoretical analysis employs the labor allocation approach where the household chooses labor allocations between the home garden and fields; and the Dixit-Stiglitz product diversity approach where crop diversity is explicitly modeled and hence labor allocation to the field and crop diversity in the home garden are the choice variables. The empirical analysis employs both in-depth study of four HIV/AIDS affected farm households and a survey analysis of 205 farm household in two woredas in Jimma zone of Southwest Ethiopia.

Results indicate that where households value crop diversity and where adult morbidity and mortality has a plot-specific labor productivity effect, a decline in productivity due to HIV/AIDS does not necessarily cause a decline in crop diversity. The effect rather depends on the degree of substitutability between the products of the field and of the home garden. A higher degree of substitutability between the two products is likely to cause an increase in crop diversity in the home garden in response to a decline in labor productivity. The findings suggest that nutrition education can be integrated as a strategy to assist farm household adjustment of crop choice in the home garden so as to maximize the nutrition role of agrobiodiversity. The results further indicate that farm households affected by adult male morbidity and

mortality as well increase the degree of sharecropping-out in the field. This suggests that taking action to enhance sharecropping such as through facilitating land titling and stipulating clear land use and transfer terms are relevant interventions.

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CHAPTER 1

GENERAL INTRODUCTION

1.1 BACKGROUND AND PROBLEM DEFINITION

In 2006, 24.7 million (63%) of the people infected with HIV lived in sub-Saharan Africa. The HIV/AIDS prevalence rate in the region for persons in the age group of 15-49 years is estimated at 5.9% (UNAIDS/WHO, 2006). The HIV prevalence in Ethiopia is estimated to have increased from 2 persons in 1984 to 2.6 million in 2000 (FDRE/MOFED, 2002). The average prevalence rate is estimated to be in the range of 2.8-6.7% with higher rates in urban areas and in the 15-24 year age group (WHO, 2005). Overall HIV/AIDS prevalence rate among VCT (Voluntary Counseling and Testing) clients in 2005/2006 is estimated at 13.7%, the rate among males and females being 15.7% and 11.6% respectively (MOH, 2007). Based on antenatal clinical data, national HIV/AIDS prevalence rates are estimated at 10.5% for the urban and 1.9% for the rural population (UNAIDS/WHO, 2006). However, the data from antenatal clinics may not give a complete picture of the prevalence rates because not all pregnant women have access to such services. Although the prevalence rate in Ethiopia is lower than in many sub-Saharan Africa countries, its impact is exacerbated because of the level of poverty in the country (MOH, 2004).

There is a growing recognition of HIV/AIDS as a potential threat to development efforts in the country (FDRE/MOFED, 2002) with the epidemic impacts manifested at macro and micro-level. Some of the macro-level impacts include reduced life expectancy and an increasing number of orphans (WHO, 2005) that is paralleled by an increasing need for care, treatment and support for the infected and affected ones (MOH, 2004)[1]. It also contributes to increasing the dependency ratio (the ratio of non-working to working population), declining productivity, income and investment capacity, and is a heavy burden for health and education services (FDRE/MOFED, 2002). It is projected that by 2014, the cost of treating AIDS patients may exceed 30% of the budget of the Ministry of Health in Ethiopia without accounting for the cost of assisting orphans and destitute households (UNAIDS/ECA, 2000, cited in Villarreal, 2006). Based on a study in South Africa, Young (2005) predicts a reduction in fertility due to a reduction in unprotected sex and an increase in the value of a woman's time with the spread of HIV/AIDS and as a result a long term

[1] In the literature, the term 'infected' is used to indicate carrying the virus and 'affected' or 'afflicted' is sometimes used to indicate both infection as well as bearing the burden. In this thesis, infected refers to carrying the virus and affected (defined in terms of households) refers to those who bear the burden of the illness or death of at least one adult due to HIV/AIDS.

rise in per capita consumption for the economy. Although his comparative static analysis indicates long-run positive effects due to the HIV/AIDS-induced reduction in fertility, long run effects on the economy may as well depend on the type and scale of prevention (e.g. awareness campaigns) and mitigation (e.g. use of antiretroviral therapy) efforts in place.

The farm household level impact of HIV/AIDS include a loss of agricultural labor and a reduction in working time due to illness, care giving, death and mourning (Rugalema, 1999; Barnett and Whiteside, 2002; Loevinsohn and Gillespie, 2003). Additionally, morbidity and mortality cause a loss of important farm skills and experience (Villarreal, 2006) and a reduction in productivity (e.g. Topouzis, 1994; Fox et al. 2004; World Development Report, 2008) which causes falling into poverty (Barrett et al. 2006; Krishna et al. 2004; Krishna et al 2006). Alumira et al. (2005) found that, based on a study in Malawi, HIV/AIDS infected households have the lowest farm and non-farm incomes. Along with these changes, there is an increasing need by households to meet additional health expenditure (Barnett and Blaikie, 1992; World Bank, 1997; Rugalema, 1999; Drimie, 2002; Villarreal, 2006). Moreover, the nutritional demand of HIV/AIDS affected individuals is higher than normal (Piwoz and Preble, 2000). UNAIDS/ECA (2000) indicates that the cost of caring for HIV/AIDS patient and meeting the funeral expenses exceeds the average annual farm income of the household.

Addressing the challenges of HIV/AIDS is possible through a response involving the agricultural sector rather than just the health sector (Villarreal, 2006). Nutrition is important in HIV/AIDS impact mitigation (Haddad and Gillespie, 2001; Loevinsohn and Gillespie, 2003; Gillespie and Kadiyala, 2005; Stillwaggon, 2006). Fawzi et al. (2004) found less likelihood of progression of HIV to advanced stages, better CD4+ T-cell counts, lower viral loads and lower rates of HIV related illness and death among pregnant women who received multivitamin supplements. Poor nutrition and health can increase vulnerability to HIV infection and may hasten the manifestation of symptoms through shortening the incubation period of the virus (Topouzis, 2001; Villarreal, 2006). In line with this, there is increasing recognition of the contribution of plant diversity to improve dietary diversity and nutrition (Johns, 2003) and the potential role of agrobiodiversity[2] in home gardens for improving nutrition (Gari, 2003 and 2004).

[2]Agrobiodiversity consists of the variety and variability of animals, plants, and microorganisms that are used directly or indirectly for food and agriculture, including crops, livestock, forestry and fisheries (FAO, 2004). In this

Possible farm household responses to the pressures of the epidemic, through resource reallocation, may affect agrobiodiversity and household nutrition. Agrobiodiversity is likely to be affected if the decline in resource availability and productivity due to HIV/AIDS causes farm households to divert more resources towards some crops or activities than to others.

One response by HIV/AIDS affected households is the reallocation of labor towards non-agricultural activities (e.g. Loevinsohn and Gillespie, 2003) and increased care giving (Rugalema, 1999; Drimie, 2002; Loevinsohn and Gillespie, 2003; Villarreal, 2006). In Ethiopia (e.g. Bishop-Sambrook et al. 2006), Kenya as well as Lesotho and South Africa (Drimie, 2002) the replacement of household labor is sought through entering into a sharecropping contract. These responses are often accompanied by a choice of less labor demanding crops (e.g. Haddad and Gillespie 2001; Villarreal, 2006). Also a shift to more food than cash crops has been observed following the death of a male household head (Yamano and Jayne, 2002).

All these reallocations may result in a change in agrobiodiversity. Gillespie and Kadiyala (2005) indicate a HIV/AIDS induced reduction in crop diversity in subsistence agriculture, abandonment of specific crops and shifts towards less labor-intensive mono-cultivation. A decrease in crop range because of reduction in area cultivated (Barnett and Whiteside, 2002) and an increase in area under fallow due to HIV/AIDS (Loevinsohn and Gillespie, 2003; Drimie, 2002) have also been documented. In contrast, Alumira et al. (2005) found in Malawi that HIV/AIDS affected households were diversifying their crops beyond the usual chilies, rice and pigeon pea into horticulture crops, mainly by growing tomatoes.

The expected crop choice and agrobiodiversity implications of changes in labor organization and labor reallocation are presented in Figure 1.1. The possible shift towards limited crop choice practices may cause a decrease in the degree of agrobiodiversity. The focus of previous research on labor reallocation and crop choice effects of HIV/AIDS has paid little attention to how such reallocations due to HIV/AIDS affects agrobiodiversity and how the effect might change with the availability of a sharecropping option and varying role of plots.

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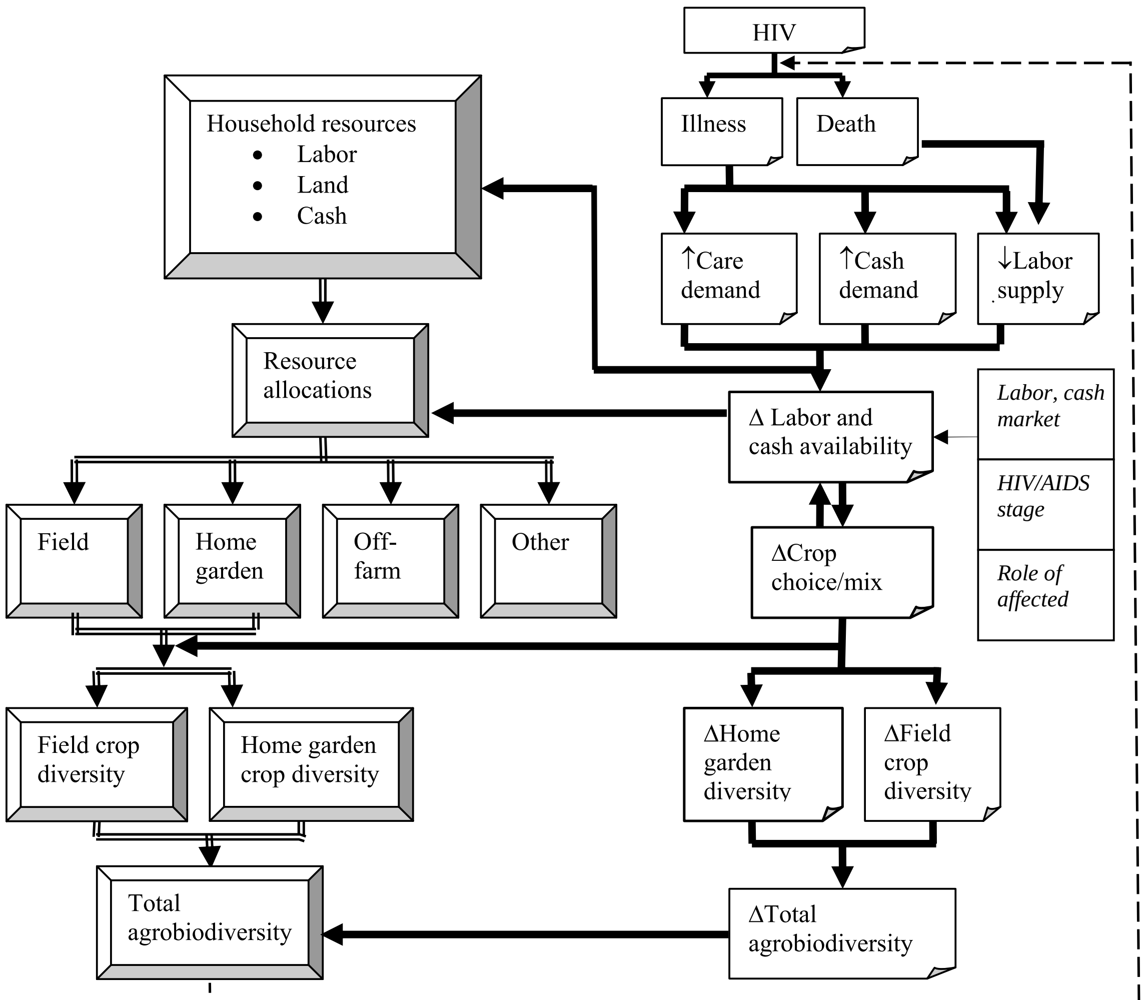
thesis, I focus on the diversity of useful plant species on the farm. In this setting, fields are more specialized with less variable crop species diversity (except in the event of abandonment) among adjacent community plots for several reasons, including customary crop choice to reduce crop loss to animal attack.



Light arrows depict household resource allocation patterns under "normal" conditions. Dark arrows indicate the impact of HIV/AIDS affecting household resource availability and allocation patterns. Compartmentalized box at the right hand side depicts hypothesized variables explaining variations in the degree of impact of HIV/AIDS on labor and land allocation. Dashed arrows indicate the feedback expected of agrobiodiversity in HIV/AIDS impact mitigation based on existing literature. ↑, ↓ and Δ stand for increase, decrease and change respectively.

Figure 1.1 Conceptual model of the effects of HIV/AIDS on agrobiodiversity through farm household resource reallocation.

1.2 RESEARCH OBJECTIVES AND METHODS

This thesis aims at examining the effect of HIV/AIDS driven changes in labor organization on agrobiodiversity by focusing on crop species composition in home gardens. In addition, a possible direct effect of HIV/AIDS on agrobiodiversity is analyzed. The analysis is considered important for three reasons. Firstly, agrobiodiversity is recognized to have a potential for improving the nutritional status of individuals and households (Johns, 2003; Gari, 2003 and 2004). Secondly, improved nutrition delays the progression of HIV into AIDS (e.g. Fawzi and Hunter, 1998; Fawzi et al. 2004; Stillwaggon, 2006)[3]. Thirdly, for the rural poor who suffer due to poor access to health services (Villarreal, 2006), agrobiodiversity is considered a locally available option to assist in reducing the negative impacts of HIV/AIDS. In line with this, it may be important to mention the relevance of the type of crops grown and agrobiodiversity for the nutritional status of subsistence farm households who consume the major share of their production. Donovan and Massingue (2007) reported that rural households in Mozambique heavily rely on own agricultural production as a basic macronutrient source and that HIV/AIDS affected rural households have lower income per adult equivalent. Transaction costs in the product markets of subsistence economies (e.g. Sadoulet and de Janvry, 1995) and the reduction in productivity and income due to HIV/AIDS imply that the market can not be considered as a sufficiently substitutable nutrient source for such households.

The thesis focuses on analyzing whether or not and to what extent HIV/AIDS affects agrobiodiversity in the home garden of farm households in Southwest Ethiopia where households allocate labour to fields and home gardens and sharecropping is an option. The analysis is based on a non-separable farm household model. The empirical analysis of the effect of HIV/AIDS driven changes in labor organization on agrobiodiversity in the thesis is uni-directional. That is, it does not explicitly study the effect of agrobiodiversity (through nutrition) on HIV/AIDS impact mitigation. This direction of the link is explored by several other studies. These include studies that directly focus on the nutritional role of agrobiodiversity (e.g. Johns, 2003; Gari, 2003 and 2004) and the role of nutrition in general (e.g. Fawzi and Hunter, 1998; Fawzi et al. 2004; Stillwaggon, 2006) in HIV/AIDS impact mitigation. However, some numerical examples are presented in the theoretical analysis to illustrate the potential labor allocation and crop diversity implication of the feedback effect of agrobiodiversity on health status.

The empirical part of the study is conducted based on in-depth analysis of 4 farm households that are affected by HIV/AIDS and data generated from a survey of 205 farm households in Southwest Ethiopia. Data obtained from secondary sources is also used to complement the primary data. I am aware of the fact that the results obtained from in-depth studies of 4 households can not be generalized into a wider

[3] Even the effectiveness of the provision of an antiretroviral therapy as an alternative strategy for delaying the progression of HIV into AIDS is conditioned by the nutritional status of the individual (Castleman et al. 2004; WHO, 2007).

context, but the insights obtainable from HIV/AIDS affected households are useful to complement the survey results. First, the larger survey data is based on adult morbidity and mortality, as proxy indicators, because of the difficulty of observing HIV/AIDS among the farm households. The in-depth analysis, although limited in size, draws on actual data from HIV/AIDS affected households. Second, the cross-sectional survey data does not capture the dynamics of the impact of HIV/AIDS. An attempt is made, through the in-depth studies, to capture the importance of the various stages of illness and the stage impacts on labor allocation, crop choice and agrobiodiversity for each affected member. Whereas the in-depth study provides insights regarding such issues that are not captured by the survey data, wider generalizations of effects are sought through econometric analysis of the survey data.

The main research questions to be addressed are:

1. What does the theory of the farm household predict concerning the effects of HIV/AIDS driven changes in labor organization on agrobiodiversity?
2. What insights can be generated from an in-depth study of the impact of HIV/AIDS on labor organization, crop choice and agrobiodiversity?
3. What generalizations can be made from a survey analysis of the implications of HIV/AIDS for labor organization and agrobiodiversity?

The main interest in research question 1 is to theoretically reflect on the potential implications of HIV/AIDS for labor organization and agrobiodiversity in home gardens. The essence in research question 2 is to compare the theoretical results with empirical evidence from an in-depth study of HIV/AIDS affected households. In addition, I look at the importance of the stages of HIV/AIDS manifestation and the household role of the affected member for labor organization and the agrobiodiversity responses of the households. Research question 3 is developed with the aim of empirically testing the theoretical and in-depth analysis results with data from a larger survey. In this case, the statistical significance of the indicators of HIV/AIDS (adult morbidity and mortality) on labor organization (sharecropping intensity) and its effect on agrobiodiversity is tested.

In order to analyze research question 1, a non-separable farm household model is employed which accounts for transaction costs in the labor markets. The model is used as a framework to illustrate the potential effects of HIV/AIDS on labor organization and agrobiodiversity in a comparative static framework. Two approaches are followed in the analysis, namely, (i) the labor allocation approach and (ii) the diversity approach using the Dixit-Stiglitz model of product diversity. In the labor allocation approach I assume that the household chooses labor allocations between the home garden and fields in the optimization process. In the diversity approach I assume that households value diversity of crops as part of their utility function and hence labor allocation to the field and crop diversity in the home garden are the choice variables in the optimization process. In both cases, the problem is analyzed under the standard case as well as with land rental market options, particularly sharecropping. Numerical illustrations are carried-out, by specifying functional forms, using GAMS to show possible outcomes where mathematical results are ambiguous. Based on the results the chapter develops a hypothesis on the association between sharecropping-out intensity and declining health status as well as on the association between agrobiodiversity and sharecropping-out intensity. Both hypotheses will be tested in the subsequent empirical chapters.

An in-depth analysis of four HIV/AIDS affected farm households was conducted to address research question 2. The research question is analyzed in the context of the potential importance of the stages of HIV/AIDS progression and the household role of the affected member for labor organization, crop choice and agrobiodiversity at the farm. In addition, attention is paid to the effect of HIV/AIDS on the household income per capita. Such effects are analyzed for the case before-HIV/AIDS manifestation and for the various stages after-HIV/AIDS. The aim of addressing this question is not to obtain a general conclusion on the importance of stages and affected member(s) to labor allocation and agrobiodiversity as four cases do not allow doing so. Rather, the research question is aimed at obtaining insights into the important variables that come into play in labor organization, crop choice and agrobiodiversity decisions among HIV/AIDS affected households. The insights, in combination with the existing literature, help in identifying variables important in labor organization and agrobiodiversity decisions which will later be tested and controlled for in the larger survey analysis.

In order to address research question 3 econometric analyses were conducted on data generated from a survey of 205 households. For this purpose adult morbidity and mortality are taken as proxy indicators for HIV/AIDS. Because it was impossible to obtain information on HIV/AIDS incidence at farm household level, using adult morbidity and mortality as proxies is considered a second best solution for analyzing the impact of HIV/AIDS. In order to establish the indicator, I test the effect of adult male morbidity and mortality on sharecropping-out intensity, which constitutes one of the hypotheses developed under research question 2. Based on this, the effect of sharecropping-out intensity on agrobiodiversity is tested. In addition, a test is conducted on the potential direct effect of health status on agrobioversity. For this purpose an agrobiodiversity index is constructed for crops in the home garden following Weikard et al. (2006). The index accounts for species relative abundance and taxonomic distance and allows for measuring the diversity profile for a range of scale parameters. The regression analysis controls for other household specific and regional variables that may affect agrobiodiversity.

1.3 THE STUDY CONTEXT AND RELEVANCE

Following the lifting, of the ban on short term land leases in Ethiopia in 1991, land rental markets such as for sharecropping and fixed rent leases has been increasing as a way of accessing farmland, where land sales and mortgaging are banned (Benin et al. 2005). Whereas the details for the operationalization of the new regulation on the land rental markets is left for regions, there remains some ambiguity concerning the land size for and length of the contract and absentee ownership (Deininger et al. 2007; Holden, 2008). Since 1998, a comprehensive HIV/AIDS policy has been in place to provide an enabling environment for a multi-sectoral approach for the prevention and control of the epidemic (HAPCO, 2003). The government launched a program in 2005 to increase access to free antiretroviral therapy throughout the country along with the Social Mobilization Strategy on HIV/AIDS and a national multi-sectoral strategy for the years 2004-2008 (WHO, 2005). To the extent that nutrition is important for the effectiveness of antiretroviral therapy and agrobiodiversity is important for nutrition, identifying local capacity and farm household responses to HIV/AIDS become relevant for the effectiveness of such programs. Specifically how HIV/AIDS affected farm households reallocate their resources and strive to sustain their capacity need to be addressed in detail.

The study focuses on an area near Jimma town, the capital of Jimma zone, which is located in Oromiya Region, about 335 km Southwest of Addis Ababa (see Figure 1.2 and Table 1.1). Jimma zone was chosen for the study because it ranks second in HIV/AIDS prevalence rates among the 12 zones of Oromiya

Region. Oromiya region makes up about 35% of the country’s population (CSA, 2006). The HIV/AIDS prevalence rate in Jimma is estimated at 8.9% in the rural and 7.0% in the urban communities (Belachew et al. 2004). The Jimma zone is divided into 13 woredas (the lowest administrative level in the current context) of which Gomma and Kersa were chosen for the study. There is a high rate of seasonal labor migration to the coffee growing Gomma woreda in search of employment during the coffee harvesting seasons which has considerable implications for the HIV/AIDS prevalence rate in the area. In the Jimma area, where a system of fixed cash rent is not common, sharecropping is the most common arrangement for allocating land between households (Demeke, 1999). About 29% of the households in Gomma zone are landless (Jimma Zone Agricultural Development Department, 2003). Labor unemployment rate is estimated at 6.1% in Oromiya Region and 8.1% in the country (FDRE/EPA, 2004).

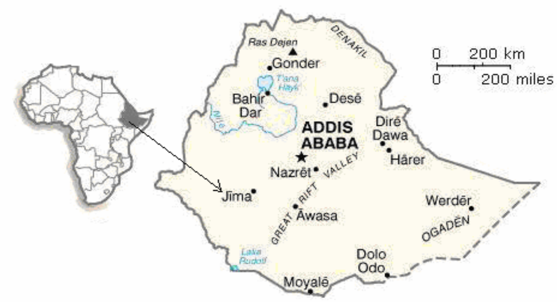


Figure 1.2 Map of the study area.

Table 1.1 Location and physical characteristics of the area.

	Gomma	Kersa	Jimma town	Jimma zone
Main town	Agaro	Serbo	Jimma town	Jimma zone
Area (sq. km)	1349	975		19293
Latitude	7^{0}40’-8^{0}04’N	7^{0}35’-8^{0}00’N	7^{0}41’N	7^{0}13’-8^{0}56’N
Longitude	36^{0}17’-36^{0}46’E	36^{0}46’-37^{0}14’E	36^{0}50’E	35^{0}52’-37^{0}37’E
Altitude (m)	1450-2280	1740-2660	1704-2000	
Mean rainfall (mm/month)	39 (Jan)-258 (Jun)	36(Jan)-214 (Aug)		
Mean rainfall (mm/year)	1200-1800			1200-2000
Mean monthly temp (^{0}C)	11 (Dec)-31(Feb)		7 (Dec)-29 (Mar)	
Distance from Addis (km)	379	312	335	
% of highland area	8	33		16
% of temperate area	88	53		62
% of lowland area	4	14		22

Source: Bureau of Planning and Economic Development for Oromiya (2002); empty spaces indicate non-availability of data.

Table 1.2 Area cultivated (ha), crop yields (quintals/ha), fertilizer use (DAP/Urea in quintals) and population ('000) in the study area.

	1995/6			1999/00			2000/01			2001/02		
	Gomma	Kersa	Zone	Gomma	Kersa	Zone	Gomma	Kersa	Zone	Gomma	Kersa	Zone
Annual crop area	25094	26281	366989	22801	36144	711848	23148	35201	392215	18442	36518	382707
Crop yield	15	13	11	14	17	7	12	14	12	11	10	9
Coffee area				16980	1802	60317	22508	1999	63052	23309	2173	70988
Coffee yield				3	3	3	5	5	5	3	2	3
Perennial area	28779	3585	107196	27396	3939	111229						
DAP			141145	4675	7021	53161	2588	8609	86971	1689	4310	29914
Urea			4537	2606	2710	22397	2041	5416	32278	1411	3100	16104
Population	261	131	2096				293	265	2338	250	147	2486

Source: Jimma Zone Agricultural Development Department, 2003 and Bureau of Planning and Development for Oromiya, 2002; empty spaces mean non-availability of data. 1Quintal = 100kg, DAP: Diammoniumphosphate.

Table 1.2 shows that the two woredas have higher yield and higher levels of fertilizer use than the average of the zone. As shown in Table 1.3 a substantial proportion of the area under annual crops is cultivated using local seed without fertilizer in both sites and for the zone total. Most of the improved seed used in both areas is for maize production. Since the use of improved maize with fertilizer is encouraged by the local Rural Development Department, through credit for seeds and fertilizer, it is difficult to fully attribute the increase in the use of this package to the autonomous choice of the farmers during the years indicated.

Tables 1.1 through 1.3 show that the area is characterized by smallholder farming with a variety of crops grown at the farm. The main food crops in the area are maize, enset (*Ensete Ventricosum*) and sorghum. Maize and sorghum are used for both home consumption and sale. Coffee, followed by fruit trees (including orange, mango, papaya, avocado, and guava), qat and sugarcane constitute the main cash crops in the area. The average household owns a home garden, fields and coffee plots in the order of increasing distance from home. Home gardens are mainly cultivated for growing enset, fruit, coffee, sugarcane, qat, maize, haricot beans, vegetables, root crops, and other trees. Fields, which may consist of several plots, are cultivated under cereals mainly maize, sorghum, haricot bean, teff, barley and millet.

Table 1.3 Various seed and fertilizer package use by crop area (ha) and seeds (quintals (qt)).

	Cropping season 2001/2												
	Improved seeds with fertilizer				Local seed with fertilizer				Local seed without fertilizer				Total
	Gomma		Kersa		Gomma		Kersa		Gomma		Kersa		zone
	ha	qt	ha	qt	ha	qt	ha	qt	ha	qt	ha	qt	ha
Teff					339	8	3117	8	2443	7	3183	5	28602
Wheat					1	11	190	14	229	8	2765	8	3149
Barley									152	7	3770	9	119
Millet									139	7			211
Maize			3494	32	22	20	385	15	9216	12	9920	10	23286
Sorghum									2421	10	5710	7	2357
Bean									138	6	1910	6	190
Pea													70
Haricot bean									80	6	470	5	
Rice													
Lentil													
Kale									12	3			
	Cropping season 2002/3												
Teff					353	8	2175	9	5288	4	2940	7	118902
Wheat							170	13	876	7	2835	9	21423
Barley									759	7	3800	11	19343
Millet									361	7			6637
Maize	1357	22	5342	34	71	15	8492	14	12044	6	3166	8	64609
Sorghum			10	20					4433	10	3200	10	41134
Bean									364	5	1800	6	18321
Pea									248	4	1270	5	8464
Haricot bean			1	9					281	5	390	5	4698
Rice									89	4			144
Lentil			6	10									488
Kale									61	3	175	4	1266

Source: Jimma Zone Agricultural Development Department, 2003; Empty spaces indicate non-use of the specified package. Rice was newly introduced in 2003.

1.4 OUTLINE OF THE THESIS

The thesis contains five chapters including the general introduction. The chapters following the introductory chapter are inspired by the research questions and aim at addressing each specific research question. The last chapter presents the main conclusions drawn from the analysis and highlights some policy recommendations. The main conclusions drawn from the thesis will provide information for scaling up intervention efforts to mitigate the effect of HIV/AIDS on farm households. It also identifies the limitation of the study thereby highlighting areas for future research. Table 1.4 presents a brief summary of the issues addressed in and the link between each chapter.

Table 1.4 Issues addressed in and interrelationship between thesis chapters.

Items	Chapters				
	Conceptual and theoretical		Empirical		Synthesis
	Chapter 1	Chapter 2	Chapter 3	Chapter 4	Chapter 5
Aim	Introduce and motivate the study	Systematic reflection	Empirical case study	Empirical testing	Summarize main findings.
Research question addressed		1	2	3	1, 2, 3 and implications.
Key variables addressed	Identify gaps in the literature addressed by the thesis	Labor organization and agrobiodiversity effects of HIV/AIDS			Implications of issues addressed in Chapter 2, 3, 4
Research approach	Core literature insights and thesis layout	Theoretical: farm household model	In-depth: HIV/AIDS affected households	Survey: proxy indicator for HIV/AIDS	
Tools	Literature	Analytical and numerical	Tabular and graphical	Econometric (regression)	Analytical synthesis
Method of analysis		Comparative static (before-after; with-without HIV/AIDS)	Before-after HIV/AIDS; stage dynamics	Comparative static (affected and non-affected)	
Chapter's link to the rest of the chapters	Set out research questions addressed in Chapters 2, 3, and 4; Core contents.	Theoretical analysis and generating hypotheses for testing in the empirical chapters	Qualitative check for consistency of hypotheses in Chapter 2	Statistical test of hypotheses in Chapter 2; Significance of effects in Chapter 3	A synthesis of answers to each research question

Chapter 2 reflects on potential labor organization and agrobiodiversity implications of HIV/AIDS, based on a non-separable household model. It starts by laying out a conceptual framework to enable understanding of how the problem translates into change in labor organization and agrobiodiversity. The analysis is based on resource allocation patterns of the utility maximizing households under alternative labor organizations before and after or with and without HIV/AIDS in a comparative static framework. The underlying argument is that HIV/AIDS affects household labor productivity in the field, which alters the shadow value of labor and of the products thereby potentially causing labor reallocation between the home garden and fields.

Whereas in the labor allocation approach, the analysis focuses on the time allocation between the home garden and fields, the diversity approach of the analysis focuses on the choice of both time allocation to the field and number of crops in the home garden. Where mathematical ambiguities exist, numerical illustrations are presented. Based on this, the chapter explores the predictions of the farm household model on labor organization and agrobiodiversity among HIV/AIDS affected households. The theoretical model makes the link to the subsequent empirical chapters. Chapter 2 concludes by generating testable hypotheses on the effect of HIV/AIDS induced reduction in labor productivity on labor organization; and on the implications of change in labor organization on agrobiodiversity for testing in the empirical chapter.

Chapter 3 presents in-depth studies of 4 affected farm households for examining the implications of HIV/AIDS for farm household labor organization, crop choice and agrobiodiversity. The aim of this chapter is not to draw conclusions that can be generalized within a wider context as the sample size would not allow doing so. The case studies, however, provide in-depth insight into the situation and decisions of the HIV/AIDS affected farm households which are difficult to obtain in a larger survey analysis. McWhinney (2001) indicates that case studies, by enhancing learning from particulars of individual cases, help to fill the gap left by large survey analysis aimed at generalization. The conclusion derived based on the in-depth insights help to check if theoretical results are consistent with actual observations and to generate hypothesis for testing in a representative context. The in-depth study also complements the larger survey analysis, both serving as grounds for checking the results as well as helping to identify sound indicators, especially because the latter relies on the use of proxy indicators for HIV/AIDS. The chapter presents a detailed description of the characteristics of each of the cases at each stage, and a discussion of results and conclusions. The households that participated in the in-depth study vary in their characteristics. Three of them are single parent households (of which one is single female) and one of them has turned from a foster parent headed into a child headed household status, following the death of both parents. The in-depth study involves observation, unstructured and semi-structured conversations with the aim of unearthing the current status and reconstructing past scenarios through their historical recollections. A framework of describing the behavior of the households throughout the various stages of progression of HIV/AIDS is formulated to explore the role of the stages on resource allocation patterns and agrobiodiversity. The stages are divided into *pre-illness*, *illness*, *death* and *current*.

Chapter 4 presents an empirical estimation of relations inspired by the model developed in the theoretical chapter (Chapter 2) by using survey data. Reduced form agrobiodiversity equations are estimated through regression analysis by controlling other factors. Based on estimation results, the hypotheses developed in Chapter 2 are tested to address the specific sub-questions. That is, the hypothesis on the direction and significance of the effect of adult morbidity and mortality on sharecropping-out intensity; and of the effect of sharecropping-out intensity on agrobiodiversity are tested. The hypothesis that the health status directly affects agrobiodiversity is tested also. Additionally, the extent to which labor organization and agrobiodiversity effects observed in the in-depth study of HIV/AIDS affected households are confirmed by the larger survey using proxy indicators is analyzed.

Chapter 5, finally, presents the main conclusions that can be drawn from the preceding chapters, and highlights the main findings of the research. Based on the findings and limitations of the study, the chapter provides suggestions for further research and points out important implications for intervention.

CHAPTER 2

INTERRELATIONS BETWEEN HIV/AIDS, LABOR ORGANIZATION AND AGROBIODIVERSITY: A FARM HOUSEHOLD MODEL ANALYSIS

Farm households that are under the stress of HIV/AIDS face the challenges of adapting to the reduction in labor supply and labor productivity. One response is adjustment in organization of labor and choice of crops. This affects farm level agrobiodiversity. Through improving nutrition, agrobiodiversity can contribute towards delaying the progression of HIV into AIDS. This also may provide incentives to change the level of agrobiodiversity in the home garden of the farm households.

The purpose of this chapter is to analyze the effect of HIV/AIDS on labor organization and agrobiodiversity. We bring together the interplay between HIV/AIDS, labor organization and agrobiodiversity in a non-separable farm household model. Two approaches are followed in the analysis, namely the labor allocation approach and the diversity approach. In the labor allocation approach, we analyze the effect of HIV/AIDS on labor allocation to the home garden and fields. In the diversity approach that employs the Dixit-Stiglitz model of product diversity, we analyze the effect of HIV/AIDS on labor allocation and crop diversity. Contrary to common knowledge of the potential negative effect of HIV/AIDS on agrobiodiversity, we highlight that HIV/AIDS affected households increase agrobiodiversity in the home garden and at the same time increase sharecropping-out fields. We also analyze the impact of HIV/AIDS on agrobiodiversity when more agrobiodiversity would reduce the negative health impacts of HIV/AIDS. This offers opportunities for interventions that so far have received little attention in the literature on HIV/AIDS impact mitigation.

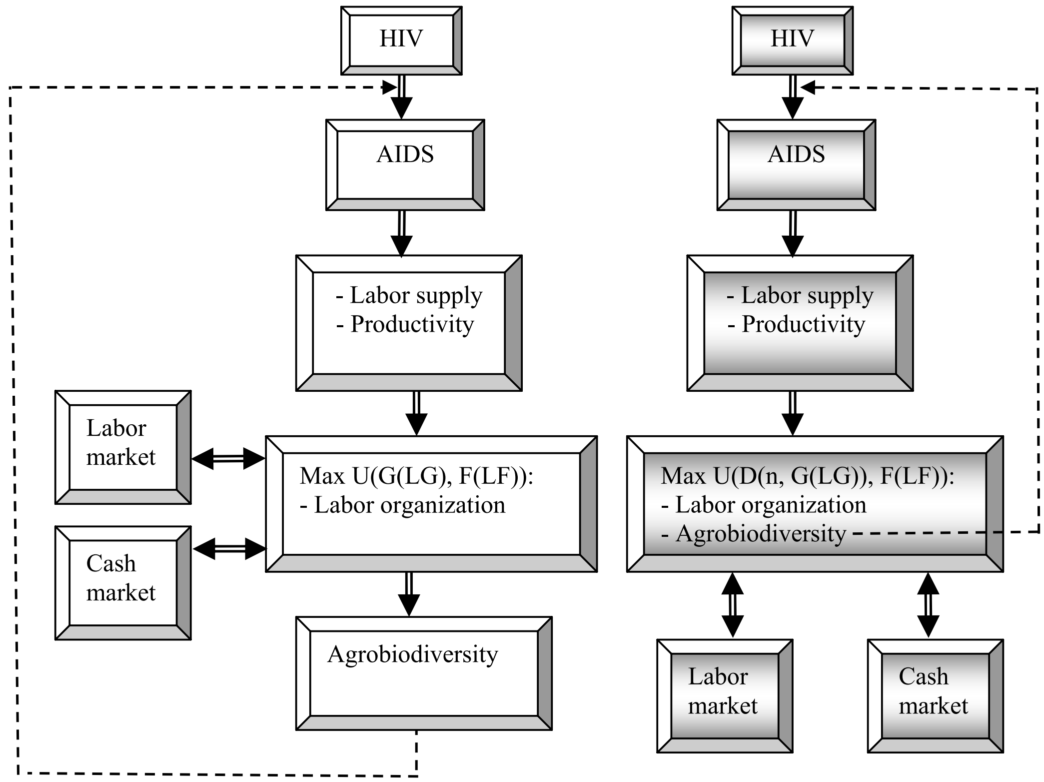
Key words: *agrobiodiversity, Ethiopia, HIV/AIDS, labor organization, sharecropping, transaction cost.*

2.1 BACKGROUND AND PROBLEM DEFINITION

HIV/AIDS is affecting farm households through withdrawal of labor force and reduced labor productivity. This occurs in response to recurring illnesses, demand for care, death, and migration (Barnett and Blaikie, 1992; Rugalema, 1999; Haddad and Gillespie, 2001; Drimie, 2002; Loevinsohn and Gillespie, 2003). Those responses are matched by an increasing demand for replacement labor (e.g. Drimie, 2002) and additional health related expenses (Barnett and Blaikie, 1992; World Bank, 1997; Rugalema, 1999) causing an increase in the demand for cash income. Moreover, people living with HIV/AIDS have higher than normal nutritional demands (Piwoz and Preble, 2000).

Obviously, HIV/AIDS, labor and nutrition are interlinked. Nutrition and food are important for the mitigation of the impact of HIV/AIDS through delaying the progression of HIV into AIDS-related diseases (e.g. Haddad and Gillespie, 2001; FAO/WHO, 2002; Loevinsohn and Gillespie, 2003; Gillespie and Kadiyala, 2005; Stillwaggon, 2006). Fawzi et al. (2004) found a lesser likelihood of progression to advanced stages of HIV disease, better CD4+ T-cell counts, lower viral loads and lower rate of HIV related illness and death among women who received multivitamin supplements. According to the World Bank (1997) HIV/AIDS has a relatively lower transmission rate among otherwise healthy adults than individuals suffering from malnutrition.

Agrobiodiversity can contribute to improving nutrition at household level (Johns, 2003; Gari, 2003 and 2004; Johns and Eyzaguirre, 2006) and thus might play a role in reducing the impact of HIV/AIDS. The contribution of agrobiodiversity in improving nutrition makes it a potentially relevant option in HIV/AIDS impact mitigation among affected farm households and subsistence farm households in particular. It is also recognized that HIV/AIDS changes farm-household labor organization (Loevinsohn and Gillespie, 2003; Donovan et al. 2003; Bishop-Sambrook et al. 2006) and that labor organization has an impact on crop choice (Haddad and Gillespie, 2001; Barnett and Whiteside, 2002; Yamano and Jayne, 2002; Gillespie and Kadiyala, 2005) with implications for agrobiodiversity. However, little attention has been paid to how changes in farm household labor allocation and crop choice may affect on-farm agrobiodiversity, particularly with labor market options as illustrated in Figure 2.1.



The left and right hand sides of the figure present a conceptualization of the effect of HIV/AIDS on labor organization and agrobiodiversity based on the labor allocation approach and the diversity approach respectively. U(.), G, F, D and n denote household utility, production in the home garden, production in the field, agrobiodiversity and number of crop species in the home garden respectively. The dashed arrow indicates the potential feedback of agrobiodiversity on health and HIV/AIDS impact mitigation established in the literature.

Figure 2.1 Implications of HIV/AIDS for labor organization and agrobiodiversity.

The objective of the chapter is to analyse, in a systematic way, the implications of HIV/AIDS on agrobiodiversity through changes in labor organization in rural Ethiopia. Through identifying the impact of HIV/AIDS on labor organization, the study assesses the potential effect of sharecropping on agrobiodiversity. The analysis assumes non-separation between production and consumption decisions due to transaction cost in the labor market (Sadoulet et al. 1998; Key et al. 2000).

The chapter is organized as follows: the first section presents an analysis of the effect of HIV/AIDS based on the labor allocation approach for modeling farm household behaviour. The second section presents an analysis of the effect of HIV/AIDS based on the Dixit-Stiglitz approach of modeling product diversity. This is followed by a section reflecting on the labor organization and crop diversity implications of accounting for the health benefits of crop diversity in the model. We close with a discussion of implications for the theory of HIV/AIDS affected farm households and generating hypotheses for empirical testing.

2.2 THE LABOR ALLOCATION APPROACH

2.2.1 Standard situation: no external labor use

The farm household is assumed to derive utility from the consumption of two goods, namely home garden products, $G(.)$, and field products, $F(.)$. While coffee production activity is also important for the households we focus on analyzing the effect of HIV/AIDS on reallocations in the field and home garden activities. This is because we assume that labor allocation to the coffee plot, usually the farthest of all plots and mostly a long established perennial activity, has a stable size and is the least affected by a change in household labor. Production in the home garden depends on the amount of effective labor allocated to the home garden, $\tilde{g}$, and production in the field depends on the amount of effective labor allocated to the field, $\tilde{f}$. We introduce α_1 and α_2 to account for possible differences between the effective labor units produced and the amount of labor allocated where $\alpha_1 \geq 1$ and $\alpha_2 \geq 1$ denote the amount of labor units required per unit effective labor for the home garden and field respectively. That is, household labor allocated to the home garden, g, is factored by α_1^{-1} to obtain the effective labor units allocated to the home garden, $\tilde{g}$, and labor allocated to the field, f, is factored by α_2^{-1} to obtain the effective labor units allocated to the field, $\tilde{f}$. g and f sum up to the fixed household labor endowment, $\overline{L}$. Labor allocations to the field and home garden are measured in labor days per year.

Optimization and first order conditions for the standard model

Max $U = U\left(G(\tilde{g}), F\left(\tilde{f}\right)\right)$ (2.1)

Subject to

$$\overline{L} = \alpha_1 \tilde{g} + \alpha_2 \tilde{f} \Rightarrow \hat{L} = \tilde{g} + \hat{\alpha}_2 \tilde{f} \quad (2.2)$$

where $\hat{\alpha}_2 = \frac{\alpha_2}{\alpha_1}$ and $\hat{L} = \frac{\overline{L}}{\alpha_1}$. It is assumed that $U(G(.),F(.))$ is increasing and concave in the arguments and that also $G(.)$ and $F(.)$ are increasing and concave. $U(.), G(.)$ and $F(.)$ are twice differentiable. The following additional assumptions are made:

$$U_G > 0, U_{GG} < 0 \text{ and } G_{\tilde{g}} > 0, G_{\tilde{g}\tilde{g}} < 0 \tag{2.3}$$

$$U_F > 0, U_{FF} < 0 \text{ and } F_{\tilde{f}} > 0, F_{\tilde{f}\tilde{f}} < 0 \tag{2.4}$$

where we assume separable production technologies such that $G_{\tilde{g}\tilde{f}} = 0$ and $F_{\tilde{g}\tilde{f}} = 0$. Equations (2.3) and (2.4) are the standard conditions for local maximum. The Lagrangian of the constrained optimization problem can be specified as

$$\ell = U\left(G(\tilde{g}), F\left(\tilde{f}\right)\right) + \lambda\left(\hat{L} - \tilde{g} - \hat{\alpha}_2 \tilde{f}\right) \tag{2.5}$$

In this model λ measures the additional utility the household generates per unit additional labor, i.e. the shadow value of relaxing the labor constraint by one additional labor unit which is the same as the opportunity cost, measured in utils of employing an additional labor unit to either activity. We assume an interior solution with respect to labor allocation across the activities such that $0 < g, f < \overline{L}$. We rule out that households are allocating all the labor endowment to the fields with no garden activities, i.e. $\overline{L} = f$, or that they are allocating all the labor endowment to the home garden with no field activities, i.e. $\overline{L} = g$. This is warranted by observation that the farm households in the area manage both types of plots in any given year. Accordingly, the necessary condition for an optimum is given by

$$\ell_{\lambda} = \hat{L} - \tilde{g} - \hat{\alpha}_2 \tilde{f} = 0 \tag{2.6}$$

$$\ell_{\tilde{f}} = U_F F_{\tilde{f}} - \hat{\alpha}_2 U_G G_{\tilde{g}} = 0 \tag{2.7}$$

where we apply

$$\lambda = U_G G_{\tilde{g}} \tag{2.8}$$

Condition (2.7) states that optimal household labor is allocated between home garden and field activities until the marginal utility of an additional labor unit is equalized across the activities. Condition (2.8) states that optimum own labor allocation to the home garden occurs at the point where the marginal utility of an additional effective labor unit allocated to the home garden is equal to the shadow price of an additional effective labor unit allocated to the home garden through tightening the labor endowment constraint. Because of (2.6), the first order conditions will fulfill the constraint, the value of $\ell(.)$ equals the value of $U(.)$ at the optimum. For simplifying the notation, subscripts have been introduced for partial derivatives, i.e. U_G and U_F are the partial derivatives of the utility function with respect to production in the field and in the home garden respectively. Based on (2.6),

$$\tilde{g} = \hat{L} - \hat{\alpha}_2 \tilde{f} \tag{2.9}$$

Given the utility function, conditions (2.6) and (2.7) can be solved to get the labor demand functions given by $\tilde{g}^*(\hat{\alpha}_2, \hat{L})$ and $\tilde{f}^*(\hat{\alpha}_2, \hat{L})$. Second order condition must hold for this optimal point which involves the bordered Hessian matrix (Turkington, 2007)[4].

We assume that under normal conditions $g = \tilde{g}$ and $f = \tilde{f}$ and hence $\alpha_1 = \alpha_2 = 1$. With HIV/AIDS, household labor productivity declines due to illness and death. Household labor endowment, $\overline{L}$, remains constant whereas the number of effective labor units per hours worked changes on plot basis. We expect that HIV/AIDS causes an increase in α_2 which implies a reduction in the effective labor units per hour worked in the field whereas productivity in the home garden remains almost constant i.e. $\alpha_1 \approx 1$. This is because activities in the home garden are less laborious than activities in the field and do not involve

[4] Specifying, for simplicity, the optimization problem in a standardized textbook specification of an objective function, $V(.)$, for maximizing as: $V = V(\tilde{g}, \tilde{f}) = U(G(\tilde{g}), F(\tilde{f}))$ subject to $\hat{L} = \tilde{g} + \hat{\alpha}_2 \tilde{f}$ where $V(.)$ is not a utility function. First order conditions corresponding to (2.6)-(2.8) are given by $\ell_\lambda = \hat{L} - \tilde{g} - \hat{\alpha}_2 \tilde{f} = 0$;
$\ell_{\tilde{g}} = V_{\tilde{g}} - \lambda = 0$ and $\ell_{\tilde{f}} = V_{\tilde{f}} - \hat{\alpha}_2 \lambda = 0$. The Hessian matrix is given by

$$\overline{H} = \begin{bmatrix} \ell_{\lambda\lambda} & \ell_{\lambda\tilde{g}} & \ell_{\lambda\tilde{f}} \\ \ell_{\tilde{g}\lambda} & \ell_{\tilde{g}\tilde{g}} & \ell_{\tilde{g}\tilde{f}} \\ \ell_{\tilde{f}\lambda} & \ell_{\tilde{f}\tilde{g}} & \ell_{\tilde{f}\tilde{f}} \end{bmatrix} \Rightarrow |\overline{H}| = |H_2| = \begin{vmatrix} 0 & -1 & -\hat{\alpha}_2 \\ -1 & V_{\tilde{g}\tilde{g}} & V_{\tilde{g}\tilde{f}} \\ -\hat{\alpha}_2 & V_{\tilde{f}\tilde{g}} & V_{\tilde{f}\tilde{f}} \end{vmatrix} = -V_{\tilde{f}\tilde{f}} + 2\hat{\alpha}_2 V_{\tilde{g}\tilde{f}} - \hat{\alpha}_2^2 V_{\tilde{g}\tilde{g}}$$. In this case,

$|\overline{H}| = |H_2|$ where $|H_2|$ is a leading principal minor of $\overline{H}$; the corresponding comparative static result is given in Annex 2A.2). $|H_2|$ can be expressed in terms of utility function $U(.)$ as: $V_{\tilde{g}} = U_G G_{\tilde{g}}$; $V_{\tilde{f}} = U_F F_{\tilde{f}}$;
$V_{\tilde{g}\tilde{g}} = U_{GG} G_{\tilde{g}}^2 + U_G G_{\tilde{g}\tilde{g}}$; $V_{\tilde{f}\tilde{f}} = U_{FF} F_{\tilde{f}}^2 + U_F F_{\tilde{f}\tilde{f}}$; $V_{\tilde{g}\tilde{f}} = U_{GF} F_{\tilde{f}} G_{\tilde{g}}$ given separable technology, i.e. $U_G G_{\tilde{g}\tilde{f}} = 0$. For a local maximum, $|H_2| > 0$ should hold at $\tilde{L}^{G^*}$, $\tilde{L}^{F^*}$ and λ^*.

fixed travel time cost. As a result the reduction in the effective labor units per unit labor allocated to the home garden after the decline in health status is negligible. We conduct comparative static analysis to see the effect of change in α_2 due to HIV/AIDS on labor allocated to the field and the home garden.

Comparative statics for the standard model

The first order conditions given by (2.6) and (2.7) give a system of simultaneous equations where $\tilde{g}$ and $\tilde{f}$ are endogenous whereas $\hat{\alpha}_2$ and $\hat{L}$ are exogenous variables. We consider the first order conditions as equilibrium equations for comparative statics around one possible solution given by $\tilde{g}^*, \tilde{f}^*$. Consider the case for comparative statics for $\tilde{g}$ when $\hat{\alpha}_2$ varies. Taking the total differentials, d, of (2.6)-(2.7),

$$d\hat{L} - d\tilde{g} - \hat{\alpha}_2 d\tilde{f} - \tilde{f} d\hat{\alpha}_2 = 0 \tag{2.10}$$

$$\begin{aligned} &U_{FG} G_{\tilde{g}} F_{\tilde{f}} d\tilde{g} + \left(U_{FF} F_{\tilde{f}}^2 + U_F F_{\tilde{f}\tilde{f}}\right) d\tilde{f} - \hat{\alpha}_2 \left(U_{GG} G_{\tilde{g}}^2 + U_G G_{\tilde{g}\tilde{g}}\right) d\tilde{g} \\ &- \hat{\alpha}_2 U_{GF} G_{\tilde{g}} F_{\tilde{f}} d\tilde{f} - U_G G_{\tilde{g}} d\hat{\alpha}_2 = 0 \end{aligned} \tag{2.11}$$

where $U_G G_{\tilde{g}\tilde{f}} = 0$ since $G_{\tilde{g}\tilde{f}} = 0$. Isolating the differentials of the exogenous variables on the right hand side,

$$- d\tilde{g} - \hat{\alpha}_2 d\tilde{f} = -d\hat{L} + \tilde{f} d\hat{\alpha}_2 \tag{2.12}$$

$$\begin{aligned} &U_{FG} G_{\tilde{g}} F_{\tilde{f}} d\tilde{g} + \left(U_{FF} F_{\tilde{f}}^2 + U_F F_{\tilde{f}\tilde{f}}\right) d\tilde{f} - \hat{\alpha}_2 \left(U_{GG} G_{\tilde{g}}^2 + U_G G_{\tilde{g}\tilde{g}}\right) d\tilde{g} \\ &- \hat{\alpha}_2 U_{GF} G_{\tilde{g}} F_{\tilde{f}} d\tilde{f} = U_G G_{\tilde{g}} d\hat{\alpha}_2 \end{aligned}$$

Condition (2.12) is given in matrix notation as

$$\begin{bmatrix} -1 & -\hat{\alpha}_2 \\ U_{FG} G_{\tilde{g}} F_{\tilde{f}} - \hat{\alpha}_2 \left(U_{GG} G_{\tilde{g}}^2 + U_G G_{\tilde{g}\tilde{g}}\right) & \left(U_{FF} F_{\tilde{f}}^2 + U_F F_{\tilde{f}\tilde{f}}\right) - \hat{\alpha}_2 U_{GF} G_{\tilde{g}} F_{\tilde{f}} \end{bmatrix} \begin{bmatrix} d\tilde{g} \\ d\tilde{f} \end{bmatrix}$$
$$= \begin{bmatrix} -d\hat{L} + \tilde{f} d\hat{\alpha}_2 \\ U_G G_{\tilde{g}} d\hat{\alpha}_2 \end{bmatrix}$$

Consider the case where $\hat{\alpha}_2$ changes while $\hat{L}$ remains constant

$$\begin{bmatrix} -1 & -\hat{\alpha}_2 \\ U_{FG} G_{\tilde{g}} F_{\tilde{f}} - \hat{\alpha}_2 \left(U_{GG} G_{\tilde{g}}^2 + U_G G_{\tilde{g}\tilde{g}}\right) & \left(U_{FF} F_{\tilde{f}}^2 + U_F F_{\tilde{f}\tilde{f}}\right) - \hat{\alpha}_2 U_{GF} G_{\tilde{g}} F_{\tilde{f}} \end{bmatrix} \begin{bmatrix} d\tilde{g} \\ d\tilde{f} \end{bmatrix} = \begin{bmatrix} \tilde{f} d\hat{\alpha}_2 \\ U_G G_{\tilde{g}} d\hat{\alpha}_2 \end{bmatrix}$$

Applying Cramer's rule to derive the effect of a change in $\hat{\alpha}_2$ on $\tilde{g}$

$$d\tilde{g}=\frac{\begin{vmatrix}\tilde{f}^{*}d\hat{\alpha}_2 & -\hat{\alpha}_2\\ U_G G_{\tilde{g}} d\hat{\alpha}_2 & \left(U_{FF}F_{\tilde{f}}^2+U_F F_{\tilde{f}\tilde{f}}\right)-\hat{\alpha}_2 U_{GF} G_{\tilde{g}} F_{\tilde{f}}\end{vmatrix}}{\left|\overline{H}\right|}$$

$$d\tilde{g}=\frac{\tilde{f}^{*}d\hat{\alpha}_2\left(U_{FF}F_{\tilde{f}}^2+U_F F_{\tilde{f}\tilde{f}}-\hat{\alpha}_2 U_{GF} G_{\tilde{g}} F_{\tilde{f}}\right)}{\left|\overline{H}\right|}+\frac{\hat{\alpha}_2 U_G G_{\tilde{g}} d\hat{\alpha}_2}{\left|\overline{H}\right|}$$

$$\frac{d\tilde{g}}{d\hat{\alpha}_2}=\tilde{g}_{\alpha_2}=\frac{-\tilde{f}^{*}\left(\hat{\alpha}_2 U_{GF} G_{\tilde{g}} F_{\tilde{f}}-U_{FF}F_{\tilde{f}}^2-U_F F_{\tilde{f}\tilde{f}}\right)}{\left|\overline{H}\right|}+\frac{\hat{\alpha}_2 U_G G_{\tilde{g}}}{\left|\overline{H}\right|} \tag{2.13}$$

Slutsky effects corresponding to (2.13) are given in Annex 2A.1. The interest is to determine the sign of $\tilde{g}_{\hat{\alpha}_2}$. Since $\left|\overline{H}\right|>0$, the sign of $\tilde{g}_{\hat{\alpha}_2}$ is determined by the sign of the numerator. By (2.4), $U_{FF}<0$ and $F_{\tilde{f}\tilde{f}}<0$, the sign of U_{GF} depends on the effect of an additional unit of own labor in the home garden on marginal productivity of labor in the field. For $U_{GF}>0$, $\tilde{f}_{\hat{\alpha}_2}<0$ (see Annex 2A.3 for details). A functional form needs to be specified to determine the sign of $\tilde{g}_{\hat{\alpha}_2}$. We specify a CES utility function with a degree of homogeneity of one because constant returns to scale is a more reasonable assumption than increasing or decreasing returns to scale (for utility with respect to consumption). Condition (2.13) can be shown to be positive under certain parametric assumptions of a CES utility function

$$U=\tau\left[\pi G^{-\rho}+(1-\pi)F^{-\rho}\right]^{-1/\rho} \tag{2.14}$$

where π is the distribution parameter for garden activity; $-1<\rho<\infty$ is the substitution parameter such that elasticity of substitution $\zeta=\frac{1}{1+\rho}$ and the efficiency parameter $\tau=1$. First order conditions corresponding to (2.14) are

$$U_G=\pi U^{1+\rho}G^{-(1+\rho)} \tag{2.15}$$

$$U_F=(1-\pi)U^{1+\rho}F^{-(1+\rho)} \tag{2.16}$$

$$U_{FF}=(1+\rho)\frac{U_F}{U}\frac{(U_F F-U)}{F} \tag{2.17}$$

$$U_{GF}=(1+\rho)\pi(1-\pi)\frac{U^{1+\rho}}{U^{-\rho}}F^{-(1+\rho)}G^{-(1+\rho)}\Rightarrow U_{GF}=\frac{(1+\rho)U_F U_G}{U}>0\,. \tag{2.18}$$

Substituting (2.17) and (2.18) into the numerator of (2.13), the expression for the numerator of (2.13) becomes (see Annex 2A.2 for details)

$$U_F\left[-(1+\rho)\frac{\tilde{f}^* F_{\tilde{f}}^2}{F} - F_{\tilde{f}\tilde{f}} + F_{\tilde{f}}\right] \tag{2.19}$$

Since $F_{\tilde{f}} > 0$ and $F_{\tilde{f}\tilde{f}} < 0$ by (2.4), the sign of ρ becomes important in determining the sign of (2.19). For $\rho \approx -1$, the left hand side term in (2.19) approaches zero and hence $\tilde{g}_{\hat{\alpha}_2} > 0$ holds. For $\rho \approx \infty$, the left hand side term in (2.19) approaches $-\infty$ and hence $\tilde{g}_{\hat{\alpha}_2} < 0$. This highlights that $\tilde{g}_{\hat{\alpha}_2} > 0$ holds given greater degree of substitutability between the home garden and field products (i.e. more likely under $-1 < \rho < 0$ which implies $\zeta > 1$). The larger is the value of ζ the greater is the substitutability between the two products and the flatter is the indifference curve. For values between the limits including for $\rho = 0$ (i.e. Cobb-Douglas utility function), the magnitudes of the negative left hand side term and the positive right hand terms in (2.19) determine the sign of $\tilde{g}_{\hat{\alpha}_2}$. Assuming constant returns to scale for a Cobb-Douglas production function $F(\tilde{f})$, (2.19) will collapse into $-\rho U_F$. This implies that for a Cobb-Douglas production function, $\tilde{g}_{\hat{\alpha}_2} < 0$, $\tilde{g}_{\hat{\alpha}_2} > 0$ and $\tilde{g}_{\hat{\alpha}_2} = 0$ when $\rho > 0$, $\rho < 0$ and $\rho = 0$ respectively. In what follows, a numerical example is presented for the case where $\rho < 0$ (see also Annex 2A.4 for a numerical example for $\rho = 0$).

Numerical illustration for the standard model

We illustrate the analytical results by using a simple numerical simulation using GAMS on a CES utility function where $\tau = 1$. The specification of the model given by

$$U = \left[\sum_{m=1}^{M} \pi^m Q^{m^{-\rho}}\right]^{-1/\rho} \tag{2.20}$$

Subject to

$$\bar{L} = \sum_{m=1}^{M} \alpha_m \tilde{g}^m \text{ ; labor constraint} \tag{2.21}$$

$$\overline{A} \geq \sum_{m=1}^{M} A^m \text{ ; land constraint} \tag{2.22}$$

$$Q^m = \tilde{g}^{m^\theta} A^{m^{1-\theta}} \text{ ; production technology constraint} \tag{2.23}$$

such that Q denotes production for each activity $m = 1,...,M$ and $\theta = a,b$. $\overline{A}$ and A denote total household land holding and land area allocations respectively. The GAMS simulation model for a labor allocation problem (ignoring (2.22)) where Q^m is denoted by G and F for production in the home garden and in the field is given as:

$$U = \left[\pi G^{-\rho} + (1-\pi)F^{-\rho}\right]^{-1/\rho} \tag{2.24}$$

Subject to

$$\hat{L} = \tilde{g} + \hat{\alpha}_2 \tilde{f} \tag{2.25}$$

$$G = \tilde{g}^{a} \tag{2.26}$$

$$F = \tilde{f}^{b} \tag{2.27}$$

Numerical simulation results for $\rho = -0.2$, $\hat{L} = 10$, $\pi = 0.1$ and $a = b = 0.6$ are given in Table 2.1.

Table 2.1 Labor allocation with declining health (increasing α_2) for the standard case.

α_2	$\tilde{g}$	$\tilde{f}$	U
1	0.761	9.239	3.330
1.2	0.778	7.685	3.010
1.3	0.786	7.087	2.880
1.8	0.819	5.101	2.406

Table 2.1 shows that labor allocated to the home garden increases while that allocated to the field decreases with the declining health status causing decline in household utility. The GAMS model for a labor and land allocation problem is given by

$$U = \left[\pi G^{-\rho} + (1-\pi)F^{-\rho}\right]^{-1/\rho} \tag{2.28}$$

Subject to

$$\hat{L} = \tilde{g} + \hat{\alpha}_2 \tilde{f} \tag{2.29}$$

$$\overline{A} \geq A^G + A^F \tag{2.30}$$

$$G = A^{G^{1-a}} \tilde{g}^{a} \tag{2.31}$$

$$F = A^{F^{1-b}} \tilde{f}^{b} \tag{2.32}$$

$$A^{G} \leq \tilde{A} \tag{2.33}$$

where A^G and A^F are area allocated to the home garden and fields respectively. Condition (2.33) is included because the garden area is confined around the houseyard and it is difficult to expand its size as desired. Assuming $\rho = -0.2$, $\hat{L} = 10$, $\overline{A} = 4$, $\tilde{A} = 1$, $\pi = 0.1$ and $a = b = 0.6$, numerical simulation results are given in Table 2.2.

Table 2.2 Labor and land allocation with declining health (increasing α_2) for the standard case.

α_2	$\tilde{g}$	$\tilde{f}$	A^G	A^F	U
1	0.603	9.397	0.241	3.759	5.249
1.2	0.619	7.818	0.247	3.753	4.736
1.3	0.626	7.211	0.250	3.750	4.528
1.8	0.655	5.192	0.262	3.738	3.771

Table 2.2 shows that labor allocated to the home garden increases whereas labor allocated to the field decreases with declining health status. It also shows that area allocated to the home garden increases whereas that allocated to the field decreases with a decline in health status. Comparison of Tables 2.1 and 2.2 shows that the main results, i.e. an increase in labor allocated to the home garden and a decrease in labor allocated to the field with declining health status, are maintained in both cases. The difference with the labor and land allocation problem lies on the rate of change in labor allocation per unit change in health status.

2.2.2 External labor option: the case of sharecropping

We consider the case where the household facing declining health has the option of obtaining replacement labor through a sharecropping contract. We focus on sharecropping as a feasible labor organization for households in need of replacement labor for two reasons. First, we expect that sharecropping demands less supervision time and has higher productivity because of better incentives than hired labor (Ellis, 1993; Beckmann, 2000). Second, sharecropping also contributes to easing the cash constraint through deferring payment for labor and possibly other inputs. Depending on the contractual aggreement the returns obtained through engaging in sharecropping likely dominates over that through use of hired labor.

Opportunity - and transaction cost differentials between family and replacement labor guides the decision on hiring replacement labor (Beckmann, 2000). Sharecropped labor is employed as a substitute to family labor if the difference between the opportunity cost of family labor and the wage rate of replacement labor exceeds the difference in transaction costs. We further assume that sharecropping is applicable only for cultivating the fields which are mainly under annual crops. This is based on the observation that stronger claims over land may arise from sharecropping plots which are under perennial crops than those under annual crops. Each unit of sharecropping labor, s, involves transaction cost (Key et al. 2000) in terms of productivity adjusted household supervision time, γ. We also assume that productivity of household supervision time remains unaffected by the decline in health status. Productivity may not be significantly different for own and sharecropped plots (Tesfay, 2006) or may even be higher on sharecropped plots due to eviction threats (Kassie and Holden, 2007) and sharecropping contracts can be arranged to be efficient (Ray, 2005). Sharecropping involves product sharing captured by the land owner's share of the produce, $0 < \delta < 1$. Therefore, the household has the option of own cultivation of the field or supervising sharecropped-in labor in the field besides cultivating the home garden.

Optimization and first order condition for the case with sharecropping activity

The simplified farm household model is given by

$$\text{Max } U\left(G(\tilde{g}), F\left(\tilde{f}\right), \delta S(s)\right) \tag{2.34}$$

Subject to

$$\hat{L} = \tilde{g} + \hat{\alpha}_2 \tilde{f} + \hat{\gamma} s \tag{2.35}$$

[5]

Where S denotes output from sharecropped-out land and $\hat{\gamma} = \dfrac{\gamma}{\alpha_1}$. For simplicity, we ignore the effect of supervision time on the productivity of sharecropped-in labor. In the model, $\hat{L}, \hat{\alpha}_2$ and $\hat{\gamma}$ are the exogenous and $\tilde{g}, \tilde{f}$ and s are the endogenous variables. It is assumed that $U(G(.), F(.), S(.))$ is increasing and concave in the arguments and that also $G(.)$, $F(.)$ and $S(.)$ are increasing and concave. $U(.), G(.), F(.)$ and $S(.)$ are twice differentiable. The Lagrangian of the constrained optimization problem can be specified as

[5] Optimization is based on household utility maximization and not on the sharecropper's utility.

$$\ell = U\left(G(\tilde{g}), F\left(\tilde{f}\right), \delta S(s)\right) + \lambda\left(\hat{L} - \tilde{g} - \hat{\alpha}_2 \tilde{f} - \hat{\gamma} s\right). \tag{2.36}$$

Assuming interior solution for $\tilde{g}, \tilde{f}$ and s, the necessary condition for an optimum is

$$\ell_\lambda = \hat{L} - \tilde{g} - \hat{\alpha}_2 \tilde{f} - \hat{\gamma} s = 0 \tag{2.37}$$

$$\ell_{\tilde{f}} = U_F F_{\tilde{f}} - \hat{\alpha}_2 U_G G_{\tilde{g}} = 0 \tag{2.38}$$

$$\ell_s = \delta U_S S_s - \hat{\gamma} U_G G_{\tilde{g}} = 0 \tag{2.39}$$

where we apply

$$\delta U_S S_s = \hat{\gamma}\lambda \text{ and } \lambda = U_G G_{\tilde{g}}. \tag{2.40}$$

From (2.37), we have

$$\tilde{g} = \hat{L} - \hat{\alpha}_2 \tilde{f} - \hat{\gamma} s \tag{2.41}$$

The first part of (2.40) states that for households who engage in sharecropping, the optimal level of sharecropped-in labor in the field occurs at the point where the marginal utility of the additional output per unit additional sharecropped-in labor is equal to the shadow price of the additional unit of sharecropped-in labor. The shadow price of the additional sharecropped-in labor (the right hand side of (2.40)) is caused by tightening the labor constraint through the additional supervision time, $\hat{\gamma}\lambda$. From (2.38) and (2.39), we have

$$\frac{U_F F_{\tilde{f}}}{\hat{\alpha}_2} = \frac{\delta U_S S_s}{\hat{\gamma}}. \tag{2.42}$$

Condition (2.42) states that for households who engage in sharecropping, optimal sharecrop-in labor allocation to the field occurs until the additional utility from the additional return per unit additional effective own labor allocated to the field is equal to the additional utility from the additional return per unit additional supervision time. If $U_F = U_S$, (2.42) becomes $\frac{F_{\tilde{f}}}{\hat{\alpha}_2} = \frac{\delta S_s}{\hat{\gamma}}$ which says that for households who engage in sharecropping, optimal sharecrop-in labor allocation to the field occurs at the point where the additional returns per unit additional effective own labor allocated to the field is equal to the additional returns per unit additional supervision time. Based on (2.38) and (2.39) we have

$$U_G G_{\tilde{g}} = \frac{U_F F_{\tilde{f}}}{\hat{\alpha}_2} = \frac{\delta U_S S_s}{\hat{\gamma}}. \tag{2.43}$$

From condition (2.43) household labor is allocated between the garden, fields, and supervising sharecropping labor until additional utility from the additional return per unit of additional effective labor is equalized across the activities. Given the utility function, (2.37)-(2.39) can be solved to get the demand functions given by $\tilde{g}^*\left(\hat{L},\hat{\alpha}_2,\hat{\gamma}\right)$, $\tilde{f}^*\left(\hat{L},\hat{\alpha}_2,\hat{\gamma}\right)$ and $s^*\left(\hat{L},\hat{\alpha}_2,\hat{\gamma}\right)$. Second order condition must hold for this optimal point which involves the bordered Hessian matrix[6] corresponding to equations (2.37)-(2.40).

Comparative statics for the case with sharecropping activity

We consider the first order conditions as equilibrium equations for comparative statics around one possible solution, $\tilde{g}^*, \tilde{f}^*, s^*$. Consider two cases for comparative statics for $\tilde{g}$ and s.

Case 1: analyze change in $\tilde{g}$ when α_2 varies. Taking the total differentials, d, of (2.37)-(2.39),

$$d\hat{L} - d\tilde{g} - \hat{\alpha}_2 d\tilde{f} - \tilde{f}d\hat{\alpha}_2 - \hat{\gamma}ds - sd\hat{\gamma} = 0 \qquad (2.44)$$

---

[6]Given $V = V\left(\tilde{g}, \tilde{f}, s\right) = U\left(G(\tilde{g}), F\left(\tilde{f}\right), \delta S(s)\right)$, the bordered Hessian corresponding to (2.37)-(2.40) is

$$\overline{H} = \begin{bmatrix} \ell_{\lambda\lambda} & \ell_{\lambda\tilde{g}} & \ell_{\lambda\tilde{f}} & \ell_{\lambda s} \\ \ell_{\tilde{g}\lambda} & \ell_{\tilde{g}\tilde{g}} & \ell_{\tilde{g}\tilde{f}} & \ell_{\tilde{g}s} \\ \ell_{\tilde{f}\lambda} & \ell_{\tilde{f}\tilde{g}} & \ell_{\tilde{f}\tilde{f}} & \ell_{\tilde{f}s} \\ \ell_{s\lambda} & \ell_{s\tilde{g}} & \ell_{s\tilde{f}} & \ell_{\tilde{f}s} \end{bmatrix} \Rightarrow \left|\overline{H}\right| = \left|H_3\right| = \begin{vmatrix} 0 & -1 & -\hat{\alpha}_2 & -\hat{\gamma} \\ -1 & V_{\tilde{g}\tilde{g}} & V_{\tilde{g}\tilde{f}} & V_{\tilde{g}s} \\ -\hat{\alpha}_2 & V_{\tilde{f}\tilde{g}} & V_{\tilde{f}\tilde{f}} & V_{\tilde{f}s} \\ -\hat{\gamma} & V_{s\tilde{g}} & V_{s\tilde{f}} & V_{ss} \end{vmatrix}$$

where $\left|H_3\right|$ is the leading principal minor of $\overline{H}$ when zero rows and zero columns are deleted.

$$\begin{aligned}\left|\overline{H}\right| = \left|H_3\right| &= \left(-V_{\tilde{f}\tilde{f}}V_{ss} + V_{s\tilde{f}}^2\right) + \left(-\alpha_2^2 V_{\tilde{g}\tilde{g}}V_{ss} + \alpha_2^2 V_{s\tilde{g}}^2\right) + \left(-\hat{\gamma}^2 V_{\tilde{f}\tilde{f}}V_{\tilde{g}\tilde{g}} + \hat{\gamma}^2 V_{\tilde{f}\tilde{g}}^2\right) \\ &+ \left(2\alpha_2 V_{ss}V_{\tilde{g}\tilde{f}}\right) - 2\hat{\gamma}V_{\tilde{g}\tilde{f}}V_{\tilde{f}s} - 2\alpha_2 V_{s\tilde{f}}V_{\tilde{g}s} + 2\hat{\gamma}V_{\tilde{f}\tilde{f}}V_{\tilde{g}s} + 2\alpha_2\hat{\gamma}V_{\tilde{g}\tilde{g}}V_{\tilde{f}s} - 2\alpha_2\hat{\gamma}V_{\tilde{g}s}V_{\tilde{f}\tilde{g}}\end{aligned} \quad \text{;where } V_{ss} = U_{SS}F_s^2 + U_S F_{ss};$$

$V_{\tilde{g}s} = U_{GS}S_s G_{\tilde{g}}$; $V_{s\tilde{f}} = U_{SF}F_{\tilde{f}}S_s$. For a local maximum, $\left|H_3\right| < 0$ should hold at $\tilde{g}^*, \tilde{f}^*, s^*$ and λ^*. The terms in parentheses are all negative by the negative definite criteria for a local maximum, i.e. $U_{FF}U_{SS} > U_{FS}^2$ in order for $\left|H_2\right| > 0$ to hold. In the case of positive marginal productivity effect of an additional sharecropping labor on $\tilde{g}^*$ and $\tilde{f}^*$ i.e. $V_{\tilde{f}s} > 0$ and $V_{\tilde{g}s} > 0$, and that of an additional labor in the home garden on marginal productivity of $\tilde{f}^*$, i.e. $V_{\tilde{f}\tilde{g}} > 0$, then $\left|H_3\right| < 0$ holds. Under the opposite case, the magnitudes of the negative terms in parentheses and those of the positive terms outside the parentheses matters for the overall effect and sign of $\left|H_3\right|$.

$$
\begin{aligned}
&U_{FG}G_{\tilde g}F_{\tilde f}d\tilde g+\left(U_{FF}F_{\tilde f}^2+U_F F_{\tilde f\tilde f}\right)d\tilde f+\delta U_{FS}F_{\tilde f}S_s ds-\hat\alpha_2\left(U_{GG}G_{\tilde g}^2+U_G G_{\tilde g\tilde g}\right)d\tilde g\\
&-\hat\alpha_2 U_{GF}G_{\tilde g}F_{\tilde f}d\tilde f-\hat\alpha_2\delta U_{GS}G_{\tilde g}S_s ds-U_G G_{\tilde g}d\hat\alpha_2=0
\end{aligned}
\tag{2.45}
$$

$$
\begin{aligned}
&\delta U_{SG}G_{\tilde g}S_s d\tilde g+\delta U_{SF}S_s F_{\tilde f}d\tilde f+\delta\left(U_{SS}S_s^2+U_S S_{ss}\right)ds-\hat\gamma\left(U_{GG}G_{\tilde g}^2+U_G G_{\tilde g\tilde g}\right)d\tilde g\\
&-\hat\gamma U_{GF}G_{\tilde g}F_{\tilde f}d\tilde f-\hat\gamma\delta U_{GS}G_{\tilde g}S_s ds-U_G G_{\tilde g}d\hat\gamma+U_S S_s d\delta=0
\end{aligned}
\tag{2.46}
$$

Isolating the differentials of the exogenous variables on the right hand side,

$$
-d\tilde g-\hat\alpha_2 d\tilde f-\hat\gamma ds=-d\hat L+\tilde f d\hat\alpha_2+sd\hat\gamma
\tag{2.47}
$$

$$
\begin{aligned}
&U_{FG}G_{\tilde g}F_{\tilde f}d\tilde g+\left(U_{FF}F_{\tilde f}^2+U_F F_{\tilde f\tilde f}\right)d\tilde f+\delta U_{FS}F_{\tilde f}S_s ds-\hat\alpha_2\left(U_{GG}G_{\tilde g}^2+U_G G_{\tilde g\tilde g}\right)d\tilde g\\
&-\hat\alpha_2 U_{GF}G_{\tilde g}F_{\tilde f}d\tilde f-\hat\alpha_2\delta U_{GS}G_{\tilde g}S_s ds=U_G G_{\tilde g}d\hat\alpha_2
\end{aligned}
\tag{2.48}
$$

$$
\begin{aligned}
&\delta U_{SG}G_{\tilde g}S_s d\tilde g+\delta U_{SF}S_s F_{\tilde f}d\tilde f+\delta\left(U_{SS}S_s^2+U_S S_{ss}\right)ds-\hat\gamma\left(U_{GG}G_{\tilde g}^2+U_G G_{\tilde g\tilde g}\right)d\tilde g\\
&-\hat\gamma U_{GF}G_{\tilde g}F_{\tilde f}d\tilde f-\hat\gamma\delta U_{GS}G_{\tilde g}S_s ds=U_G G_{\tilde g}d\hat\gamma-U_S S_s d\delta
\end{aligned}
\tag{2.49}
$$

Applying Cramer's rule on (2.47)-(2.49) to derive the effect of a change in $\hat\alpha_2$ on $\tilde g$ where $\hat\gamma$ and $\hat L$ remain constant (see Annex 2A.5 for details),

$$
\frac{d\tilde g}{d\hat\alpha_2}=\frac{\begin{aligned}&\left(\delta U_{SS}S_s^2+\delta U_S S_{ss}-\delta^2 U_{GS}S_s^2\frac{U_S}{U_G}\right)\left[\tilde f^*\left(U_{FF}F_{\tilde f}^2+U_F F_{\tilde f\tilde f}-\frac{\hat\alpha_2\delta U_S}{\hat\gamma U_G}U_{GF}F_{\tilde f}S_s\right)+U_F F_{\tilde f}\right]\\&-\left(\delta U_{SF}S_s F_{\tilde f}-\delta U_{GF}S_s F_{\tilde f}\frac{U_S}{U_G}\right)\left[\delta U_S S_s+\tilde f^*\left(\delta U_{FS}F_{\tilde f}S_s-\frac{\hat\alpha_2\delta^2 U_S}{\hat\gamma U_G}U_{GS}S_s^2\right)\right]\end{aligned}}{\left|\overline H\right|}
\tag{2.50}
$$

Similarly, the expression for the effect of a change in $\hat\alpha_2$ on s where $\hat\gamma$ and $\hat L$ remain constant

$$
\frac{ds}{d\hat\alpha_2}=\frac{\begin{aligned}&-\left(\hat\gamma U_{SG}G_{\tilde g}^2\frac{U_G}{U_S}-\hat\gamma U_{GG}G_{\tilde g}^2-\hat\gamma U_G G_{\tilde g\tilde g}\right)\left[\hat\alpha_2 U_G G_{\tilde g}+\tilde f^*\left(U_{FF}F_{\tilde f}^2-U_F F_{\tilde f\tilde f}-\hat\alpha_2 U_{GF}G_{\tilde g}F_{\tilde f}\right)\right]\\&+\left(\hat\gamma U_{SF}G_{\tilde g}F_{\tilde f}\frac{U_G}{U_S}-\hat\gamma U_{GF}G_{\tilde g}F_{\tilde f}\right)\left[U_G G_{\tilde g}+\tilde f^*\left(U_{FG}G_{\tilde g}F_{\tilde f}-\hat\alpha_2 U_{GG}G_{\tilde g}^2-\hat\alpha_2 U_G G_{\tilde g\tilde g}\right)\right]\end{aligned}}{\left|\overline H\right|}
\tag{2.51}
$$

Since $\left|\overline H\right|<0$, the signs of (2.50) and (2.51) and hence the signs of $\tilde g_{\hat\alpha_2}$ and $s_{\hat\alpha_2}$ are determined by the magnitudes of the negative and positive terms in the numerators of (2.50) and (2.51) respectively. Equations (2.50) and (2.51) show that the magnitudes of the cross partial utility effects U_{GF}, U_{SF} and U_{SG} are important in determining the signs of $\tilde g_{\hat\alpha_2}$ and $s_{\hat\alpha_2}$.

Numerical illustration for the case with sharecropping

The analytical results are illustrated by using a simple numerical simulation using GAMS on a CES utility function. Numerical analysis is conducted for the model with labor and land allocation arguments. Assuming $\tau = 1$ and constant returns to scale, the GAMS model is given by

$$U = \left[\pi G^{-\rho} + (1-\pi)(F+S)^{-\rho}\right]^{-1/\rho} \tag{2.52}$$

Subject to

$$\hat{L} = \tilde{g} + \hat{\alpha}_2 \tilde{f} + \hat{\gamma} s^2 \tag{2.53}$$

$$\overline{A} \geq A^G + A^F + A^S \tag{2.54}$$

$$G = A^{G^{1-a}} \tilde{g}^{a} \tag{2.55}$$

$$F = A^{F^{1-b}} \tilde{f}^{b} \tag{2.56}$$

$$S = \delta A^{S^{1-e}} s^{e} \tag{2.57}$$

$$A^G \leq \tilde{A} \tag{2.58}$$

S denotes output from sharecropped-out land, A^S is area sharecropped-out and γ denotes supervision time per unit of sharecropped-in labor i.e. $\hat{\gamma} = \dfrac{\gamma}{\alpha_1}$. Simulation results for $\hat{L} = 10$, $\overline{A} = 4$, $\tilde{A} = 1$, $\delta = 0.5$, $\pi = 0.1$, $\gamma = 0.4$, $\rho = -0.2$ and $a = b = e = 0.6$ are presented in Table 2.3.

Table 2.3 Labor and land allocation with declining health under sharecropping option.

α_2	$\tilde{g}$	$\tilde{f}$	s	γs	A^G	A^F	A^S	U
1	0.607	9.331	0.394	0.062	0.241	3.710	0.049	5.268
1.2	0.624	7.739	0.472	0.089	0.247	3.682	0.071	4.762
1.3	0.632	7.125	0.512	0.105	0.250	3.667	0.083	4.556
1.8	0.668	5.073	0.709	0.201	0.262	3.581	0.158	3.817

Table 2.3 shows that for the given parameter values, labor and land allocated to the home garden increase with declining health status as reflected by increasing α_2. Comparison of Tables 2.2 and 2.3 shows that sharecropping enables higher level of labor allocation to the home garden than the standard case both in total and at the margin with the decline in health status. Similarly, area sharecropped-out increases with the decline in health status. Extending the above numerical simulation by introducing off-farm opportunities, the following changes are made to (2.52)-(2.58):

$$U = \left[\pi G^{-\rho} + \pi^F (F+S)^{-\rho} + \pi^O Y^{O^{-\rho}}\right]^{-1/\rho} \tag{2.59}$$

$$\hat{L} = \tilde{g} + \hat{\alpha}_2 \tilde{f} + \hat{\gamma} s^2 + \hat{\alpha}_2 \tilde{L}^O \tag{2.60}$$

And the off-farm income constraint:

$$Y^O = w\tilde{L}^O \tag{2.61}$$

where L^O and w denote off-farm labor and wage rate respectively. Assuming $\pi = \pi^O = 0.1$, $\pi^F = 0.8$ and $w = 2$ the simulation results are given in Table 2.4 and show that with the availability of off-farm opportunities, labor and land area allocated to the home garden increase with declining health status. Depending on the magnitude of the distribution parameter, π^F, higher U may be expected with the case of off-farm options than the case without.

Table 2.4 Labor and land allocation with declining health under off-farm labor options.

α_2	$\tilde{g}$	$\tilde{f}$	s	γs	$\tilde{L}^O$	A^G	A^F	A^S	U
1	0.596	7.893	0.394	0.062	1.449	0.277	3.666	0.058	4.474
1.2	0.615	6.556	0.472	0.089	1.191	0.284	3.634	0.082	4.019
1.3	0.623	6.040	0.512	0.105	1.093	0.287	3.616	0.097	3.835
1.8	0.661	4.303	0.709	0.201	0.773	0.300	3.517	0.182	3.179

2.3 THE DIVERSITY APPROACH USING THE DIXIT-STIGLITZ MODEL

2.3.1 Introducing the Dixit-Stiglitz model of product diversity

We introduce the Dixit-Stiglitz model of product diversity for modeling crop diversity. Dixit and Stiglitz (1977) model diversity with the assumption that consumers value diversity which is inherent in the convexity of the indifference curves. They solve for the optimal product diversity under constrained optimization, unconstrained optimization and market equilibrium situations. Since we are dealing with farm households who are both producers and consumers of crop diversity, we apply the case of unconstrained optimization where the social planner can make lump sum transfers between the activities if needed. In this case, the farmer acting as a social planner in deciding crop diversity and other activities on the farm is able to make lump sum transfers between the activities as long as it increases household utility.

In the Dixit-Stiglitz specification, the representative consumer is assumed to derive utility from the consumption of two goods, namely product diversity of related products, $D(q_1, q_2, ..., q_n)$, and other goods, q_0 where q denotes quantities. Separable utility function with convex indifference surfaces is assumed. Utility is, thus, defined as $u = U(q_0, D(q_1, q_2, ..., q_n))$. They define product diversity that enters the utility function, $D(.)$, in two forms of aggregation. The first takes a CES form given as

$$D(q_l) = \left[\sum_{l=1}^{n} q_l^{\rho_1}\right]^{\frac{1}{\rho_1}} \tag{2.62}$$

where they allow $u(.)$ to be arbitrary and the substitution parameter for the related diverse products is given by $0 < \rho_1 < 1$. In the second case $D(.)$ takes an additive form

$$D(\underline{q}) = \sum_{l=1}^{n} D(q_l) \tag{2.63}$$

where $D(\underline{q})$ denotes the utility from the group of products, $D(.)$ is increasing and concave and $u(.)$ is taken to be Cobb-Douglas. Dixit and Stiglitz (1977) derive the demand curve, the demand for the numeraire and the optimal level of diversity by maximizing utility derived from diversity and consumption of other goods subject to a budget constraint. Symmetric condition such that $q_l = q$ for all $l = 1,...,n$ is assumed in deriving the expression for the optimal diversity which reduces (2.62) and (2.63) respectively into

$$D(q_l) = D(q) = qn^{\frac{1}{\rho_1}} \text{ and } D(\underline{q}) = nD(q) \tag{2.64}$$

Applying symmetry on the diversity function given in (2.63), the condition for the optimal number of crops, n, obtained by maximizing $U = [nD(q)]^{\pi}[1 - n(k + cq)]^{1-\pi}$ is given by

$$n = \frac{\pi}{k + cq} \tag{2.65}$$

where π is the preference for diversity, k is the fixed cost and c is the variable cost of crop diversity in the home garden (see Annex 2A.6 for details). Condition (2.65) shows the role of preference for diversity (π), the fixed cost of diversity (k) and the variable cost of diversity (c) in determining the optimal number of species. The fixed cost limits n from rising to infinity. We extend the Dixit-Stiglitz analysis by using a CES utility function given by

$$U = \left[\pi\left(nD(q)\right)^{-\rho} + (1-\pi)\left(1-n(k+cq)\right)^{-\rho}\right]^{\frac{-1}{\rho}} \tag{2.66}$$

where π is the preference for crop diversity in the home garden and ρ is the substitution parameter such that $\zeta = \dfrac{1}{1+\rho}$ and $-1 < \rho < \infty$. The optimal number of species, n, derived from (2.66) is (see Annex 2A.6 for details)

$$n = \left[D(q)^{\rho\zeta}\left((k+cq)\left(\frac{1}{\pi}-1\right)\right)^{\zeta} + (k+cq)\right]^{-1} \tag{2.67}$$

Condition (2.67) shows that, ceteris paribus, an increase in π causes an increase in n. It is also evident from (2.67) that crop diversity, $D(q)$, negatively affects the optimal n. An increase in $D(q)$, at the optimum causes a decrease in n implying a trade-off between increasing quantities per species and increasing uniqueness of species. Furthermore, the elasticity of substitution, ζ, appears to be important in determining the optimal n depending on the magnitudes of $D(q)$, and the cost component, $(k+cq)\left(\dfrac{1}{\pi}-1\right)$. If $\rho = 0$ as in a Cobb-Douglas utility function, (2.67) collapses into an optimal n given by

$$n = \left[(k+cq)\left(\frac{1}{\pi}-1\right) + (k+cq)\right]^{-1}$$

$\Rightarrow n = \dfrac{\pi}{k+cq}$, which is the same expression as (2.65).

We introduce the Dixit-Stiglitz model of product diversity into our optimization problem to analyze the effect of declining health on the degree of crop diversity.

2.3.2 The standard situation: no external labor use

The farm household is assumed to derive utility from the consumption of two products, namely diversity produced in the home garden, $D(.)$, and production in the field, $F(.)$. Quantity produced in the home garden, q, is diverse ranging for activities $l = 1,...,n$. $F(.)$ captures income from activities other than the home garden which corresponds to q_0 in the Dixit-Stiglitz specification. Depending on the degree of imperfection in the product market, the household has the option of obtaining product diversity from the market. Thus, the income obtained from the field can be taken to represent purchased diversity. The degree of rigidity in the product market can be reflected in the value of the substitution parameter, ρ. The household chooses the number of species, n, in the home garden and labor allocation in the field. In this case we employ the CES aggregation for $D(.)$ given in (2.62), where symmetry and non-separable utility is assumed, while we let the utility function to be arbitrary in deriving the analytical solution. Later on we will consider a specific functional form for conducting the numerical simulation.

Optimization and first order condition for the standard case in Dixit-Stiglitz model

Applying (2.56), the optimization problem can be specified in a Dixit-Stiglitz form as

$$\operatorname{Max} U = U\left(D\left(q\left(\tilde{g}^{l}\right)\right), F\left(\tilde{f}\right)\right) = U\left(q\left(\tilde{g}^{l}\right)n^{\frac{1}{\rho_1}}, F\left(\tilde{f}\right)\right) \tag{2.68}$$

Subject to

$$\hat{L} = n\tilde{g}^{l} + n\hat{k} + \hat{\alpha}_2 \tilde{f} \tag{2.69}$$

where $\hat{k} = \dfrac{k}{\alpha_1}$ and k is the fixed labor cost of growing each species implying operational labor which starts to pay only after a while. $\tilde{g}^{l}$ denotes the effective labor allocated to species l in the home garden which is assumed to be equal across each species by the assumption of symmetry. It is assumed that $U(G(.), F(.))$ is increasing and concave in the arguments and that also $G(.)$ and $F(.)$ are increasing and concave. $U(.), G(.)$ and $F(.)$ are twice differentiable. The Lagrangian of the constrained optimization problem can be specified as

$$\ell = U\left(q\left(\tilde{g}^{l}\right)n^{\frac{1}{\rho_1}}, F\left(\tilde{f}\right)\right) + \lambda\left(\hat{L} - n\tilde{g}^{l} - n\hat{k} - \hat{\alpha}_2 \tilde{f}\right) \tag{2.70}$$

Assuming interior solution, the necessary condition for an optimum is given by

$$\ell_{\lambda} = \hat{L} - n\tilde{g}^{l} - n\hat{k} - \hat{\alpha}_2 \tilde{f} = 0 \tag{2.71}$$

$$\ell_{\tilde{f}} = U_F F_{\tilde{f}} - \hat{\alpha}_2 \frac{1}{\rho_1} U_D q n^{\frac{1}{\rho_1}-1} = 0 \tag{2.72}$$

Condition (2.72) states that the additional utility derived from the return of a unit additional labor allocated to the field and the marginal utility of an additional species is equalized at the optimum.

Comparative statics for the standard case in Dixit-Stiglitz model

The first order conditions given by (2.71) and (2.72) give a system of simultaneous equations where $\hat{L}$, $\hat{k}$, $\hat{\alpha}_2$ are the exogenous variables whereas n and $\tilde{f}$ are the endogenous variables. We consider the first order conditions as equilibrium equations for comparative statics around one possible solution given by n^* and $\tilde{f}^*$. Consider the case for comparative statics for n when $\hat{\alpha}_2$ varies. Taking the total differentials, d, of (2.71)-(2.72),

$$d\hat{L} - nd\tilde{g}^l - \tilde{g}^l dn - nd\hat{k} - \hat{k}dn - \hat{\alpha}_2 d\tilde{f} - \tilde{f}d\hat{\alpha}_2 = 0 \tag{2.73}$$

$$\begin{aligned} &U_{FD}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-2}F_{\tilde{f}}dn + \left(U_{FF}F_{\tilde{f}}^2 + U_F F_{\tilde{f}\tilde{f}}\right)d\tilde{f} - \hat{\alpha}_2\left(U_{DD}\left(\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}\right)^2 + \frac{1-\rho_1}{\rho_1}U_D qn^{\frac{1}{\rho_1}-2}\right)dn \\ &- \hat{\alpha}_2\frac{1}{\rho_1}U_{DF}qn^{\frac{1}{\rho_1}-1}F_{\tilde{f}}d\tilde{f} - \frac{1}{\rho_1}U_D qn^{\frac{1}{\rho_1}-1}d\hat{\alpha}_2 = 0 \end{aligned} \tag{2.74}$$

Isolating the differentials of the exogenous variables on the right hand side,

$$-\left(\tilde{g}^l + \hat{k}\right)dn - \hat{\alpha}_2 d\tilde{f} = -d\hat{L} + nd\hat{k} + nd\tilde{g}^l + \tilde{f}d\hat{\alpha}_2 \tag{2.75}$$

$$\begin{aligned} &U_{FD}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-2}F_{\tilde{f}}dn + \left(U_{FF}F_{\tilde{f}}^2 + U_F F_{\tilde{f}\tilde{f}}\right)d\tilde{f} - \hat{\alpha}_2\left(U_{DD}\left(\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}\right)^2 + \frac{1-\rho_1}{\rho_1}U_D qn^{\frac{1}{\rho_1}-2}\right)dn \\ &- \hat{\alpha}_2\frac{1}{\rho_1}U_{DF}qn^{\frac{1}{\rho_1}-1}F_{\tilde{f}}d\tilde{f} = \frac{1}{\rho_1}U_D qn^{\frac{1}{\rho_1}-1}d\hat{\alpha}_2 \end{aligned} \tag{2.76}$$

This is given in matrix notation as

$$\begin{bmatrix} -\left(\tilde{g}^l + \hat{k}\right) & -\hat{\alpha}_2 \\ U_{FD}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-2}F_{\tilde{f}} - \frac{\hat{\alpha}_2}{\rho_1}\left(U_{DD}\left(\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}\right)^2 + (1-\rho_1)U_D qn^{\frac{1}{\rho_1}-2}\right) & U_{FF}F_{\tilde{f}}^2 + U_F F_{\tilde{f}\tilde{f}} - \frac{\hat{\alpha}_2}{\rho_1}U_{DF}qn^{\frac{1}{\rho_1}-1}F_{\tilde{f}} \end{bmatrix}\begin{bmatrix} dn \\ d\tilde{f} \end{bmatrix}$$
$$= \begin{bmatrix} -d\hat{L} + nd\hat{k} + nd\tilde{g}^l + \tilde{f}^* d\hat{\alpha}_2 \\ \frac{1}{\rho_1}U_D qn^{*\frac{1}{\rho_1}-1}d\hat{\alpha}_2 \end{bmatrix}$$

For the case where $\hat{\alpha}_2$ changes while $\tilde{g}^l$, $\hat{k}$ and $\hat{L}$ remain constant:

$$\begin{bmatrix} -\left(\tilde{g}^i + \hat{k}\right) & -\hat{\alpha}_2 \\ U_{FD}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-2}F_{\tilde{f}} - \frac{\hat{\alpha}_2}{\rho_1}\left(U_{DD}\left(\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}\right)^2 + (1-\rho_1)U_D qn^{\frac{1}{\rho_1}-2}\right) & U_{FF}F_{\tilde{f}}^2 + U_F F_{\tilde{f}\tilde{f}} - \frac{\hat{\alpha}_2}{\rho_1}U_{DF}qn^{\frac{1}{\rho_1}-1}F_{\tilde{f}} \end{bmatrix}\begin{bmatrix} dn \\ d\tilde{f} \end{bmatrix} = \begin{bmatrix} \tilde{f}^* d\hat{\alpha}_2 \\ \frac{1}{\rho_1}U_D qn^{*\frac{1}{\rho_1}-1}d\hat{\alpha}_2 \end{bmatrix}$$

Applying Cramer's rule

$$dn = \frac{\begin{vmatrix} \tilde{f}^{*} d\hat{\alpha}_2 & -\hat{\alpha}_2 \\ \frac{1}{\rho_1} U_D q n^{*\frac{1}{\rho_1}-1} d\hat{\alpha}_2 & U_{FF} F_{\tilde{f}}^2 + U_F F_{\tilde{f}\tilde{f}} - \frac{\hat{\alpha}_2}{\rho_1} U_{DF} q n^{\frac{1}{\rho_1}-1} F_{\tilde{f}} \end{vmatrix}}{\left|\overline{H}\right|}$$

$$dn = \frac{\tilde{f}^{*} d\hat{\alpha}_2 \left(U_{FF} F_{\tilde{f}}^2 + U_F F_{\tilde{f}\tilde{f}} - \frac{\hat{\alpha}_2}{\rho_1} U_{DF} q n^{*\frac{1}{\rho_1}-1} F_{\tilde{f}} \right)}{\left|\overline{H}\right|} + \frac{\frac{\hat{\alpha}_2}{\rho_1} U_D q n^{*\frac{1}{\rho_1}-1} d\hat{\alpha}_2}{\left|\overline{H}\right|}$$

$$\frac{dn}{d\hat{\alpha}_2} = \frac{-\tilde{f}^{*} \left(\frac{\hat{\alpha}_2}{\rho_1} U_{DF} q n^{*\frac{1}{\rho_1}-1} F_{\tilde{f}} - U_{FF} F_{\tilde{f}}^2 - U_F F_{\tilde{f}\tilde{f}} \right)}{\left|\overline{H}\right|} + \frac{\frac{\hat{\alpha}_2}{\rho_1} U_D q n^{*\frac{1}{\rho_1}-1}}{\left|\overline{H}\right|} \tag{2.77}$$

Since $\left|\overline{H}\right| = \left|H_2\right| > 0$, the sign of (2.77) depends on the magnitudes of the positive and negative terms in the numerator of (2.77). As shown in Section 2.2.1, for a CES utility function a decline in health status causes an increase in the number of crop species in the home garden and hence a positive sign for (2.77), if the substitutability between species diversity in the home garden and output from the field is sufficiently large.

Numerical illustration for the standard case in Dixit-Stiglitz model

The GAMS model corresponding to equations (2.68) and (2.69) for a CES utility function is given by

$$U = \left[\pi D^{-\rho} + (1-\pi) F^{-\rho}\right]^{-1/\rho} \tag{2.78}$$

Subject to

$$\hat{L} = n\tilde{g}^{l} + n\hat{k} + \hat{\alpha}_2 \tilde{f} \tag{2.79}$$

$$q_l = q = \tilde{g}^{l^a} \tag{2.80}$$

$$D = q n^{\frac{1}{\rho_1}} \tag{2.81}$$

$$F = \tilde{f}^{b} \tag{2.82}$$

where $\tau = 1$ and constant returns to scale is assumed. Assuming, $\pi = 0.1$, $\hat{L} = 10$, $k = 0.1$, $\rho = -0.2$, $\rho_1 = 0.8$ and $a = b = 0.6$, the numerical results are given in Table 2.5. Table 2.5 shows that under the given parameter values, labor allocated to the home garden, $n\tilde{g}^l$, and number of crop species, n, and crop diversity, D, in the home garden increases with declining health status (increasing α_2). On the other hand, labor allocated to the field and household utility decreases with declining health status.

Table 2.5 Declining health status and implications for the no. of crop species, crop diversity and labor allocation: the standard case in the Dixit-Stiglitz model.

α_2	$\tilde{g}^l$	$\tilde{f}$	n	D	$n\tilde{g}^l$	nk	U
1	0.092	8.055	10.114	4.318	0.934	1.011	3.573
1.2	0.092	6.675	10.346	4.442	0.955	1.035	3.239
1.3	0.092	6.147	10.449	4.497	0.964	1.045	3.103
1.8	0.092	4.394	10.875	4.728	1.004	1.087	2.608

We now consider numerical simulation whereby land area allocation, A, is also included as an argument. The GAMS model corresponding to (2.68) and (2.69) where $\tau = 1$ would thus be

$$U = \left[\pi D^{-\rho} + (1-\pi)F^{-\rho}\right]^{-1/\rho} \tag{2.83}$$

Subject to

$$\hat{L} = n\tilde{g}^l + n\hat{k} + \hat{\alpha}_2 \tilde{f} \tag{2.84}$$

$$\overline{A} \geq nA^l + A^F \tag{2.85}$$

$$q_l = q = A^{l^{1-a}} \tilde{g}^{l^a} \tag{2.86}$$

$$D = qn^{\frac{1}{\rho_1}} \tag{2.87}$$

$$F = A^{F^{1-b}} \tilde{f}^{\,b} \tag{2.88}$$

$$nA^l \leq \tilde{A} \tag{2.89}$$

where A^l is the area allocated to each crop species which is identical for each species under the assumption of symmetry. Numerical results for $\pi = 0.1$, $\hat{L} = 10$, $\overline{A} = 4$, $\tilde{A} = 1$, $\hat{k} = 0.1$, $\rho = -0.2$, $\rho_1 = 0.8$ and $a = b = 0.6$ are given in Table 2.6. Table 2.6 shows that under the given parameter values, labor allocated to home garden, number of species and crop diversity in the home garden increase with the decline in health status. On the other hand, labor and land area allocated to the field decline causing a reduction in household utility.

Table 2.6 Declining health status and implications for the no. of crop species, crop diversity, labor allocation and area allocation: the standard case in the Dixit-Stiglitz model ($\rho = -0.2$).

α_2	$\tilde{g}^l$	$\tilde{f}$	A^l	A^F	n	D	$n\tilde{g}^l$	nA^l	nk	U
1	0.240	9.120	0.099	3.745	2.587	0.552	0.621	0.255	0.259	5.243
1.2	0.240	7.581	0.099	3.738	2.656	0.570	0.638	0.262	0.266	4.733
1.3	0.240	6.990	0.099	3.735	2.687	0.579	0.645	0.265	0.269	4.526
1.8	0.240	5.024	0.099	3.722	2.816	0.614	0.676	0.278	0.282	3.773

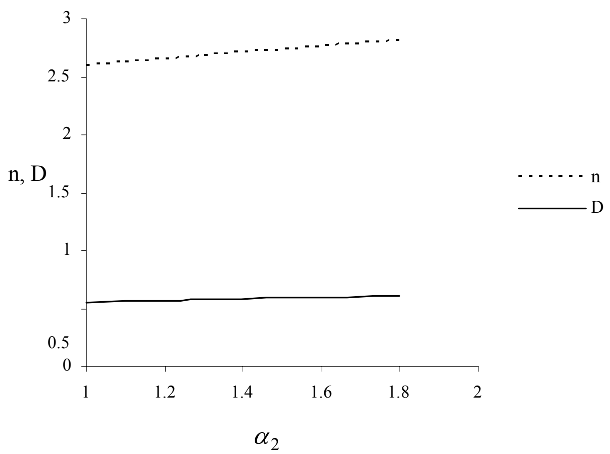


Figure 2.2 No. of crop species, n, and crop diversity, D, in the home garden as a function of declining health status (increasing α_2).

Figure 2.2 shows that the number of crop species, n, and total crop diversity, D, increase with declining health status. It also shows that the rate of increase in the number of crop species is higher than the rate of increase in the degree of crop diversity per unit decline in heath status. This is because of the effect of quantity of production of each species captured in the degree of crop diversity which requires labor and land.

Comparison of Tables 2.6, 2.7 and 2.8 shows that decline in labor productivity due to the decline in health status causes an increase in the number of species, n, and total crop diversity, D, the magnitude of which depends on the degree of substitutability between crop diversity in the home garden and income, represented by the field activity.

Table 2.7 Declining health status and implications for the no. of crop species, crop diversity, labor allocation and area allocation: the standard case in the Dixit-Stiglitz model ($\rho = -0.5$).

α_2	$\tilde{g}^l$	$\tilde{f}$	A^l	A^F	n	D	$n\tilde{g}^l$	nA^l	nk	U
1	0.240	9.862	0.096	3.961	0.405	0.054	0.097	0.039	0.040	5.656
1.2	0.240	8.201	0.096	3.955	0.467	0.064	0.112	0.045	0.047	5.076
1.3	0.240	7.562	0.096	3.952	0.497	0.070	0.119	0.048	0.050	4.840
1.8	0.240	5.435	0.097	3.938	0.641	0.096	0.154	0.062	0.064	3.992

Table 2.8 Declining health status and implications for the no. of crop species, crop diversity, labor allocation and area allocation: the standard case in the Dixit-Stiglitz model ($\rho = -0.1$).

α_2	$\tilde{g}^l$	$\tilde{f}$	A^l	A^F	n	D	$n\tilde{g}^l$	nA^l	nk	U
1	0.240	8.869	0.099	3.670	3.326	0.757	0.798	0.330	0.333	5.144
1.2	0.240	7.381	0.099	3.666	3.363	0.768	0.807	0.334	0.336	4.653
1.3	0.240	6.809	0.099	3.664	3.379	0.773	0.811	0.336	0.338	4.452
1.8	0.240	4.905	0.099	3.657	3.446	0.792	0.827	0.343	0.345	3.724

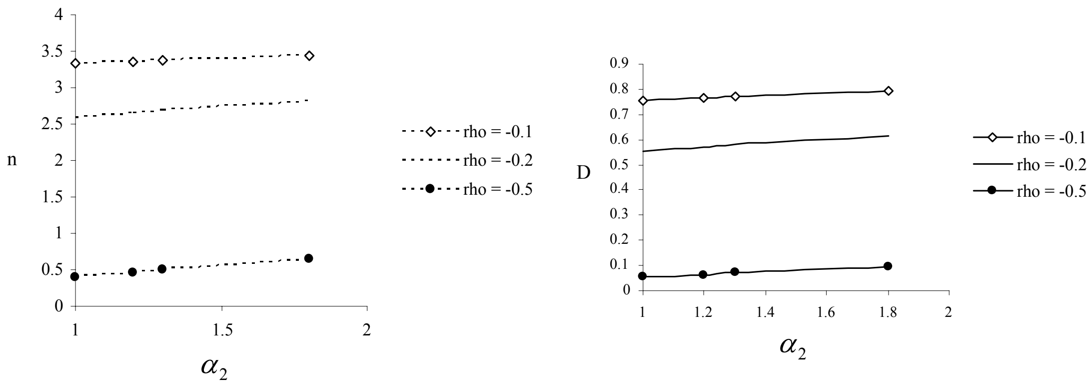


Figure 2.3 No. of crop species, n, and crop diversity, D, in the home garden as a function of declining health status for varying values of the substitution parameter, ρ.

Figure 2.3 shows that the degree of substitutability between home grown crop diversity and purchased one (here represented by income from field activities) matters for the magnitude of crop diversity, D, for a given health status. The closer is the value of the substitution parameter to -1, implying greater degree of substitutability of the home grown and purchased diversity; the lower is the corresponding degree of crop diversity produced in the home garden. That is, when the two goods are sufficiently substitutable, the household is better-off at lower degree of home produced crop diversity for a given level of health status. The intuitive argument is that if diversity can be easily obtained from the market, it does not have to be produced in large quantities at home. Imperfection in the product market may influence the degree of substitutability between home grown and purchased crop diversity.

2.3.3 External labor option: the case of sharecropping

We assume that sharecropping opportunity exists for cultivating the fields implying that a third category of goods is added in the household's utility set. With declining health status which causes declining productivity of own-cultivation, the household may decide to engage in sharecropping (a part of) their fields.

Optimization and first order condition for sharecropping activity in Dixit-Stiglitz model

The simplified farm household model is given by

Max $U\left(D\left(\tilde{g}^{l}\right), F\left(\tilde{f}\right), \delta S(s)\right)$ (2.90)

Subject to

$$\hat{L} = n\tilde{g}^{l} + n\hat{k} + \hat{\alpha}_2 \tilde{f} + \hat{\gamma}s \tag{2.91}$$

where $\hat{\gamma} = \frac{\gamma}{\alpha_1}$. It is assumed that $U(G(.), F(.), S(.))$, is increasing and concave in the arguments and that also $G(.)$, $F(.)$ and $S(.)$ are increasing and concave. $U(.), G(.), F(.)$ and $S(.)$ are twice differentiable. The Lagrangian of the constrained optimization problem can be specified as

$$\ell = U\left(D\left(\tilde{g}^{l}\right), F\left(\tilde{f}\right), \delta S(s)\right) + \lambda\left(\hat{L} - n\tilde{g}^{l} - n\hat{k} - \hat{\alpha}_2 \tilde{f} - \hat{\gamma}s\right). \tag{2.92}$$

Assuming interior solution for $n, \tilde{f}$ and s, the necessary condition for an optimum follows:

$$\ell_{\lambda} = \hat{L} - n\tilde{g}^{l} - n\hat{k} - \hat{\alpha}_2 \tilde{f} - \hat{\gamma}s = 0 \tag{2.93}$$

$$\ell_{\tilde{f}} = U_F F_{\tilde{f}} - \hat{\alpha}_2 U_D D_n = 0 \Rightarrow \ell_{\tilde{f}} = U_F F_{\tilde{f}} - \hat{\alpha}_2 \frac{1}{\rho_1} U_D q n^{\frac{1}{\rho_1}-1} = 0 \tag{2.94}$$

$$\ell_{s} = \delta U_S S_s - \hat{\gamma} \frac{1}{\rho_1} U_D q n^{\frac{1}{\rho_1}-1} = 0 \tag{2.95}$$

Where we apply

$$\delta U_S S_s = \hat{\gamma}\lambda \text{ and } \lambda = \frac{1}{\rho_1} U_D q n^{\frac{1}{\rho_1}-1}. \tag{2.96}$$

Condition (2.94) and (2.95) suggest that the marginal utility of an additional crop species, the additional utility derived from the return of a unit of additional supervision time and the additional utility derived from the return of a unit additional own cultivation labor in the field is equalized at the optimum.

Comparative statics for sharecropping activity in Dixit-Stiglitz model

The first order conditions given by (2.93)-(2.95) give a system of simultaneous equations where $\hat{L}$, $\hat{k}$, $\hat{\alpha}_2$ are the exogenous variables whereas n, $\tilde{f}$ and s are the endogenous variables. We consider the first order conditions as equilibrium equations for comparative statics around one possible solution given by

$n^*, \tilde{f}^*, s^*$. Consider the case of comparative statics for n when $\hat{\alpha}_2$ varies. Taking the total differentials, d , of (2.93)-(2.95),

$$d\hat{L} - nd\tilde{g}^l - \left(\tilde{g}^l + \hat{k}\right)dn - nd\hat{k} - \hat{\alpha}_2 d\tilde{f} - \tilde{f}d\hat{\alpha}_2 - \hat{\gamma}ds - sd\hat{\gamma} = 0 \tag{2.97}$$

$$\begin{aligned} &U_{FD}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}F_{\tilde{f}}dn + \left(U_{FF}F_{\tilde{f}}^2 + U_F F_{\tilde{f}\tilde{f}}\right)d\tilde{f} + \delta U_{FS}F_{\tilde{f}}S_s ds \\ &- \hat{\alpha}_2\left(U_{DD}\left(\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}\right)^2 + \frac{1-\rho_1}{\rho_1}U_D qn^{\frac{1}{\rho_1}-2}\right)dn - \hat{\alpha}_2\frac{1}{\rho_1}U_{DF}qn^{\frac{1}{\rho_1}-1}F_{\tilde{f}}d\tilde{f} \\ &- \hat{\alpha}_2\delta U_{DS}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}S_s ds - \frac{1}{\rho_1}U_D qn^{\frac{1}{\rho_1}-1}d\hat{\alpha}_2 = 0 \end{aligned} \tag{2.98}$$

$$\begin{aligned} &\delta U_{SD}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}S_s dn + \delta U_{SF}S_s F_{\tilde{f}}d\tilde{f} + \delta\left(U_{SS}S_s^2 + U_S S_{ss}\right)ds \\ &- \hat{\gamma}\left(U_{DD}\left(\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}\right)^2 + \frac{1-\rho_1}{\rho_1}U_D qn^{\frac{1}{\rho_1}-2}\right)dn - \hat{\gamma}U_{DF}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}F_{\tilde{f}}d\tilde{f} \\ &- \hat{\gamma}\delta U_{DS}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}S_s ds - U_D\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}d\hat{\gamma} + U_S S_s d\delta = 0 \end{aligned} \tag{2.99}$$

Isolating the differentials of the exogenous variables on the right hand side,

$$-\left(\tilde{g}^l + \hat{k}\right)dn - \hat{\alpha}_2 d\tilde{f} - \hat{\gamma}ds = -d\hat{L} + nd\hat{k} + nd\tilde{g}^l + \tilde{f}d\hat{\alpha}_2 + sd\hat{\gamma} \tag{2.100}$$

$$\begin{aligned} &U_{FD}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}F_{\tilde{f}}dn + \left(U_{FF}F_{\tilde{f}}^2 + U_F F_{\tilde{f}\tilde{f}}\right)d\tilde{f} + \delta U_{FS}F_{\tilde{f}}S_s ds \\ &- \hat{\alpha}_2\left(U_{DD}\left(\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}\right)^2 + \frac{1-\rho_1}{\rho_1}U_D qn^{\frac{1}{\rho_1}-2}\right)dn - \hat{\alpha}_2\frac{1}{\rho_1}U_{DF}qn^{\frac{1}{\rho_1}-1}F_{\tilde{f}}d\tilde{f} \\ &- \hat{\alpha}_2\delta U_{DS}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}S_s ds = \frac{1}{\rho_1}U_D qn^{\frac{1}{\rho_1}-1}d\hat{\alpha}_2 \end{aligned} \tag{2.101}$$

$$\begin{aligned} &\delta U_{SD}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}S_s dn + \delta U_{SF}S_s F_{\tilde{f}}d\tilde{f} + \delta\left(U_{SS}S_s^2 + U_S S_{ss}\right)ds \\ &- \hat{\gamma}\left(U_{DD}\left(\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}\right)^2 + \frac{1-\rho_1}{\rho_1}U_D qn^{\frac{1}{\rho_1}-2}\right)dn - \hat{\gamma}U_{DF}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}F_{\tilde{f}}d\tilde{f} \\ &- \hat{\gamma}\delta U_{DS}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}S_s ds = U_D\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}d\hat{\gamma} - U_S S_s d\delta \end{aligned} \tag{2.102}$$

Applying Cramer's rule on (2.100)-(2.102) to derive the effect of change in $\hat{\alpha}_2$ on n while $\hat{\gamma}$, δ, $\hat{k}$, $\tilde{g}^l$ and $\hat{L}$ remain constant (see Annex 2A.7 for details)

$$\frac{dn}{d\hat{\alpha}_2} = \frac{\begin{aligned}&\left(\delta U_{SS} S_s^2 + \delta U_S S_{ss} - \hat{\gamma}\delta U_{DS} S_s \frac{1}{\rho_1} qn^{\frac{1}{\rho_1}-1}\right)\left[\tilde{f}^*\left(U_{FF} F_{\tilde{f}}^2 + U_F F_{\tilde{f}\tilde{f}} - \hat{\alpha}_2 U_{DF} F_{\tilde{f}} \frac{1}{\rho_1} qn^{\frac{1}{\rho_1}-1}\right) + \hat{\alpha}_2 U_D \frac{1}{\rho_1} qn^{\frac{1}{\rho_1}-1}\right] \\ &-\left(\delta U_{SF} S_s F_{\tilde{f}} - \hat{\gamma} U_{DF} F_{\tilde{f}} \frac{1}{\rho_1} qn^{\frac{1}{\rho_1}-1}\right)\left[\hat{\gamma} U_D \frac{1}{\rho_1} qn^{\frac{1}{\rho_1}-1} + \tilde{f}^*\left(\delta U_{FS} F_{\tilde{f}} S_s - \hat{\alpha}_2 \delta U_{DS} S_s \frac{1}{\rho_1} qn^{\frac{1}{\rho_1}-1}\right)\right]\end{aligned}}{\left|\overline{H}\right|}$$

(2.103)

And the effect of change in $\hat{\alpha}_2$ on s:

$$\frac{ds}{d\hat{\alpha}_2} = \frac{\begin{aligned}&-\left(\hat{\gamma} U_{SD}\left(\frac{1}{\rho_1} qn^{\frac{1}{\rho_1}-1}\right)^2 \frac{U_D}{U_S} - \hat{\gamma} U_{DD}\left(\frac{1}{\rho_1} qn^{\frac{1}{\rho_1}-1}\right)^2 - \hat{\gamma} U_D \frac{1-\rho_1}{\rho_1} qn^{\frac{1}{\rho_1}-2}\right)\left[\hat{\alpha}_2 U_D \frac{1}{\rho_1} qn^{\frac{1}{\rho_1}-1} + \tilde{f}^*\left(U_{FF} F_{\tilde{f}}^2 + U_F F_{\tilde{f}\tilde{f}} - \hat{\alpha}_2 U_{DF} \frac{1}{\rho_1} qn^{\frac{1}{\rho_1}-1} F_{\tilde{f}}\right)\right] \\ &+\left(\hat{\gamma} U_{SF} \frac{1}{\rho_1} qn^{\frac{1}{\rho_1}-1} F_{\tilde{f}} \frac{U_D}{U_S} - \hat{\gamma} U_{DF} \frac{1}{\rho_1} qn^{\frac{1}{\rho_1}-1} F_{\tilde{f}}\right)\left[\left(\tilde{g}^l + \hat{k}\right) U_D \frac{1}{\rho_1} qn^{\frac{1}{\rho_1}-1} + \tilde{f}^*\left(U_{FD} \frac{1}{\rho_1} qn^{\frac{1}{\rho_1}-1} F_{\tilde{f}} - \hat{\alpha}_2 U_{DD}\left(\frac{1}{\rho_1} qn^{\frac{1}{\rho_1}-1}\right)^2 - \hat{\alpha}_2 U_D \frac{1-\rho_1}{\rho_1} qn^{\frac{1}{\rho_1}-2}\right)\right]\end{aligned}}{\left|\overline{H}\right|}$$

(2.104)

Since $\left|\overline{H}\right| < 0$, the sign of (2.103) and (2.104) and hence the signs of $n_{\hat{\alpha}_2}$ and $s_{\hat{\alpha}_2}$ are determined by the magnitudes of the negative and positive terms in their respective numerators.

Numerical illustration for sharecropping activity in Dixit-Stiglitz model

Assuming $\tau = 1$, the GAMS model corresponding to (2.90)-(2.91) in a CES specification is

$$U = \left[\pi D^{-\rho} + (1-\pi)(F+S)^{-\rho}\right]^{-1/\rho} \tag{2.105}$$

Subject to

$$\hat{L} = n\tilde{g}^l + n\hat{k} + \hat{\alpha}_2 \tilde{f} + \hat{\gamma} s^2 \tag{2.106}$$

$$\overline{A} \geq nA^i + A^F + A^S \tag{2.107}$$

$$q = A^{l^{1-a}} \tilde{g}^{l^a} \tag{2.108}$$

$$D = qn^{\frac{1}{\rho_1}} \tag{2.109}$$

$$F = A^{F^{1-b}} \tilde{f}^b \tag{2.110}$$

$$S = \delta {A^{S}}^{1-e} s^{e} \tag{2.111}$$

$$nA^{l} \le \widetilde{A} \tag{2.112}$$

where S denotes sharecropping activity and γ denotes supervision time per unit of sharecropped-in labor. Assuming $\pi = 0.1$, $\overline{L} = 10$, $\overline{A} = 4$, $\widetilde{A} = 1$, $\delta = 0.5$, $\gamma = 0.4$, $k = 0.1$, $\rho = -0.2$, $\rho_1 = 0.8$ and $a = b = e = 0.6$, the numerical results are given in Table 2.9.

Table 2.9 Declining health status and implications for the no. of crop species, crop diversity, labor allocation and area allocation: the case of sharecropping option in the Dixit-Stiglitz model.

α_2	$\widetilde{g}^{l}$	$\widetilde{f}$	s	γs	A^{l}	A^{F}	A^{S}	n	D	$n\widetilde{g}^{l}$	nA^{l}	nk	U
1	0.240	9.053	0.394	0.062	0.098	3.694	0.051	2.604	0.555	0.625	0.255	0.260	5.263
1.2	0.240	7.499	0.472	0.089	0.098	3.665	0.073	2.681	0.575	0.644	0.262	0.268	4.759
1.3	0.240	6.901	0.512	0.105	0.098	3.649	0.085	2.717	0.584	0.652	0.265	0.272	4.555
1.8	0.240	4.901	0.709	0.201	0.097	3.559	0.162	2.876	0.625	0.690	0.279	0.288	3.819

Table 2.9 shows that under the given parameter values, the number of crop species and crop diversity in the home garden increases with the decline in health status (increase in α_2). Comparing Tables 2.6 and 2.9, engagement in sharecropping enables a larger total amount and marginal increase in labor allocation and number of species in the home garden than the case without sharecropping discussed in Section 2.3.1. Whether this difference in magnitudes is dominant and significant is an empirical question.

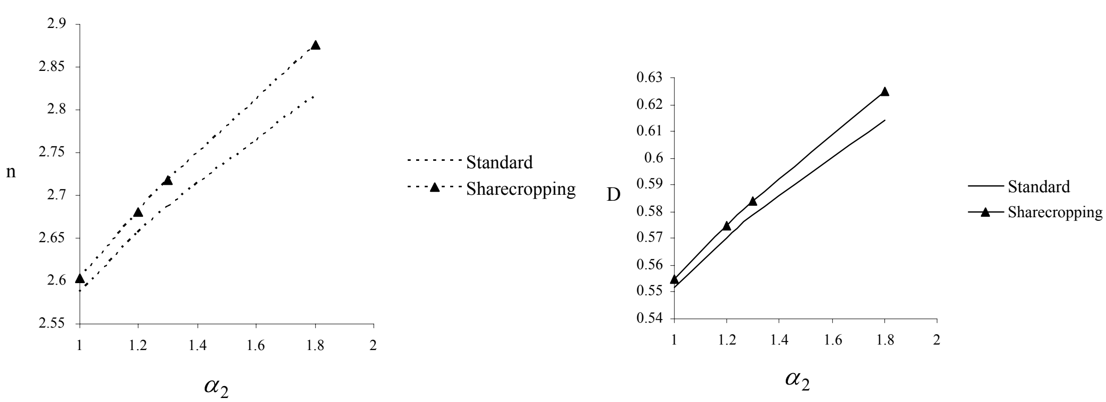


Figure 2.4 Comparison of no. of crop species, n, and crop diversity, D, in the home garden as a function of declining health status (increasing α_2) with and without sharecropping option.

Figure 2.4 shows that availability of sharecropping option enables a higher degree of crop diversity at each level of health status than the case without sharecropping. It also indicates a higher rate of increase in the degree of crop diversity per unit decline in health status than the case without sharecropping. This is because sharecropping enables more labor transfer to increase crop diversity in the home garden from which the households generate utility.

The GAMS model given by (2.105)-(2.112) is extended to include off-farm opportunity as

$$U = \left[\pi D^{-\rho} + \pi^{F}\left(F+S\right)^{-\rho} + \pi^{O} Y^{O^{-\rho}}\right]^{-1/\rho} \tag{2.113}$$

$$\hat{L} = n\tilde{g}^{l} + n\hat{k} + \hat{\alpha}_2 \tilde{f} + \gamma s^2 + \hat{\alpha}_2 \tilde{L}^{O} \tag{2.114}$$

Plus an additional off-farm income constraint

$$Y^{O} = w\tilde{L}^{O} \tag{2.115}$$

where O and w denote off-farm activity and wage rate respectively. Assuming $\pi = \pi^{o} = 0.1$ and $w = 2$, numerical simulation results are given in Table 2.10. Table 2.10 shows that the pattern of increasing labor allocation, number of species and crop diversity in the home garden with the decline in health status is maintained with the availability of off-farm options as well.

Table 2.10 Declining health status and implications for the no. of crop species, crop diversity, labor allocation and area allocation: the case of sharecropping and off-farm work options in the Dixit-Stiglitz model.

α_2	$\tilde{g}^{l}$	$\tilde{f}$	s	γs	$\tilde{L}^{O}$	A^{l}	A^{F}	A^{S}	n	D	$n\tilde{g}^{l}$	nA^{l}	nk	U
1	0.240	7.664	0.394	0.062	1.404	0.114	3.649	0.059	2.558	0.577	0.614	0.292	0.256	4.469
1.2	0.240	6.358	0.472	0.089	1.152	0.114	3.615	0.085	2.641	0.599	0.634	0.300	0.264	4.016
1.3	0.240	5.854	0.512	0.105	1.057	0.113	3.597	0.099	2.679	0.610	0.643	0.304	0.268	3.833
1.8	0.240	4.159	0.709	0.201	0.746	0.112	3.493	0.187	2.849	0.655	0.684	0.319	0.285	3.181

2.4 ACCOUNTING FOR POTENTIAL POSITIVE HEALTH EFFECT OF CROP DIVERSITY

We consider the case when crop diversity contributes to improving nutrition and thereby avoiding part of the loss in labor productivity due to declining health status (e.g. Gari, 2003 and 2004; Johns, 2003). In this case, the GAMS model given in (2.105)-(2.112) is employed along with the assumptions only by modifying equation (2.106) to capture the feedback effect of agrobiodiversity to increasing labor productivity as follows:

$$\hat{L} = n\tilde{g}^{l} + n\hat{k} + \left(\hat{\alpha}_2 - d\left(\hat{\alpha}_2 - 1\right)\left(D - 0.555\right)\right)\tilde{f} + \hat{\gamma} s^2 \ . \tag{2.116}$$

where d denotes the increase in labor productivity per unit of crop diversity produced. In the model, $d > 0$ for $D > 0.555$ where the initial level $D = 0.555$ under no health effect of crop diversity is given in

Table (2.9). Simulation was conducted for values of $d = 0.02$ (Table 2.11) and $d = 0.1$ (Table 2.12) which are compared with the results when $d = 0$ (Table 2.9).

Table 2.11 Declining health status and implications for the no. of crop species and crop diversity given sharecropping option: the case of health improvement effect of crop diversity, $d = 0.02$.

α_2	$\tilde{g}^l$	$\tilde{f}$	s	γ_S	A^l	A^F	A^S	n	D	$n\tilde{g}^l$	nA^l	nk	U
1	0.240	9.053	0.394	0.062	0.098	3.694	0.051	2.604	0.555	0.625	0.255	0.260	5.263
1.2	0.240	7.485	0.472	0.089	0.098	3.660	0.073	2.734	0.589	0.656	0.267	0.273	4.760
1.3	0.240	6.883	0.512	0.105	0.098	3.642	0.085	2.792	0.605	0.670	0.273	0.279	4.555
1.8	0.240	4.877	0.708	0.201	0.097	3.544	0.162	3.031	0.668	0.727	0.294	0.303	3.821

Table 2.12 Declining health status and implications for the no. of crop species and crop diversity given sharecropping option: the case of health improvement effect of crop diversity, $d = 0.1$.

α_2	$\tilde{g}^l$	$\tilde{f}$	s	γ_S	A^l	A^F	A^S	n	D	$n\tilde{g}^l$	nA^l	nk	U
1	0.240	9.053	0.394	0.062	0.098	3.694	0.051	2.604	0.555	0.625	0.255	0.260	5.263
1.2	0.240	7.430	0.472	0.089	0.098	3.636	0.073	2.970	0.654	0.713	0.291	0.297	4.762
1.3	0.240	6.814	0.510	0.104	0.098	3.607	0.085	3.138	0.701	0.753	0.308	0.314	4.560
1.8	0.240	4.792	0.698	0.195	0.098	3.462	0.159	3.872	0.911	0.929	0.379	0.387	3.837

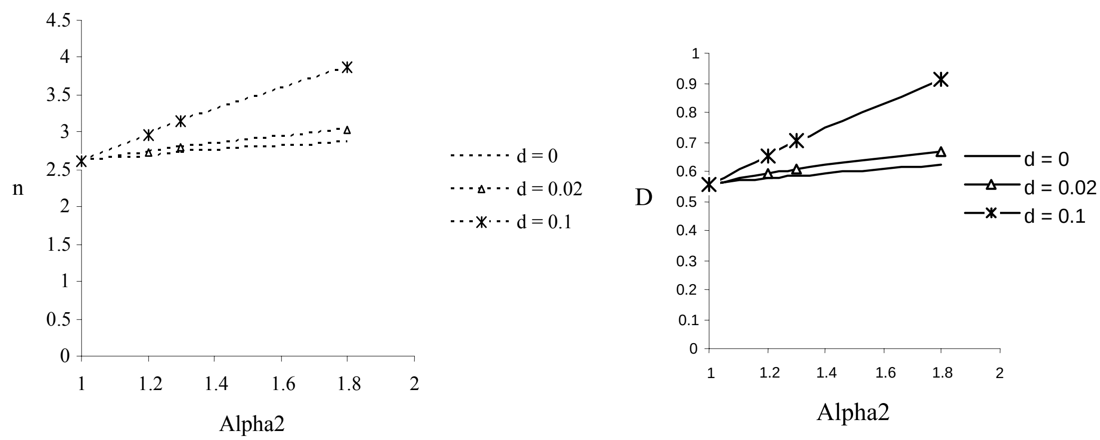


Figure 2.5 No. of crop species, n, and crop diversity, D, in the home garden as a function of declining health status for varying health improvement effect of crop diversity, d.

Tables 2.11 and 2.12 show that labor and area allocated to the home garden as well as number of crop species and crop diversity are higher for higher feedback effect of crop diversity for improving productivity. It is also shown in Figure 2.5 that the rate of increase in the number of species and crop diversity per unit decline in health status depends on the magnitude of contribution of crop diversity for improving labor productivity. A higher productivity effect of crop diversity is associated with higher rate of increase in the number of species and crop diversity per unit decline in health status.

2.5 CHANGE IN HEALTH STATUS AND PREFERENCE FOR DIVERSIFICATION

A constant preference towards crop diversity, π, after the decline in health status has been assumed throughout the analysis in Sections 2.3.1 and 2.3.2 and 2.4. The analytical solution in (2.57) and (2.59) shows that change in preferences towards crop diversity affects the optimal number of crop species that farm households choose. Therefore, factors that affect preferences towards crop diversity affect the optimal crop diversity in the same direction. Two possible outcomes are expected depending on the change in the net benefits of increasing crop diversity (including health benefits) with the decline in farm household health status. If farm households see higher net benefits of increasing crop diversity than alternative strategies with the decline in health status, preferences towards increasing crop diversity increases. This would lead to an increase in the number of species and/or crop diversity produced after HIV/AIDS. For instance, increased awareness of the health benefits of crop diversity may contribute towards this. Alternatively, farm household preference towards crop diversity may not change or may even decrease with decline in health status. This may be because with declining health status increasing crop diversity on the farm may turn out to be less paying than alternative strategies. In this case, crop diversity in the home garden may remain the same or even decrease with decline in farm household health status.

2.6 DISCUSSION AND CONCLUSIONS

Farm households under HIV/AIDS stress face the challenges of adapting to the reduction in labor productivity through adjustment in labor organization and agrobiodiversity. With alternative labor organizations, labor allocations and agrobiodiversity are influenced by productivity differentials among the alternatives. A likely reduction in agrobiodiversity has been suggested as HIV/AIDS causes labor reallocation to cash earning activities (Haddad and Gillespie, 2001; Loevinsohn and Gillespie, 2003) and reduction in the number of crops (Haddad and Gillespie, 2001; Barnett and Whiteside, 2002; Gillespie and Kdiyala, 2005).

Our main finding, however, is that given certain functional assumptions, the theory of the farm household does predict an increase in labor allocation and agrobiodiversity in the home garden of HIV/AIDS affected households, keeping other variables constant. It further predicts an increase in the degree of labor allocation and agrobiodiversity in the home garden with the degree of decline in health status. Owing to the higher income advantages of sharecropping for households facing declining health status, HIV/AIDS affected households are likely to increase sharecropping-out fields with declining health status. Sharecropping-out fields enables withdrawal of more family labor for cultivating gardens and off-farm work. The Dixit-Stiglitz model shows that given that households value diverse products, for any reason, labor allocation, number of species and crop diversity in the home garden increase with declining health status.

Our analysis does not make any *a priori* assumption on possible increase in farmers' knowledge of the health benefits of agrobiodiversity in a HIV/AIDS context. If this is the case, it would only reinforce our results on the total agrobiodiversity response to HIV/AIDS whereas the marginal agrobiodiversity response may be declining with declining health status depending on the magnitude of the positive health effect of agrobiodiversity. This could be subject to empirical testing. Based on the theoretical reflection, we draw the following hypotheses for empirical testing:

1. Garden agrobiodiversity is higher among HIV/AIDS affected farm households.
2. Sharecropping-out intensity increases among HIV/AIDS affected households.
3. Increase in awareness of the other benefits of agrobiodiversity in the HIV/AIDS context increases agrobiodiversity.

ANNEX 2A

2A.1 Slutsky effects for case 2.2.1

Consider equation (2.12)

$$-d\tilde{g}-\hat{\alpha}_2 d\tilde{f}=-d\hat{L}+\tilde{f}d\hat{\alpha}_2$$

$$U_{FG}G_{\tilde{g}}F_{\tilde{f}}d\tilde{g}+\left(U_{FF}F_{\tilde{f}}^2+U_F F_{\tilde{f}\tilde{f}}\right)d\tilde{f}-\hat{\alpha}_2\left(U_{GG}G_{\tilde{g}}^2+U_G G_{\tilde{g}\tilde{g}}\right)d\tilde{g}$$
$$-\hat{\alpha}_2 U_{GF}G_{\tilde{g}}F_{\tilde{f}}d\tilde{f}=U_G G_{\tilde{g}}d\hat{\alpha}_2$$

This is given in matrix notation as

$$\begin{bmatrix} -1 & -\hat{\alpha}_2 \\ U_{FG}G_{\tilde{g}}F_{\tilde{f}}-\hat{\alpha}_2\left(U_{GG}G_{\tilde{g}}^2+U_G G_{\tilde{g}\tilde{g}}\right) & U_{FF}F_{\tilde{f}}^2+U_F F_{\tilde{f}\tilde{f}}-\hat{\alpha}_2 U_{GF}G_{\tilde{g}}F_{\tilde{f}} \end{bmatrix}\begin{bmatrix} d\tilde{g} \\ d\tilde{f} \end{bmatrix}$$
$$=\begin{bmatrix} -d\hat{L}+\tilde{f}d\hat{\alpha}_2 \\ U_G G_{\tilde{g}}d\hat{\alpha}_2 \end{bmatrix}$$

i. The income effect

Let $\hat{L}$ change while $\hat{\alpha}_2$ remaining constant, i.e. $d\hat{\alpha}_2=0$. Applying Cramer's rule to derive the effect of change in $\hat{L}$ on $\tilde{g}$,

$$\begin{bmatrix} -1 & -\hat{\alpha}_2 \\ U_{FG}G_{\tilde{g}}F_{\tilde{f}}-\hat{\alpha}_2\left(U_{GG}G_{\tilde{g}}^2+U_G G_{\tilde{g}\tilde{g}}\right) & U_{FF}F_{\tilde{f}}^2+U_F F_{\tilde{f}\tilde{f}}-\hat{\alpha}_2 U_{GF}G_{\tilde{g}}F_{\tilde{f}} \end{bmatrix}\begin{bmatrix} d\tilde{g} \\ d\tilde{f} \end{bmatrix}=\begin{bmatrix} -d\hat{L} \\ 0 \end{bmatrix}$$

$$d\tilde{g}=\frac{\begin{vmatrix} -d\hat{L} & -\hat{\alpha}_2 \\ 0 & U_{FF}F_{\tilde{f}}^2+U_F F_{\tilde{f}\tilde{f}}-\hat{\alpha}_2 U_{GF}G_{\tilde{g}}F_{\tilde{f}} \end{vmatrix}}{\left|\overline{H}\right|}\Rightarrow d\tilde{g}=\frac{d\hat{L}\left(U_{FF}F_{\tilde{f}}^2+U_F F_{\tilde{f}\tilde{f}}-\hat{\alpha}_2 U_{GF}G_{\tilde{g}}F_{\tilde{f}}\right)}{\left|\overline{H}\right|}$$

$$\frac{d\tilde{g}}{d\hat{L}}=\left(\frac{\partial\tilde{g}}{\partial\overline{L}}\right)^{\overline{\alpha}_2}=\frac{U_{FF}F_{\tilde{f}}^2+U_F F_{\tilde{f}\tilde{f}}-\hat{\alpha}_2 U_{GF}G_{\tilde{g}}F_{\tilde{f}}}{\left|\overline{H}\right|} \tag{2.117}$$

The labor endowment effect (similar to the income effect of Slutsky) given by (2.117) is the first component in (2.13).

ii. Substitution effect: any change in $\overline{L}$ is compensated by change in α_1 and α_2 and hence the household stays in the same utility level. This means,

$$dU=U_G G_{\tilde{g}}d\tilde{g}+U_F F_{\tilde{f}}d\tilde{f}=0$$

$$dU=\frac{U_G G_{\tilde{g}}}{U_F F_{\tilde{f}}}d\tilde{g}+d\tilde{f}=0.$$

From (2.7), we have $\frac{U_G G_{\tilde{g}}}{U_F F_{\tilde{f}}} = \frac{1}{\hat{\alpha}_2} \Rightarrow \frac{1}{\hat{\alpha}_2} d\tilde{g} + d\tilde{f} = 0$

From (2.13), we have

$-d\tilde{g} - \hat{\alpha}_2 d\tilde{f} = -d\overline{L} + \tilde{f} d\alpha_2$

If $U(.)$ is to remain constant, $-d\overline{L} + \tilde{f} d\alpha_2 = 0$ must hold

If only $\hat{\alpha}_2$ is changing, we need $d\hat{L} = 0$, hence,

$$d\tilde{g} = \frac{\begin{vmatrix} 0 & -\hat{\alpha}_2 \\ U_G G_{\tilde{g}} d\hat{\alpha}_2 & U_{FF} F_{\tilde{f}}^2 + U_F F_{\tilde{f}\tilde{f}} - \hat{\alpha}_2 U_{GF} G_{\tilde{g}} F_{\tilde{f}} \end{vmatrix}}{\left|\overline{H}\right|} = \frac{\hat{\alpha}_2 U_G G_{\tilde{g}} d\hat{\alpha}_2}{\left|\overline{H}\right|}$$

$$\frac{d\tilde{g}}{d\hat{\alpha}_2} = \left(\frac{\partial \tilde{g}}{\partial \hat{\alpha}_2}\right)^{\overline{U}} = \frac{\hat{\alpha}_2 U_G G_{\tilde{g}}}{\left|\overline{H}\right|} \tag{2.118}$$

The productivity effect (similar to Slutsky substitution effect) given by (2.118) is the last term in (2.13). Equation (2.13) can be written in terms of slutsky effects as

$$\tilde{g}_{\alpha_2} = \frac{-\tilde{f}^*\left(\hat{\alpha}_2 U_{GF} F_{\tilde{f}} G_{\tilde{g}} - U_{FF} F_{\tilde{f}}^2 - U_F F_{\tilde{f}\tilde{f}}\right)}{\left|\overline{H}\right|} + \frac{\hat{\alpha}_2 U_G G_{\tilde{g}}}{\left|\overline{H}\right|} = -\tilde{f}^*\left(\tilde{g}_{\overline{L}}\right)^{\overline{\alpha}_1, \overline{\alpha}_2} + \left(\tilde{g}_{\alpha_2}\right)^{\overline{U}}$$

For simplicity we analyze the optimization problem in terms of a standardized textbook specification of an objective function, $V(.)$, for maximizing. This is given as

$$V = V\left(\tilde{g}, \tilde{f}\right) = U\left(G(\tilde{g}), F\left(\tilde{f}\right)\right) \text{ s.t. } \hat{L} = \tilde{g} + \hat{\alpha}_2 \tilde{f} \tag{2.119}$$

Where $V(.)$ is not a utility function. First order conditions are given by

$$\ell_{\lambda} = \hat{L} - \tilde{g} - \hat{\alpha}_2 \tilde{f} = 0 \tag{2.120}$$

$$\ell_{\tilde{f}} = V_{\tilde{f}} - \hat{\alpha}_2 V_{\tilde{g}} = 0 \tag{2.121}$$

Note that $V_{\tilde{g}} = U_G G_{\tilde{g}}$ and $V_{\tilde{f}} = U_F F_{\tilde{f}}$. Consider the case for comparative statics for $\tilde{g}$ when $\hat{\alpha}_2$ varies. Taking the total differentials, d, of (2.120)-(2.121),

$$d\hat{L} - d\tilde{g} - \hat{\alpha}_2 d\tilde{f} - \tilde{f} d\hat{\alpha}_2 = 0 \tag{2.122}$$

$$\hat{\alpha}_2 V_{\tilde{g}\tilde{g}} d\tilde{g} + \hat{\alpha}_2 V_{\tilde{g}\tilde{f}} d\tilde{f} + V_{\tilde{g}} d\hat{\alpha}_2 - V_{\tilde{f}\tilde{g}} d\tilde{g} - V_{\tilde{f}\tilde{f}} d\tilde{f} = 0 \tag{2.123}$$

Applying Cramer's rule on (2.122)-(2.123), the equation corresponding to (2.13) is

$$\frac{d\tilde{g}}{d\hat{\alpha}_2} = \frac{-\tilde{f}^*\left(\hat{\alpha}_2 V_{\tilde{g}\tilde{f}} - V_{\tilde{f}\tilde{f}}\right)}{\left|\overline{H}\right|} + \frac{\hat{\alpha}_2 V_{\tilde{g}}}{\left|\overline{H}\right|} \tag{2.124}$$

Where the income effect is $\frac{-\tilde{f}^*\left(\hat{\alpha}_2 V_{\tilde{g}\tilde{f}} - V_{\tilde{g}\tilde{f}}\right)}{\left|\overline{H}\right|}$ and the substitution effect is $\frac{\hat{\alpha}_2 V_{\tilde{g}}}{\left|\overline{H}\right|}$. Applying the following on (2.124): $V_{\tilde{g}} = U_G G_{\tilde{g}}$; $V_{\tilde{f}} = U_F F_{\tilde{f}}$; $V_{\tilde{g}\tilde{g}} = U_{GG} G_{\tilde{g}}^2 + U_G G_{\tilde{g}\tilde{g}}$; $V_{\tilde{f}\tilde{f}} = U_{FF} F_{\tilde{f}}^2 + U_F F_{\tilde{f}\tilde{f}}$; $V_{\tilde{g}\tilde{f}} = U_{GF} F_{\tilde{f}} G_{\tilde{g}} + U_G G_{\tilde{g}\tilde{f}}$ and given separable technology where $G_{\tilde{g}\tilde{f}} = 0$, we have

$$\frac{d\tilde{g}}{d\hat{\alpha}_2} = \frac{-\tilde{f}^*\left(\hat{\alpha}_2 U_{GF} F_{\tilde{f}} G_{\tilde{g}} - U_{FF} F_{\tilde{f}}^2 - U_F F_{\tilde{f}\tilde{f}}\right)}{\left|\overline{H}\right|} + \frac{\hat{\alpha}_2 U_G G_{\tilde{g}}}{\left|\overline{H}\right|}$$ which is also given in (2.13).

2A.2 Change in labor allocation to the garden in a CES utility function for case 2.2.1

For the CES function given by

$$U = \left[\pi G^{-\rho} + (1-\pi)F^{-\rho}\right]^{-1/\rho} \tag{2.125}$$

$$U_G = \frac{-1}{\rho}\left[\pi G^{-\rho} + (1-\pi)F^{-\rho}\right]^{\left(\frac{-1}{\rho}\right)-1}\left[-\rho\pi G^{-(\rho+1)}\right]$$

$$\Rightarrow U_G = \pi U^{1+\rho} G^{-(1+\rho)}$$

$$U_F = \frac{-1}{\rho}\left[\pi G^{-\rho} + (1-\pi)F^{-\rho}\right]^{\left(\frac{-1}{\rho}\right)-1}\left[-\rho(1-\pi)F^{-(\rho+1)}\right]$$

$$\Rightarrow U_F = (1-\pi)U^{1+\rho} F^{-(1+\rho)}$$

$$U_{GG} = \frac{-(1+\rho)}{\rho}\pi\left[\pi G^{-\rho} + (1-\pi)F^{-\rho}\right]^{\frac{-(1+\rho)}{\rho}-1}\left[-\rho\pi G^{-(\rho+1)}\right]G^{-(1+\rho)}$$
$$+\pi\left[\pi G^{-\rho} + (1-\pi)F^{-\rho}\right]^{\frac{-(1+\rho)}{\rho}}\left[-(1+\rho)G^{-(1+\rho)}G^{-1}\right]$$

$$= (1+\rho)\pi\pi\frac{U^{1+\rho}}{U^{-\rho}}G^{-(\rho+1)}G^{-(1+\rho)} - \pi U^{1+\rho}(1+\rho)G^{-(1+\rho)}G^{-1}$$

$$U_{GG} = (1+\rho)U_G\frac{U_G}{U^{1+\rho}}U^{\rho} - \frac{U_G}{G}(1+\rho) \Rightarrow U_{GG} = (1+\rho)\frac{U_G}{U}\frac{(U_G G - U)}{G} \tag{2.126}$$

$$U_{FF} = (1+\rho)\frac{U_F}{U}\frac{(U_F F - U)}{F} \tag{2.127}$$

$$U_{GF} = \frac{-(1+\rho)}{\rho}\pi\left[\pi G^{-\rho} + (1-\pi)F^{-\rho}\right]^{\frac{-(1+\rho)}{\rho}-1}\left[-\rho(1-\pi)F^{-(\rho+1)}\right]G^{-(1+\rho)}$$

$$U_{GF} = (1+\rho)\pi(1-\pi)\frac{U^{1+\rho}}{U^{-\rho}} F^{-(1+\rho)} G^{-(1+\rho)} \Rightarrow U_{GF} = \frac{(1+\rho) U_F U_G}{U} > 0 . \quad (2.128)$$

Substituting (2.127) and (2.128) into the numerator of (2.13),

$$-\tilde{f}^* \left(\hat{\alpha}_2 U_{GF} G_{\tilde{g}} F_{\tilde{f}} - U_{FF} F_{\tilde{f}}^2 - U_F F_{\tilde{f}\tilde{f}} \right) + \hat{\alpha}_2 U_G G_{\tilde{g}}$$

$$\Rightarrow -\tilde{f}^* \left(\hat{\alpha}_2 \frac{1+\rho}{U} U_F U_G G_{\tilde{g}} F_{\tilde{f}} - \frac{1+\rho}{U} U_F \frac{(U_F F - U)}{F} F_{\tilde{f}}^2 - U_F F_{\tilde{f}\tilde{f}} \right) + \hat{\alpha}_2 U_G G_{\tilde{g}}$$

$$\Rightarrow -(1+\rho)\tilde{f}^* \frac{U_F}{U} \left(F_{\tilde{f}} \left(\hat{\alpha}_2 U_G G_{\tilde{g}} - U_F F_{\tilde{f}} \right) + \frac{U}{F} F_{\tilde{f}}^2 - \frac{U F_{\tilde{f}\tilde{f}}}{(1+\rho)\tilde{f}^*} \right) + \hat{\alpha}_2 U_G G_{\tilde{g}}$$

Applying $\hat{\alpha}_2 U_G G_{\tilde{g}} = U_F F_{\tilde{f}}$ from (2.7) at the optimum,

$$\Rightarrow -(1+\rho)\tilde{f}^* \frac{U_F}{U} \left(\frac{U}{F} F_{\tilde{f}}^2 - \frac{U F_{\tilde{f}\tilde{f}}}{(1+\rho)\tilde{f}^*} \right) + U_F F_{\tilde{f}} = U_F \left[-(1+\rho) \frac{\tilde{f}^* F_{\tilde{f}}^2}{F} - F_{\tilde{f}\tilde{f}} + F_{\tilde{f}} \right]$$

$$\Rightarrow -\tilde{f}^* \left(\hat{\alpha}_2 U_{GF} G_{\tilde{g}} F_{\tilde{f}} - U_{FF} F_{\tilde{f}}^2 - U_F F_{\tilde{f}\tilde{f}} \right) + \hat{\alpha}_2 U_G G_{\tilde{g}} = U_F \left[-(1+\rho) \frac{\tilde{f}^* F_{\tilde{f}}^2}{F} - F_{\tilde{f}\tilde{f}} + F_{\tilde{f}} \right] \quad (2.129)$$

2A.3 Comparative statics for labor allocation to the field under case 2.2.1

Based on (2.12),

$$\begin{bmatrix} -1 & -\hat{\alpha}_2 \\ U_{FG} G_{\tilde{g}} F_{\tilde{f}} - \hat{\alpha}_2 \left(U_{GG} G_{\tilde{g}}^2 + U_G G_{\tilde{g}\tilde{g}} \right) & U_{FF} F_{\tilde{f}}^2 + U_F F_{\tilde{f}\tilde{f}} - \hat{\alpha}_2 U_{GF} G_{\tilde{g}} F_{\tilde{f}} \end{bmatrix} \begin{bmatrix} d\tilde{g} \\ d\tilde{f} \end{bmatrix} = \begin{bmatrix} \tilde{f}^* d\hat{\alpha}_2 \\ U_G G_{\tilde{g}} d\hat{\alpha}_2 \end{bmatrix}$$

Applying Cramer's rule to derive the effect of change in $\hat{\alpha}_2$ on $\tilde{f}$

$$d\tilde{f} = \frac{\begin{vmatrix} -1 & \tilde{f}^* d\hat{\alpha}_2 \\ U_{FG} G_{\tilde{g}} F_{\tilde{f}} - \hat{\alpha}_2 \left(U_{GG} G_{\tilde{g}}^2 + U_G G_{\tilde{g}\tilde{g}} \right) & U_G G_{\tilde{g}} d\hat{\alpha}_2 \end{vmatrix}}{\left| \overline{H} \right|}$$

$$\frac{d\tilde{f}}{d\hat{\alpha}_2} = \tilde{f}_{\hat{\alpha}_2} = \frac{-\tilde{f}^* \left(U_{FG} G_{\tilde{g}} F_{\tilde{f}} - \hat{\alpha}_2 U_{GG} G_{\tilde{g}}^2 - \hat{\alpha}_2 U_G G_{\tilde{g}\tilde{g}} \right)}{\left| \overline{H} \right|} - \frac{U_G G_{\tilde{g}}}{\left| \overline{H} \right|} \quad (2.130)$$

We expect that $\tilde{f}_{\hat{\alpha}_2} < 0$ because the increase in α_2 due to HIV/AIDS leads to a reduction in effective labor units per hour worked in the field. Since $U_{FG} = U_{GF} > 0$ from (2.128), the expression in (2.130) is negative confirming our expectation.

2A.4 A numerical example with a Cobb-Douglas objective function for case 2.2.1

Assume a simple Cobb-Douglas utility function, $U(G(\tilde{g}), F(\tilde{f}))$, where $F(\tilde{f}) = \tilde{f}$ and $G(\tilde{g}) = \tilde{g}$ under constant returns to scale such that $U(.) = \tilde{g}^{0.5}\tilde{f}^{0.5}$. Applying (2.7), we have $\tilde{f} = \frac{\tilde{g}}{\hat{\alpha}_2}$ and from (2.6) $\tilde{f} = \frac{\hat{L}}{\hat{\alpha}_2} - \frac{\tilde{g}}{\hat{\alpha}_2}$. From these $\tilde{g} = \frac{\hat{L}}{2}$ which implies that $\tilde{g}$ remains constant for a given level of $\overline{L}$ and α_1. The numerical example for $\overline{L} = 10$ and $\alpha_1 = 1$ is given in Table 2A.4.

Table 2A.1 Labor allocation with declining health under Cobb-Douglas specification.

$\hat{\alpha}_2$	$\tilde{g} = g$	$\tilde{f}$	f	$g + f$
1	5	5	5	10
1.2	5	4.166667	5	10
1.3	5	3.846154	5	10
1.4	5	3.571429	5	10

Under constant returns to scale in a Cobb-Douglas utility function, the amount of labor allocated to the home garden, $\tilde{g}$, does not change with the change in α_2, i.e. $\tilde{g}_{\hat{\alpha}_2} = 0$. The numerical illustration has been conducted for varying values of π and the conclusion of $\tilde{g}_{\hat{\alpha}_2} = 0$ still holds. The same holds for any values of π under decreasing returns to scale.

2A.5 Comparative statics for the case under sharecropping

Condition (2.47)-(2.49) is given in matrix notation as

$$\begin{bmatrix} -1 & -\hat{\alpha}_2 & -\hat{\gamma} \\ U_{FG}G_{\tilde{g}}F_{\tilde{f}} - \hat{\alpha}_2\left(U_{GG}G_{\tilde{g}}^2 + U_G G_{\tilde{g}\tilde{g}}\right) & U_{FF}F_{\tilde{f}}^2 + U_F F_{\tilde{f}\tilde{f}} - \hat{\alpha}_2 U_{GF}G_{\tilde{g}}F_{\tilde{f}} & \delta U_{FS}F_{\tilde{f}}S_s - \hat{\alpha}_2\delta U_{GS}G_{\tilde{g}}S_s \\ \delta U_{SG}G_{\tilde{g}}S_s - \hat{\gamma}\left(U_{GG}G_{\tilde{g}}^2 + U_G G_{\tilde{g}\tilde{g}}\right) & \delta U_{SF}S_s F_{\tilde{f}} - \hat{\gamma}U_{GF}G_{\tilde{g}}F_{\tilde{f}} & \delta\left(U_{SS}S_s^2 + U_S S_{ss}\right) - \hat{\gamma}\delta U_{GS}G_{\tilde{g}}S_s \end{bmatrix} \begin{bmatrix} d\tilde{g} \\ d\tilde{f} \\ ds \end{bmatrix}$$

$$= \begin{bmatrix} -d\hat{L} + \tilde{f}d\hat{\alpha}_2 + sd\hat{\gamma} \\ U_G G_{\tilde{g}} d\hat{\alpha}_2 \\ U_G G_{\tilde{g}} d\hat{\gamma} - U_S S_s d\delta \end{bmatrix}$$

Applying Cramer's rule to derive the effect of a change in $\hat{\alpha}_2$ on $\tilde{g}$ where $\hat{\gamma}$, δ and $\hat{L}$ remain constant,

$$d\tilde{g} = \frac{\begin{vmatrix} \tilde{f}^{*} d\hat{\alpha}_2 & -\hat{\alpha}_2 & -\hat{\gamma} \\ U_G G_{\tilde{g}} d\hat{\alpha}_2 & U_{FF}F_{\tilde{f}}^2 + U_F F_{\tilde{f}\tilde{f}} - \hat{\alpha}_2 U_{GF}G_{\tilde{g}}F_{\tilde{f}} & \delta U_{FS}F_{\tilde{f}}S_s - \hat{\alpha}_2\delta U_{GS}G_{\tilde{g}}S_s \\ 0 & \delta U_{SF}S_s F_{\tilde{f}} - \hat{\gamma}U_{GF}G_{\tilde{g}}F_{\tilde{f}} & \delta\left(U_{SS}S_s^2 + U_S S_{ss}\right) - \hat{\gamma}\delta U_{GS}G_{\tilde{g}}S_s \end{vmatrix}}{\left|\overline{H}\right|}$$

$$d\tilde{g} = \frac{\left(\delta U_{SS} S_s^2 + \delta U_S S_{ss} - \delta^2 U_{GS} S_s^2 \frac{U_S}{U_G}\right) d\hat{\alpha}_2 \left[\tilde{f}^* \left(U_{FF} F_{\tilde{f}}^2 + U_F F_{\tilde{f}\tilde{f}} - \frac{\hat{\alpha}_2 \delta U_S}{\hat{\gamma} U_G} U_{GF} F_{\tilde{f}} S_s\right) + U_F F_{\tilde{f}}\right] - \left(\delta U_{SF} S_s F_{\tilde{f}} - \delta U_{GF} S_s F_{\tilde{f}} \frac{U_S}{U_G}\right) d\hat{\alpha}_2 \left[\delta U_S S_s + \tilde{f}^* \left(\delta U_{FS} F_{\tilde{f}} S_s - \frac{\hat{\alpha}_2 \delta^2 U_S}{\hat{\gamma} U_G} U_{GS} S_s^2\right)\right]}{\left|\overline{H}\right|}$$

$$\frac{d\tilde{g}}{d\hat{\alpha}_2} = \frac{\left(\delta U_{SS} S_s^2 + \delta U_S S_{ss} - \delta^2 U_{GS} S_s^2 \frac{U_S}{U_G}\right) \left[\tilde{f}^* \left(U_{FF} F_{\tilde{f}}^2 + U_F F_{\tilde{f}\tilde{f}} - \frac{\hat{\alpha}_2 \delta U_S}{\hat{\gamma} U_G} U_{GF} F_{\tilde{f}} S_s\right) + U_F F_{\tilde{f}}\right] - \left(\delta U_{SF} S_s F_{\tilde{f}} - \delta U_{GF} S_s F_{\tilde{f}} \frac{U_S}{U_G}\right) \left[\delta U_S S_s + \tilde{f}^* \left(\delta U_{FS} F_{\tilde{f}} S_s - \frac{\hat{\alpha}_2 \delta^2 U_S}{\hat{\gamma} U_G} U_{GS} S_s^2\right)\right]}{\left|\overline{H}\right|} \quad (2.131)$$

Case 2: applying Cramer's rule to see the effect of change in α_2 on s ,

$$ds = \frac{\begin{vmatrix} -1 & -\hat{\alpha}_2 & \tilde{f}^* d\hat{\alpha}_2 \\ U_{FG} G_{\tilde{g}} F_{\tilde{f}} - \hat{\alpha}_2 \left(U_{GG} G_{\tilde{g}}^2 + U_G G_{\tilde{g}\tilde{g}}\right) & U_{FF} F_{\tilde{f}}^2 + U_F F_{\tilde{f}\tilde{f}} - \hat{\alpha}_2 U_{GF} G_{\tilde{g}} F_{\tilde{f}} & U_G G_{\tilde{g}} d\hat{\alpha}_2 \\ \delta U_{SG} G_{\tilde{g}} S_s - \hat{\gamma}\left(U_{GG} G_{\tilde{g}}^2 + U_G G_{\tilde{g}\tilde{g}}\right) & \delta U_{SF} S_s F_{\tilde{f}} - \hat{\gamma} U_{GF} G_{\tilde{g}} F_{\tilde{f}} & 0 \end{vmatrix}}{\left|\overline{H}\right|}$$

$$ds = \frac{-\left(\hat{\gamma} U_{SG} G_{\tilde{g}}^2 \frac{U_G}{U_S} - \hat{\gamma} U_{GG} G_{\tilde{g}}^2 - \hat{\gamma} U_G G_{\tilde{g}\tilde{g}}\right) d\hat{\alpha}_2 \left[\hat{\alpha}_2 U_G G_{\tilde{g}} + \tilde{f}^* \left(U_{FF} F_{\tilde{f}}^2 - U_F F_{\tilde{f}\tilde{f}} - \hat{\alpha}_2 U_{GF} G_{\tilde{g}} F_{\tilde{f}}\right)\right] + \left(\hat{\gamma} U_{SF} G_{\tilde{g}} F_{\tilde{f}} \frac{U_G}{U_S} - \hat{\gamma} U_{GF} G_{\tilde{g}} F_{\tilde{f}}\right) d\hat{\alpha}_2 \left[U_G G_{\tilde{g}} + \tilde{f}^* \left(U_{FG} G_{\tilde{g}} F_{\tilde{f}} - \hat{\alpha}_2 U_{GG} G_{\tilde{g}}^2 - \hat{\alpha}_2 U_G G_{\tilde{g}\tilde{g}}\right)\right]}{\left|\overline{H}\right|}$$

$$\frac{ds}{d\hat{\alpha}_2} = \frac{-\left(\hat{\gamma} U_{SG} G_{\tilde{g}}^2 \frac{U_G}{U_S} - \hat{\gamma} U_{GG} G_{\tilde{g}}^2 - \hat{\gamma} U_G G_{\tilde{g}\tilde{g}}\right) \left[\hat{\alpha}_2 U_G G_{\tilde{g}} + \tilde{f}^* \left(U_{FF} F_{\tilde{f}}^2 - U_F F_{\tilde{f}\tilde{f}} - \hat{\alpha}_2 U_{GF} G_{\tilde{g}} F_{\tilde{f}}\right)\right] + \left(\hat{\gamma} U_{SF} G_{\tilde{g}} F_{\tilde{f}} \frac{U_G}{U_S} - \hat{\gamma} U_{GF} G_{\tilde{g}} F_{\tilde{f}}\right) \left[U_G G_{\tilde{g}} + \tilde{f}^* \left(U_{FG} G_{\tilde{g}} F_{\tilde{f}} - \hat{\alpha}_2 U_{GG} G_{\tilde{g}}^2 - \hat{\alpha}_2 U_G G_{\tilde{g}\tilde{g}}\right)\right]}{\left|\overline{H}\right|} \quad (2.132)$$

2A.6 Optimal diversity in the Dixit-Stiglitz model

Putting the fixed and variable costs for garden activities together to get the net income, $\hat{y}$, the income expressed in terms of the numeraire, which is set at 1 minus the lump sum deduction to cover the losses (fixed and variable cost for the activities in the home garden). Assuming symmetric condition such that $q_l = q$ for all $l = 1, \ldots, n$, gives

$$\hat{y} = 1 - n(k + cq) \quad (2.133)$$

where k is the fixed cost and c is the variable cost of crop diversity in the home garden. Consider the farm household's problem of choosing n to maximize:

$$U = [nD(q)]^{\pi}[1-n(k+cq)]^{1-\pi} \tag{2.134}$$

First order conditions are given by

$$U_n = \pi[nD(q)]^{\pi-1}D(q)[1-n(k+cq)]^{1-\pi} - [nD(q)]^{\pi}(1-\pi)[1-n(k+cq)]^{-\pi}(k+cq) = 0 \tag{2.135}$$

$$U_q = \pi[nD(q)]^{\pi-1}D_q(q)n[1-n(k+cq)]^{1-\pi} - [nD(q)]^{\pi}(1-\pi)[1-n(k+cq)]^{-\pi}(vq) = 0 \tag{2.136}$$

From (2.135) we have,

$$\frac{\pi[nD(q)]^{\pi-1}D(q)[1-n(k+cq)]^{1-\pi}}{[nD(q)]^{\pi}(1-\pi)[1-n(k+cq)]^{-\pi}(k+cq)} = 1 \Rightarrow \pi[1-n(k+cq)] = n(1-\pi)(k+cq)$$

$$n = \frac{\pi}{k+cq} \tag{2.137}$$

From (2.137) households decision to increase crop diversity depends on the preference for diversity and the fixed and variable cost of adding the next crop species. An increase in the fixed cost of planting more crops would lead to a reduction in the number of species whereas an increase in the preferences towards crop diversity would lead to increase in the number of crop species planted. Households may obtain planting material for the first few species from their neighbors and friends but with increasing demand to plant more crop species, there would be a need to pay for the planting material. The households decide to plant more crops depending on their preferences towards diversifying crops and willingness to take the fixed cost of planting more species. Hence, any shock that causes change in the fixed costs of adding plants or in preferences towards diversifying would lead to a change in the number of crop species in the home garden. Extending the Dixit-Stiglitz diversity model to solve for n for the general CES utility function, where $\tau = 1$,

$$U = \left[\pi(nD(q))^{-\rho} + (1-\pi)(1-n(k+cq))^{-\rho}\right]^{\frac{-1}{\rho}} \tag{2.138}$$

$$U_n = \frac{-1}{\rho}\left[\pi(nD(q))^{-\rho} + (1-\pi)(1-n(k+cq))^{-\rho}\right]^{\frac{-1}{\rho}-1}$$
$$\left[-\pi\rho(nD(q))^{-(\rho+1)}D(q) - (1-\pi)\rho(1-n(k+cq))^{-(\rho+1)}(-(k+cq))\right] = 0$$

$$\Rightarrow \pi(nD(q))^{-(\rho+1)}D(q) = (1-\pi)(1-n(k+cq))^{-(\rho+1)}(k+cq)$$

$$\Rightarrow \pi(nD(q))^{-(\rho+1)}D(q) + \pi(1-n(k+cq))^{-(\rho+1)}(k+cq) = (1-n(k+cq))^{-(\rho+1)}(k+cq)$$

$$\Rightarrow \left[\frac{nD(q)}{1-n(k+cq)}\right]^{-(\rho+1)} D(q) = (k+cq)\left(\frac{1}{\pi}-1\right)$$

$$\Rightarrow \frac{nD(q)}{1-n(k+cq)} D(q)^{\frac{-1}{\rho+1}} = \left[(k+cq)\left(\frac{1}{\pi}-1\right)\right]^{\frac{-1}{\rho+1}}$$

$$\Rightarrow \frac{nD(q)^{\frac{\rho}{\rho+1}}}{1-n(k+cq)} = \left[(k+cq)\left(\frac{1}{\pi}-1\right)\right]^{\frac{-1}{\rho+1}} \Rightarrow n = \frac{\left[(k+cq)\left(\frac{1}{\pi}-1\right)\right]^{\frac{-1}{\rho+1}}}{D(q)^{\frac{\rho}{\rho+1}} + (k+cq)\left[(k+cq)\left(\frac{1}{\pi}-1\right)\right]^{\frac{-1}{\rho+1}}}$$

$$n = \left[D(q)^{\rho\zeta}\left((k+cq)\left(\frac{1}{\pi}-1\right)\right)^{\zeta} + (k+cq)\right]^{-1} \tag{2.139}$$

If $\rho = 0$ as in a Cobb-Douglas utility function, (2.139) collapses into an optimal n,

$n = \left[(k+cq)\left(\frac{1}{\pi}-1\right) + (k+cq)\right]^{-1} \Rightarrow n = \dfrac{\pi}{k+cq}$, which is also given in (2.65) and (2.137).

2A.7 Comparative statics for the Dixit-Stiglitz model under sharecropping

Applying Cramer's rule on (2.100)-(2.102) to derive the effect of change in $\hat{\alpha}_2$ on n while $\hat{\gamma}$, δ, $\hat{k}$, $\tilde{g}^l$ and $\hat{L}$ remain constant

$$\begin{bmatrix} -\left(\tilde{g}^l + \hat{k}\right) & -\hat{\alpha}_2 & -\hat{\gamma} \\ U_{FD}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}F_{\tilde{f}} - \hat{\alpha}_2\left(U_{DD}\left(\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}\right)^2 + \frac{1-\rho_1}{\rho_1}U_D qn^{\frac{1}{\rho_1}-2}\right) & \left(U_{FF}F_{\tilde{f}}^2 + U_F F_{\tilde{f}\tilde{f}}\right) - \hat{\alpha}_2\frac{1}{\rho_1}U_{DF}qn^{\frac{1}{\rho_1}-1}F_{\tilde{f}} & \delta U_{FS}F_{\tilde{f}}S_s - \hat{\alpha}_2\delta U_{DS}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}S_s \\ \delta U_{SD}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}S_s - \hat{\gamma}\left(U_{DD}\left(\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}\right)^2 + \frac{1-\rho_1}{\rho_1}U_D qn^{\frac{1}{\rho_1}-2}\right) & \delta U_{SF}S_s F_{\tilde{f}} - \hat{\gamma}U_{DF}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}F_{\tilde{f}} & \delta\left(U_{SS}S_s^2 + U_S S_{ss}\right) - \gamma\delta U_{DS}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}S_s \end{bmatrix} \begin{bmatrix} d\tilde{g} \\ d\tilde{f} \\ ds \end{bmatrix}$$

$$= \begin{bmatrix} -d\hat{L} + nd\hat{k} + nd\tilde{g}^l + \tilde{f}d\hat{\alpha}_2 + sd\hat{\gamma} \\ \frac{1}{\rho_1}U_D qn^{\frac{1}{\rho_1}-1}d\hat{\alpha}_2 \\ U_D\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}d\hat{\gamma} - U_S S_s d\delta \end{bmatrix}$$

$$dn=\frac{\begin{vmatrix}\tilde f^{*}d\hat\alpha_2 & -\hat\alpha_2 & -\hat\gamma\\ \frac{1}{\rho_1}U_D qn^{\frac{1}{\rho_1}-1}d\hat\alpha_2 & \left(U_{FF}F_{\tilde f}^{2}+U_F F_{\tilde f\tilde f}\right)-\hat\alpha_2\frac{1}{\rho_1}U_{DF}qn^{\frac{1}{\rho_1}-1}F_{\tilde f} & \delta U_{FS}F_{\tilde f}S_s-\hat\alpha_2\delta U_{DS}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}S_s\\ 0 & \delta U_{SF}S_sF_{\tilde f}-\hat\gamma U_{DF}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}F_{\tilde f} & \delta\left(U_{SS}S_s^{2}+U_SS_{ss}\right)-\gamma\delta U_{DS}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}S_s\end{vmatrix}}{\left|\overline{H}\right|}$$

$$\frac{dn}{d\hat\alpha_2}=\frac{\begin{gathered}\left(\delta U_{SS}S_s^{2}+\delta U_SS_{ss}-\hat\gamma\delta U_{DS}S_s\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}\right)\left[\tilde f^{*}\left(U_{FF}F_{\tilde f}^{2}+U_FF_{\tilde f\tilde f}-\hat\alpha_2U_{DF}F_{\tilde f}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}\right)+\hat\alpha_2U_D\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}\right]\\ -\left(\delta U_{SF}S_sF_{\tilde f}-\hat\gamma U_{DF}F_{\tilde f}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}\right)\left[\hat\gamma U_D\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}+\tilde f^{*}\left(\delta U_{FS}F_{\tilde f}S_s-\hat\alpha_2\delta U_{DS}S_s\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}\right)\right]\end{gathered}}{\left|\overline{H}\right|}\quad(2.140)$$

And the effect of change in $\hat\alpha_2$ on s

$$ds=\frac{\begin{vmatrix}-\left(\tilde g^{l}+\hat k\right) & -\hat\alpha_2 & \tilde f^{*}d\hat\alpha_2\\ U_{FD}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}F_{\tilde f}-\hat\alpha_2\left(U_{DD}\left(\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}\right)^{2}+\frac{1-\rho_1}{\rho_1}U_Dqn^{\frac{1}{\rho_1}-2}\right) & \left(U_{FF}F_{\tilde f}^{2}+U_FF_{\tilde f\tilde f}\right)-\hat\alpha_2\frac{1}{\rho_1}U_{DF}qn^{\frac{1}{\rho_1}-1}F_{\tilde f} & \frac{1}{\rho_1}U_Dqn^{\frac{1}{\rho_1}-1}d\hat\alpha_2\\ \delta U_{SD}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}S_s-\hat\gamma\left(U_{DD}\left(\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}\right)^{2}+\frac{1-\rho_1}{\rho_1}U_Dqn^{\frac{1}{\rho_1}-2}\right) & \delta U_{SF}S_sF_{\tilde f}-\hat\gamma U_{DF}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}F_{\tilde f} & 0\end{vmatrix}}{\left|\overline{H}\right|}$$

$$\frac{ds}{d\hat\alpha_2}=\frac{\begin{gathered}-\left(\hat\gamma U_{SD}\left(\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}\right)^{2}\frac{U_D}{U_S}-\hat\gamma U_{DD}\left(\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}\right)^{2}-\hat\gamma U_D\frac{1-\rho_1}{\rho_1}qn^{\frac{1}{\rho_1}-2}\right)\left[\hat\alpha_2U_D\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}+\tilde f^{*}\left(U_{FF}F_{\tilde f}^{2}+U_FF_{\tilde f\tilde f}-\hat\alpha_2U_{DF}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}F_{\tilde f}\right)\right]\\ +\left(\hat\gamma U_{SF}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}F_{\tilde f}\frac{U_D}{U_S}-\hat\gamma U_{DF}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}F_{\tilde f}\right)\left[\left(\tilde g^{l}+\hat k\right)U_D\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}+\tilde f^{*}\left(U_{FD}\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}F_{\tilde f}-\hat\alpha_2U_{DD}\left(\frac{1}{\rho_1}qn^{\frac{1}{\rho_1}-1}\right)^{2}-\hat\alpha_2U_D\frac{1-\rho_1}{\rho_1}qn^{\frac{1}{\rho_1}-2}\right)\right]\end{gathered}}{\left|\overline{H}\right|}$$

(2.141).

CHAPTER 3

IMPACTS OF HIV/AIDS ON LABOR ORGANIZATION AND AGROBIODIVERSITY: DO STAGES OF THE DISEASE MATTER?

This Chapter aims at obtaining in-depth insight into the important coping strategies for HIV/AIDS based on direct observation through an in-depth analysis of 4 case studies in Southwest Ethiopia. The emphasis is on the distinction of impacts on labor allocation, crop choice and agrobiodiversity with respect to the various stages in which HIV/AIDS affects households and the types of households. In addition, some attention is paid to the impact of the disease on household income per capita. We found that sharecropping-out fields increased following male illness and off-farm labor allocation increased during single parenthood. In three of the four cases, crop species diversity in the home garden increased during single and foster parenthood. Household income per capita decreased for the absentee single male headed and gradually increased for the single male, single female and foster parent headed households following parental death. The case study shows that land tenure plays an important role, because of the options of engaging in sharecropping contracts or working off-farm. This has implications for intervention strategies in the various phases of the disease, both for men and women.

Key words: *crop diversity, Ethiopia, HIV/AIDS, in-depth study, labor organization, stages.*

3.1 INTRODUCTION

Agrobiodiversity depends on household decisions on the allocation of labor and land which in turn are affected by the incidence of HIV/AIDS. HIV/AIDS causes households to divert labor from agricultural activities to increased care giving (Rugalema, 1999; Drimie, 2002; Loevinsohn and Gillespie, 2003; World Development Report, 2008). HIV/AIDS affected households also increase sharecropping (Drimie, 2002; Bishop-Sambrook et al. 2006) and tend to reallocate labor towards quick return non-agricultural activities (Loevinsohn and Gillespie, 2003). Decrease in crop range through reducing the area cultivated (Barnett and Whiteside, 2002) and abandonment or underutilization of land (Shah et al. 2001, cited in Gillespie and Kadiyala, 2005; Drimie, 2002; Loevinsohn and Gillespie, 2003; Gillespie and Kadiyala, 2005) are also observed responses to HIV/AIDS. Affected households favor less labor demanding crops (Haddad and Gillespie, 2001) and change their choice of food crops after the death of a male household head (Yamano and Jayne, 2002). Salick (1992) and Song (1998) found that loss of male labor causes single females to reduce labor demanding crops in the fields. Salick (1992) also reports a reduction in the number of crop species in the fields being accompanied by increasing crop diversity in the home garden. Similarly, Alumira et al. (2005) found in Malawi that HIV/AIDS affected households were increasing agrobiodiversity by adding horticultural crops to their usual chilies, rice and pigeon pea.

Agrobiodiversity matters because it contributes to dietary diversity and improves nutrition (Johns, 2003; Gari, 2003 and 2004; Johns and Eyzaguirre, 2006) and thereby helps to delay the progression of HIV into AIDS-related diseases (Fawzi et al. 2004; Gillespie and Kadiyala, 2005; Stillwaggon, 2006).

The above mentioned studies on the effect of HIV/AIDS on labor and land allocation, however, pay little attention to two aspects that may shape the effect of HIV/AIDS on labor and land allocation and hence on agrobiodiversity. First, the organization of the land rental market appears to have an effect on household responses to HIV/AIDS. Second, the stages of HIV/AIDS appear relevant for labor and land allocation because the severity of illness and hence labor loss is not uniform from infection to death of the affected household member. Holden and Bezabih (2006) and Holden et al. (2001) indicate that land rental market imperfection causes substantial productivity differentials that tend to be gender biased. Based on a study in southern Ethiopia, Holden (2008) found that land certification enhances perceived security over land which influences land rental decisions and household investments to boost land productivity. The above studies indicate that rigidities in the land rental markets limit reallocations that households are able to make in order to prevent decline in household income, food supply and nutrition due to HIV/AIDS. Given that sharecropping assists in filling labor gaps, rigidities in the sharecropping market may limit labor replacement options in the context of HIV/AIDS and thereby affecting productivity and income.

Barrett et al. (2006) conclude that loss of labor power due to HIV/AIDS causes collapse into poverty. Illness, poor health and high healthcare expenses constitute important causes for poverty. As Krishna et al. (2004; 2006) report they altogether account for 73% and 70% of all descents into poverty in Western Kenya and in Central and Western Uganda. Both studies highlight the importance of illness associated death of the major earner for falling into poverty. Longer term effects of HIV/AIDS on poverty may, however, be complicated by changes in other consumption side variables. Young (2005) predicts a long term per capita consumption rise due to HIV/AIDS induced protected sex and increase in the value of women's time as a result of labor shortage which both lead to reduction in fertility. As the explanation for current poverty can be traced back to sickness, healthcare expenses and death, paying attention to how HIV/AIDS affected households are responding can provide important information for policy intervention. Moreover, how the response to HIV/AIDS may be influenced by the characteristics of the land rental market becomes relevant considering the substantial productivity differentials mentioned above.

The objective of this chapter is to identify important effects of HIV/AIDS on labor organization, land allocation, crop choice and agrobiodiversity among farm households in Southwest Ethiopia. Information about HIV/AIDS positive patients is confidential. Trust between patients and health workers is important for the implementation of HIV/AIDS policies. This limits the implementation of a larger survey among HIV/AIDS affected households. Four households contacted through NGOs and local HIV/AIDS secretariats have been selected for an in-depth case study. In the case studies, I examine variations in labor allocation, crop choice and agrobiodiversity among HIV/AIDS affected households and identify the specific factors explaining such variations for the case studies. Two research questions are set out regarding the short run implications of the epidemic. First, I study how HIV/AIDS affected households reallocate household labor and land to the various activities, identify replacement labor and manage their agrobiodiversity[7] in the home garden and fields. The role of sharecropping in the response of the households' land and labor reallocation is stressed. Second, I focus on the implications of the HIV/AIDS stages and gender for household labor organization, crop choice and agrobiodiversity. Besides, I briefly analyze the implications of HIV/AIDS for income and children's position. For the analysis, I distinguish between four stages: (i) *pre-illness*, (ii) *illness*, (iii) *death,* and (iv) *current*.

The in-depth analysis presents detailed farm household resource allocation behavior and provides insight into the changes in labor and land allocations and agrobiodiversity throughout the stages of HIV/AIDS for each affected household member. This enhances a deeper understanding of human constraints and choices under the conditions of HIV/AIDS and gives insight into the choices they make regarding agrobiodiversity and its link to personal circumstances and histories. The results of the cases can be combined with similar studies and, at a later stage, possibly be integrated for a meta-analysis[8] on HIV/AIDS impacts and allow for formulating hypotheses for testing in a wider empirical setting.

The paper is structured as follows. Section 2 describes the setting of the case study. Section 3 provides a layout of the approach for data collection and types of data collected. Section 4 presents description of the cases and analysis of results. The last section discusses the results and draws conclusions for HIV/AIDS policies.

3.2 THE SETTING

The Oromiya Regional State is the largest of the 9 major Regional States of Ethiopia and makes up about 35% of the country's population (CSA, 2006). The study was conducted in the Jimma zone of Southwest Ethiopia, which constitutes one of the 12 zones of the Oromiya Regional State. Jimma town, the major zonal town, is located about 340 km Southwest of Addis. The research sites are located in two of the 13 woredas of the Jimma zone, namely, Gomma and Kersa. Gomma woreda is predominantly a coffee growing area whereas Kersa is primarily known for its cereal growing.

3.2.1 HIV/AIDS prevalence

[7] The role of agrobiodiversity for household nutrition and HIV/AIDS mitigation has not been an explicit part of the analysis.
[8] The role of in-depth studies for meta-analysis has also been recognized in other related fields (Poteete and Ostrom, 2008).

HIV/AIDS prevalence rate among Voluntary Counseling and Testing (VCT) clients is estimated at 15.5% for females, 8.8% for males and 11.8% for the Oromiya Region (MOH, 2007). Of the zones of the Oromiya Regional State, Jimma zone ranks second in HIV/AIDS prevalence rate after Adama. The HIV/AIDS prevalence rate in Jimma and its surrounding is estimated at 8.9% in the rural and 7.0% in the urban communities (Belachew et al. 2004). Prevalence rate among pregnant women in Jimma town is estimated at 8.6% in 2001 and 10.2% at the Jimma health center in 2003 (UNAIDS/WHO, 2006). Although official rates are unavailable, HIV/AIDS prevalence among VCT clients in Gomma woreda shows a rate exceeding 10% (Jimma zone HIV/AIDS secretariat, 2005). The coffee growing Gomma woreda is characterized by a higher rate of seasonal labor inflow, particularly during the coffee planting and harvesting seasons which might have contributed to the high HIV/AIDS prevalence rate in the woreda. A study among high school students in Agaro town, Gomma woreda's main town, indicated the prevalence of high risk sexual behavior and particularly unprotected sexual contact among the youth (Girma et al. 2004).

Several NGOs based in Jimma town provide care and support for People Living with HIV/AIDS (PLWHA) upon presentation of proof of HIV positive status. Their services include education, counselling, home-based care under critical conditions and monthly financial support of 100-150 Br/month (1USD=Br8.6 based on the rate during the fieldwork).

3.2.2 Socio-economic characteristics

This section describes the socio-economic circumstances of the farm households in our study which are considered relevant for the analysis of changes in labor and land allocation and crop diversity among the farm households. It focuses on describing farm land allocations, gendered labor and labor markets; and land and credit markets in the specific setting.

Farm land allocation

The farmland in the area can be divided into three broad categories; namely, home garden, field, and coffee plots. Main crops grown in the home garden include perennials such as enset, coffee, fruit trees (orange, mango, papaya, banana, avocado, guava, and pineapple), qat, and sugarcane; seasonal cereals such as maize and haricot beans; and roots and vegetables such as taro, yam, kale, pepper, and cabbage. A household may have several field plots that are mainly cultivated for cereal growing with the major cereal crops being maize and sorghum followed by beans, teff, barley and millet. Coffee plots are located mainly between shade trees.

Gendered farm labor and labor markets

Female and male labor is allocated to the three farm land categories according to the crops planted. When home gardens are predominated by qat and sugarcane, male labor becomes important for operating the home garden. Even in the absence of qat and sugarcane, men are involved in digging, and transplanting enset and other seedlings in the homegarden. As in many other parts of the country ploughing is the domain of males. This situation often requires single female headed households either to sharecrop-out fields or to hire-in casual labor for ploughing fields.

Households can increase labor supply through hiring-in casual labor or entering into a sharecropping contract. The role of a given household in sharecropping arrangements can be either as labor contributor (*sharecropping-in*) or as mainly land contributor (*sharecropping-out*). While this implies that a given household must have either of these two inputs to qualify for a sharecropping contract, it does not mean lack of exchange of other inputs such as seeds between the parties involved as well. The produce share of the land owner in a specific sharecropping arrangement ranges between 33%-66% depending on the input contribution of the land owner.

Off-farm labor markets can be divided into farm off-farm (which involves working on others' farms), self-employed off-farm, and employed off-farm activities. The self-employed off-farm activities include petty trading, firewood and charcoal selling, brewing, running tea/coffee houses, housing construction, carpentry, and cattle trading. The participation in employed off-farm activities include work such as a daily laborer at the local coffee pulpery, commission based coffee collecting from farmers for the pulpery, working for the local Peasant Association, and the governmental local coffee project.

Land and credit markets

Land is owned and distributed by the state and formally farmers are not allowed to trade land. Informal land transactions such as through contractual arrangements however do exist. The current land law in Ethiopia lacks clarity on the length of contract, the amount of land that can be rented-out and the ownership rights of absentee land owners which all affect land rental decisions (Deininger et al. 2007). This is particularly the case with sharecropping contracts (Holden, 2008). The average land holding per household in the area is below 1 ha.

The formal source of credit available to the farmers is the input credit provided by the local Rural Development Office which is a package containing improved maize seed varieties and fertilizer involving a down payment (Jimma Zone Agricultural Development Department, 2003). Other than this, there are informal moneylenders (mainly local merchants) lending with interest rates well above 150% on an annual basis.

3.3 METHOD AND DATA

The research method and data presented in this Chapter focus on an in-depth study of four HIV/AIDS affected case farm households. Because of the complexity of interaction between adult health status, gender roles, availability of labor and land resources and household responses in allocations, we provide detailed information on the household specific socio-economic characteristics for the cases. This enables a better understanding of the potential variations in the impact of HIV/AIDS on labor and land allocation and crop diversity and identifying the specific factors that may explain such variations. We are aware that generalization can not be made based on the evidence obtained from the 4 cases. The case studies are, however, important to understand the situation and the decisions of the farm households and the case studies provide in-depth insight that can not be obtained through empirical studies, because HIV/AIDS affected individuals can not be easily identified in large surveys. Actual case studies help to fill the gap left by large survey analysis aimed at generalization as they allow learning from particulars of individual cases (McWhinney, 2001).

3.3.1 Selection of case study households

The cases were selected based on a strategic sampling technique. The criteria used for selecting the four cases included: a) being HIV/AIDS positive, b) being a farmer in the research area and c) willingness to participate in the in-depth study. Accordingly, the four households selected for the in-depth analysis consists of the following: single male headed (case 1), single female headed (case 2), single absentee male headed (case 3) and both parents deceased (case 4). Cases 1 and 2 were selected when they came to

Agaro town health center to collect their monthly support from FIDA (a local NGO) through the collaboration of the Gomma woreda HIV/AIDS secretariat. Case 3 was identified through the collaboration of the Kersa woreda HIV/AIDS secretariat and his subsequent contacts were facilitated through OSSA (a local NGO). Case 4 was identified through the research assistants during the period of collecting the survey data.

3.3.2 Strategies for data generation

Frequency of contacts

Each case study was conducted in three phases representing three important seasons of the year; namely, (i) harvesting and marketing, (ii) land preparation and sowing, and (iii) weeding and protection. Each household was contacted for 5 consecutive days during the first phase and for 3 consecutive days during the second and third phases.

Specific activities during the visits

The main activities conducted during the visits to research households included structured interviews, recording of current and past activities, farm walks and measurement of key variables. Observing current daily activities included following the day-to-day activities of household members to identify allocation of tasks and time between men and women. These included two aspects. First, we conducted interviewing and participatory analysis whereby the participants provide information about current activities in comparison with the past. The interview on the current activities includes explaining the household demographic and endowment profile, labor and land allocations to the various activities and why they are doing what they are doing. Information about the past includes how the farming systems as well as labor and land allocations evolved over the various stages of HIV/AIDS including the history of land use and crop selection in particular. Second, we carried out farm visits and measurements to generate quantitative information about the participants' resource endowments and allocations. This includes the counting and listing of crop species grown on each plot, the number of plots and the area allocated by crop.

3.4 ANALYSIS AND RESULTS

The analysis focuses on the main research questions regarding inter- and intra-stage dynamics of effects in labor allocation, crop choice and agrobiodiversity. For the analysis we focus on the Tables 3.1-3.5.

Additional information on related household resource allocations can be obtained in the Tables 3A.1-3A.3 in Annex 3A. In the analysis of the changes in each table, *pre-illness* is taken as a base period from which changes in the rest of the columns are derived.

Table 3.1 Description of health status and HIV/AIDS.

Health	Case1: Meng	Case 2: Kalbi	Case 3: Oli	Case 4: Sam
1. TB (no. of occurrence since contraction)				
Male	0	0	0	1
Female	5	0	0	1
Child	1	0	0	1
2. Total duration of illness up to current time or death (yrs)				
Male	3	5	4	5
Female	6	2	3	4
3. Duration of continuous illness before death (months)				
Male	NA	3	NA	6
Female	12	NA	12	8
4. HIV status				
Male	+	unknown	+	+
Female	+	+	+	unknown
Child	+	unknown	-	+ (deceased)
5. Mortality				
No. of children died	1	1	0	1
Child age at death (yrs)	0.8	2	0	9

Note: +, - indicate that that the individual has been tested for HIV and proved to be HIV positive and negative respectively. NA means that the criterion is not applicable to the specific household.

A. Case 1: Meng

Meng[9] is 31 years old and his household can be classified as single male headed household. Alarmed by the severe illness of his late wife which lasted for 12 subsequent months, Meng and his children have been tested to find themselves HIV/AIDS positive (see Table 3.1). Currently, Meng has handed over his two children to an NGO orphanage with the hope of getting better healthcare and education. As a land scarce household, the household accesses a 0.25 ha maize field and a 0.13 ha coffee plot through sharecropping-in. The household is highly dependent on off-farm activities (see Table 3.2) both during the pre-illness period and the current time.

Labor allocations

Male farm labor supply remained the same for Meng's household as the household moves from stage 1 to 2 while female farm labor supply declined (see Table 3.3 and Figure 3.1). Such a response is not

[9] Names have been changed in a way to protect the privacy of the individual.

surprising given that Meng's household is land constrained and normally accesses land through sharecropping. Male farm labor supply increased in stage 4 following the death of his female spouse after a long period of severe illness demanding intensive care both for his wife as well as his young children. On the other hand, both female and male off-farm labor supply declined following his late wife's illness with the latter being reduced to zero when the female fell severely ill (see Table 3.2 and Figure 3.2). Given the good health status of Meng, there is a potential to further increase off-farm participation. At the current stage, Meng has continued sharecropping-in land, as his land is small compared to his work capability.

Table 3.2 Labor organization by household type and stage.

Labor organization	Case1 (single male parent): Meng				Case 2 (single female parent): Kalbi					
	pre-ill	illness fem	death fem	current	pre-ill	illness m	death m	re-marry	illness fem	current
1. Own farm labor in the field (days/yr)										
Male	30	30	30	40	160	60	0	0	0	0
Female	10	0	0	0	60	30	80	80	60	50
Child	0	0	0	0	0	0	12	12	10	12
2. Off-farm labor (days/yr)										
Male	240	180	130	180	110	0	0	60	0	0
Female	50	0	0	0	0	0	90	90	0	0
Child	0	0	0	0	0	0	0	0	0	0
3. Casual labor (days/yr)										
Hire-out	35	20	35	30	0	0	40	40	20	28
Hire-in	0	0	0	0	0	0	5	5	5	7
4. Sharecrop farming (ha)										
Sharecrop-out land	0	0	0	0	0	0	0.33	0.33	0.33	0.33
Sharecrop-in land	0.38	0.38	0.38	0.38	0.25	0	0	0	0	0

Labor organization	Case 3 (absent single male parent): Oli					Case 4 (both parent deceased): Sam					
	pre-ill	illness fem	death fem	illness m	current	pre-ill	illness m	death m	illness fem	death fem	current
1. Own farm labor in the field (days/yr)											
Male	120	60	0	0	0	20	0	0	0	0	0
Female	80	0	0	0	0	10	0	0	0	0	0
Child	0	0	0	0	0	0	0	0	0	30	40-60
2. Off-farm labor (days/yr)											
Male	100	60	260	260	260	240	100	0	0	0	0
Female	0	0	0	0	0	250	150	0	0	0	0
Child	0	0	0	0	0	0	0	0	0	0	0
3. Casual labor (days/yr)											
Hire-out	0	0	0	0	0	0	0	0	0	0	0
Hire-in	0	0	0	0	10	30	25	15	15	15	15
4. Sharecrop farming (ha)											
Sharecrop-out land	0	0	4	4	4	0.83	0.83	0.83	0.83	0.83	0.70
Sharecrop-in land	0	0	0	0	0	0	0	0	0	0	0

Note: m and fem refer to male and female respectively. The current stage (2004/5) is not specific in that the households could be single females, single males or foster parent at the current stage.

Table 3.3 Changes in labor organization by household type and stage.

ΔLabor organization	pre-ill	illness fem	death fem	current	pre-ill	illness m	death m	re-marry	illness fem	current
1. Own farm labor in the field										
Male		0	0	+		-	-	-	-	-
Female		-	-	-		-	+	+	0	-
Child		NA	NA	NA		NA	+	+	NA	NA
2. Off-farm labor										
Male		-	-	-		-	-	-	NA	-
Female		-	NA	NA		0	+	+	+	+
Child		NA	NA	NA		NA	NA	NA	NA	NA
3. Casual labor										
Hire-out		-	+	+		0	+	+	+	+
Hire-in		0	0	0		0	+	+	+	+
4. Sharecrop farming										
Sharecrop-out land		0	0	0		+	+	+	+	+
Sharecrop-in land		0	0	0		-	-	-	-	-

ΔLabor organization	Case 3 (absent single male parent): Oli					Case 4 (both parent deceased): Sam					
	pre-ill	illness fem	death fem	illness m	current	pre-ill	illness m	death m	illness fem	death fem	current
1. Own farm in the field											
Male		-	-	-	-		-	-	-	-	-
Female		-	-	-	-		-	-	-	-	-
Child		NA	NA	NA	NA		NA	NA	NA	NA	+
2. Off-farm labor											
Male		-	+	+	+		-	-	NA	NA	NA
Female		0	NA	NA	NA		0	-	-	NA	NA
Child		NA	NA	NA	NA		NA	NA	NA	NA	0
3. Casual labor											
Hire-out		0	0	0	0		0	0	0	0	0
Hire-in		0	0	0	+		0	-	-	-	-
4. Sharecrop farming											
Sharecrop-out land		0	+	+	+		0	0	0	0	-
Sharecrop-in land		0	0	0	0		0	0	0	0	0

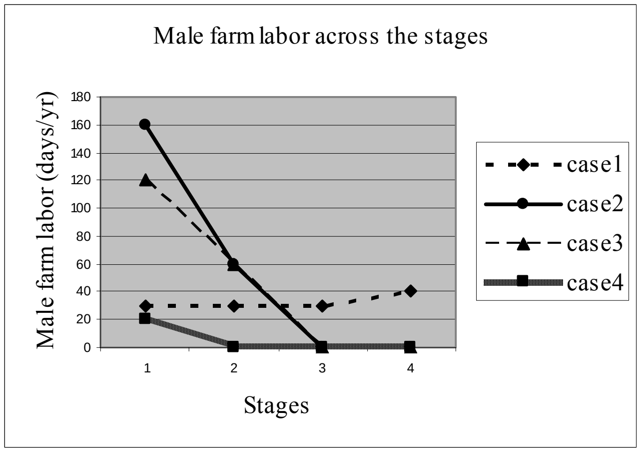
Note: m and fem refer to male and female respectively. 0,+, and - denote no change, an increase, and a decrease respectively. NA means that the criterion is not applicable to the specific family or stage. Δ stands for change. The current stage (2004/5) is not specific in that the households could be single females, single males or foster parent at the current stage. The current reduction in the size of sharecropped-out land in Sam's household is due to the reduction in total land holding. The size of sharecropped-out land as a proportion to total land holding has increased at the current stage.

Crop choice and diversity

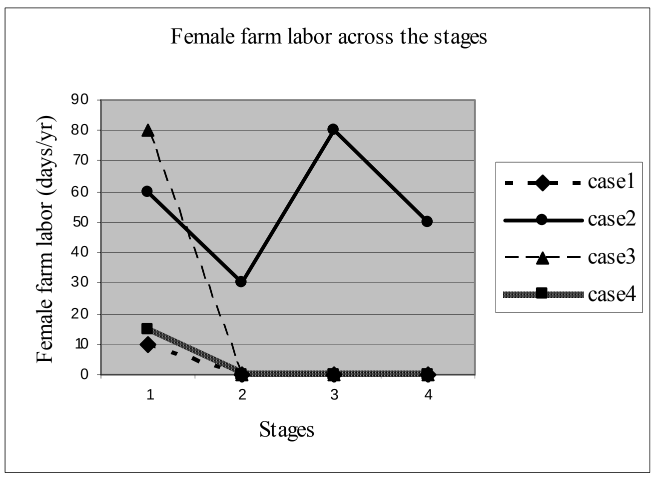
Little change has been observed in the garden of the land scarce household of Meng which includes planting of some fruit trees during his late wife's illness period (see Table 3.4). Enset planting increased in Meng's garden on existing spaces only without significantly affecting other garden crops. Since the household faced death very recently, it may be premature to talk about the responses in terms of crop choice following death. The number of crop species has slightly increased for Meng's household as the household moves from stage 1 to 2 and after which it remained the same (see Table 3.5 and Figure 3.3).

On the other hand, the number of field crop species grown did not change across the stages. Hence, the dynamics of the total number of crop species is the same as that of the dynamics in the number of garden species.

3.1a



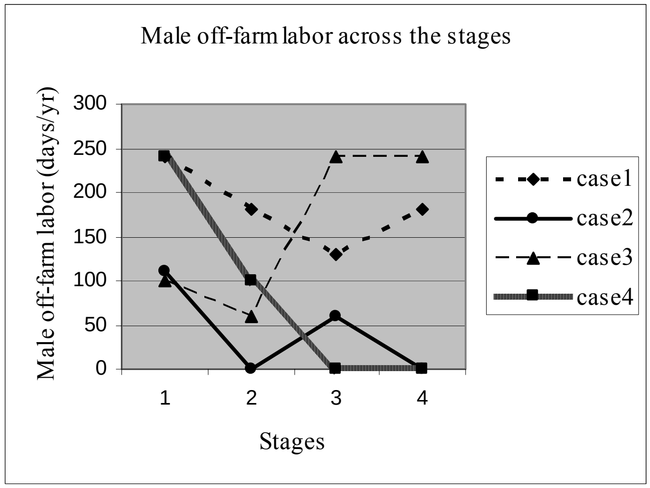
3.1b



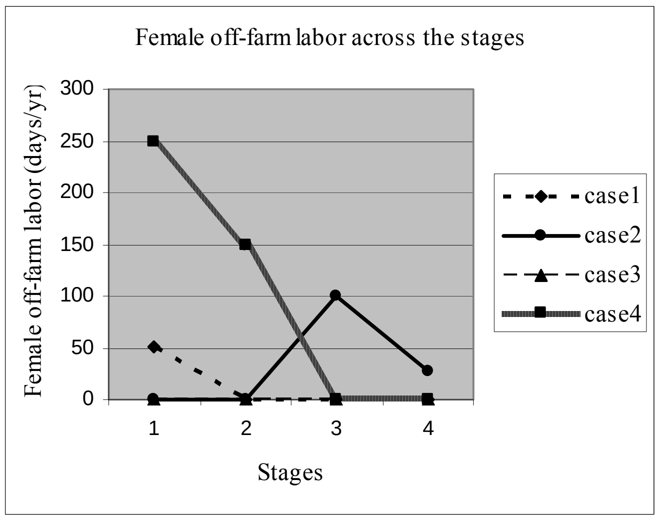
Note: Stages 1-4 in the horizontal axis represent *pre-illness, illness, death/remarriage* and *current/post-death* respectively. Points indicate stage specific allocations and the lines connecting the points are meant to help identify the case specific allocation pattern and do not imply continuity of labor allocation between any given two stages.
Note: time allocated to the fields only.

Figure 3.1 Male and female farm labor allocation across the stages, cases 1-4.

3.2a



3.2b



Note: Stages 1-4 in the horizontal axis represent *pre-illness, illness, death/remarriage* and *current/post-death* respectively. Points indicate stage specific allocations and the lines connecting the points are meant to help identify the case-specific allocation pattern and do not imply continuity of labor allocation between any given two stages.

Figure 3.2 Male and female off-farm labor allocations across the stages, cases 1-4.

Table 3.4 Land allocations to crops (ha), no. of plants (#) and quantity produced in kgs (where indicated).

Crop choice and diversity	Case1 (single male parent): Meng				Case 2 (single female parent): Kalbi					Case 3 (absent single male parent): Oli					Case 4 (both parent deceased): Sam					
	pre-ill	illness fem	death fem	current	pre-ill	illness m	death m	illness fem	current	pre-ill	illness fem	death fem	illness m	current	pre-ill	illness m	death m	illness Fem	death fem	current
1. Garden crops																				
Sugarcane	0	0	0	0	0.08	0.13	0	0	0	0.13	0.08	0	0	0	0	0	0	0	0	0
Qat	0	0	0	0	0	0	0	0	0	0.08	0.08	0.08	0.08	0.08	0.06	0.06	0.06	0.06	0.06	0.06
Maize local	0.03	0.03	0.03	0.03	0.03	0.03	0.1	0.1	0.1	0.2	0.2	0.08	0.08	0.08	0	0	0	0	0	0
Sorghum anchro	0	0	0	0	0.03	0.03	Am	Am	Am	0.05	0.05	0	0	0	0	0	0	0	0	0
H. Beans	0	0	0	0	Im	Im	Im	Im	Im	0	0	0	0	0	0	0	0	Im	0	0
Cowpeas (#)	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Taro (kg)	100	100	50	50	150	150	50	50	50	0	0	0	0	0	0	0	0	0	0	0
Yam (kg)	50	50	10	10	15	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other veg. (kg)	0	0	0	0	10	10	0	0	20	0	10	0	0	0	0	0	0	0	0	0
Enset geno (#)	2	5	9	9	60	30	10	10	13	0	40	50	53	53	0	0	0	0	0	5
Enset anchiro (#)	0	0	2	2	5	5	2	2	2	0	0	0	0	0	0	0	0	0	0	0
Enset nobo (#)	0	0	0	0	0	0	0	0	0	0	0	50	50	50	0	0	0	0	0	0
Coffee local (#)	0	0	0	0	40	40	40	40	40	50	50	50	50	50	12	12	12	12	12	12
Coffee Hyv (#)	0	0	0	0	20	20	20	20	20	0	0	0	0	0	0	0	0	0	0	0
Papaya (#)	6	6	10	10	10	10	10	10	0	2	2	14	14	14	12	12	12	12	10	2
Orange (#)	2	2	3	3	5	6	6	6	6	11	11	11	3	3	2	2	2	2	2	7
Mango (#)	0	1	1	1	3	3	3	3	3	2	2	7	7	7	1	1	1	1	1	4
Guava (#)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	5
Avocado (#)	0	0	0	0	0	0	0	0	0	0	0	4	4	4	5	5	5	5	5	1
Pineapple (#)	2	2	2	2	0	0	0	0	0	0	0	0	0	0	3	3	10	10	10	10
Banana habesha (#)	30	30	8	8	20	20	0	0	0	50	50	50	50	50	5	5	5	5	5	7
Banana Kenya (#)	0	0	0	0	20	20	0	0	0	100	100	100	100	100	0	0	0	0	0	0
Garden no. of spp.	9	10	10	10	15	15	10	10	11	9	11	10	10	10	9	9	9	9	9	10
2. Field crops																				
Maize local	0.25	0.25	0.25	0.25	0	0	0.08	0.08	0.08	0	0	0	0	0	0	0	0.31	0.31	0.31	0.31
Maize BH660	0	0	0	0	0.08	0.08	0	0	0	0.8	0.8	0.8	0.25	0.25	0.63	0.63	0.31	0.31	0.31	0.31
Maize BH140	0	0	0	0	0.07	0.07	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sorghum anchiro	0	0	0	0	0.13	0.13	0.13	0.13	0.10	0.50	0.50	0.50	0.50	0.50	am	am	am	am	am	am
H. Beans	0	0	0	0	0	0	0	0	0	Im	Im	Im	Im	Im	0	0	0	0	0	0
Teff	0	0	0	0	Dm	0	0	0	0	0.50	0.50	0.50	0.50	0.50	0	0	0	0	0	0
Pepper	0	0	0	0	0	0	0	0	0	0	0	0.25	0.25	0.25	0	0	0	0	0	0
Banana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.07	0.07	0	0	0	0
Qat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.08	0.08	0	0	0	0
Taro	0	0	0	0	0	0	0	0	0	0.2	0.2	0.2	0.12	0.12	0	0	0	0	0	0
Fallow	0	0	0	0	0	0	0	0	0	0	0	0	0.38	0.38	0	0	0	0	0	0
Field no. of spp.	1	1	1	1	2	2	2	2	2	5	5	6	6	6	3	3	1	1	1	1
Coffee	0.13	0.13	0.13	0.13	0.33	0.33	0.33	0.33	0.28	0.13	0.13	0.13	0.13	0.125	1	1	1	1	1	1

Note: m and fem stand for male and female. Am, At, As, Dm, and Im refer to the crop alternating with maize, alternating with teff, alternating with sorghum, double cropping with maize, and intercropping with maize respectively. The measures for field crops and coffee in Meng's case refer to the crops on sharecropped-in land. The re-marriage column has been left out because no change has been observed from that of the death column.

Table 3.5 Changes in crop choice and crop diversity.

ΔCrop choice	Case1 (single male parent): Meng				Case 2 (single female parent): Kalbi					
	pre-ill	illness fem	death fem	current	pre-ill	illness m	death m	Re-marry	illness fem	current
1. Garden										
No. of species		+	+	+		0	-	-	-	-
Replaced species		0	0	0		0	+	+	+	+
No. of variety		0	+	+		0	0	0	0	0
Replaced variety		0	0	0		0	0	0	0	+
2. Field										
No. of species		0	0	0		0	0	0	0	0
Replaced species		0	0	0		0	0	0	0	0
No. of variety		0	0	0		0	0	0	0	0
Replaced variety		0	0	0		0	+	+	+	+
Coffee no. of variety		+	+	+		0	0	0	0	0
Fruit planting		+	+	+		0	0	0	0	0

Crop choice	Case 3 (absent single male parent): Oli					Case 4 (both parent deceased): Sam					
	pre-ill	illness fem	death fem	illness m	current	pre-ill	illness m	death m	illness fem	death fem	current
1. Garden											
No. of species		+	+	+	+		0	0	0	0	+
Replaced species		0	+	+	+		0	0	0	0	0
No. of variety		0	0	0	0		0	0	0	0	0
Replaced variety		0	0	0	0		0	0	0	0	0
2. Field											
No. of species		0	+	+	+		0	-	-	-	-
Replaced species		0	0	+	+		0	0	0	0	0
No. of variety		0	0	0	0		0	0	0	0	0
Replaced variety		0	0	0	0		0	+	+	+	+
Coffee no. of variety		0	0	0	+		0	0	0	0	0
Fruit planting		+	+	0	+		0	+	0	0	+

Note: m and fem refer to male and female respectively. Δ denotes change. 0, +, and - denote no change, an increase, and a decrease respectively. The current stage (2004/5) is not specific in that the households could be single females, single males or foster parent at the current stage. Replaced species reflects any replacement of crop species grown; replaced variety reflects any replacement of crop variety without necessarily affecting crop species.

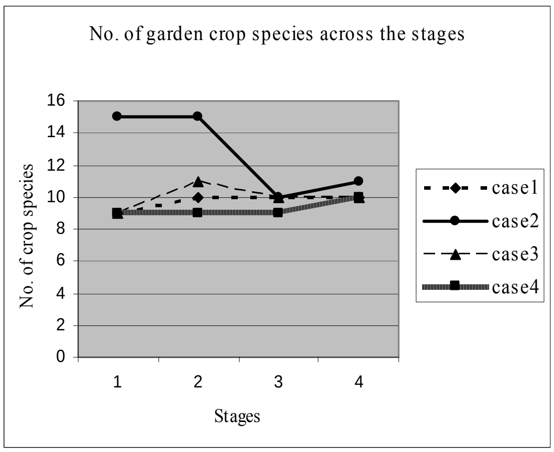
Income

Household income per capita for Meng is 60.7% higher at the current stage than the pre-illness stage. A considerable share of the gain in household income per capita is attributed to sending his children to an orphanage. Moreover, Meng's time and cash previously spent for his ill wife and children is at the current stage available for other uses. Meng is also receiving financial support from an NGO for PLWHA. Due to lack of information, the cost of taking care of Meng's children who are currently residing in an orphanage is not taken into account in the change in household income per capita. Since Meng's children are HIV/AIDS positive, we anticipate additional medical and care expenses which are covered by the orphanage house.

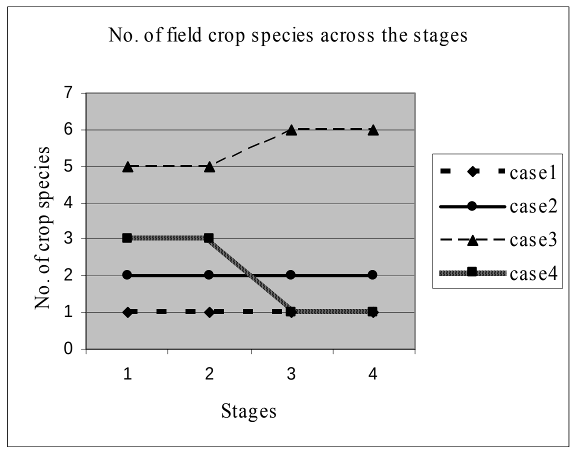
B. Case 2: Kalbi

Kalbi is 32 years old and her household is classified as a single female-headed household. Her late husband was bed-ridden for 3 months before he died of illness which lasted for a total of 5 years (see Table 3.1). She has two children (12 and 7 years) and has also lost a 2 year-old child. Kalbi is not ready to have her surviving children tested for HIV/AIDS. Household income is mainly generated from her sharecropped-out field, household and hired labor operated coffee plot, household labor operated garden, and some off-farm activities.

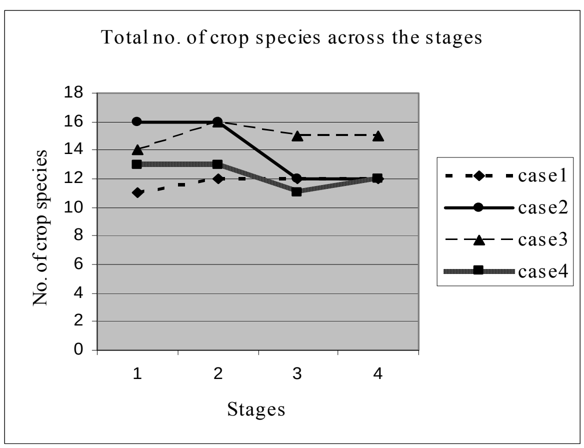
3.3a



3.3b



3.3c



Note: Stages 1-4 in the horizontal axis represent *pre-illness, illness, death* and *current/post-death* respectively. Points indicate stage specific no. of crop species and the lines connecting the points are meant to help identify the case-specific pattern and do not imply continuity of crop diversity patterns between any given two stages.

Figure 3.3 Crop diversity dynamics across the stages for the various plots, cases 1-4.

Kalbi's household exhibited a 0.08 ha reduction in land holding because of a land claim by her step daughter and a depletion of other assets through selling cattle and household items. Currently, the household receives some financial support from an NGO for PLWHA.

Labor allocations

Kalbi's household used to be labor surplus and was involved in sharecropping-in for a 50% produce share during the pre-illness stage in addition to cultivating their farm (see Table 3.2). In an attempt to mitigate farm labor scarcity following the severe illness and death of her spouse, Kalbi sharecropped-out her field plots for a 50% produce and input share contract. Male farm labor supply declined during illness until it was completely withdrawn at the death of the husband (see Table 3.3 and Figure 3.1). Increase in the demand for care during his illness also implied a decline in the amount of female farm labor supply although she managed to increase it during her early stages of single parenthood. It is, however, decreasing in the current stage as her health status deteriorates.

Her sharecropping arrangement is such that the sharecropping laborer provides his labor (including draught power) for the major operations and half of the seeds. In addition to sharing 50% of the input costs, the arrangement requires Kalbi to assist in weeding and harvesting the sharecropped plot. Although Kalbi faces labor shortage on the coffee plot as well, she considers the future risk of losing land in her decision as to whether the coffee plot should be sharecropped-out, which has implications for the children's future. Due to the associated risk of claim over the coffee land in the long run arising from its perennial nature, Kalbi decided to use hired labor for weeding and slashing of the coffee plot instead of sharecropping. An adequate amount of labor hiring could not be maintained, however, due to scarcity of cash.

The advantage of a sharecropping arrangement is that in most cases, the sharecropping laborer buys the farm inputs, mainly seeds, and Kalbi reimburses half of the input cost at harvest. In the event that Kalbi opts not to share any inputs, she gets only 33% of produce. During her illness in the production season, which is somehow recurring, her labor contribution for weeding and harvesting of fields was reduced and as a result her product share reduced to 33%. Kalbi reported increasing levels of child household labor in weeding, harvesting, crop protection, livestock herding and domestic chores currently.

Male off-farm participation started to decline at the onset of the husband's illness and Kalbi started off-farm farming after he died (see Table 3.3 and Figure 3.2). There was a slight increase in male off-farm labor supply due to remarriage for sometime after the stage of single parenthood. For Kalbi's household female off-farm participation increased during the period of single female parenthood prior to the onset of her own illness.

Finally, it is evident that Kalbi's household has transformed from a labor surplus to a labor scarce one as the household becomes increasingly dependent on sharecropping labor throughout the stages of progression of HIV/AIDS.

Crop choice and diversity

Kalbi abandoned sugarcane production in the garden since the death of her husband and replaced it by increasing the area under maize (see Table 3.4). The improved maize varieties which used to be produced in the fields before her first husband's death are now replaced by the local maize varieties. Similarly, enset and papaya declined in importance following male death, through a decrease in the number of plants. The total number of species in Kalbi's garden and overall farm is less now than during the pre-illness stage (see Table 3.5 and Figure 3.3) as her health status has been declining recently. Considering Kalbi's as the relatively most labor constrained household of the cases, her response in reducing the number of crop species in the garden indicates that maintaining or increasing diversity may be a labor demanding activity.

Income

Kalbi's household exhibited a 15.4% reduction in household income per capita in the current stage as compared to the pre-illness stage. This has happened regardless of the fact that the household has faced a two person reduction in household size and is receiving an NGO support for PLWHA in the current stage. However, household income per capita has gradually been increasing throughout the stages following male death and is about 54.7% higher now than during the stage of male illness. Overall, the shift of Kalbi's household from sharecropping-in during the pre-illness stage to sharecropping-out following the stage of illness has two employment effects with implications for income for the parties involved. First, employment has been created for the person who is cultivating Kalbi's previously sharecropped-in land as Kalbi's household shifted to sharecropping-out her own land. Second, employment has been created for the person who sharecropped-in Kalbi's own land. In the current stage Kalbi is raising and educating her children and hopes that they will take over the farming activities as they grow older.

C. Case 3: Oli

Oli is 30 year-old single father who is currently residing in town after migration following the severe illness of his late wife which lasted for 12 subsequent months before death (see Table 3.1). His household can be classified as an absentee single male parent household. He left his 5 year-old child under the guardianship of the extended household members, who moved to Oli's village home to assume responsibility for and to supervise the sharecropped-out farm of Oli. Oli's child has been tested HIV negative whereas Oli is HIV positive.

In addition to the financial support he receives from an NGO for PLWHA, Oli has in the current stage been receiving anti-retroviral treatment, which is being offered free of charge at the public hospital in Jimma town.

Labor allocations

Oli has sharecropped-out his field (see Table 3.2) regardless of his work capability because of his choice to migrate to the nearby town after knowing his HIV status. Oli thinks that productivity on his sharecropped-out farm is about 40% lower now than when his farm was cultivated by household labor. The own farm male labor supply declined in Oli's household due to parental migration (see Tables 3.3 and Figure 3.1). The casual labor demand has also increased for Oli's coffee plot since migration. Currently, Oli's off-farm participation drastically increased after his late wife's illness when he turned from a part-time to a fulltime off-farm worker (see Figure 3.2). Because of his involvement in permanent off-farm activity in town, his off-farm income as a share of the total income has increased now compared to the pre-illness stage, although the amount of income per unit of off-farm labor is lower.

Crop choice and diversity

Sugarcane disappeared in the currently absentee male-headed household of Oli whereas enset, coffee and fruit tree planting increased in his garden (see Table 3.4). Moreover, pepper was introduced in the field 3 years ago. As a result, the garden, field and total number of crop species on Oli's farm currently show a slight increase compared to the pre-illness stage (see Table 3.5 and Figure 3.3). In the field, the same varieties of crops are now being produced. During the stage of Oli's illness, his 0.375 ha plot, on which the household used to cultivate maize during the pre-illness stage, is being left fallow.

Income

Oli's household income per capita has been declining throughout the stages with a current stage household income per capita loss of 72.5% as compared to the pre-illness stage. Oli's farm has attracted new employment for the farmer who has sharecropped-in Oli's land following his wife's illness as well as for the extended family who moved in to take care of Oli's farm household. The overall change in household income per capita for the three households involved, therefore, depends on the initial income status of Oli's extended family members before they moved in to Oli's household and that of the sharecropper prior to Oli's contract for which we have no information.

D. Case 4: Sam

Sam's household contains 5 individuals and is run by fostering grandparents who joined the household since the severe illness of the late parents who both passed away within 4 months of each other. Parental death followed 6 and 8 months of subsequent illness and a total illness period of 4 and 5 years (see Table 3.1). The household faced death of a 9 year old child due to HIV/AIDS whereas the HIV/AIDS status of the surviving children is unknown. The main income is generated from the sharecropper operated field plot (see Table 3.2) as well as hired and household labor operated coffee plot (after a long period of near abandonment) and garden. Currently, Sam, as the eldest son who is now 17, has taken over considerable responsibility in household resource allocation decisions while the role of the extended household members is diminishing to domestic care giving.

The land size of the household has decreased by a total of 0.3 ha of which 0.175 ha is due to a claim from local peasant association following the death of Sam's parents and 0.125 ha is due to selling land in an effort to ease the prevailing financial constraints.

Labor allocations

For Sam's household, farm labor supply showed only little change following parental illness, as they were both involved in fulltime off-farm activities (see Table 3.3 and Figure 3.1) although the main source of income was from sharecropped-out fields and the hired labor operated coffee plot. During the current stage, child farm labor supply increased as the children are older and more able to help run their household farm.

Casual labor demand for operating the garden and coffee plots has declined due to a shortage of cash and, as a result, the coffee plot has almost been unproductive until the current stage. Shortage of cash also caused the household to sharecrop-out the part of the garden under qat in the current stage. As the gap between the male death and female severe illness was short, both female and male off-farm labor supply drastically declined following male illness (see Figure 3.2). There is a potential for additional child involvement in off-farm activities as the children grow older.

Crop choice and diversity

For Sam's household, the change in crop choice involves the introduction of enset and increased fruit tree planting (see Table 3.4) and hence an increase in crop species in the garden (see Table 3.5 and Figure 3.3) in the current stage. On the other hand, the number of species in the field declined due to loss of a part of the field through land confiscation. Thus, the total number of crop species on the farm is lower now than the pre-illness stage although it has shown a slight increase at the current stage as compared to stages 2 and 3. Moreover, the improved maize variety in the fields has been partly replaced by a local one.

Income

Sam's household income per capita has been reduced by 69.9% in the current stage as compared to the pre-illness stage. However, the current stage household income per capita is 400% higher than that at the stage of male death. In the current stage, Sam's household has substituted hired labor with sharecropper's labor as shortage of cash forced them to sharecrop-out the previously hired labor operated part of the garden under qat. If sharecropping is a more efficient organization than labor hiring, there is a net gain in overall income in the new arrangement which may offset the possible income loss by the previous hired labor who has been laid-off. The overall change in household income per capita for the three households involved depends on the income status of the foster parents prior to joining Sam's household and that of the sharecropper's for which we have no information. In the current stage, Sam's household could not afford to send two children to high school, located 14 Kms away, and as a result Sam has decided to drop out of school in order to send his younger brother to high school.

3.5 DISCUSSION AND CONCLUSION

The in-depth study results provide a detailed exposition of the labor allocation, crop choice and agrobiodiversity responses of HIV/AIDS affected households for a deeper understanding of possible variations in effects. The findings of the study on the potential effects of HIV/AIDS on labor organization, agrobiodiversity, the importance of the stages of HIV/AIDS and gender role for household responses and implications for income are presented.

ia. Labor organization: engagement in sharecropping is observed on the fields of the case households mainly as a source of replacement labor. This finding is in line with Drimie (2002) and Bishop-Sambrook et al. (2006). In our case sharecropping occurred following adult illness in the single female and absentee male headed households. Sharecropping, which was not a new phenomenon in the rest of the cases, has currently been increased in the case of the foster parent household by sharecropping-out a part of the home garden as well. Availability of sharecropping options implies that for households with land titles, a severe impact of loss of farm labor is reflected more through a reduction in income than gross production per unit of land. Lack of land titles and increased degree of confiscations following loss of adult(s) may, however, threaten the overall survival strategies. For instance, if the single female headed household of the cases did not have land title, the land confiscation she faced would mean that she would neither be able to secure a part of the land nor would she be secured enough to sharecrop-out her field. On the other hand, the observed loss of a part of the land in the foster parent household case might have occurred due to delayed transfer of land title. This has implications for the role of both facilitating land titles to the surviving household members and enhancing sharecropping. The importance of facilitating land titles to surviving members in the context of HIV/AIDS has also been discussed by Haddad and Gillespie (2001). Through increasing land access to households with higher work capability, policies of enhancing sharecropping or land rental market functioning help to prevent decline in productivity (Holden et al. 2001; Holden and Bezabih, 2006) making them more relevant under HIV/AIDS. Such policies may include strengthening land certification and provisions of clarity and/ or removing restrictions on the amount of land that can be contracted and length of contract (Deininger et al. 2007; Holden, 2008). This would contribute to increasing the options available for HIV/AIDS affected households. Facilitating legal enforcement of entitlements is also relevant to avoid unfairness in case of land confiscations reflected in the foster parent household case and the insecurity associated with sharecropping perennial plots reflected in the single female parent household case.

Off-farm participation is observed among the case households as a way of easing the cash constraint. The three single parent cases are involved in off-farm activities. This is also discussed in Loevinsohn and Gillespie (2003) where they note HIV/AIDS induces reallocation of labor towards quick return non-agricultural activities. In our case this includes a more permanent off-farm activity through migration. However, off-farm participation is not observed in the foster parent household in the case study, which may be because of lack of convenient off-farm options for the foster parents. Therefore, creating off-farm employment opportunities is among the relevant strategies to consider.

ib. Agrobiodiversity: agrobiodiversity increased in the home garden of the single male headed, single absentee male headed and foster parent households. The increase in home garden agrobiodiversity in the single male headed household case occurred without affecting crop diversity in the sharecropped-in field whereas a reduction in crop diversity in the sharecropped-out fields of the foster parent household case is accompanied by an increase in agrobiodiversity in the home garden. This results in a current stage total increase in overall farm level agrobiodiversity as compared to the pre-illness stage in the single male and single absentee male headed household cases and as compared to the stage of death in the foster parent household case. This finding is in line with Alumira et al. (2005) who found an increase in crop diversity among HIV/AIDS affected households by adding a less labor demanding crop (tomatoes) for cash income. The observed increase in agrobiodiversity in the home garden indicates a potential that can be strengthened for improving nutrition in the context of HIV/AIDS. Replacement of labor intensive crops like sugarcane by food crops following loss of the adult male has been observed as noted in Haddad and Gillespie (2001) and Yamano and Jayne (2002). A similar tendency of reducing labor demanding crops in the fields of single women is noted by Salick (1992) as a result of loss of male labor. The reduction in importance of a perennial food crop (enset) in the single female headed household case suggests that the crop cycle in the context of possible change in the decision horizon of the households may be important in crop choice decisions rather than just being a food or a cash crop.

ii. Stages and gender in household responses: the stages of HIV/AIDS manifestation and gender role of the affected member appear relevant in household responses to HIV/AIDS. The stage dynamics demonstrate varying degrees of allocation of household and replacement labor to the various activities and of crop diversity for each affected household member. The three cases who increased off-farm participation in the current stage as compared to the pre-illness stage exhibited fluctuations in allocations throughout the stages. Interaction between HIV/AIDS and gender roles in land rental decisions has been observed in the case of the single female headed household who feels insecurity over land claims from sharecropping-out her coffee plot whereas the foster parent household was secure enough to sharecrop-out the qat plot. The observed reduction in crop species diversity in the single female headed household case is in contrast to Salick (1992) who found single females increasing crop diversity in the home garden while reducing labor demanding crops in the fields. This effect may depend on the health status, degree of domestic responsibilities single female parents assume and of insecurity they face when sharecropping-out perennial crops. This suggests the importance of gender role of the affected household member in crop choice decisions. A current stage reduction in household income per capita has been observed in the single absentee male headed, single female headed and foster parent household cases as compared to the pre-illness stage. However, household income per capita has been declining throughout the stages of HIV/AIDS in the absentee single male headed household whereas it has been gradually increasing since parental death in the case of the single female headed and foster parent households. This indicates that understanding the stage and gender differentials in HIV/AIDS impact may help to understand some of the dynamic features of poverty and household adaptation strategies of relevance for policy. Moreover, efforts to impact poverty in the HIV/AIDS context need to stress stage- and gender-responsive diagnosis and response strategies.

iii. Income and children's position: changes in household income per capita and the position of children due to HIV/AIDS differ for each case household. The single female headed, foster parent and absentee male headed households exhibited a current stage reduction of household income per capita as compared to the pre-illness stage. This observation raises the question that productivity may be lower on land sharecropped-out by female headed households (Holden and Bezabih, 2008) and foster parents and that HIV/AIDS may intensify poverty (Krishna et al. 2004; 2006; Barrett et al. 2006). The loss in household income per capita in the single female headed and foster parent households is, however, partly attributable to loss of land through land confiscations. It could be said that in all the cases the possibility to engage in sharecropping has contributed to preventing further decline in household income due to HIV/AIDS. The wider economic implications of the HIV/AIDS driven adjustment in land rental contracts, particularly sharecropping, for income depends on the initial income status of the sharecroppers before engagement in sharecropping-in as well as those of the foster parents before moving in. If the sharecroppers were initially underemployed, sharecropping helps to avoid or minimize loss in income for the economy that might otherwise have occurred, the household income effect on the parties involved being mainly re-distributional. Under the case where the new sharecropping-in practice has a negative income effect on the existing or total employment, the overall income effect could be negative. Further research that explicitly accounts for the situation of both parties involved in land rental contracts and the extended household members prior to the new activity is warranted to see the overall income effect of HIV/AIDS on the economy. On the other hand, household income per capita has increased for the single male headed household in the current stage as compared to the pre-illness stage. The gain in household income per capita is attributed to the combined effect of parental death, sending children to orphanage and the increased ability to reallocate the previously care giving labor. However, due to lack of information the household income per capita estimate does not take into account the public expenditures for the children at the orphanage. The HIV/AIDS driven reduction in fertility (Young, 2005) coupled with the increase in the number of deaths observed in all the cases may in the longer run have a positive effect on per capita income for the wider economy. The long run effect of HIV/AIDS on the economy is, however, less predictable with increasing access to free antiretroviral therapy (ART) reflected in the absentee single male headed household case. With increased access to ART, the reduction in household income due to recurrent illness is partly avoided, the value of women's time may not be as high as the case without ART and children will get the chance to reach their juvenile age before their HIV/AIDS infected parents pass away. The overall income effect of HIV/AIDS for the economy will, therefore, depend on the net effect of the change in public expenditure on ART and on orphanage, the avoided income loss (current and future through children) because of use of ART and the change in fertility due to HIV/AIDS. This is left for future research. Finally, it is worth noting that as long as falling into or deepening poverty is attributable to health issues (Krishna et al. 2004; 2006; Barrett et al. 2006), poverty issues can not be addressed fully until HIV/AIDS issues are sufficiently addressed as well.

ANNEX 3A

Table 3A.1 Description of household composition.

Household composition	Case1 (single male parent): Meng				Case 2 (single female parent): Kalbi						Case 3 (absent single male parent): Oli					Case 4 (both parent deceased): Sam					
	pre-ill	illness fem	death fem	current	pre-ill	illness m	death m	re-marry	illness fem	current	pre-ill	illness fem	death fem	illness m	current	pre-ill	illness m	death m	illness fem	death fem	current
1. Period (yr)	94-6	99-04	2004	2004-5	92-94	94-99	1999	2001-2	2003-	2004-5	92-4	94-6	96	94-7	2004-5	<95	95-96	96	95-96	96	2004-5
2. Remarriage m	0	0	0	CL	1	0	NA	NA	NA	NA	1	0	0	0	CL	0	0	NA	NA	NA	NA
3. Remarriage fem	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	NA	NA
4. No. of children	0	2	2	0	2	3	3	4	3	2	0	1	1	1	1	4	4	4	4	4	3
5. Age children	NA	0.1,5	0.8, 6	0.8, 6	1, 4	2,7,12	2,7, 12	1,4,9,14	2,5, 11	7,12	0	0.6	0.6	1	7	1,4,8,9	2,5,9,10	2,5,9,10	2,5,9, 10	2,5,9,10	13,17, 18
6. Adult extended household member	0	1	1	0	0	0	0	0	0	0	0	3	3	3	3	0	0	2	2	2	2
7. Family size	2	5	4	1	4	5	4	6	5	3	2	6	5	5	5	6	6	7	7	6	5
8. Edu: no. child	NA	1	1	1	0	0	0	2	2	2	NA	NA	NA	NA	0	1	2	2	2	2	3
9. Child school dropouts	0	0	0	0	NA	0	0	0	1	0	NA	NA	NA	NA	NA	0	0	0	0	0	1
10. Migration	0	HH	0	0	0	0	0	0	0	0		1*				0	0	0	0	0	0
11. No. of children sent to orphanage	NA	0	2	NA	0						0					0					
12. Location resid.	Gomma				Gomma						Kersa					Gomma					
13. Distance from town (km)	5				13						18					14					
14. Year birth m	1975				1970						1971					1969					
15. Year birth fem	1977				1974						1976					1975					
16. Ethnicity	Dawro				Oromo						Oromo					Dawro					
17. Religion	Christian				Muslim						Muslim					Christian					
18. Education (yrs):																					
Male	8				8						8					9					
Female	4				2						5					5					

Note: HH, m and fem refer to household, male and female respectively. NA means that the criterion is not applicable to the specific household or stage. CL refers to common law partnership. *Male parent.

Table 3A.2 Household assets and endowments.

Assets	Case1 (single male parent): Meng				Case 2 (single female parent): Kalbi						Case 3 (absent single male parent): Oli					Case 4 (both parent deceased): Sam					
	pre-ill	illness fem	death fem	current	pre-ill	illness m	death m	re-marry	illness fem	current	pre-ill	illness fem	death fem	illness m	current	pre-ill	illness m	death m	illness fem	death fem	current
1. Land (ha)																					
Title holder	m	m	m	m	m1	m1	m1	m1	m1	m1	m	m	m	m	m	m	m	m	m	m	C
Garden area	0.03	0.03	0.03	0.03	0.18	0.18	0.13	0.13	0.13	0.13	0.25	0.25	0.25	0.25	0.25	0.06	0.06	0.06	0.06	0.06	0.06
Field area	0	0	0	0	0.25	0.25	0.20	0.20	0.20	0.20	4	4	4	4	4	0.80	0.80	0.80	0.80	0.63	0.63
Coffee area	0	0	0	0	0.31	0.31	0.28	0.28	0.28	0.28	0.13	0.13	0.13	0.13	0.13	1	1	1	1	1	1
Total land	0.03	0.03	0.03	0.03	0.69	0.69	0.60	0.60	0.60	0.60	4.38	4.38	4.38	4.38	4.38	1.88	1.88	1.88	1.88	1.69	1.69
Land confiscated	0	0	0	0	0	0	0.08	0.08	0.08	0	0	0	0	0	0	0	0	0	0	0.18	0
2. Livestock size																					
Poultry	15	15	11	11	27	15	6	6	4	4	0	0	10	10	10	7-10	7-10	0	0	0	0
Sheep/ or goat	5	0	2	0	0	0	0	0	0.50	1.50	9	0	0	0	0	0	0	0	0	0	0
Oxen/ or bulls	1	0	0	0	1	0	0	0	0	0	5	5	2	2	2	3	3	0	0	1	1
Cow/ or heifer	2	0	0	0	1	0	0	0	0.50	0.5	10	10	8	3	3	14	10	4	4	0	0
Donkey/ or mule	0	0	0	0	0	0	0	0	0	0	4	4	2	2	2	0	0	0	0	0	0
3. Asset selling																					
Land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.13	0
Cattle	0	4	3	0	0	1	0	0	0	0	0	10	9	2	0	0	0	4	4	1	0
Jewel	0	1	0	1	0	0	0	0	0	0	0	0	0	2	2	0	0	0	1	5	0
Utensils	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0

Note: m and fem refer to male and female respectively. m1 and C refer to the first male (in case of several husbands) and child respectively. The current stage (2004/5) is not specific in that the households could be single females, single males or foster parent at the current stage. No. of cattle sales includes all livestock sales except poultry. Where the number of cattle sales and the stock balance at each stage is not matching, multiplication of herds is involved. Case 4 faced several livestock deaths and thefts.

Table 3A.3 Income (in 100 Br/yr), medical expenses (in 100 Br/yr), net income, per capita income (in 100 Br/yr) and consumption smoothing.

Income and consumption	Case1 (single male parent): Meng				Case 2 (single female parent): Kalbi					Case 3 (absent single male parent): Oli					Case 4 (both parent deceased): Sam					
	pre-ill	illness fem	death fem	current	pre-ill	illness m	death m	illness fem	current	pre-ill	illness fem	death fem	illness m	current	pre-ill	illness m	death m	illness fem	death fem	current
1. Income																				
Farm total	10	10	10	12	33	29	12	12	14	51	45	40	35	25	70	60	30	30	25	35
Off-farm male	40	22	22	25	14	8	0	0	0	40	45	27	27	27	40	40	0	0	0	0
Off-farm female	10	0	0	0	0	0	6	2	2	0	0	0	0	0	20	10	0	0	0	0
Off-farm child	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Off-farm total	50	22	22	25	14	8	6	2	2	40	45	27	27	27	60	50	0	0	0	0
Household support	0	0	0	0	0	0	0	0	0	0	0	lb	lb	lb	0	0	0	lb	lb	lb
HIV support	0	12	12	12	0	0	0	12	12	0	0	14	14	14	0	0	0	0	0	0
Total	60	44	44	49	47	37	18	26	31	91	90	81	76	66	140	110	30	30	25	35
2. Medical expenses																				
Household	0	5	0	0.7	0	5	3	2	1.2	0	4	3.6	1	3.6	0	20	20	20	12	0
Public	0	12	0	0	0	0	0	0	0	0	0	3	22	22	0	0	5	0	0	0
3. Net income	60	39	44	48.2	47	32	15	24	29.7	91	86	77.4	75	62.4	140	90	10	10	13	35
Family size	2	5	4	1	4	5	4	6	3	2	6	5	5	5	6	6	7	7	6	5
4. Household income per capita	30	7.8	11	48.2	11.7	6.4	3.7	4	9.9	45.5	14.3	15.5	15	12.5	23.3	15	1.4	1.4	2.2	7
5. Consumption smoothing																				
Savings (Br/yr)	120	0	100	100	400	0	0	0	0	600	100	0	0	0	3000	0	0	0	0	0
Loan (Br/yr)	0	890	0	0	400	0	150	150	300	800	800	800	800	800	0	0	0	100	400	200
Interest rate (%/yr)	NA	150	NA	NA	10	NA	200	200	200	10	10	10	10	10	NA	NA	NA	150	150	150
Purpose loan	0	fd+md	0	0	I	0	fd	fd	fd	I	I	I	I	I	0	0	0	md	md	fd
Food shortage months	0	0	0	0	0	0	2.5	4	4	0	0	0	0	0	0	0	0	3	2.5	2

Note: m and fem refer to male and female respectively. fd, md, and I refer to food consumption, medical expenses, and farm inputs respectively and lb refers to labor. Current exchange rate: USD1=Br 8.6. NA means that the criterion is not applicable to the specific household or stage. Net and per capita incomes do not include medical expenses paid by the public sector. The current stage (2004/5) is not specific in that the households could be single females, single males or foster parent at the current stage.

CHAPTER 4

THE EFFECT OF HIV/AIDS DRIVEN CHANGES IN LABOR ORGANIZATION ON AGROBIODIVERSITY: AN EMPIRICAL STUDY IN ETHIOPIA

Farm households with HIV/AIDS affected adult members observe a decrease in labor supply and productivity causing them to reallocate labor. The reallocation of labor may result in a change in agrobiodiversity. Sharecropping is often used to alleviate labor shortage in agricultural production. The purpose of this paper is to analyze the implications of HIV/AIDS on agrobiodiversity through sharecropping arrangements. It also looks into possible direct effect of adult morbidity and mortality on agrobiodiversity. The study is based on a survey among 205 farm households in the Jimma zone of Southwest Ethiopia. The analysis accounts for the potential endogeneity of the variables sharecropping, labor hiring and male morbidity to agrobiodiversity decision. Results show that the share of sharecropped-out land increases among households that are affected by male mortality and increased degree of male morbidity. Results further show that a HIV/AIDS-driven increase in sharecropping has a positive effect on agrobiodiversity in the home garden. However, no direct effect of male morbidity and mortality on agrobiodiversity has been confirmed by the data. This suggests that the change in agrobiodiversity among HIV/AIDS affected households is more driven by the change in labor organization than directly through change in preference for diversity. Since agrobiodiversity is claimed to contribute to farm household nutrition, our finding offers additional intervention options to mitigate the impact of HIV/AIDS among farm households.

Key words: *agrobiodiversity; Ethiopia; HIV/AIDS; labor organization; sharecropping.*

4.1 INTRODUCTION

HIV/AIDS affects farm households in various ways. Two forces that explain the interplay between HIV/AIDS, labor organization and nutrition make the rationale for the study. Firstly, an increase in agrobiodiversity by improving nutrition (Johns, 2003; Gari, 2003, 2004; Johns and Eyzaguirre, 2006) contributes to HIV/AIDS mitigation (e.g. Haddad and Gillespie, 2001; FAO/WHO, 2002; Castleman et al. 2004; Fawzi et al. 2004; Gillespie and Kadiyala, 2005; Stillwaggon, 2006). The claim on the role of agrobiodiversity for improving dietary diversity and nutrition seems relevant in the context of subsistence farm households whose own production constitutes a substantial share of their consumption. This, however, neither states agrobiodiversity on the farm as the only source of farm household health nor does it presume farm household awareness of the health benefits of agrobiodiversity. Although the claim on the nutritional role of agrobiodiversity is debatable, given lack of empirical testing of the claim, it is worthwhile analyzing how HIV/AIDS is affecting agrobiodiversity itself[10].

Secondly, HIV/AIDS reduces labor supply (Barnett and Whiteside, 2002; Drimie, 2002; Loevinsohn and Gillespie, 2003; Gillespie and Kadiyala, 2005) whereas increasing agrobiodiversity is labor-intensive (Nair, 2001; Mendez et al. 2001). As a result, HIV/AIDS may negatively affect agrobiodiversity. Depending on the availability of replacement labor for cultivating the laborious field activities, labor allocated to the home garden may increase with increasing loss of adult labor which may lead to increase in agrobiodiversity.

The purpose of the chapter is to test the effect of HIV/AIDS-driven change in labor organization on home garden agrobiodiversity among farm households in Ethiopia. Underlying this: the premise that agrobiodiversity is potentially good to mitigate the negative effects of HIV/AIDS through improving nutrition does not necessarily imply that the pressure of HIV/AIDS causes the households to adjust agrobiodiversity in the desired way. This may be either because of lack of awareness or because such households may find it more beneficial to address other issues than attending to household nutrition through managing agrobiodiversity. For instance, HIV/AIDS- affected households are forced to shift crop choice towards less labor-intensive crops (e.g. Haddad and Gillespie, 2001) as they also increase labor

[10] It could also be that the crop diversity that the farm households choose may not be beneficial for health in the HIV/AIDS context. Even then, testing the significance of labor organization for agrobiodiversity helps to identify strategies for adjusting crop mix in a way to increase health benefits for the households.

allocation towards quick cash-generating non-agricultural activities (e.g. Loevinsohn and Gillespie, 2003; Bishop-Sambrook et al. 2006). However, the chapter neither aims at assessing the nutritional deficiencies of HIV/AIDS affected households nor at measuring the extent to which the home gardens and their fields produce the crops that are particularly needed by the AIDS sick and other family members.

The theoretical analysis in Chapter 2 shows that, through reducing labor productivity, HIV/AIDS causes an increase in sharecropping in the field and agrobiodiversity in the home garden. In this chapter, we empirically test for the significance of the effect when other variables are controlled for by estimating home garden agrobiodiversity equation. Estimation involves regression of agrobiodiversity index on variables capturing labor organization and health status and variables controlling other factors explaining agrobiodiversity; whereby the potential endogeneity of labor organization and illness variables is accounted for through a first stage estimation of their respective reduced form equations. Data for estimation was collected through a survey conducted on 205 farm households in Gomma and Kersa woredas of the Southwest Ethiopia in 2005.

The paper is organized in such a way that the next section lays out the hypotheses for testing in the light of the research questions. A section describing the method of analysis follows the section on the description of data and variables. A discussion of the results is followed by the last section presenting the conclusions.

4.2 METHOD

4.2.1 The model

The farm household is assumed to have the option of replacing its own farm labor through an increase in sharecropping or hiring casual labor each involving varying transaction costs. In addition, the household has access to off-farm opportunities. In our analysis, household utility is a function of consumption of home garden and field products where the field products represent market products consumed. Household utility maximization involves decisions on the allocation of household labor to the home garden and fields and the amount of external labor use. The objective in this chapter is to estimate the effect of HIV/AIDS-driven labor organization on agrobiodiversity. The agrobiodiversity decision is hypothesized to be jointly determined with the labor organization (sharecropping and labor hiring) decisions. Due to lack of detailed data to estimate utility functions, and thus the structural model capturing both production and consumption decisions, we employ a reduced form model. The standard system of equations (Smith and Blundell, 1986) for estimating the labor organization and crop diversity equations is given by

$$L = \theta z + u \qquad (4.1)$$

$$D = \beta x + \mu L + e$$

where L is a vector of indicators for sharecropping, labor hiring and male illness; D is the home garden crop diversity index which is censored at zero; z is a vector of health and other (weakly) exogenous variables with a corresponding parameter vector θ; and x is a vector of (weakly) exogenous variables with a corresponding parameter vector β. The parameters, μ, measure the effect of the endogenous labor variables on home garden crop diversity; u and e are the error terms. Whether the estimation should take into account simultaneity of the labor organization and illness decisions and home garden crop diversity decisions depends on whether farmers take the desired home garden crop diversity into account in making labor organization decisions and/ or whether illness is influenced by the crop diversity in the home garden. It is also possible that both decisions may be based on some of the same unobservable variables such as the already available labor contract, and previous crop diversity, or knowledge of labor saving arrangements or input uses in the field that at the same time may increase crop diversity in the home garden. These conditions lead to the correlation between the disturbances of the two equations given in (4.1) the estimates inconsistent. This requires estimation techniques that take into account endogeneity. The simultaneous equation model that takes into account possible endogeneity of the variables represented in L on crop diversity decisions can be derived by writing e_i conditional on u_i (Smith and Blundell, 1986) as $e = hu + v$ where h is a parameter and v is a new error term. This is given by

$$L = \theta z + u \qquad (4.2)$$

$$D = \beta x + \mu L + hu + v$$

Empirical model

In order to account for the potential endogeneity of L and censoring of D, we employed the instrumental variable technique to estimate the total crop diversity equation in a more generalized tobit (Heckman

(1979)) model. The technique also allows us to take care of censoring of the endogenous regressors given by vector L and allows for differences in parameters in the equations for the degree of and participation in crop diversity.

The estimation has been conducted in three steps. In the first step, each of the three censored endogenous variables denoted by, L, are regressed on a set of (weakly) exogenous variables by using a tobit model as suggested in Vella (1993). The simple tobit models for the unobserved (latent) variable, L^*_{ji}, which is assumed to be a linear function of a number of (weakly) exogenous explanatory variables (Smith and Blundell, 1986; Verbeek, 2004) is given by

$$L^*_{ji} = \theta_j{}' z_{ji} + u_{ji} \tag{4.3}$$

where j denotes the equation corresponding to each variables representing sharecropping, labor hiring and illness for household $i = 1,...,N$; the error term $u_j \sim (0, \sigma^2)$, z is a vector of explanatory variables with a corresponding parameter vector θ'; and L_{ji} is the observed labor organization given by

$$L_{ji} = L^*_{ji} \text{ if } L^*_{ji} > 0 ; \; j = 1,2,3 \tag{4.4}$$

$$L_{ji} = 0 \text{ if } L^*_{ji} \leq 0 ; \; j = 1,2,3$$

The estimated reduced form Tobit equation obtained based on (4.4) expresses each of the censored endogenous variables L_j in terms of a set of (weakly) exogenous variables**.** Estimation of (4.4) is conducted by allowing for differences in the number of variables included in z for each equation. Because the latent variables L^*_j is not observed, actual estimation takes observed values, L_j.

The second step involves calculation of the generalized residuals given by $\tilde{u}_{ji}$ corresponding to the OLS residuals $\hat{u}_{ji}$ in (4.3) based on the procedure suggested in Vella (1993), i.e.

$$\tilde{u}_{ji} = E\left(u_{ji} \middle| L_{ji}\right) = -\hat{\sigma}_{u_j}\left(1 - I_{ji}\right)\hat{\phi}_{ji}\left(1 - \hat{\Phi}_{ji}\right)^{-1} + I_i \hat{u}_{ji} \tag{4.5}$$

$$E\left(e_i \middle| L_{ji}\right) = h_j \tilde{u}_{ji}$$

Where $\hat{\sigma}_u$ is the Tobit maximum likelihood estimate of σ_{u_j}; $\hat{\phi}$ and $\hat{\Phi}$ are evaluated at the points $\hat{\theta}_j'$ and z_{ji}; $\hat{u}_{ji} = L_{ji} - \hat{\theta}_j' z_{ji}$ and I_i is an indicator function taking the value of one if L_{ji} is uncensored and zero otherwise. This implies that $\tilde{u}_{ji} = \hat{u}_{ji}$ when $L_{ji} > 0$. Accordingly, testing for endogeneity involves testing the significance of the estimated parameter of $\tilde{u}_j$ as the corresponding parameter estimate captures the dependence between the structural equation error and the reduced form equation errors. This enables conducting post-estimation test for endogeneity of each variable contained in L. The third step concerns estimation of an instrumental variable Heckman model for crop diversity equations by including the generalized residuals, $\tilde{u}_j$, obtained in step two and the observed L_j as regressors (Smith, 1987; Vella, 1993; Klemick and Lichtenberg, 2008). The reduced form Heckman model for empirical estimation consists of the selection equation given by

$$y_i^* = \Omega' \tilde{x}_i + \psi_1 L_{1i} + \psi_2 L_{2i} + \psi_3 L_{3i} + \varpi_1 \tilde{u}_{1i} + \varpi_2 \tilde{u}_{2i} + \varpi_3 \tilde{u}_{3i} + w_i \tag{4.6}$$

and the equation of interest given by

$$D_i = \beta' x_i + \mu_1 L_{1i} + \mu_2 L_{2i} + \mu_3 L_{3i} + h_1 \tilde{u}_{1i} + h_2 \tilde{u}_{2i} + h_3 \tilde{u}_{3i} + v_i \tag{4.7}$$

where L_1, L_2 and L_3, denote sharecropping, labor hiring and illness; y_i^* is unobserved latent variable that denotes the probability of having agrobiodiversity in the home garden for household, i. The observed probability of having agrobiodiversity, y_i, takes only two values such that $y_i = 1$ when $y_i^* > 0$ and $y_i = 0$ when $y_i^* \leq 0$. D_i is the observed level of agrobiodiversity index for household, i, and is observed only when $y_i > 0$. $\tilde{x}_i$ and x_i are vectors of other (weakly) exogenous variables affecting participation in and degree of agrobiodiversity with a corresponding parameter vector Ω and β for each equation respectively. $\psi_1, \psi_2, \psi_3, \varpi_1, \varpi_2$ and ϖ_3 are parameters corresponding to $L_1, L_2, L_3, \tilde{u}_1, \tilde{u}_2$ and $\tilde{u}_3$ in the participation equation respectively; and $\mu_1, \mu_2, \mu_3, h_1, h_2$ and h_3 are parameters corresponding to L_1, L_2, L_3, $\tilde{u}_1, \tilde{u}_2$ and $\tilde{u}_3$ in the degree of agrobiodiversity equation respectively. The error terms w_i and v_i are assumed to be normally distributed with $\text{var}(w_i) = 1$, $\text{var}(v_i) = \sigma^2$ and $\text{cov}(w_i, v_i) = \rho_2$. Equation (4.7) provides estimates of the effect of sharecropping, labor hiring and illness on crop diversity. The significance of parameters h_1, h_2 and h_3 indicates whether their corresponding variables are endogenous to the crop diversity decision. The vector of regressors, z, in (4.3) includes additional instruments for L_j as regressors which are not included in x in (4.7). These instruments are assumed to be highly correlated with L_j but not with v_i. The instrument that is expected to be highly correlated with the degree of sharecropping is whether or not the household owns oxen. The instruments which are expected to be highly correlated with the degree of labor hiring are whether or not the household owns an iron-roofed house and whether or not the household bought jewelry in the past years. The vector of regressors, x, in (4.7) represent socio-economic characteristics of the households including education, family composition, age, assets, off-farm and transfer income and indicators for adult morbidity and mortality. In the theoretical analysis in Chapter 2, a unitary household model is employed. In this chapter, however, we would like to allow for possible differential effects of male and female resource endowments pertaining to education and transfer income.

4.2.2 Measuring agrobiodiversity: which plots and crops?

In the study area, the household is unlikely to change crop species and agrobiodiversity in fields because of customary rules and the availability of sharecropping options (Gebreselassie et al. 2007). In the event that the household needs to adjust crop choice and diversity, home gardens provide more room for flexibility. We, therefore, focus on home gardens as the relevant plots to analyze the implications of HIV/AIDS driven changes in labor organization on crop choice and agrobiodiversity.

Two problems were encountered in applying equation (4.2), namely, (i) observing HIV/AIDS and (ii) measuring agrobiodiversity. The problem of observing HIV/AIDS among the households arises from either not knowing about, or a reluctance to declare, one's HIV/AIDS positive status. The problem of measuring agrobiodiversity includes whether to focus on relative abundance or taxonomic distinctiveness, the variation of agrobiodiversity indices with the degree of sensitivity of the measures to rare species (scale parameter), and measuring agrobiodiversity for crops with different measures of relative abundance.

The problem of observing HIV/AIDS is commonly addressed by using either duration of illness (e.g. Donovan et al. 2003; Stokes, 2003) or TB infection which is strongly associated with AIDS (e.g. Corbett et al. 2003). We opted for adult mortality and morbidity as proxy indicators for HIV/AIDS. For biodiversity, the question of whether to focus on relative abundance or taxonomic distinctiveness of species is addressed by employing the diversity index that combines both as suggested by Weikard et al. (2006) (WPW). Although the diversity index is not made for a nutritional analysis, accounting for the taxonomic distance of the crops makes the diversity index more relevant for nutritional interest than accounting for the number of species only. For instance, the diversity index employed allows two cereal crops to have closer taxonomic distance from each other than from vegetables resulting in a lower diversity index which is also reasonable from a nutritional perspective. To minimize the influence of variability of the diversity measure to the selected scale parameter, a diversity profile is employed instead of a single parameter based index (Tóthmérész, 1995). Accordingly, the diversity index is calculated for scale parameters ranging from 1-15. Based on WPW diversity index, $D_i^r(n)$, for a set of species, n, for household, i, and a scale parameter, r, is given by[11]

$$D_i^r(n) = \sum_{l \in n} \tilde{d}_{l,i} \left(1 - \left(1 - m_{l,i}\right)^r\right) \tag{4.8}$$

where k_l is the relative abundance of species l with $\sum_{l \in S} m_{l,i} = 1$, and $r \geq 1$ is a parameter determining the sensitivity of the measure to rare species. The weight is calculated as:

$$\tilde{d}_{l,i} = \sum_{o \in l} \tilde{d}_{lo,i} \ , \tag{4.9}$$

where $\tilde{d}_{l,i}$ is the aggregate taxonomic distance defined for species l and household i and $\tilde{d}_{lo}$ is the taxonomic distance between species l and o grown by the household, and $\tilde{d}_{ll} = 0$. Following Ricotta (2004), a taxonomic distance of 1 is given if two species share the same genus; 2 if they share only the same family; 3 if they share only the same order; 4 if they share only the same class, and 5 if they share only the same kingdom. The taxonomic distance of the crops found in the home garden is given in Table 4A.1 in Annex 4A. The index is constructed in such a way that higher values indicate a higher degree of diversity. We calculated relative abundance as follows:

$$m_{l,i} = \frac{C_{l,i}}{\sum_{l \in S} C_{l,i}} \tag{4.10}$$

where C measures area allocation or plant head count depending on the crop category. We followed different approaches in calculating m for annual and perennial crops in (4.10). For annual crops, m is constructed based on area allocation because data was available in terms of area. For perennial crops, m is constructed based on plant head counts because of the difficulty of assigning areas to perennial plants

[11] Originally given in a slightly different notation and modified for the purpose of consistency in this thesis.

some of which are spread out in the garden. In both cases, average agrobiodiversity index per household is employed in econometric estimation. The overall agrobiodiversity index is constructed as a weighted average of annual and perennial diversity indices by assigning equal weights.

4.3 DATA

4.3.1 Sources of data

The variables used in the analysis were constructed from data collected from a sample survey conducted in two woredas namely, Gomma and Kersa in the Jimma zone of Southwest Ethiopia. HIV prevalence rate in the rural parts of the zone is estimated at 8.9% as compared to 7% in the urban part (Belachew et al. 2003). Because of higher seasonal labor migration, the coffee growing Gomma woreda is characterized by high HIV prevalence rate among the 13 woredas of the zone and, although official rates are unavailable, Gomma woreda is expected to have a higher HIV/AIDS prevalence rate than the zonal average. A total of 205 farm households were selected from Gomma and Kersa woredas of which 160 were randomly selected from each woreda independently and 45 were included purposively because the respondents are known to be TB positive. A small sample of 28 households was taken from Kersa woreda to capture possible location variations although the focus is on Gomma woreda. This resulted in 86% of the sample households representing Gomma woreda. The farmers specializing only in coffee are excluded from the sampling frame because the focus is on analyzing labor organization and agrobiodiversity conditional on the fact that the farm households grow diverse crops in the field and home garden.

Quantitative and qualitative data are generated for describing annual agricultural production practices, crop diversity, labor and other resource allocations and household characteristics. Home garden, field, and coffee plots constitute the main plots of the households in the area. The main crops grown in the home garden include perennials like enset, coffee, fruit trees (orange, mango, papaya, banana, avocado, guava, and pineapple), sugarcane, qat; annuals like maize, haricot beans, and roots and vegetables (taro, yam, kale, pepper, and cabbage). Households may have several field plots that are mainly used for growing cereals such as maize, sorghum, beans and teff.

A standardized survey instrument was used to collect data representing the production period 2004/5. Pretest versions were modified to enhance the validity and reliability of responses. Questions were peer reviewed for technical accuracy and face-to-face interviews were employed in completing the questionnaire. Field visits to the area and informal discussion with key informants helped to generate important qualitative information to complement the survey data. Other information necessary in the course of primary data collection and analysis were obtained from secondary sources.

4.3.2 Variables and hypotheses

Tables 4.1 and 4.2 present a summary and descriptive statistics of the explained and explanatory variables considered in the econometric estimation.

Explained variable

The dependent variable is total agrobiodiversity index, *D*, which is a constructed as a weighted average of perennial and annual crop diversity indices. Average perennial and annual agrobiodiversity indices for the sample households are 95.25 and 51.94 respectively (see Table 4.1). Agrobiodiversity index is censored at zero (constituting 5.5% of the sample) because some of the households do not have a home garden. The ornamental plants-taxonomic distance-nutrition link could be misleading as it may imply that the larger taxonomic distance between ornamental plants and edible crops gives higher diversity and hence higher nutritional effect. However, apart from Eucalyptus and Tobacco found only in gardens of 1.95% and 0.49% of the sample households, the rest of the crops included in the agrobiodiversity index are edible ones. Annual crop diversity has the potential to change year by year. Annual change in annual crop diversity would allow annual change in perennial crop diversity at least on relative abundance basis which both affect total agrobiodiversity. If annual crop diversity changes as quickly as change in labor allocation (e.g. labor hiring), it may cause total agrobiodiversity to change as well and hence possibly be correlated with unobserved heterogeneity affecting labor hiring. However, potential rigidity due to perennial crop diversity may delay the change in total agrobiodiversity. We account for the potential rigidity of total agrobiodiversity by including the area under perennial crops in the model.

Table 4.1 Household agrobiodiversity index by labor organization category.

Agrobiodiversity in the home garden	Number of households (total sample = 205)			Households who sharecrop-out land (total = 61)			Households who hire-in labor (total = 59)		
	N	% Total sample	Mean agro-biodiversity index	N	% Share-croppers	Mean agro-biodiversity index	N	% Share-croppers	Mean agro-biodiversity index
Perennial crops	173	84.39	112.87	52	85.24	125.91	42	71.19	109.29
Annual crops	138	67.32	77.17	42	68.85	82.38	33	55.93	77.84
All crops	194	94.63	97.03	55	90.16	108.93	52	88.13	94.47

Note: N stands for number of households. Mean agrobiodiversity is calculated over N in each category.

Explanatory variables and hypothesized effects

The explanatory variable for empirical testing is the share of area sharecropped-out (*percsharearea*) measured in proportion to total land. The degree of labor hiring (*hireinintensity*), measured in proportion to total labor days in the field, is included to control for the effect of an alternative labor organization on agrobiodiversity.

Other continuous and dummy variables are included to control for the effect of household specific characteristics. Continuous variables are average age of parents (*avgage*); formal education level of adult male and female household members (*edum, eduf*); home garden and total land size (*gardensz*, *totld*); off-farm income (*offfarminc*) measured in Birr per year; transfer income of household members (*transferm*, *transferf*) measured in Birr per year; number of children 5 years-old and below (*childunder5*); and number of children 15 years-old and above (*childabove15*); indicator for degree of male illness (*durillm*) measured as the number of male illness days as a proportion of household potential labor endowment. The variable *perenarea*, which measures the area under perennial crops in the home garden in fechassa, is introduced to allow for the relative rigidity of the perennial crop diversity in the total agrobiodiversity estimation.

Dummy variables include being single female and male (*singlef*, *singlem*); Single male older than 50 (*singlem50*); location (*location*); obtaining credit (*credit*); increase in livestock holding over the past 5 years (*TLUincrease*) which is constructed from livestock holding measured in composite standard total livestock unit (TLU); attending informal agricultural education by household members during the year (*agredum*, *agreduf*); lack of oxen (*nooxen*), purchase of jewelry in the past 5 years (*boughtjewels*) and type of housing (*houseironrf*). Total land holding and increase in TLU are included because Benin et al. (2006) found these variables to have significant effects on intercrop diversity of cereals in Northern Ethiopia.

Table 4.2 Description of variables included in estimation.

Variable	Variable name	Unit/index	Mean	Standard deviation
I. Explained				
Total crop diversity	D	Aggregate WPW index	91.82	38.45
II. Explanatory				
Male mortality	*singlef*	1=single female headed; 0=otherwise	0.21	0.41
Male morbidity	*Durillm*	No. of male illness days per potential farm labor days	0.23	0.02
Single male	*Singlem*	1=single male headed; 0=otherwise	0.09	0.28
Average age	*avgage*	Number of years	42.32	13.38
Male parent above 50 years old	*singlem50*	1= male heads with age above 50; 0=otherwise	0.33	0.58
Female education	*eduf*	Years of formal schooling	1.35	2.28
Male education	*Edum*	Years of formal schooling	2.09	3.18
No. of children<5	*childunder5*	No. children under 5 years	0.75	0.91
No. of children>15	*childabove15*	No. children above 15 years	0.54	0.49
Share of area sharecropped-out	*percsharearea*	Area sharecropped-out/fechassa holding	0.14	0.26
Hire-in labor	*hireinintensity*	Hired-in labor days/total farm labor days	0.07	0.01
Off-farm income	*offfarminc*	Birr/year	583.01	1392.98
Transfer income male	*transferm*	Birr/year	81.29	324.11
Transfer income female	*transferf*	Birr/year	25.21	137.11
Agricultural training female over the past year	*agreduf*	1=female had training; 0=otherwise	0.17	0.37
Agricultural training male over the past year	*agredum*	1=male had training; 0=otherwise	0.12	0.33
Garden size	*gardensz*	fechassa	0.61	0.66
Garden perennial area	*perenarea*	fechassa	0.33	0.58
Land holding	*totld*	fechassa	3.91	3.25
TLU increase past 5 years	*TLUincrease*	1=increase; 0=otherwise	0.28	0.45
Lack of oxen	*nooxen*	1=do not own; 0=otherwise	0.61	0.03
Credit obtained past year	*credit*	1=obtained; 0=otherwise	0.28	0.45
Iron-roofed house	*houseironrf*	1=have; 0=otherwise	0.45	0.49
Jewelry purchase	*boughtjewels*	1=purchased jewelry in the past 5 years; 0=otherwise	0.04	0.01
Location	*location*	1=Gomma; 0=Kersa	0.86	0.34

Note: Exchange rate during the field period was Br1=USD8.6; 1 fechassa=0.25 ha. Potential farm labor days accounts for total illness days and farm labor days but not off-farm labor days.

Hypothesis 1: HIV/AIDS affectd households have a higher agrobiodiversity index than non-affected ones, ceteris paribus

This hypothesis is established based on two expectations. First, we expect that sharecropping-out a larger share of the field has a positive effect on agrobiodiversity in the home garden. This is because increased share of sharecropping-out fields is expected to release household labor from fields for increased home garden activities. Second, we expect that sharecropping-out share increases among households who are affected by adult morbidity and mortality which again will be tested for. Although some authors consider sharecropping as being an inefficient institution (Stiglitz, 1974; Chew, 1997; Federico, 2006), our expectation that HIV/AIDS increases sharecropping-out is based on the negative productivity effect of poor health (Schultz and Tansel, 1997; Fox et al. 2004; Hawkes and Ruel, 2006). We expect engagement in sharecropping is preferred over employment of hired labor as it provides better incentives to increase productivity implying less demand for supervision time (Ellis, 1993; Beckmann and Wesseler, 2003). Additionally, sharecropping assists in easing cash constraint by deferring payment for labor and possibly other farm inputs. To the extent that sharecropping-out eases the cash constraint, households who sharecrop-out more are likely, *ceteris paribus*, to increase labor supply to the home garden rather than to off-farm activities.

Table 4.1 shows the average perennial, annual and overall agrobiodiversity index among households who are engaged in sharecropping and hiring-in labor. Among households who sharecrop-out land, 85.2% grow perennial crops, 68.8% grow annual crops and 90.2% grow perennial, annual or both crops in the home garden. About 30% of the sample households sharecrop-out land and average share of sharecropping-out for the sample households is 0.14 fechassa (see Tables 4.2 and 4.3). Of the households who sharecrop-out land, 22.9% reported adult male illness (either single male (9.8%) or two-parent (13.1%)), 24.6% reported adult female illness (either single female (18.0%) or two-parent (6.6%)) and 6.6% reported illness of both parents. 19.7% of the households who sharecrop-out land are single male while 32.8% of them are single female headed. Overall, 54.1% of those who sharecrop-out reported illness of at least one parent and 26.2% of them reported death of at least one parent and the remaining 19.7% reported neither illness nor death. This indicates that 80.3% of the sharecropping-out practice is observed among households with adult illness, death or both.

Hypothesis 2: An increase in hired labor intensity by HIV/AIDS affected households has a negative effect, ceteris paribus, on agrobiodiversity in the home garden

As an additional or substitute option to sharecropping-out land, HIV/AIDS affected farm households can hire-in additional labor to compensate for effective labor loss. Due to higher demand for supervision time for hired-in labor in comparison to sharecropping-out because of differences in incentives between sharecroppers and hired labor (Ellis, 1993; Beckmann, 2000), we expect that, *ceteris paribus*, HIV/AIDS affected households that increase labor hiring in the field can transfer less labor to the home garden than those that increase sharecropping-out. If the productivity of supervision time remains constant after HIV/AIDS, households that increase labor hiring in the field are likely to increase their supervision time which may negatively affect labor allocation and agrobiodiversity in the homegarden.

Table 4.3 Sharecropping-out land and hiring-in labor by marital status, health status, off-farm participation and household location.

Category	N	%	Sample households who sharecrop-out land				Sample households who hire-in casual labor			
			n	% within group	% of total sample	% of share cropping-out	n	% within group	% of total sample	% of hire-in
Marital status										
Single male	18	8.8	12	66.7	5.8	19.7	6	33.3	2.9	10.2
Single female	43	20.9	20	46.5	9.8	32.8	12	27.9	5.8	20.3
2-parent	141	68.8	28	19.8	13.6	45.9	40	28.4	19.5	67.8
No parent	3	1.5	1	33.3	0.5	1.6	1	33.3	0.5	1.7
Total	205	100.0	61		29.7	100.0	59		28.8	100.0
Health status of adults										
A. Illness (>30 days)										
Single male	9	4.4	6	66.7	2.9	9.8	3	33.3	1.5	5.1
Single female	20	9.7	11	55.0	5.4	18.0	5	25.0	2.4	8.5
2-parent m	40	19.5	8	20.0	3.9	13.1	12	30.0	5.8	20.3
2-parent f	26	12.7	4	15.4	1.9	6.6	8	30.8	3.9	13.5
2-parent both	17	8.3	4	23.5	1.9	6.6	6	35.3	2.9	10.2
Total	112	54.6	33	29.5	16.0	54.1	34	30.3	16.6	57.6
B. No illness										
Singe male	9	4.4	6	66.7	2.9	9.8	3	33.3	1.5	5.1
Single female	23	11.2	9	39.1	4.4	14.7	7	30.4	3.4	11.9
2-parent	58	28.3	12	20.7	5.9	19.7	14	24.1	6.8	23.7
No parent	3	1.5	1	33.3	0.5	1.6	1	33.3	0.5	1.7
Total	93	45.4	28	30.1	13.7	45.9	25	26.9	12.2	42.4
Total	205	100.0	61	29.7	29.7	100.0	59	28.8	28.8	100.0
Total illness	112	54.6	33	29.5	16.0	54.1	34	30.3	16.6	57.6
Total death	35	17.1	16	45.7	7.8	26.2	11	31.4	5.4	18.6
Illness + death	147	71.7	49	33.3	23.9	80.3	45	30.6	21.9	76.3
No illness, no death	58	28.3	12	20.7	5.8	19.7	14	24.1	6.8	23.7
Off-farm participation										
No off-farm	121	59.0	39	32.2	19.0	63.9	33	28.2	16.1	55.9
Off-farm	84	41.0	22	26.2	10.6	36.1	26	29.5	12.7	44.1
Total	205	100.0	61		29.6	100.0	59		28.8	100
Location										
Gomma	177	86.3	52	29.4	25.3	85.2	56	31.6	27.3	94.9
Kersa	28	13.7	9	32.1	4.3	14.8	3	10.7	1.5	5.1
Total	205	100.0	61		29.6	100.0	59		28.8	100.0

Note: n denotes the number of households who are involved in the particular activity.

Table 4.1 shows that among households who hire-in labor, 71.2% grow perennial crops, 55.9% grow annual crops and 88.1% grow one or the other or both in the home garden. Average perennial, annual, and overall agrobiodiversity among households who hire-in labor is 77.8, 43.5 and 83.3 respectively. About

29% of the sample households hire-in casual labor and the average hired-in casual labor is 0.07 labor day per total farm days per year (see Tables 4.2 and 4.3).

Hypothesis 3: Agricultural education contributes to increasing agrobiodiversity

It is expected that special agricultural education for adults is target oriented and increases exchange of planting material and information among farmers that enhances agrobiodiversity. Hence, female and male participation in agricultural education is expected to have a positive effect on agrobiodiversity. Positive signs are expected of the estimated coefficients of *agreduf* and *agredum* dummies. One may also think of a possible causation running from agrobiodiversity to agricultural education. However, because the agricultural education in the area is offered by a governmental rural development office and does not depend on how much agrobiodiversity the households keep, this direction of causation does not seem realistic. Table 4.2 shows that 17% of the households reported female attendance in agricultural training during the year 2004/2005 and 12% of them reported male attendance.

Hypothesis 4: The ceteris paribus effect of transfer income received by the male is different from that of transfer income received by the female

Transfer income measures income received through remittances, pensions and transfers. The effect of transfer income on agrobiodiversity may occur through replacing off-farm participation. Therefore, a positive sign is expect of the estimated coefficients of *transferf* and *transferm* variables. If transfer income received by male and female members makes a difference in the effect on agrobiodiversity, it has implications for the relevance of the income-pooling hypothesis for the specific setting.

Other explanatory variables

Indicators for HIV/AIDS: male morbidity and mortality

The direct effect of adult male morbidity on agrobiodiversity in the home garden depends on whether households who are affected by male illness would find increasing or decreasing crop diversity as higher return generating activity than alternative activities. Such returns may include health benefits depending on farm household knowledge of the health benefits of agrobiodiversity. However, given the limited education level of the farm households in the area, there is little reason to believe that they are aware of the health benefits of crops. It is therefore, difficult to establish *a priori* sign to the estimated coefficient of *durillm* variable.

The agrobiodiversity decisions of single females can find their origin in gender-related differences, the extent of their sharecropping engagement or both. To the extent that females face higher transaction costs or less remuneration for off-farm participation than males (either due to less education, need for care giving or gender-related reasons), single females are expected to increase agrobiodiversity in the garden. This is even more so with an increase in the share of sharecropping-out among single females. Table 4.3 shows that 46.5% of the single female parent households are involved in sharecropping-out and hence have a higher possibility of increasing agrobiodiversity. Thus, the expected sign of the estimated coefficient of *singlef* dummy on agrobiodiversity is positive. 20.9% of the sample households are single female headed, 8.8% are single male headed and 68.8% are two-parent households. In order to use the effect of loss of adult male as an indicator for the effect of male mortality, it has to be established that the variable representing single female headed household should capture male mortality. This is because single female parenthood may arise for reasons other than spousal death. Of the single female headed households of the sample, 88.4% are single females due to spousal death whereas the rest did not report the cause for single female parenthood. Therefore, the *singlef* variable largely represents male mortality.

Off-farm income

Increased off-farm work is hypothesized to have a negative effect on agrobiodiversity. Farmers who are involved in off-farm work will have less time for gardening than those who are not. Off-farm work may also lead to increased specialization (by increasing market integration). Because of lack of data on off-farm work, off-farm income is considered as an indicator for off-farm work. Hence, *offfarminc* variable is expected to have a negative coefficient. Table 4.2 shows that 41.0% of the sample households earn off-farm income.

Household composition

Having children below 5 years old increases the time adults stay around the house to provide childcare and hence enables more labor supply in the garden on the side. An increase in the number of children older than 15 is expected to enhance labor availability for the garden through direct child labor assistance.

Both cases contribute to increasing agrobiodiversity. Thus, positive signs are expected of the estimated coefficients of *childunder5* and *childabove15* variables. Of the sample households, 51.9% have children below 5 years old and 54.5% of them have children above 15 years old. The effect of age of parents on the degree of agrobiodiversity may work through the labor demand of increasing agrobiodiversity and change in attitudes towards risk with the decline in work capability, which both may vary depending on whether the aged household gets extended family support. This makes it difficult to establish *a priori* effect of *avgage* variable. The average age corrects for the effect of age differences between the parents in the case of two parent households. Table 4.2 shows that the average age of the sample households is 42.3 years.

Access to services: education and credit

The level of formal education of household members may affect agrobiodiversity either by increasing a household member's access to off-farm activities and hence preference towards specialization or preference towards diversification by increasing awareness on the health benefits of agrobiodiversity. The overall effect on agrobiodiversity is determined by the magnitudes of the opposing effects. Hence, it is difficult to establish an *a priori* expectation on the estimated coefficients of *eduf* and *edum* variables. One may think of a possible effect of agrobiodiversity on educational attainment through the positive health effect of agrobiodiversity. This direction of causation is likely to occur if the level of formal schooling achieved by the farm households has been achieved in the same year as the current diversity is established. Alternatively, it occurs if the current level of agrobiodiversity has been unchanged since the last schooling year of the adult household members. It was not found necessary to account for potential reverse causation in this particular analysis. This is because the observed current educational attainment does not seem to be related with the observed current agrobiodiversity, i.e. as argued in Section 4.3, the agrobiodiversity index has the potential to change annually while this is not the case for the level of education. Of the sample households who reported male parent schooling level of more than one year, 43.2% reported an average of 21.7 years since the last year of schooling. Of those who reported female parent schooling level of more than one year, 35.7% reported an average of 16.6 years since the last year of schooling. The rest of the households did not report the number of years since the last year of parental schooling.

Obtaining credit is expected to enhance agrobiodiversity through enabling purchase of seeds and planting material. Hence, the estimated coefficient of the *credit* dummy is expected to have a positive sign. Table 4.2 shows that 28% of the households have obtained credit during the research period either from the local agricultural development office or local traders.

Asset holding: land and livestock

Total land holding and garden sizes are measured in fechassa. On average, the garden size of the sample households constitutes 20% of the total holding. If larger field size is associated with more field diversity and more transfer of seeds to the garden, agrobiodiversity may increase with increasing total land holding. Similarly, a positive effect on garden agrobiodiversity is expected if larger total land holding implies more sharecropping-out of fields and thus more likelihood of increasing labor supply to the garden. Thus, the sign of the estimated coefficient of *totld* variable is expected to be positive. The effect of *gardensz* variable on garden agrobiodiversity is not obvious because larger garden size may lead to specialization owing to economies of scale. On the other hand, larger garden size gives the space for more diverse crops. Table 4.2 shows that the average total land holding of the sample households is 3.9 fechassa and average garden size is 0.6 fechassa.

Livestock activity contributes to agrobiodiversity through the supply of manure for fertilization and providing income that may help to allocate more labor to gardening by replacing the need for off-farm income. The livestock production activity may as well compete with the crop production activity for household labor and with the soil fertility management practice by using crop residue for fodder. Hence, the net effect of livestock activity on agrobiodiversity depends on the magnitudes of the two opposing forces. The change in livestock holding represented by *TLUincrease* captures the effect of recent changes in wealth status of households that is not captured by the other wealth indicator (i.e. *totld*). The sign of the estimated coefficient of *TLUincrease* variable is not obvious. From Table 4.2, the average TLU of the sample households is 1.3 and 28% of the sample households exhibited increase in TLU over the past 5 years.

Location

Variation in agrobiodiversity across locations is expected due to differences in natural characteristics such as soil and terrain, water availability, the influence of dominant activities in the specific location and access to markets and services awareness on HIV/AIDS. Apart from the effect of other natural factors, if locational differences in HIV/AIDS prevalence rate is associated with differences in awareness, for e.g., of the health benefits of crops influencing preferences for agrobiodiversity in the garden a significant effect of this variable is expected. This, however, depends on the direction and size of the effect of differences in natural factors between the two locations as compared to the effect of awareness on agrobiodiversity. Hence, the sign of the estimated coefficient of *location* dummy is not obvious.

4.4 ANALYSIS

We are interested in modeling the degree of agrobiodiversity for households who have positive agrobiodiversity within a sample where agrobiodiversity is censored at zero. We employ the more generalized Tobit (Heckman (1979)) model to account for potential selection bias in the model arising from correlation between the unobserved factors influencing the presence and degree of agrobiodiversity.

An increase in the number of adult children in the household is expected to reduce engagement in sharecropping-out fields. Similarly, households that do not own oxen are likely to be involved in sharecropping-out at least part of their fields so as to access oxen. Hence, the variables capturing number of adult children, *childabove15*, and lack of oxen, *nooxen*, are used as additional instruments for *percsharearea*. The variables capturing ownership of iron-roofed house, *houseironrf*, and purchase of jewels during the past 5 years, *boughtjewels*, are used as additional instruments for *hireinintensity*. This is because of the expectation that households that are capable of paying cash for the purchase of jewels and those who own an iron-roofed house can afford to hire-in labor if needed. Additionally, there is little reason to believe that number of adult children, lack of oxen, purchase of jewels or owning iron-roofed house directly affect agrobiodiversity in the home garden.

4.5 ESTIMATION RESULTS AND DISCUSSION

4.5.1 Explaining sharecropping, labor hiring and male morbidity

The variables *percsharearea*, *hireinintensity* and *durillm* are regressed on a set of (weakly) exogenous variables to explain sharecropping-out share, degree of hiring-in labor and male morbidity in independent Tobit models. Estimation results are presented in Table 4.4.

Table 4.4 shows that *durillm* variable positively affects sharecropping-out share at the 5% level of significance indicating that adult morbidity influences sharecropping-out share. Similarly, *singlef* variable positively affects sharecropping-out share at the 5% level of significance indicating that single females increase the share of sharecropped-out land. The additional instrument *nooxen* variable positively affects sharecropping-out share at the 1% level of significance. Other explanatory variables that are found to have a significant effect on sharecropping-out share are *totld*, (1%) *childabove15* (1%) and *avgage* (5%), with respective signs consistent with the intuitive expectations.

Similarly, the additional instrument *houseironrf* variable positively affects the degree of labor hiring at 1% level of significance. The variable *durillm* variable positively affects the degree of labor hiring at the 5% level of significance indicating that adult morbidity influences labor hiring; *singlef* variable positively affects labor hiring at the 10% level of significance. This indicates that male morbidity and mortality cause an increase in the degree of labor hiring. Other variables that are found to have a significant effect on the degree of labor hiring include *totld* (5%), *childabove15* (5%), *credit* (1%) and *transferm* (10%) with the expected signs.

The variables that are found to have a significant effect on male morbidity are the additional instruments *singlem* (1%) and *agem50* (1%); and *avgage* (1%), *eduf* (5%) and *edum* (10%). Contrary to expectations, *avgage* is found to have a negative effect on male morbidity which may be because the degree of male illness is less among two-parent households as compared to the single male headed households. The variable *edum* has a positive effect on male morbidity which may be because more educated males may have greater involvement in off-farm work and as a result may have been exposed to HIV/AIDS infection.

Table 4.4 Tobit estimations for sharecropping-out, hiring-in labor and male morbidity.[12]

Explanatory Variable	Variable name	Sharecropping-out		Hiring-in labor		Male morbidity	
		Estimated coefficient	Marginal Effect (*dy/dx*)	Estimated coefficient	Marginal Effect (*dy/dx*)	Estimated coefficient	Marginal Effect (*dy/dx*)
Male mortality (single female)	*singlef*	0.335 (0.14)**	0.335 (0.14)**	0.157 (0.09)*	0.157 (0.09)*	-	
Single male	*singlem*	-		-		0.483 (0.13)***	0.483 (0.13)***
Male morbidity	*durillm*	0.339 (0.17)**	0.339 (0.17)**	0.228 (0.11)**	0.228 (0.11)**	-	
Average age	*avgage*	0.008 (0.00)**	0.008 (0.00)**	-		-0.017 (0.00)***	-0.017 (0.00)***
Male above 50 years old	*agem50*	-		-		0.453 (0.12)***	0.453 (0.12)***
Female education	*eduf*	-		-		-0.039 (0.02)**	-0.039 (0.02)**
Male education	*edum*	-0.021 (0.02)	-0.021 (0.02)	-		0.025 (0.01)*	0.025 (0.01)*
No. of children <5	*childunder5*	-		-		-0.065 (0.05)	-0.065 (0.05)
No. of children >15	*childabove15*	-0.195 (0.06)***	-0.195 (0.06)***	-0.060 (0.03)**	-0.060 (0.03)**	-	
Off-farm income	*offfarminc*	-0.000 (0.00)	-0.000 (0.00)	-		-0.000 (0.00)	-0.000 (0.00)
Transfer income male	*transferm*	-		0.000 (0.00)*	0.000 (0.00)*	-	
Garden size	*gardensz*	-0.128 (0.09)	-0.128 (0.09)	-0.119 (0.06)*	-0.119 (0.06)*	-	
Land holding	*totld*	0.073 (0.02)***	0.073 (0.02)***	0.026 (0.01)**	0.026 (0.01)**	-	
TLU increase	*TLUincrease*	0.132 (0.13)	0.132 (0.13)	-		-0.094 (0.09)	-0.094 (0.09)
Lack of oxen	*nooxen*	0.359 (0.14)***	0.359 (0.14)***	-0.109 (0.07)	-0.109 (0.07)	-	
Credit obtained	*credit*	-		0.297 (0.11)***	0.297 (0.11)***	-	
Housing type	*houseironrf*	-		0.358 (0.08)***	0.358 (0.08)***	-	
Jewelry purchase	*boughtjewels*	-		0.193 (0.14)	0.193 (0.14)	-	
Location	*location*	-		0.372 (0.17)**	0.372 (0.17)**	-	
Constant		-1.022 (0.27)***		-0.812 (0.22)***		0.616 (0.20)***	
Standard error	$\hat{\sigma}$	0.556 (0.06)		0.341 (0.04)		0.495 (0.04)	
Probability chi^2		0.0000		0.0000		0.0000	
LR ch^2		47.19		58.9		41.04	
Pseudo R^2		0.1825		0.3036		0.1320	
N		202		202		202	

Note: statistical significance is given at the 10% (*), 5% (**) and 1% (***) level. Standard errors in parentheses. - means the variable is excluded from the particular estimation.

[12] A bivariate Tobit model was initially estimated for sharecropping-out and labor hiring by allowing for cross-equation disturbance correlation. Based on Likelihood ratio test, the model was not found to have advantage over simple independent Tobit models for the equations. In the initial estimation the same set of variables were included in the sharecropping and labor hiring equations of which those with p-value >0.5 are later excluded.

Since the instruments are found to have significant coefficients with signs that support expectations in each equation, they can be considered as fairly valid (Murray, 2006).

4.5.2 Explaining agrobiodiversity in the home garden

Testing for selection bias

The initial estimation involves estimation of equations (4.6) and (4.7) in a Maximum Likelihood Heckman model. The post-estimation Likelihood Ratio test result indicates that the hypothesis of independent (selection and non-limit) equations could not be rejected at the 10% level of significance (see Table 4A.2 in Annex 4A), which can also be seen from the non-significance of the coefficients of the generalized residuals confirming absence of selection bias in the model. This may also be due to the smallness in the number of the censored observations (i.e. only 11 which makes up 5.5% of the sample) for it to matter. In the absence of selection bias, a truncated model will give unbiased and consistent results (Cameron and Trivedi, 2005; Verbeek, 2004). Table 4.5 presents estimation results based on a Truncated model.

Testing for endogeneity

In Table 4.5 individual t-tests of the generalized residuals, $\tilde{u}_1$, $\tilde{u}_2$ and $\tilde{u}_3$ suggests that the generalized residuals from the Tobit equations for the labor and illness variables are not significant at the 10% level. Joint F-tests of the residuals also confirms that the residuals are jointly non-significant at the 10% level. Both results suggest that endogeneity of any of the labor and illness variables is not confirmed by the data. This may be because the potential effect of agrobiodiversity on sharecropping, labor hiring and male morbidity may work with time lag, which can not be detected by the cross-sectional data employed. It may also be that the sample farmers do not take agrobiodiversity effects into account in making labor organization decisions and that the agrobiodiversity that the households currently maintain may not have a significant health benefit.

In Table 4.5, columns A and B provide estimations with and without correcting for the endogeneity of the specified variables respectively. The following discussion is based on the results in column B.

Table 4.5 Truncated regression for total agrobiodiversity estimation.[13]

Explanatory Variable	Variable name	Agrobiodiversity (D)			
		A. Endogeneity corrected		B. Endogeneity not corrected	
		Estimated coefficient	Marginal Effect (*dy/dx*)	Estimated coefficient	Marginal Effect (*dy/dx*)
Male mortality	*singlef*	0.094 (0.07)	0.094 (0.07)	0.051 (0.06)	0.051 (0.06)
Male morbidity	*Durillm*	0.091 (0.08)	0.091 (0.08)	0.109 (0.07)	0.109 (0.07)
Female education	*eduf*	-0.016 (0.01)*	-0.016 (0.01)*	-0.017 (0.01)*	-0.017 (0.01)*
No. of children <5	*childunder5*	0.058 (0.02)**	0.058 (0.02)**	0.050 (0.02)**	0.050 (0.02)**
Sharecropping-out	*percsharearea*	0.316 (0.09)***	0.316 (0.09)***	0.307 (0.09)***	0.307 (0.09)***
Labor hiring	*hireinintensity*	-0.485 (0.17)***	-0.485 (0.17)***	-0.427 (0.17)**	-0.427 (0.17)**
Off-farm income	*offfarminc*	$-0.3\text{x}10^{-4}$ ($0.2\text{x}10^{-4}$)*	$-0.3\text{x}10^{-4}$ ($0.2\text{x}10^{-4}$)*	$-0.3\text{x}10^{-4}$ ($0.2\text{x}10^{-4}$)*	$-0.3\text{x}10^{-4}$ ($0.2\text{x}10^{-4}$)*
Transfer income male	*transferm*	0.000 (0.00)	0.000 (0.00)	$-0.1\text{x}10^{-3}$ ($0.6\text{x}10^{-4}$)*	$-0.1\text{x}10^{-3}$ ($0.6\text{x}10^{-4}$)*
Transfer income female	*transferf*	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)
Agricultural education female	*agreduf*	0.170 (0.06)***	0.170 (0.06)***	0.186 (0.06)***	0.186 (0.06)***
Garden size	*gardensz*	-0.135 (0.05)**	-0.135 (0.05)**	-0.142 (0.05)***	-0.142 (0.05)***
Garden Perennial area	*perenarea*	0.173 (0.06)***	0.173 (0.06)***	0.163 (0.05)***	0.163 (0.05)***
Land holding	*totld*	0.007 (0.01)	0.007 (0.01)	0.009 (0.01)	0.009 (0.01)
TLU increase	*TLUincrease*	0.102 (0.05)**	0.102 (0.05)**	0.105 (0.05)**	0.105 (0.05)**
Credit obtained	*credit*	0.054 (0.06)	0.054 (0.06)	0.069 (0.06)	0.069 (0.06)
Residual *percsharearea*	$\tilde{u}_1$	0.152 (0.25)	0.152 (0.25)		
Residual *hireinintensity*	$\tilde{u}_2$	-0.479 (0.49)	-0.479 (0.49)		
Residual *durillm*	$\tilde{u}_3$	-0.365 (0.33)	-0.365 (0.33)		
Constant		0.625 (0.19)***		0.823 (0.06)***	
Probability chi2		0.0000		0.0000	
Wald ch2		69.34		66.02	
N		191		191	

Note: statistical significance is given at the 10% (*), 5% (**) and 1% (***) level. Standard errors in parentheses.

Total agrobiodiversity

Hypothesis 1: An increase in sharecropping-out intensity by HIV/AIDS affected households increases agrobiodiversity in the home garden, ceteris paribus.

[13] Note that the initial estimation included *avgage*, *edum*, *childabove15*, *location* and *agredum* variables. The reported estimation excludes variables with p-value>0.5 except the ones which we hypothesized on.

Table 4.5 shows that *percsharearea* positively affects the degree of agrobiodiversity at the 1% level of significance indicating that agrobiodiversity significantly increases with the increase in the proportion of area sharecropped-out.

This result coupled with the discussion in Section 4.5.1 which shows that male morbidity and mortality are important variables explaining an increase in sharecropping-out intensity, *ceteris paribus*, we can establish that agrobiodiversity will be higher among HIV/AIDS affected households. A unit increase in sharecropping-out share causes a 30.7 units increase in the degree of agrobiodiversity. This indicates that given access to awareness on the nutritional benefits of crops along with the sharecropping option, the farm households can afford to adopt a nutritionally relevant crop mix strategy that may entail up to 30.7 units increase in agrobiodiversity.

Hypothesis 2: An increase in hired labor intensity has a negative effect, ceteris paribus, on agrobiodiversity in the home garden

Hireinintensity variable negatively affects total agrobiodiversity at the 5% level of significance (see Table 4.5). A unit increase in labor hiring intensity decreases the degree of agrobiodiversity by 42.7 units. Hence, the type of labor organization affects agrobiodiversity and hired labor has a different effect on homegarden agrobiodiversity than sharecropping labor.

Hypothesis 3: Agricultural education contributes to increasing agrobiodiversity

Table 4.5 shows that *agreduf* variable positively affects the degree of overall agrobiodiversity at 1% level of significance confirming our hypothesis which suggests the importance of access to informal agricultural training for females to enhance total agrobiodiversity.

Hypothesis 4: The ceteris paribus effect of transfer income received by the male is different from that of transfer income received by the female

An F-test of the hypothesis of the same effect of *transferorm* and *transferorf* on agrobiodiversity could not be rejected at 5% level of significance.

The variable *eduf* has a significant negative effect on the degree of agrobiodiversity at the 10% level of significance. This might be an indication that female formal schooling may increase the likelihood of female off-farm participation and results in less female labor supply to gardening. This is also consistent with the negative effect of *offfarminc* on agrobiodiversity at 10% level of significance which may indicate that off-farm activities compete for labor with gardening. The variable *nochildunder5* positively affects the degree of total agrobiodiversity at 5% level of significance. This may be because with an increase in the number of children under 5 years old, it is more likely that adult household member(s) stay around the house for care giving. Such a possibility of combining care and gardening activities helps to increase labor supply in the garden and makes up the convenience of home gardens for flexibility as also indicated in Gari (2004). *TLUincrease* increases the degree of perennial crop diversity at 5% level of significance and the likelihood that a household grows perennial crops at 5% level of significance. This supports our hypothesis of the contribution of livestock to income and manure supply that enhances crop diversity in the garden.

Finally, the evidence of a significant effect of an increase in sharecropping-out and labor hiring on agrobiodiversity indicates that labor organization influences agrobiodiversity practices in the area. This supports the theoretical expectation that an increase in area sharecropped-out increases labor supply for gardening and thereby agrobiodiversity whereas the opposite is true for the case of increase in labor hiring. The indicators for HIV/AIDS, i.e. *singlef* and *durillm* variables, are not found to have a significant effect on agrobiodiversity, although they both are positive, whereas they are both significant in the *percsharearea* and *hireinintensity* equations. This may indicate that the agrobiodiversity decision of households affected by male morbidity and male mortality is more driven by their labor organization decision than directly through their preferences towards agrobiodiversity.

4.6 CONCLUSIONS

The results show that the degree of agrobiodiversity in home gardens is affected by HIV/AIDS-driven labor organization. Thus, efforts aimed at enhancing crop choice or agrobiodiversity among HIV/AIDS affected households can be effective through addressing constraints in labor organization. The study reveals four main findings in light of testing the hypotheses.

First, we find that HIV/AIDS affected households have higher agrobiodiversity than non-affected ones and at the same time have higher sharecropping-out intensity in their fields. Our findings are contrary to the indicated decline in agrobiodiversity due to HIV/AIDS (e.g. Barnett and Whiteside, 2002; Gillespie and Kadiyala, 2005). Those studies focus on overall farm level agrobiodiversity and do not explicitly indicate whether or not home garden agrobiodiversity has been considered as well. Our findings indicate that it is important to differentiate between the home garden and the fields and that agrobiodiversity tends to increase among HIV/AIDS affected households. In line with this, we suggest that future research seeks to improve the index for better reflecting nutritional interest along with a detailed assessment of the nutritional demand of HIV/AIDS affected households and an appraisal of to what extent such impact can be met by each plot. We would, however, like to mention that accounting for taxonomic distance in the diversity index employed in the chapter is closer to a nutritionally relevant index than the conventional diversity indices that are purely relative abundance based. We further suggest that access to more convenient labor market arrangements such as sharecropping matters for the effect of HIV/AIDS on agrobiodiversity. As the majority of the sharecropping practice is associated with adult morbidity and mortality, households who sharecrop-out less are more likely to have higher productivity in the field and as a result lower agrobiodiversity in the home garden. The findings indicate a potential local capacity to mitigate the possible negative effect of HIV/AIDS on agrobiodiversity through a sharecropping option. It also suggests that institutional support to increasing access to sharecropping opportunities could be a relevant intervention.

Underlying the above finding is the evidence of a significant positive effect of adult mortality and morbidity on sharecropping-out share. This is in line with Drimie (2002) and Bishop-Sambrook et al. (2006) who found that single female-headed households in AIDS impacted areas resort to sharecropping. Our result substantiates their findings and adds that the sharecropping-out share increases among households with single females and those with longer duration of male illness. This is also in line with Agrawal (1999) who found that differences in farming efficiency between the parties involved in a sharecropping contract influences the type of contract offered to the sharecropping laborer. Hence, contrary to the claim of sharecropping as an inefficient institution (e.g. Stiglitz, 1974; Chew, 1997; Federico, 2006), our results indicate that HIV/AIDS-affected farm households find sharecropping a more viable way of cultivating their farm in comparison to alternative forms of labor organizations. Our finding is consistent with the unfavorable productivity effect of poor health (e.g. Schultz and Tansel, 1997; Fox et al. 2004) and the positive efficiency effect of specialization (justifying increasing involvement in sharecropping-out among single females). The study indicates that although households may also engage in sharecropping-out for reasons other than male illness/death, the degree of involvement in sharecropping-out increases with male illness/death. If longer duration of male illness increases sharecropping-out intensity, then illness due to HIV/AIDS would increase sharecropping-out intensity as prolonged illness is one of the peculiarities of HIV/AIDS as compared to other illnesses (e.g. Donovan et al. 2003).

From the above findings, provided the necessary information on the health benefits of crops grown by the farmers, the nutritional demands of HIV/AIDS affected ones and the options to increase labor availability through enhancing sharecropping, agrobiodiversity makes an important nutritional resource base for HIV/AIDS affected farm households. Accordingly, crop mix and thus agrobiodiversity in the home garden can be chosen in such a way as to increase the health benefits of the HIV/AIDS affected households. If the nutritional role of agrobiodiversity is as claimed in the literature (Johns, 2003; Gari, 2003, 2004; Johns and Eyzaguirre, 2006), our finding indicates a potential for increasing farm household nutrition through enhancing sharecropping and integrating awareness inputs on the nutritional benefits of crops. In the event that the claim on the nutritional role of agrobiodiversity is not significant, the confirmed tendency to increase agrobiodiversity with the HIV/AIDS-driven change in labor organization in response to HIV/AIDS indicates a potential to improving farm household nutrition by changing crop mix.

Second, a greater degree of labor hiring has a significant negative effect on agrobiodiversity in the home garden, indicating that sharecropping and hired labor have different impacts on agrobiodiversity. This indicates that where labor and cash are highly constraining due to adult morbidity and mortality, increased agrobiodiversity as a strategy to improve nutrition is more compatible with sharecropping than with labor hiring.

Third, a favorable agrobiodiversity effect of agricultural education for females is supported. This indicates a potential area of intervention involving integrating nutrition education in the existing agricultural education so as to make crop choice and agrobiodiversity practices responsive to HIV/AIDS demands. The decision to undertake such intervention entails exploring the cost effectiveness of education on nutrition versus alternative strategies of HIV/AIDS prevention and impact mitigation e.g. distribution of multivitamin supplements, antiretroviral therapy, raising HIV/AIDS awareness, or a combination of some of them.

Fourth, the failure to find a significant effect of transfer income received by males and females on total agrobiodiversity may be due either to the low level of transfer income received by each member for it to matter, or to income-pooling behavior among the households.

ANNEX 4A

Table 4A.1 Taxonomic distances between the species grown in the home garden.

	Adenguare	Avocado	Banana	Barley	Bullheart	Cabbage	Chat	Chickpea	Coffee	Enset	Eucalyptus	Garlic	Gesho	Ginger	Guava	Hari bean	Kale	Lemon	Lentil	Maize	Mango	Millet	Niger seed	Onion	Orange	Papaya	Pepper	Pineapple	Potato	Rice	Sorghum	Sugarcane	Sweet pot	Taro	Teff	Tobacco	Tomato	Wheat	Yam	Sum
Adenguare /cowpea	0	4	5	5	4	4	4	2	4	5	4	5	4	5	4	2	4	4	2	5	4	5	4	5	4	4	4	5	4	5	5	5	4	5	5	4	4	5	5	162
Avocado	4	0	5	5	4	4	4	4	4	5	4	5	4	5	4	4	4	4	4	5	4	5	4	5	4	4	4	5	4	5	5	5	4	5	5	4	4	5	5	168
Banana	5	5	0	4	5	5	5	5	5	2	5	4	5	3	5	5	5	5	5	4	5	4	5	4	5	5	5	4	5	4	4	4	5	4	4	5	5	4	4	172
Barley	5	5	4	0	5	5	5	5	5	4	5	4	5	4	5	5	5	5	5	2	5	2	5	4	5	5	5	3	5	2	2	2	5	4	2	5	5	2	4	160
Bullheart	4	4	5	5	0	4	4	4	4	5	4	5	4	5	4	4	4	4	4	5	4	5	4	5	4	4	4	5	4	5	5	5	4	5	5	4	4	5	5	168
Cabbage	4	4	5	5	4	0	4	4	4	5	4	5	4	5	4	4	1	4	4	5	4	5	4	5	4	3	4	5	4	5	5	5	4	5	5	4	4	5	5	164
Chat	4	4	5	5	4	4	0	4	4	5	4	5	4	5	4	4	4	4	4	5	4	5	4	5	4	4	4	5	4	5	5	5	4	5	5	4	4	5	5	168
Chickpea	2	4	5	5	4	4	4	0	4	5	4	5	4	5	4	2	4	4	2	5	4	5	4	5	4	4	4	5	4	5	5	5	4	5	5	4	4	5	5	162
Coffee	4	4	5	5	4	4	4	4	0	5	4	5	4	5	4	4	4	4	4	5	4	5	4	5	4	4	4	5	4	5	5	5	4	5	5	4	4	5	5	168
Enset	5	5	2	4	5	5	5	5	5	0	5	4	5	3	5	5	5	5	5	4	5	4	5	4	5	5	5	4	5	4	4	4	5	4	4	5	5	4	4	172
Eucalyptus	4	4	5	5	4	4	4	4	4	5	0	5	4	5	2	4	4	4	4	5	4	5	4	5	4	4	4	5	4	5	5	5	4	5	5	4	4	5	5	166
Garlic	5	5	4	4	5	5	5	5	5	4	5	0	5	4	5	5	5	5	5	4	5	4	5	1	5	5	5	4	5	4	4	4	5	4	4	5	5	4	4	172
Gesho	4	4	5	5	4	4	4	4	4	5	4	5	0	5	4	4	4	4	4	5	4	5	4	5	4	4	4	5	4	5	5	5	4	5	5	4	4	5	5	168
Ginger	5	5	3	4	5	5	5	5	5	3	5	4	5	0	5	5	5	5	5	4	5	4	5	4	5	5	5	4	5	4	4	4	5	4	4	5	5	4	4	173
Guava	4	4	5	5	4	4	4	4	4	5	2	5	4	5	0	4	4	4	4	5	4	5	4	5	4	4	4	5	4	5	5	5	4	5	5	4	4	5	5	166
Hari. bean	2	4	5	5	4	4	4	2	4	5	4	5	4	5	4	0	4	4	2	5	4	5	4	5	4	4	4	5	4	5	5	5	4	5	5	4	4	5	5	162
Kale	4	4	5	5	4	1	4	4	4	5	4	5	4	5	4	4	0	4	4	5	4	5	4	5	4	3	4	5	4	5	5	5	4	5	5	4	4	5	5	164
Lemon	4	4	5	5	4	4	4	4	4	5	4	5	4	5	4	4	4	0	4	5	3	5	4	5	1	4	4	5	4	5	5	5	4	5	5	4	4	5	5	164
Lentil	2	4	5	5	4	4	4	2	4	5	4	5	4	5	4	2	4	4	0	5	4	5	4	5	4	4	4	5	4	5	5	5	4	5	5	4	4	5	5	162
Maize	5	5	4	2	5	5	5	5	5	4	5	4	5	4	5	5	5	5	5	0	5	2	5	4	5	5	5	3	5	2	2	2	5	4	2	5	5	2	4	160
Mango	4	4	5	5	4	4	4	4	4	5	4	5	4	5	4	4	4	3	4	5	0	5	4	5	3	4	4	5	4	5	5	5	4	5	5	4	4	5	5	166
Millet	5	5	4	2	5	5	5	5	5	4	5	4	5	4	5	5	5	5	5	2	5	0	5	4	5	5	5	3	5	2	2	2	5	4	2	5	5	2	4	160
Niger seed	4	4	5	5	4	4	4	4	4	5	4	5	4	5	4	4	4	4	4	5	4	5	0	5	4	4	4	5	4	5	5	5	4	5	5	4	4	5	5	168
Onion	5	5	4	4	5	5	5	5	5	4	5	1	5	4	5	5	5	5	5	4	5	4	5	0	5	5	5	4	5	4	4	4	5	4	4	5	5	4	4	172
Orange	4	4	5	5	4	4	4	4	4	5	4	5	4	5	4	4	4	1	4	5	3	5	4	5	0	4	4	5	4	5	5	5	4	5	5	4	4	5	5	164
Papaya	4	4	5	5	4	3	4	4	4	5	4	5	4	5	4	4	3	4	4	5	4	5	4	5	4	0	4	5	4	5	5	5	4	5	5	4	4	5	5	166
Pepper	4	4	5	5	4	4	4	4	4	5	4	5	4	5	4	4	4	4	4	5	4	5	4	5	4	4	0	5	4	5	5	5	3	5	5	2	2	5	5	163

Pineapple	5	5	4	3	5	5	5	5	5	4	5	4	5	4	5	5	5	5	5	3	5	3	5	4	5	5	5	0	5	3	3	3	5	4	3	5	5	3	4	167
Potato	4	4	5	5	4	4	4	4	4	5	4	5	4	5	4	4	4	4	4	5	4	5	4	5	4	4	4	5	0	5	5	5	4	5	5	4	4	5	5	168
Rice	5	5	4	2	5	5	5	5	5	4	5	4	5	4	5	5	5	5	5	2	5	2	5	4	5	5	5	3	5	0	2	2	5	4	2	5	5	2	4	160
Sorghum	5	5	4	2	5	5	5	5	5	4	5	4	5	4	5	5	5	5	5	2	5	2	5	4	5	5	5	3	5	2	0	2	5	4	2	5	5	2	4	160
Sugarcane	5	5	4	2	5	5	5	5	5	4	5	4	5	4	5	5	5	5	5	2	5	2	5	4	5	5	5	3	5	2	2	0	5	4	2	5	5	2	4	160
Sweet pot	4	4	5	5	4	4	4	4	4	5	4	5	4	5	4	4	4	4	4	5	4	5	4	5	4	4	3	5	4	5	5	5	0	5	5	3	3	5	5	165
Taro	5	5	4	4	5	5	5	5	5	4	5	4	5	4	5	5	5	5	5	4	5	4	5	4	5	5	5	4	5	4	4	4	5	0	4	5	5	4	4	175
Teff	5	5	4	2	5	5	5	5	5	4	5	4	5	4	5	5	5	5	5	2	5	2	5	4	5	5	5	3	5	2	2	2	5	4	0	5	5	2	4	160
Tobacco	4	4	5	5	4	4	4	4	4	5	4	5	4	5	4	4	4	4	4	5	4	5	4	5	4	4	2	5	4	5	5	5	3	5	5	0	2	5	5	163
Tomato	4	4	5	5	4	4	4	4	4	5	4	5	4	5	4	4	4	4	4	5	4	5	4	5	4	4	2	5	4	5	5	5	3	5	5	2	0	5	5	163
Wheat	5	5	4	2	5	5	5	5	5	4	5	4	5	4	5	5	5	5	5	2	5	2	5	4	5	5	5	3	5	2	2	2	5	4	2	5	5	0	4	160
Yam	5	5	4	4	5	5	5	5	5	4	5	4	5	4	5	5	5	5	5	4	5	4	5	4	5	5	5	4	5	4	4	4	5	4	4	5	5	4	0	175
Sum	162	168	172	160	168	164	168	162	168	172	166	172	168	173	166	162	164	164	162	160	166	160	168	172	164	166	163	167	168	160	160	160	165	175	160	163	163	160	175	

Note: Following Ricotta (2004), a distance of 1 is given if two species share the same genus, 2 if the share only the same household, 3 if they share only the same order, 4 if they share only the same class and 5 if they share only the same kingdom.

Sources: Palgrave (1984); Zomlefer (1994); Weirsema and Leon (1999); Engels and Goettsch (1991); Wickens (2001).

Table 4A.2 Heckman model estimation for total agrobiodiversity estimation.

Variable name	Agrobiodiversity (*D*)					
	A. Endogeneity corrected			B. Endogeneity not corrected		
	Eq2		Eq1	Eq2		Eq1
	Estimated parameter	Marginal Effect (*dy/dx*)	Estimated parameter	Estimated parameter	Marginal Effect (*dy/dx*)	Estimated parameter
singlef	0.094	0.094		0.052	0.052	-
	(0.07)	(0.07)		(0.06)	(0.06)	
Durillm	0.084	0.089	0.523	0.109	0.109	-0.014
	(0.08)	(0.08)	(0.8)	(0.07)	(0.07)	(0.56)
agef50	-	-1.569	-	-	-0.043	-1.337
		(0.49)***			(0.03)	(0.47)***
eduf	-0.014	-0.014	-	-0.015	-0.015	-
	(0.01)	(0.01)		(0.01)	(0.01)	
edum	-		-0.129	-	-0.002	-0.146
			(0.08)		(0.00)	(0.06)**
childunder5	0.056	0.056	-	0.049	0.049	-
	(0.02)**	(0.02)**		(0.02)**	(0.02)**	
percsharearea	0.327	0.318	-0.872	0.323	0.307	-1.049
	(0.09)***	(0.09)***	(0.81)	(0.09)***	(0.09)***	(0.72)
hireinintensity	-0.372	-0.408	-3.239	-0.304	-0.347	-2.944
	(0.18)**	(0.17)**	(1.04)***	(0.17)*	(0.16)**	(0.87)***
offfarminc	$-0.3x10^{-4}$	$-0.2x10^{-4}$	$0.4x10^{-3}$	$-0.3x10^{-4}$	$-0.2x10^{-4}$	$0.4x10^{-3}$
	$(0.2x10^{-4})$*	$(0.2x10^{-4})$	$(0.3x10^{-3})$*	$(0.2x10^{-4})$*	$(0.2x10^{-4})$	$(0.2x10^{-4})$*
transferm	0.000	0.000	-	$0.1x10^{-3}$	$0.1x10^{-3}$	-
	(0.00)	(0.00)		$(0.6x10^{-4})$*	$(0.6x10^{-4})$*	
transferf	0.000	0.000	-	0.000	0.000	-
	(0.00)	(0.00)		(0.00)	(0.00)	
agreduf	0.172	0.172	-	0.186	0.186	-
	(0.06)***	(0.06)***		(0.05)***	(0.05)***	
gardensz	-0.134	-0.134	-	-0.138	-0.138	-
	(0.05)**	(0.05)**		(0.05)***	(0.05)***	
perenarea	0.170	0.170	-	0.161	0.161	-
	(0.05)***	(0.05)***		(0.05)***	(0.05)***	
totld	0.007	0.007	-0.035	0.010	0.009	-0.047
	(0.01)	(0.01)	(0.05)	(0.01)	(0.01)	(0.08)
TLUincrease	0.103	0.098	-0.384	0.104	0.101	-0.158
	(0.05)**	(0.05)**	(0.50)	(0.05)**	(0.05)**	(0.45)
credit	0.048	0.048	-	0.059	0.059	-
	(0.06)	(0.06)		(0.06)	(0.06)	
$\tilde{u}_1$	0.160	0.164	0.293			
	(0.25)	(0.24)	(2.28)			
$\tilde{u}_2$	-0.478	-0.475	0.332			
	(0.49)	(0.49)	(4.13)			
$\tilde{u}_3$	-0.425	-0.379	4.239			
	(0.33)	(0.33)	(2.96)			
Constant	0.612		4.854	0.827		3.052
	(0.19)***		(1.83)***	(0.06)***		(0.56)***
Probability chi^2	0.0000			0.0000		
Wald ch^2	70.21			67.07		
LR test ($\hat{\rho} = 0$)	Prob>chi^2=0.33			Prob>chi2=0.25		
N	202			202		

Note: statistical significance is given at the 10% (*), 5% (**) and 1% (***) level. Standard errors in parentheses.

CHAPTER 5

GENERAL CONCLUSIONS

The purpose of this study is to understand and explain the extent to which HIV/AIDS affects labor organization, crop choice and agrobiodiversity among farm households in Ethiopia. This is done through theoretical analysis, in-depth study and econometric estimation on survey data. In Chapter 1, research questions were set out forming the basis for the analysis, focusing on understanding the factors underlying labor organization, allocation and agrobiodiversity. In the subsequent chapters, the theoretical and empirical (in-depth and regression) analysis was conducted.

This chapter presents a summary of the main conclusions drawn from the analysis. It is structured as follows: the next section provides the empirical findings of the study in light of addressing the main research questions set out in Chapter 1. This is followed by a section discussing the main implications for intervention efforts that can be drawn from the theoretical and empirical results. The last section presents the main limitations of the study indicating potential areas for further research.

5.1 EMPIRICAL FINDINGS

The main results of the analysis conducted in Chapters 2, 3 and 4 are presented by highlighting the specific research questions that each chapter addresses.

Research question 1: What does the theory of the farm household predict concerning the HIV/AIDS driven change in labor organization and grobiodiversity?

The theoretical analysis in Chapter 2, employs a non-separable farm household model with transaction costs in the labor markets, which is analyzed both in the labor allocation and product diversity approaches. The chapter employs the labor allocation and diversity approaches on which analytical and numerical analysis using GAMS are conducted to reflect on the implications of HIV/AIDS for labor organization and agrobiodiversity in a comparative static framework. The chapter develops some hypotheses for empirical testing.

The analysis shows that the availability of labor markets and particularly sharecropping opportunities matter for the effect of HIV/AIDS on labor organization and agrobiodiversity. Depending on the degree of substitutability of home garden and field products, HIV/AIDS causes households to withdraw labor from fields to the home garden and increase crop diversity in the home garden because of the reduction in the productivity of fields. It indicates that higher degree of substitutability between home garden and field products enhance the likelihood of increase in agrobiodiversity in response to declining health. In reality, considering the smallness of home garden area as compared to field area, higher degree of substitutability in the two products may not be expected. With replacement labor in the field, however, higher degree of substitutability between the products in the home garden and the products from owner cultivated part of the field is likely because the field output produced by the replacement labor makes the substitution easy.

The analysis shows that the severity of the effects of HIV/AIDS can be reduced through labor reallocation, particularly with a greater range of labor organization options. In contrast to the common expectation that HIV/AIDS causes a decline in agrobiodiversity (Barnett and Whiteside, 2002; Gillespie and Kadiyala, 2005), the theoretical model used in this thesis predicts a potential to increase agrobiodiversity in home gardens under HIV/AIDS.

Therefore, I conclude that HIV/AIDS affected households are likely to reduce labor allocation to the field and increase labor allocation to and agrobiodiversity in the home garden. The hypothesis generated from the analysis is that HIV/AIDS affected households are involved in more intensive sharecropping-out. An increase in the sharecropping-out intensity of fields releases more labor to home gardens and contributes more to increasing agrobiodiversity than is the case without HIV/AIDS.

Research question 2: What insights could be generated from in-depth analysis of the impact of HIV/AIDS on labor organization, crop choice and agrobiodiversity?

Chapter 3 employs an in-depth study of four HIV/AIDS affected farm households in Southwest Ethiopia whereby their resource allocations, crop choice and agrobiodiversity situations were analyzed in detail in three subsequent rounds during 2004/5. Through historical recollections, an attempt was made to construct the before- and/or earlier stage-HIV/AIDS situations of the households. This made it possible to examine some of the dynamic effects of the disease as it progresses through the *pre-illness*, *illness*, *death* and *post-death* stages. Although it is impossible to make generalization based on 4 cases, the results support the findings of Chapter 2.

Based on the results of the in-depth analysis, household labor and cash constraints and the resulting reallocation are influenced by the stages of HIV/AIDS and the household role of the affected member with more severe implications made manifest at the stage of severe illness. At this stage of illness, disruption of farm work is observed in all of the households because of the reduction in labor supply and productivity and an increase in the demand for cash due to the need for extra health expenses. After death, however, the households exhibited temporary relief from the constraints posed by the demand for additional health expenditures and care labor, and this results in an increase in labor supply for activities of the remaining family members.

Land confiscations were also reported by the households who faced death of the male household head causing a substantial income reduction. The claims occurred because land title was not immediately transferred to the surviving household members. In Ethiopia, farmers have user rights and in male-headed households males normally hold land titles. With the death of male household heads, land confiscations arise before the land titles are transferred to the surviving household members. Land claims may arise from the relatives (e.g. kinsmen of the deceased) or others who use the opportunity to make claims through children born outside marriage. Although in the area it is possible to transfer land titles to the surviving members, the longer it takes to do the transfer the more vulnerable the household will be to land confiscation problems. With an increased degree of land confiscation following death of adult(s), the overall survival strategies of the households are put under strain, with more severe consequences for no parent households.

Three of the case households are involved in sharecropping-out all their annual crop fields. Decisions regarding labor allocation and engagement in sharecropping differ for single male, female and fostering parent households, at each stage of the disease. For single female and fostering parent households, sharecropping-out annual fields seems to be inevitable. Single male parent households could either continue to sharecrop-in land depending on the size of their holding versus their work capability or do sharecrop-out in the event of migration. The domestic household role of single female parents implies that they are less likely to satisfy the labor requirements for equal sharecropping and as a result their product share is likely to be below 50%.

Depending on the demand for care during the stage of illness and the health status of the remaining spouse, off-farm activities provide important cash easing opportunities. Where the time lag between death of one parent and illness of the second is longer, the remaining spouse can increase off-farm participation. Such a response is also reflected in Loevinsohn and Gillespie (2003) that indicated HIV/AIDS causing households to reallocate labor towards agricultural wage work and quick return non-agricultural activities. This thesis presents evidence that the off-farm activities include more permanent off-farm work involving migration as observed in one of the single male parent households. The household role of the affected member is also important in determining the type of off-farm labor options available for the household members. Under severe male illness or death, female off-farm participation tends to be confined around the house yard or within the vicinity, for example, working on other's farms for cash or food. The domestic care giving role of women for the sick and the rest of the household restrict their mobility. It may, therefore, be important to consider gender differentials in land confiscations and off-farm labor options, which may cause differences in resource allocation, agrobiodiversity and the overall welfare of the households.

In-depth study results further show that substantial changes in crop choice and agrobiodiversity are observed during periods of illnesses and death. The main changes in the field are the labor organization, variety of crops and the product share of the household. In home gardens, change in at least one crop species is evident either through new introduction, or through partial or complete replacement of crops. More labor-intensive crops such as sugarcane decreased in importance in the cases of the single female parent and the absentee single male parent household as also reflected in Haddad and Gillespie (2001). Enset production decreased in the case of the single female parent household while it increased in the single male and no parent cases. Unlike the findings of Yamano and Jayne (2002), this thesis indicates reduction in importance of the food crop enset. This suggests that the crop cycle in the context of possible change in the decision horizon of the households following HIV/AIDS and the labor demanded for processing the produce may as well be important in crop choice decisions. Excepting the single female headed household whose health status has recently been declining, the number of crop species in the garden has increased for the cases as compared to the pre-illness stage.

Household income per capita has declined for one of the cases while it has shown a gradual increase in the rest of the cases throughout the stages of the disease. This is a result of the combined effect of the income support obtained from NGO's for PLWHA, reduction in household size through death and sending children to orphanage and possisbility for reallocation of household labor following the death of a severely ill household member.

I, therefore, conclude based on in-depth study results that the effect of HIV/AIDS is diverse depending on many household specific variables including the stages of HIV/AIDS manifestation and the household role of the affected member. Such household specific circumstances are important in the degree of constraints they pose as well as the responses they trigger among the farm households. The in-depth cases support the theoretical results that HIV/AIDS affected households increase sharecropping-out (except the highly land constrained one) fields and agrobiodiversity in the home garden (except the single female).

Research question 3: What generalizations could be made from a survey analysis of the implications of HIV/AIDS for labor organization and agrobiodiversity?

In Chapter 4, an econometric analysis is conducted on survey data to test the effect of HIV/AIDS driven changes in labor organization on agrobiodiversity. This involves testing the effect of HIV/AIDS on labor organization and the effect of such labor organization on agrobiodiversity. Observing HIV/AIDS is one of the difficulties encountered in collecting the survey data. Hence, adult mortality and morbidity were taken as indicators for HIV/AIDS. Tobit regression results indicate a significantly positive effect of adult mortality and morbidity on sharecropping-out intensity. Studies in Kenya, Lesotho and South Africa (Drimie, 2002) and in Ethiopia (Bishop-Sambrook et al. 2006) indicate that adult death due to HIV/AIDS causes households to sharecrop-out land. The analysis in Chapter 4 of this thesis substantiates this finding and adds three aspects to it. First, households affected by adult male mortality are not only involved in sharecropping-out but also increase the intensity of sharecropping-out. Second, increased male morbidity also has a positive effect on sharecropping-out intensity. Third, households who increase sharecropping-out intensity have higher agrobiodiversity in the home garden. These results are consistent with the theoretical expectations as well as the observations in the in-depth cases.

The effect of HIV/AIDS on agrobiodiversity is analyzed in two stages. First a Tobit model is estimated on the potentially endogenous variables sharecropping-out intensity, labor hiring intensity and male morbidity. Second, a truncated regression is run to estimate the agrobiodiversity equation by including the generalized residuals generated from each equation in the first stage as additional explanatory variables. This is based on testing for selection bias which is not detected by the data. Regression results indicate that HIV/AIDS affected households tend to increase sharecropping-out intensity in the field and households with higher sharecropping-out intensity in the field tend to increase agrobiodiversity in the home garden. A trade-off is indicated between increasing garden agrobiodiversity and more off-farm income which suggests competition for labor utilization between gardening and off-farm activities. An interesting result is that female participation in informal agricultural education is found to have a favorable effect on the degree of agrobiodiversity suggesting a potential area of intervention to enhance agrobiodiversity in HIV/AIDS context. Transfer income received by female and male is not found to have a significantly different effect on agrobiodiversity in the home garden. This suggests that the households in the area may pool income.

Therefore, I conclude that adult morbidity and mortality due to HIV/AIDS causes households to increase the share of sharecropped-out land. Increased intensity of sharecropping-out in the field results in an increase in agrobiodiversity in the home garden. Labor organization involving casual labor hiring has a negative effect on agrobiodiversity indicating that sharecropping and labor hiring have different impacts on agrobiodiversity. In line with this, female participation in agricultural education is found to enhance agrobiodiversity in the home garden.

The following can be observed based on the theoretical and empirical results. Firstly, unlike an often expressed claim that sharecropping is an inefficient institution (e.g. Stiglitz, 1974; Chew, 1997; Federico, 2006) and that it would disappear (e.g. Federico, 2006), the results of this study indicate that farm households under HIV/AIDS stress find sharecropping a more viable way of cultivating their farm than alternative an organization. This thesis argues that sharecropping will continue to increase with the increasing spread of HIV/AIDS and related health conditions causing prolonged illness and death of adults. This finding is consistent with the unfavorable productivity effect of poor health (e.g. Schultz and Tansel, 1997; Fox et al. 2004; Hawkes and Ruel, 2006) and the positive efficiency effect of specialization (justifying increasing involvement in sharecropping-out among single females). In line with this Agrawal (1999) argues that differences in farming efficiency between the parties involved in a sharecropping contract are important determinants of the contract offered to the sharecropping laborer. The analysis in this thesis does not make any *a priori* assumption about the efficiency differences between owner operated and sharecropped plots. Kassie and Holden (2007) show that productivity on the sharecropped plots is higher than the owner operated ones due to eviction threats. Tesfay (2006) found no significant differences in efficiency between owner-operated and sharecropped plots. This reinforces my argument for sharecropping as a more preferred form of labor organization for HIV/AIDS affected households.

The empirical finding of a significantly positive agrobiodiversity effect of increased sharecropping-out may be a confirmation of the theoretical results that indicate a higher agrobiodiversity effect of decline in health status with sharecropping than without. The theoretical results apply for elasticity of substitution between home garden and field products higher than unity. A Cobb-Douglas utility function may not be a good representation of utility behavior where the products from own cultivated field, sharecropped-out field and home garden are arguments. Moreover, the positive effect of male morbidity and mortality on sharecropping-out intensity and the lack of evidence of a direct effect of male morbidity and mortality on agrobiodiversity indicates that the effect of HIV/AIDS on agrobiodiversity is particularly realized through its effect on labor organization.

Secondly, where home gardens and fields play varying roles in the household, agrobiodiversity at the species level may not necessarily decline due to HIV/AIDS induced labor stress. The theoretical and empirical findings of this thesis that HIV/AIDS affected households tend to increase agrobiodiversity are similar to that of Alumira et al. (2005) who found in Malawi that HIV/AIDS affected households were diversifying their crops by including horticultural crops like tomatoes.

The general survey results are consistent with the in-depth study observations on the tendency of increasing sharecropping-out fields among households affected by adult illness and death. Moreover, the observation on the tendency of higher number of crop species in the home garden of households that increase sharecropping-out fields is consistent with the HIV/AIDS affected cases.

The results of the study can be applicable to other reasons causing adult labor loss and hence change in labor organization, crop choice and agrobiodiversity. An important difference, however, is that HIV/AIDS is expected to cause a more permanent resource scarcity and thereby specific responses. Three reasons explain this. First, HIV/AIDS erodes the critical age (15-49) (UNAIDS/WHO, 2006) for productivity leaving behind the relatively less productive labor force. Second, unlike other diseases, the impact of HIV/AIDS does not remain localized in individuals or households as it impacts the communities and the society (White and Robinson, 2000, cited in Villarreal, 2006). Third, the wave of HIV/AIDS effects from the stage of infection to post death of adults implies that households are under increasing pressure of coping with a gradual but continuous downturn of health and associated losses, which is far more severe and prolonged than in the case of most other illnesses such as TB and malaria.

5.2 CONSIDERATIONS FOR INTERVENTION

The effect of HIV/AIDS (through mortality and morbidity) on labor organization and agrobiodiversity is examined by using two approaches. These are through comparisons of with-without HIV/AIDS using the survey analysis and the before-after HIV/AIDS using the in-depth analysis in order to construct the counter-factual i.e. household responses if the household is not affected by HIV/AIDS as a basis of comparison with the actual record. This helped, although limited in sample size, to gain insight into some of the dynamics of impacts pertaining to the various stages after-HIV/AIDS and responses. Possible variations in responses arising from differences among the affected households is considered in the in-depth analysis by paying attention to potential variables explaining such variations. In order to minimize potential biases arising from the differences between HIV/AIDS affected and non-affected households, the variables that potentially explain differences between the households are controlled for in the regression analysis. This study suggests the use of a combination of these approaches in HIV/AIDS impact analysis, particularly where it is difficult to sufficiently observe HIV/AIDS. Combining the approaches assists in obtaining a more complete picture of the impacts rather than independent use of either approach.

The role of nutrition in HIV/AIDS impact mitigation and the decline in labor supply and productivity due to HIV/AIDS suggest that the challenge facing efforts to assist HIV/AIDS affected farm households is addressing the declining labor supply, productivity and nutrition. A HIV/AIDS driven increase in sharecropping-out intensity contributes to increasing agrobiodiversity in home gardens as demonstrated in Chapters 2, 3 and 4. Based on this, the thesis highlights the relevance of interventions to improve agrobiodiversity focusing on two aspects. First, because increasing sharecropping helps to address declining labor supply and productivity, relevant strategies may include a more formal assistance to enhance access to sharecropping. This may help to increase its competitiveness and access to more productive sharecropping labor particularly by those with limited access to information and less negotiating power. Increasing productivity also is in line with meeting the Millennium Development Goal of halving the proportion of people suffering from hunger by 2015 (Castleman et al. 2004).

Second, because HIV/AIDS affected households tend to increase agrobiodiversity which contributes to mitigating the effect of HIV/AIDS, efforts to assist such households may include providing better information on the nutritional benefits of crops. This is aligned with UNAIDS/WHO (2006) recommendations for HIV/AIDS mitigation efforts to include intervention on nutritional assistance by focusing on affected individuals and families. This thesis provides empirical evidence that informal agricultural education of females contributes to increasing agrobiodiversity. Integrating nutritional awareness in the informal agricultural education system assists households in managing a better crop mix and maximizing the benefits of agrobiodiversity in the HIV/AIDS context. Improving nutrition through agrobiodiversity also fits into the recent Ethiopian government strategy to enhance free access to antiretroviral therapy (WHO, 2005) the effectiveness of which is conditioned by the level of nutrition of the individuals (e.g. Castleman et al. 2004; Villarreal, 2006; WHO, 2007). Improvement in nutrition contributes towards attaining the Millenium Development goal of reducing morbidity and mortality rates and improving health (Castleman et al. 2004).

More recent global responses to HIV/AIDS include the June 2006 UN member states General Assembly agreement to work towards the goal of universal access to comprehensive prevention programs, treatment, care and support by 2010 (WHO, 2007). It is also indicated that nutrition should be an integral component of care and support efforts (Gillespie and Kadiyala, 2005) and that a response involving the agricultural sector rather than only the health sector should be targeted (Villarreal, 2006). Thus, increasing agrobiodiversity can be integrated in such efforts to enhance effectiveness. The recently enhanced intervention on provision of seedlings for fruit trees at lower cost by the local Agricultural Development Department in the study area is an important place to integrate agrobiodiversity improvement. Although the aim of the program is income oriented, it may contribute to reducing the impact of HIV/AIDS through enhancing nutrition as well.

Finally, to the extent that agrobiodiversity contributes to better nutrition and better nutrition to HIV/AIDS prevention and mitigation, increasing agrobiodiversity is a cross-cutting strategy which can be practiced regardless of the HIV/AIDS status of individuals and households.

As responses to HIV/AIDS are conditioned by specific household circumstances, intervention efforts should consider expanding the options to enable household responses according to their specific circumstances. The importance of the household role of the affected member in household responses, as well as the stages of illness, calls for designing affected member- and stage-specific impact analysis and intervention strategies. This is in line with Topouzis (2001) who suggested that stages of the epidemic need to be considered in programs and initiatives to alleviate HIV/AIDS impact. The observed gradual increase in household income per capita in three of the cases following loss of a severely ill adult needs to be empirically tested by taking into account the social and private costs involved in raising the household income per capita. Young (2005) predicts a long term per capita consumption rise as a result of the reduction in fertility caused by increased protected sex and increase in the value of woman's time due to HIV/AIDS.

Based on the evidence in Chapter 3 that all the cases knew their HIV status only following severe illness or death of a spouse, the scaling up of existing efforts to raise awareness on having adults and children tested for HIV becomes relevant. Moreover, HIV/AIDS awareness could be integrated into the existing informal agricultural education as well. It is evident from the in-depth analysis that financial support is more relevant at the severe illness stage.

The evidenced positive effect of HIV/AIDS on sharecropping-out intensity has implications for the labor market, implying that the demand for sharecropping labor increases with the further spread of HIV/AIDS. Apart from addressing the labor shortage and productivity issues of increased adult morbidity and mortality, sharecropping also helps to increase labor and land employment. This contributes to reducing the labor unemployment rate in the area. Moreover, because sharecropping-out presupposes land title holding, facilitating land titling may be important for households who are affected by adult male mortality.

5.3 LIMITATIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

The major limitation of the study pertains to the difficulty of observing HIV/AIDS among the farm households in the area, either due to not knowing or reluctance to disclose ones HIV positive status. An attempt was made to anonymously link clinical data to the survey households but this was not found to be a viable option for ethical and confidentiality reasons. Therefore, I opted for proxy indicators, whereby mortality and morbidity were taken as indicators for HIV/AIDS. The ideal situation to conduct an HIV/AIDS impact analysis will be to find a way so that clinical data on individual HIV status can be linked anonymously to the survey households. This requires both increasing awareness and access to testing for HIV/AIDS among farm households and a structured cooperation between medical scientists and institutions as well as social scientists. Where these arrangements are not possible, the quality of research could still be improved through identifying better indicators for HIV/AIDS.

The study does not provide empirical evidence on the extent to which the degree of agrobiodiversity in the home garden might be translated into nutritional security. Rather, it largely draws on the positive nutritional implications of agrobiodiversity from the established literature. Although I expect that higher agrobiodiversity in home gardens makes an important nutritional potential for subsistence farm households, further study is needed to establish the significance of the link. This raises, for instance, the question of whether households who sharecrop-out more and those that had agricultural education have better nutrition than others (equitably among members and over time) consistent with their higher agrobiodiversity. In line with this, further research targeted to developing a diversity index which purely reflects nutritional relevance of the crops grown in the home garden and fields is needed. This may be accompanied by an in-depth assessment of the nutritional demand of HIV/AIDS affected households. It also warrants examining the additional economic benefit that can be generated by the increase in agrobiodiversity among the households. The results of the thesis combined with previous studies suggest that the HIV/AIDS driven increase in agrobiodiversity in the home garden, through increase in sharecropping, provides positive economic benefits by improving the nutrition and thereby the health status of the households. This assists in offsetting some of the negative impacts of HIV/AIDS. For effective interventions, however, the actual change in the net economic benefits of the increase in agrobiodiversity needs to be empirically established.

The econometric analysis fails to capture the dynamic effects in labor organization and agrobiodiversity. The study is not, however, completely silent about the dynamic effects as it attempted to capture some of it through the in-depth analysis. As most of the in-depth study results are confirmed by the significance levels in the econometric analysis, after controlling for other factors, this laid the ground to make inferences based on the in-depth study results on some of the dynamic effects. More detailed longitudinal analysis of the long run economic impacts of HIV/AIDS is recommended.

Looking at the results of the thesis in a wider perspective, it suggests the relevance of institutional support to enhance flexibility in labor organization to reduce the downturn due to HIV/AIDS through information, legal protection and free labor mobility. It also suggests analyzing the alternative strategies for cost effective prevention and/ or mitigation of the impact of HIV/AIDS. These include investing on increasing awareness on HIV prevention, education on the agrobiodiversity-nutrition nexus, distributing multivitamin supplements or a combination of two or more of them.

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SUMMARY

This thesis deals with the agrobiodiversity effect of changes in labor organization due to HIV/AIDS among farm households in Southwest Ethiopia. The study has been carried out as part of the African Women Leaders in Agriculture and Environment (AWLAE) project. Awareness has been growing of the impact of the spread of HIV/AIDS among individuals, households and the economy as a whole. HIV/AIDS affects farm households through illness and death causing a reduction in available labor time and productivity, and - in the period of the disease - an increase in health expenditures and an additional demand for nutrition. It is established that better nutrition contributes to HIV/AIDS impact mitigation through strengthening the immune system of HIV/AIDS affected individuals. There is also an increasing recognition of the role of agrobiodiversity in improving nutrition. However, the way HIV/AIDS affected households adjust their agrobiodiversity in response to the pressures of the epidemic is not clear.

A number of studies in the literature indicate that farm households under the influence of HIV/AIDS respond by reallocating labor towards a more limited number of crops and away from farming, whereas a few studies indicate that they respond by increasing the number of crops grown. In this thesis, we examine whether the effect on labor organization and agrobiodiversity can be established theoretically and empirically by accounting for the implications of both diverse roles and locations of plots and alternative labor organization options. In particular, efforts to mitigate the effect of HIV/AIDS through enhancing agrobiodiversity need to be based on a full understanding of how HIV/AIDS affects agrobiodiversity and of the options to increase agrobiodiversity.

The objective of this study is to examine the effect of HIV/AIDS driven changes in labor organization on agrobiodiversity at the farm in the Southwest part of Ethiopia. To this effect, the study first examines the likely form of labor organization among HIV/AIDS affected households and second it examines the effect of such labor organization on agrobiodiversity. In doing so, it identifies variables explaining agrobiodiversity decisions among the households and investigates the extent to which agrobiodiversity in the home garden is affected by labor organization. It also looks into a possible direct effect of HIV/AIDS (through morbidity and mortality) on agrobiodiversity. This thesis addresses three main research questions:

1. What does the theory of the farm household predict concerning the HIV/AIDS driven change in labor organization and agrobiodiversity?

2. What insights could be generated from in-depth analysis of the impact of HIV/AIDS on labor organization, crop choice and agrobiodiversity?

3. What generalizations could be made from a survey analysis of the implications of HIV/AIDS for labor organization and its effect on agrobiodiversity?

In order to address these questions both a theoretical and empirical analyses are conducted. The theoretical analysis employs a standard farm household model with the aim of analyzing the labor allocation and agrobiodiversity effect of HIV/AIDS. The empirical analysis comprises an in-depth study of HIV/AIDS affected families as well as a survey analysis using cross-sectional data collected during 2004/5 in Southwest Ethiopia.

Chapter 2 employs a theoretical analysis and numerical simulations using GAMS to investigate the labor organization and agrobiodiversity effects of HIV/AIDS (research question 1). This is conducted with a model specification based on the labor allocation approach and a specification based on the diversity approach using the Dixit-Stiglitz model of product diversity. In both cases, the farm household model predicts that HIV/AIDS affected households allocate more labor to the home garden and increase sharecropping-out their fields with the decline in health status, if the possibility of substitution between the home garden and field products is sufficiently large. The increase in sharecropping is accompanied by a decrease in own labor allocation to the field and an increase in labor allocation to the home garden with the decline in health status. Additionally, the model based on the diversity approach also predicts an increase in the number of crop species as well as agrobiodiversity in the home garden with declining health status. In reality, substitutability between the products in the field and home garden can be expected with availability of replacement labor options to cultivate at least a part of the field. The theoretical analysis puts forward hypotheses for empirical testing in the subsequent chapters. The hypotheses concern the significance of the effect of HIV/AIDS on sharecropping-out fields; the significance of the effect of sharecropping-out fields on agrobiodiversity in the home garden; the effect of alternative labor organizations on agrobiodiversity.

Chapter 3 focuses on an in-depth study of four HIV/AIDS affected households in the Southwest of Ethiopia to describe the possible effects of HIV/AIDS on labor organization, crop choice and agrobiodiversity (research question 2). It looks into the importance of the stages of manifestation of HIV/AIDS for each affected household member. The in-depth study helps to increase understanding by comparing labor organization and agrobiodiversity patterns before and after the onset of HIV/AIDS as well as throughout the various stages of manifestation of HIV/AIDS.

Although generalizations can not be made based on in-depth case studies of just four households, the results of the in-depth study give insight into the effect of HIV/AIDS that warrants testing in a larger context. The effect of HIV/AIDS on household constraints and subsequent responses are diverse depending on the stage of HIV/AIDS manifestation and the household role of the affected member cannot be underestimated. More specific observations include that the case families are still sharecropping-out their fields following severe illness or death of adult household members. Agrobiodiversity in the home garden has increased for three of the case households after the onset of HIV/AIDS along with a change in crop mix. Moreover, a gradual increase in household income per capita has also been observed among the case households. The case study results also indicate the role of land titles in securing production among the households.

Chapter 4 uses econometric analysis for testing the hypotheses generated in Chapter 2 (research question 3). In order to test the significance of the effect of the sharecropping-out intensity on agrobiodiversity, a reduced form agrobiodiversity equation is estimated by using an instrumental variable technique on a truncated model after testing for selection bias. Estimation is based on cross-sectional survey data. The analysis starts with establishing the link between HIV/AIDS and labor organization by testing the significance of the effect of HIV/AIDS on sharecropping-out intensity on an estimated Tobit model. Because of the difficulty of observing HIV/AIDS in a larger survey, the analysis employs adult male morbidity and mortality as proxy indicators for HIV/AIDS.

The results of the survey analysis suggest that households affected by adult male morbidity and mortality tend to increase sharecropping-out intensity of their fields. Moreover agrobiodiversity is found to be higher among households who practice a higher degree of sharecropping-out intensity. This shows that the predictions of the theory and the observations among the HIV/AIDS affected case households are also reflected in the larger survey. The data confirms a direct effect of male morbidity and mortality on sharecropping-out intensity which in turn positively affects agrobiodiversity but not a direct effect of male morbidity and mortality on agrobiodiversity. This suggests that changes in labor organization play an important role in the change in agrobiodiversity among HIV/AIDS affected households.

In addition, households that participated in informal agricultural education tend to have higher agrobiodiversity in the home garden indicating an opportunity for intervention efforts through improving education. The effect of transfer income on agrobiodiversity does not seem to depend on whether it is received by male or female. This may be due either to the low level of transfer income received or to income pooling in the household.

The study contributes to the existing literature in four ways. First, agrobiodiversity may not necessarily decline due to HIV/AIDS at least at the species level. Rather, the effect of HIV/AIDS on agrobiodiversity works through labor organization and hence the form of labor organization matters for the effect on agrobiodiversity. Availability of a more convenient labor organization option (e.g. sharecropping) in HIV/AIDS affected areas enhances agrobiodiversity in the home garden. Although the results confirm that increase in the degree of sharecropping-out contributes to increasing agrobiodiversity in the home garden, this is not found to be the case for the increase in the degree of labor hiring. Second, the study indicates - contrary to the view of sharecropping as an inefficient institution - that it is likely to continue to be practiced with the unchecked spreading of HIV/AIDS. That is, sharecropping dominates productivity of family labor with the increase in adult morbidity and mortality. Third, the evidence that household members' participation in agricultural education enhances agrobiodiversity suggests a local potential to enhance agrobiodiversity strategies to mitigate the effect of HIV/AIDS. Fourth, the three approaches followed in the thesis enhance the understanding of the effect of HIV/AIDS on labor organization and agrobiodiversity. Thus, where it is difficult to observe HIV/AIDS, the study suggests using a combination of approaches in order to get a fuller picture of the situation of HIV/AIDS affected farm households. The results of the larger survey are consistent with the predictions of the theory as well as with the observations in the in-depth study. The findings of the larger survey results are enriched by the in-depth study results through capturing some of the dynamics of the effects that cannot be captured by the larger cross-sectional survey data. Moreover, the limitation of the reliance on the survey results, which is based on proxy indicators, is reduced by the inclusion of the in-depth study results based on actual HIV/AIDS observation.

The study provides some recommendations for intervention in order to assist household responses to the pressures of the HIV/AIDS epidemic. It is evidenced that HIV/AIDS affects farm households in a diverse way depending on the specific household circumstances including, but not limited to, the stages of HIV/AIDS manifestation and the household role of the affected member. This calls for efforts to mitigate the impact of HIV/AIDS that focus on increasing the number of options available to the households so as to enable them to respond according to their specific circumstances.

The evidence of sharecropping as a more compatible labor organization to the situation of HIV/AIDS affected households, both by enhancing productivity and agrobiodiversity indicates that the negative effect of HIV/AIDS can be reduced given flexibility in labor organization. This suggests two areas for consideration in mitigation efforts. First, because sharecropping assumes land title, it is important to facilitate land titling to surviving members of households with a deceased adult male (including to fostering parents as necessary). Second, it is important to consider some institutional assistance aimed at increasing access to more productive sharecropping labor particularly for households with less negotiating power. This may include enhancing information, legal protection and free labor mobility.

The evidence that informal agricultural training of household members has a favorable agrobiodiversity effect suggests another area of intervention. Education on nutritional values of crops grown in the area can be integrated to the already existing informal agricultural education for a potentially favorable effect on agrobiodiversity and hence nutrition.

SAMENVATTING (SUMMARY IN DUTCH)

Dit proefschrift gaat over het effect op de agrobiodiversiteit van veranderingen in de arbeidsorganisatie wegens HIV/AIDS bij rurale huishoudens in zuidwest Ethiopië. Het onderzoek vormt een onderdeel van het project African Women Leaders in Agriculture and Environment (AWLAE). Bewustwording over de invloed van de verspreiding van HIV/AIDS op individuen, huishoudens en de economie in het algemeen is toegenomen. HIV/AIDS beïnvloedt rurale huishoudens via ziekte en sterfte waardoor het arbeidsaanbod en de arbeidsproductiviteit dalen, en - in de periode van ziekte - ziektekosten toenemen en additionele vraag naar voedsel ontstaat. Het is bekend dat betere voeding bijdraagt aan de bestrijding van de gevolgen van HIV/AIDS doordat het immuunsysteem van de getroffen personen wordt versterkt. De rol van agrobiodiversiteit in de verbetering van voeding wordt ook in toenemende mate erkend. Het is echter nog onduidelijk op welke manier door HIV/AIDS getroffen huishoudens hun agrobiodiversiteit aanpassen als reactie op de epidemie.

Verschillende onderzoeken in de literatuur wijzen uit dat rurale huishoudens in reactie op HIV/AIDS hun aanwending van arbeid veranderen waarbij ze minder verschillende landbouwgewassen gaan verbouwen en minder tijd besteden aan landbouw, terwijl sommige studies juist aangeven dat hun reactie het aantal verschillende gewassen doet toenemen. In dit proefschrift onderzoeken we of het effect op de arbeidsorganisatie en de agrobiodiversiteit theoretisch en empirisch kan worden gestaafd, waarbij de gevolgen van zowel de verschillende functies en locaties van de percelen alsook alternatieve vormen van arbeidsorganisatie worden betrokken. Inspanningen om de gevolgen van HIV/AIDS te beperken door een verhoging van de agrobiodiversiteit dienen te zijn gebaseerd op een volledig begrip van het effect van HIV/AIDS op agrobiodiversiteit en van de manieren waarop agrobiodiversiteit kan worden vergroot.

De doelstelling van dit onderzoek is om het effect van veranderingen in de arbeidsorganisatie als gevolg van HIV/AIDS op de agrobiodiversiteit op agrarische bedrijven in het zuidwestelijke gebied van Ethiopië te bestuderen. Daartoe analyseert het ten eerste de waarschijnlijke arbeidsorganisatie in huishoudens die getroffen zijn door HIV/AIDS en ten tweede de invloed van deze arbeidsorganisatie op de agrobiodiversiteit. Zodoende stelt het de variabelen vast die de beslissingen over agrobiodiversiteit in huishoudens verklaren en onderzoekt het de mate waarin de arbeidsorganisatie de agrobiodiversiteit in de eigen groentetuin (‘home garden’) beïnvloedt. Het behandelt tevens het mogelijke effect van HIV/AIDS (door morbiditeit en mortaliteit) op de agrobiodiversiteit. Dit proefschrift behandelt drie specifieke onderzoeksvragen:

1. Wat voorspelt de theorie van het gedrag van rurale huishoudens met betrekking tot de door HIV/AIDS veroorzaakte verandering in de arbeidsorganisatie en de agrobiodiversiteit?
2. Welke inzichten kunnen worden verkregen uit een dieptestudie van de invloed van HIV/AIDS op de arbeidsorganisatie, gewaskeuze en agrobiodiversiteit?
3. Welke generalisaties kunnen worden afgeleid van een steekproef analyse van de implicaties van HIV/AIDS voor de arbeidsorganisatie en het resulterende effect op agrobiodiversiteit?

Om deze vragen te behandelen worden zowel een theoretische als een empirische analyse uitgevoerd. De theoretische analyse maakt gebruik van een algemene vorm van een collectief model van agrarische gezinshuishoudens om het effect van HIV/AIDS op de arbeidsorganisatie en de agrobiodiversiteit te analyseren. De empirische analyse behelst zowel een dieptestudie van huishoudens die door HIV/AIDS zijn getroffen als een steekproef analyse die gebruik maakt van cross-sectional data vergaard in 2004-2005 in zuidwest Ethiopië.

Hoofdstuk 2 gebruikt een theoretische analyse en een numerieke simulatie uitgevoerd in GAMS om de effecten van HIV/AIDS op de arbeidsorganisatie en de agrobiodiversiteit te onderzoeken (onderzoeksvraag 1). Hierbij zijn modelspecificaties toegepast gebaseerd op de arbeidsallocatie-benadering en gebaseerd op de diversiteitbenadering waarbij gebruik gemaakt wordt van het Dixit-Stiglitz model van productdiversiteit. In beide gevallen voorspelt het model van de agrarische gezinshuishouding dat er meer kans is dat huishoudens die getroffen zijn door HIV/AIDS meer arbeid voor de eigen groentetuin bestemmen en hun percelen in toenemende mate (deel)verpachten (in het Engels aangeduid als 'sharecropping') naarmate hun gezondheidstoestand slechter wordt, mits de substitutie tussen producten uit de groentetuin en die van de akker groot genoeg is. De toename in het (deel)verpachten gaat gepaard met een afname van de toedeling van eigen arbeid aan de akker en een toename van de allocatie van arbeid ten behoeve van de eigen groentetuin al naar gelang de gezondheid vermindert. Bovendien voorspelt het model dat is gebaseerd op de diversiteitbenadering ook een toename van het aantal soorten gewassen alsmede van de agrobiodiversiteit in de eigen groentetuin in correlatie met de achteruitgang in de gezondheidstoestand. In de praktijk is de verwachting dat de substitueerbaarheid tussen producten van de akker en uit de groentetuin groter is naarmate er meer vervangende arbeid beschikbaar is om althans een deel van de akker te bewerken. De theoretische analyse reikt hypotheses aan die empirisch worden getoetst in de volgende hoofdstukken. De hypotheses betreffen het belang van de invloed van HIV/AIDS op het (deel)verpachten van percelen; het belang van de invloed van het (deel)verpachten van percelen op de agrobiodiversiteit in de eigen groentetuin; en het effect van alternatieve vormen van arbeidsorganisatie op de agrobiodiversiteit.

Hoofdstuk 3 richt zich op een dieptestudie naar vier door HIV/AIDS getroffen huishoudens in zuidwest Ethiopië om de mogelijke effecten van HIV/AIDS op de arbeidsorganisatie, de gewaskeuze en de agrobiodiversiteit te beschrijven (onderzoeksvraag 2). Het bestudeert het belang van de stadia waarin de manifestatie van HIV/AIDS zich bevindt bij elk gezinslid. De analyse draagt bij aan de kennisverbetering door middel van een vergelijking van de arbeidsorganisatie en de patronen van agrobiodiversiteit vóór en na de komst van HIV/AIDS alsook tussen de verschillende stadia in de manifestatie van HIV/AIDS.

Hoewel geen algemene conclusies kunnen worden getrokken uit de case studies van slechts vier huishoudens, geven de resultaten van de dieptestudie wel inzicht in de effecten van HIV/AIDS hetgeen toetsing in een bredere context rechtvaardigt. Het gevolg van HIV/AIDS voor de beperkingen van huishoudens en de daaropvolgende reacties lopen uiteen afhankelijk van het stadium van HIV/AIDS manifestatie en de rol van de betreffende persoon in het huishouden moet niet worden onderschat. Verder is onder andere met name geconstateerd dat onderzochte families nog steeds hun percelen (deel)verpachten na ernstige ziekte of sterfgevallen van de volwassen leden van het huishouden. Bij drie van de onderzochte huishoudens is na de aanvang van HIV/AIDS de agrobiodiversiteit in de eigen groentetuin toegenomen, waarbij veranderingen in gewaskeuze (mix) een rol spelen. Bovendien is een geleidelijke toename van het inkomen per hoofd in het huishouden geconstateerd bij de onderzochte huishoudens. De resultaten van de case studies wijzen verder op de rol die eigendomsrechten op land spelen bij het veiligstellen van de productie van rurale huishoudens.

Hoofdstuk 4 past een econometrische analyse toe om de hypotheses die hoofdstuk 2 voortbracht te toetsen (onderzoeksvraag 3). Teneinde te toetsen of de invloed van de mate van (deel)verpachting op de agrobiodiversiteit significant is, is een gereduceerde vormvergelijking voor agrobiodiversiteit geschat met behulp van een instrumentele variabele techniek op een truncated model nadat is getest voor selection bias. De schattingen zijn gebaseerd op cross-sectional steekproef data. De analyse stelt ten eerste het verband vast tussen HIV/AIDS en de arbeidsorganisatie door de significantie te toetsen van het effect van HIV/AIDS op de mate van (deel)verpachting met een geschat Tobit model. In verband met problemen met het observeren van HIV/AIDS in de brede steekproef, zijn de morbiditeit en de mortaliteit van volwassen mannen gebruikt als proxy indicatoren voor HIV/AIDS.

De resultaten van de steekproefanalyse geven aan dat de door morbiditeit en mortaliteit getroffen huishoudens de neiging hebben het (deel)verpachten van hun percelen te intensiveren. Bovendien blijkt de agrobiodiversiteit groter te zijn bij huishoudens die intensiever (deel)verpachten. Hieruit blijkt dat de voorspellingen van de theorie en de waarnemingen uit de case studies van huishoudens ook worden waargenomen in de bredere steekproef. De data bevestigen het directe effect van mannelijke morbiditeit en mortaliteit op de mate van (deel)verpachting, wat weer een positieve invloed heeft op de agrobiodiversiteit, maar geen direct effect van mannelijke morbiditeit en mortaliteit op de agrobiodiversiteit. Dit wijst erop dat veranderingen in de arbeidsorganisatie een belangrijke rol spelen bij de verandering in de agrobiodiversiteit bij huishoudens die kampen met HIV/AIDS.

Daarbij hebben huishoudens die informeel agrarisch onderwijs hebben genoten vaak meer agrobiodiversiteit in de eigen groentetuin, hetgeen wijst op een mogelijkheid tot interventie door de educatie te verbeteren. Het effect van inkomsten uit andere bronnen dan arbeid op de agrobiodiversiteit blijkt onafhankelijk te zijn van de vraag of dit inkomen is ontvangen door mannelijke of door vrouwelijke leden van het huishouden. Dit kan worden veroorzaakt door het lage niveau van deze inkomsten of door ‘income pooling’ in de huishoudens.

Deze studie draagt op vier manieren bij aan de bestaande literatuur. Ten eerste, de agrobiodiversiteit op het niveau van soorten neemt niet noodzakelijkerwijs af als gevolg van HIV/AIDS. In plaats daarvan werkt het effect van HIV/AIDS op agrobiodiversiteit via de arbeidsorganisatie en dus is de vorm van arbeidsorganisatie van belang voor het effect op de agrobiodiversiteit. De beschikbaarheid van meer toepasselijke opties voor arbeidsorganisatie (zoals een pachtsysteem) in gebieden die kampen met HIV/AIDS vergroot de agrobiodiversiteit in de groentetuin. Hoewel de resultaten bevestigen dat een toename in de mate van (deel)verpachting bijdraagt aan een vergroting van de agrobiodiversiteit in de eigen groentetuin, blijkt dit niet het geval te zijn voor een toename van de hoeveelheid ingehuurde arbeid. Ten tweede geeft het onderzoek aan dat het, in tegenstelling tot de opvatting dat (deel)verpachting een inefficiënt systeem is, waarschijnlijk is dat dit systeem zal worden gecontinueerd als HIV/AIDS zich ongebreideld verspreidt. Het pachtsysteem domineert namelijk de productiviteit van familiearbeid wanneer morbiditeit en mortaliteit onder volwassenen toenemen. Ten derde suggereert het feit dat de participatie van leden van het huishouden in landbouwonderwijs de agrobiodiversiteit verhoogt, dat er lokale mogelijkheden bestaan om de agrobiodiversiteitstrategieën te verbeteren en zo de gevolgen van HIV/AIDS tegen te gaan. Ten vierde helpen de drie benaderingen die in dit proefschrift worden gevolgd de impact van HIV/AIDS op de arbeidsorganisatie en de agrobiodiversiteit beter te begrijpen. Hoewel het moeilijk is HIV/AIDS waar te nemen, beveelt dit onderzoek aan een combinatie van benaderingen toe te passen opdat een meer compleet beeld van de situatie van door HIV/AIDS getroffen agrarische huishoudens kan worden geschetst. De resultaten van de bredere statistische analyse komen overeen met zowel de voorspellingen vanuit de theorie als met hetgeen is waargenomen in de dieptestudie. De bevindingen van de bredere analyse zijn verrijkt met de resultaten van de dieptestudie door de dynamiek van de effecten bloot te leggen die niet kunnen worden waargenomen in de omvangrijke cross-sectional steekproef data. Bovendien wordt de beperking als gevolg van het feit dat de steekproef analyse is gebaseerd op proxy indicatoren verminderd door gebruik te maken van de resultaten van de dieptestudie die op feitelijke waarneming van HIV/AIDS zijn gebaseerd.

Het onderzoek brengt aanbevelingen voort voor interventie met als doel huishoudens te helpen in hun respons op de HIV/AIDS epidemie. Het is gebleken dat HIV/AIDS rurale huishoudens op een andere manier beïnvloedt naarmate de specifieke omstandigheden verschillen, bijvoorbeeld op het gebied van het stadium van de manifestatie van HIV/AIDS en de rol van de betrokken persoon in het huishouden. Dit vraagt om een inspanning teneinde de impact van HIV/AIDS te verminderen die zich richt op het vergroten van de mogelijkheden voor huishoudens om te reageren vanuit hun specifieke omstandigheden.

Het feit dat (deel)verpachting een meer geschikte vorm van arbeidsorganisatie blijkt te zijn voor de situatie waarin huishoudens zich bevinden die met HIV/AIDS kampen, door zowel de verbeterde productiviteit als toenemende agrobiodiversiteit, geeft aan dat de negatieve gevolgen van HIV/AIDS kunnen worden gereduceerd met behulp van flexibiliteit in de arbeidsorganisatie. Er zijn daarom twee terreinen die in de overweging van bestrijdingsinspanningen meegenomen kunnen worden. Ten eerste, omdat een voorwaarde voor (deel)verpachten is dat er eigendomsrechten voor land bestaan, is het belangrijk dat de overdracht van zulke rechten op overlevende leden van de huishoudens waarin een volwassen man komt te overlijden wordt vergemakkelijkt (zonodig mogelijk overdracht op een voogd). Ten tweede is het belangrijk enige institutionele steun te overwegen die ten doel heeft de toegang te vergroten tot productievere pachtarbeid, vooral voor huishoudens met een relatief slechte onderhandelingspositie. Te denken valt aan het verbeteren van informatie, rechtssteun en vrije mobiliteit van arbeid.

De bevinding dat informeel agrarisch onderwijs een positief effect heeft op agrobiodiversiteit wijst op een andere mogelijkheid tot interventie. Educatie over de voedingswaarde van gewassen die in de regio worden geteeld kan worden geïntegreerd in het bestaande informele agrarische onderwijs met een mogelijk positief effect op de agrobiodiversiteit en daarmee ook op de voeding en de impact van HIV/AIDS.

CURRICULUM VITAE

Kidist Gebreselassie was born on January 8th, 1971 in Tigray, Ethiopia. She studied at the Alemaya University during 1988-1992 obtaining a B.Sc. degree in Agricultural Economics. In 1992, she was appointed as a graduate assistant at the department of Agricultural Economics and Extension of the Jimma University, the then Jimma College of Agriculture.

With a scholarship from NORAD, she studied at the Agricultural University of Norway (NLH) during 1998-2000 and obtained M.Sc. degree specializing in Development and Resource Economics. Her M.Sc. thesis was based on farm household survey and deals with the effect of price and trade policy reform on land use and sustainability implications in Southern highlands of Ethiopia. Since then she was working as a lecturer at Jimma University. In addition to the teaching job, she assumed various administrative responsibilities at the department including coordinating a small scale credit scheme for women farmers around Jimma.

In 2003, she was awarded the African Women Leaders in Agriculture and Environment (AWLAE) scholarship, a program of Winrock International and in partnership with Wageninegn University, to pursue PhD studies at the Environmental Economics and Natural Resources Group of Wageningen University. As a component of the award, she attended the Leadership for Change workshop in Nairobi, Kenya during 17th-22nd February, 2003. Her PhD research employs farm household survey and in-depth study of case households in two woredas of Jimma zone. It focuses on analyzing the effect of HIV/AIDS on labor organization and crop diversity.

TRAINING AND SUPERVISION PLAN

Description	Institute	Year	Credits[14]
General courses			
Research Methodology: Designing and Conducting a PhD Research Project	Mansholt Graduate School	2003	2
Techniques of Scientific Writing and Presentation	Mansholt Graduate School	2006	1.5
Socio-cultural Field Research Methods	Mansholt Graduate School	2004	2
Mansholt-specific courses			
Mansholt Introduction Course	Mansholt Graduate School	2003	1
Mansholt Multidisciplinary Seminar	Mansholt Graduate School	2007	1
Discipline-specific courses			
Parametric Efficiency and Productivity Analysis	Mansholt Graduate School	2003	2
Non-parametric Efficiency and Productivity Analysis	Mansholt Graduate School	2003	2
Advanced Econometrics	Mansholt Graduate School	2006	6
Bio-economic Household Modeling	Mansholt Graduate School	2004	2
Natural Resource Economics	Netherlands Network for Economists	2004	3
HIV/AIDS and Rural Livelihoods in sub-Saharan Africa	Mansholt Graduate School	2003	2
Livelihood Analysis and Research for Poverty Reduction	Research School for Resource Studies for Development (Utrecht University)	2003	2
Gender and Economics in Rural Africa	Research School for Resource Studies for Development PhD special course (Institute of Social Studies)	2003	1
Gender, Food, Agriculture and Development	Mansholt Graduate School	2003	2
Development of Development Theory	Research School for Resource Studies for Development (Institute of Social Studies)	2003	4
Face of Poverty, Capabilities, Mobilization and Institutional Transformation	Research School for Resource Studies for Development (Univ. of Amsterdam)	2003	2
Presentations at conferences and workshops			*2*
Sustainable Global Health, Bonn, Germany		2007	
15th Annual Conference of the European Association of Environmental and Resource Economists, Thessaloniki, Greece		2007	
Annual meeting of the American Agricultural Economics Association, Portland, Oregon, USA		2007	
Total (min 20 credits)			37.5

[14] 1 credit stands for 40 hours

AWLAE (*African Women Leaders in Agriculture and the Environment*)

The present thesis is one of a series. It represents the fruits of a collaboration between African Women Leaders in Agriculture and the Environment (AWLAE), Winrock International (WI), and Wageningen University and Research Centre (WUR). AWLAE is a pan-African program that aims at training women professionals in the fields of agriculture and environment, to redress the existing gap between male and female representation in professions relating to these fields. AWLAE was initiated by Winrock International in 1989. Its headquarters are in Nairobi, Kenya.

Between AWLAE, WI, and WUR a project was formulated that was submitted for funding to the Minister for Development Cooperation of the Netherlands Ministry of Foreign Affairs. The goal of the project was to build a cadre of well-trained African women professionals working in agriculture, environment and related sectors to enhance their academic standing and capacity to contribute to gender-relevant research and policy-making on the role of women in food systems and the gendered impacts of HIV/AIDS on food security and rural livelihoods in sub-Saharan Africa. In April 2002 the project was granted. The Ministry agreed to fund twenty PhD scholarships at Wageningen University and the additional leadership-in-change training for twenty women from eleven African countries, ranging from East to West and Southern Africa. In June 2002 an agreement was signed between AWLAE, represented by its Regional Director, and the Director of the WUR Social Sciences Group, after which implementation of the project could start. The participating scholars were carefully selected from a large number of applications. The scholarships were widely advertised in relevant media in countries with AWLAE chapters, and the chapters concerned were actively involved in the recruitment and selection of the candidates. The following women participate(d) in the AWLAE scholarship project:

Susana Akrofi (Ghana)	Mariame Maiga (Ivory Coast)
Hirut Bekele (Ethiopia)	Lydia Ndirangu (Kenya)
Namizate Binata Fofana (Ivory Coast)	Aifa Fatimata Ndoye Niane (Senegal)
Joyce Challe (Tanzania)	Faith Nguthi (Kenya)
Fatimata Dia Sow (Senegal)	Carolyne Nombo (Tanzania)
Stephanie Duku (Ghana)	Regina Ntumngia Nchang (Cameroon)
Rose Fagbemissi (Benin)	Daisy Onyige (Nigeria)

Kidist Gebreselassi (Ethiopia)	Gaynor Paradza (Zimbabwe)
Monica Karuhanga (Uganda)	Corrie du Preez (South Africa)
Doris Kakuru (Uganda)	Ekaete Udong (Nigeria)