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

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Abstract—Improved micronutrient intake contributes to delaying the progression of HIV into AIDS and to reducing HIV infection rates. Higher agrobiodiversity in the homegarden contributes to improving the nutritional status of farm households. Farm households with HIV/AIDS affected members observe a decrease in labor supply and productivity causing them to reallocate labor. The reallocation of labor may result in 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. The study is based on a survey among 205 farm households in the Jimma zone of South Western Ethiopia. Results show that HIV/AIDS driven increase in sharecropping has a positive effect on perennial and overall agrobiodiversity in the homegarden. This offers additional intervention options to mitigate the impacts of HIV/AIDS among farm households.

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

I. 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 and Gari, 2004; Johns and Eyzaguirre, 2006) has a positive impact on HIV/AIDS mitigation (e.g. Haddad and Gillespie, 2001; FAO/WHO, 2002; Castleman, Seumo-Fosso and Cogill, 2004; Fawzi et al, 2004; Gillespie and Kadiyala, 2005; Stillwaggon, 2006). Secondly, HIV/AIDS causes changes in labor organization (e.g. Loevinsohn and Gillespie, 2003; Bishop-Sambrook et al. 2006) and crop choice towards less labor-intensive crops (e.g. Haddad and Gillespie, 2001). As increasing agrobiodiversity is labor intensive (Nair, 2001; Mendez, Lock and Somarriba, 2001) and HIV/AIDS reduces labor supply (Barnett and Whiteside, 2002; Drimie, 2003; Loevinsohn and Gillespie, 2003; Gillespie and Kadiyala, 2005), HIV/AIDS may on the one hand negatively affect agrobiodiversity but on the other hand as reallocation of labor may increase time spent in homegardens, it may positively affect agrobiodiversity.

The purpose of our paper is to test the effect of HIV/AIDS driven changes in labor organization on homegarden agrobiodiversity among farm households in Ethiopia in 2005. Reduced form equations for the agrobiodiversity of perennial, annual, and overall crops are estimated to test for the effect. Data for estimation is collected through a survey conducted on 205 farm households in Gomma and Kersa woredas in South West Ethiopia. Estimation involves regression of agrobiodiversity indices on variables capturing labor organization and variables controlling for other factors explaining agrobiodiversity.

Results show HIV/AIDS driven changes in labor organization, by employing sharecropping arrangements, significantly increase homegarden agrobiodiversity, while employing hired labor decreases homegarden agrobiodiversity.

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

II. HIV/AIDS, Labor Organization and Agrobiodiversity: Hypotheses

A. Hypothesis 1: HIV/AIDS Affected Households Which Increase Sharecropping-out Intensity of Their Fields Have Higher Agrobiodiversity in the Homegarden

We expect that HIV/AIDS affected households sharecrop-out a larger portion of their fields and have a higher degree of agrobiodiversity in the homegarden. This is because increased intensity of sharecropping-out fields is expected to release family labor from fields to increase homegarden activities. This proposition has the underlying hypothesis that sharecropping-out intensity increases among households which are affected by adult morbidity and mortality which again needs to be tested for. 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, 2000). Additionally, sharecropping assists in easing cash constraint by deferring payment for labor and possibly other farm inputs. Given that sharecropping-out eases some of the cash constraint, households which sharecrop-out more are more likely to increase labor supply for the homegarden rather than for off-farm activities.

Table 1 shows the average perennial, annual and overall agrobiodiversity index among households which are engaged in sharecropping and hiring-in labor. Among households which sharecrop-out land, 85.2% grow perennial crops, 68.8% grow annual crops and 90.2% grow either perennial or annual crops or both in the homegarden. About 30% of the sample households sharecrop-out land and average sharecropping-out intensity for the sample households is 0.14 fechassa (see Tables 2 and 3). Of the households which sharecrop-out land, 22.9% reported adult male illness (either single male (9.8%) or two-parent (13.1%)), 24.6% reported 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 which sharecrop-out land are single male while 32.8% of them are single female headed. Overall, 54.1% of those who sharecrop-out land 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-practice is observed among households with adult illness, death or both.

B. Hypothesis 2: HIV/AIDS Affected Households Which Increase Hired Labor Intensity have Lower Agrobiodiversity in the Homegarden

As an additional or substitute option to sharecropping-in, HIV/AIDS affected farm households can hire-in additional labor. We expect that HIV/AIDS affected households hiring labor for field activities increase their household labor supply for gardening and off-farm activities, but use the additional labor time for maintaining or increasing off-farm activities. As a result, homegarden biodiversity remains the same or even decreases. If households which have higher intensity of hire-in labor need to increase off-farm participation in order to finance their hired labor, it increases the likelihood that agrobiodiversity in the homegarden decreases due to the increase in hire-in labor intensity. Cash constraint is an important factor in driving increased off-farm involvement among HIV/AIDS affected households (e.g. Loevinsohn and Gillespie, 2003) Table 1 shows that among households who hire-in labor, 71.2% grow perennial crops, 55.9% annual crops and 88.1% grow one or the other or both in the homegarden. Average perennial, annual and overall agrobiodiversity among households who hire-in labor is 77.8, 43.5 and 83.3 respectively and lower. About 29% of the sample households hire-in casual labor and the average hired-in casual labor is 1.18 labor day per fechassa per year (see Tables 2 and 3).

C. Hypothesis 3: Agricultural Education Contributes to Increasing Agrobiodiversity

The level of formal education of household members may affect agrobiodiversity either by increasing a household member's access to off-farm activities or preference towards specialization. In both cases, it is likely that the effect of education on agrobiodiversity is negative. On the other hand, it is expected that special agricultural education for adults is target oriented and increases exchange of planting material and information among farmers which enhances agrobiodiversity. Hence, increase in female and male participation in agricultural education is expected to have a positive effect on agrobiodiversity. Table 2 shows that 17% of female and 12% of male household members participated in agricultural training during the years 2004/2005.

III. Data and Variables

The variables used in the analysis were constructed from data collected from a sample survey conducted in two woredas namely, Gomma and Kersa of the Jimma zone in South West Ethiopia. HIV prevalence rate in the rural parts of the zone is estimated at 8.9% as compared to 7% in the urban areas (Belachew, Jira and Mammo, 2003). Because of higher seasonal labor migration, the coffee growing Gomma woreda is characterized by high HIV prevalence rate 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 purposely 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. Quantitative and qualitative data is generated for describing annual agricultural production practices, crop diversity, labor and other resource allocations and household characteristics. Homegarden, field, and coffee plots constitute the main plots of the households in the area. The main crops grown in the homegarden include perennials such as enset (*Ensete Ventricosum*), coffee, fruit trees (orange, mango, papaya, banana, avocado, guava, and pineapple), sugarcane, qat; annuals such as maize, haricot beans, and roots and vegetables (taro, yam, kale, pepper, and cabbage). Households may have several field plots which are mainly for growing cereals such as maize, sorghum, beans and teff.

A standardized survey instrument is 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 was obtained from secondary sources.

The dependent variables are annual agrobiodiversity index $\left(D_A\right)$, perennial agrobiodiversity index $\left(D_P\right)$, and total agrobiodiversity index $\left(D_T\right)$. Average annual and perennial agrobiodiversity indices for the sample households are 51.9 and 95.3 respectively (see Table 1).

The explanatory variable for empirical testing is the intensity of area sharecropped-out (*percsharearea*) measured in proportion to total household land. The intensity of labor hire-in (*hireinintensity*), measured as total hired labor days per unit area of land, 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 (*averageage*); formal education level of adult male and female household members (*edum, eduf*); homegarden and total land size (*gardensz*, *totld*); off-farm income (*offfarminc*); non-labor income of household members (*nonlabm*, *nonlabf*); number of children 5 years old and below (*nochildunder5*); and number of children 15 years old and above (*nochildabove15*). Dummy variables include being single female (*singlef*); location (*location*); obtaining credit (*credit*); increase in livestock holding over the past 5 years (*TLUincrease*); attending agricultural education by household members over the past year (*agredum*, *agreduf*) and type of housing (*houseironrf*). Total land holding and TLU variables are included because Benin, Smale and Pender (2006) found these variables to have a significant effect on intercrop diversity of cereals in Northern Ethiopia.

IV. Method

A. The Model

The farm household is assumed to have the option of replacing own farm labor through increasing hiring of casual labor or entering into sharecropping. In addition, it has access to off-farm opportunities such that farm and off-farm labor market participation involves varying transaction costs. In our analysis, individual utility is a function of individual consumption of goods, leisure and common household goods which is aggregated into household utility. Household utility maximization involves decisions on the allocation of each household member's labor and amount of external labor use. 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 given by:

$$D_c^* = D_c^*(w_M, p_j, \alpha(H), y_M; z^h), \qquad (1)$$

where D_c^* is the agrobiodiversity index, $c = A, P, T$ for annual, perennial and overall crops respectively; w is the wage rate, $M = m, f$ for male and female respectively; p_j is the prices for commodities $j = 1,..., J$; α is labor organization involving sharecropping which is a function of household's health status, H; y is non-labor income and z^h captures household specific characteristics. The general equation for empirical estimation, constructed based on (1) for annual, perennial and overall agrobiodiversity can be expressed in simple form as:

$$D_{c,i} = b_0 + \mathbf{x}_i \mathbf{b} + \alpha_i \beta + e_i \text{;} \quad (2)$$

where $D_{c,i}$ is the observed agrobiodiversity index for specific crop category, c, and household, i; α_i is an indicator for labor organization with a corresponding parameter β; x_i is a vector of other (weakly) exogenous variables affecting agrobiodiversity with a corresponding parameter vector b; and e_i is the error term.

B. Measurement and Estimation Issues

Measuring agrobiodiversity: which plots and crops?

In the study area, the household is less likely to change crop species and agrobiodiversity in fields because of customary rules and availability of sharecropping options (Gebreselassie, et al. 2007). In the event that the household needs to adjust crop choice and diversity, homegardens provide more room for flexibility. We, therefore, focus on homegardens 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 (2), namely, (i) observing HIV/AIDS and (ii) measuring agrobiodiversity. The problem of observing HIV/AIDS among the households arises from either unawareness or reluctance to disclose 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 in the literature is addressed by using duration of illness (e.g. Donovan et al, 2003; Stokes, 2003) and TB infection which is strongly associated with AIDS (e.g. Corbett et al, 2003). We, therefore, opted for adult mortality and morbidity (>30 successive days) as proxy indicators for HIV/AIDS. The question of whether to focus on relative abundance or taxonomic distinctiveness of species is addressed by employing the diversity index suggested by Weikard, Punt and Wesseler (2006) (WPW) which combines both. 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, $D^r_{c,i}(S)$, for a set of species, S, in crop category, c, and household, i, and a scale parameter, r, is given by[2]:

$$D^r_{c,i}(S) = \sum_{l \in S} d_{l,i}(1-(1-k_{l,i})^r), \qquad (3)$$

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

$$d_{l,i} = \sum_{o \in 1} d_{lo,i} \qquad (4)$$

where $d_{l,i}$ is the aggregate taxonomic distance defined for species l and household i and d_{lo} is the taxonomic distance between species, l and o, grown by the household, and $d_{ll} = 0$. 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 homegarden is given in Table A1 of the annex. The index is constructed in such a way that higher values indicate a higher degree of diversity. We calculated relative abundance as follows:

$$k_{l,i} = \frac{L_{l,i}}{\sum_{l \in S} L_{l,i}} \tag{5}$$

where L measures area allocation or plant head count depending on the crop category. For annual crops, k is constructed based on area allocation because data was available in terms of area. For perennial crops, k is constructed based on plant head counts because of the difficulty of assigning areas to perennial plants some of which are spread out in the garden. In both cases, average agrobiodiversity index 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.

Estimation issues

We are interested in modeling the degree of agrobiodiversity for households who have positive agrobiodiversity within a sample where agrobiodiversity is censored at zero. Possible models include two-part models (e.g. probit and truncated) and sample selection models (Cameron and Trivedi, 2005). Sample selection models are considered in order to correct for potential sample selection bias towards over-sampling of participants in agrobiodiversity practices. We considered two of the main sample selection models: namely, Simple Tobit and the Heckman (1979) (two-step and one-step (Maximum Likelihood Estimator)).

Difference-in-Sargan and Smith and Blundell (1986) exogeneity tests are conducted to test for the exogeneity of *percsharearea* and *hireinintensity* variables which are considered as potential sources of endogeneity in the agrobiodiversity equations. An increase in duration of male illness is expected to increase engagement in sharecropping-out fields. Similarly, households which 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 the proportion of male duration of illness, *percdurillm*, and lack of oxen, *nooxen*, are used as instruments for *percsharearea* variable in running the test. The variable capturing purchase of jewels during the past years, *boughtjewels*, is used as an instrument for *hireinintensity*. This is because of the expectation that households who are capable of paying cash for the purchase of jewels can afford to hire-in labor if needed. Additionally, there is little reason to believe that duration of illness, lack of oxen, or purchase of jewels directly affects agrobiodiversity in the homegarden except through labor organization. The Sargan overidentification test shows that the extra moment conditions created by the instruments are satisfied and the instruments can be said to be exogenous at 10% level of significance for all the equations. Regressing the instruments among other variables as explanators for sharecropping-out intensity, the instruments are found to have significant coefficients with signs that support expectations (see Section V). Accordingly, the instruments are considered as fairly valid (Murray, 2006).

A simple Tobit estimation is conducted to see the effect of the two manifestations of HIV/AIDS, namely adult male morbidity (*percdurillm)* and mortality (*singlef)* on the intensity of sharecropping-out fields. As shown in Table 4, *percdurillm* variable positively affects sharecropping-out intensity at 10% level of significance indicating that adult morbidity influences sharecropping-out intensity. Similarly, *singlef* variable positively affects sharecropping-out intensity at 5% level of significance indicating that single females increase the proportion of sharecropped-out land. *Nooxen* variable positively affects sharecropping-out intensity at 5% level of significance. The instruments, *percdurillm* and *nooxen* and all the included explanatory variables have the expected signs and the signs of the instruments are consistent with the intuitive expected signs of the instrumented variable. Based on this, the instruments can be considered as fairly good and valid for *percsharearea*.

Endogeneity of *hireinintensity* is detected by the Smith-Blundell test for the annual crop diversity. Hence, the instrumental variable Tobit model is employed to estimate the annual crop diversity equation by using *boughtjewels* variable as an instrument.

Both Difference-in-Sargan and Smith-Blundell tests could not reject the null hypothesis that both *percsharearea* and *hireinintensity* variables are exogenous in the perennial and total agrobiodiversity equations at 10% level of significance. This is also the case for independent testing of the exogeneity of the variables. Exogeneity of *percsharearea* and *hireinintensity* in the perennial and total agrobiodiversity equations allows for estimation options given by simple Tobit, two-part probit and truncated, and Heckman (two-step and one-step). Additional tests are conducted to decide on the more appropriate model. A likelihood ratio test of the hypothesis of the same underlying latent variable equation explains the decision on whether and how much agrobiodiversity in the homegarden is conducted. Test results differ for perennial and overall agrobiodiversity equations.

Based on the Likelihood ratio test, the null hypothesis that the parameters are the same for the selection and censored perennial crop diversity model is rejected at 5% level of significance. Hence, a model which allows for variation in the parameters in the selection and degree of perennial crop diversity equations is considered instead of a simple Tobit one. The Heckman one-step post estimation test results suggest that the null hypothesis of no correlation between disturbances across the selection and degree of diversity equations could not be rejected at 1% level of significance. This implies that the Heckman two-step estimator or two-part probit and truncated model can be used for estimating the perennial agrobiodiversity equation. The difference is that the second step OLS regression for the degree of perennial agrobiodiversity includes the fitted value of the Inverse Mills ratio term as an additional regressor in the case of the Heckman two-step model (Cameron and Trivedi, 2005). Since the disturbances of the two equations are uncorrelated, the equation can be estimated by OLS (Verbeek, 2004). Because we found it interesting to compare the selection equation with the other agrobiodiversity categories, we estimated the Heckman two-step model for the perennial agrobiodiversity equation. We found that the additional term is insignificant (p>0.784) and close to zero and as a result the Heckman two-step and the two-part models (probit and truncated) lead to similar coefficient estimates for the degree of perennial diversity.

The likelihood ratio test rejected the null hypothesis that the parameters are the same for the selection and censored model for overall agrobiodiversity at the 1% level of significance. This suggests the use of a model that allows for variation in the selection and degree of overall agrobiodiversity. Heckman's one-step post estimation test results indicate that the null hypothesis of no correlation between disturbances across the selection and degree of overall agrobiodiversity equation is rejected at 1% level of significance. This further suggests that the disturbances affecting the two decisions are correlated and it is justifiable to simultaneously estimate the two decisions and as a result the Heckman's one-step model is employed in estimation. Model probability Wald statistic of the perennial and overall agrobiodiversity equations indicates that the included variables are important in explaining variation in perennial and overall agrobiodiversity as compared to a model with only an intercept. This, however, is not the case for the annual crop diversity.

V. Results and Discussion

In Table 5, estimated coefficients for the degree of agrobiodiversity are reported under Eq1 and those for the likelihood of practising the specific agrobiodiversity are reported under Eq2 for perennial and total agrobiodiversity equations. For annual crops, Eq2 reports the first stage instrumental variable estimates.

A. Perennial Crop Diversity

The *percsharearea* variable positively affects the degree of perennial crop diversity at the 1% level of significance. With an increase in the proportion of area sharecropped-out by a household, the degree of perennial crop diversity in the garden increases significantly. This confirms our main hypothesis. *Hireinintensity* negatively affects the likelihood of growing perennial crops at 5% level of significance. It suggests that using hired labor does not lead to higher agrobiodiversity in the homegarden whereas sharecropping does. Hence, the type of labor organization affects agrobiodiversity and hired labor cannot be a substitute for sharecropping labor with respect to agrobiodiversity. *Eduf* has a significant negative effect on the degree of perennial crop diversity at 1% level of significance. On the other hand, *agreduf* positively affects the degree of perennial crop diversity at 10% level of significance and confirms our hypothesis about the effect of agricultural education.

B. Annual Crop Diversity

Only *agredum* variable was found to have a positive effect on the degree of annual crop diversity at 10% level of significance indicating the importance of male participation in agricultural education for annual agrobiodiversity. Other variables are not found significant which may be partly explained by larger size of non-growers of annual crops (33%) as compared to non-growers of perennial crops (15%) and that gardens are dominated by perennial crops (see Section III).

C. Total agrobiodiversity

Table 5 shows that *percsharearea* positively affects the degree of total agrobiodiversity at the 1% level of significance indicating that total agrobiodiversity increases with the increase in the proportion of area sharecropped-out. *Hireinintensity* was not found significant although it has the expected sign. The effects of *eduf* (negative at 5% level of significance) and *agreduf* (positive at 10% level of significance) are also important for total agrobiodiversity with the same explanation as given for perennial crop diversity. It is found that all variables that significantly affect perennial crop diversity also affect total agrobiodiversity in the same direction. This may be because there are more producers of perennial than annual crops and average perennial crop diversity is higher than annual in the garden.

Finally, the evidence of significant effect of increase in sharecropping-out and labor hiring (although weaker evidence) on perennial and total agrobiodiversity indicates that labor organization influences agrobiodiversity practices in the area. This is also consistent with the expectation that an increase in area sharecropped-out increases labor supply for gardening and thereby agrobiodiversity. The evidenced positive effect of agricultural education on perennial and total agrobiodiversity shows a room for improving the quality of agrobiodiversity in the HIV/AIDS context through increasing female access to agricultural education.

The results of the paper combined with previous studies suggest that the HIV/AIDS driven increase in agrobiodiversity in the homegarden, through increase in sharecropping, has a positive economic benefits through 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.

VI. Conclusions

The results show that the degree of agrobiodiversity in homegardens depends on household labor organization. This indicates that efforts aimed at enhancing crop choice or agrobiodiversity can be effective through addressing constraints in labor organization. The study reveals three main findings in light of testing the hypotheses.

First, we find that increase in sharecropping-out intensity leads to increase in agrobiodiversity in homegardens which has important implications for the effect of HIV/AIDS on agrobiodiversity. Our finding is contrary to the indicated decline in agrobiodiversity due to HIV/AIDS (e.g. Barnett and Whiteside, 2002; Gillespie and Kadiyala, 2005). We suggest that access to more convenient labor market arrangements such as sharecropping is significant for the effect of HIV/AIDS on agrobiodiversity. Note that households affected by adult morbidity and mortality have the potential to increase agrobiodiversity even more than can be achieved through sharecropping as they tend to withdraw more labor from fields to homegarden activities. This, however, occurs at the expense of income earned from field activities. Moreover, such households, if not involved in sharecropping-out, are more likely to increase off-farm activities to ease some of their cash constraints which may result in less agrobiodiversity in the homegarden. Availability of sharecropping enables better income and as a result it is less likely to observe owner cultivation of farms among morbidity and mortality affected households. 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 homegarden.

The findings indicate a potential local capacity to mitigate the possible negative effect of HIV/AIDS on agrobiodiversity through the 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 the significant positive effect of adult mortality and morbidity on sharecropping-out intensity. This is in line with Bishop-Sambrook et al (2006) and Drimie (2003) who found that single female headed households in AIDS impacted areas resort to sharecropping. Our result substantiates their findings and adds that sharecropping-out intensity increases among households with single females and those with longer duration of male illness. This is also in line with Agrawal (1999) that differences in farming efficiency between the parties involved in a sharecropping contract are an important determinant of the 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 organization. Our finding is consistent with the unfavorable productivity effect of poor health (e.g. Shultz and Tansel, 1997) and the positive efficiency effect of specialization (justifying increasing involvement in sharecropping-out among single females). In line with this, sharecropping-out intensity could be used as an indicator for the degree of adult morbidity and inability to work in combination with the other common indicators for HIV/AIDS (e.g. days of illness).

Second, labor hiring intensity has a significant negative effect on the likelihood of growing perennial crops in homegardens indicating that hired labor and sharecropping are not substitutable with respect to agrobiodiversity. This indicates that where labor and cash are highly constraining due to adult morbidity and mortality, agrobiodiversity as a strategy to improve nutrition is more compatible with sharecropping than with hiring labor..

Third, a favorable agrobiodiversity effect of agricultural education to females and males is supported. This indicates a potential area of intervention to integrating nutrition education to the existing agricultural education so as to make crop choice and agrobiodiversity practices responsive to HIV/AIDS demands. The decision to adopt such a policy 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.

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REFERENCES

Agrawal, Pradeep, "Contractual Structure in Agriculture," ***Journal of Economic Behavior and Organization***, 39 (1999): 293-325.

Barnett, Tony and Allan Whiteside, ***AIDS in the 21st Century: Disease and Globalization*** (New York: Palgrave Press, 2002).

Beckmann, Volker, ***Transaktionskosten und Institutionelle Wahl in der Landwirtschaft: Zwischen Markt, Hierarchie und Kooperation*** (Berlin: Edition Sigma, 2000).

Belachew, Tefera, Chali Jira, and Yoseph Mamo, "HIV Sero-prevalence among Urban and Rural Communities in Jimma Town and its Surrounding, Jimma Zone, Southwest Ethiopia," ***Ethiopian Journal of Health Sciences*** 14 (July 2004), 55-64.

Benin, Samuel, Melinda Smale, and John Pender, "Explaining the Diversity of Cereal Crops and Varieties Grown on Household Farms in the Highlands of Northern Ethiopia," in Melinda Smale (ed.), ***Valuing Crop Biodiversity: On-farm Genetic Resources and Economic Change*** (Wallington: CAB International, 2006), 78-96.

Bishop-Sambrook, Clare, Nigatu Alemayehu, Yirgalem Assegid, Gebremedhin Woldewahid, and Berhanu Gebremedhin, "The Rural HIV/AIDS Epidemic in Ethiopia and Its Implications for Market-Led Agricultural Development," in Stuart Gillespie (ed.), ***AIDS, Poverty and Hunger: Challenges and Responses. Highlights of the International Conference on HIV/AIDS and Food and Nutrition Security*** (Washington, D.C.: International Food Policy Research Institute, 2006), 245-260.

Cameron, A. Colin and Pravin K. Trivedi, ***Microeconometrics: Methods and Applications*** (New York: Cambridge University Press, 2005).

Castleman, Tony, Eleonor Seumo-Fosso and Bruce Cogill, "Food and Nutrition Implications of Antiretroviral Therapy in Resource Limited Settings. Food and Nutrition Technical Assistance," Technical Note No. 7 (2004), Washington DC.

Chew, Tek-Ann, "Transactional Framework of Sharecropping: Empirical Evidence." ***Agricultural Economics***, 18 (1998): 47-52.

Corbett, L. Elizabeth, Catherine J. Watt, Neff Walker, Dermot Maher, Brian G. Williams, Mario C. Raviglione, Christopher Dye, "The Growing Burden of Tuberculosis: Global Trends and Interactions with the HIV Epidemic," ***Archives of Internal Medicine*** 163(9) (May 2003), 1009-1021.

Donovan, Cynthia, Linda Bailey, Edson Mpyisi, and Michael Weber, "Prime-Age Adult Morbidity and Mortality in Rural Rwanda: Which Households are Affected and What are their Strategies for Adjustment?" Contributed Paper selected for presentation at the 25th International Conference of Agricultural Economists, Durban, South Africa, August 16-22, 2003.

Drimie, Scott, "HIV/AIDS and Land: Case Studies from Kenya, Lesotho and South Africa," ***Development Southern Africa*** 20 (5) (2003), 647-658.

Ellis, Frank, ***Peasant Economics: Farm Households and Agrarian Development*** (Cambridge: Cambridge University Press, 1993).

Engels, M. M. Jan and E. Goettsch, "Konso Agriculture and its Plant Genetic Resources," in Engels, M. M. Jan, John G. Hawkes and Melaku Worede (Eds.), ***Plant Genetic Resources of Ethiopia*** (Cambridge: Cambridge University Press, 1991), 169-186.

Stokes, C. Shannon, ***Measuring Impacts of HIV/AIDS on Rural Livelihoods and Food Security*** (Rome: FAO, 2003).

FAO/WHO, ***Living Well with HIV/AIDS: A Manual on Nutritional Care and Support for People Living with HIV/AIDS*** (Rome: FAO/WHO, 2002).

Fawzi, W. Waifaie and David J. Hunter, "Vitamins in HIV Disease Progression and Vertical Transmission," ***Epidemiology*** 9(4) (1998), 457-466.

Fawzi, W. Waifaie, Gernard I. Msamanga, Donna Spiegelman, Ruilan Wei, Saidi Kapiga, Edwardo Villamor, Davis Mwakagile, Ferdinand Mugusi, Ellen Hertzmark, Mark Essex, and David J. Hunter, "A Randomized Trial of Multivitamin Supplements and HIV Disease Progression and Mortality," ***New England Journal of Medicine*** 351(1) (2004), 23-32.

Federico, Giovani, "The 'Real' Puzzle of Sharecropping: Why Is It Disappearing?" ***Continuity and Change*** 21(2) (2006): 261-285.

Gari, A. Joseph, ***Agrobiodiversity Strategies to Combat Food Insecurity and HIV/AIDS Impact in Rural Africa: Advancing Grass Roots Responses for Nutrition, Health and Sustainable Livelihoods*** (Rome: FAO Population and Development Service, 2003).

________ ***Plant Diversity, Sustainable Rural Livelihoods and the HIV/AIDS Crisis***, (Bangkok: UNDP; Rome: FAO, 2004).

Gebreselassie, Kidist, Lisa L. Price, Justus Wesseler, and Ekko C. van Ierland, "Impacts of HIV/AIDS on Labor Organization and Agrobiodiversity: Do Stages of the Disease Matter?" Mansholt Graduate School Working Paper 32 (Wageningen University, 2007).

Gillespie, Stuart and Suneetha Kadiyala, ***HIV/AIDS and Food and Nutrition Security: From Evidence to Action*** (Washington D.C.: IFPRI, 2005).

Haddad, Laurence and Stuart Gillespie, "Effective Food and Nutrition Policy Responses to HIV/AIDS: What We Know and What We Need to Know," ***Journal of International Development*** 13 (2001), 487-511.

Heckman, J. James, "Sample selection Bias as a Specification Error," ***Econometrica*** 47(1) (January 1979), 153-161.

Johns, Timothy, "Plant Genetic Diversity and Malnutrition: Simple Solutions to Complex Problems," ***African Journal of Food, Agriculture, Nutrition and Development*** 3(1) (2003), 45-52.

Johns, Timothy and Pablo B. Eyzaguirre, “Linking Biodiversity, Diet and Health in Policy and Practice,” ***Proceeding of the Nutrition Society*** 65 (2006), 182-189.

Loevinsohn, Michael and Stuart R. Gillespie, “HIV/AIDS, Food Security and Rural Livelihoods: Understanding and Responding,” Food Consumption and Nutrition Division Discussion Paper 157 (IFPRI, 2003).

Mendez, E. Victor, Regmi D. Lok, and Edwardo Somarriba, “Interdisciplinary Analysis of Homegardens in Nicaragua: Microzonation, Plant Use and Socioeconomic Importance,” ***Agroforestry Systems*** 51 (2001), 85-96.

Murray, P. Michael, “Avoiding Invalid Instruments and Coping with Weak Instruments,” ***Journal of Economic Perspectives*** 20(4) (Fall 2006), 111-132.

Nair, P. K. Ramachandran, “Do Tropical Homegardens Elude Science or is It the Other Way Around?” ***Agroforestry Systems*** 53 (2001), 239-245.

Palgrave, Keith Coates, ***Trees of Southern Africa.*** (Republic of South Africa: C. Struik Publishers, 1984).

Ricotta, Carlo, “A Parametric Diversity Measure Combining the Relative abundances and Taxonomic Distinctiveness of Species,” ***Diversity and Distributions*** 10(2) (March 2004), 143-146.

Schultz, T. Paul and Aysit Tansel, “Wage and Labor Effects of Illness in Cote d’Ivoire and Ghana: Instrumental Variable Estimates for days Disabled,” ***Journal of Development Economics*** 53(2) (August 1997), 251-286.

Smith, J. Richard and Richard W. Blundell, “An Exogeneity Test for a Simultaneous Equation Tobit Model with an Application to Labor Supply,” ***Econometrica*** 54(3) (May 1986), 679-685.

Stiglitz, E. Joseph, “Incentives and Risk Sharing in Sharecropping,” ***The Review of Economic Studies*** 41(2) (April 1974), 219-255.

Stillwaggon, Eileen, “The Ecology of Poverty: Nutrition, Parasites and Vulnerability to HIV/AIDS,” in Stuart Gillespie (ed.), ***AIDS, Poverty and Hunger: Challenges and Responses. Highlights of the International Conference on HIV/AIDS and Food and Nutrition Security*** (Washington, D.C.: International Food Policy Research Institute, 2005), 167-180.

Tóthmérész, Béla, “Comparison of Different Methods for Diversity Ordering,” ***Journal of Vegetation Science*** 6(2) (April 1995), 283-290.

Verbeek, Marno, ***A Guide to Modern Econometrics***. 2nd ed. (England: John Wiley and Sons Ltd, 2004).

Weikard, Hans-Peter, Marteen Punt and Justus Wesseler, “Diversity Measurement Combining Relative Abundances and Taxonomic Distinctiveness of Species,” ***Diversity and Distributions*** 12(2) (March 2006), 215-217.

Weirsema, H. John and Blanca Leon, ***World Economic Plants: A Standard Reference*** (USA: CRC Press LLC, 1999).

Wickens, E. Gerald, ***Economic Botany: Principles and Practices*** (The Netherlands: Kluwer Academic Publishers, 2001).

Yamano, Takashi and Thomas S. Jayne, “Measuring the Impacts of Prime-age Adult Death on Rural Households in Kenya,” Tegemo Working Paper 5 (Tegemeo Institute of Agricultural Policy and Development, 2002).

Zomlefer, Wendy B., ***Guide to Flowering Plant Families.*** (United States: The University of North Carolina Press, 1994).

TABLES

TABLE 1.— SAMPLE HOUSEHOLDS BY AGROBIODIVERSITY CATEGORY

Agrobiodiversity in the homegarden	Number of households (Total sample=205)			Households who sharecrop-out land (total=61)			Households who hire-in labor (total=59)		
	N	% Total sample	Mean	N	% Share-croppers	Mean	N	% Share-croppers	Mean
Perennial crops	171	84.65	51.94	52	85.24	107.34	42	71.19	77.81
Annual crops	136	67.33	95.25	42	68.85	56.72	33	55.93	43.54
All crops	191	94.55	91.82	55	90.16	98.21	52	88.13	83.26

N stands for number of households

TABLE 2.— DESCRIPTIVE FOR VARIABLES INCLUDED IN ESTIMATION

Variable	Variable name	Unit/index	n	Mean	Standard deviation
I. Dependent					
Annual crop diversity	D_A	Annual WPW index	136	51.94	43.14
Perennial crop diversity	D_P	Perennial WPW index	171	95.25	56.86
Total crop diversity	D_T	Aggregate WPW index	191	91.82	38.45
II. Explanatory					
Single female	*singlef*	1=single female headed; 0=otherwise	43	0.21	0.41
Average age	*averageage*	Number of years	202	42.32	13.38
Female education	*eduf*	Years of formal schooling	71	1.35	2.28
Male education	*edum*	Years of formal schooling	77	2.09	3.18
No. of children<5	*nochildunder5*	No. children under 5 years	105	0.75	0.91
No. of children>15	*nochildabove15*	1=have; 0=otherwise	110	0.54	0.49
Percent area sharecrop-out	*percsharearea*	Area sharecropped-out/fechassa holding	61	0.14	0.26
Hire-in labor intensity	*hireinintensity*	Labor days/fechassa	59	1.18	3.36
Off-farm income	*offfarminc*	Birr/year	84	583.01	1392.98
Non-labor income male	*nonlabor*	Birr/year	14	81.29	324.11
Non-labor income female	*nonlaborf*	Birr/year	10	25.21	137.11
Agricultural training female over the past year	*agreduf*	1=female had training; 0=otherwise	34	0.17	0.37
Agricultural training male over the past year	*agredum*	1=male had training; 0=otherwise	25	0.12	0.33
Garden size	*gardensz*	fechassa	205	0.61	0.66
Land holding	*totld*	fechassa	202	3.91	3.25
TLU increase past 5 years	*TLUincrease*	1=increase; 0=otherwise	58	0.28	0.45
Credit obtained past year	*credit*	1=obtained; 0=otherwise	58	0.28	0.45
Iron-roofed house	*houseironrf*	1=have; 0=otherwise	92	0.45	0.49
Location	*location*	1=Gomma; 0=Kersa	177	0.86	0.34

N stands for number of households. Exchange rate during the field period was Br1=USD8.6; 1 fechassa=0.25ha

TABLE 3.— SHARECROPPING-OUT AND HIRING-IN LABOR BY MARITAL STATUS, ILLNESS, OFF-FARM PARTICIPATION AND LOCATION

Category	N	%	Sample households who sharecrop-out fields				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

N stands for number of households.

TABLE 4.— TOBIT DEPENDENT VARIABLE: SHARECROPPING-OUT INTENSITY

Explanatory Variable	Variable name	Estimated coefficient	Marginal Effect (*dY(.)/dx*)
Garden size	*gardensz*	-0.196	-1.966
		(0.12)*	(0.12)*
Male mortality (single female)	*singlef*	0.382	0.382
		(0.19)**	(0.19)**
Average age	*averageage*	0.011	0.011
		(0.01)**	(0.01)**
Female education	*eduf*	-0.034	-0.034
		(0.03)	(0.03)
Male education	*edum*	-0.002	-0.002
		(0.03)	(0.02)
No. of children<5	*nochildunder5*	-0.012	-0.012
		(0.08)	(0.08)
No. of children>15	*nochildabove15*	-0.193	-0.193
		(0.07)***	(0.07)***
Location	*location*	-0.267	-0.267
		(0.22)	(0.22)
Land holding	*totld*	0.077	0.077
		(0.02)***	(0.02)***
TLU increase	*TLUincrease*	0.119	0.119
		(0.16)	(0.16)
Credit obtained	*credit*	-0.044	-0.044
		(0.14)	(0.14)
Off-farm income	*offfarminc*	-0.000	-0.000
		(0.00)	(0.00)
Non-labor income male	*nonlaborm*	-0.000	-0.000
		(0.00)	(0.00)
Non-labor income female	*nonlaborf*	0.000	0.000
		(0.00)	(0.00)
Lack of oxen	*nooxen*	0.425	0.425
		(0.17)**	(0.17)***
Male morbidity	*percdurillm*	0.345	0.299
		(0.17)*	(0.17)*
Constant		-1.009	
		(0.35)***	
Probability chi2		0.0008	
Pseudo R^2		0.2024	
Log likelihood statistic		-78.553861	
N		154	
		(44 uncensored)	

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

TABLE 5.— ESTIMATED COEFFICIENTS AND TEST RESULTS BY AGROBIODIVERSITY EQUATION

	Agrobiodiversity for perennials (D_P)			Agrobiodiversity for annuals (D_A)			Total agrobiodiversity (D_T)		
	Heckman (two-step); N=202; censored=31			IVTobit (N = 202; censored = 66)			Heckman (one-step); N=202; censored=11		
	Eq1: degree		Eq2: participation	Eq1: degree	Eq2: stage 1	*dY(.)/dx*	Eq1: degree		Eq2: participation
	Parameter	*dY(.)/dx*	Parameter	Parameter			Parameter	*dY(.)/dx*	Parameter
gardensz	-0.019	-0.021	-0.120	0.040	-0.217	0.040	-0.005	-0.005	0.641
	(0.06)	(0.06)	(0.22)	(0.09)	(0.42)	(0.09)	(0.04)	(0.04)	(0.58)
singlef	0.045	0.046	0.069	0.044	0.018	0.044	0.041	0.041	6.762
	(0.08)	(0.08)	(0.36)	(0.13)	(0.60)	(0.13)	(0.06)	(0.06)	(-)
averageage	0.003	0.002	-0.015	0.004	-0.002	0.004	-0.002	-0.002	-0.011
	(0.00)	(0.00)	(0.01)	(0.00)	(0.02)	(0.00)	(0.00)	(0.00)	(0.02)
eduf	-0.043	-0.044	-0.037	-0.019	0.027	-0.019	-0.026	-0.026	0.196
	(0.01)***	(0.01)***	(0.06)	(0.02)	(0.11)	(0.02)	(0.01)**	(0.01)**	(0.15)
edum	0.001	-0.000	-0.066	-0.015	0.088	-0.015	-0.003	-0.003	-0.195
	(0.01)	(0.01)	(0.04)	(0.02)	(0.08)	(0.02)	(0.01)	(0.01)	(0.07)***
nochildunder5	0.076	0.081	0.359	-0.017	-0.006	-0.017	0.052	0.052	0.231
	(0.04)**	(0.04)**	(0.19)*	(0.06)	(0.25)	(0.06)	(0.02)**	(0.02)**	(0.31)
nochildabove15	-0.011	-0.011	-0.018	-0.028	0.030	-0.028	-0.006	-0.006	0.204
	(0.03)	(0.03)	(0.10)	(0.04)	(0.19)	(0.04)	(0.02)	(0.02)	(0.17)
location	-0.052	-0.056	-0.409	-0.049	-0.296	-0.049	0.044	0.044	1.802
	(0.11)	(0.11)	(0.66)	(0.18)	(0.82)	(0.18)	(0.08)	(0.08)	(0.84)**
totld	0.020	0.019	-0.036	-0.009	-0.118	-0.009	0.009	0.009	-0.019
	(0.01)	(0.01)	(0.05)	(0.02)	(0.09)	(0.02)	(0.01)	(0.01)	(0.06)
TLUincrease	0.119	0.125	0.622	-0.036	-0.049	-0.036	0.095	0.095	-0.024
	(0.07)*	(0.07)*	(0.33)*	(0.11)	(0.49)	(0.11)	(0.05)**	(0.05)**	(0.40)
percsharearea	0.381	0.385	0.361	0.247	-0.437	0.247	0.289	0.289	-0.005
	(0.13)***	(0.13)***	(0.59)	(0.22)	(0.95)	(0.22)	(0.09)***	(0.09)***	(0.75)
hireinintensity	0.009	0.008	-0.071	0.085		0.085	-0.007	-0.007	-0.053
	(0.01)	(0.01)	(0.03)**	(0.07)		(0.07)	(0.01)	(0.01)	(0.04)
credit	0.108	0.113	0.509	0.109	-0.474	0.109	0.049	0.049	7.677
	(0.07)	(0.07)	(0.35)	(0.12)	(0.51)	(0.12)	(0.05)	(0.05)	(-)
offfarminc	0.000	0.000	-0.000	-0.000	0.000	-0.000	-0.000	-0.000	0.000

	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)*	(0.00)*	(0.00)
nonlaborm	0.000	0.000	-0.001	0.000	0.001	0.000	0.000	0.000	-0.000
	(0.00)**	(0.00)**	(0.00)	(0.00)	(0.00)*	(0.00)	(0.00)*	(0.00)*	(0.00)
nonlaborf	-0.000	0.001	0.058	0.000	-0.001	0.000	0.000	0.000	0.033
	(0.00)	(0.00)*	(-)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(-)
agreduf	0.184	0.183	-0.003	0.204	-1.026	0.204	0.126	0.126	-0.163
	(0.09)*	(0.09)*	(0.44)	(0.19)	(0.74)	(0.19)	(0.07)*	(0.07)*	(0.66)
agredum	0.073	0.068	-0.259	0.338	-0.303	0.338	0.056	0.056	-0.116
	(0.11)	(0.11)	(0.49)	(0.19)*	(0.84)	(0.19)*	(0.08)	(0.08)	(0.67)
houseironrf	-0.094	-0.094	-0.075	0.019	1.650	0.019	-0.015	-0.015	-0.960
	(0.07)	(0.07)	(0.29)	(0.16)	(0.49)***	(0.16)	(0.05)	(0.05)	(0.46)
boughtjewels	NA	NA	NA	NA	3.332	0	NA	NA	NA
					(1.13)***				
Constant	0.852		2.187	0.142	1.201		0.859		0.277
	(0.15)***		(0.79)***	(0.28)	(1.14)		(0.11)***		(0.74)
Pseudo R2	NA			NA			NA		
Log likelihood ratio statistic	NA			-686.77177			-43.93395		
Probability ch2 (Wald)	0.0000			0.6870			0.0004		

Statistical significance is given at the 10% (*), 5% (**) and 1% (***) level. Standard errors in parenthesis. The variables *singlef*, *credit* and *nonlaborf* are dropped from participation equations of perennial and total agrobiodiversity because of perfect predictions, for e.g., all single females grow perennial crops. Standard errors for the variables which are not estimated by the specific technique are presented as (-). Coefficients (0.000) and standard errors (0.00) for some variables are given beyond 4 decimal places. *dY(.)/dx* stands for marginal effects and is calculated for the degree equations in the case of perennial and total agrobiodiversity. NA means not applicable for the specific model.

ANNEX

TABLE A1.– TAXONOMIC DISTANCES BETWEEN THE SPECIES GROWN IN THE 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	Pappaya	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
Bananna	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
Pappaya	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	

Following Ricotta (2004), a distance of 1 is given if two species share the same genus, 2 if the 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.

Sources: Engels and Goettsch, 1991; Palgrave, 1984; Weirsema and Blanca, 1999; Wickens, 2001; Zomlefer, 1994..