# The Cooked is the Kept: Factors Shaping the Maintenance of Agro-biodiversity in the Andes

Kristine Skarbø

**Abstract**

This study examines farmers' agro-biodiversity decision-making through an Andean case study, and expands upon earlier approaches in two ways. First, it incorporates cultural variables into an econometric analytic framework encompassing the influence of demographic, farm physical and market factors on agro-biodiversity. Second, it encompasses a suite of different richness measures of inter- as well as intraspecific agro-biodiversity. Data are drawn from interviews with the heads of 89 farm households in Cotacachi, Ecuador. ANOVA and poisson regressions are used to analyze the relations between explanatory variables and agro-biodiversity measures. Results show that culture and subsistence play key roles in fostering diversity maintenance; those who strongly identify with local Kichwa cultural traditions and those whose production is mainly subsistence-oriented grow the most diverse fields. The findings indicate that initiatives supporting cultural revitalization and agriculture oriented at home consumption will likely enhance in situ diversity maintenance.

Keywords: Agro-biodiversity, Andes, Crop diversity, Ecuador, Farmer decision-making, *In situ* conservation

This is a post-print of an article published in Human Ecology 42(5): 711-726. The final publication is available at Springer via http://dx.doi.org/10.1007/s10745-014-9685-1.

## Introduction

There is a strong need to increase our understanding of what shapes farmers' choices of what crops and varieties to plant, with consequences for the maintenance or loss of diversity (FAO 2010). Of key importance are centers of crop origin and diversity, where the consequences of major losses would be most severe (Brush 1999, 2004; Frankel 1973). Two bodies of literature relate to this issue; one employs economic theory and the other is ethnoecology. This analysis combines these approaches.

Much research on agro-biodiversity distribution in farming communities has been carried out within a theoretical framework of rational decision-making, where the choices by farm households of what to grow are expected to maximize utility, given the human, economic and agrophysical resources available. Thus, a series of studies have examined differences among households in terms of levels of crop diversity, and analyzed these in relation to demographic, economic, farm physical and market related factors (Benin et al. 2004; Brush et al. 1992; Brush and Meng 1998; Rana et al. 2007; van Dusen and Taylor 2005). These studies show that diversity choices can partly be explained as adaptation to variation in the above conditions— allowing farmers to secure production by exploiting existing resources. This body of research has thus helped confirm that growing diverse crops and varieties, and in particular landrace varieties developed in the region, is rational and logical for many small farmers. It enables farmers to adapt production to their available labor and land resources, decreases risk, gives more stable yields, improves pest management, and, in the case of subsistence farmers, directly provides the base for a varied diet (Bellon 1996; Brush 2004; Rhoades and Nazarea 1998).

On the other hand, ethnoecological research has shown that farmers' decisions with regards to what to grow are not purely the product of rational thinking, but also linked to values, memories and principles inscribed in culture (Nazarea 1998, 2005, 2006; Rhoades and Nazarea 1998). The maintenance of crops and landraces over a long period is often associated with their incorporation in traditions and practices, especially regarding food, e.g., in studies on sweet potatoes in the Philippines (Nazarea 1998), wheat in Ethiopia (Tsegaye and Berg 2007) and potatoes in the Andes (Brush 1992). Even authors of papers that employ economic theory acknowledge the importance of cultural values, and express concern that sociocultural change might undermine agro-biodiversity maintenance in the future (Birol et al. 2006; Perales et al. 2003). Nevertheless, related variables are largely absent from their analyses. A few recent contributions, however, have included ethnicity as a variable, and indeed found that diversity choices vary by ethnic group, even if socioeconomic and agroecological conditions remain similar (Brush and Perales 2007; Perreault-Archambault and Coomes 2008; Stromberg et al. 2010).

The current study goes a step further, by analyzing the relationship between agro-biodiversity and a set of cultural variables within one ethnic group, Cotacachi's Kichwa, in an econometric framework. Based on the above research, I hypothesize that agro-biodiversity choices will vary, among other factors, depending on how firmly the household members are rooted in local cultures and traditions. I expect that farmers who express a stronger identification with Kichwa culture maintain more agrobiodiversity, and in particular more diversity of traditional crops and landraces. The study will test whether degree of cultural attachment can be linked to measures of agro-biodiversity, and speak to the strength of this association in relation to other factors.

With the exceptions of van Dusen and Taylor (2005) and Benin et al. (2004), who examined the distribution of varietal diversity across a limited subset of cultivated crops, most previous analyses of differences in agro-biodiversity distribution among households have either focused on varietal diversity of a single crop (Brush 1992; Brush and Meng 1998; Brush and Perales 2007; Perales et al. 2003; Rana et al. 2007) or interspecific diversity measured as the number of crops grown, without intraspecific detail (Major et al. 2005; Perreault 2005; Perreault-Archambault and Coomes 2008; Reyes-García et al. 2008; Stromberg et al. 2010). The current study takes a more comprehensive approach, by including a total of nine different measures encompassing different dimensions of agro-biodiversity at the inter- as well as intraspecific (varietal) levels. The assessment will thus shed light on whether influential factors vary across different diversity measures.

I begin the methods section by presenting the econometric model guiding the analysis, the study area and methodology. After a brief description of the agro-biodiversity in the area, I review dependent and explanatory variables employed in the analysis. The following section reports and discusses results from bivariate and multivariate analyses. The conclusion highlights major findings and implications for further research and conservation.

## Methods

### Econometric Model

Following previous ethnoecological and economic studies of agro-biodiversity distribution, I hypothesize that agrobiodiversity will be linked to cultural factors, in addition to household demographic and economic factors, farm physical factors, and market related factors. The following econometric expression represents this hypothesis:

$$D = \alpha + \beta C + \gamma H + \delta A + \zeta M + \varepsilon$$

In this equation, *D* is a measure of agro-biodiversity, *C* stands for a vector for cultural factors, *H* represents a vector for household demographic and economic factors, *A* stands for a vector of farm physical factors, and finally *M* denotes a vector which captures market related factors of the farm.

## Study Area, Data Collection and Analysis

Fieldwork for the study was carried out over a 12-month period in 2009–2010 in the Andean zone of Cotacachi Cantón in the Northern Ecuadorian Andes. The area covers 219 $km^2$ and an altitudinal span of 2080–4939 m, and harbors high levels of wild and cultivated biodiversity (Rhoades 2006). Agriculture is carried out from the plain fields of the Inter-Andean valley bottom at around 2300 m and up the slopes of the dormant volcano Cotacachi to an altitude of about 3300 m. Before land reforms in the 1960s and 1970s, most agricultural land belonged to haciendas, owned by mestizo-whites and labored by indigenous Kichwas (Moates and Campbell 2006). Although sizeable tracts of hacienda land remain today, 67.5 % of cropland is constituted by fields less than 5 ha, most of which are owned and farmed by Kichwa households settled in one of the 43 communities in the area's rural zone (UNORCAC 2007; Zapata Ríos et al. 2006).

Data was collected on 89 farms sampled across five communities representing differences in the geographical and altitudinal distribution in the area, as well as variations in average farm size and ratio of subsistence vs. commercial production. In these relatively small communities (mean=57 households, SD=26), purposive quota sampling taking into account age of household heads was used to ensure representative inclusion of all age groups (Teddlie and Yu 2007). The survey included 20 households in each community except for one, where no more than a total of nine households were living at the time of the study, and the sample only reached this number. Data from two-three semi-structured interviews with heads of these 89 farm households form the base for the statistical analyses reported here. Most households (79) were headed by a male and female couple, while six were headed by single women, and four by single men. Initially, the study aimed at representative inclusion of both genders among the interviewees, however, this proved difficult due to the fact that many males were unavailable because of engagement in off farm work. Accordingly, the final sample includes interviews with 66 women and 23 men. All interviews were conducted by the author either in Spanish or a combination of Spanish and Kichwa, in the majority of cases assisted by a Kichwa-Spanish translator. More details on the interview procedures and content are included in "Explanation of Variables" below.

Data analyses were performed using STATA IC 11.2 for Mac. Initially, I ran correlation analyses of the various agrobiodiversity measures to explore the degree to which the different measures overlap. Next, I ran ANOVA analyses of the direct relationship between diversity measures and each cultural variable, in order to provide a broader understanding of the previously little researched association between cultural and agro-biodiversity variables. The principal analyses consisted of multivariate regressions examining the relationships between different agro-biodiversity measures (dependent variables) and cultural, household, farm and market factors (explanatory variables). Poisson regressions with robust standard errors were employed because of the count nature of the dependent variables (Cameron and Trivedi 1998). In the interpretation of results I draw on data and insights from several visits and 16 months of ethnographic field work in Cotacachi during the past decade.

## Brief Description of Cotacachi's Agro-biodiversity and its Management

As one of the cradles of agriculture, the Andean region has fostered the domestication and development of a range of crops, including beans, potatoes, other roots and tubers, pseudo-cereals in the Amaranthaceae family, and a number of fruits (Cook 1925; National Research Council 1989). Following the Spanish conquest, a number of OldWorld crops have further been added to Andean farmers' plant repertoire (Crosby 1972; Hernández Bermejo and León 1994). In the larger research project ofwhich this study is part, a total of 103 cultivated species were documented (Table 1; see Skarbø 2012 for detailed information). Only crops grown for food and medicine were included[1]—the survey thus excluded species grown for fiber, fencing and ornamental purposes. The surveyed crops include field crops, which are usually grown in larger extents in fields, and fruits, vegetables and herbs, which are typically grown in home gardens. Twenty of the field crop species were also documented at the varietal level and among these, a total of 367 varieties was registered. The area's wealth of crop diversity has developed along with rich and varied food traditions (Camacho 2006; Nazarea et al. 2006; Ramirez andWilliams 2003; Skarbø 2012). Both males and females of different age groups collaborate in agricultural work. While men typically carry the main responsibility for tasks such as plowing and preparing fields, the management and preparation of seed and food is most often a female responsibility. Women's agricultural responsibilities have increased during the last decades as it has become more common, particularly among males, to seasonally migrate and engage in off farm work (Flora 2006).

## Explanation of Variables

### *Dependent Variables: Measures of Agro-biodiversity*

Agro-biodiversity was assessed as richness on crop and varietal levels. At each farm, all crops cultivated during the previous year were documented through structured interviews with the male or female household head. For each type of crop (field crops, fruits, vegetables, herbs), I posed an initial open-ended question regarding which crops had been grown during the past 1-year period. Subsequently, I followed this up by prompting for any forgotten crops based on a list of crops grown in the area compiled during the initial stages of the research. Next, varietal diversity was assessed for 20 of the most common field crop species by asking farmers to list the varieties they had planted of each of these crop species during the past 1-year period. In many cases, the information gathered through interviews was triangulated through garden, field and seed storage inventories. Although there is not necessarily a direct relationship between varietal diversity and diversity of alleles, former analyses indicate a high level of correspondence between varieties identified by farmers and genotypes identified through molecular analysis (Quiros et al. 1990; Sadiki et al. 2007), warranting the adoption of variety counts based on farmers' identification as a measure for a household's agro-biodiversity at the intraspecies level.

The agro-biodiversity measures applied in this study represent 1) intraspecific diversity summed across field crop species, 2) intraspecific diversity within the three most common field crops and 3) interspecific diversity (Table 2). Total variety richness is calculated as the sum of variety counts of all, out of the list of 20, field crop species grown by the household, and thus captures elements of both crop

[1] One forage species, alfalfa (*Medicago sativa*), was also registered. It is used for feeding guinea pigs and rabbits and is typically grown on a small scale in home gardens together with vegetables. For the purposes of the current analysis it is therefore included with vegetables.

species level and varietal diversity (Smale 2006). To examine differences in the distribution of landraces and modern varieties (MVs), measures are also calculated for total landrace richness (number of landraces grown, summed across all 20 field crop species), and total modern variety richness (number of modern varieties grown, summed across all 20 field crop species).[2] To explore differences between crops in terms of how the different explanatory variables are linked to diversity, measures are also given for variety richness (count of varieties) of each of the most common field crops: maize (*Zea mays*), common beans (*Phaseolus vulgaris*) and potatoes (*Solanum* spp.).[3] Finally, measures are calculated for total field crop species richness (count of field crop species), fruit and vegetable richness (count of fruit and vegetable crops[4]), and herb richness (count of herb species).

*Explanatory Variables*

Following the econometric model, explanatory variables are classified into four groups consisting of cultural factors (*C*), household demographic and economic factors (*H*), farm physical factors (*A*), and market factors (*M*) (Table 3). Below I explain them in more detail.

*Cultural Variables*

Cultural factors (*C*), or attachment to Kichwa culture, are assessed by three cultural variables: food, dress, and language. Ethnicity is a fluid concept in the Andes, and people may move between identifying as mestizo or indigenous (Orlove 1998; Weismantel 2001). Dress, language and food represent three domains or axes through which people express their identity in public and private spheres. Although it is impossible to accurately quantify and measure cultural attachment or identity, these variables may still serve as indicators for how much people identify with Kichwa culture.

*Proportion of traditional foods in diet* was calculated based on data from three dietary recall exercises (Lee and Nieman 2007). Two 72-h recall exercises of all meals eaten in the household were carried out at different points in time (2009, 2010). In addition, a 1-month recall of the use frequency of a list of 60 locally available food items was undertaken in conjunction with the first 72-h recall. With the help of key informants and focus groups all foods were classified into categories of traditional, modern and neutral (neither particularly traditional nor modern) foods. Traditional foods encompass products from grains, legumes, roots, tubers and cucurbits with a long history of cultivation in the area. Modern foods include non-local items typically accessed in stores and markets, including rice and noodle products. Meat, egg and milk products were not included in any of the two groups, nor were fruits and vegetables; these are foods that for the most part have been present locally for a long time, but only consumed to a limited degree by rural Kichwa households. The proportion of traditional foods was calculated, and the final score represents the mean of the three recalls. For the purposes of ANOVA and

[2] For this study a modern variety is defined as a crop variety which has been bred in the formal breeding sector and a landrace as a crop variety which has not been bred in the formal sector.
[3] Number of potato varieties was summed across the species *Solanum tuberosum* subsp. *andigena*, *Solanum chaucha* and *Solanum* sect. *Petota*.
[4] The vegetable count differentiated between several crops belonging to the species *Brassica oleracea*, and is as such a crop count, not a species count.

correlation analyses, this continuous variable was also converted into a categorical variable with three equally sized categories.

*Dress* was assessed as a categorical variable representing the frequency of which the female household head wore the traditional *anaku*[5] costume (1=never, 2=sometimes, 3=nearly every day). *Language* was assessed as a categorical variable representing the language(s) used in communication between household heads and their children (1=only Spanish, 2=both Spanish and Kichwa, 3=only Kichwa). As stated above, I expect cultural variables to be positively related to agro-biodiversity, and especially to diversity of landraces and crops with a long tradition of use and cultivation in the study area.

*Household Demographic and Economic Variables*

Household demographic and economic factors that were assessed included age of interviewed household head, schooling of household head, number of adults living in household, number of children (<16 years old) living in household, and off farm work. I expect diversity to be positively related to *age* of household head, since older people are likely to be keepers of traditions, and have had more time to gather agricultural experience as well as planting material. *Schooling* (measured in years) might negatively affect diversity, since it implies devotion of time and energy to activities other than agriculture. *Number of adults* might have a slight positive influence through providing more labor, whereas *number of children* might have an opposite effect through decreasing parents' time available for agricultural work. *Off farm work* was captured by three dummy variables indicating whether 1) no household head worked off farm, 2) one household head (either male or female) worked off farm, and 3) two spouses worked off farm at the time of the research. Engagement in off farm work might have a negative effect on agro-biodiversity through taking away time from agricultural work and increasing access to purchased foods. On the other hand, it might positively enhance access to planting material, as well as provide funds to cover agricultural expenses such as hired labor and tool costs.

*Farm Variables*

Assessed farm factors include size of cultivated area, livestock assets, irrigation access and agroecological zone. *Size of cultivated area* was measured in hectares. I expect diversity to be highest on the farms that are medium sized. Very small farms might be restricted in diversity due to space limitations, whereas big farms may more readily focus on production for the market, which likely implies monocultures of a low number of crops and varieties. A quadratic term for land size is included to test this hypothesis. *Livestock assets* were calculated based on counts of different livestock multiplied by local market prices. I expect livestock assets to bear a positive relation to agro-biodiversity, as animals provide manure and draught power, thus enhancing production conditions. However, very high livestock assets might be a) an investment strategy for households earning much from commercial crop production or b) a sign of large

[5] The *anaku* costume of Cotacachi consists of dark and white wraparound skirts, white, embroidered blouses, woven ribbons, in addition to other complements. It is related to, but different from the traditional dress of other regions of Andean Ecuador. Whereas men typically only wear their traditional clothing (consisting of white trousers and shirt, and a dark, woolen poncho) on special occasions, women maintain this tradition to a larger extent. In the case of single male-headed households where the man formerly had been married, the clothing habit of the former wife was recorded.

portions of the agricultural land set aside for livestock rearing as a commercial strategy—both alternatives that are likely linked to lower crop diversity levels. To test these predictions, a quadratic term is included also here. *Irrigation access* was measured as a dummy variable (0=no irrigation access, 1=irrigation access for some or all of land). Irrigation is expected to lower the need for maintaining crops and varieties adapted to different hydrological conditions, and thus reduce diversity. Cotacachi is roughly divided into three *agroecological zones* based on altitude: the low, intermediate, and high zones (Moates and Campbell 2006). Location in each agroecological zone is indicated by dummy variables. As crop adaptation varies with altitude and associated temperature regimes, I expect the crop complexes and diversity measures in each zone to show some variation.

*Market Variables*

Market relations were assessed by *proportion of farm production destined for the market* during the past 1-year period. Four dummy variables indicate whether or not the portion of the crop production sold was 1) none or 2) very small (1-10 %) 3) small or medium (11–70 %), and 4) a large part or all (>70 %).[6] I expect agro-biodiversity to bear a negative relation to commercial production, since the market typically demands high quantities of uniform products, thus incentivizing monoculture production based on few crops and varieties. Conversely, I expect a large portion destined for household consumption to be linked with higher levels of diversity, in order to meet diverse dietary needs.

## Results and Discussion

### Correlation Analysis of Agro-biodiversity Measures

The correlation matrix in Table 4 shows that nearly all the measures of agro-biodiversity employed in the study are positively correlated, and in most cases, the correlation is highly significant. Thus, in most cases, households that grow a greater diversity of one kind likely also grow more diversity by other measures. The correlation coefficients, however, display enough variation in size to merit further investigation of differences in how they are linked to explanatory variables. Total variety richness is best correlated to the other measures (mean $r$=0.73), whilst average least correlation is exhibited by richness of potato varieties (mean $r$=0.29), fruits and vegetables (mean $r$=0.41), and modern varieties (mean $r$=0.44).

### Bivariate Analyses of Agro-biodiversity and Cultural Variables

A total of 27 ANOVAs were run, one for each of the three cultural variables across the nine agro-biodiversity richness measures (Tables 5, 6, and 7). The results show that increased use of traditional dress, heavier use of Kichwa in relation to Spanish in intra-family communication, and higher proportion of traditional foods in diet are all linked with higher levels of diversity across nearly every agro-biodiversity measure. In all of the 27 analyses, the measure representing strongest attachment to Kichwa culture is associated with a higher mean diversity than the lowest measure. In 21 cases, there is a stepwise increase in mean agro-biodiversity along the cultural measures. The differences between groups are

[6] Original categories for small and medium proportions were combined due to low frequencies in each.

significant at the $p \leq 0.01$ level in 17 and at the $p \leq 0.05$ level in 20 of these analyses. The only measures exhibiting somewhat weaker relationships with the cultural variables are modern varieties and potato varieties. The latter is actually partly related to the former, as 57 % (12 of 21) of the potato varieties grown by farmers in the sample are modern varieties. The weaker association between richness of modern varieties and cultural markers might be understood as a product of their recent introduction to the study area (during the last five decades). Overall, these results strongly suggest that those who to a higher degree identify with the local Kichwa culture, as evaluated by the three cultural markers employed in the current study, aremore likely to growmore diverse fields and gardens. The following multivariate analyses will assess whether this relationship is maintained also when including a set of other variables.

## Multivariate Regression Analyses

Tables 8, 9, and 10 give an overview of the results from the regression model estimations for the nine agro-biodiversity measures. Including all three cultural variables in the regression analyses introduced severe co-linearity problems, due to the high correlation between these measures.[7] Since the continuous variable for traditional food consumption provides the most detailed level of measurement, thus allowing for a more nuanced analysis, I decided to use it as a proxy for cultural attachment in the multivariate analyses, and omit the variables for dress and language.[8] Below I comment on the results for each variable and, when relevant, discuss them in relation to previous research.

### *Results for Cultural Variable*

The set of regressions shows that the strong, positive and significant associations between cultural and agrobiodiversity measures obtained in the initial ANOVAs are maintained when controlling for a number of household, farm, and market related factors. Those who prepare and eat more traditional foods, a measure correlated with other cultural variables, are more likely to grow more varieties in total, more landraces, more varieties of maize and beans, as well as more field crop, fruit/ vegetable and herb diversity. The only measures of agro-biodiversity where this link is less clear continue to be richness of modern varieties and potato varieties.

The separate analyses of intracrop diversity show that those who have a diet composed of more traditional dishes in particular have more maize diversity and this might be explained by the importance of this crop in the local culture and cuisine. Maize plays a central symbolic role in the Andean cosmovision of the region. There is a plethora of traditional maize dishes in Cotacachi, many of which are based on different varieties of the crop,[9] whereas differentiation into varieties suited for special dishes ismuch less elaborated in the case of potatoes and beans.

[7] A Kendall's rank correlation analysis of the three variables (using the categorical variable for food consumption) yields positive bivariate correlation coefficients ranging in size from 0.46 to 0.66, significant at the $p<0.0001$ level.
[8] In order to further test the reliability of this choice, separate sets of poisson regression analyses were run with inclusion of each of the three categorical cultural variables, as well as composite measures. These produced results similar to those for the continuous variable (not shown here).
[9] For instance, in the larger dissertation research project of which this study forms part, the author collected recipes for 30 different maize dishes (Skarbø unpublished data).

Somewhat surprising is the relatively strong relation between more traditional values of cultural variables and the diversity of fruits and vegetables. Except for a few species (including Andean walnut [*Juglans neotropica*], capuli cherry [*Prunus capuli*], passion fruit [*Passiflora cumbalensis*], chili pepper [*Capsicum baccatum*]), cultivated fruits and vegetable crops have traditionally not played a prominent role among Kichwa small-scale farmers in Cotacachi. Instead, they would use wild and semi-cultivated greens (protected weeds) and fruits as condiments and snacks. Cultivated fruits and vegetables, many of which are Old World introductions, have to a larger degree been grown on haciendas, and consumed by the mestizo-white populace. However, this situation is currently changing. Local markets offer a wide variety of fruits and greens, and the crops are becoming more common also on smaller farms—a process partly fueled by educational campaigns promoting the value of these products for health and nutrition, and NGOs providing planting material. The results of this analysis indicate that those who identify more with Kichwa culture have embraced the trend of increasing fruit and vegetable diversity to a stronger degree than those who identify less. This might be linked to a general higher appreciation of and curiosity about agricultural biodiversity among the former group of farmers. The especially strong link between the proportion of traditional foods in diet and herb diversity might further be interpreted as rooted in household heads' dedication to nutritional and health matters. Herbs are used for seasoning, herbal teas, and medicinal purposes, and many are linked to positive health benefits in the local pharmacopeia (Gallaher and Fueres 2006). The close relation found between consumption of traditional foods and agro-biodiversity indicates that households in the study preferring a diet rich in traditional foods to a large degree maintain the base for such a diet in their own agricultural production, instead of relying on market or other sources for this type of food. Hence, a relatively direct link between food and agriculture is maintained. It follows that the maintenance of pride and appreciation of cultural and agricultural heritage, and preferences for a diet rich in traditional foods, are important factors enhancing the conservation and cultivation of agro-biodiversity in the area.

### *Results for Household Demographic and Economic Variables*

The analyses show no significant association between age and diversity measures. This is contrary to the positive link found in most other studies examining this relationship (van Dusen and Taylor 2005; Perreault 2005; Perreault-Archambault and Coomes 2008; Reyes-García et al. 2008). However, when the relation between total variety richness and age is analyzed separately in an ordinary least square regression, diversity increases with age (coefficient=0.327, p=0.016, $R^2$=0.06). An explanation of why the effect of age disappears in the model estimation might be that people of higher age mainly keep more diversity because of their rootedness in the local culture—a factor that has not been included in the previous studies. Indeed, when the total variety model is estimated without the cultural variable, a positive effect of age remains, albeit with low significance (coefficient=0.004, p=0.275). Closer examination of the data through a scatter plot of agein relation to total varietal diversity reveals a turning point at an age of 60; the positive relation is stronger up to 60 years, above which diversity levels are lower.[10] This result is similar to that found in Mexico by Van Dusen and Taylor (2005) and may have to do with the decreasing capacity to labor fields of those reaching high age.

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[10] Introduction of a term for age squared in the full regression model for total variety richness did not improve the significance of age and only improved the explanatory power of the model to a minuscule degree (Δ pseudo-$R^2$=0.0003), and was therefore omitted.

Most regression estimations yield a positive but insignificant relationship between schooling and agro-biodiversity. This is consistent with previous research that has found either non-significant or positive associations between education and varietal diversity (Benin et al. 2004; van Dusen and Taylor 2005; Rana et al. 2007) or crop level diversity (Perreault-Archambault and Coomes 2008; Reyes-García et al. 2008). This strongly suggests that education is indeed compatible with the maintenance of agro-biodiversity among small-scale farmers.

None of the estimations show significant associations between number of adults and diversity. These results are in accordance with Van Dusen and Taylor's (2005) analysis of varietal diversity inMexico, but depart from that of Perreault-Archambault and Coomes (2008) who found a small, positive association between number of adults and crop level diversity in the Peruvian Amazon. There is a slight negative link between number of children and all diversity measures except for fruits/vegetables and herbs, where small, positive associations are found. The modest negative link might be attributed to time constraints for the parents of many minors, whereas the positive relations can be explained in the light of children's preferences and parents' health and nutrition concerns. Growing fruits and vegetables in home gardens offers a direct supply of healthy and tasty foods and snacks, avoiding the often prohibitive costs of procuring such items in the marketplace. Number of children has rarely been included in other analyses, making it hard to compare with previous results. Overall, the results of past and the current research indicate that in relation to other factors, demographic variables do not have large effects on measures of agro-biodiversity.[11]

Off farm work is generally associated positively with agrobiodiversity measures, but significance levels are low. In most cases, the positive relationship is higher when only one spouse works off farm. Off farm work for one spouse (typically the male) is a common solution when the farm is not large enough to provide sufficient food and/or market income to cover household demand.[12] This secures some income, and at the same time allows the other to stay at home, taking care of agricultural tasks for subsistence needs. The slight positive association may be an indirect consequence of this subsistence orientation. The coefficients are particularly large for fruit/ vegetable and herb diversity, likely reflecting the enhanced access of those working off farm to planting material of these crops, many of which earlier have been uncommon in Cotacachi's communities. Variables for off farm work have surprisingly not been included in many previous analyses of agro-biodiversity distribution. One study with a result different than mine is Brush et al. (1992), who found a negative relationship between off farm work and potato landrace diversity in Southern Peru.

[11] I would like to note, however, that to my knowledge no econometric analysis, the present included, has examined possible differences between men and women in shaping decision-making about agro-biodiversity in relation to other explanatory factors. While the great majority (89 %) of the surveyed households are jointly headed by both a female and a male, making it difficult to detect variation between households due to different gender composition, research from Mexico has noted differences between males and females from the same households in terms of knowledge and perceptions related to agro-biodiversity (Chambers and Momsen 2007). The large extent of the crop diversity documented in connection with the present study might in part be related to the fact that 74 % of the interviewees were women, who in the study area typically carry the main responsibility of seed management, and therefore are highly knowledgeable regarding the area's agro-biodiversity (see also Skarbø 2006).

[12] A t-test shows that households where one or two spouses work off farm cultivate significantly less land in comparison with those with where both stay on the farm (means 0.74 [SD 2.35] ha vs. 1.82 [SD 1.31] ha, $p$=0.01).

*Results for Farm Variables*

With varying degree of strength, the regression estimations show a positive association between land size and agrobiodiversity up to a certain point, above which the reverse is the case; the coefficient signs are positive for the linear term, but negative for the square term. Closer examination of the land data in relation to total varietal diversity shows that there is a turning point at around 0.7 ha—farm households cultivating more land tend to plant less diverse fields. Thus, greatest diversity is found on the mid-sized farms. This supports the hypothesis that more land facilitates the planting of more diverse crops and varieties—up to a point where farmers are likely to switch over to monoculture-based market production.[13] Land size appears to be more important for inter- and intraspecific diversity of field crops, and less important for fruits, vegetables, and herbs. This is likely because in contrast to field crops, fruits and vegetables are more often grown around homes or along field edges, thus not requiring much land. Among the field crops, the positive link between land size and maize diversity is particularly strong. This is likely related to the high rate of out-crossing common in this crop, making it especially difficult to manage several varieties within a small area. Most previous research only supports the first part of the present findings regarding land, reporting that diversity increases with size of cultivated land (Benin et al. 2004; Perreault 2005; Perreault-Archambault and Coomes 2008; Rana et al. 2007; van Dusen and Taylor 2005). Reasons for this discrepancy—a parabolic vs. a linear relation—may be differences between studies in the range of farm sizes included, or that the alternative of a parabolic relation was not examined in previous analyses. Yet they may also reflect real differences in the relationship between land size and diversity due to variance in other regional characteristics. Like the studies just referred to, research from the Peruvian Andes also found a positive relationship between farm size and diversity for maize and quinoa, but for potatoes and ulluco, the mid-sized farms had the lowest diversity (Mayer and Glave 2002; Zimmerer 1996: 90–97). In this case, the richest farmers with larger land holdings grew native varieties of various crops destined for home consumption as luxury items along with modern varieties for sale, while the poorest households grew native varieties out of necessity because their small lands were generally so marginal and high-up that they were unsuited for anything but landraces of tuber crops. Households with midsized farms could typically not afford destining land for diverse native varieties and crops, but instead focused all their production on more marketable and thus more profitable crops and varieties. The shape and reasons behind this partially non-linear relationship thus vary from the present study. Overall, this indicates that the relationship between farm size and crop diversity is complex, and may well differ between regions.

With regards to livestock assets, a similar situation to that of land was maintained through most estimations; a positive relationship up to a point above which larger assets were linked to lower diversity levels. The positive relation can be linked to the contributions of farm animals to agricultural production in the form of manure and drought power. Livestock is a form of investment and saving in Cotacachi, and a larger value thus also indicates relatively well-off households that are not resource-limited in their agricultural production. Yet farms with very large assets tend to be commercially and monoculture oriented and/or situated in the high zone, restricting the types of crops and varieties grown.[14] These results

[13] Examination of the data supports this interpretation; as much as 50 % (16 of 32) of those with land above 0.7 ha market a large part of their crop production, while only 7 % (4 of 57) of those with less land do so.

[14] Seventy-three % (8 of 11) of the farms in the sample with livestock assets over $1,500 sell amedium to large part of their agricultural harvest. Fifty-five % (6 of 11) are farms located in the high zone.

are partly supported by some previous evidence of positive links between cattle ownership and crop diversity (Perreault 2005) as well as cereal varietal diversity (Benin et al. 2004) and between livestock number and rice landrace diversity (Rana et al. 2007). Similar to the case of land, previous studies do not report to have examined possible non-linear relations, such as those found in the present work.

Most regression estimations showed a negative link between irrigation and different diversity measures, although only in the case of two measures was it significant. This result lends some support to the general hypothesis that the presence of agricultural inputs such as irrigation reduces diversity needs (Bellon 1996, 2001).[15] It further corresponds with previous research having found that farmers with irrigation access tend to cultivate more land in modern varieties in relation to landraces (Brush and Meng 1998).

In terms of agroecological zonation, most estimations show that the highest diversity levels are found in the intermediate zone, with markedly lower levels in the high zone (high significance) and slightly lower in the low zone (low significance). This pattern is linked to differences in agroecological conditions and crop adaptations. Farmers in the intermediate zone are able to cultivatemany of the crops adapted to the warmer conditions of the lower zone (maize, beans), as well as the colder conditions of the high zone (potatoes, other roots and tubers). On the other hand, farmers only cultivating in the high zone cannot grow beans due to low temperatures, and only recently did global warming allow them to begin the cultivation of maize (Skarbø 2012). Both beans and maize are crops with especially high varietal diversity in the area, and their exclusion from the crop portfolio is therefore linked with lower numbers of varieties. The only variety measure exhibiting most diversity in the high zone is potato variety richness, reflecting the cold-adaptation of this crop. These results are consistent with previous research that has likewise found differences in diversity levels along altitudinal gradients (Brush and Perales 2007; Perales et al. 2003; van Dusen and Taylor 2005; Zimmerer 1996).

*Results for Market Variables*

A high degree of market-oriented crop production is associated with strong, negative effects on agro-biodiversity across all measures except richness of modern varieties. This result supports the expectation that a high degree of subsistenceoriented production is related to higher levels of diversity, whereas a high degree of market-orientation is linked to lower levels, due to the difference between the diverse food demands of a household's subsistence and the market's demand for uniform, large quantities of the same product, which typically is obtained by production systems involving modern varieties. Unsurprisingly, landrace richness bears the strongest negative relation to high market orientation. The negative effect of high levels of market production is also particularly strong for bean diversity, in comparison to maize and potatoes. This differentiation is likely linked to the way these crops are managed—when grown for home consumption, bean varieties are typically planted in mixed populations, whereas maize and potatoes to a larger degree are separated by variety. As a result, relatively high bean diversity is the "default" for subsistence farmers, whilst a higher diversity in maize and potatoes is not as obvious.

While the negative association between market-orientation and agro-biodiversity generally is strong and highly significant for the group of farms producing mainly or only for the market, it is often

[15] If climatic conditions continue to change in theAndes and Cotacachi as predicted (Urrutia and Vuille 2009), this relation may be altered in the future, as irrigation may actually allow farmers to maintain more diversity not adapted to lengthened periods of dry conditions.

weaker and insignificant for the small to medium level (11–70 %) of commercial production, and for three measures the association is positive. Selling only a very small part of the production (1–10 %) is actually for seven of the measures associated with slightly higher diversity than selling no part, significant in three cases. A bar graph showing mean values of principal diversity richness measures by degree of commercial production is consistent with the regression results (Fig. 1). Across measures, a large degree of commercial production is linked with strong negative effects on diversity—but in comparison to those selling nothing, those with a very small or small to medium marketorientation display similar or more diversity for several measures. Those who sell only a small part of their production are likely to be households able to covermuch of their subsistence needs through their farm, in addition to sometimes having a small surplus to market. These farm households may be less resource-limited than those completely destining their production for subsistence use, a situation that may explain their propensity to cultivate somewhat more diverse crops. Marketing per se does not automatically reduce agrobiodiversity— but when major portions of the farm are destined market production, farmers in Cotacachi generally do not maintain diverse crops for subsistence use along with their commercial plantings.

The effect of market integration on agro-biodiversity has been a topic of interest for several previous researchers. Brush et al. (1992), Nazarea (1998) and Rana et al. (2007) found that sites with average higher market-orientation of crop production exhibited lower levels of potato, sweet potato and rice landrace diversity, respectively. Van Dusen and Taylor (2005) found that farmers in villages that were closer to major market towns, had higher average use of hired labor, and more US migration, tended to grow less diverse milpa fields. Brush et al. (1992) also found that within both sites, farms closer to markets tended to grow more land in modern varieties, a variable that was related to lower landrace diversity. Brush andMeng (1998) concluded that farms where a higher proportion of the wheat harvest was marketed planted less of their land in landraces, and Abbott (2005) found that the proportion of bean harvest devoted to the market was higher among farmers growing only modern varieties of the crop. Finally, Major et al.'s (2005) results from the Brazilian Amazon indicate that those who devoted more land to market production on average had slightly fewer crop species than those who focused more on subsistence production.[16] Although these studies vary widely in geography, farming systems, and themeasures adopted formarket integration as well as crop diversity, they all lend support to the hypothesis that as the share of farm production that is marketed increases, agro-biodiversity and/or landrace diversity in particular, is likely to decrease. And, conversely, that higher subsistence orientation is linked with higher biodiversity, and especially landrace diversity. Results from Cotacachi are consistent with this body of research, but further indicate a non-linear relation between market production and agro-biodiversity which shape varies depending on diversity measure.

## Conclusion

The current study shows that a wide set of factors guide agrobiodiversity decisions in Cotacachi. Cultural variables that have previously not been included in comparable crosssectional studies are demonstrated to carry special importance, both when analyzed separately and in the context of a variety of other farm and household characteristics. The degree to which households prepare and eat traditional foods in particular

[16] However, the sample of Major's team was small (N=16), and the difference was not found to be statistically significant.

holds importance for most diversity measures, indicating that the maintenance and cultivation of local food traditions will be important for the fate of the area's rich crop diversity. Relatedly, degree of subsistence-orientation emerges as another important factor; households that destine most or all of their harvest to non-market uses on average maintain a significantly higher number of crops and varieties in comparison to those who largely market what they grow.

Farm characteristics also play their role in conditioning the diversity of crops in the area. Other things being equal, higher diversity levels are generally linked to moderate land and livestock assets—an indication of relatively well-off subsistence-oriented households whose production decisions are not compromised by lack of agricultural resources. Different altitudinal zones provide better growing environments for different crop complexes, and this is reflected in the regression results. Demographic factors carry only minor weight and employment off farm displays a weak positive link to most diversity measures.

The sign of the relationships between the different household and farm factors and agro-biodiversity remain similar for most of the inter- and intraspecific diversity measures employed in the study. Relatedly, most diversity measures are positively correlated to each other. This indicates that people who grow a high diversity by one measure are likely to also maintain other types of diversity. Still, the size and significance of the coefficients in both correlation and regression analyses vary enough to caution against drawing broad conclusions based on single diversity measures. Total variety richness stands out as the measure best reflecting the overall diversity of the farm, while richness of potato varieties and modern varieties vary substantially from the other measures. Including several different measures at both interand intraspecific levels allows for a fuller understanding of how each explanatory variable is linked to different dimensions of biodiversity.

The results show that several household and farm characteristics, including land size, livestock assets, and degree of market-orientation, are related to measures of agrobiodiversity in non-linear ways. Future analyses might benefit from examining the possibility of such non-linear relationships.

In conclusion, across agro-biodiversity measures and among potentially influential factors, culture and subsistence stand out as central to the continued cultivation of agrobiodiverse fields and gardens in Cotacachi. Farm households that maintain local food traditions and destine a large part of their harvest for home use are those most likely to grow an extensive portfolio of crops and varieties; what is cooked is what is kept. Fromthis insight onemight extend that the future conservation and cultivation of agro-biodiversity in the area will be enhanced if the structural conditions for viable subsistence-oriented small-scale farming will be improved, and if people continue to identify with and appreciate their cultural and agricultural heritage.

**Acknowledgments**

I am grateful to the many farmers who participated in this project, to the Unión de Organizaciones Campesinas e Indígenas de Cotacachi for facilitating the research, and to Rosa Ramos and Aida Guandinango for able research assistance. I thankVirginia Nazarea, Bram Tucker and Ricardo Godoy for guidance in the design and analysis of the study, and two anonymous reviewers for insightful comments. This work was supported by the National Science Foundation under Grant No. 0921859 and an Andrew E. and G. Norman Wigeland Fellowship from the American-Scandinavian Foundation.

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**Tables and Figures**

**Table 1** Number of species documented in the research

| Crop type | Number of species |
|---|---|
| Field crops | 25 |
| Fruits | 32 |
| Vegetables | 15 |
| Herbs[a] | 30 |
| Forage | 1 |
| Total species count | 103 |

[a]Another 6 herbs which scientific classification could not be determined were registered.

**Table 2** Definition and summary statistics, dependent variables

| Variable | Obs | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| Intraspecific diversity, summed across 20 field crop spp. | | | | | |
| Total variety richness | 89 | 26.74 | 19.81 | 1 | 105 |
| Total landrace richness | 89 | 23.43 | 19.02 | 0 | 99 |
| Total modern variety richness | 89 | 3.31 | 2.22 | 0 | 12 |
| Intraspecific diversity, most common crops individually | | | | | |
| Maize variety richness | 89 | 3.19 | 3.79 | 0 | 23 |
| Bean variety richness | 89 | 14.19 | 12.26 | 0 | 59 |
| Potato variety richness | 89 | 1.52 | 1.83 | 0 | 9 |
| Interspecific diversity | | | | | |
| Field crop species richness | 89 | 7.22 | 3.51 | 1 | 17 |
| Fruit and vegetable crop richness | 89 | 7.48 | 7.63 | 0 | 38 |
| Herb species richness | 89 | 3.04 | 4.08 | 0 | 28 |

**Table 3** Definition and summary statistics, explanatory variables

| Variable | Hypothesized Effect | Obs | Mean | SD | Min | Max |
|---|---|---|---|---|---|---|
| Cultural variables | | | | | | |
| Proportion of traditional foods in diet (continuous) | (+) | 88 | 0.56 | 0.17 | 0.21 | 1 |
| Proportion of traditional foods in diet, (categorical) | (+) | 88 | 2.01 | 0.82 | 1 | 3 |
| Frequency of traditional dress (categorical) | (+) | 87 | 2.72 | 0.58 | 1 | 3 |
| Language(s), intergenerational communication (categorical) | (+) | 89 | 2.15 | 0.83 | 1 | 3 |
| Household demographic and economic variables | | | | | | |
| Age of HH head (years) | (+) | 89 | 44.70 | 15.39 | 19 | 88 |
| Schooling of HH head (years) | (+, −) | 89 | 2.94 | 3.40 | 0 | 13 |
| Number of adults | (+, −) | 89 | 2.81 | 1.27 | 1 | 7 |
| Number of children | (+, −) | 89 | 2.58 | 2.11 | 0 | 9 |
| No HH head works off farm (dummy) | (+, −) | 89 | 0.28 | | 0 | 1 |
| One HH head works off farm (dummy) | (+, −) | 89 | 0.58 | | 0 | 1 |
| Two HH heads work off farm (dummy) | (+, −) | 89 | 0.13 | | 0 | 1 |
| Farm variables | | | | | | |
| Size of cultivated land (hectares) | (+) | 89 | 1.05 | 1.72 | 0.033 | 10 |
| Square of cultivated land size | (−) | 89 | 4.03 | 13.82 | 0.001 | 100 |
| Livestock assets (monetary value, 1000 USD) | (+) | 89 | 1.14 | 2.54 | 0 | 18.98 |
| Square of livestock assets | (−) | 89 | 7.68 | 41.08 | 0 | 360.16 |
| Land has irrigation access (dummy) | (+, −) | 89 | 0.44 | | 0 | 1 |
| Low zone (dummy) | (+, −) | 89 | 0.67 | | 0 | 1 |
| Intermediate zone (dummy) | (+, −) | 89 | 0.22 | | 0 | 1 |
| High zone (dummy) | (+, −) | 89 | 0.10 | | 0 | 1 |
| Market variables | | | | | | |
| No part of crop production (CP) sold (dummy) | (+) | 89 | 0.49 | | 0 | 1 |
| Very small part of CP sold (1-10%) (dummy) | (−) | 89 | 0.13 | | 0 | 1 |
| Small or medium part of CP sold (11 - 70%) (dummy) | (−) | 89 | 0.15 | | 0 | 1 |
| Large part or all of CP sold (≥71%) (dummy) | (−) | 89 | 0.22 | | 0 | 1 |

**Table 4** Correlation matrix of different measures of agrobiodiversity (dependent variables)

| Richness measure | Total var. | Total land-races | Total MVs | Maize var. | Bean var. | Potato var. | Field crop spp. | Fruits & veg. | Herbs |
|---|---|---|---|---|---|---|---|---|---|
| Total var. | 1.00 | | | | | | | | |
| Total landraces | 0.99*** | 1.00 | | | | | | | |
| Total MVs | 0.40*** | 0.30*** | 1.00 | | | | | | |
| Maize var. | 0.75*** | 0.73*** | 0.46*** | 1.00 | | | | | |
| Bean var. | 0.88*** | 0.90*** | 0.14 | 0.54*** | 1.00 | | | | |
| Potato var. | 0.26** | 0.20* | 0.58*** | 0.18* | -0.10 | 1.00 | | | |
| Field crop spp. | 0.78*** | 0.75*** | 0.52*** | 0.61*** | 0.46*** | 0.52*** | 1.00 | | |
| Fruits & veg. | 0.40*** | 0.38*** | 0.34*** | 0.38*** | 0.32*** | 0.06 | 0.42*** | 1.00 | |
| Herbs | 0.64*** | 0.62*** | 0.33*** | 0.50*** | 0.44*** | 0.34*** | 0.61*** | 0.55*** | 1.00 |

*Significant below the 0.10 level, **significant below the 0.05 level, *** significant below the 0.01 level.

**Table 5** Results of ANOVA analyses of the relationship between cultural variables and richness measures for total varieties, total landraces, and total modern varieties

| | | Total varieties | | | | Total landraces | | | | Total MVs | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Between group | | | | Between group | | | | Between group | |
| | N | Mean | SD | F | p | Mean | SD | F | p | Mean | SD | F | p |
| Traditional dress | | | | | | | | | | | | | |
| Never | 6 | 8.3 | 9.0 | 9.58 | 0.000 | 5.8 | 9.6 | 9.21 | 0.000 | 2.5 | 1.6 | 2.01 | 0.140 |
| Sometimes | 12 | 11.9 | 11.4 | | | 9.6 | 11.5 | | | 2.3 | 0.8 | | |
| Always | 69 | 31.5 | 19.4 | | | 28.0 | 18.6 | | | 3.6 | 2.4 | | |
| Total | 87 | 27.2 | 19.8 | | | 23.9 | 19.0 | | | 3.3 | 2.2 | | |
| Language | | | | | | | | | | | | | |
| Spanish only | 25 | 8.6 | 10.1 | 26.13 | 0.000 | 5.8 | 10.2 | 27.22 | 0.000 | 2.8 | 1.1 | 1.03 | 0.362 |
| Both Spanish and Kichwa | 26 | 27.8 | 12.2 | | | 24.5 | 11.3 | | | 3.3 | 2.5 | | |
| Kichwa only | 38 | 38.0 | 20.3 | | | 34.3 | 19.3 | | | 3.7 | 2.5 | | |
| Total | 89 | 26.7 | 19.8 | | | 23.4 | 19.0 | | | 3.3 | 2.2 | | |
| Traditional food | | | | | | | | | | | | | |
| Low | 29 | 13.5 | 13.4 | 14.72 | 0.000 | 11.0 | 13.5 | 14.24 | 0.000 | 2.5 | 1.2 | 2.91 | 0.060 |
| Medium | 29 | 29.7 | 16.3 | | | 26.0 | 15.7 | | | 3.8 | 2.5 | | |
| High | 30 | 37.4 | 21.0 | | | 33.7 | 19.9 | | | 3.7 | 2.6 | | |
| Total | 88 | 27.0 | 19.8 | | | 23.7 | 19.0 | | | 3.3 | 2.2 | | |

**Table 6** Results of ANOVA analyses of the relationship between cultural variables and variety richness measures for maize, beans, and potatoes

| | | Maize varieties | | | | Bean varieties | | | | Potato varieties | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Between group | | | | Between group | | | | Between group | |
| | N | Mean | SD | F | p | Mean | SD | F | p | Mean | SD | F | p |
| Traditional dress | | | | | | | | | | | | | |
| Never | 6 | 1.0 | 0.0 | 3.18 | 0.047 | 4.2 | 7.8 | 6.16 | 0.003 | 0.8 | 0.8 | 2.58 | 0.082 |
| Sometimes | 12 | 1.4 | 1.2 | | | 6.8 | 8.5 | | | 0.6 | 0.7 | | |
| Always | 69 | 3.8 | 4.1 | | | 16.6 | 12.2 | | | 1.8 | 2.0 | | |
| Total | 87 | 3.2 | 3.8 | | | 14.4 | 12.2 | | | 1.5 | 1.9 | | |
| Language | | | | | | | | | | | | | |
| Spanish only | 25 | 1.1 | 0.4 | 8.09 | 0.001 | 3.8 | 8.2 | 19.14 | 0.000 | 0.8 | 1.0 | 2.87 | 0.062 |
| Both Spanish and Kichwa | 26 | 2.9 | 4.8 | | | 15.1 | 9.7 | | | 1.9 | 2.3 | | |
| Kichwa only | 38 | 4.7 | 3.6 | | | 20.2 | 11.8 | | | 1.7 | 1.8 | | |
| Total | 89 | 3.2 | 3.8 | | | 14.1 | 12.3 | | | 1.5 | 1.8 | | |
| Traditional food | | | | | | | | | | | | | |
| Low | 29 | 1.4 | 0.9 | 6.2 | 0.003 | 7.6 | 9.8 | 8.23 | 0.001 | 0.7 | 0.6 | 4.55 | 0.013 |
| Medium | 29 | 3.6 | 4.9 | | | 15.5 | 10.8 | | | 2.0 | 1.9 | | |
| High | 30 | 4.6 | 3.7 | | | 19.4 | 13.1 | | | 1.9 | 2.3 | | |
| Total | 88 | 3.2 | 3.8 | | | 14.2 | 12.2 | | | 1.5 | 1.8 | | |

**Table 7** Results of ANOVA analyses of the relationship between cultural variables and richness measures for field crop species, fruits and vegetable crops, and medicinal plants/herbs

| | | Field crop species | | | | Fruit and vegetable crops | | | | Herbs | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Between group | | | | Between group | | | | Between group | |
| | N | Mean | SD | F | p | Mean | SD | F | p | Mean | SD | F | p |
| Traditional dress | | | | | | | | | | | | | |
| Never | 6 | 4.3 | 2.1 | 7.38 | 0.001 | 0.8 | 0.8 | 4.46 | 0.015 | 0.0 | 0.0 | 3.89 | 0.024 |
| Sometimes | 12 | 4.8 | 2.9 | | | 3.9 | 3.8 | | | 1.3 | 2.1 | | |
| Always | 69 | 8.0 | 3.4 | | | 8.2 | 7.3 | | | 3.7 | 4.3 | | |
| Total | 87 | 7.3 | 3.5 | | | 7.2 | 7.0 | | | 3.1 | 4.1 | | |
| Language | | | | | | | | | | | | | |
| Spanish only | 25 | 4.3 | 2.3 | 17.68 | 0.000 | 2.6 | 2.9 | 9.21 | 0.000 | 0.8 | 1.3 | 6.32 | 0.003 |
| Both Spanish and Kichwa | 26 | 7.7 | 2.8 | | | 10.0 | 7.7 | | | 3.4 | 3.3 | | |
| Kichwa only | 38 | 8.8 | 3.5 | | | 8.0 | 6.9 | | | 4.3 | 5.1 | | |
| Total | 89 | 7.2 | 3.5 | | | 7.1 | 6.9 | | | 3.0 | 4.1 | | |
| Traditional food | | | | | | | | | | | | | |
| Low | 29 | 5.1 | 2.7 | 11.59 | 0.000 | 3.8 | 4.3 | 8.43 | 0.001 | 1.0 | 1.8 | 8.91 | 0.000 |
| Medium | 29 | 7.7 | 3.2 | | | 6.8 | 7.6 | | | 3.0 | 3.4 | | |
| High | 30 | 8.9 | 3.5 | | | 10.7 | 6.8 | | | 5.2 | 5.2 | | |
| Total | 88 | 7.3 | 3.5 | | | 7.2 | 7.0 | | | 3.1 | 4.1 | | |

**Table 8** Poisson regression results for total variety richness measures. (Continued on next page)

| Explanatory variable/Statistic | Total varieties | | | Total landraces | | | Total MVs | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coef. | z | P>z | Coef. | z | P>z | Coef. | z | P>z |
| Cultural variable | | | | | | | | | |
| Proportion of traditional foods in diet (cont.) | 1.1472 | 2.90 | 0.0040 | 1.1936 | 2.64 | 0.0080 | 0.5265 | 1.24 | 0.2160 |
| Household demographic and economic variables | | | | | | | | | |
| Age of HH head | -0.0009 | -0.21 | 0.8330 | 0.0000 | 0.00 | 0.9980 | -0.0073 | -1.15 | 0.2490 |
| Schooling of HH head | 0.0051 | 0.34 | 0.7320 | 0.0092 | 0.56 | 0.5770 | -0.0306 | -1.11 | 0.2660 |
| Number of adults | -0.0257 | -0.65 | 0.5170 | -0.0347 | -0.83 | 0.4080 | 0.0288 | 0.64 | 0.5250 |
| Number of children | -0.0369 | -1.70 | 0.0900 | -0.0412 | -1.65 | 0.0980 | -0.0031 | -0.09 | 0.9290 |
| No HH head works off farm^ | | | | | | | | | |
| One HH head works off farm | 0.2059 | 1.57 | 0.1170 | 0.2172 | 1.51 | 0.1320 | 0.1858 | 1.00 | 0.3160 |
| Two HH heads work off farm | 0.1471 | 0.73 | 0.4680 | 0.2103 | 0.78 | 0.4370 | -0.1445 | -0.47 | 0.6380 |
| Farm variables | | | | | | | | | |
| Size of cultivated land | 0.2840 | 2.49 | 0.0130 | 0.2523 | 1.92 | 0.0550 | 0.4583 | 4.20 | 0.0000 |
| Square of cultivated land size | -0.0191 | -1.70 | 0.0880 | -0.0047 | -0.37 | 0.7100 | -0.0568 | -4.05 | 0.0000 |
| Livestock assets | 0.1751 | 2.32 | 0.0200 | 0.1734 | 1.98 | 0.0480 | 0.2058 | 3.06 | 0.0020 |
| Square of livestock assets | -0.0084 | -2.30 | 0.0210 | -0.0082 | -1.94 | 0.0530 | -0.0097 | -2.93 | 0.0030 |
| Land has irrigation access | -0.1606 | -1.18 | 0.2390 | -0.1511 | -1.00 | 0.3160 | -0.2782 | -1.56 | 0.1190 |
| Low zone | -0.1919 | -1.58 | 0.1130 | -0.2243 | -1.76 | 0.0780 | 0.1397 | 0.78 | 0.4370 |
| Intermediate zone^ | | | | | | | | | |
| High zone | -1.2323 | -5.98 | 0.0000 | -1.5007 | -5.74 | 0.0000 | -0.3772 | -1.27 | 0.2050 |
| Market relations | | | | | | | | | |
| No part of crop production sold^ | | | | | | | | | |
| Very small part of crop production sold | 0.0354 | 0.26 | 0.7920 | -0.0072 | -0.05 | 0.9600 | 0.4272 | 2.54 | 0.0110 |
| Small or medium part of crop production sold | -0.2175 | -1.33 | 0.1830 | -0.2761 | -1.48 | 0.1390 | 0.2953 | 1.06 | 0.2890 |
| Large part or all of crop production sold | -1.9814 | -6.49 | 0.0000 | -3.0499 | -6.33 | 0.0000 | 0.1287 | 0.34 | 0.7330 |
| Constant | 2.8403 | 9.38 | 0.0000 | 2.7329 | 8.26 | 0.0000 | 0.5995 | 1.25 | 0.2120 |
| Observations | 88 | | | 88 | | | 88 | | |
| Wald chi-square | 342.24 | | | 223.34 | | | 193.18 | | |

| Explanatory variable/Statistic | Total varieties | | | Total landraces | | | Total MVs | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coef. | z | P>z | Coef. | z | P>z | Coef. | z | P>z |
| Probability > chi-square | 0.0000 | | | 0.0000 | | | 0.0000 | | |
| Pseudo R-squared | 0.5658 | | | 0.5960 | | | 0.1415 | | |

^Omitted because of collinearity.
Note: All regressions are run using robust standard errors.

**Table 9** Poisson regression results for maize, common bean, and potato richness measures. (Continued on next page)

| Explanatory variable/Statistic | Maize varieties | | | Common bean varieties | | | Potato varieties | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coef. | z | P>z | Coef. | z | P>z | Coef. | z | P>z |
| Cultural variable | | | | | | | | | |
| Proportion of traditional foods in diet (cont.) | 1.4761 | 2.08 | 0.0370 | 1.2495 | 2.32 | 0.0200 | 0.1293 | 0.21 | 0.8300 |
| Household demographic and economic variables | | | | | | | | | |
| Age of HH head | 0.0082 | 0.77 | 0.4420 | -0.0027 | -0.54 | 0.5890 | 0.0052 | 0.63 | 0.5310 |
| Schooling of HH head | 0.0254 | 0.63 | 0.5310 | 0.0043 | 0.27 | 0.7890 | 0.0206 | 0.62 | 0.5360 |
| Number of adults | -0.0537 | -0.70 | 0.4840 | -0.0466 | -0.91 | 0.3620 | 0.0743 | 1.37 | 0.1700 |
| Number of children | -0.0779 | -1.72 | 0.0850 | -0.0444 | -1.56 | 0.1180 | 0.0241 | 0.48 | 0.6280 |
| No HH head works off farm^ | | | | | | | | | |
| One HH head works off farm | 0.4667 | 1.40 | 0.1610 | 0.1650 | 1.05 | 0.2920 | 0.2479 | 1.17 | 0.2410 |
| Two HH heads work off farm | 0.0155 | 0.05 | 0.9640 | 0.2646 | 1.31 | 0.1910 | -0.2703 | -0.50 | 0.6160 |
| Farm variables | | | | | | | | | |
| Size of cultivated land | 0.5928 | 1.96 | 0.0490 | 0.3090 | 1.39 | 0.1650 | 0.4166 | 3.40 | 0.0010 |
| Square of cultivated land size | -0.0664 | -1.43 | 0.1540 | -0.0233 | -0.77 | 0.4400 | -0.0475 | -3.83 | 0.0000 |
| Livestock assets | -0.0775 | -0.66 | 0.5120 | 0.1076 | 0.89 | 0.3730 | 0.1911 | 2.10 | 0.0360 |
| Square of livestock assets | 0.0045 | 0.74 | 0.4590 | -0.0064 | -0.47 | 0.6360 | -0.0076 | -1.71 | 0.0880 |
| Land has irrigation access | -0.7301 | -2.01 | 0.0450 | 0.0323 | 0.20 | 0.8450 | 0.2197 | 0.87 | 0.3870 |
| Low zone | 0.0183 | 0.07 | 0.9430 | -0.0962 | -0.62 | 0.5360 | -0.3892 | -1.41 | 0.1580 |
| Intermediate zone^ | | | | | | | | | |
| High zone | -1.7289 | -4.29 | 0.0000 | -18.8442 | -32.24 | 0.0000 | 1.0335 | 3.17 | 0.0020 |
| Market relations | | | | | | | | | |
| No part of crop production sold^ | | | | | | | | | |
| Very small part of crop production sold | 0.1571 | 0.64 | 0.5200 | -0.1917 | -1.18 | 0.2400 | 0.8310 | 3.59 | 0.0000 |
| Small or medium part of crop production sold | -0.4715 | -1.17 | 0.2440 | -0.2100 | -0.97 | 0.3320 | -0.2028 | -0.74 | 0.4610 |
| Large part or all of crop production sold | -0.4621 | -0.95 | 0.3440 | -3.1564 | -11.27 | 0.0000 | -0.7995 | -1.45 | 0.1470 |
| Constant | 0.0027 | 0.00 | 0.9970 | 2.3890 | 6.61 | 0.0000 | -0.9071 | -1.43 | 0.1530 |
| Observations | 88 | | | 88 | | | 88 | | |
| Wald chi-square | 282.46 | | | 3236.41 | | | 1085.75 | | |

| Explanatory variable/Statistic | Maize varieties | | | Common bean varieties | | | Potato varieties | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coef. | z | P>z | Coef. | z | P>z | Coef. | z | P>z |
| Probability > chi-square | 0.0000 | | | 0.0000 | | | 0.0000 | | |
| Pseudo R-squared | 0.3010 | | | 0.5829 | | | 0.3011 | | |

^Omitted because of collinearity.

Note: All regressions are run using robust standard errors.

**Table 10** Poisson regression results for crop level richness measures (Continued on next page)

| Explanatory variable/Statistic | Field crop species | | | Fruits and vegetables | | | Medicinal plants | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coef. | z | P>z | Coef. | z | P>z | Coef. | z | P>z |
| Cultural variable | | | | | | | | | |
| Proportion of traditional foods in diet (cont.) | 0.5536 | 2.61 | 0.0090 | 1.6148 | 2.47 | 0.0130 | 1.8275 | 2.11 | 0.0350 |
| Household demographic and economic variables | | | | | | | | | |
| Age of HH head | -0.0008 | -0.24 | 0.8110 | -0.0049 | -0.72 | 0.4700 | 0.0053 | 0.49 | 0.6260 |
| Schooling of HH head | 0.0071 | 0.61 | 0.5430 | 0.0652 | 2.23 | 0.0260 | 0.0117 | 0.34 | 0.7350 |
| Number of adults | 0.0203 | 0.83 | 0.4080 | 0.0048 | 0.09 | 0.9270 | 0.0128 | 0.20 | 0.8400 |
| Number of children | -0.0104 | -0.54 | 0.5910 | 0.0400 | 1.19 | 0.2320 | 0.0849 | 1.86 | 0.0630 |
| No HH head works off farm^ | | | | | | | | | |
| One HH head works off farm | 0.0534 | 0.59 | 0.5520 | 0.3463 | 1.51 | 0.1310 | 0.9472 | 2.67 | 0.0080 |
| Two HH heads work off farm | 0.0673 | 0.31 | 0.7530 | 0.1480 | 0.43 | 0.6690 | 0.7837 | 1.68 | 0.0930 |
| Farm variables | | | | | | | | | |
| Size of cultivated land | 0.1892 | 2.54 | 0.0110 | -0.0212 | -0.10 | 0.9230 | 0.1575 | 0.50 | 0.6150 |
| Square of cultivated land size | -0.0140 | -1.99 | 0.0460 | -0.0155 | -0.59 | 0.5560 | -0.0804 | -1.33 | 0.1830 |
| Livestock assets | 0.1094 | 1.86 | 0.0640 | 0.1752 | 1.24 | 0.2150 | 0.4669 | 2.35 | 0.0190 |
| Square of livestock assets | -0.0043 | -1.53 | 0.1270 | -0.0086 | -1.37 | 0.1710 | -0.0212 | -2.48 | 0.0130 |
| Land has irrigation access | -0.1953 | -2.34 | 0.0200 | -0.7785 | -3.06 | 0.0020 | -0.1457 | -0.47 | 0.6380 |
| Low zone | -0.1861 | -1.87 | 0.0620 | 0.0533 | 0.26 | 0.7940 | -0.6501 | -2.51 | 0.0120 |
| Intermediate zone^ | | | | | | | | | |
| High zone | -0.6090 | -3.55 | 0.0000 | -1.3940 | -2.78 | 0.0050 | -1.4864 | -2.33 | 0.0200 |
| Market relations | | | | | | | | | |
| No part of crop production sold^ | | | | | | | | | |
| Very small part of crop production sold | 0.1105 | 1.06 | 0.2900 | 0.2711 | 1.33 | 0.1850 | 0.7892 | 3.35 | 0.0010 |
| Small or medium part of crop production sold | -0.0567 | -0.67 | 0.5020 | 0.7593 | 3.08 | 0.0020 | 0.5332 | 1.67 | 0.0940 |
| Large part or all of crop production sold | -0.7561 | -3.21 | 0.0010 | -0.3794 | -0.78 | 0.4330 | -0.2339 | -0.41 | 0.6840 |
| Constant | 1.7328 | 6.27 | 0.0000 | 0.7609 | 1.43 | 0.1520 | -1.3244 | -1.84 | 0.0660 |
| Observations | 88 | | | 87 | | | 88 | | |
| Wald chi-square | 250.03 | | | 184.43 | | | 167.18 | | |

| Explanatory variable/Statistic | Field crop species | | | Fruits and vegetables | | | Medicinal plants | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coef. | z | P>z | Coef. | z | P>z | Coef. | z | P>z |
| Probability > chi-square | 0.0000 | | | 0.0000 | | | 0.0000 | | |
| Pseudo R-squared | 0.1883 | | | 0.3746 | | | 0.3972 | | |

^Omitted because of collinearity
Note: All regressions are run using robust standard errors

**Figure**

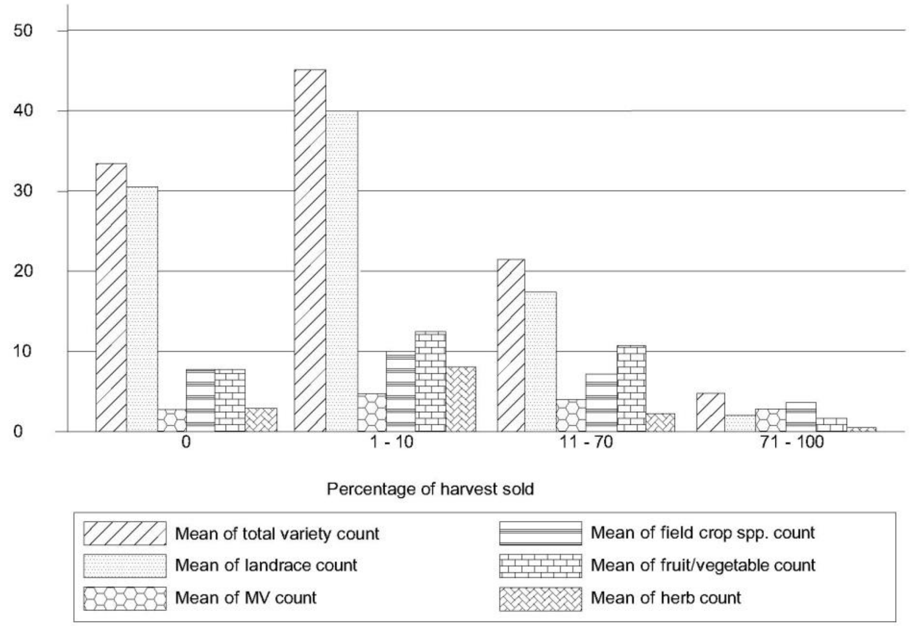


**Figure 1** Bar chart showing mean values of agrobiodiversity measures by proportion of harvest sold