Farmers' decision making on land use – the importance of soil conditions in the case of Río Cabuyal watershed, Colombia

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Abstract

Biophysical conditions and in particular soil conditions are generally seen as important determinants of land use and receive much emphasis both in land use planning and in attempts to understand actual land use patterns. This paper explores the justification for this emphasis. Based on a study of farmers' decisions regarding land use type (forest, pasture, fallow or crop) and crop choice in the Colombian Andes, the paper shows that despite farmers' detailed knowledge of the diverse soil conditions in the area, other factors, such as total farm size and market and input-related concerns, are more important for farmers' actual choice of land use type and crop.

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Many studies provide evidence of farmers' detailed knowledge of their soils and of their ability to draw agronomic management implications from this knowledge (Talawar, 1996; Talawar and Rhoades, 1998). As a classic example, Rounce (1949) and Malcolm (1953) documented the soil taxonomy of the Wasukuma people in Northwestern Tanzania, encompassing nine major soil classes and specific management practices associated with each soil type. Among the most important descriptors upon which farmers based their soil classification were soil color, soil texture and soil structure (Rounce, 1949; Malcolm, 1953; Ravnborg, 1992; Bellon & Taylor, 1993; Zimmerer, 1994; de Kool, 1996). Such 'folk' soil taxonomies have been found to correlate well with acknowledged scientific descriptions of soil properties. In a study from Chiapas, Mexico, farmers identified and ranked by quality four main classes of soils. Analysis of samples taken from these soils with respect to properties such as pH, organic matter content, and texture, showed a significant correlation between these properties and farmers' quality rankings of the soils (Bellon and Taylor, 1993).

Given this ability of farmers to distinguish different soil types, it is generally hypothesized that farmers would select the best soils for cultivation while leaving poorer soils under forest or natural pasture. As soils gradually degrade as a consequence of cultivation, crop choice should change from more demanding crops such as maize and beans to less demanding crops such as cassava, before the soil is finally put under fallow to regenerate fertility. Such hypotheses also guide capability analysis and land use planning, which tend to be based primarily upon soil and climatic data (Brinkman, 1994; Alfaro et al., 1994) though attempts have been made to also include economic and social factors (FAO, 1976; Rossiter & Van Wambeke, 1993).

However, soil properties, and more generally biophysical properties, are not the only factors recognized in farmers' decision-making process with respect to land use and crop choice. Other factors, such as market opportunities and input requirements versus availability , also play important roles (Talawar and Rhoades, 1998).

Based on a case study conducted in the Andean hillsides of Southwestern Colombia, this paper examines the importance of biophysical conditions versus other factors, such as market concerns, access to productive resources and overall objectives which enter into farmers' decision-making with respect to land use, i.e. choice of land cover (forest, fallow, pasture or type of crop).

Materials and methods

The study area

The Río Cabuyal watershed (see Figure 1) is situated in the Andes in southwestern Colombia at altitudes ranging from 1,200-2,200 meters a.s.l. and covers an area of approximately 7,000 hectares. Annual rainfall is just below 2,000 mm with a pronounced dry spell from June to August. Steep slopes and varied topography characterize the area. Based on a digital terrain model, half of the Río Cabuyal watershed is estimated to have slopes of more than 30%, and an additional third of the area to have slopes between 12 and 30% (Urbano et al., 1995). Pedology is also highly variable: highly eroded, red soils are often found side by side with deep, black soils. Overall, the soils of the area are characterized as acid soils of volcanic origin and poor fertility. Around two-thirds of the farmers use fertilizer, particularly chicken manure, which is sold commercially in the area and which for most crops is preferred to chemical fertilizers.

Río Cabuyal watershed houses a multi-ethnic population composed of Páez Indians who have the longest history in the area and constitute 20% of the population, and the mestizos, or Caucanos as they are also called, constituting 65% of the population. (This and the following descriptive information is based on the 1997 Río Cabuyal poverty monitoring survey or the 1993 Río Cabuyal household census). The mestizos came to settle in the area from other parts of Cauca around the turn of the nineteenth century (Rappaport, 1990). The remaining 15% of the population is made up of a mixed group of people, including Guambiano Indians and mestizos coming from other parts of Colombia, who all have a more recent history in the area. The watershed is densely populated (100 persons per km^2), although there are substantial variations throughout (see Figure 1). Virtually all land is titled. Small-scale farming, often combined with day-laboring on local small-scale farms, provide the main sources of income in the area. The average farm size is 3.6 hectares with half of the households owning 2 hectares or less. Barely 10% of the households are landless and an additional 8% are virtually landless, having a total farm size of less than 0.5 hectare. Renting land is of negligible importance in the area, practiced by only 1% of the households, whereas caretaker cultivation is more common, with an estimated 10% of the households earning their living as caretakers.

The principal crops grown are coffee, plantain (intercropped with coffee), cassava, maize, beans and tomatoes. In the upper part of the watershed, i.e. above 1,600-1,700m, fruits are also grown. Livestock production is of minor importance and only 14% of the households own cattle. The Pan-American Highway cuts across the middle of the watershed, giving the population in the mid- and to some extent low-altitude areas good access to markets in neighboring townships as well as in the bigger cities of Popayán and Cali. The majority of farmers sell at least part of their production. More than 90% of the households sell at least one of the principal crops mentioned above. Besides coffee, which is the main cash crop, 71% of the households sell beans, cassava, maize, plantain or tomatoes. On average, 80% of the families have access to piped drinking water and virtually all households use firewood as the primary fuel for cooking.

Data collection

As a first step towards gaining insight into farmer decision-making related to land use, a series of workshops was held with groups of farmers in three different locations at different altitudes (<1,500 m; 1,500-1,700 m; >1,700 m) and thus differing with respect to agro-ecological conditions, accessibility and population density (see Figure 1).

Prior to the workshops, a study had been conducted to develop a poverty profile of the Río Cabuyal population, based on a methodology for developing regional poverty profiles based on local perceptions (Ravnborg et al., 1999). The basis for this methodology is the identification of local perceptions of poverty using the 'well-being ranking technique', described by Grandin (1988). From these descriptions, sets of well-being indicators are identified. In the case of Río Cabuyal, these indicators covered dependency on others for livelihood security, degree of basic needs satisfaction and ownership of assets and resources. These indicators are subsequently made quantifiable, i.e. translated into questions relating to each indicator and included in a questionnaire. A scoring system couples responses with population profile information (in our case, the 1993 Río Cabuyal household census), allowing a score to be assigned to each household for each indicator. These scores are then combined as an arithmetic mean into a well-being index on the basis of which well-being categories are identified. Following this procedure, qualitative poverty indicators are turned into a single and absolute, though locally-informed measure of poverty (or well-being).

In the case of Río Cabuyal, three well-being categories were identified, of which the highest level of well-being applied to 23% of the households, implying among other things imply having cattle or non-agricultural sources of

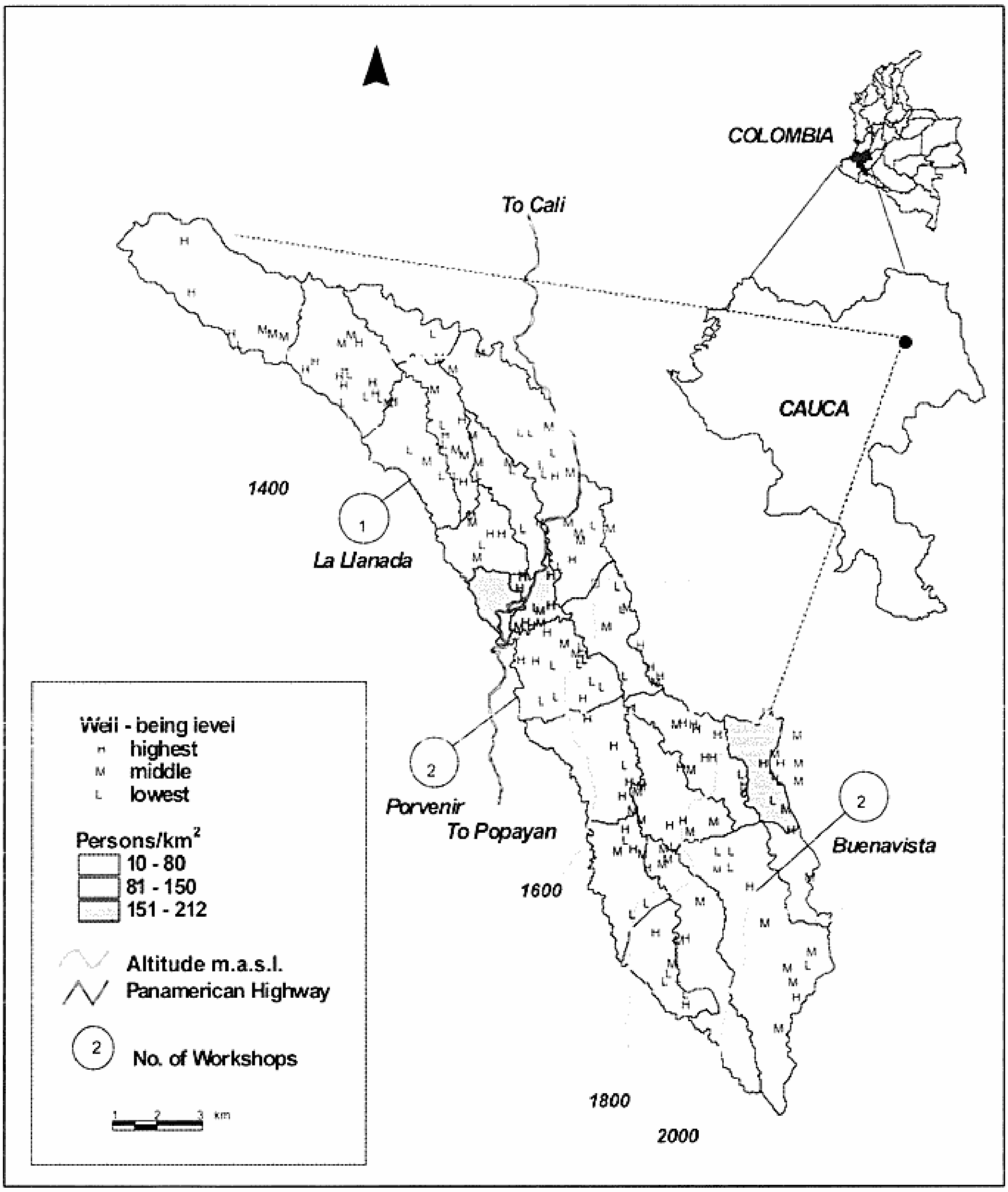

***Figure 1:** Location of Río Cabuyal watershed, altitude zones, population density, location of workshops, and location and well-being level of interviewed households*

income, good quality housing and absence of periods of food shortage. At the other end of the well-being scale, 31% of the households were categorized as suffering the lowest level of well-being, implying dependence on day-laboring on neighboring farms for a considerable part of their livelihood, owning little land and regular periods of food shortage. Finally, 46% of the households were categorized as having a middle level of well-being, for many implying earning their livelihood through farming their own land, at times supplemented by day-laboring on neighboring farms, relative lack of periods of food shortage and experiencing an intermediate housing quality.

Using this poverty profile, farmers were invited to the workshops on the basis of their well-being level so that two workshops were arranged in each of the three locations: one including participants enjoying highest and middle level of well-being; and one including participants from households enduring the lowest level of well-being. Workshop participants were asked to describe what they perceived to be different types of plots, using a maqueta, i.e. a three-di-

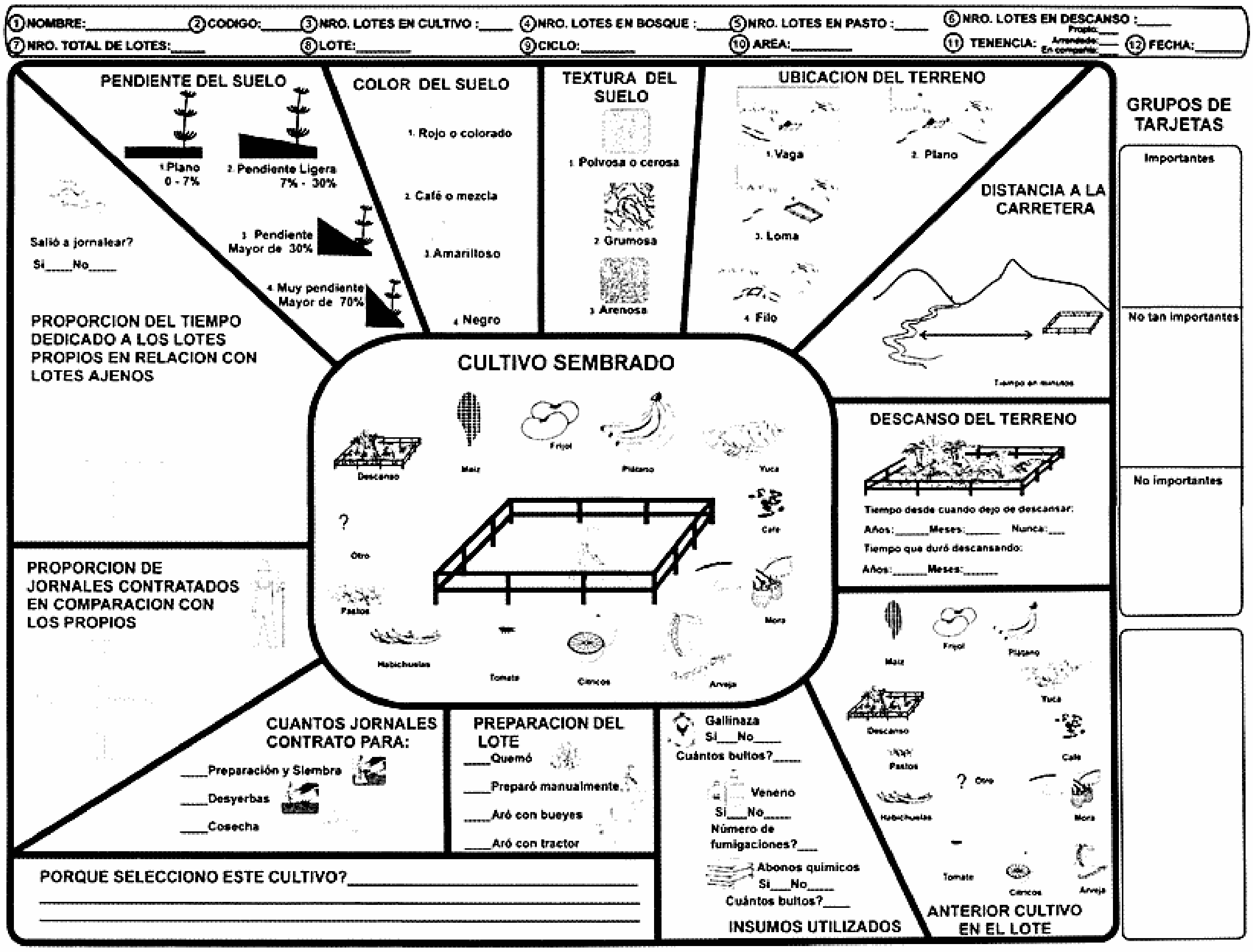

Figure 2: *Pictorial questionnaire developed for the Río Cabuyal decision-making study (The questionnaire was developed and produced in Spanish only).*

mensional scale model of the Río Cabuyal watershed (Rubiano et al., 1997) as a reference point. Thus local plot descriptors were elicited. Subsequently, with reference to these descriptors, workshop participants were asked to identify three contrasting plots. Each of these plots was visited and participants were polled with regard to the decision-making process, i.e. the objectives, concerns and reasons which had led to the actual land use of the specific plot. As well-being in Río Cabuyal is closely associated with access to productive resources such as land, labor, and capital (Ravnborg and Guerrero, 1996), having separate workshops for the poorest households allowed us to explore whether access to productive resources is associated with i) the objectives which farmers pursue; ii) the knowledge upon which decisions are based; and iii) the actual decisions made by farmers.

On the basis of the insight gained through the workshops into the conceptual and logical framework within which farmer decision-making takes place, a pictorial questionnaire (see Figure 2) was developed. The aim of the questionnaire was, with reference to specific plots, to collect quantifiable information about 1) land cover (forest, fallow, pasture or crop); 2) biophysical conditions; 3) the management for a given plot; and 4) the reason for choosing a specific type of land cover for a given plot. Quantifying these factors enabled a statistical analysis of the relationships among them. A questionnaire sheet (as the one depicted in Figure 2) was filled for each plot included in the sample (for sampling procedure, please see the section below). For each sample plot, the respondent was asked first to indicate the relevant land use type. Moving clockwise round the images on the questionnaire sheet and putting circles around the relevant options, the respondent was then asked to indicate the biophysical conditions of the plot, its previous use and the actual management given to the plot, in terms of input and labor use. Following this, the open-ended question concerning reasons for choosing a specific crop was asked. In the workshops prior to the survey, reasons leading farmers to make specific land use choices had already been identified and grouped into four sets, corresponding to the four main land use types (crops, fallow, pasture and forest). Each of these pre-identified reasons had been written onto individual cards. As the final step in the questionnaire, the respondent was asked to rank the pre-identified reasons – the cards – corresponding to the actual land use type according to their importance for making a specific choice, into three categories: 1: important; 2: less important; and 3: unimportant. If the reason mentioned under the open-ended question was not already included among the cards, it was written down and given the rank "1" (important). Each questionnaire sheet took approximately 20-25 minutes to fill in.

A sample of 198 households (17% of the households in Río Cabuyal), stratified according to well-being and altitude zone, was drawn from the Río Cabuyal watershed population. For each household, a maximum of four plots was included in the sample with one questionnaire sheet for each plot. (The average number of plots owned per household is 3.4. what is the average plot-size? The average plot size is just below 1 ha). For households having more than four plots, the respondent was asked to select four plots, representing different uses as the plots to be included in the sample. Households with plots under uses other than crops, i.e. fallow, pasture and forest, were asked to select one or if possible two plots representing such uses, however, with a maximum of one plot per land use type other than crops. With respect to plots under crops, households were asked to select the plots they considered most important to them, while at the same time representing different crops, to obtain variation within each household.

In total, 532 plots were included in the sample of which 281 plots were under crops, 54 plots under pasture, 117 plots in fallow and 80 plots under forest cover. The sample represents 13% of the land area owned by all households in Río Cabuyal watershed. Table 1 provides a description of the coverage of the sample plots compared with the total number of plots owned by the sample households. Considering only the plots under crop cultivation (281 plots), the crop distribution for the sample resembles that for all crop plots in the Río Cabuyal watershed (2522 plots) with approximately half the plots under coffee. The main difference is that the sample has an overweight of plots on which cassava is grown as a monocrop (20% in sample versus 12% in Río Cabuyal watershed) and of plots under tomato cultivation (7% in sample versus 2% in Río Cabuyal watershed). Since household respondents selected plots under different crops, as well as plots they considered most important, this reflects the importance attached to cassava and tomatoes by farmers as compared to crop combinations such as grains (maize and beans) and cassava grown in association with grains.

The location of the households was geo-referenced using aerial photographs. Figure 1 shows the location of the 198 households included in the survey differentiated by well-being level. Since most plots are situated close to the homestead, Figure 1 gives a rough indication of the location of the plots.

Data analysis

The data was entered into a database and analyzed using the Statistical Package for Social Sciences, SPSS, version 10.0. The data obtained from the questionnaire is primarily categorical (e.g. soil color and texture) and ordinal (e.g. ranges of input quantities used). Hence, in addition to two-way

Table 1: *Description of the sample plots as compared with the total number of plots owned by the sample households, by land use type (crops, fallow, pasture and forest).*

Land use type	Number of plots in sample	Total number of plots owned by sample households	Average number of plots owned by sample households	Sample plots as percentage of total number of plots owned by sample households	Percentage of households with all their plots are included in the sample	Percentage of sample households owning plots
Crops	281	404	2.0	70	61	96
Pasture	54	62	0.3	87	86	29
Fallow	117	134	0.7	87	88	63
Forest	80	83	0.4	96	96	42
All uses	532	683	3.4	78	58	100

contingency tables and the calculation of chi-square statistics based on observed and expected frequency distributions, the data was analyzed using the optimal scaling procedures available in SPSS Categories, developed by the Department of Data Theory at the University of Leiden, The Netherlands (SPSS, 1994). Optimal scaling techniques have been widely used e.g. in ecological studies with the aim to group or order sites (in our case corresponding to the plots), represented by points in a multidimensional graph, according to any number of variables included in the analysis such as soil type, rainfall, presence and abundance of specific species, etc. The ordering is carried out so that points that are close together correspond to sites that are similar with respect to the chosen variables, and points which are far apart correspond to sites that are dissimilar (ter Braak, 1995). The actual grouping or ordination of the sites as points in a multidimensional graph is done using the iterative alternating least square algorithm or. The number of dimensions in the graph must be specified prior to ordination. Usually the relationship between the variables, and thus the ordination, can be represented in a two- or three-dimensional solution. Therefore optimal scaling is often referred to as a 'data-reduction' or 'dimension-reduction' technique, as it summarizes relationships between multiple variables, each containing a number of categories, in a few dimensions. Thus, using the iterative alternating least-square technique, object scores are calculated for each site (or plot) corresponding to the coordinates of the point representing the site in the graph. As these object scores have metric properties, optimal scaling represents a form of quantification of qualitative data and can be used as input variables for other procedures requiring interval data. In this study and as a further reduction of the data, the object scores are used as input variables for a cluster analysis, using the K-means cluster analysis procedure. In addition to the object scores, the optimal scaling techniques also produce category quantifications, which are the averages of the scores for the objects or sites in each category.

Four related optimal scaling functions are available in SPSS Categories. Three of these procedures are used in the present study: i) Homogeneity analysis, also known as multiple correspondence analysis, in which all variables are processed as categorical; ii) non-linear principal component analysis, which allows the examination of any combination of categorical, ordinal and numerical variables; iii) and non-linear canonical correlation analysis, which in addition to allowing any combination of measurement levels, also allows the analysis of relationship between two or more variable-sets and thus reveals relationships among these sets of variables rather than among the variables individually.

Discussion of results

Soil conditions as an explicit determinant for farmers' choice of land use type and crop

As a first attempt towards illustrating the importance of soil conditions relative to other factors influencing farmers' choices of land use, table 2 lists the reasons mentioned by farmers during the questionnaire interviews as influencing their decision to leave a particular plot in forest, fallow, pasture or under a specific crop. Table 2 also shows the ranks assigned to these reasons as a measure of importance.

Judging from table 2, the importance of soil conditions is most notable for the decision to leave a plot in forest. With a combined score of 60, the reason to protect the soil ranked as the third most important reason for leaving a plot in forest, as compared to a score of 69 for the most important reason, to protect the water.

For plots in fallow, reasons related to soil conditions ranked second (restore fertility) and third (time for fallow in cropping cycle). Yet, in the area, fallow is known to be a means to regenerate soil fertility. Therefore, it is surprising that reasons related to regenerating soil fertility did not rank highest among the reasons for leaving a plot fallow. The most important reason for leaving a plot fallow was lack of economic resources for inputs including labor necessary for cultivation.

Reasons related to soil conditions seem to be of least importance for leaving plots under pasture or under a specific crop. The reason the soil doesn't serve for crops ranked fourth among the five reasons offered for leaving a plot under pasture, whereas the reasons ranked as most important related directly to the short-term economic gains of pasture-related enterprises. With respect to crop choice, none of the reasons directly relate crop choice to the soil conditions, and only two reasons, doesn't require a lot of inputs and having a crop that improves the soil, relate indirectly to soil conditions.

The fact that soil conditions are not prominent among the reasons explicitly stated for choosing a specific land use type or specific crop is not, however, in itself sufficient to rule out the importance of soil conditions. Like climate, farmers might very well consider soil conditions as given at the moment of deciding upon land use. Certain land use types or crops may simply be discarded prior to the explicit decision-making process due to the known actual soil con-

Table 2: *Reasons for choosing specific land use type and crop, ranked in terms of importance, by land use type Frequency of ranks and combined, weighted scorea. Soil related reasons are indicated in italics.*

	No. of times ranked as *important* [1]	No. of times ranked as *less important* [2]	No. of times ranked as *unimportant* [3]	Combined, weighted score
Reasons for leaving plots under forest (n=78 plots)				
To protect the water	65	0	13	69
To have firewood and building materials	54	13	11	64
To protect the soil	*41*	*37*	*0*	*60*
To give shade	19	44	15	46
Haven't had time to cut it down	0	7	71	27
The soil doesn't serve for crops	*0*	*4*	*74*	*27*
We are paid to conserve the forest	0	4	74	27
Reasons for leaving plots under fallow (n=110 plots)				
Lack of money for inputs *and* laborers	69	8	33	84
Restore fertility	*50*	*14*	*46*	*72*
Time for fallow in cropping cycle	*32*	*14*	*64*	*60*
Prefer to cultivate other plots	21	31	58	56
Lack of time for planting/laborers	18	23	69	53
Pays better to day-labor	9	18	83	46
Drought/climate	0	16	94	39
Low crop prices	0	8	102	38
Lack of seeds	0	6	104	38
Reasons for keeping plots under pasture (n=54 plots)				
Feed for horses	30	12	12	40
Feed for cattle	31	7	16	40
Livestock pays better	27	7	20	37
The soil doesn't serve for crops	*0*	*11*	*43*	*20*
Haven't had time to plant a crop	0	9	45	20
Reasons for crop choice (n=281 plots)				
Having products for sale	205	31	44	235
Doesn't require a lot of inputs	*169*	*48*	*63*	*214*
Having a crop for home consumption	153	85	42	210
The crop has a secured buyer	148	78	54	205
The crop is easier to sell than other crops	138	75	67	198
Having a crop that is easier to transport	119	102	59	190
Doesn't require so much work	101	79	100	174
The crop doesn't cause health problems	99	118	63	179
Having a crop that pays better	98	62	120	169
Having a short season crop	62	53	165	144
Having a crop that improves the soil	*58*	*69*	*153*	*144*
The crop has no fixed planting season	57	57	166	141
The crop that can be harvested all year	40	29	211	125
The crop has a stable price	18	10	252	107

a. In the ranking, no limit was put on the number of reasons which could be ranked e.g. as 'important'. The combined, weighted score was calculated as [1]/1 + [2]/2 + [3]/3.

Descriptor *characteristic*	Soil condition cluster Best (n=112)	Good (n=82)	Fair (n=236)	Worst (n=102)
Soil color	black (95%)	brown (59%) black (31%)	black (80%)	red (74%) black (20%)
Soil texture	dusty (50%) lumpy (29%)	dusty (82%)	dusty (62%) sandy (21%)	lumpy (52%) dusty (36%)
Location	plain (62%) valley/depression (34%)	ridge (50%) hillside (34%)	hillside (86%)	hillside (86%)
Slope *a:>7%, b: 7-29%, c: 30-69%, d: >69%*	b (54%) a (38%)	b (50%) c (38%)	b (45%) c (44%)	c (59%) b (27%)

***Table 3:** Clusters of soil condition according to color, texture, location and slope (532 plots). Percentages in brackets indicate the proportion of the plots contained in the cluster for which the characteristic applies. Only the most dominant characteristics are included in the table, however so that 75% of the plots contained in each cluster are described according to each descriptor.*

ditions. Supposing this to be the case, we should then be able to detect significant correlation between soil conditions, on the one hand, and choice of land use type or crop, on the other. The remaining part of this section examines the extent to which this is the case.

Soil conditions as implicitly correlated with farmers' choice of land use type

Establishing a soil conditions variable

In the workshops held prior to the questionnaire survey, farmers were found to characterize soil conditions according to descriptors such as soil color (black, reddish, yellow or brown) and soil structure/texture (sandy, clayish, dusty or lumpy) as well as according to the plot's location in the landscape and its slope. Clear preferences were expressed in favor of black or brown, lumpy soils located on flat or gentle slopes. No difference was found with respect to farmers' ability to classify soils, or the ways in which farmers of different well-being level characterize soil conditions. The local descriptors were included as variables in the questionnaire survey (see Figure 2).

In order to combine or reduce the soil-related features into a smaller number of dimensions and thus group the plots according to soil type, the variables soil color, soil texture and location were entered as categorical variables and slope as an ordinal variable into the optimal scaling procedure known as non-linear principal components analysis. A two-dimensional solution was selected and the resulting object scores were subsequently entered into a K-means cluster analysis from which a solution with four clusters, that is related classes of soil conditions, was selected. Table 3 summarizes the characteristics of these clusters ranking from 'best' to 'worst' soil conditions, according to the constituting variables. The cluster representing the 'best' soil conditions is characterized by black, dusty or lumpy soils located on relatively flat plains. The 'good' soils are located on sloping ridges or hillsides and are brown to black, dusty soils, whereas the 'fair' soils are black, dusty or sandy soils located on slightly steeper hillsides. Finally, the 'worst' soils are the predominantly red lumpy to dusty soils located on very steep hillsides. As an indication of the variability in soils conditions in the area, 71% of the households with more than one plot included in the sample submitted plots with different soil conditions or types.

Examining the relationship between land use type and soil conditions

Using this new soil conditions variable, the relationship between soil conditions and farmers' actual choices of land use type can be analyzed. Table 4 presents the results of this analysis. It shows that a slightly higher proportion of forest plots (51%) than plots under other land use types (42-45%) is situated on 'fair' soils, and that a slightly higher proportion of plots under fallow (23%) is found on the 'worst' soils (as compared with 18-19% of the plots under other land use types). Overall, however, no significant association is found between land use type and soil conditions. This indicates that other factors than soil conditions dominate when farmers make decisions about land use for a particular plot.

The importance of soil conditions vis-à-vis other factors in determining farmers' choices of land use types

Thus, to explore which other factors influence farmers' choice of land use and relate the importance of these factors to that of soil conditions, three more variables were included in the analysis. The first of these is distance to the plot from the road, based on the assumption that the closer the plot, the more intensive the use (i.e. cropping). The second variable is total farm-size, based on the assumption that the bigger the farm, the more likely a farmer would be to choose uses other than cropping. The final variable is household well-being level, based on the assumption that farms [it should be 'farmers' shouldn't it?] enjoying higher levels of well-being will more likely choose uses such as pasture which require not only sufficient land but also other resources such as livestock. It should be noted that well-being level and total farm size are closely associated ($p<0.001$), farm area being one of seven variables constituting household well-being.

Before proceeding to explore the relationship, on the one hand, among these 3 factors and, on the other hand, between these factors and land use type, their pair-wise relationship with land use type was examined. Crossing each of these variables with farmers' actual choice of land use, significant correlation emerged between farmers' actual choice of land use and total farm size ($p=0.042$) and well-being level ($p=0.015$), while no significant relationship was found between land use type and distance to the plot ($p=0.146$).

The likelihood of a randomly selected plot being used for crops is significantly greater for small farms, particularly those of one hectare or less. Two-thirds of the plots belonging to farms of one hectare or less are under crops, compared with 56% of the plots belonging to 1-3 hectare farms and 45% of the plots belonging to farms bigger than six hectares. Conversely, the likelihood of a plot being under forest or pasture increases with farm size. One fifth of the plots belonging to farms larger than six hectares are under forest whereas this is the case for only 7% of the smallest farms and 15-16% of the middle sized farms. With respect to pasture, 15% of the plots belonging to the largest farms are under pasture, whereas this is the case for as little as 5% for the smallest farms. No significant association was found between fallow and total farm size.

A similar pattern of association is found between land use type and well-being level. The likelihood of plots being under pasture or forest is significantly greater on farms displaying the highest well-being level, whereas the saturation of cropping is significantly greater for plots belonging to households of middle and particularly the lowest well-being level. Again, no significant association emerges between the use of fallow and well-being level.

Finally, although no overall significant relationship was found between distance to plot and land use, one fifth (21%) of the forest plots are situated more than 20 minutes' walk from home; the same is true for only 10-13% of the plots under other uses.

Although no overall correlation was found between land use type, on the one hand, and soil conditions or distance to the plot, on the other, partial [ital.] association between these variables might still exist. To explore whether such an association exists while considering simultaneously all the potential determinants (total farm size, well-being level, distance to plots and soil conditions), these variables were entered into a non-linear canonical correlation analysis. The potential determinants for farmers' choice of land use type were entered as one set of variables, while the variable representing the observed land use was entered as the second 'set'. By entering all the potential determinant variables as one set, the effects of association between these variables – such as that between well-being level and total farm size – are minimized, while focusing on the correlation with the second set, namely farmers' actual choice of land use type. It should be noted that no significant correlation was found between soil conditions and well-being level ($p=0.28$) or total farm size ($p=0.533$).

Figure 3 shows the category quantifications graph resulting from this analysis. Each point in the figure represents the average object scores obtained by the cases (i.e. plots) contained in a particular category (indicated by the label). The figure is interpreted by looking at the distance between the points representing the average object scores for the plots contained in a particular category. Thus, the closer the points representing two or more categories, the more likely it is that they contain the same objects, and the further the points representing the categories of a particular variable are from the intersection between the two dimensions, the better this variable discriminates the objects.

Looking first at the land use types furthest from the intersection of the axes, Figure 3 indicates that the choice to leave a plot under forest is most strongly associated with the plot's position relative to the road (>20 minutes) and to a lesser extent with farm size (>6 hectares). Plots under pasture are associated with large farms (>6 hectares) of the highest well-being level with 'good' soil conditions. Also

Table 4: *Soil conditions by land use type (N=532) Percent plots per land use type having.*

Soil condition	Crops (n=281)	Pasture (n=54)	Fallow (n=117)	Forest (n=80)	All land use types (N=532)
Best soils	22	19	19	23	21
Good soils	18	20	13	8	15
Fair soils	42	43	45	51	44
Worst soils	18	19	23	19	19
All soil conditions	100	100	100	100	100

Observed significance level of Pearson chi-square: p=0.464 (not significant)

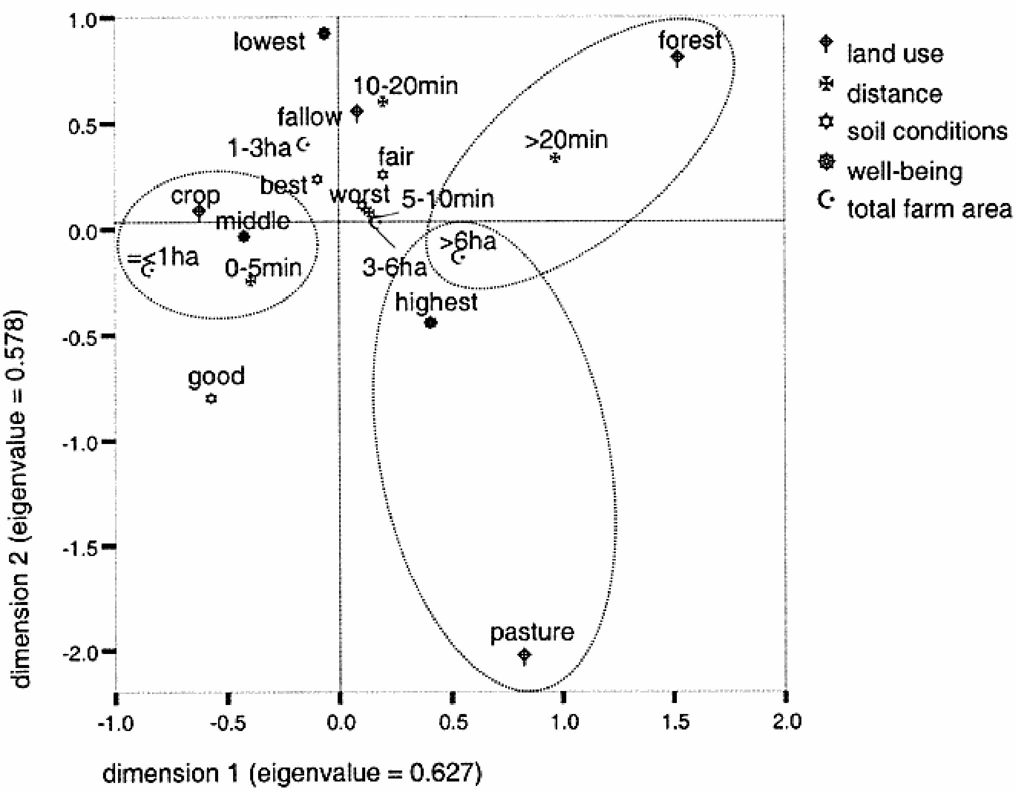

***Figure 3:** Land use type correlated by soil conditions, distance (in minutes) from road, total farm area and household well-being level (N= 532) Category quantifications (centroids) resulting from non-linear canonical correlation analysis.*

the choice to have a plot under crops is associated with 'good' soil conditions, though especially for households with a middle level of well-being; with very small or small farms (=<1 hectare or 1-3 hectares); and with being situated close to the road (0-5 minutes). Finally, plots under fallow appear to be associated with moderate distance from the road (10-20 minutes), with households of the lowest well-being level, and with small farms (1-3 hectares).

Apart from a single data-point representing 'good' soil conditions which appears to be correlated with plots under crops and pasture, all the other points representing specific soil conditions are located very close to the intersection of the axes in the graph. This indicates that soil conditions are not significantly correlated with any specific land use type, supporting the conclusion drawn from table 4. Rather farmers' choice of land use appears to be conditioned by total farm size (pasture, crops and forest), level of well-being (pasture, crops and fallow) and distance to the plot from the road (forest, fallow and crops).

In conclusion, both the reasons explicitly stated by farmers for choosing a specific land use type as well as our efforts to disclose an implicit correlation between land use type and soil conditions, suggest that soil conditions are of only marginal importance in determining farmers' actual choice of land use type. Rather, farmers' choices around land use appear to be determined by their total farm size, their well-being level and distance to the plot. Farmers with small farms have little choice but to plant crops to satisfy household needs, even though soils conditions dictate their plot(s) would be better suited to pasture or forest. Likewise, it makes little sense for poorer farmers to leave a plot under pasture since they often do not own livestock. Finally, farmers tend to choose the more labor intensive land use types, i.e. crops, for their most accessible plots and the least intensive land use types, i.e. forest for the most distant plots. Thus, at the time of actual decision-making , these concerns override soil conditions as determinants of land use.

Soil conditions as an implicit determinant for farmers' crop choices

Examining the relationship between crop choice and soil conditions

We now turn to consider only plots under crop cultivation and hence to examine the importance of soil conditions as an implicit factor influencing farmers' crop choices. Since the plots under crop cultivation show a distribution along the four variables constituting the constructed soil conditions variable similar to that of the total sample, the same classification of soil conditions was used for analyzing crop choice as for the analysis of land use type.

In the workshops held prior to the questionnaire survey, farmers had described the existence of decision-making rules such as 'red soils being good for cassava while bad for coffee', or 'valley bottom soils being good for maize'. Hence, crop choice was described as related, at least partly, to soil conditions. Yet, although grains (maize and beans) appear slightly more likely to be cultivated on 'fair' soils than the other crops, no significant association was found in the analysis of the association between soil conditions and farmers' actual crop choice (table 5). Without questioning the agronomic logic of the soils-related decision-making guidelines stated in the workshops, table 5 indicates that such rules may only be normative in the sense that, in the actual decision-making process with respect to crop choice, the importance of soil conditions is overshadowed by other concerns.

The importance of soil conditions vis-à-vis other factors in determining farmers' choices of crops

As a first step towards identifying which other factors might influence farmers' crop choice, a closer analysis was conducted of the reasons, ranked by importance, motivating crop choice undertaken as part of the questionnaire survey. Referring to Table 2, fourteen reasons potentially motivating a particular crop choice had been ranked as either 'important', 'less important' or 'unimportant'. Hence, to discover possible patterns of association between these reasons and their level of importance, and thus to reduce the data to a number of different 'sets' of concerns motivating individual crop choice, the corresponding fourteen variables were entered into a homogeneity analysis from which the three-dimensional solution was selected. Reasons related to marketing such as having a product for sale, and having a crop with secured buyer discriminate most along the first of these dimensions whereas in the second dimension, the best discriminants are the reasons related to stability, e.g. having a crop with a stable price and having a crop that can be harvested all year round. Finally, the third dimension is associated with reasons related to input requirements, most notably with having a crop that doesn't require a lot of inputs. The variables representing the object scores for the crop plots along these three dimensions were subsequently entered into a cluster analysis and the solution with four clusters, i.e. different sets of concerns motivating crop choice, was selected. The plots contained in these four clusters are described in table 6 with respect to the specific importance of the fourteen reasons as concerns motivating crop choice.

The first cluster comprises plots for which having a short season of sale was the overriding motivation for crop choice whereas no importance was attached to input use or risks of applying pesticides. The second and most common set of concerns, applying to more than half of the plots, relates to having a cash crop with an easy and secure market, combined with low input requirements and a flexible planting season. For the plots contained in the third cluster, having a cash crop with an easy and secure market is also an important concern motivating crop choice. In addition, however, the input requirements of the crop are considered less important whereas price stability and being able to harvest and thus obtain income year-round basis are dominating concerns. Finally, a fourth cluster is composed of plots where no importance is attached to market-related features. Instead, the concerns motivating crop choice relate to cropping for home consumption and to low input requirements. The concerns motivating farmers' crop choice do not appear to be associated with the household's level of well-being since no significant correlation was found between these two variables (p=0.117).

Actual crops choice are significantly associated with the

Table 5: Soil conditions by actual crop (N=249)Percent plots per crop having (N=249) Percent plots per crop having.

Soil conditions clusters	Actual crop grown				
	Coffee (n=138)	Cassava (n=70)	Grains (n=20)	Tomatoes (n=21)	Total (N=249)
'Best' soil conditions	17	20	15	14	18
'Good' soil conditions	17	23	10	29	19
'Fair' soil conditions	45	40	55	43	44
'Worst' soil conditions	21	17	20	14	19
All soil conditions	100	100	100	100	100

Observed significance level of Pearson chi-square = 0.855 (not significant)

Characteristic	'Reason' cluster			
	Short cycle, marketable (n=43)	Secure market, low input and flexible labor requirements (n=163)	Secure market, year round income and environmentally sound (n=36)	Home consumption and low input requirements (n=38)
Having products for sale	♦♦♦ 72%	♦♦♦ 88%	♦♦♦ 69% ♦♦ 22%	♦ 79%
Easier to sell than other crops	♦♦♦ 40% ♦ 33%	♦♦♦ 60% ♦♦ 33%	♦♦♦ 64% ♦♦ 19%	♦ 92%
Pays better than other crops	♦ 67% ♦♦ 21%	♦♦♦ 46% ♦ 31%	♦♦♦ 47% ♦♦ 36%	♦ 92%
Secured buyer	♦♦♦ 47% ♦ 30%	♦♦♦ 60% ♦♦ 36%	♦♦♦ 83%	♦ 87%
Stable prize	♦ 98%	♦ 98%	♦♦♦ 47% ♦ 39%	♦ 97%
Easier to transport	♦♦ 47% ♦ 30%	♦♦♦ 53% ♦♦ 41%	♦♦♦ 58% ♦♦ 31%	♦ 84%
Short season	♦♦♦ 56% ♦ 42%	♦ 70%	♦♦♦ 42% ♦ 31%	♦ 58% ♦♦ 24%
No fixed planting season	♦ 63% ♦♦♦ 23%	♦♦♦ 71%	♦♦♦ 44% ♦♦ 33%	♦ 42% ♦♦♦ 40%
Harvested all year round	♦ 88%	♦ 84%	♦♦♦ 69% ♦ 19%	♦ 76%
Doesn't require a lot of inputs	♦ 86%	♦♦♦ 72%	♦♦♦ 44% ♦ 33%	♦♦♦ 79%
Doesn't require a lot of labor input	♦ 95%	♦♦♦ 42% ♦♦ 31%	♦♦♦ 44% ♦♦ 36%	♦♦♦ 45% ♦ 36%
Doesn't cause health problems	♦ 51% ♦♦ 26%	♦♦ 48% ♦♦♦ 33%	♦♦♦ 56% ♦♦ 25%	♦♦ 53% ♦♦♦ 40%
Helps to improve the soil	♦ 54% ♦♦♦ 33%	♦ 62% ♦♦ 25%	♦♦ 53% ♦♦♦ 28%	♦ 58% ♦♦♦ 32%
Serves for home consumption	♦ 37% ♦♦ 33%	♦♦♦ 53% ♦♦ 39%	♦♦♦ 58% ♦ 25%	♦♦♦ 84%

Table 6: *Description of 'reason' clusters (N=280 plots). The importance of the reason is indicated by diamonds, so that '♦♦♦' indicates 'important'; '♦♦' indicates 'less important' and '♦' indicates 'unimportant'. Percentages indicate the proportion of the plots contained in the cluster for which the level of importance applies. When the most prominent level of importance accounts for at least 70% of the plots contained in the cluster, only the percentage for that level of importance is included in the table. The shaded areas indicate the concerns that best characterize the clusters.*

variable representing different sets of reasons motivating crop choice ($p<0.001$). Thus, the choices to grow coffee and cassava are primarily associated with having a crop for which a secure market exists and which is not too demanding in terms of input and labor use. The choice to grow tomatoes, on the other hand, is associated with the wish to have a short cycle and marketable crop. Finally, the decision to grow basic grains (maize and beans) is associated with having crops for home consumptions with low input requirements and, to a lesser extent, with having a short cycle marketable crop.

In addition to the explicit concerns motivating farmers' crop choice reflected in the reason variable, other factors such as distance of the plot, total farm size and household well-being level can be expected to influence farmers' choice of crop. Pair-wise correlations between each of these variables on the one hand, and actual crop choice (coffee, cassava, grains and tomatoes) on the other, show that only total farm size is significantly associated with farmers' crop choice ($p<0.05$). Tomatoes and cassava appear to be crops associated with moderately large to large farms. More than half of all tomato plots belong to moderately large farms (3-

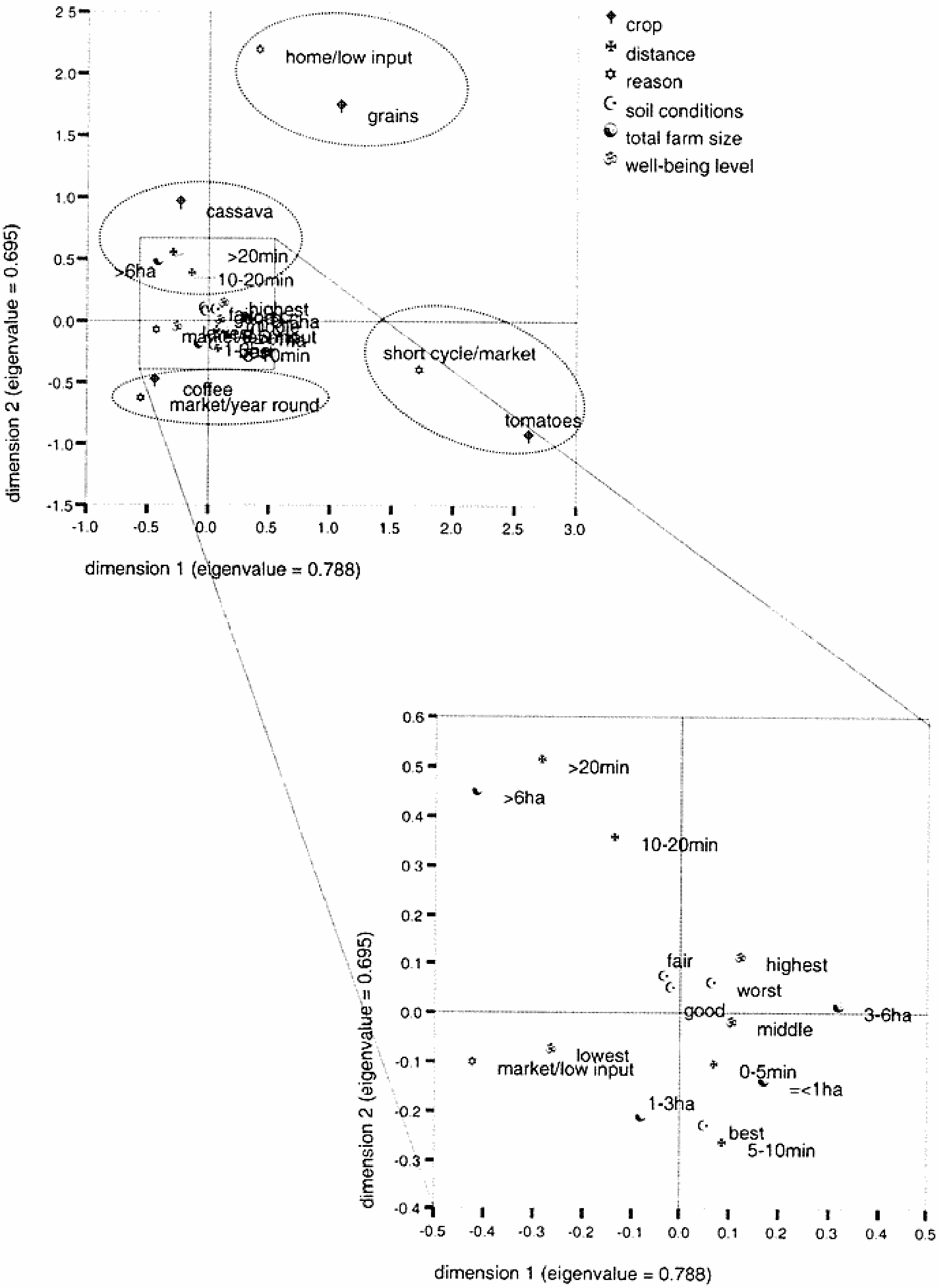

***Figure 4**: Actual crop choice (coffee, cassava, grains or tomato) correlated with soil conditions, reasons for crop choice, well-being level, total farm size, and distance (in minutes) from the road (N=248). Category quantifications (centroids) resulting from non-linear canonical correlation analysis.*

6 hectares); the same is true for only 21-35% of the plots under other crops. 30% of all cassava plots belong to farms bigger than 6 hectares as compared with 5-25% of plots under other crops. Although no overall significant association is found with the other variables, there is a tendency for cassava to be planted on more distant plots (10-20 and >20 minutes' walk from the road). Forty percent of the plots under cassava are situated more than 10 minutes walking from the road as compared to 10-27% of the plots under other crops. Finally, coffee becomes a more likely crop choice as well-being decreases. Half of the plots belonging to the households with the highest level of well-being are under coffee, as compared with two-thirds of the plots belonging to households with the lowest level of well-being.

To analyze simultaneously the patterns of association between farmers' crop choice and all the factors which potentially influence this choice, a non-linear canonical correlation analysis was conducted. As for the analysis relating to farmers' choice of land use type, two sets of variables were defined. The first of these sets consists of all the variables representing factors which potentially might influence farmers' crop choice, i.e. soil conditions, reasons mentioned to motivate crop choice, total farm size, household well-being level and distance of the plot from the road. The second 'set' consists of the variable representing farmers' crop choice (only plots under coffee, cassava, grains or tomatoes are included in the analysis). Figure 4 shows the category quantification graph resulting from the analysis (including an enlargement of the area where the axes intersect).

Figure 4, which should be interpreted in the same way as Figure 3, confirms the close association (described on the basis of the pair-wise analysis above) between crop choice and the sets of reasons motivating crop choice: tomatoes are associated with the wish to have a short cycle, marketable crop; grains with having crops for home consumption with low input requirements; and coffee with the wish to have a marketable crop providing a year-round income. Only plots under cassava appear to be associated with factors others than those reflected in the reason variable – namely with distance of the plot from the road (cassava being grown on the more distant plots) and with total farm size (being more likely on large farms) – as was also revealed in the pair-wise analysis. Even more pronounced than in the analysis of factors influencing choice of land use type, all the points representing different sets of soil conditions are situated close to the intersection of the axes, indicating the lack of association between soil conditions and farmers' crop choice. Despite the existence of significant pair-wise correlation between well-being level and actual crop choice, even the importance of household well-being level appears negligible when other factors, most notably reasons motivating crop choice, are included in the analysis. In conclusion, both the reasons explicitly stated as motivating crop choice and the statistical analysis (pair-wise and non-linear canonical correlation analysis) suggest that concerns with the market opportunities existing for specific crops (short cycle crops or year-round, stable markets) and with the input requirements of the specific crops, and to a lesser extent with farm-size, strongly influence farmers in their choices of crops for a specific plot. Soil conditions as well as household well-being level are of marginal importance.

Conclusions

Soil conditions are normally considered an important factor in shaping farmers' choices of land type (forest, fallow, pasture or type of crop(s)) for a specific plot. Numerous studies reported in literature provide evidence of farmers' ability to distinguish different soil types and how they deliberately determine which land use, crop, and management practice best suit a particular soil type.

Workshops conducted as part of the study reported in this paper showed that also in the Río Cabuyal watershed in the Colombian Andes, farmers distinguish different soil types and know what would be the ideal land use for each soil type. However, our examination of farmers' actual decision making suggests that the importance of soil conditions is only nominal in the sense that at the time of actual decisions on land use or crop type, other concerns outweigh soil conditions.

First, in the questionnaire survey, soil conditions were only explicitly mentioned as having some importance for deciding to keep a plot in forest and to a lesser extent in fallow, while hardly mentioned as important for choosing a specific crop or leaving a plot under pasture. Even in the case of forest and fallow, other reasons related to protecting water sources in the case of forest and lack of economic resources in the case of fallow were ranked as more important.

Second, in the statistical analysis of the questionnaire data, the importance of soil conditions as a determinant both of overall land use type and of specific crop choice was found to be almost negligible. Rather farmers' actual choice of land use type was found to be associated with total farm size and well-being level whereas the actual choice of crop for a given plot was found to be closely associated with con-

cerns related to marketability and the input and labor requirements of a given crop. The importance of market and input-related concerns did not relate to household well-being level. Acknowledging that farmers, due to the importance attached to concerns such as having certain land use types and crops and thereby market opportunities within their portfolios, are conscious of making sub-optimal land use and crop choice from the point of view of soil conditions, it becomes important to explore to what extent farmers take measures to compensate for such sub-optimal choices. This is a topic for further research.

The study reported in this paper is a case study, and as such, it cannot conclusively discard the importance of soil conditions as a determinant in farmers' decision-making process on land use. However, it seriously questions the widespread emphasis on biophysical conditions, and particularly soils conditions, in the study of land use patterns and their determinants. Also it questions the often limited attention paid to socio-economic factors which in this study were found to be significantly more prominent than soil conditions in explaining farmers' actual land use.

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