IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 07, Issue 01 (Jan. 2017), ||V1|| PP 01-11

Evaluation of smallholder farming systems in the Western Highlands of Cameroon

C.M. Tankou[1*], G.R. de Snoo[2], G. Persoon[3]and H.H. de Iongh[2]
[1]*Faculty of Agronomy and Agricultural Sciences, University of Dschang, P.O. Box 222 Dschang, Cameroon.*
[2]*Institute of Environmental Sciences, Leiden University, P.O. Box 9518, 2300 RA Leiden, The Netherlands*

ABSTRACT:- Small scale farming systems in the Western Highlands of Cameroon (WHC) are influenced by many factors. Understanding the determinants that influence the system is essential when targeting appropriate intervention strategies for improvement. A field survey was carried out and analysed to understand the forces that drive the farming systems in this area. The impacts of farming practices on farm sustainability were used as indicators to score sustainability. The results revealed that the household characteristics were very similar across the villages while the sustainability differed depending on the intensity of off-farm inputs in the production systems and other socio-economic factors. Sustainability had significant negative relationships with the intensity of land use, off-farm inputs, and sole cropping practice and a positive relationship with the age of the head of the household. The determinants of the system which explained 62.15% of the total variation of sustainability in the study area were grouped to indicate a number of underlying common factors influencing sustainability. The villages of the WHC had much in common and could benefit equally from the same improved technologies and recommendations.

Key words: *Determinants, Farming systems, Sustainability, Western Highland of Cameroon*.

I. INTRODUCTION

Agriculture is a major earner of foreign exchange for Cameroon (30% of Gross Domestic Product) and provides employment for the bulk of the population. Most of the agricultural production is by small-scale farmers of the rural areas who make up about 90% of the farming population (FAO, 2002). Farming systems in the Western Highlands of Cameroon (WHC) have evolved over time yielding both positive and negative contributions to rural welfare and livelihood. The traditional on-farm input-dependent system characterized by shifting cultivation and intercropping is no longer sustainable because factors such as socio-economic and demographic pressure have shortened the duration of the fallow period (Tchabi *et al*., 2008). Conventional farming approaches characterized by high dependence on off-farm chemical inputs and sole cropping have come with environmental externalities, leaving soils degraded, increased spread of diseases and other pests (Rahman and Thapa, 1999). The sustainability of the farming systems are negatively linked to poor soil fertility management and continuous cropping that exacerbates soil nutrient depletion (Waithaka *et al*., 2006). Based on modern research, the introduction of improved technology and methods of conservation for smallholder farming, without efforts first being made to understand the determinants of the system and farmers' perceptions, are usually not effective (Isaac *et al*., 2009).The evaluation of agricultural production systems is an important step in the diagnosis of the systems which will yield strategies that can be used to improve the system (Russillo and Pintér, 2009). Very few research attempts have so far been carried out to diagnose the factors governing agricultural production in the rural areas of Cameroon and especially in the WHC which is considered to be the food basket of the country. The specific objectives of this study were:

i. to evaluate the relationship existing between agricultural production variables in the WHC
ii. to illustrate possible interpretations of the influence of farming system determinants on sustainability
iii. to identify the main constraints that influence agricultural production in the area

II. MATERIALS AND METHODS

This research was conducted in the western highlands agro-ecological zone of Cameroon which is one of six agro-ecological zones of the country characterised by a tropical climate with a monomodal rainfall pattern. The growing season is between mid march and mid November. The soils are ferralitic with high moisture retention (Fotsing 1994).

Data collection

A survey based on interviews with 144 households was carried out in three villages in the WHC: Bafou, Baleveng and Fongo-Tongo (Fig. 1) in 2009, 2010 and 2011. The variables analysed in this study were: age of head of household (AHH), size of household (SHH), distance of farthest farm plot (DFF), number of irrigable farm plots (FIRR), number of sole cropping species (SCR), number of animal species raised by the household (NAN), number of different farm tools owned by the household (NTO), number of companion crops in intercropping systems (ICR), number of farm plots owned by the household (FOW), distance of the closest farm plot from the homestead (DCF), number of swampy farm plots owned by the household (FSW), average wage paid to hired workers by the farmer (AWA), fallow duration of cropland (FDU) and estimated sustainability score (SUS)

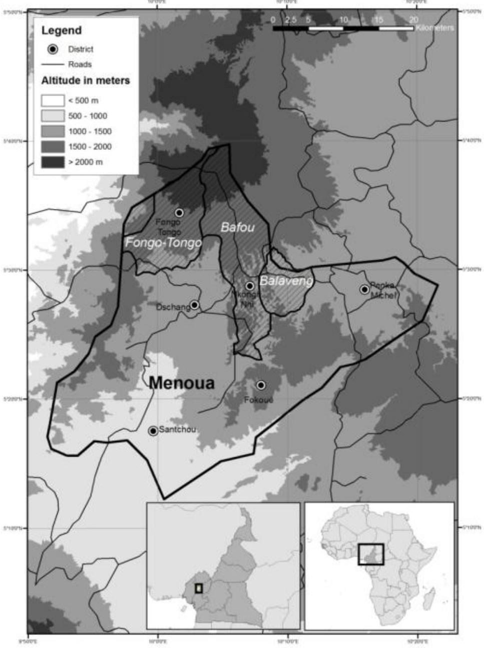

Figure 1: Geographical location of research site.
Localisation géographique du site de la recherche

III. SUSTAINABILITY SCORE

Based on the principles of sustainability and the indicators outlined by Rigby *et al*., (2001), the impact of farming practices on farm sustainability has been used as indicators to score the relative impact of farming practices on farm sustainability in our research area. Information was collected on source of planting material, soil fertility management, pest and disease control, crop management and weed control. The different options within each of the categories are outlined in Table 1.The scoring practice with respect to sustainability is given in Table 2 and it combines information from Table 1 on the different types of practices. Each farming practice was scored in absolute terms ranging from 0 to +3 points based on the criterion. The scoring system is interpreted thus: 0 = no significant impact, 0.5 = marginal impact, 1 = significant impact, 2 = strong significant impact and 3 = very strong significant impact. The five categories of farm practice represent different proportions of the total number of points available. For example if a farmer depends totally on organic sources of fertilizer that accounts for +2.5 points whereas a farmer who depends totally on synthetic fertilizer would earn -8 points for that farm practice (soil fertility).

Table 1: Farm practices used in the research area adapted from Rigby *et al.* (2001).
Les pratiques agricoles utilises dans les lieux de la recherche d'après Rigby *et al* (2001)

Planting material	Fertilizers	Pest/disease control	Crop management	Weed control
Impr = Improved planting material obtained off-farm	Synth = Synthetic fertilizers such as compound NPK, urea, superphosphate	Nat = Use of woodash, fallow	Rotat= rotation	Herb=chemical herbicides
Prev = Planting material	Org = Organic fertilizers such	Synth= Synthetic	Inter= intercropping	C&C= Crop and Compost

obtained from previous harvest	as non-composted straw, FYM, animal dung, plant waste.	pesticides (insecticides, fungicides, nematocides)	to encourage ecological diversity	control (crop rotation, composting manure and crop waste to kill weed seeds)
	Comp = Composted such as organic fertilizers aerobically composted to kill pathogens			C Mgt. = Management of the crop (hand weeding or manual cultivation)

The score for each household was calculated by multiplying the total score attributed to each farm practice in Table 2. Hence the index values ranged between -14.5 and 23.5 depending on each household's pattern of input use in production. A linear transformation was applied to the values calculated so that the index scores ranged between 0 and 1.

Table 2: Scoring practices with respect to sustainability adapted from Rigby *et al.* (2001).
Notation des pratiques par apport a la durabilité d'après Rigby *et al* (20010

Farm practice	Dimension of sustainability				Total
	Minimises off-farm input	Minimises non-renewable inputs	Maximises natural biological processes	Promotes local biodiversity	
Seed sourcing					
Impr					+0
Prev	+1	+1			+2
Soil fertility					
Synth	-1	-1	-1		-3
Org	+1			+1	+2
Comp	+1	+1		+2	+4
Pest/Disease control					
Nat		+0.5	+1	+1	+2.5
Synth	-1	-1	-3	-3	-8
Crop management					
Rotat	+0.5	+0.5	+1		+2
Inter	+1	+1	+1	+1	+4
Weed control					
Herb	-1	-1	-1	-0.5	-3.5
C&C	+1	+1	+1	+1	+4
C. Mgt	+1	+0.5	+1	+0.5	+3

Statistical analysis:

The sustainability parameter was subjected to analysis of variance with the different villages used as the factor and mean separation at 5% probability was carried out using the Student-Newman-Keuls test. For other quantitative variables, means and standard errors were calculated. In the case of analysis of degree and sense of the relationship between qualitative variables, the corresponding contingency tables were constructed and the statistics calculated were used as the basis for the Chi-squared distribution. Simple correlation analyses were performed for the variables collected from the study area. Groups of correlated variables (excluding sustainability score) were defined for the study site by using factor analysis. Factors were extracted with the factor procedure of the SPSS version 13 package using the principal factor analysis and the Varimax rotation method. New variables were created by standardizing and averaging selected variables from each factor for which the eigenvalues of the correlation matrix were one or greater. The basis for selecting measured variables from each factor is in partial correlation coefficients that are often referred to as factor loadings (Johnson and Wichern, 1992). The new variables are called latent variables. To study the relationships between the latent variables and sustainability score, a multiple regression model was determined for the study area. Sustainability score was the dependent variable and the latent variables were the independent variables. The model was of the form $Y = b_0 + b_1L_1 + b_2L_2 + \ldots b_nL_n + \varepsilon$, where Y represents estimated sustainability score, b_0 to b_n are coefficients, L_1, to L_n are the latent variables and ε represents residual error.

IV. RESULTS

Relationship between agricultural production variables and different villages of the WHC

The relationship between the production variables and the different villages are presented in Tables 3. Chi square analysis was used to explain the relationship between qualitative variables and the villages while the analysis of variance and mean separation was used to compare the villages with respect to the sustainability score.

Table 0: Relationship between the villages and production variables.

Relation entre les villages et les variables de production

Variable		**Village**			χ^{2a}
		Bafou	Balevn eng	Fongo-Tongo	
Type of farming (%)	N	47	52	45	3.04 ns
Mainly crop production		51.1	34.6	37.8	
Crop and livestock production		48.9	65.4	62.2	
Labour source (%)	N	43	49	43	10.73*
Family		23.3	55.1	46.5	
Hired		23.3	12.2	20.9	
Both family and hired		53.5	32.7	32.6	
Level of education of head of household (%)	N	44	51	44	5.32 ns
No formal education		4.5	7.8	4.5	
Primary		36.4	49.0	55.3	
Secondary		56.8	43.1	43.2	
Tertiary		2.3	0.0	0.0	
Gender of head of household (%)	N	47	52	45	0.88 ns
Male		80.9	75	82.2	
Female		19.1	25	17.8	
Major means of transportation of head of household (%)	N	45	36	47	10.9*
Pedestrian transportation		26.7	58.7	48.6	
Motorcycle		62.2	39.1	43.2	
Motor vehicle		11.1	2.2	8.1	
Major sources of income by household (%)	N	47	52	42	0.12 ns
Farming		27.7	30.8	28.6	
Farming and off-farm activities		72.	69.2	71.4	

		3			
Sustainability score[+]		0.26a	0.44b	0.31a	

[+]Means followed by the same letter are not significantly different ($p<0.05$)

[a]*indicates significant difference at 5% probability level while ns indicates non-significant difference at 5% probability level for the different Chi square contingency table analysis.

The Pearson's chi-square test indicated that the villages were not independent with regard to the labour source and means of transportation. There was a strong relationship (at 5% level of significance) between the different villages and the labour source used for production and between the villages and the means of transportation to their farms. The households of Baleveng and Fongo-Tongo depended more on family members as labour source while the Bafou households used more hired labourers. In the same light, more Bafou households used motorcycles for transportation compared to the Baleveng and Bafou villages. All the other production variables were independent of the villages (Table 3). The farming types, level of education, gender of heads of households and major sources of income were similar across the study sites (Table 3). With regard to sustainability, the sustainability score was significantly higher ($p<0.05$) in Baleveng village than in Bafou and Fongo-Tongo villages (Table 3).

V. DETERMINANTS USED FOR THE FACTOR ANALYSIS.

The mean values and the variability of the determinants selected for factor analysis are presented in Table 4. Some of the variables collected in the study area were very closely related and had to be eliminated after preliminary analysis.

Table 1: Descriptive statistics for the selected variables used for factor analysis in the study.

Statistiques descriptives des variables sectionnées pour l'analyse factorielle dans l'étude

Variable	**Mean**	**Maximum**	**Minimum**	**Standard deviation**
AHH (years)	51.65	91	23	13.34
SHH	11.19	35	2	6.54
FOW	3.88	1	20	2.81
DFF (km)	4.39	0	35	5.64
FIRR	0.90	0	10	1.44
FSW	0.56	0	6	1.06
SOLE	1.53	0	7	1.75
NAN	1.74	0	4	1.13
NTOO	3.27	1	7	1.16
NINT	3.19	0	10	2.24
SUS	0.34	0.09	0.94	0.18

The correlation coefficient of all pairs of the variables is shown in Table 5.

The highest number of correlations were recorded with the number of farm plots owned by the household (FOW) followed by the sustainability score (SUS) and the number of companion crops used in intercropping (NINT) while the least number of correlations was between the distance of the furthest farm plot from the homestead (DFF) and the other variables. The number of significant correlations in Table 5 suggested that a multivariate approach to data reduction was productive.

Table 2: Simple correlation coefficients for the variables studied in the study area

Coefficients de corrélations pour les variables étudiées dans l'étude

Variable	AHH	SHH	FOW	DFF	FIRR	FSW	SOLE	NAN	NTOO	NINT
AHH										
SHH	0.26**									
FOW	-0.27**	0.21*								
DFF	-0.08	-0.05	-0.01							
FIRR	-0.37**	0.03	0.32**	-0.03						

FSW	-0.01	0.06	0.33**	-0.10	0.36**					
SOLE	-0.27**	-0.04	0.13	0.04	0.35**	0.20*				
NAN	-0.09	0.21*	0.22*	0.13	0.05	0.13	0.02			
NTOO	0.14	0.17	0.10	-1.11	0.09	0.12	0.19*	0.13		
NINT	-0.05	0.20*	0.19*	-0.25**	0.06	-0.04	0.14	0.19*	0.36**	
SUS	0.28**	0.07	-0.27**	-0.07	-0.39**	-0.24**	-0.23**	-0.08	-0.17	-0.22*

*and ** represent significance at 5% and 1% probability levels respectively.

The factor analysis extracted four factors (Table 6) from 10 explanatory variables initially identified (see Table 4) with eigenvalues greater than one. These four factors explained 62.15% of the total variance. The signs of the factor loadings provide information on how these variables relate when representing the common factor. It is observed that the most important variable in the first component is the number of companion crops used in intercropping (NINT) and its influence is positive in the component. The other important variable which exhibits positive influence on the first component is the number of farm tools owned by the household (NTOO). The second component is positively influenced by the number of farm plots in swampy areas owned by the household (FSW), the number of total farm plots owned by the household (FOW) and the number of irrigable farm plots owned by the household (FIRR). The third component is negatively influenced both by the age of the head of the household (AHH) and the size of the household (SHH) and positively influenced by the number of crops produced under sole cropping (SOLE). The fourth factor is positively influence by the distance of the furthest farm plot from the homestead and the number of animal species raised by the household.

Table 3: Results of principal components factor analysis and varimax rotation of the first three factors.
Resultat d'analyse des facteurs des principaux composants et rotation varimax de trios premier facteurs

Variable	Factor 1	Factor 2	Factor 3	Factor 4
AHH	0.09	-0.05	**-0.83**	-0.06
SHH	0.37	0.27	**-0.45**	0.32
FOW	0.18	**0.59**	0.21	0.35
DFF	-0.39	-0.20	0.20	**0.70**
FIRR	0.06	**0.61**	0.50	0.01
FSW	-0.06	**0.86**	-0.04	-0.08
SOLE	0.26	0.22	**0.60**	-0.05
NAN	0.25	0.18	-0.17	**0.71**
NTOO	**0.71**	0.10	-0.03	0.00
NINT	**0.84**	-0.08	0.14	0.05
Eigen value	1.68	1.67	1.64	1.23
% variance	16.79	16.67	16.42	12.67
% Cum. Var.	16.79	33.46	49.88	62.15

Relative importance of the factors influencing the sustainability of the farming system

Table 7 shows coefficients and statistics of models relating sustainability scores with the latent variables for the study area.All the latent variables had negative coefficients indicating that they are all negatively related to the sustainability score.

Table 4: Coefficients and statistics of multiple regression models relating sustainability with the latent variables identified for the three villages.

Coefficients et statistiques du model de la régression multiple entre la durabilité et lesvariables latents identifies pour les trios villages

Intercept	Factor 1	Factor 2	Factor 3	Factor 4	R^2	P>F

0.32 (0.02)[a]	-0.03 (0.02)	-0.04 (0.02)	-0.06 (0.02)	-0.02 (0.02)	0.23	0.001

[a]Numbers in parenthesis are standard errors of the estimates.

Main constraints influencing agricultural production in the study area
The constraints faced by the farmers are summarized on Table 8. Except for their views on road infrastructure, all the other constraints were similar for farmers in all the villages.

Table 5: Percentage of farmers' priority of agronomic production constraints
Pourcentage de priorité paysan par rapport aux contraints de production agronomique

Constraint	Bafou	Baleveng	Fongo-Tongo	χ^2
Poor yield	71.1	75.5	77.8	Ns
Poor road infrastructure	55.6	36.7	68.9	**
Problems with crop pests	60.0	64.6	64.4	Ns
High cost of inputs	82.2	79.6	73.3	Ns
Low price of outputs	62.2	38.8	57.8	Ns

** Significant at $p < 0.01$, ns not significant

VI. DISCUSSIONS

More wage labourers were needed in the high input vegetable production system common in the area which explained the importance of this practice in the three villages studied. Baleveng was least dependent on off-farm chemical inputs and hence the lower number of wage labourers employed. This could be due to the fact that high altitudes favourable for cool-season crops that are highly dependent on chemical inputs are not available in Baleveng. As a result farmers in Baleveng were not greatly involved in cool-season vegetable crops. Labour type and requirement in the study area depended on household size; number of farms owned and the size of adult household members. Labour is the primary instrument for increasing production within the framework of traditional agriculture. Amaza *et al.* (2009) found that fertilizer and hired labour were the major factors associated with changes in the output of food crops in the Borno state, Nigeria. In their study they found that chemical fertilizer and hired labour had significant positive contributions on output. This is similar to the results of this study as the use of off-farm inputs and hired labour explain the differences among the villages studied in the same manner.The fact that the head of many households had at least completed high school education was an encouraging sign as it implied they were forward-looking and opened to the idea of change. Many studies have revealed that the level of education is a factor in helping farmers to use production information efficiently (Hayami 1969; Phillips, 1994; Wang *et al*., 1996; Yang, 1997). Education is also influential when it comes to making use of opportunities available to improve livelihood strategies, enhance food security, and reduce the level of poverty. It affects the level of exposure to new ideas and managerial capacity in production as well as the perception of the household members on how to adopt and integrate innovations into the household's survival strategies. Female headship is often believed to increase the likelihood of the household being poor but World Bank data indicated that while this may be true in Asia and Latin America it is less obvious in Africa (Chant, 2003). In the WHC, many women competed well with men in nearly all activities. However the rural-urban division of labour required women to undertake all the agricultural tasks, thus curtailing the extent to which they could participate in the labour market. This same tendency was also noted by Gwaunza (1998).

The Bafou farmers had an edge over the other villages in their possession of a greater number of motorbikes which facilitated their farming operations. Roads and transportation facilities are essential for the sustainability of agricultural production in Sub-Saharan Africa as it positively impacts factors such as mobility (John and Carapetis, 1991), the adoption of high yielding varieties, high productivity crops and bigger farm size (Sieber, 1999). The greater involvement and higher success in agriculture of the Bafou farmers could thus be attributed to the better transportation facilities they possessed.

The low percentage of farmers whose main occupation is agricultural was due to the pluriactivity of households in the WHC. The dependence of farm families on off-farm activities as an income source is absolutely necessary, owing to the uncertainties commonly dictated by weather, market prices and attacks by pests. In sub-Saharan Africa, it is common for some farm household members to engage in other non-farming occupations to complement their earnings from farming. A study by Herbert (1996) in Burundi revealed the need of income diversification through extra-agricultural activities to complement farming.

On the whole the sustainability scores of all the sites in our study were below average due to their reliance on off-farm non-renewable inputs and the reduction of the genetic base through sole cropping. Hodge (1993) noted that this results to environmental pollution, habitat destruction and risks to human health and welfare. Amongst the three villages studied, a significantly higher sustainability score was recorded by the Baleveng village owing to the absence of high altitude areas favourable for intensive off-farm dependent crop production system common in the Bafou and Fongo-Tongo villages. As such, farmers in Baleveng village relied less on off-farm inputs because a majority of the farmers practiced intercropping where annidation or complementarity provided appropriate growing conditions for the crops (Trenbath, 1976). Intercropping has been an agricultural practice for thousands of years (Kass, 1978), which testifies to its level of sustainability. Ofori and Stern (1987) suggested that intercropping was more efficient than mono-cropping in the exploitation of limited resources. Food challenges will be met using environmentally friendly and socially equitable technologies and methods, in a world with a shrinking arable land base (which is also being diverted to produce biofuels), with less and more expensive petroleum, increasingly limited supplies of water and nitrogen, and within a scenario of a rapidly changing climate, social unrest, and economic uncertainty (IAASTD, 2009). The only agricultural system that will be able to confront future challenges is one that will exhibit high levels of diversity, productivity, and efficiency.There were various degrees of correlation among the determinants associated with the farming systems of the WHC. The sustainability score in the whole research area was negatively related to the number of farms owned by households (FOW), the number of irrigable plots owned by households (FIRR), the number of farm plots in swampy areas (FSW), the number of crops used in sole cropping (SOLE), the number of companion crops used in intercropping (NINT) and positively related to the age of the head of household (AHH). This indicated that the older heads of households carried out more sustainable farm practices with respect to seed source, soil fertility, crop management, pest and disease control and weed control. Household characteristics are thus important determinants of the farming system. However, Rougoor *et al*. (1998) found that the influence of the age of the head of the household on farm productivity was very diverse. Other studies found that age had a positive effect on productivity (Kalirajan and Shand, 1986; Stefanou and Sexena, 1988) while Adubi (1992) revealed that age, in correlation with farming experience, had a significant influence on the decision making process of farmers with respect to risk aversion, adoption of improved agricultural technologies, and other production-related decisions. Age has been found to determine how active and productive the head of the household would be. It has also been found to affect the rate at which households adopted innovations, which in turn, affects household productivity and livelihood improvement strategies (Dercon and Krishnan, 1996). All the determinants that had negative relations with the sustainability score are linked directly or indirectly to either dependence on off-farm agrochemical inputs or soil mining. Increasing numbers of companion crops (NINT) leads to less sustainability because of the intensity of land use over space by the high density of species with varied requirements as noted by Fasching (2001).

After factoring the correlation matrix by the principal component method, the first four factors explained 62.15 % variation. The first latent variable had high loadings with the number of farm tools used by the household (NTOO, 0.71) and the number of companion crops used in intercropping (NINT, 0.84). This means that both NTOO and NINT lie near the first axis. The first axis was termed *land use intensity over space* because it is most correlated with components that have to do with land use in space. The second axis was most correlated with practices that require high off-farm inputs for intensive production (FOW, FIRR, FSW); overall this axis appears to measure *the intensity of off-farm inputs*. The third axis (*household adjustment factor*) was most correlated with components that influence the household (AHH, SHH) lying near the third axis, and the number of sole crops used by the household (SOLE) lying on the opposite end of the third axis. The fourth axis was most correlated with components that have to do with the movement of the household(DFF) and the number of animals produced by the household (NAN); overall this factor appears to measure the *mobility of the household* owing to the fact that animal production is not very intensive in the area.

All the latent variables had negative correlations with the sustainability score. The negative sign for the land use intensity characterised by "plant biodiversity" (NINT) seems agronomically unreasonable as it should not decrease sustainability since it implements many different functions such as biomass decomposition, nutrient cycling, soil structure enhancement, pest regulation, pollination, detoxification, local hydrological process regulation and macroclimate control (Altieri, 2000). Having less diversity than needed can eventually lead to production and profitability problems. Adding more diversity than needed can reduce efficiency since it increases the number of crops that must be managed, handled, and marketed (Fasching, 2001). This explains why increasing the number of companion crops in intercropping will decrease sustainability. Though intercropping is envisaged as a contributor to sustainability, human efforts are required to make this happen. The suggested advantages of the intercropping system include yield stability under adverse environmental conditions, efficient use of limited growth resources, biological diversity, and potential control of pests and diseases. Many studies have shown that intercropping systems out yielded sole cropping systems of component crops (Baumann *et al*., 2001; Lesoing and Francis, 1999; Ghaffarzadeh *et al*., 1997; Fortin*et al*., 1994; Mandal *et al*., 1990).

The negative relationship between the intensity of off-farm inputs and sustainability should be obvious. Intensification and concomitant increase use of inputs in agricultural production has led to environmental pollution and low quality products (Rahman and Thapa, 1999). In order to combat this, efforts are now required to minimise off-farm inputs in order to guarantee the sustainability of farming systems. Sustainable agriculture is often viewed as low input and regenerative (Reijntjes *et al*., 1992), making better use of the farm's internal resources through the incorporation of natural processes into agricultural production and the greater use of knowledge and skills of farmers to improve their self-reliance and capacities.

The household adjustment factor had a negative relationship with sustainability. This latent variable was characterised by a negative sign for both the age of members of the household and size of the household. Taking this into account, it would mean that these components of the household adjustment factor have positive relationships with the sustainability score given that the product of two negatives is positive. The findings of this study thus suggest that sustainable farming practices in the research area are executed more by more populated households and households headed by older people. Many studies have shown the positive correlation between age and environmentally friendly agricultural practices. In Mexico, age was found to play a significant role in determining how much diversity farmers maintain. Almost 50% of the farmers growing significant numbers of traditional cultivars were over 56 years. Wakeyo and Gardebroek (2013) postulated that in developing countries, households allocate financial resources to buying inputs after putting aside a minimum amount for household food, especially when there is a credit constraint. As such, some households exhaustively consume their harvest and are later constrained to buy inputs such as fertilizer. This attitude is positively related to the size of the household which explains the dependence on natural resources for farming by more populated household and hence the positive relationship between sustainability and the size of the household shown by the results of this study.With respect to the mobility component, the results of this study suggest that farmers whose farm plots were very far from their homestead carry out less sustainable practices. This can be justified by the fact that suitable farming areas for the important cash crops of the area were located at high altitudes, generally far from the homestead. The method of production of these cash crops require intensive use of agrochemical and improved seeds all of which are negative contributors to sustainability based on our assumptions. Generally crop diversity decreases with the distance of the farm plots from the homestead. In Ethiopia, Deribe (2000) showed that sorghum diversity was related to distance from the homestead: the nearer the plot to the homestead, the larger the number of varieties grown.

With regard to farmers' priorities, households in the Baleveng village did not consider the road infrastructure as a problem simply because the tarmac road connecting the division and the region cuts across the centre of the village. This made it fairly easy for inhabitants to move compared to other villages where the transportation of people and goods was sometimes impracticable especially in the rainy season. The problems related to poor yields and crop pests could be linked to a lack of information on improved technology. If agricultural productivity is to grow in Africa, research and extension services need to develop and disseminate science-based information about improved technologies that address the resource constraints and risks faced by the majority of Africa's farmers (Snapp *et al.*, 2003). Agricultural advisers are few and far between in the WHC which explains many of the farmer's problems. There is a need to upgrade the researcher-agricultural adviser-farmer network in the WHC. Limited adoption of recommended technologies must be expected if there is a poor connection between research, technical advisers and African smallholders (Meertens, 2003). Cameroon and many other countries have removed subsidies on fertilizers since the collapse of the coffee and cocoa markets making their affordability extremely difficult for small scale farmers. Integration of crops and livestock can lead to more efficient use of natural resources.

The significance of household size in farming hinges on the fact that the availability of labour for farm production, the total area cultivated for different crop enterprises, the amount of farm produce retained for domestic consumption and the marketable surplus, are all determined by the size of the farm household (Amaza *et al*., 2009). Increasing dependence on hired labour in our study site was due to the decreasing size of households influenced by rural-to-urban migration.

VII. CONCLUSION

With respect to the different variables that determine agricultural production, the results of this study show that the different villages studied had much in common and could benefit equally from the same improved technologies and recommendations. Sustainable agricultural intensification in the WHC would involve scaling up farming practices that maintain the resource base on which smallholders depend, so that it continues to support food security and rural development into the future. This could be done by addressing land use intensity, off-farm inputs intensity, household adjustment factors and the mobility of the household.

VIII. ACKNOWLEDGEMENTS

This research was made possible by funding from Volkswagen foundation.

REFERENCES

[1] FAO, Food and Agricultural Organization, Rome.FAOSTAT data base, 2002.Tchabi A., Coyne D.,

Hountondji F., Lawouin L., Wiemken A. and F. Oehl, Arbuscular
[2] mycorrhizal fungal communities in sub-Saharan Savannas of Benin, West Africa, as affected by agricultural land use intensity and ecological zone, *Mycorrhiza, 18*, 2008, 181-195.
[3] Rahman S. and G. B. Thapa, Environmental impacts of technological change in Bangladesh agriculture: farmers' perceptions and empirical evidence, *Outlook on*
[4] *Agriculture, 28(4),* 1999, 233–238.
[5] Waithaka M. M., Thornton P. K., Herrero M. and K. D. Shepherd, Bio-economicevaluation of farmers' perceptions of viable farms in western Kenya, *Agricultural*
[6] *Systems, 90,* 2006, 243-271
[7] Isaac M. E., Dawoe, E.and K. Sieciechowicz, Assesing local knowledge use in agroforestry management with cognitive maps, *Environmental Management, 43*, 2009, 1321-
[8] 1329.
[9] Russillo A.and L. Pintér, Linking Farm-Level Measurement Systems to Environmental Sustainability Outcomes: Challenges and Ways Forward, *International Institute for*
[10] *Sustainable Development (IISD)*, 2009.
[11] Fotsing J. M., L'évolution du bocage bamiléké : exemple d'adaptation traditionnelle à une forte démographie, in : introduction à la gestion conservatoire de l'eau, de la biomasse et
[12] de la fertilité des sols (GCES), *Bull. Pédologique de la FAO, 70,* 1994, 292-307
[13] Rigby, D., Woodhouse P., Burton M.and T. Young, Constructing a Farm-Level Indicatorof Agricultural Sustainability, *Ecological Economics 39,* 2001, 463-478
[14] Johnson R. A. and D.W. Wichern, *Applied multivariate analysis, 3rd edition*(Prentice Hall Inc.: Englewood Cliffs, NJ, 1992).
[15] Amaza P. S., Abdoulaye T., Kwaghe P.and A. Tegbaru, Changes in household food securityand poverty status in PROSAB areas of southern Borno State, Nigeria. Promoting
[16] Sustainable Agriculture in Borno State (PROSAB), *International Institute of TropicalAgriculture, Ibadan, Nigeria*, 2009.
[17] Hayami Y., Sources of agricultural productivity gap among selected countries, *American Journal of Agricultural Economics 51(2),* 1969, 564-575.
[18] Phillips J. M., Farmer education and farmer efficiency: a meta-analysis, *Economic Development and Cultural Change, 43,* 1994, 1439-1465.
[19] Wang J., Wailes E. J., and G. L. Cramer, A shadow-price frontier measurement of profit efficiency in Chinese agriculture, *American Journal of Agricultural Economics 78,* 1996, 146-
[20] 156.
[21] Yang D. T., Education in production: measuring labor quality and management. *AmericanJournal of Agricultural Economics 79(3),* 1997, 764-772.
[22] Chant S., *`New Contributions to the Analysis of Poverty: Methodological and Conceptual Challenges to Understanding Poverty from a Gender Perspective'* (CEPAL, U.N. Women's
[23] Development Unit, Santiago:Chile, 2003).
[24] Gwaunza E., *`The impact of labour migration on family organisation in Zimbabwe'*, (inSachikonye, Lloyd eds. Labour Markets and Migration Policy in Southern Africa,Harare: Sapes, 1998)
[25] John D. N. R.and S. Carapetis, Intermediate Means of Transport in Sub-Saharan Africa: ItsPotential for Improving Rural Travel and Transport,*World Bank Technical Paper No. 161*,
[26] *Africa Technical Department Series.World Bank,* Washington, D.C., USA, 1991..Sieber N., Transporting the yield. Appropriate transport for agricultural production and
[27] marketing in Sub-Saharan Africa, *Transport Reviews 19 (3),* 1999, 205-220.Herbert J. P., A study of the diversification of farm activities resulting from demographic and land pressure; a case study of Burundi, *Tropiculture 14 (1),* 1996, 17-23.
[28] Hodge I., Sustainability: Putting Principles into Practice. An Application to Agricultural Systems. *Paper presented to 'Rural Economy and Society Study Group*, Royal Holloway
[29] College, December 1993.Trenbath B.R, Plant interactions in mixed crop communities. In: Papendick, R.I.; Sanchez,
[30] P.A.;Triplett, G. B. (eds.). Multiple cropping. Madison: *American Society of Agronomy,* 1976, 129-169.
[31] Kass D. C. L., Poly culture cropping systems: review and analysi, *Cornelllnt. Agric. Bull.*
[32] *No. 32.Ithaca*, NY: Cornell Univ, 1978. 69 pp.Ofori C. F. and W. R. Stern, Cereallegume intercropping systems, *Adv. Agron. 26,* 1987,177-204.
[33] Oreszczyn, S., Lane, A.and Carr, S. 2010. The role of networks of practice and webs ofinfluencers on farmers' engagement with and learning about agricultural innovations. J.
[34] Rural Studies 26: 404-417.IAASTD, *Agriculture at a Crossroads*, (In: International Assessment of Agricultural

[35] Knowledge, Science and Technology for Development Global Report, Island Press, Washington, D.C., 2009).

[36] Rougoor C. W., Ruud G. T., Huirne B. M. and J. A. Renkema, How to define and study farmers' management capacity: theory and use in agricultural economics, *Agricultural*

[37] *Economics, 18,* 1998, 261-272.

[38] Kalirajan K. and R. T. Shand, Estimating Location-Specific and Firm-Specific TechnicalEfficiency: An Analysis of Malaysian Agriculture, *Journal of Economic Development 11,* 1986,

[39] 147-160.

[40] Stefanou S. E. and S. Sexena, Education, experience and allocative efficiency: a dual approach. *American Journal of Agricultural Economics, 70,* 1988, 338-345.

[41] Adubi A. A., *An empirical analysis of production risks and attitudes of small farmers inOyo State, Nigeria*, PhD thesis, University of Ibadan, Nigeria, 1992.

[42] Dercon S. and P. Krishnan, Income portfolios in rural Ethiopia and Tanzania: choices and Constraints, *Journal of Development Studies 32 (6),* 1996, 850-875.

[43] Fasching R. A., Crop rotation intensity rating and diversity index.United States Departmentof Agriculture Natural Resources Conservation Service. *Crop Production Agronomy Technical Note. No. 150.14*, 2001.

[44] Altieri M. A., Agroecology: the science of natural resource management for poor farmers in marginal environments, *Agriculture, Ecosystems and Environment 93,* 2000, 1-24

[45] Baumann D. T., Bastiaans L.and M. J. Kropff, Competition and crop performance in a leek-celery intercropping system, *Crop Sci. 41*, 2001, 764-774.

[46] Lesoing G. W. C. A. and Francis, Strip intercropping effects on yield and yield components of corn, grain sorghum, and soybean, *Agron. J. 91*, 1999, 807-813.

[47] Ghaffarzadeh M., Garcia Prechac F. and R. M. Cruse, Tillage effect on soil water content and corn yield in a strip intercropping system, *Agron. J. 89*, 1997, 893-899.

[48] Fortin M. C., Culley J.and M. Edward.. Soil water, plant growth, and yield of strip intercropped corn, *J. Prod.Agric. 7,* 1994, 63-69.

[49] Mandal B. K., Dhara M. C., Mandal B. B., Das, S. K. and R. Nandy, Rice, mungbean, soybean, peanut, ricebean, and blackgram yields under different intercropping systems.

[50] *Agron. J. 82,* 1990, 1063-1066.Reijntjes C., Bertus H. and A. Water-Bayer, *Farming the future: An introduction to low*

[51] *external inputs and sustainable agriculture*, (London: Macmillan, 1992).Wakeyo M. B. and C. Gardebroek, Does water harvesting induce fertilizer use among

[52] smallholders? Evidence from Ethiopia, *Agricultural systems 114*, 2013, 54-63Deribe S., *A study on the agrobiodiversity with special emphasis on the relationship*

[53] *between distance from homestead and crop diversity on-farm in Fontanina South Welo*, MSc Thesis University of Addis Ababa, 2000.

[54] Snapp S. S., Blackie M. J. and C. Donovan, Realigning research and extension to focus on farmers' constraints and opportunities, *Food Policy 28,* 2003, 349-363

[55] Meertens H. C. C., The prospects for integrated nutrient management for sustainable rainfed lowland rice production in Sukumaland, Tanzania, *Nutrient Cycling Agroecosystems 65(2),* 2003, 163-171.