Working Paper

Agricultural livelihood systems (ALS) typology of Grain Legume and Dry Cereal- based smallholder farming systems in Western Burkina Faso

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Agricultural Livelihood Systems (ALS) typology of grain legumes and dry cereals – based smallholder farming systems in Western Burkina Faso

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Abstract

Efficiently improving sub-Saharan smallholder farms' livelihood requires targeted policy intervention accounting for their livelihood heterogeneity. The main objective of the present study was to empirically identifying agricultural livelihood systems in the sub-district of Satiri in western Burkina Faso with the aim of designing decision support tools for assessing productivities, resources use efficiency, and sustainability of GLDC-based smallholder systems in BURKINA FASO The methodological approached consisted in multivariate analyses combining PCA and K-CA. A total number of 445 farm-households were randomly sampled in five village of the sub-district and face-to-face interviews were conducted to collect multi-dimensional data. The analysis results showed that the main variables discriminating agricultural livelihoods in the study zone were found to be human (education and dependency), natural (land holdings and livestock), financial (annual gross income), physical (access to road and important market) social (Share of remittance income) assets, and production orientation (cotton and marketable food crops production). Three agricultural livelihood types were identified: *Better-off, land rich, cotton-oriented and better road access; Middle-Income, diversified activities, and better road access; and Poor, landless and subsistence based, and low road access*.

Keywords: Agricultural livelihood system typology, Smallholder farms, Sustainable livelihoods, semi-arid areas, grain legumes and dry cereals, Burkina Faso

1. Introduction

Smallholders in Sub-Saharan African semi-arid regions are facing important issues needing the support of farming systems research to propose innovative pathways and solutions. These issues range mainly from land degradation to food insecurity and poverty. The interrelated food insecurity and land degradation can be argued to be the most important threat to agricultural livelihood as it contributes to maintaining a poverty trap(Thiombiano and Le 2015). Indeed, the number of undernourished people continues to increase since 1990-92 (FAO 2015). Studies support the existence of widespread soil nutrient depletion (Cobo, Dercon et al. 2010). In Burkina Faso in particular, successive studies have shown a worsening

of soil nutrient depletion (Thiombiano 2015). In most cases poverty constraints the investment in soil fertility, and wealthy farms which draw most of their income from soil nutrient mining (Van der Pol 1992)are running into poverty trap in the near future if the nutrient mining process is not reversed (Thiombiano and Le 2015) to improve farms' livelihoods. Crop and animal production systems are still very extensive as inputs use (soil nutrient resources, animal feed and equipment) remain weak (Coulibaly 2012).

The farming system in Burkina Faso is generally mixed crop-animals system with a clear domination of crops. Millet and sorghum are the most cultivated cereals in Burkina Faso either in sole or in association with legumes. However, the yield remains low for these three crops like for all other crop in the country (MAAH 2017). The low yield of these food crops are caused mainly by rainfall variability, low soil fertility, but also the poor farm management by producers. Improving food crops production for food and nutrition security requires addressing main issues undermining the production: soil fertility loss, rainfall variability, crop and animal diseases, and inefficiency of agricultural policies.

Affordable practices such as legumes-cereals association may help significantly improving soil fertility in a poverty context constraining the use of mineral fertilizer by farmers. Beside fertility effects, legumes are dual crops used for feed human as well as forage. Synergies and positives feed-backs may contribute to improve smallholder farmers' livelihoods.

To analyse the conditions of successfully promoting legume-cereal association and support decision making, the heterogeneity of smallholder farming livelihoods systems which affects technologies and practices use, need first to be addressed. The main objective of this paper is therefore to analyse agricultural livelihood heterogeneity in the sub district of Satiri. The specific objectives are to (i) identify main factors discriminating agricultural livelihoods at village level and (ii) identify and characterize agricultural livelihood systems in the sub-district.

2. Methods and materials

Conceptual framework

Households-farms are characterized by their settings comprising biophysical resources (e.g. land, water and trees), economic resources (e.g. financial and infrastructures) and socio-demographic resources (e.g. labour, capabilities and networks). These settings vary from

household-farm to household-farm defining thereby the heterogeneity of a given population in a given region or location. Therefore, this heterogeneity needs to be captured for successfully designing efficient and profitable, adaptive or resilient farming systems as well as effective policy interventions. The Sustainable Livelihood Framework (Chambers and Conway 1991; Sconnes 1998) offers the possibility to holistically apprehending the household-farm as it considers all the settings of the household-farm. These settings are grouped into five types of capital: human capital (demography, education of household members and their profession), natural capital (e.g. land holdings and tenure, planted trees), physical capital (e.g. agricultural equipment, transportation means, farming and household tools), financial capital (livestock, off-farm employment remittance) and social capital (e.g. networks and membership to organization/association). The level of endowment in these capitals will define different livelihood strategies of household-farms. Our study therefore used the Sustainable Livelihood Framework as a guide for collecting a multidimensional dataset used for identifying the agricultural livelihood types in the sub-district of Satiri.

Study site

The study was conducted in the sub district of Satiri, in the Houet province, Western Burkina Faso. The sub-district belongs to the South-Sudanian climatic zone with an average annual rainfall of 900-965 mm. The vegetation cover is savannah. The farming system is the Satiri department is characterized by mixed crop-livestock farming. The average annual rainfall is estimated to be 920 mm. Five villages were purposively selected based on the criteria of legume production in pure cultivation cropping system and associated to cereals crops cropping system. From literature review and information provided by agricultural extension services, the villages of Sissa, Neferelaye, Ramatoulaye and Kadomba were selected (Fig.1). These village are all located on a transect East-West with a distance gradient to the main road and Satiri, the main town of the subdistrict. Kadomba is located 15 km away Satiri, Ramatoulye 20 km, Néférélaye and Sissa from 25 and 31 km, respectively.

The main cash crops are cotton and sesame for all three villages. Livestock production comprises mainly cattle goat and sheep. Poultry is raised by almost all farmers. Due to the existence of a small dam, irrigated crops are produced in Kadomba, mainly tomatoes, onion and a bit of maize. Farmers face the general issue of land degradation with soil and water

conservation measures (stone bunds, compost) being inconsistently practiced. Natural tree regeneration is often encountered. The legislation on tree conservation in Kadomba is particularly strong with the monitoring system put in place the Ministry of environment to preserve the neighboring protected forest. Farmers are therefore encouraged to leave as much trees as possible in their fields.

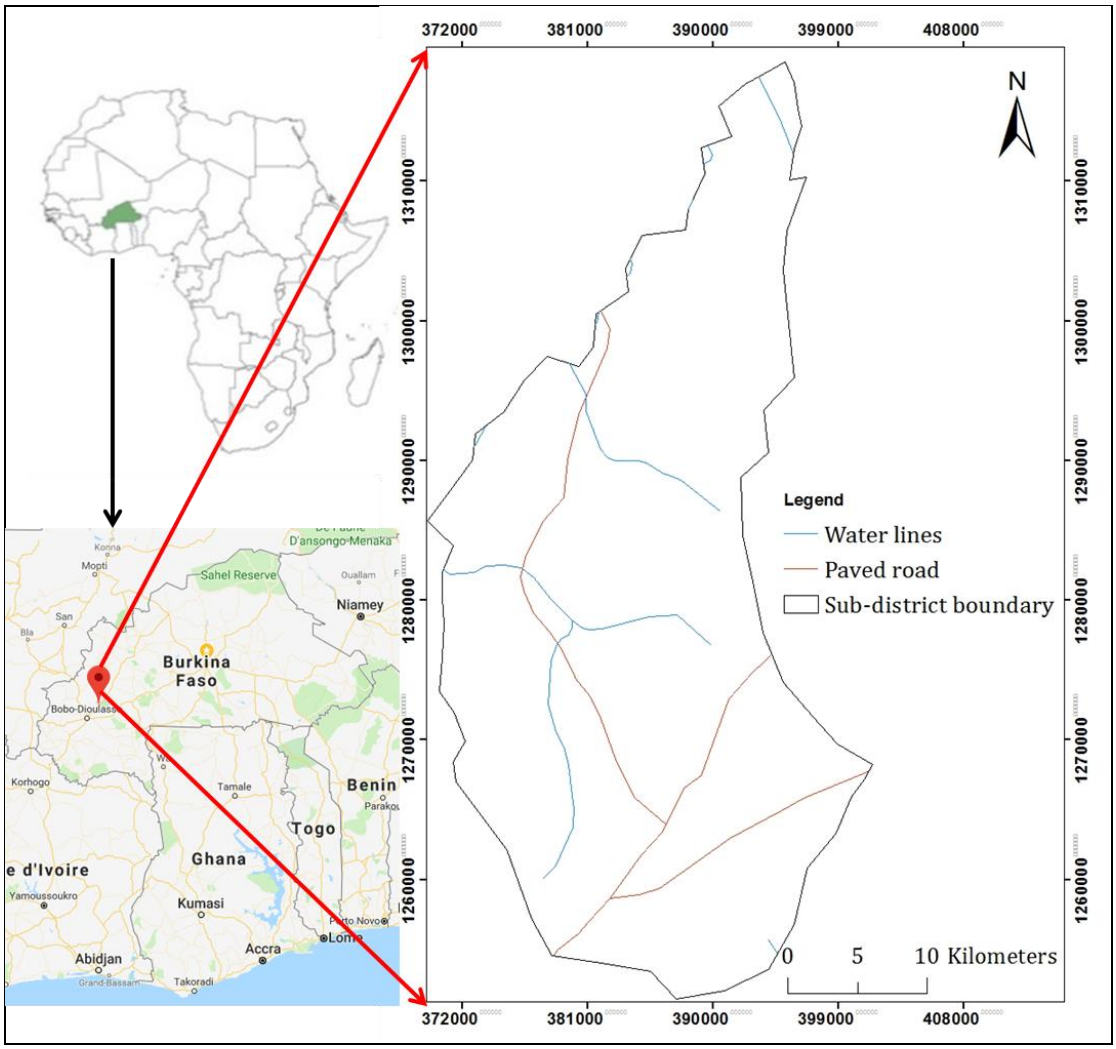

Fig. 1. Study site. The sub district of Satiri

Household-farm sampling and surveys

The household-farms were randomly sampled from a list of households of the village provided by local leaders. We sampled and surveyed 445 household-farms over 1077 in total, meaning 41% of the study sites household-farms. The data was collected through face to face interview with the head of the household-farm helped by other key members of the household-farm. Open Data Kit (ODK) platform was used for collecting the data. Households' geographic

coordinates were recorded. The questionnaires was guided by the Sustainable Livelihood Framework covered mainly household characterization (e.g. demography, education and profession), farm lands inventory and land tenure, agricultural and farm tools inventory, crop and livestock production, off-farm income and remittance. The proximity of households from permanent roads was extracted from map reading.

Method for identifying household-farm types

The identification of the agricultural livelihood types Satiri combined multivariate analysis and expert knowledge. The multivariate analysis consisted in two steps. The first step used Principal Components Analysis (PCA) for identifying the main factors that discriminate household-farms. The collected multidimensional dataset was prepared by selecting main variables per capital in reference to the Sustainable Livelihood Framework (Table 1). The PCA was run with the varimax option and only Principal Components (PC) with Eigen values of at least 1 (>=1) were considered. The second step consisted in K-mean cluster analysis (K-CA). The key variables contributing most to the factors loadings from the PCA results were used. The knee method was employed to decide on the optimal number of clusters. ANOVA was used to characterize identified agricultural livelihood types and the results were confronted to expert knowledge.

Table 1. Household variables for Principal Component Analysis.

Livelihood asset	*Variable*	*Variable definition*	*Source*[a]
Human	$H_{HEADAGE}$	Household head age (year-old)	D
	H_{HEDUYR}	Number of years of classic education of household head	C
	H_{SIZE}	Household size (no. of people in the household)	D
	H_{LABOUR}	Number of workers of the household (labour)	C
	H_{DEPEND}	Dependency ratio of the household	C
Physical	$H_{DMARKET}$	Distance to important market (Main town) from household house	R
	H_{DROAD}	Distance to permanent road from household house (m)	R
	$H_{VEHICLE}$	Number of transportation means (bicycle and motorbike) possessed by the household	C
	$H_{BULLOCK}$	Number of bullock possessed by the farm	D
Natural	$H_{CULTLAND}$	Farm cultivated land (ha)	C
	$H_{CULTLANDCP}$	Farm cultivated land per capita (ha/person)	C
	$H_{SHCOTTON}$	Share of cotton area in land holdings (%)	C
	$H_{SHCEREAL}$	Share of cereals area in land holdings (%)	C
	H_{TLU}	Tropical livestock units (TLU)	C
	H_{TLUHA}	Tropical livestock unit per ha of cultivated land (TLU/ha)	C
Financial	$H_{GROSSINC}$	Household annual gross income (FCFA)	C
	$H_{GROSSINCCP}$	Household annual gross income per capita (FCFA/capita)	C
	H_{NFINC}	Non-farm income of the household (FCFA/year)	C
	$H_{SHNFINC}$	Share of Off-farm income in household annual gross income (%)	C
	$H_{LIVESTINC}$	Livestock income of the household (FCFA/year)	C
	$H_{SHLIVESTINC}$	Share of livestock income in household annual gross income (%)	C
	$H_{SHCOTINC}$	Share of cotton income in household annual gross income (%)	C
	$H_{SHCERINC}$	Share of cereals income in household annual gross income (%)	C
	$H_{MFCRPINC}$	Marketable food crops income of the household	C
	$H_{SHMFCRPINC}$	Share of marketable food crops income in household annual gross income (%)	C
	$H_{FMNRINC}$	Income from farmer managed naturally regenerated trees (FCFA/year)	C
	$H_{SHFMNRINC}$	Share of income form farmer managed naturally regenerated trees	C
Social	$H_{REMITINC}$	Annual remittance income of household (FCFA/year)	
	$H_{SHREMITINC}$	Share of remittance income in household annual gross income (%)	C

Note: [a] D = Direct extracted from the questionnaire; C = Compound information calculated based on information coded in the questionnaire; R = Extracted from map reading.

Testing the heterogeneity amongst the identified agricultural livelihood systems

The heterogeneity amongst the different agricultural livelihood systems in the Sub-district of Satiri was tested. We used analysis of variance (ANOVA) to detect differences amongst the ALS. According to whether the equal variance across groups is assumed or not different post-hoc tests are used to decide on the groups' heterogeneity. For deciding on the post-hoc test to use, we first run the Levene's test of variance equality. This test indicates if the null hypothesis of equal variance across the different groups can be rejected. When the p-value of the Levene's test is lower than the chosen threshold p-value (0.05), the null hypothesis is rejected and the equal variance is not assumed. The Least Square Difference (LSD) test was used when the Levene's test of equal variance indicates that there is equal variance. When the Levene's test suggested that the equal variance cannot be assumed the Games-Howell test was used instead of the LSD. Two main indicators were used for testing the difference amongst ALS: the yield performance of main crops and the land use choice through the land area allocated to each land use type (crop).

3. Results

Farming main settings in Sub-district of Satiri

In the study zone, households have an average size of 11 members and are dominantly headed by males: only 7% of households' heads were female. Around 60% of household's heads were illiterate reflecting the low literacy rate in the country and particularly in rural areas. This situation is a potential constraint to the adoption of good practices/innovations susceptible of improving farms' livelihood. The networking amongst farmers appeared to be high as up to 80% of farmers belong to farmer or credit organization (Table S1). Farms cultivate less than 1 ha of land per person (0.61 ha/person). The cropping system is subsistence based with 55% of households' farmed land allocated to basic cereals (sorghum, millet and maize). The equipment among farmers was very high: up to 74.70% of the sample was equipped with bullocks for land ploughing. The ratio livestock to land was however low is low: 0.77 TLU/ha.

Main factors discriminating agricultural livelihood types in Satiri sub-district

The PCA results revealed 10 factors with total Eigen values of at least 1 (Table S2). The 10 factors beard 82.01% of initial total variance. Using the rotated component matrix, the factors were named after variables with greater loadings and most correlated to the factors as shown in Table 2. The most discriminating factors of household-farms in the study zone, with at least 10% of initial total variance, where PC1 and PC2 which were highly correlated with Natural capital ($H_{CULTLAND}$ with loadings b=0.83) and Financial capital ($H_{SHLIVESTINC}$ with loadings b=0.88). They were therefore named Land PC and Livestock PC, respectively. The PC3 represented 8% of initial total variance while PC4 and PC5 represented 7% of initial total variance each. Like PC1, PC3 where also highly correlated with natural capital ($H_{SHCOTTON}$ with loadings b=0.91) and was named Cotton PC. PC4 was highly correlated with financial capital ($H_{GROSSINCCP}$ with loadings b=0.87) and was named Income PC. As for PC5, it was highly correlated with physical capital ($H_{DMARKET}$ with loadings b=0.96, and H_{DROAD} with loadings b=0.96) and was named Road PC. Other discriminating factors were PC6 to PC10 which carried less than 7% of initial total variance each. The PC6, PC7 and PC8 which were all most correlated with financial capital (H_{SNFINC} with loadings b=0.92 for PC6, $H_{MFCRPINC}$ with loadings b=0.91 for PC7, and $H_{SHREMITINC}$ with loadings b=0.94 for PC8) carried 6% of initial total variance each. They were then named Non-farm income PC, Marketable food crops PC and Remittance PC, respectively. The PC9 were also most correlated with financial capital ($H_{SHFMNRINC}$ with loadings b=0.92) but carried only 5% of initial total variance. It was name Farmer managed naturally regenerated trees PC. The PC with the lowest initial total variance was the PC10 which was most correlated with human capital (H_{DEPEND} with loadings b=0.68). This PC was therefore named Dependency PC.

Table 2. Rotated Component Matrix (i.e., loadings) using Varimax rotation method and Kaiser Normalization of first ten PCs

Livelihood asset	Variable	Principal Components									
		1-Land PC 20%	2-Liv. PC 13%	3-Cot. PC 8%	4-Inc.PC 7%	5-Road PC 7%	6-NF PC 6%	7-MF PC 6%	8-Remit PC 6%	9-FMNR PC 5%	10-Dep. PC 4%
Human	$H_{HEADAGE}$	0.14	-0.03	-0.08	-0.03	-0.01	-0.20	0.02	0.11	0.19	-0.62
	H_{HEDUYR}	0.06	-0.05	0.03	-0.01	-0.18	-0.06	0.07	0.07	0.08	**0.60**
	H_{SIZE}	**0.76**	0.16	0.14	-0.51	0.11	0.14	0.09	-0.02	0.02	-0.07
	H_{LABOUR}	**0.76**	0.14	0.12	-0.49	0.04	0.14	0.10	0.01	0.01	-0.22
	H_{DEPEND}	0.00	0.01	0.01	-0.09	0.26	0.00	-0.01	-0.07	0.00	**0.68**
Physical	$H_{DMARKET}$	-0.08	0.05	-0.10	-0.08	**0.96**	0.02	0.03	0.05	-0.04	0.03
	H_{DROAD}	-0.07	0.05	-0.12	-0.07	**0.96**	0.01	0.05	0.04	-0.05	0.01
	$H_{VEHICLE}$	**0.77**	0.07	0.06	0.04	-0.16	-0.06	-0.01	0.09	0.13	-0.01
	$H_{BULLOCK}$	**0.73**	0.20	0.03	0.19	0.00	-0.06	-0.09	0.04	-0.06	0.11
Natural	$H_{CULTLAND}$	**0.83**	-0.11	0.26	0.29	-0.16	-0.05	0.11	-0.06	0.01	-0.02
	$H_{CULTLANDCP}$	0.14	-0.18	0.24	**0.80**	-0.27	-0.14	0.05	-0.09	-0.01	-0.09
	$H_{SHCOTTON}$	0.18	-0.08	**0.91**	0.09	-0.09	-0.07	-0.19	-0.03	-0.01	0.02
	$H_{SHCEREAL}$	-0.11	0.05	-0.89	-0.07	0.02	0.03	-0.22	0.01	0.02	-0.05
	H_{TLU}	0.63	0.56	-0.03	0.14	-0.08	-0.05	-0.06	-0.03	-0.05	0.02
	H_{TLUHA}	0.12	**0.87**	-0.13	-0.06	-0.03	-0.02	-0.08	0.02	-0.08	0.02
Financial	$H_{GROSSINC}$	**0.79**	0.32	0.15	0.28	0.05	0.24	0.15	0.02	0.09	-0.05
	$H_{GROSSINCCP}$	0.21	0.16	0.09	**0.87**	0.05	0.18	0.05	0.04	0.07	-0.06
	H_{NFINC}	0.20	0.02	-0.02	0.06	0.05	**0.92**	0.01	-0.01	0.00	0.00
	$H_{SHNFINC}$	-0.13	-0.08	-0.12	-0.05	-0.01	**0.92**	-0.09	-0.02	-0.03	0.09
	$H_{LIVESTINC}$	0.29	**0.88**	0.00	0.04	0.04	0.07	0.07	-0.01	0.05	-0.05
	$H_{SHLIVESTINC}$	0.07	**0.88**	-0.02	-0.04	0.13	-0.05	-0.02	0.03	0.04	-0.02
	$H_{SHCOTINC}$	0.16	-0.18	**0.85**	0.10	-0.14	-0.19	-0.18	-0.10	-0.02	0.03
	$H_{SHCERINC}$	0.02	-0.32	-0.65	0.02	0.09	-0.42	-0.22	-0.13	-0.20	-0.08
	$H_{MFCRPINC}$	0.26	0.03	0.07	0.10	0.09	0.06	**0.87**	-0.01	0.06	0.01
	$H_{SHMFCRPINC}$	-0.14	-0.08	-0.09	-0.04	-0.01	-0.12	**0.91**	-0.06	-0.03	0.04
	$H_{FMNRINC}$	0.28	0.05	0.07	0.15	-0.01	0.05	0.07	0.03	**0.88**	-0.02
	$H_{SHFMNRINC}$	-0.14	-0.04	-0.03	-0.08	-0.09	-0.06	-0.04	-0.05	**0.92**	-0.05
Social	$H_{REMITINC}$	0.10	0.02	0.00	0.02	0.07	0.01	-0.02	**0.93**	0.02	-0.04
	$H_{SHREMITINC}$	-0.04	0.00	-0.05	-0.05	0.01	-0.03	-0.05	**0.94**	-0.04	-0.05

*Note: **Liv**= Livestock, **Cot**= Cotton, **Inc.** =Gross Income; **NF**=Non-farm income; **M.F**= Marketable Food crops, **Remit.** = Remittance; **FMNR.** = Farmer managed naturally regenerated tree; **Dep**= Dependency. Numbers in parenthesis are percentages of total variance of original variables explained by the principal components. Bold and underlined are the high loadings, indicating most important original variables representing the principal components and used for clusters analysis.*

Agricultural livelihood types in Satiri sub-district

The typology analysis results revealed four agricultural livelihood systems types in the sub-district of Satiri. These agricultural livelihood types were characterized as follow using ANOVA (Table 3) .

Livelihood type I. Pro-poor, landless and cereal-based

This livelihood system type (ALS) represented 47% of the total study sample. The main characteristics discriminating this ALS type with other are its level financial and natural assets endowment as well as crop production orientation. It comprises the least endowed farms in the study area. The annual gross income per household member was found to be 82,371 FCFA/Person/Year. Land ownership is very low as well as they cultivated 4.03 ha in total pour all crops, meaning 0.57ha per person. Their livelihood is dominated by cereals given that cereals crops (Sorghum, millet and maize) alone provide up to 49.25% of household annual income. Cotton which is the main non-food cash crop of the region is not a major contributor to the farm income. Indeed only 18.92% of household incomes come from cotton production. They have low access to paved road with the mean distance from a paved road being 4.17 Km. This distance which is quite long giving the limited available transportation means in the rural areas and the importance played by permanent road in accessing market for buying factors and selling crop products.

Livelihood type II: Poor, landless and cereal-based livelihood

The livelihood type II concerne 32% of the total study sample. Farmers of this ALS type are Poor, landless, and cereal-based livelihood. They also have low annual gross income (131,438 FCFA/Person/Year) but statistically significatly higer than the Pro-poor, landless, and cereal-based livelihood type (ALS type I). They have slightly, but still significant higher area of cultivated land than ALS type I (5.82 ha in total, and 0.60 ha per capita). Their livelohood is also dominated by cereals income which contribute for 44.67% to the annual gross income of the household. This contribution is statiscally significantly lower than the contribution of cereals income to farm annual income of ALS type I. The contribution of cotton to the annual farm income (20.90%) is not significantly different from the contribution in ALS type I. However, livestock income contribution to the annual gross income of the household

(11.15%) is significantly higher than this contribution for farms of ALS type I. In definitive ALS type II has better annual income, better libvestock income contribtion but are remoted from paved road (5.4km) and less based on cereal than farms of ALS type I.

Livelihood type III: Medium, land rich, cereal-based livelihood

The livelihood type III Medium, land rich, cereal-based livelihood was statistically significantly better endowed in financial and natural capital than the ALS types I and II which are pro-poor and poor. Farmers in ALS type III have annual gross income of 154,029 FCFA/Person/Year. They cultivate more lands: 9.87 ha in total, meaning 0.68 ha/Person. Though strong contribution from cereal income to household annual gross income, farmers of this ALS type statistically significantly rely less on cereal income (39.84%) than ALS type I (around 49%) and ALS type II (around 45%). However, no significant difference was found between this ALS type III and ALS types II for cotton income contribution and livestock income contribution to the household annual gross income. These differences (Cotton income and livestock income) were significant only between this ALS type III and ALS type I (the pro-poor ALS). In terms of road access, ALS type III has similar access with ALS type I but better access than ALS type II.

Livelihood type IV: Better-off, land rich, diversified and livestock-preference livelihood

This ALS type is the better-off. It was named Better-off, land rich, diversified and livestock-preference livelihood and represent only 5% of the study population. Farmers of that ALS type have the highest annual gross income per person (188,914 FCFA/Person/Year). They also cultivate the biggest share of land area (12.91ha in total, meaning 0.68 ha/person). Compared to the three other ALS types, there are little differences between the three main sources of income (Cereal, Cotton and livestock) for the contribution to household annual gross income. Cereals income contributes for 32.81%, cotton income for 24.44% and livestock income for 24.63%. This make the ALS type IV a diversified agricultural livelihood system type. Farmers of ALS type IV are the closest to paved road with a mean distance of 3.18 km.

Table 3: Descriptive statistics of the agricultural livelihood types in Sub-district of Satiri. ANOVA was used to test the difference amongst identified agricultural livelihood types. Key variables are which significantly discriminate ALS groups

Key variable	ALS type	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Minimum	Maximum
Household annual gross income (FCFA/yr)	I	200	82,731	43,493	3,075	76,666	88,795	13,325	295,433
	II	137	131,438	65,832	5,624	120,315	142,560	39,909	392,206
	III	71	154,029	74,740	8,870	136,339	171,720	72,503	514,013
	IV	20	188,914	72,719	16,261	154,881	222,948	84,260	333,958
Household cultivated lands (ha)	I	200	4.03	1.98	0.14	3.76	4.31	0.50	12.25
	II	137	5.82	2.49	0.21	5.40	6.24	1.50	20.50
	III	71	9.87	4.35	0.52	8.84	10.90	2.75	27.50
	IV	20	12.91	6.47	1.45	9.88	15.94	2.75	29.00
Share of cereal income in household annual gross income (%)	I	200	49.25	19.94	1.41	46.47	52.03	0.00	94.97
	II	137	44.67	15.75	1.35	42.01	47.33	9.59	95.26
	III	71	39.84	12.88	1.53	36.79	42.89	18.42	76.51
	IV	20	32.81	14.35	3.21	26.09	39.52	0.00	55.70
Share of livestock income in household annual gross income (%)	I	200	5.96	9.20	0.65	4.68	7.25	0.00	50.49
	II	137	11.15	12.23	1.05	9.08	13.21	0.00	59.13
	III	71	12.14	12.56	1.49	9.17	15.12	0.00	58.69
	IV	20	24.63	25.62	5.73	12.64	36.62	0.38	90.01
Share of cotton income in household annual gross income (%)	I	200	18.92	19.62	1.39	16.18	21.65	0.00	83.85
	II	137	20.90	14.75	1.26	18.41	23.40	0.00	64.20
	III	71	24.52	15.81	1.88	20.78	28.27	0.00	56.38
	IV	20	24.44	20.42	4.57	14.88	34.00	0.00	56.71
Mean distance of household to paved road (Km)	I	200	4,170	3,933	278	3,622	4,719	3	11,309
	II	137	5,408	3,879	331	4,752	6,063	34	11,264
	III	71	3,887	4,120	489	2,912	4,862	6	11,142
	IV	20	3,185	3,450	772	1,571	4,800	4	9,802

ALS type I = Pro-poor, landless, cereal-based, **ALS Type II**= Poor, landless, cereal-based livelihood, **ALS type III**= Medium, land rich, cereal-cotton based livelihood and **ALS type IV**= Better-off, land rich, diversified and livestock-preference livelihood.

4. Conclusion

Combining PCA and CA, the present study succeeded in clearly identifying main discriminating factors among smallholder farms in the sub district of Satiri. The study findings on factors discriminating among smallholder farms in Satiri sub-district helped formulate empirical typology of smallholder farms in four villages. We found the same number of discriminating factors (10) as Thiombiano and Le (2015) who used a similar methodological procedure in Ioba province in south-western Burkina Faso. The main variables discriminating agricultural livelihoods in the study zone were found to be human (education and dependency), natural (land holdings and livestock), financial (annual gross income), physical (access to road and important market) social (Share of remittance income) assets, and production orientation (cotton and marketable food crops production). Four agricultural livelihood types were identified: Pro-poor, landless, cereal-based; Poor, landless, cereal-based livelihood; Medium, land rich, cereal-cotton based livelihood; and Better-off, land rich, diversified and livestock-preference livelihood. This shows the need for clearly distinguishing agricultural livelihood types for research and policy intervention. The results of this study therefore offer a basis for policy intervention. They are also useful for further studies in the village and for integrated farming systems modelling. The failure to consider farm heterogeneity in a location hampers the effectiveness of interventions aiming at improving rural livelihood. Accounting for farms' heterogeneity is key to farming design studies, in particular for integrated farming systems modelling seeking to propose innovative solutions for adaptive and sustainable agricultural livelihoods.

5. The ways forward

The present work formulated Agricultural Livelihood Systems typology in the sub-district of Satiri. It serves as a preliminary work to the upcoming work toward achieving the main objective of this research which to propose a decision support tools for assessing productivities, resources use efficiency, and sustainability of GLDC-based smallholder systems in Burkina Faso. The ways forward consist mainly of:

- Performing behavioural analysis in terms of the practice legumes-cereal association and the use of improved seed for millet/sorghum, and cowpea

- Analysing technical efficiencies of GLDC-based farming systems

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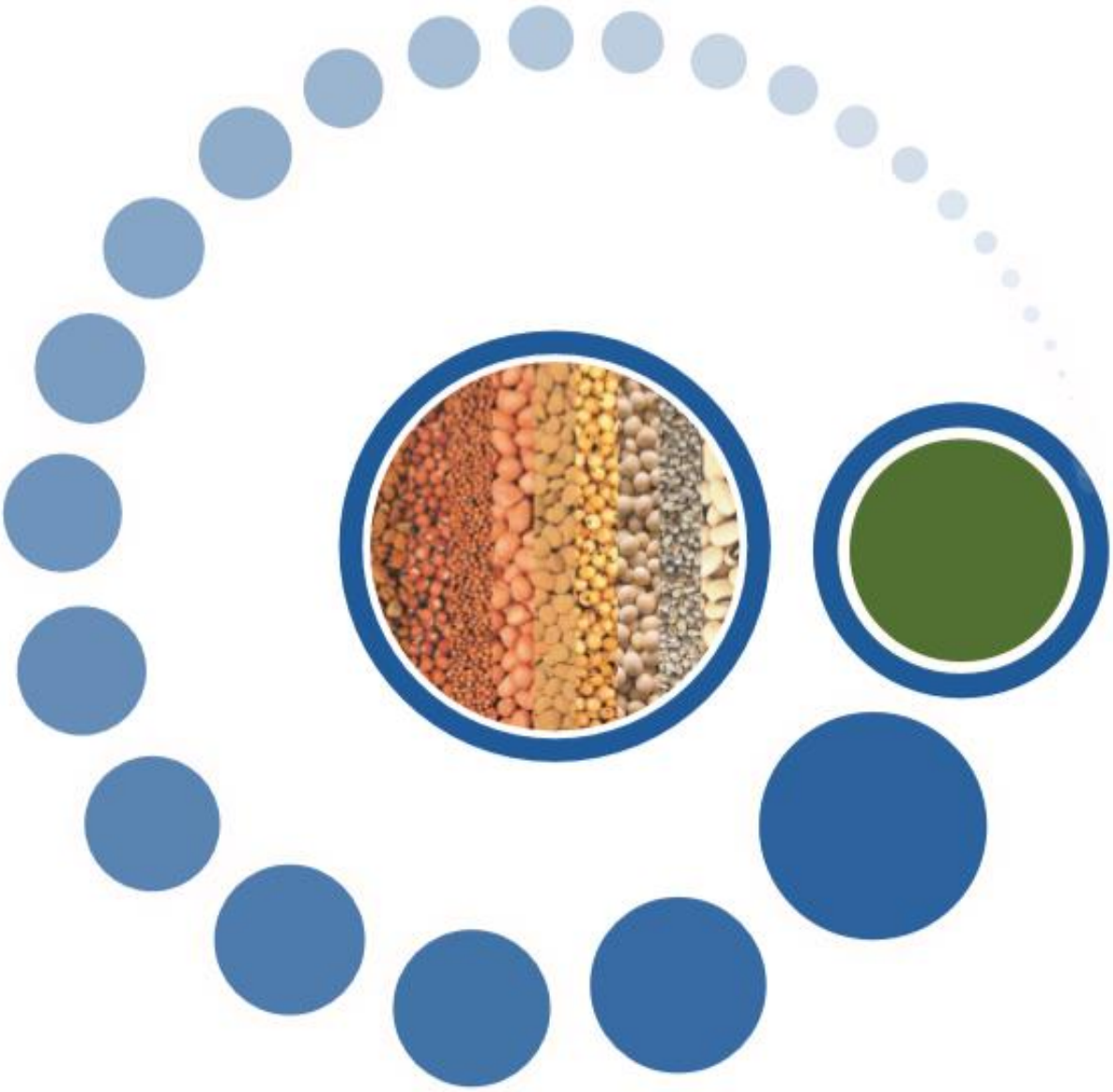

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