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Research Paper

Financial and economic analyses of rice based production systems in lowlands in South Benin

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Abstract. This paper aims to make a financial and economic analysis of rice based production subsystems of Houéyogbé and Dogbo districts. The data used for the study were collected from 104 randomly selected producers in the two districts. The variables costs, the gross margin and net margin are the indicators used for this financial analysis; the economic profit was calculated to value the economic profitability of these subsystems. Five subsystems of rice based production associated with vegetables were identified in lowlands. Among these subsystems, the subsystem rising water level rice and falling water level *crincrin* (*Corchorus tridens*) is the most financially profitable and the subsystem rising water level rice and falling water level pepper is the most economically profitable. On the other hand, the subsystem rising water level rice and falling water level tomato is the least financially and economically profitable in all the lowlands. Given the greater profitability values in non-developed lowland of Houinga, it is unlikely that the development of lowland alone will lead to improved farmers' income; formulation of good promotion policies and efficient utilization might also be of great importance. The development of tomato conservation technique will help to improve its financial and economic profitability.

Keywords: Rice, vegetables, profitability, crop subsystems, lowlands.

INTRODUCTION

The issue of food security is of the major challenges for African countries in general and for Benin in particular. Indeed, the rapid growth of the population in many developing countries, without a subsequent progress of agricultural technology, has increased the pressure on arable lands. As a result, fallow cycles have been shortened and marginal lands have been cultivated namely in densely populated regions (Nolte *et al.*, 2007). In such context, a best rise in value of lowlands is an opportunity to seize for the increase of the national agricultural production and consequently for the reduction of poverty.

Actually, lowlands were formerly considered repellent and dirty for agricultural activities (Delville *et al.*, 1996). In West Africa, lowlands are estimated at about 20 million hectares (WARDA/ADRAO, 2009). In Benin, only less than 8 % of the 205 000 hectares of available lowlands (Verlinden and Soulé, 2003) are presently under cultivation. According to expert's estimations, if only 10% of lowlands were cultivated in rice, with a yield of 3 tons/hectare, the region could put an end to the costly importation of rice (WARDA/ADRAO, 2009). Studies on lowlands profitability have been carried out by Sadou (1996), Adegbola and Singbo (2003), Agbazahou (2003), Yabi *et al.* (2006), Danhounsi (2007) and Kinkingninhoun *et al.* (2010). However, these studies are limited to rice production in rising or falling water level period only, whereas gardening was also practiced in lowlands. Also most of these studies see the non-development of lowlands as the most important constraint in increasing farmers' production and incomes. It should therefore be objective to study the financial and economic profitabilities of all the crops produced in lowlands. Moreover, an understanding of the financial and economic profitabilities of lowlands exploitation in the context of the production systems combining all produced crops is crucial. This article aims to classify the various rice based production subsystems in Southern of Benin and to analyze their financial and economic profitabilities. The underlying hypothesis of the study was that all the identified rice-based subsystems are not profitable, whatever the subsystems and the lowlands may happen to be.

Theories on economic profitability

The neoclassical theory is trying to build the company with individuals who are subject, at least firstly, only to constraints resulting from the limited character of their resources and possibilities offered by technology. The neoclassical claim is that all individuals being "free and equal", though their resources differe. This approach is frequently considered as methodological individualism (Guerrien, 1993). In the neoclassical model, the producer is rational. He tries to minimize the costs (fix and variable). He maximizes his profit under the constraint of his costs. Obtaining as much income as possible is frequently identified as first objective of most producers. To achieve these objectives, the producer must opt for the combination of agricultural production factors (labor, capital) where marginal revenues are equal to marginal costs for all business alternatives. The ecological conditions and availability of resources are not the only elements taken into account when farmers choose and implement their agricultural production system. Considerations related to economic and social environment influence much their decision. Farmers never produce in isolation, but they maintain permanent relationship with other economic agents including neighboring producers, land owners, traders, usurers, craftmen, transporters, agri-food industries, banks, administration, civil servants, the State etc. Obviously, these social relationships influence the choice of farming systems practiced by producers and economic results obtained from farms (CIRAD-GRET, 2002).

In the framework of this study, a combination of elements resulting from these considerations has been used. Farmers produce rice according to their economic, social and political area. The choice of the crop following the rice will be considered to be related to rationality conditions imposed on producers who are into relationship with the other agents of the production chain.

METHODOLOGY

Study area, sampling and data gathering

Data used in the present study were collected in 2011 in Houéyogbé district (department of Mono) and Dogbo district (department of Couffo). The main criteria that guided the selection of villages is the existence of usable lowlands for agriculture. Thus, three villages were purposely selected in both districts to represent the study villages in their usable lowland diversity. These include Agbédranfo and Vovokammey villages located in the Dogbo district and Houinga village from Houéyogbé district. Only the lowlands of Agbédranfo and Vovokammey have been developed and provided with an irrigated perimeter each. However, the developed perimeter of Vovokammey does not have a water control possibility unlike that of Agbédranfo where water control is total.

Farmers surveyed in each of these villages were chosen randomly. A census of all the farmers who cultivate lowland during the two cycles in each low land was performed. The formula for determining the sample size of Yamane's (1967) was then applied, like Boz and Akbay (2005), to define the minimum size of farmers to investigate in each of the selected lowland. This formula is as follows:

$$n_i = \frac{N \Sigma N_h S_h^2}{N^2 D^2 + \Sigma N_h S_h^2}, \text{ with } D^2 = \frac{e^2}{t^2}, \quad (1)$$

Where *n* is the minimum sampling size, N total number of farmers for the study from the two lowlands, N_h the number of farmers per lowland, S_h standard deviation for the area sown in each lowland, D^2 desired variance, e the error of the average accepted and t is the t corresponding to the accepted confidence interval. With a 5% error of the average (e) and 95% confidence interval, t = 1.645.

A total of 104 producers were randomly surveyed, with 62 being women (that is, 60% of the surveyed sample). About 66% of the surveyed producers occupy Vovokanmey-Gbédranfo lowland. About 62% of women of the sample are at Vovokanmey-Gbédranfo and 38% at Houinga.

Data analysis tools

The analysis of rice based production systems was done in two main stages: identification of representational crop subsystems and analysis of financial and economic profitability of identified subsystems.

Categorization of crop systems

Known as a « set of plots homogeneously cultivated and particularly subjected to the same cultivation succession », the production system can be understood at different scales (Bergeret *et al.*, 1993). Indeed, rice and vegetables production in lowlands can be considered as rice based production system. Thus, the various rice and vegetable combinations following the rice production by producers in lowlands are considered as rice based production subsystems.

In the framework of this study, the Principal Component Analysis (PCA) supported by the Discriminant Analysis (DA) is used to categorize the rice based production system into different subsystems. The PCA, known as a widely used statistical technique in data processing and dimensionality reduction, is applied to reduce the number of production subsystems, eliminating the problems of multicolinearity between projected variables (Vogt, 1993). It is for this reason that the Varimax orthogonal rotation was adopted. Such rotation helps, on the one hand, to simplify the structure of the solution maximizing the variance of components, and on the other hand to preserve the independence of components to be extracted (Wuensch, 2001). The number of main components that can be extracted has been determined using Kaiser criterion (Kaiser, 1966). In order to refine the PCA, the variables whose commonalities, that is, the proportion of the variance represented by the solution of factors, are less than 0.5 are eliminated from the analysis. It was the same for variables presenting a complex structure (whose factorial weights over at least two components are more than 0.3).

The DA was then carried out to validate the production systems resulting from the PCA. The aim was to identify the main measured variables which discriminate subsystems. The quality of the DA was appreciated by the prediction rate, which is the rate of classified items.

Financial analysis

In the perspective of carrying out the financial analysis of production systems identified in the study area (Houéyogbé and Dogbo lowlands), the gross margin and the net margin, indicators of the financial analysis (Penot, 2007), were calculated.

The Gross Margin (GM), expressed in FCFA per hectare, is calculated by deducting from the gross product per hectare the variable costs per hectare. The variable costs (VC) or direct costs stand for the production costs which depend on the total produced quantity. In agricultural field, these costs are represented by costs related to agricultural inputs (seeds, fertilizers, insecticides, herbicide etc.), to the workforce and other costs which depend on the produced quantity (rent of land). The GM is obtained through the following formula:

$$GM_i = GP_i - VC_i \quad (1)$$

If the GM is positive, the production covers the direct costs engaged by the producer. The production can therefore be considered profitable; otherwise, it is not profitable.

The net margin (NM) per hectare for one production system is the difference between the gross margin and the fixed costs. The fixed costs (FC), in the short run, are independent from the production and include paid profits, depreciation of renting costs of agricultural equipments, paid taxes, paid wages and other fixed costs. FC can be written as follows:

$$NMi = GMi - FCi \quad (2)$$

Economic analysis

Producers efficiently allocate their resources to relatively expensive local goods. Allocation of resources takes place without the intervention of the State and is optimum for the whole society. State intervention creates malfunctions which must be adjusted in order to reach the ideal aforementioned situation.

In a malfunction context, the prices in the market (financial prices) must be adjusted on taxes subsidies in order to determine the opportunity cost of national resources. These adjusted prices are called economic prices or reference prices. To determine reference prices, imported goods (rice, fertilizers and pesticides) have been evaluated at the CIF price adjusted by the customs taxes, stocking costs and the transportation to the consumption region following standard practices in the literature (Monke and Pearson 1989; Pearson *et al.*, 2003). On the other hand, for vegetables [crincrin *(*Corchorus tridens*)*, gboma (*Solanum macrocarpon* L.), tomato, pepper, okra], reference prices have been generated from the field edge price adjusted by the costs of handling, transportation to the consumption area, and the commercial margin. Past studies, post-farm costs from the Ministry of Agriculture, Livestock, and Fisheries, and data on import duties and fees from the Ministry of Trade and Industry were exploited to calculate reference prices. These reference prices have been used in the calculation of the economic profit of the product$_i$ (EP_i) as follow:

$$EP_i = P_i * Q_i - [\sum (P_i * A_{m,i}) + \sum (P_1 * B_{1,i})] \quad (3)$$

with P_i reference price of the final good (i); P_m reference price of the imported input; P_l reference price of the local input (l); Qi quantity of the final good (i); $A_{m,i}$ quantity of the imported input (m) used for the production of the final good (i) et $B_{l,i}$ quantity of the local input (l) used for the production of the final good (i). Thus, the activity is economically profitable when the economic profit is positive.

RESULTS AND DISCUSSION

Categorization of rice based production systems

The global Measurement of Sampling Adequacy (MSA)

Table 1. Characteristics of rice based production subsystems*.

Region	Criteria	Pepper (SS1)	Gboma (SS2)	Tomato (SS3)	Crincrin (SS4)	Okra (SS5)
Vovokanmey-Agbédranfo	% producers belonging to the subsystem	5	31	30	9	25
	Sex (% present women)	50	57	53	67	50
	Age (years)	34 (±0.70)	43 (±12.40)	44 (±12.10)	38 (±7.89)	45 (±17.25)
	Cultivated area for rice (hectare)	0.24 (± 0.33)	0.15 (±0.07)	0.32 (±0.37)	0.12 (±0.08)	0.19 (±0.33)
Houinga	% producers belonging to the subsystem	23	9	59	0	9
	Sex (% present women)	40	50	69	-	100
	Age (years)	46 (±19.17)	37 (±4.95)	45 (±11.06)	-	57 (±24.74)
	Cultivated area for rice (hectare)	0.08 (±0.13)	0.12 (±0.05)	0.31 (±0.25)	-	1.54 (±2.06)
All	% producers belonging to the subsystem	15	20	40	9	16
	Sex (% present women)	50	56	56	67	54
	Age (years)	42 (±16.63)	42 (±11.78)	44 (±11.36)	38 (±7.89)	47 (±17.86)
	Cultivated area for rice (hectare)	0.12 (±0.19)	0.15 (±0.07)	0.32 (±0.31)	0.12 (±0.08)	0.4 (±0.83)

*In all the subsystems, rice is cultivated in rising water level period while all the vegetables are cultivated in falling water level period. Subsystems are represented by the vegetable which cultivated in falling water level.
F_{Age} = 1.495, Sig. = 0.225
F_{sex}= 0.126, Sig. = 0.724
$F_{cultivated\ area}$= 4.168, Sig. = 0.045
Source: Survey 2011

for all the variables included in the analysis is 0.575 (Appendix 1); which exceeds the minimum requirement of 0.50 for overall MSA. This indicates the existence of sufficient intercorrelations between variables introduced in the model and that data were adequate for the factor analysis. The degree of correlation between the different variables introduced in the analysis has been tested using the the Bartlett's test of sphericity. The value of the Bartlett's test of sphericity (164.943, sig = 0.00) is small enough to reject the hypothesis that the variables in the PCA are not correlated; therefore, there is a strong relationship between the data and that the data is adequate and the factor analysis justified.

Four main components were identified according to the PCA results. These four components alone explain 63% of the variance of the choice of the type of rice based production subsystem (Appendix 2). Taking these four components into account helped to obtain five production subsystems.

The DA done to validate the number of subsystems obtained reveals an accurate prediction rate of about 80%; which means that globally, 80% of interviewed producers have accurately classified. The most discriminative variables of the various production subsystems include the production in falling water level period of *gboma*, *crincrin*, tomato, pepper and okra (Appendix 3).

The discrimination functions revealed a significant association between the various subsystems and all the differential variables. Thus, the five production subsystems obtained include:

i) Production subsystem 1: production of rice in rising water level and production of pepper in falling water level (SS1).
ii) Production subsystem 2: production of rice in rising water level and production of *gboma* in falling water level (SS2).
iii) Production subsystem 3: production of rice in rising water level and production of tomato in falling water level (SS3).
iv) Production subsystem 4: production of rice in rising water level and production of *crincrin* in falling water level (SS4);
v) Production subsystem 5: production of rice in rising water level and production of *okra* in falling water level (SS5).

Characterization of production subsystems

Apart from the SS4 subsystem which is practiced only in Vovokkanmey-Agbédranfo lowlands, all the other subsystems including SS1, SS2, SS3 and SS5 were practiced in the two studied lowlands. The SS2 and SS3 subsystems were highly represented in Vovokanmey-Agbédranfo lowlands while the SS3 subsystem was highly represented in Houinga lowland (Table 1).

The SS2 and SS3 are characterized by a high presence of women compared to the other subsystems. In Houinga, the SS5 subsystem is made up of only women whereas in Vovokanmey-Agbédranfo, the proportion of men is nearly equal to that of women. The

Table 2. Financial performances of subsystems by lowland.

Region	Production subsystem	Gross Product (GP) FCFA/hectare	Variable Costs (VC) FCFA/hectare	Part rice in variable costs	Gross Margin (GM) FCFA/hectare	Depreciation (FCFA/hectare)	Net Margin (NM) FCFA/hectare
Vovokanmey-Agbédranfo	Production of rice and pepper (SS1)	212,261	7,351	0.14	204,910	20,613	184,297
	Production of rice and gboma (SS2)	837,010	189,095	0.53	647,914	591,129	56,785
	Production of rice and tomato (SS3)	287,278	103,866	0.71	183,411	39,875	143,536
	Production of rice and crincrin (SS4)	1,192,343	162,262	0.31	1,101,081	188,245	912,835
	Production of rice and okra (SS5)	1,420,005	446,403	0.60	973,601	333,189	640,411
Houinga	Production of rice and pepper (SS1)	515,625	63,773	0.5	451,851	196,738	255,113
	Production of rice and gboma (SS2)	1,274,987	330,765	0.72	944,221	161,500	782,721
	Production of rice and tomato (SS3)	317,958	155,616	0.62	162,342	253,866	-91,524
	Production of rice and okra (SS5)	42,187	105,349	0.17	-63,161	115,628	-178,790
All	Production of rice and pepper (SS1)	322,575	27,868	0.27	294,707	84,658	210,048
	Production of rice and gboma (SS2)	895,407	207,984	0.56	687,422	533,845	153,576
	Production rice and tomato (SS3)	302,089	128,849	0.67	173,240	143,181	30,058
	Production rice and crincrin (SS4)	1,192,343	162,262	0.31	1,101,081	188,245	912,835
	Production rice and okra (SS5)	1,190,369	389,561	0.53	800,807	296,929	503,878

F_{GP} = 3.768, Sig. = 0.056
F_{VC} = 0.014, Sig. = 0.905
F_{GM} = 4.452, Sig. = 0.038
$F_{Depreciation}$ = 0.057, Sig. = 0.812
F_{NM} = 2.536, Sig. = 0.116
Source: Survey 2011

age of producers is not significantly different neither between the different subsystems nor between the types of lowland they belong to. On average, the surveyed producers are 44 years old.

In general, on average 0.26 hectares of rice are cultivated yearly by the respondents. The largest area of land was cultivated in the SS5 subsystems of Houinga (1.15 hectares). Lowland rice areas production in rising water level were on average 1.5 times that of lowland legumes areas production in falling water level. It is in the subsystem 1 that the areas produced in rice in rising water level were much greater than that of vegetables in falling water level (4 times considerably greater than that of pepper).

Economy of rice based production systems

Financial profitability

Production costs: Variable costs differ according to lowlands and production subsystems (Table 2). In Vovokanmey-Agbédranfo lowlands, the highest variable costs were observed in SS5 production subsystems. This might be due to the cost of chemical fertilizers used in the production of crops in this subsystem. Actually, the cost of chemical fertilizers (NPK and urea) used in SS5 subsystem represent nearly 95% of the variable costs of the subsystem. The lowest variable costs were observed in the SS1 subsystem. The producers of this subsystem use neither chemical fertilizers nor pesticides for their production.

In Houinga lowland, the highest production variable costs were found in the SS2 subsystem. These costs result mainly from the production of rice including 72% for total variable costs from the

Table 3. Economic performances of subsystems by lowland.

Region	Production subsystem	Economic Gross Product (GP) FCFA/hectare	Economic Variable Costs (CV) FCFA/hectare	Part rice in variable costs	Economic Gross Margin (GM) FCFA/hectare	Economic Depreciation (FCFA/hectare)	Economic Net Margin (NM) FCFA/hectare
Vovokanmey-Agbédranfo	Production rice and pepper (SS1)	118,703	4,570	0,90	114,133	17727	96,406
	Production rice and gboma (SS2)	107,353	43,467	0,82	63,886	508371	-444,485
	Production rice and tomato (SS3)	62,000	20,544	0,89	41,455	34292	7,163
	Production rice and crincrin (SS4)	101,430	13,469	0,5	87,960	161891	-73,931
	Production rice and okra (SS5)	89,671	65,792	0,51	16,198	286543	-270,345
Houinga	Production rice and pepper (SS1)	229,487	13,625	0,87	215,862	169194	46,668
	Production rice and gboma (SS2)	145,000	15,439	,94	129,560	138890	-9,330
	Production rice and tomato (SS3)	81,024	29,468	0,60	51,555	218325	-166,770
	Production rice and okra (SS5)	6,000	35,219	0,33	-29,219	99440	-128,659
All	Production rice and pepper (SS1)	1,58,988	7,863	0,89	151,125	72806	78,319
	Production rice and gboma (SS2)	112,373	39,730	0,84	72,642	459107	-386,465
	Production rice and tomato (SS3)	71,184	24,852	0,75	46,331	123136	-76,805
	Production rice and crincrin (SS4)	101,430	13,469	0,5	87,960	161891	-73,931
	Production rice and okra (SS5)	69,326	60,697	0,48	8,628	255359	-246,731

F_{GP} = 0.224, Sig. = 0.637
F_{VC} = 0.304, Sig. = 0.583
F_{GM} = 0.416, Sig. = 0,521
$F_{Depreciation}$ = 0.057, Sig. = 0.812
F_{NM} = 0.089, Sig. = 0.766
Source: Survey 2011

subsystem. The high cost of work force (186,875 FCFA) and of herbicides (234,375 FCFA) used in this subsystem should justify the observed high variable costs. The SS1 subsystem presents the lowest production variable costs in Houinga lowland.

Gross margin: Globally, all the gross margins of studied subsystems were positive, indicating that the exploitation of lowlands in the study areas pays off and the different rice-based production subsystems identified can survive at least in the short term. Therefore, the hypothesis that all the identified rice-based subsystems are profitable was accepted. The SS4 subsystem is the most financially profitable while the SS3 is the least profitable of all the identified and analyzed subsystems (Table 2).

Specifically, for each lowland identified in Vovokanmev-Agbedranfo, the production subsystems were found profitable. The production subsystem SS4 displayed the highest gross margin. In Houinga, however, only four of the five studied subsystems are financially profitable. The rice-based production subsystem SS5 that produces ricein the rising water level and okra in falling water level has a negative gross margin, therefore not financially profitable in this lowland. The hypotheses that all the identified rice-based subsystems are profitable are rejected in the case of the Houinga lowland. The highest gross margin was recorded in the SS2 subsystem despite its high variable costs. This might be due to the significant yield (6875 kg/hectare against 3500 kg/hectare, 976 kg/hectare and 312 kg/hectare respectively for SS1, SS3, and SS5 subsystems).

On average and without distinguishing between subystems, the gross margins are on average higher in Vovokanmey-Agbédranfo than in Houinga (789,779 and 537,689 FCFA/hectare, respectively). These findings can be explained by the development of lowlands in Vovokanmey-Agbédranfo, suggesting that the development of lowlands has a positive effect on the production margins of farmers. However, a close analysis across sites for the rice-based production subsystems that are common across the two production sites shows different patterns. Individual subsystems in Houinga recorded higher gross margin than those in Vovokanmey-Agbédranfo, except the subsystem SS5. The most probable explanation would be practice effects. As we have higher proportion of women exploiting these lowlands, and because the literature sometimes suggests that women left on farms without the benefit of male labor are at a disadvantage compared to other households, these findings suggest that farmers in Vovokanmey-Agbédranfo who are mostly female-farmers, are likely to be technical (financial) inefficient as compared with their peers in Houinga mostly men.

Production net margin: Globally from the analysis of Table 2, it can be observed that the net margins of all the subsystems are positive, indicating the different rice-based production subsystems were economically profitable, regardless of subsystems. The highest net margin is recorded for the SS4 subsystem (912,835 FCFA/hectare), while the lowest net margin is recorded for the SS3 subsystem (30,058 FCFA/hectare). The SS3 subsystem is the least profitable for all the sites due to the low gross product obtained by the producers of this subsystem. In fact, tomato is a perishable crop, compared to the other crops, which prevents farmers from speculating on this crop. However, these results vary significantly across sites. In Vovokanmey-Agbédranfo lowlands, the net margins of the various subsystems were positive, with the highest net margin recorded for the SS4 subsystem. In Houinga however, a positive net margin was recorded for only 50% of the identified subsystems (the SS1 and SS1 subsystems).

Economic profitability and divergences

In general, all the identified rice-based subsystems recorded positive economic gross margins, indicating that they were all profitable economically. These finding pointed to the ability of the identified rice-based subsystems to create value for the farmers and to add to national income at social prices. The rice-based subsystem SS1 with production of rice in rising water level and production of pepper in falling water level was found to be the most profitable economically (151,125 FCFA/hectare), while that of SS5 producing rice in rising water level and okra in falling water level ended up with the least profitable economic gross margin (only 8,628 FCFA/hectare). The analysis across production sites displays the same trends across lowlands as found in the financial analysis. The rice-based subsystem SS5 is not economically profitable for the observed average farms in Houinga (-29,219 FCFA/hectare in Houinga against 16,198 FCFA/hectare in Vovokanmey- Agbédranfo), suggesting the production of rice in rising water level and okra in falling water level in the Houinga lowland does not create value for farmers nor add to national income at social prices. Its contribution to value creation for farmers and to national income in Vovokanmey- Agbédranfo can be explained by the development made for water management and control. However, the fact the economic gross margins for the rice-based subsystems SS1, SS2 and SS3 were greater in Houinga lowland than those recorded in Vovokanmey-Agbédranfo challenges the assumption about the positive contribution of the development of lowlands to farmers' financial and economic profitability in the study areas. These findings suggest that there exists a mix of factors affecting the production profitability among farmers, including the development or not of the lowland.

The analysis of the effects of divergences defined as the difference between the gross margins measured in "private prices or farm gate prices" and those measured in "social prices". From the results in Table 4, private profitability is greater than economic (that is, social) profitability for all the subsystems. These findings are an indication, at the first hand, that production in the studied lowland benefits from governmental (and non-governmental) support in terms of any facilities that can lead to an increase in production, therefore in farmers' income. This subsidy could be attributed to the development of lowland and its corresponding lower cost of irrigation, subsidized inputs (seeds, fertilizer, pesticides, herbicides and other services), and land tenure in the study areas.

CONCLUSIONS

Benin in general and the department Mono-Couffo in particular has a significant potential in natural resources for production of rice and vegetables all year round. The lowlands selected in this study were used by both men and women, with women been greater users of these lowlands in general. Generally, the production carried out with basic and rudimentary tools (hoe, machete, cutlass etc). The difficulty of ploughing operations was the main constraint identified by these farmers. Five rice-based subsystems have been identified including subsystem rice in rising water level and pepper in falling water level (SS1), subsystem rice in rising water level and gboma in falling water level (SS2), subsystem rice in rising water level and tomato in falling water level (SS3), subsystem rice in rising water level and crincrin in falling water level

Table 4. Private profitability, economic profitability and net transfers.

Region	Production subsystem	Financial profitability	Economic profitability	Divergences
Vovokanmey-Agbédranfo	SS1 production rice and pepper	204,910	114,133	90,777
	SS2 production rice and gboma	647,914	63,886	584,028
	SS3 production rice and tomato	183,411	41,455	141,956
	SS4 production rice and crincrin	1,101,081	87,960	1,013,121
	SS5 production rice and okra	973,601	16,198	957,403
				0
Houinga	SS1 production rice and pepper	451,851	215,862	235,989
	SS2 production rice and gboma	944,221	129,560	814,661
	SS3 production rice and tomato	162,342	51,555	110,787
	SS5 production rice and okra	-63,161	-29,219	-33,942
				0
All	SS1 production rice and pepper	294,707	151,125	143,582
	SS2 production rice and gboma	687,422	72,642	614,780
	SS3 production rice and tomato	173,240	46,331	126,909
	SS4 production rice and crincrin	779,651	87,960	691,691
	SS5 production rice and okra	800,807	8,628	792,179

Source: Survey 2011.

(SS4), subsystem rice in rising water level and okra in falling water level (SS5).

In general, all the identified subsystems are financial and economically profitable. However, this profitability varies across lowlands, and the production of rice in rising water level and okra in falling water level (SS5) is likely to be not profitable in the non-development lowland of Houinga. The average fixed costs per farmer in the study areas are likely much higher since the average cultivated areas remains much smaller, leading to decrease in net margins across the study sites. Subsidize the production in these lowlands in form of the development of the lowlands, increasing access to technology such as improved varieties and other inputs, or any facilities can increase the incentives of production.

The findings of the study have some important policy implications. First, policies based on the development of lowlands (and thereby the dissemination of best practices) could improve overall financial and economic profitability of rice-based farming systems in South Benin. For example, the development of lowlands and water management control has led to an increase in the financial and economic profitability of the rice-based subsystem of rice in rising water level and okra in falling water level. Second, while this study indicates that the development of lowlands might enhance farmers' profitability, financial as well as economic, it does not suggest that under the currently observed production systems, the non-development of lowland (example of the Houinga case) is the most important constraint in increasing the production and thereby incomes gained from these crops. Given the greater profitability values in non-developed lowland of Houinga, it is unlikely that the development of lowland alone will lead to improved farmers' income. Everything being considered, not only the development of lowlands, but also the designing of a good promotion policy might improve the profitability of these identified subsystems. Additionally, the establishment of a tomato conservation method might contribute to reducing recorded post harvest losses and consequently the increase in the producers' income.

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APPENDIXES

Appendix 1. Measurement of sampling adequation and Bartlett test.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.575
	Approx. Chi-Square	164.943
Bartlett's Test of Sphericity	Df	45
	Sig.	.000

Appendix 2: Total explained variance.

Component	Initial Eigen values			Extraction sums of squared loadings			Rotation Sums of Squared Loadings		
	Total	% de Variance	Cumulative %	Total	% de Variance	Cumulative %	Total	% de Variance	Cumulative %
1	2.233	22.325	22.325	2.233	22.325	22.325	1.696	16.956	16.956
2	1.591	15.914	38.239	1.591	15.914	38.239	1.662	16.625	33.581
3	1.406	14.056	52.295	1.406	14.056	52.295	1.526	15.261	48.842
4	1.049	10.490	62.786	1.049	10.490	62.786	1.394	13.944	62.786
5	0.877	8.766	71.551						
6	0.780	7.797	79.348						
7	0.672	6.722	86.071						
8	0.620	6.199	92.270						
9	0.451	4.514	96.784						
10	0.322	3.216	100.000						

Extraction method: Analysis by Main Component.

Appendix 3: Results of subsystems classification.

Classification results[c]								
			Predicted Group Membership					
		Subsystems	**Production rice + pepper**	**Production rice + gboma**	**Production rice + tomato**	**Production rice + crincrin**	**Production rice + okra**	**Total**
Initial	Frequence	Production rice + pepper	1	4	2	0	5	12
		Production rice + gboma	0	34	0	1	1	36
		Production rice + tomato	0	2	35	0	0	37
		Production rice + crincrin	0	6	0	1	0	7
		Production rice + okra	1	0	0	0	15	16
		Ungrouped cases	0	5	0	0	0	5
	%	Production rice + pepper	8.3	33.3	16.7	0.0	41.7	100
		Production rice + gboma	0.0	94.4	0.0	2.8	2.8	100
		Production rice + tomato	0.0	5.4	94.6	0.0	0.0	100
		Production rice + crincrin	0.0	85.7	0.0	14.3	0.0	100
		Production rice + okra	6.2	0.0	0.0	0.0	93.8	100
		Ungrouped cases	0.0	100.0	0.0	0.0	0.0	100
Cross-validated[a]	Frequence	Production rice + pepper	0	4	2	0	6	12
		Production rice + gboma	0	32	0	1	3	36
		Production rice + tomato	1	2	34	0	0	37
		Production rice + crincrin	0	7	0	0	0	7
		Production rice + okra	2	1	0	0	13	16
	%	Production rice + pepper	0.0	33.3	16.7	0.0	50.0	100
		Production rice + gboma	0.0	88.9	0.0	2.8	8.3	100
		Production rice + tomato	2.7	5.4	91.9	0.0	0.0	100
		Production rice + crincrin	0.0	100.0	0.0	0.0	0.0	100
		Production rice + okra	12.5	6.2	0.0	0.0	81.2	100

a. Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case.
b. 79.6% of original grouped cases correctly classified.
c. 73.1% of cross-validated grouped cases correctly classified.