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A household model to assess consumption-production-resources nexus in West Africa: The rice based farming systems in Sierra Leone

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1 Introduction

In West Africa, several programmes have been established in order to boost rice production and consumption in those countries. However, these actions are often carried out at a national level without real consideration for the highly contrasting needs of agricultural households across a territory. This also implies the use of more specific approaches and methods that can quantify agricultural production while taking into account the diversity of cropping systems and of household food needs (Herrero *et al.*, 2014). The aim of this paper is to present a non-linear optimization model that highlighting the production strategies of rice farming households with non-separability between production, consumption, and available resources. The model is applied for rice production in the north of Sierra-Leona, which is known for its significant rice production, but also for its low and variable yields and consumption levels, which are among the lowest in the world. It also defines and assesses political alternatives encouraging agricultural production, and therefore the improvement of food consumption.

2 Materials and Methods

The methodology is composed from 3 steps:
- Selection of representative rice farming household: Based on clustering analysis, only four rice farming households were selected and studied by taking into account structural, resources, production and consumption criteria (table 1, for more details see Chenoune *et al.*, 2014).

Table 1. Farm types by considering structural, production and consumption criteria. The intensification level is determined based on seeds and labour amounts and the denomination of lowland or upland is expressed based on the percentage of each ecosystem by farm type (for more details see Chenoune *et al.*, 2014).

	Class 1: high rice consumption household				Class 2: low rice consumption household			
	$upland_{intensive}$		$lowland_{intensive}$		$upland_{extensive}$		$lowland_{extensive}$	
	Mean	Std.deviation	Mean	Std.deviation	Mean	Std.deviation	Mean	Std.deviation
Total farm area (ha)	3.7	0.87	1.92	0.65	3.14	0.63	0.94	0.35
Rice seed density (t/ha)	0.05	0.03	0.09	0.03	0.02	0.01	0.02	0.02
Rice production (t/farm)	1.18	0.3	0.8	0.28	0.3	0.19	0.2	0.12
Rice total labour (d/ha)	145	39	121	67	99	30	59	30
Size of family (member)	10.2	5	5.6	1	8.3	4	6.8	4
Rice consumption (t/capita/year)	0.075	0.013	0.094	0.012	0.057	0.008	0.054	0.005
Total calorie /cap/day (kcal)	1338	180	1739	850	900	169	843	695

- The farm household model specification: The household model developed in this study is a static annual model with a utility based on the full income approach, which includes both consumption and farm income (Strauss, 1984). The Utility function is described as following:

$$Max\ U = \left(\sum_{pr} R_{pr}^{v} + \sum_{pr} A_{pr} P_{pr}^{a} - \sum_{mo,pe} Q_{mo,pe} P_{mo}^{l} - \sum_{c,s,t,j} C_{c,s,t,j} X_{c,s,t,j} \right) - \emptyset\partial$$

Where U is the value of the utility function, P is the matrix of agricultural revenue by products (pr) sold and price v; A is the matrix of the amounts of products consumed (self-consumption), Pa are the shadow prices of agricultural products kept for self-consumption, Q is, for each activity, the total labour cost expressed by gender (mo) and period (pe), i.e. sowing, weeding and harvesting, Pl are the daily labour prices expressed by gender, C are the total input costs (other

than labour) expressed by crop (c), ecosystem type (s), intensification level (t) and fallow duration (j), Ø risk aversion coefficient and standard deviation of farm income by considering market price and yield variability in the study area.
- Scenario specifications: Table 2 summarizes the 4 tested scenarios targeting to promote the rice production and consumption in the Bombali District.

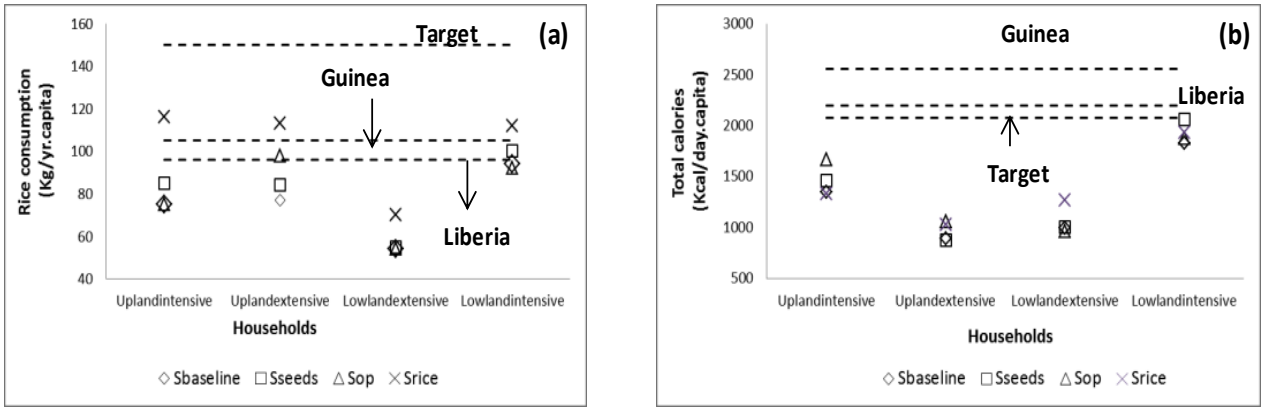
Table 2. Scenarios definition.

Scenario definition
$S_{baseline}$: Baseline scenario. This scenario represents the current situation and should be serving as a reference to evaluate the impacts of below incentive scenarios in terms of rice production and consumption.
S_{seeds} **scenario:** Subsidizing the purchase of rice seeds. It seeks to assess the impact of a gradual covering of rice seed purchase cost per hectare, varying its value from 0% to 100%, with a 20% pitch
S_{op} **scenario**: Subsidizing the plantation of oil palm scenario as a cash crop. Several levels of subsidization are applied to cover the cost of oil palm plantation per hectare gradually, varying from 0% to 100% (with a 20% pitch)
S_{rice} **scenario**: Subsidizing rice plantation in lowland ecosystems. Several levels of subsidization are tested, in relation to the gradual covering (from 0 to 100% with a 20% pitch) of the cost per hectare of lowland ecosystem conversion to rice production

3 Results and discussion

The scenario for the subsidization of rice plantation in lowland ecosystems seems to be the most relevant in the current context of Sierra Leone (Fig. 1). In fact, only this scenario has induced a significant rise in rice consumption to reach the same level as that of the two bordering countries : Guinea and Liberia, but far away from the consumption planning hoped for by the National Sustainable Agriculture Development Plan 2010-2030 (fig. 1). In terms of calories, the $Lowland_{intensive}$ households alone are at the FAO's recommended minimum level but far from Guinea which shows an average number of calorie intakes of 2500 capita/day (fig. 1). The other households, especially extensive ones, show very low caloric intakes. Similarly, regardless of the type of household, the scenarios have only had a slight effect on the number of calories consumed per day and per capita. This study also highlights the fact that lowland-based households with low intensification means ($Lowland_{extensive}$) and rice consumed per capita barely respond to the scenarios.

Fig. 1. Variation of rice consumption (a) and total calorie (b) for the 4 farm types, Guinea (average national values), Liberia (average national values) and the targets set by the Sierra Leone Government for the National Agricultural Strategy (2010-2030) and the FAO organization.



4 Conclusion

The scenario that contemplated subsidizing rice plantation in lowland ecosystems has been identified as the most efficient, which is relatively coherent with the numerous initiatives that contemplated this type of investment (SLIEPA, 2012). Nevertheless, this scenario has also generated a rice-cash crop specialization (data not shown) which could raise questions as to the resilience of such systems. Besides, the effects of these scenarios remain below the expectations of public authorities. The structure of the current model based on the notion of activity would make it possible without any major changes to test other scenarios strongly contemplated by several initiatives such as the introduction of irrigation, of fertilization, and intensification of others food crops.

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