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Comparative Analysis of Agricultural Assets, Incomes and Food Security of Rural Households in Ghana, Senegal and Liberia

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Abstract: This article compares and examines the relationships among agricultural assets, incomes and food security in rural communities of Ghana, Senegal, and Liberia. A total of 1483 rural households were surveyed and data on agricultural endeavors, incomes and food security were collected. The analyses of incomes and agricultural assets show signs of high inequality of resource distribution. In addition, facets of food insecurity were observed among the surveyed households. The study used a multivariate logistic model, then evaluated how agricultural assets affect the food security status of rural households in Ghana, Senegal and Liberia distinctly. Overall, the results show several similarities at country level, but disparities were also noted. In particular, the study outlined significant relationships between technology assets and the food security status of rural households in Ghana and Senegal. However, the logistic model did not show any statistically significant relationship with the rural households surveyed in Liberia. This paradigm suggests critical inter-regional dissimilarities which the study discussed by emphasizing relevant socio-economic features at the country level.

Keywords: resource distribution; farm assets; food security; rural communities; sub-Saharan region

1. Introduction

Across the globe, agriculture plays a prominent role as it sustains the social and economic stability of several countries [1,2]. Generally, improvements in agricultural practices lead to positive effects on crop productivity and the capacity of the population to have access to food [3]. However, low agricultural productivities are frequently reported in rural communities of sub-Saharan Africa. Meanwhile, the majority of the rural population in the sub-Saharan region lives on farming. For that reason, several development projects aimed at livelihood improvement in sub-Saharan Africa have prioritized the agricultural sector. Unfortunately, the poverty level of the rural population has virtually stagnated over years. Moreover, rural communities are constantly described as vulnerable to hunger and climatic hazards [4]. In such a situation, food security and agricultural development represent real challenges for all the actors of development of the region. Meanwhile, the response to these challenges may not be systematic because of the socio-economic realities in sub-Saharan Africa as the region has often suffered from instability in time and space. Thus, a thorough understanding of the realities in

rural communities of sub-Saharan Africa is probably a determinant step toward the planning and implementation of adequate strategies of sustainable development in the region. The content of this manuscript aligns with this scope as the study aims at analyzing how agricultural assets in rural households contribute to food security. Specifically, the study uses survey data, then evaluates the role of a number of agricultural assets (including lands and technologies use) on food security in Ghana, Senegal, and Liberia. Although the scope of the study may appear familiar, the outcomes reveal meaningful inter-regional disparities which should be integrated in regional approaches of development. Besides this introduction, this paper reports four sections, including the following:

(i) the methodological approach, which provides information on the study region; the household sampling; then, the theoretical frame of the analyses;
(ii) the results, which report the analyses of agricultural assets and income distribution among the rural households surveyed; then, the outcomes of the multivariate logistic model application are presented;
(iii) the discussion, which reports a critical appraisal of the results and discusses them from a multifaceted prospect;
(iv) the conclusion, which summarizes the essential of the study then concludes on the significance of the research at a regional level.

2. Methodological Approach

2.1. Survey and Study Region

Surveys were conducted separately in Ghana, Senegal and Liberia. In each country, three to five rural communities were targeted. At the country level, the communities were located in different administrative districts in order to capture social and agro-ecological variabilities (Figure 1). Indeed, the surveys were conducted in four administrative districts in Ghana (including: Ga West, Ejura, Antwima, Gambaga), five in Senegal (including: Fatick, Kafrine, Matam, Tambacounda, Kolda) and three in Liberia (including: Grand-Bassa, Nimba, Lofa). The locations of these districts are portrayed by the maps in Figure 1. Thus, in Ghana, four agro-ecological regions were represented including the Coastal Savannah (Ga West), the Transition Forest Savannah (Ejura), the Semi-Deciduous rainforest (Antwima) and the Sudan Savannah (Gambaga) [5]. In Senegal, the agro-ecological regions encompassing the surveyed locations include the Groundnut Basin zone (Fatick and Kafrine), the Sylvopastoral zone (Matam), the Eastern Senegal zone (Tambacounda) and the Upper Casamance zone (Kolda) [6]. In Liberia, the agro-ecological regions corresponding to the studied locations include the Coastal Plains (Grand Bassa), the Northern Savannah (Nimba) and the Upper Highland Tropical Forest (Lofa) [7]. The climatic characterizations of these agro-ecological regions are detailed in the literature [5–7]. In each rural community, households were sampled on a basis of the demographic structure and size adequacy [8]. The sampling did not use farming activity as a criterion of selection, but all the households surveyed were located in rural areas and this justified the use of the terminology "rural households" in this paper. A minimum of 100 households were surveyed in each district in accordance with the guideline developed by Sandelowski [8]. Ultimately, a total of 1483 rural households were surveyed during the study; 647 in Ghana, 510 in Senegal, and 326 in Liberia. During the field surveys, the supports received were not similar in all the three countries and this explains in part the difference of sample sizes. However, this difference does not affect the consistency of the statistical analyses reported in the study as the analyses were conducted distinctly for each country. Moreover, the sample sizes align with the minimum size recommended for such study [8]. Through the surveys, quantitative and qualitative data were collected on agricultural assets, farm production, nonfarm endeavors, incomes and food access in individual household during the year 2012. Based on the data collected, revenues and production costs were estimated for individual household. Beside the surveys conducted at household level, additional information was collected through interviews with

farmers, local extension agents, local professionals and social groups, with an objective of verifying the household-level data.

The three countries surveyed represent more or less the actual paradigm of human development in sub-Saharan Africa. Indeed, at the present stage, Liberia can be classified among sub-Saharan countries with high poverty pattern; Senegal may be identified as a middle level country while Ghana could be considered within progressive level countries. Referring to statistics released by the World Bank, the estimate headcount ratio of poverty, based on the international standard, was 25.2% in Ghana (year 2005), 38.4% in Senegal (year 2005), and 63.8% in Liberia (year 2007) [9]. Although these statistics are not available for all years, the historical trends suggest a stagnation of poverty in West Africa over the last decade. Likewise, the gross domestic product GDP per capita (constant 2010 USD) for year 2012, was 1570 USD in Ghana, 996 USD in Senegal, and 360 USD in Liberia [9]. However, the three countries did not have the same socio-political realities during the past decades. For instance, Liberia had a violent socio-politic conflict history with two successive civil wars during the last decades. The first conflict in Liberia spanned over the period 1989–1996 and was followed with the second one during the period 1999–2003. Contrariwise, Senegal and Ghana did not have a record of major socio-political conflicts during these time frames.

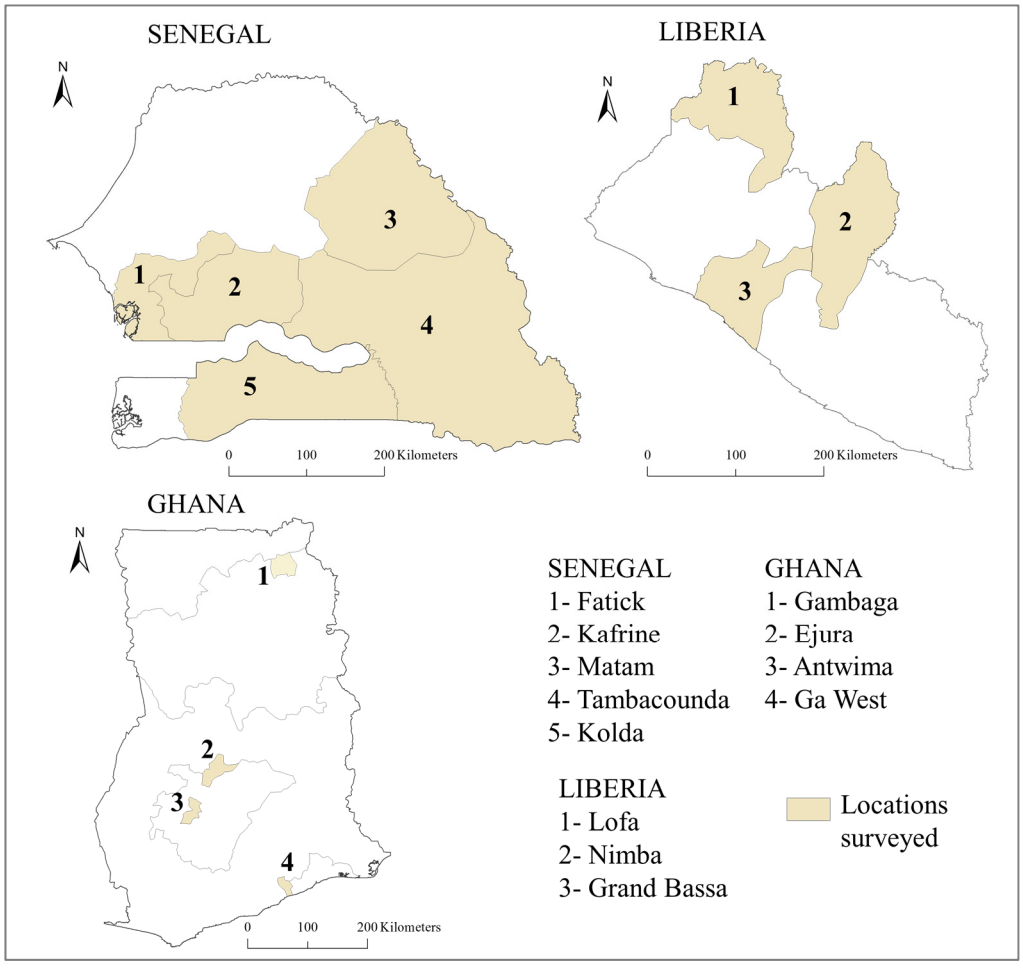

Figure 1. Maps presenting the locations surveyed in Ghana, Liberia and Senegal.

2.2. Theoretical Approach

In sub-Saharan Africa, rural populations are often reported as the most affected by poverty [4]. For that reason, the rural communities are frequently targeted by studies related to food security and poverty reduction. Likewise, this study investigates rural households and addresses relevant aspects

including the distribution of agricultural assets, households' incomes and food security. The study estimates the annual incomes of individual households based on the reported endeavors of the year 2012. The data on these endeavors were collected during the survey, then used to estimate the production cost and the revenues of the households for the year 2012. In general, the total income of each rural household comprises both farm and nonfarm incomes as shown by the Equation (1).

$$\begin{aligned}\text{Household's Income} = \text{Revenue from Crops} + \text{Revenue from Livestock} + \\ \text{Nonfarm Income} - \text{Cost of Production}\end{aligned} \quad (1)$$

In practice, the World Bank defined an international poverty line as US$1.90/day at 2011 purchasing-power parity [10]. Although this indicator may inform on the likelihood to food accessibility, it seems problematic to define the food security status based on income thresholds. Indeed, the inter-regional discrepancy of food prices is such that an income insuring food security in a given location may not be sufficient for the same purpose in a different location. Furthermore, the concept of food security has been diversely interpreted over the time [11]. Hence, Maxwell [12] and Mechlem [13] reported the existence of more than 200 definitions for food security and 450 indicators used to evaluate the level of food security. However, the contents of these definitions and indicators often overlap.

In 1996, the world food summit defined food security as a situation when all people, at all times, have physical and economic access to sufficient safe and nutritious food to meet their dietary needs and food preferences for a healthy and active life [14]. Since, some terminologies included in that definition have been clearly debated and discussed. For instance, Mechlem [13] asserted that the definition proposed by the world food summit was more oriented to the right to food. According to Pinstrup-Andersen [11], the terms "food preference" and "safe and nutritious" included in the world food summit's definition may not be appropriate as their interpretations depart from the basic meaning of having access to enough food. At the household level, Pinstrup-Andersen [11] extended the notion of food security to an intra-household view in order to distinguish food allocation based on the need of each individual. This later conception of food security seems practical to reveal cases of undernourishment and temporary food insecurity status in a household. However, in the context of large-size households, Pinstrup-Andersen [11] highlighted the difficulty to describe a household as food insecure just because a single member is undernourished. Nevertheless, some definitions are more accepted and are thereby utilized to provide statistics on the phenomenon. Hence, the FAO's report on food insecurity in Western Africa indicates that the proportion of undernourished population during the period 2010–2012, represents 5.6% of the population in Ghana, 14.3% in Senegal and 34.7 in Liberian [15].

At the state-of-the-art, it is difficult to come out with one universal standard list of indicators for food security. Thus, in food security studies, the identification of indicators of food security often requires the ability and sense of the researchers. The present study measured food security status by emphasizing food allocation behavior and the households' capacity to acquire food. The questions listed in Table 1 were utilized to address the food security status in each household surveyed. However, the food security status of a given household was characterized through a scoring process. The surveys addressed five queries to each of the households. Then, the study considered a household as food insecure when at least two of the five questions addressed received a positive answer. The responses to the questions were equal weighed with a score of "1" and "0" as presented in the Table 1. Finally, each respondent was characterized as food secure (event "1") when the total score was below 2/5, otherwise the household was considered food insecure (event "0"). Such binary formulation allowed to apply a multivariate logistic model where the independent variables were related to agricultural assets. Yet, agricultural assets refer to all the factors contributing to the production and management of crops or livestock [16]. In the case of rural households, agricultural assets encompass a wide range of factors including land holdings, livestock, storage facilities (garners), machineries and technology usage (tractors, fertilizers, irrigation systems). However, the logistic model frame reported in this study involved only representative variables such as land size and technology usage (tractor, irrigation, fertilizer).

Glonek and McCullagh [17] emphasized the relevance of the multivariate logistic model for analyzing the joint distribution of a binomial response to its predictors. Actually, high unequal distribution of resources will later be demonstrated for the sampled households (Sections 3.1 and 3.2). Indeed, the inequality of agricultural assets distribution indicated a skewness of the independent variables which failed the Gaussian fitting test (Kolmogorov–Smirnov test with p-value = 0.05). In such case, Finney and Stevens [18] suggested the use of logit model, and this justifies it use in this study. The predicting variables tractor, irrigation, and fertilizer were assigned a binary form as well ("1" for "yes" and "0" for "no"). Meanwhile, the land size is normalized and used as a quantitative variable in the model. By defining p as the probability of getting food security event "1", the multiple logistic regression model is given by the Equations (2) and (3).

$$Logit\,(p) = Log\left(\frac{p}{1-p}\right) = \alpha T + \beta I + \gamma F + \delta L + \varepsilon \tag{2}$$

In terms of probability, the equation above becomes:

$$\hat{p} = \frac{Exp\,(\alpha T + \beta I + \gamma F + \delta L + \varepsilon)}{1 + Exp\,(\alpha T + \beta I + \gamma F + \delta L + \varepsilon)} \tag{3}$$

T = tractor; I = irrigation system; F = fertilizer; L = land size; α, β, γ, δ and ε are the model parameters.

Table 1. Queries considered for assessing the food security status of each of the 1483 households (HHDs).

Query	Scoring Criteria
During the past 5 days, did the family members have insufficient food?	"1" = yes; "0" = no
During scarce seasons does the household reduce the number of meals per day?	"1" = yes; "0" = no
During the last 12 months how long did the household rely on less quality and variety of food?	"1" if >30 days; "0" otherwise
During the last 12 months, was there ever no food to eat in the household?	"1" = yes; "0" = no
During the last 12 months, did any member in the household slept hungry because there was not enough food?	"1" = yes; "0" = no

3. Results

3.1. Agricultural Assets

As mentioned earlier in the methodology section, the variables considered for agricultural assets in this study are the total size of lands exploited by individual household, and the use or not of specific agricultural technologies including tractors, fertilizers and irrigation. Actually, the land is essential for agriculture and represents the main factor of production in rural households [19]. However, the rate of population growth in the sub-Saharan region has exacerbated the pressure on land resources during the last decades. This section of the paper reports the distribution of land resources among the surveyed households. Specially, Figure 2 presents the box–whisker plots of lands in Ghana, Senegal and Liberia distinctly. In the plots, the land sizes were normalized using a z-scores transformation. This normalization was performed in order to ease the comparative analysis among the three countries. Given a country k, a household i having a land size value $V_{k,i}$, the score was computed using the Equation (4).

$$z - score_{k,i} = \frac{V_{k,i} - \overline{V}_k}{\sigma_k} \tag{4}$$

where $\overline{V}_k$ represents the mean and σ_k the standard deviation of the land sizes of the surveyed households.

With the *z*-scores normalization, the country level data were attributed a standard deviation of one and a mean of zero. This made the inter-regional comparison possible. From the box–whisker plots (Figure 2), one can easily infer on the unequal resources access in each of the countries. However, disparities are also remarkable from one country to another and this is confirmed by the estimated shape coefficients (i.e., skewness and kurtosis) of lands distribution among the households in each country: for Ghana (skewness = 7.4; kurtosis = 92.2), for Senegal (skewness = 2.8; kurtosis = 11.4), for Liberia (skewness = 6.3; kurtosis = 49.5). Notice that the distributions are all positively skewed, indicating a very unequal land resource distribution among the surveyed households. However, this inequality is also noticed in relation to the distribution of technology assets (irrigation, tractors, fertilizers).

For the surveyed households in Liberia, the endowments related to agricultural technologies seem very low; irrigation system usage (5%), tractor usage (0%) and fertilizer usage (9%). In Ghana, these endowments are relatively more important among the surveyed households; irrigation system usage (12%), tractor usage (51%) and fertilizer usage (81%). The situation is intermediate among the households surveyed in Senegal; irrigation system usage (5%), tractor usage (2%) and fertilizer usage (43%).

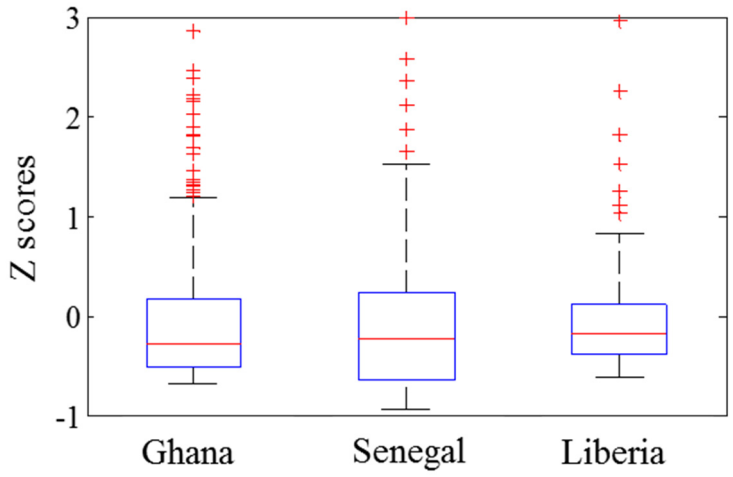

Figure 2. Boxplot of farm assets distribution among households using the *z*-scores.

The land tenure distribution among the households surveyed in each of the three countries is presented by Figure 3. Notice that only 26% of the households surveyed in Liberia owned their lands, while this percentage is 46% in Ghana and 69% in Senegal. In addition, only a low percentage of the households have official documents attesting their land ownership title as presented in Table 2 (5% in Ghana, 2.5% in Senegal, 11.5% in Liberia). As one could notice, the percentages of title ownership matches the percentages of households buying lands (5% in Ghana, 2.5% in Senegal, 11.5% in Liberia). This shows that households buying lands constitute a determinant factor for official title documents procession in the studied communities. In such context, the land tenure right may explain, in part, the low investment in agricultural technologies. Indeed, Goldstein and Udry [20] reported a consistent relationship between land tenure rights and farmers investment. Although 51% of the households in Ghana use tractors for their farm activities, only 4% of those users are tractor owners. The rest of the farmers have access to the tractor services through rental. This model of renting tractor services probably suits better with the socio-economic context of sub-Saharan communities where the cultivated plots are relatively restricted to few acres per household and only the farmers with sufficient financial resources are capable of buying a tractor.

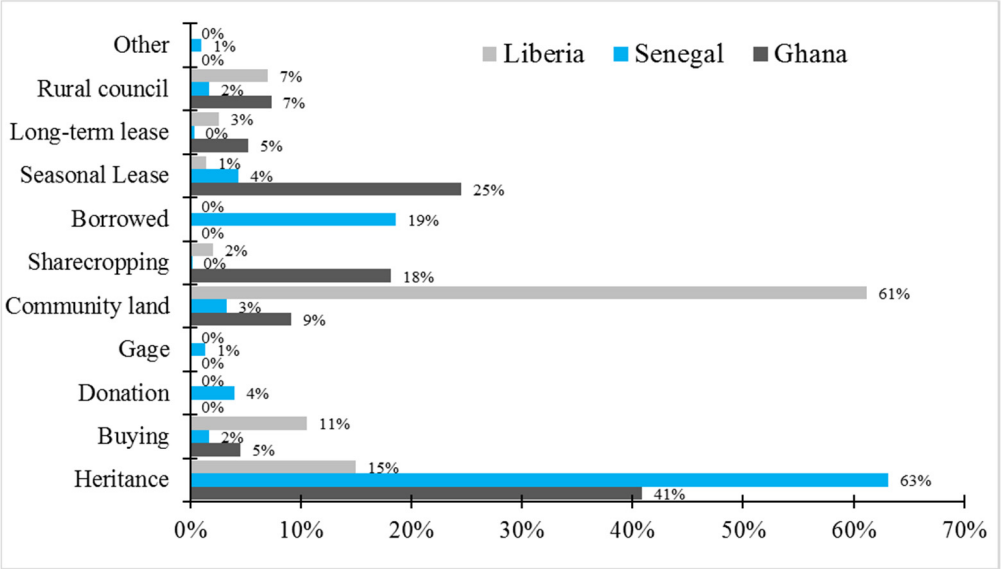

Figure 3. Land tenure distribution among the households surveyed in Ghana, Senegal and Liberia.

Table 2. Overview of land holding right (ownership title) and the average land size exploited per household. The ownership title indicates the percentage of households holding official documents which attest their ownership of their lands.

Country	Total Lands Exploited by Household		Ownership Title (%)
	Average (ha)	St. Dev. (ha)	
Ghana	3.9	6.4	5.0%
Senegal	4.0	4.3	2.5%
Liberia	1.8	2.7	11.5%

Note, St. Dev. stands for standard deviation.

3.2. Income Distribution

This section reports the actual distribution of the total incomes among the surveyed households. The nonfarm components of these incomes are detailed in the next section (i.e., Section 3.3). The result of the income estimate using Equation (1), indicated for the surveyed households in Ghana an average of 1735 USD, 1344 USD for those in Senegal, and 926 USD for those in Liberia. Figure 4 portrays the overall estimated incomes and production costs for 326 households in each of the countries. This number of 326 households is only considered for consistency purposes such that the three countries could be easily compared. Actually, all the households in Liberia (326) were considered, but for Ghana and Senegal, a sub-sampling was proceeded by randomly selecting 326 households within the original samples for which sizes were larger. In Figure 4, the overall cost of production appears very high in Liberia (Figure 4b) compared to Ghana (Figure 4a) and Senegal (Figure 4c). However, this does not reveal the actual income distribution among the surveyed households.

Figure 5 exemplifies the unequal income distribution among the surveyed households in Ghana, Senegal and Liberia. Indeed, the Lorenz curves of the income distribution (Figure 5) depart remarkably from a diagonal line, indicating a high inequality of income distribution. For instance, 80% of the incomes are shared by the upper 22% of households in Liberia while the same percentage of incomes is shared by the upper 30% and 33% of households respectively in Senegal and Ghana.

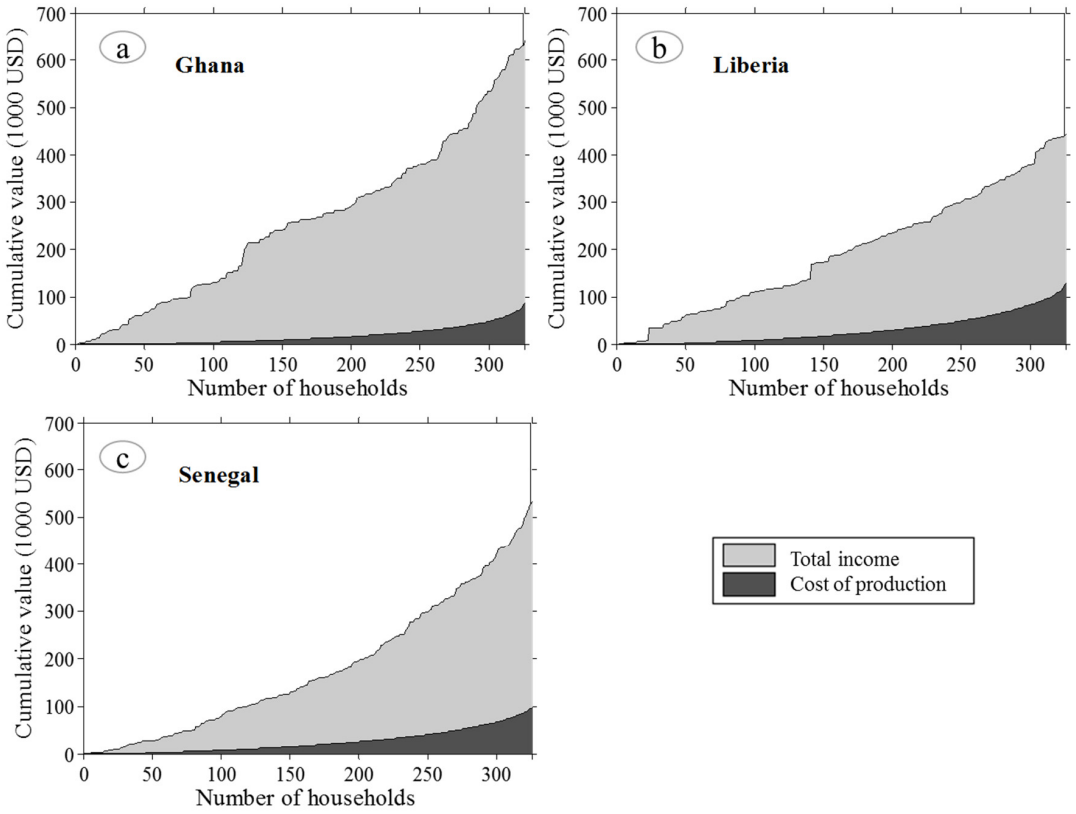

Figure 4. Comparative analyses of income and costs of production based on 326 households randomly selected in each of the three countries (Ghana, Senegal and Liberia). The Liberia sample size is conserved (326 households), while the original samples in Ghana and Senegal were sub-sampled. The cumulative values were computed by ranking the production costs from the lower to the larger value. Figure 4a–c illustrate respectively the contrast within the households in Ghana, Liberia and Senegal.

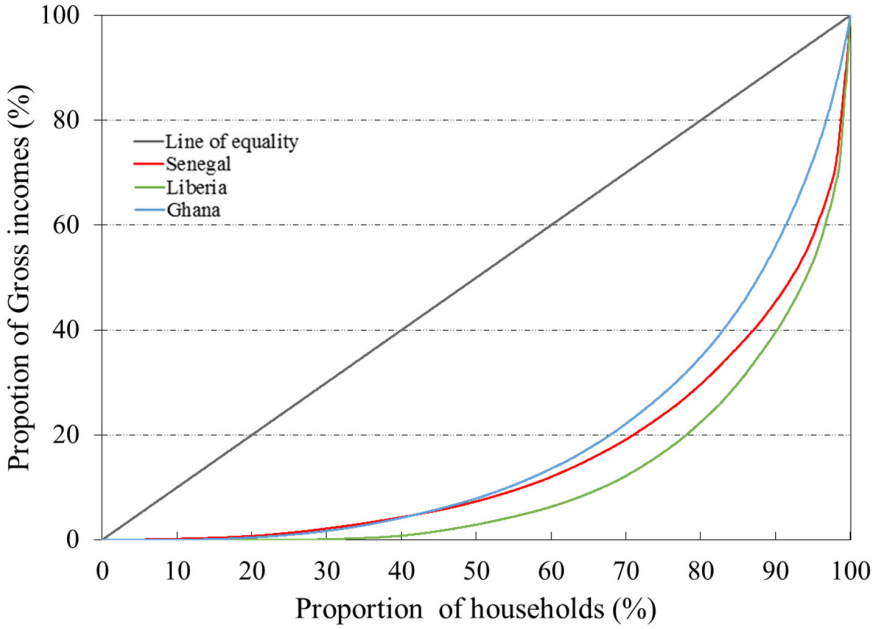

Figure 5. Lorenz curves for income equality among the 1483 households surveyed in Ghana, Senegal and Liberia.

3.3. Nonfarm Incomes

Nonfarm incomes are those generated by the endeavors which are not related to agriculture or farm exploitation [21]. Nonfarm incomes also include remittances which the households receive periodically or occasionally from individuals living inside or outside the community [22]. The importance of nonfarm incomes varies depending on the regions and the households. In the case of the households surveyed during this study, the type of activities generating the nonfarm incomes included fire wood exploitation, wood–charcoal production, bush meat trade, traditional salt production, etc. Unfortunately, these listed nonfarm endeavors do not necessarily comply with the scope of a sustainable development in the rural communities. For instance, the majority of the households involved in fire wood exploitation rely on the natural forest resources. However, this exploitation is often practiced without a strict control, and is thereby causing damages to the local flora and the environment [23]. Concerning the bush meat trade, this activity relies on hunting wild animals and is particularly reported by households in Liberia. Yet, the non-compliance with hunting regulations and controls is very common in the rural communities. This is probably due to a lack of awareness regarding the long-term consequences on wildlife diversity and public health. Regarding traditional salt production, the practice was particularly noticed in the rural households surveyed in Senegal (Fatick region). The practice consists of drying saline water on the shore. In the long-term, this practice resulted in a soil salinization which was very remarkable as several acres of lands were affected and became improper for agriculture. In sum, the magnitude of the environmental damages associated to the nonfarm activities reported in the surveyed households are critical and worthy of attention.

Overall, the contribution of nonfarm incomes is variable in the rural communities. Only 18% of the households in Liberia reported incomes from nonfarm opportunities. This percentage is higher in Ghana (42%) and Senegal (59%). Similarly, the average incomes emanating from nonfarm opportunities vary very much from one country to another. Among the households which reported nonfarm incomes, the average weight of the nonfarm income in Senegal was 43% of their total income and this value is nearly double those in Ghana (21%) and Liberia (26%). To better understand this paradigm, it is important to recall that Senegal is a country with one of the highest migration rates in Africa [22]. Hence, an important part of the nonfarm incomes of several households in Senegal are in terms of remittances coming from relatives living in foreign countries.

3.4. Food Security Analysis

Based on the food security indicators listed in Table 1 and the scoring procedure outlined in Section 3.2, 54% of the surveyed households in Ghana were found to be food secure (event "1") while this percentage was 37% and 12% for the surveyed households in Senegal and Liberia respectively. In the analysis, the study defined the dependent variable as "1" if the household is characterized as food secure and "0" otherwise. Unsurprisingly, there is a positive link between the total income and the food security status of the household. However, what seems unusual is the relationship between nonfarm incomes and the food security status of the surveyed households (Table 3). Indeed, Table 3 presents the probabilities for a household to be food secure, given different thresholds of nonfarm incomes. These probabilities are particularly higher in Liberia, intermediate in Senegal, but relatively lower in Ghana. This means that the nonfarm incomes play a critical role in the food security status of the surveyed households in Liberia.

Table 3. Probability for a household to be food secure given different thresholds of nonfarm incomes. The designation of food security status for a household is described in Section 2. In sum, the table describes the conditional probability $p(Food\ Secure/Weight\ of\ Nonfarm\ Income)$.

Weight of Nonfarm Income	Ghana	Senegal	Liberia
0–25%	0.47	0.64	0.87
>25%	0.57	0.60	0.93
>50%	0.58	0.60	0.89

The results of the multivariate logistic model are presented in Table 4. Note, in the logistic model, the number of events per predictor variable is above the minimum line of 10, justifying the adequacy of the statistical approach [24]. From these results (Table 4), one may notice consistent differences within countries. For instance, the logistic model is overall significant in Ghana and Senegal (p-value < 0.001) while in Liberia the model is not significant. Furthermore, in Ghana and Senegal, the use of agricultural technologies (such as irrigation system, fertilizer) tends to significantly affect the food security status of households. On average, a household using an irrigation system has a 2.8/1 odd to be food secure in Ghana and 9/1 chance in Senegal. When a household uses fertilizers, the odd for this household to be food secure is 1.53/1 in Ghana and 1.74/1 in Senegal. Paradoxically, the use of a tractor did not show significant relationships in any of these two countries. However, the pooled analysis indicates a significant effect of tractor usage. In fact, this should be interpreted as an inter-regional pattern due to the fact that the tractor users are represented in Ghana and Senegal and these two countries have a larger proportion of food secure households. The non-significant results obtained with Liberia households raise awareness regarding inter-regional dissimilarities. Indeed, the socio-economic context in Liberia is much different from that in Ghana and Senegal. While the poor use of agricultural technologies seems to be consistently reported in the households, the results suggest more caution regarding the generalization of inferences from the pooled analysis which may hide prominent inter-regional discrepancies.

Table 4. Logit estimate of the impacts of land size, the use of irrigation system, the use of fertilizer, the use of a tractor on households' food security status. The multivariate logistic model was applied to each country separately and later to the three countries together (pooled).

Country	Variable	Model Coefficients	Odd Ratio	Odds Ratio 95% CI	Sample Size	Model's p-Value
Ghana	Land Size	0.08	0.86	(0.62, 1.34)	647 HHDs	<0.001
	Irrigation	1.02 **	2.78	(1.59, 4.86)		
	Fertilizer	0.64 **	1.53	(1.34, 2.83)		
	Tractor	0.10	1.11	(0.78, 1.56)		
Senegal	Land Size	0.23 *	1.26	(1.03, 1.53)	509 HHDs	<0.001
	Irrigation	2.20 **	9.00	(2.97, 27.25)		
	Fertilizer	0.56 **	1.74	(1.17, 2.59)		
	Tractor	0.85	2.34	(0.54, 10.20)		
Liberia	Land Size	0.17	1.19	(0.93, 1.51)	326 HHDs	0.35
	Irrigation	−0.97	0.38	(0.05, 3.01)		
	Fertilizer	0.43	1.54	(0.55, 4.34)		
	Tractor	-	-	-		
Pooled	Land Size	−0.03	0.97	(0.87, 1.09)	1483 HHDs	<0.001
	Irrigation	1.02 **	2.79	(1.85, 4.20)		
	Fertilizer	0.71 **	2.03	(1.59, 2.61)		
	Tractor	0.34 *	1.41	(1.06, 1.86)		

Significance level: * p-value < 0.05, ** p-value < 0.01; LR = model's likelihood ratio, HHDs = households.

4. Discussion

In general, agricultural practices in sub-Saharan Africa suffer several deficiencies which likely explain the low profitability of the agricultural sector [25]. Yet, prior studies emphasized the possibility of using agricultural technologies as a solution to improve the production and thereby reduce poverty [25,26]. The outcomes of the present study align with this general assertion as the results show that the usage of fertilizer and irrigation systems has a significant effect on the food security status of the surveyed households. However, the study highlighted a critical disparity of agricultural technologies among the three countries. Particularly, the use of a tractor for farm activities was not observed among the households surveyed in Liberia, whilst in Ghana 51% of the surveyed households

use tractors for their farm activities. This observation is probably due to the labor cost in each country. To put it another way, one may assume that the labor cost in Liberia is probably lower than the cost of using tractors. However, such an assertion may not be absolutely true because the use of tractors was also minor in Senegal (2%) whilst the average incomes of several households in Senegal were comparable to those in Ghana. Actually, in Ghana, the surveys show that the upper-level income households (4%) are the ones that acquire tractors and lease them to the middle- and low-level income households. However, the situation in Liberia is different owing probably to the general social and economic realities of the country. This observed paradigm seems to align with Oke et al. [26] who concluded that the technology usage in sub-Saharan communities depends also on the prior economic environment. Moreover, Christiansen and Demery [27] reported that sociological factors such as education level, culture, religion, and geo-political situation consistently affect the adoption of technologies [27]. Unfortunately, this study did not address these social factors, but the results are worthwhile as they build on the previous knowledge.

The Lorenz curves of farm assets (Figure 5) exemplified the high unequal distribution of resources among the surveyed households. It appeared that the large part of the resources (80%) is controlled by almost 30% of the sampled households. Thus, Christiansen et al. [3] asserted that development strategies aiming to improve agriculture assets distribution are expected to be more beneficial to the poorer classes in sub-Saharan Africa. Furthermore, Harris and Orr [28] emphasized the potentiality of new technologies to play a determinant role in poverty reduction in sub-Saharan Africa where agriculture represents the main activity sector. For instance, significant differences exist between households using an irrigation system and those relying absolutely on rainfalls. Indeed, rainfed agriculture is likely vulnerable to climatic hazards (e.g., drought) which often cause crop failures and production losses.

In Ghana, Senegal and Liberia, crop seasons, also known as rain seasons, last 4 to 6 months a year, depending on the agro-ecological region. These rainy months represent the main working period for the farmers. Outside the crop seasons, farmers have few alternatives and rely very much on harvests from the rainy seasons. Incorporating appropriate technologies such as irrigation systems, may significantly increase farm opportunities outside the boundary of the regular rainy seasons, and generate additional revenues for rural households. However, it may be difficult to achieve such an objective without considering wisely local socio-economic and political contexts. Yet, Beck and Nesmith [29] supported that the understanding of communities' perception of their own livelihood status is critical for the success of development projects. Fortunately, from the results of the present study, it can be inferred that there is room for improvement in several aspects of agricultural practices in the surveyed households. This is true with agricultural fertilizers (organic, non-organic), which are virtually under-used by the households. However, in the long-term, this under-use is likely to exacerbate soil quality depletion.

According to Christiansen et al. [3], the contribution of agricultural growth on poverty reduction is up to five times greater compared to other economic sectors. To demonstrate this assumption, Christiansen et al. [3] considered two scenarios of gross domestic product (GDP) growth, one with 1% growth in agriculture and alternatively the second with 1% growth in non-agricultural sectors. They found that the 1% growth of agricultural GDP would have a five-fold impact on poverty reduction compared to the non-agricultural sector. More interestingly, Christiansen et al. [3] reported that the investment toward this 1% increase is lower for agriculture compared to non-agricultural sectors. Their finding corroborates very much with the outcomes of this study which outlined the positive effect of agricultural technologies on the food security status of the surveyed households in Ghana, Senegal and Liberia. However, it is important to also highlight several limitations in this study. For instance, the study did not address factors such as soil quality, climate change and the access to credits which are likely to also interplay with food security in the communities. In addition, the sample sizes were limited and the results should be more associated to the context of the studied communities.

5. Conclusions

The present study reports highly unequal distribution of agricultural assets and incomes among rural households surveyed in Ghana, Senegal and Liberia. Using defined indicators of food security, the study outlined patterns of food insecurity among the households surveyed. However, the application of the multivariate logistic model analysis revealed the positive effect of agricultural technologies usage (i.e., tractor, fertilizer and irrigation systems) on the food security status of the surveyed households in Ghana and Senegal. However, the effect was not statistically significant among the households surveyed in Liberia. Thus, generalizing conclusions for the entire study region may be misleading because a model that works for rural households in Ghana and Senegal may not be systematically applicable for those in Liberia. This contrast suggests critical inter-regional disparities among rural communities and this finding aligns with previous studies conducted in sub-Saharan Africa [29]. However, the large discrepancy of agricultural assets and income distribution observed among households is probably the consequence of complex social and political factors which are not addressed in this study. Although the scope of the study is not to generalize findings at the national levels, the results reported indicate the potentiality of improving food security through an adequate use of agricultural technologies. Ultimately, this study recommends improving the agriculture sector to reduce poverty and improve food security in the rural communities studied [3]. However, the variabilities noticed among the studied communities are indications of the prominence of integrating local insights while addressing questions related to food security.

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