INVEST SALONE

The Cashew Sector in Sierra Leone

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CONTENTS

Abstract

A scientific survey of raw cashew nuts (RCN) in Sierra Leone was undertaken to estimate size of the sector (number of farmers, yield, area) and to describe the cashew farmers and farms. A new "atlas" of Sierra Leone delineating all districts, chiefdoms, and sections (parts of chiefdoms) was compiled using maps from 2019. All sections were assigned by government experts to one of four strata based on anticipated cashew abundance. A systematic sample of sections in each stratum was selected (*n* = 186) including sections from all districts. Selected sections were visited to identify all villages with cashew, and each of these villages was visited. Surveyors determined the number of cashew farmers and interviewed as many as possible asking questions about farm size, yield, age of trees (henceforth farm age), and management methods. A sample of farms was also visited so surveyors could make their own judgements, especially about management methods. Many sections had no cashew farmers, especially in the south, but interviews were conducted in 60 chiefdoms, 86 sections, and 309 villages, and surveys were made on 432 farms. We also collected samples of dried RCNs (*n* = 45) and analysed them recording nut count, kernel outturn ratio (KOR), and number of "good" kernels/lb. Standard survey sampling methods were used to analyse the data. Major findings (applicable to 2021) included:

- Sierra Leone has an estimated 8,422 cashew farmers (CV = 0.19, 85% CI 6,000–10,000). Their farms cover 226 km^2 (an area of approximately 15 x 15 km).
- Yield in 2021 was approximately 772 tonnes. enough to fill 31 40-foot containers. Many trees have been planted in the past three years. Within three years, as they become productive, yields will increase to more than 1,000 tonnes, enough to fill 41 containers.
- Mean reported yields (tonnes/ha) were 0.07 (4–5 years), 0.10 (7–10 years), and 0.12 (11–22 years). In contrast, neighbouring countries report yields that are 5–15 times higher. The reasons for this large difference are unclear. Increasing yields in Sierra Leone should be feasible and should be given high priority.
- The RCNs are of remarkable quality: having nut counts, KORs, and good nuts/lb in the "exceptional, suitable for export" category. Sierra Leonean producers should make the most of this.

Taken together, these findings show that cashew nuts can become one of Sierra Leone's major export products assuming that companies deal professionally, especially with farmers and buyers.

Introduction

Although other reports on the cashew sector in Sierra Leone, such as those by Invest Salone (2020) and the European Commission (2019), contain many valuable insights, the authors were not able to undertake rigorous surveys to estimate parameters such as the number of cashew farmers, yield, and area in production. Nor were they able to interview farmers to estimate replanting rates, survival of replanted seedlings and frequency of various management methods. This study was undertaken to augment the previous work by conducting a statistically valid survey of the cashew sector in Sierra Leone.

We surveyed cashew farmers throughout Sierra Leone during March and April 2022. The main goals were to (1) estimate the number of cashew farmers in Sierra Leone, (2) estimate the amount of raw cashew nuts they produced in 2021 and (3) describe the quality of the RCNs. Secondary goals describing the area in cashew production, the condition of cashew farms, the cashew farmers (age, gender, experience). We also hoped to make recommendations for improving the quantity and quality of the cashew crop and to help cashew farmers improve their living conditions.

Methods

Design

The "population unit" used was a cashew farmer defined as an individual who manages a farm containing cashew trees of any age. The statistical population was all cashew farmers in Sierra Leone. To select farmers, we defined "primary sampling units" each of which was all the farmers in one section (i.e. part of a chiefdom). The sampling plan required that we have a map of all sections in the country. We used district maps, mainly prepared in 2019, to delineate sections. Although the district maps were in digital form they were images of paper maps that could not be used for GIS analysis. We therefore converted them to GIS format and combined them into an "atlas" of Sierra Leone showing district, chiefdom, and section borders as re-drawn in 2017. The atlas has 1,243 sections.

Experts from the Ministry of Agriculture classified the sections (except in Pujehun) using the categories

0 = few or unknown number of cashew farmers
1 = low number of cashew farmers
2 = medium number of cashew farmers
3 = high number of cashew farmers

All the sections in each category were each defined as a stratum. We selected sections to survey within strata using one-stage (systematic) sampling (details in Table 1).

Within selected sections, surveyors first identified the villages with cashew farmers by talking with community leaders. They then visited each of these villages and determined the number of cashew farmers. The surveyors interviewed all the farmers they were able to locate and who were willing to take part.

We recognise that some boundaries have changed since 2019 (or were portrayed incorrectly on the 2019 maps), but this does not affect the validity of the section map for our purposes; it was intended only to partition cashew farmers into groups (the farmers in each section).

Data collection

We prepared an overview map for each district (Fig. 1), showing the major features and the sections to be surveyed. The maps were extracted from the Sierra Leone Tourist Map (Figs. 2, 3) to help staff find each section. We also prepared detailed maps (Fig. 4) of the sections, showing villages and roads.

Table 1. Design of the survey

Stratum	0	1	2	3	Total
Stratum size	999	74	83	87	1,243
Fraction of population	0.80	0.06	0.07	0.07	1
Sample size	93	14	26	53	186
Sampling fraction	0.09	0.19	0.31	0.61	-

Figure 1. Example of a map showing sections to be surveyed in a district

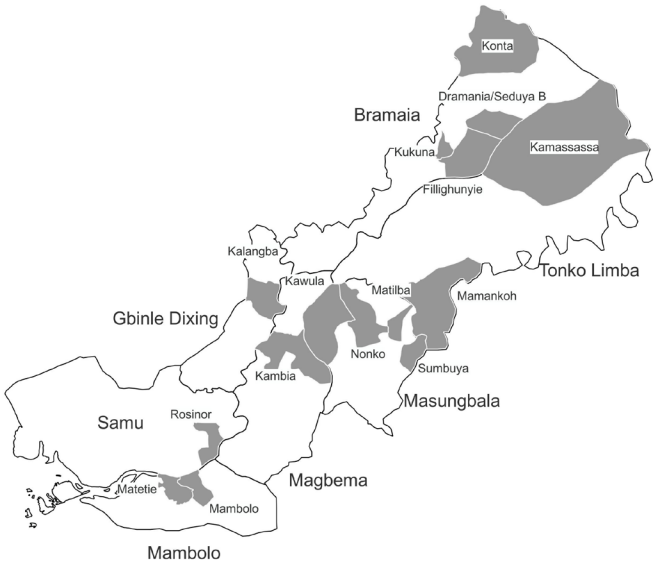


Figure 2. Section from Tourist Map of Sierra Leone showing major roads and towns and the selected sections

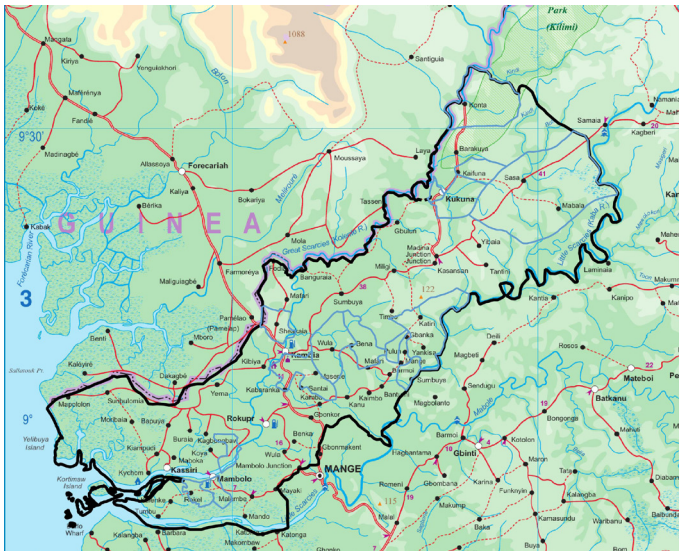


Figure 3. Sample section from Tourist Map of Sierra Leone provided to help surveyors find the sections

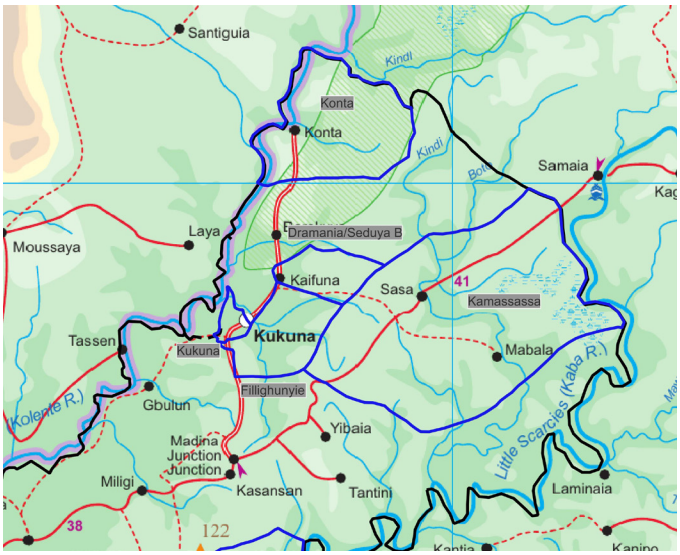


Figure 4. Sample section map (source: Open Street Maps)

Data were collected by seven long-time Village Hope staff all of whom have conducted surveys for us and worked in the cashew sector. All were Sierra Leone residents and together spoke all the local languages.

The survey (see Appendix) collected general information (farmer name, location, age, sex, certifications); information about the farm (size, year planted, source of planting material, survival of seedlings); management practices (brushing, pruning, fire belts); pest control (species, severity, control methods); yield and sales (total yield, buyers, prices received); other crops grown and detailed information about the farm (coordinates of each corner, tree spacing and size, extent of brushing, shade, and variety).

Upon entering a section, surveyors first talked to community leaders such as the Section Chief, Village Chief or Youth Leader to introduce the project and learn which villages in the section had cashew farms. They usually asked three or four people with long experience in the section. They then visited each village that any of those interviewed thought might have cashew farms. In the villages, they made a list of all cashew farmers and attempted to interview them all. They recorded the number of cashew farmers they could not interview. When the interviews were done, they made a list of farm sizes, separating them into equal sized groups: small and large. They then randomly selected one farm in each group and carried out the survey, recording data on their phones. The two selected farms were then visited to complete the survey (part eight of the survey). The team leader entered all the data within a few days of collection and forwarded it to the Principal Investigator at least once a week.

Samples of RCNs were obtained whenever possible from the farmers we visited. We then determined nut count, the KOR, and the number of "good" cashews/lb for each sample. After the initial nut count, we removed the ten smallest kernels (determined by visual inspection) and re-calculated the nut count (1,000 g/mean weight of the remaining RCNs) yielding a sample we called NC-10, We repeated the process twice more obtaining NC-20 and NC-30. The objective was to determine how much the nut count could be improved by removing small RCNs (which, in practice, would be sold to other buyers). We also attempted to identify the defective RCNs from external characteristics.

Analysis

Our notation follows the classic text *Sampling Techniques* by Cochran (1979).

The sampling plan and analytic methods differed for different subsets of the data.

Number of cashew farmers in the country, F. The sampling plan was stratification followed by one-stage (systematic) sampling.

Let

f_{hi} = number of cashew farmers in section *i* of stratum *h*.
n_h = number of sections surveyed in stratum *h*
$\bar{f}_h$ = mean of the f_{hi} in stratum *h*
N_h = number of sections in stratum *h*

The estimate was

$$\hat{F} = \sum_{h=0}^{4} N_h \bar{f}_n \quad (1)$$

With estimated variance

$$v(\hat{F}) = \sum_{h=0}^{4} N_h^2 \frac{s_h^2}{n_h} \quad (2)$$

and coefficient of variation (*CV*),

$$CV(\hat{F}) = \frac{SE(\hat{F})}{(\hat{F})} = \frac{\sqrt{v(\hat{F})}}{(\hat{F})} \quad (3)$$

We calculated 85% (rather than the customary 95%) confidence intervals (CI) because only an approximate estimate is needed. We may interpret results by saying that we have moderate (i.e., 85%) confidence that the true value lies within the confidence interval. The 85% CI for an estimate, *x*, is $x \pm 1.44x\ CV(x)$.

Other national totals. We also estimated yield, $\hat{Y}$; area (ha) planted with cashew, $\hat{A}$; and the number of cashew trees, $\hat{T}$. For these estimates, we did not know the totals within sections, we only had estimates. The sampling plan was thus stratification followed by two-stage sampling: selection of sections and then selection of farmers within sections. The number of farmers per section and the number of farmers interviewed per section both varied substantially. Several different analytic approaches are available for this case. We explain our approach using yield.

Total yield, Y, may be expressed as the sum of yields within strata which may each be expressed as number of farmers multiplied by the mean yield/farmer.

$$Y = \sum_{h=0}^{3} F_h \overline{Y}_h \quad (4)$$

This expression suggests the estimate

$$\hat{Y} = \sum_{h=0}^{3} \hat{F}_h \hat{\overline{Y}}_h \quad (5)$$

Calculation of $\hat{F}$ is discussed above. For $\hat{\overline{Y}}_h$, we used the simple mean of the reports in each stratum. Use of this estimate ignores the possibility of a relationship (i.e., covariance) between number of farmers in the section and their average yield. Note, however, that we have already partly accounted for such variation by calculating separate estimates for each stratum (which differ by farmer numbers). We assume that any residual covariance between yield and farmer numbers is small enough to be ignored for practical purposes.

The estimate was thus

$$\hat{Y} = \sum_{h=0}^{3} \hat{F}_h \overline{Y}_h \quad (6)$$

With estimated variance

$$v(\hat{\overline{Y}}) = \sum_{h=0}^{3} \hat{F}_h^2 \left(\frac{s_h^2}{n_h} \right) \quad (7)$$

where $\overline{y}_h$ is the simple mean of the observations in stratum h, n_h is the number of observations in stratum h, and s_h^2 is the sample variance of the observations. The SE and CV are estimated as above (equation 3).

District estimates. We also wanted estimates for the major cashew-growing districts, Kambia, Port Loko, Karene, Bombali, and for all other districts. Obtaining separate estimates for such small areas presented a problem because we did not have interviews in all strata in each of these districts. We therefore treated interviews in each district as a one-stage sample and used the simple mean as the estimate.

For proportions, we coded the data as 1 = "success" (e.g., farmer is under 30) or 0 = "otherwise" and used the mean of these data as the estimated proportion. Estimated totals were calculated as the estimated mean multiplied by the estimated number of farmers in the district.

Data management. The survey data were placed in an Excel workbook with tables describing the survey and three data tables:

- *Sections*, with one row for each section and estimated totals for the section such as number of cashew farmers.
- *Farmers*, with one row for each farmer interviewed and columns for each question (see Appendix) and for some derived variables such as 1 = farmer is under 30 years old, 0 = otherwise.
- *Farms*, with one row for each survey of a farm made by our staff.

The RCN data were placed in a separate Excel workbook with a separate sheet for each sample of RCNs containing all the calculations and a summary sheet. Both workbooks are available with this report.

Results

We conducted 1,333 interviews, 81% of them in the four cashew-rich districts. Many of the selected sections did not have any cashew farmers, especially in the south, but we conducted interviews in 13 districts (Kailahun and Western Area did not have any cashew farmers in the selected sections), 60 chiefdoms, 86 sections, and 309 villages. We also surveyed 432 farms.

Sector

Number of cashew farmers. The estimated number of cashew farmers was 8,422 (CV 0.19). The average number of farmers per sector increased from 5 in stratum 0 to 21 in stratum 3 showing that the stratification was effective. The within-stratum variance in stratum 0 was more than ten times the other within-stratum variances. This indicates that even though 50% of the sample came from stratum 0 – in which we expected to find virtually no cashew farms – precision would have been increased by devoting an even higher share of the effort to stratum 0. The 85% confidence interval was roughly 6,000–10,000. Nearly 60% of the cashew farmers are in stratum 0, showing how important it was to include these areas (we initially planned to exclude them to reduce costs). Only about a fifth of the farmers are in high-density cashew areas. If higher precision were needed, it would be straightforward – and entirely legitimate – to gather more data from stratum 0. Surveying 200 more sections in stratum 0 would cost less than $5,000 and would reduce the overall CV to 0.12.

We also estimated the number of cashew farmers per district. The estimates have low precision due to small sample sizes, but they clearly identify the major cashew-growing areas, including the three most important districts (Kambia, Karene, and Port Loko).

Table 2. Estimated number of cashew farmers in Sierra Leone

Stratum	0	1	2	3	Total
Average per section	5	10	12	21	
N of sections – sample	93	14	26	53	186
N of sections – population	999	74	83	87	1,243
V(nfar/sec)	191	327	522	1,103	
Var comp & V(total)	2,048,273	127,859	138,343	157,490	2,471,965
Estimated N of farmers	4,898	703	1,018	1,802	8,422
%	58	8	12	21	100
SE (estimated total)					1,572
CV					0.19
85% CI half-width (Z = 1.44)					2,264
85% CI lower					6,158
85% CI upper					10,686

Tables 3 and 4. Estimated number of cashew farmers by district[1]

MAJOR CASHEW AREAS

District	N farmers	%
Bombali	486	6
Kambia	2,364	30
Karene	1,299	16
Port Loko	1,586	20
Tonkolili	985	12
Total	**6,720**	85
Grand total	**7,933**	

MINOR CASHEW AREAS

District	N farmers	%
Bo	189	2
Bonthe	11	0
Falaba	138	2
Kailahun	0	0
Kenema	280	4
Koinadugu	156	2
Kono	41	1
Moyamba	212	3
Pujehun	186	2
W. Area Rural	0	0
All	**1,213**	**15**

[1] Totals in Tables 3 and 4 are slightly different because different sampling plans were used. The estimate in Table 4 is slightly more accurate.

Area and number of trees in cashew production. The estimated area in cashew production was 226 km^2 (Table 5; CV = 0.088) very close to the estimate of 280 km^2 made in 2020 by Invest Salone (2020). If the area were square, it would only be approximately 15 km by 15 km. Many upland locations in the country are suitable for growing cashew and a large proportion of this area is currently not being used. There is thus enormous opportunity to expand production. The spacing of trees is almost always 10 m (see next section) which means 100 trees/ha and 10,000 trees/km^2. Using these figures, the estimated number of cashew trees in the country is a little over 2 million (CV = 0.088).

Yield. The estimated yield (Table 6) for 2021 was about 770,000 kg (CV = 0.048) which is not dissimilar to the estimate of 612,000 kg by Invest Salone (2020). Both values are much higher than the reported export amounts (Invest Salone 2020), indicating that much of the production is consumed within-country or exported by land and not reported.

Our estimate of yield/ha – across the entire study area – is 772/22,600 which is just 0.034 t/ha, but this includes a great many young stands not yet in production. A better indication of yield/ha is provided by age-specific data (Table 7). Reported yields increase steadily with farm age (i.e. age of the trees) reaching 0.10–0.12 t/ha by ages 7 and above. Invest Salone (2020) reports a nationwide estimate by ComCashew of 0.148 tonnes/ha, not dissimilar from our estimates for mature stands.

Reported yield/ha using all stands was 0.057 t/ha in the north and 0.026 in the south (Table 8) suggesting that yields might be higher in the north. But two of the five southern districts from which we obtained yield data had yields similar to those in the north, so it is uncertain – from these data – whether an intrinsic difference exists between regions.

Table 5. Estimated cashew area and number of cashew trees

Stratum	0	1	2	3	Total
Mean (ha)	2.47	3.97	2.78	2.74	-
N farmers	4,898	703	1,018	1,802	8,421
Total area km^2	121	28	28	49	226
N trees (millions)	1.21	0.28	0.28	0.49	2.26

Table 6. Estimated yield of raw cashew nuts in 2021

Stratum	0	1	2	3	Total
Mean	73	128	77	135	
N farmers	4,898	703	1,018	1,802	8,422
Estimated yield					
Kg	359,680	89,797	78,182	244,072	771,732
Tonnes	360	90	78	244	772
40-foot containers	14	4	3	10	31

Table 7. Yield (t/ha) in relation to farm (tree) age

Farm age (years)	Mean yield	N farms	%	Cumulative %
0–3	0.01	502	38	38
4–6	0.07	510	39	77
7–10	0.10	299	23	100
11–22	0.12	8	1	101
All		**1319**		

Table 8. Reported yield (tonnes per hectare)

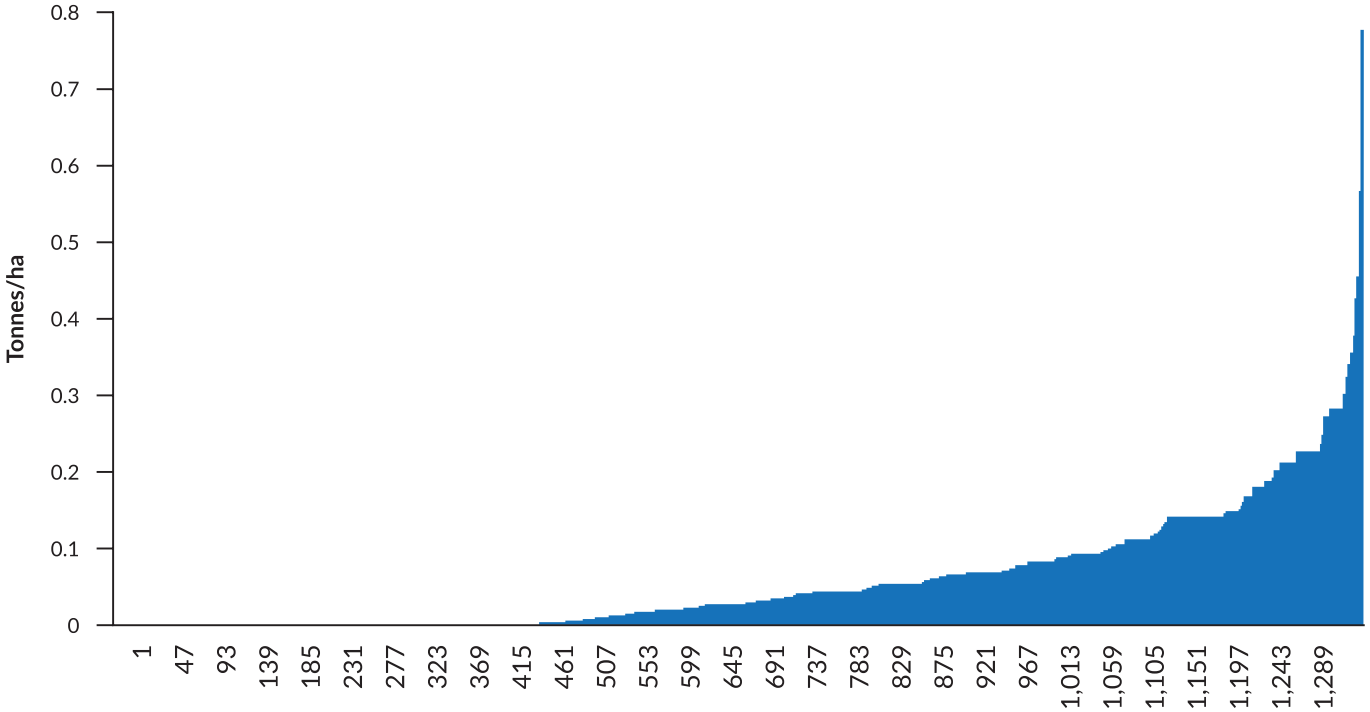
NORTH

District	kg/ha	N interviews
Bombali	103	158
Falaba	33	14
Kambia	51	301
Karene	54	409
Koinadugu	0	14
Kono	51	7
Port Loko	69	213
Tonkolili	8	115
Mean/total	57	1,231
Sample variation	8,161	
SE of kg/ha	2.57	
CV	0.05	
t/ha	0.057	

SOUTH

District	kg/ha	N interviews
Bo	33	32
Bonthe	5	2
Kenema	70	22
Moyamba	0	27
Pujehun	0	17
Mean/total	26	100
Sample variation	5,956	
SE of kg/ha	7.72	
CV	0.30	
t/ha	0.026	

Figure 5. Yield in tonnes per hectare on farms with stands more than three years old in ascending order. Each bar represents one farm (one report of 2.1 t/ha was excluded)

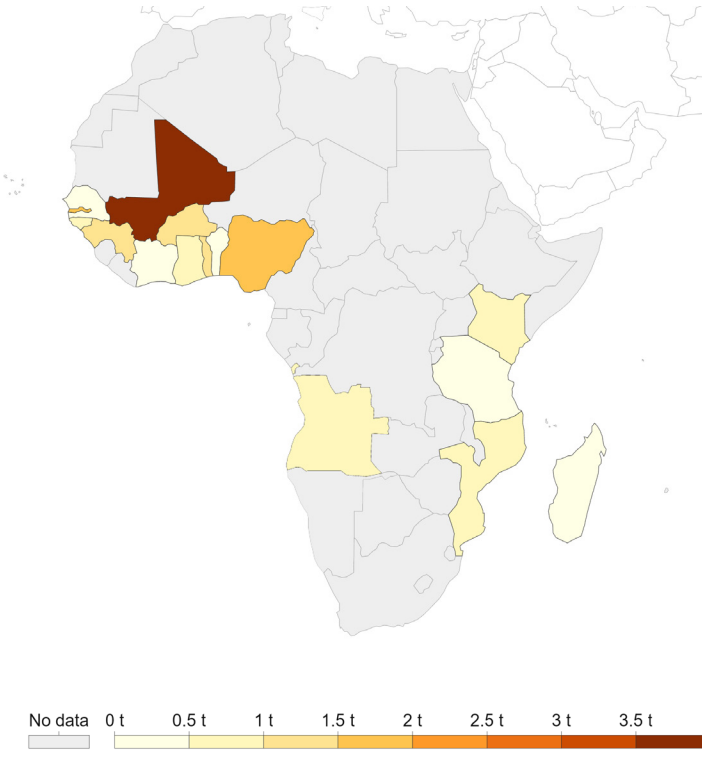


Many yields, even from farms with stands more than three years old, were zero. We may therefore wish to ask what the maximum yields were. The answer (Fig. 5) is that only 4 of the 1,330 farmers who reported farm size and yield said they obtained more than 0.4 t/ha. These 4 farms were small (only one exceeded 1 ha) so it is difficult to evaluate reports from them. The over-whelming majority of farmers, however, reported yields well below 0.4 t/ha.

It thus appears that the average yield in mature cashew stands in Sierra Leone is probably in the range of 0.12–0.15 t/ha and that few farmers achieved yields much above this range. These are distressingly low values compared to many other cashew-growing nations (Fig. 6).

Sierra Leone is in the lowest category, while many countries, including several neighbouring countries, have yields in the 1.5 to 3.5 t/ha range, more than ten times our yield. The possible reasons for this low yield are discussed further below.

Figure 6. Reported yields (t/ha) of RCN (source: Our World in Data)



Farmers

Only 8% of cashew farmers are women. Mean ages are in the mid- to late 40s though some are much younger or much older. Perhaps the most surprising finding on farmer ages is that only 4% are less than 30 years old. Although 52% of farmers reported being certified as organic producers we think this probably includes many farmers who have been certified in the past but are not now and others who may feel they are "certified" because they use organic methods. The true percentage is unknown but is probably much less than 50%. The major certifiers listed were Balmed, Coopi, Cottontree, Develop Salone, IDA and Melo. Given how many regions around the world cannot be certified organic due to pesticide usage, the finding that many of our cashew farmers are already certified (and most of the rest could be) will be attractive to buyers seeking certified RCNs.

Farms

Type of seeds. Among the 1,333 respondents, 89% said they had polyclonal trees and the remaining 11% said they were unsure. The vast majority of the trees thus appear to be improved, polyclonal varieties – a conclusion also reached by Invest Salone (2020).

Stand management. Spacing between trees was nearly always 10 m which was also reported by Invest Salone (2020). Nearly all farmers reported that they use brushing, pruning and fire belts, and that fire belts are effective (Table 9).

Our farm surveys helped clarify the farmers' comments about pruning. While most farmers probably do prune their trees on occasion, the extent of pruning is not large. Our staff found no pruning in 28% of the farms they inspected; 1–10% of trees pruned in 34% of the stands; 11–50% of the trees pruned in 31% of the stands and 51–100% of the trees pruned in only 7% of the stands examined.

Table 9. Farmer characteristics

Metric	Bombali	Kambia	Karene	Port Loko	Other	Sierra Leone	CV
Prop. women	0.11	0.07	0.09	0.11	0.04	0.08	0.09
Mean farmer age	49	45	46	47	45	46	0.01
Minimum age	25	22	25	24	22	22	-
Maximum age	75	82	90	81	80	90	-
Prop. under 30	0.04	0.04	0.05	0.05	0.05	0.04	0.09
Prop. certified organic	0.76	0.64	0.73	0.39	0.29	0.52	0.09
Prop. certified fair trade	0	0	0	0	0	0	-

Table 10. Brushing, pruning and fire belts

Proportion of farmers who:	Bombali	Kambia	Karene	Port Loko	Other
Brush	1.00	0.88	0.98	0.99	0.97
Prune	1.00	0.88	0.98	0.98	0.96
Use fire belts	1.00	0.83	1.00	0.98	0.97
Say fire belts are effective	1.00	0.83	1.00	0.98	0.97

The most common ground cover (*n* = 427) was dead leaves less than 3 inches thick (45% of stands) followed by living plants (42%). Only a few stands were covered by dead leaves more than 3 inches thick (6%) or bare ground (7%).

Among 1,333 respondents, 86% said pests were not a problem, and 13% said pests were a minor problem. A few mentioned that they remove pests by hand but none reported using pesticides. Invest Salone (2020) also reported a low incidence of pest or disease problems.

Stand expansion. Among the 1,333 farmers interviewed, 49% said they had planted additional trees in their stands at least once since the stands were established. The number replanted varied from 1 to 400; 24% of the farmers reported planting 10 or fewer seedlings and 89% reported planting 50 or fewer seedlings. The majority of the seeds were provided by Coopi, but Balmed and the Cottontree Foundation also supplied seeds along with many other minor sources. Nearly all (89% of 1,333 farmers) reported that they received improved seeds. The Invest Salone 2020 report also found that imported, polyclonal seeds were provided to farmers in most cases. Most (79%) of the farmers said they had estimated survivorship, usually (in 75% of the cases) when the seedlings were 1 year old. Most (95%) said all or most of the seedlings survived. Only 2 of 1,168 respondents said all their seedlings died. Farm inspections by our staff supported the claim of high survivorship. They walked rows of trees recording gaps and found that only 3% of the trees (*n* = 15,052) were missing. The Invest Salone 2020 report also concluded that survivorship was generally high.

Table 11. Prices (Le/kg) received by farmers for raw cashew nuts (Le/kg)

Price/kg (Le)	Number	Proportion
4,000	10	0.01
5,000	196	0.23
6,000	366	0.44
6,001-6,099	17	0.02
7,000	82	0.10
8,000	165	0.20
All	**836**	**1.00**

Harvest and drying. Among the 1,121 farmers who responded to questions about harvest methods, 60% reported they harvest from both trees and ground; 38% said they harvest exclusively from the ground and only 2% said they harvest exclusively from trees.

Among the 1,120 farmers who responded to questions about drying methods, 74% said they dry in the shade, 22% said they dry in the sun and the rest say they don't dry (3%) or use other methods (1%).

Among the 1,120 farmers who responded to questions about drying floors, 59% said they dry on concrete, 34% said they dry on tarps, 7% said they dry on mats and 1% (8) said they dry on metal sheets.

Among the 1,120 farmers who responded to questions about storage of the RCNs, 70% said they used 50 kg rice bags; 24% said they used jute bags and the rest said they use wooden boxes (5%) or drums (1%).

Among the 1,333 farmers who responded to questions about sorting, 83% said they sort their RCNs after drying and the remainder said they do not sort their RCNs at all.

Our survey included a question on harvest per tree we did not receive any responses.

Sale of product. The main buyers mentioned (*n* = 879) were "traders" (56%), Melo Africa (27%), and Coopi (13%). The price received varied widely and showed a distinct bi-modal pattern (Table 11) with most farmers receiving Le6,000/kg or less but 20% receiving Le8,000/kg. In 2022 the price jumped and most farmers are now receiving Le8,000–8,500/kg.

Other crops. Among the 327 farmers who mentioned other species they grow, the most commonly mentioned was oil palm (48%), followed by mango (37%), pineapple (19%), cassava (17%), banana (9%), pears (9%), and 14 other species that were each mentioned by less than 5% of the farmers. The Invest Salone 2020 report found a similar mix of other species.

Raw cashew nuts

We obtained 45 samples of RCNs, most from the north but two from Bo. The average KOR was 53.5 (CV = 0.01). All but three of the values were above 50, which is regarded as the threshold for high-quality RCNs. Nine of the values were above 56. Our mean is similar to the mean (52) reported recently by an exporter. Invest Salone (2020) reported a much lower mean KOR (45) but do not provide details such as sample sizes and it is not entirely clear that they are reporting the same quantity as the standard KOR.

The mean nut count in the original samples was 172 (CV = 0.01), very similar to the value (170) reported by Invest Salone (2020) and to the nut count (169) reported by the exporter mentioned above. Nut counts of less than 230 are considered acceptable and counts of 190–200 are considered good. Our mean, 172, is thus extremely good already. The mean counts after removing the smallest 10, 20, and 30 nuts were 168, 164, and 161. These are exceptionally good scores.

The mean number of "good nuts per pound", another standard measure of quality, was 250 (CV = 0.01) which is also an extremely good score. Thus, by all commonly used measures, the RCNs we collected were of extremely high quality.

Discussion

This study demonstrates that Sierra Leone is ready to enter the international cashew market if exporters work professionally with both farmers and international buyers. In this section we defend this assertion and describe in detail the steps needed to develop the cashew sector in Sierra Leone.

Yield per hectare

A full discussion of why reported yields were so low and what can be done about it is beyond the purview of this report, but we can offer a few suggestions. Firstly, there are several factors can be ruled out:

- The low reported yield does not appear to be due to variety, because nearly all producing cashew trees are imported, polyclonal varieties.
- Based on both farmer testimonies and our inspections of farms, the stands appear to be fairly well brushed overall. Brushing could certainly be improved, but it is not going to result in a 5-10-fold increase in yields.
- Damage from disease and pests appears to be rare (in contrast to many parts of the world).
- The stands are not over-mature; only 2 of 1321 reported ages were more than 15 years.
- Although many stands are still young, yields in 10-12-year-old stands – which should be at their maximum productivity – are low.
- Poor soils are unlikely to be the explanation for low yields because Sierra Leonean soils are broadly similar to soils in neighboring countries which report yields ten times higher and more. Furthermore, extensive soils surveys in the 1960s and 70s by the UK government concluded that our soils are excellent for cashew trees.
- In dry climates – which Sierra Leone has for half the year – bare ground can lead to loss of soil moisture which may impact crops. But our staff reported that only 7% of the stands they visited had extensive areas of bare ground.
- There are production methods for cashew nuts that vary culturally, and potentially these could influence yield. But production methods do not appear to differ much between here and neighbouring countries. For example, Pro-cashew (2021) – the West African Cashew Project active in Benin, Burkina Faso, Côte d'Ivoire, Ghana, and Nigeria – surveyed 1,733 farmers and reported the following rates of management methods: fire breaks 55%, pruning 39%, thinning 23%, fertilisers 5%, irrigation not reported. These results are not very different from this report, so it is hard to attribute the large difference in yields to differences in production methods (reported yield in the Pro-cashew survey was 0.58 t/ha).

Our study thus unfortunately does not answer the question "Why are reported yields so low in Sierra Leone?"

Quantity of cashew nuts

We estimated that production in 2021 was 770 tonnes. Data in Table 7 show that 38% of the cashew area is young stands (0–3 years old) in which production is very low (0.01 t/ha). Using the data in Table 7 it can be seen that three years from now, when these areas have entered the next cohort, production (*ceteris paribus*) will increase by about 37% increasing production to 1,055 tonnes. This would remain a small quantity on the world market, yet it would be sufficient to attract the attention of major buyers, especially since there are ways to increase production substantially (see *Opportunities* below).

Quality

This study reveals that the quality of cashews from Sierra Leone is exceptionally high. The *mean*, unadjusted nut count was 172, at the lower (and better) end of the lowest range (170–180) usually published for RCNs and described as "excellent and recommended for export" by the website Just Agric. Furthermore, by removing the smallest 3–6% of the nuts, which could be done quickly and cheaply even by hand (and more efficiently using a mechanical sorter), the nut count can be driven into the 160s, virtually unheard of in the sector. Much the same can be said of the KOR scores we observed. The average score among 45 samples was 53.5. This is near the upper end of the highest scores reported by Just Agric, 48–55, which they also describe as "excellent and recommended for export". A final – and major – advantage of Sierra Leonean cashews is that many farmers are already certified as organic suppliers and most of the rest could be. This situation stands in stark contrast to many other parts of the world, including some countries in West Africa, where pesticide use is so extensive that organic certification is difficult or impossible.

Opportunities

The biggest opportunities in the cashew sector are attracting major buyers; expanding the area in cultivation; increasing productivity (t/ha) and attracting higher prices from buyers by catering to their specific needs.

We believe that recent developments, including the completion of this report, put Sierra Leone in a strong position to attract major buyers. An aggressive programme of promotion needs to be launched by companies who wish to export. It is essential that all communications be at a professional level, but if that is done, we believe finding buyers willing to talk seriously about purchasing large volumes will not be difficult.

In the 1960s, the UK government commissioned three major soil surveys covering all of Sierra Leone. The authors of all three surveys concluded that Sierra Leonean soils and climate are well-suited to growing cashew trees. It has been well documented that there are vast uncultivated areas in Sierra Leone that could support cashew farms. As international buyers appear willing to purchase large volumes, the government and companies should make plans for a large expansion of cashew production area.

The low reported productivity is puzzling and needs to be investigated. Farmers would benefit substantially by boosting production from 0.10 to 0.40 t/ha (or higher), which should be perfectly feasible. Discussing the options is beyond the purview of this report, but they include traditional fertiliser and pesticides; organic (including liquid) fertiliser; organic methods for restoring degraded soils (including lime, biochar and cover crops); tree management (including pruning and grafting); and other methods. In appropriate cases, irrigation might also be considered.

Meeting the individual needs of specific buyers has proven to be an effective strategy for Sierra Leone in developing cocoa markets and it might also be successful with the cashew sector. In addition to removing small cashew nuts, mentioned above, efforts should be made to ensure that cashew apples are harvested when ripe (not unripe or over ripe) and that the RCNs are dried properly, which includes not subjecting them to rain during drying. This may require carrying out processing at a central facility.

Finally, although outside the scope of this report, establishing RCN processing factories would substantially increase the benefits that Sierra Leone derives from the cashew sector.

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Appendix: Questionnaire

1 Introduction

1.1 Surveyor name
1.2 Date
1.3 Start time
1.4 End time
1.5 Farmer's name
1.6 Farmer's sex
1.7 Farmer's age
1.8 District
1.9 Chiefdom
1.10 Section
1.11 Village
1.12 Is the farmer certified as an organic producer? If so, by which group(s)?
1.13 Is the farmer certified as a fair trade producer? If so, by which group(s)?

2 Description of farm

2.1 Farmer's estimate of cashew farm size (ac)
2.2 Type of cashew tree (if more than one, include proportions)
2.3 Year the farm was planted (if more than one block, include years and proportions of trees)
2.4 Has the farmer replaced or added new trees (yes/no)? If yes, describe when and how many?
2.5 Has the farmer planted seeds (yes/no). If yes. answer 2.6, 2.7, & 2.8; otherwise, skip those questions
2.6 Where did the seeds come from (local trees, name source if known)?
2.7 Were they "improved" varieties?
2.8 Has the farmer determined the seedling survival rate (yes/no)? (If yes, answer 2.9 & 2.10)
2.9 How old were the seedlings or trees when the survival rate was estimated?
2.10 What was the survival rate?

3 Improving harvest

3.1 Do you brush under your cashew trees (yes/no)?
3.2 Do you prune your cashew trees (yes/no)?
3.3 Do you construct fire belts around your cashew farm (yes/no)?
3.4 Is the fire belt effective in preventing damage to the trees (yes/no)?

4 Crop protection

4.1 How much of a problem are pests and diseases in your farm?
4.2 How do you control pests in your cashew farm?
4.3 How are diseases controlled on your farm?

5 Post-harvest

5.1 How do you harvest cashew (a=pick from tree, b=collect from ground, c=both)?
5.2 Do you dry your harvest before storage (a=no, b= in sun, c=in shade, d=other)?
5.3 What type of floor do you use to dry your cashew (a=woven mat, b=concrete floor, c=tarpaulin, d=metal sheet, e=other)?
5.4 How do you store your cashew (a=50 lb rice bag, b=drum, c=jute bag, d=wooden box)?
5.5 Do you sort your cashew after drying (yes/no)?

6 Yield and sales

6.1 What was the total yield from your farm last year in kg?
6.2 What is the average yield of dried RCNs per tree?
6.3 Who do you sell to (a=agents at the farm gate, b=in village, c=other, describe)
6.4 For each buyer, what price do they pay (just in general, not what they paid the farmer).

7 Other crops grown on the cashew farm (not on other plots)

7.1 List the crops and amounts produced last year; ask specifically about honey, Include “economic trees”, meaning trees being grown for the wood.

8 Farm survey

8.1 Record GPS locations at each corner.

8.2 Description of farm. Walk 4–6 rows, recording the following information:

r = row number (1, 2, 3,...)
d = distance (paces) between trees
b = brushing (little or none, medium, lots)
t = trunk diameter (average, in inches)
h = height (average) of trees
p = pruning (a=0%, b=1-10%, c=10-50%, d= >50% of trees)
g = ground cover (a=bare ground, b=dead leaves mainly <3” thick, c=dead leaves mainly >3” thick, d= living ground cover with description)
s = shading (proportion of line)
v = variety of tree (if they can tell)
o = other useful information.

8.3 Other commercial species and abundance

8.4 Other information.

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