Farmer yield and income in Côte d'Ivoire

an analysis of Farmer Field Books (FFBs)

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Foreword

This paper summarizes the key findings of research conducted by Agri-Logic, in partnership with IDH & Rainforest Alliance, using the Farmer Field Book Methodology, to draw a picture of the cocoa sector in Côte d'Ivoire on behalf of Barry Callebaut.

This report marks the sixth year of collaboration between Barry Callebaut, IDH, Rainforest Alliance and Agri-Logic. This paper aims to share key insights gained from this collaboration, with a focus on data collected and analyzed during the cocoa agronomic season of 2021/22. In addition, these findings provide actional steps that underpin Barry Callebaut's commencement of a transformative and formalized approach to change the existing cocoa farming model in West Africa, and a vision of where we believe smallholder cocoa farming should be in 10–20 years.

Executive Summary

In 2016, Barry Callebaut established a collaboration in Côte d'Ivoire with the IDH, Rainforest Alliance, and Agri-Logic. The results of the Agri-Logic research provides the foundation for the sharpening of Barry Callebaut's strategy to support cocoa farmers in achieving higher cocoa yields, living income and protect the forests surrounding cocoa farms. The results form the basis of our shift in approach from less training to more doing – with less emphasis on farmer training, and increasing investment to support the farmer with more labor, soil management techniques, and planting material. These findings provide actionable steps that underpin Barry Callebaut's commencement of a transformative approach to change the existing cocoa farming model in West Africa.

A picture of farming in Côte d'Ivoire

Cocoa cultivation, unlike many other food crops, is still largely dependent on manual labor in many cocoa-growing regions. Almost two-thirds of global cocoa is produced in Côte d'Ivoire and Ghana and is predominantly grown by independent smallholder farmers supplying a range of companies, sometimes via several cooperatives. Cocoa farmers and their families usually live in villages and are required to travel a few kilometers to work on the farm, with most of the work and labor on the farm undertaken by the farmer and their families themselves. Most farmers work on more than one field, sometimes owning one of the plots and leasing the others. Cocoa accounts for a significant part of these smallholder farmers' income, at around 70% to 85%[1].

Poverty reduction is driven by three factors

Using Farmer Field Book Methodology, data and insights were collected from farmers on a range of topics, including farm investment, household profile, and environmental impacts. The data analysis shows that poverty reduction is driven by three key factors – yield, size of farm and price.

Yield

Annual rainfall of between 1,500 mm and 2,000 mm, well distributed throughout the year, is required to grow cocoa in optimal conditions in Côte d'Ivoire.[2] With regards to yield, the data analysis shows two findings. The first is farm location. Farmers reporting highest cocoa yield in farms are located in regions which received significantly more rainfall (1,699–2,500 mm), relative to the cocoa region's average. In contrast, farms that are located in the center north and northeast of Côte d'Ivoire received below average rainfall, reported lower yields in these areas. The second finding is that the level of farm investment in the form of additional labor and input, such as soil management techniques, also impacts cocoa yield. The data shows the difference between the bottom and the top quintile of investment levels was significant, with the top 20% of farmers collecting nearly double the yield (around 620 kg/ha on average) relative to the bottom quintile, where average yields were a little over 350 kg/ha.

Farm size

Investment is also a critical factor with regards to farm size. The analysis shows that larger farm size does not automatically equate to increases in cocoa yield, in comparison to smaller farms. This is particularly representative when farm management is undertaken only by the household, without the investment of additional labor. In contrast, a large farm with an adequate level of investment, can drive a higher level of income by more cocoa being grown, resulting in higher yields and subsequently higher reported income.

Price

With regards to higher price, the findings show that price mechanisms can support an increase in farmer income, which should be coupled with the other factors such as yield and farm size and farm location. Barry Callebaut and IDH acknowledges that higher farmgate prices lead to poverty reduction and that the appropriate mechanisms to achieve this should be analyzed in a broader context of price construction, for example the importance of farm gate price as well as export price, to achieve the biggest impact on farmers' incomes.

A valuable contribution to the discussion of current cocoa farming practices in West Africa

A fully sustainable cocoa and chocolate sector can only be achieved when all supply chain actors are committed to supporting the development of an enabling environment. By sharing this research, we hope that our change in approach from less training and more investment into doing, will be a valuable contribution to the wider cocoa sector discussion on adaptations to the existing cocoa farming model in Côte d'Ivoire, and more broadly, West Africa.

Whilst our key findings indicate what activities and approaches should be undertaken to support farmers to reach a living income, this must go hand in hand with the development of supporting policies to drive poverty reduction. This includes the development of integrated agricultural policies and land titles that align national production targets with global demand. In addition, given the reported rate of deforestation in Côte d'Ivoire, it is critical that there is broader discussion on reforestation strategies and production of the same amount of cocoa on less land.

1 UNICEF Côte d'Ivoire. Available from https://sites.unicef.org/csr/css/synthesis-report-children-rights-cocoa-communities-en.pdf (accessed August 5, 2021)

2 ICCO: https://www.icco.org/growing-cocoa/#:~:text=Rainfall%20should%20be%20plentiful%20and,should%20not%20exceed%20three%20months

Introduction

In 2016, Barry Callebaut established a collaboration in Côte d'Ivoire with the IDH, Rainforest Alliance, and Agri-Logic. The purpose of this partnership was to generate quantitative and qualitative evidence about the cocoa farming model pursued by Ivorian farmers and derive insights on themes ranging from household and farm profiles, farm management practices, yield, and farm economics. This evidence base is used to identify key factors driving improvements in farmer cocoa yields and incomes and inform better program design and targeting for farmer support interventions.

This report marks the sixth year of collaboration between Barry Callebaut, IDH, Rainforest Alliance and Agri-Logic. We summarize the findings of Agri-Logic's analysis and use it to answer the following research questions:

1. **What is the overall state of the Ivorian farming model, notably in terms of labor use, farm management, and farm economics?**
2. **What are the factors contributing to improvements in farmer yields and incomes?**
3. **To what extent does the adoption of "Good Agricultural Practices" lead to increased cocoa yields?**
4. **Are there major differences in terms of yield and income between farmers who adopt "Good Agricultural Practices" and those who do not?**

This paper begins by providing readers with an understanding of the methodology used to obtain the data and analyses. Subsequently, it describes the primary features of the Ivorian cocoa farming model and emphasizes key limitations to improvements in cocoa yields and farmer incomes, notably low investment levels in pre-harvest labor and inputs, which contribute to low productivity levels for cocoa production. It also details factors that facilitated higher farmer yields and incomes, based on the analysis conducted by Agri-Logic. The report concludes by highlighting priorities for future farmer support interventions in the country and identifying opportunities to help farmers diversify their income sources.

We expect this paper to be used to build alignment in the sector among cocoa supply chain actors including farmers, farmer organizations and chocolate makers. Only by working together, combining investments and having coherent business practices it will be possible to make a living income a reality for increasing numbers of cocoa farming households.

IDH works with companies on solutions that enable smallholder farmers in the cocoa sector to earn a living income. The IDH Living Income Roadmap provides an important framework for value chain actors committed to making living income a reality in their supply chains (including members of DISCO and Beyond Chocolate). An important step in this framework is around investing in improved company action which the insights consolidated in this paper are an important example of.

IDH and Barry Callebaut collaborate to gather strategic insights on farm management and farmer economics across West African countries and cocoa sustainability programs linked to major brands. The conclusions on what works or not in improving yields and farmers' incomes reinforce the need for a "smart-mix strategies" tailored to different needs of farmers. This involves identifying the services and procurement practices that are essential to improve "income drivers" including yield, production costs, alternative incomes and price. Improving procurement practices such as payment terms, payment of premiums, farm gate pricing and long term relationships are part of this strategy mix to distribute value more fairly to cocoa farmers to make a transition towards a more remunerative and resilient cocoa farming business. Segmentation of cocoa farms and their cooperatives is key for more targeted and effective interventions that can have an impact on the living income on farming households.

1 Methodology

1.1 Data collection approach and data sources

During the six years of collaboration between Barry Callebaut, IDH, Rainforest Alliance and Agri-Logic, the latter was engaged to oversee the data collection and analysis process. Agri-Logic gathered the majority of the quantitative and qualitative evidence presented in this paper by implementing a data collection method known as the Farmer Field Book (FFB), which, combined with a dedicated FFB software, helps to generate information that can provide a better understanding of the economic and agronomic situation on the ground. For example, the FFB approach can help facilitate the calculation of key estimations, such as the return on investment, which is often a challenge to calculate with large numbers of small-scale farmers. The FFB can also be used to understand the impact of farm products on the environment and ways to minimise their impact. Information generated by this approach can therefore be used to improve program design and targeting for farmer support interventions and improve yields for farmers and suppliers.

The 2021–2022 data collection period marked the sixth year of data collection and analysis using the FFB approach. Each year, data was gathered during the agronomic cocoa season, which spans from March 1 to the end of February. In this report, this period will be subsequently referred to as the production season.

During the 2021–2022 production season, 561 farmers from 12 regions[3] of the country were surveyed, effectively representing areas where cocoa is produced in Côte d'Ivoire. Farmers included in the sample managed a total of 3,325 hectares (ha) of farmland, of which 2,132 ha were devoted to cocoa production.

Using the FFB approach, farmers received weekly pre-printed forms that were filled out each day they worked on their cocoa farm. Farmers would record key details such as hours devoted to each type of farming activity, division of labor and associated costs, and inputs used and associated costs. These forms were collected on a bi-weekly basis by field staff from Barry Callebaut and verified with the farmer present to validate entries. For example, if a farmer indicated that he/she applied fertilizer, the data collector would confirm that the associated pieces of information, such as the name of fertilizer used, volume, cost, and labor hours were reported and in the correct units. If required, corrections or clarifications were added as needed.

These forms were then centrally deposited and entered into the FFB database using the FFB software and paper records were filed for future reference. Each farmer in the system has a box file with his/her paper records, filed chronologically.

Information generated through the FFB approach was also complemented by an annual 1–1.5-hour survey conducted at the end of the season (January/February) to collect additional information on loans and repayments, services used and income from non-cocoa sources. Internal data from Barry Callebaut and external data sources were also utilized, ranging from rainfall data from the Climate Hazards Center InfraRed Precipitation with Station (CHIRPS)[4], to the Align tool, which helped to calculate living income reference values[5]. The methodological approach included an annual loop back with farmers and coops to facilitate sharing and interpreting the information.

1.2 Key research questions

The overarching purpose of this initiative was to better understand factors impacting farmer yields and incomes. Within this, the following research questions were identified:

1. **What is the overall state of the Ivorian farming model, notably in terms of labor use, farm management, and farm economics?**
2. **What are the factors contributing to improvements in farmer yields and incomes?**
3. **To what extent does the adoption of "Good Agricultural Practices" lead to increased cocoa yields?**
4. **Are there major differences in terms of yield and income between farmers who adopt "Good Agricultural Practices" and those who do not?**

To this end, the term "Good Agricultural Practices" (subsequently referred to as GAP) is utilized to refer to practices that can be expected to have a positive effect on yields. Based on Agri-Logic's previous field research, the firm determined the following activities as GAP: pruning, collecting diseased pods, spraying and applying fertilizer. More activities are done of course, but these four tend to have a statistically significant association with yield and hence income earned.

3 San Pedro, Cavally, Guemon, Haut Sassandra, Nawa, Gbokle, Marahoue, Yamoussoukro, Goh, Loh Djiboua, Agneby-Tiassa & Indenie-Djuablin
4 Data Sets | Climate Hazards Center – UC Santa Barbara (ucsb.edu)
5 Resource library – ALIGN (align-tool.com)

1.3 Analytical methods

To help answer the aforementioned research questions, Agri-Logic conducted a series of correlation and regressions, and where possible difference-in-difference analyses using the data collected during the 2021/22 cocoa production season. Particular emphasis was placed on assessing the differences between farmers that produced the highest cocoa yields versus those that produced the lowest yields. To this end, Agri-Logic tested key variables, such as the size of farmer investments in pre-harvest activities, fertilizer application, and use of GAP to determine the impact of said variables on yields and farmer incomes and account for differences in yields and income.

To investigate the relation between higher yields and key variables, Agri-Logic developed a GAP score based on investments and labor hours committed to pruning, fertilizing, spraying and collecting diseased pods by farmers. Under this rubric, farmers earned a score between one and five, with five signifying high levels of efficient farming practices in terms of the aforementioned pre-harvest activities. The GAP score is referred to throughout Agri-Logic's analysis to help identify variables that positively impact yields and income.

1.4 Farm and farmer profiles

During the 2021/22 production season, the average farm size covered approximately 5.9 ha, of which 3.8 ha were devoted to cocoa production, accounting for 64% of the farm.

The average farmer in the sample was around 50 years of age, with an average household size of 10.6 individuals. Within this, the average household size without dependents was estimated at around nine individuals, with dependents considered to be individuals who may or may not be relatives, but rather individuals that are dependent on the farm. Within this, 95% of farmers were male, while 54% had no formal education.

1.5 Limitations

Agri-Logic noted the following limitations to the data sampling, collection and analysis process:

- Farmers in this study are not randomly selected. Many farmers self-selected into the study so as to be included in certain program activities. In an ideal study design, the sampling of farmers would have been randomized. Agri-Logic sought to control for this to some degree by isolating selection effects and through the use of Propensity Score Matching (PSM), but there may well be unobservable selection effects that are not factored in. This may bias the outcomes.

- The collection of FFB data across a large group of farmers is labor intensive and a large group of data collectors is involved. While all have been trained on how to collect data, conduct data quality checks and digitize information, differences in staff performance and diligence can affect the quality of data. For some farmers, it was clear that the data in their FFB files could not be correct and these have been excluded from the analysis, though it is possible that not all faulty entries were identified by Agri-Logic. However, given the large sample size, Agri-Logic concluded that this would not drastically skew the results of their analysis.

- Data that is recorded in near real-time tends to be quite accurate, but the additional survey that is conducted once a year is likely to suffer from recall bias. Agri-Logic sought to limit the questions in that survey to aspects that are easier to remember. For example, loan values can be expected to suffer less from recall bias than cocoa production outcomes because farmers with a loan tend to have a single loan in any given year, whereas cocoa yields come in gradually after each session of harvesting and pod breaking. Similarly, data on tree numbers and particularly tree age are difficult to obtain accurately. Agri-Logic is not overly confident in the tree numbers and tree age data and assumes that there can be large deviations from the actuals on any given farm. Agri-Logic did not identify a particular reason for farmers to consistently over- or under-estimate tree numbers and age and so the analysis assumes that at population level, the numbers are likely fairly accurate.

2 Cocoa Farming Model in Côte d'Ivoire

2.1 Snapshot of the 2021/22 production season

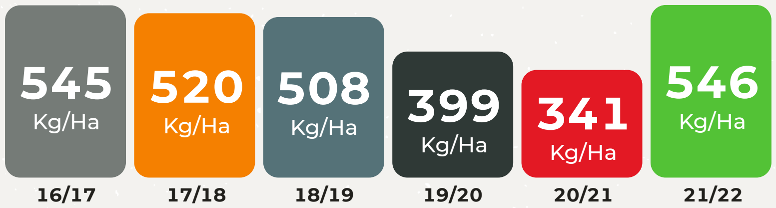
After four years of declining cocoa yields, 85% of cocoa farmers surveyed by Agri-Logic across Côte d'Ivoire reported improvements in cocoa yields during the 2021/22 cocoa production season over the previous year. During this period, average yields among respondents reached 546 kg/ha – the highest since the 2016/17 growing year. This represents a 60% increase over the 2020/21 production season, when the average yield reached a five-year low of 341 kg/ha. (See Graph A and Graphic A: Yield Evolution)

This reported increase in average yields can largely be attributed to better rainfall. Surveyed farmers operating in the regions with the five highest average yields were all located in western Côte d'Ivoire, where rainfall averaged between 1,699–2,500mm between March 2021 and February 2022. (See Graph B: Rainfall average, Côte d'Ivoire (March 2021–February 2022)

Farms in the regions of San Pedro, Gbokle and Cavally received significantly more rainfall relative to the cocoa region's average. The highest average yield was reported in Cavally, with 645 kg/ha, followed by San Pedro (636 kg/ha) and Nawa (622 kg/ha). (See Table A: Regional yield average)

Graph A: Yield evolution

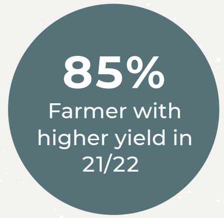
In terms of methodology yield is calculated based on dried beans declared as sold in the FFB



To challenge the relevance of its yield data, Agri-Logic has looked at the ratio between hours spent harvesting and yield/dry beans sold and analyzed it over multiple years. Yield figures for the past three seasons are consistent with the amount of harvesting labor farmers used. Agri-Logic therefore has a high level of confidence in the accuracy of the production and yield data.

Graphic A: Yield evolution

Increased yield is observed across the spectrum of farmers



In contrast, farms in the center north and northeast of Côte d'Ivoire received below average rainfall. This accounted in part for lower yields reported in these areas, particularly for farmers operating in the regions of Yamoussoukro, Goh, Marahoue, Loh Djiboua and Agneby-Tiassa. In Yamoussoukro, the average yield was reportedly just 289 kg/ha, reflecting relatively low average rainfall across the region at around 1,000mm.

As a result of higher average yields relative to previous years, surveyed farmers during the 2021/22 cocoa production season reported the highest average income per farm since the 2018/19 production season, with an average farm income of around XOF1.35 mn. Among farmer respondents, cocoa was by far the main driver of income, which accounted for 83% of reported incomes. Meanwhile, non-cocoa-based income represented just under 17% of incomes. (See Graph C: Cocoa Income P & L 2017/18–2021/22)

Graph B: Rainfall average, Côte d'Ivoire (March 2021–February 2022)

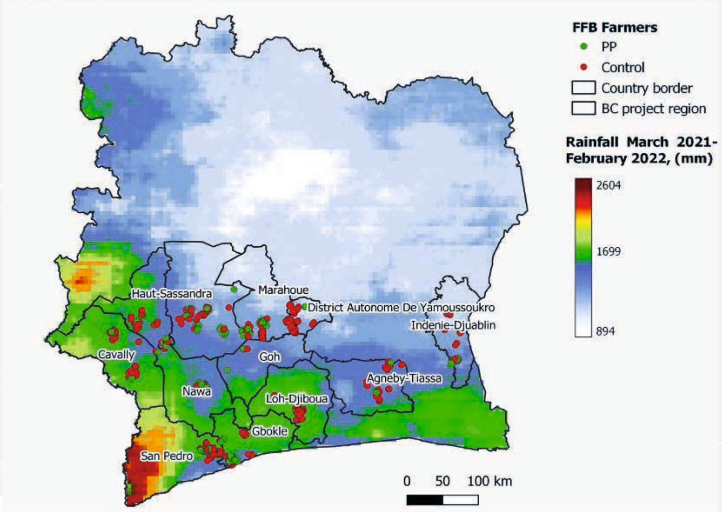


Table A: Regional yield average

Regions	Average Yield
Cavally	645 kg/Ha
San Pedro	636 kg/Ha
Nawa	622 kg/Ha
Guemon	613 kg/Ha
Haut Sassandra	591 kg/Ha
Indenie Djuablin	548 kg/Ha
Gbokle	545 kg/Ha
Agneby Tiassa	517 kg/Ha
Loh Djiboua	508 kg/Ha
Marahoue	461 kg/Ha
Goh	308 kg/Ha
Yamoussoukro	289 kg/Ha

Top five regions all located in Western Côte d'Ivoire

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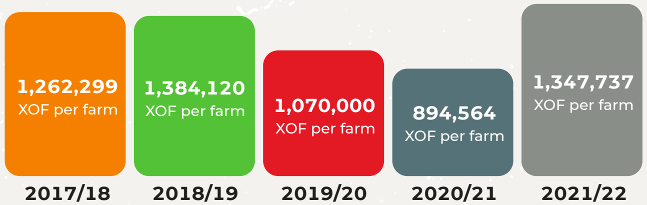
Lowest five regions all located in Central Côte d'Ivoire where precipations are lower

Graph C: Cocoa Income P & L 2017/18–2021/22



2.2 Low yields

Despite the relatively positive production outcomes for the 2021/22 production season, average yields for cocoa farmers in Côte d'Ivoire remain low. Although average reported yields increased in 2021/22, less than 10% of farmers produced 800 kg/ha, while only around 30% were able to produce between 600–800 kg/ha. As a point of comparison, industrial producers such as APROCAFA (The Association of Producers of Fine and Aroma Cocoa) report achieving yields of between 2,000–2,500 kg/ha, using high-yielding cocoa varieties and smart irrigation systems. (See Graph D and Graphic B: Breakdown of farmers per average yield)

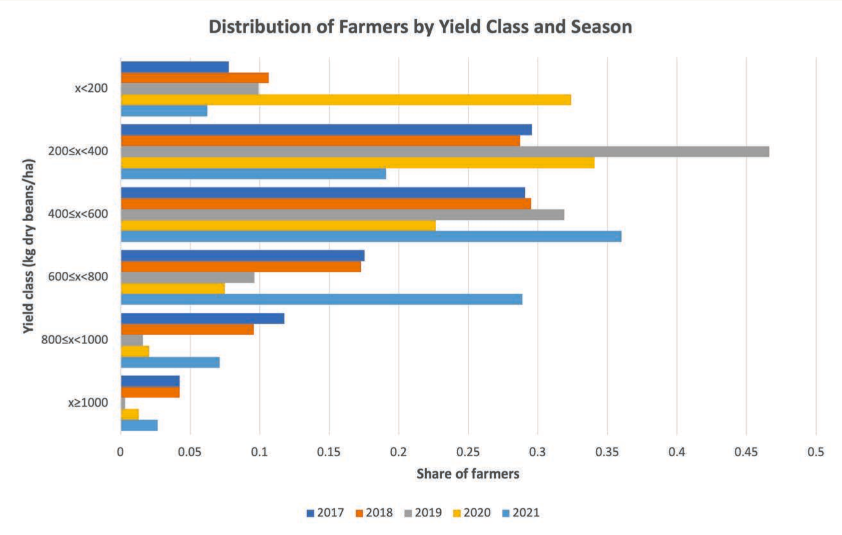
The figure of 800 kg/ha is significant because this is considered by Fairtrade International to be the sustainable yield, or the yield level that farmers should achieve in order to have a high probability of earning a living income. Fairtrade International defines a living income as "sufficient income to afford a decent standard of living for all household members – including a nutritious diet, clean water, decent housing, education, health care and other essential needs, plus a little extra for emergencies and savings – once farm costs are covered"[6].

Based on the findings of Agri-Logic's assessment, less than 10% of surveyed farmers were able to produce yields that could provide a living income in 2021/22. Indeed, the majority of farmers, or around 60%, produced less than 600kg/ha. High poverty levels among farmers continues to be a significant challenge in the Ivorian cocoa value chain, which prevents farmers from investing in more productive and efficient farming methods to increase income levels. This in turn also limits wages for laborers engaged in the sector and can have negative repercussions on farmers' reliance on child labor (Fairtrade International, 2023). Considerable progress remains to be made to close the living income gap, constraining farmers' ability to break out of poverty, while adversely affecting yields and limiting the broader productivity of the Ivorian cocoa sector.

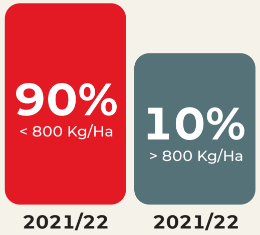
The remaining discussion in Section 9 will elaborate on broader productivity and operational challenges that characterize the Ivorian cocoa growing model, which contribute to low average yields in the sector.

The increase of yield has mainly benefited categories of farmers moving from 0–400 kg/Ha to 400–800 kg/Ha

Graph D: Breakdown of farmers per average yield



Graphic B: Breakdown of farmers per average yield



800 kg/Ha is the "sustainable yield" considered in the assumptions of the Living Income calculation

6 According to Fairtrade International, farmers have a high probability of achieving a living income if they have a minimum productive cocoa area of 4.4 ha, or a total cocoa area of 5.3 ha, receive the Living Income Reference Price (LIRP), and produce 800 kg/ha. For more information, see https://www.fairtrade.net/issue/living-income.

2.3 Low levels of investment in Ivorian cocoa farms

The Ivorian cocoa growing model is characterized by low levels of investment at the farm level. This trend can be observed within the low cost of production for cocoa farming.

Between the 2020/21 and 2021/22 cocoa production seasons, average production costs increased from around USD65/ha last year to USD119/ha. However, these costs were mainly driven by yield increases, which led to an increase in harvest and post-harvest hired labor. According to Agri-Logic, surveyed farmers reported spending around 56% of total cost on hired labor on average, versus 24% on fertilizers, 12% on pesticides, and 8% on other costs. (See Graph E: Average cost of production and Graphic C: Breakdown per type of costs 2021/22)

One objective of Agri-Logic's assessment was to analyze the relationship between level of investment per hectare and margins and yield. To establish this correlation, Agri-Logic segmented surveyed farmers into five quintiles based on the level of investment/cost of production, where the top 20% of farmers in the fifth quintile invested over XOF82,000/ha. In contrast, the bottom quintile invested up to XOF11,000/ha.

In terms of yields, the difference between the bottom and the top quintile of investment levels was significant, with the top 20% of farmers garnering nearly double the yield (around 620 kg/ha on average) relative to the bottom quintile, where average yields were a little over 350 kg/ha. (See Graph F: Yield and profit by investment segment)

In terms of production margins, the top quintile also outperformed most of their peers, earning margins of around XOF350,000 XOF/ha, relative to around XOF300,000 XOF/ha for the bottom quintile. Profit margins for the fourth and fifth quintile were roughly stable, though yields for the top quintile were still around 100kg/ha higher than the fourth quintile.

The remainder of Section 9 will elaborate on the distribution of labor hours per task and assess investments levels at the farm level in terms of resources committed to pre-harvest activities, hired labor and production inputs.

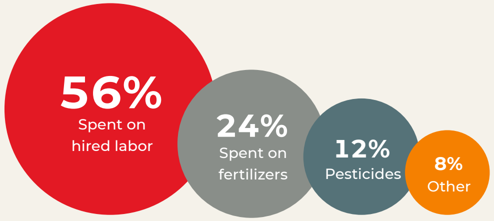
Graph E: Average cost of production

78,979 XOF/Ha (119 US$/Ha)

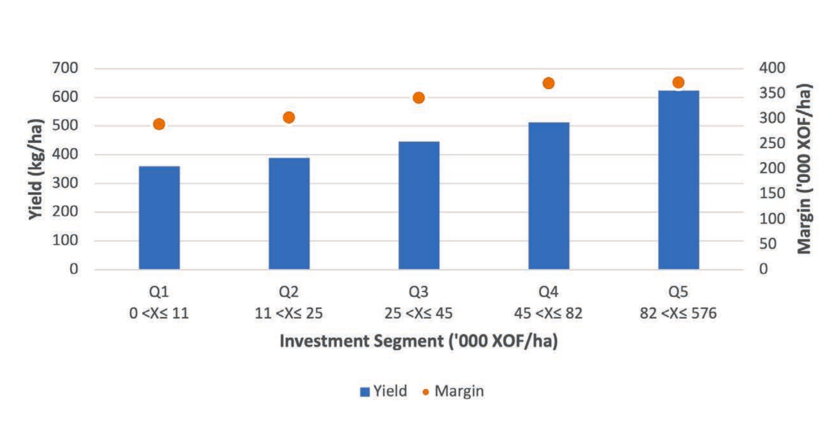
Based on exchange rate of 667, average costs of production are around **119 US$/Ha.**

To be compared with an average of **65 US$/Ha last year.** Increase of costs of production mainly driven by the increase of yield and therefore the increase of post-harvest hired labor.

Graphic C: Breakdown per type of costs 2021/22



Graph F: Yield and profit by investment segment



2.3.1 Distribution of labor hours skewed towards post-harvest activities

During the 2021/22 production season, sampled farmers used an average of 448 labor hours per ha. Within this, approximately two-thirds (66%) of farmer labor investments on average are devoted to post-harvest activities as opposed to pre-harvest activities. This amounts to around 300 hours on average spent on post-harvest activities, versus only around 147 hours spent on pre-harvest activities.

In terms of post-harvest labor hours, the majority of time investment was devoted to processing, which accounted for around 129 hours of work per ha, or 43% of the total hours spent on post-harvest activities. Harvesting also accounted for a significant portion of post-harvest labor hours (94 hours per ha, or 31% of the total), followed by pod breaking (74 hours, or 25% of the total) and selling (3.59 hours, or 1% of the total).

Regarding pre-harvest activities, the largest labor allocations were spent on weeding, with an average of 104 hours spent per ha, or 71% of the total hours allocated per ha to pre-harvest activities. In contrast, only 16 hours per ha were devoted to pruning (11% of the total), while only 27 hours per ha were cumulatively allocated to planting, collecting diseased pods, fertilizing, spraying and other pre-harvest tasks. In particular, only 4.7 hours were spent on fertilizing, or 3% of the total hours per ha devoted to pre-harvest activities.

2.3.2 Limited investments in pre-harvest activities

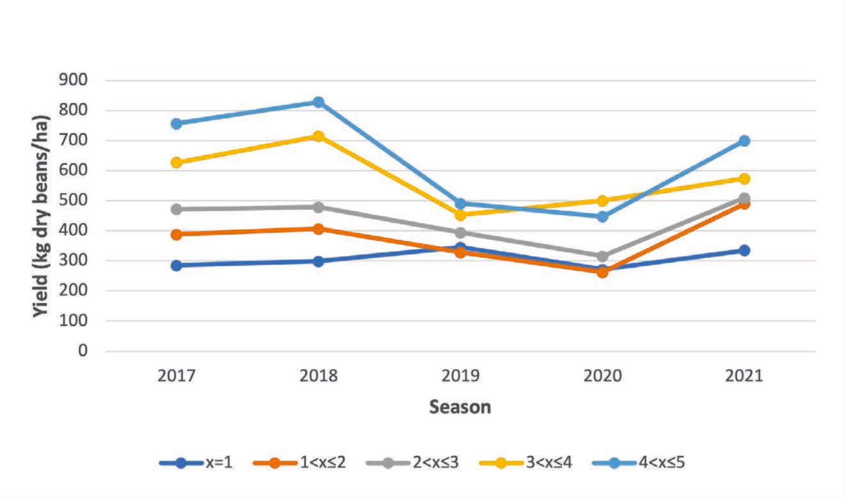
As previously mentioned, farmers tend to spend a disproportionate amount of labor resources on post-harvest activities as opposed to pre-harvest activities. Given that investments in pre-harvest activities are where most of the yield gains can be garnered by farmers, this trend serves to constrain crop productivity and limits improvements in cocoa yields.

To establish a correlation between higher yields and support to pre-harvest activities, Agri-Logic developed a GAP score based on farmer investments in pre-harvest activities such as pruning, fertilizing, spraying and collecting diseased pods. As mentioned in the Methodology section (see Analytical methods), under this rubric, farmers earned a score between one and five, with five signifying high levels of efficient farming practices in terms of the aforementioned pre-harvest activities.

Based on Agri-Logic's assessment, across all five seasons, farmers with higher GAP scores, i.e. farmers pursuing key pre-harvest investments and activities, consistently reported higher yields. (See Graph G: Yield by GAP score segment and season)

For example, during the 2021/22 production season, farmers with an average GAP score of between four and five reported average yields reaching 700 kg/ha, versus around 325 kg/ha for farmers with an average GAP score of one.

Graph G: Yield by GAP score segment and season



2.3.4 Limited pre-harvest labor investments

Similar to trends in pre-harvest investments, the Ivorian cocoa production model is characterized by relatively low levels of pre-harvest labor investments vis-à-vis post-harvest labor investments.

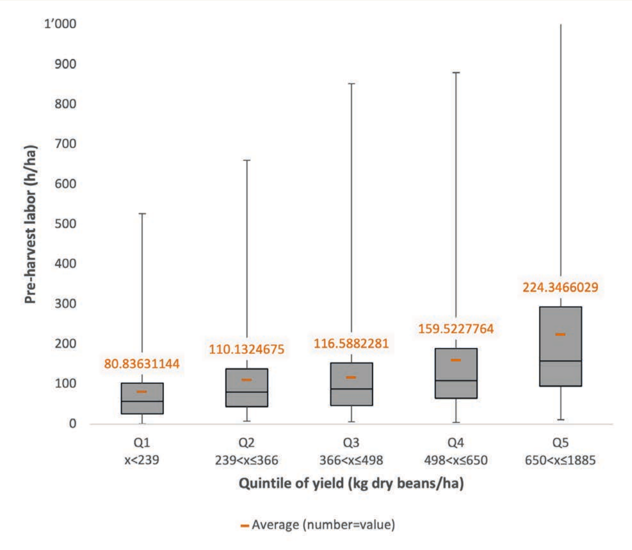
In order to establish a correlation between higher yields and the amount of pre-harvest labor invested in farms, Agri-Logic segmented surveyed farmers into five quintiles based on the level of yield. Farmers within quintile five (Q5) constituted the top 20% of farmers in terms of yield, garnering over 650kg/ha, while farmers in the bottom 20% in quintile one (Q1) reported yields under 239kg/ha. (see Graph H: Pre-harvest labor by quintile of yield)

Based on Agri-Logic's assessment, the top 20% of farmers in terms of yield invested three times more time in pre-harvest labor – or an average of around 224 hours – relative to the bottom 20% of farmers, who only invested 81 hours on average. The top 20% of farmers also invested 40% more than farmers in the fourth quintile, who spent around 160 hours on average. These results support the importance of pre-harvest labor investments to increase yields.

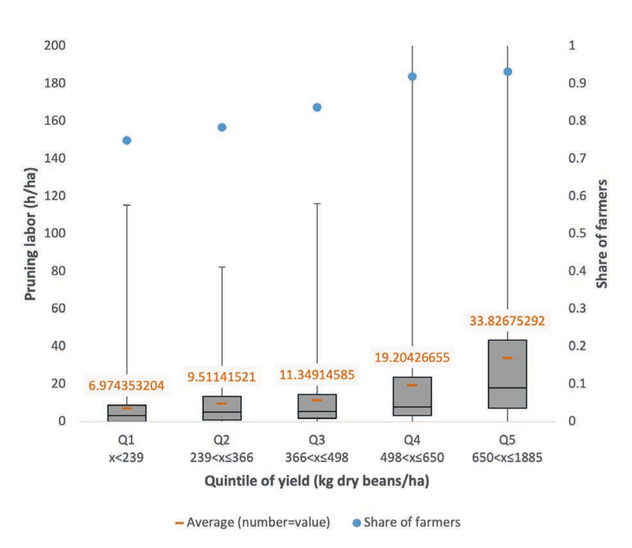
When analyzing the correlation between higher yields and individual pre-harvest activities, Agri-Logic concluded that farmer investments in pruning contribute the most to higher yields. Farmers who produced yields within the highest 20% of the sample (i.e. produced over 650kg/ha) invested three to five times more labor hours in pruning than farmers in the bottom 60% of yield distribution. (see Graph I: Pruning labor by quintile or yield and share of farmers pruning)

Although there remains significant room for improving farmer labor investments in pre-harvest activities, there is evidence to suggest that some farmer groups are beginning to invest more in critical pre-harvest activities such as pruning, spraying, fertilizing and collection of diseased pods. In 2021, Agri-Logic recorded the highest average GAP score among surveyed farmers (3.05 out of 5), indicating improvements in the uptake of these activities among surveyed farmers.

Graph H: Pre-harvest labor by quintile of yield



Graph I: of Pruning labor by quintile of yield and share of farmers pruning



2.3.5 Despite overuse of pesticides, limited investments in fungicides

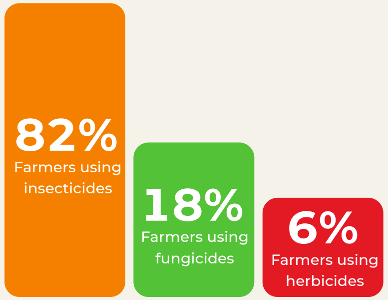
The cocoa farming model in Côte d'Ivoire is also characterized by limited investments in fungicides and herbicides, in contrast to high use of insecticides. Approximately 82% of surveyed farmers during the 2021/22 production period used insecticides. In Barry Callebaut's view, this suggests that farmers are applying irrespective of insect attacks. Given that insecticides should only be applied to address the presence of a pest, this represents an excessive emphasis on this form of crop protection. However, only 18% used fungicides and only 6% used herbicides. The latter trend is particularly concerning given the prevalence of black pod disease, which requires, amongst others, targeted use of fungicide. (See Graph J: Crop protection use and Graph K: Fungicide application)

2.3.6 Limited technical knowledge of, and investments, in fertilizer use

To facilitate soil fertility and help increase cocoa yields, fertilizer mixes should incorporate an appropriate balance of nitrogen, potassium and phosphorus. To determine nutrient balance levels of surveyed cocoa farms, Agri-Logic assessed how much farmers applied of each nutrient through fertilizing, as well as how much of a nutrient was removed from the farm through harvesting. This approach, however, is limited in its capacity to evaluate nutrient levels and determine appropriate nutrient needs. For cocoa trees, a soil nutrient assessment must capture these factors as well as other parameters, notably rainfall levels, soil, pruning and the reproduction type (fruiting or vegetative).

Although Agri-Logic's methodological approach has its limitations, the results of their assessment indicated that nutrient management is inadequate on most farms, as technical know-how surrounding best practices in fertilizer use and investments in fertilizer application are still limited in the Ivorian cocoa farming model.

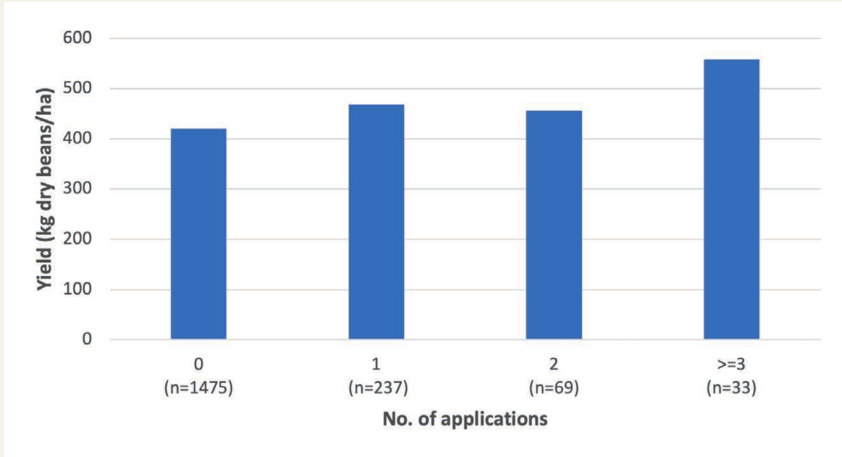
Graph J: Crop protection use



Most farmers apply pesticides with a widespread use of insecticides, some marginal use of fungicides and very little use of herbicides.

Low use of fungicides is surprising knowing the prevalence of black pod disease.

Graph K: Fungicide application



The low use of fungicides is surprising as systematic analysis over five years of data shows higher yield associated with use of fungicides. **More targeted use of fungicide makes sense to fight black pod disease.**

Graphs La, Lb and Lc display the distribution of nitrogen, phosphorous and potassium use efficiency within Agri-Logic's sample during the 2021/22 growing year. The y axis displays the extraction of nutrients, while the x axis displays the application of nutrients. The space between the two dotted black lines represents a range where application and extraction are roughly balanced. The space above the two lines represents soil depletion, whereas the space below represents over-application of nutrients.

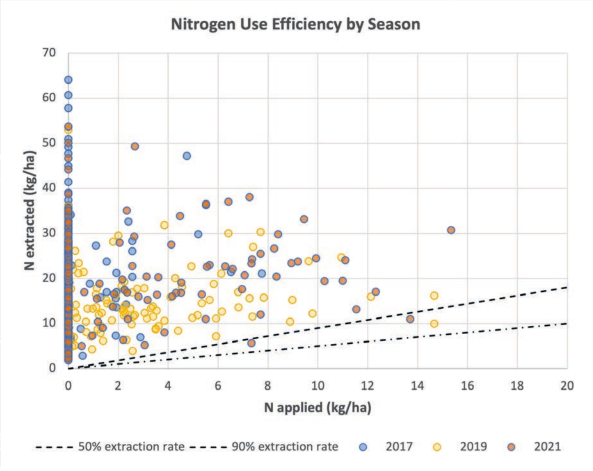
As seen in Graph La and based on Agri-Logic's assessment, the majority of sampled respondents during the 2021/22 production season underused nitrogen, resulting in soil depletion of nitrogen for the majority of surveyed farmers. Although there was a higher number of respondents that appropriately balanced potassium application, farmers largely underdosed fertilizer mixes with potassium (see Graph Lc). In contrast, the majority of farmers applied phosphorus in excess (see Graph Lb)[7].

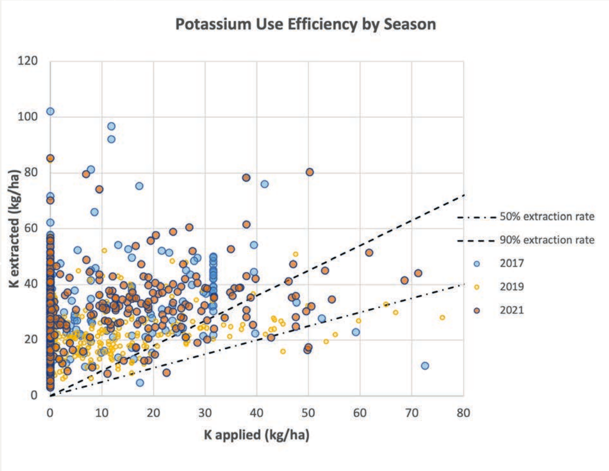
These results are reflected in the fertilizer mixes applied by farmers. Over 40% of surveyed farmers utilized poultry manure, while nearly 25% utilized SuperCao, which provides a mix of potassium and phosphorus[8]. In contrast, only 4% of fertilizers applied were nitrogen-based, notably Nitrabor, though Barry Callebaut generally recommends the application of nitrogen for promoting cocoa production.

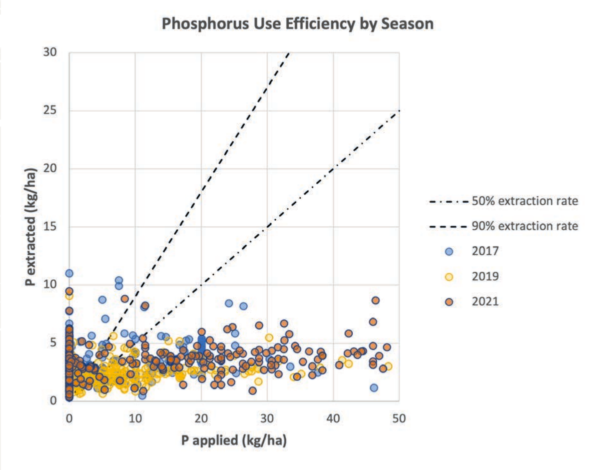
7 Note: The Agri-Logic rationale on Nitrogen and Potassium does not take into account the natural input of nutrients through the decomposition of pods, which could provide additional quantities of potassium, or rainfall and silt-loaded winds, which provide additional quantities of nitrogen.

8 SuperCao contains no nitrogen. The mix is 0-23-19, potassium and phosphorus.

Graphs La, Lb, Lc: distribution of nitrogen, phosphorous and potassium use efficiency within Agri-Logic's sample during the 2021/22 growing year.





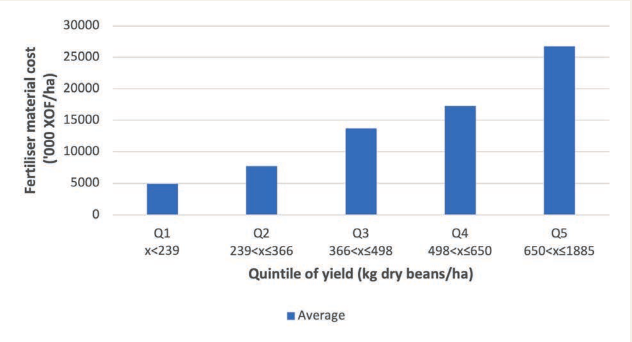


To validate the importance of investments in fertilizer to promote higher yields, Agri-Logic conducted correlation analyses and divided farmers into five quintiles based on the level of yield. Farmers within the fifth quintile (Q5) constituted the top 20% of farmers in terms of yield, garnering over 650kg/ha, while farmers in the bottom 20% in the first quintile reported yields under 239kg/ha. Agri-Logic then evaluated the amount of investment farmers committed to fertilizers. (See Graph M: Fertilizer material cost and share of farmers fertilizing by quintile of yield)

The top 20% of farmers in terms of yield invests five times more in fertilizers than the bottom 20%, establishing a strong correlation between fertilizer investments and higher yields. Specifically, farmers producing over 650kg/ha invested around XOF26,000/ha in fertilizer material costs. In contrast, farmers in the lowest quintile that produced less than 239kg/ha invested only around XOF5,000/ha in fertilizer. Even between the fourth and fifth quintile, there was a significant difference reported in investments on fertilizers, with the former producing between 498-650kg/ha and investing nearly XOF10,000 less than farmers in the latter quintile.

That said, it is important to note that overall investment levels in fertilizers are generally low. Although farmers in the top 20% of yields produced (i.e. farmers in the fifth quintile) invested the highest amount per hectare (XOF26,000/ha), this amount remains limited in contrast to recommendations from Barry Callebaut, which suggests farmers should invest between XOF100,000-150,000/ha[9] to ensure the appropriate level and balance of nutrients.

Graph M: Fertilizer material cost and share of farmers fertilizing by quintile of yield



9 This range also depends in part on the prevailing market price of fertilizers.

2. 4 Child work trends

The involvement of child labor in the Ivorian cocoa value chain has historically been prevalent, prompting large-scale stakeholders in the sector to prioritize initiatives to reduce the prevalence of child labor. Consequently, Agri-Logic sought to assess the participation of children in the specified sample.

Within the context of this study, Agri-Logic aims to measure child work prevalence as opposed to child labor. This approach stems from the fact that with the data at hand, it was not possible for Agri-Logic to make a clear distinction between child work and child labor, as defined by the International Labor Organisation. Consequently, Agri-Logic do not use the term child labor. For the labor executed by boys and girls under 16 in the household, Agri-Logic uses the term child work, which is defined as all labor that is executed by boys and girls younger than 16 years. This age-specific data is only collected for labor from household members.

According to Agri-Logic's assessment, the prevalence of child work has declined significantly in sampled farmers since 2018/19, when nearly two-thirds (61%) of farmers reported the presence of child work on their farms. Since then, the prevalence of child work on surveyed farms has steadily declined to 31% in 2021/22.

Similarly, the average number of hours worked by children has declined from an average of around 146 hours per farm in 2018/19 to 31 hours per farm in 2020/21. Although the number of hours worked by children increased slightly in 2021/22 to an average of 41 hours, the average number of hours worked still remained considerably below hours reported in 2018/19 and 2019/20.

2. 5 Vulnerability to fluctuations in precipitation and climate change

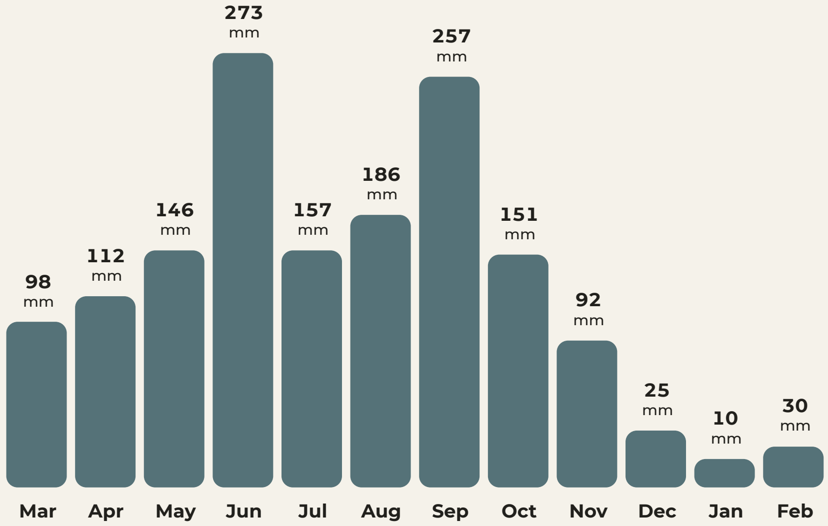
Cocoa trees are highly sensitive to water deficiencies in the soil and require plentiful rainfall that is well distributed throughout the year to produce higher yields. Of all climatic factors, rainfall is the most determining factor in yield variations for cocoa trees, with preferred annual rainfall of between 1,500mm and 2,000mm[10]. Dry spells, which are defined as rainfall that is less than 100mm per month, should not exceed three months.

Differences in rainfall by region can have significant repercussions on average yields. Between regions such as San Pedro and Yamoussoukro, rainfall differences over a full year can account for more than 1,000mm, contributing to considerably higher average yields in the former region over the latter.

In addition to preferred annual rainfall of between 1,500-2,000mm, rainfall must also be regularly distributed for farmers to achieve higher average cocoa yields. Although the average level of precipitation in 2021/22 was generally beneficial to cocoa production, rainfall fell below 100mm during five months of the 2021/22 crop year, which could result in reduced yields. Towards the end of 2021 and early 2022, there were four consecutive months where average rainfall reportedly fell below 100mm, which could adversely impact yields in the next season. (See Graph N: 2021/22 regular pattern of precipitation)

Cocoa production in Côte d'Ivoire is also becoming increasingly vulnerable to the impacts of climate change. Changes in the climate have contributed to erratic and declining rainfall patterns and higher temperatures, which may result in increased drought stress in cocoa-growing areas of West Africa. Based on climate models recognized by the Intergovernmental Panel on Climate Change (IPCC), climate change may decrease the suitability of the climate in Côte d'Ivoire for cocoa production, which could threaten both the sustainability of the cocoa industry in the country as well as the productivity of cocoa farming[11].

Graph N: 2021/22 regular pattern of precipitation



10 ICCO: https://www.icco.org/growing-cocoa/#:~:text=Rainfall%20should%20be%20plentiful%20and,should%20not%20exceed%20three%20months

11 Schroth et al., 2016: https://www.sciencedirect.com/science/article/pii/S0048969716304508

2.6 Income

Agri-Logic performed a regression analysis to identify the key determinants of income for surveyed cocoa farmers (See Graph O: Regression model output for income μ=1.58 million XOF/farm). Based on the results of the regression analyses, the following four factors had the highest positive correlations to higher income levels for farmers: precipitation levels, fertilizer use, the size of cocoa farms, and cocoa yields. According to other research, the payment of Living Income Reference Price can also influence farmers' income levels. The regression analysis explained 84% of observed variability in total household income.

Precipitation

The level of precipitation was highly positively correlated with income. This correlation was also confirmed by the yield breakdown per region. Agri-Logic sought to identify correlations between particular periods of rainfall and income. Higher rainfall levels in January and May were identified as having particularly high positive correlations with income, while rainfall in July and November had significantly negative correlations with income levels.

Fertilizer use

Agri-Logic's regression analysis identified a strong positive correlation with the application of nitrogen and potassium. Farmers that utilized relatively sufficient amounts of nitrogen and potassium were able to produce higher yields, thereby translating into higher income levels. In contrast, the application of phosphorus was negatively correlated with income. This can likely be attributed to the nutrient mix of fertilizer protocols, where farmers generally apply phosphorus in excess, while nitrogen and potassium use are largely insufficient for soil needs in Côte d'Ivoire.

Size of cocoa farms

Agri-Logic's regression analysis also concluded that larger farms drive higher levels of income, given the fact that the larger the farm is, the more cocoa trees are able to be grown, resulting in higher yields and subsequently higher reported income.

A caveat must be made however, as Agri-Logic's assessment concluded that higher GAP scores are positively associated with smaller farms. This is likely because respondents with larger cocoa farms are usually not able to invest the appropriate level of labor to maintain GAP practices that a smaller farm is able to implement through labor provided by the household.

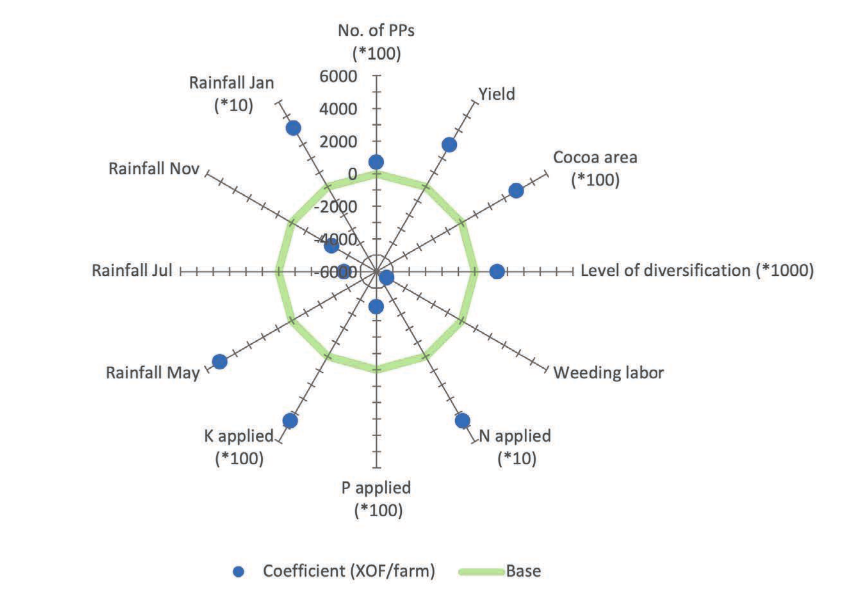
Yield

The final determinant to account for the variability of incomes is explained by the evolution of yields. In 2021/22, income increased significantly, which was largely driven in turn by positive yield performance.

Generally positive yield performance in turn has had a positive impact on the proportion of farmers living above the poverty line, which is defined as earning USD1.90 per day[12].

12 In September 2022, the World Bank adjusted the extreme poverty line from $1.90 to $2.15 per person per day. This adjusted rate was covered in the calculation.

Graph O: Regression model outputs for income (μ=1.58 million XOF/farm)



In 2021/22, around two-thirds of surveyed farmers were living above the poverty line, relative to only 40% of farmers in 2020/21. In other words, the proportion of surveyed farmers living below the poverty line declined from 60% in 2020/21 to 34% in 2021/22.

Although this also resulted in a modest increase in the percentage of farmers earning a living income in 2021/22, only 8% of farmer respondents in the sample are earning above the living income threshold. Consequently, significant progress remains to be made to enable more farmers to rise out of poverty and earn a sustainable income.

2.6. 1 Implications of sectoral challenges on yields and ability of farmers to earn a Living Income

As highlighted by Agri-Logic's assessment, the Ivorian cocoa farming model is characterized by a number of challenges that serve to constrain productivity levels and diminish yields. Although the majority of farmers enjoyed improvements in cocoa yields during the 2021/22 cocoa production season, higher yields are largely the result of better rainfall, which benefitted farmers in western Côte d'Ivoire in particular. Higher yields in turn helped surveyed farmers attain the highest average income per farm since the 2018/19 production season.

Despite these improvements, average yields for Ivorian cocoa farmers remain low, with less than 10% of farmers able to produce 800kg/ha or more. This figure stands in stark contrast to industrial producers such as APROCAFA, who have reported achieving yields of between 2,000-2,500kg/ha, using high-yielding cocoa varieties and smart irrigation systems[13].

Low yields reflect an array of challenges, notably limited labor and investments in pre-harvest activities and inputs such as fertilizer and fungicides. Farmers also face constraints due to increasingly erratic variations in the distribution and quantity of rainfall, which stem from the effects of climatic changes.

As a result of these challenges, less than 10% of surveyed farmers produced yields that could provide a living wage in 2021/22, based on Fairtrade International's sustainable yield standard. As a result, many Ivorian cocoa farmers remain entrenched in poverty and unable to make investments in productivity improvements that could help them increase yields and close the living income gap.

13 Sources: https://www.spglobal.com/commodityinsights/en/ci/research-analysis/interview-ecuador-aiming-to-double-cocoa-production-in-next-se.html#:~:text=As%20specialist%20producers%2C%20we%20achieve,the%20country's%20average%20is%202.6
https://www.confectionerynews.com/Article/2016/03/29/Cocoa-s-future-lies-in-Latin-America-Report

3 Priorities for the future: An evidence-based approach to support the cocoa sector

Although there remains considerable scope for improving the productivity and profitability of the Ivorian cocoa sector to farmers' benefit, Agri-Logic's assessment highlights a number of strategic actions that could improve cocoa yields and promote higher farmer incomes.

The following section will summarize priority areas for future sustainability interventions and identify opportunities to help farmers diversify income sources.

3. 1 Priority areas for future interventions

Based on findings of Agri-Logic's assessment, the productivity and profitability of the Ivorian cocoa farming model could be enhanced by providing support to the following areas:

1. **Pre-harvest activities:** Ivorian cocoa farmers would generally benefit from higher levels of investments, both from an inputs and labor perspective, in pre-harvest activities. Given the importance of pre-harvest labor and input investments to boost yields, educating farmers on the importance of these activities and best practices remains an important component of future sustainability initiatives. Farmers and laborers would also benefit from improved access to key inputs and dedicated training in these areas, which could help promote work opportunities for the latter group.

2. **Fertilizer access and application:** Improvements are needed in terms of both farmer technical know-how regarding fertilizer application as well as access to appropriate fertilizer mixes. Focussing on these issues in future sustainability issues would help promote soil fertility and higher yields, thereby facilitating income improvements.

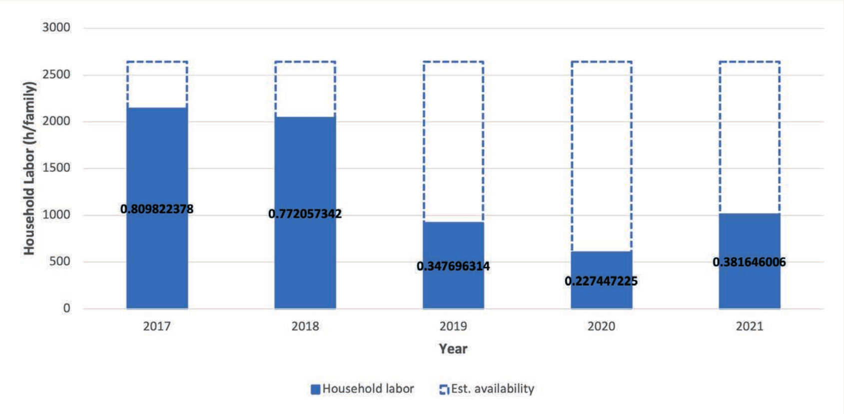
3. **Vulnerability to erratic and declining rainfall:** Boosting farmer investments in more drought-resistant cocoa varieties could help improve farm resilience to drought and climatic-induced environmental changes. Based on current climate predictions for the West Africa region in particular, elements of climate-smart agriculture will need to be incorporated into the Ivorian cocoa model to boost yields and ensure the sustainability of the industry.

4. **Food for thought:** Helping farmers diversify their income sources could also increase incomes and lower risks associated with seasons characterized by low yields. Based on data gathered by Agri-Logic, when assuming that each household has, on average, approximately 1.5 full-time equivalent (FTE)[14] available to work on cocoa and 220 working days per season, cocoa production is not a full-time job. Although cocoa accounts for 83% of farmer income, labor hours dedicated to cocoa are 38% of overall available labor hours. For the remaining 62% of labor hours, farmers could produce fruit, vegetables and poultry, thereby diversifying agricultural products sold, or establish agricultural service provider units, which provide professionalized pruning and spraying services as two examples. Promoting such activities in parallel to the adoption of good agricultural practices could enable more farmers to achieve a living income. (See Graph P: Household labor used in cocoa relative to estimated household labor availability by season and Graph Q: Household labor used in cocoa relative to estimated household labor availability in 2021).

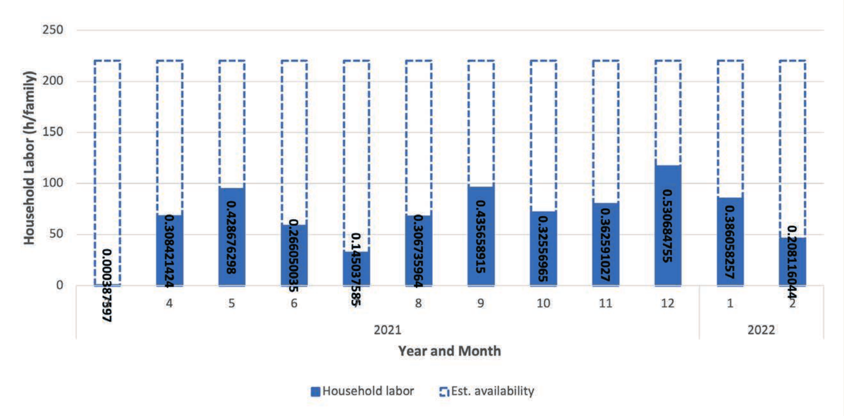
In addition, price mechanisms can support farmers in progressing towards a Living Income, which should be coupled with the other priority areas mentioned above (as shown by this research, much of the farmers' performance on Living Income is driven by yields, then by cocoa area and lastly by the cocoa price). Barry Callebaut acknowledges that higher farmgate prices lead to poverty reduction and that the appropriate mechanisms to achieve this should be analyzed in a broader context of price construction (farmgate price vs export price) to achieve the biggest impact on farmers' incomes.

All of the aforementioned priority areas could spur improvements in yields, incomes, and ultimately serve to reduce poverty levels among Ivorian farmers. Nevertheless, the majority of these recommendations necessitate an increase in the costs of production, stemming from higher investments in labor and key inputs such as fertilizer. Given high levels of poverty among farmers, many are unable to afford additional investments in their farms. Future sustainability initiatives should therefore strive to fill critical gaps in investment capacities while bolstering technical know-how among cocoa farmers and laborers. At the same time, stakeholders in major sustainability programs would benefit from further investments in farmer segmentation, thereby allowing stakeholders to continue deepening their understanding of the needs and challenges of Ivorian farmers to help inform more targeted, effective interventions.

Graph P: Household labor used in cocoa relative to estimated household labor availability by season



Graph Q: Household labor used in cocoa relative to estimated household labor availability in 2021



14 Full-time equivalent (FTE) is a unit of measurement that reports on the workload of an employed person in a way that helps make workloads comparable across various forms of employment. An FTE of 1.0 amounts to a full-time worker.