# A GLOBAL REVIEW OF COCOA FARMING SYSTEMS

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Front cover photos: Philippe Bastide

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# INTRODUCTION

Cocoa is cultivated throughout the humid tropics by an estimated 5-6 million farmers, a large proportion of whom are smallholders. According to FAO (2021), 61 countries currently produce cocoa, although almost 90% of global production is produced by only seven countries, with Côte d'Ivoire and Ghana accounting for more than 60% of global production for the year 2020/21 (Table 1). The largest proportion of cocoa is cultivated in West Africa where 77.3% of cocoa was produced in the season 2020/2021 (ICCO, 2021). Significant volumes of cocoa are also produced in Latin America and in South/ South-East Asia.

Cocoa productivity, that is yield produced per unit area, varies greatly between farms and from year-to-year. Six key drivers of on-farm productivity are: variety cultivated, soils, farm husbandry, farm age, abiotic factors (climate) and biotic factors (pests, diseases, weeds, parasitic plants) (Figure 1). These factors are not mutually exclusive, for example, an improved variety may only achieve its full yield potential in fertile soil and with a favourable climate, whilst the impact of pests and diseases may be offset through improved control and husbandry methods combined with adoption of more disease tolerant varieties. The profitability of a cocoa farm does not only depend on cocoa bean yield but also depends on a range of other factors including farm gate price, any premium paid (e.g. Fairtrade, organic, fine or flavour), income derived from other farm activities (e.g. companion crops, livestock), labour and costs of inputs. Optimisation of agricultural practice can reduce on-farm costs. For example, targeted fertiliser use will reduce fertiliser costs, whilst planting of more disease resilient varieties will reduce dependence on costly agrochemicals and associated labour costs.

A sustainable cocoa economy needs to employ husbandry methods that maximise productivity, whilst minimising environmental impact and maintaining soil health, thus enabling the same land to be used for cocoa production by future generations. Such a sustainable approach improves farmer livelihoods through continuity of income and optimisation of resources whilst maximising biological diversity.

The purpose of this review is to assess the characteristics of cocoa farming systems globally. This will facilitate a better understanding of routes to more sustainable and high-yielding cocoa farming systems that will improve the income of farmers whilst meeting all the quality and food safety requirements of the cocoa market. To achieve this, a review of the published literature has been conducted on the characteristics of cocoa farms in 28 countries (Figure 2). Furthermore, expert consultants have provided an analysis of the cocoa farming systems within five key producing countries: Brazil, Côte d'Ivoire, Ecuador, Ghana, and Indonesia. The information derived has been used to characterise different farming systems globally and to identify key traits that differentiate such systems by means of a comparative matrix. By characterising farming systems in this way, it has been possible to identify routes towards higher and more sustainable cocoa production.

Table 1. Forecasted cocoa production from the top seven cocoa-producing countries for the year 2020/21 (ICCO, 2021). Values are for dried cocoa beans.

| Country | Production (1000 tonnes) | % of total |
|---|---|---|
| Côte d'Ivoire | 2,225 | 43.3 |
| Ghana | 1,040 | 20.2 |
| Ecuador | 350 | 6.8 |
| Cameroon | 290 | 5.6 |
| Nigeria | 270 | 5.3 |
| Indonesia | 200 | 3.9 |
| Brazil | 180 | 3.5 |
| Other countries | 586 | 11.4 |
| **TOTAL** | **5,141** | |

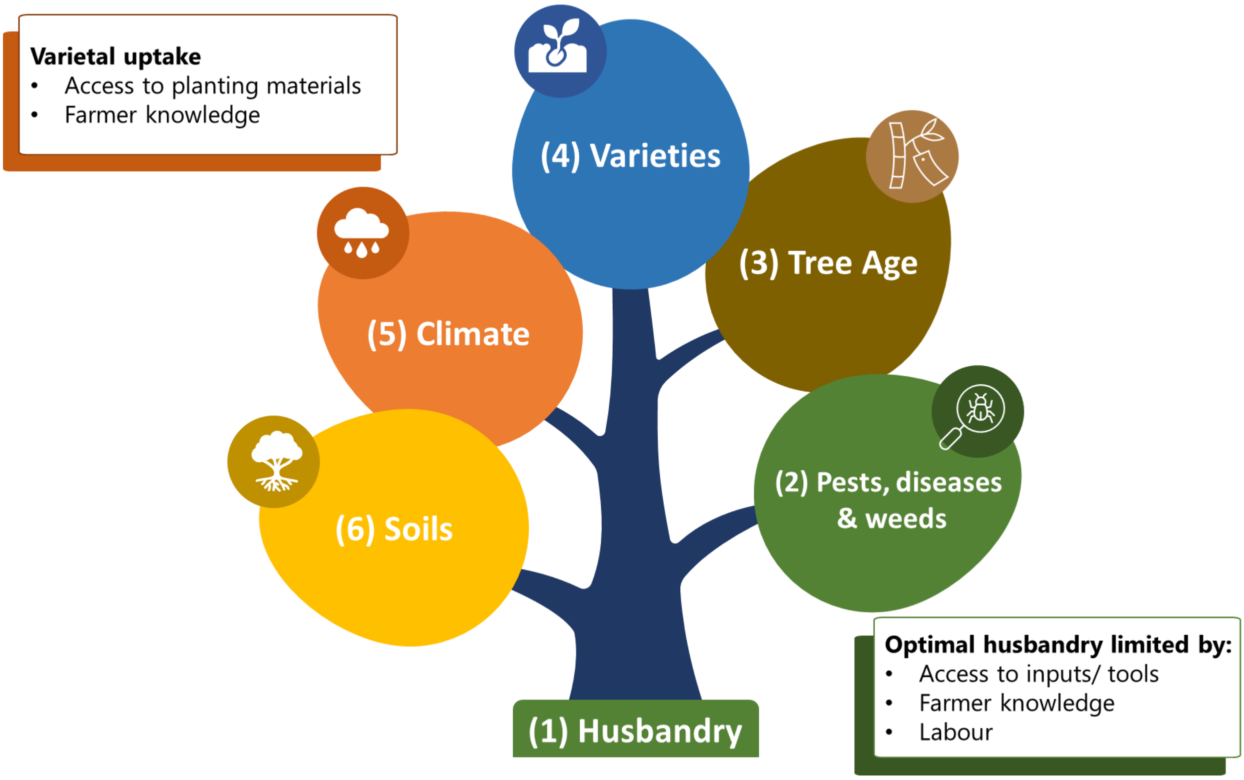



Figure 1. The six pillars of variability in on-farm cocoa yield (spatial and temporal).

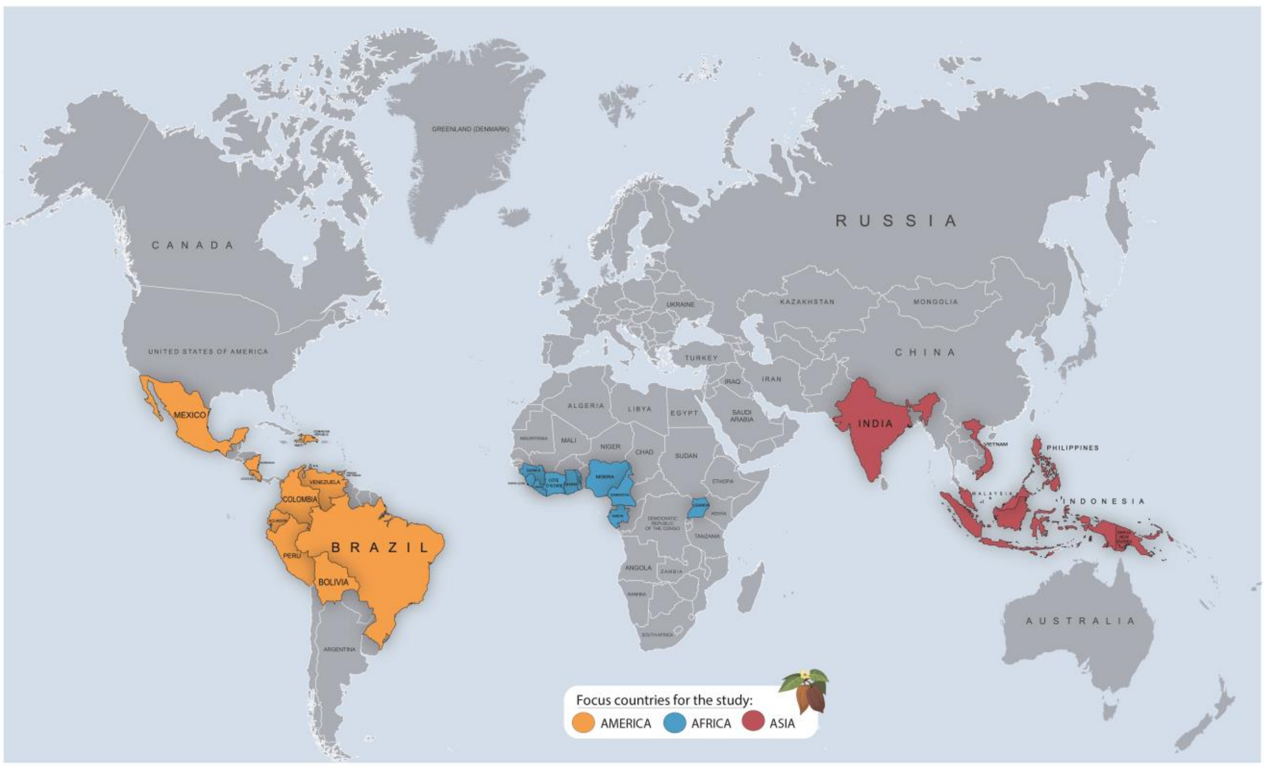



Figure 2. Focus countries for the study. In Africa = Cameroon, Côte d'Ivoire, Gabon, Ghana, Guinea, Liberia, Nigeria, Sierra Leone, Togo, Uganda. In America = Bolivia, Brazil, Colombia, Costa Rica, Dominican Republic, Ecuador, Haiti, Mexico, Nicaragua, Peru, Trinidad and Tobago, Venezuela. In Asia = India, Indonesia, Malaysia, Papua New Guinea, Philippines, Vietnam

# 1. COCOA FARMER

Key findings:

- A wide range of farmer age profiles are observed in different cocoa-growing countries.
- Notable countries that have an aging farmer population include Ghana, Colombia and Ecuador.
- A number of studies have shown a link between farmer level of education with technology adoption and cocoa income.

## 1.1 AGE PROFILE

A concern is often expressed of an aging population of cocoa farmers and that younger generations are less interested in cocoa farming (Hainmueller et al., 2011; Vigner et al., 2016). However, a review of the literature indicates a wide range of farmer age profiles in different cocoa-growing countries (Figure 3). In **Ghana**, a survey of 96 farmers across four cocoa-growing regions revealed that 52% of farmers were over the age of 50 (Daymond et al., 2018). In **Côte d'Ivoire**, Yves et al. (2016) reported an average farmer age of 44 in the Allogene Baoulé region, whilst Tano (2012) reported average ages ranging from 45-54 according to region and ethnic group. In contrast, in **Uganda** the agriculture sector plays a critical role in providing occupation to many Ugandan youth (FAO, 2018).

In South-East Asia, in a survey of 120 farms across eight different provinces in **Indonesia**, the largest proportion (32%) of farmers were in the age group of 41-50, 23% were between 51-60, whilst 15% were over 60 (Daymond et al., 2020), suggesting a more middle-aged farmer profile.

In South America, a number of countries have an age profile that is skewed towards older cocoa farmers. In **Ecuador**, various studies across different production areas have revealed an aging farmer population. For example, the proportion of farmers/ head of households over 50 years old was reported to be 43% and 58.8%, respectively by Anzules et al. (2018) and Barrezueta Unda & Chabla Carrillo (2017). A further study of the main producing areas of Ecuador reported 87% of producers to be over 55 years old (Agama et al., 2009). An extensive survey in **Colombia**, revealed an average age of the head of household of cocoa farming families to be 50 (DANE, 2014). The typical cocoa farmer profile in the **Dominican Republic** is a male aged 58+ (Berlan & Bergés, 2013).

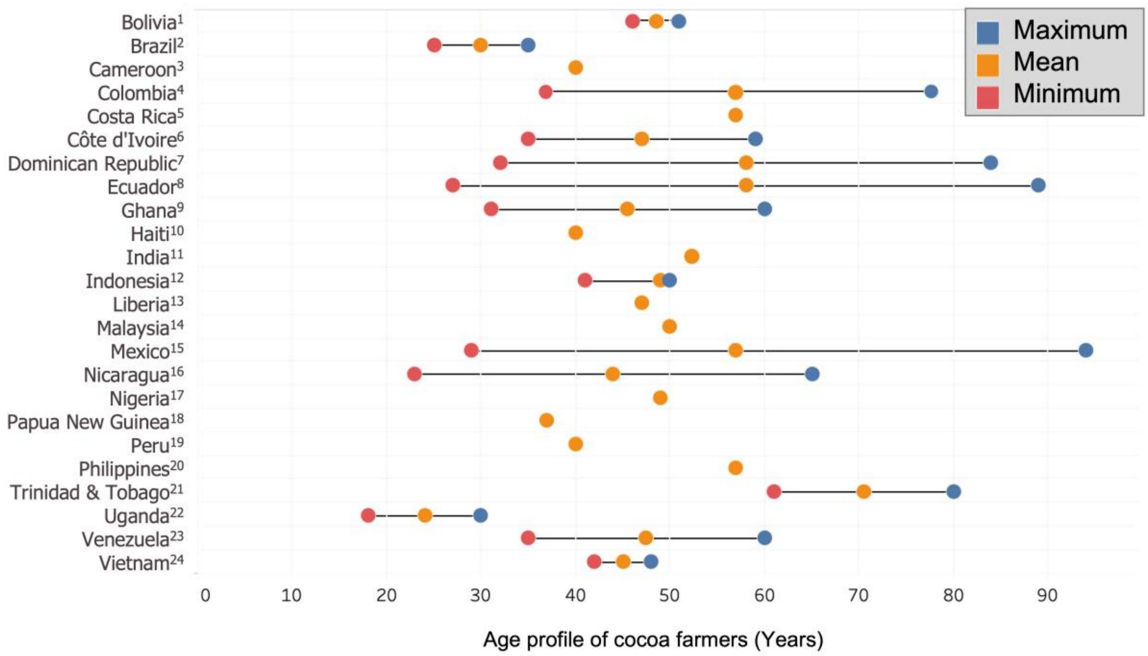



Figure 3. Age profile of cocoa farmers in different cocoa producing countries. The orange dot represents the mean (note in some cases that mean age is only reported). The red and blue dots correspond to the minimum and maximum respective farmer age reported in surveys.

[1]Cruz & Condori (2005); [2]CENSO AGROPECUÁRIO IBGE (2017) & Estival et al. (2016); [3]Wessel & Quist-Wessel (2015); [4]Abbott et al. (2018) ;[5]UCR (2020); [6]Zanh et al. (2019); Yao et al. (2016); Tano (2012) [7]Berlan & Bergés (2013); [8]Anzules et al. (2018), Barrezueta Unda & Chabla Carrillo (2017). Agama et al. (2009); [9]Löwe (2017); [10]Chery (2015); [11]Jaganathan et al. (2015); [12]Daymond et al. (2018); [13]English (2008); [14]Yusof et al. (2017); [15]Díaz-José et al. (2014); [16]Aguad (2010); [17]Ojo et al. (2019); [18]Daniel et al. (2011); [19]Higuchi et al. (2015); [20]Hamrick et al. (2017); [21]Maharaj et al. (2018); [22]FAO (2018); [23]Alvarado et al. (2014); [24]Ruf & Paulin (2016).

## 1.2 LEVEL OF EDUCATION

A number of studies have demonstrated an apparent link between higher levels of education and willingness to adopt new farming technologies and that there is a positive correlation between literacy and total cocoa income (Audet-Belanger et al., 2018; Goldstein et al., 2014). Results of published surveys of the level of cocoa farmer education reveal a higher level of education in some cocoa-growing countries compared with others (Table 2) with illiteracy amongst farmers being high in **Côte d'Ivoire** (Tano, 2012) and **Sierra Leone** (African Enterprise Challenge Fund, 2011). In other countries, for example **Indonesia** and **Venezuela**, it has been reported that most farmers have at least a basic level of education (Arsyad et al., 2019; Alvarado et al., 2014). In **Nicaragua**, generational differences have been noted in levels of education attained, such that a higher proportion of the children of cocoa farmers have a basic level of education compared with that of the farmers themselves (Escobedo Aguilar, 2010).

Table 2. Summary of level of education attained by cocoa farmers as reported in various published surveys

| Country | Level Education |
|---|---|
| Ghana | 71% of farmers surveyed had a formal education (Junior high school (JHS)/ middle school), and the most common category of educational attainment in Ghana was Junior high school (JHS), which was attained by 46% of household heads (Audet-Belanger et al., 2018; Ehiakpor et al., 2016). |
| Nigeria | The mean number of years of spent in education was 12.5 ± 3.8 years (Ojo et al., 2019).<br>92.3% respondents were educated to at least primary level (Osas et al., 2016). |
| Uganda | 55% of respondents had not completed primary education (FAO, 2018). |

| | |
|---|---|
| Liberia | 80% of respondents had participated in some level of formal education (English, 2008). |
| Sierra Leone | Literacy levels in Sierra Leone are extremely low – around 30% (African Enterprise Challenge Fund, 2011). |
| Côte d'Ivoire | 67% of respondents had no education; 25% had a primary education; 6% secondary education; 0.9% higher education (Tano, 2012).<br>A higher proportion of household heads in Côte d'Ivoire had no formal education (32%) or only primary school education (34%). A lower proportion of respondents had completed junior high school (21%) (Audet-Belanger et al., 2018). |
| Cameroon | 70% of respondents had a level of education less than or equal to primary level (of these 56% were men and 44% of women) (Belek & Jean-Marie, 2020). |
| Indonesia | Most farmers had some level of education; less than 2% of farmers surveyed had no education, whilst 8.6% of farmers had attended University (Daymond et al., 2020).<br>Most respondents had attended primary school, 35% attended high school (Arsyad et al., 2019). |
| Malaysia | Farmers surveyed had only attended primary school (Yusof et al., 2017). |
| India | 62% of women and 43% of male farmers surveyed had no education (Barrientos, 2014). |
| Nicaragua | Parents in most cases do not have a primary education or it is incomplete (43%) unlike children of farmers who have completed primary education (72% of cases) and some have a secondary education (Escobedo Aguilar, 2010). |
| Mexico | More than 50 % of cocoa growers had not finished elementary education, and only 4.6 % hold a bachelor's degree (Hernández et al., 2015). |
| Colombia | 20.5% of farmers had no education, 58.8% were educated to primary level, 17.5 to secondary level and 3.1% to tertiary level (technical or university) (DANE, 2014). |
| Costa Rica | Only 14% of the population reached secondary education. Illiteracy rates are as high as 30%. |
| Ecuador | 56.1% of farmers had primary education and 30.8% had completed secondary education (Mata Anchundia et al., 2018).<br>7.7% of farmers had no schooling, 84.6% had basic schooling, 3.8% had completed secondary school, while 3.8% had attended college courses (Morales, 2013).<br>16% of farmers had attended basic school, 60% high school, 15% University, 9% no formal education (Anzules et al., 2018). |
| Peru | Most farmers had attended elementary school; farmers who had commercialized on their own had a higher level of education (Higuchi et al., 2015). |
| Venezuela | 92% of farmers had only completed primary school (Alvarado et al., 2014). |
| Brazil | 7.7% of farmers were illiterate, 67.3% of farmers had elementary school level education, 21.4 had high school level and 3.6% had University degrees (CENSO AGROPECUÁRIO IBGE). |
| Dominican Republic | 14% of farmers had no formal education; 3% were educated to pre-primary level, 71% to primary level, 9% to secondary and 3% to University level (Berlan & Bergés, 2013). |

### 1.3 FAMILY SIZE

A large family can be beneficial for cocoa households as they may, depending on the age of household members, be able to rely more on household labour than hired labour (Anang et al., 2011). On the other hand, a large household can also mean a higher number of dependants, which increases the overall living costs of a household (Audet-Belanger et al., 2018). Family size by country as reported by published surveys is summarised in Figure 4.

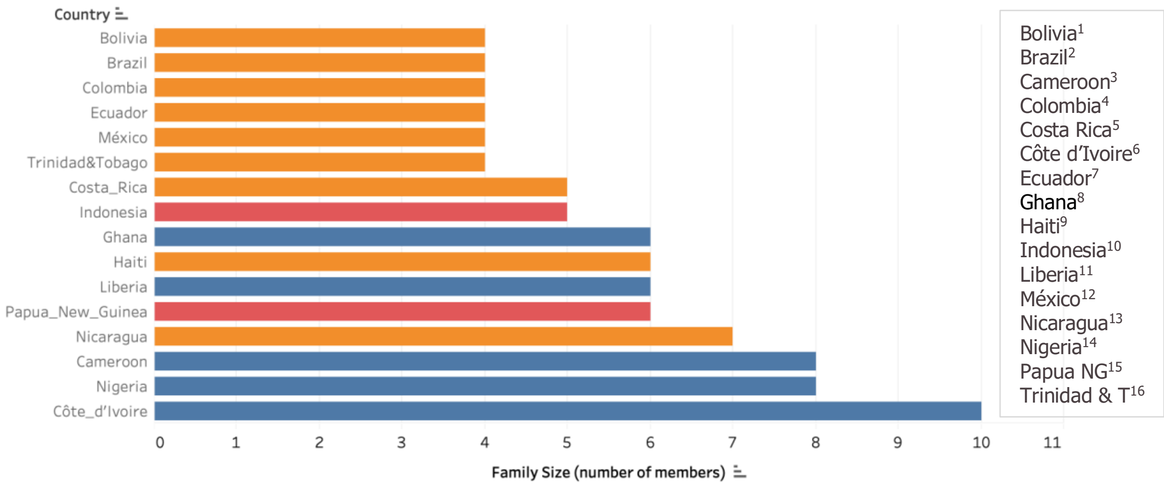



Figure 4. Family size by country (colours represent different countries)

[1]Bazoberry et al. (2008); [2]CENSO AGROPECUÁRIO IBGE (2016); [3]Belek & Jean-Marie (2020); [4]Pabón et al. (2016); [5]Bosque-Perez et al. (2007); [6]Côte d'Ivoire Consultant; [7]Barrera et al (2019); [8]Afriyie-Kraft et al. (2020); [9]Schwartz & Maass (2014); [10]Arsyad et al. (2019); [11]English (2008); [12]Hes et al. (2017); [13]Aguad (2010); [14]Ojo et al. (2019); [15]Daniel et al. (2011); [16]Maharaj et al. (2018).

## 2. COCOA FARM

Key findings:-

- The majority of cocoa farms worldwide are smallholdings; the size of the farm will impact on its functions, use of labour and mix of crops grown.
- There are notable examples of large cocoa plantations in Brazil, Colombia, Ecuador, Peru, Côte d'Ivoire and Indonesia.
- The countries with the largest areas under cocoa production are Côte d'Ivoire, Ghana, Indonesia and Nigeria.
- Optimal planting density varies according to variety grown and the amount of solar radiation received by the crop.
- In a number of countries (e.g. Côte d'Ivoire, Ghana and Indonesia) planting density often deviates quite considerably from recommendations, with a potential impact on yields.
- A wide range of farm ages have been reported globally; yield declines can be expected to be seen in farms with aging trees stocks.

### 2.1 SMALLHOLDER FARM SIZE

The majority of cocoa farms worldwide are smallholdings. Reported sizes of smallholdings in different cocoa-producing countries are summarised in Figure 5. In some countries, a broad range of farms sizes has been reported. For example, Daymond et al. (2018) reported a range of small-holder farm sizes from 0.26 to 11.6 ha in **Ghana** and 0.44 to 14.8 ha in **Côte d'Ivoire**. In **Ecuador**, Estupiñán (2011) reported an average farm size of 3.62 ha in a survey of 350 cocoa producers, although the range was between 0.4 to 12 ha. Farm size will have an impact on its functioning, use of labour and the balance of crops grown. A study by Martínez (2000) in the Guayas river basin region of Ecuador found that the size of farms with cocoa as one of the main crops, ranged from 0.1 to 2000 hectares and that the percentage of the land devoted to cocoa increases with the size of the farm (See also Case Study 2 in Section 8.1).

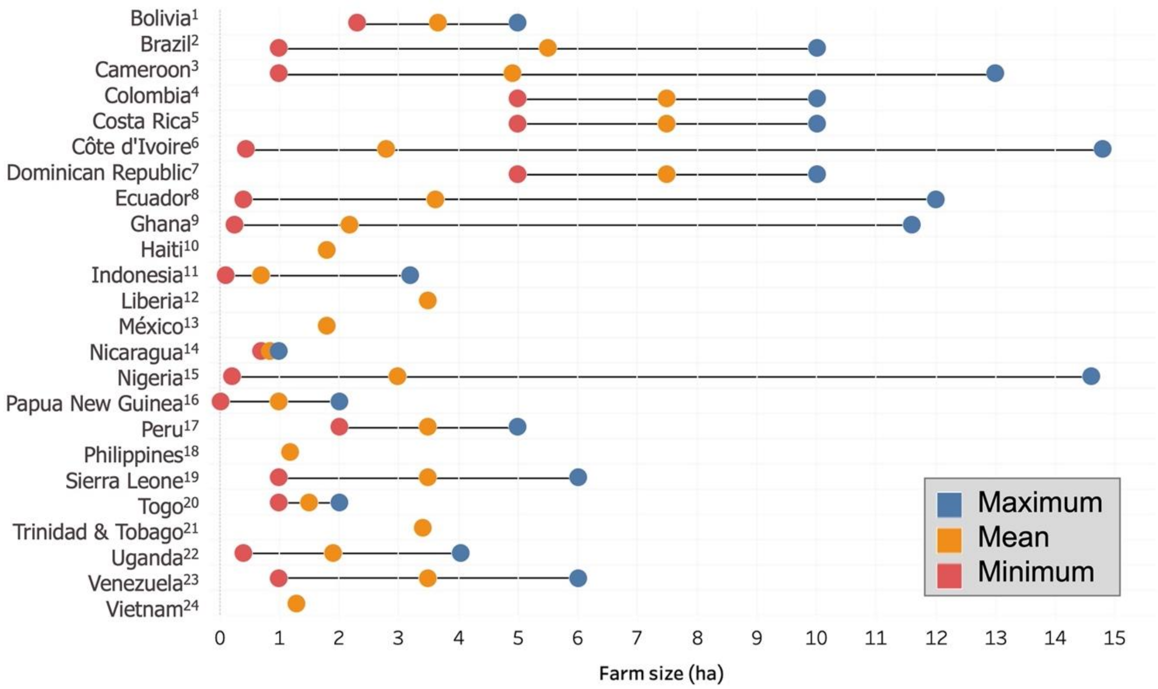
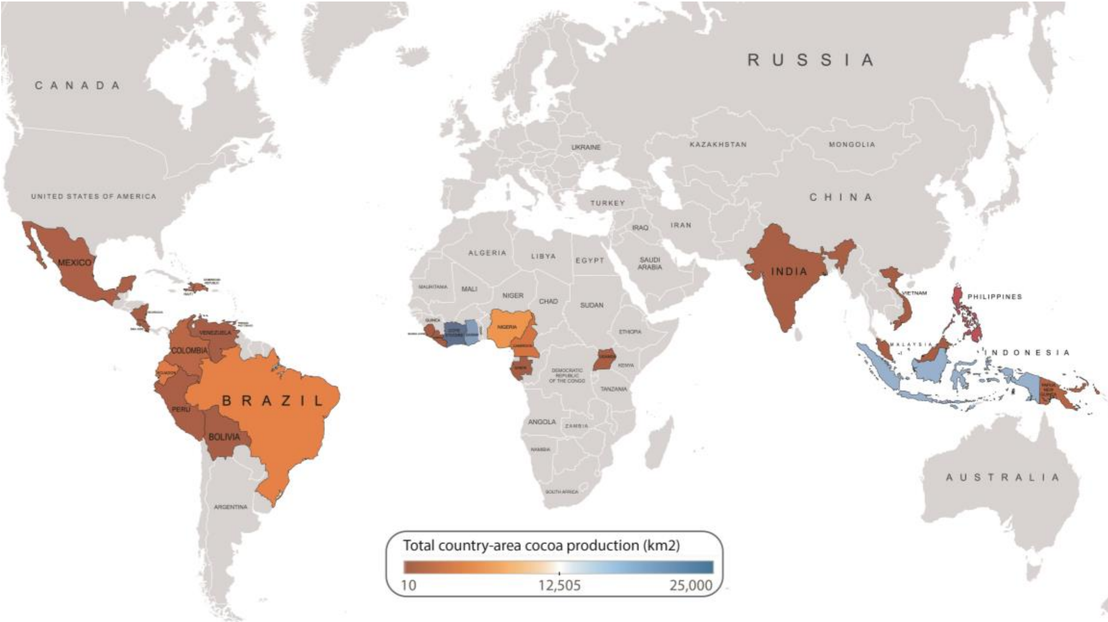



Figure 5. Smallholder farm size (ha). The orange circle represents the mean, whilst the red and blue circles represent the minimum and maximum, respectively of reported values (note in some cases mean sizes have only been reported).

[1]Jacobi et al. (2014); [2]CENSO AGROPECUÁRIO IBGE (2017) & Estival et al. (2016); [3]Belek & Jean-Marie (2020); [4]Eschavarría et al. (2010); [5]Amburo (2017); [6]Daymond et al. (2018); [7]Siegel et al. (2004); [8]Estupiñán (2011) ; [9]Daymond et al. (2018); [10]Chery (2015); [11]Daymond et al. (2020); [12] GrowLiberia (2016); [13]Díaz-José et al. (2013); [14]Trognitz et al. (2011); [15]Eyitayo et al. (2011); [16]Garnevska et al. 2014; Singh et al. (2019); [17]Scott et al. (2015); [18]Quilloy (2015); [19]Amara et al. (2015); [20]Buama et al. (2018); [21]Maharaj et al. (2018); [22]Gopaulchan et al. (2019); [23]Alvarado et al. (2014); [24]Ruf & Paulin (2005)

## 2.2 TOTAL COUNTRY-AREA UNDER COCOA PRODUCTION

The total area under cocoa production based on the literature review and data reported by FAO (2019) are summarised in Figure 6 and Figure 7 respectively (the raw figures are provided in Appendix I). In most cases data from the FAO database corresponds to the average of the area harvested for the period 2018 - 2019. The countries with the largest areas under cultivation are Côte d'Ivoire, Ghana, Indonesia and Nigeria. Whilst for many countries the estimates are similar for some, there are divergencies, most notably, the FAO estimate for the area under cultivation for Nigeria is 60% higher than that quoted by Phayanak (n.d.).




Bolivia[1]
Brazil[2]
Cameroon[3]
Colombia[4]
Costa Rica[5]
Côte d'Ivoire[6]
Dominican R[7]
Ecuador[8]
Gabon[9]
Ghana[10]
Haiti[11]
India[12]
Indonesia[13]
Liberia[14]
Malasya[15]
México[16]
Nicaragua[17]
Nigeria[18]
Papua NG[19]
Peru[20]
Philippines[21]
Sierra Leone[22]
Trinidad & T[23]
Uganda[24]
Venezuela[25]
Vietnam[26]

Figure 6. Total country-area cocoa production (km$^2$) according to a range of literature sources

[1]Bourguet & Guillemaud, (2016); [2]Cassano et al. (2009); [3]Manga Essouma et al. (2020); [4]Suárez Salazar et al. (2018); [5]Chacón (2019); [6]Côte d'Ivoire Consultant; [7]Boza et al. (2013); [8]Ecuador Consultant ; [9]GABON (n.d.); [10]Ghana Consultant; [11]Schwartz & Maass (2014); [12]Peter & Chandramohanan (2011); [13]Dewanta (2019); [14]GrowLiberia (2016); [15]Omar et al. (2018); [16]Díaz-José et al. (2014); [17]López Acevedo (2019); [18]Phayanak (n.d.); [19]Fidelis & Rajashekhar Rao (2017); [20]Donovan et al. (2017); [21]Department of Agriculture - BPI (2016); [22]Amara et al. (2015); [23]Bekele (2004); [24]Lutheran World Relief (2015); [25]Gomez & Azócar (2002); [26]Cao (2013)

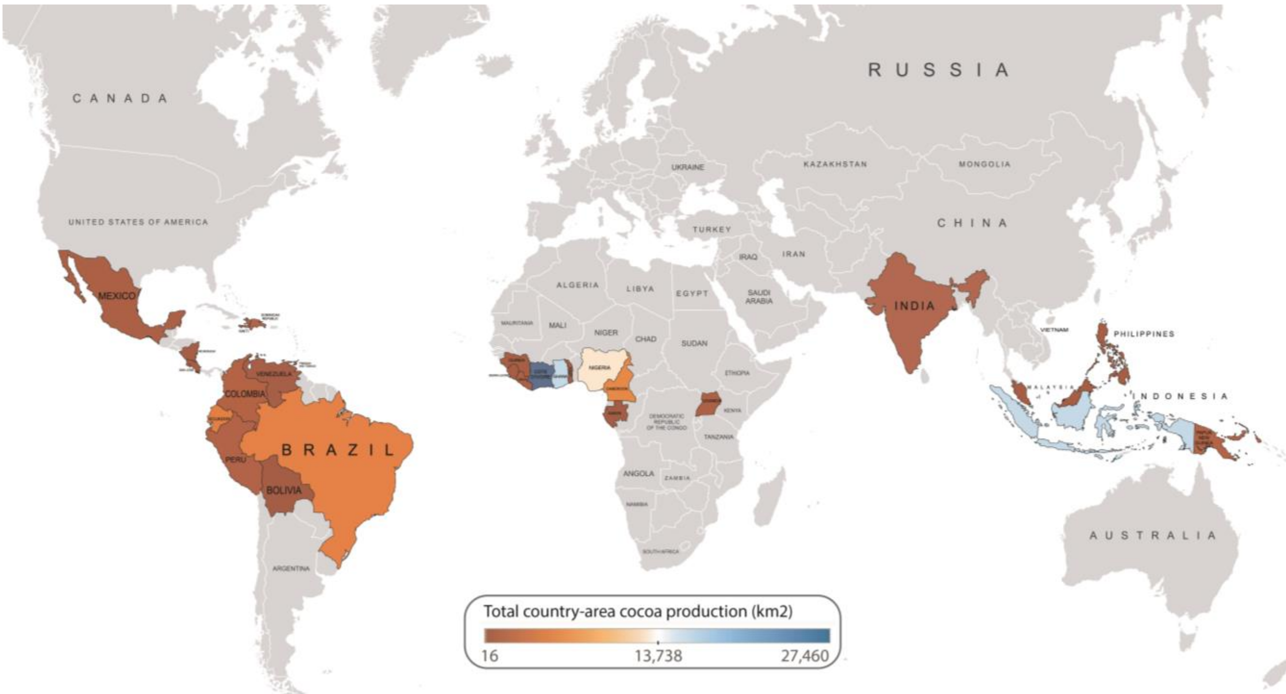



Figure 7. Total country-area under cocoa production (km$^2$) by FAO (2019)

## 2.3 PLANTING DENSITY AND ARRANGEMENT

Cocoa tree planting density is an important factor in maximising productivity. Planting at too low a density means that the attained yield will be below the potential yield, whilst very high-density plantings can be difficult to maintain, requiring a large amount of pruning. The optimal planting density will vary according to the vigour of the variety grown. This is particularly the case for clonal materials, which tend to vary more in their vigour. Environmental conditions will also impact on the optimal planting density. For example, in **Ecuador**, plant density tends to be lower in the areas that receive less annual sunshine (800 plants ha$^{-1}$) and higher (> 1000 plants ha$^{-1}$) in those with greater solar radiation (Ecuador Consultant).

Average tree densities across different cocoa-growing countries are summarised in Figure 8. Often there is considerable variation in planting density. For example, Daymond et al. (2018) recorded tree planting densities from 276 to 3626 trees ha$^{-1}$ in **Ghana**, 556 to 1848 trees ha$^{-1}$ in **Côte d'Ivoire** and 272 to 2598 trees ha$^{-1}$ in **Indonesia**. These figures compare against recommended planting densities of 1111 trees ha$^{-1}$ in Ghana and Indonesia and 1333 trees ha$^{-1}$ in Côte d'Ivoire. In **Ecuador**, a study in the main cocoa-producing area showed an average plant density per hectare of 626 with a minimum of 400 and a maximum of 1111, while higher densities were observed in farms with clonal varieties (Morales, 2013).

In addition to the considerable variation recorded between and within countries in planting density, there is a stronger culture of planting in lines within some cocoa-growing countries compared to others. For example, Daymond et al. (2018) observed that a considerable proportion of farmers planted their cocoa irregularly in **Ghana** and **Côte d'Ivoire**, whereas in **Indonesia** most farmers plant in lines. In **Ecuador**, planting in lines is practiced in all cocoa production systems. Row planting is sometimes adapted to a triangular planting (termed "three bolillo") in rolling fields as a means of reducing the risk of water erosion and to increase slightly the plant density (Ecuador Consultant). One innovation is the practice of double-row planting on some farms, whereby a large space is maintaining between each double row, enabling more mechanised spraying and pruning. Challenges with such systems include the need to shred large volumes of prunings and weed control between the double rows. Trials are on-going to quantify the relative advantages of such systems (Ecuador Consultant). In **Brazil**, it is estimated that around 40% of farms plant in rows, although there has been a trend of increasing row planting since the 1980s such that almost all farms now plant in lines (Brazil Consultant).

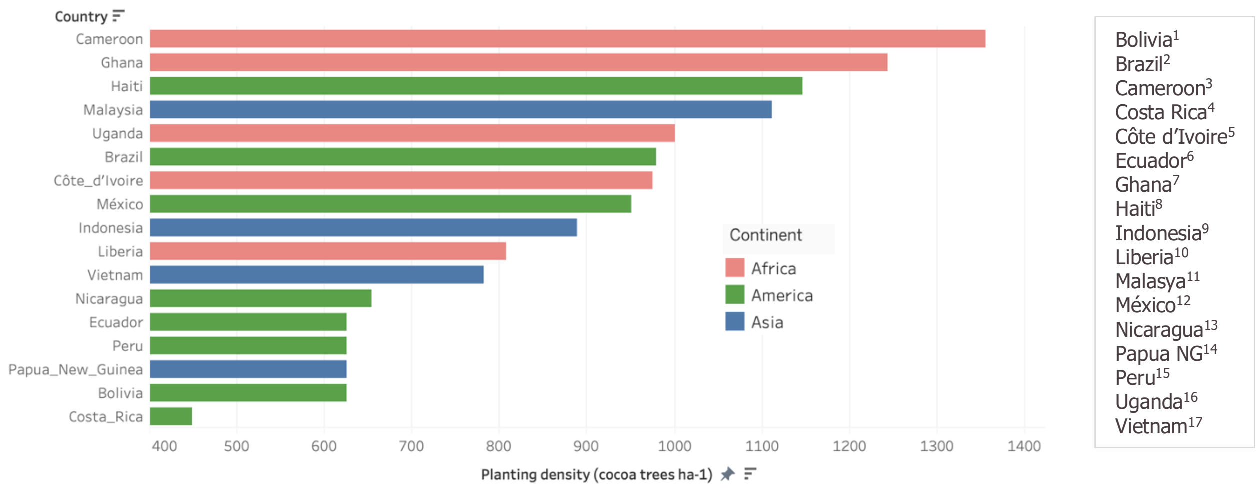



Figure 8. Planting density in cocoa producing countries (cocoa trees ha$^{1}$)
[1]Jacobi et al. 2014; Niether et al. (2018); [2]Gateau-Rey et al. (2018); [3]Ndoumbè-Nkeng et al. (2009); [4]Ryan et al. (2009); [5]Daymond et al. (2018); [6]Morales (2013); [7]Daymond et al. (2018); [8]Schwartz & Maass (2014); [9]Daymond et al. (2018); [10] GrowLiberia (2016); [11]Vanhove et al. (2020); [12]Jiménez-Pérez et al. (2019); [13]Cerda et al. (2014); [14]Daniel et al. (2011); [15]Gamarra (2012); [17]Pauwels (2016)

## 2.4 AGE OF FARMS

Cocoa trees start to become productive after two to four years depending on whether the variety is an improved hybrid and whether or not fertiliser is used. Clonal cocoa often comes in to bearing more quickly after around two years after planting in the field. Trees typically reach maximal yields within about eight years and can maintain good yields until they are approximately 25 years old. Thereafter productivity begins to decline, however trees can remain relatively productive for 40 years (Assiri, 2009). In **Ghana**, the Cocoa Research Institute of Ghana recommends replacing trees when they are over 30 years old. A wide range of farm ages has been observed both within cocoa producing countries and between them (Figure 9). It should be noted that reported ages of plantations often reflects the age of the tree stock but may in some cases reflect the time when the farm was originally established. In **Cameroon**, the mean cocoa plantation age was 48.8 years in Akongo, indicating that there was a low rate of renewal of these plantations (Manga Essouma et al., 2020). In **Côte d'Ivoire**, it has been reported that around 20% of the cocoa tree stock is more than 30 years old and needs replanting (Côte d'Ivoire Consultant). In contrast, in **Sierra Leone** most cocoa farms are young (average of 10 years), and are at peak productivity (Hofman, n.d.).

In **Ecuador**, surveys have revealed a wide range of farm age. For example, Agama et al. (2009) reported that 40% of cocoa plantations were older than 40 years, 22% fell in the age range from 21 to 40 years old, 20% from 11 to 20 years old, 10% from 6 to 10 years and 12% from 1 and 5 years old. Much of the new planting in Ecuador has used the CCN 51 variety (Ecuador Consultant). In **Brazil**, the average farm age is estimated to be 50 years (Brazil Consultant).

In a survey of 120 farms in **Indonesia**, the mean farm age was 15 years, with a range from 2 to 34 years. Younger farms in this survey were observed in Western Sumatra which reflects the more recent spread of cocoa production in this province (Daymond et al. 2020).

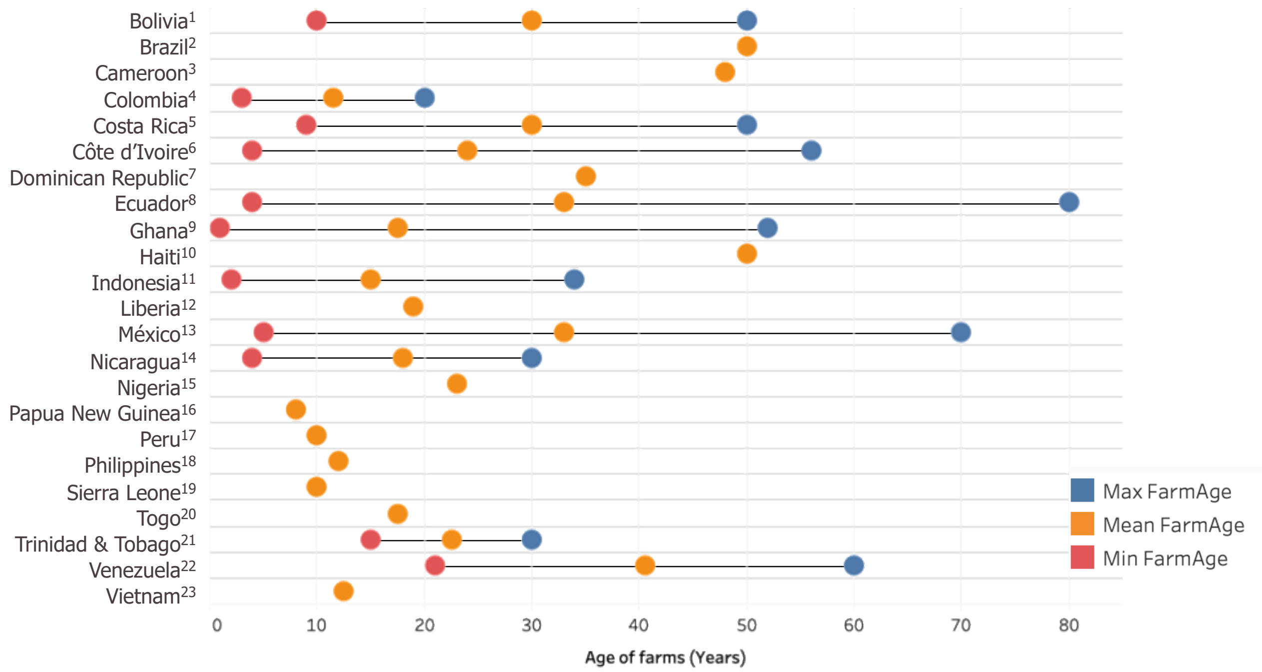



Figure 9. Age of farms in cocoa producing countries (years). The orange dot represents the mean age of farms by country (note in some cases that mean age has only been reported). The red and blue dots correspond to the minimum and maximum respective farm age as found in farmer surveys.

[1]Bazoberry et al. (2008); [2]Brazil Consultant; [3]Manga Essouma et al. (2020); [4]Puentes-Páramo et al. (2016); [5]Chacón (2019); [6]Daymond et al. (2018); [7]Siegel et al. (2004); [8]Barrezueta-Unda (2019) ; [9]Daymond et al. (2018); [10]Chery (2015); [11]Daymond et al. (2018); [12]English (2008); [13] Díaz-José et al. (2014); [14]Aguad (2010); [15]Meludu et al. (2017); [16]Daniel et al. (2011); [17]MINISTERIO DE AGRICULTURA (2003); [18]Lasco et al. (2001); [19]Hofman (n.d.); [20]Tschora & Cherubini (2020); [21]Johnson et al. (2009); [22]Parra et al. (2009); [23]Pauwels (2016)

## 2.5 LARGE PLANTATIONS

Whilst the vast majority of cocoa farms are small-holdings, there are examples of large plantations, particularly in parts of South America and also in **Indonesia**; some examples are illustrated in Table 3. The majority of large plantations are privately owned, although in East Java, **Indonesia**, a large, government-owned plantation produces fine flavour and bulk cocoa. In **Brazil**, medium and large farms (defined as between 50 to 500 ha) are estimated to account for about 3% of the total cocoa farm area. There is a trend in Brazil of plantations increasing in size because of the availability of new technologies: self-compatible clones, irrigation, fertigation and mechanization. Investors moving into cocoa cultivation is another factor driving towards an increase in farm size (Brazil Consultant). The number of large cocoa plantations (100-500 ha) in Ecuador is estimated to be between 50 and 60 (Ecuador Consultant).

Table 3. Examples of large cocoa plantations

| Country | Farm name | Location | Size (ha) | Other information |
|---|---|---|---|---|
| **Côte d'Ivoire** | Solea (KKO International) | Bocanda, N'Zi-Comoé Region (Centre-East) | 700 | 1500 ha planned |
| | SAO (Société Agricole de l'Ouest)- owned by Touton | Near Guiberoua (Western Central Côte d'Ivoire) | +/- 200 | Surrounded by oil palm plantations |
| **Indonesia** | PTPN XII | East Java | 5,236 | Government owned,1538 ha of fine flavour cocoa, 3698 ha of bulk cocoa |
| | Kaliputih | East Java | 124 | Private, locally owned |
| | Treblasala | East Java | 1,738 | Private, locally owned |
| | PT Tribakti Sarimas | Riau | 2,800 | Private, locally owned |
| | PT Sumberdaya Wahana | Seram island (Molucca) | 3,420 | Private, internationally owned |
| | Coklat Ransiki | West Papua | 1350 | Private/cooperative, locally |
| **Ecuador** | Tenguel | Guayas river basin | 100 - 500 | Few large private irrigated plantations aged between 6 to 30 years |
| | Las Cañas | South of Guayaquil | 340 | |
| | El Saman | South of Guayaquil | 120 | |
| | Bola de Oro | South of Guayaquil | 200 | |
| | La Victoria | North-west of Guayaquil | 350 | |
| | Secadal & Guabital | | 500 | |
| | San Jacinto, La Danesa, Terranostra, Tripoli, La Sofia | | 120 - 200 | |
| | Costa Esmeraldas | | 150 | |
| | San Jose, La Chola | | 400 | |
| | Rio Lindo | | 306 | |
| **Brazil** *(Private plantations)* | Fazendas Reunidas Valle do Juliana | Igrapiuna, State Bahia | 210 | Cocoa with rubber. Plan to expand to 1200 ha. |
| | Fazenda Tres Lagoas | Linhares, State Espirito Santo | 500 | Sun-grown |

| | | | | |
|---|---|---|---|---|
| | Fazenda São Luiz | São Mateus, State Espirito Santo | 320 | Cacao with coconut |
| | Fazenda D´Martins | Eunapolis, State of Bahia | 350 | Cacao with coconut |
| | Fazenda Santa Colomba | Cocos, state of Bahia | 100 | They will plant more 100 ha. Sun-grown |
| | Fazenda Lembrance | Southern Bahia | 250 | A semi mechanized farm that uses drip fertigation |
| | Fazenda Perfil, Evai | Road transamazônica, Pará | 500 | |
| | Fazenda Panorama, Indupra, Junqueira, Ivan | Road transamazônica, Pará | 200 | |
| | Fazenda Zezinho | Road transamazônica, Pará | 150 | |
| | Fazenda do Belmiro | Road transamazônica, Pará | 300 | |
| | Fazenda Carmen Gotardo | Road transamazônica, Pará | 100 | |
| **Colombia** | Las Palmas de Casanare | Casanare Department | ~1000 | |
| | Monte Oscuro | Santander Department | ~600 | |
| | Bacao | Meta department | ~500 | |
| | Agrotropical | El Cesar Department | ~500 | |
| | Yariguies | Santander Department | ~300 | |
| **Peru** | Tamshi | | 1,300 | |

# 3. PLANTING MATERIALS

Key findings

- Almost all cocoa grown in West Africa is seed propagated, whereas in Asia and the Americas a mix of seed-propagated and clonal material is grown.
- Farmers will sometimes use seed from their own farms due to a lack of appreciation of the importance of using hybrids from controlled pollinations or as a result of poor infrastructure and supply.
- The cultivation of fine flavour cocoa can provide a route for some farmers to receive improved income from cocoa bean sales.

## 3.1. SOURCES OF PLANTING MATERIALS

As a general rule, in Africa cocoa is propagated from seed, whereas in Asia and the Americas a mix of seed-propagated and clonal material is grown. Improved (or "hybrid") seeds derived from manual crosses of known parents are provided by the public and/ or private sector in many cocoa-producing countries (Table 4). Nevertheless, farmers will often plant seed from their own trees rather than improved varieties. For example, in West Africa, Gockowski (2011) reported 10% to 40% adoption of improved varieties across the sub-region. Deficiencies in infrastructure for seed production and delivery combined with a lack of appreciation of improved varieties appear to be factors contributing to low adoption rates of improved seed (Asare et al., 2010). In the case of provision of clonal material, in both Brazil and Ecuador, these are provided by the private sector (see Case Study 1).

Table 4. Sources of planting material in the major cocoa-growing countries.

| Country | Source |
|---|---|
| Brazil | 1 - Seed gardens: in the Amazon region, these are provided by the government, via CEPLAC<br>2 - Clonal planting material: In Bahia, the Northeast and central states these are provided by the private sector (Brazil Consultant) |
| Ecuador | INIAP nurseries (limited capacity to produce planting material)<br>Private nurseries (great capacity to produce planting material, particularly the clone CCN 51) (Ecuador Consultant) |
| Côte d'Ivoire | The majority of cultivated cocoa trees are derived from seeds collected from existing fields (Kouassi, 2014).<br>ANADER provides improved (hybrid) seed to farmers (Côte d'Ivoire Consultant) |
| Ghana | Hybrid seed are provided by the Seed Production Unit of COCOBOD (Ghana Consultant) |
| Indonesia | Public and private sector seed gardens (Indonesia Consultant) |

## 3.2. RECOMMENDED CLONES/HYBRIDS

Cocoa varieties (hybrids and clones) recommended for planting (usually by the public sector body responsible for cocoa) are summarised in Table 5. Case Study 1 provides an illustration of how adaptation of planting materials has changed over time in Ecuador.

Table 5. Recommended planting material.
The information is based on the most up to date references available. Recommended planting materials may change from time to time.

| AMERICAS | | |
|---|---|---|
| **Country** | **Recommended material** | **References/ notes** |
| Bolivia | International clones: CCN 51, EQZ 27, EET 96, ICS 1, ICS 6, ICS 8, ICS 95, ICS 111, PA 121, PLAYA ALTA 2, SIC 5, SPEC 54/1<br>Numerous local clones are also distributed (see web link) | http://iiaren.agro.umsa.bo/index.php/2020/07/29/genotipos-de-cacao-en-alto-beni-bolivia-catalogo-de-selecciones-locales-de-cacao/ |
| Brazil | Clones: (large scale planting) CCN 51, CEPEC 2002, CEPEC 2007, CP 49, Ipiranga 1, PH 16, PS 1319, SJ 02<br>Clones (small-scale planting): BJ 11, BN 34, CCN 10, CEPEC 2204, CEPEC 2176, FA 13, LP 06, PH 09, PH 15, Salobrinho 3, Vencedora 20<br><br>Hybrids: Parents: IMC 67, P7, PA 121, PA 150, SCA 6 (upper Amazon); MA 15, CA 6, MOCORONGO 1, BE 8, BE 10, SIC 644, SIAL 505, SIC 17, CAB 24, CAB 28 (lower Amazon); ICS (Trinitario). Crosses are made between Upper and Lower Amazon clones and the seed released to farmers. | CEPEC/CELAC, Brazil Consultant<br><br>Clones have been widely adopted in Bahia<br><br>Hybrid cultivars are recommended for Amazon states |
| Colombia | Clones recommended by Agrosavia: TCS 06, TCS 01, TCS 13, TCS 19<br>Recommended by FEDECACAO: FLE 2, FLE 3, FSV 41, FEC 2, FTA 2, FSA 11, FSA 12, FEAR 5 | https://www.agrosavia.co/productos-y-servicios |
| Costa Rica | Clones recommended by CATIE: CATIE-R1, CATIE-R4, CATIE-R6, CC 137, ICS 95-T1, PMCT 58<br>ICS 1, ICS 6, ICS 39, ICS 60, UF 273, UF 613, IMC 67, TSH 565 | https://www.cacaonet.org/fileadmin/templates/CacaoNet/Uploads/publications/CatalogueofClones_ENGLISH.pdf<br><br>A. Mata (pers. comm.) |

| | | |
|---|---|---|
| Dominican Republic | Clones: CC 10, CCN 51, CEPROGPS-1C, CEPROGPS-2C, CEPROGPS-3C, CEPROGPS-4C, CEPROGPS-5C, CEPROGPS-6C, ICS 1, ICS 6, ICS 39, ICS 40, ICS 95, IMC 67, IML 44, IML 53, ML 105, ML 106, ML 22, ML 22, ML 3, UF 677, UF 221, UF 296, UF 613, UF 676 | www.cedaf.org.do/publicaciones/guias/download/cacao.pdf |
| Ecuador | Recommended Clones: EET 576, EET 554, EET 558, EETP 800, EETP 801, EET 95, EET 19, EET 96, EET 103, EET 62<br>Other clones cultivated: CCN 51, PMA 10, JHV 10, Sacha Gold<br>INIAP does not currently recommend any hybrid types | Source: Ecuador Consultant and https://www.iniap.gob.ec/pruebav3/venta-de-semillas-y-plantas/ |
| Mexico | Clones: CAERI 3, Chak, Lacandón, Olmeca, Regalo de Dios, Supremo, Tabscoop, Caehui, Canek, Chibolon, K´in | www.gob.mx/agricultura/prensa/ |
| Peru | CCN- 51, Criollo mejorado, TCH-172, VRAEM-15, VRAEM-94, VRAEM-99 | www.inia.gob.pe/2020-nota-065/ |
| Trinidad and Tobago | TSH 728, TSH 730, TSH 919, TSH 973, TSH 1076, TSH 1095, TSH 1102, TSH 1104, TSH 1188, TSH 1220, TSH 1313, TSH 1315, TSH 1330, TSH 1334, TSH 1347, TSH 1350, TSH 1352, TSH 1362, TSH 1364, TSH 1380 | Maharaj (2012) |
| Venezuela | Hybrids: IMC 67 * OC 61, IMC 67 * OC 67, IMC 67 * ICS 6, IMC 11 * OC 61, IMC 11 * OC 67, IMC 11 * ICS6 | Venture et al. (2010)<br>Note: these were released in 1960s/ 70s. Recommendations may have since changed |

| **AFRICA** | | |
|---|---|---|
| **Country** | **Recommended material** | **References/ notes** |
| Cameroon | Male parents: IMC 60, UPA 143, UPA 337, PA 70, BBK 726, P7, PA 7, GU 255/V, GU 144/C, IMC 67, PA 107, PA 150, SCA 12, SCA 6, SCA 24, T 60/887, T 79/501, UPA 134<br>Female parents: SNK 630, ICS 84, SNK 15, SNK 413, SNK 64, SNK 608, SNK 620, TIKO 32, BBK 1016, BBK 109 | Sounigo & Efombagn Mousseni (2012) |
| Côte d'Ivoire | Hybrids with the following clones as parents: ICS 1, IFC 1, IFC5, IFC 412, IMC 67, NA 32, PA 150, POR, SCA 6, T 60/887, T 79/501, T 85/799 | Note the terms "Cacao Mercedes" is used to describe mixed hybrids |
| Ghana | PA 7 * T85/799, PA 150 * T85/799, POUND 7 * T85/799, T60/887 * T85/799, T63/967 * T85/799, T 63/971 * T85/799, T 79/467 * T85/799, T79/501 * T85/799, T85/799 * T79/501 | Lockwood (2015) |
| Nigeria | Hybrids: CRIN TC-1 {T65/7 [POS] * N38 [T38]}, CRIN TC-2 {T101/15 [POS] * N 38[T38]}, CRIN TC-3 {POUND 7 * PA 150}, CRIN TC-4 {T65/7 [ POS] * T57/22 [POS]},<br>CRIN TC-5 {T82/27 [POS] * T12/11 [POS]}, CRIN TC-6 {PA 150 * T60/887}, CRIN TC-7 {T82/27 * T16/17}, CRIN TC-8 {T65/7 * T9/15} | http://www.crin-ng.org/index.php/14-crin-monthly-seminar/26-the-new-cocoa-hybrids.html |

| ASIA | | |
|---|---|---|
| **Country** | **Recommended material** | **References/ notes** |
| India | CCRP1, CCRP2, CCRP3, CCRP4, CCRP5, CCRP6, CCRP7, VTLCC1, VTLCS1, VTLCS2 | Sujith & Minimol (2016) |
| Indonesia | Recommended clones: Sul 1, Sul 2, MCC1, MCC 2 (renamed clone 45), DR 1, DR 2, DR 38, PNT 16, ICS 60, ICS 13, TSH 858 | Indonesia Consultant |
| Malaysia | Clones: BR 25, KKM 22, KKM 25, MCB C1, MCB C2, MCB C3, MCB C4, MCB C5, MCB C6, MCB C7, MCB C8, MCB C9, PBC 123, PBC 130, PBC 131, PBC 139, PBC 140, PBC 159, QH 1003, QH 22 | Malaysian Cocoa Board |
| Papua New Guinea | CC1-S1, CC1-S2, CC1-S3, CC1-S4, CC1-S5, CC1-B1, CC1-B2, CC1-B3, CC1-B4 | (Marfu, 2015) |
| Philippines | BR 25, DR 1, ICS 40, K 1, K 2, K 4, K 5, PCB 123, P 7, S 5, UIT 1, UF 18 | https://nseedcouncil.bpinsicpvpo.com.ph/approved.php |

## 3.3 FINE FLAVOUR CULTIVATION

Fine flavour cocoa (alternatively termed “fine or flavour” cocoa) is a steadily growing market and can provide opportunities for some farmers to obtain a higher market price on their product. Whilst some cocoa-producing countries, such as Peru, Venezuela and a number of countries in the Caribbean are known for their fine flavour cocoa, there are also a number of initiatives under way in countries more traditionally associated with bulk cocoa cultivation to pilot the development of fine or flavour cocoa (Table 6).

Table 6. Fine flavour cultivation

| Country | Fine flavour cultivars grown | Additional information |
|---|---|---|
| Ghana | Eight fine flavour clones are being tested in Ghana (CFT111, CFT101, CFT106, CFT600, CFT880, CFT202, CFT500, CFT004) | So far, no fine flavour types have been released to Ghanaian cocoa farmers (Ghana Consultant, 2020). |
| Uganda | | Ugandan cocoa is reputed to have special aromatic properties that are favoured by chocolates manufacturers (Lutheran World Relief, 2015). |
| Indonesia | DR 1, DR 2, DR 38, PNT 16 | Fine flavour clones are primarily cultivated on a government estate in East Java. |
| Papua New Guinea | | PNG cocoa is known globally for its fine-flavoured cocoa beans (Fidelis & Rajashekhar Rao, 2017). |
| Vietnam | | In May 2016, Vietnam obtained fine flavour status for 40% of its cocoa export (Everaert et al., 2020). |
| Nicaragua | Criollo and Trinitario varieties are widely cultivated (Dar Ali Rothschuk, 2019). | |
| Mexico | | Cocoa obtained from plantations in the Soconusco region has been shown to have fine flavour characteristics (Vázquez-Ovando et al., 2015). Participatory plant breeding developed in Mexico has included the selection and conservation of criollo materials (Díaz-José et al., 2013). |
| Colombia | A number of recommended clones are fine flavour. | |
| Ecuador | EET 103, EET 96, EET 95, EET 544, EET 558, INIAP 800, INIAP 801, PMA 10 and Sacha Gold are considered fine flavour cocoa (Ecuador Consultant, 2020). | |
| Venezuela | Porcelana, Guasare, Choroni, Ocumare (61 + 67 varieties), Carenero Superior, Rio Caribe (ICCO fine flavour panel, 2010). | |
| Brazil | local cultivars: Maranhão and Catongo; fine flavour clonal cultivars such as SJ 02, Salobrinho 03 and BN 34 (Brazil Consultant, 2020). | |
| Peru | | Fine flavour cocoa is grown in Tumbes, Piura, Cajamarca, Amazonas, Loreto, San Martín, Huánuco, Pasco, Junin, Ayacucho, Cusco and Madre de Dios regions across Peru (https://newyork.cbslocal.com/2016/09/14/fine-flavors-perus-cocoa-coffee/). |
| Trinidad and Tobago | The TSH clones are recognised as having fine or flavour characteristics (https://agriculture.gov.tt/divisions-units/divisions/research/cocoa/) | |

## 3.4 AWARDS

Awards for high quality chocolate can provide small scale producers and farmer co-operatives with a mark of recognition for their product. The Cocoa of Excellence- International Cocoa Awards are the most widely recognised chocolate awards globally (http://www.cocoaofexcellence.org/). All of the study countries in this report participated in the most recent edition of the awards with a range of farmers and co-operatives winning prizes in the 2019 edition (Figure 10). In the UK, the Academy of Chocolate has held annual awards since 2005 (https://academyofchocolate.org.uk/).

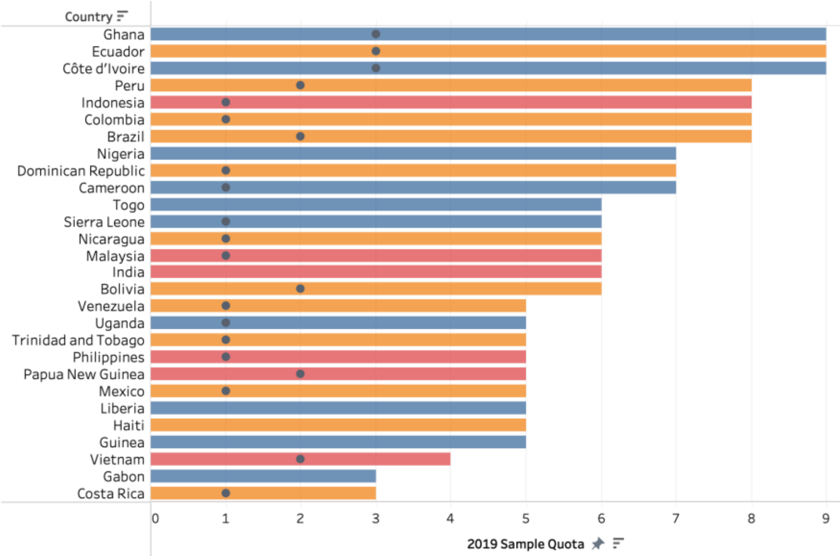



Figure 10. Summary of country participation 2019 sample quota (Orange = America; Blue = Africa; Red = Asia). The black dots correspond to number of awards won in the 2019 Edition of the Cocoa of Excellence – International Cocoa Awards.

**Case Study 1: The development of planting materials in Ecuador (Ecuador Consultant, Freddy Amores)**

Traditional production systems of the Nacional type cocoa are made up of trees from natural hybrid seeds planted more than 30 years ago. To do this, the farmers used to collect pods from selected trees in their own or neighbouring farms. Then the seeds were used for direct field planting. Placing three seeds in a hole dug in the ground was necessary to increase the probability of having at least one plant surviving the dry period typical of the marked seasonal rainfall distribution in the main cocoa growing zones. In the 60's, 70's 80's, INIAP distributed hybrid seeds from different crosses (upper Amazonian genotypes x Nacional genotypes). There was significant distribution of EET clones in the 80's and 90's.

A large plantation planted with the CCN 51 variety in 1991-92 became a great showcase of the productive potential of this clonal variety, awakening the interest of producers to renew and expand cocoa farms with this new variety. Planting with CCN 51 gained momentum in early 2000s and grew annually at a rate of more than 10,000 hectares per year. Currently the area planted with this variety is 40% of the total area planted with cocoa in the country. Plantings with the clonal variety PMA 12 in the south-eastern zone of the Esmeraldas-Quininde river basin, clonal variety JHV 10 in the south east of the Guayas river basin and Sacha Gold in the Napo river basin in the Amazon region have won the preference of producers in these zones in the last decade. The sale of clonal plants of the high yielding varieties INIAP 800 and INIAP 801 started 3 years ago. INIAP 800 yields more than CCN 51 and INIAP 801 yields the same as CCN 51. To increase the plantings with these varieties demands the presence of large commercial plots planted with both varieties, to be used as showcases, as already happened with CCN 51 in early 2000. There are also serious limitations that restrict the supply of planting material which need to be overcome. Two new high yielding clonal varieties produced by INIAP are in the pipeline and will be released soon. Currently the yield standard is that of CCN 51 and farmers wishing to start new cocoa plantings will not do so using varieties that yield less than 1 MT/ha in rainfed systems or less than 2.0 MT in high-tech production systems (with irrigation).

# 4. SHADE MANAGEMENT/AGROFORESTRY

Key findings:-

- A broad range of shade systems can be observed across cocoa farms ranging from no shade to heavy shade; shade trees may be structured in rows or scattered across the farm.
- Additional advantages of shade trees include protection against very high temperatures and low humidities, soil nutrient cycling and addition of soil organic matter and suppression of some insect pests, such as mirids.
- Shade trees can also provide an import additional source of income to the farmer.
- Disadvantages of shade trees can include reduction in yield under heavy shade and increased prevalence of fungal diseases.

## 4.1 SHADE/ AGROFORESTRY- BROAD DESCRIPTION

Cocoa-shade systems are a type of agroforestry, a broad term used for farming systems that incorporate trees. Leaky (1996) has define agroforestry as "a dynamic, ecologically based, natural resource management system that, through the integration of trees in farm- and rangeland, diversifies and sustains smallholder production for increased social, economic and environmental benefits". The shade trees in such cocoa agroforestry systems vary considerably in their origin, density, arrangement and species mixture. As well as reducing solar radiation levels, benefits of shade trees include amelioration of the microenvironment against very high temperatures and low humidities, soil nutrient cycling and addition of soil organic matter, suppression of some insect pests, such as mirids and providing an alternate source of income (e.g. tree crop species and timber trees). Disadvantages of shade can include reduced cocoa yields when shade is excessive and increased disease prevalence if the humidity is too high. Broad descriptions of shade/ agroforestry cocoa systems in different countries are summarised in Table 7.

Whilst cocoa is traditionally grown under the shade of other tree species, in many cocoa-growing areas, notably in Ghana and Côte d'Ivoire, there has been a trend towards shade removal over time. Nevertheless, there is some anecdotal evidence of farmers starting to reintroduce shade on to their farms (Ghana Consultant). In Ghana, COCOBOD's Seed Production Unit (SPU) as well as the Cocoa Health and Extension Division (CHED) provide seedlings of timber species together with cocoa seedlings as part of the ongoing national cocoa rehabilitation effort. In Côte d'Ivoire, Barry Callebaut distributes seedlings of shade trees to farmers (Barry Callebaut, 2017).

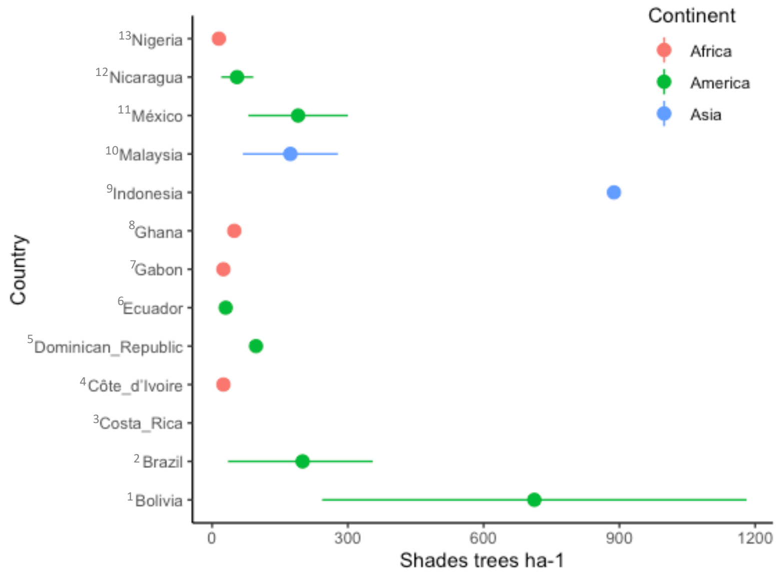
When it comes to establishing new cocoa farms, if it is established on forested or scrub land then trees that provide suitable shade are typically left in place (see also Thematic Study 1 regarding encroachment of cocoa farming into forest reserves). Temporary shade is typically provided by banana or plantain. Alternatively, or in addition, leguminous species such as *Gliricidia sepium* and *Albizzia lebbeck* may be used. Temporary shade can be planted at the same time or slightly before the cocoa and at a similar density. Depending on how vigorous the established cocoa is, the temporary shade can be cut out after two to three years (Côte d'Ivoire Consultant).

Table 7. Shade/ agroforestry description in different cocoa producing countries

| Country | Shade /Agroforestry |
|---|---|
| Ghana | The crop is traditionally cultivated under the shade of the selectively thinned forest (Abdulai et al., 2020). |
| Côte d'Ivoire | The landscape is composed of a mosaic of land uses including forests and cocoa plantations (Guéi et al., 2019). It has been estimated that 66% of cocoa plantations have little or no shade (Côte d'Ivoire Consultant). |
| Nigeria | Traditionally, cocoa-based agroforestry is practiced (Dada & Hahn, 2020). |
| Cameroon | Cocoa agroforestry, is still dominant in Central Cameroon (Wessel & Quist-Wessel, 2015). |
| Togo | Various agroforestry systems can be encountered including shaded agroforests (Tschora & Cherubini, 2020). |
| Gabon | A current project aims at improving the productivity of cocoa farms and encouraging agroforestry for sustainable cacao production. In: https://manandnature.org/en/projects-to-support-2/425-gabon-caco-en |
| Guinea | Traditionally grown under a shade canopy (Gockowski & Sonwa, 2011). |
| Indonesia | Both regular and irregular intercropping is practiced (Tothmihaly & Ingram, 2019). |
| Malaysia | Agroforestry systems are one of the main components of small-scale farming in Malaysia (Arshad et al., 2015). |
| India | Cocoa is commonly cultivated under areca nuts and coconuts, particularly in Kerala, Karnataka and Tamil Nadu. In: https://www.indiaagronet.com/horticulture/CONTENTS/Cocoa.htm |
| Philippines | Cocoa is often intercropped with coconut (Lasco et al., 2001). |
| Vietnam | Often intercropped with coconuts, sometimes in association with various fruit trees (Ruf & Paulin, 2005). |
| Nicaragua | Agroforestry products have been cited as being important sources of diversification (Cerda et al., 2014). |
| Mexico | A survey in Chiapas revealed that only 38 % of cocoa growers used shade trees and regulate the shade (Hernández et al., 2015). |
| Colombia | Almost all of the cocoa production system is under an agroforestry system (Naranjo-Merino et al., 2017). |
| Costa Rica | Much of the cocoa is produced in smallholder farms with diverse integrated agroforestry and high levels of shade (Ehiakpor et al., 2016). |
| Ecuador | Various shade systems are present including regular, irregular and full sun. It is estimated that around 57% of cocoa farms are shaded with timber, fruit and shade trees (Mata Anchundia et al., 2018). |
| Bolivia | To make cocoa plantations more sustainable, development projects and extension services have promoted the shift from monoculture to agroforestry systems with diversified plantations combining cocoa and multifunctional shade trees (Jacobi et al., 2015a). |
| Venezuela | Cocoa trees are shaded by various fruit trees species, usually randomly planted (Tezara et al., 2016). |
| Brazil | Various systems are present. The diversified tree canopy of the cabrucas, is the predominant land use in the Atlantic forest region of southern Bahia (Schroth et al., 2016). Intercropping, for example, with rubber is also encountered. |
| Dominican Republic | All cocoa is produced exclusively under agroforestry systems (Notaro et al., 2020). |
| Haiti | Cocoa production integrates an agroforestry system, where cocoa is associated with many annual crops and other trees (Chery, 2015). |
| Trinidad and Tobago | Cultivation is largely under shade trees (Cocoa Republic, 2018). |

## 4.2 SHADE TREES

Key types of shade trees and companion crops cultivated on cocoa farms are summarised in Figure 10.




Which shade trees are grown?

Timber trees, fruit trees, vegetable crops, vining crops and tuber crops. Pioneer timber tree. Kola, oil palm and banana, herbaceous crops (taro), lianas (yam) and trees. Plantains, avocado, orange, mango, and guava.

Coconut, cashew and fruit trees. Yemane (*Gmelina arborea Roxb.*). Timber species and the perennial leguminous. Gliricidia trees.

Fruit trees such as citrus species, banana, plantain, avocado and mango; and service and timber trees. Palms and Musaceae. *Erythrina fusca* and *Gliricidia sepium*. Native trees timber.

Figure 10. Range of shades trees density (ha$^{1}$) by country and the predominant shade trees/ companion crops grown in each continent.

[1]Marconi & Armengot (2020); [2]Brazil Consultant; [3]Ehiakpor et al. (2016); [46]Côte d'Ivoire Consultant; [5]Notaro et al. (2020); [6]Ecuador Consultant; [7]Asare (2017); [8]Abdulai et al. (2020); [9]Riedel et al. (2019); [10]Daymond et al. (2020); [11]Suárez-Venero et al. (2019); [12]Cerda et al. 2014; Poveda et al. (2013); [13]Wessel & Quist-Wessel (2015)

A study in **Ghana**, identified *Morinda alucida*, *Milicia* spp. and *Terminalia* spp. as being amongst the most widespread shade trees on cocoa farms (MCP, 2017; Figure 11). In **Côte d'Ivoire** surveys carried out in cocoa farms identified 105 species commonly used by farmers; these were classified accordingly: food, 28% medicinal, 38%; firewood, 56%; timber, 24%; other, 6% (Côte d'Ivoire Consultant). The same study also identified shade species that were perceived to have a beneficial, negative or neutral impact on the cocoa system.

A survey in **Indonesia** revealed that a large number of shade species with edible fruits or nuts were cultivated by farmers including coconut, banana, durian and mango (Daymond et al., 2020; Figure 11). Coconut is often used as a shade tree in **Malaysia** (Arshad et al., 2015).

In **Ecuador**, shade species used include: caña guadua (*Guadua augustifolia*), laurel (*Cordia alliodora*), balsa (*Ochroma piramidale*), palo prieto (*Erythrina glauca*), guava de bejuco (*Inga edulis*), guaba de machete (*Inga spectabilis*), aguacate (*Anthocarpus altilis*), avocado (*Persea americana*), chontilla (*Bactris gasipaes*), guayacan (*Tabebuia achrisanta*), zapote (*Matisia cordata*), mango (*Mangifera indica*), orange (*Citrus sinensis*), mandarin (*Citrus reticulate*), lemon (*Citrus limon*), fruta de pan (*Antocarpus altiles*), guanabana (*Anona muricata*), achotillo (*Nephelium lappaceaum*) (Bentley et al., 2004; Maridueña, 2006; Coello Avalos & Haro Chambo, 2012). In Brazil, the most common shade trees that have an economic use are rubber trees (rubber), coconut trees (coconut water, fibre and pulp), acai (pulp), mahogany (timber), caja (pulp), jackfruit (fruit and timber), jenipapo (fruit and timber), cupuaçu (*T. grandiflorum*) (pulp), clove (cloves) (Brazil Consultant).

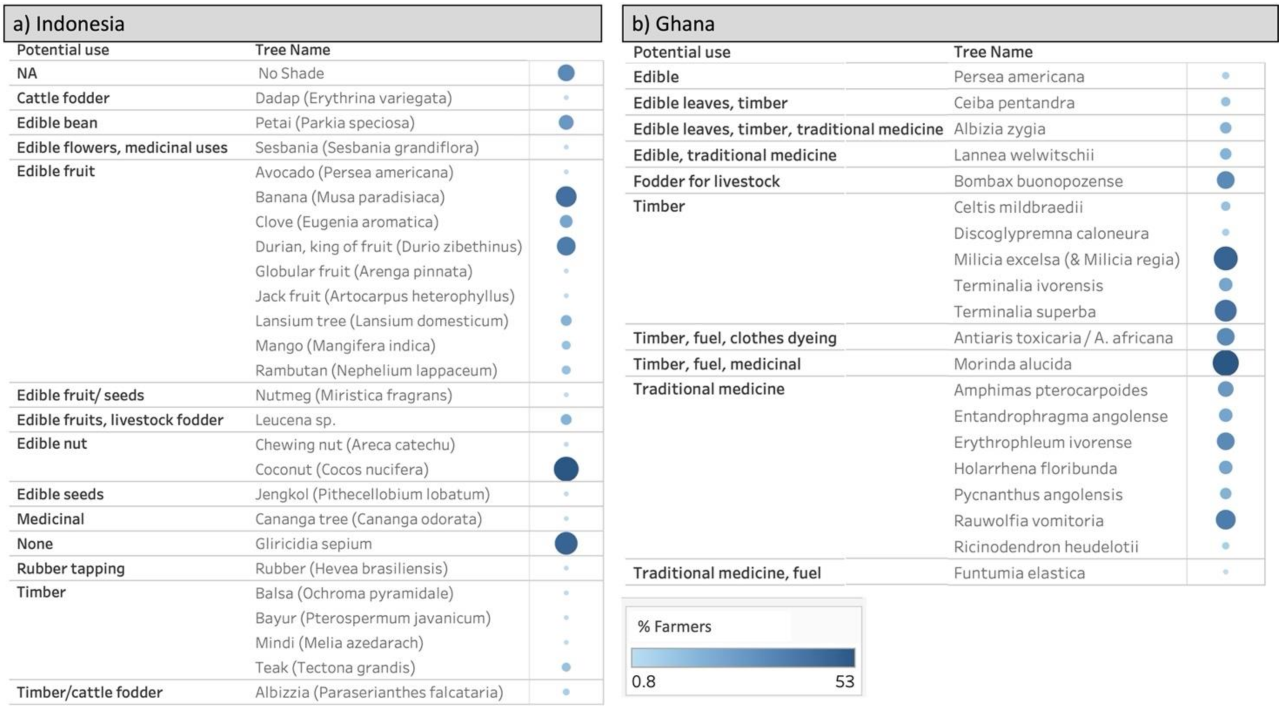



Figure 11. The frequency of key shade species in a) Indonesia (Daymond et al., 2020) b) Ghana (MCP, 2017)

**Thematic Study 1: Illegal Cocoa Cultivation**

Illegal cocoa cultivation, that is encroachment of cocoa farming into protected areas has been reported in number in a number of countries. For example, Bitty et al. (2015) reported that cocoa farming is the major cause of deforestation in protected areas in Côte d'Ivoire. In Ghana, encroachment of cocoa farming has been reported in the Bia conservation area and in the Krokosua Hills, both in the Western Region (Afari-sefa, 2014). In trying to establish underlying causes of encroachment into protected forest areas in Ghana, Brobbey et al. (2020) identified a number of factors including: low cocoa productivity and associated factors such as pests and diseases and drought, various land related issues including land insecurity, lack of maintenance of farm boundaries and also limited amount of land to maintain a livelihood. Another factor identified was lack of options for alternative livelihoods in rural areas.

In response to the need to de-couple cocoa-farming from deforestation, in 2017 the governments of Côte d'Ivoire and Ghana along with 35 cocoa and chocolate companies signed the Cocoa and Forest Initiative (CFI). This aims not only to end deforestation associated with cocoa farming but also to restore former forest areas. In a parallel initiative in Colombia, the Cocoa for Peace Initiative is a public-private partnership that aims to eliminate cocoa-related deforestation (WCF, 2021).

# 5. SOIL AND WATER MANAGEMENT

Key findings:

- Globally, cocoa is grown across a broad range of soil types. Deficiencies in major nutrients as well as a very low soil pH (less than 5.0) have a negative impact on production.
- A general decline in soil health, particularly in terms of reduced availability of key nutrients and reduced soil organic matter, is a key issue for cocoa farmers.
- High concentrations of cadmium can be an issue in soils of volcanic origin but also following the use of certain phosphate fertilisers.
- Fertiliser use is highly variable across cocoa growing areas. In many areas there is a need to tailor fertiliser recommendation to local soil conditions
- Only a very small proportion of cocoa globally is currently irrigated.

## 5.1 SOIL TYPES

Cocoa is cultivated across a wide range of soil types across cocoa zones as summarised in Figure 12; it should also be noted that variations in soil types exist within cocoa-growing areas of some countries. Some additional information regarding Ghana, Côte d'Ivoire and Ecuador is provided in Table 8. Cocoa performs best in slightly acidic soils but production has been reported to fall where the pH of soils is below 5.0 (Snoeck et al. 2016). Examples of cocoa-growing areas that have a very low pH include parts of Sulawesi (Mulia et al., 2019). Such soils tend to be less responsive to fertiliser addition. In such situations, it is recommended that the soil is limed. Cocoa is also notable for having relatively high zinc and iron requirements. The review of Snoeck et al. (2016) also proposes a series of upper and lower thresholds for particular soil nutrients.

Table 8. Characteristics of soils in Ghana, Côte d'Ivoire and Ecuador

| Country | Soil characteristics |
|---|---|
| Ghana | Most of the cocoa growing areas have soils in the ochrosols class which are less leached and better for cocoa than other intergrades (oxysols which are more leached and are less suitable for cocoa cultivation). Other soil types in the cocoa growing regions are the Acrisols, Lixisols, Nitisols, Leptosols and Ferralsols (Ahenkorah et al. 1982). |
| Côte d'Ivoire | 72% of cocoa trees in Côte d'Ivoire are cultivated on six major soil types with two geological origins: granitic and schistose (Côte d'Ivoire Consultant). |
| Ecuador | More than 90% of the area planted with cocoa in Ecuador is in the coastal region, distributed in the basins of the Guayas river and Carrizal-Chone river systems and can be classified into the following broad groups: Eutrandepts, Dystrandepts, Ustifluvents and Udifluvents (Ecuador Consultant). The volcanic soils present in some growing regions are fertile but can be contaminated with heavy metals (see section 5.2). |

A common issue in many cocoa-producing regions is a general decline soil health, particularly in terms of reduced availability of key nutrients and reduced soil organic matter (Hartemink, 2003) and various initiatives are in place to address this issue, for example, the Cocoa Soils Project (https://cocoasoils.org/).

The potential for on-farm waste (particularly pod husks) to be used as organic fertiliser and biochar is currently being explored through a collaboration between the University of Reading, the Cocoa Research

Institute of Ghana and KNUST, Kumasi, Ghana (https://research.reading.ac.uk/cocoa/soil-amendments-project/).

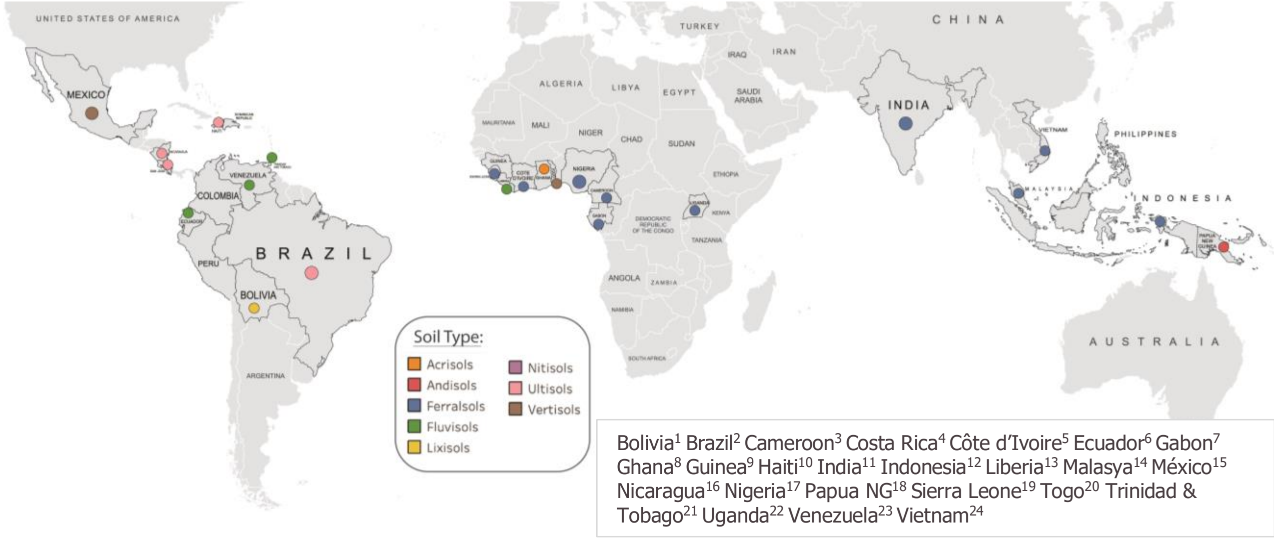



Figure 12. Soil types predominant in cocoa zones

[1]Marconi & Armengot (2020); [2]Cassano et al. (2009); [3]Sauvadet et al. (2020); [4]Google (n.d.); [5]Zanh et al. (2019); [6]Côte d'Ivoire Consultant; [7]Wade (2015); [8]Abdulai et al. (2020) ; [9]Vanla uwe et al. (2002); [10]Bargout & Raizada (2013); [11]AgriFarming (2018); [12]Santosa et al. (2018); [13]LACE (2014); [14]Shamshuddin et al. (2011); [15]Torres-De La Cruz et al. (2015); [16]Aguad (2010); [17]Fonta et al. (2018); [18]Singh et al. (2019); [19]Jalloh et al. (2011); [20]Tschora & Cherubini (2020); [21]Lans (2018); [22]Kamanyire (2000); [23]Leal et al. (1999); [24]FAO (1989)

## 5.2 SOIL CADMIUM

The issue of cadmium in cocoa beans has become more prominent as a result of European Union Regulation 488/2014 implemented in January 2019 that reduced the permissible amount of cadmium in chocolate and cocoa powder (0.1 mg kg$^{-1}$ for milk chocolate, 0.3 mg kg$^{-1}$ chocolate with 30-50% cocoa and 0.8 mg kg$^{-1}$ for dark chocolate, 0.6 mg kg$^{-1}$ for cocoa powder). Generally, the issue is most prevalent in central and south America and in the Caribbean on soils of volcanic origin but also following the use of certain phosphate fertilisers contaminated with Cadmium (Figure 13; Meter et al., 2019). A Recent survey conducted across cocoa farms in Ecuador and has demonstrated considerable spatial variation in soil and bean cadmium content and that high Cd concentrations occur in localized regions within these countries (Argüello et al., 2019).

In a recent survey of cocoa farms with known high calcium content in Central Colombia, mean soil concentrations of total and available cadmium were 10.68 and 7.48 mg kg$^{-1}$, respectively at a depth of 0-30 cm (Rodríguez Albarrcín et al., 2019). The same study reported a decrease in cadmium content with soil depth such that between 60-100 cm depth mean total and available cadmium content was 7.92 and 4.48 mg kg$^{-1}$, respectively. A survey in Costa Rica, found cadmium concentrations in the beans ranged from 0 to 8.70 mg kg$^{-1}$ (Furcal-Beriguete & Torres-Morales, 2019). High levels of cadmium in soils and cocoa beans are generally not reported in West Africa. In Indonesia, high cadmium concentrations may occasionally be found in soils around mining areas (Indonesia Consultant). A study into cocoa beans originating from East Luwu, South Sulawesi, found that cadmium concentrations were below the critical levels, established by the European Food Safety Authority (Assa et al., 2018).

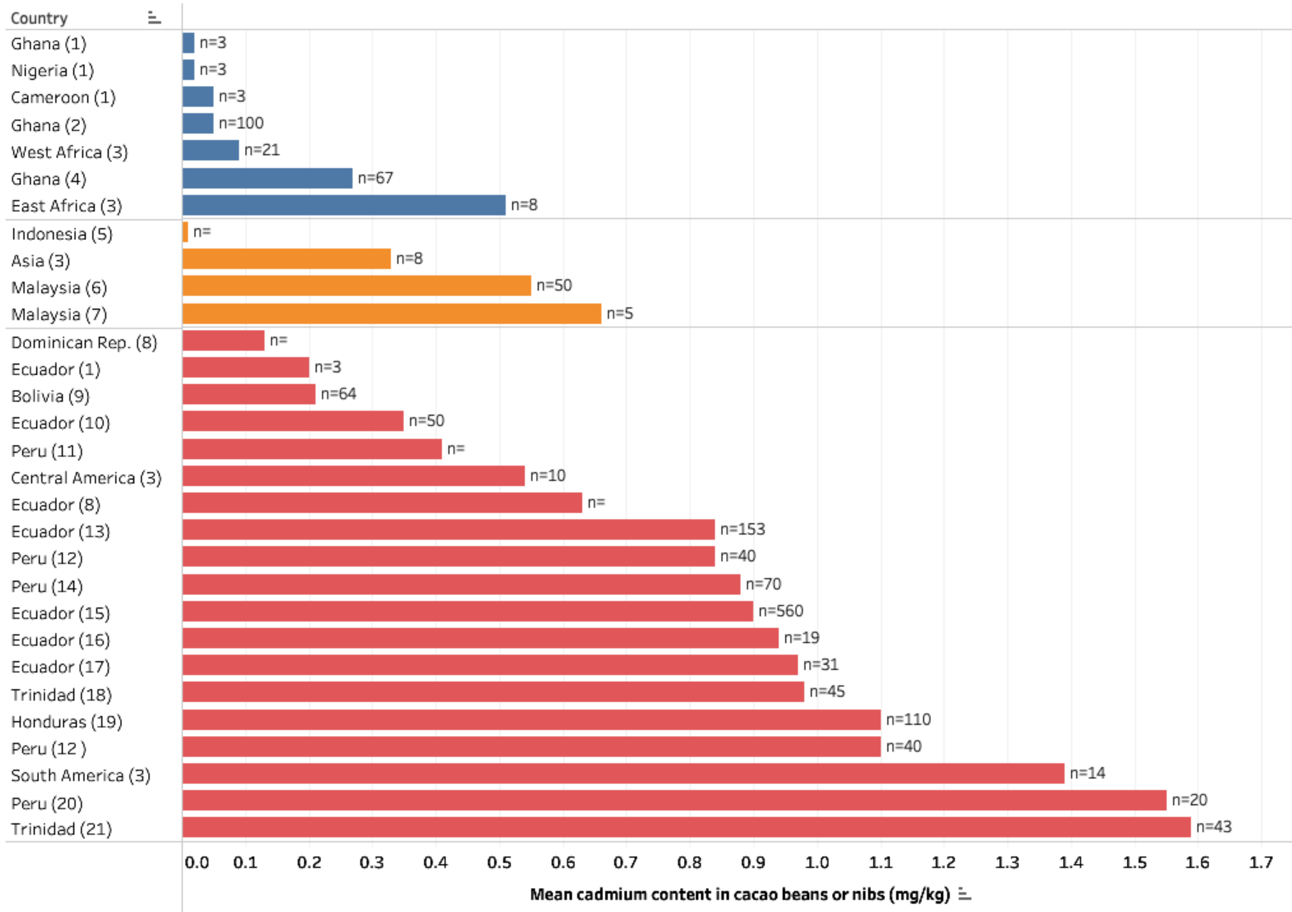



Figure 13. Worldwide occurrence of cadmium in cocoa bean or nibs. Reproduced from Meter et al. (2019). The number above each country refers to the original source reference and the n = sample size which is listed in Meter et al. (2019).

## 5.3 FERTILISATION

The use of fertilisers (both inorganic and organic), particularly by cocoa smallholders is highly variable (Table 9). Factors limiting fertiliser use include cost, accessibility and lack of awareness of their benefits and/ or correct usage. Since there is often heterogeneity in soil properties/ nutrient deficiencies in some cocoa-producing regions, there is often a need for fertiliser recommendations to be tailored to local conditions.

Table 9. Summary of surveys of the proportion of farmers who apply inorganic / organic fertiliser and the most common fertilisers used.

| Country | Inorganic fertiliser | Organic fertiliser |
|---|---|---|
| Côte d'Ivoire | 90% of farms surveyed were not fertilised. The low level of adoption of fertiliser was due to insufficient knowledge, lack of local availability, inefficient old formulas of fertilisers and excessive cost of fertilisers (Koko, 2014) | Organic manure: composting of pod husk and production of compost from pod residues is sometimes practiced (Ruf, 2016) |
| Ghana | In a survey of cocoa farmers, 80 % applied fertilisers. Of these, 30% applied *Asaasewura*, the most used fertiliser. Other frequently used fertilisers are '*Cocoa Nti*', '*Cocofeed Plus*', '*Cocoa So Dosoo*' and '*Cocoa Aduane*'. The survey indicated that most | In some parts of Ghana, chicken manure is used (Afrifa et al., 2009). An impediment to the use of organic fertilisers which has been identified is their "bulkiness" along with the added barrier of limited knowledge on low cost practices (Nasser et al., 2020). |

| | | |
|---|---|---|
| | Ghanaian cocoa farmers prefer granular over liquid fertilisers (Ehiakpor et al., 2016) | |
| Nigeria | 76.7 % of farmers surveyed did not apply any fertiliser to their cocoa trees. Affordability and availability of the fertilisers were cited as constraints (Babalola et al., 2017). | |
| Uganda | Some farmers have been reported to use cocoa pod husks to produce compost (Lutheran World Relief, 2015). | |
| Liberia | The use of agricultural inputs in Liberia is rare, the absence of a functioning inputs market in Liberia translates into increased operating costs and logistical challenges (English, 2008) | Traditionally, cocoa production in Liberia has used organic rather than inorganic fertilisers (International Trade Centre, 2014) |
| Sierra Leone | Fertiliser, pesticides, and herbicides were applied by less than 2% of farmers surveyed (Hofman, n.d.) | Farmers use compost, cover crops, manures, and naturally occurring pest control materials (Oakland & AFSA, 2008) |
| Cameroon | Fertiliser use is minimal due to the fertility of the volcanic soils (Laird et al., 2007). Farmers use pesticides and fungicides but no inorganic fertiliser (Tsiboe et al., 2016). | |
| Togo | Togolese agriculture is characterized by the predominance of smallholder rainfed farms with a low level of inputs (Tschora & Cherubini, 2020). | |
| Indonesia | In Western Sumatra, Sefriadi et al. (2013) found that 69% of farmers applied fertiliser. Daymond et al. (2020) found around 80% of farmers applied inorganic fertilisers (although the sample included a high proportion of highly managed farms) Fertilisers, appropriate for cocoa are often scarce and expensive in Sulawesi due to poor infrastructure, inefficient markets, and costly credit (Hoffmann et al., 2020). | Organic fertiliser from farmers' own cattle is sometimes used (Indonesia Consultant) |
| Malaysia | A common compost in Malaysia is made from rice husk obtained from rice mills (Shamshuddin et al. 2011) | |
| Philippines | Complete fertiliser (16-16-16) at a rate of 250 g per plant and urea (46-0-0) at a rate of 50 g per plant are applied by the banding method twice a year (Leyte et al., 2017) | |
| Vietnam | In a survey, all farmers used NPK fertiliser although composition and additional micronutrient content varied (Pauwels, 2016) | In the Mekong Delta manure and other organic matter is commonly thrown into the ditches and left to rot. During the next growing season, the decomposed material is shovelled out again and used as fertiliser for cocoa trees (Pauwels, 2016) |
| Colombia | In a survey of over 10,000 farmer, 63.5% applied some sort of fertiliser (FEDECACAO, 2019) | |
| Nicaragua | In a survey of 11% of farmers in the country, 33% applied inorganic fertiliser (Dar Ali Rothschuh, 2019). | 30% of the producers maintain or improve the "fertility" of the soil with bio compost prepared with the shell of cocoa pods, bovine manure, soil, lime, remains of Musaceae and bean stubble (Ayestas et al., 2013). |
| Ecuador | Inorganic fertilisers are not applied in traditional production systems. With more intensive systems growing CCN 51, urea and complete fertiliser (NPK) are regularly applied in amounts ranging between 0.25 to 1.2 MT /ha. Rates at the upper end of the | About 20% of Ecuadorian cocoa is certified organic, although few of these farmers use organic fertilisers. When organic fertiliser practices are in place these are based commonly on the use of, manure tea and compost produced in the farms (Ecuador |

| | | |
|---|---|---|
| | range are applied to CCN 51 plantations under irrigation or fertigation technology. These rates are associated with yields of 2 to 3 tonnes $ha^{-1}$. About one third of the cocoa farms (approx. 220,000 ha) regularly benefit from some level of fertilisation. In high input cocoa production systems, the cost of fertilisation represents around 20% of the total production cost and is equal to US$ 3,500 USD $ha^{-1}$ (Ecuador Consultant). | Consultant). Chicken manure, tree litter and cattle manure are also used (Barraza et al., 2019). |
| Bolivia | In conventional growing systems, an organic fertiliser was applied around the cacao trunks twice per year (Marconi & Armengot, 2020). | Compost, leguminous crops, bio control and manual weeding are applied in organic cocoa systems (Marconi & Armengot, 2020). |
| Venezuela | 96% of the producers use fertilisers and organic manure (Alvarado et al., 2014). The husk is used as raw material for organic fertiliser and animal feed (Sangronis et al., 2014). | |
| Brazil | Around 30% of farmers apply fertiliser. Macronutrients applied are urea, potassium and phosphate. Micronutrients are: Sulphates of copper, manganese, zinc, iron and boric acid.<br>It is estimated that about 10% of farmers send soil samples for laboratory analysis (Brazil Consultant). | The proportion of farmers estimated to apply organic fertiliser in 2006 was 3.3%. It is believed that the proportion has not changed since then. The most common manures are: cow manure, chicken manure, cacao husks and ash from the cacao processers in Ilhéus and Itabuna (Brazil Consultant). |
| Dominican Republic | Decomposing cocoa pods, branches, and leaves are used by producers as fertiliser (Berlan & Bergés, 2013) | |
| Haiti | The intensity of fertiliser use is low. Reasons cited for this include lack of supply, financial means, and lack of knowledge of soil components and nutrients (Kokoye et al., 2018). | |
| Trinidad & Tobago | Smallholder farmers often practice composting and vermiculture (Graham, 2012). | |

## Sources of fertilisation:

In various cocoa-growing countries, notably Côte d'Ivoire and Ghana, government schemes have been in place at different times to promote and sometimes subsidise fertilisers. In other instances (e.g. in Brazil) farmers can only obtain fertilisers from the market. Some examples are presented as follows:-

### AFRICA

→ **Ghana:** The Ghana Government has periodically provided farmers with fertiliser. For example, in 2002/03, the COCOBOD rolled out the 'Cocoa High-Tech' programme which was managed jointly by the CRIG, COCOBOD and the Ministry of Food and Agriculture-MoFA. Under this programme, the Government supplied fertilisers on credit at subsidised prices to farmers to encourage them to apply a minimum of 5 bags per hectare (Yamoah et al. 2020). Currently, farmers have to purchase fertilisers at a government subsidised (50%) price (Ghana Consultant).

→ **Côte d'Ivoire:** In 2012, the Cocoa Fertiliser Initiative started a programme to deliver fertilisers to 200,000 farmers by 2020 (Wessel & Quist-Wessel, 2015). The sources of organic fertiliser are the private sector and international NGOs, including CALLIVOIRE, AIFA, SOLEA and YARA. It should be noted that distribution of fertilisers was halted in 2018 due to perceived over-production in the cocoa sector.

→ **Cameroon:** The Cocoa Livelihood Program (CLP-I) has provided training through Farmer Business Schools (FBS) and Farmer Field Schools (FFS). Once FBS and FFS have been successfully completed, farmers gain access to credit for purchasing inputs such as fertiliser (Tsiboe et al., 2016).

→ **Togo**: The government has at times cut the price of fertiliser to increase use. For example, the Togolese government reduced the fertiliser price for a 50 kg bag by 9% and made 1,000 tonnes available to farmers during 2010-2011 (Tsiboe et al., 2016).

**ASIA**

→ **Indonesia:** Farmers obtain fertiliser from the government and the private sector. Between 2009 and 2013 the government "Gernas" programme included an intensification element, which included fertilisation (alongside pruning and pest and disease control) (Indonesia Consultant). Cocoa Care is a non-governmental social enterprise that aims to raise the living standards and productivity of cocoa farmers in Sulawesi. They provide farm management training, community support and assists in obtaining the tools and other inputs that the farmers require (Hoffmann et al., 2020).

→ **Papua New Guinea:** Subsidisation of inputs in cocoa production has been used in the past by the government of Papua New Guinea as an alternative to output price support to producers. Historically, the prices of fertiliser inputs to cocoa producers were reduced by 10% (Fleming & Milne, 2003).

**AMERICA**

→ **Ecuador:** Companies operating in the private sector import mineral fertilisers. The most commonly used fertilisers are Urea, Diammonium Phosphate and Muriate of potassium. Compound fertilisers with NP and NPK and NPK + micronutrients are available (Ecuador Consultant).

→ **Brazil:** All fertilisers used by Brazil come from the private sector.

## 5.4 WATER MANAGEMENT

The extent to which irrigation is used on cocoa farms depends on a number of factors including the duration of the dry season (if present), the age of the crop (young cocoa plants are much more liable to die when droughted), access to water sources, the general terrain of the land and access to infrastructure and resources. Irrigation is rarely used and may remain too expensive for most cocoa farmers in West Africa (Schroth et al., 2016). It is likely that 0.5% or less of Ghanaian cocoa is irrigated (Nasser et al., 2020); extreme climate events may intensify the risk of crop failure given that very few producers have irrigation facilities (Afriyie-Kraft et al., 2020). There are a small number of large farms in Côte d'Ivoire that are irrigated (Figure 14).

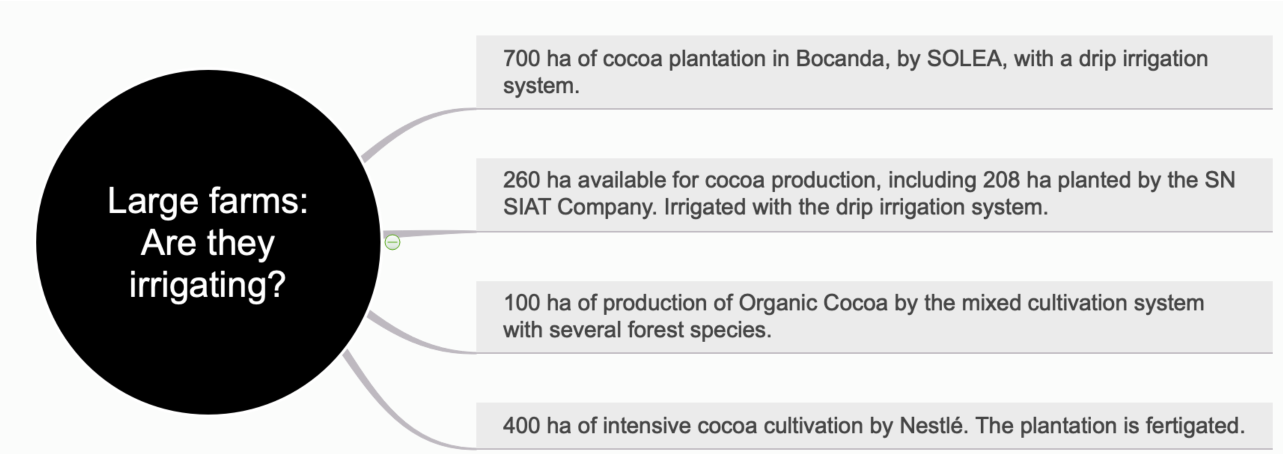



Figure 14. Examples of large irrigated farms in Côte d'Ivoire (Côte d'Ivoire Consultant).

In South America, the picture regarding irrigation is more mixed. Most cocoa cultivated in **Colombia** is not irrigated (Naranjo-Merino et al. 2017b). In **Peru**, irrigation is sometimes needed where rainfall is insufficient (Laroche et al., 2012). A pilot fertigation system in Peru was installed by TechnoServe with drip irrigation to demonstrate the benefits of increased access to water and improved fertiliser delivery through irrigation systems (TechnoServe, 2015). Examples of use of irrigation by smallholder farmers can be found in parts of **Ecuador**. For example, some small traditional producers of the Nacional type cacao irrigate by furrows in the southern floodplains of the Guayas river basin and alluvial banks of the Carrizal-Chone river basin. Other producers managing 1 to 5 hectares of the CCN 51 variety of cocoa have invested in more sophisticated irrigation systems (micro-sprinklers) to irrigate in hilly land with clayey soils obtaining average yields of 2.0 tonne $ha^{-1}$ or higher (Ecuador consultant). All medium and large farms in Ecuador growing the CCN 51 variety irrigate; the monthly cost of applying water to a cocoa hectare ranges from US$ 40 to 60 USD (Ecuador Consultant). Depending on the length of the dry season, this translates to between approximately 200 and 500 US$ $ha^{-1}$ $year^{-1}$ (Ecuador Consultant).

In **India**, most cocoa farmers have adopted surface irrigation with soil application of fertilisers. During the dry season, plants have to be irrigated at weekly intervals (Krishnamoorthy et al., 2015).

# 6. CROP MANAGEMENT

Key findings:

- Replanting old tree stock is important for maintaining and improving productivity. Notable government-driven replanting schemes operate in Côte d'Ivoire and Ghana.
- Whilst pruning is often practiced, the quality of pruning can often be sub-standard.
- The cropping season is driven primarily by seasonal rainfall, although temperature can also be a factor, particularly in regions that have a cool season.
- Whilst yields per hectare vary between countries there is also considerable yield variation within cocoa-growing countries.

## 6.1 REPLANTING

The need to replant cocoa trees is often due to the decline in productivity as trees age. Farmers may also choose to replant their trees with more productive and/ or disease resistant varieties. In areas where there have been acute disease problems, this has sometimes driven large scale re-planting. For example, the spread of witches' broom disease in Bahia, Brazil has led to replacement of trees with more disease-resistant varieties since the early 1990s. In Ghana and Côte d'Ivoire, cutting out has been used a means of attempting to control cocoa swollen shoot virus. Notable examples of replanting/rehabilitation are set out as follows:-

### AFRICA

→ **Côte d'Ivoire:** The Programme Quantité-Qualité-Croissance << 2QC >> aims to replant a cocoa area of 800,000 ha by 2023 (including 150,000 ha affected by swollen shoot virus disease) with improved planting material (Wessel & Quist-Wessel, 2015). However, due to a perceived over-supply of cocoa in the market, this scheme was suspended from the 2018/2019 season (Agro, 2021).

→ **Ghana:** The COCOBOD has secured a US$600 million receivable-backed syndicated loan facility, a large proportion of which will go in to rejuvenating old cocoa farms. To date, as part of this programme 11,564 hectares of swollen shoot affected farms in the Western North and Eastern Regions have been replanted with cocoa, plantain, and economic shade trees. Replanted cocoa farms are maintained by the COCOBOD. Additionally, affected farmers are paid compensation (One thousand Ghana Cedis = $ 180 per hectare) as financial support covering the period of establishment (Ghana Consultant).

→ **Nigeria:** A previous goal set by the government included plans to rehabilitate 15,000 hectares of cocoa trees annually (Tokgoz et al., 2020).

→ **Uganda:** Rehabilitation of neglected cocoa was conducted under the former USAID/IDEA project (Lutheran World Relief, 2015).

### ASIA

→ **Papua New Guinea:** In 2008, PAL (a private company) introduced the Manus Agriculture and Livestock Development Plan (MALDP) promoting a cocoa rehabilitation programme (Garnevska et al., 2014).

→ **Indonesia:** Side grafting as a means of rehabilitation is commonly practiced in Sulawesi. This is carried out by the farmers or by service providers. The latter are groups of farmers who have been trained by the government or an NGO. They offer a grafting service to other farmers, with the cost consisting of the price of the scion (upper part graft) and service fee. The cost, based on the number of successful grafts only, is currently around USD 50 cents per graft (Indonesia Consultant).

### AMERICA

→ **Brazil:** Current recommendations by CEPLAC on techniques to rehabilitate cocoa plantations include the grafting of witches' broom resistant cocoa varieties on diseased trees and the replacement of *Erythrina* shade trees with rubber trees (*Hevea brasiliensis*) in order to increase and diversify farm income (Cassano et al. 2009). Around 3% or 2000 producers are rehabilitating cacao per year utilising new clonal cultivars that are available (Brazil Consultant, 2020).

→ **Dominican Republic:** In the early 2000s, a major programme of the Cocoa Department focussed on renovation and rehabilitation of some 13,000 hectares of cocoa to increase productivity and quality of cocoa (Siegel et al., 2004).

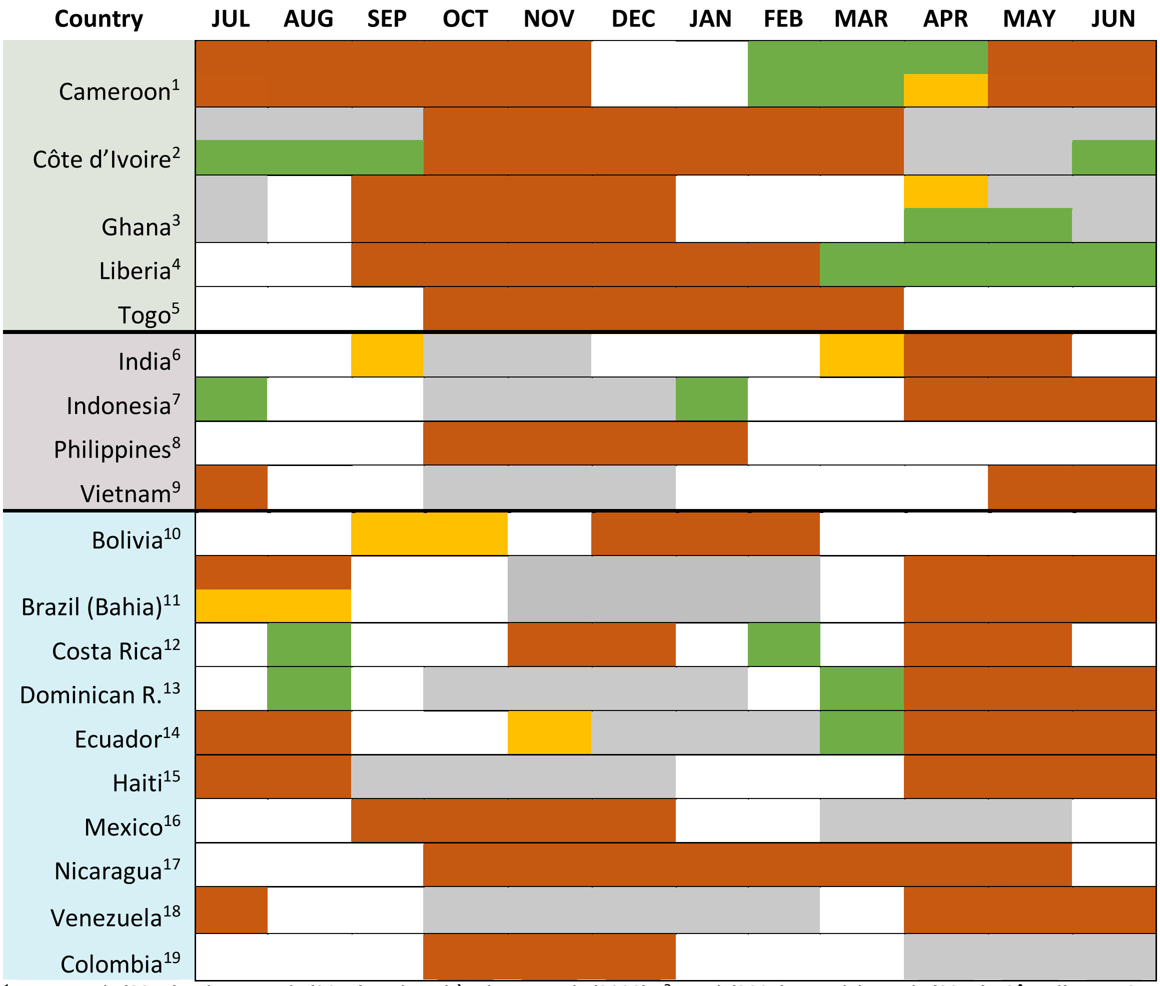
→ **Trinidad and Tobago:** Old plantation trees, Imperial College Selection (ICS) clones, have been replaced on some farms by newer commercial varieties (Trinidad Selected Hybrids) with increased resistance to diseases and favourable agronomic traits (Bekele, 2004). It is recommended that only superior planting material in terms of yield potential and disease resistance (black pod and witches' broom disease) should be used for replanting and rehabilitation of farms and in expansion programmes (Bekele, 2019).

→ **Ecuador:** The preferred practice to recover the productivity of the land devoted to cocoa is the gradual elimination of the old cacao trees for total replanting with clonal cocoa, mainly by the CCN 51 variety. Grafting low yielding clonal plants, or simply replacing one variety for other, by changing its crown through grafting the main branch with buds from high yielding varieties is showing promise as a rehabilitation practice (Ecuador Consultant, 2020).

## 6.2 COCOA PRODUCTION SEASONS

In most areas where cocoa is grown, there is some cocoa to be harvested all year round although there is often a main harvest period and one or more smaller harvest periods (Table 10). Rainfall is a key driver of cropping intensity impacting on flowering, pod-setting and pod retention. Temperature can also play a role in cropping patterns, for example, in the Brazilian state of Bahia where the relatively cool winter period of May to August results in reduced flowering and pod set with consequently few mature pods present from December to March (see Thematic Study 2: effects of climate change on cocoa).

Table 10. Main Cocoa production seasons (**Brown** =main harvest, **grey** = light harvest, **yellow** = flower initiation, **green**= weeding and pruning)




[1]Asare et al. (2017); Klarer et al. (2014); Ndoumbè-Nkeng et al. (2009); [2]David (2005); Tondoh et al. (2015), Côte d'Ivoire Consultant (2020); [3]Cocoa Health and Extension Division [CHED] & World Cocoa Foundation [WCF] (2016); Ghana Consultant (2020); Adjaloo et al. (2012) [4]English (2008); [5]Dendi (2016); [6]Krishnamoorthy et al. (2015); [7]Aidenvironment. (2016); Moriarty et al. (2014); [8]Department of Agriculture - BPI (2016); [9]Phuc (2013); [10]de Schawe et al. (2013); [11]Gateau-Rey et al. (2018); Venturieri (2011); [12]Chacón (2019); [13]Siegel et al. (2004); [14]Moreno-Miranda et al. (2019); Torres (2012); [15]Chery (2015); [16]Córdoba-ávalos et al. (2001); [17]Trognitz et al. (2013); [18]Gomez & Azócar (2002); [19]IICA (2017)

**Thematic Study 2: Climate Change and Cocoa**

Increases in radiatively active gases in the atmosphere are driving changes in climate globally. The extent to which atmospheric $CO_2$ and temperatures will continue to increase will depend on the trajectory over time of global emissions of $CO_2$ and other radiatively-active gases. Under the most optimistic scenario, towards the end of the century global temperature increases would be confined to 1°C, whilst under the most pessimistic scenario, temperatures would on average be 3.7°C higher (IPCC, 2013). Model predictions of changes in rainfall across the tropics vary with some models predicting increases in annual totals and others predicted decreases. For West Africa, a recent study suggests that the timing of the onset of the rainy season may be delayed (Dunning et al., 2018).

A number of experimental studies have examined the impact of key factors associated with climate change. An increase in growth of juvenile cocoa has been observed at elevated $CO_2$ (Baligar et al., 2021; Lahive et al., 2018). There is evidence that elevated $CO_2$ concentration can partly offset the negative impacts of moderate water deficit (Lahive et al., 2018; 2021). Nevertheless, intense drought episodes result in reduced yield and tree losses at establishment for rainfed cocoa. Regarding temperature, it has been suggested that the optimal temperature for cocoa is between 31 and 33°C (Balasimha et al., 1991), although this may vary between varieties. Temperatures significantly higher than this would be expected to have a negative impact on cocoa productivity.

A number of studies have modelled the vulnerability of cocoa across particular geographical areas. Schroth et al. (2016) concluded that there is strong differentiation of climate vulnerability within the Western African cocoa belt. More recently, Black et al. (2020) combined meteorological modelling with a plant functional model and predicted that total plant growth ("net primary productivity") will be maintained across the West African cocoa belt even under the worst climate change scenario.

The extent to which areas remain suitable for growing cocoa also depends on adaptation measures that farmers are able and willing to employ. Such measures might include use of irrigation (where feasible), use of appropriate shade trees to ameliorate the microenvironment and use of mulching during establishment which can improve water retention of the soil (Acheampong et al., 2019). There is also increased interest in breeding for resilience to environmental stresses that are likely to be encountered at a greater frequency under climate change (e.g. drought stress).

## 6.3 PRUNING

Pruning activities can be broadly divided into phytosanitary pruning, to remove dead or diseased branches and structural pruning, designed to maintain a particular shape of the trees and to increase the proportion of the canopy that is illuminated. Whilst farmers commonly prune to a greater or lesser extent, an issue can sometimes be the quality of pruning, for example, farmers may simply remove lower branches rather than opening up the canopy. On larger plantations, for example, those in Brazil and Ecuador, the farmer may contract out pruning activities. The following are some examples of studies on pruning in different cocoa-producing countries.

### AFRICA

- → **Ghana:** Available data indicate that a high proportion of Ghanaian farmers (above 80%) prune their cocoa trees to some extent (Ehiakpor et al., 2016).
- → **Liberia**: Pruning along with under-brushing are typically performed ahead of the main harvest from March to July (GrowLiberia, 2016).

→ **Cameroon**: A study by Tsiboe et al. (2016) demonstrated that selectively applying a set of field management protocols, which included pruning alongside shade management and proper phytosanitary control could achieve a yield enhancement of 14%.

## ASIA

→ **Malaysia**: A trial by Riedel et al. (2019) used severe pruning as a means of rehabilitating old cocoa trees. The main pruning was done at the beginning of flowering (June), half a year before the main harvest.

→ **India**: Trees are pruned at an early stage in order to maximize future crop yield. Women play an important role in early pruning (Barrientos-Fuentes, 2014).

→ **Philippines**: Manual weeding and pruning have been reported to be conducted regularly (Leyte et al. 2017).

→ **Indonesia**: Farmers prune their cocoa trees regularly (Indonesia Consultant, 2020).

## AMERICA

→ **Ecuador**: Little pruning takes place within low input traditional production systems growing the Nacional type cacao. Pruning tall and old cacao trees is costly ($1 USD per tree) and the yield gain is marginal, making it uneconomical. However, chupon removal is a common practice. In clonal cocoa plantations of EET's or CCN 51 varieties, pruning is a common practice. More intensively managed cocoa plots are pruned twice per year. First, a strong pruning of the tips of the main and secondary branches control vertical and lateral growth and removes diseased tissues. Later a thinning pruning is applied to clear up the interior of the canopy structure allowing additional light interception and ventilation to reduce the incidence of fruit diseases. On smallholder farms, the farmers do the pruning themselves, whereas on larger estates pruning is contracted out. The cost of pruning ranges from US$150-200 ha$^{-1}$ (Ecuador Consultant).

→ **Nicaragua**: Producers prune cocoa three times a year (May, August, and November). "Strong or maintenance" pruning occurs in May, once the rainy season has started (Ayestas et al., 2013).

→ **Brazil**: Farmers prune and remove chupons. Often they do these activities themselves but may sometimes hire out contractors (Brazil Consultant).

→ **Bolivia**: Cocoa trees are usually pruned once a year, following the main harvest (Jacobi et al., 2014)

### 6.4 YIELD

Average yields (in terms of kg ha$^{-1}$) in different countries according to literature sources are presented in Figure 15, whilst figures from the FAO website are presented in Figure 16. A large differential between literature sources and FAO can be seen for Malaysia where the estimates of Riedel et al. (2019) are much higher than those of FAO. In the case of Colombia and Peru, the estimates of FAO are somewhat higher than those of FEDECAO (2019) and USAID (2019). Typically, country wide yields are calculated according to an estimate of area cultivated and the amount of cocoa produced annually. Since the production area is difficult to calculate accurately, any error in calculating this will have an impact on calculating yields per hectare. This may account for some differences in yield calculated by FAO and some of those in the literature. It should be noted that yields can vary considerably within countries. For example, Daymond et al. (2020) recorded an approximately 90-fold difference in three-year yields across 120 smallholder cocoa farms in Indonesia. Furthermore, some large plantations are now achieving yields of over 2-3 tonnes per hectare (Ecuador Consultant).

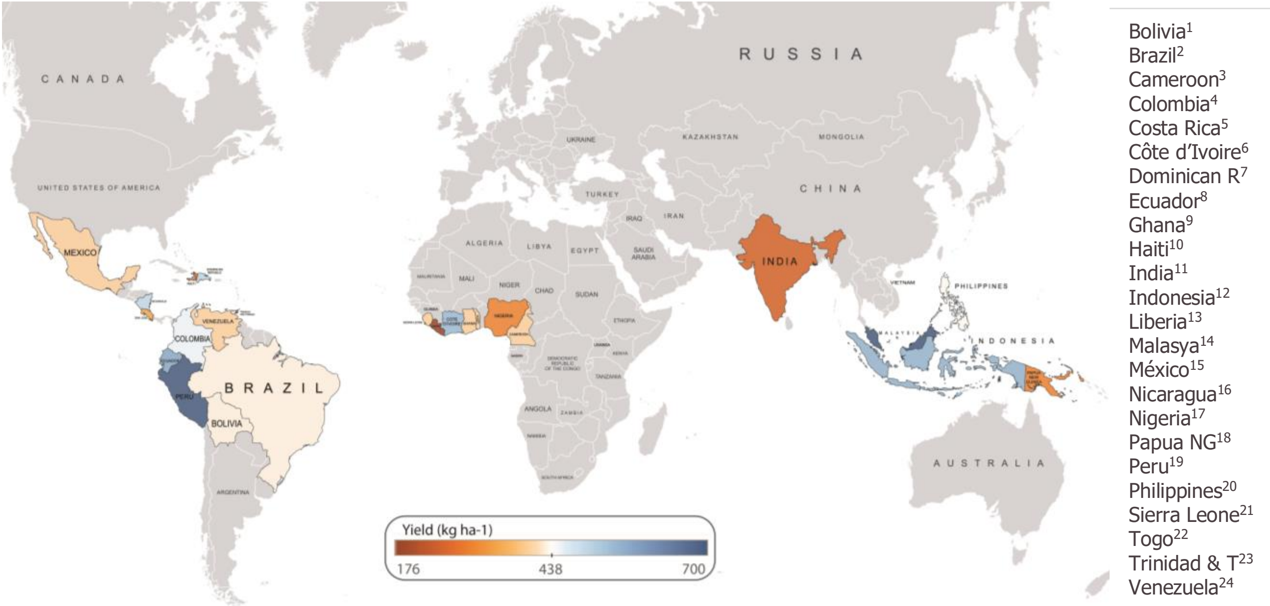



Figure 15. Yield (kg ha$^{-1}$) by Literature review

[1]Jacobi et al. (2015); [2]Brazil Consultant (2020); [3]Wessel & Quist-Wessel (2015); [4]FEDECACAO (2019); [5]INFOAGRO; [6]Sellare et al. (2020); [7]Boza et al. (2013); [8]Barrezueta-Unda (2019); [9]Ofori et al. (2020); [10]Chery (2015); [11]Malhotra & Elain Apshara (2017); [12]Mithöfer et al. (2017); [13]English (2008); [14]Riedel et al. (2019); [15]Córdoba-ávalos et al. (2001); [16]Cerda et al. (2014); [17]Adeniyi et al. (2019); [18]Faheem (2019); [19]USAID (2019); [20]Hamrick et al. (2017); [21]Amara et al. (2015); [22]Dendi (2016); [23]Bekele (2004); [24]Alvarado et al. (2014)

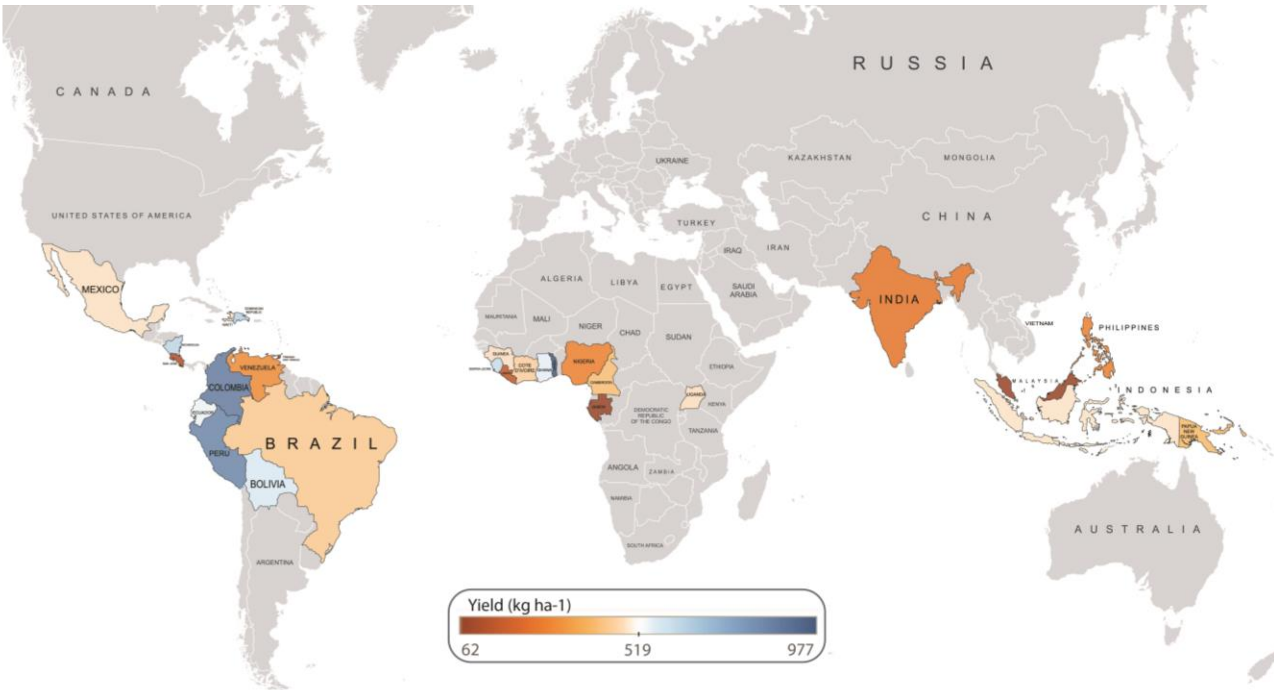



Figure 16. Yield (kg ha$^{-1}$) using FAO figures from 2019 (FAO, 2021)

# 7. PEST AND DISEASE MANAGEMENT

Key findings:

- Pest and diseases account for an estimated yield loss of 30-40% of potential production.
- Whilst some pests and diseases are ubiquitous, others are confined to particular parts of the world.
- Control of pests and diseases includes use of agrochemicals, husbandry (e.g. pruning, diseased pod removal), cultural (e.g. frequent harvesting) and biological control.
- Improved varieties have often been selected for improved resistance to pests and/or diseases.

Pests and diseases can be a major cause of yield loss on cocoa farms, accounting for an estimated 30-40% yield loss globally. Whilst a number of pests and diseases are commonly found across all cocoa-growing areas, notably *Phytophthora palmivora* (the causal agent of *Phytophthora* pod rot or "blackpod") and various species of mirids, other pests and diseases are confined to particular geographical regions. For example, frosty pod rot (causal agent: *Moniliophthora rorei*) is found in parts of Central and South America and Jamaica, Cocoa swollen shoot virus disease is confined to West Africa and Vascular Streak Dieback is found throughout the cocoa-growing regions of Asia. Cocoa pod borer is a notable pest in many parts of south-east Asia.

All of the major pests and diseases found in the study countries are included in Table 11, along with reported minor pests and diseases. Control of pests and diseases can take a number of forms including use of agrochemicals, husbandry (e.g. pruning, diseased pod removal), cultural (e.g. frequent harvesting) and biological control. Furthermore, breeding efforts are often geared toward producing more resistant varieties.

Table 11 includes examples of published control methods used in different countries. An example of a government pest and disease control programme is described in Case Study 2 (see also Thematic study 3: the impacts of climate change on cocoa pests and diseases).

Table 11. Prevalence of pests and diseases and examples of reported control measures. Information on pest and disease prevalence is from End et al. (2017) and appended references. *P. palmivora* is ubiquitous in almost all cocoa-growing areas as well as a number of mirid species and so these are not listed by country.

| Country | Main pest and disease | Pest and disease control |
|---|---|---|
| Ghana | *Cacao necrosis virus* (CNV)<br>*Cacao swollen shoot virus* (CSSV)<br>*Phytophthora megakarya*<br>Thread Blight Disease,<br>Pink Disease,<br>Anthracnose Disease (Ghana Consultant)<br>Parasitic mistletoe (*Tapinanthus bangwensis*) (Dormon et al. 2004) | Ghanaian cocoa farmers frequently report using fungicides; an initial application is typically made in June with subsequent application(s) often made afterwards. Farmers source fungicides mainly from the Ghana government through the CODAPEC programme (Opoku et al., 2000) (see Case Study 2). |
| Côte d'Ivoire | *Cacao swollen shoot virus (CSSV)*<br>*Phytophthora megakarya*<br>Parasitic mistletoe (*Tapinanthus bangwensis*)<br>Stem borer | Fungicides are used in the control of blackpod. The control of Cocoa swollen shoot disease is agronomic, i.e. through cutting out and re-planting (Guiraud et al., 2018). |

| | | |
|---|---|---|
| Nigeria | *Cacao necrosis virus* (CNV)<br>*Cacao swollen shoot virus* (CSSV)<br>*Phytophthora megakarya* | The Cocoa Research Institute of Nigeria (CRIN) is responsible for the screening of new agro-chemicals such as insecticides, fungicides and herbicides as well as new spraying pumps (Ojo et al., 2019). |
| Uganda | *Verticillium* wilt | |
| Liberia | *Cacao swollen shoot virus* (CSSV) | The prohibitively high costs of insecticides and fungicides has been identified as a constraint to control (English, 2008). |
| Sierra Leone | *Cacao swollen shoot virus* (CSSV)<br>*Cacao yellow mosaic virus* | |
| Cameroon | *Phytophthora megakarya*<br>*Ceratocytis fimbriata* (Laird et al., 2007) | Most farmers purchase chemicals from agents who come to the village from the regional cities. Farmers use a cocktail of chemicals (to control pests and diseases) (Ndoumbè-Nkeng et al., 2009). |
| Togo | *Phytophthora megakarya*<br>*Cacao swollen shoot virus (CSSV)* | Little in the way of regular maintenance of cocoa trees and insecticide treatments has been reported (Oro et al., 2012). |
| Indonesia | Cocoa pod borer<br>Vascular streak dieback<br>*Rosellinia* root rot | Farm maintenance and application of chemicals are the main means of pests and disease management. In a survey, around a third of farmers applied fungicides and between 70 and 74% of farmers used pesticides (Daymond et al., 2020). Cultural controls include sanitary pruning and frequent harvesting (Indonesia Consultant). |
| Malaysia | *Phytophthora arecae*<br>*Phytophthora citrophthora*<br>*Phytophthora hevea*<br>*Phytophthora megasperma*<br>*Phytophthora nicotiana*<br>*Rosellina* pod rot<br>Vascular streak dieback<br>Cocoa pod borer | |
| Papua New Guinea | Cocoa pod borer<br>*Vascular Streak Dieback* | Spraying to control outbreaks of particular pests and diseases is a specialised job that can use motorised equipment that is normally beyond the purchasing power of an individual farmer (CCI, 2017; Faheem, 2019). |
| India | *Phytophthora arecae*<br>*Phytophthora capsici*<br>*Phytophthora citrophthora*<br>*Phytophthora hevea*<br>*Phytophthora megasperma*<br>*Phytophthora nicotianae*<br>*Rosellinia* root rot<br>*Vascular streak dieback* | Disease control methods include: frequent removal of chupons, sanitary pruning, removal, and destruction of *Phytophthora* infected pods and correct spacing (Peter & Chandramohanan, 2011). |
| Philippines | *Phytophthora arecae*<br>*Phytophthora citrophthora*<br>*Phytophthora hevea*<br>*Phytophthora megasperma*<br>*Phytophthora nicotianae*<br>*Rosellinia* root rot<br>Cocoa pod borer<br>Vascular streak dieback | |
| Vietnam | Cocoa pod borer<br>Vascular streak dieback<br>Stem borers (*Xyleborus* morstatti) (Pauwels, 2016) | Preventative pesticide and fungicide application on intensively managed farms is thought to be widespread. The Ministry of Agriculture and Rural Development (MARD) actively promotes integrated pest management, which includes pruning and mulching and has introduced *Lasius* |

| | | |
|---|---|---|
| | | *niger* ants as a form of biological control to combat mirids in the Mekong Delta (Pauwels, 2016). |
| Nicaragua | *Moniliophthora roreri* | In a survey, the most common means of controlling *Moniliophthora* (40% of farmers interviewed) was cutting and burying diseased and damaged fruits and applying lime to the fruits (Ayestas et al., 2013). |
| Mexico | *Moniliophthora roreri*<br>*Phytophthora arecae*<br>*Phytophthora capsici*<br>*Phytophthora citrophthora*<br>*Phytophthora hevea*<br>*Phytophthora megasperma*<br>*Phytophthora nicotianae* | Maintenance practices carried out on farms include formation pruning, rehabilitation, and removal of diseased fruits (Díaz-José et al., 2013). |
| Colombia | *Moniliophthora roreri*<br>*Monalonion dissimulatum* (Meneses-Buitrago et al., 2019)<br>*Moniliophthora perniciosa*<br>*Ceratocystis* wilt<br>*Verticillium* wilt of cacao<br>Cacao Cob Perforator (*Carmenta foraseminis*) (Cubillos, 2013) | Control measures include: cultural, biological, physical, chemical and genetic (Cubillos, 2013). In a survey of over 10,000 cocoa farmers 96.6% said that they applied some sort of pest control (FEDECACAO, 2019). |
| Costa Rica | *Moniliophthora roreri*<br>*Ceratocystis* wilt<br>*Rosellina* root rot | |
| Ecuador | *Moniliophthora perniciosa*<br>*Moniliophthora roreri*<br>*Ceratocystis* wilt | Fungicides are applied only in large and medium size cocoa plantations. An average of 40% of the cocoa pods is lost to diseases. In most clonal cocoa farms, producers face this problem by removing diseased pods at harvest time (Ecuador Consultant). |
| Peru | *Moniliophthora perniciosa*<br>*Moniliophthora roreri* | |
| Bolivia | *Monalonion dissimulatum* Bourguet & Guillemaud (2016)<br>*Moniliophthora perniciosa*<br>*Moniliophthora roreri* | |
| Venezuela | *Moniliophthora perniciosa*<br>*Moniliophthora roreri*<br>*Phytophthora arecae*<br>*Phytophthora capsici*<br>*Phytophthora citrophthora*<br>*Phytophthora hevea*<br>*Phytophthora megasperma*<br>*Phytophthora nicotianae*<br>*Ceratocystis* wilt | Control methods include cultural control measures, fungicides and pesticides. Potential biological control agents are currently being researched (Arvelo Sánchez et al., 2017). |
| Brazil | *Moniliophthora perniciosa*<br>*Phytophthora arecae*<br>*Phytophthora capsici*<br>*Phytophthora citrophthora*<br>*Phytophthora hevea*<br>*Phytophthora megasperma*<br>*Phytophthora nicotianae*<br>*Phytophthora palmivora*<br>*Ceratocystis* wilt<br>*Rosellinia* root rot | The proportion farmers that apply agrochemicals is estimated to be 30%. Sanitary pruning is conducted to remove infected pods, branches, and cushion brooms. All sources of fungicides come from the private sector (Brazil Consultant). |

| | | |
|---|---|---|
| Dominican Republic | Rats (Batista, 2009) | Agri-chemicals are typically used in cocoa production. Organic producers use snakes as a means of biological control, whilst others use chemical raticides (Siegel et al. (2004). |
| Haiti | *Phytophthora spp.* | |
| Trinidad and Tobago | *Moniliophthora perniciosa*<br>*Phytophthora capsici*<br>*Rosellinia* root rot<br>*Ceratocystis* wilt | In Caribbean countries, agrochemicals have been commonly used against pests (Pereira et al., 2007). |

**Case Study 2: Government support for pest control in Ghana: Ghana Consultant, Kofi Acheampong**

In Ghana, institutional support is provided to cocoa farmers by the Government's COCOBOD via a programme called the Cocoa Disease and Pest Control (CODAPEC). The Cocoa Health and Extension Division (CHED) also part of COCOBOD provides free services for fungicide and pesticide application through CODAPEC. CODAPEC is also tasked with identifying Cocoa Swollen Shoot Virus Disease outbreaks and countering the spread of disease by uprooting infected trees. CODAPEC's national spraying programme uses spraying gangs, which are formed of selected community members who are paid by CODAPEC for the amount of land sprayed. The spraying gangs are given free pesticides (to combat mirids) and fungicides (to combat black pod) as well as fuel to perform the spraying tasks. For mirid control, the spraying gangs are supposed to spray each farm four times a year between July and September. The national spraying programme is paid for through deductions made from the 'Free on Board' (FOB) price received by COCOBOD for cocoa sales. Therefore, it may be argued that cocoa producers indirectly pay the costs of the spraying programme through the lower producer price that they receive from their sales.

**Thematic Study 3: Impacts of climate change on pests and diseases of cocoa**

There are a number of ways in which pests and disease of cocoa might be impacted by climate change. Firstly, is the direct climatic impact on the pests, diseases and disease vectors (in the case of cocoa swollen shoot virus). For example, in areas where rainfall is predicted to increase, this may favour fungal diseases such as *Phytophthora* pod rot. It has been suggested that the increased intensity and frequency of hurricanes in Central America may have been a factor in the spread of frosty pod rot from Costa Rica to Mexico (Cilas & Bastide, 2020). Conversely, in regions where the dry season is becoming more intense, then this may help to break the cycle of fungal diseases.

Increased physiological stress resulting from more intense droughts or very high temperatures, may increase its susceptibility to particularly diseases or pests. It has been suggested that cocoa swollen shoot virus symptoms are greater in trees that are more stressed, for example, under high light intensity and water deficit (Andres et al., 2018). The fungal disease *Lasiodiplodia theobromae* is often more prevalent in plants that are stressed, e.g. through drought or in no shade situations (Mbenoun et al., 2007). For this reason, this disease is predicted to become significant. In the cases of pests, a cocoa tree that is growing vigorously can withstand damage to its canopy by pests such as mirids much more so than one that is experiencing drought.

Strategies to adapt cocoa farming to climate change is likely also to have an impact on pests and diseases. For example, as cocoa trees grown under shade are less susceptible to mirid damage (Awudzi et al., 2020), increased use of shade trees/ agroforestry as an adaptation to climate change may also reduce the severity of mirid attack. It is important, however, if new trees are introduced on to cocoa farms that they are not hosts to diseases, such as cocoa swollen shoot virus.

# 8. FARM DIVERSIFICATION

Key findings:

- On-farm diversification is a means of both increasing income and reducing dependency on a single crop.
- Additional valorisation of the cocoa harvest may be achieved by means of farmer or farmer co-operative chocolate production and utilisation of cocoa bi-products (e.g. pulp and husk).
- Cultivation of additional crops and livestock production are other sources of on-farm diversification.

Production of chocolate by farmers or by farmer co-operatives can be a means of enhancing farmer income. Similarly, by-products from the pulp and the husk can add income from the crop. Some examples of cocoa products in different countries are presented in Table 12.

Table 12. Examples of cocoa products (chocolate or bi-products) made by farmers or farmer co-operatives

| Country | Cocoa products |
|---|---|
| Côte d'Ivoire | Farmers Solidarity, a cooperative of cocoa producers, recently presented its first chocolate bars. The cocoa butter made by the 200 women of the Coopérative du Bélier, is considered exceptional. Cocoa mucilage juice has been used in marmalade production (Côte d'Ivoire Consultant, 2020). |
| Ghana | Ghana's COCOBOD Law 84 does not permit farmers to process their own cocoa into chocolate. Recent requests have been made for this law to be amended so that farmers could be allowed to produce chocolate, with COCOBOD's permission. This area of activity is in its infancy. A growing number of companies are processing the beans into cocoa powder mainly for local consumption (Ghana Consultant). |
| Indonesia | Some cocoa farmer cooperatives process beans to chocolate, e.g. Guyub Santoso (Kampung Cokelat/Chocolate Village) cooperative at Blitar, East Java; Rumah Cokelat (House of Chocolate) at Trenggalek, East Java; Soccolate at Pidie, Aceh; also, there are some cooperatives producing chocolate in South Sulawesi and Central Sulawesi (Indonesia Consultant, 2020). |
| Bolivia | El Ceibo (co-operative owned by over 1,200 farming families) sells hot chocolate, cocoa powder, and chocolate bars (Bazoberry et al., 2008). |
| Brazil | In Bahia bi-products made by farmers include:<br>1 – Pulp sold in the local market, but on a small scale, sold for around US$ 1 per kg<br>2 – Honey sold on a small scale for the local community for US$ 2 per litre<br>3 – Jelly sold on a small scale in the local community for US$ 2 for 300 g<br>4 – Placenta is used for sweets and for fish food sold for US$ 20 cents per kilo<br>5 – Cachaça of cacao honey sold for US$ 30 for a 700 ml bottle<br>6 – Wine is sold on a small scale for US$ 10 for a 700ml bottle<br>(Brazil Consultant, 2020) |
| Ecuador | Juice from pulp is the most common bi-product, which is sold at supermarkets and on agrotourism tours. Jam made from cocoa pulp may also be available. There is at least one company that exports frozen cocoa pulp. The cost of a tonne exported is US$ 1200 (Ecuador Consultant, 2020). |
| Mexico | Cocoa producers in Chontalpa produce artisan chocolates (Jaramillo-Villanueva et al., 2018). |

## 8.2. OTHER SOURCES OF ON-FARM INCOME

Cocoa is crucial for household income in rural communities. For example, in Ghana and Côte d'Ivoire the average cash income solely earned from cocoa is estimated at about 80-90% of the total household income for organised cocoa farmers (Kiewisch & Waarts, 2020). However, diversification of income sources beyond cocoa, either on-farm or off-farm, plays a dual role: it addresses the sustainability risks of the lowest income cocoa farmers and it can decrease the overall dependency on cocoa, providing opportunities to respond to price-bust cycles. In areas where year-to-year yield variability is high, for example in areas affected by climate change, risks to income are greater and so diversification or shifting from cocoa as the main source of income to other income-generating activities is a way of reducing this risk (Waarts et al., 2019). Some specific examples of diversification are summarised as follows (see also Case Study 3).

### AFRICA

→ **Ghana:** In the first 2-3 years of establishment, cocoa may be intercropped with food crops, such as maize, plantain, cassava and vegetables (Ghana Consultant). A survey by Aneani et al. (2012) showed that cocoa farmers also reared poultry and livestock such as pigs, sheep and goats for home consumption and sale, although the income from these was not quantified.

→ **Côte d'Ivoire**: Additional crops grown on cocoa farms include yams, bananas, taro or cassava. One study found that food crops, associated with coffee and cocoa farms, were a source of income for 53.9% of cocoa farmers (Côte d'Ivoire Consultant, 2020). Livestock has also been cited as an additional source of income (Gyau et al., 2014).

→ **Nigeria:** In a survey by Meludu et al. (2017) major companion crops cultivated included cassava (39.2%), maize (33.3%), kola nut (16.7%) and oil palm (10.8%).

→ **Uganda:** Farmers intercrop cocoa with food crops, especially bananas. Smallholders growing cocoa in Uganda primarily grow food and staple crops, mainly maize and beans, followed by cassava, sweet potatoes and groundnuts (FAO, 2018).

→ **Liberia:** In a survey by English (2008) species such as avocado, kola nut, and plantain were commonly grown alongside cocoa.

→ **Sierra Leone:** In some cases, annual crops are grown for two consecutive years during establishment where crops such as cotton beans, maize, guinea corn, bulrush millet, melon, sesame, cassava, pigeon peas, okra, pumpkin, chilli, tomatoes, cocoyam and yams are planted. Harvests from these crops are used partly for consumption by the farming household and are also sold (Amara et al., 2015).

→ **Cameroon:** In a survey in the Akongo subregion of central Cameroon, on average cocoa stands accounted for 75% of the total cocoa area (Manga Essouma et al., 2020b). A survey by Jagoret et al. (2014) found that fruit tree species were commonly grown on farms in Central Cameroon, allowing farmers to diversify their income. These included: *D. edulis*, *Persea americana*, *Citrus sinensis*, *Elaeis guineens* and *Mangifera indica*

### ASIA

→ **Indonesia:** Coconut, banana, durian, rambutan, avocado, robusta coffee, spice, ginger and other fruit crops are commonly grown on cocoa farms (Indonesia Consultant, 2020). Sometimes livestock may be incorporated into the farming system, e.g. integrated cocoa-goat mixed farming uses tree prunings and cocoa pod husks for feed for penned goats (Arsyad et al., 2019).

→ **Papua New Guinea:** Smallholder cocoa farmers typically adopt mixed farming with a variety of cash income sources in addition to cocoa, including copra, vegetables, betel nut, vanilla, livestock (Kerua & Glyde, 2016).

→ **India:** Cocoa is often intercropped in existing coconut and areca nut gardens (Peter & Chandramohanan, 2011).

→ **Philippines:** cocoa is often intercropped with other agricultural crops, such as coconuts and bananas (Hamrick, 2017).

## AMERICA

→ **Ecuador:** Smaller cocoa farms often have a larger area devoted to subsistence crops (cassava, rice, sweet potato, beans, tomatoes, bananas) corn, passion fruit. (Ecuador Consultant, 2020) (see Case Study 3).

→ **Brazil:** Cocoa is the main crop on a cocoa farm. Some farms have cows, others cultivate bananas and other fruits (Brazil Consultant, 2020).

→ **Bolivia:** A number of agroforestry systems include a range of companion species (e.g. banana, papaya and pineapple from which the farmer is able to obtain additional income (Jacobi et al., 2014).

→ **Trinidad and Tobago:** Farmers concentrate on cocoa growing for sale and grow root crops, corn and plantain for home use. Plantain, maize and cassava are sometimes grown between the juvenile cocoa (Lans, 2018).

→ **Mexico:** A survey of cocoa farmers revealed that many grow additional crops including banana (95.1%), sugar cane (93.5%), corn (89.2%) and also grasses used for livestock feed (87.9%) grow in the production cocoa units (Díaz-José et al., 2013).

**Case Study 3: Income from other crops in Ecuador (Ecuador Consultant, Freddy Amores)**

Very small farms (<2 hectare) usually do not grow cocoa. For cocoa farms up to 5 hectares, some 40% of the income comes from the sale of cocoa and 60% from other productive activities on the farm (sale of annual crop products and animal products). Income derived from the sale of farm products is complemented by off-farm work. Income from the sale of labour for off-farm activities represents 20 to 80% of the total household income. The smaller the farm, the more the producer sells their labour off-farm.

On farms with areas greater than six hectares, 60% of the income can come from the production and sale of cocoa and 40% from other productive activities on the farm (banana, corn, rice, beans, fruit trees), including pig production and poultry. In contrast to smaller farms, as the size of the farm grows, the greater the need to buy in labour from outside the farm, even more so in periods of high labour demand.

In farms with a size of 30 to 100 hectares, the area planted with cocoa grows and the rearing and sale of cattle emerges as an additional source income to boost the home economy. In these cases, hired labour performs at least 60% of the work on the farm.

Estimates from observations in the most important cocoa zone (60% of the annual production) indicate that 95% of the farms have areas from 0.1 to 30 hectares, 4% are between 30 and 100 hectares and 1% are between 100 and 2000 ha. Farms that are up to 5 hectares in area represent <10% of the total production area, whilst those with an area of 5 to 10 hectares represent 45% of the total cultivated area. As the size of the farm decreases, the household's economy depends less on cocoa which is planted in a smaller area. The producer ensures the subsistence of the family by planting rice, beans, corn, and raising pigs and poultry. What is left from this subsistence production is sold to generate income that is complemented by that of cocoa.

# 9. POST-HARVEST MANAGEMENT AND COCOA SALES

Key findings:

- Fermentation is important in improving the flavour of the final product. The heap and box methods are the most widely employed.
- In some countries, cocoa needs to be well fermented to ensure market access. Where such a requirement does not exist or no premium is paid, farmers may not be incentivised to ferment their beans.
- The most common method of selling cocoa is as dried beans (fermented or unfermented). In some cocoa-growing countries (for example, Indonesia, Ecuador and Nicaragua) there are localised markets for wet cocoa beans.
- The two most notable examples of semi-nationalised markets, where the government Cocoa Board sets a fixed price for the growing season, are Côte d'Ivoire and Ghana. In most other countries the cocoa price follows the international market.
- The Living Income Differential has been an important development in Côte d'Ivoire and Ghana in improving farmer livelihoods.

## 9.1 PROPORTION OF FARMERS WHO FERMENT THEIR COCOA BEANS

The process of fermentation is important in improving the flavour of the final product, particularly in reducing astringent flavour notes. Typically, the methods used are low-cost (see 9.2) and are not labour intensive.

The culture of fermenting cocoa beans is ingrained in cocoa cultivation in **Ghana** and **Côte d'Ivoire**. In Ghana, beans must be well fermented and dried for local buying companies to accept them. While farmers in West Africa have traditionally fermented and dried their beans themselves, a new model has recently emerged whereby farmers sell wet beans to large processors. An example of this is Cemoi in Côte d'Ivoire.

Much of the cocoa beans produced in **Nigeria**, **Bolivia**, and **Venezuela** are fermented. In **Papua New Guinea** fermentation and drying are highly specialised operations, involving registration with the Cocoa Board (CCI, 2017). In **Ecuador**, a survey of the second most important cocoa-growing region revealed that 62.9 % of the producers carry out some level of fermentation before selling the product (Barrera et al (2019). In **Mexico**, the primary producers, mainly, sell their cocoa as raw pods to associations who have an infrastructure which allows them to carry out the fermentation and drying of the beans (Díaz-José et al., 2013).

In **Colombia**, the classification of cocoa beans is governed by the Colombian technical standard NTC 1252 and the Certification of Good Agricultural Practices (GAP). This provides clear protocols on fermentation practice, and the validation of fermentation through monitoring the structure and colour of fermented beans using the cut-test (Gomez et al., 2019). In a survey of around 10,000 farmers, 96.2% said that they fermented their beans (FEDECACAO, 2019).

In countries where there are few incentives to farmers to ferment their beans, the proportion of farmers who ferment their cocoa beans is often limited. Examples here include **Indonesia** and the **Dominican Republic**. Numerous attempts have been made to encourage Dominican cocoa producers to practice on-farm cocoa fermentation, or to process their product through producer associations and other processors. However, the Dominican Republic predominantly exports unfermented cocoa beans (Siegel et al., 2004). In **Brazil**, it is estimated that around 20% of the farmers ferment cocoa beans. Here, there is no price differential between fermented beans and non-fermented beans, so there is little incentive for farmers to ferment (Brazil Consultant).

## 9.2 METHODS USED FOR FERMENTATION AND DRYING

The heap method of fermentation is commonly practiced in West Africa whereby the beans are piled on to banana leaves, which are then covered with further banana leaves. The fermentation typically lasts 5-7 days during which period the beans are turned to achieve a more even fermentation (Figure 17 A&B). The box method is the most common method used in South America. Here, the beans are placed in large wooden boxes with slits in the base that allow drainage of the pulp ("sweatings") (Figure 17 C). The beans are turned on a daily basis. Sometimes, this is achieved by having a line of boxes where the beans are moved from one box to the next each day (Figure 17 D).

Solar drying can be achieved on raised platforms (Figure 18 A), on a concreted area or on black plastic sheeting. Drying on bare soil is considered poor practice. The use of raised platform as means of solar drying contributes to cleaner cocoa and is therefore recommended for good marketable cocoa quality. A challenge to drying can be prolonged wet periods. Plastic drying houses are sometimes constructed as a means of achieving faster drying and protecting the beans against rainfall (Figure 18 B). Artificial drying methods can be encountered in many cocoa-growing areas. An issue with this method can be smoke contamination.

Examples of country-specific fermentation and drying practices are given below.

### AFRICA

→ In **Côte d'Ivoire**, the commonly used fermentation practice is the heap method followed by the use of wooden crates (or vats) (Côte d'Ivoire Consultant, 2020). Cocoa beans are sun-dried on thin layers of bamboo 3 to 4 cm thick on various supports such as a platform, concreted areas or black plastic sheeting (Côte d'Ivoire Consultant).

→ A large proportion of cocoa from **Ghana** is fermented using the heap method and a smaller proportion is fermented in fermentation boxes (sweatboxes). After fermentation, cocoa beans are spread out over raised platforms covered with bamboo mats to dry in the sun for about six days (Ghana Consultant and Camu et al., 2008) (Figure 17).

→ In **Nigeria**, the tray method (a variation on the box method) is commonly used by farmers and smallholders to ferment their beans (Akinfala et al., 2020).

→ In **Liberia**, cocoa fermentation is completed via the heap methods or else in baskets for a period of two days to a week (English, 2008).


Figure 17. Fermentation methods. A. and B. Heap fermentation in Ghana. C. and D. Box fermentation in Peru. The beans are transferred from one box to the next each day to ensure an even fermentation.
Photo credit: Andrew Daymond

## ASIA

→ In **Indonesia**, public extension services were active in distributing fermentation boxes and teaching farmers how to use them (Aidenvironment, 2016); however, the proportion of farmers that ferment remains small. Where fermentation is practiced, farmers use fermentation boxes or bags/sacks. Drying methods include spreading beans on tarpaulins on the ground, drying on a concrete floor, or else on raised racks. Some growers use a polythene greenhouse for drying, where the beans are typically dried on raised racks (Figure 18B) (Indonesia Consultant).

→ In **Malaysia,** where fermentation is practiced this is typically by the box method (Hii et al., 2011).

→ In **Papua New Guinea**, beans are fermented for up to 10 days, which is a long or heavy fermentation (Payne et al., 2010).

→ In **Philippines,** fermentation is usually via the box method for 5-7 days. Drying takes place in a solar drying house, where they are spread on the floor (Leyte et al., 2017).


Figure 18. Methods of sun-drying. A. Raised platform in Ghana. B. Plastic solar dryer house in Indonesia. Photo credit: Andrew Daymond.

## AMERICA

→ In **Ecuador**, producers of non-certified cocoa carry out a short post-harvest process that does not include fermentation and lasts for two to three days. This aims to free the beans of the pulp to facilitate drying. Post-harvest handling on drying platforms consists of piling up the cocoa beans at sunset on a harvest day and distributing it the next day on the drying platform, piling it up again in the afternoon, and distributing it on the platform again the next day. By the third day the beans are ready to be bagged and transported to the place of sale. Alternatively, sometimes the fresh cocoa mass is placed on the drying deck (or paved roadside) for just a few hours to decrease bean moisture.
On large cocoa farms, usually with contracts for direct export, beans are fermented in wooden boxes, usually organized in ladder-type structures but sometimes in a horizontal arrangement. Then, the cocoa is spread on large wooden platforms for drying.
A third model that applies to 75 thousand hectares of cocoa with some type of certification involves fresh cocoa beans being collected from farms or transported by producers to centralized post-harvest centres (producers organisations and exporters' warehouses). There, the cocoa is fermented using the box method where the quality indicators of the fermentation process are closely monitored (Ecuador Consultant).

→ In **Mexico**, cocoa fermenting, and drying is carried out in collection plants using wooden containers each with the capacity to ferment approximately one tonne of fresh beans (Hernández- Hernández, 2016). Producers sell fresh beans, then dry it in the sun for five days and deliver it to cooperatives or collection centres (Arrazate et al., 2011).

→ In **Colombia**, farmers typically use box fermentation. Solar drying in the open air and using a plastic roof solar dryer are the most widely used drying methods in rural areas of Colombia (Barrientos et al., 2019; Gil et al., 2020).

→ In the **Dominican Republic**, Rizek Cacao, who maintain 2,000 ha of land under cocoa cultivation have invested in a large-scale fermentation and drying facility (WCF, 2018).

→ In **Peru**, in the northern coastal and jungle areas in summer conditions, both the fermentation and drying processes require up to 12 days to produce the final product ready for exportation to European markets (Orbegoso et al., 2017). The box fermentation method technique is used (Figure 17 C, D).

→ In **Brazil**, where fermentation is practiced, it is usually via the box method. For drying cocoa three methods are used: natural drying, artificial drying and mixed systems. The latter involves pre-drying in the sun and final drying with artificial heating (Brazil Consultant). Sun drying is done on wooden platforms with movable roofs, called barcaças. Plastic greenhouses are also sometimes used. Artificial drying can be carried out in various types of driers including tubular, platform, pinewood. The drying temperature is between 60 and 70°C.

→ In **Venezuela**, a farmer survey revealed that 96% of the farmers ferment cocoa beans and 92% use plastic containers as a fermenter; only 8% of the producers ferment in wooden boxes. In the same survey, 72% of the producers sun dried the cocoa (Alvarado et al., 2014).

→ In **Haiti**, (FECCANO) and its affiliated cooperatives use the box method for fermentation. Some farmers solar-dry their cocoa on sand (Chery, 2015).

→ In **Trinidad and Tobago**'s farmers use the box fermentation method. Fermentation usually lasts between 6-8 days. During fermentation, the beans are turned twice, the first time at 48 h and the second time at 96h (Velásquez, 2016). Traditionally, beans are carefully sun-dried rather than artificially dried, (therefore avoiding smoke contamination) with regular turning on the drying floor (Ramtahal et al., 2015).

→ In **Nicaragua** it is common for farmers sell wet beans that are processed independently of the farmers (Dar Ali Rothschuh, 2019).

## 9.3 INCENTIVES/DISINCENTIVES FOR FERMENTATION

In **Ghana** and **Côte d'Ivoire**, the incentive to ferment beans arises from the fact that buyers will usually only accept beans that have been fermented. Similarly, in **Uganda**, Esco only accepts cocoa that had been fully fermented and properly dried (Jones & Gibbon, 2011). In some areas of Uganda, poor knowledge of post-harvest techniques such as fermenting and drying means farmers often do not receive as high a price as they could if they produced better quality cocoa (Lutheran World Relief, 2015).

In **Indonesia**, only a small premium price is paid for fermented beans (+/- IDR 2000-3000/kg); a small number of buyers provide higher premiums (> IDR 3000/kg), such as Mason Bali and Primo Bali (Indonesia Consultant, 2020). Therefore, there is insufficient financial incentive for farmers to ferment. In **Vietnam**, buyers prefer to purchase fermented beans and usually pay a premium for this type (AusAID, 2009). In **Ecuador**, certification cocoa schemes provide incentives, in the form of better prices for farmers grouped in cocoa producers' organisations. These receive wet cocoa in their post-harvest facilities where a properly monitored fermentation and drying process takes place (Ecuador Consultant). In **Haiti** traditional or ordinary cocoa sold in the less regulated market attracts a lower price than conventional fermented cocoa sold in a more regulated market (Chery, 2015). There is little incentive for cocoa farmers in **Brazil** to ferment as they do not usually receive a premium (Brazil Consultant).

## 9.4 SELLING METHODS

The most common method of selling cocoa is as dried beans (fermented or unfermented). In cocoa-growing countries (for example, Indonesia, Ecuador and Nicaragua) there are localised markets for wet cocoa beans. Typically, the purchasing agent will be a local buyer or a co-operative. Details of different selling methods and local markets across cocoa-growing countries are provided below.

### AFRICA

→ In **Ghana**, dry beans are sold to COCOBOD through Licensed Buying Companies (LBCs) who serve as buying agents. Cocoa farmers send dried beans to these agents whose representatives (purchasing clerks) inspect and weigh them and then buy them based on the dry bean weight. This is on condition that the purchasing clerk determines that the beans are sufficiently dry and meet the basic quality criteria such as being reasonably free from stones and other foreign material (Ghana Consultant).

→ In **Côte d'Ivoire**, for dry cocoa, the payment period depends on the availability of funds within the cooperative. It is estimated that farmers are paid directly in 70% of cases and must wait for payment from the cooperative in 30% of cases (Côte d'Ivoire Consultant).

- → In localised cases of the sale of fresh cocoa, payment is immediate. Cocoa producers typically sell their unprocessed cocoa beans through local buyers (pisteurs) or farmer cooperatives. These in turn sell to larger buyers (traitants), processors and exporters, who sell to international traders (Audet-Belanger et al., 2018).
- → In **Uganda**, Esco has offered a premium for fermented cocoa (Jones & Gibbon, 2011).
- → In **Liberia**, cocoa buyers in the villages and buying centres often focus on moisture content and percentage of foreign material to determine the cocoa price. Farmers sell (partially) dried and fermented beans to any available buyer who approaches them or they head-carry the load to a nearby buying centre for sale (English, 2008).

## ASIA

- → In **Indonesia**, the beans sold are mostly dried, unfermented cocoa, which are sold to local buyers. In some areas, wets beans are sold (Indonesia Consultant). The majority of Indonesia's cocoa production is exported in the form of raw cocoa beans (Zikria et al., 2019).
- → In **Papua New Guinea**, cocoa is sold as either dry beans (fermented and dried) or wet beans (beans straight from cocoa pods), depending on various factors such as the age of their cocoa trees, yields and access to processing facilities (Kerua & Glyde, 2016). Traders include wet and dry bean buyers/dealers who facilitate (1) buying and processing of wet beans from farmers who do not have their own processing facilities and (2) buying of dry beans where there are no major exporters in the local area (CCI, 2017).
- → In **India**, for climatic reasons cocoa cannot be easily dried in Kerala, so most beans are sold wet and taken to commercial drying facilities elsewhere (Barrientos, 2014).
- → In the **Philippines**, there are seven cacao products sold to local and international markets. These are wet beans, dried beans, dried fermented beans, cacao nibs, tablea (ground beans used to make chocolate drinks), cocoa powder, and cocoa butter. The value of each product generally depends on the value-added inputs and demand in the market (Department of Agriculture - BPI, 2016).

## AMERICA

- → In **Ecuador**, fermented-dried cocoa bean lots are sold directly to the warehouses of exporters and collection centres of the Producer Associations. Non-fermented and semi-dry or medium-fermented and semi-dry cocoa is sold mainly to retailers and wholesalers. The sale of wet cocoa is usually done in the collection centres of the Producers Associations and exporters warehouses (Ecuador Consultant).
- → In **Mexico**, a survey revealed that 76.1 % cocoa growers sell their harvest as dried beans after processing, while 20.2 % sell their production as wet beans (Hernández et al., 2015).
- → In **Brazil**, all cocoa farmers sell dry cacao beans. Usually, the beans are purchased by the cocoa processers and the price is based on the New York and London stock exchange (Brazil Consultant).
- → The **Dominican Republic's** unfermented beans are known in the export market as Sanchez, and fermented beans under the name Hispaniola. Most cocoa is exported in 70kg bags as Sanchez and Hispaniola cocoa beans. Sanchez is considered a good, lower cost, cocoa for cocoa butter and powder production (Siegel et al., 2004).
- → In **Haiti**, all cocoa producers could potentially sell fermented cocoa. Nonetheless, farmers who are more likely to hold back their cocoa to sell to institutions that collect conventional fermented cocoa are those who are not subsistence farmers (Chery, 2015). In the study of Schwartz & Maass (2014) the most common reasons cited for selling to someone other than a cooperative was that they were able to offer immediate payment. Another common reason was that other buyers accepted lower quality cocoa. This is critical for farmers who grow cocoa far from a cooperative that purchases fresh cocoa to ferment, because many producers cannot get their cocoa to fermentation facilities in time, so they must dry it themselves or sell it wet to an intermediary who will process it.

## 9.5 BUYER PROFILES

A summary of buyer profiles is presented in Figure 19 and some detailed examples in Case Study 4.

### AFRICA

**Ghana[1]:**
A cocoa buyer must be licensed by COCOBOD - there are over 49 Licensed Buying Companies

**Côte d'Ivoire[2]:**
Representatives of export (Cargill, SIFCA, SACO and Ammajarro), independent buyers and small buyers found in camps and some villages

**Uganda[3]:**
Local traders and the biggest buyers included; ESCO (U) Ltd, OLAM, UGADEN, Agro Crop, Vanish, UCCL Brukam and ICAM.

**Nigeria[4]:**
Farmers sell the cocoa beans at prices fixed by intermediaries from local buying agents (LBAs)

**Liberia[5]:**
Produce and Marketing Corporation (LPMC), acted as the market avenue for farmers to export cocoa.

### ASIA

**Papua New Guinea[7]:**
cooperative involved in cocoa production, collection, processing in the field and the selling of cocoa (on behalf of its members) to the market.

**India[8]:**
Domestic production provides around 50% of Mondelēz cocoa requirements.

### AMERICA

**Colombia[9]:**
Nutresa and Casa Luker

**Bolivia[10]:**
Rainforest Exquisite Products S.A. (REPSA), Rational Amazon Floors and Hands (SUMAR) and COMRURAL XXI S.R.L.

**Mexico[11]:**
Cocoa Producers Association. The rest of the production (62%) is marketed through intermediaries and multidimensional companies that export the dry grain.

**Nicaragua[12]:**
Ritter, Cocoa S.A. (Costa Rica), Daarnhouver, and Zotter.

**Peru[13]:**
Intermediates and domestic market.

**Haiti[14]:**
Penetrated new markets in France and Canada. More than 50% was sold in the U.S. Algeria and Canada historically bought a noticeable quantity of cocoa.

Figure 19. Cocoa buyer profiles.

[1]Ghana Consultant (2020); [2]Côte d'Ivoire Consultant (2020); [3]Lutheran World Relief (2015); [4]Babalola et al. (2017); [5]English (2008); [7]Garnevska et al. (2014); [8]Barrientos (2014); [10]Espinoza et al. (2014); [11]Arrazate et al. (2011); [12]Trognitz et al. (2011); [13]Scott et al. (2015); [14]Chery (2015).

**Case Study 4: Examples of buyer profiles**

ECUADOR:

According to a survey by Barrera et al. (2019), producers sell to: intermediaries who visit the farms to buy cocoa (3.1%), retail intermediaries in towns near the farm (50.5%), retail warehouse (23.1%), producer organizations (17.1%), wholesale intermediaries (10.1%) and export warehouse (1.3%). Ramirez (2006) reports that the number of intermediaries buying cocoa across the country may approach 1000.

The national chain culminates in Guayaquil where there are approximately ten bulk export companies buying from wholesalers. Within this export monopoly, the biggest company is Transmar and together these companies control nearly 70% of national production, almost all Ecuador's export volume. By 2011, Transmar exported 24,500 tons of cocoa (25% as semi-finished cocoa liquor and 75% as raw beans). For semi- finished products their clients include Mars in the United States and Ritter Sport in Europe (Ecuador Consultant).

BRAZIL:

Three categories of buyer are encountered: 1 - Cooperatives: smallholders' cooperatives, 2 - Intermediates (brokers): this category is present in all regions and it is estimated that they purchase 70% of beans, 3 - Processor companies: Cargill, Barry Callebaut and Olam. So-called "middlemen" help with aspects such as production flow and transport of beans to processing facilities. They are also known as grain dealers and act as a bridge between cocoa producers and industry (Brazil Consultant, 2020).

According to the National Association of Cocoa Processing Industries (AIPC), in 2017 four companies (three international and one national) processed 97 per cent of Brazil's cocoa production in five plants, four of which are located in Bahia (three in Ilhéus and one in Itabuna) and one in São Paulo (Brazil Consultant).

DOMINICAN REPUBLIC:

Intermediaries purchase cocoa beans from producers at the farmgate or from nearby villages. Some buy cocoa beans and sell them to exporters, while a larger number of intermediaries act as purchasing agents for large commercial exporters. Approximately 1000 agents currently work as intermediaries in the Dominican Republic (Siegel et al., 2004).

Exporters also buy directly from the larger producers and from associations of producers, and some producers deliver their cocoa beans directly to the exporters. Two firms - Nazario Rizek and Commercial Roig accounted for about 70-75% of all cocoa exports in the early 2000s. However, over time the CONOCADO producers' cooperative has become more important. As of 2002, CONOCADO had some 11,000 members, about 25% of all cocoa producers, and the highest market share of all exporters (Siegel et al., 2004).

## 9.6 SELLING PRICES

In semi-nationalised markets, the government Cocoa Board sets a fixed price for the growing season. The two most notable examples here are Côte d'Ivoire and Ghana, which together account for over 60% of the world market. In countries where the cocoa prices are not regulated then generally prices follow the international markets (Table 13). An important recent development has been the Living Income Differential or the African Regional Standard for sustainable cocoa. The Living Income Differential (LID) was introduced in Ghana and

Côte d'Ivoire in October 2020. The principle of the LID is that is bridges the gap between the amount that farmers earn (not just from cocoa but all forms of income) and that required to maintain a basic standard of living. The LID is currently set at $400 per tonne.

Farmers may also receive a premium, i.e. an amount paid over and above the market price for cocoa as a result of certification (see also Section 10.3). There are two types of premium, fixed and flexible.

- **Fixed premiums:** Fairtrade has a fixed premium of 240 US-Dollar per tonne conventional cocoa (https://www.fairtrade.net/standard/minimum-price-info); farmers and their organisations that are certified by UTZ or Rainforest Alliance/SAN have to negotiate the premiums with their buyers
- **Flexible premiums:** can be negotiated directly as a private sector agreement between farmers or their organisations and cocoa buying companies. These negotiations can take place on a regional level, avoiding an unworkable global one-size-fits-all level.

Some smaller companies, such as Taza, Ingemann, and Tony's Chocolonely, already work with flexible premiums based on farmgate price developments. Taza and Ingemann work in Latin America and process high quality cocoa for high quality and high- priced chocolate. Tony's Chocolonely works in Ghana and Côte d'Ivoire through a supply chain comparable to that of the big chocolate producers on the world market. In other cocoa producing countries the situation is more complex. Many companies, farmer organisations and single farmers already have experiences with flexible systems, as some cocoa is already traded with differentials depending on the cocoa quality. This is specifically true for cocoa from Central and Latin America and other regions producing Fine Flavour Cocoa (Hütz-Adams, 2017).

Higher prices are sometimes operationalised through a premium model, which rewards farmers for engaging in sustainable production. In some countries, quality differentiation (such as for fine flavour cocoa) has also enabled price differentiation (Audet-Belanger et al., 2018).

Table 13. Examples of pricing structures in different cocoa-growing countries.

| Country | Selling Price |
|---|---|
| Côte d'Ivoire | Producer price is fixed at 60% of the CIF price. Systematic codification of all the parties involved is employed to improve the traceability of operations (Côte d'Ivoire Consultant). The Living Income Differential (LID) came in to effect from October 2020. |
| Ghana | The government through the COCOBOD, has created a pricing policy by which prices are set by the regulator through the PPRC- a committee that sets the price together with stakeholders. Cocoa beans are bought from the farmers at a price that has sometimes amounted to a government subsidy. The LID came into effect in October 2020. |
| Uganda | The most important marketing challenge for the farmer has been reported to be the fluctuating prices which can change on a monthly or sometimes weekly basis (Lutheran World Relief, 2015). |
| Liberia | Liberian cocoa has carried an origin discount on the world market, often ranging $200 to $330 per metric tonne, due to the inability of exporters to access high quality cocoa (English, 2008). |
| Indonesia | The price that the farmer receives depends on the international price and water content. The water content is only known from the number of drying days, i.e the price for beans dried for 1 day is lower than that with 2 days drying. Some buyers only use their "feeling" by putting the beans in their hands and predicting the water content. A very small numbers of local buyers use a bean moisture meter, whilst most large buyers use this equipment (Indonesia Consultant). There can be a small variation in price between provinces at a particular time. |
| Brazil | There is no local price regulation. The price is based on the New York and London stock exchange. For fine flavour cocoa some specialist buyers can pay up to 100% over the regular market price (Brazil Consultant, 2020). |

| | |
|---|---|
| Ecuador | The selling price follows closely the international cocoa price. The price at which the producer sells is 8% to 15% lower than the international price at the time of sale, depending on the sale point.<br>The smaller the distance between the point of sale and the port where the cacao is exported, the closer the price paid is to the international price. For example, if at a given moment the international price of a metric tonne of cocoa is $ 2,500 USD and a producer transports and sells the product in the producer's warehouse at Guayaquil, they would receive (after discounting exporter operation costs) $ 102 USD per quintal (45.45 kg) of dry and clean cocoa. If the producer sells to an intermediary in a city near a cocoa zone, they will receive 8 to 10% less per quintal. If they sell to an intermediary who in turn sells to a village wholesaler or retailer, they will receive 8 to 10% less per quintal (Ecuador Consultant, 2020). |
| Nicaragua | The cocoa price paid by the cooperatives to their farmers is influenced by international prices with organic cocoa attracting a modest premium (Aguad, 2010). |
| Trinidad and Tobago | Prior to Oct 2012, a two-stage payment system was in place whereby farmers received one payment at the time of delivery of the beans and a second at the end of the crop year. This was then changed by the Cocoa and Coffee Industry Board of Trinidad and Tobago such that farmers received a single payment at the time of harvest (Maharaj et al., 2018). |

# 10. FARM ECONOMICS

Key findings:-

- The amount and type of labour utilised on a cocoa farm depends on a range of factors that include farm size, farm management, the age of the farmer and cultural factors.
- Defined gender roles are sometimes apparent on cocoa farms.
- Land acquisition and inheritance laws that can lead to the division of farmers' land are amongst the land tenure challenges faced by smallholder farmers.
- The proportion of cocoa that is certified has been increasing, providing opportunities for premiums to farmers.
- The number of farmers globally in co-operatives appears to be increasing. Co-operative membership is often a pre-requisite for participation in certification schemes.
- Benefits of cooperative membership include: access to government assistance, access to loans, low interest financing and social funds, access to training and shared use of agricultural equipment.
- Extension services may be provided by the government sector, the private sector or a combination. Governmental extension is more active in some countries (e.g. Ghana and Côte d'Ivoire) compared with others (e.g. Indonesia and Brazil).

Cocoa households employ a combination of household labour, hired labour and communal labour. The amount and type of labour utilised on farm depends on factors including the size of the farm, the extent the farm is the main source of income, the age of the farmer and cultural factors, such as the extent to which farmers cooperate within a community. Familial labour is often important on smallholdings. For example, a survey conducted by Audet-Belanger et al. (2018) revealed a high proportion of respondents use household labour for nearly all activities, sometimes combined with hired labour, as summarised in Figure 20.

Surveys of labour arrangements in different producing countries are summarized as follows.

## AFRICA

→ In **Ghana**, a recent study commissioned by the International Cocoa Initiative (ICI) reported that households use an average of 120 labour days per hectare of cocoa, including household, hired and communal labour. The hired labourers earn between US$4.91 and US$7.05 per day (Audet-Belanger et al., 2018). Social groups in farming communities in Ghana often serve as rotational farm labour and sometimes provide credit to farmers, particularly women (Danso-Abbeam et al., 2020). Whilst a higher proportion of farmers use household labour more than hired labour for most activities, labour-intensive tasks such as land clearing and weeding might involve a higher proportion of hired labour. Households also tend to use more hired labour for the application of liquid fertiliser, pesticides, and fungicides (Bymolt et al., 2018b).

→ In **Côte d'Ivoire,** the estimated labour requirement is 73 labour days $ha^{-1}$, and hired labourers earn between US$2.20 and US$6.42 per day (Audet-Belanger et al., 2018). The family remains the main source of labour, with about 94% of producers using unpaid family labour consisting of the producer's spouse, children and other family members. Temporary workers are made up of task workers (or day workers) and seasonal workers ("six-month workers"). The "six-month workers" are young men and women who generally work for a period of about six months (from July-August to December-January) on cocoa or coffee farms (Côte d'Ivoire Consultant).

→ A survey in **Nigeria** found that 37.5% of the respondents were using family as their major source of labour (Meludu et al., 2017). Another survey reported a much higher proportion (65.8%) relied on family members for their farm operations (Babalola et al., 2017).

→ In **Uganda**, cocoa farmers rely on a combination of family labour and cheap hired labour (Lutheran World Relief, 2015).

→ In **Liberia**, farmers are limited financially in their ability to hire labour from outside the household (English, 2008). In some areas of the country, farmers use the "kuu" system, where farmers voluntarily work communally to complete labour-intensive activities on everyone's farms in a shorter time. In other areas of the country where familial labour is short, farmers may hire casual labourers to assist with farm establishment and maintenance; these are usually male youth (GrowLiberia, 2016).

→ In **Cameroon**, cocoa farmers use family members and paid workers (Belek & Jean-Marie, 2020).

→ In **Togo**, a network of 50 service providers has been established with priority given to employing young farmers. Those selected are literate cocoa farmers who are able to carry out the spraying services. In this model, the providers work as part-time employees of the cooperatives for 2 services, spraying against black pod with a knapsack sprayer and spraying against mirids with a mist blower (Buama et al., 2018).

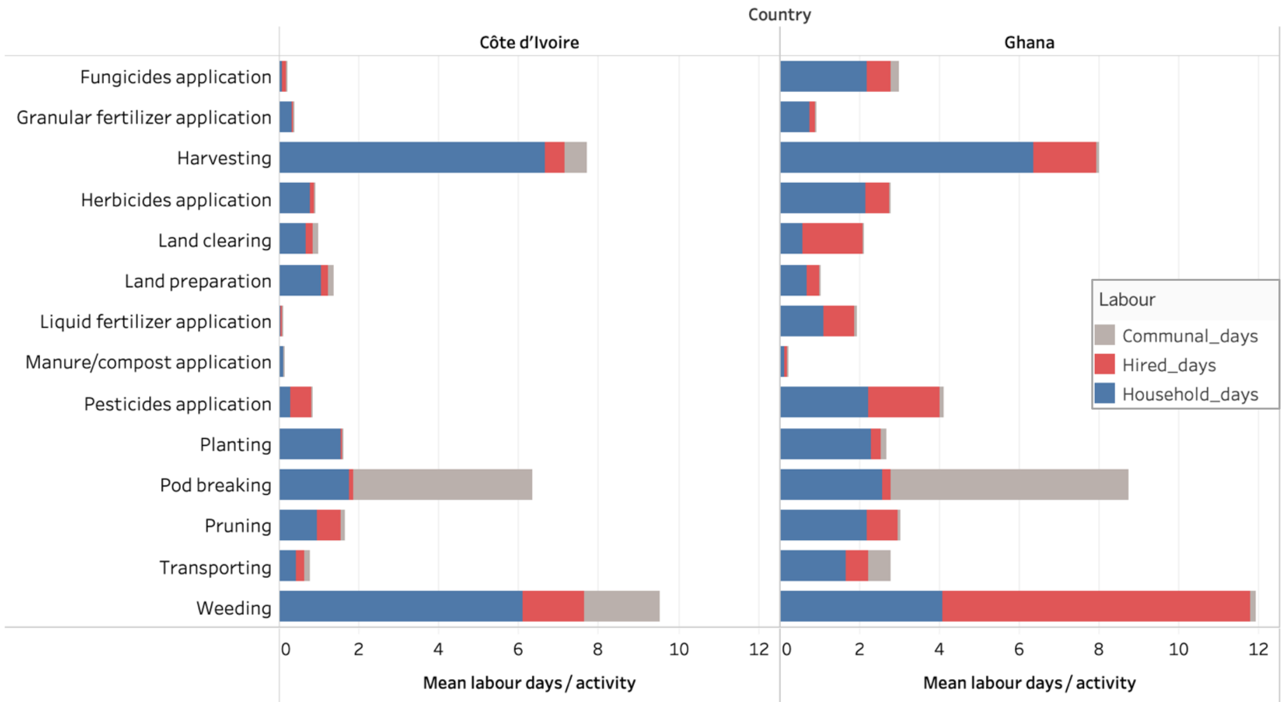



Figure 20. Mean labour days per cocoa activity, per hectare. In Ghana and Côte d'Ivoire. Adapted from (Audet-Belanger et al., 2018).

## ASIA

→ In **Indonesia**, usually the landowner pays casual labour based on the daily wage rate (Indonesia Consultant). An analysis of gender roles revealed a substantial role of women in that they constituted 40% of the total labour input, and 36% of farms were managed by women (Effendy et al., 2019).

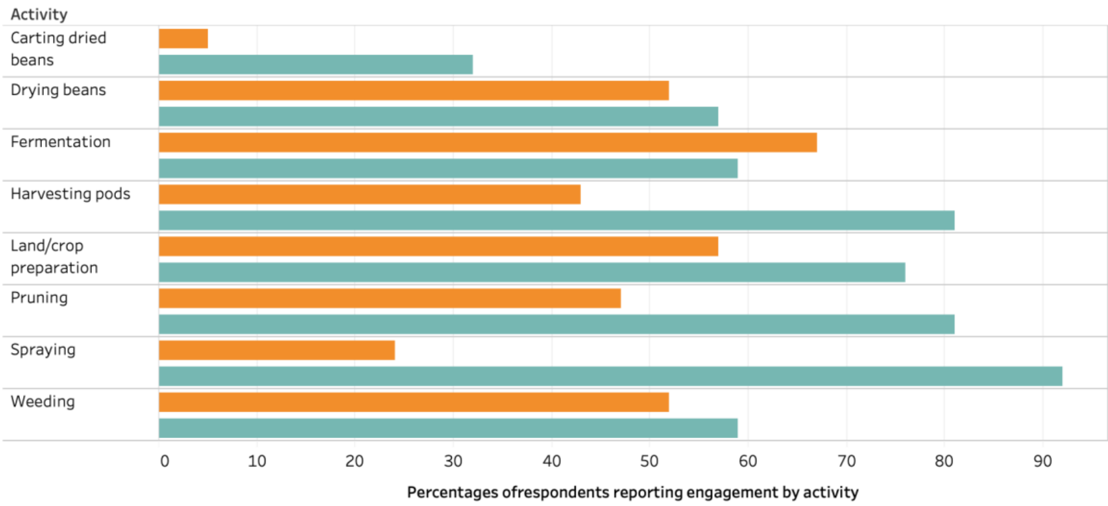
→ In **Malaysia**, most hired labourers are short-term migrants. Cocoa farmers are increasingly finding it difficult to hire workers due to competition from estates growing crops that require low-maintenance and low-skills such as oil palm (Omar et al., 2018).

→ In **Papua New Guinea**, most smallholder households rely on unpaid family labour for farming and/or off-farm activities. Often there are defined gender roles (Kerua & Glyde, 2016).

→ In **India** a particular socio-economic challenge for larger commercial farms is the rising cost and shortage of labour for cocoa, with the move of workers (particularly men) out of agriculture in search of better opportunities elsewhere. Within India, cocoa is grown only in four states within the South region of the country. Barrientos (2014) observed a different balance of gender roles in in two states – Andhra Pradesh (AP) and Tamil Nadu (TN) (Figure 21).

→ In **Vietnam** cocoa farms are typically small family-owned and operated plots.

**A.** Andhra Pradesh



B. Tamil Nadu

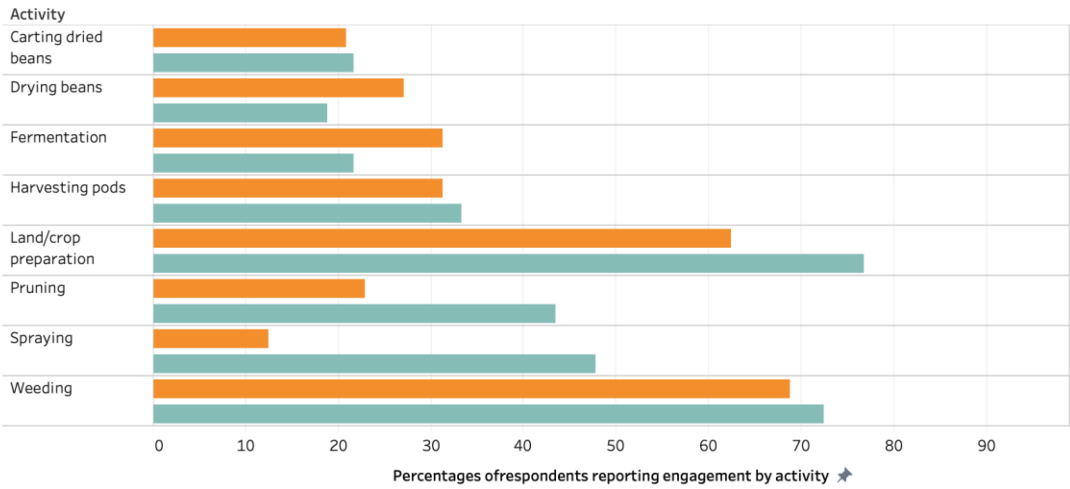



Figure 21. Gender roles in the cocoa value chain: seasonal labour in India (percentages of respondents reporting engagement by activity) in two states A. Andhra Pradesh and B. Tamil Nadu. Adapted from (Barrientos, 2014)

## AMERICA

→ In **Nicaragua**, cocoa production, including harvest, collection, transfer, and removal of seeds is mostly completed by the male heads of the household (45%) and secondly by the wife (35%). During fermentation and drying, there is more equal participation between genders. Packaging and transporting, is most likely to be completed by a male family member (38%), followed by hired labour (35%) (Gumucio et al. 2016). The number of labour days invested by family members has been reported as 91 days per year (Cerda et al., 2014).

→ In **Mexico**, farmer age is a factor influencing the amount of hired labour contracted. Older producers need to hire additional personnel for more labour-intensive practices such as pruning and weed control, thereby increasing the cost of production (Díaz-José et al., 2013). A survey by Hernández et al. (2015) revealed that 54.1 % of cacao growers used labour in at least one of the following activities: weeding, pruning and shade regulation.

→ In **Ecuador**, smallholder farmers carry out their agricultural activities with the help of their relatives. Older producers need to hire additional personnel for agricultural practices such as pruning and weed control as these practices must be carried out periodically and require more physical effort; these practices ultimately increase the cost of production (Mata Anchundia et al., 2018). It has been estimated that cocoa requires only 39 working days ha$^{-1}$ year$^{-1}$ (Salazar et al., 2018). Each weed control event requires 4 to 6 man-days per hectare, at a total cost of \$ 60 to 90 USD since the value of one day's work is \$ 15 USD. There are verbal agreements for daily work in peak periods of labour demand. This modality is practiced in medium-sized cocoa farms (Ecuador Consultant).

→ In **Peru**, a survey of the role of women in cocoa production revealed limited involvement, except in cases where they own and manage their own farm. However, the one activity in which they are regularly involved is harvesting, which is more labour intensive (Laroche et al., 2012). Paid labourers are employed on a daily basis and very few farms employ permanent labourers. It appears that daily workers are becoming difficult to find (Laroche et al., 2012).

→ In **Brazil**, approximately 282 thousand people work in the cocoa chain in Brazil. This includes wage earners and temporary workers in the field, industry and market. In general, when it comes to family farming, the largest labour force comes from the family itself, which usually owns the property. During harvesting, they usually hire independent workers or share work with neighbours. An example of a larger farm operation is Luz do Vale farm which employs about 160 people. The hiring system is by signed contract, and the base salary is 1.25 of the minimum salary (Brazil Consultant).

→ In **Dominican Republic**, migrants (often from Haiti) form a significant part of the workforce. In some regions, the coffee and cocoa harvesting seasons overlap and compliment work in other crops to provide continual employment for Haitian migrants who follow harvest cycles (Siegel et al., 2004). The activities that require the greater amount of labour are those associated with harvesting and establishment (Berlan & Bergés, 2013). A shortage of labour has sometimes been encountered and worker incomes (for Dominicans and Haitians alike) have been reported to be low (Berlan & Bergés, 2013; Figure 22).

→ In **Haiti**, the research of Schwartz & Maass (2014) demonstrated that the amount of land worked by household members is closely correlated with how much cocoa land is controlled by the family.

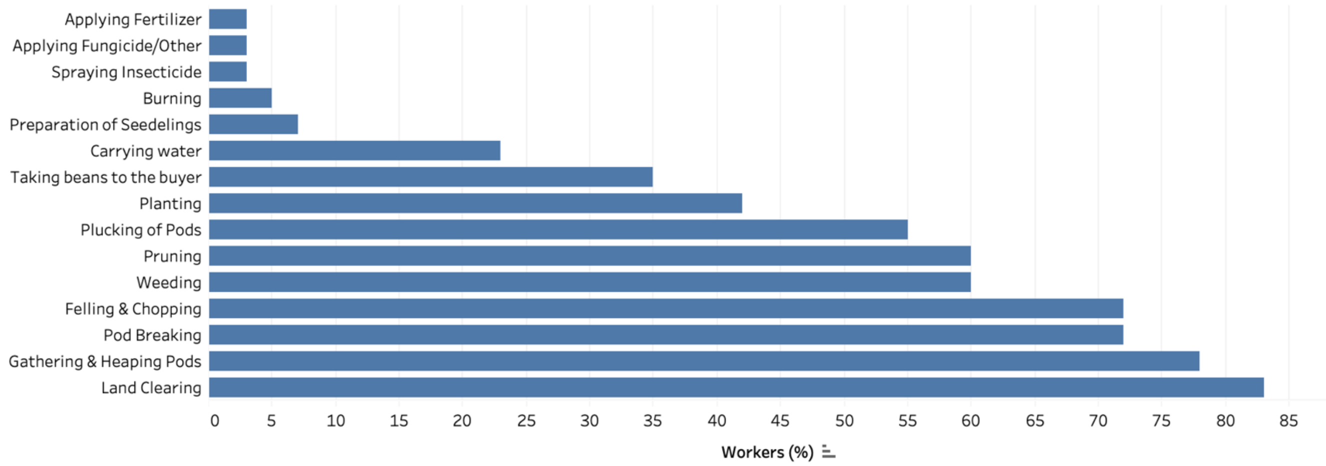



Figure 22. Activities of cocoa farm workers in the Dominican Republic. Adapted from: Berlan & Bergés (2013)

### 10.2 LAND TENURE AND DIVISION OF CAPITAL

Land acquisition and inheritance laws that lead to the dividing of farmers' land are challenges that can be faced by smallholder farmers. A summary of land tenure issues across the study countries is summarised below.

## AFRICA

→ In **Cote d'Ivoire**, even though many migrant families have worked the same land for generations, they have less secure tenure, especially in some regions, where nationals have tried to reclaim the land ceded to migrants in the past (Ongolo et al., 2018). A survey conducted in 2001, revealed the predominant mode of acquisition is access to land by inheritance (43%) (Côte d'Ivoire Consultant).

→ In **Ghana**, the land tenure system (notably, sharecropping) acts as a mechanism to maintain cocoa farms (Aboah et al., 2019). Approximately 20% of land in Ghana is owned by the State and governed by statutory law. The rest (approximately 80% of all land) is governed through usufructuary (sometimes termed customary) tenure arrangements and vested in chiefs or other customary authorities. Most of the cocoa is farmed on customary land (Ghana Consultant; Figure 23). In a CRIG/WCF collaborative survey on land tenure and cocoa production in Ghana (Asamoah & Owusu-Ansah, 2017) of the 3,900 plots surveyed in the Eastern, Ashanti and Western Regions 62.7% were managed by the land-owners while 22.7% and 14.5% fell under the 'Abunu' and 'Abusa' tenancy arrangements, respectively. The remaining 0.1% of the plots were established on rented land. Quaye et al. (2014) reported that in the Wassa East district of the Western Region, of the farmers who practised sharecropping, 'Abunu' and 'Abusa' (see Figure 23) accounted for 27.8% and 22.8% of the sample of farmers interviewed, respectively. For those who practised sharecropping in the Asunafo East district of the Brong Ahafo Region 'Abunu' and 'Abusa' accounted for 50.0% and 23.5%, respectively and in the Amansie West district of Ashanti, 'Abunu' was largely practised accounting for 28.9% of the sample interviewed.

→ In **Nigeria**, acquisition of land for cocoa farming has been cited as a major problem. The main mode of land acquisition is through family inheritance. Some of the farmers use a lease system, which can impact on the profitability of the farm (Akinnagbe et al., 2018).

→ In **Liberia**, land tenure has been reported as an issue since farmers return to their ancestral villages to reinstate claims on their property. Proof of ownership may be difficult given disputed property demarcations and rudimentary records (English, 2008).

→ **Sierra Leone**, farm ownership is high: 92% of farmers own their farm (as opposed to leasing or sharecropping) (Hofman, n.d.).

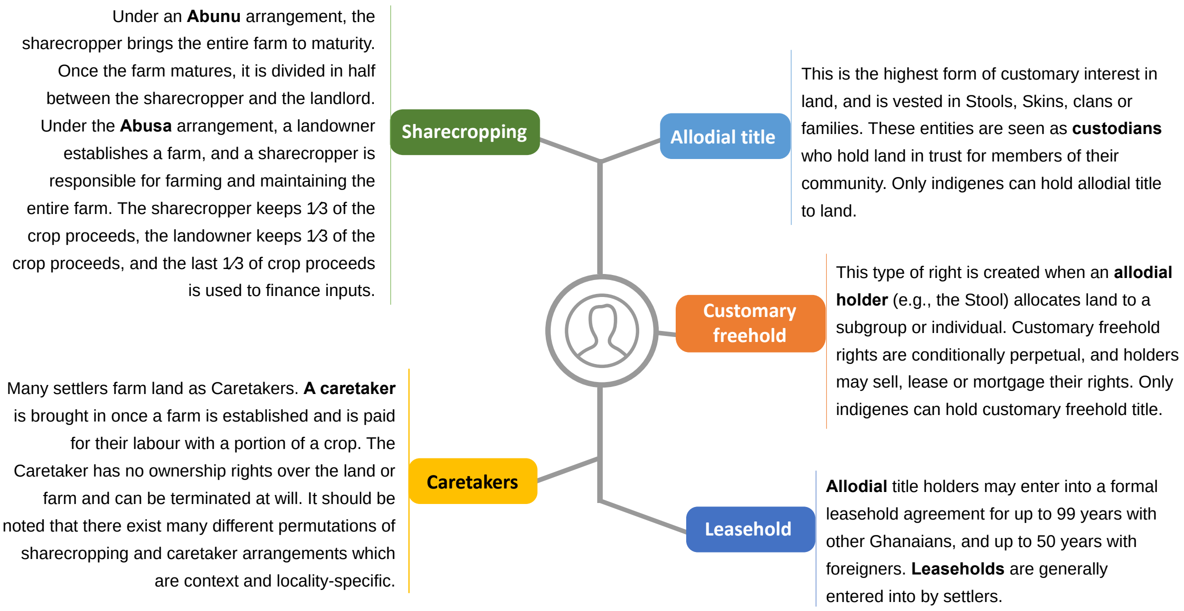



Figure 23. Types of customary tenure in Ghana (Ghana Consultant)

## ASIA

→ In **Indonesia**, land tenure, and rules governing land inheritance includes permanent/fixed ownership and 25 years management rights (leases), which can be extended for a further 25 years (Indonesia Consultant).

→ In **Papua New Guinea**, the matrilineal land tenure system, has been cited as potentially deterring men from involvement in cocoa farming as they would not want to risk losing their cocoa and other investments to the female lineage. The alternative is to purchase land elsewhere, however, most farmers do not have sufficient resources to secure adequate funding (Kerua & Glyde, 2016).

## AMERICA

→ In **Mexico**, 58.7 % of smallholders' own farms of less than two hectares and 41.3 % hold larger plots. Regarding legal status of plots, 67 % are ejidos (a tract of land held in common by the inhabitants of a Mexican village and farmed cooperatively or individually) whilst the remainder are private property. In Mexico, the ejido is the most important form of collective land ownership, and is governed by an internal regulation that sets outs the terms of its economic and social organization (Moret-Sánchez & Cosio-Ruiz, 2017). Hernández et al. (2015) reported that 66.1 % of the production units were inherited and only 34 % were purchased.

→ In **Dominican Republic** cocoa producers without formal title can use their plantations as a proxy for land ownership (Siegel et al., 2004). In the past, the tenure and formalization of rural properties in the Dominican Republic has been reported to face serious problems, since only 47% of cacao land is in the hands of farmers with property titles (Batista, 2009).

→ In **Haiti**, land tenure plays a significant role in decisions about choice of crops that farmers grow. Only farmers who are landowners plant cocoa on the land they farm and own. Most farmers indicated that planting cocoa on someone else's land would not be a sustainable decision. Farmers showed a tendency to grow cocoa as a retirement plan (Chery, 2015).

→ In **Ecuador,** a study in one of the most important cocoa zones showed that, in 98.2% of the cases, the land devoted to cocoa is owned by the producer. Less than 2% of producers lease land to another farmer or share the work and profits of a cocoa plot with someone else (Barrera et al., 2019). Also, landless peasants usually rent small plots of land to grow a crop that will generate a quick income. Owners of medium-sized farms often lease a portion of the land to landless peasants, although not for cocoa growing (Ecuador Consultant).

→ In **Brazil** the farmers are usually owners of the land they work on. The exception is sharecroppers that work on a contractual basis (Brazil Consultant).

## 10.3 CERTIFICATION ARRANGEMENTS

The proportion of cocoa that is certified to particular standards (environmental or social) has been increasing in recent years. Certification arrangements often involve the farmer receiving a premium based on the amount of cocoa beans sold and often rely on cooperative structures. Available information of certification in different cocoa-cultivating countries is summarised in Table 14.

Table 14. Certification arrangements

| Country | Certification Arrangements |
|---|---|
| Ghana | Certification arrangements are worked through Local Buying Companies and tend to rely on cooperative structures. Thus, farmers may either decide to join the programmes or not. Fairtrade, UTZ and Organic Cocoa are all present in Ghana. Kuapa Kokoo which has had Fairtrade certification for many years currently works across 57 designated 'cocoa districts' spread across the major cocoa producing regions of Ghana (Ghana Consultant). |
| Côte d'Ivoire | Côte d'Ivoire accounts for the largest proportion of global rainforest alliance certified cocoa (71% in 2018), UTZ certified cocoa (67%) and Fairtrade cocoa (70% in 2017) (https://www.cbi.eu/market-information/cocoa-cocoa-products/certified-cocoa/market-entry). The first applications of the cocoa sustainability certification schemes were introduced during the 2004/2005 campaign for Fairtrade and in 2005/2006 for Rain Forest Alliance and UTZ Certified. Their number has increased significantly, from one Fairtrade certified cooperative in 2004/2005 to 531 cooperatives in 2013, including 267 UTZ Certified cooperatives, 206 Rain Forest Alliance certified cooperatives and 58 Fairtrade certified cooperatives (Côte d'Ivoire Consultant). |
| Sierra Leone | In 2014 around 13,000 smallholder cocoa farmers, working in farmer groups and cooperatives, set out the aim of achieving UTZ, Fairtrade and Rainforest Alliance certification (Witteveen et al., 2017). |
| Indonesia | Rainforest Alliance and UTZ started operations in West Sulawesi in 2010 through the trader Armajaro (Mithöfer et al., 2017). A smallholder farmer cooperative in Bali is certified by UTZ/RA and organic. The cooperative is Kerta Semaya Samaniya, located in Jembrana Regency, in the west of Bali island. The cooperative has 35 members of farmer groups, with 876 ha of cocoa farm. The cooperative is supervised by a local NGO named Kalimajari Foundation (Indonesia Consultant). |
| Ecuador | Estimated volumes of cocoa produced and exported under different certification arrangements are as follows:<br>i) Fair-trade cocoa (2019): 42,000 tonnes, ii) Organic cocoa (2019): 37,000 tonnes, iii) UTZ-RA certified cocoa, and iv) Other certifications: 18,000 tonnes. All the exported certified cocoa receives a premium price (Ecuador Consultant). |

| | |
|---|---|
| Peru | Amazonas Trading Peru and Sumaqao SAC entered the cocoa trade in 2009 and 2010, respectively. In the ten years up to 2015 Peru, became the world´s second largest exporter of organic cocoa and was among the world´s largest exporters of Fairtrade cocoa. At this time, it was estimated that 20% of Peru's total cocoa bean exports were Fair Trade certified. UTZ certification is also present in Peru (Scott et al., 2015). |
| Costa Rica | Organic certification is present in Costa Rica and aligns relatively well with traditional shade grown cocoa production systems. As of 2012, Fairtrade was reported to be relatively new in the cocoa trade in Costa Rica and was proving challenging for many growers (Haynes et al., 2012). |
| Bolivia | In a survey, organic cocoa producers mentioned that joining an El Ceibo cooperative to obtain organic certification offered the prospect of better prices for their product (Jacobi et al., 2014). |
| Brazil | RA/UTZ certification, although still not that common in Brazil attracts a premium of \$US150 tonne$^{-1}$. Organic certification is also done by IBD-Brazil and others (Brazil Consultant) |
| Dominican Republic | Cocoa-based agroforestry systems in the Dominican Republic are mostly under organic certification schemes (Notaro et al., 2020). As such the Dominican Republic is the largest producer of organic cocoa. |
| Haiti | Specialty markets such as organic and fair-trade offer a premium, which has led to increased returns to the industry and to producers (Chery, 2015). |
| Trinidad and Tobago | The Montserrat Cocoa Farmers' Cooperative Society Limited (MCFCSL) became the first group of cocoa plantations in Trinidad and Tobago to achieve Rainforest Alliance certification (https://thefrogblog.es/category/cacao/ ). |

## 10.4 FARMER ASSOCIATIONS, CO-OPERATIVES

A number of arrangements regarding farmer associations and co-operatives can be found across different cocoa-growing countries. There appears to be a recent trend of an increase in co-operative arrangements in many cocoa-producing countries. Memberships of a cooperative is often a prerequisite for participation in particular certification schemes. Other benefits cited of cooperative membership across different countries include: access to government assistance, access to loans, low interest financing and social funds, access to training and shared use of agricultural equipment.

Examples of co-operative arrangements across cocoa-growing countries are set out below.

## AFRICA

→ In **Côte d'Ivoire,** since the Co-operatives Act of 1997, co-operatives have steadily evolved from being co-operative groups (CVGs) to full-fledged co-operatives and are now governed by the OHADA treaty. Only certified cooperatives with a coffee-cocoa board code are allowed to operate in the coffee-cocoa sector. At the beginning of the 2016-2017 campaign, there were 2,780 cooperatives licensed to operate in the coffee-cocoa sector. This figure has been steadily increasing (2447 in 2014-2015 and 2561 in 2015-2016, 2984 in 2017). Membership of a cooperative facilitates support from the Cocoa Coffee Council and the ANADER extension agency (Côte d'Ivoire Consultant). The average cocoa cooperative is around eight years old and has more than 400 members. Fairtrade certified cooperatives are significantly older than non- certified cooperatives (Sellare et al., 2020). It is estimated that 30-40% of Ivorian farmers are in co-operatives (www.ohada.com).

→ In **Ghana**, farmer associations can be grouped in to five categories (see Figure 24).

→ In **Nigeria**, a survey of farmers revealed that, out of the 99.0% of the cocoa farmers that belong to a social organisation, about 42% belong to a cooperative society. The study highlighted diffusion of information among the farmers and enhanced farmers' access to government assistance in the form of loans and other inputs as benefits of cooperatives and farmer associations (Akinnagbe et al., 2018).

→ In **Uganda**, various cocoa producers' associations (Bundibugyo Cocoa Association, BCA; Western Bundibugyo Farmers Development Association, WEBUFADA; Bundibugyo Improved Cocoa Farmers Coop Society) have been able to link up directly with international buyers (from Switzerland) and sell to them. In addition, these organised farmer groups have been able to attract low interest financing (Lutheran World Relief, 2015).

→ In **Sierra Leone**, farmer groups receive support and service provision; they receive training on integrated crop and pest management, fertilisers and also credit support by organisations such as cocoa traders, NGOs and the government (Witteveen et al., 2017). Kpeya Agricultural Enterprises (KAE), an association of cocoa farmers, had over 1,200 as of 2010 including 50 separate village committees (Oakland, 2008).

→ In **Cameroon**, various cooperatives are in operation. The Société Coopérative des Producteurs de Cacao de Mbangassina Sud (MBANGASSUD) cooperative in Cameroon, formed in 2009, MBANGASSUD achieved Rainforest Alliance certification in 2012. (In: https://www.rainforest-alliance.org/articles/cocoa-farmers-cameroon-transform-community)

→ In **Togo**, the body representing cocoa farmers nationally is the Fédération des Unions de Producteurs de Café-Cacao du Togo (FUPROCAT) (Buama et al., 2018)

1. **Cocoa farmer marketing societies**
   These consist of non-registered, semi-cooperative primary societies which evolved around the cocoa buying centers at the time of the dissolution of the United Ghana Farmers Cooperative Council (UGFCC, a politically controlled cooperative). The structure is based on that of formal cooperatives. Funds not used for input purchases are used to grant credit to the farmers for other welfare facilities and services.
2. **The Farmers marketing input company**
   The main objective is to improve inputs distribution to farmers. The company sets up a number of depots in the cocoa growing areas from where farmers buy their input needs.
3. **Cocoa farmers' cooperative marketing organisations**
   These are registered cooperative societies that operate according to cooperative principles. They are non-profit making, and members have an equal voice under democratic control. Any profit realised and not used for new equipment is shared proportionately in accordance with the volume of trade conducted by each member with the society. Currently, there is a total number of 45,068 farmers belonging to associations which are yet to be registered as cooperatives (GhanaWeb, 2020a)
4. **Cocoa farmers' production association**
   These are relatively new associations which are emerging in the cocoa growing areas. They consist of informal self-help farmer groupings with memberships of up to 300 farmers in some areas and concentrated around cocoa farming villages and small townships.
5. **Farmers' assistance societies**
   These are also a recent forms of farmer associations that are springing up around the cocoa buying centres. The approach of these societies includes the mobilization of funds and labour in the cocoa farming communities for carrying out farm maintenance operations such as weeding, spraying against pest and diseases.

Figure 24. Five main types of cocoa farmer associations in Ghana (Ghana Consultant, 2020)

## ASIA

→ In **Indonesia**, it is estimated that there are around 100 cooperatives in total representing about 10% of farmers. Each co-operative typically has between 100 and 700 farmers (Indonesia Consultant). In Polewali-Mandar (West Sulawesi), the Amanah Cooperative has partnered with the NGO Rikolto and is one of the larger farmer organisations. Membership of the cooperatives provides benefits to farmers in the form of training in good agricultural practice, financial management and safe pesticide use. Other benefits include market access and bonuses/premiums for compliance to sustainability standards set by certification bodies or companies, such as Nestlé and Mondelez (Arsyad et al., 2019). There are a few cooperatives with up to 1000 member farmers operating in West Sulawesi (Mithöfer et al., 2017). One cooperative is certified by Utz/Rainforest Alliance - KSS Coop, Jembrana, Bali (Indonesia Consultant).

→ In **Papua New Guinea**, in Manus province it was reported in 2014 that there were five registered cocoa cooperatives, although at that time only two were producing, processing, and selling cocoa. The Akale cooperative had a total membership of 460 as of 2014. The aim of this association is to assist the cocoa farmers with start-up capital, seek markets, provide new income- generating opportunities and improve standards of living for the members (Garnevska et al., 2014).

→ In the **Philippines**, membership in farmer associations is low compared to other nations. One of the larger associations is the Subasta Integrated Farmers Multi-Purpose Cooperative which has over 100 members (Hamrick, 2017).

## AMERICA

→ In **Brazil**, there are many cooperatives and associations. The largest one is the Cooperative Agrícola de Gandu in Bahia with 1300 members which functions very well (Brazil Consultant) (see Appendix III).

→ In **Nicaragua,** 5943 producers are registered, of which 3,585 producers are associated in one of the producer organizations that exist in Nicaragua and 2,358 are not associated (López Acevedo, 2019) (see Appendix III)

→ In **Mexico**, as of 2015, 60.6% of cocoa growers belonged to an association that facilitates their access to the financial and training resources offered by the government. Of these, 51.1 % were reported to be municipal and 43.4 % are divided in 11 different agricultural associations (Hernández et al., 2015) (see Appendix III).

→ In **Colombia**, FEDECAO is large farmer association, that was founded in 1960 to protect the interests of cocoa farmers at a national level (http://www.fedecacao.com.co/portal/index.php/es/). Other associations include the "Asociacioon de productores de cacao de Remolinos del Caguan y Suncillas CHOCAGUAN" (Suárez Salazar et al., 2018), the Departmental Association of Cocoa Producers and Timber Species of Caquetá (ACAMAFRUT) (Gutiérrez García et al., 2020) and Asociación de Productores de Cacao - APROCASUR (Gutiérrez García et al., 2020).

→ In **Peru**, as of 2010 about 20% of cocoa producers belonged to a producer association or cooperative (TechnoServe, 2015). Such cooperatives are often engaged in multiple certification systems (e.g. Fairtrade, Rainforest Alliance and UTZ Certified) (Donovan et al., 2017). Farmers who belong to ACOPAGRO are focused on competitive sustainable techniques based on high export standards (Higuchi et al., 2015). NorAndina is a mega-cooperative alliance of 94 organizations consisting of 6,600 members founded in 2005. The Cooperativa Pangoa is based in the Junin region and exports beans to France (Scott et al., 2015).

→ In **Ecuador**, the proportion of producers belonging to a cocoa association is estimated between 20 and 23% of the country's total (Ecuador Consultant). Among the benefits derived from the membership of a farmer association cited by Barrera et al. (2019) are: training (58%), purchase of wet cocoa (46%), technical assistance (35%), greater access to credit (18%), shared use of agricultural equipment (16%), joint purchase of inputs (13%), access to social funds (4%) and public subsidies (2%). Co-operatives in Ecuador can be considered groups of small farmers associations. These include: UNOCACE, SECAO, FORTALEZA DEL VALLY and APROCANE (all in the Coastal region) and KALLARY in the northern Amazonia region. The UNOCACE cooperative, which represents almost 1000 small producers directly exports 6000 tonnes annually through an innovative price fixing policy (Ecuador Consultant).

→ In **Bolivia**, as of 2014 there were 4,400 producers organised in associations and groups in the process of organisation, whose members would constitute 45.8% of the country's total producers. At this time there were 1,200 producers organized in cooperatives, which represented 12.6% of the total (Espinoza et al., 2014). The umbrella organisation of cocoa cooperatives El Ceibo active in Alto Beni provides farmers with access to organic certification and related extension services. As of around 2014, El Ceibo, which bred cocoa and had a tree nursery, had around 1,300 member families in 49 cooperatives and so-called pre-cooperatives. (Jacobi et al., 2014; Jacobi et al., 2015).

→ In **Dominican Republic**, associations include Confederacion Nacional de Cacaocultores Dominicanos (CONACADO) (Boza et al., 2013) and Asociación de Productores de Cacao del Cibao, Inc. (APROCACI) (Batista, 2009).

→ In **Haiti**, in 2012, cocoa producers in northern Haiti have gained increasing benefits from cocoa production via penetration into some markets by Fédération des Coopératives Cacaoyère Nord (FECCANO) (Chery, 2015). Other examples include CAUD, Anse d'Hainaultand Les Irois (Schwartz & Maass, 2014).

→ In **Trinidad & Tobago**, an example of a co-operative is the Montserrat Cocoa Farmers' Co-operative (http://barbusinesstt.com/the-business-of-cocoa-and-coffee-in-trinidad-tobago/).

## 10.5 EXTENSION SERVICES

Extension services may be provided by the government sector, the private sector or a combination. Whilst governmental support is quite widespread in Ghana and in Côte d'Ivoire, in Indonesia there is very little governmental support and government extension in Brazil is long present in the cocoa sector. Details of extension services in different cocoa-growing countries are set out below.

## AFRICA

→ In **Ghana**, extension support is provided by the public sector via COCOBOD through the Cocoa Health and Extension Division (CHED); the majority of farmers obtain their advice from these extension agents of COCOBOD. Each cocoa district has an average of five staff providing extension services to farmers. Every Cocoa Extension Agent (CEA) trains 300 farmers per operational area (Ghana Consultant).

→ In **Côte d'Ivoire**, extension services are provided by the public sector via the Agence Nationale d'Appui au Développement Rural (ANADER) through about 450 agents responsible for disseminating agricultural information on coffee and cocoa in the 48 different regions of the country. The result of the merger of three providers operating in agricultural extension, ANADER was founded in 1993 as part of a World Bank project. ANADER provides training for producers who are generally members of a cooperative, approximately 26,000 people graduated from cocoa Farmer Field School in 2011/2012, or roughly 3– 4% of the estimated 600–900,000 cocoa smallholders (Muilerman & Vellema, 2017). On 24 August 2012 an agreement between the Cocoa-Coffee Council and development support structures (FIRCA, ANADER, CNRA) was put in place for the training of producers in good agricultural practice and for research and development activities, against swollen shoot disease (Côte d'Ivoire Consultant).

→ In **Nigeria**, Adebayo et al. (2015) estimated that more than 70% of extension services were from the private sector. The authors described the public extension system as being weak. Ajetomobi & Olaleye (2019) have suggested that The Cocoa Research Institute of Nigeria (CRIN) should work closely with the various agricultural extension services (national and private) in the country to disseminate new cocoa hybrids.

→ In **Sierra Leone**, The Ebola outbreak in West Africa in 2014/2015 resulting in restrictions on gatherings was the motivation to explore new ways of training farmers, particularly in certification training, without face-to-face meetings. Jula Consultancy employed 'trainers' and 'field monitors' to conduct seminars, training and demonstrations in the field (Witteveen et al., 2017).

→ In **Togo**, the most notable extension agent is Unité Technique du Café-Cacao (UTCC), a department under the Ministry of Agriculture & Rural Development. UTCC hires agronomists, agricultural engineers, and other professionals in coffee and cacao to provide technical assistance and training to farmers (In: https://perfectdailygrind.com/2018/09/why-you-should-know-about-fine-togolese-cacao/).

## ASIA

→ In **Malaysia**, there are various programmes designed to improve productivity including the Cocoa Smallholder Development Program, Consolidated Group Development Program, Entrepreneur

Development Cocoa Program and Capacity Building Program (Fadzim et al., 2017). In the past, the governmental Malaysian Cocoa Board (MCB) introduced several programmes such as the Cocoa Farmers Marketing Support Service Scheme and the Quality Certification Scheme for Dry Cocoa Beans (Tiraieyari et al., 2014).

→ In **Indonesia**, it is estimated that 64.8% farmers have been trained by the government, 31.3% by NGOs, 18% trained by the research institute (ICCRI), and the rest trained by companies (pesticides, cocoa industries). The budget for extension service in cocoa sector from the government is very low and is mostly for food crops. There is one national (government) extension agency in Jakarta, with +/- 10 branches in some provinces, but the agents are for all crops, not just cocoa (Indonesia Consultant).

→ In **Papua New Guinea**, the private sector is an important player in providing extension, particularly in promoting certification schemes. These initiatives form the basis of the Productive Partnerships in Agriculture Project (PPAP), which is supported by the World Bank, which provides loans to stakeholders for nursery establishment, farm rehabilitation and improving cocoa agronomy and quality. The programme encourages subsistence farmers to become commercial farmers (Faheem, 2019). CABI has played a role in developing region-specific farmer field schools (FFS) whose focus includes management of cocoa pod borer and good agricultural practice (GAP).

→ In **India**, Cocoa Life is Mondelez International's cocoa sustainability programme. It supplies seedlings to farmers, provides technical guidance and encourages economic development. The Cocoa Life programme in India worked with 23,000 cocoa farmers in 2015 and adds 5,000 new cocoa farmers every year (https://www.cocoalife.org/).

→ In **Philippines**, CIDAMI- a local NGO that links private and government sectors, non-government organizations, and all cocoa stakeholders across Mindanao is expanding to the rest of the nation. ACDI/VOCA is an international NGO focused on improving the livelihoods of the poor in developing countries by connecting them with cocoa and coffee international markets. Another local NGO is CocoaPhil that links farmers, processors, buyers and others to promote integration and sustainable development of the cocoa sector (Hamrick, 2017). Recognising the fact that the cocoa industry can create employment has resulted in various government agencies to initiate programmes to support the development of the industry (see Appendix IV). Kennemer Foods operates a contract scheme with farmers whereby they provide planting materials and advice on good agriculture practice and post-harvest techniques. The also provide access to credit. The farmers then sell their cocoa to Kennemer (http://www.kennemerfoods.com/).

→ In **Vietnam**, currently, developments in the cocoa industry developments are planned and guided by Vietnam's Cocoa Coordinating Board, together with the Ministry of Agriculture and Rural Development (MARD). A notable public-private partnership has been 'Sustainable Cocoa Enterprise Solutions for Smallholders (SUCCESS) program', co-funded by USDA, USAID and Mars Inc. It provided technical training for farmers, led to an increase in the area of cocoa cultivated and helped to set up a purchasing network for fermenters. Over 20, 000 farmers in the Southeast and Mekong Delta have received some form of training (Pauwels, 2016).

## AMERICA

→ In **Ecuador**, agrarian reform policies were replaced by the Programme of Rural Development, which initiated the first wave of structural adjustment policies and market deregulation in Ecuador's cocoa sector (Ecuador Consultant). In a study by Barrezueta et al. (2018), more than 50% of farmers had not received any training during the five-years up to the time of the delivery of their survey. During 2002, the Ministry of Agriculture led a process of Cocoa Arriba (nacional cocoa) revaluation, through the project "Recovery of Production and Improvement of the Quality of National Cocoa" (Moreno-Miranda et al., 2019).

It is estimated that there is one extension technician for every 250 producers or the equivalent of 1 extension technician for every 1375 hectares. The local decentralised autonomous governments (in provinces and cantones) have about 50 technicians working in the technical modernisation of cocoa.

INIAP and Universities have about 30 technicians who devote part of their time to carrying out extension activities related to cocoa. It is estimated that there are currently about 400 full/part time field technicians providing some type of extension services. The main sources of technical assistance are MAG (Ministerior de Agricultura), INIAP, second level producer organisations, ANECACAO and exporters, some NGOs and also some GAD's (decentralized autonomous governments) in cantons and provinces as part of specific projects (Ecuador Consultant).

→ In **Brazil**, there is no longer any government extension service provided to farmers; all of the extension is provided by the private sector (Brazil Consultant). For example, Barry Callebaut has assisted farmers in converting their fields from conventional to organic farming and have helped ensure compliance with the requirements of organic certification (Barry Callebaut, 2008).

→ In **Colombia**, the Government, through the Ministry of Agriculture, in 2014 invested funds aimed at supporting 20,892 cocoa-producing farmers in the farm rehabilitation, post-harvest and disease management as well as international certifications. In 2015, actions were initiated for the control and mitigation of pests and diseases (Cely, 2017).

→ In **Nicaragua**, PROCACAO, works on the improvement of the organizational and productive capacities of the cocoa producers. For this, the Ministry allocated US$4.2 million, to strengthen the capacity of 1,200 producers through technical assistance and credit granting. NICADAPTA is an additional programme that supports both cocoa and coffee producers, with a focus on helping them to adapt to climate change (Gumucio et al., 2016). The World Bank, with the financial support of the Japan Social Development Fund (JSDF), is implementing the Alternative Indigenous and Afro- Descendants and Agroforestry Project (COCOA – RAAN) is using Farmer Field Schools (FFS) to improving agricultural practice and provide markets for Fairtrade and sustainable chocolate companies (Gonzalez, 2012). The PROCACAO programme is focused on improving the income of families and generating employment in areas where cocoa is produced (López Acevedo, 2019).

→ In **Peru**, TechnoServe has established demonstration plots and farmer field schools to train smallholder cocoa farmers (TechnoServe, 2015). Ecom, also operates in Peru and is a partner in the Alianza Cacao. In addition to buying cocoa from established growers, Ecom has supported the diffusion of fine flavour varieties and the development of a computerized database of 13,000 ha of new cocoa planting. Each grower is provided with data that includes GPS coordinates and dimensions of his/her cocoa fields, the varieties grown, planting dates, etc. (Scott et al., 2015).

→ In **Dominican Republic**, as of the early part of the early 2000s, the Cocoa Department had some 102 area extension agents with a role of promoting high yields and improving post-harvest management of the crops (Siegel et al., 2004).

→ In **Haiti**, in November 2013, the Haitian government, launched a $4.8 million cocoa project in partnership with the Multilateral Investment Fund of the Inter-American Development Bank (IADB). The project is targeting 7000 farmers with the aim of increasing yields through good agricultural practice and improving fermentation practices. Technical exchange with farmers from other Latin American countries has been an important element of extension in Haiti.

→ In **Trinidad and Tobago**, the Cocoa Research Centre (CRC) provides extension training to farmers partnering with organisations including the Centre for Development of Enterprise (CDE) and Centre de Coopération Internationale en Recherche Agronomique pour le Développement, France (CIRAD) (Bekele et al., 2015).

## 10.6 OTHER SOURCES OF NON-FARM INCOME

Many smallholder farmers combine farming with other activities, which can be an important source of income. Some examples are presented as follows:

- → In **Ghana,** a survey of cocoa farmers revealed cocoa farming to be the main occupation of 91% of respondents; other sources of income included petty trading and work for cocoa marketing companies (Asamoah et al., 2013).
- → In **Nigeria,** the households receive income from off-farm sources, whereby self-employed activities account for nearly one quarter of total income. Such activities include handicrafts, food processing, shop-keeping, and other local services, as well as trade in agricultural and non-agricultural goods. Many cocoa-farming households also receive remittances (Babatunde & Qaim, 2009).
- → In **Côte d'Ivoire**, on average, 90% of producers carry out supplementary or extra-agricultural activities. Fishing and handicrafts are generally carried out by agricultural producers during the dry season, as well as masonry. Commercial activities are carried out throughout the year. Income from extra-agricultural activities enables farmers to meet urgent needs, i.e. those considered as unforeseen expenses (Côte d'Ivoire Consultant).
- → In **Ecuador**, on small cocoa farms, the producer spends less time managing their crop and may spend part of their time on off-farm in other income-generating activities, sometimes non-agricultural activities. Small-sized cocoa farm producers employ 20% to 80% of their workforce off-farm (Martinez, 2000).
- → In **Papua New Guinea**, apart from farming, household income is also generated through non/off-farming activities by gathering bush materials (for building houses) and making and selling of mats and baskets from coconut leaves. Some villagers earn their living from casual employment including sawmilling, trucking, and trade stores (Kerua & Glyde, 2016).
- → In **Indonesia,** a small proportion of farmers' income is from non-farm sources such as a trading, collector/middleman, Government/private worker (Indonesia Consultant, 2020).
- → In **Cameroon,** a survey of farmers in the Southwest Region of Cameroon revealed that a small proportion ( 4.1%) do petty jobs - carpentry, seamstresses, hair dressing etc. (Andoh & Mbah, 2018).
- → In **Peru,** the average farmer spends only about half of his or her time cultivating cocoa, and most producers generate additional income through other crops and off farm labour (TechnoServe, 2015).
- → In **Bolivia,** a survey of farmers revealed that off-farm income accounted for up to 40% of income; remittances and handicrafts being important income sources (Barrientos-Fuentes & Torrico-Albino, 2014).
- → In **Haiti**, a survey revealed that women were generally more involved in off-farm activities, primarily small businesses (Chery, 2015). Fishing and skilled and manual labour have been cited as lucrative, although less common off-farm income sources (Schwartz & Maass, 2014).

# SECTION 2: SYNTHESIS

In this section, based on the literature review, we bring together factors that influence both yield and farmers' incomes. When considering these factors, it is useful to examine the cocoa farming system, as a whole (Figure 25). By analysing the different components of the system on yield and income, its efficiency can then be improved. Another approach is to consider different farming systems and identify factors within those systems that lead to increases in yield and income (Figure 26).

A number of factors vary considerably geographically and between systems that can impact on the productivity and economy of the farming system. These are summarised as follows:

**Planting materials**. West African farms are distinguished by growing seed-derived materials. In both Côte d'Ivoire and Ghana, seeds are distributed to farmers as mixed hybrids from seed gardens. Nevertheless, a significant proportion of farmers grow seed from pods that they have selected from their own farms, leading to a high degree of heterogeneity in tree-to-tree productivity. Both countries have ambitious national targets for re-planting aging cocoa farms, although this is likely to require increased infrastructure capacity. In contrast to West Africa, at least in the two largest cocoa-producers in South America, Ecuador and Brazil, an increased usage of clones and an increase in larger plantations that utilise clonal materials has led to higher farm productivity. Similarly, in Sulawesi, Indonesia a large proportion of farms use clones. Here, replanting via grafting improved clones on to old tree stocks or else replacing trees with improved clonal material has led to higher yields.

**Crop husbandry**. Greater deployment of good farming practice will result in increased yields and farmers' income (Figure 27). In the context of global warming and a better use of natural resources, a number of key husbandry practices were identified that varied considerably between production areas and farming systems:

*Planting density*. Considerable variation in planting density was noted within and between countries. In some cases, this will reflect a deliberate decision by the farmer, e.g. if the farmer is intercropping then the overall cocoa density is likely to be lower than under a monocrop. In other instances, farmers may lack knowledge of optimal planting density with poor practice impacting on yield.

*Water management* is an increasingly relevant issue on farms, particularly given less predictable rainfall patterns being encountered under conditions of climate change. Globally, irrigated cocoa accounts for a small proportion of the production area. Many large plantations in the review have irrigation systems in place. Although limitations to the adoption of irrigation for smallholders are often cited, the review has highlighted some specific areas in Ecuador where smallholders are irrigating, which may provide models for elsewhere.

Adequate *soil management* is also a major issue in cocoa-producing areas due to the degradation of land over time, notably particular in parts of West Africa. There is a general trend of increased fertiliser use on cocoa farms and international projects such as CocoaSoils are geared towards recommendations on more targeted fertiliser use. Some large-scale plantations are using fertigation which is another route to more targeted fertiliser use. Both small and large-scale farm models produce considerable organic waste, including pod husks, pruning and sometimes animal manure. Incorporation of this waste in the form of compost, mulching and biochar represents low-cost routes to soil improvement.

*Pest and disease* challenges are present in all cocoa-producing regions, although there are clearly much greater challenges in some areas compared with others. Identification and management of risks are key elements. The CODAPEC system in Ghana is notable as an example of a state-run system of pest and disease control, whilst in most other countries pest and disease control is at the farm or community level.

**Shade & land-use.** Broad categories of land use and shade systems are summarised in Figure 28. Factors influencing the system adopted include tradition and perception of what is the best way to grow cocoa, current land use (e.g. a grower may decide to adapt an existing coconut farm to intercrop with cocoa) or whether a farmer makes a conscious decision to intercrop. The latter will be influenced by factors such as knowledge of the intercrop, land suitability and access to markets. Political and socio-economic factors will also impact on land-use, for example, laws governing forest protection. Whilst intercropping will not be suitable for all farmers, where it is practiced it provides a means of income diversification and in more marginal areas, use of shade may provide some protection against abiotic stresses.

**Post-harvest.** The need for improved postharvest practices to increase quality and add value was highlighted by the review. Cocoa producers in Indonesia, Brazil and Dominican Republic generally do not ferment beans. Lack of financial incentives is a clear barrier to encouraging farmers to ferment. Other issues are small harvest volumes which do not permit a good fermentation (e.g. when farmers have a very small plot of land and are harvesting frequently) and the need for subsistence farmers to have rapid access to funds after harvesting. An alternate model is to sell wet beans to processors who have facilities for fermenting the beans as takes place in several countries such as Ecuador, Nicaragua, São Tomé and Principe, Indonesia, Côte d'Ivoire. Here the responsibility for post-harvest practices is taken away from the farmers and represents another route towards maintaining or improving cocoa quality to better access to added-value markets.

**Diversification and farm economics.** Diversification can lead both to increases and diversification of income, the latter being important if the cocoa crops is badly affected in a particular year by, for example, adverse weather conditions or a particularly bad disease outbreak or else if the cocoa price falls. On-farm diversification can include additional valorisation of cocoa beans, utilisation of bi-products, cultivation of other crops and the keeping of livestock (Figure 29). Ultimately, farmer income will be maximised through a combination of gross income as compared to expenditure (Figure 30).

**Farmer co-operation.** Increased farmer co-operation in many cocoa-producing countries was highlighted by the review. This reflects the diverse benefits of co-operation ranging from access to inputs and extension services. Often it is mandatory to be part of a cooperative to participate in certification schemes.

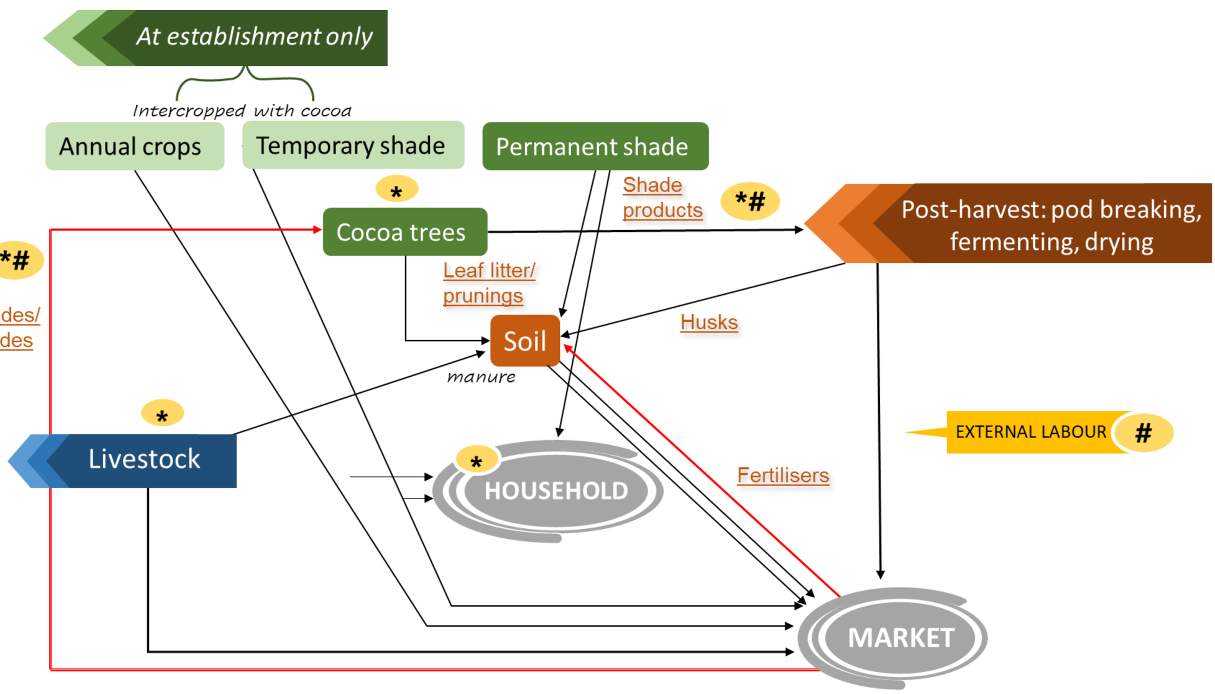



Figure 25. A generalised farm system diagram for cocoa. The specific components and interaction will vary between different farm models. * represents household labour, # represents external labour. The red arrows are inputs coming in from the market.

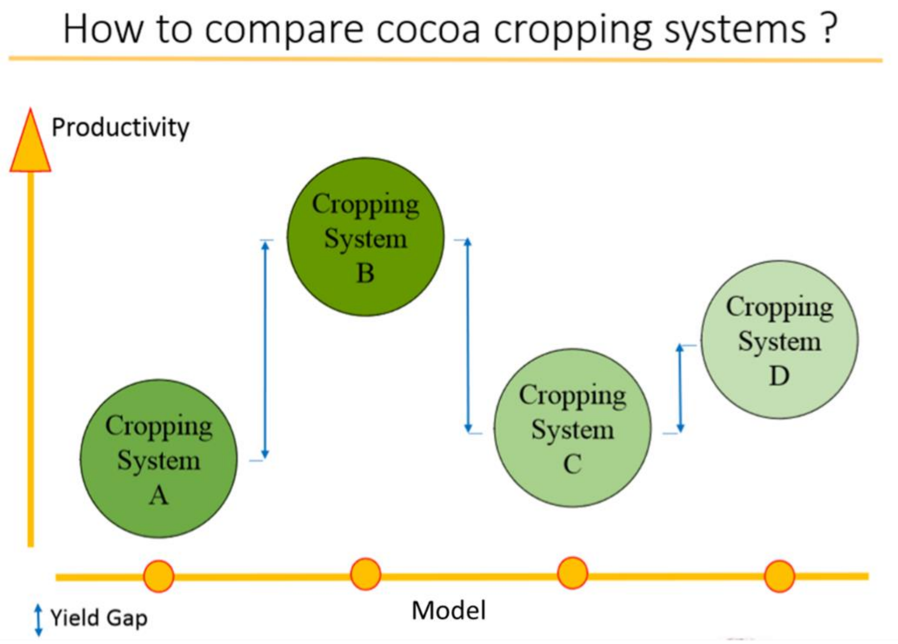



Figure 26. Comparison of cropping system models to identify factors leading to differences in productivity.

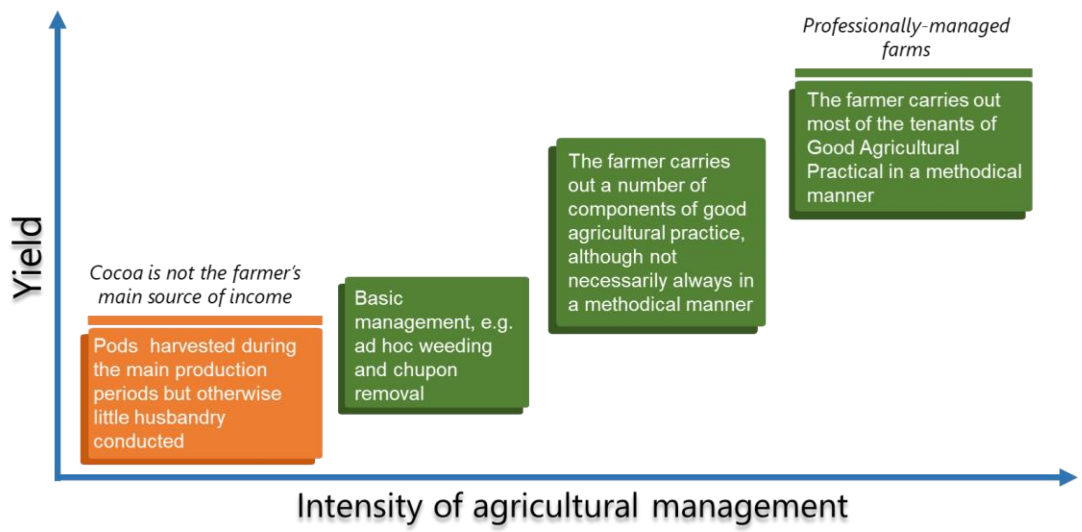



Figure 27. Categories of farm management and their relationship with yield.

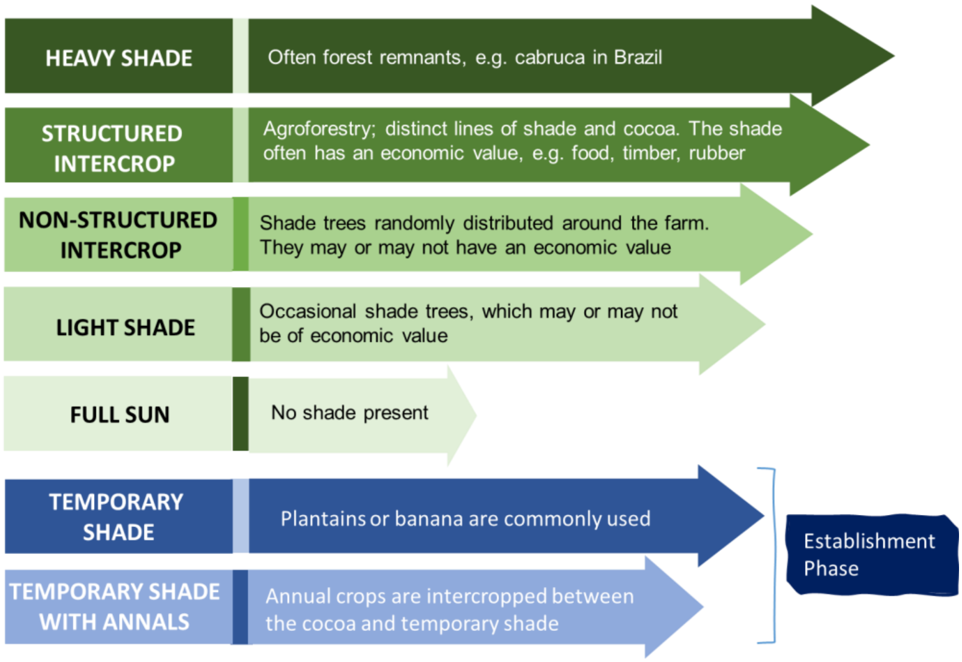



Figure 28. Shade/land use models in cocoa farming systems

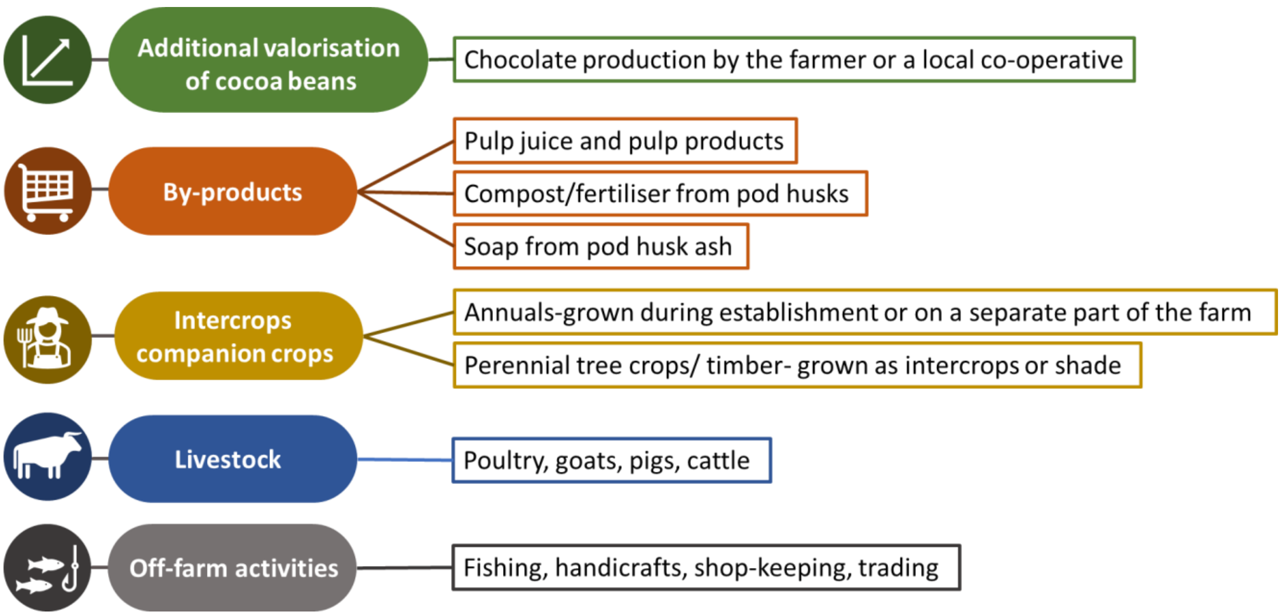



Figure 29: Summary of ways in which cocoa farmers diversify their income.

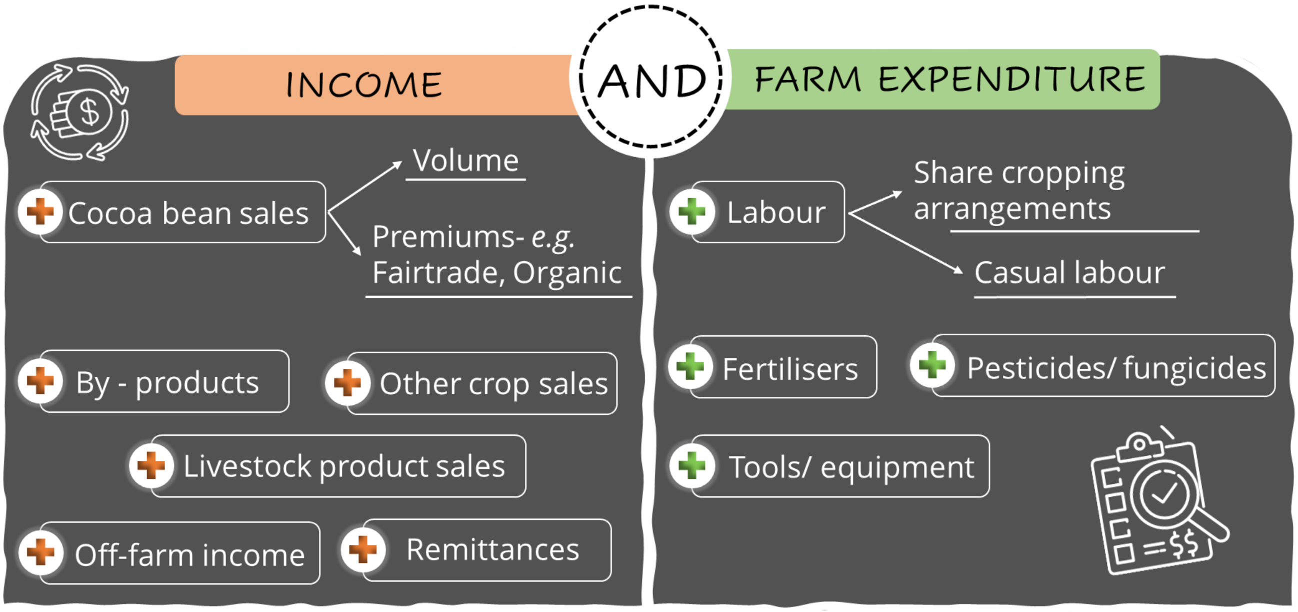



Figure 30. Cocoa farm income and expenditure

# SECTION 3: FARMING SYSTEM COMPARISONS

Table 15. Comparative matrix of cocoa farming systems

| | Trait | Categories |
|---|---|---|
| **Capital and Land Status** | **Farm Ownership** | Owned & Operated/ Landlord/ Sharecropping |
| | **Size of Farm** | Smallholding (<5ha)/ Medium (5-20 ha)/ Large (20-100 ha)/ Plantation (>100 ha) |
| | **Land Devoted to Cocoa** | All/ Most of Farm/ Part of Farm |
| | **Land Accessibility and Resources** | No Expansion Possible/ Land Reserves Available/ Systematic Land Expansion |
| **Labour** | **Labour** | Familial/ Familial + Casual Labour/ Hired Labour Force |
| | **Management Structure** | Smallholder/ Manager + Hired Labour |
| | **Level of Professionalism** | Sole Source of Income/ Major Source of Income/ Occasional Source of Income |
| **Farm layout and management** | **Planting Material: Genetics** | Traditional Varieties/ Uses Seed from Own Farm/ Improved Varieties |
| | **Planting Material: Propagation** | Seed/ Clonal |
| | **Cocoa planted in organised row** | Yes/ No |
| | **Replanting** | Never/ *Ad hoc*/ Systematic |
| | **Rehabilitation** | Never/ Partial/ Heavy |
| | **Shade Intensities** | Full-sun/ Light/ Moderate/ Heavy |
| | **Shade Distribution** | None/ Scattered/ In Organised Rows |
| | **Economic Shade Usage** | No Shade/ Shade not of Economic Value/ Shade of Economic Value but not Utilised/ Economic Value of Shade is Utilised |
| **Farm operations** | **Inorganic Fertilizer Application** | Not Applied/ Occasionally Applied/ Regularly Applied |
| | **Organic Fertilizer Application** | Not Applied/ Occasionally Applied/ Regularly Applied |
| | **Soil Testing** | Not Carried out/ Carried Out |
| | **Fertigation** | Not Practiced/ Practiced |
| | **Water Management and Irrigation** | None/ *Ad hoc/* Systematic Irrigation |
| | **Weed Management** | None/ *Ad* hoc/ Systematic |
| | **Pest and/or Disease Management** | None/ *Ad hoc*/ Systematic |
| | **Mechanisation on-Farm** | None/ Occasional/ Integrated into System |
| **Post-Harvest management** | **Harvest frequency** | *Ad hoc*/ Quite Frequent/ Frequent/ Very Frequent |
| | **Fermentation** | None/ Small Scale/ Large Scale/ Outsourced |
| | **Drying** | None/ Small Scale/ Large Scale/ Outsourced |
| | **Market** | Bulk-Fermented/ Bulk- Not Fermented/ Specialised- Fine Flavour & Organic |
| **Farmer Support** | **Extension services** | Provided by the State/ Provided by private sector/ Provided by NGOs/ None |
| | **Subsidised provision of inputs/ services** | Provided by the State/ Provided by Private Sector/ Provided by NGOs/ None |

In order to compare cocoa farms and farming systems, a series of key traits were identified in the review of farming systems and are summarised in Table 15. Each trait is then categorised according to the range of practices known to be carried out on cocoa farms. A range of these traits have then been used to identify and differentiate different cocoa farming systems.

## DESCRIPTION OF FARMING SYSTEMS

In Table 16 five broad categories of farming system are identified and 11 specific farming systems. The categories and systems are differentiated by parameters within the comparative matrix, which include variety of cocoa grown, whether cocoa is grown with other crops, the intensity of crop management and the market in which the cocoa is sold. It should be noted that whilst this list covers key systems, in many cocoa-producing regions a spectrum of systems can be observed. For, example, on West African smallholdings, the amount of farm management employed varies greatly from farm to farm, which is also reflected in yield variability. A detailed description of three of these systems is then described.

Table 16. Categories of cocoa farming systems

| Category | System | Key system traits | Location (s) |
|---|---|---|---|
| Large plantation | Large plantation-fertigated | Professionally run plantation (>100 ha) with a manager(s) and hired staff. Clonal cocoa is grown. The marked dry season necessitates irrigation and fertilizer is supplied through the irrigation (i.e. fertigation). The market is bulk fermented. Yields range typically from 1.5-2.5 tonne $ha^{-1}$. | Ecuador – W Coast; Brazil-S. Bahia, Espirito Santo, Dominican Republic |
| | Large plantation-not irrigated | Professionally run plantation (>100ha) with a manager(s) and hired staff. Clonal cocoa is grown and fertilizer inputs used. There is no irrigation/ fertigation. The market may be bulk, fine flavour or both. Yields are typically in excess of 1 tonne $ha^{-1}$. | Indonesia- Java |
| Medium, mixed cropping | Mixed crop with cocoa | Here, the overall farm size is 20-100 ha. The system is characterised by having different portions of the farm being given over to different crops, with cocoa being one if these. In this way, the farmer spreads their risk. Yields in the range of 600 – 1000 kg $ha^{-1}$. Market is usually bulk fermented. | Côte d'Ivoire, Brazil, Ecuador |
| | Mixed crop with intercropped cocoa | Similar to the system above; the main differentiating factor being that in the portion of the farm where the cocoa is grown it is intercropped agroforestry, for example with rubber. Yields are typically in the range of 600 -1200 kg $ha^{-1}$. The market is usually bulk fermented | Côte d'Ivoire, Brazil, Ecuador |
| Structured intercrop smallholding | Well-managed intercrop -not irrigated | Smallholding (~1 ha) agroforestry with clonal cocoa and shade trees planted in regular lines. The farm is fertilised and pests/ diseases are managed. Yields are high (1-1.5 tonne $ha^{-1}$) and the market is bulk (often unfermented, sometimes fermented). Additional income is derived from the shade tree. | Indonesia, Peru |
| | Irrigated intercrop | Smallholding (~1 ha) agroforestry with clonal cocoa and shade trees (typically coconut or areca nut) planted in regular lines. Irrigation is necessary as there is a distinct dry season. The market is bulk fermented. Additional income is derived from the shade tree. Yields range from 525-950 kg $ha^{-1}$ | India |
| Well managed smallholding | Full-sun farms growing CCN 51 | Smallholdings (typically <5 ha) that grow CCN 51 under no shade conditions. Fertilizer inputs are used and yields are high (often greater than 1 tonne $ha^{-1}$). The market is bulk (usually fermented). | Ecuador |
| | Well managed small-holding, light shade | Smallholding (typically 1-5 ha). Planted with improved hybrids which are fertilised. Pest and diseases are managed. Yields are reasonably high (0.8-1.2 tonnes $ha^{-1}$). The market is bulk fermented. | Ghana, Côte d'Ivoire |
| Traditional smallholding | Cabruca- biodiverse shade system | Small to medium farms grown under trees (agroforestry) that are remnants of forest shade and hence biodiversity rich. The high shade intensity means that yields are often modest (120-180 kg $ha^{-1}$). The market is bulk- fermented or unfermented. | Brazil: Bahia, Costa Rica, Cameroon |
| | Traditional fine flavour producing | Characterised by cultivation of nacional fine flavour cocoa. Cocoa is not always the main source of farmer income. Fertilizer is not used; yields range from 100-500 kg $ha^{-1}$. The market is fine flavour. | Ecuador |
| | Rustic- limited management | Familial small-holding where cocoa is not the main source of income. Varieties grown are traditional and farm management is minimal (limited or no fertilizers). Yields are low (typically 200-400 kg $ha^{-1}$) and the market is bulk fermented. | Ghana, Côte d'Ivoire |

## TRADITIONAL SMALLHOLDING: RUSTIC WITH LIMITED MANAGEMENT

Location: Ghana

Synonymous systems in other parts of West Africa, the main factor that varies between countries being the amount of support that the farmer gets in terms of subsidised inputs from the respective government.

### Capital and Land Status

In this system various types of ownership arrangements may be in place (e.g. owned and operated, landlord and sharecropping). A typical farm size would be 2-3 hectares with a large proportion of it devoted to cocoa but some of it put over to other crops. Yields are low (200-400 kg $ha^{-1}$) due to the low level of management, few (if any) inputs and aging tree stock. The farm is surrounded by other small-holdings and so any potential for land expansion is limited.

### Labour

The running of the farm is familial and would not be considered as a professional operation since the family also has other sources of income.

### Farm Layout and Management

The farm is planted with traditional varieties (Amelonado plus possibly early generation hybrids), which are planted irregularly. The tree stock is old and no systematic replanting or rehabilitation has taken place. The shade intensity is moderate and the shade trees are scattered around the farm. Any economic value of the shade trees is not particularly utilised (if there are fruit trees amongst the cocoa these might be utilised by the family).

### Farm Operations

The farmer typically would not add any fertiliser or carry out any pest management. Weeding would be carried out periodically as would pruning. The farmer may benefit however from the government spraying programme (see below).

### Post-harvest Management

Harvesting is conducted very much on an *ad hoc* basis with the farmer's family going on to the farm during peak harvest periods but spending little time on the farm at other times. The beans are fermented using the heap method (i.e. piled on to banana leaves) and sun-dried. They are then sold to local buying company agents.

### Support

The farmer receives periodic support for pest control through the CODAPEC scheme, whereby spraying gangs spray the plants against mirids and *Phytophthora* pod rot.

## STRUCTURED INTERCROP SMALLHOLDING: WELL-MANAGED INTERCROP -NOT IRRIGATED

Location: Indonesia, Sulawesi

Synonymous systems in Peru

### Capital and Land Status

In this system, the smallholding is an area of land that is owned by the farmer and typically is of an area of around 1 hectare. All of the farm is devoted to cocoa and, due to the fact that it is well managed, relatively high cocoa yields are obtained of 1-1.5 tonnes $ha^{-1}$. The farm is surrounded by other small-holdings and so any potential for land expansion is limited.

## Labour

Small-holdings such as this are primarily familial operations but may involve casual labour, for example, during periods of peak harvest or during establishment/ re-planting. The farm can be seen as a professional operation in that all, or else the vast majority of the farmer's income comes from the farm. Most of the farm income is from the sale of cocoa beans but additional income is also derived from the intercrop.

## Farm Layout and Management

The farm is laid out in a structured manner with the cocoa planted at a distance of 3 * 3 meters in a square planting arrangement. Shade is planted provided by coconut trees, planted in rows at a distance of six meters. This structured arrangement of shade is sufficient to provide some protection to the cocoa trees, for example against high temperatures, but is not so dense as to result in a significant reduction in cocoa yields. The shade intercrop also provides a useful supplementary income to the farmer.

The farm has been re-habilitated by replacing the original cocoa grown with improved clonal varieties that have a high yield potential and also partial resistance against diseases. On part of the farm, rehabilitation has been achieved through side grafting of clonal material on to old trees stocks and then subsequently removing the crown of the original tree. This method enables a relatively rapid replacement of tree stock. Elsewhere on the farm, the original trees have been replaced with grafted clonal plants.

## Farm Operations

Regular applications are made of inorganic fertilisers, which may be supplemented with organic fertilisers (e.g. chicken manure). Pests and diseases are controlled by a combination of cultural practices (phytosanitary pruning and frequent harvesting) and through application of pesticides/ fungicides.

Whilst the farm can be considered well managed, more high-tech innovations such as irrigation, fertigation or mechanisation are not practiced. In the case of water management, irrigation would not necessarily be of great benefit since any dry periods tend to be short (except perhaps in *El Nino* years). There is no on-farm mechanisation.

## Post-harvest Management

Harvests take place on a very frequent basis (2-4 weeks depending on the number of pods on the trees) in order to reduce infestations from cocoa pod borer. The beans are sun-dried on or near to the farm; they are not fermented since there is no benefit to the farmer to do so. The farmer sells the beans to local buyers who frequently pass through the area.

## Support

Whilst the farmer does not get any subsidies for inputs, they are able to get advice from government bodies.

# LARGE PLANTATION-FERTIGATED

Location: Ecuador

Synonymous systems in Brazil and Colombia

## Capital and Land Status

In this system the ownership status is either owned and operated or leased from a land-owner. The size of such farms can be between 100 and 500 ha. The organised nature of the farm combined with high levels of inputs and the use of improved planting materials means that yields on such plantation are high, in the regions of 1.5 to 2.5 tonnes ha$^{-1}$. There may be the potential for physical expansion, for example if neighbouring farms are purchased.

### Labour

The farm is a highly professional venture with labour consisting of a farm manager and permanent core staff. *Ad hoc* labour is often hired to carry out specific tasks, such as pruning. Cocoa may be the sole source of income, or else a second crop or timber might be grown (either as an intercrop or on another part of the farm).

### Farm Layout and Management

The farm is planted with high yielding clonal material, typically CCN 51, which are planted in regular lines. Many of the high-tech farms in Ecuador are relatively young but it would be expected that, over time, the farms are replanted in a systematic manner. The cocoa may be grown in full sun, or else a systematic shade arrangement may be in place (for example, lines of timber trees).

### Farm Operations

In order to match fertiliser inputs with latent soil conditions, soil testing is carried out periodically. Appropriate inorganic fertilisers are then applied. Irrigation is essential in such farming systems due to the long dry season. Some nutrients will be applied via the irrigation system, i.e. fertigation. The location of the plantation in a dry area means that latent disease pressures are relatively low. Pest and disease management is systematic through the application of pesticides/ fungicides. Aspects of mechanisation are integrated in to the system, for example, tractors are used to transport the harvested pods to a processing area.

### Post-harvest Management

The pods are harvested frequently, this being a continuous operation during peak harvest periods. A part of the plantation is set aside as a fermentation and drying area. The dried and fermented beans are then sold in to the bulk cocoa market.

## CONCLUSION

Cocoa production systems worldwide continue to be dominated by smallholder farmers, although the number of plantation-scale farms is on the increase. The large proportion of aging farmers in some (although not all) producing countries illustrates the need to attract a younger generation. A route towards this end is through adoption of technologies that improve the efficiency of production and returns to farmers, i.e. professionalisation of farming.

The review has highlighted a broad range of cocoa farming systems and a considerable variability in the intensity of management between farms. This is reflected in large farm-to-farm yield variation. When considering key parameters that limit yield, the following can be concluded:-

o Adoption of improved varieties varies greatly within and between cocoa-growing countries. The proportion of farmers who plant improved varieties in Côte d'Ivoire and Ghana remains relatively low.

o Pest and diseases represent a challenge to production to a greater or lesser extent in most cocoa-growing regions. The most effective pest and disease management is achieved through integrated management that involves a combination of growing more pest/ disease tolerant varieties and if pesticides/ fungicides are applied this in conjunction with cultural control. An alternative model is to grow irrigated cocoa in dryer areas (such as the west coast of Ecuador) where disease pressures are lower.

o Soil degradation is an issue in many cocoa-growing regions, especially parts of West Africa. Whilst fertiliser use has been increasing in the sector, adoption varies within and between cocoa-growing countries. There is a particular need to target fertiliser formulations to local soil conditions to reflect the considerable heterogeneity of soil types. There is also a need to improve soil health generally, e.g. through increasing soil organic matter content.

Notable examples of innovation practice to improve yield and profitability can be seen, for example, in water management, adoption of improved varieties, and agroforestry. The latter, whilst not suited to all farmers, can provide opportunities for income diversification as well as bringing environmental benefits.

Regarding post-harvest practices, the main barrier to adoption of fermentation, in particular, appears to be a lack of financial incentive to the farmer, or simply that such practices are not engrained in local farming cultures. Model systems whereby farmers sell wet beans to central fermentation facilities, represent an alternative route to improved cocoa quality.

Economic analysis of cocoa production by a range of authors have calculated different numbers of labour days for particular activities in different countries, although it is not entirely clear why this should be the case. More detailed economic studies of different farming systems are needed in order to understand better the cost: benefit ratio of a given system.

To conclude, for cocoa production to become more sustainable both for the cocoa-farmer and the environment, particularly in the context of climate change and other challenges in the sector, there is a need for growers to adopt new practices. It is recommended that policy makers consider the best practices adopted globally as well as new innovations and whether any of these can be adopted locally.

This review provides an overview of the main cocoa farming systems worldwide. However, the adoption of practices in a particular context would require an in-depth understanding of the functioning of most successful cocoa farming models and of any potential constraints before they can be applied to a location. Therefore, this analysis could be deepened by conducting detailed case studies analysis of the selected cocoa growing systems, including their cost structure.

# REFERENCES


Abbott, P. C., Benjamin, T., Burniske, G. et al. (2018). An analysis of the supply chain of cacao in Colombia climate-smart agriculture. Technical Report. https://doi.org/10.13140/RG.2.2.19395.04645

Acheampong, K., Daymond, A.J., Adu-Yeboah, P. & Hadley, P. (2019) Improving field establishment of cacao (*Theobroma cacao*) through mulching, irrigation and shading. Experimental Agriculture, 55 (6). pp. 898-912. doi.org/10.1017/S0014479718000479

Abdulai, I., Hoffmann, M. P., Jassogne, L. et al. (2020). Variations in yield gaps of smallholder cocoa systems and the main determining factors along a climate gradient in Ghana. *Agricultural Systems*, *181*, 102812. https://doi.org/10.1016/j.agsy.2020.102812

Adebayo, K., Chandra Babu, S., Rahman, S., & Motunrayo, S. (2015). Private sector articipation in agricultural extension for cocoa farming in Nigeria: The case of multi-trex integrated food. In Y. Zhou & B. S. Chandra Babu (Eds.), Knowledge driven development. Private extension and global lessons. Academic Press. pp. 141-162.

Adeniyi, S. A., de Clercq, W. P., & van Niekerk, A. (2019). Assessing the relationship between soil quality parameters of Nigerian alfisols and cocoa yield. *Agroforestry Systems*, *93*, 1235–1250. https://doi.org/10.1007/s10457-018-0238-2

Adjaloo, M. K., Oduro, W., & Banful, B. K. (2012). Floral phenology of upper amazon cocoa trees : implications for reproduction and productivity of cocoa, *ISRN Agronomy*, *2012*, 461674 https://doi.org/10.5402/2012/461674

Afari-sefa, R. A. V. (2014). Cocoa agroforestry for increasing forest connectivity in a fragmented landscape in Ghana. *Agroforestry Systems*, *88*, 1143–1156. https://doi.org/10.1007/s10457-014-9688-3

Afrifa, A. A., Frimpong, K. O., Acquaye, S., Snoeck, D., & Abekoe, M. K. (2009). Soil nutrient management strategy required for sustainable and competitive cocoa production in Ghana. *Proceedings of the 16th International Cocoa Research Conference* 16–21.

Afriyie-Kraft, L., Zabel, A., & Damnyag, L. (2020). Adaptation strategies of Ghanaian cocoa farmers under a changing climate. *Forest Policy and Economics*, *113*, 102115. https://doi.org/10.1016/j.forpol.2020.102115

African Enterprise Challenge Fund (2011). Bio-United Ltd. https://assets.publishing.service.gov.uk/media/57a08acbe5274a27b200078d/Bio-United-case-study-Final.pdf

Agama J., Suarez, C., & Amores, F. (2009). Estudio base sobre el conocimiento y desarrollo de tecnologías para el manejo integrado del cultivo de cacao aplicado a las escuelas de campo en el Ecuador. *Proceedings of the 16th International Cocoa Research Conference*.

AgriFarming. (2018). Cocoa Cultivation Information Guide. https://www.agrifarming.in/cocoa-cultivation

Agro. (2021). Retrieved from https://www.agenceecofin.com/cacao/1203-55121-le-ccc-suspendra-les-activites-d-amelioration-de-la-production-cacaoyere-a-partir-de-2018/2019

Aguad, C.P.S. (2010). Farmers ' knowledge of tree attributes and shade canopy management of cocoa agroforestry systems in Waslala , Nicaragua. MSc Thesis. University of Wales, Bangor.

Ahenkorah, Y., Halm, B.J., Appiah, M.R. & Akrofi, G.S. (1982). Fertilizer use on cacao rehabilitation projects in Ghana. *Proceedings of the 8th International Cocoa Research Conference*. pp. 165-170.

Aidenvironment. (2016). Evaluation of UTZ in the Indonesian cocoa sector. https://utz.org/wp-content/uploads/2016/04/Evaluation-of-UTZ-in-the-indonesian-cocoa-sector.pdf

Ajetomobi, J. O., & Olaleye, A. O. (2019). Auto-regressive integrated moving average (ARIMA) modeling of cocoa production in Nigeria: 1900-2025. *Journal of Crop Improvement*, *33*(4), 445–455. https://doi.org/10.1080/15427528.2019.1610534

Akinfala, T. O., Houbraken, J., Sulyok, M., Adedeji, A. R., Odebode, A. C., Krska, R., & Ezekiel, C. N. (2020). Moulds and their secondary metabolites associated with the fermentation and storage of two cocoa bean hybrids in Nigeria. *International Journal of Food Microbiology*, *316*, 108490. https://doi.org/10.1016/j.ijfoodmicro.2019.108490

Akinnagbe, O. M., Adeniran, T. P., & Adeniran, A. A. (2018). Intra-household roles in cocoa production in Ondo State, Nigeria. *Journal of Agricultural Extension*, *22*(3), 77–86.

Alvarado, M. L., Portillo, E., Boulanger, R., Bastide, P., & Macia, I. (2014). Socioeconomic characterization of cocoa producers (*Theobroma cacao* L.) in Portuguesa State-Venezuela. *Revista de La Facultad de Agronomia*, *31*, 856–864.

Amara, M. K. D., Momoh, J. J. E., & Oladele, A. T. (2015). An economic analysis of the production and export of cocoa in Sierra Leone. *Research Journal of Agricultural Sciences*, *5*(1), 65–71.

Amburo, D. (2017). Condiciones productivas de cacao de los territorios rurales de la zona norte y caribe de Costa Rica. *Instituto Interamericano de Cooperación Para La Agricultura*. http://repositorio.iica.int/bitstream/handle/11324/6460/BVE18029637e.pdf;sequence=1

Anang, B. T., Adusei, K., & Mintah, E. (2011). Farmers' assessment of benefits and constraints of Ghana's cocoa sector reform. *Current Research Journal of Social Sciences*, *3*(4), 358–363.

Andoh, M. A., & Mbah, M. J. (2018). Poor rural cocoa producers in Cameroon. *Universal Journal of Agricultural Research*, *6*(6), 231–234. https://doi.org/10.13189/ujar.2018.060605

Andres, C., Blaser, W. J., Dzahini-Obiatey, H. K. et al. (2018). Agroforestry systems can mitigate the severity of cocoa swollen shoot virus disease. *Agriculture, Ecosystems and Environment*, *252*(September 2017), 83–92.

https://doi.org/10.1016/j.agee.2017.09.031

Aneani, F., Anchirinah, V.M., Owusu-Ansah, F. & Asamoah, M. (2012). Adoption of some cocoa production technologies by cocoa farmers in Ghana. (2012). *Sustainable Agriculture Research*, *1*, 103-117. http://dx.doi.org/10.5539/sar.v1n1p103

Anzules, V., Borja, R., Julca, V., & Castro, A. (2018). Caracterización de fincas productoras de cacao (*Theobroma cacao* L.) en Santo Domingo de Los Tsachilas, Ecuador. *Bosques Latitud Cero*, *8*(2), 39–50.

Arrazate, C. H. A., Fuentes, J. M. V., Rojas et al. (2011). Diagnóstico del cacao en México. Universidad Autónoma Chapingo. https://www.gob.mx/cms/uploads/attachment/file/232186/Diagnostico_del_cacao_en_mexico.pdf

Arguello, D., Chavez, E., Lauryssen, F., Vanderschueren, R., Smolders, E. & Montalvo, D. 2019. Soil properties and agronomic factors affecting cadmium concentrations in cacao beans: a nationwide survey in Ecuador. *Science of the Total Environment*, *649*, 120-127.

Arshad, F. M., Bala, B. K., Alias, E. F., & Abdulla, I. (2015). Modelling boom and bust of cocoa production systems in Malaysia. *Ecological Modelling*, *309–310*, 22–32. https://doi.org/10.1016/j.ecolmodel.2015.03.020

Arsyad, D. S., Nasir, S., Arundhana, A. I. et al. (2019). A one health exploration of the reasons for low cocoa productivity in West Sulawesi. *One Health*, *8*, 100107. https://doi.org/10.1016/j.onehlt.2019.100107

Arvelo Sánchez, M. A., González León, D., Maroto Arce, S., Delgado López, T., & Montoya López, P. (2017). Manual del cultivo de cacao Buenas prácticas para América Latina. Instituto Interamericano de Cooperación para la Agricultura (IICA). https://agroavances.com/img/publicacion_documentos/BVE17089191e_1.pdf

Asamoah, M, & Owusu-Ansah, F. (2017). Report on land tenure and cocoa production in Ghana. A CRIG/WCF Collaborative Survey. Retrieved from https://www.worldcocoafoundation.org/wp-content/uploads/files_mf/1492612620CRIGLandTenureSurveyFinal41217.pdf

Asamoah, M., Owusu Ansah, F., Anchirinah, V., Aneani, F., & Agyapong, D. (2013). Insight into the standard of living of Ghanaian cocoa farmers. *Greener Journal of AGricultural Science*, *3*(5), 363–370. https://cocoainitiative.org/wp-content/uploads/2017/10/insight-into-the-standard-of-living-of-Ghanaian-cocoa-farmers.pdf

Asare, R., Afari-Sefa, V., Gyamfi, I. & Mva Mva, J. (2017). Cocoa seed multiplication: an assessment of seed gardens in Cameroon, Ghana and Nigeria. STCP Working Paper Series Issue 11. https://doi.org/10.13140/RG.2.2.34500.01922

Assa, A., Noor, A., Yunus, M.R., Misnawi & Djude, M.N. (2018). Heavy metal concentrations in cocoa beans (*Theobroma cacao* L.) originating from East Luwu, South Sulawesi, Indonesia. *Journal of Physics: Conf. Series, 979 (2018)* 012011 doi :10.1088/1742-6596/979/1/012011

Assiri A.A., Y. (2009). Les caractéristiques agronomiques des vergers de cacaoyer (*Theobroma cacao* L.) en Côte d'Ivoire. *Journal of Animal and Plant Sciences (Kenya)*, *2*(1), 55–66.

Audet-Belanger, G., Buurman, B., Minneboo, E., & Vaast, C. (2018). Demystifying the Cocoa Sector in Ghana and Côte d'Ivoire. https://www.kit.nl/project/demystifying-cocoa-sector/

AusAid. (2009). Cocoa Processing Methods for the Production of High Quality Cocoa in Vietnam. https://docplayer.net/22132034-Cocoa-processing-methods-for-the-production-of-high-quality-cocoa-in-vietnam.html

Awudzi, G. K., Hadley, P., Hatcher, P. E., & Daymond, A. J. (2020). Mirid feeding preference as influenced by light and temperature-mediated changes in plant nutrient concentration in cocoa. *Annals of Applied Biology*, *177*(3), 395–403. https://doi.org/10.1111/aab.12636

Ayestas, E., Orozco, L., Astorga, C., Munguia, R., & Vega, C. (2013). Caracterización de árboles promisorios de cacao en fincas orgánicas de Waslala, Nicaragua. *Agroforestería en las Américas*, *49*, 18-25. http://repositorio.bibliotecaorton.catie.ac.cr/bitstream/handle/11554/5861/3.Ayestas.pdf?sequence=1&isAllowed=y

Babalola, F. D., Ayinde, O. E., Chirwa, P. W., & Thiam, D. R. (2017a). Risks and coping strategies of production and marketing of cocoa in Ondo State, Nigeria. *Agroforestry Systems*, *91*(2), 211–220. https://doi.org/10.1007/s10457-016-9905-3

Babatunde, R. O., & Qaim, M. (2009). Patterns of income diversification in rural Nigeria: determinants and impacts. *Quarterly Journal of International Agriculture*, *48*(4), 305–320.

Balasimha, D., Daniel, E., & Bhat, E. (1991). Influence of environmental factors on photosynthesis in cocoa trees. *Agricultural and Forest Meteorology*, *55*, 15–21.

Baligar, V. C., Elson, M. K., Almeida, A.-A. F., de Araujo, Q. R., Ahnert, D., & He, Z. (2021). Carbon dioxide concentrations and light levels on growth and mineral nutrition of juvenile cacao genotypes. *American Journal of Plant Sciences*, *12*(5), 818–839. https://doi.org/10.4236/ajps.2021.125056

Bargout, R. N., & Raizada, M. N. (2013). Soil nutrient management in Haiti, pre-Columbus to the present day: Lessons for future agricultural interventions. *Agriculture and Food Security*, *2*, 11. https://doi.org/10.1186/2048-7010-2-11

Barraza, F., Moore, R. E. T., Rehkämper, M. et al. (2019). Cadmium isotope fractionation in the soil-cacao systems of Ecuador: A pilot field study. *RSC Advances*, *9*(58), 34011–34022. https://doi.org/10.1039/c9ra05516a

Barrera, V., Alwang, J., Casanova, T. et al. 2019. La cadena de valor del cacao y el bienestar de los productores en la provincia de Manabí, Ecuador. INIAP/MAG. Quito.

Barrezueta-Unda, S. (2019). Propiedades de algunos suelos cultivados con cacao en la provincia El Oro, Ecuador. *CienciaUAT*, *14*(1), 155. https://doi.org/10.29059/cienciauat.v14i1.1210

Barrezueta Unda, S. A., & Chabla Carrillo, J. E. (2017). Características sociales y económicas de la producción de cacao en la provincia El Oro, Ecuador. La Técnica: *Revista de Las Agrociencias, Special Edition*, 25-34. https://doi.org/10.33936/la_tecnica.v0i0.952

Barrientos-Fuentes, J. C., & Torrico-Albino, J. C. (2014). Socio-economic perspectives of family farming in South America: cases of Bolivia, Colombia and Peru. *Agronomía Colombiana*, *32*(2), 266–275.

Barrientos, L. D. P., Oquendo, J. D. T., Garzón, M. A. G., & Álvarez, O. L. M. (2019). Effect of the solar drying process on the sensory and chemical quality of cocoa (*Theobroma cacao* L.) cultivated in Antioquia, Colombia. *Food Research International*, *115*, 259–267. https://doi.org/10.1016/j.foodres.2018.08.084

Barrientos, S. (2014). Gendered global production networks: Analysis of cocoa–chocolate sourcing. *Regional Studies*, *48*(5), 791–803. https://doi.org/10.1080/00343404.2013.878799

Barry Callebaut. (2017). Improving cocoa farmer productivity through farm services. https://www.barry-callebaut.com/en-GB/group/media/news-stories/improving-cocoa-farmer-productivity-through-farm-services

Batista, L. (2009). Guía técnica el cultivo de cacao en la República Dominicana. CEDAF, Santo Domingo, República Dominicana. 250pp. http://www.cedaf.org.do/publicaciones/guias/download/cacao.pdf

Bazoberry Chali, O. & Salazar Carrasco, C. (2008). El cacao en Bolivia : una alternativa económica de base campesina indígena. CIPCA, Centro de Investigación y Promoción del Campesinado. 282 pp.

Bekele, F. L. (2004). The History of Cocoa Production in Trinidad and Tobago. *Re-Vitalisation of the Trinidad & Tobago Cocoa Industry: Proceedings of the APASTT Seminar*, (September 2003), 1–14.

Bekele, F., Naailah, A., Sukha, D., Foury, G., Maharaj, K., & Umaharan, P. (2015). Safeguarding and enhancing the regional cocoa industry through training of cocoa farmers at Farmer Field schools: recent outreach activities of the Cocoa Research Centre. Project Report.

Bekele, F. (2019). Rehabilitating the Cocoa Industry in Trinidad and Tobago. Technical Report. Available at: https://www.researchgate.net/publication/333145672_Rehabilitating_the_Cocoa_Industry_in_Trinidad_and_Tobago

Belek, A., & Jean-Marie, A. N. (2020). Microfinance services and the productivity of cocoa family farms in Cameroon. *Journal of Agribusiness in Developing and Emerging Economies*, *10*, 557-571. https://doi.org/10.1108/JADEE-12-2018-0186

Bentley, J. W., Boa, E., & Stonehouse, J. (2004). Neighbor trees: Shade, intercropping, and cacao in Ecuador. *Human Ecology*, *32*(2), 241–270. https://doi.org/10.1023/B:HUEC.0000019759.46526.4d

Berlan, A., & Bergés, A. (2013). Cocoa production in the Dominican Republic: Sustainability, challenges and opportunities. Report of findings commissioned by Green and Black's. https://www.cocoalife.org/~/media/CocoaLife/News%20Articles%20PDF/SCI_cocoa_report.pdf

Bitty, E. A., Bi, S. G., Bene, J.-C. K., Kouassi, P. K., & McGraw, W. S. (2015). Cocoa farming and primate extirpation inside Côte d'Ivoire's protected areas. *Tropical Conservation Science*, *8*(1), 95–113. https://doi.org/10.1177/194008291500800110

Black, E., Pinnington, E., Wainwright et al. (2020). Cocoa plant productivity in West Africa under climate change: A modelling and experimental study. *Environmental Research Letters*, *16*(1). https://doi.org/10.1088/1748-9326/abc3f3

Bosque-Perez, N. A., Dahlquist, R. M., Whelan et al. (2007). Improving livelihoods in biodiversity conservation: a case study of cacao agroforestry systems in Talamanca, Costa Rica. *Biodiversity and Conservation*, *16*(8), 2311–2333.

Bourguet, D., & Guillemaud, T. (2016). *Sustainable Agriculture Reviews*. *Sustainable Agriculture Reviews* (Vol. 19). https://doi.org/10.1007/978-3-319-26777-7

Boza, E. J., Irish, B. M., Meerow, A. W. et al. (2013). Genetic diversity, conservation, and utilization of *Theobroma cacao* L.: Genetic resources in the Dominican Republic. *Genetic Resources and Crop Evolution*, *60*(2), 605–619. https://doi.org/10.1007/s10722-012-9860-4

Brobbey, L. K., Agyei, F. K., & Osei-Tutu, P. (2020). Drivers of cocoa encroachment into protected forests: the case of three forest reserves in Ghana. *International Forestry Review*, *22*, 425–437.

Buama, M., Matthess, A., Rommel, A., M'Bo, Y. & Apedo, D. (2018). Technical business services for cocoa farmers. Concepts developed and experience from in Côte d 'Ivoire , Ghana and Togo. https://www.snrd-africa.net/wp-content/uploads/2018/05/2018_Techn.-business-services-SSAB-programme-2.pdf

Bymolt R., Laven A., & Tyszler M. (2018b). Demystifying the cocoa sector in Ghana and Côte d'Ivoire The Royal Tropical Institute (KIT). https://www.kit.nl/project/demystifying-cocoa-sector/

Camu, N., González, Á., De Winter, T. et al. (2008). Influence of turning and environmental contamination on the dynamics of populations of lactic acid and acetic acid bacteria involved in spontaneous cocoa bean heap fermentation in Ghana. *Applied and Environmental Microbiology*, *74*(1), 86–98. https://doi.org/10.1128/AEM.01512-07

Cao, L. (2013). Growth of Cocoa Production in Vietnam. *The Manufacturing Confectioner*, *98(6)*(June), 50–57.

Cassano, C. R., Schroth, G., Faria, D., Delabie, J. H. C., & Bede, L. (2009a). Landscape and farm scale management to enhance biodiversity conservation in the cocoa producing region of southern Bahia, Brazil. *Biodiversity and Conservation*, *18*(3), 577–603. https://doi.org/10.1007/s10531-008-9526-x

CCI. (2017). Cocoa Extension Manual. http://www.cocoaboard.org.pg/wp-content/uploads/2019/09/PNG_ExtensionManual_final_draft25Aug17.pdf

Cely Torres, L. A. (2017). Oferta productiva del cacao colombiano en el posconflicto. Estrategias para el aprovechamiento de oportunidades comerciales en el marco del acuerdo comercial Colombia-Unión Europea. Equidad y Desarrollo, (28), 167-195. https://doi.org/10.19052/ed.4211

CENSO AGROPECUÁRIO IBGE. (2017). https://censos.ibge.gov.br/agro/2017

Cerda, R., Deheuvels, O., Calvache, D. et al. (2014). Contribution of cocoa agroforestry systems to family income and domestic consumption: looking toward intensification. *Agroforestry Systems*, *88*(6), 957–981. https://doi.org/10.1007/s10457-014-9691-8

Chacón, M. (2019). Situación actual del cultivo de cacao en Costa Rica. http://ofinase.go.cr/wp-content/uploads/blog-situacioncacao2019.pdf

Chery, W. (2015). Factors influencing sustainable cocoa production in northern Haiti. Masters Thesis. Louisiana State University. https://digitalcommons.lsu.edu/cgi/viewcontent.cgi?article=4082&context=gradschool_theses

Cilas, C., & Bastide, P. (2020). Challenges to cocoa production in the face of climate change and the spread of pests and diseases. *Agronomy*, *10*(9), 1–8. https://doi.org/10.3390/agronomy10091232

Cocoa Health and Extension Division [CHED], & World Cocoa Foundation [WCF]. (2016). Manual for cocoa extension in Ghana, 104 pp. Available at: https://cgspace.cgiar.org/handle/10568/93355

Cocoa Republic. (2018). The Importance of sustainable organic practices to Trinidad & Tobago's Cocoa Industry. https://www.cocoa-republic.com/2016/06/29/importance-of-sustainable-and-organic-practices-in-trinidad-and-tobago/

Coello Arechua, M.J, & Haro Cambo, R.I. (2012). Caracterización de sistemas agroforestales comúnmente asociados al cultivo del cacao en la zona de Febres Cordero, provincia de Los Ríos. Universidad Técnica de Babahoyo, Ecuador. Available at: http://dspace.utb.edu.ec/handle/49000/956

Córdoba-ávalos, V., Sánchez-Hernández, M., Estrella-Chulím, N., Marcias-Layelle, A., Sandoval-Castro, E., Martinez-Saldana, T., & Ortiz-García, C. (2001). Factores que afectan la producción de cacao (*Theobroma cacao* L.) en el ejido Francisco I. Madero del plan chontalpa, Tabasco, Mexico. *Universidad y Ciencia*, *17*(34), 93-100. Available at: https://www.researchgate.net/publication/28171094_Factores_que_afectan_la_produccion_de_cacao_Theobroma_cacao_L_en_el_ejido_Francisco_I_Madero_del_Plan_Chontalpa_Tabasco_Mexico

Cruz, L., & Condori, G. (2005). Desarrollo de base. *Revista de la Fundacion Interamericana*, *26*. Available at: https://www.google.co.uk/books/edition/Desarrollo_de_base/XJf-4mGRjQIC?hl=en

Cubillos, G. (2013). Manual del Perforador de la Mazorca del Cacao. https://chocolates.com.co/wp-content/uploads/2020/06/manual-del-perforador-de-la-mazorca-del-cacao.pdf

Dada, E., & Hahn, M. (2020). Application of satellite remote sensing to observe and analyse temporal changes of cocoa plantation in Ondo State, Nigeria. *GeoJournal*, 1–16. https://doi.org/10.1007/s10708-020-10243-y

DANE. (2014). Colombian statistical service. Retrieved from https://www.dane.gov.co/index.php/en/

Daniel, R., Konam, J. K., Saul-Maora, J. Y. et al. (2011). Knowledge through participation: The triumphs and challenges of transferring Integrated Pest and Disease Management (IPDM) technology to cocoa farmers in Papua New Guinea. *Food Security*, *3*(1), 65–79. https://doi.org/10.1007/s12571-011-0115-6

Danso-Abbeam, G., Baiyegunhi, L. J. S., & Ojo, T. O. (2020). Gender differentials in technical efficiency of Ghanaian cocoa farms. *Heliyon*, *6*(5), e04012. https://doi.org/10.1016/j.heliyon.2020.e04012

Dar Ali Rothschuh, M. (2019). Factors that affect cocoa yield variation in Nicaragua. MSc Thesis. University of Reading.

David, S. (2005). Learning about sustainable cocoa production : A guide for participatory farmer training 1 . Integrated crop and pest management. Sustainable Tree Crops Program, International Institute of Tropical Agriculture. http://biblio.iita.org/documents/U05ManDavidLearningNothomNodev.pdf-422241a272be87f97e89322621f53a34.pdf

Daymond, A.J., Acheampong, K., Prawoto, A. et al. (2018). Mapping Cocoa Productivity in Ghana, Indonesia and Côte d'Ivoire. In *International Symposium on Cocoa Research (ISCR)*. Lima, Peru.

Daymond, A. J., Prawoto, A., Abdoellah, S., Susilo, A. W., Cryer, N. C., Lahive, F., & Hadley, P. (2020). Variation in Indonesian cocoa farm productivity in relation to management, environmental and edaphic factors. *Experimental Agriculture*, *56*(5), 738–751. https://doi.org/10.1017/S0014479720000289

de Schawe, C. C., Durka, W., Tscharntke, T., Hensen, I., & Kessler, M. (2013). Gene flow and genetic diversity in cultivated and wild cacao (Theobroma cacao) in Bolivia. *American Journal of Botany*, *100*(11), 2271–2279. https://doi.org/10.3732/ajb.1300025

Dendi, D. (2016). A road map for a sustainable cocoa development in Togo, West Africa. https://doi.org/10.7287/peerj.preprints.1812

Department of Agriculture - BPI. (2016). 2017-2022 Philippine cacao industry roadmap. http://bpi.da.gov.ph/bpi/images/PDF_file/Cacao%20Industry%20Roadmap%20-%20Signed%20%20%20March%2010,%202017.pdf

Dewanta, A. S. (2019). Demand for Indonesian cocoa beans in a dilemma: Case study Malaysian market. *Economic Journal of Emerging Markets*, *11*(1), 59–72. https://doi.org/10.20885/ejem.vol11.iss1.art6

Díaz-José, J., Díaz-José, O., Mora-Flores, S., Rendón-Medel, R., & Tellez-Delgado, R. (2014). Cacao in mexico: restrictive factors and productivity levels. *Chilean Journal of Agricultural Research*, *74*(4), 397–403. https://doi.org/10.4067/S0718-58392014000400004

Díaz-José, O., Aguilar-Ávila, J., Rendón-Medel, R., & Santoyo-Cortés, V. H. (2013). Situación actual y perspectivas de la producción de cacao en México. *Ciencia e Investigacion Agraria*, *40*(2), 279–289. https://doi.org/10.4067/S0718-16202013000200004

Donovan, J., Blare, T., & Poole, N. (2017). Stuck in a rut: emerging cocoa cooperatives in Peru and the factors that influence their performance. *International Journal of Agricultural Sustainability*, *15*(2), 169–184. https://doi.org/10.1080/14735903.2017.1286831

Dormon, E. N. A., Van Huis, A., Leeuwis, C., Obeng-Ofori, D., & Sakyi-Dawson, O. (2004). Causes of low productivity of cocoa in Ghana: Farmers' perspectives and insights from research and the socio-political establishment. *NJAS - Wageningen Journal of Life Sciences*, *52*(3–4), 237–259. https://doi.org/10.1016/S1573-5214(04)80016-2

Dunning, C. M., Black, E., & Allan, R. P. (2018). Later wet seasons with more intense rainfall over Africa under future climate change. *Journal of Climate*, *31*(23), 9719–9738. https://doi.org/10.1175/JCLI-D-18-0102.1

Effendy, Fardhal Pratama, M., Rauf, R. A., Antara, M., Basir-Cyio, M., Mahfudz, & Muhardi. (2019). Factors influencing the efficiency of cocoa farms: A study to increase income in rural Indonesia. *PLoS ONE*, *14*(4). https://doi.org/10.1371/journal.pone.0214569

Ehiakpor, D. S., Danso-Abbeam, G., Baah, J. E. et al. (2016). Assessment of climate change impacts on cocoa roduction and approaches to adaptation and mitigation: A contextual view of Ghana and Costa Rica. *Environment, Development and Sustainability*, *14*(1), 1210557. Retrieved from http://dx.doi.org/10.1080/23311932.2016.1210557

Ehiakpor, D. S., Danso-Abbeam, G., Zutah, J. et al. (2016). Adoption of farm management practices by smallholder cocoa farmers in Prestea Huni-Valley district, Ghana. *Russian Journal of Agricultural and Socio-Economic Sciences*, *53*(5), 117–124.

End, M.J., Daymond, A.J. & Hadley, P. Eds. (2017). Technical guidelines for the safe movement of cacao germplasm. Third Update. Bioversity International. https://www.cacaonet.org/information-resources/publications-and-reports/publication/technical-guidelines-for-the-safe-movement-of-cacao-germplasm

English, A. (2008). Determinants for Liberian farmgate cocoa prices. Masters Thesis, University of Tennessee. https://doi.org/10.13140/RG.2.1.2769.3280

Eschavarría, R.A., Vasquez, A.G. & Baena, J.A.A. (2010). Análisis socioeconómico del sector cacaotero Colombiano. Thesis. Universidade EIA. Available at: https://repository.eia.edu.co/

Escobedo Aguilar, A. (2010). Cadena productiva de cacao de Nicaragua. Proyecto Cacao Centroamérica. http://agronegocios.catie.ac.cr/images/pdf/cadena%20productiva%20nicaragua.pdf

Espinoza, S., Olivera, M., Ledezma, J. (2014). Producción del cacao y del chocolate en Bolivia. Datos 2010-2013 en base a encuestas a productores y empresarios chocolateros. https://www.conservation-strategy.org/sites/default/files/field-file/Produccion_del_cacao_y_del_chocolate_en_Bolivia.pdf

La Paz. Conservación Internacional Bolivia y Conservation Strategy Fund.

Estupiñan V. (2011). Matriz de potencialidades y debilidades del eje de comercialización del sector cacaotero del canton Río Verde, provincia de Esmeraldas en el periodo Abril 2011 a Julio 2011. Instituto de Altos Estudios Nacionale. Quito, Ecuador.

Estival, K. G. S., Corrêa, S. R. S., Mariani, M. A. P., & Benini, M. A. P. (2016). Análisis de la participación de los productores de la agricultura familiar de los asentamientos y comunidades rurales del Sur de Bahía, Brasil, en la Cadena de Valor del Cacao (Chocolate). *Revista Espacios*, *37*,17. https://revistaespacios.com/a16v37n17/16371702.html

Everaert, H., De Wever, J., Tang, T. K. H. et al. (2020). Genetic classification of Vietnamese cacao cultivars assessed by SNP and SSR markers. *Tree Genetics and Genomes*, *16*(3), 1–11. https://doi.org/10.1007/s11295-020-01439-x

Eyitayo, O. A., Chris, O., Ejiola, M. T., & Enitan, F. T. (2011). Technical efficiency of cocoa farms in Cross River State, Nigeria. *African Journal of Agricultural Research*, *6*(22), 5080–5086. https://doi.org/10.5897/AJAR11.594

Fadzim, W. R., Aziz, M. I. A., & Jalil, A. Z. A. (2017). Determinants of technical efficiency of cocoa farmers in Malaysia. *International Journal of Supply Chain Management*, *6*(1), 254–258.

Faheem, M. (2019). Improved management strategies for cocoa in Papua New Guinea. Project summary. https://www.cabi.org/projects/improved-management-strategies-for-cocoa-in-papua-new-guinea/

FAO. (2018). Rural youth employment and agri – food systems in Uganda. http://www.fao.org/3/ca5739en/CA5739EN.pdf

FAO. (2021). FAO statistics. www.fao.org/faostat/en/#home

FEDECACAO. (2019). Survey of farm members.

Fidelis, C., & Rajashekhar Rao, B. K. (2017). Enriched cocoa pod composts and their fertilizing effects on hybrid cocoa seedlings. *International Journal of Recycling of Organic Waste in Agriculture*, *6*(2), 99–106. https://doi.org/10.1007/s40093-017-0156-8

Fleming, E., & Milne, M. (2003). Bioeconomic modelling of the production and export of cocoa for price policy analysis in Papua New Guinea. *Agricultural Systems*, *76*(2), 483–505. https://doi.org/10.1016/S0308-521X(02)00078-1

Fonta, W. M., Kedir, A. M., Bossa, A. Y., Greenough, K. M., Sylla, B. M., & Ayuk, E. T. (2018). A Ricardian valuation of the impact of climate change on Nigerian cocoa production: Insight for adaptation policy. *International Journal of Climate Change Strategies and Management*, *10*(5), 689–710. https://doi.org/10.1108/IJCCSM-05-2016-0074

Furcal-Beriguete, P., & Torres-Morales, J. L. (2020). Determinación de concentraciones de cadmio en plantaciones de *Theobroma cacao* L. en Costa Rica. *Revista Tecnología En Marcha*, *33*(1), 122–137. https://doi.org/10.18845/tm.v33i1.5027

Pabón, M.G., Herrera-Roa, L.I., & Sepúlveda, W.S. (2016). Caracterizacion socio-económica y productiva del cultivo de cacao en el departamento de Santander (Colombia). *Revista Mexicana de Agronegocios*, *38*, 283-294.

GABON. (n.d.). https://www.wto.org/english/tratop_e/tpr_e/s285-02_e.pdf

Gamarra, G.C. (2012). Asistencia técnica dirigida en manejo integrado del cultivo de cacao. http://infocafes.com/portal/wp-content/uploads/2016/05/010-f-cacao.pdf

Garnevska, E., Joseph, H., & Kingi, T. (2014). Development and challenges of cocoa cooperatives in Papua New Guinea: case of Manus province. *Asia Pacific Business Review*, *20*(3), 419–438. https://doi.org/10.1080/13602381.2014.931046

Gateau-Rey, L., Tanner, E. V. J., Rapidel, B., Marelli, J.-P., & Royaert, S. (2018). Climate change could threaten cocoa production: Effects of 2015-16 El Niño-related drought on cocoa agroforests in Bahia, Brazil. *PLOS ONE*, *13*(7), e0200454. https://doi.org/10.1371/journal.pone.0200454

Gil, M., Llano, S., Jaramillo, Y., Quijano, J., & Londono-Londono, J. (2020). Matrix effect on quantification of sugars and mannitol developed during the postharvest of cocoa: an alternative method for traceability of aroma precursors by liquid chromatography with an evaporative detector. *Journal of Food Science and Technology*, *57*(1), 210–221. https://doi.org/10.1007/s13197-019-04049-1

Gockowski, J., & Sonwa, D. (2011). Cocoa intensification scenarios and their predicted impact on $CO_2$ emissions, Bbiodiversity conservation, and rural livelihoods in the Guinea rain forest of West Africa. *Environmental Management*, *48*, 307–321. https://doi.org/10.1007/s00267-010-9602-3

Goldstein, M. J., Hiscox, & Goldstein, R. (2014). Gender Inequality in the Ghanaian Cocoa Sector, 1–8. Report available at: https://www.cocoalife.org/progress/gender-inequality-in-the-ghanaian-cocoa-sector

Gomez, A., & Azócar, A. (2002). Áreas potenciales para el desarrollo del cultivo cacao en el Estado Mérida. *Agronomía Tropical*, *54*, 4. http://ve.scielo.org/scielo.php?script=sci_arttext&pid=S0002-192X2002000400001

Gonzalez, M.L. (2012). Innovative training in cocoa agroforestry: the farmer field schools of Nicaragua. *En Breve*. The World Bank. https://documents1.worldbank.org/curated/en/572411468097459087/pdf/682660BRI0Box30nBreve01750Printable.pdf

Google. (n.d.). Soil types, formation & mapping - Costa Rica. https://sites.google.com/site/costaricansoil/soil-formation

Gopaulchan, D., Motilal, L. A., Bekele, F. L., Clause, S., Ariko, J. O., Ejang, H. P., & Umaharan, P. (2019). Morphological and genetic diversity of cacao (*Theobroma cacao* L.) in Uganda. *Physiology and Molecular Biology of Plants*, *25*(2), 361–375. https://doi.org/10.1007/s12298-018-0632-2

Graham, B. (2012). Profile of the Small-Scale Farming in the Caribbean. *Workshop on Small-Scale Farming in the Caribbean*. http://www.fao.org/3/au343e/au343e.pdf

GrowLiberia (2016). Cocoa Market Systems Analysis. https://www.growliberia.com/resources/cocoa

Guéi, A. M., N'Dri, J. K., Zro, F. G. B., Bakayoko, S., & Tondoh, J. E. (2019). Relationships between soil morpho-chemical parameters and earthworm community attributes in tropical agro-ecosystems in the Centre-West region of Côte d'Ivoire, Africa. *Tropical Ecology*, *60*(2), 209–218. https://doi.org/10.1007/s42965-019-00021-4

Guiraud, B. S. H. B., Tahi, M. G., Fouet, O. et al. (2018). Assessment of genetic diversity and structure in cocoa trees (*Theobroma cacao* L.) in Côte d'Ivoire with reference to their susceptibility to Cocoa swollen shoot virus disease (CSSVD). *Tree Genetics and Genomes*, *14*(4), 1–21. https://doi.org/10.1007/s11295-018-1264-y

Gumucio, T., Yore, H., Mello, D. G., & Loucel, C. (2016). Coffee and cocoa value chains: Gender dynamics in Peru and Nicaragua. *CIAT Publication No. 434*. https://core.ac.uk/download/pdf/132687835.pdf

Gutiérrez Garcia, G.A., Gutiérrez-Montes, I., Hernández Nunez, H.E., Suarez-Salazar, J.C. & Casonoves, F. (2020). Relevance of local knowledge in decision-making and rural innovation: A methodological proposal for leveraging participation of Colombian cocoa producers. *Journal of Rural Studies*, *75*, 119-124.

Gyau, A. Smoot, K. & Kouame, C. Diby, L., Kahia, J. & Ofori, D. (2014). Farmer attitudes and intentions towards trees in cocoa (*Theobroma cacao* L.) farms in Côte d'Ivoire. *Agroforestry Systems*, *88*, 1035-1045. DOI 10.1007/s10457-014-9677-6

Hainmueller, J., Hiscox, M. J., & Tampe, M. (2011). Sustainable development for cocoa farmers in Ghana. *International Growth Centre Working Paper*, (January), 1–59.

Hamrick, D., Fernandez-Stark, K. & Gereffi, G. (2017). The Philippines in the cocoa- chocolate global value chain. Report prepared for USAID. http://industry.gov.ph/wp-content/uploads/2017/08/The-Philippines-in-the-Cocoa-Global-Value-Chain.pdf

Hartemink, A. E. (2003). Soil fertility decline in the tropics: with case studies on plantations. CABI. https://doi.org/10.1079/9780851996707.0000

Haynes, J., Cubbage, F., Mercer, E., & Sills, E. (2012). The search for value and meaning in the cocoa supply chain in Costa Rica. *Sustainability*, *4*(7), 1466–1487. https://doi.org/10.3390/su4071466

Hernández- Hernández, C., López-Andrade, P. A., Ramírez-Guillermo, M. A., Guerra Ramírez, D., & Caballero Pérez, J. F. (2016). Evaluation of different fermentation processes for use by small cocoa growers in mexico. *Food Science & Nutrition*, *4*(5), 690–695. https://doi.org/10.1002/fsn3.333

Hernández, E., Hernández, J., López, G., Garrido, E., Romero, J., & Nava, C. (2015). Factores socieconómicos y parasitológicos que limitan la producción del cacao en Chiapas, México. *Revista Mexicana de Fitopatología*, *33*(2), 16.

Hes, T., Mintah, S., Sulaiman, H., Banda, J., Ramírez, J., Martínez, T., & Aguirre, J. (2017). (PDF) The falling production of Mexican cacao analyzed through the lens of mincerian earnings function in the context of social capital of smallholders. *Revista de La Facultad de Ciencias Agrarias*, 19.

Higuchi, A., Moritaka, M., & Fukuda, S. (2015). Socio-economic characteristics impact on Peruvian Cocoa Farmers' Welfare: Acopagro Cooperative-A Case Study. *Agrarian Perspectives*, *2015*, 71–76.

Hii, C. L., Law, C. L., Cloke, M., & Sharif, S. (2011). Improving Malaysian cocoa quality through the use of dehumidified air under mild drying conditions. *Journal of the Science of Food and Agriculture*, *91*(2), 239–246. https://doi.org/10.1002/jsfa.4176

Hoffmann, M. P., Cock, J., Samson, M. et al. (2020). Fertilizer management in smallholder cocoa farms of Indonesia under variable climate and market prices. *Agricultural Systems*, *178*, 102759. https://doi.org/10.1016/j.agsy.2019.102759

Hofman, P. (n.d.). Opportunities for the Sierra Leone cocoa sector. https://knowledge4food.net/wp-content/uploads/2016/12/2016_BL_PolicyBrief.pdf

Hütz-Adams, F. (2017). Alternative approaches to achieve a living income: A roadmap for flexible premiums. Available at: http://www.cocoaconnect.org/publication/alternative-approaches-achieve-living-income-roadmap-flexible-premiums

ICCO. (2021). Production statistics. www.icco.org

INFOAGRO (n.d.). http://infoagrocr.blogspot.com/2019/02/cacao-costarricense-obtiene.html

IPCC (2014). Summary for policymakers. In: Climate Change 2014: Impacts,Adaptation, and Vulnerability.Part A: Global and Sectoral Aspects. https://www.ipcc.ch/site/assets/uploads/2018/02/ar5_wgII_spm_en.pdf

IICA. (2017). Manual técnico del cultivo de cacao Buenas prácticas para América Latina. Instituto Interamericano de Cooperación para la Agricultura. https://agroavances.com/img/publicacion_documentos/BVE17089191e_1.pdf

International Trade Centre. (2014). National Export Strategy: Cocoa Export Strategy 2014-2018. *Republic of Liberia and International Trade Center*. https://www.moci.gov.lr/doc/Liberia_National_Cocoa_Export_Strategy2014_2018.pdf

Jacobi, J., Andres, C., Schneider, M., Pillco, M., Calizaya, P., & Rist, S. (2014). Carbon stocks, tree diversity, and the role of organic certification in different cocoa production systems in Alto Beni, Bolivia. *Agroforestry Systems*, *88*(6), 1117–1132. https://doi.org/10.1007/s10457-013-9643-8

Jacobi, J., Schneider, M., Pillco Mariscal, M., Huber, S., Weidmann, S., Bottazzi, P., & Rist, S. (2015). Farm resilience in organic and nonorganic cocoa farming systems in Alto Beni, Bolivia. *Agroecology and Sustainable Food Systems*, *39*(7), 798–823. https://doi.org/10.1080/21683565.2015.1039158

Jaganathan, D., Thamban, C., Jose, C.T., Jayasekhar, S., Muralidharan, K. & Chandran, K.P. (2015). Analysis of organic farming practices in cocoa in India. *Journal of Plantation Crops*, *43*(2):131-138.

Jagoret, P., Kwesseu, J., Messie, C., Michel-Dounias, I., & Malézieux, E. (2014). Farmers' assessment of the use value of agrobiodiversity in complex cocoa agroforestry systems in central Cameroon. *Agroforestry Systems*, *88*(6), 983–1000. https://doi.org/10.1007/s10457-014-9698-1

Jalloh, A., Rhodes, E., Kollo, I., Roy-Macauley, H., & Sereme, P. (2011). Nature and management of the soils in West and Central Africa. A review to inform farming systems research and development in the region. Conseil Ouest et Centre Africain pour la Recherche et le Development Agricoles/West and Central African Council for Agricultural Research and Development (CORAF/WECARD). CORAF/WECARD,Dakar, Senegal. http://www.coraf.org/documents/NATURE%20AND%20MANAGEMENT%20OF%20SOILS%20IN%20WCA.pdf

Jaramillo-Villanueva, J. L., Córdova-Lázaro, C. E., & Córdoba-ávalos, V. (2018). Willingness to pay for cultural attributes in handmade chocolates from the Chontalpa region, Tabasco, México. *Economia Agraria y Recursos Naturales*, *18*(2), 53–73. https://doi.org/10.7201/earn.2018.02.03

Jiménez-Pérez, A., Cach-Pérez, M. J., Valdez-Hernández, M., & de la Rosa-Manzano, E. (2019). Effect of canopy management in the water status of cacao (*Theobroma cacao*) and the microclimate within the crop area. *Botanical Sciences*, *97*(4), 701–710. https://doi.org/10.17129/botsci.2256

Johnson, E. S., Bekele, F. L., Brown, S. J., Song, Q., Zhang, D., Meinhardt, L. W., & Schnell, R. J. (2009). Population structure and genetic diversity of the Trinitario cacao (Theobroma cacao L.) from Trinidad and Tobago. *Crop Science*, *49*(2), 564–572. https://doi.org/10.2135/cropsci2008.03.0128

Jones, S., & Gibbon, P. (2011). Developing agricultural markets in sub-Saharan Africa: Organic cocoa in rural Uganda. *Journal of Development Studies*, *47*(10), 1595–1618. https://doi.org/10.1080/00220388.2011.579107

Kamanyire, M. (2000). Natural resource management and policy in Uganda: Overview paper. Economic Policy Research Centre. https://assets.publishing.service.gov.uk/media/57a08d70e5274a27b200184f/3Kamanyire.pdf

Kerua, W., & Glyde, S. (2016). Beyond the cocoa farm: a new look at farmers' choices in livelihood activities and impact on productivity in selected areas of Papua New Guinea. *Rural Extension Farming Systems Journal*, *12*(1), 1–11.

Kiewisch, M., & Waarts, Y. R. (2020). No silver bullets: Closing the $10 billion income gap in cocoa calls for cross-sector action. Wageningen Economic Research. https://www.cocoalife.org/~/media/CocoaLife/en/download/article/no-silver-bullets-executive-summary-paper-by-mdlz-cocoa-life-and-wageningen-university-november-2020.pdf

Klarer, A. J. (2014). The evolution and expansion of cacao farming in south west Cameroon and its effects on local livelihoods. Masters Thesis. Copenhagen University. https://afs4food.cirad.fr/content/download/4549/34434/version/1/file/Klarer,+Evolution+of+cacao-AFS+&+effect+on+local+livelyhood+SW+Cameroon.pdf

Koko, L. (2014). Teractiv Cacao as a new fertilizer based reactive phosphate rock for cocoa productivity in Côte d'Ivoire: A participatory approach to update fertilization recommendation. *Procedia Engineering*, 83, 348–353.

https://doi.org/10.1016/j.proeng.2014.09.027

Kokoye, S., Molnar, J., Jolly, C., Shannon, D., & Huluka, G. (2018). Farmer knowledge and willingness to pay for soil testing in Haiti. *International Journal of Social Economics*, *45*(7), 1109–1121. https://doi.org/10.1108/IJSE-02-2017-0048

Kouassi, D. (2014). Study of the agro-morphological diversity of plant material used by cocoa farmers (*Theobroma cacao* (L.), Malvaceae)] from the Nawa region of Côte d'Ivoire. Thesis. Université Virtuelle de Côte d'Ivoire.

Krishnamoorthy, C., Rajamani, K., Mekala, S., & Rameshkumar, S. (2015). Fertigation through trickle and micro sprinkler on flowering characters in cocoa (*Theobroma cacao* L.). *Scientific Research and Essays*, *10*(7), 266–272. https://doi.org/10.5897/SRE2015.6155

LACE. (2014). Environmental and social management Fframework (ESMF). Report available at: https://documents1.worldbank.org/curated/en/701741468055445382/pdf/E46040EA0Liber0Box385270B00PUBLIC0.pdf

Lahive, F., Hadley, P., & Daymond, A. J. (2018). The impact of elevated $CO_2$ and water deficit stress on growth and photosynthesis of juvenile cacao (*Theobroma cacao* L.). *Photosynthetica*, *56*(3), 911–920. https://doi.org/10.1007/s11099-017-0743-y

Laird, S. A., Awung, G. L., & Lysinge, R. J. (2007). Cocoa farms in the Mount Cameroon region: Biological and cultural diversity in local livelihoods. *Biodiversity and Conservation*, *16*(8), 2401–2427. https://doi.org/10.1007/s10531-007-9188-0

Lans, C. (2018). A review of the plant-based traditions of the cocoa panyols of Trinidad. *GeoJournal*, 83, 1425-1454. https://doi.org/10.1007/s10708-017-9835-2

Laroche, K., Jiménez, R., & Nelson, V. (2012). Assessing the impact of fairtrade for Peruvian cocoa farmers. Natural Resources Institute, University of Greenwich. Available at: https://files.fairtrade.net/publications/2012_FairtradeImpactCocoaPeru.pdf

Lasco, R. D., Sales, R. F., Estrella, R., Saplaco, S. R., Castillo, A. S. A., Cruz, R. V. O., & Pulhin, F. B. (2001). Carbon stock assessment of two agroforestry systems in a tropical forest reserve in the Philippines. *Philippine Agricultural Scientist*, *84*(4), 401–407.

Leal, F., Avilán, L., & Valderrama, E. (1999). Areas potenciales para el desarrollo *del* cacao en Venezuela. *Agroalimentaria*, *8*. https://www.researchgate.net/publication/44449196_Areas_potenciales_para_el_desarrollo_del_cacao_en_Venezuela

Leakey, R. R. B. (1996). Definition of agroforestry revisited. *Agroforestry Today*, *8*(1), 5-7

Leyte, J. E. D., Pacardo, E. P., Rebancos, C. M., Protacio, C. M., & Alcantara, A. J. (2017). Environmental performance of cacao (*Theobroma cacao* L.) Production and primary processing. *Philippine Journal of Crop Science (PJCS)2*, *42*(1), 51–58.

Lockwood, G. (2015). Report of cacao planting materials from various cocoa-growing countries. In B. Laliberté & M. J. End (Eds.), A review of propagation methodologies (pp. 121–150). Bioversity International, Rome.

López Acevedo, J. J. (2019). Competitividad comercial del cacao (*Theobroma cacao* L.), en el mercado de Nicaragua, Guatemala, Hondura, Panamá, Costa Rica y El Salvador en el periodo del 2011-2015. *REICE: Revista Electrónica de Investigación En Ciencias Económicas*, *7*(13), 60–76. https://doi.org/10.5377/reice.v7i13.8172

Löwe, A. (2017). Creating opportunities for young people in Ghana's cocoa sector. Overseas Development Institute, Working Paper 15. www.pdaghana.com/images/opinion_papers/2017/Creating%20Opportunities%20for%20Youth%20in%20Ghana.pdf

Lutheran World Relief. (2015). Players and stakeholders in the cocoa value chain of Bundibugyo. *Mountains of the Moon University*, *2015*(6), 1–25. https://mmumf.files.wordpress.com/2015/10/2015-05-27-occasional_papers_no_6-lwr.pdf

Maharaj, K. (2012). cacao breeding and planting material situation in Trinidad and Tobago and some of the other carribean islands. In *INGENIC 7th Workshop: Cocoa variety development and the supply of planting materials to farms*. Yaonde, Cameroon.

Maharaj, S., Pemberton, C., De Sormeaux, A., & Patterson-Andrews, H. (2018). Are Cocoa Farmers in Trinidad Happy? Exploring Factors Affecting their Happiness. *The Journal of the Caribbean Agro-Economic Society*, *10*(2), 14-32.

Malhotra, S. K., & Elain Apshara, S. (2017). Genetic resources of cocoa (*Theobroma cacao* L.) and their utilization-an appraisal. *Indian Journal of Genetics and Plant Breeding*, *77*(2), 199–213. https://doi.org/10.5958/0975-6906.2017.00027.X

Manga Essouma, F., Michel, I., Mala, W. A. et al. (2020a). Cocoa-based agroforestry system dynamics and trends in the Akongo subregion of central Cameroon. *Agroforestry Systems*, 1–12. https://doi.org/10.1007/s10457-020-00510-9

Marconi, L., & Armengot, L. (2020). Complex agroforestry systems against biotic homogenization: The case of plants in the herbaceous stratum of cocoa production systems. *Agriculture, Ecosystems and Environment*, *287*, 106664. https://doi.org/10.1016/j.agee.2019.106664

Marfu, J. (2015). Development and selection of new clones of CPB tolerance in PNG. In *Asia-Pacific Regional Cocoa Research Workshop*. Davao, Philippines.

Maridueña, R.L. & Freire, G.G. (2006). Diversidad vegetal asociada a las zonas agroecológicas del Litoral del Ecuador. Report available at: https://www.dspace.espol.edu.ec/bitstream/123456789/1656/1/3263.pdf

Martínez, A. (2000). Análisis de los sistemas agrarios de una pequeña zona rural de la Costa ecuatoriana. Mocache, provincia Los Ríos, Ecuador.

Mata Anchundia, D., Rivero Herrada, M., & Segovia Montalvan, E. (2018). Sistemas agroforestales con cultivo de cacao fino de aroma: entorno socio-económico y productivo. *Revista Cubana de Ciencias Forestales: CFORES*, *6*(1), 103–115.

Mbenoun, M., Zeutsa, E. H. M., Samuels, G., Amougou Nsouga, F., & Nyasse, S. (2007). Dieback due to *Lasiodiplodia theobromae*, a new constraint in Camerron. *New Disease Reports*, *15*, 59.

MCP. (2017). Mapping cocoa productivity. A project conducted by the University of Reading, the Cocoa Research Institute of Ghana and the Indonesian Coffee and Cocoa Research Institute and supported by Mondelez International.

Meludu, N. T., Elijah, B., Okanlawon, O. M., & Olanrewaju, P. O. (2017). Perceived effect of agricultural transformation agenda on livelihood of cocoa farmers in Osun State, Nigeria. *Journal of Agricultural Extension*, *21*(2), 17–29. https://doi.org/10.4314/jae.v21i2.2

Meter, A., Atkinson, R. J., & Laliberte, B. (2019). Cadmium in Cacao from Latin America and the Caribbean – A Review of Research and Potential Mitigation Solutions. Bioversity International, Rome.

Ministerio de Agricultura (2003). Manuel de cultivo del cacao. https://repositorio.midagri.gob.pe/bitstream/MIDAGRI/372/1/cacao%20-%20copia.pdf

Mithöfer, D., Roshetko, J. M., Donovan, J. A. et al. (2017). Unpacking 'sustainable' cocoa: do sustainability standards, development projects and policies address producer concerns in Indonesia, Cameroon and Peru? *International Journal of Biodiversity Science, Ecosystem Services and Management*, *13*(1), 444–469. https://doi.org/10.1080/21513732.2018.1432691

Morales Intriago F.L. (2013). Los productores de cacao de tipo Nacional en la provincia de Los Ríos, Ecuador: Un análisis socio económico. Programa de Postgrado en Extension Rural. Masters Theis, University of Vicosa, Brazil. https://www.locus.ufv.br/bitstream/123456789/4193/1/texto%20completo.pdf

Moreno-Miranda, C., Jordán, J., Moreno, R., Moreno, P., & Solis, J. (2019). Protected Designation of Origin and Sustainability Characterization: The Case of PDO Cocoa Arriba. *Agriculture*, *9*(10), 229. https://doi.org/10.3390/agriculture9100229

Morett-Sánchez, J.C., & Celsa Cosío-Ruiz, C. (2017). Panorama de los ejidos y comunidades agrarias en México. Agricultura, sociedad y desarrollo, 14, 125-152.

Moriarty, K., Elchinger, M., Hill, G., & Katz, J. (2014). Cacao Intensification in Sulawesi : A Green Prosperity Model Project. Report Available at: https://www.nrel.gov/docs/fy14osti/62434.pdf

Muilerman, S., & Vellema, S. (2017). Scaling service delivery in a failed state: cocoa smallholders, Farmer Field Schools, persistent bureaucrats and institutional work in Côte d'Ivoire. *International Journal of Agricultural Sustainability*, *15*(1), 83–98. https://doi.org/10.1080/14735903.2016.1246274

Mulia, S., McMahon, P., Purwantaeas, A. et al. (2019). Effect of organic and inorganic amendments on productivity of cocoa on marginal soil in Sulawesi, Indonesia. *Experimental Agriculture*, *55*, 1–20.

Naranjo-Merino, C. A., Ortíz-Rodriguez, O. O., & Villamizar-G, R. A. (2017). Assessing Green and Blue Water Footprints in the Supply Chain of Cocoa Production: A Case Study in the Northeast of Colombia. *Sustainability*, *10*(1), 1–9.

Nasser, F., Maguire-Rajpaul, V. A., Dumenu, W. K., & Wong, G. Y. (2020). Climate-Smart Cocoa in Ghana: How Ecological Modernisation Discourse Risks Side-Lining Cocoa Smallholders. *Frontiers in Sustainable Food Systems*, *4*, 73. https://doi.org/10.3389/fsufs.2020.00073

Ndoumbè-Nkeng, M., Efombagn, M. I. B., Nyassé, S., Nyemb, E., Sache, I., & Cilas, C. (2009). Relationships between cocoa Phytophthora pod rot disease and climatic variables in Cameroon. *Canadian Journal of Plant Pathology*, *31*(3), 309–320. https://doi.org/10.1080/07060660909507605

Niether, W., Armengot, L., Andres, C., Schneider, M., & Gerold, G. (2018). Shade trees and tree pruning alter throughfall and microclimate in cocoa (Theobroma cacao L.) production systems. *Annals of Forest Science*, *75*(2), 1–16. https://doi.org/10.1007/s13595-018-0723-9

Notaro, M., Gary, C., & Deheuvels, O. (2020). Plant diversity and density in cocoa-based agroforestry systems: how farmers' income is affected in the Dominican Republic. *Agroforestry Systems*, *94*(3), 1071–1084. https://doi.org/10.1007/s10457-019-00472-7

Oakland, & AFSA. (2008). Organic cocoa in Sierra Leone. Agroecology case studies. Available at: https://www.oaklandinstitute.org/sites/oaklandinstitute.org/files/Organic_Cocoa_Sierra_Leone.pdf

Ofori, A., Padi, F. K., & Amoako-Attah, I. (2020). Field evaluation of cacao progenies derived from Guiana clones for yield and black pod disease resistance. *Crop Science*, *60*(1), 249–261. https://doi.org/10.1002/csc2.20101

Ojo, T. F., Kolodeye, G. F., & Oladele, T. S. (2019). Agrochemical based information usage among farmers: A pathway to sustainable cocoa production in Osun state. *Scientific Papers Series - Management, Economic Engineering in Agriculture and Rural Development*, *19*(1), 331–338.

Oro, F.Z., Bonnot, F., Ngo-Bieng, M.-A.Delaitred, E., Dufoura, B.P., Ametefee, K.E., Mississoe, E., Wegbee, J., Muller, E. & Cilas, C. (2012). Spatiotemporal pattern analysis ofCacao swollen shootvirusin experimental plots in Togo. *Plant Pathology*, *61*, 1043–1051.

Omar, S. C., Bee, Y. G., & Sazali, N. T. (2018). A Monograph of a Malaysian Cocoa Smallholder: Technical Report. Khazanah Research Institute, Working paper 1/18. http://www.krinstitute.org/assets/contentMS/img/template/editor/20180213_Working%20Paper_Cocoa%20Smallholder.pdf

Ongolo, S., Kouassi, S. K., Chérif, S., & Giessen, L. (2018). The tragedy of forestland sustainability in postcolonial Africa: Land development, Cocoa, and politics in Côte d'Ivoire. *Sustainability (Switzerland)*, *10*(12), 1–17. https://doi.org/10.3390/su10124611

Opoku, I., Appiah, A., Akrofi, A., & Owusu, G. (2000). *Phytophthora megakarya*: A potential threat to the cocoa industry in Ghana. *Ghana Journal of Agricultural Science*, *33*(2), 237–248. https://doi.org/10.4314/gjas.v33i2.1876

Orbegoso, E. M., Saavedra, R., Marcelo, D., & La Madrid, R. (2017). Numerical characterisation of one-step and three-step solar air heating collectors used for cocoa bean solar drying. *Journal of Environmental Management*, *203*, 1080–1094.

https://doi.org/10.1016/j.jenvman.2017.07.015

Osas, U. E., Meludu, N. T., & Omiunu Agbebaku, E. E. (2016). Adoption of integrated pest management among cocoa farmers in cross river and Osun States of Nigeria. *Journal of Agricultural Extension*, *20*(2), 188–201. https://doi.org/10.4314/jae.v20i2.14

Pabón, M.G., Herrera-Roa, L.I., & Sepúlveda, W.S. (2016). Caracterizacion socio-económica y productiva del cultivo de cacao en el departamento de Santander (Colombia). *Revista Mexicana de Agronegocios*, *38*, 283-294.

Parra, D., Pérez, S., Sosa, D., Rumbos, R., Gutiérrez, B., & Moya, A. (2009). Avances en las investigaciones venezolanas sobre enfermedades del cacao. *RET. Revista de Estudios Transdisciplinarios*, *1*. Available at: https://www.researchgate.net/publication/51994792_Avances_en_las_investigaciones_venezolanas_sobre_enfermedades_del_cacao

Pauwels, A. (2016). Review of the Quality Potential of Cocoa in Southern Vietnam. Masters thesis. Gent University. https://libstore.ugent.be/fulltxt/RUG01/002/305/175/RUG01-002305175_2016_0001_AC.pdf

Payne, M. J., Hurst, W. J., Miller, K. B., Rank, C., & Stuart, D. A. (2010). Impact of fermentation, drying, roasting, and dutch processing on epicatechin and catechin content of cacao beans and cocoa ingredients. *Journal of Agricultural and Food Chemistry*, *58*(19), 10518–10527. https://doi.org/10.1021/jf102391q

Pereira, L. M. P., Boysielal, K., & Siung-Chang, A. (2007). Pesticide regulation, utilization, and retailers' selling practices in Trinidad and Tobago, West Indies: Current situation and needed changes. *Revista Panamericana de Salud Publica/Pan American Journal of Public Health*, *22*(2), 83–90. https://doi.org/10.1590/S1020-49892007000700002

Peter, P. K., & Chandramohanan, R. (2011). Occurence and distribution of cocoa (*Theobroma cacao* L.) diseases in India. *The Journal of Research ANGRAU*, *39*(4), 44–50.

Phayanak. (n.d.). Where is cocoa grown around the world? | Chocolate Phayanak. https://chocolatephayanak.com/unkategorisiert/where-is-cocoa-grown-around-the-world/

Phuc, C. N. (2013). Quality of Vietnamese cocoa liquor and butter. Masters Thesis, University of Gent. http://www.cocoaconnect.org/sites/default/files/publication/RUG01-002063615_2013_0001_AC.pdf

Poveda, V., Orozco, L., Medina, C., Cerda, R., & Lopez, A. (2013). Almacenamiento de carbono en sistemas agroforestales de cacao en Waslala, Nicaragua. *Agroforestería en las Américas*, *49*. Available at: http://repositorio.bibliotecaorton.catie.ac.cr/bitstream/handle/11554/5760/Almacenamiento_de_carbono_en_sistemas_agroforestales.pdf;sequence=1.

Puentes-Páramo, Y. J., Menjivar-Flores, J. C., & Aranzazu-Hernández, F. (2016). Concentración de nutrientes en hojas, una herramienta para el diagnóstico nutricional en cacao. *Agronomía Mesoamericana*, *27*(2), 329. https://doi.org/10.15517/am.v27i2.19728

Quaye, W., Ampadu, R., & Onumah, J. A. (2014). Review of existing land tenure arrangements in cocoa growing areas and their implications for the cocoa sector in Ghana. Available at: https://www.semanticscholar.org/paper/Review-of-Existing-Land-Tenure-Arrangements-in-And-Onumah-Sarpong/f42584f76b1c5114d0eea54ab09ff82b781a9852

Quilloy, K. P. (2015). Empowering Small Farmers through Cooperative: The Success Story of Subasta Integrated Farmers Multi-Purpose Cooperative. *International Review of Management and Business Research*, *4*(1), 361–375.

Ramírez, P. 2006. Estructura y dinámica de la Cadena del Cacao en el Ecuador: Sistematizacion de Información y Procesos en marcha. GTZ. Available from: http://infocafes.com/portal/biblioteca/estructura-y-dinamica-en-la-cadena-de-cacao-en-el-ecuador-sistematizacion-de-informacion-y-procesos-en-marcha-2/

Ramtahal, G., Chang Yen, I., Bekele, I., Bekele, F., Wilson, L., Maharaj, K., & Sukha, B. (2015). Implications of distribution of cadmium between the nibs and testae of cocoa beans on its marketability and food safety assessment. *Quality Assurance and Safety of Crops and Foods*, *7*(5), 731–736. https://doi.org/10.3920/QAS2013.0388

Riedel, J., Kägi, N., Armengot, L., & Schneider, M. (2019). Effects of rehabilitation pruning and agroforestry on cacao tree development and yield in an older full-sun plantation. *Experimental Agriculture*, *55*(6), 849–865. https://doi.org/10.1017/S0014479718000431

Ruf, F.O. (2016). Mineral and Organic fertilization stories in Côte d ' Ivoire Reinternalization of deforestation-led externalized costs. *ICCO World Cocoa Conference*.

Ruf, F. O. & Paulin, D. (2005). The Success Alliance cocoa project in Vietnam. Contribution to its monitoring and evaluation system. CIRAD Technical Report. Available at: https://www.researchgate.net/publication/296835061

Ryan, D., Bright, G. A., & Somarriba, E. (2009). Damage and yield change in cocoa crops due to harvesting of timber shade trees in Talamanca, Costa Rica. *Agroforestry Systems*, *77*(2), 97–106. https://doi.org/10.1007/s10457-009-9222-1

Salazar, O. V., Ramos-Martín, J., & Lomas, P. L. (2018). Livelihood sustainability assessment of coffee and cocoa producers in the Amazon region of Ecuador using household types. *Journal of Rural Studies*, *62*, 1–9. https://doi.org/10.1016/j.jrurstud.2018.06.004

Sangronis, E., Soto, M. J., Valero, Y., & Buscema, I. (2014). Cascarilla de cacao venezolano como materia prima de infusiones. *Archivos Latinoamericanos de Nutrición*, *64*, 123.

Santosa, E., Sakti, G. P., Fattah, M. Z., Zaman, S., & Wahjar, A. (2018). Cocoa production stability in relation to changing rainfall and temperature in East Java, Indonesia. *Journal of Tropical Crop Science*, *5*(1), 6–17. https://doi.org/10.29244/jtcs.5.1.6-17

Sauvadet, M., Saj, S., Freschet, G. T. et al. (2020). Cocoa agroforest multifunctionality and soil fertility explained by shade tree litter traits. *Journal of Applied Ecology*, *57*(3), 476–487. https://doi.org/10.1111/1365-2664.13560

Schroth, G., Garcia, E., Griscom, B. W., Teixeira, W. G., & Barros, L. P. (2016). Commodity production as restoration driver in the Brazilian Amazon? Pasture re-agro-forestation with cocoa (*Theobroma cacao*) in southern Pará. *Sustainability Science*, *11*(2), 277–293. https://doi.org/10.1007/s11625-015-0330-8

Schwartz, T. T., Maass, H., & Brookes, K. (2014). Haiti Cacao Impact Evaluation Baseline. Report available at: https://www.scribd.com/document/433415293/Haiti-Cacao-Baseline-CRS-12-31-2014

Scott, G. J., Donovan, J., & Higuchi, A. (2015). Costs, quality, and competition in the cocoa value chain in Peru: An exploratory assessment. *Custos e Agronegocio*, *11*(4), 324–358.

Sefriadi, H., Villano, R., Fleming, E. and Patrick, I. (2013). Production constraints and their causes in the cacao industry in West Sumatra: From the farmers' perspective. *International Journal of Agricultural Management* 3, 30–42

Sellare, J., Meemken, E., Kouamé, C., & Qaim, M. (2020). Do sustainability standards benefit smallholder farmers also when accounting for cooperative effects? Evidence from Côte d'Ivoire. *American Journal of Agricultural Economics*, *102*(2), 681–695. https://doi.org/10.1002/ajae.12015

Shamshuddin, J., Anda, M., Fauziah, C. I., & Omar, S. R. S. (2011a). Growth of cocoa planted on highly weathered soil as affected by application of basalt and/or compost. *Communications in Soil Science and Plant Analysis*, *42*(22), 2751–2766. https://doi.org/10.1080/00103624.2011.622822

Siegel, P. B., Alwang, J., & Tech, V. (2004). Export commodity production and broad-based rural development : Coffee and cocoa in the Dominican Republic. *World Bank Policy Research Working Paper*, *3360.* Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=610351

Sehgal, J. (1989). Classification and correlation of the Vietnamese soils. A technical report. https://agris.fao.org/agris-search/search.do?recordID=XF2016022802

Singh, K., Sanderson, T., Field, D., Fidelis, C., & Yinil, D. (2019, June). Soil security for developing and sustaining cocoa production in Papua New Guinea. *Geoderma Regional*, *17*, e00212. https://doi.org/10.1016/j.geodrs.2019.e00212

Snoeck, D., Koko, L., Joffre, J., Bastide, P., & Jagoret, P. (2016). Cacao nutrition and fertilization. In E. Lichtfouse (Ed.). Sustainable Agriculture Reviews. pp.155–200. Switzerland: Springer International Publishing. https://link.springer.com/chapter/10.1007/978-3-319-26777-7_4

Sounigo, O., & Efombagn Mousseni, I. B. (2012). Cocoa improvement and variety delivery effort in Cameroon. In *INGENIC 7th Workshop: Cocoa variety development and the supply of planting materials to farms*. Yaonde, Cameroon.

Suárez-Venero, G. M., Avendaño-Arrazate, C. H., Ruiz-Cruz, P. A., & Estrada-De-Los-Santos, P. (2019). Structure and impact of taxonomic diversity on cocoa of Soconusco, Chiapas, México. *Agronomy Mesoamerican*, *30*(2), 353–365. https://doi.org/10.15517/am.v30i2.34032

Suárez Salazar, J. C., Ngo Bieng, M. A., Melgarejo, L. M., Di Rienzo, J. A., & Casanoves, F. (2018). First typology of cacao (Theobroma cacao L.) systems in Colombian Amazonia, based on tree species richness, canopy structure and light availability. *PLOS ONE*, *13*(2), e0191003. https://doi.org/10.1371/journal.pone.0191003

Sujith, S. S., & Minimol, J. S. (2016). Kerala Agricultural University (KAU) released cocoa varieties. *Advances in Life Sciences*, *5*, 2278–3849.

Tano, A. M. (2012). Crise cacaoyère et stratégies des producteurs de la sous-préfécture de Meadji au sud-ouest ivoirien. PhD Thesis. Toulouse University. https://tel.archives-ouvertes.fr/tel-00713662/document

TechnoServe. (2015). Building a Sustainable and Competitive Cocoa Value Chain in Peru. https://www.technoserve.org/wp-content/uploads/2015/09/case-study-building-a-sustainable-and-competitive-cocoa-value-chain-in-peru.pdf

Tezara, W., Urich, R., Jaimez, R., Coronel, I., Araque, O., Azócar, C., & Chacón, I. (2016). Does criollo cocoa have the same ecophysiological characteristics as forastero? *Botanical Sciences*, *94*(3), 563–574. https://doi.org/10.17129/botsci.552

Tiraieyari, N., Hamzah, A., & Samah, B. A. (2014). Extension agents and sustainable cocoa farming: A case study of extension agents in Sabah state, Malaysia. *Modern Applied Science*, *8*(6), 210–218. https://doi.org/10.5539/mas.v8n6p210

Tokgoz, S., Allen, S., Majeed, F., Paris, B., Adeola, O., & Osabuohien, E. (2020). Distortions to agricultural incentives: Evidence from Nigerian value chains. *Review of Development Economics*, *24*(3), rode.12664. https://doi.org/10.1111/rode.12664

Tondoh, J. E., Kouamé, F. N. guessa., Martinez Guéi, A., Sey, B., Wowo Koné, A., & Gnessougou, N. (2015). Ecological changes induced by full-sun cocoa farming in CÔte d'Ivoire. *Global Ecology and Conservation*, *3*, 575–595. https://doi.org/10.1016/j.gecco.2015.02.007

Torres-De La Cruz, M., Ortiz-García, C. F., Bautista-Muñoz, C., Ramírez-Pool, J. A., Ávalos-Contreras, N., Cappello-García, S., & De La Cruz-Pérez, A. (2015). Diversidad de Trichoderma en el agroecosistema cacao del estado de Tabasco, México. *Revista Mexicana de Biodiversidad*, *86*(4), 947–961. https://doi.org/10.1016/j.rmb.2015.07.012

Torres, L. A. (2012). Manual de producción de cacao fino de aroma a través de manejo ecológico. *Universidad De Cuenca, Ecuador*. http://dspace.ucuenca.edu.ec/bitstream/123456789/3250/1/TESIS.pdf

Tothmihaly, A., & Ingram, V. (2019). How can the productivity of Indonesian cocoa farms be increased? *Agribusiness*, *35*(3), 439–456. https://doi.org/10.1002/agr.21595

Trognitz, B., Cros, E., Assemat, S., Davrieux, F. et al. (2013). Diversity of Cacao Trees in Waslala, Nicaragua: Associations between Genotype Spectra, Product Quality and Yield Potential. *PLoS ONE*, *8*(1), e54079. https://doi.org/10.1371/journal.pone.0054079

Trognitz, B., Scheldeman, X., Hansel-Hohl, K., Kuant, A., Grebe, H., & Hermann, M. (2011). Genetic population structure of cacao plantings within a young production area in Nicaragua. *PLoS ONE*, *6*(1). https://doi.org/10.1371/journal.pone.0016056

Tschora, H., & Cherubini, F. (2020). Co-benefits and trade-offs of agroforestry for climate change mitigation and other sustainability goals in West Africa. *Global Ecology and Conservation*, *22*, e00919. https://doi.org/10.1016/j.gecco.2020.e00919

Tsiboe, F., Dixon, B. L., Nalley, L. L., Popp, J. S., & Luckstead, J. (2016a). Estimating the impact of farmer field schools in sub-Saharan Africa: the case of cocoa. *Agricultural Economics*, *47*(3), 329–339. https://doi.org/10.1111/agec.12233

UCR. (2020). La agricultura costarricense se reinventa frente a la pandemia del COVID-19. https://www.ucr.ac.cr/noticias/2020/05/16/la-agricultura-costarricense-se-reinventa-frente-a-la-pandemia-del-covid-19.html

USAID. (2019). Instrumentos para un crecimiento libre de deforestación en el cacao peruano: la propuesta de la Alianza Cacao Perú *22°Convención Nacional de Café y Cacao*. https://camcafeperu.com.pe/convencion/assets/files/exposicion-22-CONVENCION-CAFE-Y-CACAO-2019.pdf

Vanhove, W., Yao, R. K., N'Zi, J. C., N'Guessan Toussaint, L. A., Kaminski, A., Smagghe, G., & Van Damme, P. (2020). Impact of insecticide and pollinator-enhancing substrate applications on cocoa (*Theobroma cacao*) cherelle and pod production in Côte d'Ivoire. *Agriculture, Ecosystems and Environment*, *293*, 106855. https://doi.org/10.1016/j.agee.2020.106855

Vanlauwe, B., Diels, J., Lyasse, O. et al. (2002). Fertility status of soils of the derived savanna and Northern Guinea savanna and response to major plant nutrients, as influenced by soil type and land use management. *Nutrient Cycling in Agroecosystems*, *62*(2), 139–150. https://doi.org/10.1023/A:1015531123854

Vázquez-Ovando, A., Chacón-Martínez, L., Betancur-Ancona, D., Escalona-Buendía, H., & Salvador-Figueroa, M. (2015). Sensory descriptors of cocoa beans from cultivated trees of Soconusco, Chiapas, Mexico. *Food Science and Technology*, *35*(2), 285–290. https://doi.org/10.1590/1678-457X.6552

Velásquez, L. M. (2016). Influencia del proceso de fermentación sobre las características de calidad del grano de cacao (*Theobroma cacao*). Masters thesis. Universidad Nacional de Colombia. Available at: https://repositorio.unal.edu.co/handle/unal/59884

Venture, G. R., Varguillas, C. G., Vidal, R., & Castillo, A. (2010). INIA-Venezuela. In *CFC/ICCO/Bioversity project on cooca productivity and quality improvement: a participatory approach. Final Institute Report*. Bioversity International, Rome.

Venturieri, G. A. (2011). Flowering levels, harvest season and yields of cupuassu (Theobroma grandiflorum). *Acta Amazonica*, *41*(1), 143–152. https://doi.org/10.1590/s0044-59672011000100017

Vigneri, M., Serra, R., & Wilson, S. (2016). Researching the impact of increased cocoa yields on the labour market and child labour r.isk in Ghana and Côte d'Ivoire. ICI Labour Market Research Study. https://www.researchgate.net/publication/322987637_Researching_the_Impact_of_Increased_Cocoa_Yields_on_the_Labour_Market_and_Child_Labour_Risk_in_Ghana_and_Cote_d'Ivoire.

Waarts, Y., Janssen, V., Ingram, V., & Slingerland, M. (2019). A living income for smallholder commodity farmers and protected forests and biodiversity: how can the private and public sectors contribute? Research Report. Available at https://library.wur.nl/WebQuery/wurpubs/556298

Wade, A. (2015). Understanding the distribution of soil carbon in Gabon, Central Africa. Masters thesis. Duke University. file:///C:/Users/daymo/Downloads/Wade%20MP%202015.pdf

WCF (2018). Transitioning to high quality sustainable cocoa in the Dominican Republic: A success story. https://www.worldcocoafoundation.org/blog/transitioning-to-high-quality-sustainable-cocoa-in-the-dominican-republic-a-success-story/

WCF. (2021). Cocoa & Forests Initiative. https://doi.org/https://www.worldcocoafoundation.org/initiative/cocoa-forests-initiative/

Wessel, M., & Quist-Wessel, P. M. F. (2015). Cocoa production in West Africa, a review and analysis of recent developments. *NJAS - Wageningen Journal of Life Sciences, 74-75,* 1-7. https://doi.org/10.1016/j.njas.2015.09.001

Witteveen, L., Lie, R., Goris, M. & Ingram, V. 2017. Design and development of a digital farmer field school. Experiences with a digital learning environment for cocoa production and certification in Sierra Leone. *Telematics and Infomatics*, *34*, 1673-1684.

Yamoah, F. A., Kaba, J. S., Amankwah-Amoah, J., & Acquaye, A. (2020). Stakeholder Collaboration in Climate-Smart Agricultural Production Innovations: Insights from the Cocoa Industry in Ghana. *Environmental Management*, 1–14. https://doi.org/10.1007/s00267-020-01327-z

Yusof, N. M., Syahlan, S., Zulkefli, F., & Bakar, M. A. (2017). Factors influencing the Cocoa Smallholders Behavior Decision Making in Hilir Perak. *International Journal of Academic Research in Business and Social Sciences*, *7*(10), 637–643. https://doi.org/10.6007/ijarbss/v7-i10/3418

Yao, C. Y. A, Kpangui, K. B, Vroh, B. T. A., & Ouattara, D. O. (2016). *Revue d'ethnoécologie*, *9*. https://doi.org/10.4000/ethnoecologie.2474

Zanh, G. G., Kpangui, K. B., Barima, Y. S. S., & Jan, B. (2019). Migration and agricultural practices in the peripheral areas of côte d'ivoire state-owned forests. *Sustainability (Switzerland)*, *11*(22), 1–13. https://doi.org/10.3390/su11226378

Zikria, V., Takahashi, K., Maeda, K. (2019). International Competitiveness of Indonesia's Cocoa Sector: From the Viewpoint of Product Differentiation. *Journal-Faculty of Agriculture Kyushu University, 64*(2), 407–413.

APPENDIX I. Comparison of cocoa production areas from various literature sources compared to that listed by FAO.

| Continent | Country | Total area (data from literature sources) ($km^2$) | Total area according to FAO ($km^2$) |
|---|---|---|---|
| Africa | Liberia | 364 | 759 |
| Africa | Sierra Leone | 330 | 244 |
| Africa | Uganda | 190 | 724 |
| Africa | Ghana | 19500 | 16898 |
| Africa | Nigeria | 8000 | 12821 |
| Africa | Gabon | 10 | 16 |
| Africa | Guinea | - | 358 |
| Africa | Togo | - | 100 |
| Africa | Cameroon | 4500 | 6047 |
| Africa | Côte d'Ivoire | 25000 | 27460 |
| Asia | India | 319 | 890 |
| Asia | Philippines | 250 | 271 |
| Asia | Vietnam | 225 | - |
| Asia | Malaysia | 174 | 150 |
| Asia | Papua New Guinea | 1300 | 1124 |
| Asia | Indonesia | 17000 | 16006 |
| America | Nicaragua | 79 | 116 |
| America | Ecuador | 5600 | 5254 |
| America | Mexico | 613 | 585 |
| America | Peru | 400 | 1304 |
| America | Colombia | 1730 | 1178 |
| America | Costa Rica | 32 | 43 |
| America | Haiti | 180 | 346 |
| America | Dominican Republic | 1520 | 1509 |
| America | Trinidad and Tobago | 70 | 28 |
| America | Venezuela | 40 | 809 |
| America | Bolivia | 89 | 104 |
| America | Brazil | 6205 | 5819 |

Appendix II: Summary of available information in the literature on cocoa farm traits in different countries

KEY

- Information available
- Information available but may need verifying
- Information available but not up to date
- Little information
- No information

| AFRICA | Cameroon | Côte d'Ivoire | Gabon | Ghana | Guinea | Liberia | Nigeria | Sierra Leone | Togo | Uganda |
|---|---|---|---|---|---|---|---|---|---|---|
| Age profile | Information available | Information available | No information | Information available | No information | Information available | No information | No information | No information | Information available |
| Level of education | Information available | Information available | No information | Information available | No information | Information available | Information available | Information available | No information | Information available |
| Family size | Information available | Information available | No information | Information available | No information | Information available | Information available | No information | No information | No information |
| Total area under production | Information available but may need verifying | Information available but may need verifying | Information available but may need verifying | Information available but may need verifying | Information available but may need verifying | Information available but may need verifying | Information available but may need verifying | Information available but may need verifying | Information available but may need verifying | Information available but may need verifying |
| Planting density | Information available | Information available | No information | Information available | No information | No information | Information available | Information available | Information available | No information |
| Farm age | Information available | Information available | No information | Information available | No information | No information | Information available | Information available | Information available | No information |
| Farm size | Information available | Information available | No information | Information available | No information | Information available | Information available | Information available | No information | Information available |
| Large plantations | No information | Information available | No information | No information | No information | No information | No information | No information | No information | No information |
| Recommended clones/ hybrids | Information available | Information available | No information | Information available | No information | No information | Information available | No information | No information | No information |
| Fine flavour | No information | Information available | No information | Information available | No information | No information | No information | No information | No information | Little information |
| Awards | Information available | Information available | Information available | Information available | Information available | Information available | Information available | Information available | Information available | Information available |
| Shade trees | Information available | Information available | Information available | Information available | Information available | No information | No information | No information | No information | Information available |
| Soil type | Information available | Information available | No information | Information available | Information available | Information available | Information available | Information available | Information available | No information |
| Cadmium | Information available | No information | No information | Information available | No information | No information | No information | No information | No information | No information |
| Fertiliser use | No information | Information available | Information available | No information | Information available | Information available | No information | Information available but not up to date | Little information | Little information |
| Water management | No information | Information available | No information | Information available | No information | No information | No information | No information | No information | No information |
| Replanting | No information | Information available | No information | Information available | No information | No information | Information available | No information | No information | Information available but not up to date |
| Pruning | Information available | No information | No information | Information available | No information | Information available | No information | No information | No information | No information |
| Yield | Information available but may need verifying | Information available but may need verifying | Information available but may need verifying | Information available but may need verifying | Information available but may need verifying | Information available but may need verifying | Information available but may need verifying | Information available but may need verifying | Information available but may need verifying | Information available but may need verifying |
| Pest and disease prevalence | Information available | Information available | Information available | Information available | Information available | Information available | Information available | Information available | Information available | Information available |
| Other sources of income | Information available | Information available | No information | Information available | No information | Information available | Information available | Information available | No information | Information available |
| Cocoa products | Information available | Information available | No information | Information available | No information | No information | No information | No information | No information | No information |
| Fermentation | No information | Information available | No information | Information available | No information | Information available | Information available | No information | No information | No information |
| Selling methods | No information | Information available | No information | Information available | No information | Information available but not up to date | No information | No information | No information | Information available but not up to date |
| Buyer profiles | No information | Information available | No information | Information available | No information | Information available | Information available | No information | No information | Information available |
| Sources of labour | Information available | Information available | No information | Information available | No information | Information available | Information available | No information | Information available | Information available |
| Land tenure | No information | Information available | Information available | No information | Information available | Information available | Information available | No information | No information | No information |
| Certification | No information | Information available | No information | Information available | No information | No information | No information | Information available | No information | No information |
| Farmer associations | No information | Information available | No information | Information available | No information | No information | Information available | Information available | Information available | Information available |
| Extension services | No information | Information available | No information | Information available | No information | No information | Information available | Information available | Information available | No information |

| AMERICA | Bolivia | Brazil | Colombia | Costa Rica | Dominican Republic | Ecuador | Haiti | Mexico | Nicaragua | Peru | Trinidad and Tobago | Venezuela |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age profile | | | | | | | | | | | | |
| Level of education | | | | | | | | | | | | |
| Family size | | | | | | | | | | | | |
| Total area under production | | | | | | | | | | | | |
| Planting density | | | | | | | | | | | | |
| Farm age | | | | | | | | | | | | |
| Farm size | | | | | | | | | | | | |
| Large plantations | | | | | | | | | | | | |
| Recommended clones/ hybrids | | | | | | | | | | | | |
| Fine flavour | | | | | | | | | | | | |
| Awards | | | | | | | | | | | | |
| Shade trees | | | | | | | | | | | | |
| Soil type | | | | | | | | | | | | |
| Cadmium | | | | | | | | | | | | |
| Fertiliser use | | | | | | | | | | | | |
| Water management | | | | | | | | | | | | |
| Replanting | | | | | | | | | | | | |
| Pruning | | | | | | | | | | | | |
| Yield | | | | | | | | | | | | |
| Pest and disease prevalence | | | | | | | | | | | | |
| Other sources of income | | | | | | | | | | | | |
| Cocoa products | | | | | | | | | | | | |
| Fermentation | | | | | | | | | | | | |
| Selling methods | | | | | | | | | | | | |
| Buyer profiles | | | | | | | | | | | | |
| Sources of labour | | | | | | | | | | | | |
| Land tenure | | | | | | | | | | | | |
| Certification | | | | | | | | | | | | |
| Farmer associations | | | | | | | | | | | | |
| Extension services | | | | | | | | | | | | |

| ASIA | India | Indonesia | Malaysia | Papua New Guinea | Philippines | Vietnam |
|---|---|---|---|---|---|---|
| Age profile | | | | | | |
| Level of education | | | | | | |
| Family size | | | | | | |
| Total area under production | | | | | | |
| Planting density | | | | | | |
| Farm age | | | | | | |
| Farm size | | | | | | |
| Large plantations | | | | | | |
| Recommended clones/ hybrids | | | | | | |
| Fine flavour | | | | | | |
| Awards | | | | | | |
| Shade trees | | | | | | |
| Soil type | | | | | | |
| Cadmium | | | | | | |
| Fertiliser use | | | | | | |
| Water management | | | | | | |
| Replanting | | | | | | |
| Pruning | | | | | | |
| Yield | | | | | | |
| Pest and disease prevalence | | | | | | |
| Other sources of income | | | | | | |
| Cocoa products | | | | | | |
| Fermentation | | | | | | |
| Selling methods | | | | | | |
| Buyer profiles | | | | | | |
| Sources of labour | | | | | | |
| Land tenure | | | | | | |
| Certification | | | | | | |
| Farmer associations | | | | | | |
| Extension services | | | | | | |

## APPENDIX III. Additional information on co-operatives and marketing

Examples of co-operatives and farmer organisations

| | |
|---|---|
| Brazil | Cooperativa dos Produtores Orgânicos do Sul da Bahia, Cooperativa Agroindustrial da Transamazônica, Coopercacau Transamazônica, Cooperativa Ouro Verde, Associação Cacau Sul Bahia, Rede Povos da Mata, Cooperativa de Serviços Sustentáveis da Bahia and Cooperativa da Agricultura Familiar e Economia Solidária da Bacia do Rio Salgado e Adjacências (Coopfesba) |
| Mexico | The main cacao growers associations in the state of Chiapas are Asociación Agrícola Local de Productores de Cacao de Tapachula (Tapachula Local Agricultural Association of Cacao Growers); Asociación Agrícola Local de Productores de Cacao de Tuxtla Chico (Tuxtla Chico Local Agricultural Association of Cacao Growers); Sociedad de Producción Rural Cuevas de Tigre de Pichucalco (Pichucalco Tiger Caves Rural Production Society); Asociación Agrícola Local de Productores de Cacao de Tuzantán (Tuzantán Local Agricultural Association of Cacao Growers); and Alianza del Cacao de Tuxtla Chico (Tuxtla Chico Cocoa Cooperative Alliance). |
| Nigaragua | Farmer organisations include: Coosemucrim (173); Cooprocafuc (191); Coodeprosa (36); Asiherca (45); UCA (186); Sano y Salvo (106); Compor (234) (Saballos et al., 2017). CACAONICA (Cooperativa de Servicios Agroforestales y de Comercialización de Cacao) is one of the largest cooperatives and grew from 69 to 446 partners from the year 2000 to 2010 (Aguad, 2010). |

Directory of organizations dedicated to the production and marketing of cocoa in Mexico. In Arrazate et al. (2011, p. 63)

| Organización |
|---|
| Asociación Agricola Local de Juárez Chiapas |
| Asociación de Cacao Tecpateco, S.P.R. de R.L. |
| AMSA |
| Asociación de Prod. Rural Tuxtla Chico |
| Asociación de Productores de Cacao y Coco, Cosa Pacífico |
| Asociación Agrícola P.C. Huixtla |
| Asociación de Soconusco |
| Asociación de Tapachula |
| Asociación Local Agricola de Productores de Cacao de Huimanguillo |
| Asociación Nacional de Fabricantes de Chocolates, Dulces y Similares de la República Mexicana, A.C |
| Cacao Maya de la Asociación de Acapetahua |
| Cacao Mazatan |
| Centro de Agroecología San Francisco de Asís, A.C. |
| Red Maya de Organizaciones Orgánicas |
| Chocolates El Chontal |
| Chocolate Mayordomo |
| Chocolates Finos San José |
| Chocolates Wolter y Museo del Cacao |
| Consejo Nacional de Productores de Cacao, A.C. |
| Integaradora de Cacao y Productos Ecológicos de la Zona Norte de Chiapas México, S.A. de C.V (INCRAPRECH) |
| Integradora de Cacao Zona V Norte. |
| Intermediario de cacao |
| Nestlé de México, S.A de C.V. |
| Ostuacán S.P.R. |
| Unión Independiente de Productores de Cacao |
| Asociación Agrícola Local de Prod. de Cacao |
| Unión Nacional de Productores de Cacao |
| Sistema-Producto Cacao representantes |

APPENDIX IV. Additional information on Extension Services

| | |
|---|---|
| Philippines | Government agencies involved in the development of the cocoa industry include: the High Value Crops Development Program of the Department of Agriculture (DA); Philippine Rural Development Program of DA; National Greening Program of the Department of Environment and Natural Resources; Coconut-Cacao Enterprise Development Project of Philippine Coconut Authority; Industry Clustering, Market Assistance, Trade Promotion and Shared Service Facility Programs of the Department of Trade and Industry (DTI); Market Resurgence Program (MRP) of DTI; Agrarian Production Credit Program of the Department of Agrarian Reform; Mindanao Sustainable Agrarian and Agriculture Development (MinSAAD) Project; Credit Program of the DA-Agricultural Credit Policy Council; SETUP, MPEX, and CAPE Programs of DOST (Department of Science and Technology); and the Research and Development Projects of the DA-Bureau of Plant Industry and Academe (Department of Agriculture - BPI, 2016). |