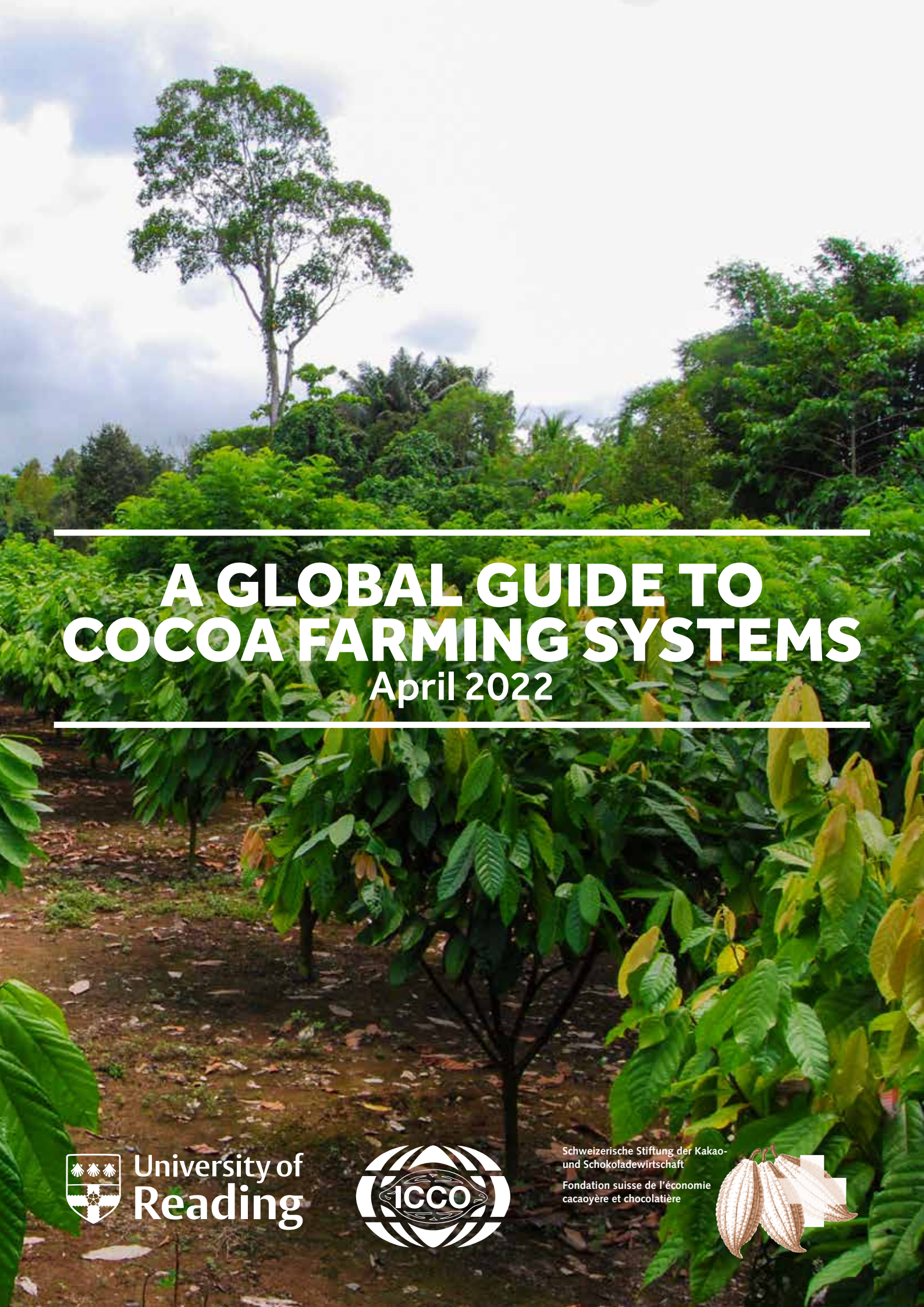

A GLOBAL GUIDE TO COCOA FARMING SYSTEMS

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University of Reading

ICCO

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Fondation suisse de l'économie cacaoyère et chocolatière

A global guide to cocoa farming systems

FIRST EDITION

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Disclaimer

This guide is intended as an aid to policy makers and producers to summarise the range of practices and production models in place for cocoa production globally, thereby illustrating routes to improved and more sustainable production. The information provided is based on available published literature (refereed papers, reports and theses) as well as first-hand knowledge of the contributors and does not necessarily reflect the views of International Cocoa Organization (ICCO) nor of the Swiss Foundation of the Cocoa and Chocolate Economy. In some cases, public domain information is limited on a particular facet of cocoa farming and therefore information presented may not always represent the totality of cocoa farming practices. Graphs and tables are presented as examples of global variability in practices. Further figures and tables are presented in an accompanying comprehensive report entitled "A Global Review of Cocoa Farming Systems".

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 2019/20 (Table 1). The largest proportion of cocoa is cultivated in West Africa where 75.7% of cocoa was produced in the season 2019/2020 (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 fertilizer use will reduce fertilizer 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.

This Global Guide to Cocoa Growing Systems is a summary of a comprehensive review of cocoa farming systems prepared by the University of Reading for the International Cocoa Organisation. The comprehensive review of farming systems, The Global Review of Cocoa Farming Systems, can be found here: **www.icco.org**. The review covered published literature on the characteristics of cocoa farms in 28 countries (Figure 2). Furthermore, expert consultants 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, the comprehensive review and the present guide aims to help stakeholders better to identify routes towards higher and more sustainable cocoa production.

Table 1: Estimated cocoa production from the top seven cocoa-producing countries for the year 2019/20 (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**	

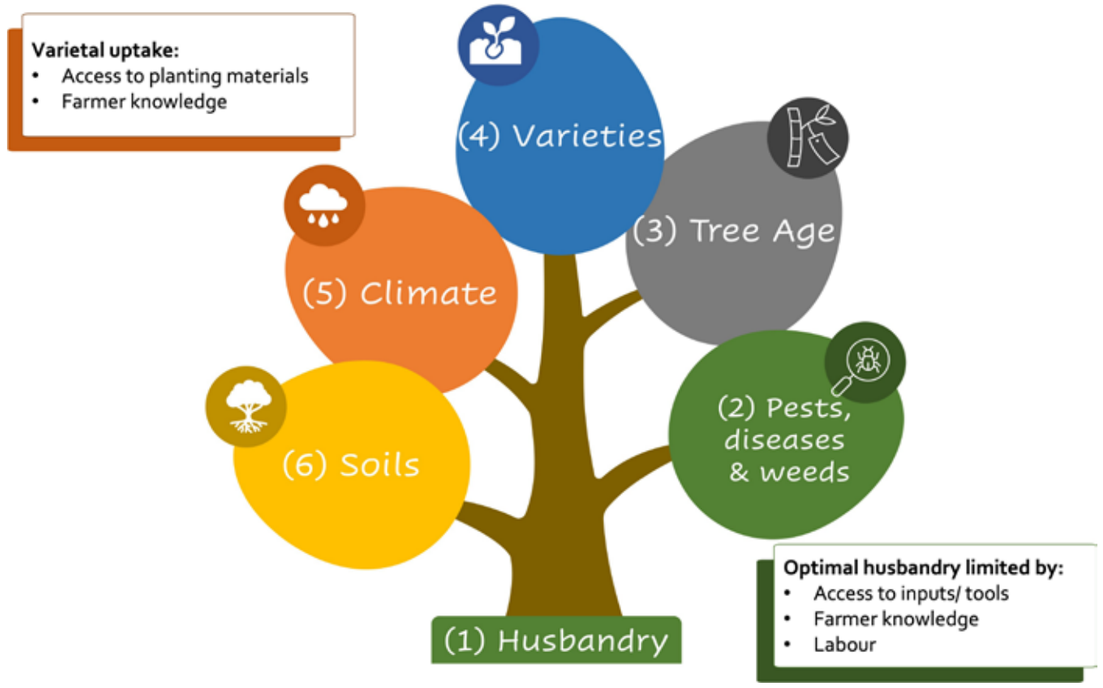


Figure 1: The six pillars of variability in on-farm cocoa yield (spatial and temporal).

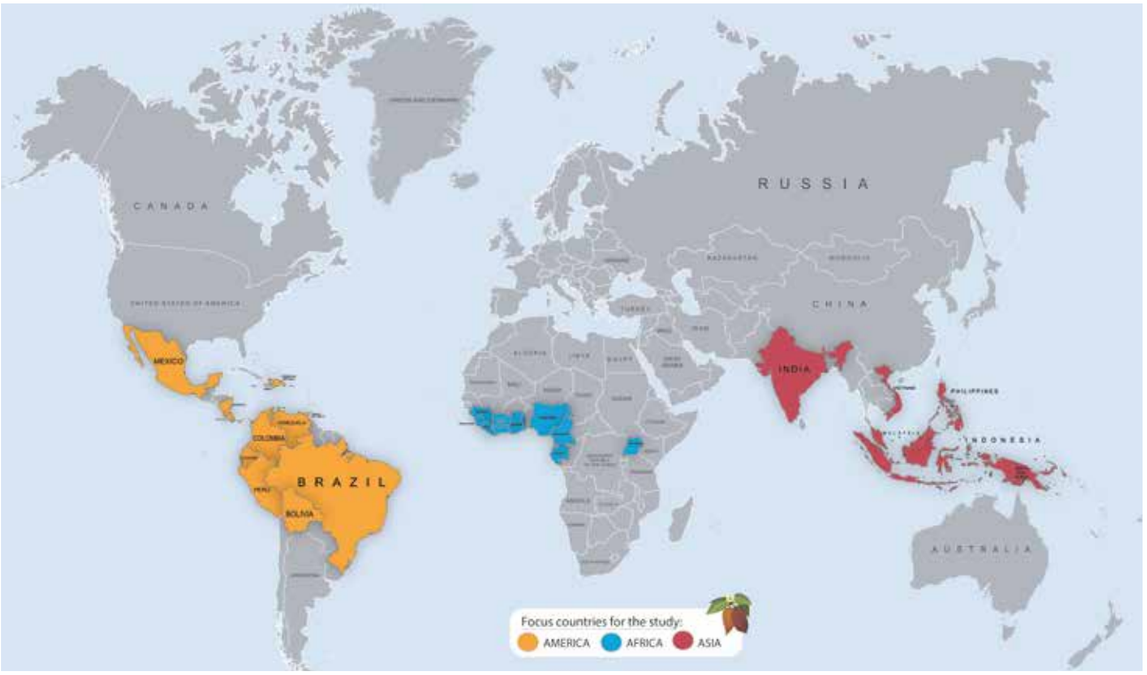


Figure 2: Focus countries for the study. In Africa: Cameroon, Côte d'Ivoire, Gabon, Ghana, Guinea, Liberia, Nigeria, Sierra Leone, Togo, Uganda. In America: Bolivia, Brazil, Colombia, Costa Rica, Dominican Republic, Ecuador, Haiti, Mexico, Nicaragua, Peru, Trinidad and Tobago, Venezuela. In Asia: India,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

Cocoa Farmer

Key findings.

A wide range of farmer age profiles are observed in different cocoa-growing countries (Figure 3).

Notable countries that have an aging farmer population include Ghana, Colombia and Ecuador.

Results of published surveys reveal a higher level of education in some cocoa-growing countries compared with others with illiteracy amongst farmers being high in Côte d'Ivoire and Sierra Leone.

A number of studies have shown a link between farmer level of education with technology adoption and cocoa income.

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. On the other hand, a large household can also mean a higher number of dependents, which increases the overall living costs of a household.

Particularly large family sizes are observed in Nicaragua, Cameroon, Nigeria and Côte d'Ivoire.

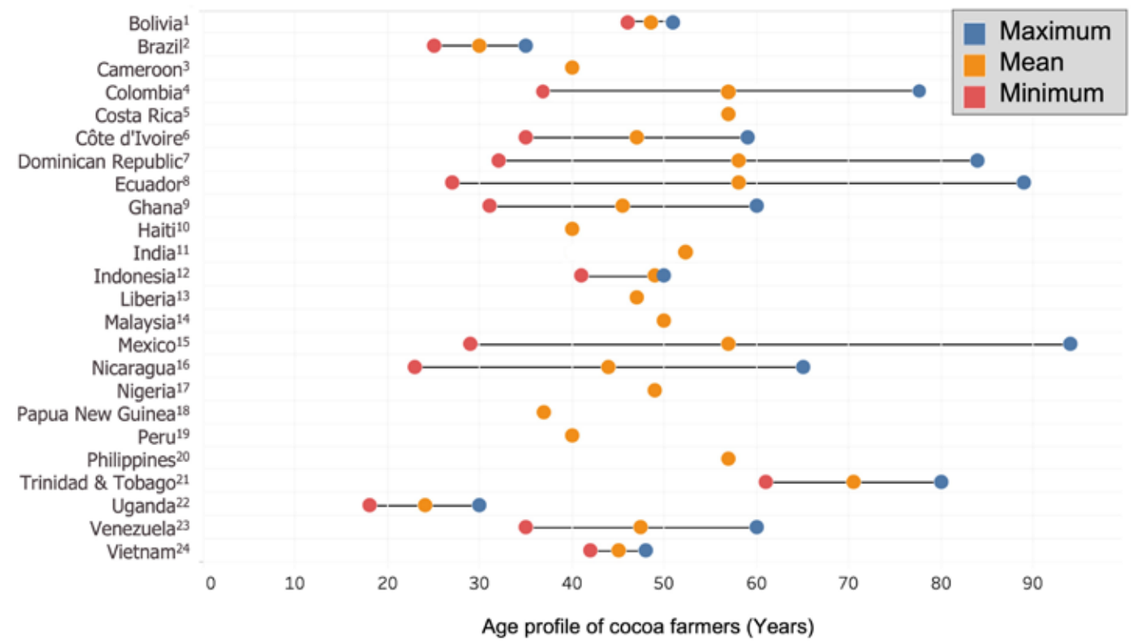
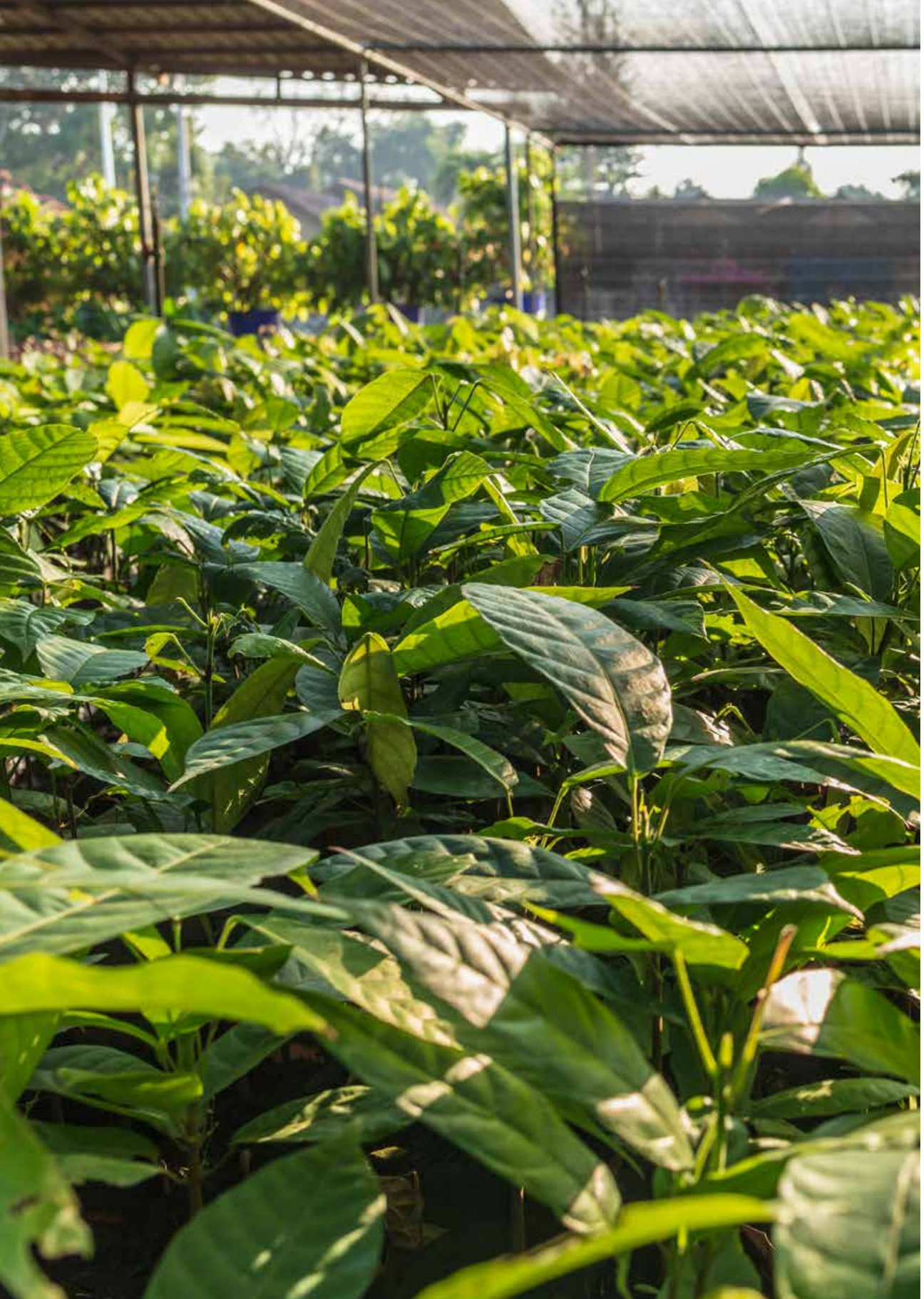


Figure 3: Age profile of cocoa farmers in different cocoa producing countries. The orange dot represents the mean (note in some cases that mean age is only reported). The red and blue dots correspond to the minimum and maximum respective farmer age reported in surveys. Data are from multiple reference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

[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. (2010); [20]Hamrick et al. (2017); [21]Maharaj et al. (2018); [22]FAO (2018); [23]Alvarado et al. (2014); [24]Ruf & Paulin (2005)



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 (Figure 4).

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 and crop management (Daymond et al., 2018).

A wide range of farm ages have been reported globally; yield declines can be expected to be seen in farms with aging trees stocks.

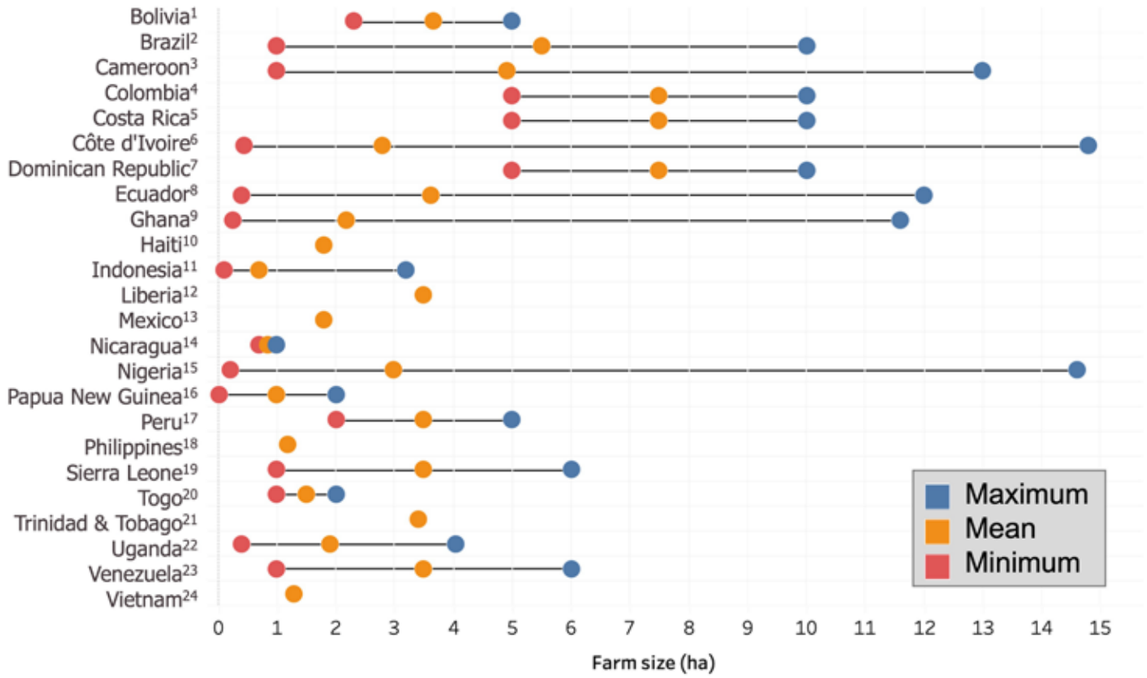


Figure 4: Smallholder farm size (ha). The orange dot represents the mean (note in some cases that mean is only reported). The red and blue dots correspond to the minimum and maximum respective farm size.

[1]Jacobi et al. (2015); [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]Ecuador Consultant; [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)

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.

Both the public and private actors have roles in the supply of planting materials in different cocoa-growing countries. The public sector is particularly important in Côte d'Ivoire and Ghana for the supply of mixed hybrids (Table 2).

The cultivation of fine flavour cocoa can provide a route for some farmers to receive improved income from cocoa bean sales.

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 (**www.cocoaofexcellence.org/**).

Table 2: Recommended planting materials and their source in five of the major cocoa-growing countries.

Country	Planting materials supplied	Source of materials
Brazil	Hybrids between upper and lower Amazon parent (Amazon region). Clonal cultivars have been widely adopted in Bahia.	1 - Seed gardens: in the Amazon region, these are provided by the government, via CEPLAC. 2 - Clonal planting material: In Bahia, the Northeast and central states these are provided by the private sector.
Ecuador	A range of clones are recommended. INIAP does not currently recommend any hybrid varieties.	INIAP nurseries (limited capacity to produce planting material). Private nurseries (great capacity to produce planting material, particularly the clone CCN 51).
Côte d'Ivoire	Mixed hybrids (bi-parental crosses) The term "Cacao Mercedes" is often used to describe the mix of hybrids that are supplied.	The majority of cultivated cocoa trees are derived from seeds collected from existing fields. ANADER provides improved (hybrid) seed to farmers.
Ghana	Mixed hybrids (bi-parental crosses)	Seed Production Unit of COCOBOD
Indonesia	A range of clones are recommended.	Public and private sector seed gardens

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. As examples, Figure 5 illustrates the range of shade trees found on smallholdings surveyed in Ghana and Indonesia.

As well as protection against full sun, 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 important additional source of income to the farmer as well as means of income diversification.

Disadvantages of shade trees can include reduction in yield under heavy shade and increased prevalence of fungal diseases.

Photo credit: Philippe Bastide

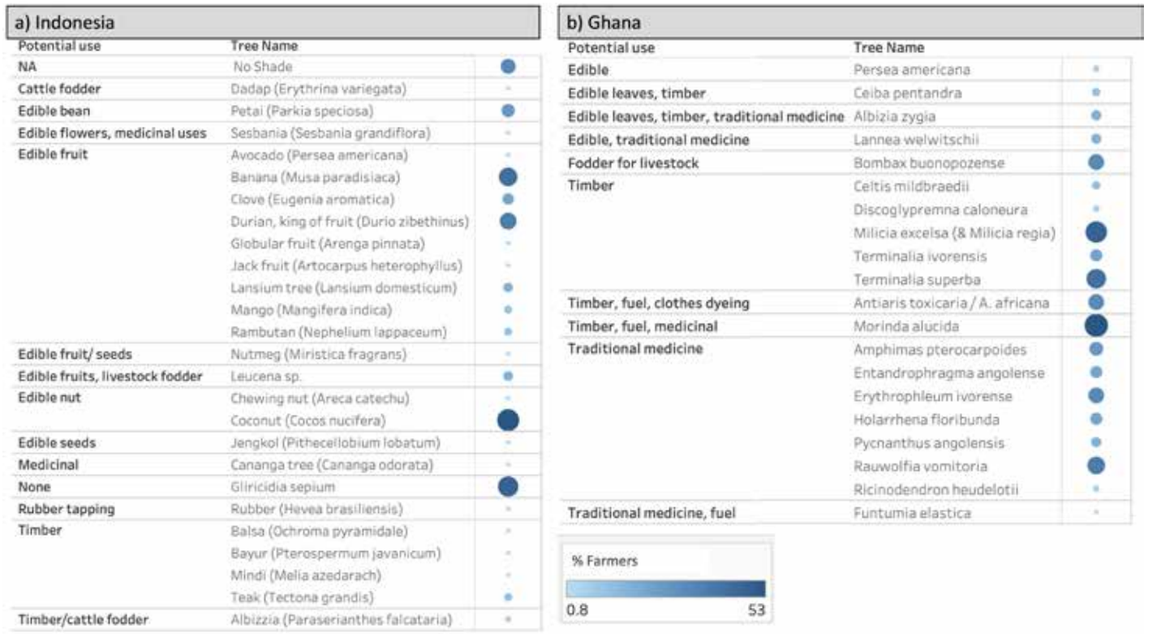


Figure 5: The frequency of key shade species in a) Indonesia (Daymond et al., 2020) b) Ghana (MCP, 2017).

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 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.

A number of initiatives are in place to address this issue, for example, the Cocoa Soils Project (**cocoasoils.org**).

High concentrations of cadmium can be an issue in soils of volcanic origin but also following the use of certain phosphate fertilizers.

Inorganic fertilizer use is highly variable across cocoa growing areas. In many areas there is a need to tailor fertilizer recommendation to local soil conditions.

A range of organic fertilizers are used by farmers globally including chicken and cattle manure, composted pod husks, branches and litter and composted residues of other crops.

In some cocoa-growing countries, notably Côte d'Ivoire and Ghana, government schemes have been in place at different times to promote and sometimes subsidise fertilizers. In other instances (e.g. in Brazil) farmers can only obtain fertilizers from the market.

Water availability is a significant determinant of yield in cocoa. For rainfed cocoa, rainfall totals and yearly distribution are important factors determining where cocoa can be cultivated.

Only a very small proportion of cocoa globally is currently irrigated. These include some large plantations (Figure 6) and there are also examples of irrigated smallholdings.

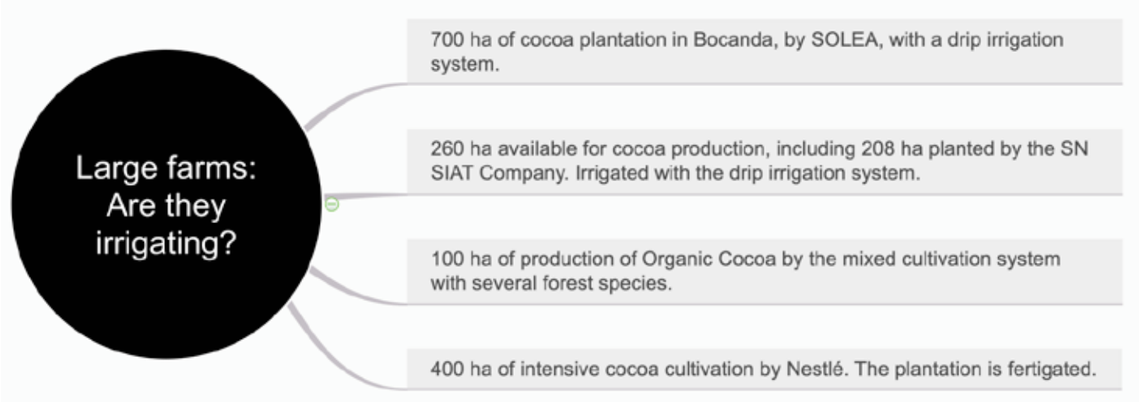


Figure 6: Examples of large, irrigated farms in Côte d'Ivoire.

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. In other cocoa-growing areas, for example Bahia, Brazil, disease spread has been a driver for replanting more tolerant materials.

Whilst pruning is often practiced, the quality of pruning can often be sub-standard.

A gradient can be observed across farming systems from little managed through to intensive. Farm management practices, alongside soil properties, climate and variety cultivated are drivers of farm-to-farm yield variation.

The cropping season is driven primarily by seasonal rainfall, although temperature can also be a factor, particularly in regions that have a cool season (e.g. Bahia, Brazil).

Whilst yields per hectare vary between countries there is also considerable yield variation within cocoa-growing countries (Figure 7).

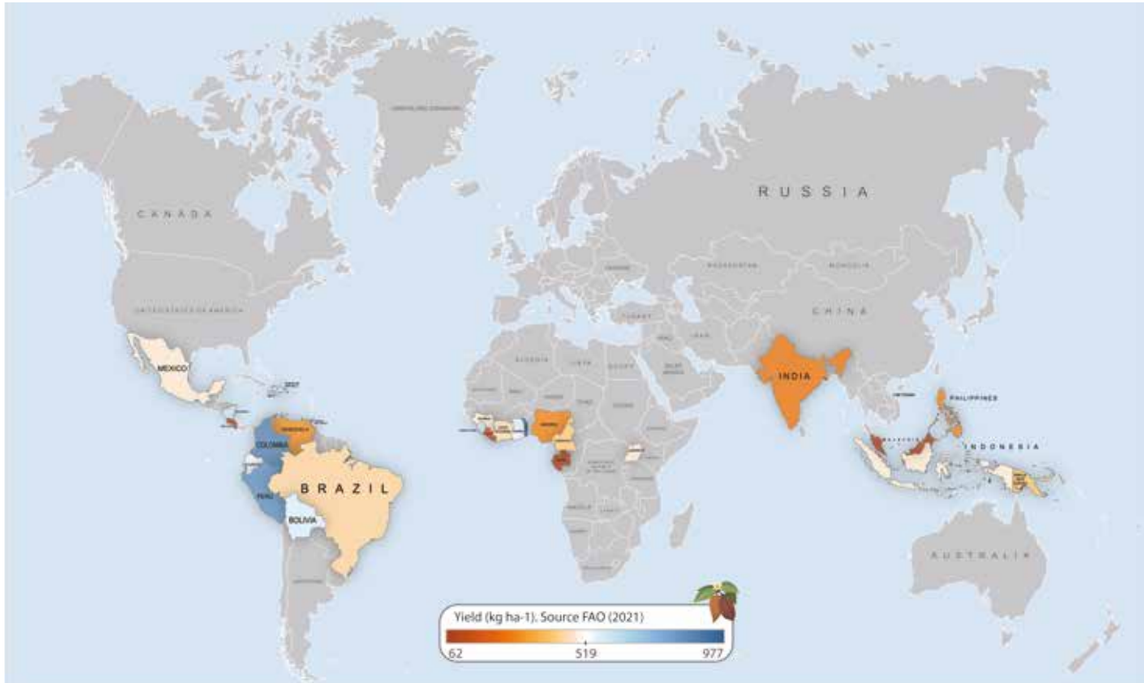


Figure 7: Yield (kg ha^{-1}) using FAO figures from 2019 (FAO, 2021)

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 (see Table 3 for examples).

Control of pests and diseases includes use of agrochemicals, husbandry (e.g. pruning, diseased pod removal), cultural (e.g. frequent harvesting) and biological control.

In Ghana, the Cocoa Health and Extension Division (CHED- a division of COCOBOD) provides free services for fungicide and pesticide application through the CODAPEC scheme.

Improved varieties have often been selected for improved resistance to pests and/or diseases.

Table 3: Prevalence of pests and diseases and examples of reported control measures. Information on pest and disease prevalence is primarily from End et al. (2021) 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 pests and diseases	Pest and disease control
Ghana	*Cacao necrosis virus* (CNV) *Cacao swollen shoot virus* (CSSV) *Phytophthora megakarya* Thread Blight Disease, Pink Disease, Anthracnose Disease Parasitic mistletoe (*Tapinanthus bangwensis*)	Ghanaian cocoa farmers frequently report using fungicides. Farmers source fungicides mainly from the Ghana government through the CODAPEC programme.
Côte d'Ivoire	*Cacao swollen shoot virus* (CSSV) *Phytophthora megakarya* Parasitic mistletoe (*Tapinanthus bangwensis*) Stem borer	Fungicides are used in the control of blackpod. The control of Cocoa swollen shoot virus disease is agronomic, i.e. through cutting out and re-planting.
Indonesia	Cocoa pod borer Vascular streak dieback *Rosellinia* root rot	Farm maintenance and application of chemicals are the main means of management. Cultural controls include sanitary pruning and frequent harvesting.
Brazil	*Moniliophthora perniciosa* *Various Phytophthora spp* *Ceratocystis* wilt *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.
Ecuador	*Moniliophthora perniciosa* *Moniliophthora roreri* *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.

Farm Diversification

Key findings.

On-farm diversification is a means of both increasing income and reducing dependency on a single crop (see Table 4 for examples)

Additional valorisation of the cocoa harvest may be achieved by means of farmer or farmer co-operative chocolate production and utilisation of cocoa by-products (e.g. pulp and husk).

Cultivation of additional crops and livestock production are other sources of on-farm diversification.

Table 4: Examples of cocoa products (chocolate or by-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. High quality cocoa butter is made by the 200 women of the Coopérative du Bélier. Cocoa mucilage juice has been used in marmalade production.
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.
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.
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 by-products made by farmers include: 1 – Pulp sold in the local market, but on a small scale, sold for around US$ 1 per kg 2 – Honey sold on a small scale for the local community for US$ 2 per litre 3 – Jelly sold on a small scale in the local community for US$ 2 for 300 g 4 – Placenta is used for sweets and for fish food sold for US$ 20 cents per kilo 5 – Cachaça of cacao honey sold for US$ 30 for a 700 ml bottle 6 – Wine is sold on a small scale for US$ 10 for a 700 ml bottle
Ecuador	Juice from pulp is the most common by-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.
Mexico	Cocoa producers in Chontalpa produce artisan chocolates (Jaramillo-Villanueva et al., 2018).

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 (Figure 8).

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.

Figure 8: 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

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 (see Figure 9 as an example of labour usage in Côte d'Ivoire and Ghana).

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).

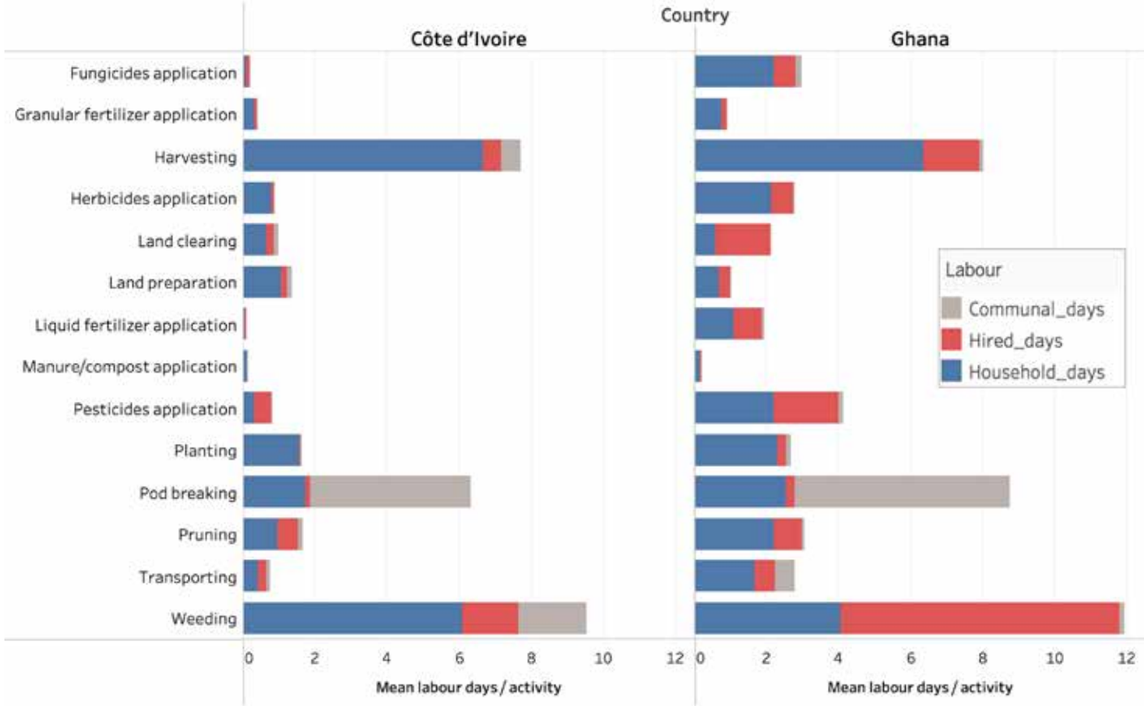


Figure 9: Mean labour days per cocoa activity, per hectare in Côte d'Ivoire and Ghana. Adapted from Audet-Belanger et al. (2018). Blue = household labour, red = hired labour and grey = communal labour. The figure illustrates similarities in labour days for some activities (e.g. harvesting) between the two countries and differences for others (e.g. more time spent on pesticide and fertilizer application in Ghana comparted to Côte d'Ivoire). The figure also highlights greater use of hired labour for some activities in Ghana.

Comparative Matrix of Cocoa Farming Systems

Table 5: Comparative matrix of cocoa farming systems.

	Trait	Categories
Capital and Land Status	Farm Ownership	Owned & Operated/ Landlord/ Sharecropping
	Size of Farm	Smallholding (<5 ha)/ 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 rows	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

	Trait	Categories
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 Global Review of Cocoa Farming Systems and are summarised in Table 5. 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.

In Table 6, five broad categories of farming system are identified and eleven 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 described below.

Traditional Smallholding: Rustic with Limited Management

Location: Ghana

Similar 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 fertilizer 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.

Photo credit: Andrew Daymond

Structured Intercrop Smallholding: Well-managed Intercrop -Not Irrigated

Location: Indonesia, Sulawesi

Similar 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 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 fertilizers, which may be supplemented with organic fertilizers (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.

Photo credit: Andrew Daymond

Large Plantation-Fertigated
Location: Ecuador

Similar 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 plantations are high, in the region 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 fertilizer inputs with latent soil conditions, soil testing is carried out periodically. Appropriate inorganic fertilizers 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 into 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 into the bulk cocoa market.

Photo credit: Philippe Bastide

Table 6: 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

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:

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.

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.

Soil degradation is an issue in many cocoa-growing regions, especially parts of West Africa. Whilst fertilizer use has been increasing in the sector, adoption varies within and between cocoa-growing countries. There is a particular need to target fertilizer 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 (for example the comparison between Côte d'Ivoire and Ghana presented in Figure 9), although it is not always 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: benefits 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 guide 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 a detailed case study analysis of the selected cocoa growing systems, including their cost structure.

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Summary

The Global Guide to Cocoa Growing Systems is a summary of a comprehensive review of cocoa farming systems prepared by the University of Reading for the International Cocoa Organisation. An overview is presented of the characteristics and variability that exists in cocoa production globally, focussing on 10 thematic areas: cocoa farmer, cocoa farm, planting materials, shade management/ agroforestry, soil and water management, crop management, pest and disease management, farm diversification, post harvest management and cocoa sales and farm economics. A comparative matrix is presented as a means of comparing farming systems based on a range of farming system traits along with examples of different systems. 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.