

# FROM JUNGLE RUBBER TO RUBBER AGROFORESTRY SYSTEMS

History of Rubber Agroforestry Practices  
in the World

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# Introduction

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## ►► Rubber in the world

### The place of rubber

This section has been originally partly published in a Cirad report for AFD using IRSG data in Penot et al. (2020)<sup>1</sup>.

Natural rubber is a key product for the global economy because its elasticity and strength have never been perfectly reproduced in synthetic rubber. Natural rubber is extensively used in the tire industry, whose growth due to increasing transport by car, truck and plane, has a direct impact on the demand for rubber (Sainte-Beuve, 2015). As a result, in one decade, rubber plantations grew by more than 2 million hectares to reach 12 million hectares worldwide (Figure I.1).

World production of natural rubber (2017) reached 13.5 million tons, while synthetic rubber production accounted for 15.06 million tons (IRSG, 2018). The vast majority of natural rubber is produced in Asia (Figure I.2)<sup>2</sup>.

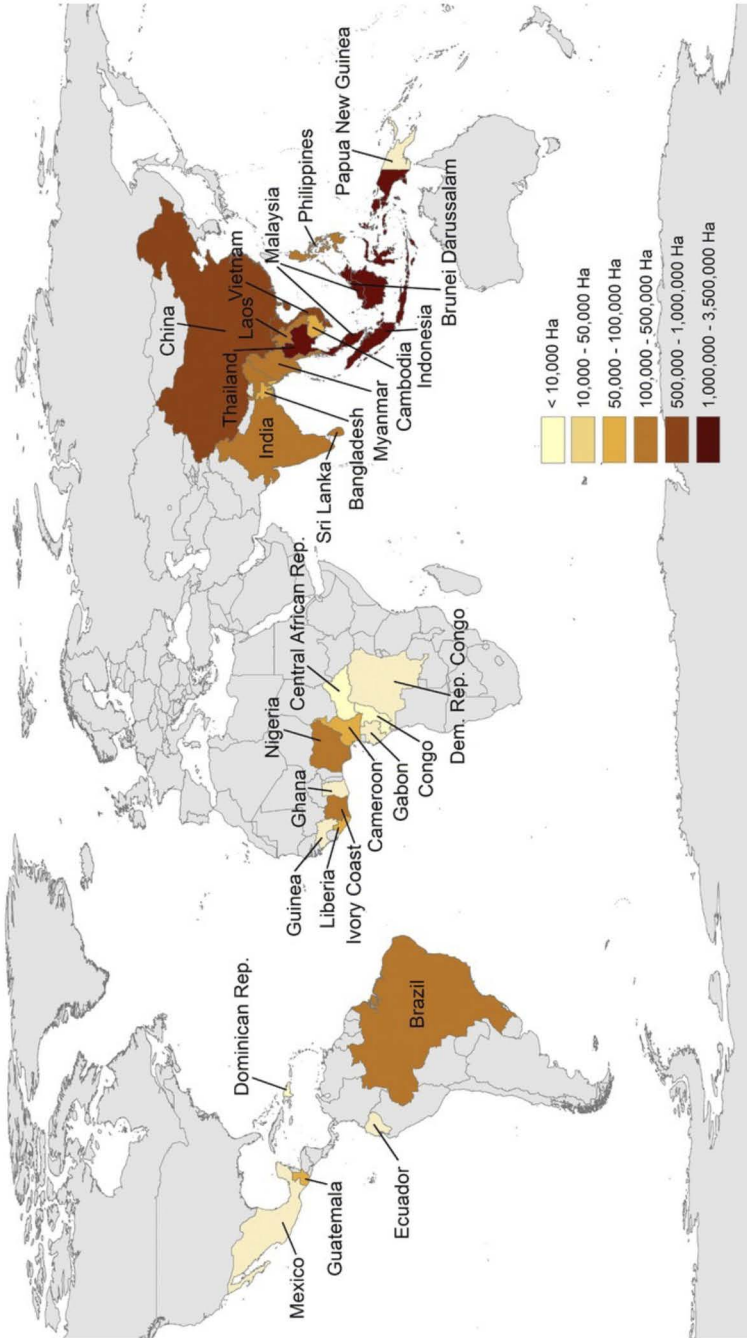
The order of the top 10 rubber producing countries has remained virtually unchanged since the 2000s, but in the decade 2007 to 2017, annual world production increased from 10.1 to 13.55 million tons (Figure I.3).

The top 25 producing countries can be classified in five groups based on their annual production (Table I.1). The following pages describe the increase in production in each of these groups.

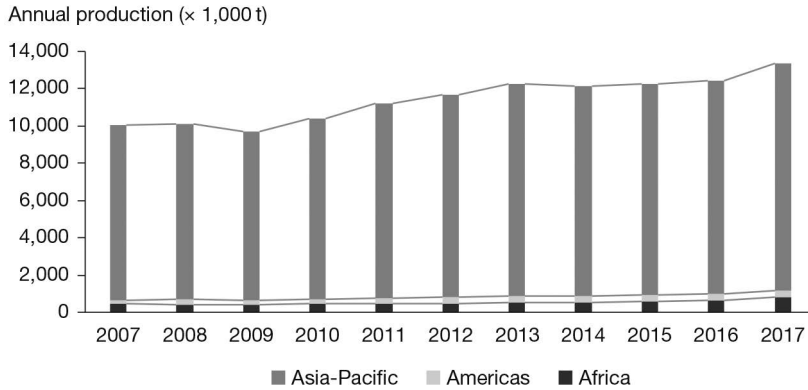
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1. Éric Penot, Philippe Thaler, Yann Nouvellon, Bénédicte Chambon, Jérôme Sainte Beuve, 2020. Revue de la littérature sur les Standards de la Filière Hévéa. Rapport AFD. 41 p.

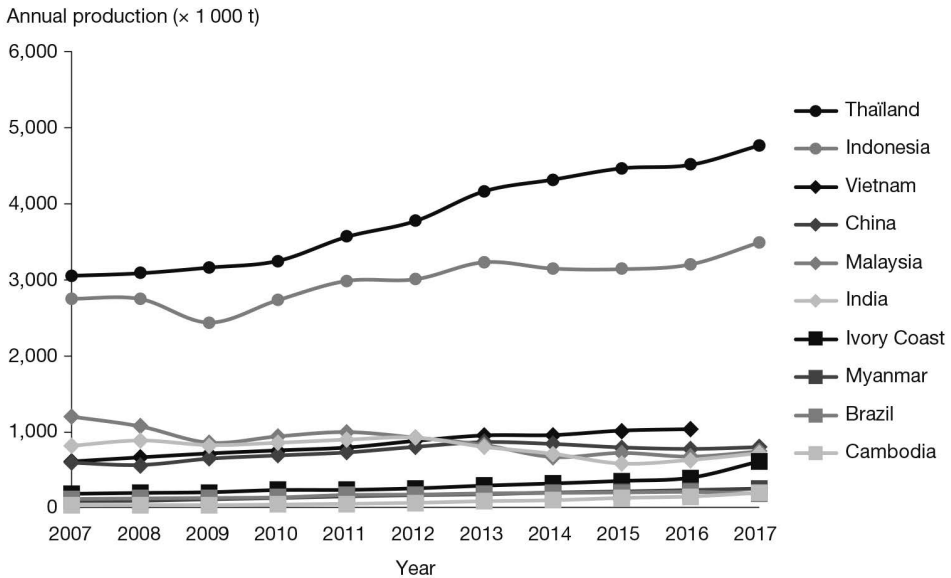
2. Partial source: IRSG data and report by Hugo Lehoux, Adrien Peroches, Lucie Poline, Éric Penot, Jérôme Sainte-Beuve. Rubber in the world. Rubber growing throughout the World. Overview of production dynamics, market and value-chain sustainability challenges. FTA project. Montpellier, 2019.



**Figure I.1.** Surface area of plantations in rubber producing countries (© 2015 The Authors Conservation Letters Published by Wiley Periodicals, Inc.; Warren-Thomas et al., 2015)



**Figure I.2.** Annual rubber production per continent between 2007 and 2017 (IRSG, 2018)



**Figure I.3.** Annual production of the 10 biggest rubber producing countries (IRSG, 2018)

**Table I.1.** Countries grouped based on their annual production

Category	Country	Production in 2018 (x 1,000 tons)
Group A 3 to 5 million tons	Thailand	4,755.0
	Indonesia	3,499.0
Group B 0.5 to 1 million tons	Vietnam	1,032.0
	China	798.0
	Malaysia	741.0
	India	713.0
	Côte d'Ivoire	604.0
Group C 100 to 250,000 tons	Myanmar	249.0
	Brazil	184.0
	Cambodia	193.3
	Philippines	1022
	Guatemala	100.2
	Sri Lanka	83.1
	Laos	78.3
Group D 40 to 60,000 tons	Liberia	63.0
	Nigeria	53.0
	Cameroon	53.0
	Ghana	37.0
Group E Less than 20,000 tons	Gabon	21.2
	Bangladesh	21.0
	Guinea	17.0
	Mexico	18.1
	Republic of Congo	13.2
	Colombia	12.0
	Americas – Other countries	9.2
	Bolivia	5.7
	Papua New-Guinea	5.7
	Africa – Other countries	4.8

### The development of rubber plantations. Booms in China, Côte d'Ivoire, Laos, Cambodia and Vietnam

Two countries account for 61% of world production: Thailand and Indonesia. This is also the case for the last countries to have joined or are in the process of joining the leading group (Myanmar, Cambodia, Côte d'Ivoire, Vietnam and Brazil, a special case), which significantly increases the total area planted (Table I.2).

**Table I.2.** Increasing production by countries with growing global production dynamics (IRSG, 2018)

Country	Rank	2007 (x 1,000 tons)	2017 (x 1,000 tons)	Increase (x 1,000 tons)	Increase (Percentage)
Thailand	1	3,056	4,775	+ 1,719	+56%
Indonesia	2	2,755	3,499	+ 744	+27%
Vietnam	3	606	1,094	+ 488	+80%
Côte d'Ivoire	7	183	604	+ 421	+230%
Myanmar	8	89	249	+ 160	+ 180%
Brazil	9	116	184	+ 68	+ 59%
Cambodia	10	33	193	+ 160	+ 485%

These countries operate under different models. While production in Thailand and Côte d'Ivoire is mainly based on village plantations (family and family business), Cambodia is developing industrial plantations on private concessions. Private investment is all the more important as land prices are low and the country's policy favour the development of large plantations (Chambon et al., 2018).

It is interesting to note that in Cambodia, the development of large industrial plantations follows more or less the same logic as in this group of countries at the beginning of the last century: attractive selling prices for raw materials and labour, public policies favouring domestic and foreign private investment and the desire to develop an agricultural model based on agribusiness (Byerlee, 2014).

In the case of Brazil, production is growing slightly but suffers from severe constraints. The rubber comes from industrial plantations under the pressure of the phytopathogenic fungus *Microcyclus ulei*, which limits its expansion to so-called "escape" zones. An escape zone corresponds to an area whose agro-ecological conditions limit the development of *Microcyclus ulei*. The rest of the rubber comes from tapping in spontaneous forest areas.

Thailand is currently the world's largest producer with 4.77 million tons in 2017, corresponding to 37.1% of global production. Rubber production has continued to increase at an average rate of 4.3% per year for the last 5 years. Thailand is the only country where rubber cultivation has been developed exclusively by family farms. This is largely due to the fact that the country has never been colonised, the Thai state has strongly supported these family farms (Fox and Castella, 2013), and had no policy to encourage private investment and large-scale industrial plantations. Support for family farms in southern Thailand, the traditional cradle of rubber cultivation in the 1950s and 1960s, was also established for political reasons, mainly to counter the communist rebellion (like in Malaysia) and to ensure a good source of income for local farmers. Industrial plantations occupy a very small place in Thailand, 3.5% to 7% of the total rubber production area (Chambon et al., 2018; IRSG, 2018). The world's major industrial groups have acquired land in Thailand, but most of it is fragmented, with an average area of 63 ha for this type of industrial plantations. It should be noted that the model of family business plantations is in full development, particularly in the so-called marginal areas (Chambon et al., 2018; Fox and Castella, 2013). Their average surface area ranges between 10 and 300 ha.

Indonesia<sup>3</sup> has been the world's second largest producer for many years, with 3.4 million tons in 2017, or 25% of the world's natural rubber production. Like in many countries in Southeast Asia, rubber tree cultivation was developed under colonisation in the form of "domains". At the beginning of the 20th century, natural rubber prices were very volatile, which pushed tire manufacturers to internalise the production stage. In Indonesia, this was the case of Goodyear (Barlow, 1978). Small family farms very quickly adopted rubber in the 1920s, which reached 85% of the country's total area (Fox and Castella, 2013; IRSG, 2018). In the 1960s, some of the large plantations were nationalised to form the state-owned company PTP (PT Perkebunan Nusantara III). The State introduced concession policies promoting the development of oil palm in the 1990s, thereby contributing to massive deforestation (Byerlee, 2014; Feintrenie *et al.*, 2010).

Over the last decade, natural rubber production has increased at an average rate of 2.4% per year, with a slight slowdown in growth since 2013. This growth is due to the conversion of land formerly dedicated to cocoa, tea and coffee to rubber, but also to oil palm and *Acacia mangium* (Feintrenie *et al.*, 2010). The slowdown is being caused by the reduction in available land and competition with other types of speculation. Yields in Indonesia are reported to be lower than in other producing countries, mainly due to the use of unproductive tree planting material in jungle rubber systems (ANRPC<sup>4</sup>), the ageing of the trees and competition with oil palm when replanting.

Industrial plantations represent 14% of the area planted with rubber trees (Chambon *et al.*, 2018), but are decreasing in favour of village plantations, but also of industrial plantations of *A. mangium* and oil palm. These industrial plantations often belong to the state-owned PTP or are foreign-owned private plantations (owners from China and Singapore). Private plantations can be very large: 35,000 hectares for Michelin and 24,000 hectares for Bridgestone. These plantations mainly follow the hybrid planting model called NES<sup>5</sup>, i.e., an industrial plantation feeding a factory, surrounded by family plantations. The possibility to increase the extent of industrial plantations is currently quite limited. Some private plantations may consider taking over concessions that have fallen into the public domain or planting in areas that are still untouched but difficult to access. Access to land is strongly dependent on policies, which are not as favourable to major concessions as in the past. At the moment, the Indonesian government does not wish to open new concessions, but this could change in the future.

GAPKINDO, the association of Indonesian rubber producers, introduced a policy to improve rubber quality in the 1990s. Actions to improve quality are also successfully implemented by private companies themselves (Dao, 2015).

India is the world's sixth largest producer with 713,000 tons produced in 2017, representing 5.3% of global production. Developed under English colonisation, rubber plantations have always been in the hands of smallholders, with production for the domestic market. These are intensive, small-scale family farm systems, resulting in very high land productivity (Viswanathan and Shivakoti, 2008); 89% of Indian production

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3. This section has been originally published in: Éric Penot, Bénédicte Chambon, Jérôme Sainte Beuve, 2023. An analysis and comparison of the rubber smallholder sector in 5 countries: Cote d'Ivoire, Thailand, Indonesia, Vietnam and Cambodia. FTA/CIFOR final report, Montpellier France.

4. The Association of Natural Rubber Producing Countries (ANRPC). <http://www.anrpc.org/>

5. PIR/NES: NES = Nucleus Estate Scheme which has its Indonesian equivalent; PIR = Perkebunan Inti Rakyat.

is provided by family plantations (Fox and Castella, 2013). India wanted to increase its domestic market for natural rubber, in line with its increasing economic growth. It therefore put in place policies to support plantation renewal, including through its rubber production department at the Indian Rubber Office. However, the policies do not seem to have been sufficient to generate a strong trend towards planting or renewal of rubber plantations. The very significant ageing and fragmentation of the plantations has limited the expected growth. Over the past ten years, production has declined at an average annual rate of 1.2%. Currently, prices are subsidised to maintain or even restart plantations, with the aim of producing for the domestic market. It should be noted that there are also plantations in the seven northeastern states, but yields are lower there (ANRPC).

The dynamics and problems are similar in Sri Lanka with an additional constraint due to the prevalence of heavy rains. Production drops drastically when heavy rains fall every day. This has led farmers to implement rain protection practices such as installing a rainguard to protect the notch and the cup. Agroforestry systems in association with tea were developed in the 1990s.

The years following 2010 saw significant rubber booms in some countries: Côte d'Ivoire, Vietnam, Laos, Cambodia, and China, mainly through the development of rubber monoculture. Rubber agroforestry systems (RAS) remain an interesting alternative in some other countries such as Indonesia, Thailand, Sri Lanka, Columbia and India.

## ► The concept of agroforestry and agroforestry systems

This section has been published in 1999 as a Cirad working document<sup>6</sup>.

The objective of agroforestry can be defined as the reconciliation of two types of land exploitation which have deeply affected the countryside of both tropical and temperate countries in recent centuries: agriculture and forestry. The main feature which characterises agroforestry is the combination, or association, of several annual and perennial plants in the same field.

Agroforestry systems (AFS) are one type of “cropping system”, in which the field is homogeneously managed, using a particular technical pathway (or “technological pattern”) and a defined plant succession. One may consider AFS as cropping systems, possibly based on one main species. A systemic approach is appropriate to define systems in which labour, inputs, land use and know-how are managed under a particular strategy. Agroforestry strategies can be defined mainly through three features: (i) the minimisation of risk (crop failure), (ii) the optimisation of labour efficiency, different levels of intensification depending on the system, and (iii) the possible use of improved planting material and inputs, according to a strategy that takes land tenure and occupation into account. At the field level, combinations of crops, planted or the result of natural regeneration, lead to interactions between plants: competition and sometimes complementarity.

The traditional definition of ICRAF (International Center for Research in Agroforestry) is the following: “*A collective name for land use systems and practices in which woody perennials are deliberately integrated with crops and/or animals on the same land management unit*”.

6. Éric Penot, Bernard Malet, 1999. Agroforestry systems: some definitions and contribution to forests dynamics. Cirad, Montpellier.



Agroforestry is generally practiced with the intention of developing a more sustainable form of land use that can improve farm productivity and the welfare of the rural community (Leakey, 1996).

The general definition provided by Somarriba in 1992 seems to us to be a less “reducing” definition: “*Agroforestry involves diverse technical practices that have in common the following: (i) there are at least 2 different plants in biological interaction, (ii) one of the 2 plants is a perennial and (iii) one of the 2 plants is a forage crop, a food crop or a tree crop.*”

The definition was revisited by Leakey in 1996: “*Agroforestry should be considered 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.*”

Another definition was suggested by the “*Laboratoire de Botanique Tropicale*” in Montpellier, France: “*Agroforestry is a land use system, controlled by the local population in which perennial trees are associated with agriculture and/or stock farming on the same piece of land in such a way that the resulting ecosystem tends to mimic the natural forest ecosystem in terms of aerial and soil biomass, vegetation structure and species richness.*”

That definition paves the way for complex agroforestry (CAF). The definition of an “agroforest” was made by de Foresta and Michon: “*Agroforests are a particular kind of agroforestry land use, but the word “agroforest” is sometimes understood as the end-result of all agroforestry systems, whatever their structure and composition. For us<sup>7</sup> as for many scientists and laymen, using the word “agroforest” to describe structures that have no forest features, like alley-cropping or trees on contour lines systems, represents a language abuse that only leads to confusion*” (de Foresta and Michon, 1996). This definition is perfect for jungle rubber and complex agroforestry systems.

A typology is therefore necessary to classify agroforestry systems. Many typologies have been defined (King, 1979; Huxley, 1883; Nair, 1985; Macdicken, 1990; Somarriba, 1992; Mary and Besse, 1996; Torquebiau, 1998) and are generally based on their components (crops, trees and livestock) and their combination in space and over time. De Foresta and Michon proposed another classification with two components: simple agroforestry (SAF) systems and complex agroforestry systems (de Foresta and Michon 1965), that perfectly reflect most agroforestry situations: “*Simple agroforestry systems (SAF) refers to associations involving a small number of components arranged in obvious, usually well-ordered patterns: one or a couple of tree species, either as a continuous canopy, in equally distant lines or in edges, and some annual species for ground cover.*”

The tree component is generally a crop of major economic importance, coconut, rubber, clove, teak and now oil palm, or plays a qualitative or environmental role, with *Erythrina*, *Leucaena*, *Calliandra* planted for fodder or to improve soil fertility. The annual species are usually important economically as intercrops during the immature period, such as paddy, maize, vegetables, forage crops or banana, pineapple, cassava or sugarcane. These simple agroforestry associations represent the classical

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7. This represents the “Montpellier group *Laboratoire de Botanique Tropicale*” with F. Hallé, J.M. Bombard, F. Mary, G. Michon, H. de Foresta, E. Torquebiau, and other Cirad/ICRAF researchers (E. Penot, F. Besse, etc.).

agroforestry model most favoured in the development programmes of most institutions dealing with agroforestry (Steppler and Nair, 1987; Nair, 1989) as they are simple to promote (shading systems with coffee/cocoa, alley-cropping, hedgerows, improved fallows, etc.). The structure and functioning of these SAF do not resemble a “forest structure” and do not provide the same environmental outputs in the humid tropics.

Complex agroforestry systems are tree-based systems with a forest-like configuration that associate a large number of components, including trees as well as tree-lets, lianas, herbs, crops, and medicinal plants. Agroforests mimic the structure of natural forests, with a complex multi-strata structure and a closed canopy dominated by a few tree species (definition in van Noordwijk et al., 1997). The word “complex agroforestry systems” (CAF) is far more appropriate for agroforestry systems that match this definition such as jungle rubber, RAS (Rubber agroforestry systems, etc.). According to these authors, the CAF concept implies relative continuity in space and over time. Forest biodiversity in agroforests is usually quite high, as most farmers do not systematically eliminate “unused species”, thereby allowing the regeneration of numerous forest species. CAF functioning is close to that of natural ecosystems. Complex systems are encountered almost exclusively in agriculture in the humid tropics. Except for home-garden systems, a particular form of CAF association that is relatively well documented worldwide, complex systems are now better recognised after having been ignored for decades. The functional reference to a natural forest ecosystem is one of the main features that distinguish “complex” from “simple” agroforestry systems. CAF are far more relevant for the analysis of forest dynamics as their ecological structure and physiological functioning in the mature period is very similar to that of a forest. However, as perennial cropping systems, CAF are also closer to plantations than to forests in terms of investment, management, economic strategies and outputs.

The dimension of the concepts of simple and complex agroforestry systems goes far beyond this physiognomic description or its intrinsic implications for the respective qualities of both systems. SAF and CAF relate to two different, though potentially complementary, conceptions of land development. One refers to field management: SAF address the integration of trees in agricultural lands. The other refers to resource management: CAF address the integration between forests and agriculture. This difference does not only involve important ecological aspects but has also essential socio-political implications, especially concerning the global role and interest of smallholder farmers in the management of forest lands and resources (de Foresta and Michon, 1995).

In the case of rubber, some AFS with rubber include only one tree, which could be one fruit tree (Thailand) or only one associated species (coffee or cocoa). Historically, jungle rubber was the most developed and famous CAF in southeast Asia and, in particular, in Indonesia. Modern RAS such as CAF also exist with several fruit tree and timber species all mixed together.