



Global Platform for Sustainable Natural Rubber



Rubber agroforestry systems (RAS) for sustainable agriculture
 Systèmes agroforestiers à base d'hévéa pour une agriculture durable

Workshop GPSNR 2024

with rubber smallholders in Liberia

Version for external sharing¹

**Held at: Rubber Planters Association of Liberia (RPAL) Training Hall,
Montserrado County, May 2024**



By Dr Eric Penot (CIRAD UMR Innovation, France), Dr Maria Wang Mei Hua

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¹ Participant personal information redacted from this version for confidentiality purposes.

1 Introduction: A GPSNR Rubber Agroforestry Systems (RAS) training session in Liberia

We extend our gratitude to our local partners RPAL and Firestone Liberia for organizing this fruitful two-day workshop with rubber smallholders and producers. We are especially thankful to the RPAL committee and staff, especially Executive Director Mr Joe Gator, Vice President Mr Bannie Browne, and President Ms. Wilhemina G.M. Siaway, as well as Firestone Liberia Head of Compliance and Sustainability Ms. Rhea Cinco for their essential help in ensuring the smooth running of the workshop.

1.1 Objectives

The global objectives of this session with Liberian rubber smallholders were the following:

- To share technical information on current existing RAS in the world to illustrate examples of what is feasible
- To provide information to farmers and profit as well of their own experience and RAS.
- To Identify constraints and opportunities to develop RAS in various socio-economic environment
- To Identify RAS cropping patterns suitable to local farmers
- To identify conditions for further potential actions (demo-plots, On-Farm Trials)
- To share farmers perceptions on RAS and conditions to develop opportunities

For GPSNR, the objectives were the following;

- To collate global, country, and region-specific best-evidence and best-practice materials on agroforestry for natural rubber systems
- Where feasible, collated material to be disseminated to GPSNR smallholder members and their communities even where workshops are not planned for the period 2023-2024
- To conduct workshops for GPSNR smallholder members and their communities to introduce agroforestry concepts and practices, and provide guidance and answers for the following questions:
 - a. What is possible to grow in your region or specific location, and how can this be achieved?
 - b. What is the market availability and demand of particular products in your region?
 - c. How can agroforestry investments benefit smallholders economically, environmentally, and socially?

The target countries for 2023-2024 were Cote d'Ivoire, Indonesia and Liberia. In Indonesia, agroforestry possibilities and practices would vary widely across the country's

major rubber-producing regions. There is strong interest from smallholders as well. It will be critical to blend or merge more traditional concepts such as jungle rubber with evidence-based and structured forms of agroforestry.

In Liberia, as in Cote d'Ivoire, there is no history of agroforestry systems with rubber. However, interest by smallholder is great for 2 reasons: the possibility to increase income from associated plants to rubber and for environmental/sustainability reasons.

The program of the workshop is detailed in Annex 1. A consent form was distributed to all participants (Annex 2) as well as a questionnaire about current rubber practices (Annex 3). The list of participants is provided in Annex 4. Participant feedback and suggestions for future workshops through an anonymous exit survey is provided in Annex 5. A quick guide or brief introduction to rubber agroforestry, which was distributed as printed copies to all participants, is presented in Annex 6.

1.2 Background and context: Rubber in Liberia

In 1926, the Liberian government granted Firestone a 99-year lease for a million acres (to be chosen by the company wherever in Liberia). Firestone made efforts to foster the development of Liberia's local rubber industry. In 2005, the Firestone Company and the Liberian government signed a new 37-year deal for a license of 404 000 hectares of land, and it currently occupies some 61,9 thousand hectares. The total concession area of Firestone represents 4% of Liberia's territory and nearly 10% of its arable land. The Firestone industry, based in Harbel, produces ribbed smoked sheet (RSS) to be exported to the United States to produce tires. In 2022, Liberia exported \$ 112.7 Million US\$ in Rubber. Liberia is highly dependent on NR production and commercialization for economic growth. NR is the most important cash crop in Liberia, it ranks second in value of export (after iron ore) and is a major source of foreign exchange earnings for the government and rural livelihoods in Liberia.

Rubber has a long and controversial history in Liberia. Observers largely agree that the sector has served as a much-needed generator of state revenues and a creator of formal, salaried employment in a country with a largely subsistence agricultural economy. However, there has been persistent concern and tension around the terms of the contracts signed between the Liberian state and rubber companies, on the one hand, and the living and working conditions on Liberian plantations, on the other.

The LAC plantation is one of the largest in Liberia with a labour force of approximately 3,000 workers (regular and seasonal) and a total population of 25,000. This makes it second only to the Firestone plantation in population and workforce size. The LAC plantation is located close to Liberia's capital, Monrovia.

In August 2003, Liberia emerged from the devastating 14 years civil war with almost every institution and piece of infrastructure destroyed. Liberia has a primarily agrarian economy, with the majority of the population dependent

on some form of subsistence agricultural production for their livelihood. It is estimated that almost 70 percent of the labor force in Liberia is engaged in agriculture.

In 2022, It is estimated that more than 20,000 people are employed by commercial rubber farms and up to 60,000 smallholder households are involved in the growing of rubber trees.

All seven of the large company-owned rubber plantations in Liberia are unionized. Large-scale rubber plantations operating in Liberia include:

- Firestone – near Harbel, Margibi County
- Liberia Agricultural Company (LAC) – near Buchanan, Grand Bassa County
- Guthrie (also known as Goodrich plantation) near Baha, Bomi County
- Liberia Company (LIBCO) – near Cocopa, Nimba County
- Salala Rubber Corporation – near Nienka, Margibi County
- Cavalla (initially part of the Firestone concession) – near Harper, Maryland County
- Sinoe Rubber Corporation (SRC) – near Greenville, Sinoe County

It is estimated that more than 20,000 people in Liberia are employed by multinational NR farms, while more than 60,000 smallholders depend on NR for livelihood. The sector is dominated by small and medium farms and covers more than 5 percent of the agricultural land.²

² Verite (2016) Rubber Production in Liberia: An Exploratory Assessment of Living and Working Conditions, with Special Attention to Forced Labor. https://verite.org/wp-content/uploads/2016/11/Research-on-Working-Conditions-in-the-Liberia-Rubber-Sector__9.16.pdf



2 General comments: Composition of Participants & Summary of Questionnaire Survey Data

Many farmers have no technical knowledge and know-how on mixing rubber and other plants. The questionnaire has also been modified based on our experience in Cote d'Ivoire and Sumatra (Annex 3).

Composition of Participants & Summary of Survey Data

Participants: 25 smallholder farmers from RPAL, 3 officers from LAC (Liberian Agricultural Company – a rubber plantation company), 3 officers from Firestone Liberia (rubber plantation company) attended both days of the workshop. Among RPAL members, there were 13 county coordinators (who are responsible for coordinating activities for RPAL members in their counties), 1 extension officer, and the President, Vice President, Executive Director. Two other RPAL committee members came on the second day. All RPAL members must be themselves farmers.

Geographical representation: Excellent. 14 out of 15 counties in Liberia were represented (only Grand Gedeh was not represented).

Gender representation: 4 women, 21 men. Female participation could be improved.

Total survey respondents: 25

Age: 38-69, average age is 53.

Age range	Count of participants
<= 35	0
36-49	11
50-59	14
>=60	5

Ethnicity/Indigenous/minority representation:

20 self-identified as indigenous.

14 self-identified as minority, 9 as not minority, and 2 did not answer.

A range of Ethnicities were reported: Kpelle (7), Grebo (6), Bassa (3), Mano (1), Sarpo (1), Vai (1), and mixed (1).

Education levels:

Education	Count of participants
Junior high	3
High school	8
AA	3
AA/Bachelors	2 (1 BSc)
Bachelors	5 (1 BSc)
College (unspecified)	4
MBA	1

Participation in Cooperatives: 11 participants listed the cooperative they were in (RPAL was not counted), i.e.: Chenokwah Coop., Dordeala, Gee River-Rubber Cooperative, Maryland Farmers Multi-Purpose Cooperative (MAFARCO), Bellema Rubber Coop., Todee Rubber Farmer and Multipurpose Cooperative Society.

Rubber hectarage: Ranged widely from 2-280 ha³. Participants also interpreted “rubber area not in production” as including areas of mature rubber (aged 7 and above) which were not being tapped (e.g. due to labour shortage). There were 3 participants with only immature rubber.

Total rubber area (ha)	Count of participants
2-10	7
11-20	6
21-50	8
>50	4

Other crops: Only 5 farmers reported not planting other crops. Cocoa was the most common other major crop planted (10). Other crops planted: oil palm (6), peppers (3), banana (3), coffee (2), cucumber (2), cola (2), rice (1), oranges (1), corn (1), pineapple (1), plaintain (1), and beans (1). The area of other crops was always smaller than rubber (mostly 4ha or less in production), but some participants also reported other 1.2-6 ha of cropland not in production. This shows that rubber is the main commodity crop but most farmers are diversified.

Rubber age: Ranged from 1-45. 11 farmers had immature rubber trees (aged 6 and below).

³ Please note that the approximate conversion rate of 2.5 acre = 1 ha was used to standardize reported hectarage.

Spacing: Majority of respondents plant rubber trees with spacing of 6x3m or 10x20 ft (n=11) followed by 9x18 ft (n=4). Others used a range of spacings, from the closest 5x11 ft (1.52x3.35m) to the largest 4x8m.

Clones: Most farmers reported using seedlings (without naming any clones). Clones mentioned were: GT1 (5), IRCA41 (5), IRCA317 (3), IRCA331 (3), PB260 (4), PB350 (2), RRIM 600 (3), Harbel 1 (2), Harbel 10 (1), RINI100 (1), and PR17 (1).

Tapping Frequency:

Commonly ranged from D1-D3. Some respondents applied two tapping systems. The two tapping systems may have to do with labour availability, or differing productivity of different stands. D4 is only applied by one participant, so low frequency tapping is not common. Some of the answers (e.g., 4 days a week) were ambiguous and excluded from analysis, as it could have meant the number of tapping days per week, rather than how many times the same tree would be tapped per week.

Stimulation Frequency: Majority applied stimulation 3x/year (n=9), followed by 4x/year (n=6).

Stimulation Frequency (times/year)	Count of Respondents
0	3
1	1
2	2
3	9
4	6
Not yet in production	3

Weeding:

Most participants use manual weeding method (n=21). Only 3 used a combination of manual + herbicide (n=3). Frequency of weeding varies (from once to four times a year, most commonly is twice a year). The cost also varied (USD 1.50-5000 /year)⁴.

⁴ Please note that the approximate exchange rate of 200 LRD = 1 USD was used to convert between the two currencies for this analysis.

Fertiliser:

Most participants did not use fertilizer (n=14) or chemical (n=9). Other responses were: organic (2). The cost also varied (USD 25-1000 /year).

Household dependents: The number of dependents per household in Liberia seems rather high, ranging from 6 to 31. Perhaps this question was misinterpreted.

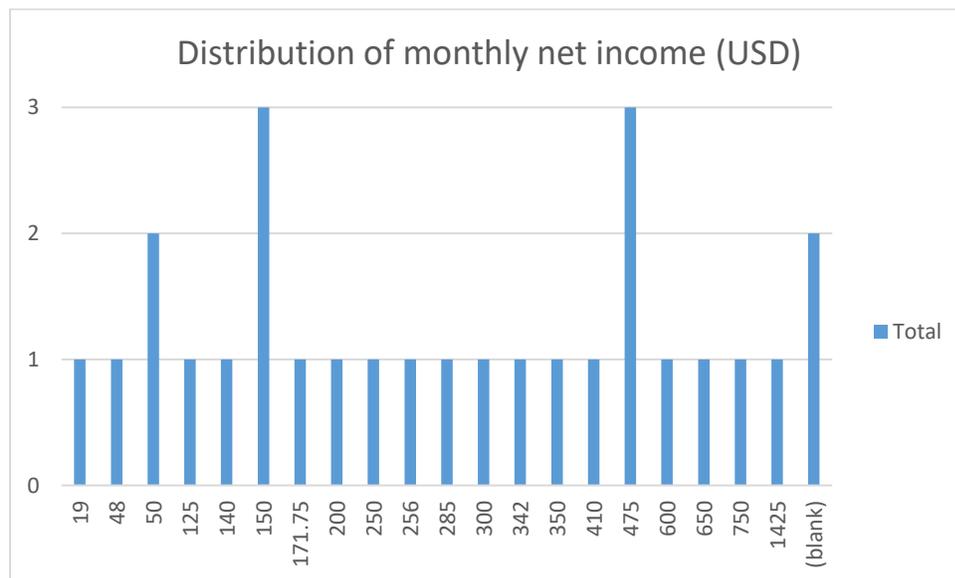
Income

In the survey, we asked respondents about the net monthly income, net income from rubber, from other agricultural sources, and from other sources. We note that the answers are merely rough estimates and not be taken as accurate data, but as a general reflection of the income situation of our workshop participants.

For reference, the minimum wage for a formal sector job (industry, business, company, etc) in Liberia is USD5.50/day, and for domestic/casual workers it is USD3.50/day⁵. The international poverty line is USD2.15/day.

Net monthly income:

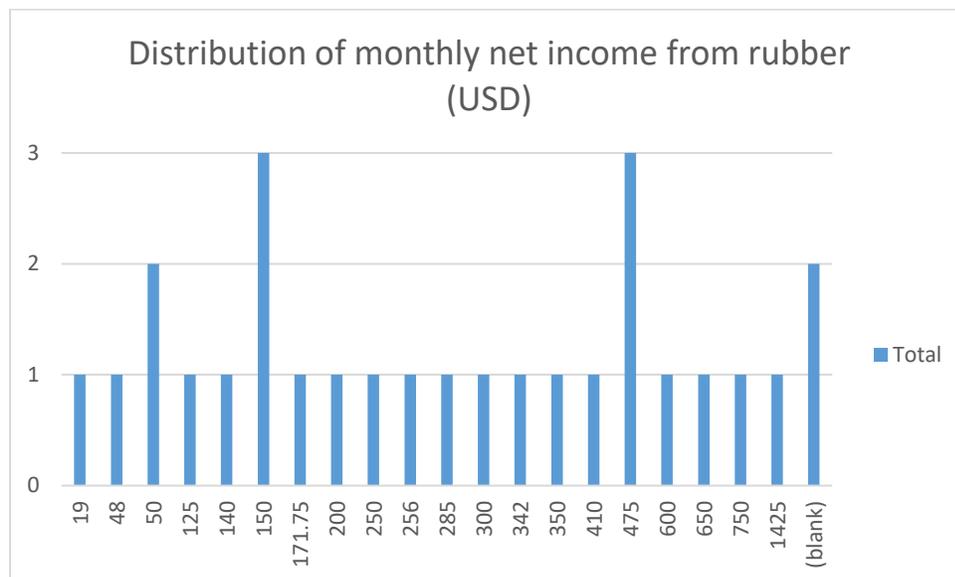
Notably, there may be 4 participants earning below the international poverty line (USD2.15*30=64.5), and 6 below monthly minimum wage rate for a formal sector job (approximately USD150). However, we cannot make any formal conclusion from this basic data.



⁵ https://liberiahrjobs.com/wp-content/uploads/2021/02/DECENT-WORK-ACT-2015_MOL-1-1.pdf (page 45)

Income from rubber (net):

Note that some respondents reported income from rubber that was higher than monthly net income, so the % monthly income contributed by rubber is likely to be inaccurate. A few respondents also answered in % rather than monetary value.



Percentage of monthly net income from rubber*	No. of respondents
0% (not yet in production)	3
> 0% - 49%	3
50% - 100%	13
> 100%	6

*data quality not assured only for information

Income from other sources:

16 participants reported having income from **other agricultural sources**, ranging from LRD 3800-95000 to USD 50-298. In almost all cases, this income was less than the reported income from rubber (excluding those whose rubber were not yet in production).

13 participants reported having income from **non-agricultural sources**, such as from business, pastor, teaching, charcoal production, cooperative training and research, and plumbing.

Labour:

Count of...	No. of respondents			
	All labour (family external + sharecroppers)	Family labour (relatives included)	External hired workers	Sharecroppers
0	0	1	2	12
1-2	1	2	3	3
3-5	2	15	9	5
6-10	10	5	6	0
11-20	10	2	2	0
>20	2	0	1	0

Smallholder farmers were dependent on both family (likely including relatives who may be hired) and hired labour, with the majority needing a workforce of 6-20.

8 respondents have some form of sharecropping arrangement. There was a discussion about what sharecropping meant so it was a new term for some participants.

Prior knowledge/experience:

We asked participants to rate their knowledge and experience with agroforestry (with any crop), on a scale of 1-4:

Self-assessment of prior knowledge/experience	No. of respondents
<i>1 – No knowledge</i>	1
<i>2 - Some knowledge, but no experience - Unsure of how to practice</i>	6
<i>3 - Some knowledge, some experience - Sufficient knowledge to practice agroforestry, or just started practicing agroforestry (only intercropping during immature period)</i>	15
<i>4 - Experienced, ready to teach others</i>	3

Based on these responses, many participants have some knowledge and practice of agroforestry. Years of experience ranged from 1 to 10 years. Type of prior agroforestry experience includes cocoa agroforestry, and intercropping rubber with banana, vegetables, and animals.

They learned about agroforestry from various sources, most commonly: themselves (n=7), through friends (n=4), and government (n=4). One respondent said they learned about agroforestry from Firestone.

Reasons for interest in agroforestry:

Majority gave economic reasons (more money or income, increase productivity). Eight were motivated by knowledge (to learn and increase experience). Two mentioned environmental reasons. One mentioned food inequality.

Several saw this training as a capacity building opportunity, and were motivated by the opportunity to learn

Expectations for Programme:

Common expectations are to improve knowledge, experience, and welfare of farmers. Five expressed hope that this type of workshops will continue, perhaps for other crops. Some also hoped for exchange/sharing of ideas, and to spread the knowledge to farmer communities.

Feedback about workshop

We collected feedback about the workshop through an anonymous written exit survey (Annex 5).

- 29 of 30 participants (including officers from LAC and Firestone) gave the workshop a satisfaction rating of 5/5 (Very satisfied), and the remaining 1 participant rated the workshop 4/5 (Satisfied).
- All participants would recommend the workshop to others and/or to their management/employer. 7 participants said they wanted to share the knowledge with other farmers.
- Majority said that the most useful thing about the workshop was new knowledge.
- Suggestions for future workshops:
 - Extend to more farmers (n=9), more communities (n=5)
 - More trainings (n=4)
 - Additional days of training (n=4)
 - Training on the farm/in the field (n=3)
 - Other topics (including: clones, disease bud-grafting, tapping) (n=4)
 - Materials – hard, soft, audio visual (n=2)
 - Invite other large planters (1)
 - increase allowance and transportation subsidies for far counties (1)

Participant engagement

In general, the participants were warm, friendly and engaged. Officers from LAC and Firestone Liberia were active participants in the discussion. Participants had a positive perception towards agroforestry.

Based on survey responses and from open floor discussions, Liberian farmers were hungry for new knowledge, and were eager to apply what they have learned, as well as share the knowledge more widely to others.

RPAL executive committee played essential roles in facilitating engagement and clarifying confusion over new terms.

The consultant brought rubber agroforestry products (stingless bee honey and palm sugar, produced by Indonesian rubber smallholders) for participants to taste and it was well received.

The workshop venue (RPAL training hall) was generously provided at no additional cost by RPAL with access to open space. We are also deeply thankful to RPAL committee and staff for their essential help in ensuring the smooth running of the workshop and successful smallholder engagement.

Gender issues

Ms. Wilhemina Siaway, is the first female president of RPAL, and she played a key role in the workshop proceedings along with other committee members, as well as in inclusion of female smallholders. The three other female participants were more reserved and had to be encouraged to speak. There were a few other women assisting with catering, some of whom worked at RPAL's nursery or had family members working in rubber. The non-participant female assistants requested copies of the training material, showing their interest in participating but unfortunately there were not enough hard copies for everyone. However, RPAL should be able to facilitate distribution of photocopies.

Other studies have found that women tend to be excluded from tree-cropping and access to agroforestry technical knowledge⁶. Researchers suggest possible reasons for this trend, including insecure land tenure due to gender, gender roles in labor, and gender discrimination⁷.

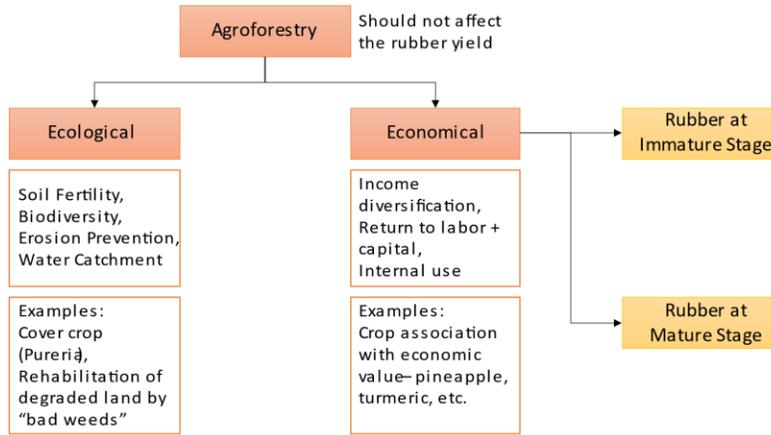
⁶ Fouladbash, L., Currie, W.S. Agroforestry in Liberia: household practices, perceptions and livelihood benefits. *Agroforest Syst* 89, 247–266 (2015). <https://doi.org/10.1007/s10457-014-9763-9>. Relevant excerpt: “Regarding the finding that female-headed households were less likely to practice tree cropping than male-headed households, ... this result is consistent with other studies both in Liberia (MOA 2007, Weise and Wilcox 2007) and across Sub-Saharan Africa (Kiptot and Franzel 2011), which consistently show that women are often excluded from tree-cropping and agroforestry technologies.”

⁷ *Ibid.*, 4

GPSNR Agroforestry Workshop in Liberia



• Importance of Agroforestry



• Agroforestry Patterns

Agroforestry is not a general practice in Liberia; But SHs' response is positive and willing to try out; FSLB to install demo plots in the plantation

Normal Spacing	Double Spacing
10 ft x 21 ft Examples: <ul style="list-style-type: none"> • Pineapple, banana • Spices • Vegetables 	10 ft x 30-42 ft Examples: <ul style="list-style-type: none"> • Cocoa • Coffee • Cocoa-pineapple • Coffee-banana
Examples: <ul style="list-style-type: none"> • Timber • Durian 	Examples: <ul style="list-style-type: none"> • Timber-coffee-pineapple • Durian-coffee-banana

Source: This slide was made by Rhea Cinco (Firestone) as part of the reporting to Bridgestone's Capacity Building Task Force, and formed part of Dr. Maria's presentation to the Task Force on May 23, 2024

Workshop Flow

Day 1:

Introductions by organisers

Presentation about agroforestry during immature period

Presentation about agroforestry during mature period

Issues that came up during discussion on the first day

1. Disease
 - How to prevent transmission of leaf diseases?
 - Example of how clones infected with *Phytophthora* was transported from Cote d'Ivoire to Liberia
 - PB260: good clone commonly planted in Malaysia, but susceptible to leaf disease
 - Southeast Asia characterized by monsoon, but no clear monsoon in West Africa?
2. Clones and Certified Planting Material
 - Rely on Firestone and LAC to get planting materials, copying their methods
 - No rubber research institute in Liberia
 - Just started planting some new clones in RPAL nursery
 - Access to quality planting material important for rural participation
 - Recommendation: to plant a minimum of 5-6 clones to spread out risks; average 2 to 3 clones per 2.5ha
3. Some tips about intercroops
 - For example, rubber+banana+soy is a good combination
 - Fertilizer is important for best yield from intercroops, e.g. cassava + NPK
 - Intercropped cassava should be harvested in less than a year
 - Taro is not recommended as digging to 30cm may impact rubber roots
 - Cardamom and turmeric are recommended because these shade-adapted plants can grow up to Year 5 in Liberia, after which shading will likely be too much
 - *Acacia mangium* is not recommended because it grows faster than rubber
 - Timber can be grown every 6m - timber grows slowly
 - Big mammals are generally not recommended, but some participants have kept goats in their rubber farms and not faced problems
 - Rattan grows wild abundantly in Liberia so there is little market for cultivating rattan
4. EUDR
 - Participant shared that most land in Liberia is hilly, but EUDR policy advised not to plant on slopes, which limits options for Liberian smallholders
 - Question was asked: Are smallholders in other countries following EUDR/ICC policies?
 - o Firestone is pushing for traceability with digitization

- Other tire companies are also working towards traceability and supplier/smallholder engagement
 - NGOs are also working to increase awareness and build capacity among smallholders (for oil palm too)
5. Weeds/cover crops
 - Bare soils lose 30% fertility (happened in Vietnam)
 - With weeds, soil fertility can be maintained for 30 years
 - Some cover crops require less than 5-6 months of dryness to work well
 - Natural regrowth and weeds are ok
 6. Rubber prices
 - A participant asked if it were true that China is responsible for low rubber prices?
 - It was argued that as consumers who prefer cheaper tires, everyone is partly responsible, as this is how capitalism works
 - Another participant gave examples of how other countries manage rubber prices:
 - In Sri Lanka, they have auctions to determine the price of rubber twice a week
 - In Nigeria, rubber processors provide a deposit
 - While prices cannot be directly controlled by farmers, farmers can control what they do, e.g. improve their yields/productivity through applying Good Agricultural Practices; and apply agroforestry/income diversification
 7. Oil palm
 - Good crop with stable prices
 - Concessions supposed to buy oil palm from Liberian smallholders but they just buy processed oil and dump it on the market
 8. Climate Change
 - Smallholders reported earlier leafing in rubber trees for the first time (a month early, from Jan 15-February 15)
 9. Lack of financial support for smallholders
 - Compared to Cote d'Ivoire where the government invested 4 billion into agriculture
 - Bigger farmers, mostly government officials, got Firestone to plan their concessions, now drying up, so Liberian production decreased
 - Sri Lanka, Uganda set up cooperatives for smallholder support
 - Rubber farmers have to pay 4% tax
 - Lack of cash flow and no financing options
 10. Carbon credits
 - Question was posed about how rubber tree density can contribute to carbon credits
 - It was said that carbon credit projects have failed to deliver, so recommended to not have expectations

- Another participant commented that petroleum countries are calling for blue carbon while downplaying carbon credits. How to ensure money goes to the right people?
- Shell wants to buy carbon credits from forestry
- Green Energy Fund – Ghana, Cote d'Ivoire, Nigeria are benefitting from this fund

Day 2:

Special address by Hon. Tokpah J Mulbah, RPAL Board Chair and Liberia Rubber Development Fund.

Discussion to clarify how to answer questions in survey, led by Mr. Bannie Browne, RPAL Vice President

Small group discussion about existing agroforestry practices they've experienced and presentation by group leaders

Closing by Ms. Wilhemina G.M. Siaway, RPAL President

Distribution of daily allowance and transportation subsidies to smallholder participants

Issues that came up during small group and whole group discussions on the second day

1. Lack of knowledge on chemical use among smallholders
 - Some smallholders don't know the formula ratio for diluting chemicals
 - FSC bans certain chemicals
 - Need for research/survey farmers and educate them on what to use
2. Sharecropping
 - The definition of sharecropping was shared by a participant to the room, as not everyone understood the term
3. Intercropping during immature period is practiced by many, but few practice it during mature period.
4. LAC has not practiced agroforestry so far on their concessions. Firestone has trialled intercropping.
5. **Problems faced with agroforestry:** Labour intensive; needs increase in labour force; high theft rate; pest and disease; smaller yields in intercrop due to shading (sometimes loss in quality); lack of storage facility; damage during intercrop harvesting (e.g. rice); shading of rubber by intercrops (for banana...)
6. Benefits of agroforestry
 - Places that were intercropped we experienced fast growth of the rubber and reduced the weeding process
 - Engaging in agroforestry helps for sustainability and also increases farmers' income.
 - Most importantly, helps us maximize the use of land space.

- Legumes like groundnuts are good for soil
 - Can avoid shifting cultivation, land grabbing
7. Jungle rubber
- Reportedly may exist in Liberia

General recommendations for participants interested in agroforestry

1. Exchange experience with each other and with other countries especially those with similar ecological conditions. Cote d'Ivoire has a well-established rubber industry and can provide useful resources.
2. Explore markets; find buyers and organize smallholders for greater leverage
3. The more biodiversity on farm, the better the soil, but fertilizer is needed.

Rubber agroforestry practices currently implemented by workshop participants

The most common agroforestry practices are presented in the following table.

Agroforestry Type	Species	Duration	Reasons	Problems
Animals	mature rubber (15 years old) with goats (male and female)	3 years	help to eat weeds and grass	goat theft - need to bring goats in and out of plantation
Immature	rice, plantain, banana	Year 1-3	It generates income while waiting for maturity of the rubber	Rice-sometimes damage during harvesting. Plantain-Improper spacing affect the growth of rubber. Increased labor
Immature	pineapple, rice	Year 1-4	provides extra income while awaiting production	High thief rate, labor intensive
Immature	pepper, bitterballs	Year 1	Helps immensely during immature stage of rubber	Increases labor force, high thief rate
Immature	plantain, groundnut, pepper	Year 1-3	It provides income which helps me to maintain the rubber and family. Nitrogen fixation	High rate of human pest

Agroforestry Type	Species	Duration	Reasons	Problems
Immature	rice, pepper, bitterballs	Year 1-3	helps in the maintenance of the farm	High stealing rate
Immature	rice, pepper and beans	Year 1-3	improve nutrients and reduces weeding	High thief rate, labor intensive
Immature	plantain, beans	Year 1-3	For food while awaiting for maturity or production	High thief rate
Immature	pineapple	1-5 years	sustain us, food income	cost of maintenance, marketing, road
Immature	Rice	1 year	To provide food, income etc.	Weeding, Pest and Disease
Immature	Yam	1-3 years	As food sources. Income generation	Storage, maintenance
Immature	Plantain	1-3 years	Food and marketing.	Pest and field upkeep
Immature	Tomatoes	1 year	Food , income, marketing	Intensive maintenance
Immature	Potatoes	1-2 years	Food and marketing.	Pest and disease
Immature	Groundnut	1-2 years	Food, marketing, fertilizers	Pest and disease
Immature	pineapple, cocoa	5-6 years	to sell	theft, weeding takes time
Immature/mature	Cocoa	17 years, planted from Y1	safeguard income	shaded by rubber, small harvest
Immature/mature	corn, banana, pineapple, potato, coconut	corn-0.5 years. Other crops - as long as the rubber	more income	corn shades out other crops
Immature/mature	pepper, bitterball, Dahoma (hardwood -			pineapple size is small when shaded (but still flavorful). Insects, snakes

Agroforestry Type	Species	Duration	Reasons	Problems
	spontaneous growth)			

Questions to go through for each farmer during the Small Group Discussion:

1. Do you intercrop during rubber immature period (years 1-3)? [Yes/No]
 - If so, which plants?
 - How long do you grow each crop?
 - What are your reasons for planting these crops?
 - What are the problems you face?

2. Do you grow other plants or trees between rubber trees during mature period (years 4-6, 7 and above)?
 - If so, which plants or trees?
 - What are your reasons for planting these other plants?
 - What are the problems you face?

3. Do you keep livestock in your rubber plantation?
 - If so, which animals?
 - How long have you been keeping each livestock in your rubber plantation?
 - What are your reasons for keeping livestock in your rubber plantation?
 - What are the problems you face?

The suggestions to improve the workshop are presented in annex 5

Conclusion

The is no history of agroforestry practices in Liberia, however many farmers do practice intercropping during rubber immature period.

Intercropping during immature period has been largely practised. Smallholder might have an interest for double spacing agroforestry systems however it is clearly a new paradigm for them. Training is necessary to develop ultimately such design.

Field visit notes

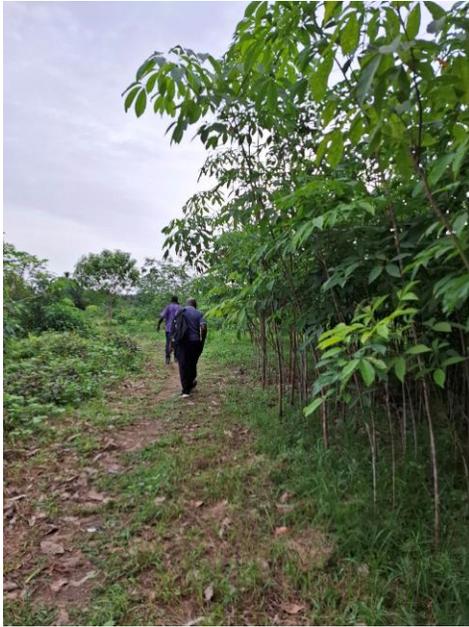
On May 10, RPAL took Dr. Maria to visit a smallholder farm and two rubber nurseries in Montserrado and Margibi counties. The smallholder had inherited the farm from his late brother. He has difficulty walking, so we saw the tapping/cup lump collection was being done by two women. From conversation with the local farmers, they expressed frustration over the difficulty in securing financial support (e.g. loans) from Firestone to improve/expand their plantations. They also expressed that Jetty Rubber offered cash upfront for any rubber from any farmer. Whereas, to sell rubber to Firestone, farmers were required to get a number and the money doesn't come in until the next day or few days later.

Most farmers do not own cars or trucks, most owning only motorcycles. Given the lack of paved roads or poor road conditions especially in rural areas, motorcycles were likely the more logical choice.



Photos: (left) Smallholder rubber farm in Montserrado county; (right) Canopy coverage.

One of RPAL's priorities is to create more nurseries throughout the country to provide access to a variety of clone seedlings. First, we visited a rubber nursery run by a farmer group. Mr. Augustine Fallah, who attended the workshop, is one of the farmers managing this nursery.



Photos: (top left) Montserrado County Farmers Group Nursery; (top right) PB260 seedlings; (bottom left) Mr. Augustine Fallah, one of the farmers managing this nursery; (bottom right) IRCA 41 seedlings.

Next, we visited the main RPAL nursery near Kakata city. There, we saw Ms. Esther Singbah and Ms. Marie Yah (both rubber farmers, bud-grafters, and attendees of the agroforestry workshop), and a few women who assisted with catering needs during the workshop (also bud-grafters and nursery caretakers). They demonstrated their precise skill and nimble speed with bud grafting. Among them, Ms. Esther was lauded as the best bud grafter who runs her own nursery in Kakata and supplies other local

farmers Since the 1960s, women were hired in plantation nurseries for their skills in germination, grafting, and nurturing rubber seedlings.⁸



Photos: (top left) Female bud-grafters; (bottom left) Group photo with RPAL farmer, committee, extension officer, and staff; (top right) Ms. Esther Singbeh; (bottom right) Ms. Marie Yah.

⁸ <https://www.sciencehistory.org/stories/magazine/the-human-price-of-american-rubber/>

Photo documentation:



Left: Mr. Joe Gator, Executive Director of RPAL; Ms. Wilhemina Siaway, President of RPAL; and Dr. Maria Wang, consultant. **Right:** Mr. Bannie Browne, Vice President of RPAL and GPSNR Smallholder Champion.



Participants making their voice heard and attentively listening to presentations during the workshop.



Female smallholders sharing their thoughts about the workshop.



Left: Dr. Maria explaining to the room about the rubber agroforestry honey produced by Indonesian smallholder. **Right:** Group photo outside the RPAL Training Hall.

Annexes

Annex 1: GPSNR Agroforestry Workshop Programme for Liberia (2024)

DAY 1: 8 MAY 2024 (Wednesday)

Time	Programme
07:30 – 08:30	Registration & Breakfast Consent Forms Participants Survey Questionnaire
08:30 – 09:30	Introduction - RPAL, Firestone, any other relevant local partners, Dr. Eric, Dr. Maria introduce themselves & about the workshop - Self introductions by all participants
09:30 – 10:30	What is Agroforestry? We discuss what participants understand about agroforestry, and give definition Presentation on Agroforestry during Immature Period by Dr. Eric Penot with Q&A (during/after)
10:30 – 10:45	Break
10:45 – 12:00	Presentation on Agroforestry during Immature Period by Dr. Eric Penot with Q&A (during/after)
12:00 – 13:00	Lunch
13:00 – 13:30	Time to fill in survey questionnaire and return forms Give “Intro to Agroforestry” guide when forms are returned
13:30 – 15:00	Presentation on Agroforestry during Mature Period by Dr. Eric Penot
15:00 – 15:15	Break
15:15 – 17:00	Continuation of presentation / Q&A session

DAY 2: 9 MAY 2024 (THURSDAY)

Time	Programme
07:30 – 08:30	Registration & Breakfast
08:30 – 10:00	Small group discussion: Smallholders’ Experiences with <u>Agroforestry during Immature Period, Mature Period & Agroforestry with Animals</u> Depending on number of groups, facilitators (Eric, Maria, Rhea, other facilitator) to record information in writing. Regroup and each group will briefly summarize what they discussed with the whole group.
10:00 – 10:15	Break
10:15 – 12:30	Smallholder Presentations – smallholders present about their farm situation, ideas/plans for agroforestry, available markets. Encouraged to bring drawing/sketches of their land, photos and videos
12:30 – 13:30	Lunch
13:30 – 15:00	Smallholder Presentations (cont.) / Open discussion about smallholder situation in Liberia
15:00 – 15:30	Break + Exit Survey
15:30 – 16:30	Verbal feedback from participants about workshop Conclusion & Thanks!
16:30 – as needed	Handing out of subsidy allowance at the end of workshop

Annex 2: Consent Form

Participant Information Sheet (You may keep this sheet for your reference)

Project title: Rubber Agroforestry Workshop in Liberia

Researchers involved: Dr. Eric Penot (consultant, CIRAD), Maria Wang Mei Hua (consultant, independent)

Local project partners: Rubber Planters Association of Liberia (RPAL), Firestone Liberia (FSLB)

Organizer: GPSNR

Funder: Bridgestone

Introduction and purpose:

Workshop Objectives: (1) To share the latest technical information on rubber agroforestry with participants; (2) To create a space for participants to share their own experiences; (3) To understand participants' perceptions on rubber agroforestry; (4) To identify constraints and opportunities, including special concerns for female, youth (age ≤35), and minority participants.

Research Objectives: (1) To understand participants' perceptions and experiences of rubber agroforestry and of the workshop; (2) To collect baseline data on participants' existing knowledge and practices of rubber cultivation and agroforestry.

Rationale: (1) To monitor and evaluate effectiveness of this workshop; (2) To improve the quality of future trainings; (3) To improve agroforestry knowledge and dissemination.

Research Methods: semi-structured survey, participation observation, note-taking, and informal conversations by researchers during the workshop; analysing written material (document analysis).

Output: After the workshop, we will write a report which will be sent to GPSNR, local project partners, and the Funder. The anonymised outputs of this project may contribute to broader research projects on agroforestry.

Participation:

Your part in this investigation is to participate in a rubber agroforestry workshop, which includes a written survey, group discussions, presentations, and providing comments via written or verbal methods. The written survey will ask you about your rubber plantation, your current practices, and your existing knowledge and practice of agroforestry.

Your participation is voluntary and you can choose to withdraw at any time without consequences. Your participation in the workshop is financially supported by GPSNR through a grant provided by Bridgestone. The workshop will take place over 2-3 days.

With your approval we may contact you again to conduct a follow up survey or interview.

Use of information:

The information collected from this study will be recorded via audio recorder / on paper / on a computer. Paper records will be transformed into digital records to be stored electronically. The information collected will be used to better understand participants' perceptions and experience with rubber agroforestry, and for monitoring and evaluation by GPSNR and project partners to assess effectiveness of the training and improve future trainings.

A report of the workshop will be written by the consultants for GPSNR. The report will be shared internally within GPSNR, CIRAD, the funders, and local project partners. GPSNR may choose to make the report or parts of the report available to members of the public who request it. Anonymised data may be shared with external research partners for the purpose of scientific studies.

Your personal data (e.g. phone number) will not be shared outside the two researchers involved, GPSNR, the funders, and the local project partners.

Contacts:

If you have any further questions or concerns about this study, please use the contact information below. Thank you for reading this information – please ask any questions if you are unsure about what is written here / you have heard here.

Dr. Maria Wang Mei Hua
WhatsApp: +60142734182
Email: wang.mh.maria@gmail.com

Dr. Eric Penot
Email: eric.penot@cirad.fr

CONSENT FORM (PLEASE TEAR AND RETURN TO ORGANIZERS)

- I confirm that I have read or have been told and understood the information sheet and the researcher has answered any queries to my satisfaction.
- I consent to being a participant in the Rubber Agroforestry Workshop.
- I understand that my participation is voluntary and that I am free to withdraw from the project at any time, up to the point of completion, without having to give a reason and without any consequences. If I exercise my right to withdraw and I do not want my data to be used, any data which have been collected from me will be destroyed.
- I understand that I can withdraw from the study any personal data (i.e. data which identify me personally) at any time.
- I understand that anonymized data (i.e. data which do not identify me personally) cannot be withdrawn once they have been included in the study.
- I understand that the information I provide will be anonymized before any dissemination. This also covers direct quotes. The information will not be traceable to me.
- I consent to my answers being recorded on paper and/or in electronic format.

PRINT NAME:

Participant signature:

Date:

Annex 3: Survey Questionnaire

Survey for GPSNR Rubber Agroforestry Workshop

Adapted from a baseline questionnaire of Rubber Agroforestry for Sustainability Foundation (RAFS) (2023). For more information about RAFS: rafs.thailand@gmail.com | <https://www.rafsfoundation.org/index.php>

1. Name: _____
2. Are you a GPSNR Member? Yes / No
3. Are you an indigenous in your district? Yes / No
4. Are you a member of a minority group in your district? Yes / No
5. If you are a member of an indigenous or minority group, please state the name of your ethnicity or minority group that you belong to: _____
6. Are you a member of an Agricultural Cooperative? Yes / No
7. Please state the name(s) of the cooperative(s): _____

Information about Rubber Plantation and Management

8. Size of rubber plantation (ha) in production: _____
9. Size of rubber plantation (ha) not in production: _____
10. What is the **second most** important crop you plant? _____
 - a. Size of the second crop (ha) in production: _____
 - b. Size of the second crop (ha) not in production: _____
11. What is the **third most** important crop you plant? _____
 - a. Size of the third crop (ha) in production: _____
 - b. Size of the third crop (ha) not in production: _____
12. Age of rubber trees in production: _____
13. Age of rubber trees not in production: _____
14. Spacing between rubber trees (e.g., 6x3m,): _____
15. Rubber clone used? _____

16. Frequency of tapping? _____
17. How many times a year do you use stimulation? _____
18. How do you manage weeds? Circle all that apply.
 No Weeding / Herbicide / Manual Weeding / Other: _____
19. How many times in a year do you weed?
20. What is the cost of weeding per year? _____ (L\$ per year)
21. What fertilization method do you use in your rubber farm?
 None / Organic / Chemical / Other: _____
22. What is the cost of fertilizer per year? _____ (L\$ per year)

Economics and Labour

23. Total number of dependents in your household? _____
24. Total household **net** income per month?
 _____ (L\$ per month)
25. From the total household **net** income per month, about how much income is from rubber?
 _____ (L\$ per month)
26. From the total household **net** income per month, about how much income is from other farming activities?
 _____ (L\$ per month)
27. From the total household **net** income per month, about how much income is from non-farming activities?
 _____ (L\$ per month)
- a. Please state the source:

28. Number of family members who work on the rubber plantation (including yourself)?

29. Number of external paid workers who work on the rubber plantation? _____
30. Number of sharecroppers? _____

Agroforestry knowledge and practice

31. Rate your knowledge & experience with agroforestry (with any crop).

Choose ONLY ONE from 1, 2, 3, 4:

1 - No knowledge

2 - Some knowledge, but no experience - Unsure of how to practice

3 - Some knowledge, some experience - Sufficient knowledge to practice agroforestry,
or just started practicing agroforestry

4 - Experienced, ready to teach others

32. How many **years** of agroforestry experience do you have, and with **what type of agroforestry** (which crop/animals)?

33. Who taught you about agroforestry?

No prior knowledge / Yourself / Friends / Relatives / Government /

Other (please specify): _____

34. Why are you interested in agroforestry?

35. What are your expectations of this program?

Annex 4: List of Participants (Complete Survey Data provided in separate Excel File)

No	Gender	Age	Profession	Position with RPAL	County
1	M	69	Agriculture	Coordinator	Bong
2	M	47	Farmer	Farmer	Montserrado
3	M	59	Farmer	Vice President	Maryland
4	M	57	Farmer	Coordinator	Montserrado
5	M	55	Farmer	Coordinator	G. Cape Mount
6	M	57	Agriculture	Extension Officer	Margibi
7	F	45	Farmer	Farmer	Nimba
8	M	60	Farmer	Coordinator	Bomi
9	M	52	Farmer	Coordinator	Sinoe
10	M	38	Farmer	Farmer	Bassa
11	M	51	Theology	Coordinator	River Gee
12	M	47	Agriculture	Executive Director	Montserrado
13	M	56	Farmer	Farmer	Maryland
14	M	58	Farmer	Coordinator	Grand Bassa
15	F	60	Farmer	Farmer	Bong
16	F	51	Farmer	Farmer	Maryland
17	M	58	Farmer	Coordinator	Gbarpolu
18	M	66	Farmer	Farmer	Grand Bassa
19	M	39	Farmer	Farmer	Grand Kru
20	M	56	Farmer	Coordinator	River Cess
21	M	51	Farmer	Coordinator	Nimba
22	M	59	Accountant	Coordinator	Grand Kru
23	M	46	Farmer	Farmer	Maryland
24	F	40	Farmer	President	Montserrado
25	M	47	Farmer	Coordinator	Margibi
26	M	60	Management	Board Chair/Farmer	Bong
27	M	57	Farmer	Coordinator	Lofa
28	M		Staff	Firestone	n/a
29	M		Staff	Firestone	n/a
30	M		Staff	LAC	n/a
31	M		Staff	LAC	n/a
32	M		Staff	LAC	n/a
33	F		Staff	Firestone	n/a

Annex 5: Exit Survey Data & Suggestions for Future Workshops

Exit Survey (Anonymous): Feedback on the GPSNR Rubber Agroforestry Workshop

1. On a scale of 1-5, please rate how satisfied you are with the workshop?
(1 = Very Dissatisfied; 5 = Very Satisfied)

Very Dissatisfied 1 2 3 4 5 Very Satisfied

2. Would you recommend this workshop to others?
3. What did you find most useful about this workshop?
4. What suggestions do you have for improving future workshops?

Responses:

Satisfaction Rating	Would you recommend this workshop to others?	What did you find most useful about this workshop?	useful_short	What suggestions do you have for improving future workshops?	suggestions_short
5	Yes	importance of agroforestry	new knowledge; importance	I first thank the GPSNR for coming to help us. I will like to ask that you come again. To improve future workshops I need empowerment that will enable me to do more.	empowerment
5	Yes. As county coordinator, I am going to have small meeting with some of my farmers to give/pass the information to them and explain to some of them how to carry on this practice on their farms	Make me to understand what agroforestry means; How to go about practicing by teaching other people about agroforestry; Types of crops that are to be intercropped	new knowledge	I will suggest to have this workshop with us after every 1-2 years. Thank you for good presentation and understanding.	every 1-2 years
5	Yes	Agroforestry and intercropping	new knowledge	To go to other communities	extend to other communities
5	Yes	Intercropping and agroforestry	new knowledge	To go to other communities	extend to other communities
5	Yes	Intercropping and agroforestry	new knowledge	To have it in rubber farm communities that will be identified by RPAL	extend to other communities
5	Yes	I find everything in this workshop useful		I am pleased to recommend another workshop like this on counties level	extend to other communities
5	Yes	Intercropping rubber with timber or fruit crops	new knowledge	Provide hard and soft copies of presentations prepared by facilitators	hard and soft copies
5	Yes	Rubber agroforestry	new knowledge	To extend more days for training	more days

Satisfaction Rating	Would you recommend this workshop to others?	What did you find most useful about this workshop?	useful_short	What suggestions do you have for improving future workshops?	suggestions_short
5	Yes, I recommend more training for others	Rubber agroforestry	new knowledge	I suggest additional days next time	more days
5	Yes, share the knowledge	Knowledge on agroforestry, especially rubber agroforestry	new knowledge	I suggest extension in the days of the workshop	more days
5	Yes	Knowledge that I never had. I am very happy and impressed by the two-day workshop. I have understood the importance of agroforestry	new knowledge	I personally suggest that the organizer extend the day of the workshop	more days
5	Yes. We will share knowledge with other farmers that are not in attendance to this workshop	The practice of agroforestry should be given more priority in going forward in new planting.		Increase the number of participants.	more farmers
5	Yes. I feel very pleased to attend this workshop and I will recommend it to others	The knowledge I've gained	new knowledge	I suggest that future workshops should include more participants in order to quick and widely transform the knowledge to smallholders across the country	more farmers
5	Yes, to pass on the training	Maximum use of small plot to maximize income	new knowledge	Please involve more farmers	more farmers
5	Yes, by carry on the awareness to other farmers	importance of agroforestry; how it improves the livelihood of the farmers	importance	More farmers to participate so as to carry on the awareness and practice	more farmers

Satisfaction Rating	Would you recommend this workshop to others?	What did you find most useful about this workshop?	useful_short	What suggestions do you have for improving future workshops?	suggestions_short
5	Yes, my employer and smallholders	Very educational when it comes to intercropping (agroforestry). It helps to keep your land space, and to generate income from immature stage to mature stage of your rubber	new knowledge	To encourage a lot of smallholders participation. Transfer this workshop to rubber producing belt	more farmers; extend to rubber producing belt
5	Yes	Knowledge to improve income generation; intercropping spacing with rubber	new knowledge	To increase the number of participants and also to invite other large farmers in the future	more farmers; large farmers
5	Yes	I look at agroforestry to be my working tool	new knowledge	I suggest that this workshop be conducted once more for the benefit of our farmers in and around Liberia. Thanks for the workshop. I learned a lot.	more workshops
5	Yes	The intercropping of other crops among the rubber. It can help to create extra income to enable us to sponsor the farm until maturity period	new knowledge	First of all I want to thank the organizer for the workshop. I will recommend that they carry on another workshop in the course of this year. Suggestions: To bring together more farmers, to produce audio materials for our consumption; to increase our allowance and transportation of those of us from far counties	more workshops within the year; more farmers; audio material; increase allowance and transportation subsidies for far counties

Satisfaction Rating	Would you recommend this workshop to others?	What did you find most useful about this workshop?	useful_short	What suggestions do you have for improving future workshops?	suggestions_short
5	Yes	I am technician and find agroforestry to be useful to me because it direct my attention to new thing called agroforestry	new knowledge	To come back and educate more farmers into this programme	more workshops; more farmers
5	Yes	Met different people with different experiences about rubber planting and learn more about agroforestry which I have not known anything about. From here today I go with an idea cropping	new knowledge; meeting different people	I suggest that in the future you organize a workshop that can bring farmers on board	more workshops; more farmers
5	Yes	agroforestry	new knowledge	Let it be done on the farm	on farm training
5	Yes	Learn many things	new knowledge	workshop in the rubber farm	on farm training
4	Yes	intercropping	new knowledge	Some of the learning should be done out in the field or rubber farms	on farm training
5	Yes	The most useful thing the Agroforestry is, it makes you to have money to keep up your family and maintain your rubber until it reaches tapping stage	new knowledge	My key suggestion is to come up with other trainings like bud-grafting and tapping that will serve as managing tools for all farmers across Liberia - through RPAL	other topics (bud-grafting, tapping)
5	Yes	I find in this workshop a new knowledge or methods that will help me improve my farming activity	new knowledge	For future workshops I will want you to teach about disease that affect our crops or trees	other topics (disease)

Satisfaction Rating	Would you recommend this workshop to others?	What did you find most useful about this workshop?	useful_short	What suggestions do you have for improving future workshops?	suggestions_short
5	Yes	The usefulness of this workshop is that things in the past I didn't know, I have learned in this two day s workshop. So I will put it into use for better income	new knowledge	I like to recommend for future workshop about the improve rubber clones as well as improve agroforestry techniques	other topics (rubber clones)
5	Yes	I find that intercropping plants with rubber	new knowledge	I will like the next workshop to bring up new ideas again as we learned about agroforestry	other topics (new)
5	Yes	agroforestry	new knowledge	-	
5	Yes. I will recommend this workshop to the LAC management	It was very participatory and new ideas about agroforestry were learned	new knowledge; participatory	Improve on the ventilation	

Annex 6: An Introduction to Rubber Agroforestry⁹ (ver. 1.0.4 April 2024)

Rubber agroforestry is an innovative and sustainable land-use system that **combines the cultivation of natural rubber trees (*Hevea brasiliensis*) with other complementary crops, fruit or timber trees, shrubs, or livestock on the same piece of land**. This integrated approach offers numerous benefits, including income diversification, improved soil health, increased biodiversity, enhanced economic resilience, and reduced environmental impacts compared to conventional monoculture rubber plantations.

The idea is to maintain rubber production **at/near monoculture productivity levels**, while **supplementing** with additional production from complementary crops and trees. Agroforestry patterns can be based on classical rubber planting density (with 500-550 trees per ha) or with a modified planting design that allows for larger inter-spacing between rubber rows.

Why Rubber Agroforestry?

Traditionally, rubber cultivation has often been associated with **monoculture plantations**, where large areas of land are dedicated solely to rubber tree cultivation. While this approach can yield substantial latex production, it has some significant **drawbacks**, such as vulnerability to pests and diseases, soil degradation, and limited income diversification for farmers. **Low rubber prices** since 2012 and 40 years of **high price volatility** have triggered the necessity for income diversification.

Rubber agroforestry encourages the cultivation of a variety of crops, livestock, and/or trees alongside rubber trees to **maximize land use, optimize family/external labor, and diversify income**. Agroforestry can yield a mind-dazzling array of products from sharing the land with rubber trees, ranging from commercial food crops like coffee, cocoa and tea, herbs and spices, vegetables, flowers, nuts, fruits, resins, timber, and honey. This **diversity** enhances the economic and ecological resilience of the system. Agroforestry challenges the farmer to be **creative** and adaptive, and it can be done on **rubber plots of any size!**

Transitioning to rubber agroforestry requires **careful planning** and adaptation to local environmental conditions and markets. In rubber agroforestry, the different species should interact in ways that are **mutually beneficial or not harmful**, especially in terms of maintaining rubber productivity. For example, nitrogen-fixing shrubs can enhance soil

⁹ This guide was prepared for GPSNR by consultants Dr. Maria Wang (wang.mh.maria@gmail.com), Dr. Eric Penot (eric.penot@cirad.fr). It is intended as a general reference. The authors, their institutions, GPSNR and their funders are not responsible for any outcomes or losses resulting from the advice presented in this document and during training.

fertility for rubber trees. As a counter example, integrating other crops may undermine rubber productivity under severe climatic constraints in areas with long dry seasons, such as Cambodia, Burma or the eastern zone of Sri Lanka.

Types of Rubber Agroforestry

There are various types of rubber agroforestry. For simplicity, rubber agroforestry can be categorized into:

- 1) Intercropping during **immature** period (years 1-3, 4-6)
- 2) Intercropping during **mature** period (year 6 and above)
- 3) Rubber trees with **livestock**
- 4) Jungle rubber (“hands-off” approach)*

Most farmers will be interested in 1-3, which require more intensive management but also more predictable returns.

***Box 1: What is jungle rubber?**

Traditional jungle rubber is a unique system where non-clonal rubber seedlings were planted in forests via slash-and-burn or gap-planting (“sisipan”) in Indonesia. It is rarely practiced nowadays and most jungle rubber has been replaced by clonal rubber and oil palm plantations.

Modern jungle rubber is the result of leaving monoculture rubber plantations unmanaged, resulting in natural regrowth of shrubs and trees similar to secondary forest. Useful plants can be harvested alongside rubber latex (e.g. in Nigeria, Thailand).

Among rubber agroforestry types, **jungle rubber is best for native biodiversity** and requires little management and inputs. However, it may not be attractive for farmers due to low economic productivity (if using non-clonal seedlings), fear of attracting snakes and mosquitoes in an overgrown plantation, or being seen as “lazy” for having an “untidy” farm.

Benefits of Rubber Agroforestry

1. Economic Resilience

Diversifying crops and income sources can protect farmers from price fluctuations and market uncertainties associated with rubber production alone. In addition to rubber latex, farmers can harvest valuable timber and non-timber products such as resins,

nuts, fruits, spices, and medicinal plants, enhancing overall income. Cover crops can reduce the need for weeding and provide fodder for livestock.

2. Improved Soil Health

The inclusion of nitrogen-fixing trees and organic matter from companion crops improves soil fertility and structure as well as soil microbial diversity, reducing the need for synthetic fertilizers and preventing soil erosion.

3. Enhanced Biodiversity & Conservation

Rubber agroforestry can promote biodiversity by providing additional habitats for various plant and animal species. A more structurally and functionally diverse environment tends to support a greater diversity of pollinators, beneficial insects, and wildlife.

In addition, growing native species such as valuable timber trees or rare and endangered native trees, can help conserve native tree biodiversity and even restore unique ecosystem services to support other native flora and fauna.

4. Climate Change

While it has not been definitively proven that rubber agroforestry systems hold a significant advantage over monocultures in terms of climate resilience, it is likely that rubber agroforestry can provide some benefits. Rubber agroforestry keeps soils moist and provides shade for other crops, possibly creating a cooler environment within the plot. Adding more woody species like trees to rubber plantations can increase the total carbon stored in the system, and offer potential for carbon credits. However, the additional carbon sequestered depends on various factors like how the latex and wood are used, the length of the plantation cycle, and how the trees are harvested.

5. Land conservation (indirect)

By maximizing land use on existing farmland, rubber agroforestry can reduce deforestation and the expansion of cropland into ecologically sensitive areas. This indirectly helps preserve existing natural habitats and biodiversity.

Key Principles of Rubber Agroforestry

1. Adapt to rubber trees and local environmental conditions:

Choose species that are well-suited to your specific climate and soil conditions.

To avoid latex yield loss, avoid planting intercrops that will shade out mature rubber trees. Species that compete with rubber trees for water or increase the risk of rubber tree disease/damage should be avoided.

2. Adapt to local markets:

Assess the market demand for intercroops in your area to ensure profitability and sales of agroforestry products. Also consider access to markets and the additional costs and labor required. Successful implementation often involves a phased approach, with gradual integration of intercroops to minimize risks.

3. Implement Good Agricultural Practices (GAP) for Rubber Trees:

Do not neglect Good Agricultural Practices (GAP) for your rubber trees, in particular tapping techniques! GPSNR has developed a detailed GAP manual which provides lots of useful information vetted by experts.¹⁰ The GAP manual covers useful practical knowledge like tapping techniques, disease management, soil preparation, and proper use of stimulation.

3.1 Improving tapping quality and techniques should be the **top priority**, whether or not you implement agroforestry in your rubber plantation.

3.2 Low frequency tapping (e.g. tapping every three or four days using appropriate stimulation) can free up labor for agroforestry activities without reducing yield.

3.3 Plan for appropriate spacing and arrangement to ensure that intercroops do not out-compete rubber trees for resources like sunlight, water, and nutrients. To avoid latex yield loss, **avoid planting intercroops that will shade out mature rubber trees** and **avoid planting intercroops within 1 m of rubber trees**.

3.4 Choose a suitable rubber clone for your needs (e.g. less bushy clones like PB 260 to reduce shading; disease-resistant clones). In Thailand, agroforestry has been implemented successfully with RRIM 600 and RRIT 251.¹¹ Other countries like Indonesia are testing new superior rubber clones like IRR 112 and IRR 118 in agroforestry systems with promising results.¹² Similarly, the Cambodian Rubber Research Institute is developing high yielding clones adapted to Cambodian soils. Hence, when possible, please **consult your national rubber research institute** for the latest information on the best clones for your area, and to obtain these clones.

3.5 Crop rotation for intercroops should be considered to prevent soil depletion and disease buildup, in particular during the immature period. This is especially important for root crops.

¹⁰ GPSNR Good Agricultural Practices (GAP) manual (free to download):
<https://sustainablenaturalrubber.org/reports/>

¹¹ For more information about rubber agroforestry in Thailand, please contact: rafs.thailand@gmail.com | <https://www.rafsfoundation.org/index.php>

¹² https://www.e3s-conferences.org/articles/e3sconf/pdf/2021/81/e3sconf_rubis2021_03006.pdf

Putting Rubber Agroforestry into Practice

Before implementing a rubber agroforestry system, please consider the following questions. Proper planning and management are essential for a successful rubber agroforestry venture.

First, consider, what are your **agroforestry goals**?

- **Improve soil health and reduce weeds?** You may want to plant cover crops, grasses, and shrubby herbs that provide ground cover.
- **Food security?** You may want to plant your favorite staple foods, fruits, or vegetables.
- **Additional income in the short term?** You may want to choose crops with low starting costs that you can harvest and sell within 1-2 years.
- **Medium-term investment?** You may want to choose crops with assured demand and high profitability in the market. You may consider integrating small livestock.
- **Longer term investment or pension income?** You may consider incorporating timber.
- For medium and long term investments, you should ask yourself: Are you willing to **invest the labor, time, and skills** to grow and harvest intercrops?

Some **physical criteria** to consider when choosing plants:

- Which plants are suitable to be planted in mature rubber plantations with normal spacing and high shade?
- Which plants need more light to yield economic returns (and thus might be more suitable for larger spacing design)?
- Which plants are suitable for the water, soil, and climate conditions on your farm?
- How long does it take for the plants to yield harvest (short term, medium term, long term)?

Once you have considered your goals, your capacity, and the physical suitability of your farm, it is time to consider the next steps. Do **consult with local agricultural experts and extension services** to identify the most suitable intercrop species for your specific goals and location.

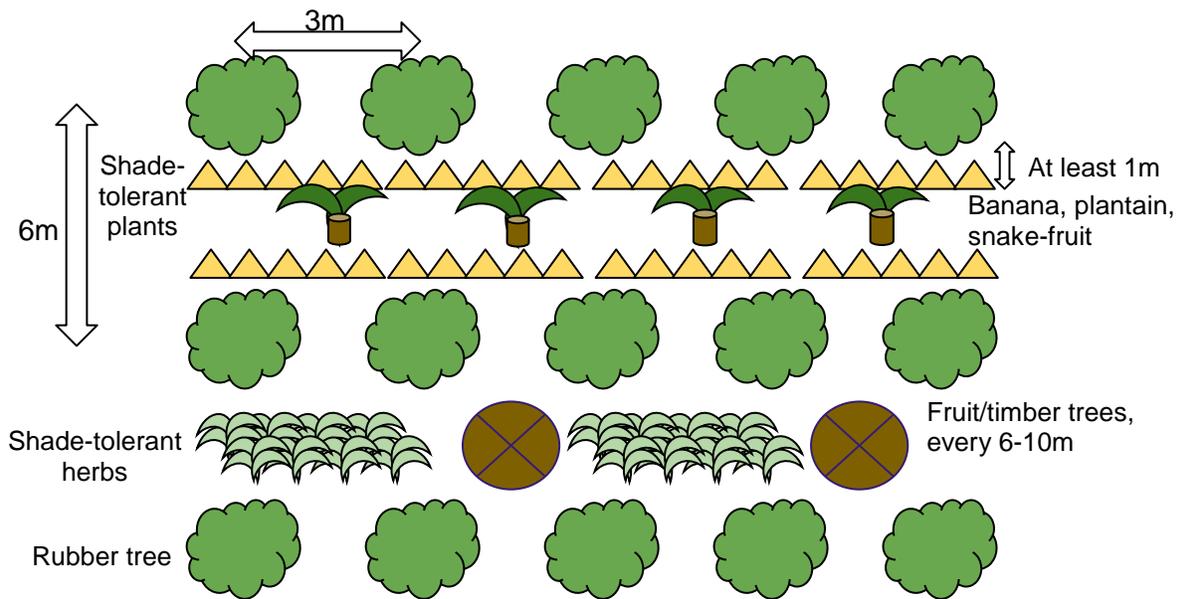
Planting design

1. **Normal spacing** (6x3m or 7x3m, ~ 555 trees or ~ 476 trees per hectare)
Most farmers will already have rubber trees growing with a normal spacing. You can still plant crops, or trees, with adequate spacing among them. There will then be higher shade for intercrops, so intercrops will be less productive. However, the global gross margin per hectare is likely to be higher than a pure rubber monoculture.
2. **Larger spacing: Double row of rubber** (3x3m) with **larger inter-row spacing** (8-25m)
Density: 238-450 trees per hectare. Optimum density is around 400 trees per hectare.

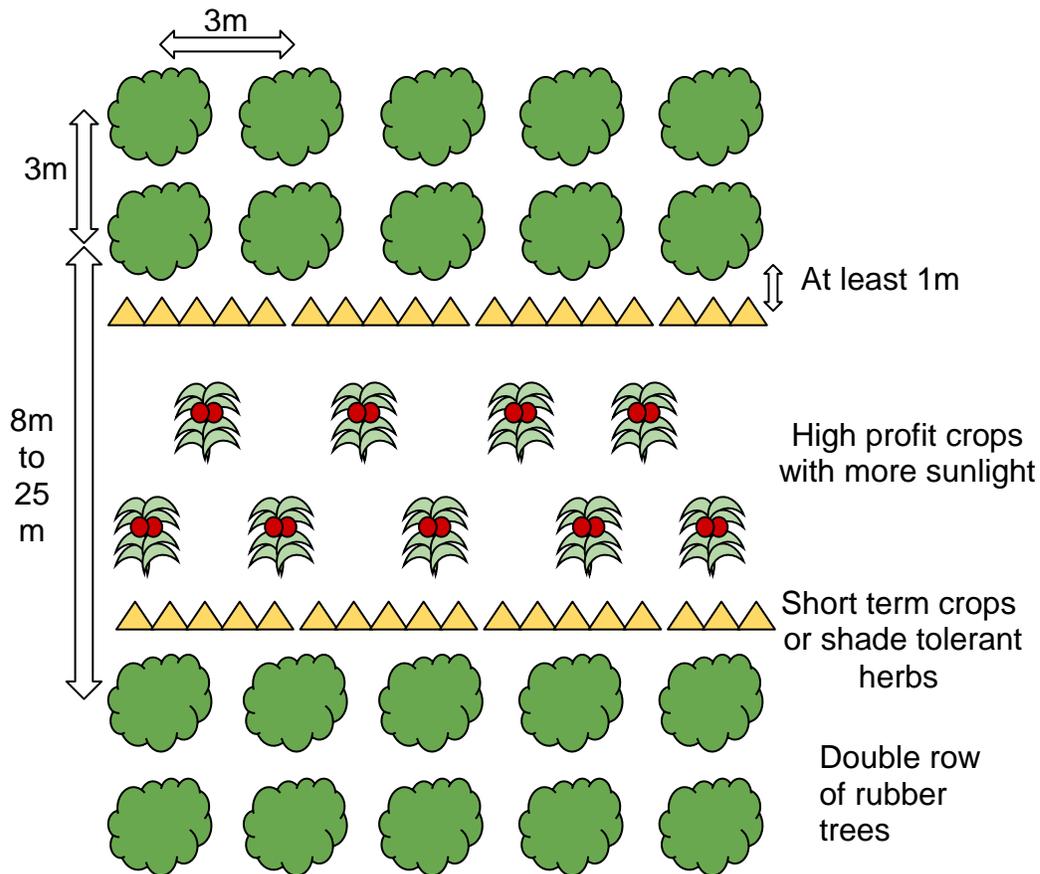
This is a more recent innovation. Larger inter-row spacing gives more sunlight for intercrops, but may also mean fewer rubber trees. For example, an inter-row spacing of more than 13m corresponds to fewer than 400 rubber trees per hectare.

The profit from intercrops should be **high enough** to compensate for potential losses from having fewer rubber trees (minus 10% of production). However, production loss is limited if you don't go below 400 trees per hectare. Intercrops should fetch a high price and a secure market to ensure a profitable margin per hectare. Thus, an **economic assessment** is recommended before implementing this type of planting design. If planned properly, the available land can be maximized for multiple crops yielding higher profits.

Example of possible rubber agroforestry design with normal planting density:



Example of double-row rubber with larger inter-row spacing:



Choosing intercrops

Many types of crops have been grown with rubber all over the world. When choosing plants, consider your **goals** for agroforestry, **markets**, and **local climate and soil conditions**.

Here are some examples of commonly planted intercrops, but there are **many other examples** not listed here that can be planted with rubber. Be creative! For example, think about plants that can fulfill a **niche market** in your country or for export (e.g., marigolds in Thailand for religious use, traditional medicinal herbs for export, Agarwood for the perfume industry).

Cover crops - Legumes, grass (cow fodder)

There are many cover crop species which have been tested in rubber plantations. They should be planted at the same time as rubber. Generally, they will almost disappear after the rubber immature period. Some common cover crop species are: *Pueraria phaseolides*, *Mucuna spp*, *Stylosanthes guianensis*, *Flemingia macrophylla*.

Sun-loving annuals/semi-annuals:

Sun-loving annuals/semi-annuals are suitable for short-term intercropping during the immature period, when the rubber trees are still young. They should be planted in years 1-3.

Vegetables: As vegetables are highly perishable, choose vegetables that you can sell to local markets. Some vegetables are more shade tolerant and can be planted with mature rubber. In Thailand, *pakliang* is a popular vegetable commonly planted in rubber plantations.

Grains/beans: rice, upland rice, corn, cowpeas, groundnut, soybean etc. can all be planted during the immature period.

Tubers: Generally **less recommended** for intercropping with rubber due to possible interference with roots. For example, **cassava** is a popular root crop in many tropical countries. However, intercropping with cassava for more than 12 months may increase white root disease. Cassava is in the same family as rubber, and competes for minerals and nutrients with rubber. Cassava can also decrease soil fertility and thus will need to be fertilized.

Sugarcane: a classic in eastern Sri Lanka with success

Bamboo: only in old irrigated land like former paddy fields in Thailand, because **bamboo competes with rubber for water**. However, you can consider planting bamboo around borders (not really agroforestry but a hedgerow system)

Shade tolerant annuals/semi-annuals

Can be planted at years 4-6, or earlier. Common examples are: **Banana, plantain, pineapple** (shade for pineapple should not exceed 60-70%)

Medicinal herbs, spices, mushrooms

Can be planted at year 1, or after year 3 if shade tolerant.

Common examples: Cardamom, ginger, turmeric, chili, mushrooms

Shade should not exceed 60% for the following species: Pepper, vanilla

Fruit and nut trees

How many woody trees you intercrop in your rubber plantation will depend on local climatic and physical conditions (e.g. water availability, soil fertility). In **good climate and soil** conditions, you can plant **up to 250 fruit trees** per hectare. All types of fruit trees can be planted, as long as you have a market to sell them. **Shading should not exceed 75%** for each tree. Some studies note that **intercrop yields** of cash crops and fruit trees may **decline** after several years due to shading by rubber canopy, and thus become unprofitable.

There are many examples of tropical fruit and nut trees that have been planted with rubber: durian, rambutan, duku, longan, jackfruit, mango, snake-fruit (a type of palm, also known as *salacca* or *salak*), cashew nut, macadamia nut, stinky beans (a family of legumes eaten as vegetables, e.g. *petai/sator*, *jengkol*); as well as lemon, oranges and other citrus fruits.

Recommended only with **large inter-spacing**: Coffee and cocoa

- note that yields will start to **decrease significantly** with >30% shade.

Timber trees

Timber trees can be integrated into rubber agroforestry systems to provide **long-term income** (e.g. pension income) when harvested, offering both ecological and economic benefits. Do **consult with local authorities** before growing timber trees as you may need specific **permits** to grow and harvest timber on your land.

Timber trees can be planted in year 1, with some banana trees to provide shade if necessary (e.g., for Dipterocarpaceae). Some common examples of timber that can be

intercropped with rubber: Teak (*Tectona grandis*), Mahogany (*Swietenia* spp.), Rosewood (*Dalbergia* spp.), African timberwoods (*iroko*, *sapelli*, etc.).

Some **fast growing trees** can be planted, but will need to be **cut earlier** as they might compete with rubber. For example: *Gmelina arborea*, *Paraserianthes falcataria*, *Albizia lebbbeck*, *Acacia mangium*.

Integrating Livestock into Rubber

Stingless bees have been successfully integrated within rubber plantations in Thailand and Indonesia. Other **small livestock** that could be suitable for rubber agroforestry include: **ants** (a popular delicacy in Thailand), **honey bees, and edible snails**. In Nigeria, rubber farmers have integrated honey bees, snails and rabbits as a diversification strategy. Fish farming and chicken farming are also possible to do within rubber plantation (although it is not considered “agroforestry” unless there is an ecological interaction with the rubber trees).

Keeping larger livestock like cows, sheep, and goats in rubber plantations is possible in an extensive way, but they may damage trees. Hence, it is not widely recommended. Instead, you can **grow grass** in your rubber plantation and harvest it to feed your large livestock.

Concluding remarks

These materials aim to help you on your rubber agroforestry journey. They are intended as general guidance, not as a guarantee of success or a replacement for professional advice from local agricultural experts. Farming is a dynamic blend of art and science, where individual circumstances vary significantly. Always use your best judgment when implementing new practices on your farm.

Wishing you a successful and rewarding rubber agroforestry experience!