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REVIEW ARTICLE

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## RUBBER CULTIVATION IN INDIA: CONSIDERED A PROFITABLE ENTERPRISE BY PROVIDING EMPLOYMENT OPPORTUNITIES FOR ROUND THE YEAR TO A SUBSTANTIAL WORKFORCE MAINLY IN RURAL AREAS

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### ABSTRACT

Rubber trees (*Hevea spp.*) are among the essential plants cultivated and have contributed to India's economy growth for many decades. Latex harvested from rubber trees is an irreplaceable raw material and accounts for a wide range of uses in tires, tubes, footwear, rubber gloves, and other rubber-based products. There were many attempts to produce ideal rubber tree for increasing latex yield production through the improvement programmes. However, the risk of inbreeding depression and the planting materials produced from the chosen parents that are closely related in the improvement programmes is fairly high. Inbreeding depression caused discouraging effects such as uneven bark surface, leaf disease infection, easily damaged by wind blows and eventually reducing the production of latex yield overall. Rubber cultivation involves growing the *Hevea brasiliensis* tree, primarily in tropical regions, for its latex, which is harvested by tapping. This process requires specific conditions like warm temperatures and high rainfall, and is influenced by factors such as soil type and elevation. Key challenges include labour costs and environmental impacts, though modern techniques like agroforestry may mitigate some issues, while marketing inefficiencies are another major obstacle for smallholders. The first rubber plantations in India were set up in 1895 on the hill slopes of Kerala. However, rubber cultivation on a commercial scale was introduced in 1902. Kerala is the largest producer of natural rubber in India. India is the fourth largest producer of rubber in the world. Rubber is harvested mainly in the form of the latex from the rubber tree or others. Rubber is cultivated in 16 states of India. States like Kerala and Tamil Nadu are traditionally rubber-growing regions in India. Nilgiri, Madurai, Kanyakumari, Coimbatore and Salem are the chief rubber producing districts of Tamil Nadu. Indian rubber industry is characterized by the co-existence of a well-established rubber production sector and a fast-growing rubber products manufacturing. Rubber plantation is a real threat for the tropical forest. It is harmful for watersheds and destroys forest ecosystems. It negative effects on hydrological change, severe species, sediment run off etc. It overall affects the habitat and stream hydrology. But the latex has a high commercial value which can support rural people in socioeconomic development. Smallholder farmers' livelihoods affected due to price fluctuations and food insecurity. The effective management and proper sustainable planning is important for minimizing the evil effects of rubber plantation and involvement of rural communities as an income earning making process.

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## INTRODUCTION

Rubber cultivation, primarily from the *Hevea brasiliensis* tree, involves growing trees for their latex, the source of natural rubber. It thrives in tropical climates with consistent rainfall, high temperatures, and well-drained, acidic soil. Successful cultivation requires proper land preparation, planting, fertilization, weed control, and disease management. Rubber is a significant

agricultural commodity made from the latex of the *Hevea brasiliensis* tree. Rubber is useful because of its unique attributes, including elasticity, water resistance and electrical non-conductivity. It can be used to insulate, waterproof and also create pneumatic tires. Rubber cultivation has a significant impact on bolstering the economy of the country. Farmers earn plenty of profit from rubber cultivation too. Kerala is the largest rubber-producing state, Tripura is the second highest. Rubber plantation plays a significant role in the economy of

the country. The production of rubber is one of the oldest as it was first planted in India during the early British colonialism in the late 19th century. It was mainly cultivated to supply natural rubber to the rising market to source the products from countries such as Malaysia and Sri Lanka. Rubber business in India is improving immensely as exports have a large impact on India's income. It also renders employment to so many people across the nation. The rubber products made from rubber trees can therefore be categorized as export oriented and are used in automobile manufacture, shoe production, construction, and medical use among others. Rubber plantations are among the important sources of cash crops in the agricultural fields of India and it also uplifts the socioeconomic standard of those areas where it is grown. Rubber plantation in India started in 1895 at the hilly regions of Kerala particularly in the Kottayam and Kollam districts. The major factor that supports Kerala to as a suitable region for rubber plantation is the climatic factors of tropical region coupled with right amount of rainfall. However, it has to be noted that commercial cultivation of rubber was initiated in 1902. Natural rubber is selectively collected as latex from the rubber tree. Rubber trees are versatile as rubber materials are used in day-to-day life and some parts of the tree including the leaves portions are used as natural anti-inflammatory agent. Malaysia, Indonesia, Thailand and Africa are the main rubber producing countries. Natural rubber for commercial production is available from *Manihot glaziovii* (cera rubber), *Ficus elastica* (India rubber), *Castiolla elastica* (Panama rubber), *Parthenium argenatum* (Guayul), *Taraxacum koksaghyz* and *Hevea brasiliensis* (Para rubber) and among them, *Hevea brasiliensis* is the most important commercial source of natural rubber. It is native of Brazil and was introduced in Asia in 1876. After proper chemical treatment, rubber wood provides enough strength and durability of any semi-hard wood available in India and can be used for the manufacture of useful articles like door and window components, furniture, wall panelling, interior decoration, tool handles etc. Rubber tree belongs to the natural order Euphorbiaceae. This tree is sturdy, tall and quick growing. It has a well-developed tap root and laterals. The leaves are trifoliate, with long petioles. Flowers are unisexual, small and fragrant. Staminate flowers are small and numerous. Pollination is by insects. Latex vessels are present in all parts of the tree except in the wood.

**Distribution:** Rubber cultivation in India is primarily concentrated in the following states:-Kerala is the leading rubber-producing state in India, with the largest area under rubber cultivation. The Kanyakumari district in Tamil Nadu also contributes significantly to rubber production. Karnataka has a growing rubber industry, particularly in the Malnad region. In the Northeastern region, Tripura is a major rubber-producing state.

#### KEY ASPECTS OF RUBBER CULTIVATION

- **Climate and Soil:** -Rubber trees need a warm, humid climate with temperatures between 25-34°C and well-distributed rainfall of 2000-4500 mm. Well-drained, deep, acidic soil with a pH of 4.5 to 6.0 is ideal.
- **Land Preparation and Planting:** -Land is prepared for planting using square or rectangular systems, ensuring good drainage. Seedlings are raised in nurseries and then transplanted into prepared pits.
- **Fertilization and Weed Control:** -Fertilizers are used to provide essential nutrients like nitrogen, phosphorus, potassium, and magnesium. Effective weed control is crucial to prevent competition for resources.
- **Tapping:** -After about 6 years, trees are ready for tapping, where controlled cuts are made in the bark to extract latex.
- **Disease and Pest Management:** -Rubber plantations are susceptible to diseases like white root disease, pink disease, and Fusarium, as well as pests like termites. Control measures include removing infected parts, using appropriate chemicals, and practicing good hygiene.
- **Sustainability:** -Proper land management, including crop rotation and soil conservation techniques, is important for long-term sustainability.

**INDIA'S RUBBER INDUSTRY:** -India is a major rubber producer, with Kerala being the leading state, followed by Tamil Nadu and other northeastern states. The rubber industry is important for both domestic and international markets. Rubber cultivation contributes significantly to the economy, providing livelihoods for many farmers. Rubber plantations require careful planning and execution, from nursery development to tapping and processing. It involves preparing the land, establishing nurseries, planting, managing the plantation, and finally, latex collection and processing. Tamil Nadu is the 2nd largest producer of rubber plantations in India.

#### FACTORS OF PROFITABILITY OF RUBBER PLANTATIONS IN THE FUTURE

- **Market Demand:** The global demand for natural rubber is influenced by industries such as automotive (for tires), manufacturing, and consumer goods.
- **Production Costs:** The cost of establishing and maintaining rubber plantations can be high. Factors like labour costs, land availability, and input costs (fertilizers, pest control) will affect profitability.
- **Climate Change:** Rubber trees are sensitive to climate conditions. Changes in rainfall patterns, temperatures, and the incidence of pests and diseases can impact yields.
- **Technological Advancements:** Innovations in cultivation techniques, disease resistance, and processing methods can enhance productivity and reduce costs, potentially improving profitability.
- **Sustainability Trends:** There is a growing emphasis on sustainable practices in agriculture. Rubber plantations that adopt eco-friendly practices may benefit from premium pricing and access to certain markets.
- **Geopolitical Factors:** Trade policies, tariffs, and geopolitical stability in major rubber-producing countries can also influence market conditions and profitability.

#### RUBBER CULTIVATION IS CONSIDERED PROFITABLE

**High Demand:** -The demand for natural rubber is consistently high due to its diverse applications in various industries, including tires, footwear, and industrial products.

- **Long-Term Investment:** - Rubber cultivation is a long-term investment, with trees producing latex for up to 30-40 years.
- **Government Support:** - Both the central and state governments provide financial assistance and subsidies to rubber farmers, further boosting profitability.
- **Growing Market:** - The rubber market is expanding, driven by increasing demand from the automotive and other industries, creating more opportunities for farmers.
- **Employment Generation:** - Rubber cultivation provides employment opportunities in rural areas, contributing to local economies and poverty reduction.
- **Environmental Benefits:** - Natural rubber is considered an environmentally friendly alternative to some synthetic materials, aligning with growing sustainability concerns.

#### FACTORS THAT INFLUENCE PROFITABILITY

- **Proper Cultivation Practices:** -Adopting best practices for planting, tapping, and processing latex is crucial for maximizing yields and quality.
- **Market Prices:** - Fluctuations in rubber prices can impact profitability, so farmers need to be aware of market trends.
- **Labor Costs:** - Labor costs for tapping and processing can vary, affecting overall profitability.
- **Government Policies:** -Government support and subsidies can significantly impact the profitability of rubber cultivation.

## USES OF RUBBER

In addition to the rubber itself, the rubber tree produces a substance called rubber milk or latex, which can be processed into high-quality rubber.

- Manufacturing of shoes
- Tires
- Engine seals
- Balls
- Belts
- Elastic bands, and
- Electrical equipment.
- Industrial rubber goods
- Medical equipment
- Consumer products
- Door components
- Window components
- Furniture
- Wall panelling
- Interior decoration
- Tool handles etc.



Various products of rubber



Main product of rubber

## STEPS IN RUBBER CULTIVATION

Rubber cultivation in India involves several steps to ensure a successful yield. Here are the key steps involved in rubber plantation:

**Soil & Climate:** -Rubber plants need a warm and humid climate with adequate rainfall throughout the year. The average temperature required for its growth is 20 to 35°C and the annual rainfall required for its cultivation is 1500-3000 mm. Rubber plants bloom in well-drained, loamy soils that are rich in organic matter and have good moisture retention capacity with a proper source of drainage.

**Land Preparation:** -The major pre planting preparation before starting rubber cultivation is to clear all vegetation. Rubber plantation can be done on hilly, forest areas, and flat lands too. The process of land preparation remains the same except between hilly and flat land type.

**Varieties:** -Rubber Research Institute of Malaya, Rubber Research Institute of India, Kottayam and other institutes have developed clonal varieties. These clones are broadly classified into three

categories viz., primary, secondary and tertiary, based on the method adopted for the development of their mother trees. When mother trees are selected from existing seedling populations of unknown parentage and are multiplied vegetatively to give rise to the clones, they are called primary clones. When the mother trees clones and are then multiplied vegetatively, they are known as secondary clones.

## PROPAGATION

**Seeds:** Propagation through seed is practised to raise seedlings for rootstock purpose or to raise polyclonal seedling progenies. Seeds normally ripen during July-September in South India. As the viability is very short (8 weeks), they are to be sown immediately raised beds of river sand of 1m width and of convenient length are formed and the seeds are sown in a single layer touching one another and pressed firmly with the surface of the seed just visible above. Nursery may be protected from direct sun by providing a temporary shade. Regular watering is attended to maintain the moisture in the beds. Seeds start germinating within 6 to 10 days. Such raise seedling stumps or at 60x90cm or 60x120cm to raise bud wood nursery or stumped budding. Otherwise, sprouted seeds can be directly planted in the field.

**Budding:** The scions of a particular clone is maintained in the bud wood nursery by planting the budded stumps or by budding the clone on the seedlings in situ at nursery. Budded stump often refers to the budded plant whose scion shoot is cut very close to the budding zone leaving few dormant buds in the scion shoot. On the other hand, if the root stock is cut as a stump and budding is done, usually green budding at four to five months stage, then it is known as stumped budding.

When the budwood nursery plants are one year old, about 1m of usable budwood can be obtained. The budwood is cut when atleast 1m of brown bark has developed. The immature green portion should be removed to a point about 1m below the terminal bud, leaving the leaf stalks in position. The budwood may be cut off about 15cm at the base, leaving a few dormant buds to develop into bud shoots for the subsequent season. Two such sprouting shoots may be allowed for next year, from one metre shoot, 15 to 20 buds may be obtained. Modified forket method is followed and is done during April-May, when the weather is not dry or wet. Two types of budding techniques are practiced. Brown budding is done by using buds taken from bud wood of one year growth on to a stock plant of ten months old. Green budding on the other hand involves young green budwood and stock. Bud wood of 6-8 weeks old is used on stock seedlings of 2 to 6 months old. Recently, polybag plants are raised as such plants reach tapping stage quickly. Black polythene bags of 60x30cm with 400 gauge are filled with topsoil alone along with 25g of rock phosphate. Green budded stumps are planted in these polybags and the scions are allowed to develop 2 to 3 whorls of leaves.

**Plantation:** -The best season for rubber plantation is July-September. In the course of plantation, sufficient space is provided while planting seeds in the pit. It is recommended that there should be a space of 6 to 7 meters between each plant with regards the type of rubber plant that is being grown. This enables each tree to find a place to grow without crowding in an effort to get adequate amount of sun light.



## Rubber sapling

### Ideal Spacing:

Triangular Shape- 4. 9m x 4. 9m

Hilly areas - 6. 7 x 3. 4 m

On areas which are flat (square) – 4. 9m x 4. 9m

### After care

**Cover crop:** - Growing cover crops is important in rubber plantations to prevent soil erosion, conserve soil moisture, keep down the soil temperature and add mulch and organic matter to the soil. Some of the cover crops commonly used in South India are Pueraria phaseoloides, Calopogonium mucunoides, Centrosema pubescens and Mimosa invisa var. inermis. Mulching and covering the plant with dry leaves is a best practice in rubber plantations to protect the crop and avoid soil degradation, improves the water holding capacity of the soil, Improves the soil, Helps in maintaining a cool and moist condition around the crop during summer, Protecting the soil from heavy rainfall to avoid soil erosion.

**Weeding:** The weeds can be eradicated either by labour or by employing weedicides. When weedicides are employed, care should be taken that the cover crops are not affected. 2,4-D formulations (Fernoxone @2kg in 450 litres of water) may be sprayed early in the season to eradicate the weeds.

**Manures and fertilisers:** -The manuring differs according to the stages of growth. The Rubber Research Institute in India recommends the following manurial schedule.

**Seedling nursery:** Application of 25kg of compost and 2.5kg of rock phosphate once in three years per 100m<sup>2</sup> of the nursery bed is practised. Application of 25 kg of 10:10:4:1.5 NPKMg mixture per 100m<sup>2</sup> of the nursery bed 6 to 8 weeks after planting and application of 12.5kg of the mixture per 100m<sup>2</sup> 6-8 weeks after the first application but before mulching are followed.

**Budwood nursery:** Powdered rock phosphate 1.5kg per 100m<sup>2</sup> of the nursery bed is applied as a basal dressing at the time of preparing the nursery bed. Besides 250g of 10:10:4:1.5 NPKMg mixture per plant in two split doses of 125g each, the first dose is applied two to three months after planting the budded stumps or cutting back, if budding is carried out in situ and the second dose eight to nine months after planting.



Rubber tree field

**Rubber trees under tapping:** Application of NPK 12:6:6 grade mixture at the rate of 400kg per hectare per year in two split doses is recommended. In plantation where the trees show deficiency symptoms of magnesium (interveinal yellowing of leaves) addition of 10kg commercial magnesium sulphate to every 100kg of the mixture is recommended during September-December.

**Plant protection:** -The important diseases and pests of rubber and their control measures are-

**Abnormal leaf fall (*Phytophthora palmivora*)**

**Symptoms:** Infected leaves fall in large numbers prematurely.

**Control measures:** -Spray Bordeaux mixture (1%) as prophylactic measure, prior to the onset of South West monsoon.

**Powdery mildew (*Oidium haveae*):**

**Symptoms:** Ashy coating noticed on tender leaves

**Control measures:** Dusting 3 to 6 rounds at 10-15 days interval using 11-14 kg of 325 mesh fine sulphur dust per round per hectare.

**Scale insects (*Saissetia nigra*):** Severely affected portion dry up and die.

**Control measures:** Spray malathion at 0.05% concentration.

**Tapping:** -During the tapping process, latex is obtained from the bark of the rubber tree. Tapping is performed to control wounds while removing the thin shaving from the barks. During the tapping process, latex is obtained from the bark of the rubber tree. Tapping is performed to control wounds while removing the thin shaving from the barks. The rubber trees attain tappable stage in about seven years provided they possess the required girth of the trees. Seedling must attain a girth of 55cm at a height of 50cm from the ground. In the case of budded trees the girth should be 50 cm. Tapping is the periodical removing of thin slices of bark to extract rubber latex. Tapping is done by skilled men. While tapping the depth should be 1mm close to cambium without any damage to it, otherwise callus formation will take place causing swellings. Tapping has to be done on a slope of 300 to the horizontal zone in the case of budded trees and 250 in the case of seedlings. Tapping is done early in the morning, as late tapping will cause reduction in the flow of latex. In the early morning the turgor pressure in the latex vessels is high and rapid flow of latex occurs. Tapping system: The following tapping systems are generally followed in India.



Latex secretion

In South India, rubber trees shed their leaves during December-January and immediately again they put forth new leaves and flowering. During this period the trees are given rest since the yield of rubber will be poor if tapped. The yield of rubber steeply increases year by year and the peak is reached 14-18 years after planting. Then it slowly declines. After 40 years it may not be economical to maintain the trees. Tapping is not done on rainy days but by fixing a polythene rain guard to the trunk of the tree above the tapping panel, tapping can be carried out during rainy season also. About 35-40 additional tapping per annum can be obtained by rain guarding the trees under the alternative daily system.

**Processing of rubber:** -The latex that flows out from the rubber trees on tapping is channelled into a container, generally coconut shell cups, attached to them. Latex collected in coconut shell cups is transferred to clean buckets, two to three hours after tapping. The latex which gets dried up on the tapping panel (tree lace) and the collection cups (shell scrap) also form a part of the crop and are collected by the tapper in baskets just prior to tapping. The latex spilt including overflows on the ground (earth scrap), when gets dried up, is also collected once in a month. Normally 10-20 % of the total crop constitute the tree lace, shell scrap and earth scrap. Rubber can be

processed and marketed as Preserved latex concentrates: The latex is collected in the storage tank, from there it is brought to a centrifuge machine, rotating at 1440 rpm. Due to the centrifugal action, liquid portion comes out. The upper layer, the concentrated latex, is collected and brought to bulking tank and mixed with chemical and packed in drums. 60% rubber is present in it. Skim latex is taken to another tank and sulphuric acid is added and coagulated and milled to get skim crepe. It is of poor quality while the concentrated latex fetches very higher price. Dry ribbed sheet rubber: Anti-coagulants (solutions of aminonia, formalin or sodium sulphite) are added to the cups to prevent the coagulation of latex before it reaches the factory. The latex so collected is bulked and then strained to remove the impurities. It is then diluted to a standard consistency of 12-13% rubber. Special hydrometers like metrolac, latex meter are employed to measure the percentage of rubber. After dilution, the latex is strained through a 60 mesh screen for the second time. Then it is poured into the special coagulating tanks or aluminium pans which is divided into many compartments by thin aluminium sheets and acetic acid or formic acid to used for coagulation. Slow coagulation produces a soft rubber, which is easy to work on the rollers. The acid is to be added quickly and mixed thoroughly with the surface of rubber sheets. After coagulation, rubber sheets are repeatedly washed several times with changes of water and passed through hand or power operated rollers. In the roller excess water and dissolved impurities are pressed and squeezed out. The surface of the rollers may be either smooth or grooved or zig zag or straight or diamond pattern, its impression is normally left on the surface of the sheets when they come out of the press. These sheets are hung in shade for two to three hours for dripping in a dust free place. They are then taken to smoke houses for thorough drying. Smoking of rubber sheets is done to dry the sheets properly and to avoid formation of blisters. In the smokehouse, the sheets are smoked at a low temperature of 48-50°C with fairly high humidity during the first day subsequently during 2nd to 4th day the temperature being 68°C with low relative humidity. They are taken out, graded and packed. Such products are known as smoked sheets or dry ribbed sheet rubber. High grade rubber sheets are clear, free from blisters, translucent and of a golden-brown colour and fetch a better price.

**Yield:** -In South India, the annual yield of rubber is about 375kg per hectare per annum from the seedlings, whereas budded plantations yield 900 to 1000kg of rubber/ha.

#### Way forward to promote sustainable growth in rubber production

- **Research and Development:** Investing in research and development is crucial for the rubber industry's future. This includes developing disease-resistant rubber varieties and sustainable cultivation practices. Research can also focus on improving yield and quality.
- **Market Diversification:** To reduce dependence on price fluctuations in the global rubber market, India should explore new markets and product avenues for rubber exports.
- **Sustainable Practices:** Promoting sustainable rubber farming practices is essential to address environmental concerns. Adopting organic farming methods and responsible pesticide use can minimize the environmental impact of rubber production.
- **Farmer Training:** Providing training and support to rubber farmers is crucial for enhancing their productivity and income.
- **Government Support:** Encouraging government support is vital for the rubber industry's growth. Governments can provide subsidies and incentives for rubber cultivation, infrastructure development, and research initiatives.

**SIGNIFICANCE OF RUBBER PRODUCTION:** -Rubber cultivation and the rubber industry play a pivotal role in the Indian economy by providing employment opportunities to a substantial workforce, particularly in rural areas. The rubber sector generates jobs across various stages, from planting and harvesting rubber trees to processing and manufacturing rubber products. India's rubber exports make a substantial contribution to the country's foreign exchange

earnings. Rubber and rubber products are in demand worldwide, and India's position as a major rubber exporter allows it to earn valuable foreign currency. Rubber is an indispensable raw material for a wide range of industries in India, including the automotive and manufacturing sectors. In the automotive industry, rubber is used for manufacturing tires, hoses, gaskets, and various components. In manufacturing, rubber is used in the production of belts, seals, and a multitude of other products.

#### KEY HIGHLIGHTS

- Currently, there are approximately 8.5 lakh hectares of land dedicated to rubber cultivation in India. Out of this, Kerala and the Kanyakumari district of Tamil Nadu account for almost 5 lakh hectares, while Tripura has 1 lakh hectares under rubber cultivation.
- The Rubber Board aims to expand rubber cultivation in states that are not traditionally associated with rubber production. This includes the Northeastern States of India, excluding Sikkim, but including West Bengal.
- The potential for rubber cultivation in these Northeastern States is estimated to be around 4 lakh hectares.
- In the previous financial year, approximately 27,000 hectares were brought under rubber cultivation. The plan is to cover about 40,000 hectares in the coming years.
- The expansion of rubber cultivation is expected to bring about socio-economic benefits to these states.

#### PROBLEMS

- Maximum required trained labourers and hired labourers
- The major constraints were lack of local trained labourers
- Lack of government funding
- Lack of market
- Price instability
- Lack of training programmes
- Poor road condition.
- During harvest season there is a shortage of workers
- There is no fixed price for the raw materials

#### CHALLENGES AND OPPORTUNITIES IN MODERN RUBBER FARMING:

Like many agricultural sectors, rubber production faces both challenges and opportunities in the modern era. Climate change has introduced new variables, with changing rainfall patterns and temperature fluctuations affecting latex yield and quality. Many farmers are adapting by implementing improved irrigation systems and adopting climate-resilient farming practices. Price volatility remains a significant challenge for rubber farmers. International rubber prices are influenced by global supply and demand dynamics, often leaving small farmers vulnerable to market fluctuations. To address this, farmer cooperatives and government support schemes have been developed to provide price stability and market access. Farmers may face difficulties in predicting and planning for their earnings, making financial stability a concern. Technology is creating new opportunities for efficiency and quality improvement. Modern plantation management includes soil testing, precision fertilization, and disease monitoring systems that help optimize yield while reducing environmental impact. Some plantations are experimenting with GPS-guided machinery for maintenance operations and drone surveillance for disease detection.

- Rubber plants are vulnerable to a range of pests and diseases. These pests and diseases can cause significant damage to rubber trees and reduce rubber yields.
- Effective management and control measures, such as the use of pesticides and disease-resistant varieties, are necessary to mitigate these risks and maintain healthy rubber plantations.
- Rubber cultivation, especially when not managed sustainably, can have adverse environmental impacts.

- To create rubber plantations, natural forests are often cleared, leading to deforestation and habitat loss. This can have negative consequences for biodiversity and local ecosystems.
- Intensive rubber cultivation practices, such as monoculture farming and excessive use of agrochemicals, can lead to soil degradation.
- The use of pesticides and fertilizers in rubber farming can result in chemical runoff into nearby water bodies, potentially polluting them and harming aquatic life.

#### **SUSTAINABILITY AND ENVIRONMENTAL CONSIDERATIONS**

- Rubber plantations play an interesting role in environmental sustainability. As perennial crops, rubber trees sequester significant amounts of carbon dioxide, contributing to climate change mitigation. A mature rubber plantation can store 150-200 tons of carbon per hectare.
- Sustainable plantation management requires careful attention to biodiversity conservation. Modern rubber plantations are increasingly adopting agroforestry approaches, integrating other tree species and crops to maintain ecological balance.
- Water management is another crucial sustainability aspect. Rubber trees require consistent moisture but are sensitive to waterlogging. Plantation managers are implementing sophisticated drainage and irrigation systems that optimize water use while preventing soil erosion and nutrient loss.

#### **THE FUTURE OF RUBBER PRODUCTION IN INDIA**

- The future of India's rubber industry looks promising, driven by growing domestic demand and technological innovations. The automotive industry's continued growth, particularly in the electric vehicle segment, is creating new applications for specialized rubber products.
- Research institutions are developing new rubber tree varieties that offer higher yields, disease resistance, and adaptation to changing climatic conditions.
- Digital technology is also transforming plantation management. Mobile apps help farmers track tapping schedules, monitor tree health, and access market information.
- The integration of rubber production with rural development programs has the potential to transform entire regions.
- Emerging technologies like artificial intelligence and biotechnology further revolutionize rubber production, and in leading global innovations in sustainable plantation management.
- The Rubber Board, in collaboration with the Central government and the Automotive Tyre Manufacturers' Association, is undertaking a project to increase the cultivation of natural rubber in the Northeastern States of India.

## **CONCLUSION**

Rubber cultivation is a one-time investment that can result in a profit for up to 40 years. Rubber plantations can be profitable, but their profitability can vary based on several factors like global rubber prices, production costs, and efficient management practices. While some farmers have reported significant income from rubber cultivation, others have faced challenges due to price fluctuations and increasing production costs. In summary, while there is potential for profitability in rubber plantations, it will depend on navigating the complexities of market dynamics, environmental conditions, and technological changes. Conducting thorough market research and considering local conditions will be essential for making informed decisions. Rubber cultivation can be a profitable enterprise in India, particularly in regions with suitable climates like Kerala and Tripura. Farmers can earn a substantial profit from rubber plantations, with some estimates indicating potential income of around one lakh rupees per acre annually. Rubber cultivation in India presents a viable and potentially lucrative business opportunity for farmers, especially with the right knowledge, resources, and market awareness.

The rubber industry in India has shown remarkable growth to date and has been indispensable for its economic contributions, foreign exchange earnings, and industrial use. However, there are many challenges involved in the cultivation of rubber plants such as ideal climatic and soil conditions, prevention from pests, price volatility, and environmental concerns. To ensure sustainable growth of rubber plants, it is required to focus on research, sustainable practices, market diversification, and government support. By fulfilling these requirements, India can produce more rubber and strengthen its position globally in the export of rubber goods. Rubber cultivation is a one-time investment that can result in a profit for up to 40 years. It obviously expresses that rubber cultivation is low-cost technology. Rubber plantations play an interesting role in environmental sustainability, making it an important carbon sink. Rubber cultivation can be a profitable enterprise in India, particularly in regions with suitable climates. Hence, rubber cultivation must be promoted among farmers by public and private both efforts. Farmers can earn a substantial profit from rubber plantations, with some estimates indicating potential income of around one lakh rupees per acre annually. It indicates a stable income for farmers. Rubber cultivation and the rubber industry play a pivotal role in the Indian economy by providing employment opportunities to a substantial workforce, particularly in rural areas. The rubber sector generates jobs across various stages, from planting and harvesting rubber trees to processing and manufacturing rubber products. Round the year employment opportunities of farm labourers and skilled labourers. Rubber is an indispensable raw material for a wide range of industries in India, including the automotive and manufacturing sectors. Day by day various govt. of various countries investing more money on transport, means more cars, means more rubber requirements. Ultimately, rubber industry is a viable industry. Considering all, govt. should promote rubber cultivation & rubber industries' development, investors can invest on this field for a viable & potentially lucrative business opportunity and farmers can arouse their interest more for rubber cultivation. "The rubber industry is of much significance to our countries. For millions of our smallholders, the rubber tree is a tree of life, serving as a crucial source of income for earning a living and raising families."--Thaksin Shinawatra (Former PM of Thailand).

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