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Natural Rubber : Agromanagement and Crop Processing
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Chapter 34

Rubber tree, man and environment

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1. INTRODUCTION

The rubber tree, *Hevea brasiliensis* is a renewable, sustainable, non-polluting and environment-friendly source of elastomer in sharp contrast to synthetic rubber (SR) manufactured from petroleum bases. Natural rubber (NR) was used almost exclusively to meet 98 per cent of the world elastomer demand in 1939 just at the beginning of the second World War (RSG, 1948). Even after the war, about 75 per cent of rubber consumed by the industry globally was NR and the rest SR. The consumption pattern has changed almost the other way round since then and SR currently makes up nearly 61 per cent of the total global elastomer consumption (IRSG, 1998) due to the extensive research and development efforts by the developed countries during the post-war years. Many western countries, for socio-political and economic reasons wanted to reduce their dependency on NR which is produced mostly in the South Asian countries. Evidently, the above change in trend in rubber consumption has not seriously taken into account the environmental impacts (Jones, 1994). Besides international politics and human rights, world trade is often linked to environmental issues. Modern man, who is experiencing fast deterioration of the quality of his habitat is sensitive to environmental issues (Fullerton and Stavins, 1998).

2. ECO-FRIENDLINESS OF RUBBER PLANTATIONS

Rubber plantations have a green image and are inherently environment-friendly (Jones, 1994; Wan and Jones, 1996). The carbon dioxide scavenging and oxygen recharging effects of the plantations on the atmosphere are too well known (Sethuraj, 1996). The rubber plantations are capable of producing a fairly high volume of wood per unit land area in a comparatively short span (Sivanadyan and Moris, 1992). These plantations aid soil and water conservation (Krishnakumar *et al.*, 1991; Krishnakumar and Potty, 1992) and indirectly help flood control (Sethuraj, 1996). Rubber plantations are a self-sustainable ecosystems and could maintain a fair degree of biodiversity, if properly managed (Sethuraj and Jacob, 1997).

2.1 Biomass generation

Of late, there has been a lot of interest in harvesting solar energy in the form of plant biomass because of the increasing global demand for carbon-emission-free power and fuel production (Hoffert *et al.*, 1998; Victor, 1998). The relevance of plant biomass is not only in its uses as firewood, timber, fuel, *etc.* but also in the fact that during the growth of the plants, the atmosphere is purified through photosynthesis. Biomass production potential of a plant species is related to its photosynthetic capacity per unit leaf area and the total leaf area produced per individual plant. In full sunlight, the photosynthetic rate of a mature rubber leaf is 10 to 15 µmol CO_2 per m^2 per second (Nataraja and Jacob, 1999) as compared to 5 to 13 µmol CO_2 per m^2 per second in many other tree species (Sethuraj and Jacob, 1997). The leaf area index (LAI) of a mature *Hevea* plantation can be as high as six or more (Devakumar *et al.*, 1998a). With a tree stand of about 450 per ha, the canopy closes in less than five years of field planting. Because of the high photosynthetic rate and large LAI, the biomass production per unit land area in a given time is very high in *Hevea*. This should make *Hevea* a good candidate for the fast afforestation of marginal and denuded lands preventing further degradation of their exposed soils (Plate 76. c,g).

The rate at which a *Hevea* plantation accumulates biomass is higher than that of many forest ecosystems (Sivanadyan and Moris, 1992). The biomass stand of a *Hevea* plantation under normal agronomic practice reaches near that of a humid tropical forest in about 30 years (Shorrocks, 1965; Kato *et al.*, 1978). If the rubber trees are left untapped for the same duration, the standing biomass of a rubber plantation can be even more than twice that of the humid tropical evergreen forest.

Hevea is not only a high biomass producer, but also an efficient water user. Studies have shown that *Hevea* uses much less amount of water than many other forestry species such as *Eucalyptus* for comparable biomass production. The total volume of water taken up by a mature rubber tree on a dry, hot and sunny summer day is around 50 L only which is substantially less than many other tree species of comparable size. An eight-year-old *Eucalyptus* tree can consume almost 90 L of water in a day (Kallarackkal and Somen, 1997).

The carbohydrates produced by the rubber trees through photosynthesis are partitioned between latex synthesis and biomass production. Obviously, when the trees are tapped, more carbohydrates would be diverted to latex synthesis affecting the biomass production. Compared to untapped trees, there is a net loss of biomass in tapped trees even after accounting for the biomass that was converted into rubber. This missing fraction of biomass, termed the k factor (Sethuraj, 1981), varies in different clones. An eco-friendly ideotype of *Hevea* should have a small k factor. The genetic variability of this factor existing among different clones could be exploited to develop an ideal genotype of *H. brasiliensis* for concomitant high rubber and timber yields.

Planting fast-growing tree species such as *Hevea* is one means of ameliorating the atmospheric CO_2 concentration which is now 25 per cent more than the pre-industrial times and is rising at the rate of 0.5 per cent annually (UNEP, 1992).

Predictions based on studies conducted with many plant species (Drake *et al.*, 1998) and *Hevea* seedlings (Devakumar *et al.*, 1998b) indicate that C_3 species such as *Hevea* will benefit through increased growth and reduced water consumption in a future world with increased concentration of CO_2 in its atmosphere. If this prediction nears reality, *Hevea* will be an ideal species for marginal and denuded soils with low water availability, leading to better greening of these landscapes, prevention of further deterioration of marginal soils and gradual reclamation of degraded soils. *H. brasiliensis* is quite versatile in its adaptation to different agroclimatic conditions ranging from hot and drought-prone sub-humid tropics to even sub-Himalayan climate.

2.2 Natural recycling

A mature rubber plantation is an excellent repository for mineral nutrients which is comparable to that of native forests (Shorrocks, 1965; Samarappuli, 1996). Annual litter addition in rubber plantation amounts to 7 t per ha (RRII, 1996) and nutrient recycling through litter decomposition is very high (Joseph, 1991). In spite of the comparable or even higher standing biomass in a mature rubber plantation, the rate of litter accumulation on the floor of a rubber plantation is less than many native ecosystems and monoculture plantations such as teak, *etc.* This reveals the fast rate of decomposition of the litter and thus efficient nutrient recycling in rubber plantations (Krishnakumar *et al.*, 1991), which often reaches the level of forest ecosystems in mature rubber plantations (Shorrocks, 1965, Morris and Lau, 1990). The substantial addition of organic matter to the soil from rubber trees and cover crops improves the soil organic matter and water content. It also improves the soil physical (bulk density, porosity), chemical (nutrient availability) and biological (soil microbes) properties (Krishnakumar *et al.*, 1991; Krishnakumar and Potty, 1992).

2.3 Sustainability

A mature rubber plantation is a dynamic and self-sustaining ecosystem and a renewable source of rubber with minimum external agronomic inputs (Goldthorpe and Tan, 1996). Few other agricultural systems enjoy this status. A well-managed mature rubber plantation can yield as high as 3 t of rubber per ha per year (Sethuraj, 1998) the carbohydrate equivalent of which is comparable to approximately 6.8 t grain yield per ha per year. A good crop of wheat or paddy yields up to 3.5 to 5.0 t grains per ha per season stretching three to four months (Singh, 1994). While the rubber plantation gives the above yield with 30 kg each of N, P and K per ha per year, wheat or rice agriculture consumes about 100 to 120 kg N and 50 kg each of P and K per ha per season (Singh, 1994). Thus, the nutrient use efficiency of rubber plantation is far superior to these field crops. Apart from the enhanced consumption of nutrients, substantially larger amounts of water and other inputs such as insecticides and pesticides are needed for the cultivation of field crops. Several perennial plantation crops like tea and cardamom also require intensive cultivation and plant protection measures. The requirement of insecticides and fungicides is limited in rubber plantations. A single annual prophylactic spray of copper fungicide is adequate to control the abnormal leaf fall disease caused by *Phytophthora* and there are some clones that do not require even this. Other major diseases often require only localized chemical control. *Hevea* does not have any major known insect pests. Over all, rubber agriculture presents a unique example of low intensity agriculture while sustaining the productivity of the soil.

Many plantations in India are now under the third cycle of rubber cultivation. Continuous cultivation of rubber in these areas for the past several decades has not deteriorated the productivity of the soil. In fact, during this period, scientific cultivation of this crop has resulted in tremendous increase in the yield without sacrificing the long-term productivity of the soil (Sethuraj, 1998). It is worth mentioning here that there has been a tremendous decline in the soil productivity in areas where intensive agriculture was practised in the past couple of decades. Unfortunately, and perhaps unavoidably, a high environmental price has been paid for the increased productivity of wheat and other field crops which appear to have reached a plateau or even diminishing gradually (Swaminathan, 1998). In contrast, *Hevea* cultivation does not deteriorate the environment, but improves and preserves the ecosystem (Krishnakumar and Potty, 1992); a fitting example of an 'evergreen revolution' which is both ecologically sustainable and economically viable (Swaminathan, 1998).

The practice of shifting cultivation in forest areas followed by the native tribal people in the north-eastern states of India poses a serious environmental hazard, because of habitat deterioration and loss of biodiversity. Shifting cultivation, locally known as 'jhumming' involves slashing, digging and burning of forest vegetation (Plate 76. a) before taking up the crop. As forest land now available for shifting cultivation is limited, reforested areas are often cleared for cultivation at an increasing frequency even before they are fully formed. This has led to large-scale soil erosion and loss of forest wealth besides damaging nature and human habitat to precarious levels (Plate 76. b-d). Extending scientific rubber cultivation to these new areas requires motivating the native people (Plate 76. e). Rubber cultivation helps to restore the ecosystem (Plate 76. g) and improve the soil conditions (Krishnakumar *et al.*, 1991; Krishnakumar and Potty, 1992) as well as the living standards of the people. The pressures on forest for firewood is also reduced to some extent. Rubber cultivation can act as a catalyst for desirable social changes. It offers good employment opportunity for rural youth in impoverished and remote regions and can help to change their attitudes for the better, accelerating their integration with the mainstream society and thus enabling them to help themselves (Plate 76. f). This boosts their morale and they become less vulnerable to antisocial life styles. Thus, rubber plantations, through providing employment and improving the earning capacity of the rural peasants could even be a partial solution for many socio-political problems.

The huge imbalances in the income distribution brought about by the green revolution is attributed to be one of the reasons for the socio-economic imbalances seen in Punjab in the seventies and the eighties (Bhalla and Chadha, 1982). The rich landlords reaped most of the benefits of the green revolution leaving the peasants and agricultural workers with little to share from. It is worth mentioning here that the sale of lands held by the native tribal population in the north-eastern India to any non-tribal is prevented by law and therefore, the benefits of planting rubber will remain with the tribal community.

2.4 Alternative timber source

The South Asian countries where *Hevea* is grown, once had large areas under natural forests. Forest products, particularly timber, were a major source of national income in these countries during the early part of this century. Deforestation, mostly as a consequence of the colonial exploitation of the forests for timber, followed by planting the deforested areas with rubber and other plantation crops was common during the later part of the nineteenth century and early part of the twentieth century in all these former colonies, except Thailand which was never under any colonial power. At present, the annual rate of deforestation in some of these countries is alarming and countries like Thailand has completely banned logging. In Sri Lanka, the forested area decreased from 70 to 23 per cent between 1900 and 1995 and this is predicted to reach 17 per cent by AD 2020 (MALF, 1995). The South Asian countries are some of the most populous and fast developing ones in the world and the demand for timber is obviously on the increase. In these countries, forest timber has become a premium commodity unaffordable to many people. In this context, rubber wood assumes importance both from sociological and from environmental points of view.

Rubber plantations have become an important source of timber of commercial value (Sekhar, 1992). In 1993, rubber wood contributed to more than 10 per cent of the total log production in Malaysia (Najib and Ramli, 1996). Natural rubber wood has become the main non-forest timber resource decreasing the logging pressure on natural forests and teak plantations in rubber growing countries. Although not considered to be a premium quality timber like teak or rosewood, *Hevea* timber has many attractive physical properties such as good density, texture and colour and can be used for multiple purposes after appropriate treatments which increase its durability. Breeding strategies are changing in rubber and efforts to evolve latex-timber clones are under way in major NR producing countries.

Logging, either from a natural forest or a plantation, is not environment-friendly. But logging in a rubber plantation is done only during replanting when the trees have ceased to be economically viable in terms of latex yield. Immediate replanting of the area helps to conserve the environment effectively.

2.5 Soil conservation

Every cultural operation in a rubber plantation, from land preparation to replanting aids in improving the soil conditions (Goldthorpe and Tan, 1996). Field establishment of rubber plants is fast and the canopy closes in about four to five years. By the time the canopy closes, root concentration occurs in the top 18 cm of the soil and horizontally they spread up to 2 m from the plant base (Philip *et al.*, 1996). Being a surface feeder, rubber tree affords good soil binding and erodibility of soil is considerably reduced (Sethuraj, 1996).

The thick foliage of a rubber plantation helps in cutting down the direct radiation falling on the soil surface. The canopy effectively intercepts rain. The former helps to improve the soil moisture status and the latter to prevent soil erosion and better recharging of soil moisture by preventing fast run off of rain water from the field. Reduction in soil temperature in a rubber plantation leads to reduced oxidation of soil organic matter and favour its build up. Contour planting, cultivation of leguminous cover crops, *etc.* also help to prevent erosion and improve soil physical, chemical and biological properties. A rubber plantation is a man-made forest (Plate 76. g) representing a reasonably stable and self-sustaining ecosystem; though certainly not an alternative to native forests.

2.6 Biodiversity

A well-managed rubber plantation is different from a native ecosystem for the obvious lack of biodiversity, because rubber is grown as a monoculture. From the environmental angle, perhaps the biggest drawback of a rubber plantation is its lack of biodiversity. But this is more due to historical reasons than any fault of the rubber tree *per se*. Throughout the world, large plantations of rubber, coffee, tea, *etc.* were always maintained as monoculture, as land was not a limiting factor and management considerations were in favour. However, as a result of progressive reduction in the size of holdings due to steep rise in the population in almost all the NR producing countries, there has been intense pressure on small-scale planters to produce maximum economic profit from limited land. Though large plantations in the estate sector are most often monoculture devoid of cash and timber crops, it is common for a small-scale planter to maintain a limited number of coconut (*Cocos nucifera*), arecanut (*Areca catechu*), jackfruit (*Artocarpus heterophyllus*), 'anjili' (*A. hirsuta*), *etc.* in the plantation. Establishment of leguminous cover crops (*Pueraria phaseoloides, Calopogonium mucunoides, Centrosema pubescens* and *Mucuna bracteata*) as a routine cultural practice in rubber plantations makes rubber cultivation different from typical monoculture cropping systems. Rubber plantations do support different plant species.

Hevea does not seem to have allelopathic effects on other plants. Several plant and animal species can establish themselves in unmanaged rubber plantations mimicking native ecosystems in faunal and floral diversity. Many varieties of plants can coexist with *Hevea*. Presence of more than 40 species belonging to about 30 different families has been recorded on a rubber plantation. The only limitation for commercial cultivation of another crop in a mature rubber plantation is the relatively low light availability inside the rubber plantation. But shade loving crops such as orchids and certain species of medicinal plants can be grown in a mature rubber plantation. Medicinal plants like *Phyllanthus niruri, Sida rhombifolia, Hemidesmus indicus, Asparagus officinalis, Hydrocotyle asiatica* and *Glycosmis pentaphylla* are frequently present in rubber plantations. Various species of weeds and common plants like grasses, *Chromolena odorata, Mimosa pudica, Cleome viscosa, Cassia tora, Euphorbia hirta,* *Lantana camara, Borreria latifolia, Dendrophthoe falcata* and *Vanda* sp. do coexist with rubber in plantations. Crops such as banana and pineapple are grown in immature plantations where the canopy is not closed and light intensity is not a limiting factor. Shade tolerant accessions of grasses, legumes and broad-leaved weeds are grown in young rubber plantations in Malaysia as forage species (Ng *et al.*, 1997) for integration of sheep farming to rubber cultivation (Chong *et al.*, 1997). The extrafloral nectaries in *Hevea* attract different species of honey bees and *Hevea* plantations are a rich source of honey (Nehru *et al.*, 1995). Thus, *Hevea* plantations do support biodiversity, though to a limited extent.

The concept of monoculture plantations of rubber is undergoing changes. Research attempts to develop rubber-based multicropping systems are also under way. Tea and certain clones of *Hevea* have been found to be a good combination for multiple cropping (Yogaratnam and Iqbal, 1995).

Seasonal changes in the number of colonies of actinomycetes, bacteria and fungi present in the soils from native forests and mature rubber plantations are interesting and somewhat surprising. The number of actinomycetes and bacterial count was more in the rubber plantation than in native forest soils. The number of fungal colonies was comparable in both the soils (Deka *et al.*, 1998). *Hevea* soils also contain large numbers of earthworms. All these suggest that there are no root exudates from rubber tree or any by-product of the leaf litter decomposition which are unfriendly to the soil macro- and micro-fauna which are very crucial components of nutrient cycling in the ecosystem.

3. NATURAL vs. SYNTHETIC RUBBER

Production of 1 t of NR requires 15 to 16 Gj energy (Wan and Jones, 1996) whereas for 1 t of SR, the energy requirement ranges from 108 to 174 Gj according to the type of SR (Wan, 1994). This low energy requirement for NR production is largely due to the fact that the bulk of the energy needed for the growth of rubber trees and biosynthesis of rubber is met through photosynthesis by which the most abundant and freely available solar energy is used to synthesize rubber from sucrose produced through photosynthesis.

It is not only that SR manufacture is more energy-demanding, but it is also polluting. It should be emphasized that in NR cultivation, there is very little polluting of the environment and this is confined to the site of primary processing. The effluent which causes pollution can effectively be handled at the processing site itself to produce biogas (Mathew *et al.*, 1997). The waste water can also be recycled for use in the processing factory or can be used for irrigation after appropriate treatment (Seneviratne, 1997; Mathew *et al.*, 1998). Latex sludge, a waste from latex centrifuging, can be used as fertilizer (George *et al.*, 1994). Rubber plantations remove CO_2 and release O_2 to the atmosphere, but SR production contributes to the increase in global CO_2 levels.

The greatest advantage of SR is that SR of different specifications can be produced from a factory. But more than 80 per cent of the SR requirement can be effectively met by NR. Encouraging more SR producing factories is to encourage more urbanization and migration of people from villages to cities which is not always desirable. Throughout the NR producing countries, smallholdings contribute most to the rubber production

(Dove, 1993). Rubber plantations provide occupation for a large number of people and the employment generation in the rural sector is substantial. Unlike the SR producing factories, rubber plantations are scattered over large geographical areas. These aspects of NR production have very important social ramifications. Shifting from NR to SR would take away the livelihood of a large number of people and alter their agrarian way of living, leading to rural unemployment which is a good recipe for social unrest in the populous NR growing countries in South Asia.

There is better dispensation of gender equity and natural justice and an even geographical distribution of wealth among agrarian peasants in the NR plantation sector compared to the corporate SR manufacturing sector. Therefore, the question is whether we want to make more factories or plant more rubber trees to meet the increasing demand for rubber. Obviously a return to ecological sanity would call for the abandonment of SR and increase of NR production to meet the world demand (Commoner, 1972). And when it comes to the choice between NR and SR, let us not forget that the real choice is between greenery and factory (Plate 76. g,h).

4. *HEVEA* LATEX ALLERGY ?

Although latex products such as surgical gloves, catheters, *etc.* have been in use for decades, there were only rare incidents of contact reactions, those are of the Type IV allergy, mostly due to the allergic reactions of the person to a chemical additive present in the product. All of a sudden NR latex proteins became a lethal allergen in the 1980s. This surge of Type I allergy coincided with the increase in the use of NR latex gloves throughout the world, particularly in the West and other major rubber consuming developed countries, due to the increased awareness of transmission of blood-borne viruses such as HIV and hepatitis B (Bodycot, 1993). The US Food and Drug Administration reacted to this by issuing a medical alert concerning use of NR latex products in 1991. It is not difficult to see a well-orchestrated effort from certain corners to blow out of proportion the problem of *Hevea* latex allergy in human beings (Cornish and Siler, 1996).

An increase in the use of surgical gloves has however, led to some increase in the incidents of allergy. These reactions include local or systemic utricaria, rhinitis, oedema, conjunctivitis, bronchospasm, tachycardia, anaphylaxis, *etc.* (Slater *et al.*, 1990; Tomazic *et al.*, 1994). While it can be debated how widespread these reactions are and whether NR latex proteins *per se* or any chemical ingredients used during product manufacturing are primarily responsible for the allergy, the issue deserves further attention. It is possible that with the entry of more and more entrepreneurs into the area of surgical glove manufacture to meet the increasing demand, quality was probably compromised to save on the cost (Russel-Fell, 1993). The soluble protein content present in the gloves and other latex products should be minimal to prevent the occurrence of allergy in people who use them. By appropriate and adequate treatments, it is possible to meet this specification and make NR latex products almost totally allergy-free (Pailhories, 1993). Substituting NR with SR for manufacturing surgical gloves is not the right solution for the allergy problems.

Many ingredients present in the SR could well be potentially lethal for certain hypersensitive individuals, and therefore, by switching over to synthetic gloves, it is likely that the problem could be worse. As with any product, the number of reported cases of allergy depends on the total quantity of the product used, the total number of persons involved and the duration of use. Only after a sufficiently large number of gloves made from synthetic rubbers are used by a large population for a considerable duration, the gravity of the problem will become apparent. It would appear that while it is possible to make NR latex-derived products allergy-free by adopting appropriate processing technology, the concerted effort by certain vested interest groups to dump more and more of gloves and other products made from SR polymers is an attempt to promote business interests in the most unethical way, naturally using NR latex allergy as a convenient plank.

Regrettably, the irony of today's world is that resources are spent to solve the man-made problems in the name of development, and in doing so, even worse problems are created. There is always a high environmental cost for every developmental activity. It should be wisdom and a great sense of respect for the environment and not mere monetary motives that should guide in drawing the right balance between the cost we pay and the fruits of the development that we reap (Fullerton and Stavins, 1998). It is in this context that one should realize the increasing need for us to protect the environment, lest we impart irrepairable damages to our planet making it poor for future generations to survive.

It is a paradox that consumers in the West are making a hue and cry about NR latex allergy (and use more products made from SR and thus reduce the price of NR), while international funding agencies such as the World Bank, are funding for increased cultivation of NR in the rubber producing countries in South Asia to ensure continued availability of NR at cheaper prices. After all, by any estimate, NR is far safer than many SR both for man and environment (Tillekeratne and de Silva, 1997).

5. ENERGY PLANTATION CONCEPT

The concept of energy plantations is based on production of biomass through solar energy harvest and converting the biomass into various products based on the requirement. For example, it is possible to convert plant biomass into alcohol or methane by the enzymatic conversion of carbohydrates. However, a large portion of the cellulose present in the plant biomass may remain recalcitrant and therefore, the conversion of plant biomass into other products of economic importance may not have very high efficiency. In this context, it is exciting to consider the possibility of *Hevea* producing various compounds of secondary metabolism which are of immense use to man. These include sugar-alcohols, proteins, low molecular weight hydrocarbons, *etc.* An interesting parallel can be drawn here on the recent report that a UK-based therapeutic company developed a cow that produces milk containing human milk proteins which could be fed to human babies who cannot be fed by their mothers. This is a classical example of using modern biological technology for the betterment of man. *Hevea* offers a wonderful system for genetic manipulations to overproduce several secondary metabolites.

Rubber (cis-polyisoprene) is a high molecular weight hydrocarbon. If the molecular weight of *Hevea* cis-polyisoprene is controlled close to those of petrol and diesel, it should be possible to harvest fuel from rubber trees. This is no fiction at the turn of the 20th century when highly advanced genetic technology is available and could be actually materialized, provided the mechanism of control of the molecular weight of the *Hevea* hydrocarbon is known (Calvin, 1975). Though much of the molecular biology and enzymology of the elongation of the length of the hydrocarbon chain in *Hevea* is now known, more remains to be understood. By suitable molecular manipulations, it is not beyond the scientific capability to control the molecular weight of the *Hevea* hydrocarbon. A self-sustaining and renewable source of NR with different properties to suit different applications and fuel-grade hydrocarbon from the rubber plantation is probably the 'green' solution to global rubber and energy requirements.

6. CONCLUSION

Natural rubber enjoys excellent environmental image and rubber plantations are unique in many respects. Low intensity agriculture practised in rubber plantations has helped to sustain long-term productivity of the soil and maintain an economically viable source of income for the planter in the rubber growing countries. The diversification of activities in NR farming, harvesting, processing, value addition and trading as well as manufacturing and marketing of rubber products ranging from condoms to rubber nipples and shoes to aircraft tyres helps to engage a large number of people from different walks of life. There is perhaps no other agricultural commodity that affects human life like NR and few other agricultural systems that have employment potential similar to NR farming. These activities offer a fairly high degree of social and gender equity.

Many of the environmental problems are caused by man and the single most important factor leading to environmental pollution is population explosion. Naturally, any attempt to check population growth has beneficial influence on environment. In this context, the contribution made by the tiny rubber product, condom, made mostly from NR latex towards protecting the quality of the environment by controlling the population growth is overwhelming (Mathew, 1996) in addition to the substantial role condom has in preventing sexually transmitted diseases throughout the world.

The increasing industrial demand makes NR cultivation economically viable. The ecological compatibility and sustainability of NR farming are unquestionable. Natural rubber plantations are a good example for ecologically and socially sustainable agriculture with minimum environmental cost and social harm.

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