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SUSTAINABLE RUBBER CULTIVATION IN DIGITAL INDIA: TECHNOLOGY-BASED INTERVENTIONS, SKILL DEVELOPMENT AND RUBBER-BASED ENTERPRISES

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Abstract

Given growing unsustainability of rubber cultivation in India due to mounting production costs as against low market prices which are widely fluctuating too, this paper delves into some specific technology-based interventions for the sustained growth of rubber cultivation in India. Technology-based interventions, organic rubber farming, rubber-based micro enterprises, ICT based training, skill development for the cultivators including women, technology-driven farming practices, etc. have been dealt. Suitable policy suggestions have been offered based on the study.

Keywords: Rubber, Organic farming, Sustainability, Micro Enterprises, ICT, AI, e-NAM.

1. INTRODUCTION

There are apprehensions regarding the long term sustainability of natural rubber (NR) cultivation in India, as its production is growingly becoming unaffordable to growers. The ever-growing production costs as against relatively low market prices and that too of highly fluctuating nature (Pradeep and Jacob 2021)[2], (Sruthy et. al. 2021)[3]. In India, the NR sector represents nearly 0.4 percent of the cropped area and it contributes 0.64 percent only India's Agriculture-GDP. Yet, its contribution to the Manufacturing-GDP is vital, viz. 3.63 percent (Sajitha 2023)[1]. NR production co-exists with the fast growing rubber products' manufacturing sector. As a key segment NR contributes significantly to India's GDP or GVA since NR helps the fast growth of manufacturing. Despite all these, there is a clear stagnancy in India's NR production over the years. (Figure I).

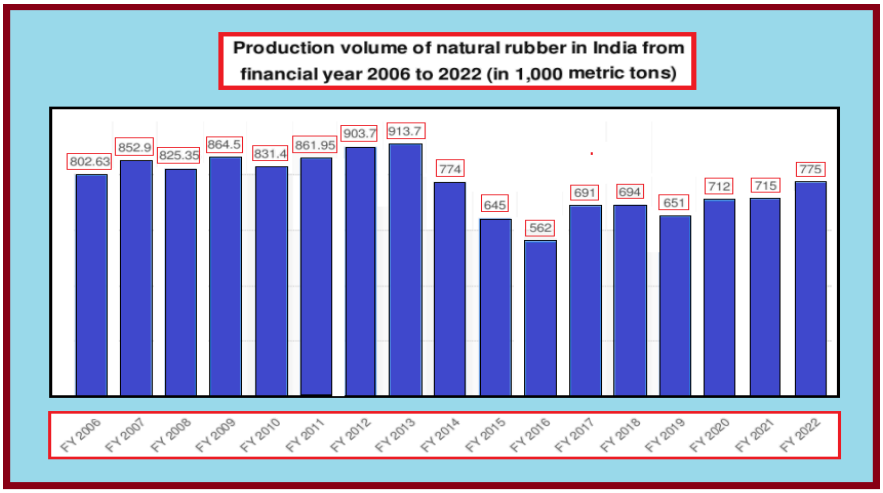

Figure I: Trend in NR Production in India

Source: Rubber Board (2023).

2. SIGNIFICANCE OF THE STUDY

Ensuring the sustainability of the cultivation and production of NR is vital not only for the NR cultivators alone but for the rubber-based industries in India, their employees as well as other stakeholders. As NR industry has vast linkages with manufacturing sector and such other sectors which are dependent on NR supply, there is an imminent need to ensure that the NR cultivation and consumption in India has long term sustainability. The falling trend in yield is a serious concern that must be immediately addressed. Besides, as exports show a discouraging and zig-zag trend while imports are fast growing. (Table I).

Table I: Vital Statistics relating to NR Production, Yield, Consumption, Exports etc.

Year (April to March)	Rubber area (ha)	Tappable Rubber area (ha)	Production (tonnes)	Average yield (kg/ha)	Consumption (tonnes)	Import (tonnes)	Export (tonnes)	Average price of RSS-4 at Kottayam (Rs/100kg)
2005-06	5,97,610	4,47,015	8,02,625	1,796	8,01,110	45,285	73,830	6,699
2006-07	6,15,200	4,54,020	8,52,895	1,879	8,20,305	89,799	56,545	9,204
2007-08	6,35,400	4,58,830	8,25,345	1,799	8,61,455	86,394	60,353	9,085
2008-09	6,61,980	4,63,130	8,64,500	1,867	8,71,720	77,762	46,926	10,112
2009-10	6,86,515	4,68,480	8,31,400	1,775	9,30,565	1,77,130	25,090	11,498
2010-11	7,11,560	4,77,230	8,61,950	1,806	9,47,715	1,90,692	29,851	19,003
2011-12	7,34,780	4,90,970	9,03,700	1,841	9,64,415	2,14,433	27,145	20,805
2012-13	7,57,520	5,04,040	9,13,700	1,813	9,72,705	2,62,753	30,594	17,682
2013-14	7,78,400	5,18,100	7,74,000	1,629	9,81,520	3,60,263	5,398	16,602
2014-15	7,95,135	5,33,675	6,45,000	1,443	10,20,910	4,42,130	1,002	13,257
2015-16	8,10,800	5,58,900	5,62,000	1,437	9,94,415	4,58,374	865	11,306
2016-17	8,18,000	5,84,600	6,91,000	1,553	10,44,075	4,26,188	20,920	13,549
2017-18	8,20,900	6,12,000	6,94,000	1,458	11,12,210	4,69,760	5,072	12,980
2018-19	8,22,000	6,37,900	6,51,000	1,453	12,11,940	5,82,351	4,551	12,595
2019-20	8,22,300	6,63,700	7,12,000	1,459	11,34,120	4,57,223	12,872	13,522
2020-21	8,23,000	6,92,900	7,15,000	1,442	10,96,410	4,10,478	11,343	14,185
2021-22	8,26,660	7,18,300	7,75,000	1,472	12,38,000	5,46,369	3,560	17,101

Source: Rubber Board (2023) (www.rubberboard.org.in).

3. OBJECTIVES AND RESEARCH QUESTIONS

Objectives are: (i) to critically study the trend and pattern of production, consumption, exports, imports, and yield of NR production in India; (ii) to study how technology adoption, skill development and other innovative practices bring about competitiveness and sustainability in NR rubber production, (iii) to make suggestions for the sustainability of the NR rubber cultivation in India and hence fast GDP growth of the nation.

The study being primarily exploratory in nature, no hypothesis has been set for the same. Instead, the following are the research questions set for the study: (i) what is the general trend in the NR production, consumption, exports, imports, yield etc. from a global view?; (ii) how technology advances and innovative practices ensure sustainability in the NR sector; and (iii) what are the strategies for the sustainable growth of the sector?

4. METHODOLOGY AND DATA SOURCES

Designed as a descriptive-analytical and also an exploratory study, this study has drawn data from authentic secondary sources, like, the publications of the Govt. of India (GOI), RBI, Rubber Board, etc. Common statistical tools have been used for data analysis.

5. PREVIOUS STUDIES

Several studies have noted that ICT could adorn a key position as a catalyst of rapid economic growth, including growth of diverse economic sectors and economic issues like, rural economy, women empowerment, etc. The prospects of the ICT industry too were studied by some scholars, and so also the need for adopting scientific methods. Manoj (2007)[20] “ICT industry in India: a SWOT analysis” *Journal of Global Economy* has studied at national level about ICT industry in India, pointed out the vital significance of this industry in the development of Indian economy, and made suggestions for sustainably promoting it. Manoj, P.K. (2005) [21] “Cost accounting systems in Banks-for strategic advantage through effective cost management” *The Management Accountant* has noted the need for managing costs scientifically in banks, and in Manoj, P.K. (2005) [22]. Scientific pricing of bank products through cost accounting-a vital need in the LPG regime, *The Management Accountant*, the need for scientific pricing of bank products for prudent financial management in banks is noted.

Pickens (2009)[23] has demonstrated as to how a common ICT tool (mobile phone) has played a key role in financial inclusion, empowerment of women and rural development through ‘banking the unbanked’ in Philippines. Manoj (2010) [24] “Impact of technology on the efficiency and risk management of old private sector banks in India: Evidence from banks based in Kerala” has observed that ICT-adoption by banks has made them more efficient. The imminent need for a concrete policy at the national level to address the issues of the rubber sector has been dealt in detail. *The Hindu* (2015) [25] wherein the welcome features of the new policy announced in April 2015 has been discussed. A study by Nasar and Manoj (2013)[26] “Customer satisfaction on service quality of real estate agencies: An empirical analysis with reference to Kochi Corporation Area of Kerala State in India” has noted that greater level awareness should be provided to real estate agents; and that transparency and social networking are needed for customer service and business growth. Manoj (2013)[27] “Prospects and Challenges of Green Buildings and Green Affordable Homes: A Study with Reference to Ernakulam, Kerala” has noted the good growth potential of green homes as they can create huge employment avenues and can ensure fast and sustained economic growth.

Besides ICT adoption, some studies have pointed out the need for faster sustained economic growth through diverse kinds of technological interventions, development models and tools; right from educational loans to exports and from SEZs to ecotourism. Varghese, K.X, and Manoj, P.K. (2013)[28], "Educational loans and the higher education sector in India" have noted that study loans can improve HR quality in the nation, youth employability and they should be promoted. Manoj, P.K. (2014) [29] "Role of ICT in Women Empowerment: A Study with a Focus on 'Kudumbashree' programme in Kerala State of India". *International Journal of Information Technology & Computer Sciences Perspectives* has pointed out the excellent women empowerment potential of SHGs under *Kudumbashree* poverty alleviation programme. K.K Nasar and P.K Manoj (2014) [30] Factors influencing the purchase of apartments: some empirical evidence. *Clear International Journal of Research in Management, Science and Technology* have noted the major factors influencing the apartment buyers which include infrastructure like ICT. Manoj, P.K. (2015) [31] "International Container Transhipment Terminal (ICTT) and its impact on coffee exports from India: An analysis" has observed the vital role of ICTT to boost exports and economic growth. Manoj, PK (2009)[32], *Special economic zones in India: financial inclusion: challenges and opportunities* has noted the role of SEZs for expediting economic development. Manoj, P.K.(2017)[33]"Segmentation Strategy for Promotion of Ecotourism Products: Evidence from Thenmala Ecotourism" the author has pointed out that meticulous planning using segmentation of tourists can lead to economic growth through ecotourism.

Rajesh and Manoj (2015)[34]"Women Employees work life and challenges to Industrial Relations: Evidence from North Kerala" has noted the crucial importance of a trade-off between job life and family life of employed women to improve the industrial relations. Manoj (2016)[35]"Employment Generation from Rural Tourism: A Field Study of the Local Community at Kumbalangi, Kerala" has noted the vital capability of tourism to create employment avenues, along with suggestions like better infrastructure, ICT resources, online services, etc. Manoj (2016)[36] "Real Estate Investment Trusts (REITs) for Faster Housing Development in India: An Analysis in the Context of the New Regulatory Policies of SEBI" has observed that innovations in financing models such as REITs are vital to bring about rapid development of India's housing status which could lead to faster development of the whole Indian economy, given the linkages of housing. Manoj (2016)[37] "Bank marketing in India in the current ICT era: Strategies for effective promotion of bank products" observed ICT-enabled marketing as a key need for India's banking sector in this digital era. A study by Lakshmi and Manoj (2017)[38] "Service quality in rural banking in north Kerala: A comparative study of Kannur district co-operative bank and Kerala Gramin bank" has pointed out that KGB could make greater use of ICT than KDCB thus enabling the former to get an edge in the market. Another paper by Lakshmi and Manoj (2017)[39] "Rural Customers and ICT-based Bank Products A Study with a Focus on Kannur District Co-operative Bank and Kerala Gramin Bank" has observed that ICT-enabled services of Kerala Gramin Bank (KGB) have been accepted to a greater level than KDCB's non-ICT-enabled services. A study by Joju, Vasantha, and Manoj (2017)[40] "Future of brick and mortar banking in Kerala: Relevance of branch banking in the digital era" has observed the vital need for 'human touch' as in 'brick and mortar' banking even if ICT or virtual banking is the new normal. Another study by Joju, Vasantha, and Manoj (2017)[41] "Financial technology and service quality in banks: Some empirical evidence from the old private sector banks based in Kerala, India" has

observed that Fin-Techs could significantly enhance quality of banking service and they have become essential for superior service delivery by banks. Manoj (2017)[42] "Construction costs in affordable housing in Kerala: Relative significance of the various elements of costs of affordable housing projects" ordered the different elements of cost based on their relative priority for effective control of costs, and ICT has been noted to be a vital tool for effective cost control. Manoj (2017)[43] "Cost management in the construction of affordable housing units in Kerala: A case study of the relevance of earned value analysis (EVA) approach" has demonstrated EVA as a powerful weapon that could effectively manage various costs of construction.

A study by Joju, Vasantha, and Manoj (2017)[44] "Electronic CRM & ICT-based banking services: An empirical study of the attitude of customers in Kerala, India" has noted the key significance of ICT-based banking practice called e-CRM (Electronic Customer Relationship Management) as an enabler of efficient and competitive banking, along with noting good feedback of customers to latest ICT-based products like e-CRM. Another CRM paper relating to bank management area by Manoj (2018)[45] "CRM in old private sector banks and new generation private sector banks in Kerala: A comparison" has noted that CRM adoption by the new private sector banks (NPBs) being to a greater extent than that of the old private sector banks (OPBs) particularly in respect of the latest ICT-enabled or Electronic version of CRM (i.e. e-CRM); thus enabling the NPBs to get a clear competitive edge in the market vis-à-vis the OPBs. Manoj (2019)[46] "Social banking in India in the reforms era and the case of financial inclusion: Relevance of ICT-based policy options" has suggested ICT-based strategic options to enhance social banking that fits into the current digital banking regime. Manoj (2019)[47] "Dynamics of human resource management in banks in the ICT era: A study with a focus on Kerala based old private sector banks" observed the key relevance of ICT-enabled policies for the management as well as development of bank staff in this very competitive digital era. Manoj (2019) [48] "Competitiveness of manufacturing industry in India: need for flexible manufacturing systems" pointed out the vital significance for adoption of ICT as well as other technological advances such as flexible manufacturing systems (FMS) so as to make Indian manufacturing sector more competitive, given the globalization pressures.

A paper by Joju and Manoj (2019)[49]"Digital Kerala: A study of the ICT Initiatives in Kerala state" has studied the major initiatives in the ICR front in Kerala, the State in India having many unique 'firsts" like the topmost in internet penetration, topmost in literacy (universal literacy) etc. and has suggested strategies for the better use of Kerala's vast ICT potential for its faster development. Joju and Manoj (2019) [50] "Banking Technology and Service Quality: Evidence from Private Sector Banks in Kerala" have observed ICT as an enabler of banking quality and as such ICT-adoption should be encouraged. Ali and Manoj (2020) [51] "Impact of Falling Price of Rubber-A Case Study of KothamangalamTaluk in Ernakulam District" has pointed out that due to frequent price falls affect the livelihood of farmers and that governmental interventions like minimum support prices are vital. Manoj (2015)[52] "Prospects of Responsible Tourism in Kerala: Evidence from Kumarakam in Kottayam District" has noted that responsible tourism (RT) has vast potential for supporting economic growth, if sustainably promoted. Manoj (2016)[53] "Determinants of sustainability of rural tourism: a study of tourists at Kumbalangi in Kerala, India" has noted the key variables affecting tourism's sustainability in the rural context and also suggested strategies like upgrading digital (ICT) resources as of the factors. Manoj (2015)[54] "Impact of Rural

Tourism on the Environment and Society: Evidence from Kumbalangi in Kerala, India" noted certain adverse impacts that are imminent in rural tourism and that it is vital to control such effects. Manoj (2019)[55] "Tourism Sector in Kerala in the Post-Flood Scenario: Strategies for its Sustainable Growth With a Focus on Responsible Tourism" observed the crucial part that RT could play for revival of flood-hit Kerala economy.

A study by Saritha and Manoj (2023) [56], "Social inequalities in IT sector: Evidence from Kerala State in India" has observed the existence of inequality among IT sector employees in Kerala along with the key requirement for removing it for equitable development of Kerala's IT sector. Manoj, P.K. (2015) [57] Housing Microfinance: A Study on Quality, Cost and Default Rate with Respect to Bhavanashree in Kerala has noted that housing microfinance (HMF)type home loans have lower quality (higher NPAs) and also that their transactional costs are higher. Manoj (2023)[58] "Affordable Healthcare and Affordable Housing: Need for an Integrative Approach for the Holistic Growth of the Digital Economy of Kerala, India" *Community Practitioner,* has noted that a knowledge society like Kerala must promote housing and healthcare sectors holistically using ICT. Manoj, P.K. (2023) [59]. ICT for Sustained Community Development in India in the 5G Era. *Community Practitioner* has noted the vital need of high-end ICT resources to provide better internet connectivity for fast and equitable growth. A more recent study by Sruthy Krishna, and Manoj, P. K. (2023)[60] 'Technological Advances and the Sustainability of Natural Rubber Cultivation in Digital India: A Study with a Focus on Kerala State' has studied as to how technology influences the sustainability of rubber cultivation in India, and has also suggested some strategies for sustainability.

6. RUBBER SECTOR IN INDIA: A STUDY FROM A GLOBAL PRESENCE

It may be noted that India is one of the major producers of natural rubber (NR) in the whole world. India comes sixth in the world and is after Thailand in the first place, followed by Indonesia, Vietnam, Ivory Coast, and China in the second, third, fourth and fifth positions respectively. (Figure II).

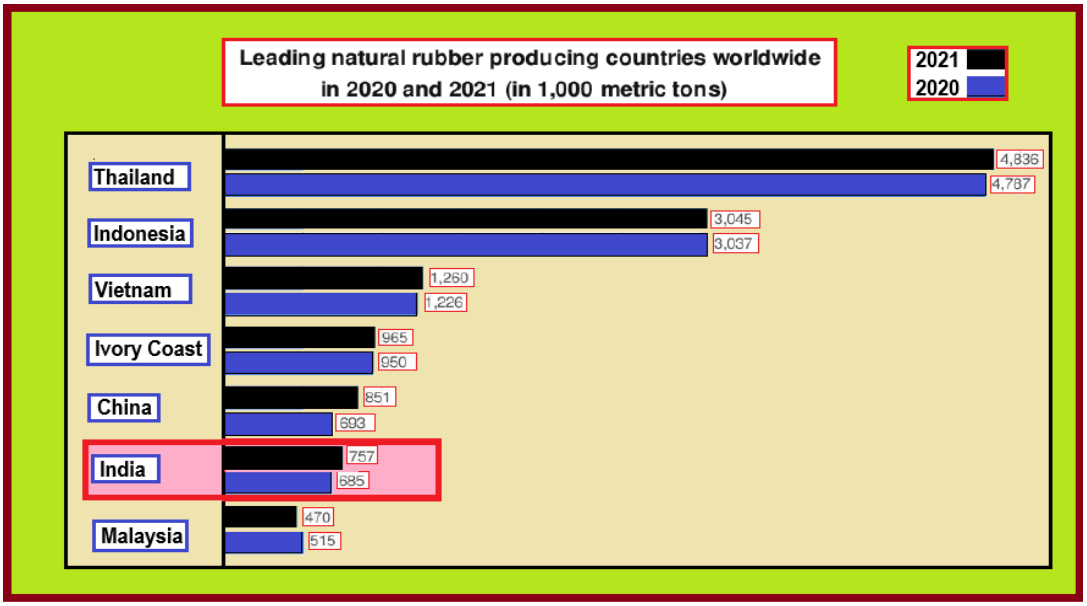

Figure II: Leading Producers of in the world.

Source: Adapted from, Statistica (2023)

However, as already pointed out there has been a clear stagnancy in NR production in India as evident from Figure I and Table I. A more disturbing trend is that NR exports from India over the years have been very disappointing as it shows a generally declining trend. From as high as 73.83 ('000 Metric Tons) exports in FY 2006 it has come down to 12.87 ('000 Metric Tons) in FY 2020. In the meantime in FY 2015 and FY 2016 the NR exports from India was virtually nil, at a too low level of 1 ('000 Metric Ton) or less. This desperate state of affairs is obvious from Figure III relating NR exports from India.

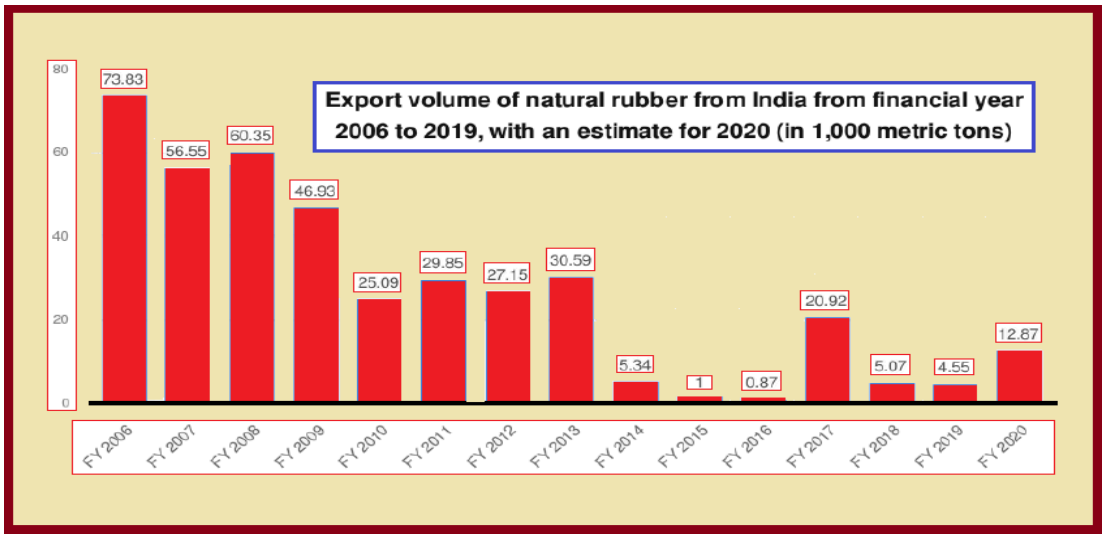

Figure III: Trend in the NR Exports from India.

Source: Adapted from, Statistica (2023)

Even when the NR exports are fast declining in general, there has been a steadily growing trend in respect of NR imports into India. Thus, exports have been falling and imports have been growing over the years. This is a very embarrassing situation as far as the sustainability of this sector is concerned. This is because, huge imports make the production of NR by the domestic cultivators unstainable.

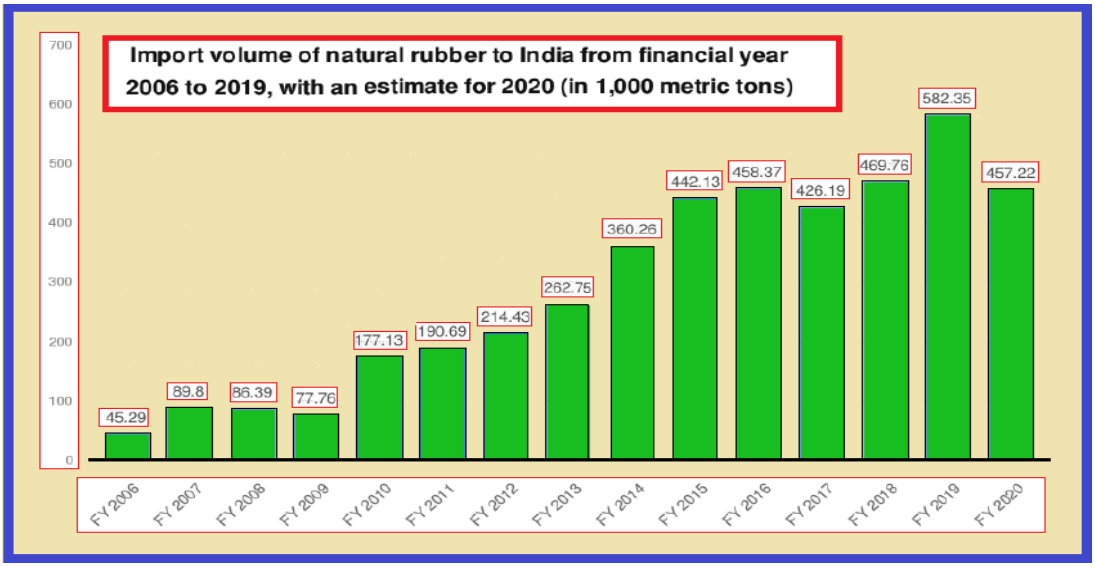

Figure IV: Trend in the NR Imports into India.

Source: Adapted from, Statistica (2023)

So, as the NR market prices are in general fast falling and these are fluctuating too. This situation is pointed out by an empirical study by Ali, O.P. and Manoj, P.K. (2020) 'Impact of Falling Price of Rubber-A Case Study of KothamangalamTaluk in Ernakulam District' wherein the undue hardships that rubber farmers are facing due to low NR prices and the need for a minimum support price make the NR cultivation sustainable have been clearly noted. Similar is the finding by Pradeep Balan and James Jacob (2021) in their study on rubber growers in Kerala.

The major finding of the study by Sruthy Krishna et. al. (2021), "Rubber Economy in Digital Kerala and the Problems Faced by the Rubber Cultivators: Need for Technology-Based Interventions" wherein the low NR prices is noted as a major challenge that makes rubber cultivation unsustainable for the farmers.

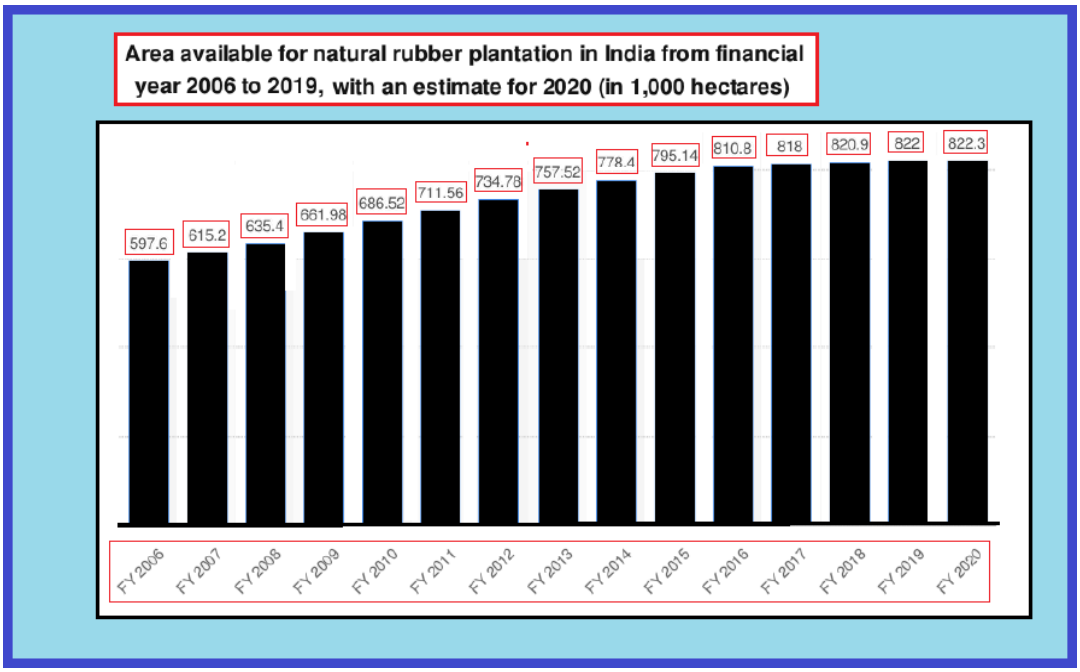

Figure V: Area under NR Cultivation in India.

Source: Adapted from, Statistica (2023)

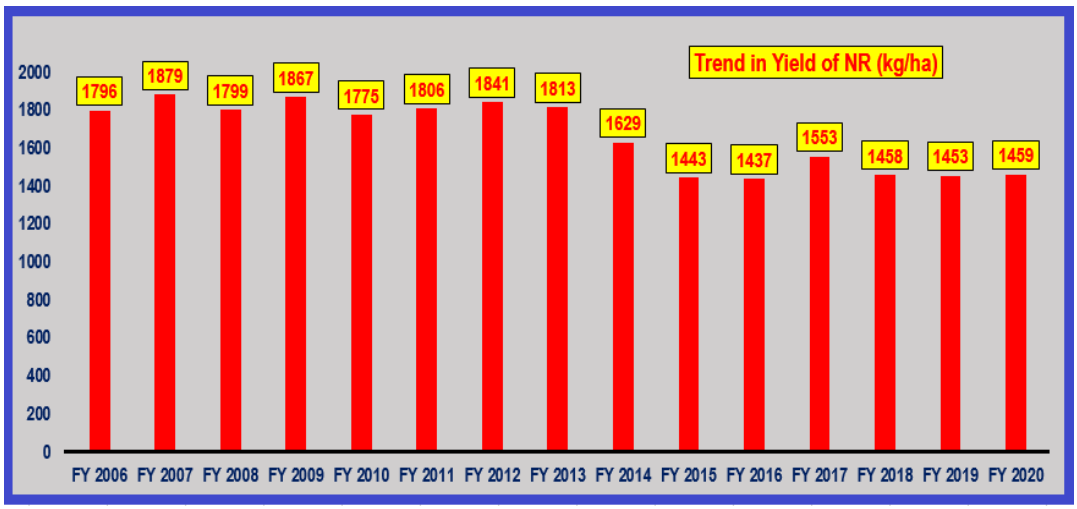

Figure VI: Yield of NR Cultivation in India (kg/ha).

Source: Rubber Board (2023) (www.rubberboard.org.in).

It may be noted that a general stagnancy is noted in the area under NR cultivation since FY 2015 and accordingly the yearly growth is very low in respect of the area under NR cultivation (Figure V). Besides, if the yield per ha of NR cultivation is considered, then a stagnancy is observed during the said period (Figure VI). In short, whether it is the area under NR cultivation or it is the yield per ha of the area so cultivated by NR, there is generally a stagnancy. Or, both the area under NR cultivation and the yield per ha of NR cultivated are discouraging, and there is enough scope for improvement in this regard.

In short, a discouraging picture is revealed from the declining exports, growing imports, stagnancy in area of cultivation and also in the yield, and above all the quantity of NR produced. These are all indicators of unsustainability of NR cultivation in India.

7. NEED FOR TECHNOLOGY ADOPTION, INNOVATIVE PRACTICES AND SKILL DEVELOPMENT

The market prices of NR in India are observed to be closely following those prevailing in the global markets (Figure VII). So, it may be noted that for the sustainability of NR cultivation, especially from the perspective of the NR farmers, it is advisable to focus on minimizing the production cost, improving the yield, expanding the cultivation area etc. – all with the use of modern technology, innovative farming practices, etc. This can reduce and even avoid the intermediaries in the NR supply chain, from production to marketing.

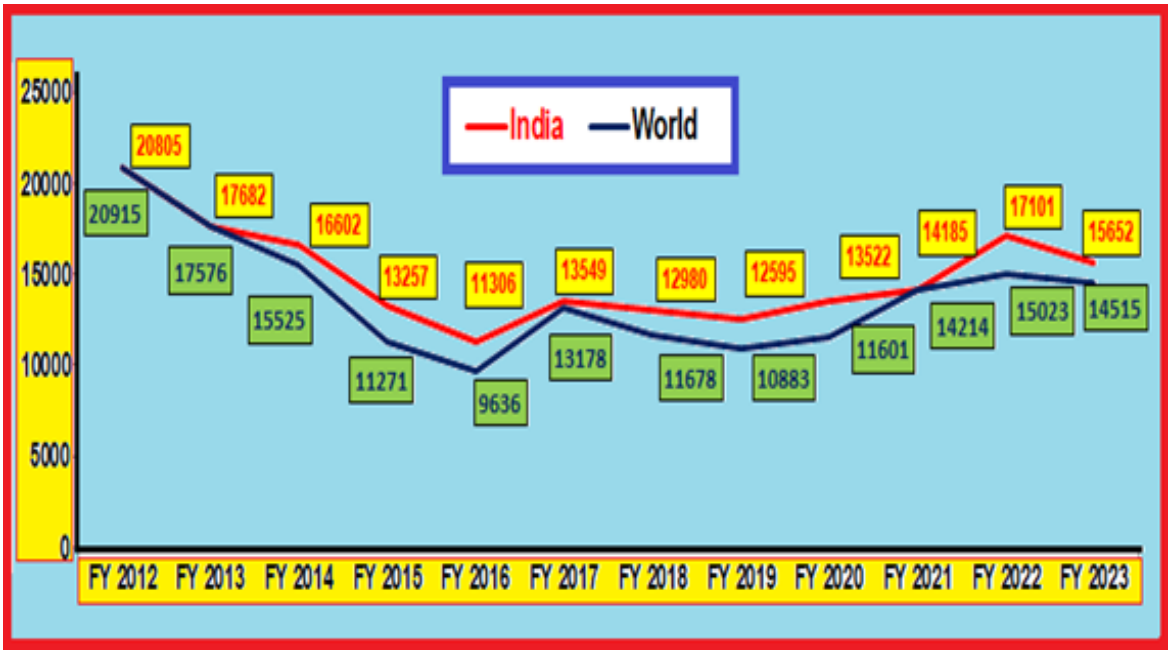

Figure VII: Market Prices of NR – Indian and Global Markets

Source: GOI (2023). Official Statistics of Rubber Board.

As noted earlier, for attaining sustainability for the NR cultivation in India, it is imperative that various technologies (e.g. ICT and its diverse forms, including AI) are adopted, innovative practices are employed, and suitable skill development is undertaken. For instance, use of ICT-enabled platforms like kiosks ensures the updates on NR prices. Electronic National Agriculture Market (e-NAM), an electronic trading portal came into being on 14th April 2016, completely funded by GOI and SFAC

(Small Farmers Agribusiness Consortium). By 2018 e-NAM could provide a common e-market platform for 585 selected wholesale markets. The benefits of e-NAM are greater accessibility, price discovery on real time basis. Better as and stable price realization (for producers) and lower transaction costs (for buyers) are the other benefits of e-NAM. Availability of the information on commodity prices on the e-NAM mobile app, SMS alerts on the price and quantity of commodities sold, better efficiency in respect of supply chain and warehouse based sales, direct online-mode payment to the bank accounts of farmers etc. are some of the other advantages of e-NAM. Figure V shows the stakeholders of e-NAM. In short, ICT and other technology advances like AI (artificial intelligence) have already revolutionized the agriculture globally.

Diverse kinds of technologies are being adopted by the Governments worldwide across the globe, e.g. the use of drones for spraying pesticides in rubber plantations. Often called 'Agtech' (Agriculture technology), these technologies seek to use modern and scientific practices (like, through the use of ICT-based tools), artificial intelligence (AI) etc. as well as innovative methods of farming, application of pesticides etc.

Widespread and fast mechanization of various agricultural operations are going on. A recent McKinsey study (2023) has estimated that Agtech would add about USD95 Billion to Indian economy annually by the year 2030. The use of ICT and other digital technologies have been reported to be of immense help to embrace the latest agricultural practices with the use of digital technologies. By way of embracing modern technologies hundreds of Billions of dollars can be added to the Indian economy, according to the report. It has been pointed that Indian Agtech start-ups could raise nearly USD 1.6 Billion funding from investors over the last 4 years, by primarily focusing on platforms and products that play across the value chain, generate digital solutions, offer "Agribiotech" – one that uses biotechnology platform to design innovative and sustainable products.

Figure VII: Market Prices of NR – Indian and Global Markets

Source: Compiled from IBEF (2023), *India's Agritech Ecosystem*

Agtech is being fast adopted by nations worldwide in order to improve the quality, reduce the production cost and also to enhance the competitiveness of their agricultural produce. It is observed that at the global level, Agtech is used to the extent of 39 percent as a farm management software. Europe used Agtech to the level of 62 percent whereas North America uses it almost to the same level viz. 61 percent. In respect of South America, Agtech is used to the extent of 50 percent, and here the most popular use of Agtech is that of remote sensing as against the other three cases where the most popular use of Agtech is farm automation. (McKinsey, 2023, Feb.) (Figure VIII).

In fact, Asia is the one that lags behind all other continents and in respect of Asia the most popular use of Agtech is farm automation and robotics. Even though Asia as a whole is lagging far behind many other nations, India's position is much better than China in Asia. It has been reported in McKinsey report of Feb. 2013 that farmers in India are using more Agtech products than those in China. So, despite the poor status of Agtech usage in Asia, the position of India is relatively better. (McKinsey, 2023). (Figure VIII).

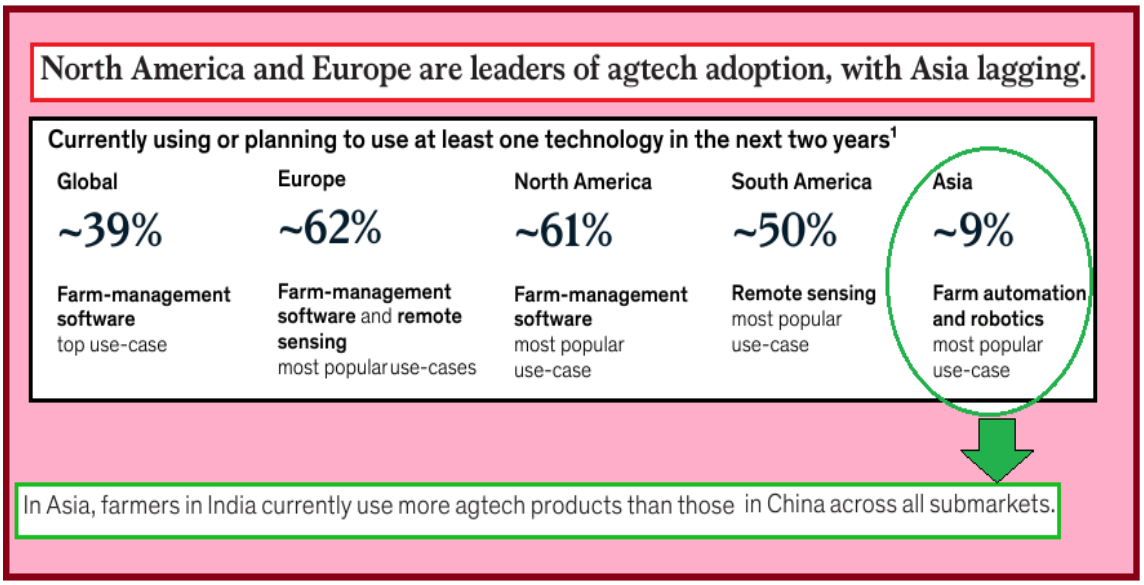

Figure VIII: Agtech adoption across the world – Major nations / regions.

Source: McKinsey (2023), *Agtech: Breaking down the farmer adoption dilemma*, Feb.

It has been reported by McKinsey (2023) that the major barrier or challenge to Agtech adoption in India is its high cost. This is followed by another major barrier viz. unclear ROI. It has also been reported that half of the Indian farmers are unwilling to pay for Agtech purpose and also that the expected ROI by the farmers for Agtech adoption is in the ratio 3:1. That is, the farmers expect at least 3 times more returns by using Agtech. In short, high cost and unclear ROI deter farmers from using Agtech. (Figure IX)

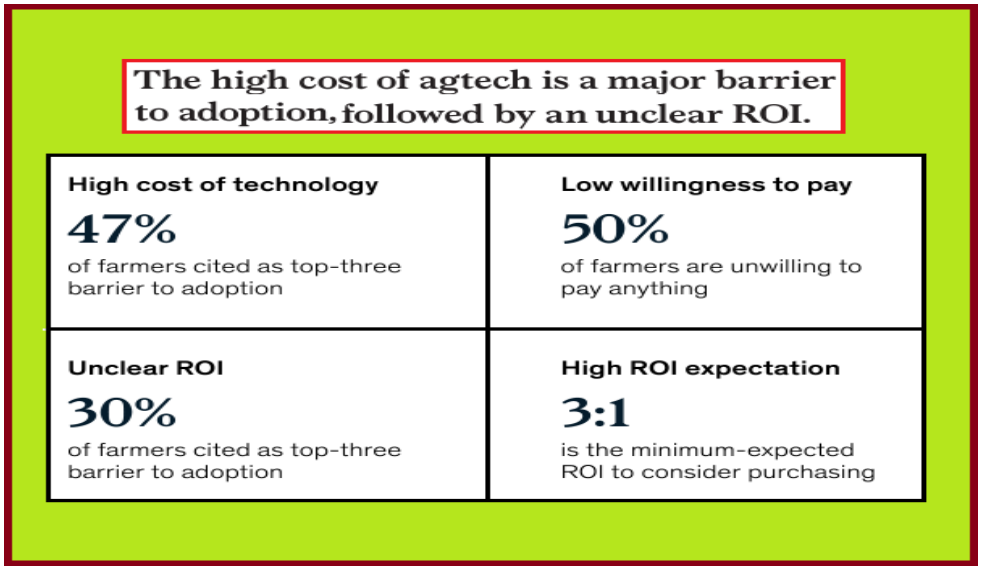

Figure IX: Agtech Challenges – High costs and unclear ROI.

Source: McKinsey (2023), *Agtech: Breaking down- the farmer adoption dilemma*, Feb.

NR exports is showing a fast falling trend (Figure III) as already noted. It is also noted that in respect of rubber-based goods produced in India is not very encouraging. For instance, such products with good export potential also, like, in respect of the rubberised coir products produced in India there is a general stagnation in its production over the years (Figure X). This is a typical example of a rubber-based industry in India.

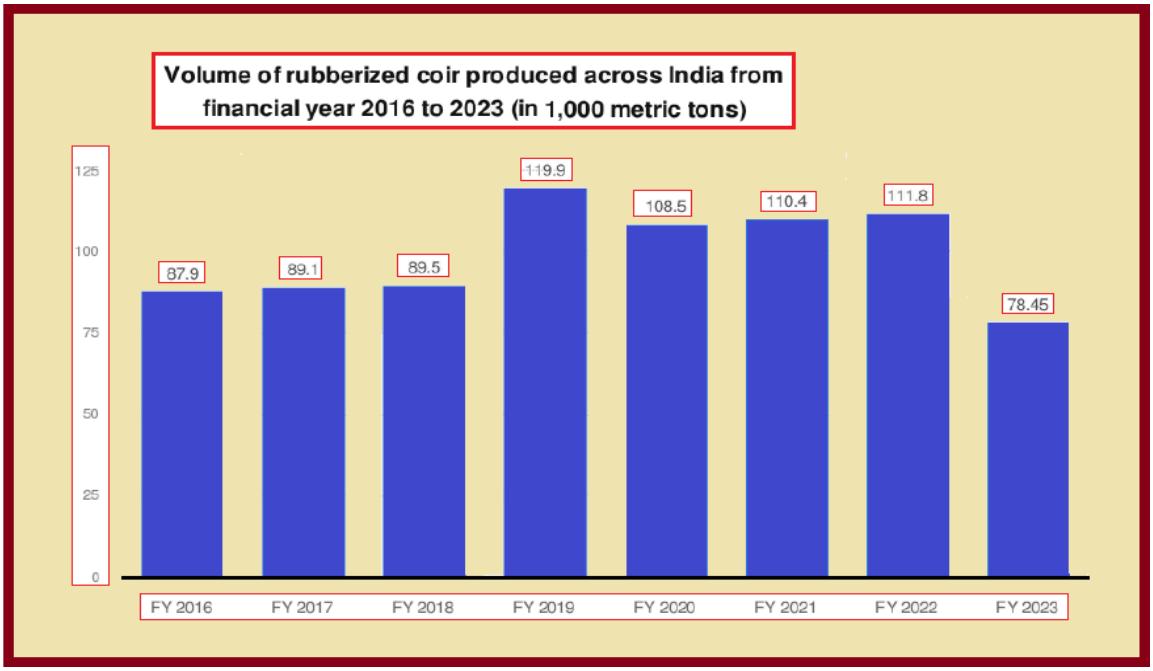

Figure X: Trend in the Rubberised Coir Products Produced in India.

Source: Adapted from, Statistica (2023)

In view of the above, it may be noted that there is an urgent need for technology adoption by NR farmers for the sustainability of their crop. Farmers need to develop their skills in rubber cultivation, processing etc. till marketing of their produce. Even

women need to upgrade their skills in various activities relating to NR cultivation, like, scientific tapping of rubber trees, processing the NR latex to make sheets and smoking the sheets to preserve them and finally sell to them. Use of ICT is desired throughout the process.

8. SUSTAINABLE NR CULTIVATION IN DIGITAL INDIA: SOME BROAD STRATEGIC OPTIONS

Given the relatively low and also falling NR exports from India, the Government need to improve the use of NR by the domestic industries by limiting the imports of NR which is steadily on the rise. Growing imports suggest cheaper availability of NR from other countries. This in turn suggests that through technology-adoption the yield of NR per ha needs to be enhanced and the production costs be reduced also. Then only domestic NR production can be made competitive enough to compete in the global markets. The governments, both at the Union and State levels, should start suitable arrangements to facilitate the scientific methods of NR cultivation, like, providing high yielding variety (HYV) of rubber saplings for the cultivators, mechanization of processing of the rubber latex, scientific methods of control of fungi, bacteria, pests, insects etc., like, application of Bordeaux mixture etc., use of drones for spraying pesticides in NR plantations etc.

NR cultivators have to embrace the technological advances in the field such as the use of high-yielding varieties of NR saplings, application of fertilizers scientifically, use of ICT-enabled detection and/or prediction of weather, enhanced and scientific tapping practices etc. Use of kiosks for price monitoring, ICT-based marketing of products, use of e-WOM (electronic Word of Mouth) for prudent decisions, etc. are also advisable. The use of ICT-based market information services, including AI-based tools and techniques is also desirable in this digital era.

Collective initiatives to start rubber-based micro-enterprises (MEs) appears to be promising, especially in States like Kerala where the SHG movement is strong. Women too can start MEs that are based on rubber has a primary raw material. *Kudumbashree,* the poverty alleviation mission under the Govt. of Kerala (GOK) has already running many MEs with its SHG women as the members. Such collectives should take up skill development programmes for the benefit of those involved in NR-related activities, like, cultivation, processing etc. of women. Women's initiatives like 'Green Army' that strive to make various environment-friendly enterprises need to be promoted in NR sector also. They may go for ICT-enabled and other environment-friendly processes and methods for taking up various rubber-based MEs that suitable to the local environment. Thus, a model as suggested in Figure XI appears to be suitable for the sustained growth of NR sector.

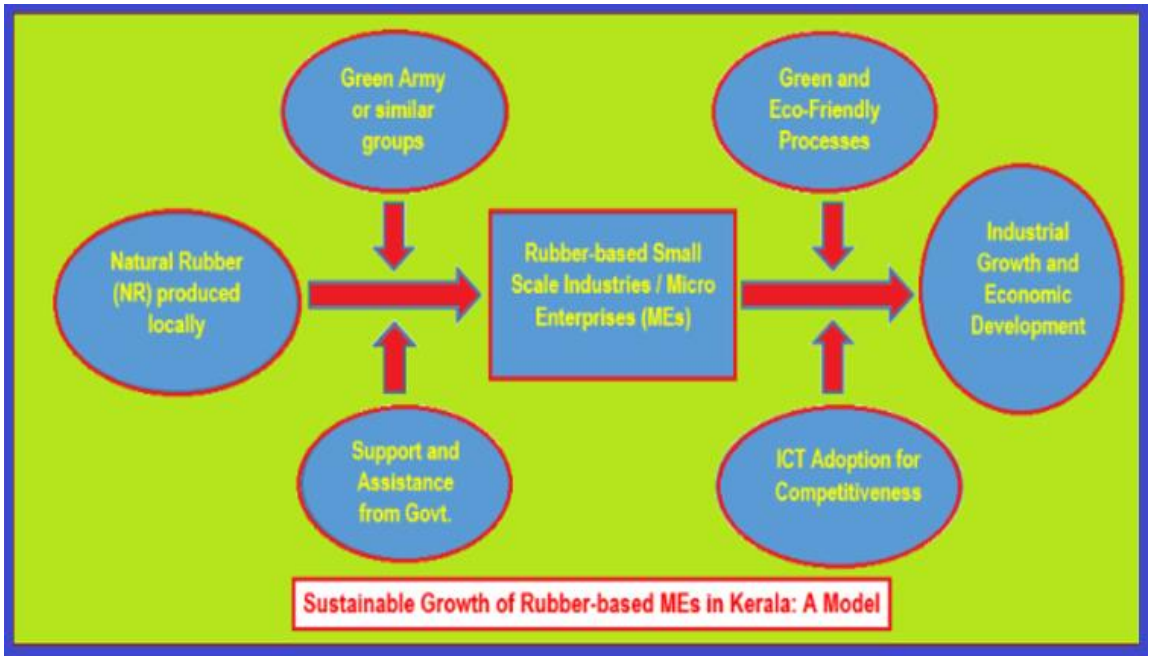

Figure XI: Sustained Growth NR Sector in India – A Conceptual Model.

Source: Developed by the authors

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