HOW MUCH NATURAL RUBBER CAN INDIA PRODUCE IN THE COMING YEARS?

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Received: 19 November 2020 Accepted: 01 December 2020

Jacob, J., Siju, T. and Chandy, B. (2020). How much natural rubber can India produce in the coming years? *Rubber Science*, 33(3): 229-241.

In the context of rising demand for natural rubber (NR) and fall in its domestic production, it is important to assess the country's capacity to produce NR in the coming years. Since productivity is highly dependent on the age of rubber trees, age composition of the NR holdings is a major determinant of production capacity. By analysing the demographic trends using historic data of new/replanting in the country between 1956-57 and 2018-19, it was evident that the rate of annual replanting was highly inadequate to replace all the old holdings existing at any point of time. We adopted a scientifically precise and robust method to estimate the fraction of the older holdings getting added to the less productive senile category every year after replanting. Share of the senile holdings consistently increased over the years. As of 2020-21, 35 per cent of the holdings was 25 years or older (which was as high as 41% of the mature area) and this share will increase in the coming years if the present low planting tempo continued. Given that most growers in India adopt alternate daily tapping, holdings that are 25 years or older are likely to be highly unproductive and therefore unprofitable to tap when NR price is low.

We modelled the past and future trajectories of NR production capacity, defined as the sum of the product of mature area in different ages and the corresponding productivity. Our analysis revealed two peaks in production capacity, one reaching a high in 2001-02 (8.7 to 9.0 lakh tonnes yr^{-1}) and the other in 2024-25 (10.9 to 11.5 lakh tonnes yr^{-1}). The first peak reflected the planting boom during the decade of the 1980s, catalysed by the release of the first indigenously developed high yielding hybrid rubber clone, RRII 105 and supported by proactive extension efforts by the Rubber Board. The second peak reflected the massive planting activity for several years that was seen around the world from the middle of the decade of 2000 triggered by a steep rise in NR price. Presently the planting rate in the country is at a historic low. Our model predicts that NR production capacity which is presently on the rise will steadily decline in direct proportion to an increasing share of senile holdings from as early as the middle of the current decade which will be hard to reverse for several years to come even if aggressive re/new planting is done now; thanks to the long gestation period of the crop.

Our model forecasts that NR deficit is likely to increase drastically, warranting more imports in the coming years which will be incongruous with the vision envisaged in the National Rubber Policy and may not be the best desirable option for the NR consuming industry in India. Alternatively, and more likely, the industry may increase the share of consumption of synthetic rubbers which is not in the best interest of the NR grower community or environmental sustainability. Yet another eventuality might be migration of the industry to those countries that produce surplus quantities of NR, but this will be contradictory to the spirit of *Aatma Nirbhar Bharat Abhiyaan*.

Key words: Age composition, Natural rubber, New planting, Production capacity, Replanting, Replanting age, Senile area

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INTRODUCTION

As the country's demand for natural rubber (NR) is expected to continue to grow (Jacob *et al.*, 2018), two relevant questions arise, namely (i) what is the maximum capacity of annual NR production in India and (ii) how much NR will the country actually produce in the coming years. Answers to these questions are important for the consuming industry and policy makers. While NR production capacity is determined by the total area available for tapping, its age composition, and productivity, the realized production is determined by tapping behavior of growers which is largely determined by the price of NR and other factors such as availability of skilled tappers, weather *etc.*

Production capacity is defined as the sum of the product of age-wise mature area and the corresponding productivity. Theoretically, the total amount of rubber actually produced per year will be equal to the production capacity if no holdings remained untapped during that year. However, in practice, realized production can be at variance with production capacity as several factors such as price of NR influence tapping behavior of growers. While the age composition of the NR holdings is determined by the past planting decisions of growers, productivity is a biological function determined largely by the age and health of the rubber tree. Obviously, age composition of the rubber holdings is an important determinant of total NR production (Chandy and Sreelaksmi, 2008; Jacob and George, 2008; 2016). But this vital statistical information on the present and future age composition of the existing holdings is not readily available, making predictions of the present and future production capacities difficult.

If replanting is done every year regularly and consistently, replacing all the old trees that have crossed a fixed age of replanting, then it is easy to calculate the age composition of NR holdings during any year from the annual new/replanting statistics. In such an ideal scenario, there will not be any tree in the field that is older than the replanting age. However, in practice that is not the case. Neither is the replanting age constant in time and space, nor when replanting is done are all the existing old trees fully replaced by new plants. An individual grower is likely to replant her existing oldest holdings first, but that cannot be taken as a general rule while considering replanting in the national scenario. For various reasons, it may not be the oldest holdings always getting replanted each year; hence the need to determine the age-composition of the holdings.

The objective of the present study was to determine the age composition of NR holdings based on a meticulous analysis of the demographic trend emerging from the long term data of new and replanting (1956-57 to 2018-19) and estimate the maximum capacity for NR production during any given year in the past and future. The robustness of the long term planting data and the logic adopted here make the analysis insensitive to the replanting age (Table 1) which was the biggest unknown variable influencing age composition of the holdings. We show that the share of old/senile holdings has been steadily rising over the years, impeding national average productivity and this will begin to have a profound negative impact on production capacity in the immediate future. The method adopted by us has universal applicability to work out the age composition of rubber holdings and production capacity in other natural rubber growing countries, provided long term data of new/replanting and age-wise productivity are available.

MATERIALS AND METHODS

New planting (NP) and replanting (RP) data from 1956-57 to 2018-19, published by Rubber Board were used for the present analyses. It was assumed that when replanting was done during a given year, the then existing oldest holdings were the ones that were preferentially replanted. Therefore, the age profile of the holdings obtained in the present study has a bias towards the left (young) which is advantageous to the objective of this study which is to predict the maximum NR production capacity in a given year.

Since replanting age (r) is not a constant, we considered a range of realistically possible r, ranging from 22 to 30 years to estimate the age composition of the holdings for each r. The net difference between the areas under the curves NP+RP from 1956-57 to 1997-98 and RP from 1978-79 to 2019-20 (Fig. 1) is the total area of NR holdings above the replanting age 'r' existing as of 2019-20. But this simple arithmetic will only give one lump-sum figure of the entire area of the holdings falling in all different ages above r and will not give a decomposition of the area in the various age categories. Therefore, in order to get the distribution of area in each age group above r, namely r+1, r+2, r+3 *etc.* we adopted a scientifically precise method of analysing historic data of new/replanting, the logic of which is explained below.

Take for instance the analysis of age composition of NR holdings using replanting age, $r = 22$. If replanting is done in an area of a_n ha during the year n it is assumed here that all trees planted in the year n-22 are completely replaced with new plants (and so on and so forth for r=23, 24 ...30). But in reality, a_n was < a_{n-r} (Fig. 1). This meant that a "remainder fraction" of older holdings (a_{n-r}- a_n) always got added to an aging group of holdings, progressively putting more holdings in the ages r+1, r+2, r+3 *etc.* Thus, as years progressed, more and more area fell in the senile group of defined ages (r+1, r+2 *etc.*). This robust approach allowed us to earmark the extent of senile holdings according to each year above the replanting age, r. Analyses were done the same way for each replanting age from r = 22 up to r = 30 and the results were essentially similar, irrespective of the r used in the analysis (Table 1). Results of age composition obtained based on r=22 were used for further estimation of production capacity.

The maximum capacity for NR production during a given year was worked out as the sum of the product of mature area in each age group (as of that year) and the corresponding productivity as depicted below.

$$\text{NR production capacity} = \sum_{1}^{17} a_i \cdot p_i$$

where, a_i and p_i are, respectively, the area and productivity of a holding of age i as of any given year which was tapped for a maximum of 17 years followed by another four years of Controlled Upward Tapping (CUT). Productivity for each age group was obtained from a polynomial function ($y=-0.491x^2+7.349x+34.74$, $R^2=0.82$**) which was developed using yield data from a number of experimental trials. Thus, the capacity for NR production estimated here based on an age-composition that is biased to the left (young area) and based on experimental yields is therefore, theoretically, an upper limit of production capacity.

Table 1. **Share of area (%) under different age groups according to replanting age (22 years or 30 years)**

Replanting age: 22 years									
Age group (Years)	1980-81	1990-91	2000-01	2010-11	2014-15	2018-19	2020-21	2025-26	2030-31
Below 13	52	70	48	44	49	48	44	28	15
14-23	48	16	39	28	20	18	21	33	39
Above 23	0	14	13	28	31	34	35	39	46
Total	100	100	100	100	100	100	100	100	100
24-28	0	11	6	18	16	11	9	8	11
>=29	0	3	7	10	15	22	26	31	35
Replanting age: 30 years									
Age group (Years)	1980-81	1990-91	2000-01	2010-11	2014-15	2018-19	2020-21	2025-26	2030-31
Below 13	49	64	45	42	47	46	42	27	15
14-23	46	15	36	27	19	18	20	31	37
Above 23	5	21	19	31	34	36	38	42	48
Total	100	100	100	100	100	100	100	100	100
24-28	5	11	6	17	15	10	9	8	11
>=29	0	10	13	14	19	26	29	34	37

Source: Estimated by authors based on area data published in various issues of *Indian Rubber Statistics*.

The capacity of NR production predicted here is based on the age-wise potential productivity of the clone RRII 105 (which occupies more than 95 per cent of the tapped area in the country) obtained from several long term field trials. The present study does not take into consideration the expected incremental contribution of yield from the RRII 400 series clones (over RRII 105) to the overall national production. It may be noted that although RRII 400 series clones are now increasingly getting planted (since their first release in 2005), their share in the total tapped area is only negligible because of the long immaturity period of this species and a relatively small rate of planting in the recent years. Therefore, production capacity estimated here based on the yield of RRII 105 is unlikely to go up because of the incremental increase in productivity of RRII 400 series clones during the period under consideration. A stand of 450 trees ha^{-1} was used in the present analysis. Although there is an annual tree attrition rate of roughly 1.1 to 1.2 per cent, this had only small effect on the results when considered at the national level. It was assumed that holdings that were 25 years or older were subjected to CUT for four years before their productivity was treated as zero. For these four years, a tree stand of 275 ha^{-1} was considered and three CUT productivity levels were considered, namely 1040, 1120 and 1200 kg ha^{-1} yr^{-1}. Possible shifting of rubber holdings to other crops was also not considered in this study.

RESULTS AND DISCUSSION

The rate of annual replanting was not large enough to completely replace all the old trees (Fig. 1) that had crossed their actively yielding age (or replanting age), resulting in progressive accumulation of older trees each year. This was the case irrespective of the replanting ages (*r*) used in the present analyses (Fig. 1). In other words, despite replanting taking place every year, a fraction of older trees continued to get accumulated, skewing the demography to the right.

Interestingly, it can be seen that given the replanting/new planting dynamics over the long period of time since 1956-57 and the rationale of working out the demographic trend that is adopted in this study, despite the replanting age taken as any year between 22 and 30, the age composition of the holdings was more similar in the recent years (Table 1). For example, during 2010-11, for *r*=22 and 30, the share of area older than 29 years was 10 and 14 per cent, respectively. This share increased to 26 and 29 per cent, respectively for *r*=22 and 30 in 2020-21 (Table 1). It is pertinent to point out that the variation between mature area estimated in the present study and the actual mature area collected by Rubber Board through field survey for *r*=22 and 30 became marginal in more recent years (Table 2). These results suggest that the choice of *r* (between 22 and 30 years) became redundant in the present analysis because of the subsuming or carry forward effect of the long term data set (1956-2019) on any likely confounding bias arising from different replanting ages. Thus, we could successfully circumvent the most crucial unknown in the present analysis, namely the replanting age.

Estimating the age composition of the natural rubber holdings in the country has been attempted earlier also (Jacob and George, 2008; Jacob and George, 2016) by

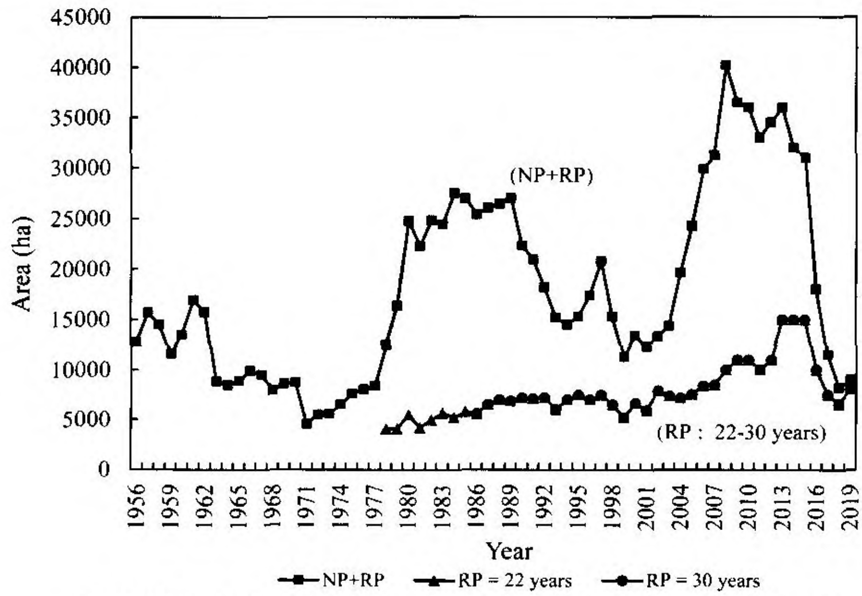

Fig. 1. Historic data of new and replanting used to estimate the age composition of NR holdings. Replanting rates were insufficient to replace all the older holdings irrespective of replanting ages

Source: Various issues of *Indian Rubber Statistics* (Vol. 17 to Vol. 41)

Table 2. **Extent of mature area estimated based on replanting ages of 22 or 30 years compared with published data of Rubber Board**

Year	Replanting age: 22 years		Replanting age: 30 years		Mature area (ha) (Published data of RB)
	Estimated mature area (ha)	Deviation from Published data of RB (%)	Estimated mature area (ha)	Deviation from Published data of RB (%)	
2005	471349	5.4	510778	14.3	447015
2006	478269	5.3	517698	14.0	454020
2007	481069	4.8	520498	13.4	458830
2008	484489	4.6	523918	13.1	463130
2009	485799	3.7	525228	12.1	468480
2010	488079	2.3	527508	10.5	477230
2011	492409	0.3	531838	8.3	490970
2012	501039	-0.6	540468	7.2	504040
2013	510309	-1.5	549738	6.1	518100
2014	525189	-1.6	564618	5.8	533675
2015	541439	-3.1	580868	3.9	558900
2016	571639	-2.2	611068	4.5	584600
2017	600639	-1.9	640068	4.6	612000
2018	630139	-1.2	669568	5.0	637900

RB-Rubber Board
Source: Estimated by authors based on area data published in various issues of *Indian Rubber Statistics*

taking into account the new and replanting data for a shorter period of time (1980-81 to 2014-15). In both these earlier studies, it was assumed that rubber trees attained maturity (tappability) in the 7th year. Replanting age was taken as 29 years after validating an empirical model through a "trial and error" approach for the short period considered for the study. It was estimated that the total area of rubber holdings that were more than 29 years old increased from 10250 ha in 2008-09 to 99,313 ha in 2014-15 (Jacob and George, 2016). In the present study, the extent of senile area (29 years or older) was considerably higher than the previous studies which may be due to the difference in the period for which planting data was considered for analysis. As planting data for a longer period (62 years) was used in the present analysis, the accumulated senile area is also more in the present study than in the previous one which considered planting data only for a much shorter period (34 years). Importantly, like the previous study, ours also predict that the share of old and senile holdings has been growing in the past and this trend will continue into the future if the current low rate of planting persists (Fig. 2).

Although the share of senile holdings steadily increased, two planting booms (particularly new planting) that lasted for well over a decade - first starting from 1980 and later starting from around 2005 (Fig. 1) led to two peaks in the production capacity (Fig. 3). Release of the first indigenously developed high yielding clone RRII 105 in 1980 and the proactive extension schemes for

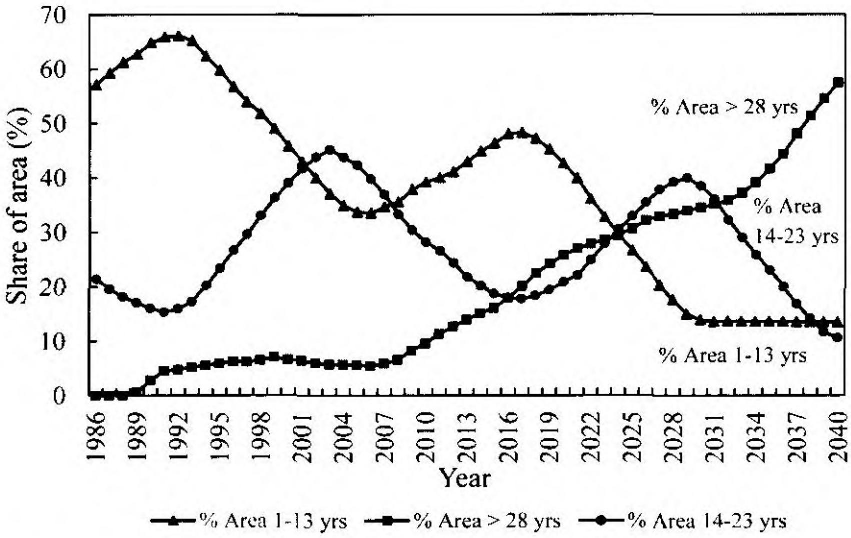

Fig. 2. Changes in the age composition of NR holdings
There is a steady increase in the share of senile area even as share of younger holdings, particularly that below 13 years shows a marked decline
Source: Derived from data used in Fig.1

promoting natural rubber cultivation (especially the "new planting subsidy" approved in 1979) were the main factors that contributed to the planting boom during the decade of 1980 which saw more than 2.5 lakh ha of planting. The first peak in NR production capacity was in 2001-02 with a capacity of 8.7 to 9.0 lakh tonnes as against a realised production of 6.3 lakhs tonnes when NR price was rather low (Fig. 4). This peak mirrored the planting boom of the 1980s. Production capacity subsequently showed some decline for about a decade, but realized production steadily increased riding on record increase in the price of NR during this period. Presently, the NR production capacity is on the rise (Fig. 3) although realised production is much below it (Fig. 4). NR production capacity will again peak around 2025 beyond which this is certainly poised to decline irrevocably if the current low planting rate persisted (Fig. 3).

Theoretically, realised production will be equal to the production capacity if all holdings were fully tapped during a year. Normally, the realised production cannot be more than the production capacity. However, it may be noted that it is possible to over-exploit the rubber trees (by intensive tapping or over stimulating) and produce more than the potential yields, as we have witnessed when NR price peaked (Fig. 4), but such spikes in production over and above the maximum capacity is not biologically sustainable for long and can adversely affect health of the trees and their future productivity (Vijayakumar *et al.*, 2000). Realized production going above the production capacity for a few years when the price of NR was sharply moving north may

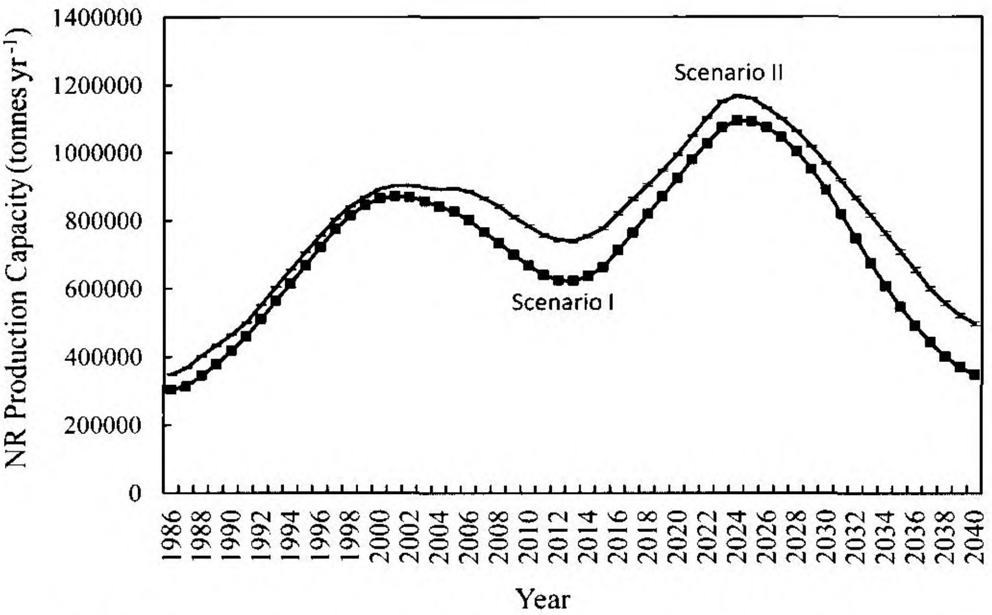

Fig. 3. NR production capacity estimated from the age composition of the Indian NR plantation sector with and without CUT adopted in old/senile holdings*

be also due to growers resorting to more slaughter tapping of senile holdings to capitalise on the high price. It is pertinent to note that even when the NR price was on the rise, over-production of NR beyond the production capacity had started to flatten off from 2006-07 onwards (at about 9 lakh tonnes yr^{-1}) and then declined sharply in tandem with fall in NR price (Fig. 4). In other words, the realized production will not remain higher than the production capacity for long even if price of NR remained high.

Presently, the production capacity is on the rise again (Fig. 3); thanks to the last planting boom that occurred for a decade from 2006 onwards (Fig. 1). But currently the realised production is well below the production capacity as considerable extents of mature area remain untapped due to the prevailing low price of NR (Rubber Board, 2019).

Realised production stayed flat for a couple of years before it went up again and remained well above the production capacity for a few years when the NR price continued to rise (Fig. 4). We worked out a NR "production estimator" as a proxy to realized production and compared it with

*Scenario I is the estimated production capacity without CUT in old/senile holdings. Scenario II is Scenario I + production from CUT in old/senile holdings for four years. Scenario II is the mean curve of three CUT yield levels envisaged for the old/senile holdings, *viz.* 1040, 1120 and 1200 $Kg ha^{-1} year^{-1}$. Production capacities estimated based on these three CUT yield levels were very similar as can be seen from the very small standard error. Any additional planting that is done now will begin to reflect in improved production capacity 7-8 years later.

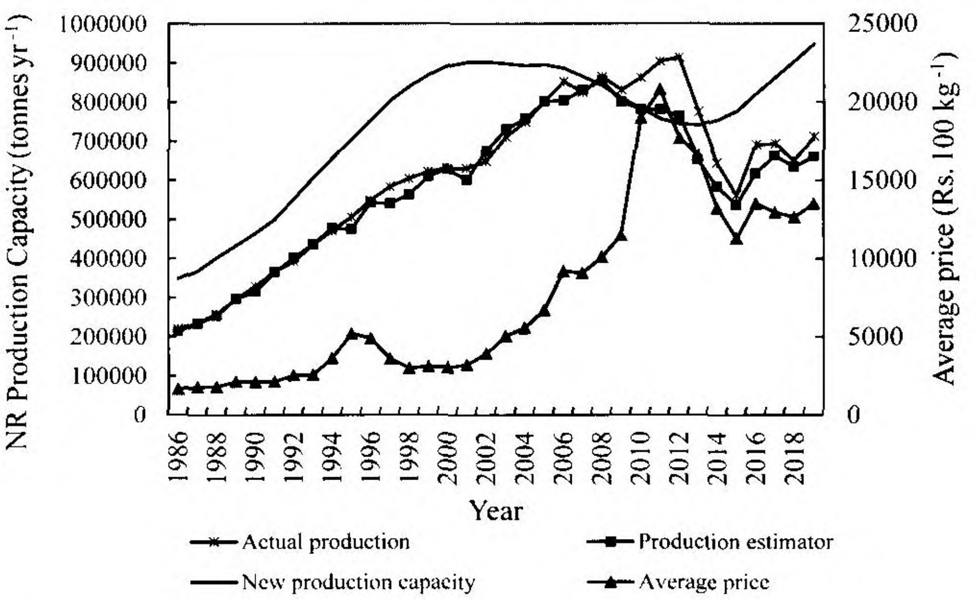

Fig. 4. Actual production of NR in relation to NR price and production capacity

Source: 1. New production capacity: Estimated by authors

2. Production estimator: Derived by authors based on NR consumption, NR export and NR import data published in various issues of *Indian Rubber Statistics*

3. Actual production and average price: Various issues of *Indian Rubber Statistics* (Vol. 17 to Vol. 41)

the NR production capacity. Natural rubber production estimator was calculated using the following formula.

NR Production Estimator = NR Consumption + NR Export – NR Imports

Consumption, export and import data of NR were taken directly from documented data whereas the realised production data of NR is collected through field sample survey and hence could be more prone to errors.

Until 2009, realised production and production estimator closely agreed with each other (Fig. 4). But after that for about 3-4 years, the realised production continued to increase as NR price peaked, whereas the production estimator showed a gradual decline. The realised production remained well above the production estimator during 2010 to 2013. From 2014 onwards, the realised production and production estimator data showed more agreement with each other (Fig. 4). The production estimator remained close to the production capacity (Scenario II) during the peak NR price years, but it declined together with realised production even as the price started to decline from 2012.

Here it is pertinent to point out that the model used to estimate the production capacity was a second degree polynomial function ($y = -0.491x^2 + 7.349x + 34.739$,

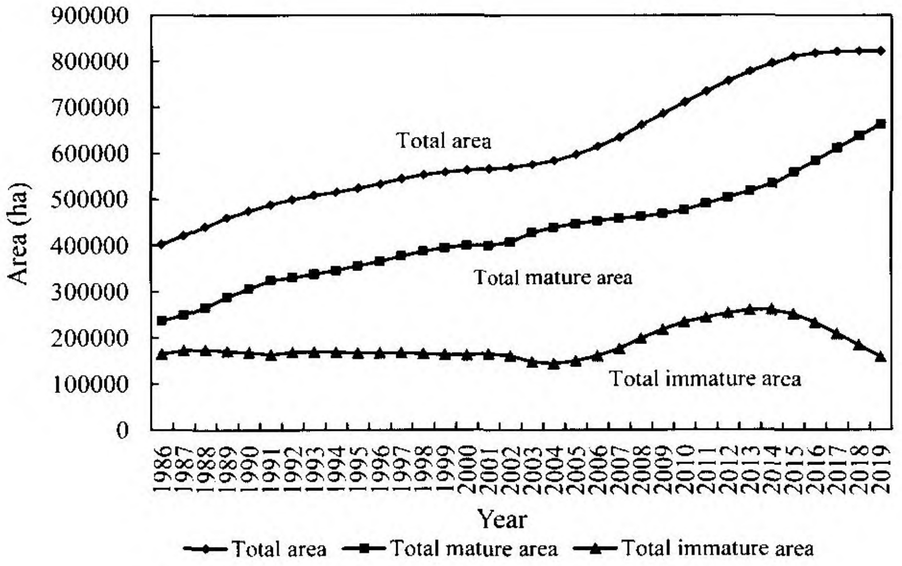

Fig. 5. Declining trend in immature area and flattening of total area
Sources: Various issues of *Indian Rubber Statistics* (Vol. 17 to Vol. 41)

R^2 = 0.82**, where y is the production capacity and x is the tapping year; 1 to 17 years). This model was developed based on long term yield data collected from several field trials conducted under best managed conditions and therefore the yields were likely to be on the higher side. Similarly, as per the assumption used in the demographic analysis (namely, the older trees were preferentially getting replanted), the age-composition was biased towards the younger side. Therefore, the NR production capacity estimated in the present study is theoretically on the higher side. However, as per the above equation, there is no rubber yield after 17 years of tapping (*i.e.* when the trees are 24-25 years old). Therefore, the production capacity (Scenario I) that we have estimated in the present study does not include any possible yield that might have been actually accrued from such older trees (*e.g.* through slaughter tapping as the high price was a good incentive to harvest even older trees). We envisaged three productivity levels for trees 25 years or older, namely 1040, 1120 and 1200 kg ha^{-1} yr^{-1} when tapped under CUT (limited to four years). The production capacity improved when potential CUT yields were added (Scenario II) (Fig. 3). Interestingly the three production capacity curves for the three CUT yield levels mentioned above were very similar as can be seen from the small standard errors. Yet, when the NR price was at its peak, realised production (and the production estimator) remained above the production capacity (Scenarios I and II) and *vice versa*. In future too, a low NR price can tend to keep the realised production below the production capacity which itself is expected to slide down after 2025.

Reduction in NR production capacity can be attributed to the impact of the rising share of senile holdings (Fig. 2) even as the total

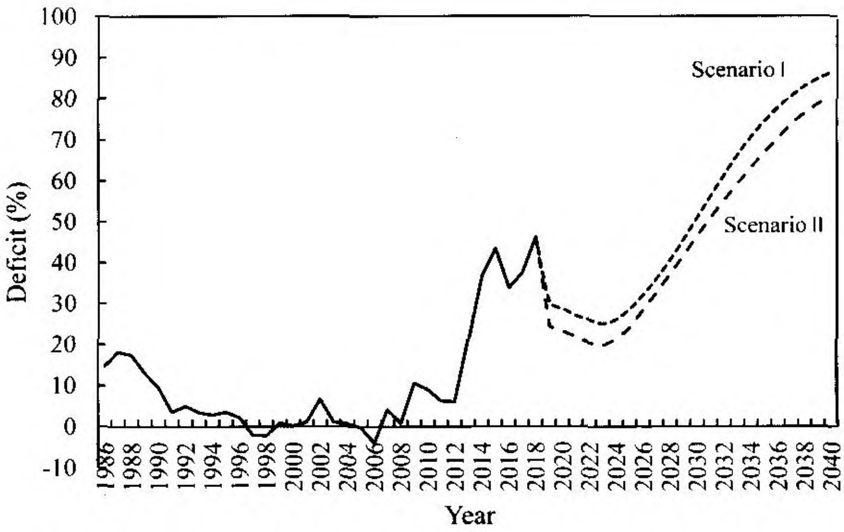

Fig.6. Actual and projected deficit of NR production*
Source: Derived from data published in *Indian Rubber Statistics* (Vol. 17 to Vol. 41)

mature area witnessed a steady increase over the years (Fig. 5). The rate of growth in total area has now nearly flattened off (Fig. 5); thanks to the poor planting rate in the recent years which is the lowest in the last six decades. Our model predicts that if the current low rate of new/replanting persisted into the future, the share of old/senile holdings will further increase (Fig. 2) and the capacity for NR production will see a steady decline from the middle of the current decade (Fig. 3) and the decline could continue well into the decade of the 2030 when the capacity could be close to 4 lakh tons per year.

Based on the Compound Annual Growth Rate (CAGR) for NR consumption in the country for the past seven years, the estimated demand for NR would be close to 17 lakh tonnes per year by 2030. (Likely impact of economic contraction due to COVID-19 is not taken into account). Several externalities like low price of NR, climate change, occurrence of extreme weather events, changing socio-economic status of growers, losing growers' confidence in rubber cultivation, further fragmentation of holdings, absentee planters, scarcity of skilled laborers *etc.* may make a profound negative impact making realised production going below the production capacity in the years ahead. Therefore, as things stand today, NR production is very likely to take a big beating in the immediate future for the twin reasons of reduced NR production capacity and adverse externalities, particularly low price of NR and climate change. Due to the long gestation period and

*Based on actual production and consumption until 2018-19 and estimated deficit (based on predicted production capacity under Scenario I and Scenario II and estimated consumption) in future. (For explanation of Scenarios I and II please see Fig. I.)

the current low planting rates, loss in production capacity will be difficult to recover for many years (Narayana, 1994). The net result will be huge deficits in domestic NR supply which will see exponential growth in the coming years (Fig. 6) and this will have serious and long term implications for the consuming industry, unless the NR production capacity is immediately augmented.

When the price of NR was good, growers hesitated to replant their old holdings as the earnings were attractive even as they remained unaware of the lost economic opportunity, had the holdings been younger and more productive. When the price plummeted, growers lost confidence in the future of rubber cultivation and they have chosen not to invest by way of replanting old/senile holdings. Net effect of both was the same: increase in the share of old/senile holding and loss in production capacity. The impending decline in production capacity cannot be averted at least until 2028 even if rate of replanting is increased immediately because of the long gestation period. Most of the new planting has to happen in non-traditional areas where land is available. Without institutional support, including planting subsidy, it may be difficult to nudge the resource-poor growers there to take up NR cultivation simply because of the long gestation period of rubber with no returns. In the traditional region, more than planting subsidy, a better price of NR will be the incentive for growers to remain in rubber cultivation. There is little chance that price of NR will immediately go up to the record levels of 2011-12 or planting subsidy will be restored.

CONCLUSION

Findings of the present study reflect the current reality of the Indian rubber plantation industry. The writing is on the wall and it is unambiguous. Decline in NR production appears very certain; this is highly likely to be irrevocable unless urgent augmenting measures are taken up immediately.

Regaining self-sufficiency in NR production any time in the near future appears to be nearly impossible (Jacob *et al.*, 2018). Even realising 75 per cent of the requirement through domestic production as envisaged in the National Rubber Policy (GoI, 2019) may remain a distant dream unless there is a workable action plan which is immediatly implemented with adequate funding to enhance the NR production capacity in the country. If that is not achieved the consuming industry may have to depend more on NR imports or substitute NR with synthetic rubbers or move offshore to those countries where NR production is in surplus. Capacity for SR production in the country has markedly increased in recent years (Rubber Board, 2019) even as NR production capacity is destined to decline immediately. A trend has been recently emerging in major NR producing/exporting countries towards manufacturing value added rubber products which may reduce the availability of NR for exports from these countries (Joseph and Jacob, 2018). This shift in policy in the major NR producing/exporting countries in favour of making value added products using NR might attract industries from foreign shores, including India to these countries as NR, labour and other inputs such as power *etc.* are available there in plenty and at a lower cost. The crisis in the Indian rubber industry begs for a policy decision: Should Indian rubber industry be part of the grand *Aatma Nirbhar Bharat Abhiyaan* or not?

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