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NATURAL DAMAGE AND CROP LOSS IN RUBBER PLANTATIONS: A CASE STUDY OF THE ESTATE SECTOR IN INDIA

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The extent of natural damage and crop loss in rubber plantations in the estate sector was studied and the economic loss was estimated based on a life cycle approach. The results highlighted the contradictions between popular perceptions and field-level data on the nature of natural damage which was dominated by wind (66%) across different age groups and regions. The dominance of weather-related damage (79%) indicates limited role of policy interventions targeted towards preventive mechanisms. However, identification of phasewise sources of damage during the entire life cycle assumes significance since the generation of reliable annual database on the natural damage in rubber plantations is an essential pre-requisite for the adoption of policy initiatives for minimising loss through the coverage of comprehensive insurance schemes.

Keywords: Crop loss, Discounted value of economic loss, Life cycle approach, Natural damage

INTRODUCTION

Throughout the human history, natural disasters have caused immense financial loss and loss of life with long-term implications on the development and survival of the affected regions and countries. As agricultural production is highly dependent on weather, water availability and other weather-related parameters, natural disasters will have serious impact on the performance of the agricultural sector. Agricultural production can vary widely from year to year due to unforeseen weather and disease/pest infestations, causing wide swings in yields and thereby affecting commodity prices. These wide swings in yields and output prices generate high variability in farm income. At the farm level, yield risk is generally greater than price risk. Given that revenue is the product of price and yield, the volatility in yield will generally contribute more to income risks than price volatility. Clearly, yield output risks in agricultural production process have important implications for farm profitability and survival and this also bears serious repercussions for the dependant industries and communities (Harwood *et al.*, 1999; Martin *et al.*, 2001; Skees *et al.*, 2006).

In India, agricultural production has been highly prone to uncertainties originating mainly from on-farm risks due to natural calamities such as wind, fire, flood, drought, *etc.* and off-farm risks occurring from price movements, market uncertainties and government policies. The impact of such damage will be more serious in the case of

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perennial crops compared to seasonal and annual crops on account of a prolonged span of economic life, longer gestation period and initial investment (Joseph *et al.*, 2001). Natural rubber (NR) being a perennial crop with a gestation period of around seven years and an estimated economic life span of more than 20 years, the gravity of the impact of loss due to natural disasters will be much higher than the annual and seasonal crops. However, documented information on the extent and composition of natural loss of trees in the NR sector is inadequate.

An earlier study on natural damage of rubber trees in India (Haridasan and Unni, 1970) reported a net annual loss of trees around 0.30% during the five-year period between 1964 and 1968. The major cause of damage was wind, accounting for 53.86% of the total estimated loss, followed by fire (44.64%). Subsequently, Joseph *et al.* (2001) also identified wind as the major cause of damage (66%) in rubber plantations, followed by fire (24%), during 1985-86 to 1989-90. The reported annual loss of trees to the extent of 0.96% indicated a more than threefold increase compared to the 1960s. A common feature of both phases had been the tree loss dominated by wind. In the 1980s, the composition of loss exhibited a higher vulnerability to wind than the previous phase. However, these two estimates were based on data for a shorter period rather than on the life cycle profile of the plantations. Hence, the estimates of the present study based on life cycle loss of trees are expected to provide a more reliable database so as to approach the issues of natural damage from a policy angle.

It is reported that clones differ in their susceptibility to diseases, wind, drought and other natural calamities (Edathil *et al.*, 2000; Kothandaraman and Idicula, 2000; Vijayakumar *et al.*, 2000). It is reported that wind is a major natural disaster of hydro meteorological origin which can cause drastic damage to the rubber plantations (Rajalakshmy and Jayarathnam, 2000). At a wind velocity beyond 17 m/s, the trunks and branches of wind susceptible clones snap and at wind speeds of over 24 m/s most of the rubber trees are uprooted (Vijayakumar *et al.*, 2000). Clonal variations in the susceptibility to wind have also been reported (Saraswathyamma *et al.*, 2000). It was observed that RRIM 600 and RRII 5 showed low susceptibility to wind damage and RRII 105, though prone to branch snap, remains free from serious wind damage if the branch development is kept balanced. The occurrence of wind damage in GT 1 is reported to be mild where as in PB 260, it is moderate (*ibid*). Regional and clonal variations in the susceptibility to drought are also reported. Annual rainfall of 2000 mm or more which is evenly distributed without any marked dry season and 125 to 150 rainy days/annum are required for the optimum growth of rubber trees (Webster and Baulkwill, 1989). Unusual droughts, besides causing yield depression, leads to drying up of young budded plants in the field. Even rubber trees more than 10 years of age die back and dry due to severe drought (Rajalakshmy and Jayarathnam, 2000). Vijayakumar *et al.* (2000) reported that the traditional zone experiences moderate soil moisture stress in summer, the intensity of which increases towards the north. Seasonal droughts are common in humid climates where wet and dry seasons are clearly defined (Thornthwaite, 1947). At Dapchari, situated in the sub-humid tropics of India, inhibition of growth was observed in rainfed plants compared to irrigated plants

(Vijayakumar *et al.*, 1998). Among the popular clones, RRII 105 is reported to be less suitable for planting in drought-prone areas (Rubber Board, 2010). Chandrashekar *et al.* (1998) reported that clones RRII 208, RRIC 52, RRII 6, RRIC 100 and RRIC 102 are more tolerant to drought while RRII 105, RRIC 105, RRII 5, RRIM 605, PB 310, PB 260, PB 311, PR 255, RRII 308 and PR 261 are less tolerant.

The combination of clones selected by the growers for field planting may change with the introduction of new high yielding clones. Earlier studies on adoption of clones in the smallholdings and estate sectors (Joseph and Haridasan, 1991; Veeraputhran *et al.*, 1998; Chandy *et al.*, 2004), substantiated this presumption and found that the preferences for clones have changed over decades both in the smallholdings and the estate sectors. As reported by Joseph *et al.* (2001), there has been a threefold increase in the tree loss during 1985-90 period compared to the 1960s, indicating an apparent association between the adoption of high yielding clones and tree loss. However, the extent and composition of tree loss since 1990 have not been systematically studied. This issue assumes importance in the context of growing share of high yielding clones in the total planted area. The adoption of high yielding clones which was less than 50% during the second half of 1960s increased to 64, 97 and around 100% during 1970-71, 1999-00 and 2003-04, respectively (Rubber Board, 1996; 2005). Across regions, the planting community is confronted with the competing considerations of yield and comparative vulnerability of a chosen clone. In this context, the present study was undertaken to asses the extent, nature and composition of natural damage in the rubber plantations and to assess the economic loss due to natural damage across the major planting regions in the states of Kerala and Tamil Nadu. The major objectives of the study are: to assess the extent and composition of tree loss due to natural damage in rubber plantations in the estate sector; to evaluate the variations in the damage due to clonal differences; to investigate the regional differences in the natural damage; and to assess the economic loss due to natural damage.

METHODOLOGY

Though the estate sector covers only 10.4% of the total area under NR in India, the study is confined to the data related to the tree loss in this sector in the traditional rubber growing regions of Kerala and Tamil Nadu, during the year 2006-07. The selection of estate sector is based on the availability of reliable documented information. The study covered 671 fields of different ages in 40 estates with a total area of 13761 ha. To examine the regional differences in natural damage, the rubber growing regions were classified into five regions based on the soil and agroclimatic conditions (Pushpadas and Karthikakuttyamma, 1980).

- A Kanykumari district of Tamil Nadu
- B South Kerala (Kollam, Pathanamthitta and Thiruvananthapuram districts)
- C Central Kerala (Kottayam, Idukki, Alleppey and Ernakulam districts)
- D North Central Kerala (Palakkad and Thrissur districts)
- E North Kerala (Malappuram, Kozhikkode and Kannur districts)

Since there are clonal and regional differences in the susceptibility to diseases and natural disasters, an understanding of the composition and distribution of clones across regions is very vital to elucidate the regionwise differences in the impact of the natural damage. Hence, an evaluation of the regionwise composition of clones was made, on the basis of which further evaluation of the regionwise and clonewise loss of trees due to natural disasters and disease was made and the composition is given in Table 1.

The total life cycle of the trees was divided into seven different phases. The phase I corresponds to the immature phase and the mature phase was divided into six phases, each phase spanning a period of five years which corresponds to panel duration.

The physical and economic loss of the crop for different phases and for the entire life cycle were estimated by using the average productivity during the corresponding phase and the remaining phases and the number of trees lost during the phase. The discounted value of the

Table 1. **Regionwise share of different clones**

Clone	Share in area (%)					
	A	B	C	D	E	Total
GT 1	3.83	15.19	4.64	30.53	10.06	14.59
Mixed planting	45.77	11.87	31.23	1.19	33.58	18.48
PB 217	0.00	5.37	2.66	19.47	1.62	6.91
PB 235	0.00	2.40	2.42	12.46	0.95	4.22
PB 260	8.11	0.34	3.14	1.46	2.88	1.83
PB 5/51	0.00	0.00	0.94	0.38	0.00	0.33
PB 86	0.00	0.00	0.00	0.00	0.00	0.00
PB 28/59	14.33	3.38	2.59	5.97	0.00	3.51
PB 311	0.00	0.20	0.87	3.66	0.00	1.06
PB 5/51	0.00	0.00	0.00	0.00	0.00	0.00
PB 86	0.00	0.00	0.00	2.56	0.00	0.53
PCK 1	0.00	0.00	0.00	0.08	0.00	0.02
Polyclonal seedlings	0.00	0.00	0.00	3.44	0.00	0.70
RRII 105	18.45	36.88	27.98	13.00	39.18	29.50
RRII 118	0.00	0.00	2.86	0.35	0.00	0.83
RRII 414	0.00	0.00	0.00	0.08	0.16	0.04
RRII 429	0.00	0.00	0.78	0.04	0.00	0.21
RRII 208	0.00	0.00	0.00	0.46	0.00	0.09
RRIM 600	8.81	19.85	9.70	4.66	8.00	12.22
RRIC 100	0.00	0.00	1.99	0.00	0.11	0.54
RRIM 701	0.00	0.00	0.00	0.23	0.00	0.05
Others	0.70	4.53	8.19	0.00	3.47	4.34
Total	100	100	100	100	100	100

Table 2. **Sourcewise composition of life cycle loss**

Source of tree loss	Life cycle loss of trees (no.)	Life cycle loss of trees/ha	Share (%) in total no. of trees lost	Loss (%) on initial stand
Wind	768361	55.84	66.44	13.23
Fire	14938	1.09	1.29	0.26
Drought	145403	10.57	12.57	2.50
Tapping panel dryness	98657	7.17	8.53	1.70
Diseases	85721	6.23	7.41	1.48
Other reasons	43401	3.15	3.75	0.75
Total	1156481	84.00	100.00	19.91

economic loss for different phases and the entire life cycle were also estimated by using the discounted cash flow analysis (DCFA).

RESULTS AND DISCUSSION

The initial number of trees planted under the seven age groups covered under the study was 5808066 with an average stand per ha of 422 trees. However the number of trees and average stand per hectare declined to 4651585 and 338 respectively during the year of study (2006-07). The extent and composition of tree loss for the entire life cycle of the trees during the study period are shown in Table 2. The life cycle loss of trees was 84/ha and wind was the major cause of damage accounting for 66% of the total loss of trees. The second major cause of damage was drought accounting for 12.57% of the total loss. The share of tapping panel dryness (TPD) in total loss was 8.53% and that of diseases was 7.41%. The life cycle loss of trees due to natural damage during the study period was 19.91% (0.80% per annum) compared to the annual average loss of trees of 0.30 and 0.96% during the second halves of 1960s and 1980s, respectively.

Table 3 shows the extent and composition of natural damage during the immature phase and at different phases of

Table 3. **Phasewise loss of trees during the life cycle**

Growth phase	Area (ha)	Share in area (%)	Initial stand/ha	Current stand/ha	Composition of phasewise life cycle loss (trees /ha)	Phasewise share (%) in loss/ha
Immature	960.01	6.98	471	453	2.55	3.03
Mature (YOT)* 1-5	2115.23	15.37	422	360	8.79	10.46
6-10	2451.13	17.81	406	338	9.45	11.34
11-15	1685.07	12.25	445	330	16.32	19.40
16-20	3610.40	26.24	424	347	10.89	12.98
21-25	1686.12	12.25	418	299	16.83	20.02
>25	1253.29	9.11	385	250	19.17	22.77
Life cycle total/mean	13761.25	100	422	338	84	100

*Years of tapping

tapping. The phasewise composition of tree loss clearly showed that more than 55% of the loss was during the declining yield phase. The clonewise differences in the susceptibility to natural calamities and diseases and the variations in the share in area of clones existing under each phase due to differences in the adoption of clones during different time periods may be the reasons for the variation in the loss of trees during different phases.

From Table 4 it can be seen that during all the phases, wind was the major cause of damage and its share in total loss in all the age groups was above 50% ranging from 57.60 (immature phase) to 79.89% (16-20 phase). Incidents other than wind influenced differently in various age groups. Fire was the second major cause of damage during the immature phase (16.18%) but in the mature phase, the second major cause of damage varied for different years of tapping.

The impact of loss of trees on the grower will be different depending on the age at which the trees are lost. If the trees are lost during the immature phase, the grower will be losing the crop for the entire life cycle of the tree resulting in much higher yield and monetary loss compared to later phases.

Out of the total area covered for the study, the immature phase had 960 ha which accounted for 6.98% of the total area. During the immature phase, the maximum loss was due to wind (57.60%) whereas the share of any other single incident was less than 17%. Fire and drought were the other major reasons (16.18 and 14.34 %) but no tree loss due to TPD was found during the phase. The share of disease in total loss during the phase was only 8.06% indicating that compared to other casualties the damage due to disease during this phase was very low.

The share of mature area covered under the study was 93% and the number of trees lost during the phase was 81.45/ha. Wind, the major cause of damage during the mature phase, accounted for 66.94% of the total loss. The second major cause of damage was drought (12.50%). Though, fire was the second major cause of damage during immature phase (16.18%), its share during mature phase was only negligible (0.77%). During the mature phase, the third major cause of damage was TPD accounting for

Table 4. **Sourcewise loss of trees (%) in different phases**

Growth phase		Wind	Fire	Drought	TPD	Diseases	Others	Total
Immature		57.60	16.18	14.34	0.00	8.06	3.82	100
Mature (YOT)*	1-5	62.49	4.07	11.98	7.06	10.54	3.86	100
	6-10	58.07	0.47	16.04	11.97	9.81	3.64	100
	11-15	59.89	1.14	13.88	14.69	5.86	4.54	100
	16-20	79.89	0.01	4.90	8.22	3.19	3.79	100
	21-25	69.32	0.23	11.47	4.25	11.62	3.11	100
	>25	62.85	0.07	21.94	5.93	6.71	2.50	100
Mature phase mean		66.94	0.77	12.50	8.70	7.45	3.59	100
Life cycle mean		66.44	1.29	12.57	8.53	7.41	3.76	100

*Years of tapping

8.70%. The assessment indicated that except wind, all other causes of damage impacted differently during immature and mature phases.

Sourcewise and regionwise differences in life cycle loss of trees

Among the five regions, the highest share in area was for region B (37.57%) followed by region C (25.98%) and the lowest share was for region A (Table 5). The loss per hectare was the highest in region D (25.34 trees/ha) and the region accounted for 30.15% of the total loss. The reason for more damage in the region is high wind which resulted in a loss of 22.39 trees per hectare accounting for 88.36% share in total number of trees lost. The preference, evinced by the growers of region D, for the wind tolerant clone GT 1 (30.53%) is to be viewed in this background. The lowest loss was recorded in region A (12.28 trees/ha) and the share of the region was 14.64% in total loss per ha. Loss due to TPD was the highest in region C (3.07 trees/ha).

The highest initial stand per hectare (Table 6) was recorded in Region D (446 trees/ha) and the highest loss per ha was also in region D (121/ha). The high initial stand in region D might be for compensating the high loss in later years. The lowest initial stand was recorded in region A (373/ha) and loss per ha also was the lowest in this region (72/ha). The share of different incidents in total loss within each region showed that wind was the major cause of damage in all regions with a share of more than 50% except for region A where its share was only 16.33%. TPD was the second major cause of damage in regions C and D (15.92 and 6.97%). The share of TPD

Table 5. **Sourcewise and regionwise share in life cycle loss (trees/ha)**

Region	Area covered (ha)	Regionwise area covered (%)	Loss (trees/ha) due to: Wind	Fire	Drought	TPD	Diseases	Others	Total	Regionwise loss/ha (%)
A	317.05	2.3	3.17	0	6.5	1.23	0	1.38	12.28	14.64
			(25.81)	(0)	(52.93)	(10.02)	(0)	(11.24)	(100)	
B	5170.14	37.57	8.92	0.48	1.5	0.6	1.89	0.17	13.56	16.14
			(65.78)	(3.54)	(11.06)	(4.42)	(13.95)	(1.25)	(100)	
C	3574.51	25.98	12.52	0.27	1.44	3.07	1.85	0	19.15	22.79
			(65.38)	(1.41)	(7.52)	(16.03)	(9.66)	(0)	(100)	
D	2764.19	20.09	22.39	0.1	0.51	1.67	0.52	0.15	25.34	30.15
			(88.36)	(0.39)	(2.01)	(6.6)	(2.05)	(0.59)	(100)	
E	1935.36	14.06	8.83	0.23	0.61	0.59	1.96	1.45	13.67	16.28
			(64.59)	(1.68)	(4.46)	(4.32)	(14.34)	(10.61)	(100)	
Total	13761.25	100	55.83	1.09	10.56	7.16	6.22	3.15	84	100
			(66.46)	(1.3)	(12.57)	(8.52)	(7.4)	(3.75)	(100)	

Figures in parentheses show the percentage share of the incident in the region

Table 6. **Region and sourcewise shares in loss of trees (%)**

	Region				
	A	B	C	D	E
Area (ha)	317.05	5170.14	3574.51	2764.19	1935.36
Total number of trees (initial)	118396	2155833	1461056	1232321	840460
Stand/ha (initial)	373	417	409	446	434
Total number of trees (final)	95331	1755945	1194759	898586	683218
Total number of trees (final)	301	340	334	325	353
Incident	Share of the incident in total loss in the region (%)				
Wind	16.33	60.54	62.56	86.11	56.57
Fire	0.00	2.60	1.02	0.32	1.17
Drought	61.53	18.74	12.70	3.63	7.16
TPD	6.94	4.40	15.92	6.97	4.13
Disease	0	11.30	7.80	1.78	11.07
Others	15.20	2.42	0.00	1.19	19.90
Total	100	100	100	100	100

ranged between 4.13 (region E) to 15.92% (region C).

Economic loss due to natural damage

The economic loss due to natural damage during different phases is given in Figure 1. The life cycle crop loss was the highest if the tree was lost in the immature phase. The estimated life cycle loss was 135.90 kg per tree if it was lost during the immature phase . The life cycle loss declined as age advanced and the crop loss was the lowest if the tree was lost during the 26-30 year phase (11.75 kg/ tree). The estimated life cycle loss due to natural damage was 5308 kg per ha.

Table 7 shows the discounted value of economic loss due to natural damage during different phases. The estimated discounted value of economic loss per tree was the highest for the immature phase (Rs. 4428.30). In other words, if one tree is lost during the immature phase, the grower will be losing a potential income of Rs 4428.30 during its entire life cycle. The discounted value of economic loss per tree also declined with age of the tree and the loss is the lowest if the tree was lost during the 26-30 year phase (Rs. 96.15). Though the per tree discounted loss was the highest during immature phase, the estimated discounted value of economic loss per ha was found to be the highest during the 1-5 year phase (Rs. 32003.26) because of the combined influence of number of trees lost per ha and the discounted value of loss per tree. The discounted value of life cycle economic loss per tree due to natural

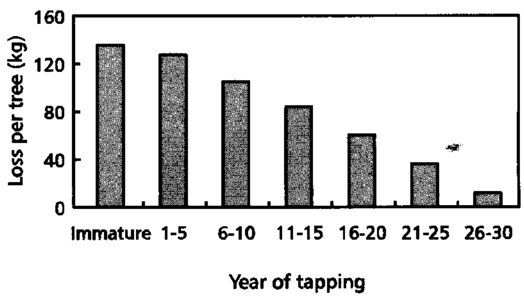

Fig. 1. Estimated phasewise crop loss per tree

Table 7. **Discounted value of economic loss**

Growth phase		Yield/tree/year	No of trees lost/ha	Discounted value of loss (Rs/tree)	Discounted value of loss per ha (Rs)
Immature		4.53	2.55	4428.30	11292.17
Mature (YOT)*	1-5	4.62	8.79	3640.87	32003.26
	6-10	4.73	9.45	2360.47	22306.47
	11-15	4.79	16.32	1426.72	23284.09
	16-20	4.82	10.89	795.88	8667.12
	21-25	4.76	16.83	367.66	6187.76
	>25	4.70	19.17	96.15	1972.28
Life cycle		4.71	84	1873.72	157393.00

*Years of tapping

damage was Rs. 1873.72 with respect to the study period. The estimated discounted value of economic loss per ha due to natural damage during the entire life cycle of the plantation was Rs. 157393.

CONCLUSION

The results of the study highlighted the loss of trees due to various natural damages in rubber plantations, extent of crop loss and the estimated economic loss based on a life cycle approach. Though the database of the study is confined to only the estate sector, it is more comprehensive in terms of the extent of coverage and analytical contents compared to the previous studies. From the analytical angle, the results highlighted the contradictions between popular perceptions and field-level data on the composition of natural damage dominated by wind across phases and regions. The dominance of weather-related damage (79.01%) indicates limited role of policy interventions targeted towards preventive mechanisms. However, from a policy angle it is important to identify the phasewise sources of damage in physical and economic terms during the entire life cycle of rubber plantations. The main objective behind this proposition is to minimise the loss for the planting community through the coverage of comprehensive insurance schemes. An essential pre-requisite for such a policy initiative is the generation of reliable annual database on the natural damage in rubber plantations.

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