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SHIFT TO RUBBER CULTIVATION AND CONSEQUENCES ON ENVIRONMENT AND FOOD SECURITY IN KERALA

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ABSTRACT

Over the last fifty years from 1960-61 to 2009-10, agriculture sector in Kerala has shown a degree of change in the cropping pattern. The analysis of cropping pattern shows that the years 1976-77 and 1980-81 marked two important turning points in the Kerala agrarian economy. The area under tapioca was at its maximum in 1976-77 and then declined continuously and the area under rice was at its peak in 1980-81 and then continuous decline set in. The area under total food crops rapidly declined since 1976-77. Rice and tapioca lost the maximum area during the period while rubber and coconut gained the maximum area. The substitution of rubber and coconut at the cost of rice and tapioca has far reaching implications for food and price policies. The change in cropping pattern has given a new dimension in the last decade, that is, rubber seems to be replacing both food crops and non-food crops among the major crops in Kerala. The expansion of rubber and the conversion of food and other non-food crops brought significant change within the farm sector of Kerala. In this context, the negative impact of changing cropping pattern towards rubber is analysed on four grounds, namely, food security (rice security), land degradation, water depletion and chemical pollution. The results show that the supply demand gap of rice in Kerala has widened tremendously; there is a high decrease in the soil fertility status in the rubber cropped areas; the average groundwater level is very lower in rubber cropped areas as compared to other cropped areas; and that rubber farmers are applying overdose of chemical fertilisers and less of organic manures and lime.

Introduction

Analysis of the cropping pattern is necessary for identification of major crops that are grown in a region and changes in their shares over time. Changes in cropping pattern broadly reflect changes in the relative profit expectations of the alternative crops at different points of time. Cropping pattern indicates the level of development and economic prosperity of a region. The farmers' area allocation decisions are conditioned not only by the indigenous factors associated with the farm households but also by a group of exogenous variables.

The cropping pattern of Kerala is quite different from the rest of India owing to the physiographic and climatic conditions of the

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State. In addition to rice and tapioca, a number of other garden crops have contributed to the State's food supply. Predominance of cash crops and plantation crops, homestead farming system, high rainfall, etc., make Kerala agriculture unique in many respects.

One of the major changes that have been taking place in Kerala is the gradual shift of area from food crops like rice and tapioca to plantation crops like coconut, rubber, coffee, etc (Lakshmi KR and Pal TK, 1988). The reduction in area under food crops in Kerala from 40.43 per cent in 1970-71 to 18.74 per cent in 1992-93 and 16.52 per cent in 2002-03 is a phenomenon happened very rarely in any State (Mani KP, 2009). Present trend reveals that Kerala is being converted to non-food crop area and the ratio of food crop to non-food crop area is 12: 88. The main feature of the present trend is change in the cultivated area under foodgrain crops to non-foodgrain crops and change in the cultivated area under one non-foodgrain crop to another non-foodgrain crop. Data on the area under major crops in Kerala depict this trend. The area under paddy decreased from 347.46 thousand hectare in 2000-01 to 234.01 thousand hectare in 2009-10, the area under coconut cultivation decreased from 925.78 thousand hectare in 2000-01 to 778.62 thousand hectare in 2009-10, the area under cashewnut cultivation decreased from 92.12 thousand hectare in 2000-01 to 48.97 thousand hectare in 2009-10, the area under pepper cultivation decreased from 202.13 thousand hectare in 2000-01 to 171.49 thousand hectare in 2009-10. On the other hand, the area under rubber cultivation increased from 474.36 thousand hectare in 2000-01 to 525.41 thousand hectare in 2009-10.

The data clearly show that rubber is replacing both food crops and non-food crops. District-wise data on changes of cropping pattern also reveal the same picture as at the State level. The expansion of rubber and the conversion of area under food and other non-food crops to rubber plantations brought significant economic and environmental consequences within the farm sector of Kerala. Hence in this paper an attempt has been made to analyse the negative impact of the change in cropping pattern towards rubber in terms of various parameters like food security, land degradation, water depletion and chemical pollution.

Methodology and Materials

The negative impact of change in cropping pattern towards rubber was on chemical pollution, land degradation, water depletion and food security.

The paper analyses the impact of chemical pollution on the basis of the difference between actual and suggested dose of chemical fertilisers by farmers. The data on the actual use of fertilisers by farmers to various crops were collected from 150 farmers from five panchayats in the Kasaragod district. Five principal crops in the Kasaragod district such as paddy, coconut, arecanut, rubber and banana are selected with 30 farmers from each of the five panchayats selected from the Analytical Register, Vasutha Programme of the District Panchayat, Kasaragod. Among the five panchayats, Vorkady was selected for paddy, Panathady for coconut, Karadka for arecanut, West-Eleri for rubber and Mangalpady for banana; where these crops were largely cultivated. Information on the total quantity of NPK fertilisers applied, lime used and organic manure consumed in their respective plants or farms were collected by interviewing each farmer. Information was also collected on the recommended dose of fertilisers to plants.

Decline in native soil fertility, deficiency of plant nutrients and decline in micro-nutrients are the three main indicators for land degradation. Among these three, the first one was considered in this study due to lack of data on the other two. Soil fertility status in different crop growing areas (paddy, coconut, arecanut and rubber) is taken from the Analytical Register, Assistant Soil Chemist Office of Kasaragod district from 2000 to 2009.

Crop-wise analysis of average groundwater level in different years is made for arecanut, coconut, paddy and rubber to work out the impact of groundwater depletion. Like that of soil fertility status, groundwater analysis was also done by taking Kasaragod district as a case.

The secondary data used for this study were collected from various publications of the Government of Kerala like Economic Review, Statistics for Planning, Agricultural Statistics and Season and Crop Reports. Secondary data were also collected from the Analytical Register, Assistant Soil Chemist Office, Kasaragod, Soil Fertility Card, Vasutha Programme, District Panchayat, Kasaragod, Groundwater Department, Kasaragod District and Package of Practices, Kerala Agricultural University, Trissur.

Herfindahl Index (HI) is used to measure the extent of crop diversification towards rubber in Kerala. It is defined as the sum of squares of acreage proportions in the total cropped area.

$$HI = \sum_{i=1}^{N} p_i^2$$

Where, N is the total number of crops and P_i represents acreage proportion of i^{th} crops to total cropped area.

With the increase in diversification, the Herfindahl Index would decrease. The index takes a value one when there is a complete specialisation and approaches zero as N becomes large, that is, if diversification is perfect. Thus, the HI is a measure of concentration. To convert it as a measure of diversification, the value is subtract from unity:

Diversification Index (DI) = 1 – HI

Supply demand gap of rice in Kerala was worked out to measure the extent of food shortage. Demand for rice for the State as a whole was developed by multiplying per capita consumption of rice in rural and urban areas with corresponding population and aggregated. An attempt has been made to project the demand for rice in Kerala up to the year 2026 under different scenarios of growth in income.

The demand projections for rice were obtained by using the formulae developed by Sekhon MK, Rangi PS and Tejinder Dhaliwal (2008).

$$Dt = do*Nt\ (1+ y*e)\ t$$

Where,

D_t = individual demand of rice in year t (2011, 2021, and 2026),

d_o = per capita demand of rice in the base year (2001),

N_t = projected population in year t (2011, 2021, and 2026),

y = growth in per capita income (five to ten per cent).

e = expenditure elasticity of demand for rice.

Shift in Cropping Pattern in Kerala Towards Rubber

Originally rubber was introduced into areas with degraded forests. From there it spread all over. It replaced natural vegetation, tapioca, cashewnut, fruit trees and coconut. During 1960-61, the area under rubber cultivation was 5.23 percentage of the total cropped area, increased to 13.63 per cent in 1990-91 and 19.65 per cent during 2009-10 (Table1). Among the districts in Kerala, Thiruvananthapuram district recorded highest increase in area under rubber cultivation.

Table1: Shift in Cropping Pattern in Kerala Towards Rubber (Percentage to Total Cropped Area) (1960-61 to 2009-10)

S. No.	Districts	1960-61	1970-71	1980-81	1990-91	2000-01	2009-10 increase in 2009-10 over 1960-61	Percentage
1	Thiruvananthapuram	1.89	2.89	3.83	10.94	14.48	17.06	850.26
2	Kollam	8.38	8.71	13.22	13.48	17.32	19.15	128.52
3	Pathanamthitta	-	-	-	34.31	41.53	43.32	26.26
4	Kottayam	13.88	14.57	27.47	44.62	49.33	51.56	271.47
5	Alappuzha	0.88	1.46	1.96	1.67	2.74	3.66	315.91
6	Ernakulam	7.15	9.32	9.02	24.68	25.37	28.80	302.80
7	Idukki	-	-	10.22	17.76	14.24	12.57	22.99
8	Trissur	3.18	3.47	4.06	3.20	6.76	7.77	144.34
9	Palakkad	1.59	2.22	3.29	7.09	9.31	10.06	532.70
10	Malappuram	-	-	7.63	7.44	10.88	12.88	68.81
11	Kozhikkode	4.18	4.99	6.48	5.26	7.71	8.56	104.78
12	Wayanad	-	-	-	2.98	3.08	4.14	38.93
13	Kannur	3.88	4.01	6.25	8.84	12.35	16.37	321.91
14	Kasaragod	-	-	-	12.92	14.43	18.20	40.87
15	State	5.23	6.11	8.24	13.63	15.70	19.65	275.71

Source: - Computed from (i) Statistics for Planning (various issues), Department of Economics and Statistics, Govt. of Kerala, Thiruvananthapuram. (ii) Economic Review (various issues), State Planning Board, Govt. of Kerala, Thiruvananthapuram.

During 1960-61 the order of the first five crops was rice, coconut, tapioca, rubber and pepper in the descending order of shares to the total cropped area. Table 2 reveals that in 2009-10, the first five crops were coconut, rubber, rice, pepper and arecanut. Rubber occupied fourth position in area during 1960-61, went to second position during 2009-10. The main crops losing area between 1960-61 and 2009-10 were rice and tapioca. This change in cropping pattern clearly established a shift from the traditional subsistence cropping to the recent commercial cropping like rubber. From Table 2 it is very clear that among the four plantation crops, rubber emerged as the most significant crop with largest area in the State next only to coconut.

Table 2 : Cropping Pattern According to Land Use Statistics in Kerala (Percentage to Total Cropped Area (TCA))

S. No.	Crops	1960-61	1970-71	1980-81	1990-91	2000-01	2009-10
1	Rice	33.16 (1)	29.83 (1)	27.79 (1)	18.53 (2)	11.50 (3)	8.77 (3)
2	Coconut	21.32 (2)	24.52 (2)	22.56 (2)	26.72 (1)	30.63 (1)	29.18 (1)
3	Arecanut	2.31 (6)	2.93 (7)	2.12 (7)	2.15 (10)	2.89 (8)	3.72 (5)
4	Rubber	5.23 (4)	6.11 (4)	8.24 (4)	13.63 (3)	15.70 (2)	19.65 (2)
5	Pepper	4.25 (5)	4.03 (5)	3.75 (6)	5.58 (4)	6.69 (4)	6.43 (4)
6	Cashewnut	2.31 (6)	3.50 (6)	4.90 (5)	3.83 (6)	3.05 (7)	1.84 (9)
7	Tapioca	10.31 (3)	10.01 (3)	8.49 (3)	4.85 (5)	3.79 (5)	2.80 (7)
8	Coffee	0.72 (10)	1.08 (11)	2.02 (8)	2.49 (7)	2.80 (9)	3.18 (8)
9	Tea	1.60 (8)	1.28 (10)	1.25 (11)	1.15 (11)	1.22 (11)	1.35 (11)
10	Cardamom	1.22 (9)	1.62 (9)	1.87 (9)	2.21 (8)	1.37 (10)	1.56 (10)
11	Ginger	0.51 (11)	0.41 (12)	0.44 (12)	0.47 (12)	0.38 (12)	0.20 (12)
12	Banana and other plantains	1.89 (7)	1.66 (8)	1.72 (10)	2.17 (9)	3.29 (6)	3.71 (6)
13	Other crops	15.17	13.02	14.87	16.22	16.69	17.27
14	T C A	100.00	100.00	100.00	100.00	100.00	100.00

Figures in bracket show rank.
Source: - Computed from (i) Statistics for planning (various issues), Department of Economics and Statistics, Govt. of Kerala, Thiruvananthapuram. (ii) Economic Review (various issues), State Planning Board, Govt. of Kerala, Thiruvananthapuram.

Table 3 clearly supported this shift from food crops, mainly rice and tapioca, in favour of tree crops such as rubber and coconut in Kerala, which was shown in the form of diversification index. It may be observed that the transformed values of Herfindahl Index, that is, Diversification Index were lower in the initial years of study, viz, 1960-61 and 1970-71 and higher in the later years, viz, 1980-81, 1990-91, 2000-01 and 2009-10 which indicates more diversification. The diversification in cropping pattern mainly towards rubber was noticed during the recent years (Srikumar Chattopadhyay, et.al, 2006).

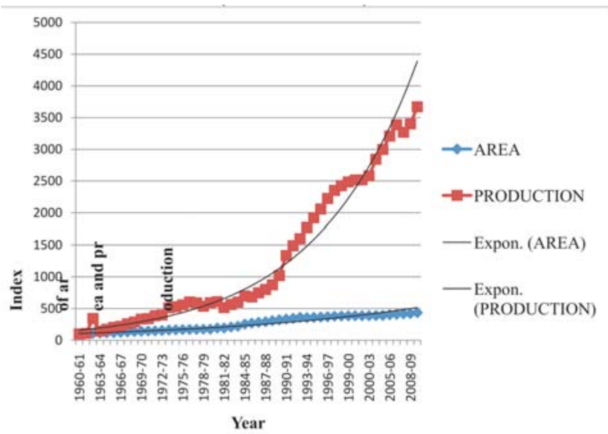
Table 3 : Crop Diversification Indices for Districts in Kerala (1960-61 to 2009-10)

S. No.	Districts	1960-61	1970-71	1980-81	1990-91	2000-01	2009- 10
1.	TVM	0.799	0.793	0.809	0.779	0.749	0.785
2.	KOLM	0.844	0.817	0.833	0.819	0.805	0.848
3.	PATT	-	-	-	0.813	0.778	0.781
4.	KOTM	0.892	0.896	0.842	0.746	0.713	0.701
5.	ALAP	0.739	0.736	0.764	0.727	0.736	0.763
6.	ERN	0.824	0.822	0.776	0.799	0.813	0.848
7.	IDUK	-	-	0.876	0.831	0.898	0.918
8.	TRIR	0.692	0.718	0.676	0.734	0.747	0.784
9.	PALK	0.631	0.693	0.694	0.783	0.821	0.873
10.	MALM	-	-	0.824	0.812	0.803	0.833
11.	KOZH	0.828	0.806	0.857	0.667	0.673	0.699
12.	WAYD	-	-	-	0.808	0.835	0.870
13.	KANR	0.808	0.828	0.879	0.831	0.837	0.853
14.	KSGD	-	-	-	0.834	0.801	0.813
15.	Kerala	0.821	0.833	0.852	0.867	0.858	0.863

TVM - Thiruvananthapuram, KOLM - Kollam, PATT - Pathanamthitta, KOTM -Kottayam, ALAP - Alappuzha, ERN - Ernakulam , IDUK - Idukki, TRIR - Trissur, PALK - Palakkad, MALM - Malappuram , KOZH - Kozhikkode, WAYD - Wayanad, KANR - Kannur, KSGD - Kasaragod.

Figure 1 clearly shows that the area and production of rubber cultivation had tremendously increased in Kerala during 1960-61 to 2009-10 periods.

Figure 1 : Growth in Area and Production of Rubber Cultivation in Kerala (1960-61 to 2009-10)



Negative Impact of Shift in Cropping Pattern Towards Rubber

Environmental degradation is a serious challenge to the life forms on the planet earth. It is adversely affecting not only the individuals and human societies in various ways and in different degrees, but is also influencing the changes that are detrimental to the health and growth of all forms of life (Johl SS, 2006).

The environmental impacts of agriculture can be classified into beneficial and harmful effects. Except for production of food, fodder, fibre, etc., and generation of employment, agriculture is not beneficial to the environment (Reddy KK, 2003). The adverse and harmful effects of agriculture on environment are far and wide. These effects are direct and indirect in nature.

The direct effects are mainly due to the extensive use of chemical fertilisers and pesticides in agricultural sector.The growing use of fertilisers leads to chemical pollution of water resources. The use of nitrogenous fertilisers produces nitrates which end up in streams and groundwater reservoirs. Continuous high intensity fertiliser use leads to a progressive increase in the nitrate content of confined water bodies particularly groundwater. If nitrate content of groundwater goes beyond a permissible limit, water is said to be polluted and not safe for drinking (nitrate content in excess of 50 mg NO3-N/1 is considered unsafe for drinking).

Studies also revealed that Nitrogen loss to the atmosphere through de-nitrification (change of N compounds into nitrous oxide) may contribute to greenhouse gases in the atmosphere (Kayarkanni S, 2006).

Once chemical substances have entered the environment (in the form of fertilisers, pesticides and herbicides), they undergo physical and chemical changes, including combination with other chemicals, that affect their toxicity. Through such chemical transformation, a relatively harmless chemical may become a toxic by-product in the environment. It may further enter the food chain and accumulate in living organisms (Essam El Hinnawi, 1982).

Chemical Pollution : The district and State-wise consumption of chemical fertilisers (NPK) in Kerala shows that the rate of application of fertilisers varied substantially across regions during different years. It has been found that in some areas farmers are using chemical fertilisers and pesticides excessively by 20 – 50 per cent and has created chemical pollution (Chandrasekhar TC, 2008). Studies also show that there is difference between the actual and suggested dose of chemical fertilisers to various crops in the various parts of India (Raja Sekhara Bapu M and Sambasiva Rao B, 2003).

To know whether there is overuse of chemical fertilisers in Kerala, data on the difference between suggested dose and actual used doses of chemical fertilisers to various crops (paddy, coconut, arecanut, rubber and banana) were collected using primary data. On the basis of the data collected , average actual dose of chemical fertilisers (NPK), lime and organic manures used by farmers for paddy, coconut, arecanut, rubber and banana plants were worked out and presented in Table 4. The Table also gives information on the recommended dose of NPK fertilisers, lime and organic manures suggested by the Agricultural Department on the basis of the soil fertility status tested (for each panchayat) and given in the form of the soil fertility card to each panchayat.

Table 4 : Difference Between the Suggested Dose and Actual Used Dose of Fertilisers to Various Crops in the Kasaragod District in Kerala

(1) Soil fertility status (Macro-nutrients) of the sample Panchayat
(PH in percentage, Macro-nutrients (NPK) in Kg per hectare)

Item / Crops	Paddy	Coconut	Arecanut	Rubber	Banana
PH	4.90	4.20	4.50	4.20	4.60
N	1.26	2.30	1.85	2.17	1.30
P	12.25	8.00	20.60	15.00	6.98
K	112	135	156	160	130

(2) Suggested Dose

Item / Crops (Kg per hectare)	Paddy (Kg per plant)	Coconut (Kg per plant)	Arecanut (Kg per plant)	Rubber (Kg per plant	Banana
Lime	300	1.500	0.700	0.700	0.600
N	61	0.400	0.136	0.105	0.322
P	74	0.900	0.120	0.477	0.610
K	28	1.065	0.194	0.192	0.470
NPK Total	163	2.365	0.450	0.774	1.402
Organic manure	2500	25	24	10	10

(3) Average Actual Dose Used

Item / Crops (Kg per hectare)	Paddy (Kg per plant)	Coconut (Kg per plant)	Arecanut (Kg per plant)	Rubber (Kg per plant)	Banana
Lime	250	0.500	0.200	0	0.250
NPK Total	175	2	0.400	2	3
Organic manure	1250	20	10	2	2

(4) Difference between Actual and Suggested Dose

Item / Crops (Kg per hectare)	Paddy (Kg per plant)	Coconut (Kg per plant)	Arecanut (Kg per plant)	Rubber (Kg per plant)	Banana
Lime	(-) 50.00	(-) 1.00	(-) 0.500	(-) 0.700	(-) 0.350
Deviation (in %)	(-) 16.67	(-) 66.67	(-) 71.43	(-) 100.00	(-) 58.33
NPK Total	(+) 12.00	(-) 0.365	(-) 0.05	(+) 1.226	(+) 1.598
Deviation (in %)	(+) 7.36	(-) 15.43	(-) 11.11	(+) 158.40	(+) 113.98
Organic manure	(-) 1250	(-) 5.00	(-) 14	(-) 8.00	(-) 8.00
Deviation (in %)	(-) 50.00	(-) 20.00	(-) 58.33	(-) 80.00	(-) 80.00

Source: - (i) Soil fertility card (2009), Vasutha Programme, District Panchayat, Kasaragod (Item (1) and (2)).
(ii) Primary data (Item (3)).

From Table 4, it is revealed that paddy, arecanut and coconut farmers were using, to a certain extent, the same quantity of NPK fertilisers as suggested by the scientists; whereas the rubber cultivators using thrice of the suggested dose of NPK (158.40 percentage more of the suggested dose) and banana cultivators using more than double of the suggested dose of NPK fertilisers (113.98 percentage more of the suggested dose).

Another important feature revealed is that farmers in these panchayats were using very low quantity of lime (paddy farmers were using 50 kg per hectare short of suggested dose, coconut cultivators one kg per plant short of the suggested dose, arecanut cultivators 0.500 kg per plant short of the suggested dose and banana cultivators 0.350 kg per plant short of the suggested dose).The rubber cultivators were not using lime in the study area. Paddy cultivators and arecanut cultivators were using almost half of the organic manure as suggested by the agriculture department. Coconut cultivators were using 20 kg per plant as against 25 kg per plant of organic manure as suggested by the department (five kg per plant short as suggested). Rubber cultivators in the study area were using only two kg per plant instead of ten kg per plant of organic manure as recommended (80 percentage short as suggested). Like that, banana cultivators were also using a shortage of eight kg per plant of organic manure as suggested. Out of the five crops selected for the study, rubber and banana cultivators used overdose of chemical fertilisers and under-use of organic manures and lime showing ineffective application of fertilisers compared to other three crops, which leads to chemical pollution of the soil.

Land Degradation : An inter-crop comparison of changes in the soil fertility status for arecanut, coconut, rice and rubber crops in Kerala was also worked out for the period from 2000 to 2009. The soil fertility evaluation on the basis of soil test results in the four crop based systems are done in two ways – firstly by analysing the macro-nutrients (NPK) and secondly by analysing the PH status.

Table 5 shows that there is decrease in the average soil PH status from 2000 to 2009 in all the crop growing systems. An inter-crop comparison reveals that the decline was severe in rubber cropped systems than other crop growing systems. In 2009, average soil PH status in the rubber cropped system was very low (4.20 per cent).

Table 5 : Average Soil Fertility Status in the Different Crop Growing Areas in Kasaragod District in Kerala in Different Years (2000 to 2009)

(PH in percentage, Macro-nutrients (NPK) in Kg per hectare)

Year	Rubber				Arecanut			
		Macro-nutrients (NPK)				Macro-nutrients (NPK)		
	PH	N	P	K	PH	N	P	K
2000	5.65	2.96	19.56	131.48	6.10	3.11	51.94	261.53
2001	5.55	2.91	19.02	130.13	6.00	2.93	50.63	257.18
2002	5.45	2.82	18.51	129.70	5.95	2.88	47.75	252.75
2003	5.45	2.75	18.38	127.44	5.90	2.75	47.02	248.75
2004	5.40	2.69	18.21	123.70	5.60	2.60	32.63	243.73
2005	5.35	2.55	17.55	122.62	5.45	2.57	29.39	231.25
2006	5.35	2.46	13.94	96.13	5.40	2.42	27.83	227.58
2007	5.15	2.41	12.06	76.89	5.15	2.37	24.13	225.45
2008	4.40	2.36	11.62	68.13	4.95	2.34	20.89	216.66
2009	4.20	2.14	11.23	61.50	4.80	2.07	20.31	208.33

(Contd...)

Table 5 *(Contd...)*

Year	Paddy Macro-nutrients (NPK)				Coconut Macro-nutrients (NPK)			
	PH	N	P	K	PH	N	P	K
2000	6.15	2.91	36.34	211.36	5.96	3.37	55.14	292.56
2001	6.10	2.84	34.24	209.85	5.90	3.18	45.34	284.53
2002	6.05	2.67	33.06	201.15	5.83	3.00	43.59	270.03
2003	6.00	2.53	31.15	195.18	5.76	2.78	42.23	262.16
2004	5.85	2.45	29.57	185.94	5.53	2.62	32.11	220.41
2005	5.45	2.27	26.13	172.23	5.40	2.49	29.44	205.18
2006	5.45	2.20	24.21	164.66	5.33	2.42	28.69	203.90
2007	5.30	2.14	21.83	156.33	5.33	2.31	27.27	203.67
2008	5.00	2.06	19.09	149.50	5.03	2.11	26.08	198.29
2009	4.95	2.01	18.11	145.50	4.46	2.09	24.50	193.50

Source : - Computed from the Analytical Register, Assistant Soil Chemist Office, Kasaragod District.

The NPK status revealed that during 2000 except for the rubber cropping system all other systems had a very high NPK status. In the case of rubber cropping system, the NPK status was 2.96, 19.56 and 131.48 kg per hectare, during 2000, decreased to 2.14, 11.23 and 61.50 kg per hectare, respectively during 2009.

Table 5 derives the continuous decline of soil fertility and soil health in general and the deterioration of P and K soil status in particular to the rubber cropping system in Kerala. It is found that P and K elements are low in the rubber plantations of the study area. Studies by Balagopalan (1995) and Karthikakutty Amma, et.al (1996) found that NPK components are lower on rubber plantations than with other vegetations (Srikumar Chattopadhyay, et.al, 2006).

This established the findings of earlier studies that the organic matter content on rubber plantations had lower values than other cropping systems and vegetations.The analysis confirmed that the change in cropping pattern towards rubber had started the soil NPK status declining and had been in fact, showing a tendency of further deterioration in the soil fertility status of Kerala indicating land degradation.

Groundwater Depletion : There is wide concern in the world that groundwater resources are deteriorating in the long term both in quantity and quality. Studies on groundwater balance in the State have observed that the water table has been receding in many parts of Kerala (Srikumar Chattopadhyay, et.al, 2005). The depletion of underground water has important implications from the economic angle as well as from the point of view of sustainability of agricultural system.Though many factors are responsible for groundwater decrease, the problem is being largely linked to the changes in cropping pattern.

To study the effect of changes in cropping pattern on groundwater depletion the average groundwater level in different crop growing areas were analysed. For that the average groundwater level in the four crop growing (paddy, coconut, arecanut and rubber) areas were worked out for the period from 1998 to 2009 in the Kasaragod district. The data were collected from the Groundwater Department, Kasaragod district and are shown in Table 6. The Table reveals that during 1998 to 2009, the average groundwater level of dug well in the paddy, arecanut and coconut growing areas increased and rubber areas decreased. The average groundwater level in the rubber crop growing areas were very low (below four metre) compared to other crop growing areas. It was observed that the recharge of water in the rubber cropped areas was very low compared to other crops and the discharge of water is high. The exercise as shown in Table 6 therefore, reveals that the shift in cropping pattern in favour of rubber will decrease the groundwater level.

Table 6 : Average Groundwater Level in the Different Crop Growing Areas of Kasaragod District in Kerala in Different Years (1998to2009) (Groundwater level in meters)

S.No.	Year	1-Paddy		2- Arecanut		3- Coconut		4- Rubber	
		Dug well	Bore well	Dug	Bore well	Dug	Bore well	Dug	Bore well
1	1998	13.46	5.56	12.13	9.08	14.90	15.82	3.50	2.11
2	1999	13.98	5.14	13.17	9.08	14.16	15.62	2.53	2.72
3	2000	15.12	5.98	16.15	9.02	15.41	15.23	2.67	3.25
4	2001	25.52	6.11	13.25	9.20	16.78	14.27	2.56	3.28
5	2002	19.81	6.05	15.64	8.91	16.41	15.10	2.61	3.57
6	2003	19.84	6.38	15.31	8.63	16.13	15.30	2.31	3.32
7	2004	18.42	5.83	16.12	8.06	17.80	15.01	2.12	3.22
8	2005	20.63	6.60	17.28	8.54	17.07	15.33	2.49	3.59
9	2006	20.92	6.18	16.71	8.53	16.06	15.07	1.92	2.79
10	2007	15.62	5.89	15.12	8.92	16.65	15.33	2.43	3.48
11	2008	19.06	5.18	17.32	8.30	16.68	15.21	2.11	3.18
12	2009	17.71	7.03	17.87	8.37	15.41	15.07	2.52	2.84

Source: - Computed from the Groundwater Department, Govt. of Kerala, Kasaragod District.

Food Security : The substitution of rubber at the cost of rice lands decreased the supply of rice in Kerala and widened the supply demand gap of rice. An analysis of Table 7 demonstrated the demand and supply gap of rice in Kerala from 1960-61 to 2009-10. The data clearly revealed the continuous decrease in the supply of rice in Kerala compared to the demand. In 2009-10, the rice shortage in Kerala was 3022.64 thousand tonnes of the total demand (that is, 83.45 per cent shortage).

Table 7 : Demand and Supply Gap of Rice in Kerala in Different Years (1960-61 to 2009-10)

S. No.	Year	Demand for Rice (in'000 tonnes)	Supply of Rice (in'000 tonnes)	Demand and Supply Gap (in'000 tonnes)
1	1960-61	1782.93	1067.53	-715.40 (40.12)
2	1970-71	2248.86	1298.01	-950.85 (42.28)
3	1980-81	2674.29	1271.96	-1402.34 (52.44)
4	1990-91	3032.43	1086.58	-1945.85 (64.17)
5	2000-01	3319.82	751.33	-2568.49 (77.37)
6	2009-10	3615.98	598.34	-3022.64 (83.45)

Figures in bracket show percentage to total demand.

The results of the projected household demand for rice in Kerala are presented in Table 8. It is estimated that the household demand for rice at five per cent to ten per cent growth rate is very high in the State among rural and urban population during 2011, 2021 and 2026. The figures clearly established the increasing demand for rice particularly among rural people in Kerala in the future years compared to urban population. In 2026 AD, the total demand for rice in Kerala is estimated as 10606.55 thousand tonnes with an average growth rate of ten percentage.

Table 8 : Projected Demand for Rice in Kerala in Different Years (2011 to 2026)

S. No.	Year	Growth rate (%)	Rural (in'000 tonnes)	Urban (in'000 tonnes)	Total (in'000 tonnes)
1	2011	5	3427.11	1017.60	4444.71
		6	3574.13	1054.47	4628.60
		7	3726.81	1092.53	4819.34
		9	4050.34	1172.26	5222.60
		10	4222.10	1213.91	5436.01
2	2021	5	4503.48	1265.32	5768.80
		6	4898.18	1358.67	6256.85
		7	5325.59	1458.53	6784.12
		9	6289.05	1679.48	7968.53
		10	6830.55	1801.34	8631.89
3	2026	5	4673.28	1761.27	6434.55
		6	5190.75	1925.16	7115.91
		7	5762.98	2103.63	7866.61
		9	7095.05	2509.66	9604.71
		10	7866.60	2739.95	10606.55

The analysis of data presented in Table 8 pointed out the increasing demand for rice in Kerala in the coming years compared to the existing supply as shown in Table 7. This will enlarge the supply demand gap of rice in Kerala in the future years indicating a threat to food security.

Conclusion

From the analysis of the change in cropping pattern and the growth trends of area under principal crops in Kerala, it is clearly established that there is a shift in cropping pattern from food crops to non-food crops and recently towards rubber. The measure of diversification reveals that it was less in the initial years and diversification is taking place mainly towards rubber.

Diversification of crops and the overuse of chemical fertilisers lead to chemical pollution. Data analysis on the difference between suggested and applied doses of chemical fertilisers for five crops – paddy, coconut, arecanut, banana and rubber shows that rubber and banana farmers are using overdose of chemical fertilisers and under-use of organic manures and lime as compared to the farmers of other three crops. Paddy, coconut and arecanut farmers are using approximately the same amount of NPK chemical fertilisers as suggested. The diversification of crops towards rubber and the consequent heavy application of chemical fertilisers is resulting in soil pollution which is a great threat to the agrarian economy of the State.

Land degradation is measured on the basis of decline in soil fertility status and is calculated by the average soil fertility status of the four crops, namely, paddy, coconut, arecanut and rubber for the period 2000 to 2009. The soil fertility status is evaluated by analysing the PH status and NPK status. The analysis reveals that (i) though PH status is decreasing over the years in all crop growing areas, the decline is severe in rubber cropped systems, (ii) the continuous decline of soil health and soil fertility in general and the decline of P and K soil status in particular is observed in the rubber cropped areas compared to other cropped areas.

Average groundwater level during 1998 to 2009 shows that the water level in rubber growing areas is very low (below four meters) compared to rice, coconut and arecanut growing areas.

The change in cropping pattern has also led to food security problem. The conversion of rice lands decreased the supply of rice in Kerala and widened the supply demand gap of rice. During 1960-61, the shortage of rice was 40.12 per cent of the total demand and it increased to 83.45 per cent in 2009-10.

These findings clearly reveal the implementation of an appropriately devised nutritional management programmes in the State of Kerala. This comprises soil testing, distribution of soil health cards to all farmers, creating awareness on farm nutrition management, effective monitoring, etc. Adequate soil testing facilities within the easy reach of the farmers would need to be provided to enable them to get their soil tested for efficient fertiliser usage. This would need to be supplemented by appropriate extension facilities to make the farmers understood the necessity of following the recommendations of soil testing. Fertiliser usage should be on the basis of these recommendations. The effective coordination of various research institutions, government departments, local administrative bodies, etc., should be strengthened and encouraged in this regard.

Attention should be given to the balanced use of fertilisers for crops in the State. To improve efficiency of fertiliser use, what is really needed is location-specific research on efficient fertiliser practices such as correct soil testing practices, correct use of balanced nutrients (in the form of organic manures, chemical fertilisers, lime, etc.), correct timing and placement of fertilisers, monitoring of the overuse or under use of fertilisers, availability of improved fertilisers, development and efficient use of physical and institutional infrastructure, etc.

Agriculture is the biggest user of water, and it is revealed that groundwater level is decreasing in the crop growing areas and it is very acute in rubber cropped areas. To increase the recharge of groundwater in the rubber cropped areas various water recharging methods should be practised. For that the existing programmes in the State should be extended to all areas.

In the paddy sector, strict enforcement of various laws relating to land use should be followed. There is a need to enhance the positive contributions that agriculture makes to the environment. At the same time environmental protection and sustainability are to be adopted in the overall planning for agricultural growth and development. Development and usage of agro-chemicals and organic manures, strengthening of integrated plant nutrient system, monitoring of the usage of chemical fertilisers and pesticides, etc., should be practised in the agricultural sector of Kerala.

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