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Crop Diversification and Environmental Conflicts in Kasaragod District of Kerala

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Abstract

The agricultural sector of Kerala in general and of Kasaragod district in particular has witnessed a paradigm shift in the cropping pattern away from food crops towards non-food crops, and from one non-food crop to another non-food crop as to capture benefits of emerging markets. These changes have caused severe challenges to the environment in the form of land degradation, groundwater depletion and chemical pollution. To elicit the facts and issues connected with this changing paradigm, the analysis in this paper has shown a significant decline in soil fertility and groundwater level, and over-use of chemical fertilisers in the plantation-dominated Kasaragod district.

Key words: Crop diversification, environmental conflicts, land degradation, groundwater depletion, chemical pollution, Kerala

JEL Classification: Q1, Q24, Q25, Q51, Q54, Q56

Introduction

Kasaragod is the northernmost district of Kerala. The land-use pattern in the district has undergone considerable diversification in the past few decades, especially in favour of rubber and coconut. Area under paddy has decreased to almost half from 9158 ha in 2000-01 to 4991 ha in 2009-10, and most of it was diverted to plantation crops, especially rubber, raising its area to 28230 ha from 22232 ha. Tapioca is another crop that has lost significant area during this period.

The diversification of land use creates environmental conflicts in the form of groundwater depletion and land degradation. The over-use of chemical fertilisers and pesticides also generates chemical pollution threatening the sustainability of the agricultural sector. In this paper, the changes in cropping pattern in the Kasaragod district have been analysed and an insight has been provided into their impact on environment.

Data and Methodology

The study has used both primary and secondary data. The secondary data were collected from the *Economic Review* (GoK, 2010b), *Statistics for Planning* (GoK, 2010c), *Cost of Cultivation of Important Crops* (GoK, 2010a), *Season and Crop Reports* (GoK, 2010g), *Agricultural Statistics* (GoK, 2010d), *Analytical Register* (GoK, 2010e), *Soil Fertility Card* (District Panchayath Kasaragod, 2009) and *Groundwater Department* (GoK, 2010f).

The decline in native soil fertility, macro-nutrients, and micro-nutrients are the main indicators of unsustainability of land-use pattern. Amongst these, the decline in native soil fertility in the Kasaragod district was selected as a proxy for land degradation. The soil fertility status of 36 out of 39 panchayaths in the Kasaragod district was considered for the period

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2000 to 2009. The changes in soil fertility status were examined for important crops (paddy, coconut, arecanut and rubber) using data from the Assistant Soil Chemist Office of Kasaragod district. The data on groundwater level collected from the Groundwater Department of Kerala Government, Kasaragod, were analysed to assess the decline in groundwater level.

To study the over-use of chemical fertilisers, data on their recommended and actual applications in different crops were collected trough primary surveys in five panchayaths, viz, Vorkady for paddy, Panathady for coconut, Karadka for arecanut, West-Eleri for rubber and Mangalpady for banana; where these crops were largely cultivated. A total number of 150 farmers, 30 from each panchayath, were interviewed. On the basis of the data collected, the average dose of chemical fertilisers (NPK), lime, and organic manures used by the farmers for paddy, coconut, arecanut, rubber and banana plants was worked out.

Divisia-Tornqvist index was used to measure the total factor productivity indices for the crop sector. The total output, total input and total factor productivity indices were computed for seven crops (rice, coconut, arecanut, pepper, tapioca, ginger and banana) for two sub-periods, viz. 1990-91 to 1999-2000 and 2000-01 to 2009-10 (Amarender Reddy, 2009).

For constructing input index, eight inputs (human labour, animal labour, machine labour, farm yard manure, chemical fertilisers, irrigation, land and, repair and maintenance) were included. Human labour was taken as the total number of workers employed in the agricultural sector, animal labour was measured as the number of adult bullocks and male buffalos, machine labour input was taken as the number of four wheel tractors, farm yard manure input was considered as the number of livestock, chemical fertiliser input was measured as the total use of NPK fertilisers, irrigation was measured as the area under irrigation, land was taken as the gross cropped area, and repair and maintenance charge was taken as the number of pump sets. The cost share of each input was computed by dividing the individual input cost by the total production cost for all the principal crops based on cost of cultivation data. The input cost-share and input quantity data for the district were used for computing the input index. The total factor productivity index was computed by dividing the output index with input index.

The total factor productivity measures the extent of increase in the total output, which is not accounted for by increases in the total inputs. The Divisia-Tornqvist index of total factor productivity was computed as follows:

(i) Output Index (TOI)

$$TOI_t / TOI_{t-1} = \Pi_j (Q_{jt} / Q_{jt-1})^{½(R_{jt} + R_{jt-1})} = A_t \quad \ldots(1)$$

(ii) Input Index (TII)

$$TII_t / TII_{t-1} = \Pi_i (X_{it} / X_{it-1})^{½(S_{it} + S_{it-1})} = B_t \quad \ldots(2)$$

where, R_{jt}= Share of the jth crop output in total revenue in the year t, R_{jt-1} = Share of the jth crop output in total revenue in the year t-1, Q_{jt} = Output of the jth crop in the year t, Q_{jt-1} = Output of the jth crop in the year t-1, S_{it} = Share of input i in the total input cost in the year t, S_{it-1} = Share of input i in the total input cost in the year t–1, X_{it} = Quantity of input i in the year t, X_{it-1} = Quantity of input i in the year t–1, and t = Time period.

(iii) Total Factor Productivity Index (TFP)

$$TFP_t = (TOI_t / TII_t) \quad \ldots(3)$$

Cropping Pattern Changes

The changes in cropping pattern in Kasaragod district, presented in Table 1, reveal that the most significant change is the shrinking of area under food crops. During 1985-86 to 2009-10, coconut, arecanut, rubber and banana gained area, while rice, pepper, cashewnut, tapioca, cardamom and ginger experienced a decline. The area-share of paddy declined from 16.19 per cent to 3.22 per cent and of rubber increased from 9.57 per cent to 18.20 per cent during this period.

Crop Diversification and its Impact on Environment

Crop diversification is normally reflected in the changes of cropping pattern of a region (Goswami and Challa, 2004). It is observed that diversification of crops creates environmental conflicts in the form of land degradation, groundwater depletion and chemical pollution, which are all serious challenges. These not only affect the individuals and human societies but also influence the changes that are detrimental to the health and growth of all forms of life (Johl, 2006).

Table 1. Cropping pattern change in Kasaragod district: 1985-86 to 2009- 10

(in per cent)

Crops	1985-86	1990-91	1995-96	2000-01	2005-06	2009-10
Paddy	16.19	10.08	7.39	5.94	3.89	3.22
Coconut	25.35	31.28	38.15	38.33	37.52	36.79
Arecanut	6.46	8.66	8.06	8.77	11.38	9.71
Rubber	9.57	12.92	12.22	14.43	16.39	18.20
Pepper	6.72	4.80	4.19	4.04	4.31	4.29
Cashewnut	20.58	17.46	15.57	13.27	11.67	7.52
Tapioca	4.00	1.72	0.94	0.89	0.37	0.29
Cardamom	0.00	0.59	0.53	0.33	0.24	0.24
Ginger	0.40	0.12	0.10	0.09	0.04	0.04
Banana and other plantains	1.32	1.74	1.92	2.30	2.14	1.81

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

Land Degradation

Changes in land-use and cropping pattern influence soil fertility. The Centre for Earth Science Studies (CESS) has pointed out that the deteriorating soil fertility is due to changes in the cropping pattern in Kerala (Chattopadhyay and Richard, 2006). The changes in soil fertility status in the Kasaragod district between 2000 and 2009 were examined in terms of pH and NPK status for each panchayath.

The NPK status of the soil in the district was grouped into different classes, viz from 0 to 10. The class 0 to 3 indicated low soil fertility status group, the class 4 to 6 indicated medium soil fertility status group, the class 7 to 9 was of adequate soil fertility status group and the class above 9 showed high soil fertility status group.

In the year 2000, of 36 panchayaths, 21 showed soil pH status up to 5 and 15 showed pH above 5 (Table 3). The number of panchayaths showing pH status above 5 decreased to 8 in 2003 and reached zero in 2009. In the year 2000, 58 per cent panchayaths showed pH level 5.6-6.0, 36 per cent showed pH 6.1-6.5 and the remaining showed pH as 6.6-7.0. In 2009, no panchayath recorded soil pH status above 5.

Table 3 shows considerable variations in the soil fertility status in Kasaragod district. Of 36 panchayaths, 32 had high N-content, 24 had high P-content and 4 had high K-content in 2000. In 2009, the numbers of panchayaths showing high content of macronutrients were 9 for N, 1 for P, and zero for K. For the available P and K, more than 50 per cent of the panchayaths have been rated low (< 17 kg/ha P and < 155 kg/ha K). Of these, the status of low available P is of great concern, as soil parent materials are generally rich in K and this is reflected in predominantly moderate-to-high levels of exchangeable-K (Karma Lhendup and Duxbury, 2008).

Table 2. Classification of soil fertility status in Kasaragod district

(kg/ha)

Soil fertility class		N	P	K
Low	0	0-0.16	0-3.0	0-35
	1	0.17-0.33	3.1-6.5	36-75
	2	0.34-0.50	6.6-10.0	76-115
	3	0.51-0.75	10.1-13.5	116-155
Medium	4	0.76-1.00	13.6-17.0	156-195
	5	1.01-1.25	17.1-20.5	196-235
	6	1.26-1.50	20.6-24.0	236-275
Adequate	7	1.51-1.83	24.1- 27.5	276-315
	8	1.84-2.16	27.6-31.0	316-355
	9	2.17-2.50	31.1-34.5	356-395
High	10	2.51 and above	34.6 and above	396 and above

Source: Assistant Soil Chemist Office, Govt. of Kerala, Kasaragod District

Table 3. Class-wise analysis of soil fertility status and pH in Kasaragod district, 2000–2009

No. of panchayaths = 36

Class	Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
pH below 5	21	26	27	28	35	36	36	36	36	36
pH 5 and above	15	10	9	8	1	-	-	-	-	-
N										
Low	-	1	-	-	-	-	-	-	1	3
Medium	1	1	1	1	2	2	6	6	7	9
Adequate	7	7	11	13	8	27	28	28	27	23
High	28	27	24	22	26	7	2	2	1	1
P										
Low	1	-	1	1	1	1	2	4	6	11
Medium	6	6	8	9	10	12	14	17	19	20
Adequate	9	8	8	10	12	15	18	14	10	5
High	20	22	19	16	13	8	2	1	1	-
K										
Low	6	6	8	8	8	15	15	15	20	19
Medium	20	23	21	20	22	21	21	20	15	17
Adequate	10	7	7	8	6	-	-	-	1	-
High	-	-	-	-	-	-	-	-	-	-

Source: Computed from the Assistant Soil Chemist Office, Govt. of Kerala, Kasaragod District.

The major features revealed by the trends in the soil fertility status are: nearly 97 per cent of the panchayaths had low soil pH status; the total-N levels were high in more than 60 per cent of the panchayaths; the available-P levels were low in more than 50 per cent of the panchayaths; K nutrients were relatively low in 53 per cent of the panchayaths; and there was nutrient depletion.

A number of studies have shown that intensive cropping with high doses of inorganic fertilisers had led to deficiencies in the soil fertility status in several parts of India (Chandrasekhar, 2008). In the present paper, the changes in soil fertility status have been measured in four areas dominated by (i) paddy, (ii) coconut, (iii) arecanut, and (iv) rubber.

Figure 1 shows the decline in soil pH in all the cropping systems during 2000 to 2009, but more so in the rubber cropped systems. In 2009, the soil pH status was lower in the rubber cropped system than in other cropping systems.

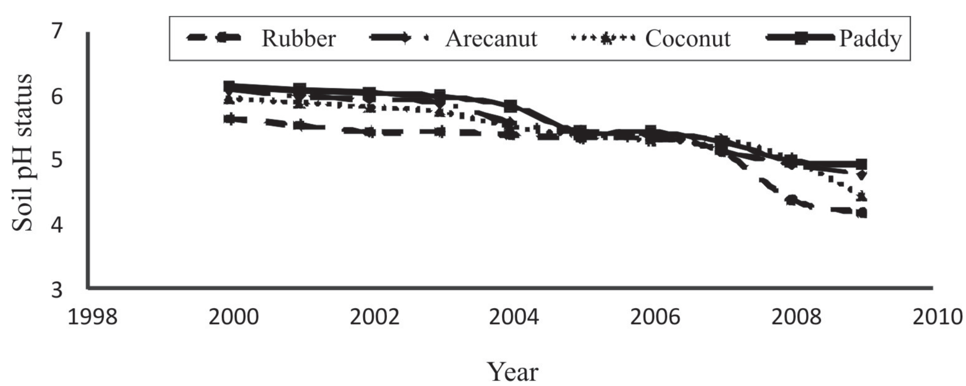

Figure 1. Soil pH in major crop-growing areas in Kasaragod district, 2000 to 2009

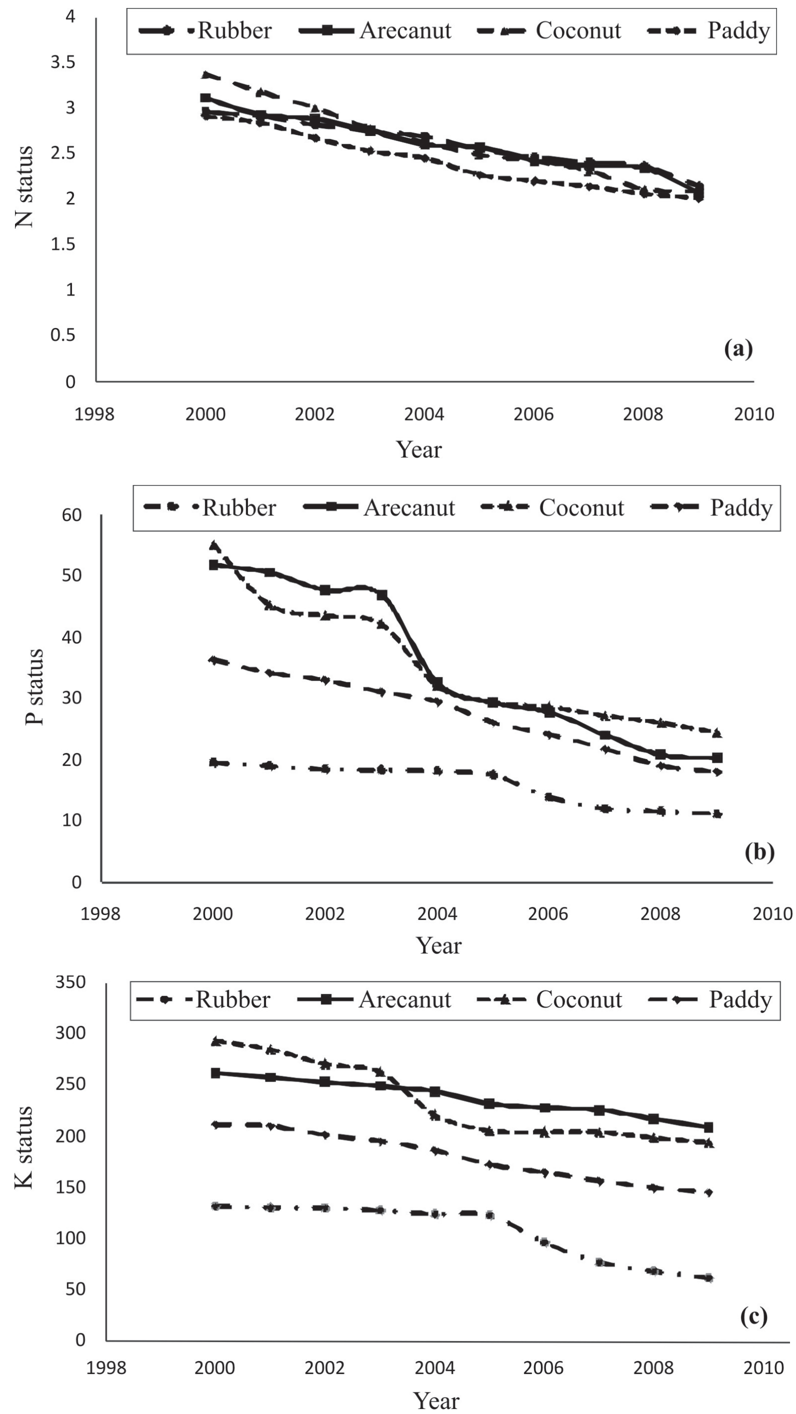

Figure 2. NPK status in major crop growing areas in Kasaragod district, 2000 to 2009: (a) N Status; (b) P status; and (c) K status

In the year 2000, all the cropping systems, except rubber, had high NPK status. The analysis also shows a continuous decline in soil fertility status and soil health in general, and in P and K contents in particular in all the cropping systems. The deterioration is severe in the rubber cropping system (Figure 2). It is found that P and K elements are low in the rubber plantations. Various studies have pointed out that NPK component is lower on rubber plantations than with other vegetations (Shaji and Abraham, 1994; Chattopadhyay and Richard, 2006; Kayarkanni, 2006; Karunakaran, 2013). The analysis confirms that changes in cropping pattern in favour of rubber had caused deterioration in available NPK, which may creates conflict to the sustainability of the cropping system.

Groundwater Depletion

The groundwater level in India is declining in many parts of the country due to excess draft over the recharge (Rajan and Narayanamoorthy, 2000). The water level also goes down when the rate of recharge is low due to the changes in the land-use pattern. In many parts of India groundwater discharge is even up to 99.4 per cent of the groundwater recharge, leaving little or no water as storage (Chattopadhyay *et al.*, 2005). This will eventually result in falling of groundwater level and gradual depletion of the groundwater resources. Recently, symptoms of overdrawing have started appearing in Kerala also. The aggregate data for Kerala indicate that the state is only using up to 15 per cent of its annual rainfall recharge. This ranges from 4.93 per cent in the Wayanad district to 32.88 per cent in Kasaragod district (GoK, 2010f). The Central Groundwater Board has reported lowering of the state of water levels throughout Kerala.

The groundwater level data (bore-well and dug-well) for the Kasaragod district were collected from the Groundwater Department, Government of Kerala, from 1985 to 2009. There are 53 dug-well monitoring stations and 21 bore-well monitoring stations in this district. Block-wise average groundwater level was worked out by taking 18 dug-wells and 13 bore-wells, where complete data were available. Figure 3 shows the trends in groundwater level in all the blocks in Kasaragod district. The average data are not sufficient for a definitive measurement, since water level fluctuates depending on a number of parameters like site, lithology, distance from river or other basin, rainfall, etc. Nevertheless, the tendency of the groundwater level, as shown in Figure 3, towards a decline is a matter of great concern.

The depletion of underground water has important implications for sustainability of agricultural systems. Though many factors are responsible for groundwater decline, the problem is being largely linked to the changes in cropping pattern (Chattopadhyay *et al.*, 2005). To study the effect of changes in cropping pattern on groundwater depletion in the Kasaragod district, the groundwater level in different cropping systems was analysed and the results are shown in Table 4. The groundwater level of dug-well in the paddy, arecanut and coconut cropping systems increased, but decreased in rubber-based cropping system. The groundwater level in the rubber-based cropping system was very low (below 4 m).

Table 4. Groundwater level in major crop-growing areas of Kasaragod district, 1998 to 2009

(in metres)

Year	Paddy		Arecanut		Coconut		Rubber	
	Dug-well	Bore-well	Dug-well	Bore-well	Dug-well	Bore-well	Dug-well	Bore-well
1998	13.46	5.56	12.13	9.08	14.90	15.82	3.50	2.11
1999	13.98	5.14	13.17	9.08	14.16	15.62	2.53	2.72
2000	15.12	5.98	16.15	9.02	15.41	15.23	2.67	3.25
2001	25.52	6.11	13.25	9.20	16.78	14.27	2.56	3.28
2002	19.81	6.05	15.64	8.91	16.41	15.10	2.61	3.57
2003	19.84	6.38	15.31	8.63	16.13	15.30	2.31	3.32
2004	18.42	5.83	16.12	8.06	17.80	15.01	2.12	3.22
2005	20.63	6.60	17.28	8.54	17.07	15.33	2.49	3.59
2006	20.92	6.18	16.71	8.53	16.06	15.07	1.92	2.79
2007	15.62	5.89	15.12	8.92	16.65	15.33	2.43	3.48
2008	19.06	5.18	17.32	8.30	16.68	15.21	2.11	3.18
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.

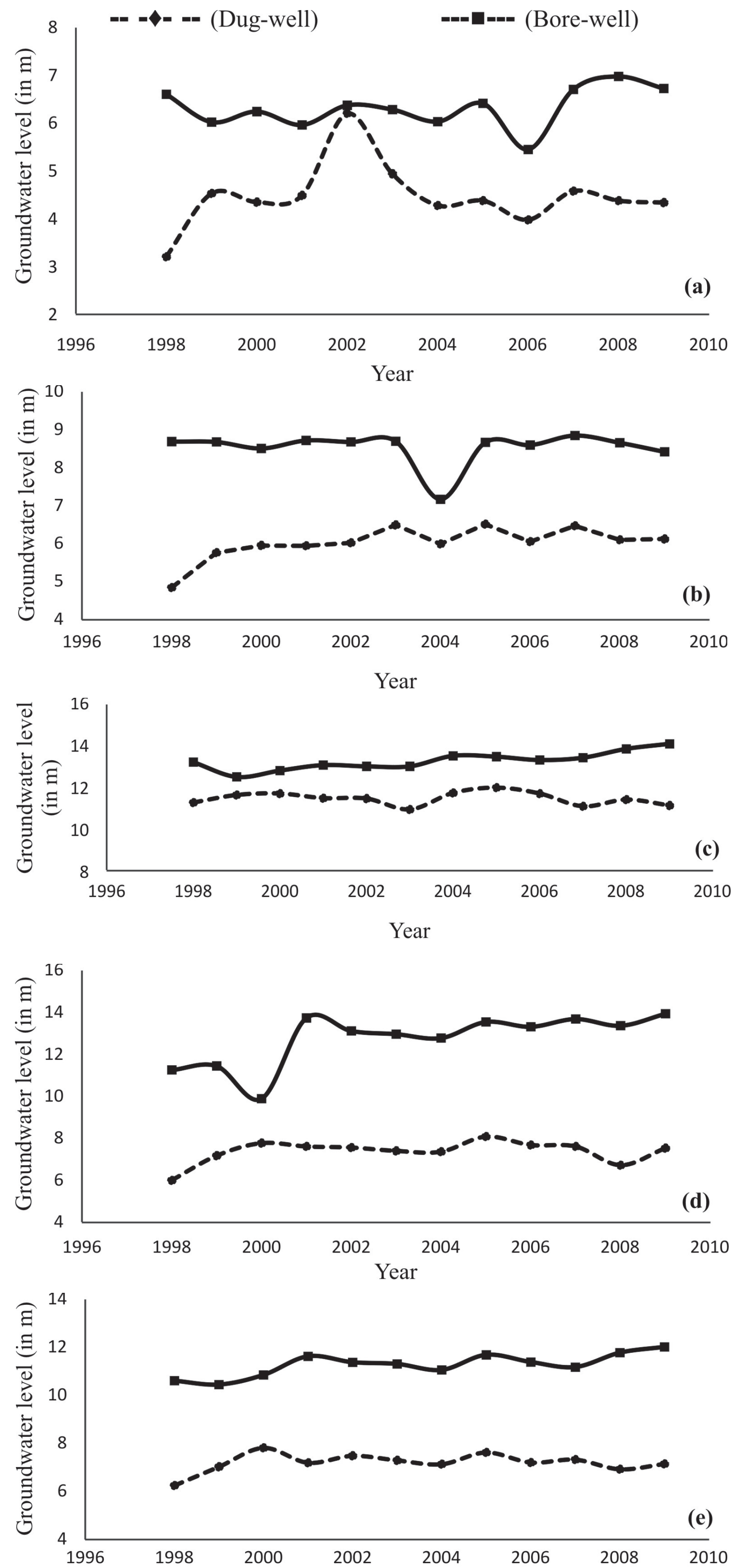

Figure 3. Groundwater level in Kasaragod district, 1998 to 2009: (a) Nilishwar block, (b) Kanhangad block, (c) Kasaragod block, (d) Manjeshwar block, and (e) Kasaragod district

Table 5. Difference between recommended and actual doses of fertilizers applied to various crops in Kasaragod district

Item	Crops				
	Paddy	Coconut	Arecanut	Rubber	Banana
(1) Soil fertility status (macronutrients–NPK in kg/ha) of sample panchayaths					
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
	Paddy (kg/ha)	Coconut (kg/plant)	Arecanut (kg/plant)	Rubber (kg/plant)	Banana (kg/plant)
(2) Recommended dose of fertilizers					
Lime	300	1.500	0.700	0.700	0.600
N	61	0.400	0.130	0.100	0.320
P	74	0.900	0.120	0.480	0.610
K	28	1.070	0.190	0.190	0.470
NPK total	163	2.370	0.450	0.770	1.400
Organic manure	2500	25	24	10	10
(3) Average actual dose of fertilizers used					
Lime	250	0.500	0.200	0	0.250
NPK total	175	2.0	0.400	2.0	3.0
Organic manure	1250	20.0	10.0	2.0	2.0
(4) Difference between actual and recommended doses of fertilizers					
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: For item Nos. 1 and 2: Soil fertility card (2009), Vasutha Programme, District Panchayath, Kasaragod. For item No. 3: Primary data collected by the author.

Chemical Pollution

To study overuse of chemical fertilizers in Kasaragod district, data on the recommended and actual applications of chemical fertilizers to various crops (paddy, coconut, arecanut, rubber and banana) were collected and are given in Table 5. It shows that in paddy, arecanut and coconut, farmers apply the recommended quantities of NPK to some extent. The actual quantity of chemical fertilisers applied in rubber is three-times and in banana two-times of the respective recommended dose. In the West-Eleri panchayath, the suggested dose of NPK in rubber is 0. 774 kg/plant, but the actual use is 2 kg/plant. Likewise, in banana the recommended dose of NPK is 1.4 kg/plant, while the actual consumption is 3.0 kg/plant in the Mangalpady Grama panchayath. Another important feature is that farmers use very low quantity of lime and organic manure.

Total Factor Productivity Growth

Table 6 shows that the share of TFP in the output growth was negative during the period 1985-86 to 2009-10. The sub-period-wise analysis also revealed deceleration in the TFP growth. Therefore, agricultural

Table 6. Total factor productivity growth (TFPG) in the crop sector in Kasaragod district, 1985-86 to 2009-10

(per cent per annum)

1990-91 to 1999-2000			2000-01 to 2009-10			1985-86 to 2009-10		
Output	Input	TFP	Output	Input	TFP	Output	Input	TFP
0.22Ns	-0.09Ns	0.308	0.622	1.111	-0.489	1.502	2.259	-0.757

Ns - Statistically non-significant.

growth has been an important issue in the context of diversification of crops and environmental conflicts in the Kasaragod district of Kerala for the past few decades.

Conclusions

The cropping pattern in the Kasaragod district has undergone significant changes during the past two decades or so. The major crops that have lost area are rice and tapioca, while rubber has gained area. This change has caused a severe challenge to sustainability of the agricultural production in the area.

The study on soil fertility status has revealed that soil pH was 5.6 – 6.0 in 58 per cent of the panchayaths, 6.1 – 6.5 in 36 per cent of the panchayaths, and 6.6 – 7.0 in the remaining 6 per cent panchayaths in the year 2000. In 2009, the picture changed completely as 97 per cent of the panchayaths had low values of soil pH (pH below 5). In terms of macronutrients, out of the 36 panchayaths studied, 32 had high N-content, 24 had high P-content and 4 had high K-content during 2000; but in 2009, the number of panchayaths depicting high macronutrients were 9 for N, one for P and zero for K. In 2009, for available-P and available-K, more than 50 per cent of the panchayaths rated low status.

In terms of cropping system, the study has observed that (i) pH was decreasing over time everywhere, but was more so in the rubber-based cropping systems, and (ii) there was a continuous decline in soil fertility in general and in P and K in particular, especially in the rubber-based cropping systems. A decline in groundwater level has been observed throughout Kerala, including Kasaragod district. The decline in groundwater level has been found deep and severe in rubber-based cropping system.

The diversification of crops has led to overuse of chemical fertilisers. The actual use of NPK has been found much higher than the recommended level in rubber and banana. The use of lime and organic manure was almost negligible. Given these changes in the cropping pattern and input use, a negative growth has been found in total factor productivity in the crop sector of Kasaragod district.

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