Chapter-V

CROPPING PATTERN, CROP COMBINATION REGION

It is well known that the growth of agricultural production depends on both area and productivity growth. The productivity growth can be further decomposed into yield growth and cropping pattern change. The former measures the impact of changes in output per unit of area while the later captures shift of acreage from one crop to another.

In this chapter we attempt to analyse the cropping pattern prevailing in the district, the changes happening, the growth trend of various crops, the crop combination and its changes. The chapter has been divided into 4 sections viz. a) cropping pattern, b) changing cropping pattern, c) growth trend analysis and d) crop combination analysis.

5.a Cropping pattern

The cropping pattern means both the time and space sequence of crops. The variety of cropping pattern is the result of physical economic and social factors. It is due to the variation in various components of physical environment- relief, climate, vegetation and soil. The economic factor affect cropping through a comparative return, which a farmer receives from a particular crop or a combination of crops. (Bishinoi, 1981)

Cropping pattern also depends on nature and availability of irrigation facilities. Where water is available, not only different crops can be grown but even a double or triple cropping will also be possible. When new irrigation facilities are provided thewhole method of production may also change. (Dayal, 1965)

Thus cropping pattern gives an indication of the relative importance a region gives to any particular crop. It is important to analyse cropping pattern as farmers in each agro-climatic region try to follow the cropping pattern to match geographical condition and also invite new technology to introduce a new pattern, to maximize farm income.

For the purpose of this section we have analysed the area under cultivation for each of the 13 crops individually at the block level for the period 1993-94 to 2000-01 (Appendix V.i to V.xiii). Individual years show variation in area under cultivation for each crop. This is mainly because of cyclical pattern of crop cultivation adopted by the farmers, natural calamities etc. To make a comment in the cropping pattern of the districts and its blocks we have avoided the cyclic nature and considered the average area under cultivation for each crop at block level for the period 1993-94 to 2000-01.

We then calculated the share of each crop to the gross cropped area. We found for any block the top six-crop command at least three quarter of the gross cropped area. So for the purpose of analysis we have clubbed the remaining crops. The Map No-5.1 provides an illustration of the cropping pattern, at the block level.

Analysing the cropping pattern, block wise we find in Harishchandrapur-I, aman (34.6 percent), boro (17.6 percent), wheat (13.9 percent) and jute (13.4 percent) are the major crops. [The figures in the parenthesis denote the area of individual crop as percentage of gross cropped area]. The major crops stated here are purely based on the cut off limit of 10 percent, i.e. if the area cropped is greater than 10 percent then we consider the said crop as the major crop.

The major crops for the other blocks are provided below:

Harischandrapur II: aman (36.2 percent), boro (22.3 percent) and wheat (12.0 percent. The other crops are having a share less than 10 percent individually.

Chanchal I: aman (33.6 percent), boro (16.9 percent), wheat (12.6 percent), Jute (10.5 percent and mustard (10.3 percent).

Chanchal II: aman (37.2 percent), boro (19.3 percent) and wheat (10.0 percent).

Ratua I: aman (22.4 percent), boro (16.3 percent) and wheat (13.9 percent).

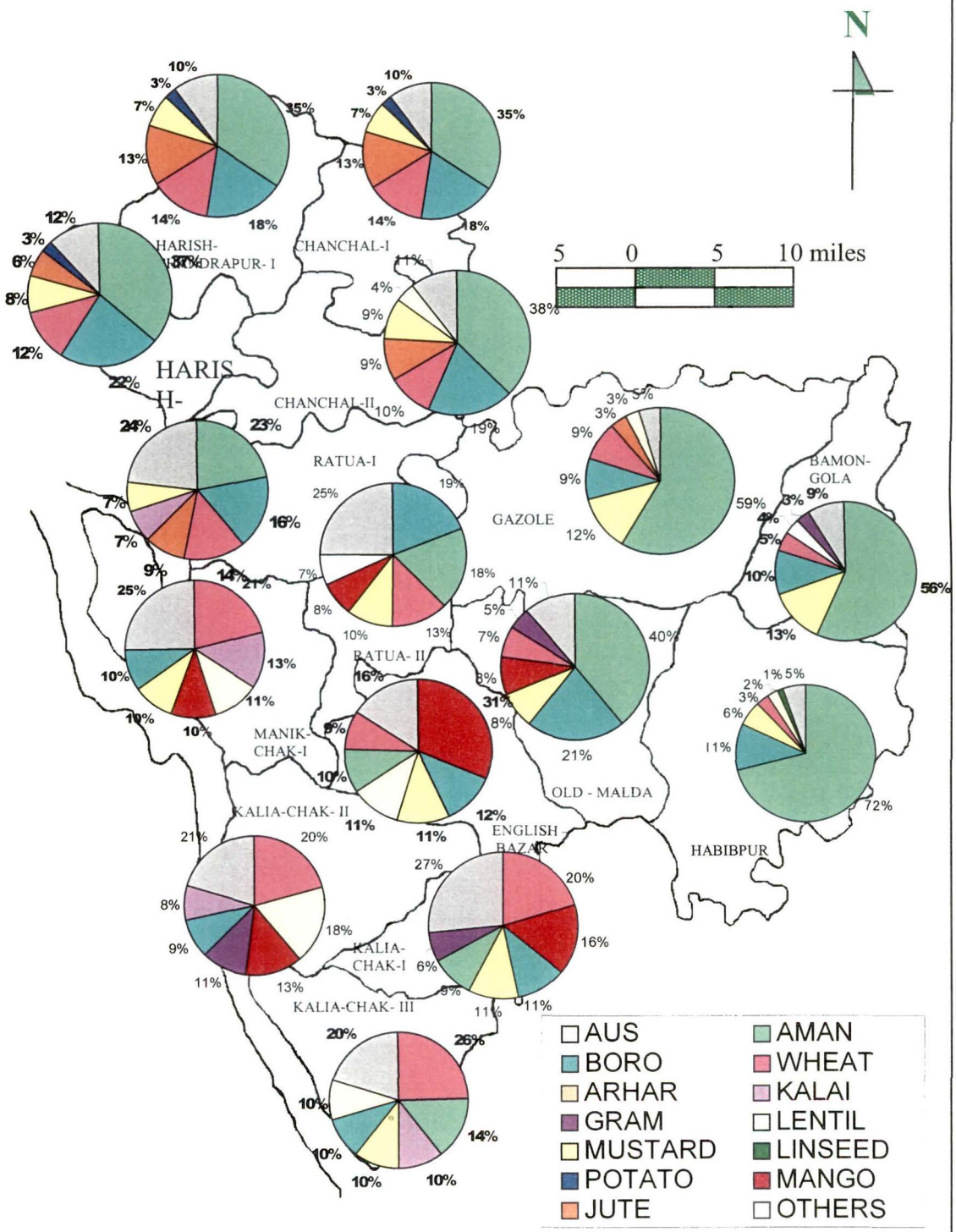
Ratua II: boro (19.2percent), aman (18.4 percent), wheat (12.5percent) and mustard (10.2 percent).

Gazole: aman (58.7 percent) and mustard (12.0 percent).

Bamongola: aman (56.2 percent), mustard (13.0 percent) and boro (10.1 percent).

Map No: 5.1

CROP DISTRIBUTION IN MALDA: BLOCK WISE (93-94 to 00-01)



Habibpur: aman (70.7 percent), and boro (11.1percent).

Old Malda: aman (39.3 percent), and boro (21.1percent).

English Bazar: mango (31.3 percent), boro (11.9 percent), mustard (11.2 percent), aus (11.0 percent) and aman (10.0 percent).

Manikchak: wheat (21.0 percent) kalai(13.4percent), aus (10.6 percent) and mango (10.2 percent)

Kaliachak I: wheat (20.2 percent), mango (15.6 percent), boro (11.0 percent) and mustard (10.8 percent)

Kaliachak II: wheat (20.8 percent), aus (18.2 percent), mango (12.8 percent) and gram (10.5 percent)

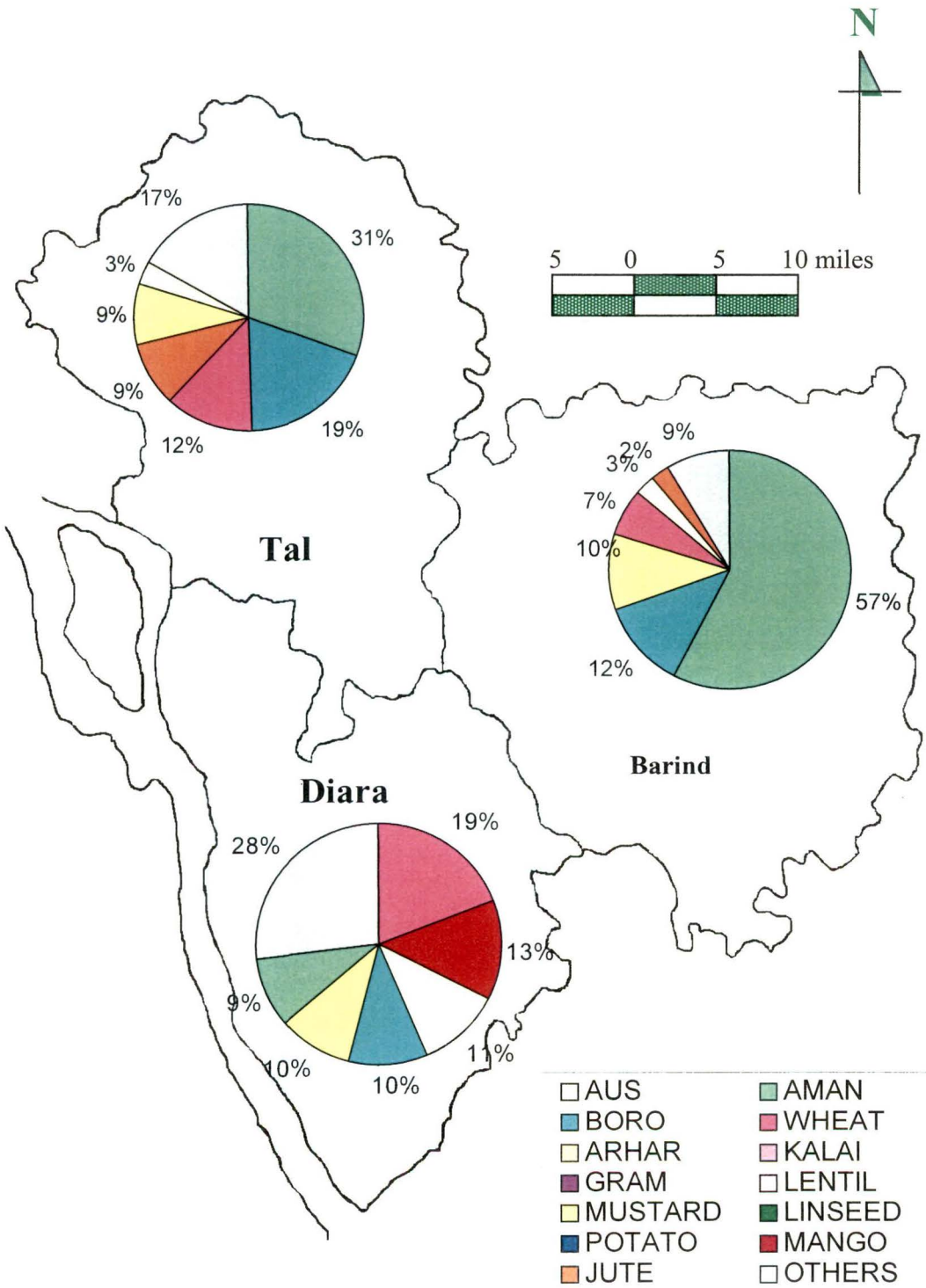
Kaliachak III: wheat (25.1 percent), aman (14.4 percent), kalai (10.3 percent), mustard (10.2 percent) and boro (10.1 percent)

We have also analyzed the cropping pattern at region level shown in the Map No-5.2. This illustrates that while aman (30.5 percent), boro (18.6percent) and wheat (12.5 percent) are the major crops in Tal region. Aman (57.5 percent), boro (12.0 percent) and mustard (10.0) percent are for Barind region. Diara has a different crop combination with wheat (19.0 percent), mango (13.5 percent), aus (11.0 percent) and boro (10.3 percent) are the major crops.

For Malda district as a whole the cropping pattern as shown in the Map No-5.3 It is interesting to note that aman commands around 37 percent of gross cropped area for the four blocks viz. Harishchandrapur-I, Harishchandrapur-II, Chanchal-I and Chanchal-II in the northern part of the district. Aman also commands the majority shares in the three eastern blocks of Gazole, Bamongola and Habibpur. Aman is found to have a varied share in the central part of Malda i.e. Ratua-I (23 percent), Ratua-II(18 percent) and Old Malda (40 percent) while in southern half of Malda the cropping pattern is more diverse with less prevalence of aman.

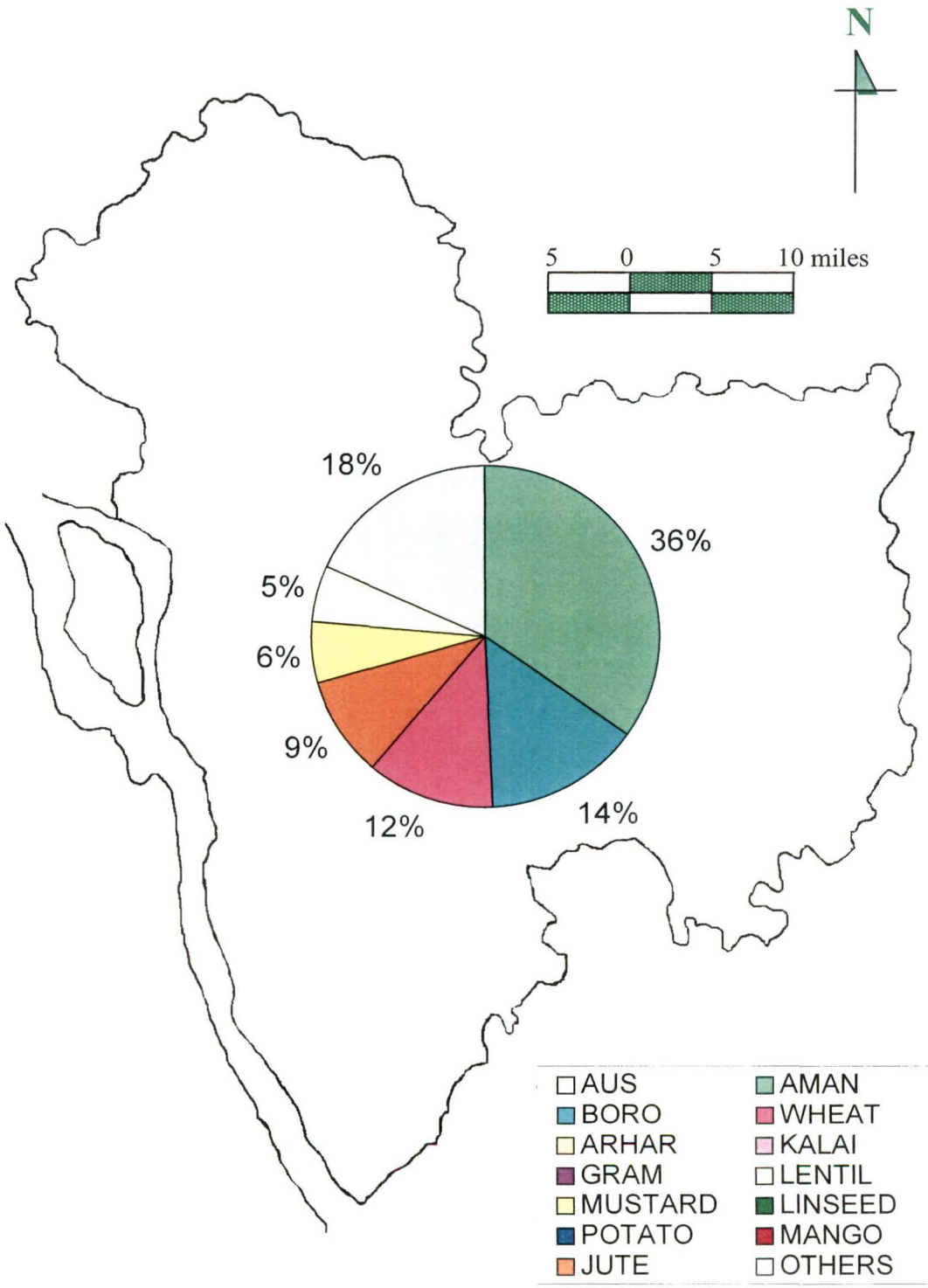
Map No: 5.2

CROP DISTRIBUTION IN MALDA: REGION WISE (93-94 to 00-01)



Map No: 5.3

CROP DISTRIBUTION IN MALDA: MAJOR CROPS (93-94 to 00-01)



5.b Changing Cropping Patterns

After analysing the cropping pattern and understanding its importance we now attempt to analyse the changes of cropping pattern. Cropping pattern change is a great concern to the agricultural geographers for its notable contribution to agricultural output.

With the dynamics of agricultural productivity the area under cultivation for different crops is bound to experience a shift. The causes for this shift can be

1) Increase in returns of any particular crop
2) Technological feasibility
3) Change of preference
4) Non-availability of resources.

In this section we attempt to analyse the changing cropping pattern of crop cultivation in the district. The objective of this section is to identify the cropping pattern in each region and analyse the changing nature of it.

Methodology:

To estimate the pattern of the shift at the block level we have considered the area under cultivation for individual crops. This analysis makes a comparative study between Period I (1993-94 to 1996-97) and Period II (1997-98 to 2000-01). The analysis is made at the crop group level viz. Cereals (Aus, Aman, Boro and Wheat), Pulses (Arhar, Gram, Kalai and Lentil), Oil-seeds (Mustard and Linseed) and Cash crop (Potato, Mango and Jute) as breaking these crop groups to individual crops makes the analysis complex and inappropriate to draw conclusions. Using the average area for Period I as base (=100) the average area for Period II is calculated.

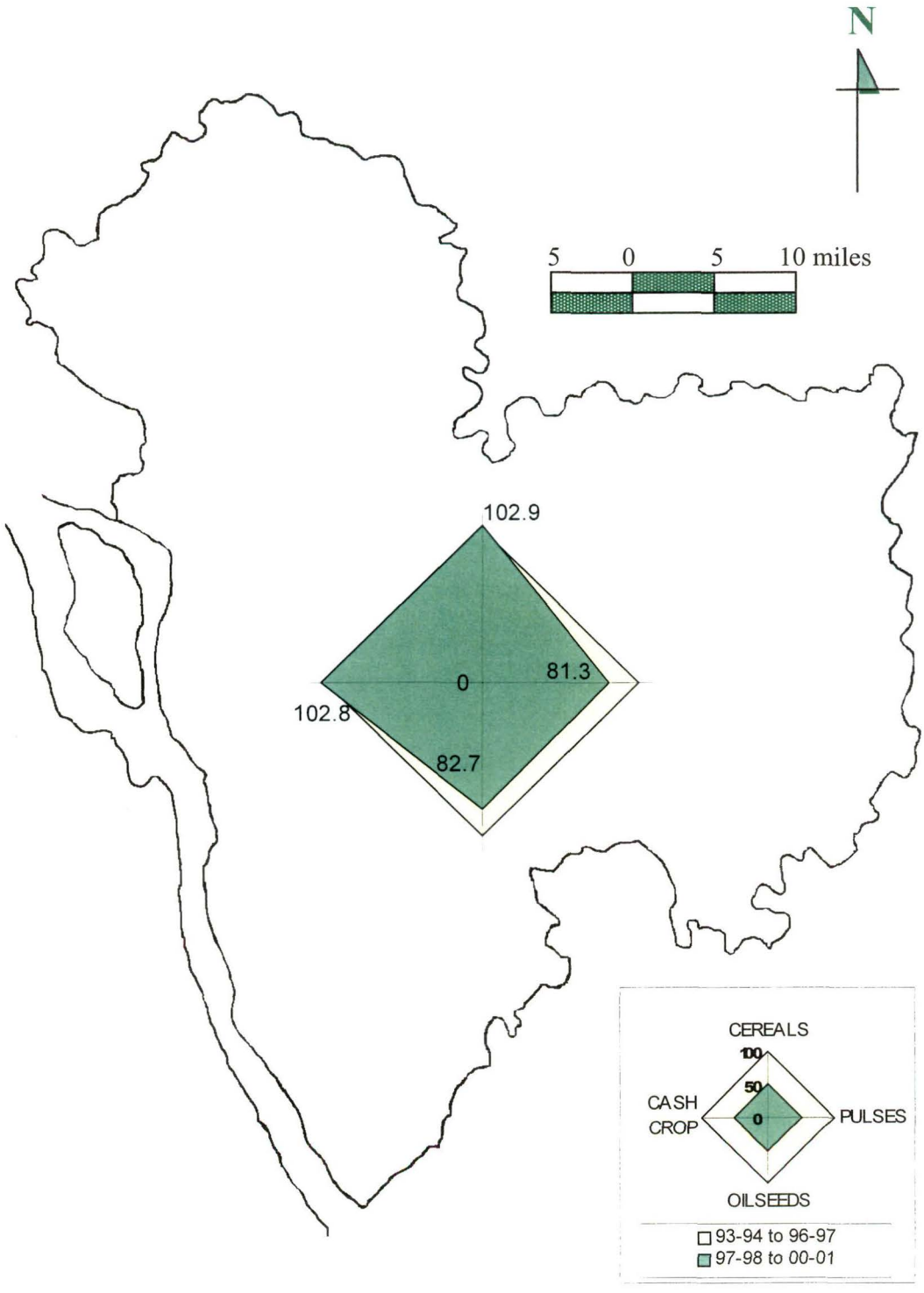
Results:

For all crop groups as the index for Period I is equated to 100, so the index value for Period II gives an indication whether the average area in absolute terms have increased or decreased at the block level.

Map no. 5.4 show the changing cropping pattern using radar diagram for the Malda district as a whole, wherein the North, East, South and West axes of the radar diagram

Map No: 5.4

CHANGING CROPPING PATTERN IN MALDA (93-94 to 96-97 vs 97-98 to 00-01)



represent Cereals, Pulses, Oil-seeds and Cash crops respectively. The 'yellow' shade represents the base period while the 'green' shade indicates the index for Period II.

For the district as a whole it is observed that area under cereals have increased in Period-II (102.9 percent of Period-I). Similar increase, of 2.8 percent is noticed, for cash crops too. For pulses and oilseeds the area under cultivation in Period-II, have decreased to 81.3 percent and 82.7 percent of Period-I respectively.

We now analyse the changing cropping pattern at the block level. Map 5.5 provides the nature of change in the cropping pattern at the block level.

From the map we find that in Harishchandrapur I while the area under cultivation for cereals have increased to 104.2 percent of Period I in Period II, for pulses, oilseeds and cash-crops it has declined to 62.2 percent, 76.3 percent and 86.3 percent respectively. Thus we find that the area under pulses has been significantly hit.

In Harischandrapur-II, area under cereals have increased in Period-II, by 16.5 percent of Period-I. In period-II decline of pulses, oilseeds and cash crops to 63.7 percent, 85.0 percent and 95.3 percent respectively depicts the shift to cereals in the block. The causes of increase for cereals can be explained by multiple cropping of paddy.

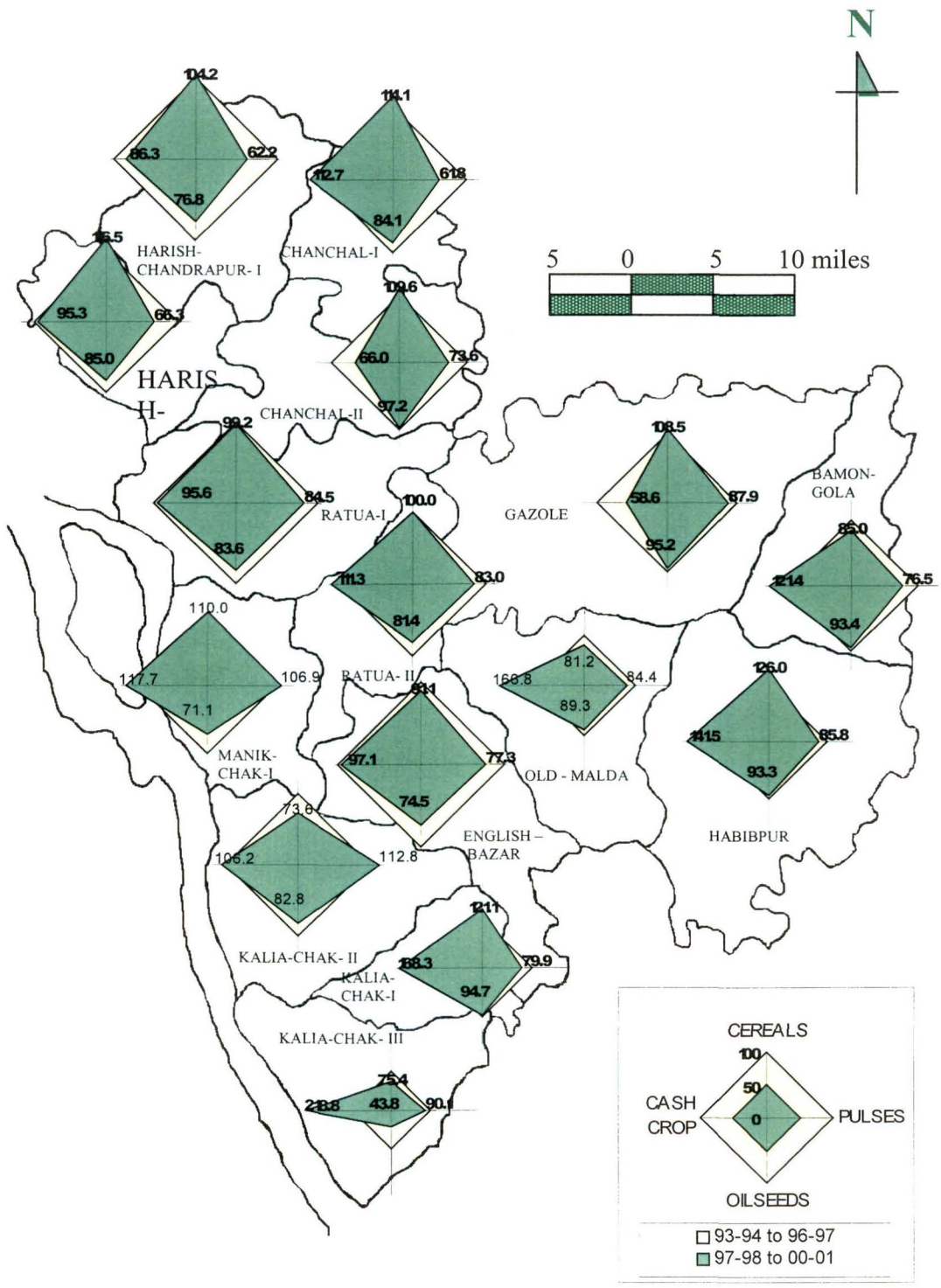
In Chanchal-I the area under cereals and cash crops have both increased to 114.1 percent and 112.7 of Period-I respectively. This increase is at the cost of decline in pulses and oilseeds to 59.0 percent and 84.1 percent respectively.

For Chanchal-II we find a drop in pulses, oilseeds and cash crops to 71.7 percent, 97.2 percent and 66.0 percent respectively. Only cereals have increased to 109.6 percent over the period.

A peculiar pattern is noticed for Ratua-I, wherein for all crop groups viz. cereals, pulses, oilseeds and cash crops there is a decline of 99.2 percent, 82.8 percent, 83.6 percent and 95.6 percent respectively.

Map No: 5.5

CHANGING CROPPING PATTERN IN MALDA: BLOCK WISE



In Ratua-II where cereals maintained same area under cultivation and area under cash crops increased by 11.3 percent, there is a decline for pulses and oilseeds to 82.0 and 81.4 respectively.

In Gazole a severe drop in area under cash crop is noticed. This drop is primarily because of decline in jute cultivation. There is a decline in pulses and oilseeds to 79.7 percent and 95.2 percent respectively. In Period-II only cereals cultivation in the block increased to 108.5 percent of Period-I.

In Bamongola a different pattern of crop changed is noticed. Here, area under cereals pulses, oilseeds have declined to 85.0 percent, 74.3 percent and 93.4 percent respectively, while area under cash crop has increased to 121.4 percent.

For Habibpur, cereals and cash crops are the two major crop groups where in the area under cultivation have increased to 126 percent and 141.5 percent. This major increase in cash crops is not to be considered very seriously as it is basically the impact of low base for cash crops. For pulses and oil seed the area has declined to 76.8 percent and 93.3 percent respectively.

In Old Malda while there is a drop in area under cereals, pulses and oilseed to 81.2 percent, 76.6 percent and 89.3 percent respectively, a sharp rise to 166.8 percent is noticed for cash crop. This sharp rise is causes by the rise in the mango and jute cultivation.

A peculiar trend is noticed in English Bazar as the area under cultivation for all major crop groups have declined. The figures of Period-II for cereals, pulses, oilseed, and cash crop are 91.1 percent, 73.4 percent, 74.5 percent and 97.1 of Period-I, respectively. The cause for this decline can be attributed to the urbanization of the block.

Manikchak, portrays a different pattern of change, as in this blocks the area under cultivation have increased for cereals, pulses and cash crops to 110.0 percent, 103.5 percent and 117.7 percent respectively. This increase for three major crop groups have

been achieved at the cost of oil seeds, which has declined to 71.1. This rise is mainly due to effective use of multiple cropping.

In Kaliachak-I a phenomenal increase of cash crop is noticed. It has increased to 168.3 percent mainly due to more area coming under mango orchards. Area under cereal cultivation has also increased by 21.1 percent while, area under pulses and oilseed cultivation have declined to 71.8 percent and 91.7 percent respectively.

In Kaliachak-II the change in the pattern is of an increase of pulses and cash crop (109.6 percent and 106.2 percent) and that of a decline for cereals and oilseeds to 73.6 and 82.8 percent.

Finally, Kaliachak-III shows a pattern, which is marked by staggering growth to 218.8 percent in area under cash crop. This impressive growth has been achieved by more area coming under jute cultivation. For cereals and pulses the decline to 75.4 and 79.4 percent is noticed. A prominent feature for this block is a severe drop in area under oilseed to 43.8 percent. This drop is primarily because of the drop in area under mustard cultivation.

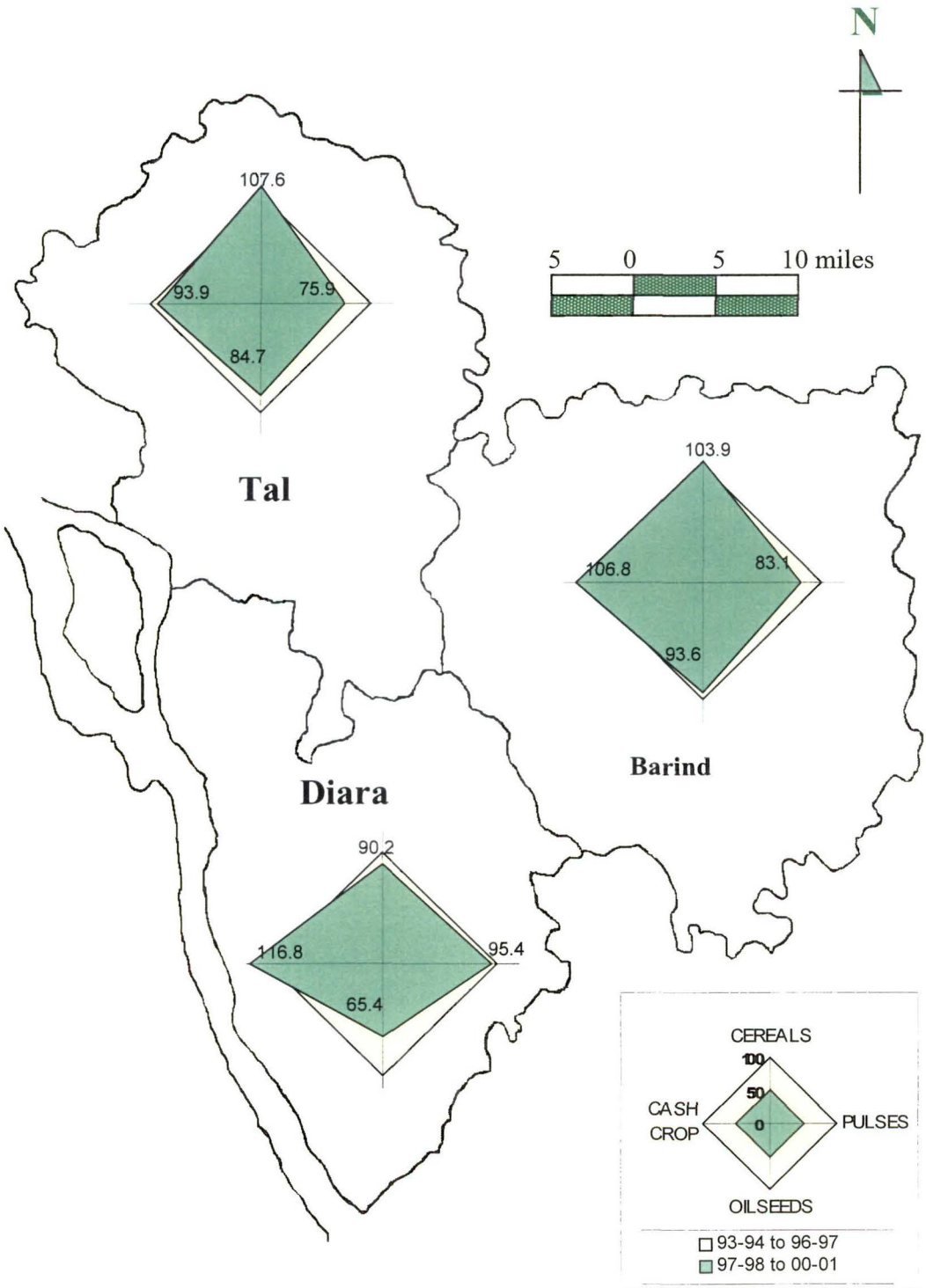
When we consider the change comparatively in larger domain i.e. region, (Map 5.6 depicts the change of area under cultivation in a comparative form at the region level) we find that cereals have gained in Tal and Barind region as in Period-II 107.6 percent and 103.9 percent of Period-I area is under cereals cultivation for the two blocks. It has decreased for Diara region to 90.2 percent. Thus a marginal increased is noticed for area under cereal cultivation for the district as a whole (102.9 percent of Period-I)

The area under pulses cultivation has declined across regions. The decline is severe in Tal (74.1 percent of Period-I), Barind (76.6 percent of Period-I) and moderate for Diara (89.4 percent of Period-I). Thus total area under cultivation for the district has declined by 19.7 percent.

For oilseed cultivation too we observe a declining trend in the area under cultivation. But the rate of decline varies between blocks; while the decline of 34.6 is severe in Diara it is moderate in Tal (15.3 percent) and Barind (6.4 percent)

Map No: 5.6

CHANGING CROPPING PATTERN IN MALDA: REGION WISE



For cash crop cultivation there is a marginal increased of 2.8 percent noticed for the district. The region wise break-up is as follows: Tal- decline of 6.1 percent, Barind- growth of 6.8 percent and Diara- growth of 16.8 percent.

Thus we find that there is a change in the cropping pattern in the district with marginal rise for the area under cereals and cash crops and a drop in pulses and oilseeds. When we compare the total area under cultivation for all these crop groups combined we find a marginal drop of 1.9 percent. This is mainly due to drop in area under cultivation for 1998-1999 due to flood.

This analysis at region level do not help in analyzing the factors that have driven this change as we make a simplistic assumption that the pattern of change within a region is similar across the blocks. To overcome this, the approach adopted is of clustering the blocks based on the composition of change in cropping pattern. In this direction we have analyzed the indices for Period II and tried to group them based on the commonality of change. For this cluster analysis has been applied and the acceptable number of cluster has been defined as three. For the purpose of cluster analysis the indices for each block vs crop is categorized in a scale of 1 to 5 as shown in the Table 5.2. The scale has been assigned as in Table 5.1.

Table 5.1 Scale used for Index Range: Cluster Analysis

Index Range	Scale
< 85	1
85-95	2
95-105	3
105-115	4
>115	5

Table 5.2 Block wise Index of Area under Crop Groups for 1997-98 to 2000-01 (Base 1993-94 to 1996-97)

	CEREALS		PULSES		OILSEEDS		CASHCROP	
	Index	Scale	Index	Scale	Index	Scale	Index	Scale
Harishchandrapur I	104.2	3	60.4	1	76.8	1	86.3	2
Harishchandrapur II	116.5	5	63.7	1	85.0	1	95.3	3
Chanchal I	114.1	4	59.0	1	84.1	1	112.7	4
Chanchal II	109.6	4	71.7	1	97.2	3	66.0	1
Ratua I	99.2	3	82.8	1	83.6	1	95.6	3
Ratua II	100.0	3	82.0	1	81.4	1	111.3	4
Gazole	108.5	4	79.7	1	95.2	3	58.6	1
Bamongola	85.04	2	74.3	1	93.4	2	121.4	5
Habibpur	126.0	5	76.8	1	93.3	2	141.5	5
Old Malda	81.2	1	76.6	1	89.3	2	166.8	5
English Bazar	91.1	2	73.4	1	74.5	1	97.1	3
Manikchak	110.0	4	103.5	3	71.1	1	117.7	5
Kaliachak I	121.1	5	71.8	1	94.7	2	168.3	5
Kaliachak II	73.6	1	109.6	4	82.8	1	106.2	4
Kaliachak III	75.4	1	79.4	1	43.8	1	218.8	5

We then attempted to group blocks based on the pattern of shift. The initial cluster centers for the blocks and the final centers is shown below in Table 5.3 and Table 5.4 respectively.

Table: 5.3 Initial Cluster Centers

	Cluster		
	I	II	III
CEREALS	5.00	4.00	1.00
PULSES	1.00	1.00	1.00
OIL	2.00	3.00	1.00
CASH	5.00	1.00	4.00

Table 5.4 Final Cluster Centers

	Cluster		
	I	II	III
CEREALS	4.14	3.67	1.40
PULSES	1.29	1.00	1.60
OIL	1.29	2.33	1.40
CASH	4.14	1.33	4.40

The cluster wise number of blocks are Cluster I: 7, Cluster II: 3 and Cluster III: 5.

Map 5.7 shows the different blocks that form these clusters. By the pattern of change in the cropping pattern we find that Cluster I comprising of Harishchandrapur II, Chanchal

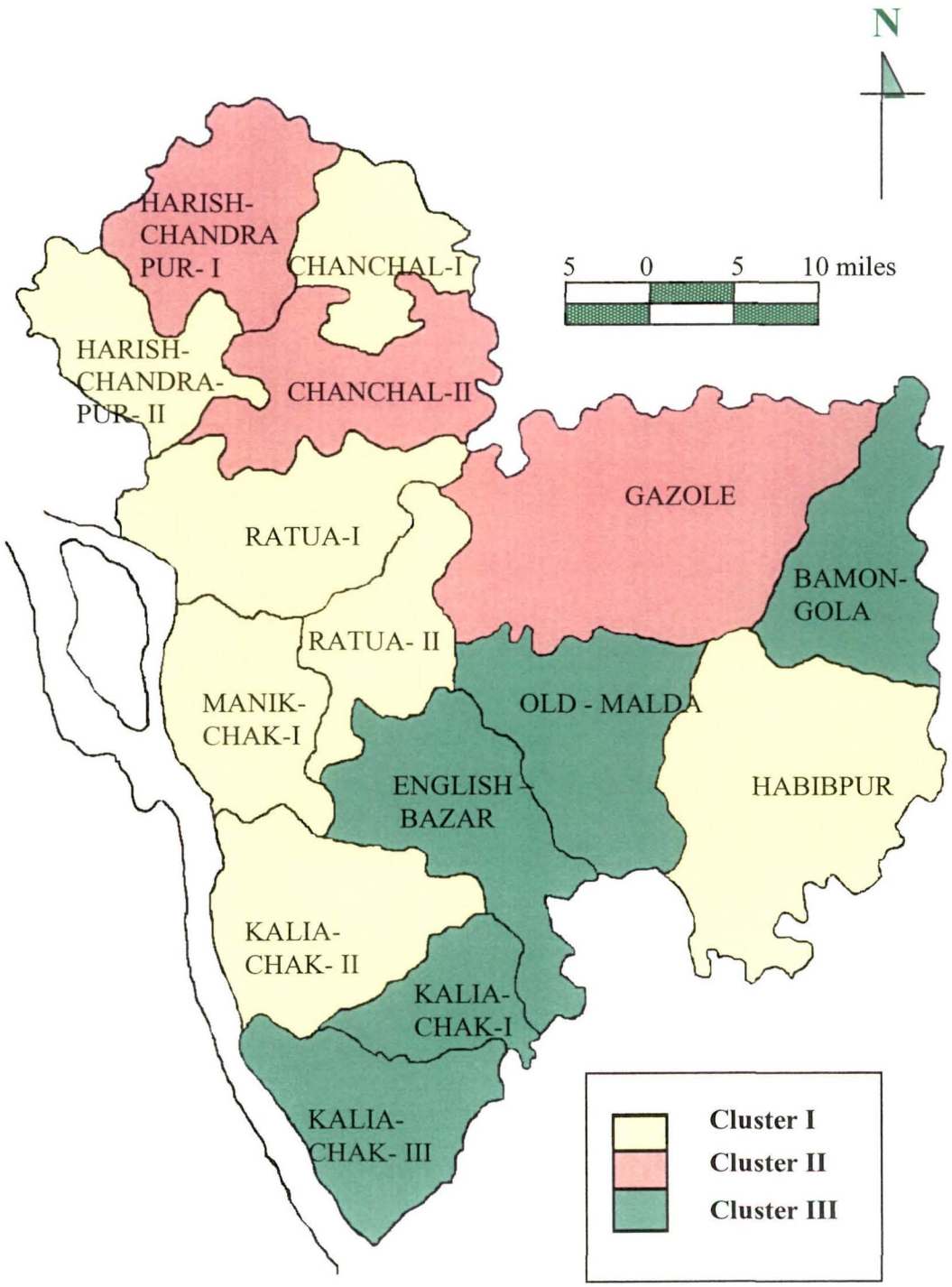
I, Ratua I, Ratua II, Habibpur, Manikchak, Kaliachak I shows spectacular growth in area under cereals and cash crops cultivation while a severe decline in pulses and oil seeds cultivation. The inference that can be drawn from this shift is that in these blocks there is a reallocation of cultivable area happening.

For cluster II the blocks Harischandrapur-I, Chanchal-II and Gazole shows a similar pattern of change. Herein the area under cultivation for pulses and cash crops have declined severely while for oilseeds there is a marginal decline. Area under cereal cultivation has moderately increased in these blocks.

Cluster-III comprising of Bamongola, Old-Malda, English Bazar, Kaliachak-II and Kaliachak-III shows a different pattern of change from the previous clusters in terms of change in area under cereal cultivation. Herein there is a decline for area under cereal cultivation. For oilseeds and pulses too there is a decline noticed in this cluster. It is the cash crop which has significant increased its area in this cluster.

Map No: 5.7

CHANGING CROPPING PATTERN: CLUSTERS IN MALDA



c) Growth Trend Analysis

This section attempts to illustrate the trend of area under each crop over the period. The following figures show the area under each crop group for the individual blocks (Fig 5.1 for cereals, Fig 5.2 for pulses, Fig 5.3 for oil-seeds and Fig 5.4 for cash crops). Fig 5.5 shows the trend for each region viz. Tal, Barind and Diara. The trend for each cluster formed in the previous section is shown in Fig 5.6. We then show the trend of the crop groups in Malda district as a whole in Fig 5.7.

To facilitate comparison across blocks and then across regions we have considered the area under each crop group as a percentage of total geographical area of the particular block or region. Please note that the percentage for certain crop groups in the figures are greater than hundred percent in certain years. This happens as the analysis is done on crop group basis and not at individual crop level i.e. multiple cropping is possible.

Fig 5.1 Trend of Area Under Cereal Cultivation: Block Wise (1993-94 to 2000-01)

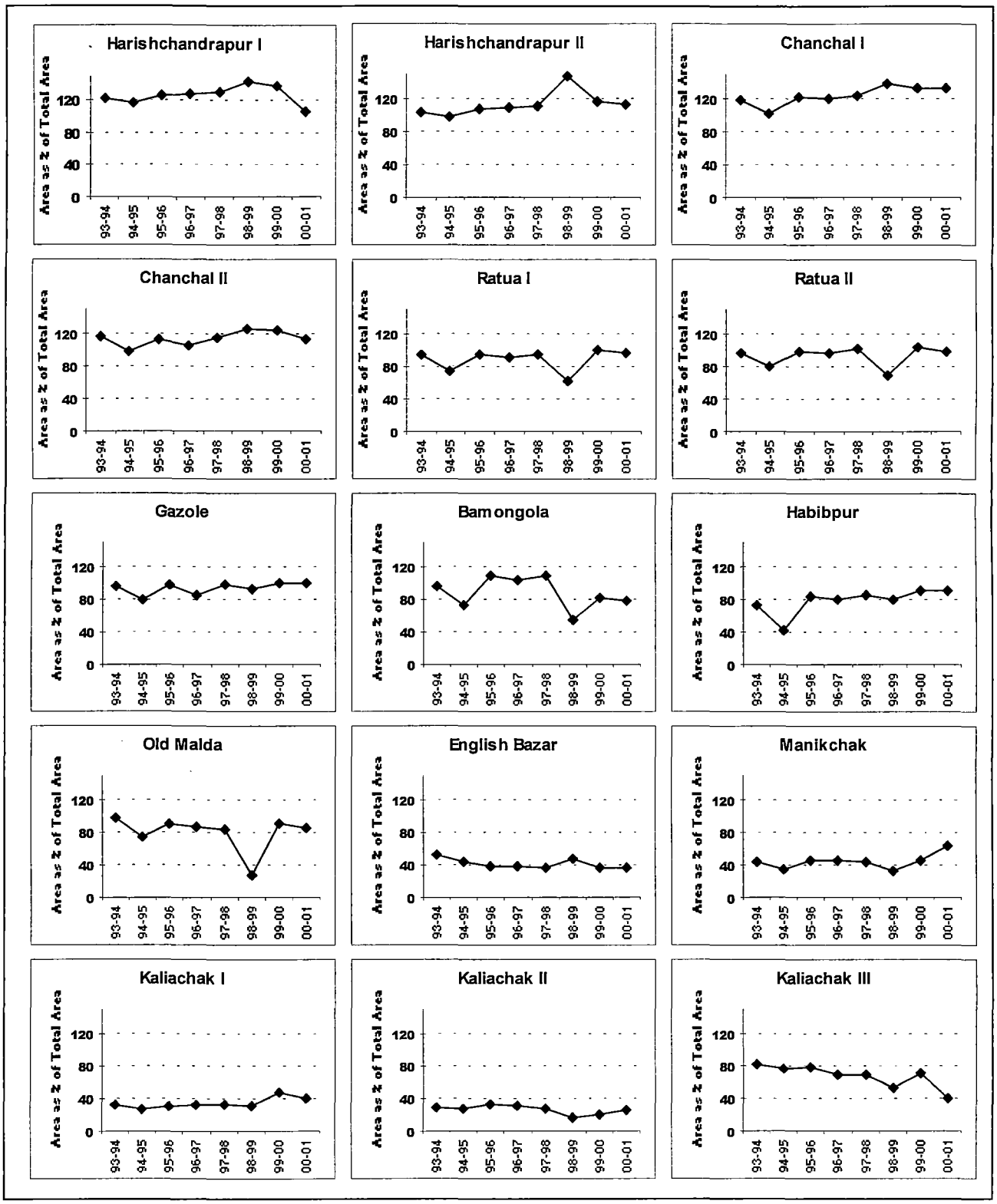


Fig 5.2 Trend of Area Under Pulses Cultivation: Block Wise (1993-94 to 2000-01)

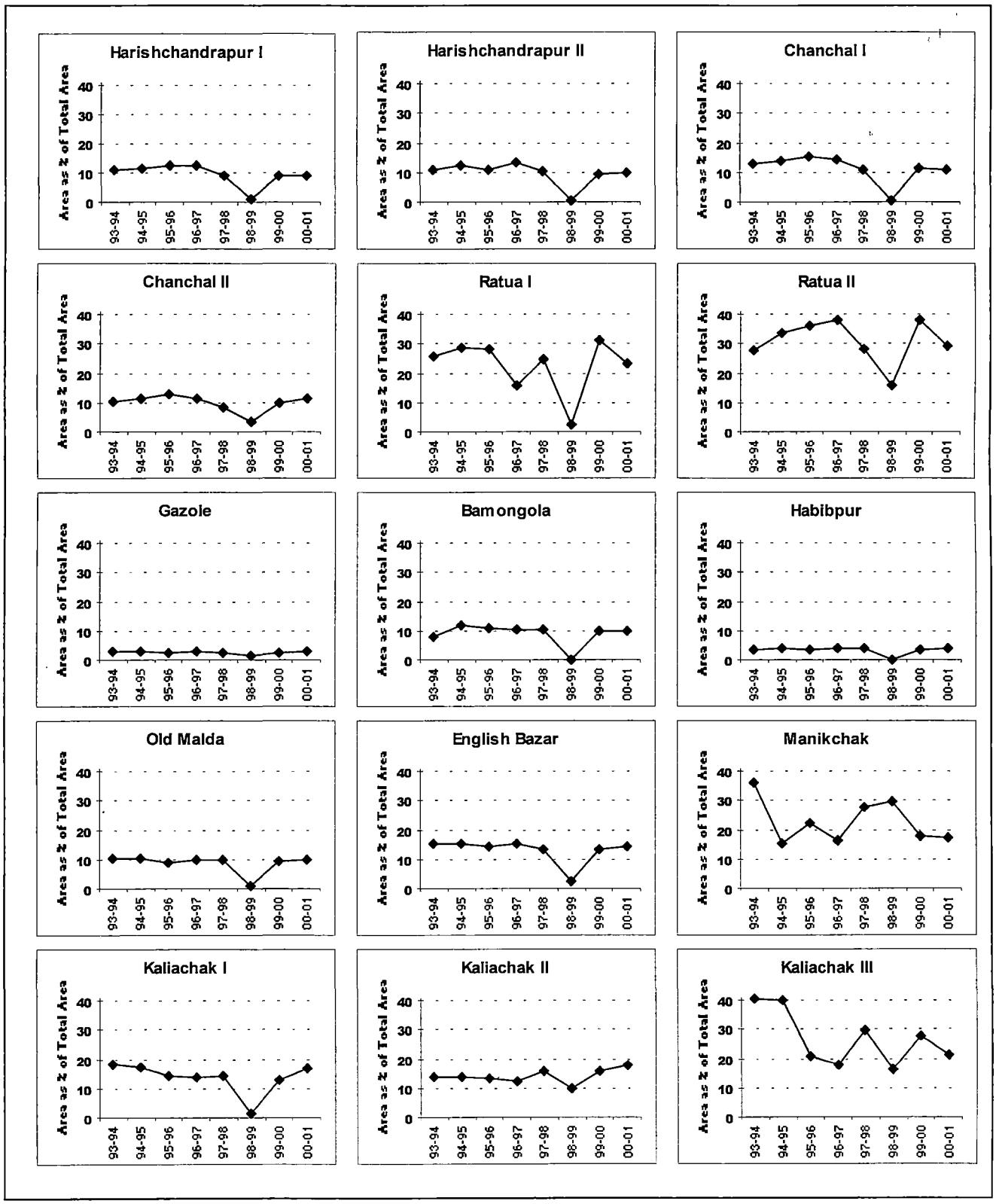


Fig 5.3 Trend of Area Under Oil Seed Cultivation: Block Wise (1993-94 to 2000-01)

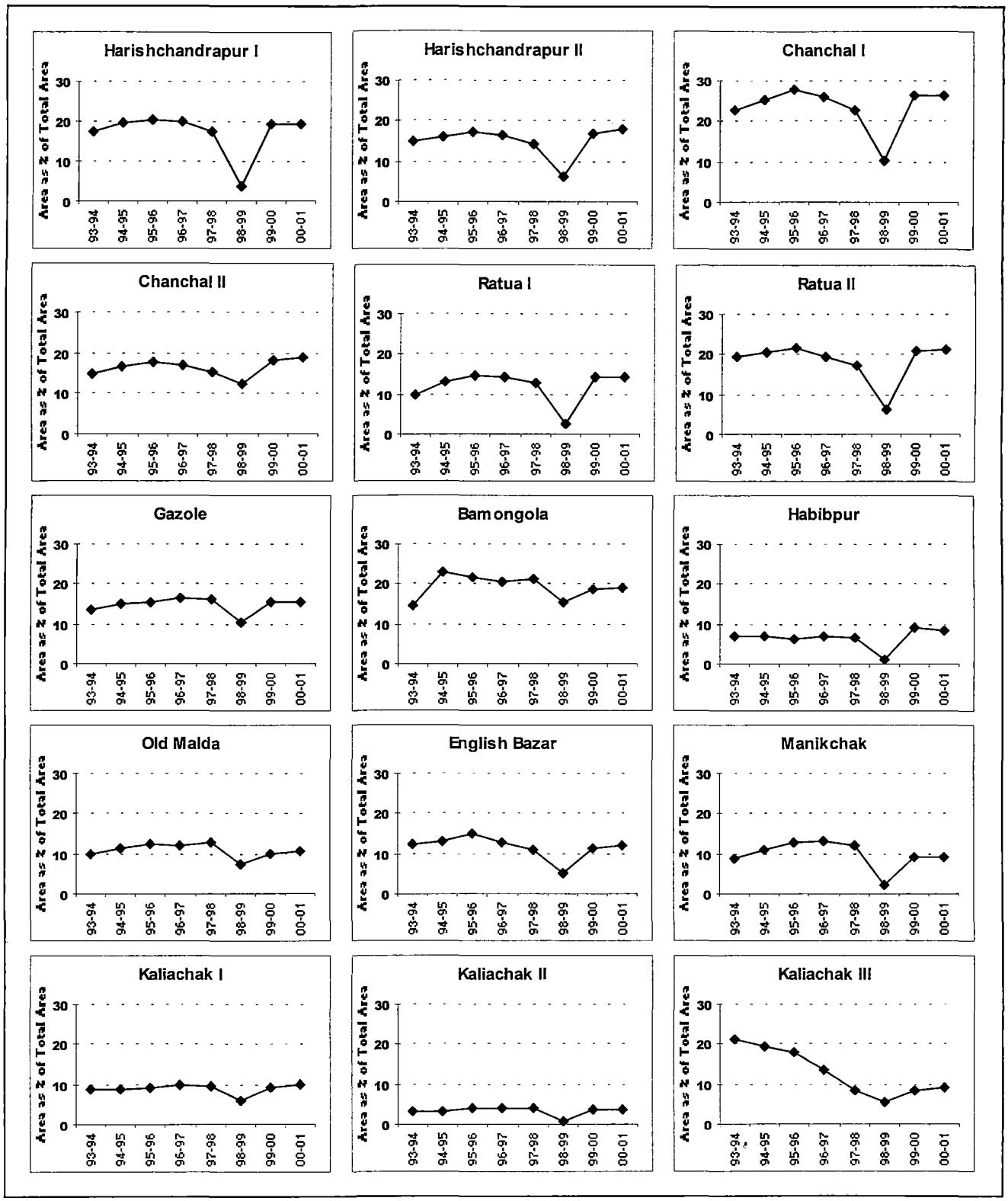


Fig 5.4 Trend of Area Under Cash Crop Cultivation: Block Wise (1993-94 to 2000-01)

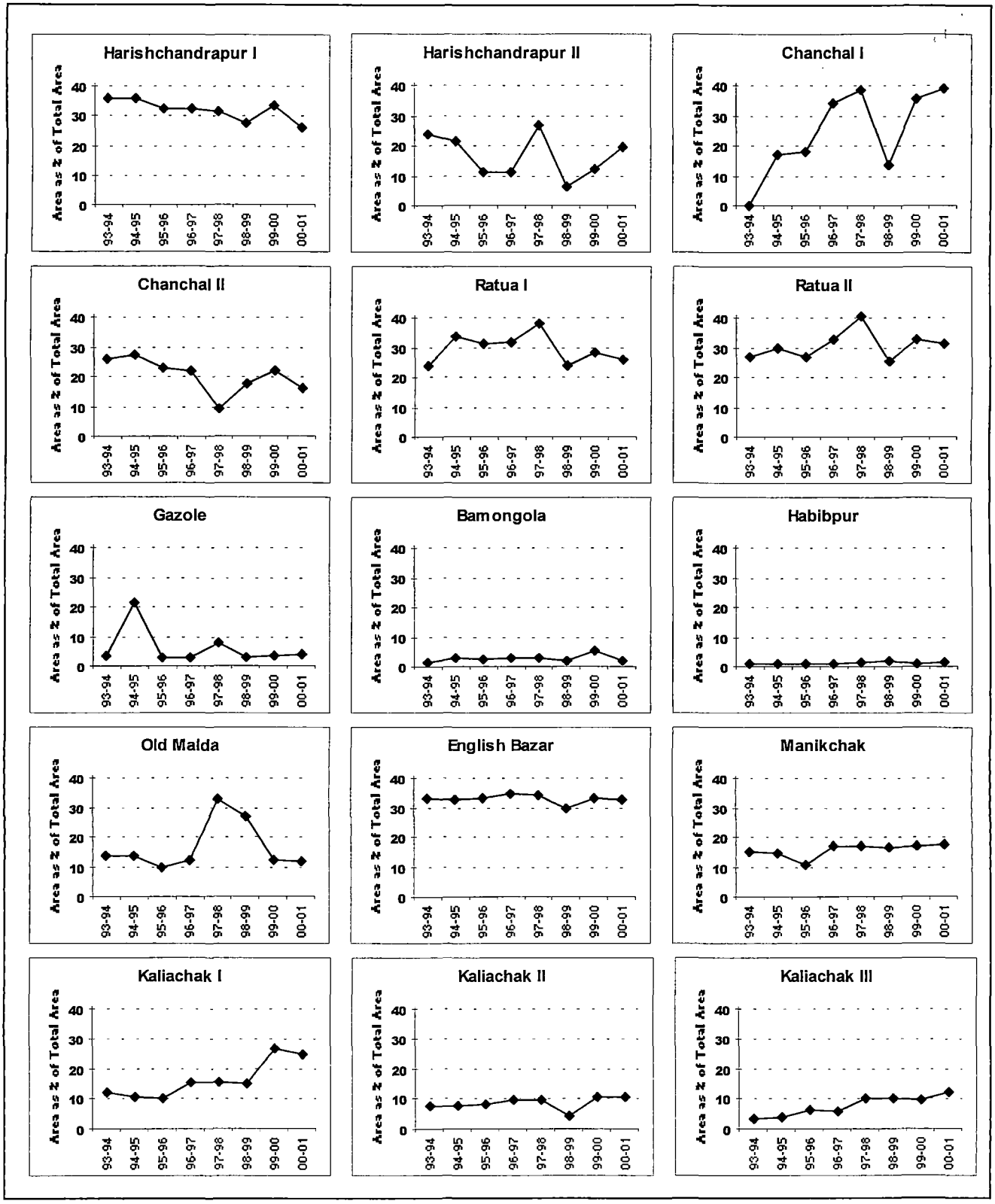
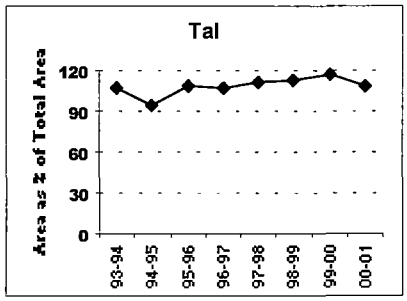
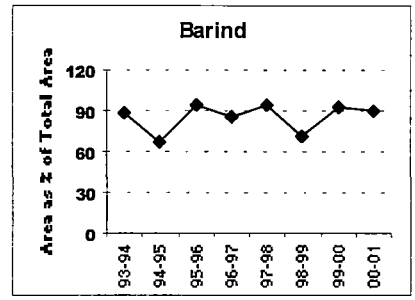
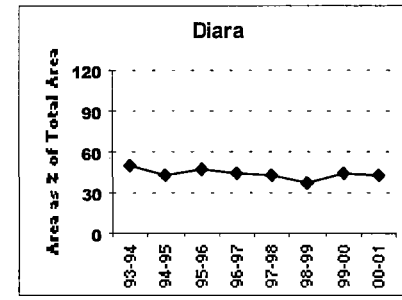


Fig 5.5 Trend of Area Under Cultivation: Region Wise (1993-94 to 2000-01)

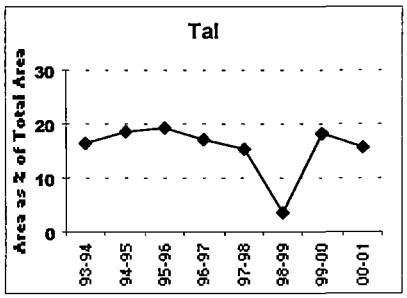
Cereals

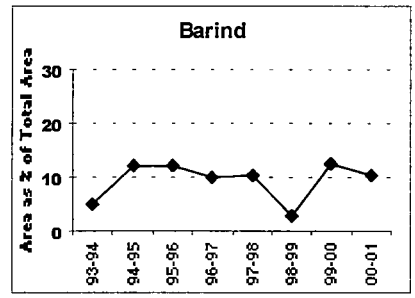


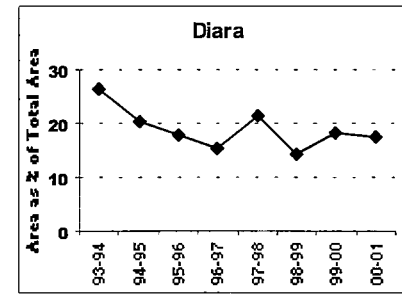




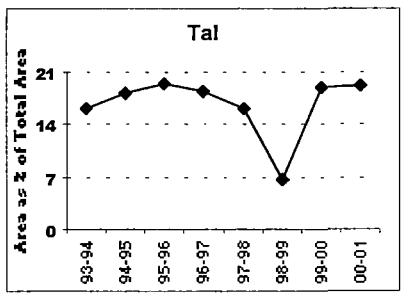
Pulses

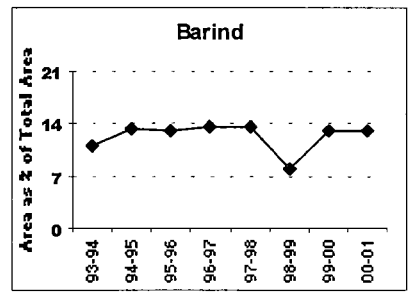


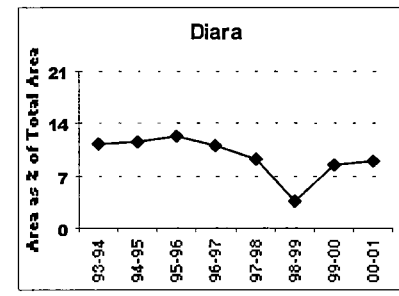




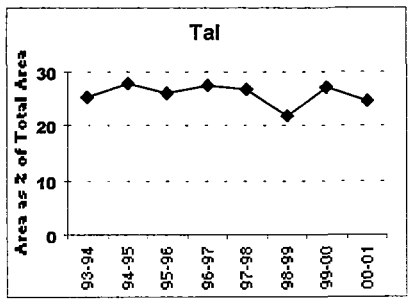
Oil Seeds

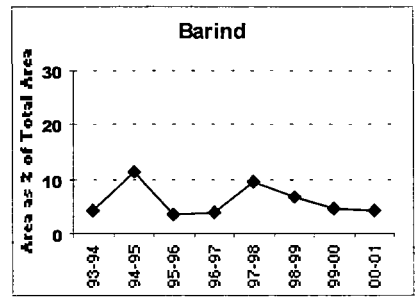






Cash Crops





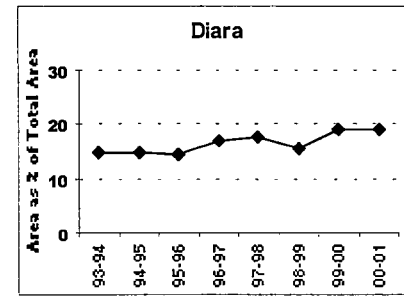
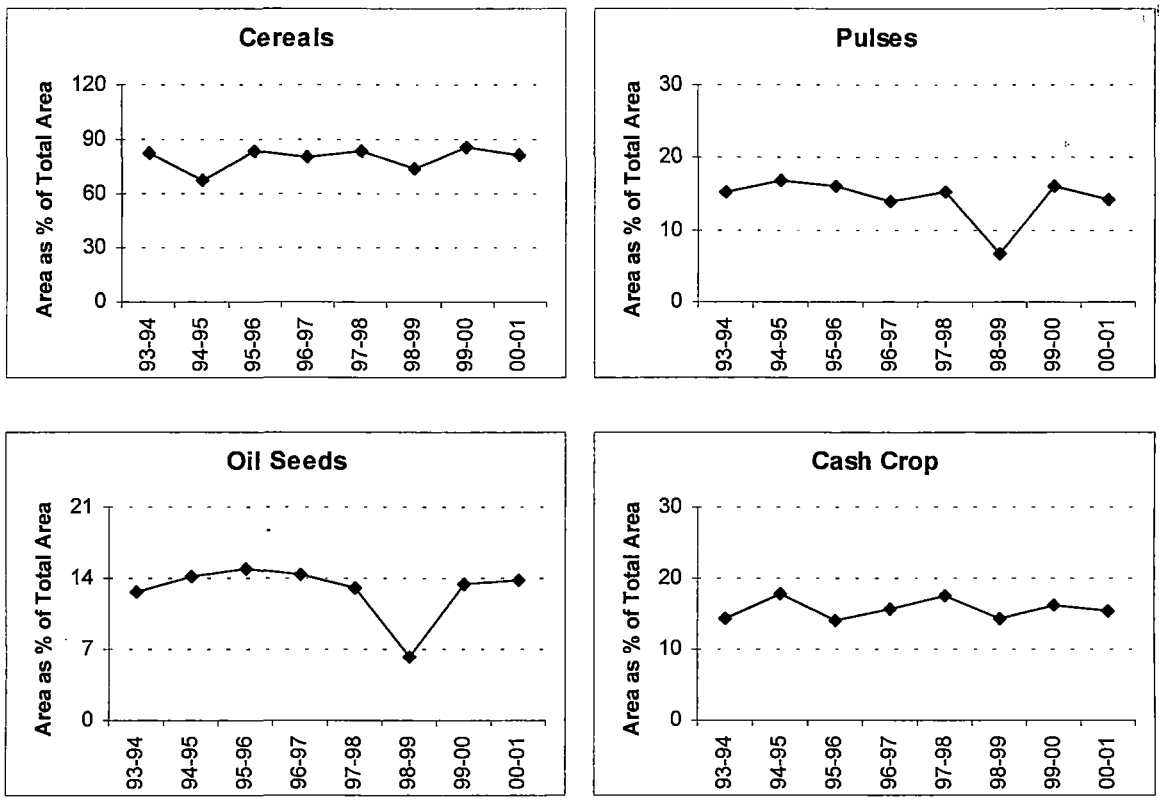


Fig 5.6 Trend of Area Under Cultivation: Malda (1993-94 to 2000-01)



After analyzing the spatial pattern of various crop groups and illustrating the trend of area under cultivation for each crop groups we have found that cash crops have gained area under cultivation during the period. But the analysis was unable to estimate whether the rise or decline is statistically significant. Moreover, it failed to identify the crop in particular which has affected the shift. To overcome this and to identify the dragging and lagging crops at the region level we analyzed the growth trends. This section analyses the trends in growth rates over the period 1993-94 to 2000-01 for the major crops of Malda District

Methodology:

Time series data for 8 years (1993-94 to 2000-01) of major crops of Malda viz. aus, aman, boro, wheat, arhar, kalai. gram, lentil, mustard, linseed, potato, mango, jute are used in this analysis

The exponential function $Y=AB^t$ was fitted to the data to compute the compound growth rates. Compound growth rate (r) =(Antilog b) 1* 100. The compound growth rates were tested for their significance by the students 't' test.

Similar studies for the calculation of growth trend use indexing of the actual area. In our case this is not required as the problem arising due to use different unit of measurement is not applicable here.

The co-efficient (eg. 0.056) given in the tables to explain trend growth can be interpreted as 5.6 compounded annual growth.

Result discussion:

In the following paragraphs we discuss the trend of area under cultivation for four crop groups. The analysis for Malda and its three regions reveals some interesting trends.

Cereal: There is no significant fixed pattern emerging for area under cultivation of cereals in Malda (Table 5.5). But the decline of 13.7 percent is significant for aus. For boro a significant growth of 5.5 percent is observed over the same period. For aman,

which happens to command, maximum area under cultivation in the district though shows a slight increase in the area under cultivation but the growth rate is not significant. In contrast wheat's minor decline is also not significant over the period.

When these growth rates are analyzed across region we find the decline of aus to be most prominent in Diara and Barind region, and comparatively low in Tal. For aman the general trend is of growth but the growth of 1.8 percent in Tal is significant. For boro the growth rates of 6.3 and 9.3 percent for Tal and Diara respectively are significant.

Table 5.5 Growth trend of cereals in Malda: Region wise (1993-94 to 2000-01)

		Tal	Barind	Diara	Malda
AUS	co-eff	-0.099	-0.122	-0.177	-0.137
	t-stat	-1.6	-2.5	-4.6	-4.4
Aman	co-eff	0.018	0.018	-0.049	0.017
	t-stat	2.2	0.7	-0.3	0.9
Boro	co-eff	0.063	0.011	0.093	0.055
	t-stat	3.6	0.7	4.2	8.5
Wheat	co-eff	-0.028	0.046	-0.019	-0.010
	t-stat	-1.4	1.8	-0.8	-0.6

PS: shaded co-efficients are significant at 5% level of confidence

The growth rates for wheat over the period across region are found to be insignificant.

Pulses: The growth rates for area under cultivation for pulses are found to be insignificant for Malda as a district (Table 5.6). For individual crops viz. arhar, kalai, gram and lentil the growth rates are insignificant either. Though insignificant but there is an overall general decline of pulses cultivation in Malda district. Region wise analysis shows significant decline of only arhar in Diara region (26.0 percent) and kalai in Barind region (8.7 percent). A decline is noticed for individual crops across region but none of the decline rates are significant.

Table 5.6 Growth trend of pulses in Malda: Region wise (1993-94 to 2000-01)

		Tal	Barind	Diara	Malda
Arhar	co-eff	-0.200	-0.260	-0.260	-0.219
	t-stat	-0.8	-1.1	-3.3	-1.9
Kalai	co-eff	-0.028	-0.087	-0.030	-0.033
	t-stat	-0.5	-3.1	-0.3	-0.7
Gram	co-eff	-0.133	-0.134	-0.062	-0.088
	t-stat	-1.1	-0.6	-0.8	-0.9
Lentil	co-eff	-0.046	0.014	-0.012	-0.014
	t-stat	-0.4	0.1	-0.5	-0.2

PS: shaded co-efficients are significant at 5% level of confidence

Oilseeds: The general trend for the area under cultivation for oilseeds is of decline in the district in the given period (Table 5.7). This trend is seen across the regions. But the decline is not significant at individual region level. When we individually consider the two crops viz. 'Mustard' and 'Linseed' we notice a similar declining trend. Again the drop is not significant for the individual regions for Mustard. The analysis does not improve for the Linseed at region level.

Table 5.7 Growth trend of oilseed in Malda: Region wise (1993-94 to 2000-01)

		Tal	Barind	Diara	Malda
Mustard	co-efficient	-0.015	0.004	-0.074	-0.021
	t-stat	-0.3	0.1	-1.4	-0.5
Linseed	co-efficient	-0.110	-0.147	-0.285	-0.146
	t-stat	-0.7	-0.8	-1.5	-0.9

PS: shaded co-efficients are significant at 5% level of confidence

Cash crops: For the district as a whole no definite trend emerges for the cash crop during the 1993-94 to 2000-01 (Table 5.8). When we consider the crops individually for the district as a whole, the analysis throws significant growth (1.7 percent) for Mango. The change over the period is insignificant and negligible for Jute and Potato. But considering the crops individually for the region throws some interesting facts. For Jute the growth trend is opposite for Tal and Diara region. For Tal the decline (2.8 percent) is significant; but for Diara the scenario is just opposite with a significant growth (14.3 percent).

Though we get significant growth for Mango at the district level but the growth rates at region level is not significant.

Table 5.8 Growth trend of Cash Crop in Malda: Region wise (1993-94 to 2000-01)

		Tal	Barind	Diara	Malda
Potato	co-efficient	-0.016	0.019	-0.044	0.000
	t-stat	-0.1	0.8	-0.7	0.0
Mango	co-efficient	0.003	0.052	0.014	0.017
	t-stat	1.1	1.0	1.3	4.5
Jute	co-efficient	-0.028	-0.093	0.143	-0.015
	t-stat	-2.4	-0.5	3.3	-0.5

PS: shaded co-efficients are significant at 5% level of confidence

The above analysis is based on the regions defined by the physiographic divisions but as in this chapter we have developed clusters based on the changing pattern of area under different crop groups we now analyse the significance of such change in these clusters. The methodology applied is similar to the growth trend analysis for the regions, which we have just discussed.

The following tables (Table 5.9 to Table 5.12) show the growth trend for area under individual crops for the individual clusters.

Table 5.9 Growth Trend of Cereals in Malda: Cluster wise (1993-94 to 2000-01)

		Cluster I	Cluster II	Cluster III	Malda
AUS	co-eff	-0.093	-0.145	-0.182	-0.137
	t-stat	-1.9	-2.2	-4.8	-4.4
Aman	co-eff	0.041	0.019	-0.050	0.017
	t-stat	1.9	1.4	-0.7	0.9
Boro	co-eff	0.073	0.057	0.015	0.055
	t-stat	8.0	3.7	0.9	8.5
Wheat	co-eff	0.014	-0.024	-0.043	-0.010
	t-stat	0.9	-0.8	-1.8	-0.6

PS: shaded co-efficients are significant at 5% level of confidence

Table 5.10 Growth Trend of Pulses in Malda: Cluster wise (1993-94 to 2000-01)

		Cluster I	Cluster II	Cluster III	Malda
Arhar	co-eff	-0.112	-0.183	-0.355	-0.219
	t-stat	-1.5	-1.3	-1.8	-1.9
Kalai	co-eff	-0.026	-0.033	-0.057	-0.033
	t-stat	-0.5	-0.5	-0.5	-0.7
Gram	co-eff	-0.118	-0.194	-0.052	-0.088
	t-stat	-0.9	-1.0	-0.7	-0.9
Lentil	co-eff	-0.043	-0.108	-0.009	-0.014
	t-stat	-0.4	-0.5	-0.4	-0.2

PS: shaded co-efficients are significant at 5% level of confidence

Table 5.11 Growth Trend of oilseed in Malda: Cluster wise (1993-94 to 2000-01)

		Cluster I	Cluster II	Cluster III	Malda
Mustard	co-efficient	-0.023	0.001	-0.048	-0.021
	t-stat	-0.4	0.0	-1.8	-0.5
Linseed	co-efficient	-0.121	-0.138	-0.195	-0.146
	t-stat	-0.8	-0.8	-1.1	-0.9

PS: shaded co-efficients are significant at 5% level of confidence

Table 5.12 Growth Trend of Cash Crop in Malda: Cluster wise (1993-94 to 2000-01)

		Cluster I	Cluster II	Cluster III	Malda
Potato	co-efficient	-0.007	-0.011	0.006	0.000
	t-stat	-0.1	-0.2	0.2	0.0
Mango	co-efficient	0.020	0.009	0.014	0.017
	t-stat	4.6	2.2	3.5	4.5
Jute	co-efficient	0.023	-0.100	0.106	-0.015
	t-stat	1.1	-2.4	1.5	-0.5

PS: shaded co-efficients are significant at 5% level of confidence

From the above tables we find that the growth trends do not turn significant for individual crops even when we do the analysis at cluster level. This is because the clusters have been formed using crop group data and not individual crops. We now attempt to analyze the growth trend for the clusters using crop group data. Table 5.13 shows the growth trend and the significance level of each crop group for the clusters.

Table 5.13 Growth trend of crop groups in Malda: Cluster wise (1993-94 to 2000-01)

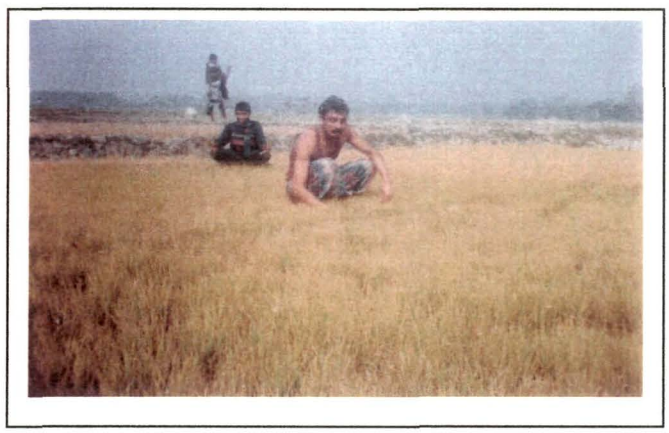
		Cluster I	Cluster II	Cluster III	Malda
Cereals	co-eff	0.032	0.012	-0.045	0.008
	t-stat	2.2	1.2	-1.8	0.6
Pulse	co-eff	-0.045	-0.066	-0.055	-0.038
	t-stat	-1.2	-0.9	-1.0	-0.8
Oil Seed	co-efficient	-0.023	0.001	-0.048	-0.029
	t-stat	-0.4	0.0	-1.8	-0.6
Cash crop	co-efficient	0.023	-0.071	0.031	0.002
	t-stat	1.7	-2.1	1.8	0.2

PS: shaded co-efficients are significant at 5% level of confidence

In the above table too we do not find significant growth trend of the crop groups for the clusters. We had expected that the growth trend will be more significant when we use the crop group level data for the clusters but our hypothesis that 'the trend of area under different crop cultivation is similar to the pattern of change among these blocks' is negated as the clusters are formed with blocks which shows similar pattern of change over two periods Period I (1993-94 to 1996-97) and Period II (1997-98 to 2000-01) for all crop groups taken together and not on individual crop groups.

Thus to conclude this section we find that there is general tendency of decline in area under various crops. It is aman, boro and mango whose area under cultivation is on the rise. The drop in area of pulses and oil seeds needs to be considered by the policy makers seriously as this goes against the theory that with modernization in agriculture, multiple cropping is more prevalent resulting in general rise of net area cropped and farmers tend to reduce area under cereals to produce more of varied crops. One can raise the point that with progress in agriculture the productivity increases so in the district with lower area under various crops the production is not affected and moreover with urbanisation and land being used for other purposes the area under cultivation for various crops are on the fall. We are not in a position to defend this or refute this idea now. For this we will analyze the growth trend of yield and production in following chapters.

5.1 Paddy Cultivation



Seedling

Sowing

5.2 Types of Crop

Wheat

Mustard

Potato

5.3 Mango Plantation

'Kalam'

Young tree

Orchard

5.4 Jute Cultivation

d. Crop Combination Region:

Crop combination analysis is defined as the geographical investigation of agriculture, which purports to select various crops to be studied collectively in an area. It is a method of analysis, first developed by J.C,Weaver, for delimiting agricultural regions on the basis of multi crop pattern.

There are mainly two techniques with which we can establish crop combination, viz. semi-statistical and statistical. The former is subjective as the patterns of crop combination are established arbitrarily, whereas the later is objective where the patterns of crop combination is established by reckoning the least deviation of the actual crop percentages from the theoretical distribution.

The semi-statistical technique is very simple and does not require any complicated calculations. Being an arbitrary choice technique there is every chance of repetition in presentation and interpretation of crop combination.

The statistical technique is more accurate, scientific and popular than the semi-statistical one for establishing crop combinations. Moreover this approach has wider applicability and has the capacity to handle the strongly developed cropping diversity or even agricultural rediversification in an area.

Weaver's method consist of comparing the actual percentages of the cropped area occupied by the different field crops with theoretical distributions in which the cropped area is equally divided among the component crops in an enumeration unit. The purpose of the procedure is to establish and designate crop combinations which are established by the most closed resemblance in the actual crop percentages and the theoretical distributions. The ideal theoretical distributions are explicitly out lined in Table No 5.14 as a basis to determine the identity and number of crops involved in the basic crop combination in the sub-clusters.

Now the problem is to accurately compare the actual percentages with in the individual regional units with the theoretical distribution as given in Table No-5.14. The variance

and standard deviation formulae were selected for this purpose and these may be stated as follows:

1. Variance = $\frac{\sum d^2}{n}$

2. Standard Deviation= $\sqrt{\frac{\sum d^2}{n}}$

Where d is the difference between the actual crop percentages in a given regional unit and the percentages in the theoretical distributions and n is the number of crops in a given combination.

Table 5.14 Theoretical distribution of cropped area

Monoculture = 1 crop accounts for 100.0% of total cropped area
2 crop combination = each crop 50.0%
3 crop combination = each crop 33.3%
4 crop combination = each crop 25.0%
5 crop combination = each crop 20.0%
6 crop combination = each crop 16.7%
7 crop combination = each crop 14.3%
8 crop combination = each crop 12.5%
9 crop combination = each crop 11.1%

The least sum of squared deviations and variance and lowest standard deviation and co-efficient of variation analysis for cropping in the Malda district for the year 1993-94 to 2000-01 is indicative of the magnitude of deviation of the actual percentage from the theoretical distributions (Table- 5.15). The sum of the squared deviation is the lowest for 5 crop combination, the coefficient of variation is least for 4 crop combination, and the variance and the standard deviation do not reported the lowest even upto a 9 crop combination which includes even minor crops like lentil sharing only 3.5 percent of the total cropped area. The share of the 10th ranking crop when placed against the 1st ranking crop that is aman is considerably small. Therefore it suggested that either the sum of the squared deviations or coefficient of variation analysis should be used for the identification of the desired combination. The computation established both the identity and the number of crops in the ranked combination for the district as aman, boro, wheat, mustard and jute i.e. 5 crops: Am, B, W, Mu & J and 4 crops: Am, B, W & Mu.

Table 5.15 Analysis of Crop Combination for Malda district, (1993-94 to 2000-01)

Crop combination	Mono Culture	2 Crops		3 Crops			4 Crops				5 crops				
Crop Ranking	1	1	2	1	2	3	1	2	3	4	1	2	3	4	5
Crops	Aman	Aman	Boro	Aman	Boro	Wheat	Aman	Boro	Wheat	Mustard	Aman	Boro	Wheat	Mustard	Jute
Actual % of total Cropped Area	33.9	33.9	14.4	33.9	14.4	11.9	33.9	14.4	11.9	9.5	33.9	14.4	11.9	9.5	5.8
Theoretical Distribution of Crops in %	100.0	50.0	50.0	33.3	33.3	33.3	25.0	25.0	25.0	25.0	20.0	20.0	20.0	20.0	20.0
Deviation of Actual % from theoretical distributions (d)	66.1	16.1	35.6	0.5	18.9	21.4	8.9	10.6	13.1	15.5	13.9	5.6	8.1	10.5	14.2
(d^2)	4373.4	260.2	1268.1	0.3	358.9	458.6	78.6	112.6	171.1	241.0	192.3	31.5	65.3	110.8	202.8
$(\sum d^2)$	4373.4	1528.3		817.8			603.4				**602.7**				
Variance = $\frac{\sum d^2}{n}$	4373.4	764.17		272.6			150.85				120.55				
SD (σ) = $\sqrt{\frac{\sum d^2}{n}}$	66.132	27.644		16.511			12.282				10.979				
Co-efficient of Variation	66.132	55.287		49.532			**49.128**				54.897				

contd.

Table 5.15 contd.

Crop combination	6 crops						7 Crops						
Crop Ranking	1	2	3	4	5	6	1	2	3	4	5	6	7
Crops	Aman	Boro	Wheat	Mustard	Jute	Mango	Aman	Boro	Wheat	Mustard	Jute	Mango	Aus
Actual % of total Cropped Area	33.9	14.4	11.9	9.5	5.8	5.2	33.9	14.4	11.9	9.5	5.8	5.2	4.9
Theoretical Distribution of Crops in %	16.7	16.7	16.7	16.7	16.7	16.7	14.3	14.3	14.3	14.3	14.3	14.3	14.3
Deviation of Actual % from theoretical distributions (d)	17.2	2.3	4.7	7.2	10.9	11.5	19.6	0.1	2.4	4.8	8.5	9.1	9.4
(d^2)	295.9	5.2	22.6	51.7	119.0	131.4	383.5	0.0	5.6	23.1	72.7	82.5	87.9
$(\sum d^2)$	625.7						655.3						
Variance = $\frac{\sum d^2}{n}$	104.29						93.621						
SD (σ) = $\sqrt{\frac{\sum d^2}{n}}$	10.212						9.6758						
Co-efficient of Variation	61.272						67.73						

contd.

Table 5.15 contd.

Crop combination	8 Crops								9 Crops								
Crop Ranking	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	9
Crops	Aman	Boro	Wheat	Mustard	Jute	Mango	Aus	Gram	Aman	Boro	Wheat	Mustard	Jute	Mango	Aus	gram	lentil
Actual % of total Cropped Area	33.9	14.4	11.9	9.5	5.8	5.2	4.9	3.6	33.9	14.4	11.9	9.5	5.8	5.2	4.9	3.6	3.5
Theoretical Distribution of Crops in %	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.1
Deviation of Actual % from theoretical distributions (d)	21.4	1.9	0.6	3.0	6.7	7.3	7.6	8.9	22.8	3.3	0.8	1.6	5.4	5.9	6.2	7.5	7.6
(d^2)	456.6	3.6	0.3	9.1	45.5	53.2	57.6	79.7	517.9	10.7	0.7	2.7	28.7	34.9	38.5	56.8	58.1
$(\sum d^2)$	705.7								748.9								
Variance = $\frac{\sum d^2}{n}$	88.209								83.207								
SD (σ) = $\sqrt{\frac{\sum d^2}{n}}$	9.392								9.1218								
Co-efficient of Variation	75.136								82.096								

Doi (1959), Thomas (1963), Coppock (1964), Jasbir Singh (1974) and many others have modified this technique involving the examination the examination of cropland occupancy by various crops with the help of standard statistical algorithm, namely the least squares. It has been observed that the technique of least deviation of actual percentages from the standard theoretical combination values is of little help for the identification of crop combination in the enumeration units where the regional share of several crops is quite close to one another; the least squares technique may be adopted as a substitute to overcome this difficulty. Besides, the actual percentages of crops at first or second rank may be much higher than the crops at the lower ranks in the computed crop combination; such variation with a significant magnitude in actual percentages is shown in the combination only in a ranked format without giving any weight to the percentage strength of each crop or without any regard as to ratio between crops in crop combination. Though the Weaver's technique is mathematically sound, it requires much calculation work. Furthermore Weaver (1954) himself admits that this technique occasionally trend to show the lowest deviation for a crop combination which includes even a crop occupying as much as one percent at the total harvested cropland. A modified form of Weaver's technique has been put forward by Doi (1959).

The modified format of Doi's technique solves the problem of Weavers technique simultaneously substituting the variance ($\frac{\sum d^2}{n}$) or least standard deviation ($\sqrt{\frac{\sum d^2}{n}}$) of Weaver with the sum of square deviations ($\sum d^2$). The combination having the lowest $\sum d^2$ will be the crop combination.

In Doi's technique it is not required to calculate $\sum d^2$ for each combination but the crop combination is actually established by consulting one sheet table (which presents critical values for various elements at different rank against cumulative percentage of elements at higher ranks; for an agricultural geographer elements here mean crops. The use of one sheet table requires only the summing up of actual

percentages under different crops instead of findings the differences between actual percentages and theoretical distributions.

All those crops are included in the combination whose cumulative percentage is less than 50; or the critical value for all the elements at different ranks against 50 is zero. Therefore, the cumulative percentage starts from above 50 percent, which is contributed by the higher ranks, may be first one, two, or three crops or so on. In Malda the first crop, aman occupies 33.87 percent. The next crop, boro, is included in the crop combination which makes the sum of the first two crops 48.26 percent (Table5.16).

Table 5.16 Crop wise % area & cumulative % cropped area for Malda. (1993-94 to 2000-01)

Crop	% Cropped Area	Cumulative % cropped area
Aman	33.87	33.87
Boro	14.39	48.26
Wheat	11.92	60.18
Mustard	9.48	69.65
Jute	5.76	75.41
Mango	5.21	80.61
Aus	4.91	85.52
Gram	3.57	89.09
Lentil	3.49	92.59
Kalai	2.91	95.50
Potato	1.79	97.29
Linseed	1.10	98.39
Arhar	0.00	98.39

Thus it is found that the district is 5-crop combination region for the period 1993-94 to 2000-01 using Doi's sum of least square method.

Table 5.16 shows the significance crops as shaded along with their percentage cropped area. It is found that 75.4 percent of the area is covered by these 5 crops. Jute with only 5.76 percent area of total cropped area gives an indication that the remaining crops are not that significant. For the period 1993-94 to 2000-2001, Map No 5.8 illustrates the crop combination for the blocks and Map No 5.9 for the regions. Map No-5.8 shows Habibpur

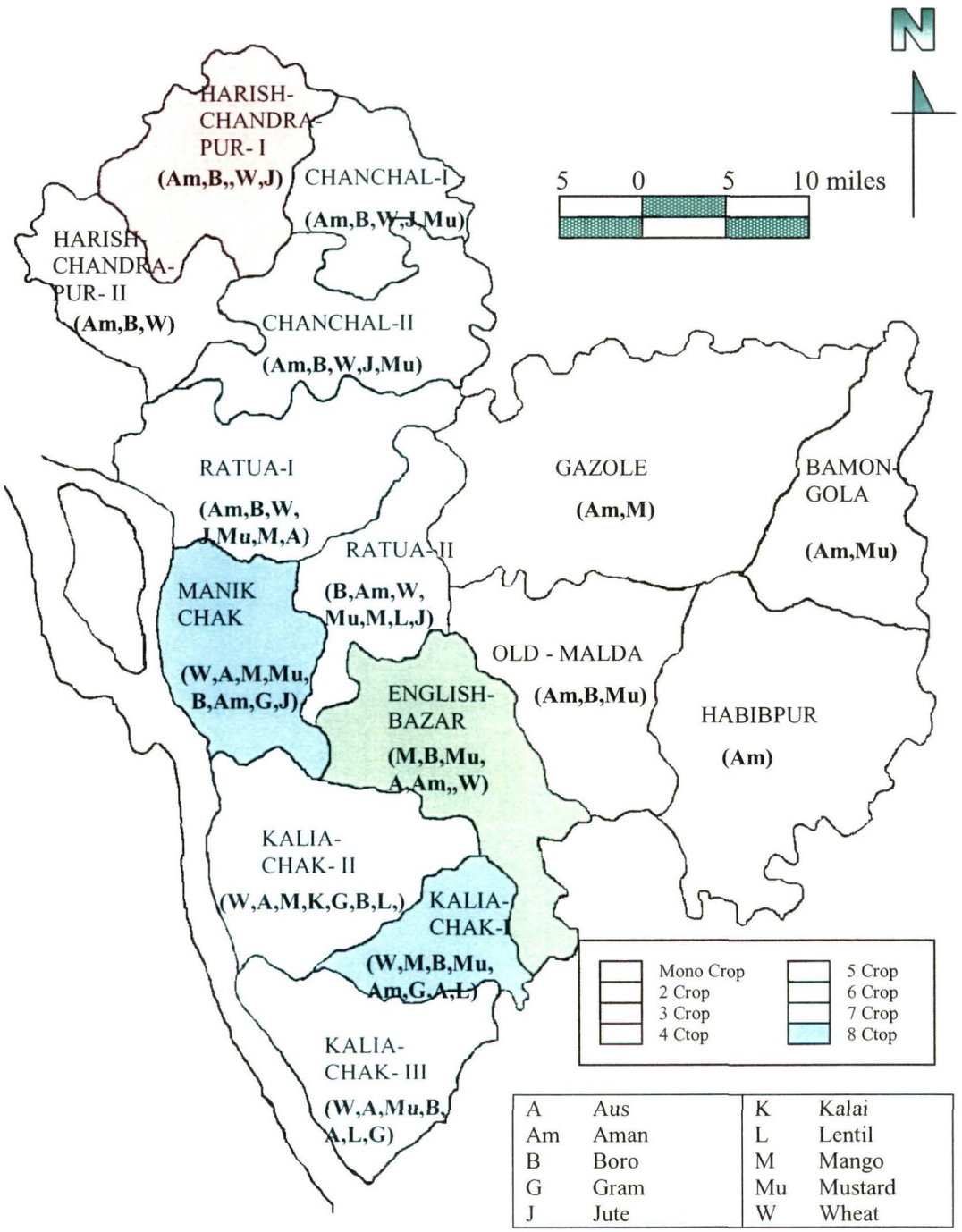
to be a mono cropped region. Gazole and Bamongola as 2 crop region, Harishchandrapur-II and Old Malda as 3 crop region, Harishchandrapur-I as 4 crop Chanchal-I and Chanchal-II as 5 crop region, English Bazar as 6 crop region, Ratua-I, Ratua-II, Kaliachak-II and Kaliachak-III as 7 crop region while Manikchak and Kaliachak-I as 8 crop region.

Map No-5.9, which analyses the cropping, pattern, for the regions, shows Tal as 5 Crop Region, Barind 3 crop region and Diara 8 crop region.

Thus we find that it is the less develop Barind region with poor irrigation facilities cannot adopt multiple cropping. In contrast Tal region has balanced between the *Kharif* and *Rabi* crops and are cultivating aman, jute in the summer months while boro, wheat, mustard in the winter months. Diara region has diversified further to have mango, gram and kalai along with wheat, aus, boro, mustard and aman as the major crops. This analysis shows that with proper irrigation facilities and a mix of food crop and cash crop, the crop combination can be made effective. This is likely to provide stability to the agricultural scenario of the district.

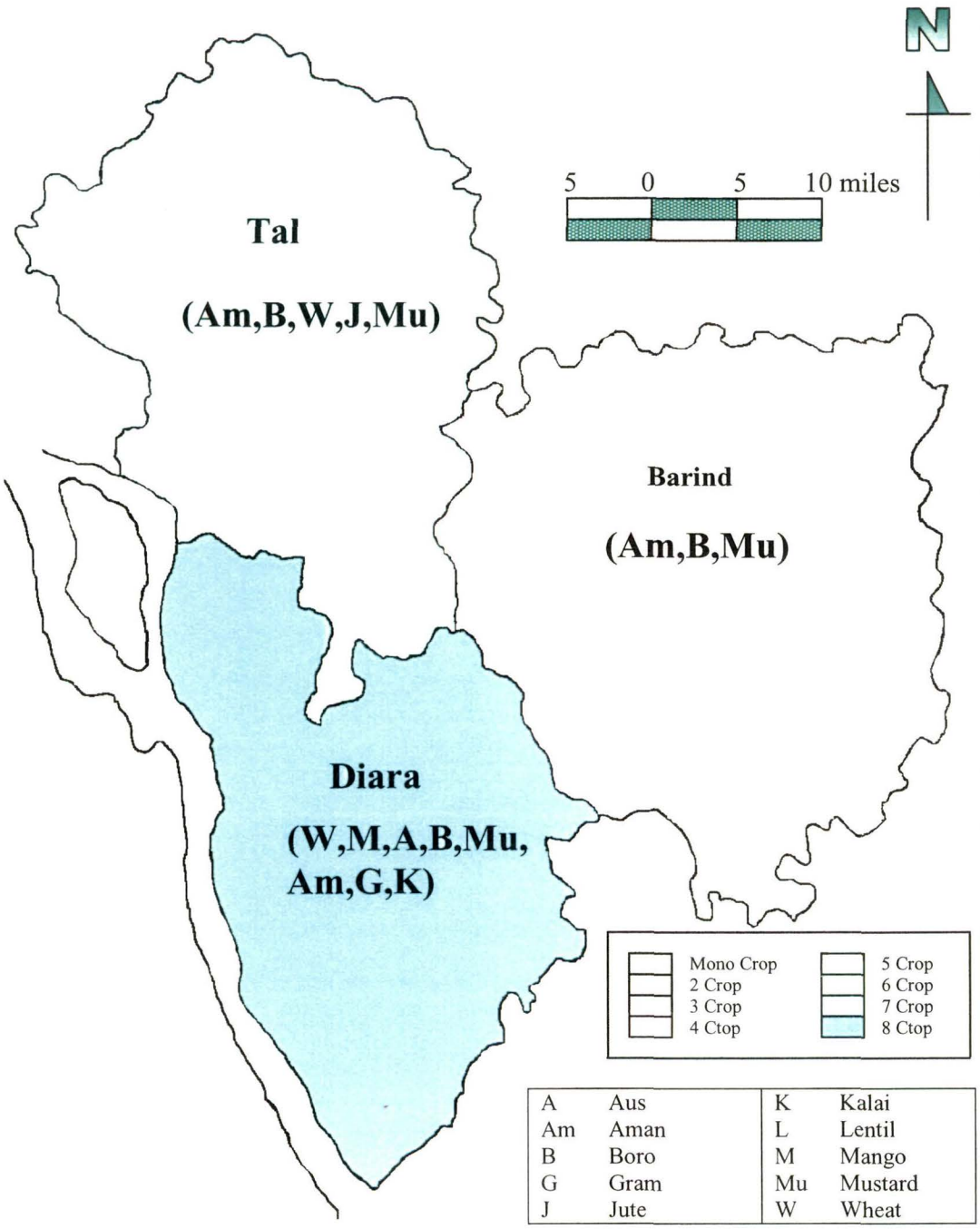
Map No: 5.8

PATTERN OF CROP COMBINATION IN MALDA: BLOCK WISE (93-94 to 00-01)



Map No: 5.9

PATTERN OF CROP COMBINATION IN MALDA: REGION WISE (93-94 to 00-01)



This analysis provides important information about the combination pattern in the district during the 90s but is unable to gauge the nature of change happening in the district. To gauge the change we divide the period 1993-94 to 2000-2001 into two sub periods: Period-I: 1993-94 to 1996-97 and Period-II: 1997-98 to 2000-2001. Similar crop combination analysis is then repeated for the two periods. The result of this analysis at block level is shown in Map-5.10 for Period-I and Map-5.11 for Period-II and at region level in Map 5.12 and Map- 5.13 for the Period-I and Period- II respectively.

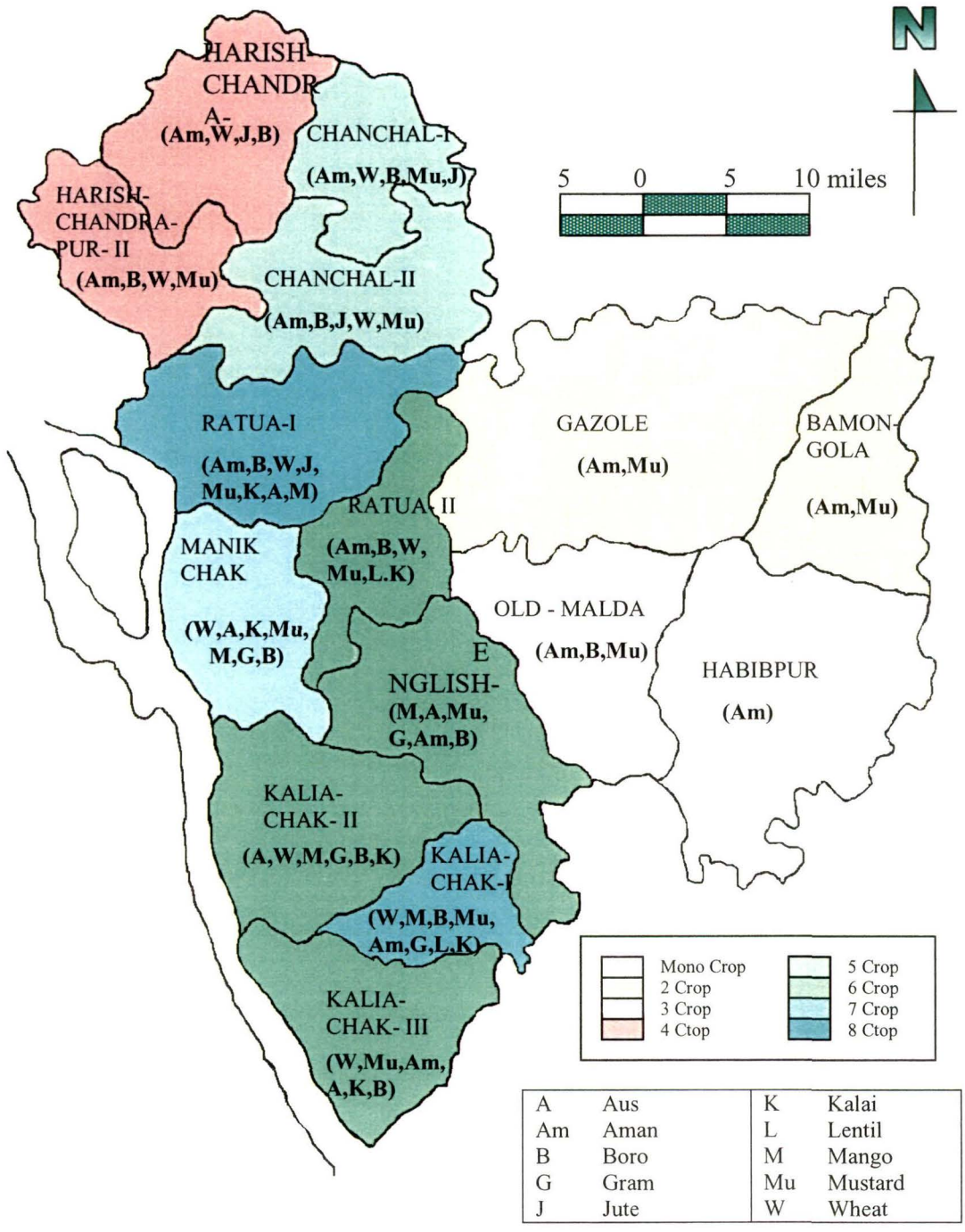
Thus Map-5.10 shows that during 1993-94 to 1996-97 while Habibpur was a mono crop region; Gazole and Bamongola are 2 crop region, Harishchandrapur-II and Old Malda have 3 crops; Harishchandrapur-I is the only 4-crop block, Chanchal-I and Chanchal-II are the 5-crop blocks; Ratua-II, English Bazar, Kaliachak-II and Kaliachak-III are 6 crops regions, Manikchak 7 crop region and Kaliachak-I as 8 crop region

During Period I, we find Manikchak and Kaliachak-II are the only two blocks of Malda where aman do not feature as the significant crop. Otherwise all other blocks have aman as one of the principal crop though the relative position of aman in the hierarchy varies from block to block. It is in English Bazar, Kaliachak_I and Kaliachak-III that aman is not the most significant crop, otherwise in all other blocks it was top on the hierarchy.

Map 5.10 also shows the various significant crops in each block during the period 1993-94 to 1996-97. Though no fixed pattern is emerging but taking a closer look we find the blocks in the northern low land basically cultivated aman, boro, jute wheat and mustard as shown in the Map-5.12 explaining the crop combination pattern region wise for Period-I. In the western highland of Barind plagued with irrigation problem aman and mustard were the major crops, while in the southern part i.e. Diara, cultivation had really diversified with wheat, aus, mango, mustard, aman, boro, gram and kalai as the significant crops.

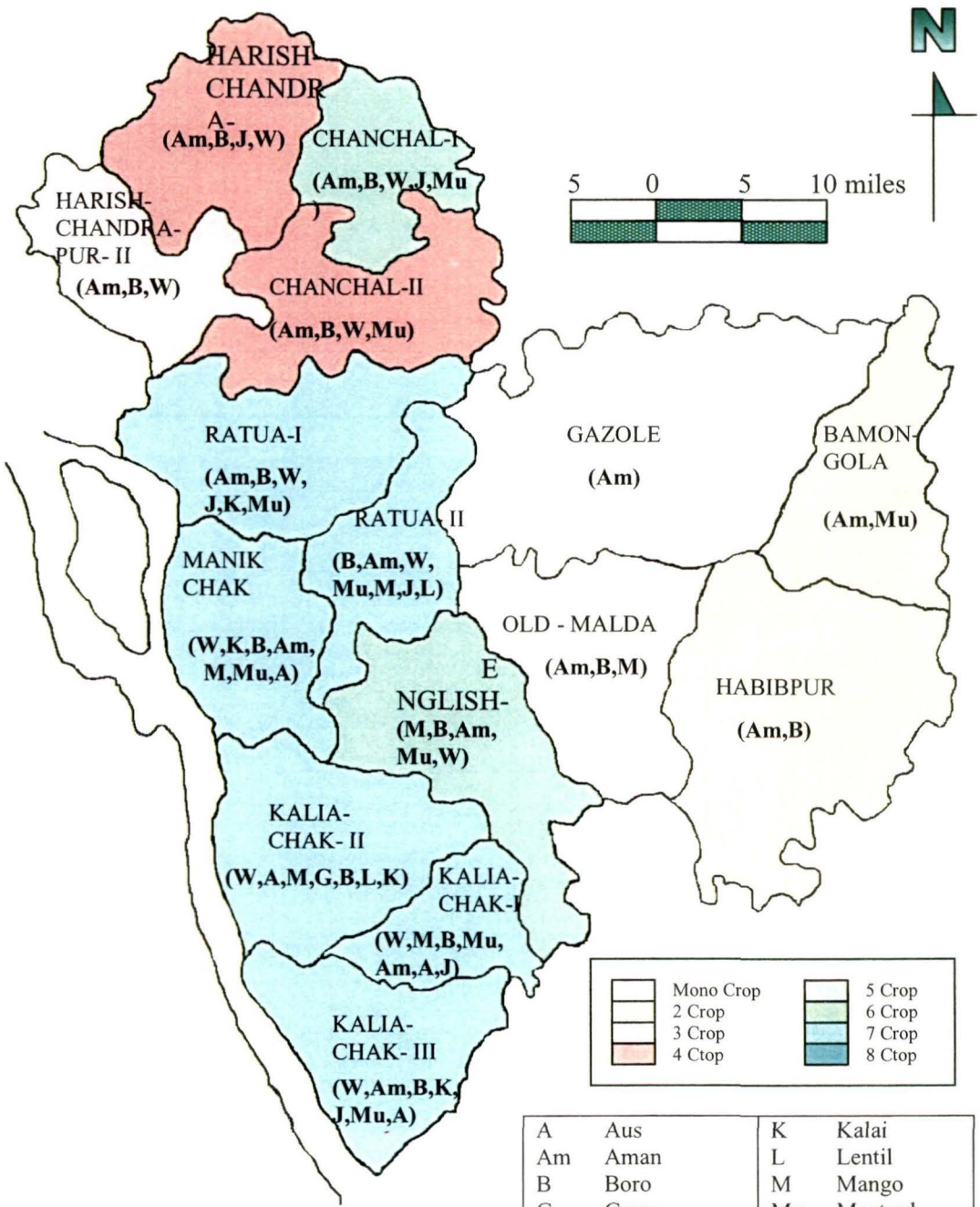
Map No: 5.10

PATTERN OF CROP COMBINATION IN MALDA: BLOCK WISE (93-94 to 96-97)



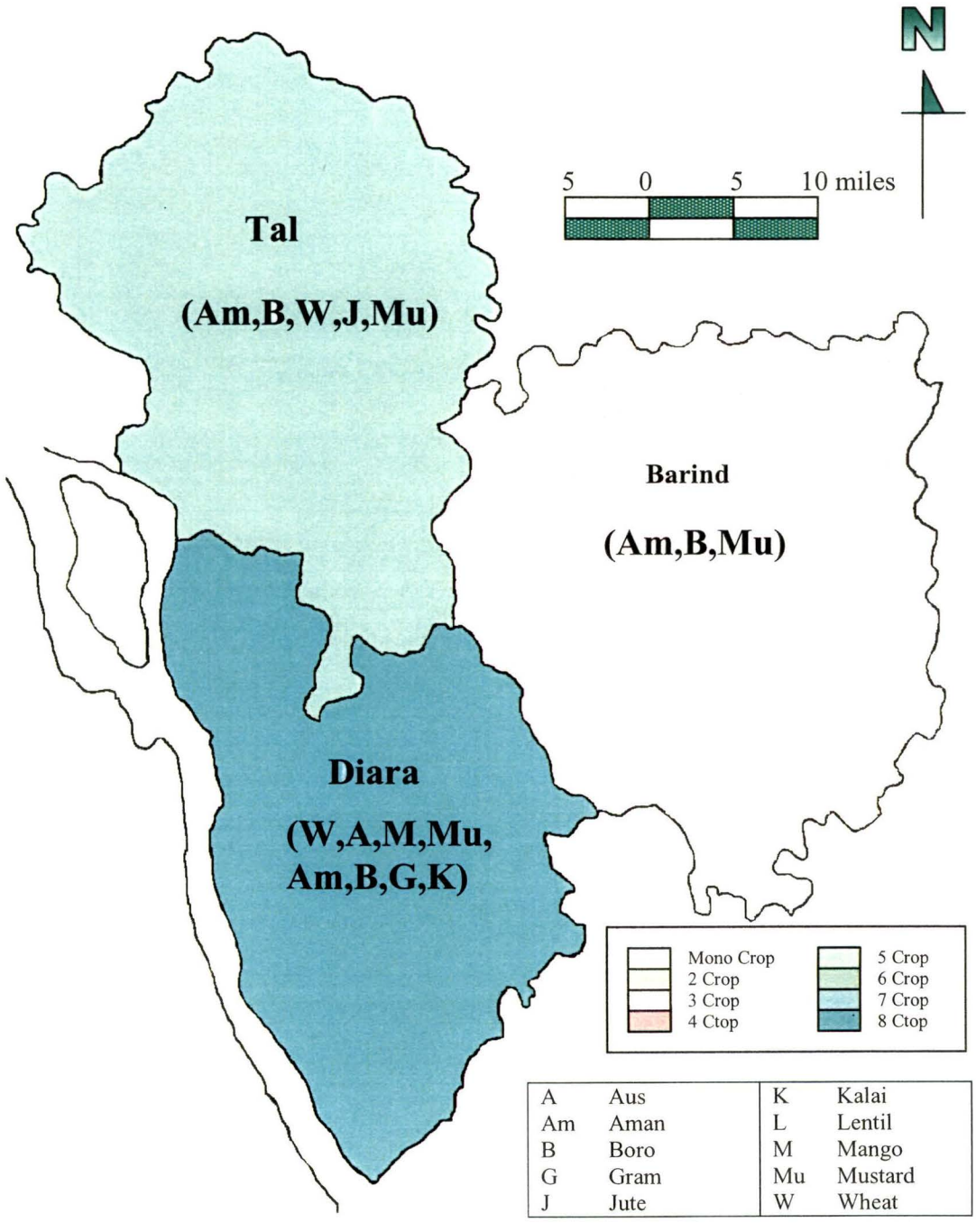
Map No: 5.11

PATTERN OF CROP COMBINATION IN MALDA: BLOCK WISE (97-98 to 00-01)



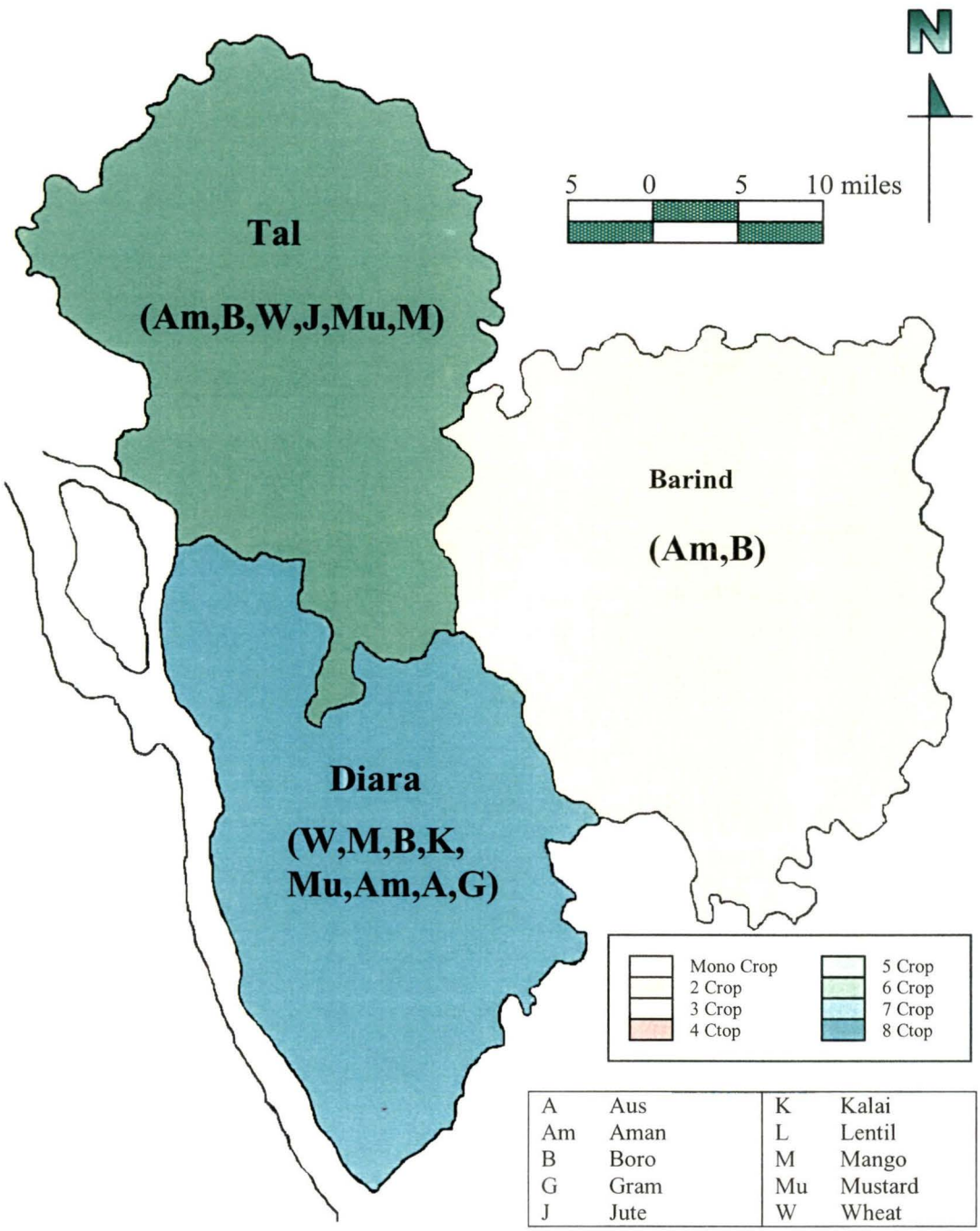
Map No: 5.12

PATTERN OF CROP COMBINATION IN MALDA: REGION WISE (93-94 to 96-97)



Map No: 5.13

PATTERN OF CROP COMBINATION IN MALDA: REGION WISE (97-98 to 00-01)



When we compare the above findings with the crop combination pattern for Period-II, (1997-98 to 2000-01), shown in Map 5.11, we hardly find any major change happening. Table 5.17 shows the change in crop combination pattern in terms of significant crops cultivated.

Table 5.17 Number of Significant crops: Block wise

	Number of significant crops	
	Period I	Period II
Harishchandrapur I	4	4
Harishchandrapur II	3	3
Chanchal I	5	5
Chanchal II	5	4
Ratua I	8	7
Ratua II	6	7
Gazole	2	1
Bamongola	2	2
Habibpur	1	2
Old Malda	3	3
English Bazar	6	5
Manikchak	7	7
Kaliachak I	8	7
Kaliachak II	6	7
Kaliachak III	6	7
Tal	5	6
Barind	3	2
Diara	8	8
Malda	5	4

It is found that though the number of significant crops has not changed dramatically but the relative importance of individual crops have changed over the years (Appendix V.xv to Appendix V.xvii). Thus we find over the decade of 90's there is no major change inthe crop combination pattern in the blocks of Malda. In fact in some of blocks viz. Chanchal-II, Ratua-I, Gajole, English Bazar and Kaliachak I the number of significant crops have decreased. One may propose that 1998-99 being the flood year affect the number of crops in Period II; but one need to note that in this crop combination analysis number of significant crops is determined based on percentage of gross cropped area and not geographical area. Thus the crop combination of the district is skewed in favour of Diara region and heavily against Barind region. This is primarily due to low irrigation facility

of Barind.

To sum up the chapter, we find that

- The district is primarily a cereal producing area with aman and boro as the primary crops for all the blocks of Tal and Barind region. In Diara region wheat and mango assume greater importance.
- There is a definite pattern of the cropping pattern change in the district as it is found pulses and oilseeds are loosing the steam while cereals and cash crop are marginally growing.
- There is difference for sure in the change of cropping pattern between the regions, as it is found that the cereal cultivation is on the growth path in Tal and Barind, while it is not so for Diara; Diara shows a definite preference towards cash crops.
- There is no significant growth pattern observed for Malda district as a whole for the crops individually other than boro and mango increasing while aus declining.
- Further, Malda is found to be primarily a five-crop region, though there is wide regional variation as Diara is a eight cropped region against Barind a three cropped region and Tal a six cropped region.

These differences itself highlight the regional variation in the cropping pattern, pattern of change and crop combination for the district.