Chapter VII

Delineation of Agricultural Land Use Regions

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7.1. Concept of Agricultural Land Use Regions

After unfolding the clear picture of spatio-temporal analysis of general and agricultural Land use of Siliguri subdivision in Darjeeling district in previous chapter III and IV, an attempt has made to identify physical, cultural responsible for agricultural Land use. It is the result of the decision made by the farmers regarding the choice of crops and methods for production. Thus, this decision making is based on not only physical constraints and limitations but also on farmer's perception of the total environment. Agricultural region is an uninterrupted area having some kind of homogeneity with specifically defined outer limit. Agricultural region, in fact, is a device for selecting and investigating regional groupings of the complex phenomena found on the earth surface. In other words, any segment or portion of the earth surface possessing a distinctive form of agriculture is an agricultural region. Thus, it is a dynamic concept which changes in space and time.

The main characteristics of agricultural region are: (i) they have location, (ii) they have transitional boundaries, (iii) they may be either formal or functional, (iv) they may be hierarchically arranged.

Agricultural regionalization has attracted the attention of many scholars in the field of agricultural geography. Geographers have shown interest in the overall agricultural region, although they by no means completely agree on its definition or the importance of its study in agricultural geography. Agricultural geographers have used the physical and cultural attributes to define agricultural region. Engelbrecht (1883) constructed individual distribution maps of major crops and animals for the U.S.A. and later in 1930 for other countries. Finally, he summarized his findings in his world map of "agricultural zones" (Landbauzonen). Then Multiple-feature regions have attracted many a geographers. Instead of emphasizing one factor, a number of variables were considered in combination to demarcate complex multi-factor regions. All these efforts can be grouped in four

categories viz., land capability regions, field system regions, farming system regions and functional regions (Gregor, 1970).

Buchanan (1959) thinks that the definition must be in agricultural terms – a crop, a crop association, a crop and livestock association, a system of organization of farm processes etc.

Further, it was "usually determined principally by climatic conditions. Subdivisions of the region were the results of differences in land reliefs, or in slope and in soils", which might cause variations in the proportion of land used for crops, pasture or forest, or in the relative importance of the crops. Economic principles were important also, but only in the capacity to "strengthen the influence of the physical factors to join with them in determining the boundaries of the region."

Whittlesey (1939) and Hartshorne and Dicken (1935) have emphasized the economic factors like operational structures of the farm rather than crop. Hartshorne and Dicken classified the agricultural regions of N. America and Europe using statistics for the measurement. Besides the physical and economic aspects, a cultural concept of the agricultural regions was espoused by Waibel (1933), Cholley (1946), and Carol (1952). The worldwide classification of agricultural systems was worked out by Whittlesey (1936) and Hahn (1892). Based on a combination of various economic forces, Whittlesey identifies thirteen major regions. Hahn stressed more the cultural outlook in his six regions or economic forms. A third worldwide classification is based upon Bakers (1926-33) approach, but only in full detail for the U.S.A. and Canada. In the late 1930's British geographers used statistical data for delimitation of agricultural regions. Agricultural Atlas of England and Wales used parish statistics which has several limitations. The quantitative revolution induced geographers to apply different quantitative methods in the analysis of data. At the same time, introduction of the digital computers enabled geographers to handle a large volume of data. Making use of these facilities in the delimitation of crop association regions of the Middle-west of the U.S. Weaver (1954) used the standard deviation to measure the deviation of actual occurrences against the theoretical curve. The Weaver approach to determining multifactor crop combination

regions can be regarded as a vital step forward in the integration of a number of variables for regional delimitation, Thomas (1963), modified the Weaver approach, making use of all the data available for the calculation of variance for each crop combination. Coppock (1964) extended the Weaver method to the whole spectrum of agricultural activity by converting livestock and crop production to common units and differentiating between various intensities of production by weighting in England and Wales. Johnson (1958) used simple scale of gradation based on averages, for identification of crop association regions of East Pakistan. In the last four decades, Indian geographers have been applying quantitative techniques to study the crop association regions.

Indian geographers have delimited agricultural regions based upon techniques like crop-association, cropping pattern, crop concentration, crop diversification and agricultural efficiency. Most of these works are the modifications and applications of the ideas of Weaver, Kendall (1939), Pownall (1953), Nelson (1965), Doi (1957) and others. Other techniques introduced by scholars like Rao (1954), Rafiullah (1956), Shafi (1960), Bhatia (1960, 1964, 1965), Athawale (1966), Ahmad and Siddiqui (1967), Sengupta and Sadasyuk (1968), Sinha (1968), Ayyar (1969), Mohammad and Amani (1970), Sharma, (1971), Sharma (1972), Husain (1972), Dikshit (1973). Bagchi and Jana (1974), Majid Husain (1996) have contributed to the various aspects of agricultural regionalization in India.

7.1.1. Techniques for the delimitation of Agricultural Land Use Regions

Since the boundaries of agricultural regions are transitional and not sharply diving lines, their precise delimitation is a difficult task. The main techniques used by geographers for the delimitation of agricultural regions are:

I. Empirical technique
II. Single element technique
III. Multi-element (statistics) technique
IV. Quantitative- cum- qualitative technique, and
V. Normative technique.

I.Empirical technique

This technique is largely based on the experience of the farmers and the observed facts. Baker was the first geographer who invented the empirical technique and demarcated the agricultural belts of USA. The Cotton belt, Corn belt, and the wheat belt of USA were demarcated on the basis of observed data. This technique gives a generalized picture of the cropping pattern and has the tendency of overgeneralization. By adopting the empirical technique, Jonasson, Jones, Taylor, Valkenberg and Cressay demarcated the agricultural regions of the different parts of the earth. The technique has, however, been criticized as it is less objective and relatively unscientific.

II.Single element technique

This is an arbitrary technique in which the single element of agricultural landscape is taken into consideration. In this technique the relative position of different agricultural enterprises is taken into consideration. The demarcation of rice, wheat and bajra regions of India on the basis of first ranking crops is an illustration of this technique. The main weakness of this technique is that it conceals the position and importance of other crops grown in the region. In other words, it leads to overgeneralization. The demarcation of Punjab as a wheat region and western Uttar Pradesh as sugarcane belt conceals the importance of rice and other cash crops which are also grown in these areas.

III.Multi-element (statistics) technique

The multi-element technique is an improvement over the empirical and single element techniques of agricultural regionalization. In the statistical technique combinations of closely associated features are taken into consideration. The crop combination and livestock regions as demarcated by Weaver, Doi and Coppock are the examples of this methodology. The main advantage of multi-element technique is that it is free from biasness and does not conceal the various agricultural phenomena which may be significant in the decision making process of the farmers.

IV. Quantitative- cum- qualitative technique

For the demarcation of agricultural regions, when the physical (terrain, slope, temperature, rainfall, soil etc.), social (land tenancy size of holdings, religion, customs,

etc.) and economic factors (capital investment, marketing, storage etc.) are taken into consideration such a technique is known as a quantitative-cum-qualitative technique of agricultural regionalization. This technique has been applied by Baker (1926), Whittlesey (1936) and Carol (1952).

V.Normative technique

Von Thunen (1826) developed the model of agriculture based on pre-decided restrictive conditions, considered as normative technique. A normative technique explains how a land use pattern will develop over a flat plain surface of uniform fertility and equal transport facility assuming that only one market exists. It makes use of only one factor, namely, cost of transportation which influences land rent, intensity of land use, and location of agricultural activity to be practiced by the farmers.

7.2. Crop Ranking Regions

The most elementary method for studying crop associations is the crop ranking but it helps one to understand the overall spatial pattern of crop distribution. The relative strength of individual crop could be assessed from the actual share of total harvested land that a crop occupies. Ranking of crops have been carried out by ranking the principal crops of the region according to the relative significance of each crop. The ranking of crop provides the best measure of the areal significance of individual crops. The ranking of crops obtained for eight crops in the subdivision to identify the relative significance of individual crop in cropping pattern. The first five ranking regions of crops have been identified.

7.2.1. Methodology

In the area under review ranking of crops have been studied for two time periods: Period I (1990-91) and Period –II (2010-11). The secondary data have been collected for two time periods from the Agricultural offices of each block and it is supplemented by various spot-inquiries. The ranking regions of different crops have been calculated by considering the relative strength of percentage share to GCA of the gram panchayat for each crop. The crop areas have been arranged into descending order of magnitude and termed first, second, third, fourth and fifth ranks. Table 7.3. and 7.6. display gram

panchayats and ranking of crops in the study area. The rank grouping may be useful to identify the major crop or crops in the study area.

7.2.2. Results and Discussions

7.2.2.1. Period – I: (1990-91)

7.2.2.1.1. First Ranking

Only Paddy, one crop, has been identified occupying first rank in all the gram panchayats. Paddy is found to have largest coverage in the study area in period-I. Paddy being the dominant crop in the area occupied 32520 hectares area (100% to GCA).

Second Ranking

The study reveals that two crops, i.e. Wheat and Jute ranked second in 1990-91. Wheat was more dominant than Jute and it was found in sixteen GPs, namely, Gossaipur, Hatighisa, Lower Bagdogra, Upper Bagdogra, Naxalbari, Moniram, Binnabari, Buraganj, Kharibari-Panisali, Raniganj-Panisali, Bidhannagar-I, Chathat-Bansgaon Kismat, Jalas-Nizamtara, Bidhannagar-II, Phansidewa-Bansgaon Kismat and Hetmuri-Singhjhora. It covered 26274 hectares area (80.79% to GCA). In 1990-91 Jute was another second ranking crop which was found in six GPs, i.e, Atharakhai, Matigara- I, Matigara- II, Patharghata, Champasari and Ghoshpukur covering 6246 hectares (19.21% to GCP) in the subdivision.

Third Ranking

The third ranking crops of the study area in Period-I were Jute, Potato and Wheat. Jute occupied dominant position covering 14479 hectares (44.52% to GCA) in nine GPs, namely, Binnabari, Buraganj, Kharibari-Panisali, Bidhannagar-I, Chathat-Bansgaon Kismat, Jalas- Nizamtara, Bidhannagar-II, Phansidewa-Bansgaon Kismat and Hetmuri-Singhjhora. Potato held third rank in the subdivision and observed in seven GPs covering 11795 hectares (36.27% to GCA). These GPs were Gossaipur, Hatighisa, Lower Bagdogra, Upper Bagdogra, Naxalbari, Moniram and Raniganj-Panisali. Wheat, another third ranking crop, occupying 6246 hectares (19.21% to GCA) was found in six GPs of the area. These GPs were Atharakhai, Matigara- I, Matigara- II, Patharghata, Champasari and Ghoshpukur.

Table 7.1 Gram Panchayat-wise Area (Hectare) Under Principal Crops (1990-91)

Gram Panchayats	Paddy	Wheat	Pulses	Oilseeds	Potato	Jute	Maize	Other Crops	Total
Atharakhai	884	34	-	35	16	121	..	14	1104
Matigara- I	762	28	-	7	20	108	..	11	936
Matigara -II	989	29	-	8	28	116	..	10	1180
Patharghata	1058	79	-	38	21	120	..	19	1335
Champasari	656	25	-	2	10	55	..	7	755
Gossaipur	1550	77	-	-	23	8	..	5	1663
Hatighisa	1145	59	-	-	21	5	..	9	1239
Lower Bagdogra	900	35	-	-	14	4	..	10	963
Upper Bagdogra	1160	65	-	-	17	3	..	5	1250
Naxalbari	1820	147	-	-	36	13	..	16	2032
Moniram	966	32	-	-	24	7	..	4	1033
Binnabari	1598	165	17	136	80	93	..	13	2102
Buraganj	2429	130	19	145	64	76	..	7	2870
Kharibari-Panisali	3411	423	20	254	76	97	..	20	4301
Raniganj-Panisali	2899	412	9	177	60	48	..	10	3615
Bidhannagar-I	294	106	8	117	33	92	..	8	658
Chathat-Bansgaon Kismat	394	158	18	178	58	108	..	14	928
Ghoshpukur	473	122	13	153	42	123	..	10	936
Jalas- Nizamtara	610	159	14	224	55	89	..	17	1168
Bidhannagar-II	235	121	6	96	31	91	..	9	589
Phansidewa-Bansgaon Kismat	555	172	20	177	63	153	..	28	1168
Hetmuri- -Singhjhora	324	102	6	130	28	100	..	5	695
TOTAL	22213	2680	150	1877	820	1538		251	32520

Source: Office of the Assistant Director of Agriculture, Matigara-Naxalbari block and Kharibari-Phansidewa block

Fourth Ranking

Three crops have been identified as fourth ranking crops during the Period-I (1990-91) namely Potato, Jute and Other crops. Among them Potato occupied largest areal coverage having 20725 hectares (63.73% to GCA) comprising fifteen GPs, namely, Atharakhai, Matigara- I, Matigara-II, Patharghata, Champasari, Binnabari, Buraganj, Kharibari Panisali, Bidhannagar-I, Chathat-Bansgaon Kismat, Jalas- Nizamtara, Bidhannagar-II, Phansidewa-Bansgaon Kismat, Hetmuri-Singhjhora and Ghoshpukur. Jute occupying 7550

Table 7.2 Crops Rank Frequency for Period-I: (1990-91)

SL NO	CROPS	CROP RANKS AND NUMBER OF GRAM PANCHAYATS				
		I	II	III	IV	V
1	PADDY	22	-	-	-	-
2	WHEAT	-	16	6	-	-
3	POTATO	-	-	7	15	-
4	JUTE	-	6	9	4	3
5	OTHER CROPS	-	-	-	3	19
TOTAL		**22**	**22**	**22**	**22**	**22**

(Compiled by the Researcher)

Table 7.3 Ranking of Crops, Area Coverage and Distribution in Siliguri Subdivision Period-I: (1990-91)

CROPS	NO. OF GRAM PANCHAYATS	GRAM PANCHAYATS IN %	AREA IN HECTARE	AREA IN %
FIRST RANKING				
Paddy	22	100	32520	100
SECOND RANKING				
Wheat	16	72.73	26274	80.79
Jute	6	27.27	6246	19.21
THIRD RANKING				
Wheat	6	27.27	6246	19.21
Potato	7	31.82	11795	36.27
Jute	9	40.91	14479	44.52
FOURTH RANKING				
Potato	15	68.18	20725	63.73
Jute	4	18.18	7550	23.22
Other crops	3	13.64	4245	13.05
FIFTH RANKING				
Jute	3	13.64	4245	13.05
Other crops	19	86.36	28275	86.95

(Compiled by the Researcher)

hectares (23.22% to GCA) area found in Gossaipur, Hatighisa, Moniram and Raniganj-Panisali GPs. Other crops including different types of vegetables etc. were found in three GPs, namely, Lower Bagdogra, Upper Bagdogra and Naxalbari covering 4245 hectares (13.05% to GCA) area of the study region.

Fifth Ranking

Other crops and Jute ranked fifth during 1990-91 and observed in nineteen and three GPs respectively. Other crops including vegetables etc. were cultivated in Atharakhai, Matigara- I, Matigara-II, Patharghata, Champasari, Binnabari, Buraganj, Kharibari-Panisali, Bidhannagar-I, Chathat-Bansgaon Kismat, Jalas- Nizamtara, Bidhannagar-II, Phansidewa-Bansgaon Kismat, Hetmuri-Singhjhora, Ghoshpukur, Raniganj-Panisali, Moniram, Gossaipur and Hatighisa GPs covering largest area of 28275 hectares (86.95% to GCA). Jute cultivation observed in Lower Bagdogra, Upper Bagdogra and Naxalbari GPs covering 4245 hectares (13.05% to GCA) area of the study region.

7.2.2.2. Period – II: (2010-11)

7.2.2.2.1. First Ranking

During 20 years of study there is no change in first ranking crop. In Period-II (2010-11), same as the earlier period, Paddy has ranked first and spreads throughout all 22 GPs of the subdivision covering 100% areal strength of the GCA.

7.2.2.2.2. Second Ranking

There were two crops, which ranked second in Period- I, namely Wheat and Jute while this number increased into four crops in Period-II including Jute, Potato, Wheat and Other crops. The relative significance of Jute increased from six GPs to fourteen GPs covering 28230.7 hectares (81.81% to GCA) area of the subdivision. Potato is the second dominant crop and found in four GPs occupying 3234.6 hectares (9.37% to GCA). The areal coverage of Wheat declined from sixteen GPs in Period-I to only two GPs covering 2248.4 hectares area (6.53% to GCA) in Period-II. Hence the dominance of Wheat replaced by the other three crops in Period-II. Another second ranking crop namely Other crops including vegetables etc. cultivated in two GPs only which occupied hectares 441 (1.29% to GCA) area of the subdivision.

Table 7.4 Gram Panchayat-wise Area (Hectare) Under Principal Crops (2010-11)

SL NO	Gram Panchayats	Paddy	Wheat	Pulses	Oilseeds	Potato	Jute	Maize	Other Crops	Total
1	Atharakhai	203	0.5	-	0.2	9	12	3	11	238.7
2	Matigara- I	175	1	-	-	8	4	2	8	198
3	Matigara -II	186	1	-	-	12	9	2	6	216
4	Patharghata	278	1	1	0.5	10	10	4	12	316.5
5	Champasari	110	0.5	-	-	4	4	1	5	124.5
6	Gossaipur	1110	37	2	9	54	82	26	11	1331
7	Hatighisa	801	22	3	10.8	55	77	21	12	1001.8
8	Lower Bagdogra	483	12	-	0.6	19	16	15	5	550.6
9	Upper Bagdogra	706	34	3	0.4	13	20	16	3	795.4
10	Naxalbari	1142	66	6	13	80	87	38	21	1453
11	Moniram	332	3	-	5.2	31	49	19	9	448.2
12	Binnabari	1198	79	4	17	120	230	42	15	1705
13	Buraganj	2127	83	8	17	141	312	18	11	2717
14	Kharibari-Panisali	3035	276	25	34	229	491	93	32	4215
15	Raniganj-Panisali	2298	300	22	18	125	423	40	15	3241
16	Bidhannagar-I	1368	111	3	1	76	113	9	10	1691
17	Chathat-Bansgaon Kismat	2071	153	21	31	150	257	19	16	2718
18	Ghoshpukur	1599	95	11	24	134	202	12	12	2089
19	Jalas- Nizamtara	1856	114	9	33	120	111	14	13	2270
20	Bidhannagar-II	1492	110	3	2	88	99	7	6	1807
21	Phansidewa-Bansgaon Kismat	3041	167	14	34	190	299	21	41	3807
22	Hetmuri- Singhjhora	1224	139	1	2	50	139	6	14	1575
TOTAL		26835	1805	136	252.7	1718	3046	428	288	34508.7

Source: Office of the Assistant Director of Agriculture, Matigara-Naxalbari block and Kharibari-Phansidewa block

7.2.2.2.3. Third Ranking

Four crops have been identified as third ranking crops during Period-II which consists of Wheat, Potato, Jute and Other crops. Wheat is the dominant crop among the third ranking

crops which covers 15710 hectares (45.52% to GCA) comprising six GPs. The second important crop in third ranking is Potato which cultivated in ten GPs occupying 14993 hectares (43.45% to GCA). Jute comes to next in third ranking covering 3369 hectares (9.76% to GCA) area including four GPs in the study area. Other crops have been identified as fourth ranking in third ranking crop consists of two GPs which occupy 436.7 hectares area (1.27% to GCA) in the subdivision.

Table 7.5 Crops Rank Frequency for Period-II: (2010-11)

SL NO	CROPS	CROP RANKS AND NUMBER OF GRAM PANCHAYATS					
		I	II	III	IV	V	VI
1	PADDY	22	-	-	-	-	-
2	WHEAT	-	2	6	7	1	6
3	POTATO	-	4	10	7	1	-
4	JUTE	-	14	4	4	-	-
5	MAIZE		-	-	3	16	3
6	OTHER CROPS	-	2	2	1	4	13
TOTAL		**22**	**22**	**22**	**22**	**22**	**22**

(Compiled by the Researcher)

7.2.2.2.4. Fourth Ranking

There were three crops, which ranked fourth in Period- I, namely Potato, Other crops and Jute while this number increased into five crops in Period-II including Potato, Wheat, Jute, Maize and Other crops. The crop distributional pattern in this ranking has been found fragmented and diversified throughout the subdivision. Among these Potato is the principal crops and found in seven GPs covering 15485.7 hectares (44.87% to GCA). Wheat is cultivated in seven GPs which covers 14103.8 hectare area (40.87% to GCA) of the subdivision. Jute is cultivated in four GPs covering 2909 hectares (8.43% to GCA) while Maize is cultivated in three GPs covering 1794.2 hectares (5.20% to GCA) in the study area. Other crop is the least significant crop in fourth ranking found only in one GPs covering 216 hectares (0.63% to GCA).

7.2.2.2.5. Fifth Ranking

Four crops namely Maize, Other crops, Potato and Wheat have been identified as fifth ranking crop during Period-II while there were only two crops in Period-I including Jute

and Other crops. Maize holds the largest coverage of 25641.5 hectares (74.30% to GCA) among fifth ranking crops. It is cultivated in sixteen GPs in the subdivision. Next to this come Other crops which observed in four GPs occupying 7521.2 hectares (21.80% to GCA). Wheat and Potato having least a real strength is found in one GP of each crop. Wheat and Potato have the coverage of 550.6 hectares (1.60% to GCA) and 795.4 hectares (2.30% to GCA) respectively.

Table 7.6 Ranking of Crops, Area Coverage and Distribution in Siliguri Subdivision Period-II: (2010-11)

CROPS	NO. OF GRAM PANCHAYATS	GRAM PANCHAYATS IN %	AREA IN HECTARE	AREA IN %
FIRST RANKING				
Paddy	22	100	34508.7	100
SECOND RANKING				
Wheat	2	9.09	2248.4	6.53
Potato	4	18.18	3234.6	9.37
Jute	14	63.64	28230.7	81.81
Other crops	2	9.09	441	1.29
THIRD RANKING				
Wheat	6	27.27	15710	45.52
Potato	10	45.46	14993	43.45
Jute	4	18.18	3369	9.76
Other crops	2	9.09	436.7	1.27
FOURTH RANKING				
Wheat	7	31.82	14103.8	40.87
Potato	7	31.82	15485.7	44.87
Jute	4	18.18	2909	8.43
Maize	3	13.64	1794.2	5.20
Other crops	1	4.55	216	0.63
FIFTH RANKING				
Wheat	1	4.55	550.6	1.60
Potato	1	4.55	795.4	2.30
Maize	16	72.72	25641.5	74.30
Other crops	4	18.18	7521.2	21.80
SIXTH RANKING				
Wheat	6	27.27	1541.9	4.47
Maize	3	13.64	7073	20.50
Other crops	13	59.09	25893.8	75.03

(Compiled by the Researcher)

7.2.2.2.6. Sixth Ranking

There are three crops in Period-II which emerged as sixth ranking in Siliguri subdivision. The crops are Wheat, Maize and Other crops. Sixth rank crops indicate diversity in number and crop distribution in the area under study. Other crops including different types of vegetables, etc. is the principal crop in sixth ranking covering 25893.8 hectares area (75.03% to GCA) in thirteen GPs. The next one is Maize which covers 7073 hectares (20.50% to GCA) in three GPs. Wheat is the another sixth ranking crop which cultivated in six GPs covering 1541.9 hectares (4.47% to GCA) in the area under study.

7.3. Crop Combination Regions

The study of crop combination regions play an important role in agricultural geography as it provides a good basis for agricultural regionalization. The crops are generally grows in combinations and it is rarely that a particular crop occupies a position of total isolation other crops in a given areal unit at a given point of time. These regions would also become helpful for agricultural planning of the region. Agricultural regions are used as a basis for planning and have been advocated as a suitable device for planning improvements in underdeveloped countries.

Crop combination study in geography is fruitful in many ways; firstly it provides an adequate understanding of an individual crop. Secondly, combination is in itself an integrative reality and finally crop combination regions are essential for the construction of more complex structure of vivid agricultural regions (Weaver, 1954). The study of crop combination thus forms an integral part of agricultural geography and such study is greatly helpful for regional agricultural planning.

7.3.1 Methodology

Different methods have been introduced to demarcate the crop combination regions. But in the present study an attempt is made to delineate the patterns of crop combination by applying the Weaver's least (minimum) standard deviation (1954) and K. Doi's method (1959). Data has been taken from secondary sources only. The sources of data are Agricultural report from Agricultural Block Office and District Statistical Handbook of

Darjeeling District 1986-89, 1996-97, 2006 and 2010-11. To find out the agricultural regions in the Subdivision Gram panchayat has been taken as unit of study.

i)Crop combination method of Weaver: In agricultural geography Weaver was first to use statistical technique, known as least (minimum) standard deviation, to establish the crop combination of the Middle West (USA). Weaver based his analysis on acreage statistics. Weaver computed the percentage of total harvested cropland occupied by each crop that held as much as 1 per cent of the total cultivated land. He calculated deviation of the real Percentages of crops (occupying over 1 per cent of the cropped area) for all possible combinations in the component areal units against a theoretical standard is as follows:

Monoculture = 100 % of the total harvested crop land in one crop.
Two crop combination = 50 % in each of two crops.
Three crop combination = 33.3 % in each of three crops.
Four crop combination = 25 % in each of four crops.
Five crop combination = 20 % in each of five crops.
Ten crop combination = 10 % in each of ten crops.

For the determination of the minimum deviation the standard deviation method was used:

$$\mathbf{SD} = \sqrt{\frac{\sum \mathbf{d}^2}{\mathbf{n}}}$$

Where, d = the difference between the actual crop percentages in a given areal unit and the appropriate percentage in the theoretical standard and n = number of crops in a given combination.

As Weaver pointed out, the relative, not absolute value being significant, square roots were not extracted so, the actual formula used was as follows:

$$\mathbf{d} = \frac{\sum \mathbf{d}^2}{\mathrm{n}}$$

Least value of the combination will be taken for consideration. Weaver's method has been admirably accepted and applied for the demarcation of crop combination and agricultural regionalization.

ii) Crop combination method of K. Doi: Weaver's technique was subsequently modified by Doi (1959). The Doi's formula is as follows:

$$(\sum d^2)$$

Where, $(\sum d^2)$ = sum of the squares deviations.

The combination having the smallest $(\sum d^2)$ will be the crop combination. But it is not required to calculate $(\sum d^2)$ for each combination, as it can be found only by consulting a table provided by Doi which presents critical values for different element at various cumulative percentages. If the percentage held by a single crop is lower than the critical value, the crop is dropped from the combination and vice versa.

7.3.2. Results and Discussions

7.3.2.1. Period – I: (1990-91)

During the Period-I (1990-91), based on Weaver's method, the study region was dominated by monocrop. Out of 22 GPs, 15 GPs were dominated by monoculture. Among the remaining GPs, 4 have been characterized by four crop combinations and 3 have been characterized by seven crop combinations.

Based on Doi's method, 15 GPs were dominated by monoculture, 4 GPs have been characterized by four crop combinations and 3 GPs by three crop combinations.

7.3.2.1.1. Crop combinations by Weaver's Method

Monoculture

Based on Weaver's method, 15 GPs were dominated by monoculture. These GPs were Atharakhai, Matigara- I, Matigara-II, Patharghata, Champasari, Binnabari, Buraganj, Gossaipur, Hatighisa, Moniram, Lower Bagdogra, Upper Bagdogra, Kharibari-Panisali, Raniganj-Panisali and Naxalbari. Paddy was the only dominant crop in monoculture regions.

Four crop combination

There were 4 GPs in four crop combination in the study region. These GPs were Bidhannagar-I, Chathat-Bansgaon Kismat, Hetmuri-Singhjhora and Bidhannagar-II. Four crops observed in this combination were Paddy, Oilseeds, Wheat, and Jute.

Table 7.7 Gram Panchayat-wise Area (Hectare) Under Principal Crops (1990-91)

GRAM PANCHAYATS	PADDY	WHEAT	PULSES	OILSEEDS	POTATO	JUTE	MAIZE	OTHER CROPS	TOTAL
Atharakhai	884	34	-	35	16	121	..	14	1104
Matigara- I	762	28	-	7	20	108	..	11	936
Matigara -II	989	29	-	8	28	116	..	10	1180
Patharghata	1058	79	-	38	21	120	..	19	1335
Champasari	656	25	-	2	10	55	..	7	755
Gossaipur	1550	77	-	-	23	8	..	5	1663
Hatighisa	1145	59	-	-	21	5	..	9	1239
Lower Bagdogra	900	35	-	-	14	4	..	10	963
Upper Bagdogra	1160	65	-	-	17	3	..	5	1250
Naxalbari	1820	147	-	-	36	13	..	16	2032
Moniram	966	32	-	-	24	7	..	4	1033
Binnabari	1598	165	17	136	80	93	..	13	2102
Buraganj	2429	130	19	145	64	76	..	7	2870
Kharibari-Panisali	3411	423	20	254	76	97	..	20	4301
Raniganj-Panisali	2899	412	9	177	60	48	..	10	3615
Bidhannagar-I	294	106	8	117	33	92	..	8	658
Chathat-Bansgaon Kismat	394	158	18	178	58	108	..	14	928
Ghoshpukur	473	122	13	153	42	123	..	10	936
Jalas- Nizamtara	610	159	14	224	55	89	..	17	1168
Bidhannagar-II	235	121	6	96	31	91	..	9	589
Phansidewa-Bansgaon Kismat	555	172	20	177	63	153	..	28	1168
Hetmuri -Singhjhora	324	102	6	130	28	100	..	5	695
Total	22213	2680	150	1877	820	1538		251	32520

Source: Office of the Assistant Director of Agriculture, Matigara-Naxalbari block and Kharibari-Phansidewa block.

Seven crop combination

The GPs classified as seven crop combination were 3 in number. These were Phansidewa-Bansgaon Kismat, Jalas- Nizamtara and Ghoshpukur. The combination crops were Paddy, Oilseeds, Jute, Wheat, Potato, Pulses and Other crops.

7.3.2.1.2. Crop combinations by Doi's Method

Monoculture

Based on Doi's method, 15 GPs were dominated by monoculture. These GPs were Atharakhai, Matigara- I, Matigara-II, Patharghata, Champasari, Binnabari, Buraganj, Gossaipur, Hatighisa, Moniram, Lower Bagdogra, Upper Bagdogra, Kharibari-Panisali, Raniganj-Panisali and Naxalbari. Paddy was the only dominant crop in monoculture regions.

Three crop combination

Three GPs were identified as three crop combination in the region namely Chathat-Bansgaon Kismat, Jalas- Nizamtara and Ghoshpukur. In the first two GPs the combination crops were Paddy, Oilseeds and Wheat. In Ghoshpukur the combination was Paddy-Oilseeds-Jute.

Four crop combination

Bidhannagar-I, Bidhannagar-II, Hetmuri-Singhjhora and Phansidewa-Bansgaon Kismat were characterized by four crop combination. The combination was Paddy-Wheat-Oilseeds-Jute in Bidhannagar-II while in the rest of three GPs the combination was Paddy-Oilseeds-Wheat-Jute.

7.3.2.2. Period – II: (2010-11)

During the Period-II (2010-11), based on Weaver's method, the study region was dominated by monoculture. Out of 22 GPs, 18 GPs were dominated by monoculture. Among the remaining GPs, 2 have been characterized by five crop combinations and 2 have been characterized by six crop combinations.

Based on Doi's method, 22 GPs were dominated by monoculture.

7.3.2.2.1. Crop combinations by Weaver's Method

Monoculture

Most of the GPs are dominated by monoculture. Paddy is the only dominant crop in this category. The 18 GPs which are characterized by monoculture are Atharakhai, Matigara-I, Matigara-II, Patharghata, Champasari, Gossaipur, Hatighisa, Moniram, Lower Bagdogra, Upper Bagdogra, Naxalbari, Buraganj, Bidhannagar-I, Bidhannagar-II, Hetmuri-Singhjhora, Ghoshpukur, Jalas- Nizamtara and Phansidewa-Bansgaon Kismat. Paddy was the only dominant crop in monoculture regions.

Five crop combination

In this classification two GPs have been identified namely Kharibari-Panisali and Raniganj-Panisali. The combination crops are Paddy-Jute-Wheat-Potato-Maize. During Period-II these two GPs were identified as mono crop region and only Paddy was the dominant crop at that time. From this it is clear that these two GPs during Period-II have been availed proper irrigation facilities and also other agricultural facilities which can be made effective this type of combination.

Six crop combination

Two GPs namely Moniram and Binnabari have been identified as six crop combination in the subdivision. In Moniram the combination is Paddy-Jute-Potato-Maize-Other crops-Oilseeds while in Binnabari the combination is Paddy-Jute-Potato-Wheat-Maize-Oilseeds. This combination shows the agricultural development in these two GPs while during Period-II these were identified as monoculture region.

7.3.2.2.2. Crop combinations by Doi's Method

Monoculture

According to Doi's method all GPs have been identified as monoculture areas where Paddy is the dominant one in Period-II. During Period-I based on this method three type of combination region have been identified namely, monocrop, three crop and four crop combination.

Table 7.8 Delineation of Crop Combination Regions of Siliguri Subdivision for Period-I (1990-91)

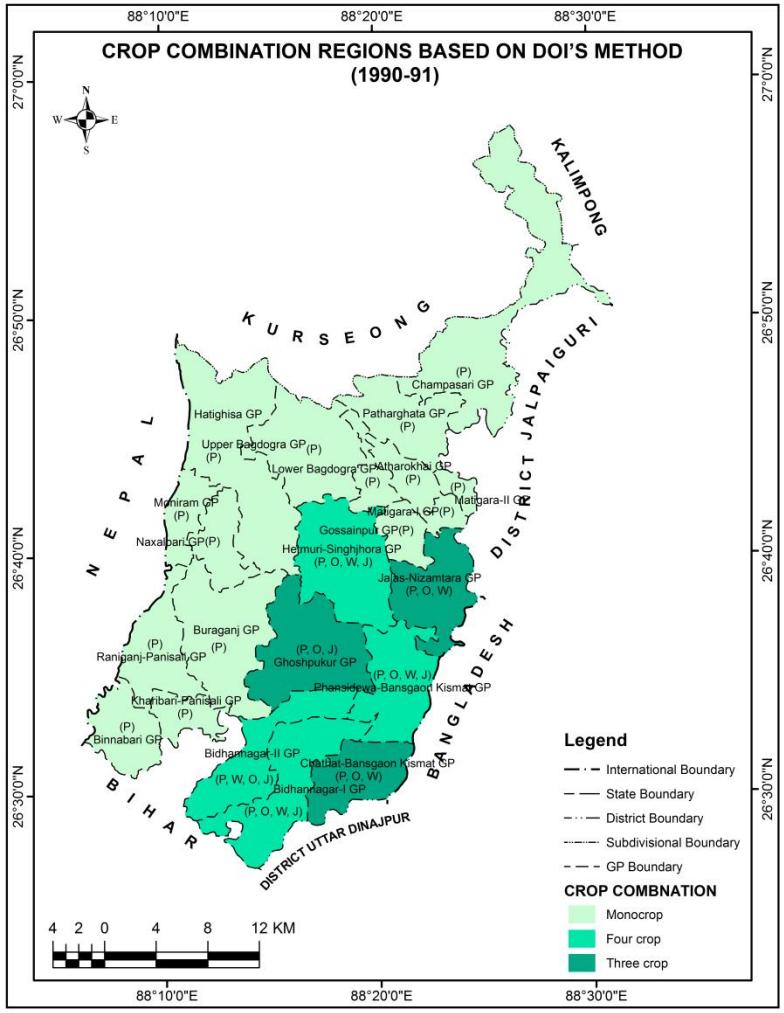
Gram panchayats	1990-91			
	Crop combination (J.C. Weaver)	Combination crops	Crop combination (Doi)	Combination crops
Atharakhai	Monocrop	P	Monocrop	P
Matigara- I	Monocrop	P	Monocrop	P
Matigara -II	Monocrop	P	Monocrop	P
Patharghata	Monocrop	P	Monocrop	P
Champasari	Monocrop	P	Monocrop	P
Gossaipur	Monocrop	P	Monocrop	P
Hatighisa	Monocrop	P	Monocrop	P
Lower Bagdogra	Monocrop	P	Monocrop	P
Upper Bagdogra	Monocrop	P	Monocrop	P
Naxalbari	Monocrop	P	Monocrop	P
Moniram	Monocrop	P	Monocrop	P
Binnabari	Monocrop	P	Monocrop	P
Buraganj	Monocrop	P	Monocrop	P
Kharibari-Panisali	Monocrop	P	Monocrop	P
Raniganj-Panisali	Monocrop	P	Monocrop	P
Bidhannagar-I	Four crop	P, O, W, J	Four crop	P, O, W, J
Chathat-Bansgaon Kismat	Four crop	P, O, W, J	Three crop	P, O, W
Ghoshpukur	Seven crop	P, O, J, W, Po, Pu, Oc	Three crop	P, O, J
Jalas- Nizamtara	Seven crop	P, O, W, J, Po, Oc, Pu	Three crop	P, O, W
Bidhannagar-II	Four crop	P, W, O, J	Four crop	P, W, O, J
Phansidewa-Bansgaon Kismat	Seven crop	P, O, W, J, Po, Oc, Pu	Four crop	P, O, W, J
Hetmuri-Singhjhora	Four crop	P, O, W, J	Four crop	P, O, W, J

(Compiled by the Researcher)

Table 7.9 Delineation of Crop Combination Regions of Siliguri subdivision for Period-II (2010-11)

Gram panchayats	2010-11			
	Crop combination (J.C. Weaver)	Combination crops	Crop combination (Doi)	Combination crops
Atharakhai	Monocrop	P	Monocrop	P
Matigara- I	Monocrop	P	Monocrop	P
Matigara -II	Monocrop	P	Monocrop	P
Patharghata	Monocrop	P	Monocrop	P
Champasari	Monocrop	P	Monocrop	P
Gossaipur	Monocrop	P	Monocrop	P
Hatighisa	Monocrop	P	Monocrop	P
Lower Bagdogra	Monocrop	P	Monocrop	P
Upper Bagdogra	Monocrop	P	Monocrop	P
Naxalbari	Monocrop	P	Monocrop	P
Moniram	Six crop	P, J, Po, M, Oc, O	Monocrop	P
Binnabari	Six crop	P, J, Po, W, M, O	Monocrop	P
Buraganj	Monocrop	P	Monocrop	P
Kharibari-Panisali	Five crop	P, J, W, Po, M	Monocrop	P
Raniganj-Panisali	Five crop	P, J, W, Po, M	Monocrop	P
Bidhannagar-I	Monocrop	P	Monocrop	P
Chathat-Bansgaon Kismat	Monocrop	P	Monocrop	P
Ghoshpukur	Monocrop	P	Monocrop	P
Jalas- Nizamtara	Monocrop	P	Monocrop	P
Bidhannagar-II	Monocrop	P	Monocrop	P
Phansidewa-Bansgaon Kismat	Monocrop	P	Monocrop	P
Hetmuri-Singhjhora	Monocrop	P	Monocrop	P

(Compiled by the Researcher)



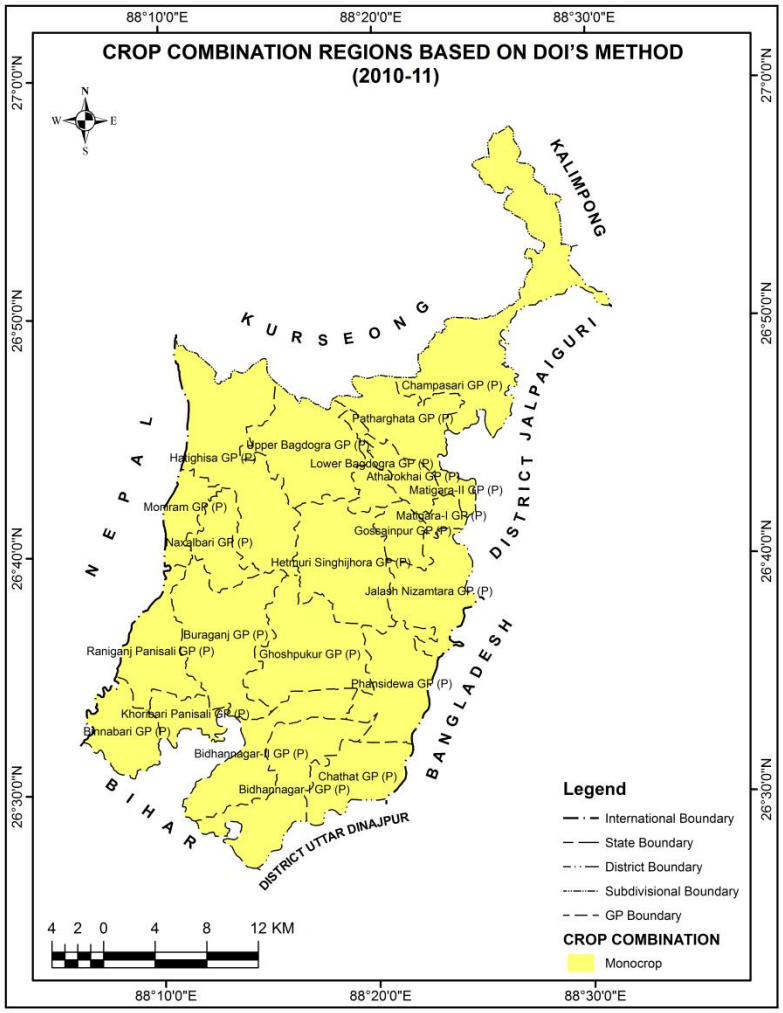


Figure 7.1 (a) Crop Combination Regions Based on Doi's Method 1990-91 and 2010-11

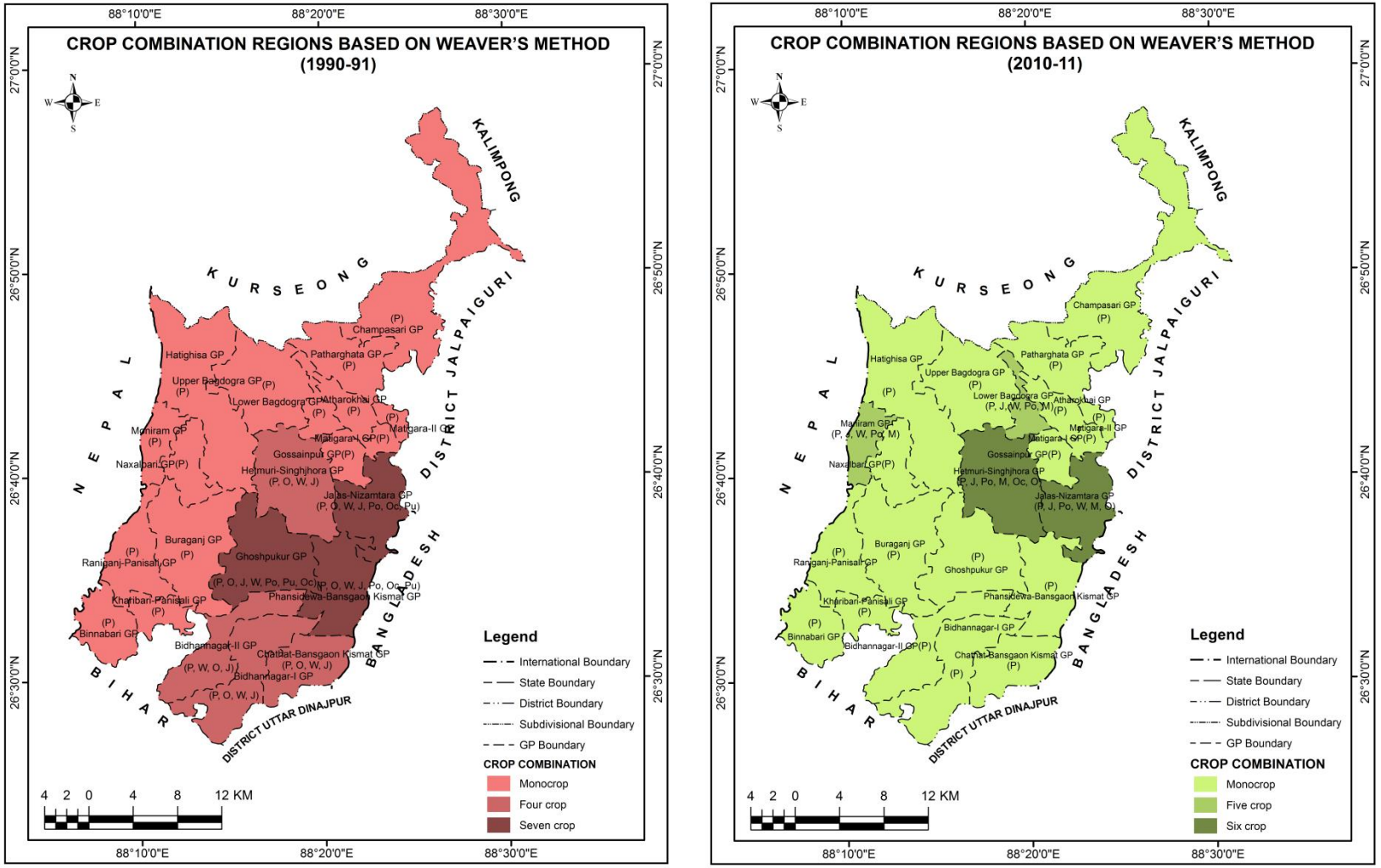


Figure 7.1 (b) Crop Combination Regions Based on Weaver's Method 1990-91 and 2010-11

7.3.3. Changing crop combination pattern (1990-91 to 2010-11)

According to Weaver's method the changing crop combination pattern shows that during Period-I monoculture observed in 15 GPs, four crop combination in 4 GPs and seven crop combination in 3 GPs of the subdivision. By the year 2010-11, after 20 years, monoculture has been identified in 18 GPs. Four crop and seven crop combinations have been found non-existent and two new crop combinations, namely five and six crop combinations, have been observed during Period-II. Five and six crop combinations are found in 2 and 2 GPs respectively.

Table 7.10 Change in Crop Combination Pattern in Siliguri Subdivision (1990-91 to 2010-11)

Crop Combination	Based on J.C. Weaver				Based on K. Doi			
	No. of GPs		Change		No. of GPs		Change	
	1990-91	2010-11	Increase	Decrease	1990-91	2010-11	Increase	Decrease
Monoculture	15	18	3	-	15	22	7	-
Three crop	-	-	-	-	3	-	-	3
Four crop	4	-	-	4	4	-	-	4
Five crop	-	2	2	-	-	-	-	-
Six crop	-	2	2	-	-	-	-	-
Seven crop	3	-	-	3	-	-	-	-
Total	22	22			22	22		

(Compiled by the Researcher)

Based on Doi's method, the changing crop combination pattern shows that during Period-I 15 GPs identified as monoculture areas, 3 GPs identified as three crop combination and 4 GPs observed as four crop combination regions. During Period-II three and four crop combinations have been found non-existent. The crop combination pattern changed from period-I to period-II and all GPs have been identified as monoculture regions in the study region.

7.4 Crop Diversification Regions

Crop diversification is a concept which is opposite to crops specialization. Crop diversification means growing of a variety of crops. The greater number of crops led to greater competition, the higher is the magnitude of diversification. The level of crops diversification largely depends on the geo-climatic/socio-economic conditions and technological development in a region. In general, higher the level of agricultural technology, lesser the degree of diversification. Moreover, the rich farmers prefer to specialize in agricultural enterprise while poor and subsistent farmers are generally more interested in the diversification of crops. The degree of crops diversification is closely influenced by the soil characteristics, soil moisture, amount of rainfall received, the availability of irrigation facilities, the accessibility of the arable land and the technology deployed by the cultivators.

In the third world country like India where man-land ratio is high enough, agricultural diversification especially in term of crop diversification is very much necessary (Let, 2011). At the same time, Indian agricultural is gamble in monsoon i.e., to get rid from helpless dependency on seasonal monsoonal rainfall, irrigation facilities one of the most efficient infrastructure technological aids are earnestly required so that agricultural economy is established in the strong relative platforms (Let & Bhattacharya,2010).

7.4.1. Methodology

Data has been taken from secondary sources only. The sources of data are Agricultural report from Agricultural Block Office and District Statistical Handbook of Darjeeling District 1986-89, 1996-97, 2006 and 2010-11. To find out the agricultural regions in the Subdivision Gram panchayat has been taken as unit of study.

In order to identify spatial pattern of crop diversification in present study Bhatia's method has been adopted. Bhatia (1965) has evolved a simple formula by taking into account the cropped area, to make an objective measurement of crop diversification. The formula is:

$$\text{Index of Crop Diversification} = \frac{\text{Percent of sown area under } x \text{ crops}}{\text{Number of } x \text{ crops}}$$

Where, *x* crops are those crops that individually occupy 5% or more of the cultivated area in a regional unit.

The crop having five or less than five percentages has been excluded from computation. The indices of crop diversification have been calculated for two periods, 1990-91 and 2010-2011 and been displayed in table 7.11 and figures 7.2. (a) and (b). Table 7.12 shows the spatial patterns of crop diversification in the Subdivision.

7.4.2. Results and Discussions

7.4.2.1. Crop diversification Regions by Bhatia

There are three regions of crop diversification has identified in Siliguri subdivision by applying Bhatia's method for both the period. Table no. 7.11 and figure 7.2. (a) and (b) displays the crop diversification pattern of the study area. The three regions identified in the study area are as follows:

a) Area of High Crop Diversification
b) Area of Moderate Crop Diversification
c) Area of Low Crop Diversification

7.4.2.1.1. Crop Diversification Regions in Period-I (1990-91)

Three regions have been identified in Period-I. These are as follows:

(a)Area of High Crop Diversification

It is identified that area of high crop diversification appears in 10 GPs covering 42.68% area of total gross cropped area of the subdivision. The largest numbers of crops are found in this region. There were five major crops; namely, Paddy, Wheat, Jute, Oilseeds and Potato enter in this diversification category. The main occupation of the residents of the GPs under this category is agriculture. So they produce a variety of crops for their earning and also for their livelihood. They use crop diversification because it increases the sustainability of the arable soil. Diversification of crops also generates more employment as the farmers and agricultural workers remain busy in the sowing, weeding, harvesting and marketing of different crops throughout the year.

(b)Area of Moderate Crop Diversification

Moderate crop diversification appears in 7 GPs covering 38.41% area of total gross cropped area of the subdivision. There are three crops; namely, Paddy, Wheat and Jute

Table 7.11 Diversification Pattern Based on Bhatia's Method**:** Gram Panchayat wise

Gram panchayats	Crop Diversification (1990-91)	Crop Diversification (2010-11)
Atharakhai	45.52	45.04
Matigara- I	46.48	88.38
Matigara -II	46.82	45.84
Patharghata	31.39	87.83
Champasari	47.09	88.35
Gossaipur	93.21	44.78
Hatighisa	92.41	31.04
Lower Bagdogra	93.46	87.72
Upper Bagdogra	92.80	88.76
Naxalbari	48.40	30.03
Moniram	93.51	30.64
Binnabari	30.11	30.26
Buraganj	44.84	31.65
Kharibari-Panisali	31.68	23.91
Raniganj-Panisali	45.80	31.07
Bidhannagar-I	19.51	31.38
Chathat-Bansgaon Kismat	19.31	24.20
Ghoshpukur	23.26	30.87
Jalas- Nizamtara	23.16	30.69
Bidhannagar-II	19.49	31.38
Phansidewa-Bansgaon Kismat	19.18	43.87
Hetmuri-Singhjhora	23.60	31.79

(Compiled by the Researcher)

enter in this diversification category. Fertile alluvial soil and adequate irrigation facilities made possible to cultivate diversified crops in this region.

(c)Area of Low Crop Diversification

Low crop diversification has been identified in 5 GPs occupying 18.91% are of total gross cropped area of the study region. There is only one crop namely Paddy comes under this category. Though the GPs are located on fertile alluvial soil but due to tea plantation the cropped area have been reduced and diversification of crop has been also limited.

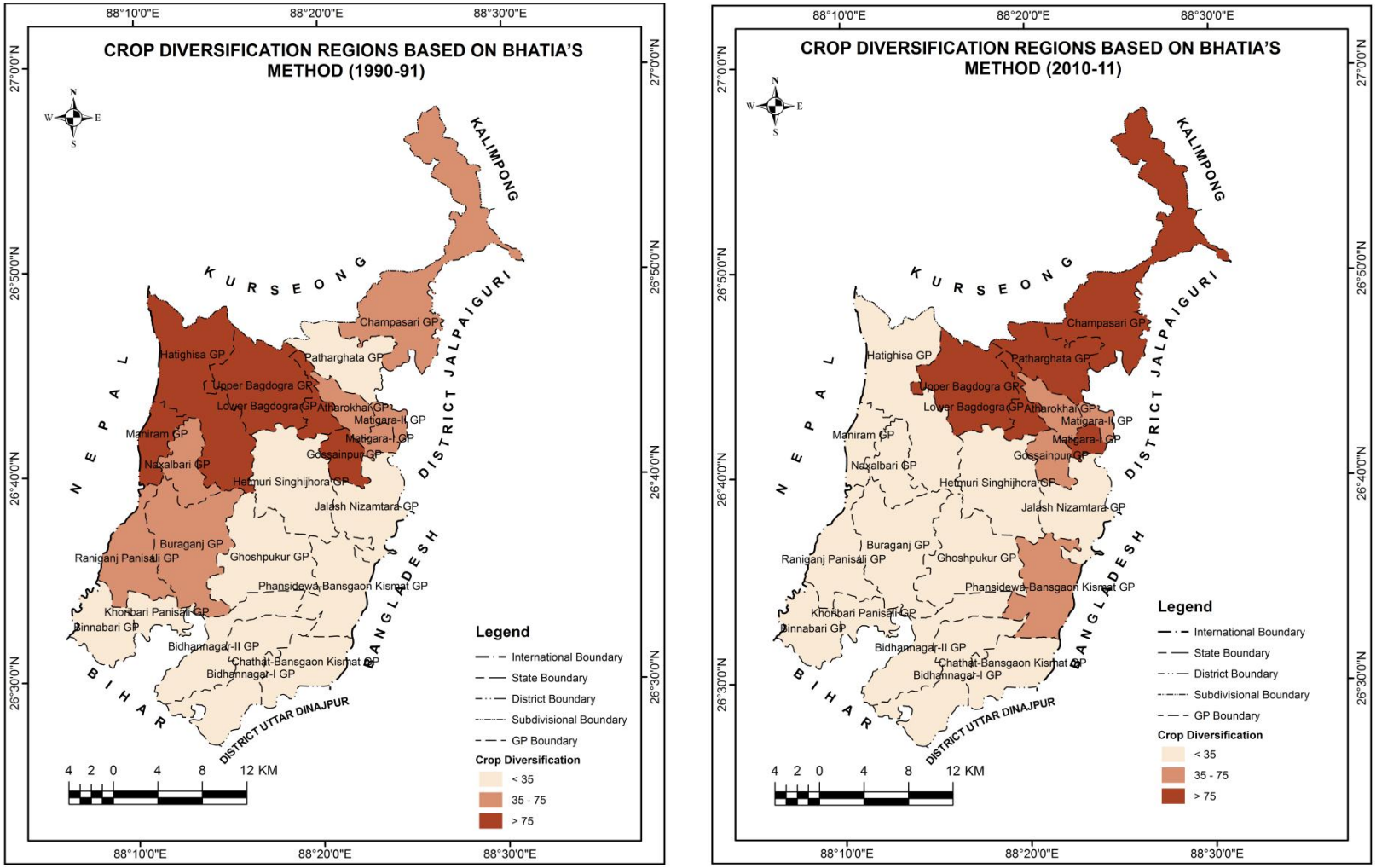


Figure 7.2 Crop Diversification Regions Based on Bhatia's Method 1990-91 and 2010-11

7.4.2.1.2. Crop Diversification Regions in Period-II (2010-11)

The crop diversifications regions have been identified in Period-II are as follows:

(a)Area of High Crop Diversification

The maximum area having high crop diversification is appeared on 78.04% of total gross cropped area of the study region. It covers 13 GPs in the subdivision. The index value of this region ranges below 35. The largest numbers of crops are found in this region. There were four major crops; namely, Paddy, Wheat, Jute and Potato enter in this diversification category.

(b)Area of Moderate Crop Diversification

This category covers 16.21% area of total gross cropped area of the study region. The area of moderate crop diversification appears in 4 GPs. The index value of this region ranges between 35 to 75. Paddy, Potato and Jute are the three crops which have been found in this type region.

(c)Area of Low Crop Diversification

It is identified that area of low crop diversification appears in 5 GPs covering 5.75% area of total gross cropped area of the subdivision. There is only one crop namely Paddy comes under this category. The index value of this region ranges over 75.

Table 7.12 Crop Diversification Pattern in Siliguri subdivision

Sl. No.	Range of Category	Category	1990-91		2010-11	
			No of GPs	Area covered (%)	No of GPs	Area covered (%)
1	High	< 35	10	42.68	13	78.04
2	Moderate	35 - 75	7	38.41	4	16.21
3	Low	> 75	5	18.91	5	5.75

(Compiled by the Researcher)

7.4.3. Changing Crop Diversification Pattern in Siliguri Subdivision (1990-91 to 2010-11)

During both the period, three regions, namely, high, moderate and low crop diversification have been identified. Maximum area is found under high crop diversification region for both the period. But during Period-II area under high crop diversification increased by 82.85%. On the other hand, the area under moderate crop diversification has been decreased by 57.80% during Period-II. And in case of low crop diversification study area experienced decrease in area by 69.59%.

Therefore, it can be summarized that during the period 2010-11 crop is more diversified than that of the 1990-91 period. The high degree of diversification during Period-II may be due to increased rate of population pressure, introduction of HYVs seeds, use of fertilizers and manures, provision of irrigation facilities and effectiveness of land reforms, etc.

7.5. Conclusions

This chapter attempts to analyze the agricultural regions of the study area namely, crop ranking region, crop combination region and crop diversification region. The area strength of individual crop has been discussed by ranking. The first five ranking crops have been identified in Period –I while sixth ranking crops have been identified in Period-II. Paddy stands as first ranking crop in all GPs for both time periods. Wheat, jute, potato, other crops and maize have been ranking below the paddy.

Two methods have been applied for determining crop combination regions, i.e. Weaver's and K. Doi's technique. According to Weaver's method the changing crop combination pattern shows that during Period-I monoculture observed in 15 GPs, four crop combination in 4 GPs and seven crop combination in 3 GPs of the subdivision. By the year 2010-11, after 20 years, monoculture has been identified in 18 GPs. Four crop and seven crop combinations have been found non-existent and two new crop combinations, namely five and six crop combinations, have been observed during Period-II. Five and six crop combinations are found in 2 and 2 GPs respectively. Based on Doi's method, the changing crop combination pattern shows that during Period-I 15 GPs identified as

monoculture areas, 3 GPs identified as three crop combination and 4 GPs observed as four crop combination regions. During Period-II three and four crop combinations have been found non-existent. The crop combination pattern changed from period-I to period-II and all GPs have been identified as monoculture regions in the study region.

In order to understand the competition among crops in the region the crop diversification has been computed by applying Bhatia's formula. During Period-I 42.68% area was under high crop diversification while it increased to 78.04% in Period-II. The moderate diversification area has been covered 38.41% in Period-I and 16.21% in Period-II. Low diversification has been covered 18.91% area in Period-I and 5.75% area in Period-II. So, it has been easy to understand that 2010-11 is more diversified than 1990-91. due to increased rate of population pressure, introduction of HYVs seeds, use of fertilizers and manures, provision of irrigation facilities and effectiveness of land reforms, etc.

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