Chapter 5 Sustainable management of agro natural resources

5.1 Introduction

Sustainable agro-natural resources management has the highest priority in all countries of the world, whether developed or developing. But in developing country, agro-natural resources management is an important challenge because, undeveloped technology, lack of infrastructure, proper planning and unconsciousness etc. are the major obstacles to resources management. The broad objectives of sustainable agro-natural resource management is to balance the inherent land resource with agricultural requirements, paying special attention to proper and optimisation of agro-natural resource use towards achievement of sustained productivity over a long period and which is key concern in Agenda 21 (Bhan et al., 1997). The success of sustainable agro-natural resource management could be achieved by adopting an appropriate planning. As discussed in the previous chapters it can be observed that the aspects of agro-natural resources management in the study area which need to be planned are as follows:

i. Firstly, the region needs to be divided into several micro-zones. Micro-zonation is suitable for implementation of micro level planning. Because micro level planning involves planning at the grass root level (Dutta and Sing, 2007). Micro level planning is done from the lowest unit of the administrative boundary. Therefore it considers the situation of local natural resources as well as agricultural resources and takes the plan accordingly by analyzing and understanding it.
ii. Suitable cropping system should be adopted in different categories of land.
iii. Appropriate arrangement should be taken to ensure proper use of agricultural product, such as setting up agro-industry, agro-market and warehouses etc.

iv. Other management policies must be taken at the right time, such use of advanced technology, increase awareness, proper development aspects etc.

Remote Sensing and GIS is an important tool in sustainable agro-natural resources management and development. This technology helps to implement all those plans and also can predict and visualize future scenarios and helping managers in taking decisions (Johnson et al., 2007).

5.2 Physiographic micro zonation for agro natural resources management

According to Oxford English Dictionary, physiography means the "study of nature or of natural phenomena". T. H. Huxley (1877) says in his book entitled "Physiography" that physiography referred to causal relationship of natural phenomena. Later on, however several geographers limit its application to physical geography. As mentioned in the Collins English Dictionary and Webster's New World College Dictionary, another meaning for Physiography is physical geography. According to this dictionary, it is the study of natural features of the earth's surface such as landforms, water, climate, and distribution of flora and fauna. Shortly it studies the physical patterns and process of the earth. On the other hand physiographic zonation is the division of the earth's surface on the basis of physical features. The geographers draw the physiographic zone on the basis of one or more measurable traits that distinguish them from the surrounding area. A physiographic region has a distinct type of geological structure, landform, drainage, climate, and flora and fauna etc.

In developing country like India, the level of resource management and development at the regional level is very weak and inconsistence (Binda, 2019). So, the study area have also the considerable dereliction in resource management and development. The main reason of disparities in management and development is the uneven and unorganised planning (Binda, 2019). Therefore, a proper and organised planning need to be taken for resource

management and development. It is mentioned that the planning should be made in the hierarchical pattern. It must be ensured that it starts from the higher level and reach to grass root level. The disparities of resources management and development can be eliminated if the planning reaches at the grass root level.

At present, the government sector and planners are very interested in management and development from the grass root level, also known as micro-level planning and various developmental works are being decided based on the above theme (Binda, 2019). The government is emphasizing the formation of micro-regions for various planning. Because, to implement of different management and development activities in the grass root level, it is essential to divide an area into several micro-region. According to FAO, “A micro-region is a distinct territorial unit with clearly marked boundaries below the regional level, but above the village level, and associated network of different actors from government, local government, the privet sector and civil society”. Micro-region is a territorial unit which is smaller than the state but larger than municipalities (Behr and Juha, 2011). According to Einhard Schmidt-Kallert (2005), the "micro-region" is usually much smaller than conventional planning regions and it can be defined by physical features like water catchment areas. So, physiographic micro-region can be defined as a distinct territorial unit whose boundaries are determined by the physical characteristics. This region is made based on the concept of areal homogeneity (Sharma, 2016). Micro-region has several advantages to achieve the goal of all-round management and development of agro-natural resources such as:

i. Micro region is the important unit for management and development of resources from grass root level because local issues regarding resources can be identified.
ii. Micro region is suitable for micro planning, which makes the implementation of the plan efficiently at the local level and which will hopefully achieve better planning effectiveness.

iii. Planning is a hierarchical in character. Micro-region exists at the bottom of the planning process.

iv. Horizontal networks can be established within small regions which help to develop the living conditions of the people of the rural areas. This network can be a means of localised trade links between neighbouring villages, exchange of goods, information and innovation.

v. In micro-region, management and development of resources can be initiated by the local people or their representatives. Therefore, socio-economic condition of the people is improved for their involving in the management system.

vi. Micro-region develops its own inherent potential.

vii. It is oriented towards sustainable use of natural resources, economic development and social and institutional practices. It is an important conceptual orientation for any spatial planning and development (Schmidt-Kallert, 2005).

Now, the study is focusing on the delimitation of geographical regions at micro-level with reference to Purba Medinipur district. The approach is empirical, inter-disciplinary, analytical and quantitative (Sharma, 2016). The main target behind the formation of micro-physiographical regions is sustainable agro-natural resources management considering the different situation related to this resource. With the help of micro-physiographical regions, planner and policy makers can easily solve out the problems regarding resources, be able to prepare a design for resources management and development and after all can take effective micro planning at the village level about the resources. It should be mentioned that the term ‘zone’ has been used as a same sense of region in the study.

Earlier, various authors and agencies have made the physiographic micro-zonation of Purba Medinipur district on the basis of various physical features. The National Atlas & Thematic Mapping Organization (NATMO) has divided the district into different micro-zone

on the basis of physical features such as micro-zonation based on soil types, relief and slope, and climatic condition. The NRDMS (Natural Resources Data Management System) centre, Office of the District Magistrate, has prepared a soil zonation map with ten types of soil. NRDMS centre has also divided the district into several micro watershed zones. A map has been prepared to show the flood prone area of Purba Medinipur district by the Disaster Management Authority of the district. Central Ground Water Board (CGWB) and Geological Survey of India (GSI) have divided the district into six hydro-geological zones. Different organization like ICAR (Indian Council of Agricultural Research), NARP (National Agricultural Research Project), Planning Commission has categorised the district in different agro-climatic/ecological zones. In addition, several authors in their paper have also shown the division of micro-zone of the district based on the different physical phenomena. However, this types of physiographic micro-zonation mentioned in the study, not attempted in previous literature in my knowledge.

Now, in this study Purba Medinipur district has been divided into several physiographic micro-zones based on drainage basin area. A drainage basin area also commonly referred to as river basin, is a portion of land surface in which theoretically any drop of water that falls eventually flows out through a single known point. A drainage area consists of a set of watercourse which has one main river and many tributaries connected to it. This watercourse carry out total water of the basin area and finally out flows through the main river at a single point. There are ten main rivers in the district of Purba Medinipur and these rivers have numerous tributaries and connected canal (Fig. 2.11 & 2.12). These main rivers are Hooghly, Rupnarayan, Haldi, Durbachati, Kangsabati, Rasulpur, Pichaboni, Champa, Keleghai and Chandia river. All these rivers and their tributaries carry as much water as that part has been identified as the basin of that river. Although the district is divided into 8 basin area as follows (Fig. 5.2).

A. Downstream sub-basin of Rupnarayan-Hooghly

B. Durbachati sub-basin hydro-system

C. Downstream sub-basin of Kangsabati

D. Downstream sub-basin of Keleghai - Chandia

E. Haldi sub-basin hydro-system

F. Rasulpur basin hydro-system

G. Pichaboni basin hydro-system

H. Champa basin hydro-system

However, here another type of method has been adopted for delimitation of basin boundary. In this case, a set of watercourse that flows over villages, all these villages together have been marked as the basin of that watercourse and adding all these villages, the boundary that is found is the outer boundary of that basin. Three things should be mentioned here, firstly, if tributaries of two different basins flow in a village then the village has been included in the corresponding basin whose river length is longer in that village. Secondly, a part of any river basin may be outside the study area. However, the study area as is included within political boundary, so as much as there are basin within this boundary has been considered. Lastly, in determining the basin area, the main river, tributaries and their associated canals has also been considered (Fig. 5.1). The eight physiographic micro-zones of the district have been discussed as follows and the table (Table 5.1) below shows the different basin name and its area and number of village within it (Annexure 10).

A. Downstream Sub-basin of Rupnarayan-Hooghly

Downstream sub-basin of Rupnarayan-Hooghly is located along the eastern boundary of the district (Fig. 5.2). It consist of the lower reaches of two rivers like, Hooghly and

Rupnarayan and where Rupnarayan river is connected with Hooghly river then combined flow falls into Bay of Bengal. So, this basin area consist of all those villages whose water carries these two rivers. Total number of village in the basin is 491 and it includes Tamluk municipality and part of Haldia municipality. Total area of the basin in the district is 707.26 km^2. Geologically this basin is covered with younger alluvial soil (Fig. 5.3). Salinity of soil is below 2.0 dS/m throughout of this part, but in lower part of the basin the salinity of soil varies from 2.0 to 8.0 dS/m (Fig.5.4). The saline tidal water entering the upper part of the basin is below 0.3 dS/m, middle part 0.3 to 0.8 dS/m and in lower part 0.8 to 2.5 dS/m (Fig. 5.5). Agriculturally, this basin is very high significant. The characteristics of land use, agricultural pattern, forest and fishery of the basin is shown in different table and respective diagram.

B. Durbachati Sub-basin Hydro-system

Durbachati Sub-basin Hydro-system is located in the north side of the district. It is situated along the bank of Durbacahati river which is the affluent of Rupnarayan river. The size of the basin is smaller than the other basin area of the district. Area of the basin is 77.07 km^2 and consists of 62 villages of the district. Most of the part of the basin is covered with younger alluvial soil and some part of western side is covered with older alluvial soil. Salinity of soil is below 2.0 dS/m in whole part of the basin (Fig. 5.4). The salinity of tidal water in the basin is below 0.3 dS/m in most part but a small part in eastern side the salinity is 0.3 to 0.8 dS/m. This basin is most important for different crops cultivation.

C. Downstream Sub-basin of Kangsabati

Downstream Sub-basin of Kangsabati is situated along the lower reaches of Kangsabati river which is located on the western side of the district. The total area of the basin in the

district is 293.13 km^2. It consists of 249 villages and it includes the part of Panskura municipality. Most area of the basin is composed by younger alluvial soil and only some part of the north is formed of older alluvium. Soil salinity in the whole part of the basin is below 2.0 dS/m. The salinity level of tidal water entered in the basin is below 0.3 dS/m in most part of the area but small part in southern side the salinity varies from 0.3 to 0.8 dS/m. In this basin, use of cultivated land is maximum in every crop seasons. So, this basin is also important for agriculture. Cropping intensity, crop diversification and crop combination is very high in this zone. Large scale fisheries have also developed here.

D. Downstream Sub-Basin of Keleghai - Chandia

Downstream sub-basin of Keleghai-Chandia is situated in the lower reaches of the Keleghi and Chandia river. The total area of the basin in the district is 253.33 km^2 and includes 187 villages. The most part of the basin is composed with younger alluvial soil, but very small part of the western side is composed of older alluvial soil. Soil salinity is below 2.0 dS/m throughout the area of the basin but in some part of the south-eastern side the salinity is 2.0 to 4.0 dS/m. Salinity level of tidal water in the basin is 0.3 to 0.8 dS/m. In some places, the salinity of tidal water is below 0.3 dS/m. Agriculturally, this basin belongs to medium to high significant zone.

E. Haldi Sub-basin Hydro-system

The combined flow of two rivers like Kangsabati and Keleghai is the river Haldi. So, Haldi sub-basin hydro-system is situated on the bank of Haldi river. The area of the basin is 588.89 km^2 and it consists of 322 villages which includes some part of Haldia municipality. Two-thirds of the basin is covered with younger alluvial and rest portion by coastal alluvial soil. The salinity of the soil in about half of the land of the basin is 4.0 to 8.0 dS/m and

salinity is 2.0 to 4.0 dS/m and below 2.0 dS/m in some places. In most part of the basin, salinity level of tidal water is 0.8 to 2.5 dS/m. The salinity of tidal water is high i.e. 2.5 to 5.8 dS/m in some part of the southern side in the basin. Agriculturally this basin is belongs to medium to high significant zone.

F. Rasulpur Basin Hydro-system

Rasulpur basin hydro-system comprises of Rasulpur river and its tributaries. This basin is located entirely within the district which is the south-eastern part of coastal plain. It is the largest basin of the district. The total area of the basin is 1175.55 km^2. The total number of villages within the basin is 933 which includes Egra municipality. Almost area of the basin is made up of coastal alluvial soil. Along the coast of the basin soil is saline and saline alkali in nature. Some part of northern side of the basin is composed of younger alluvial and western side composed of older alluvial. Soil salinity in half of the basin is 4.0 to 8.0 dS/m and some part is 2.0 – 4.0 dS/m. In upper most part salinity is below 2.0 dS/m. Besides, the salinity of soil along the coast is high such as above 8 dS/m. Extremely high salinity tidal water enters the coastal part of this basin and then gradually it decreases towards the upper reaches. In coastal part the salinity of tidal water is above 5.8 dS/m then it reduce to 0.3 to 0.8 dS/m at the upper reaches.

G. Pichaboni Basin Hydro-system

Pichaboni basin hydro-system consists of river Pichaboni and its tributaries. It is confined within the district and its southern part is coastal area. The area of the basin is 445.29 km^2. The number of villages belongs to the basin is 442 and with Contai municipality. The most of the area of the basin is covered with coastal alluvial soil and along the coast, the soil is saline and saline alkali in nature. Soil salinity in most part of the area is moderate which is varies

between 4.0 to 8.0 dS/m. High saline soil such as above 8.0 dS/m is found along the coast. In upper reaches of the basin the soil of some part is slightly saline with 2.0 to 4.0 dS/m. The whole basin is inundated by tidal water with extremely high salinity such as above 5.8 dS/m.

H. Champa Basin Hydro-system

Champa basin hydro-system consists of Champa river and its tributaries. Southern part of the basin is coastal belt. The area of the basin is 367.51 km^2 and consists of 308 villages. Half of the basin is made up of coastal alluvial soil and upper reaches is composed of older alluvial soil. Saline and saline alkali soil is found along the coast of the basin. Two-third of the basin is consists of moderately saline soil such as 4.0 to 8.0 dS/m and coastal area is composed of high saline soil. Some part of upper reaches of the basin is formed by light saline soil like 2.0 to 4.0 dS/m and in rest part soil has no salinity or negligible such as below 2.0 dS/m. Extremely high saline tidal water enters in most part of the basin with salinity level of above 5.8 dS/m.

Table 5.1 Area of different basin hydro-system with number of village

Name of Basin Hydro System	Area (sq.km)	Total No of Village and Municipality under different basin
Downstream Sub-basin of Rupnarayan-Hooghly River	707.26	499 (Tamluk Panskura municipality and part of Haldia municipality)
Durbachati Sub-basin Hydro-system	77.07	62
Downstream Sub-basin of Kangsabati River	293.13	245 (Panskura municipality)
Downstream Sub-basin of Keleghai - Chandia River	253.33	186
Haldi Sub-basin Hydro-system	588.89	323 (Part of Hldia municipality)
Rasulpur Basin Hydro-system	1175.55	929 (Egra municipality)
Pichaboni Basin Hydro-system	445.29	444 (Contai mnicipality)
Champa Basin Hydro-system	367.51	311

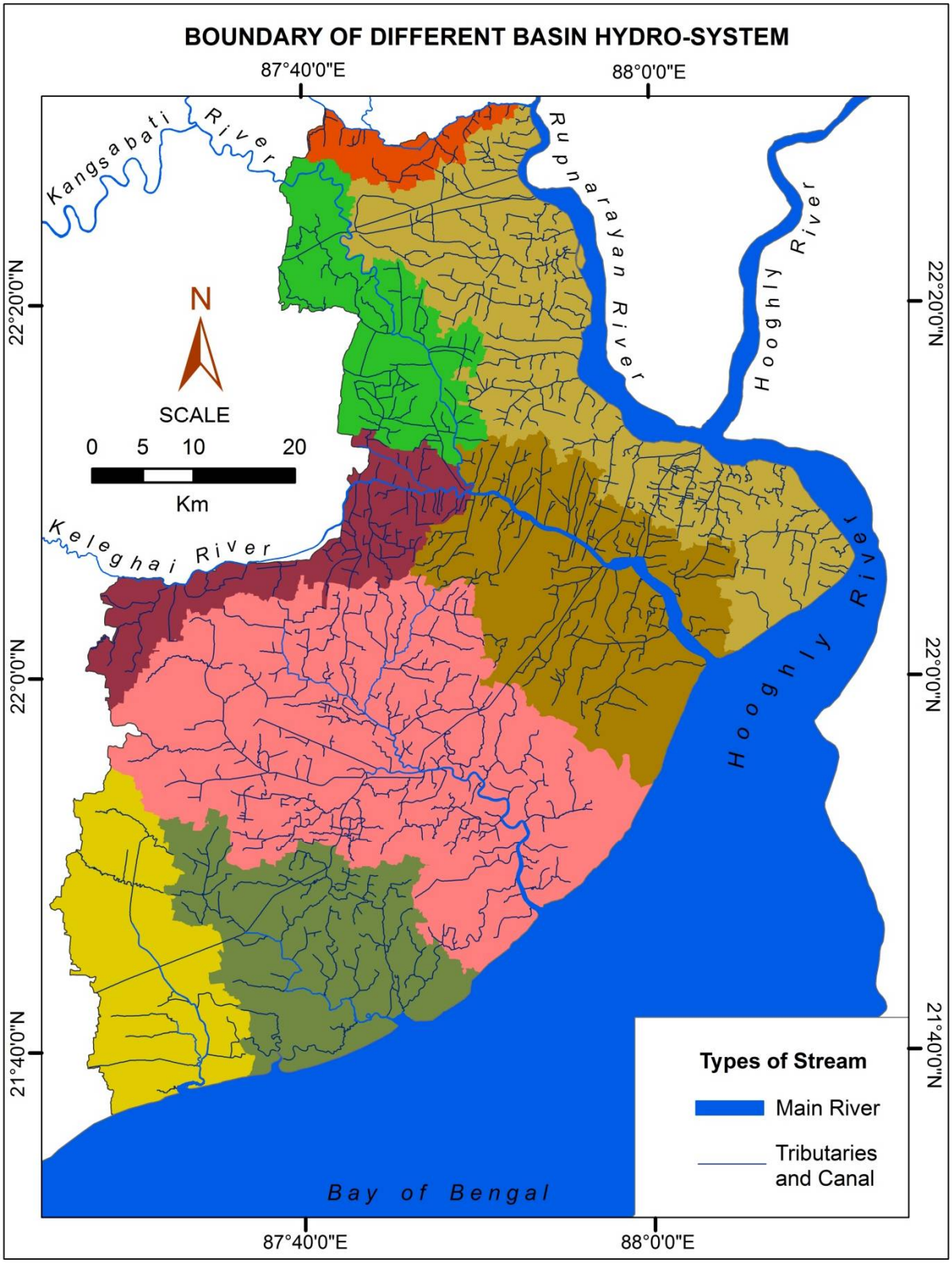

Fig. 5.1 Area of different basin hydro-system with drainage.

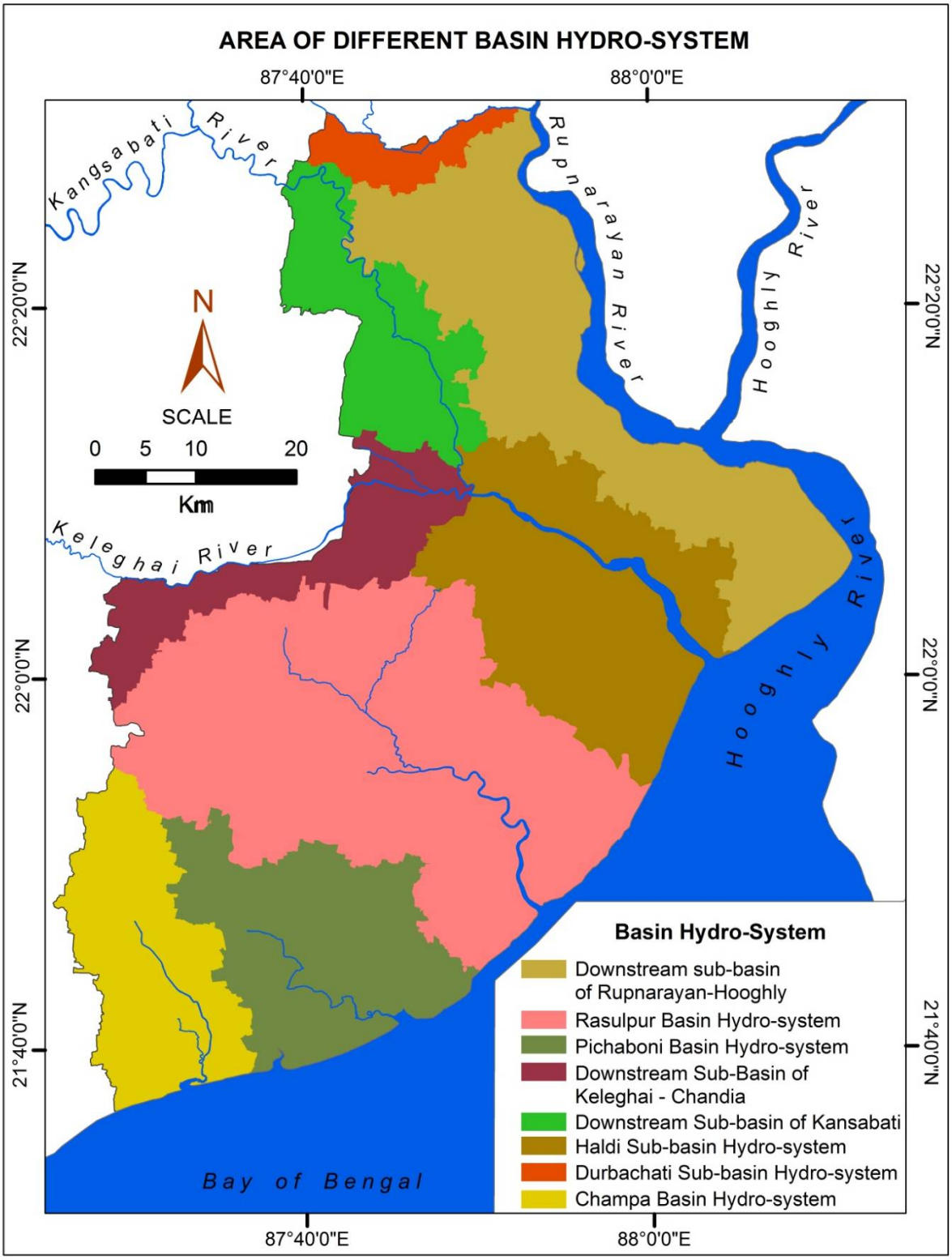

Fig. 5.2 Physiographic micro-zonation of Purba Medinipur district.

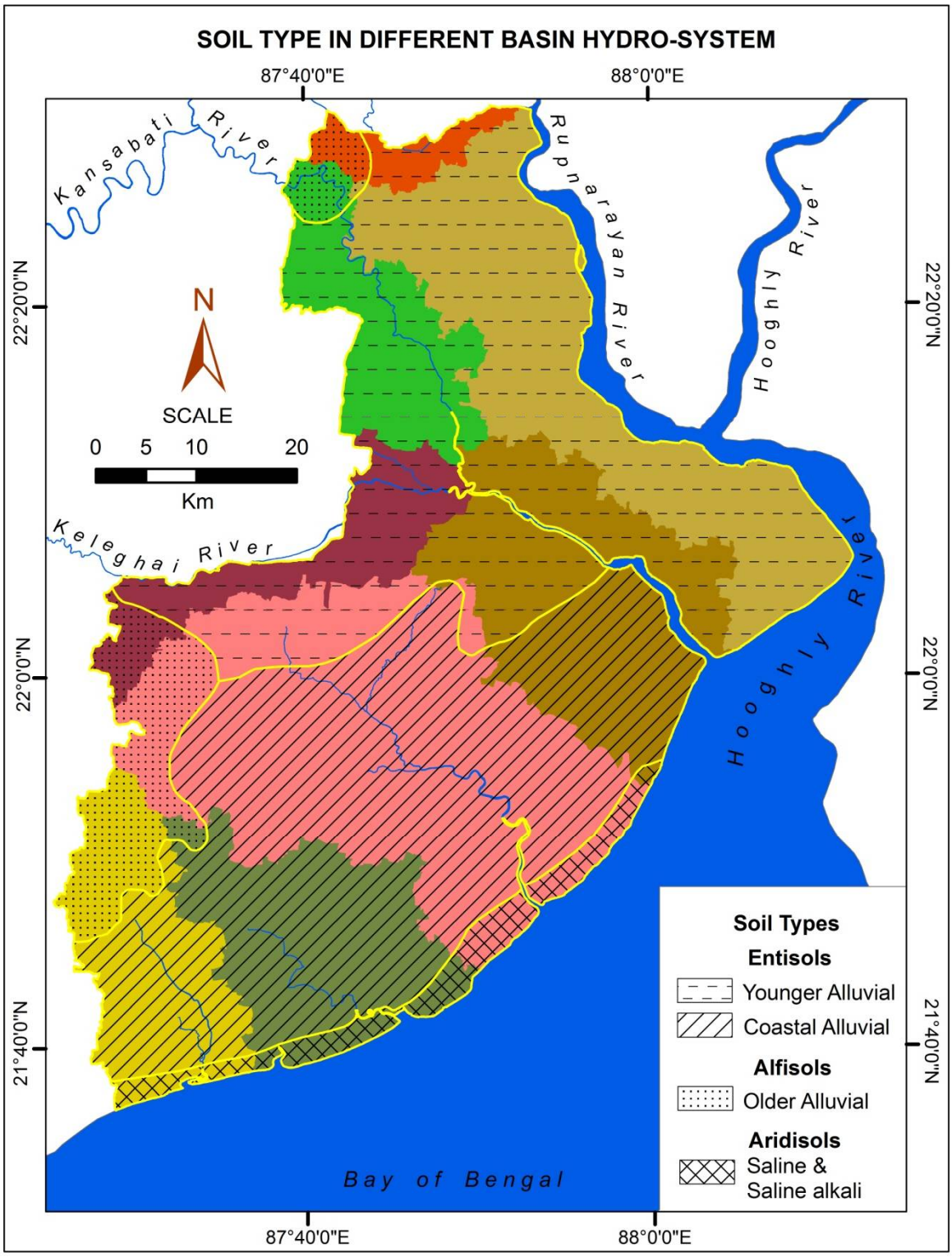

Fig. 5.3 Soil type of different basin hydro-system.

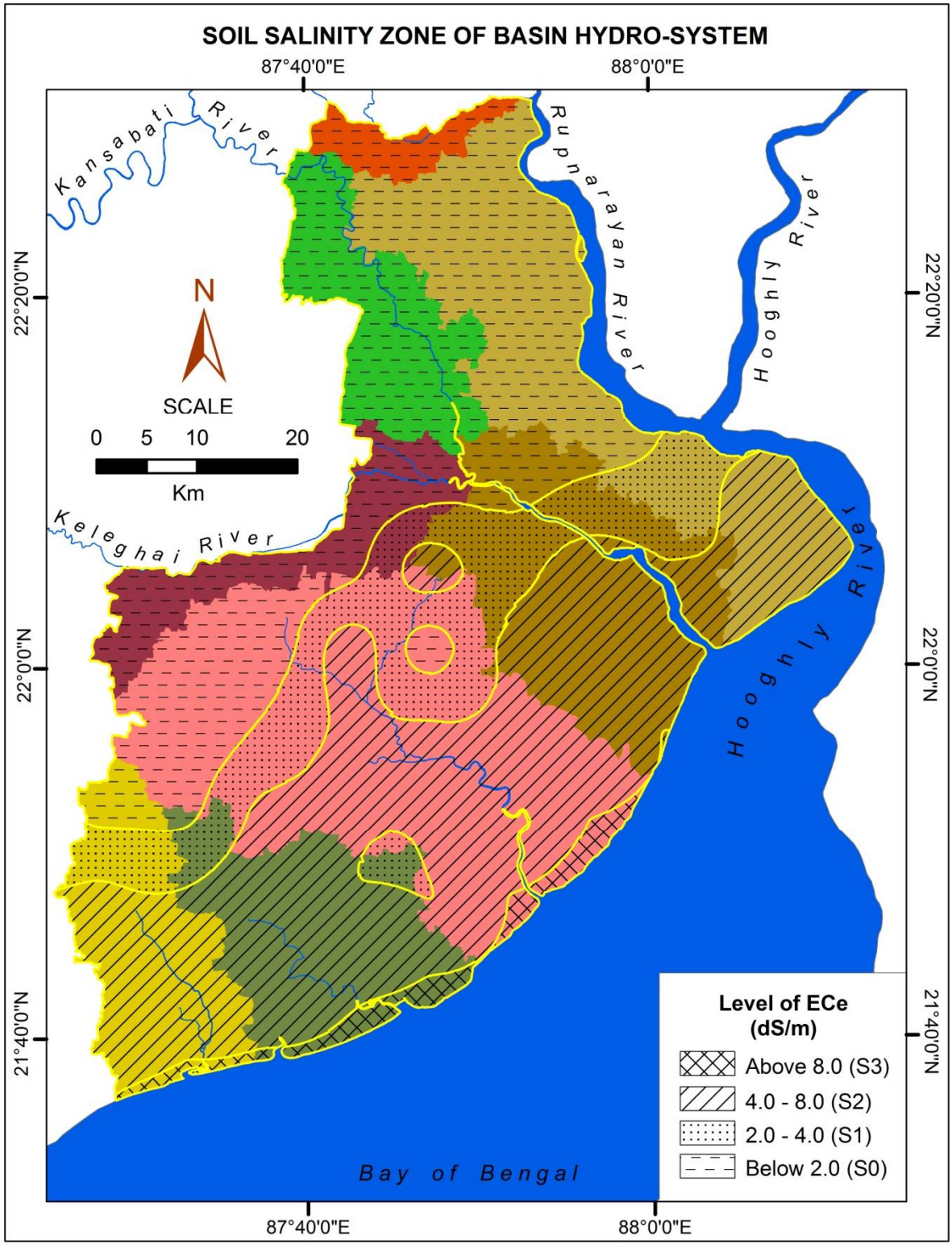

Fig. 5.4 Nature of soil salinity of different basin hydro-system.

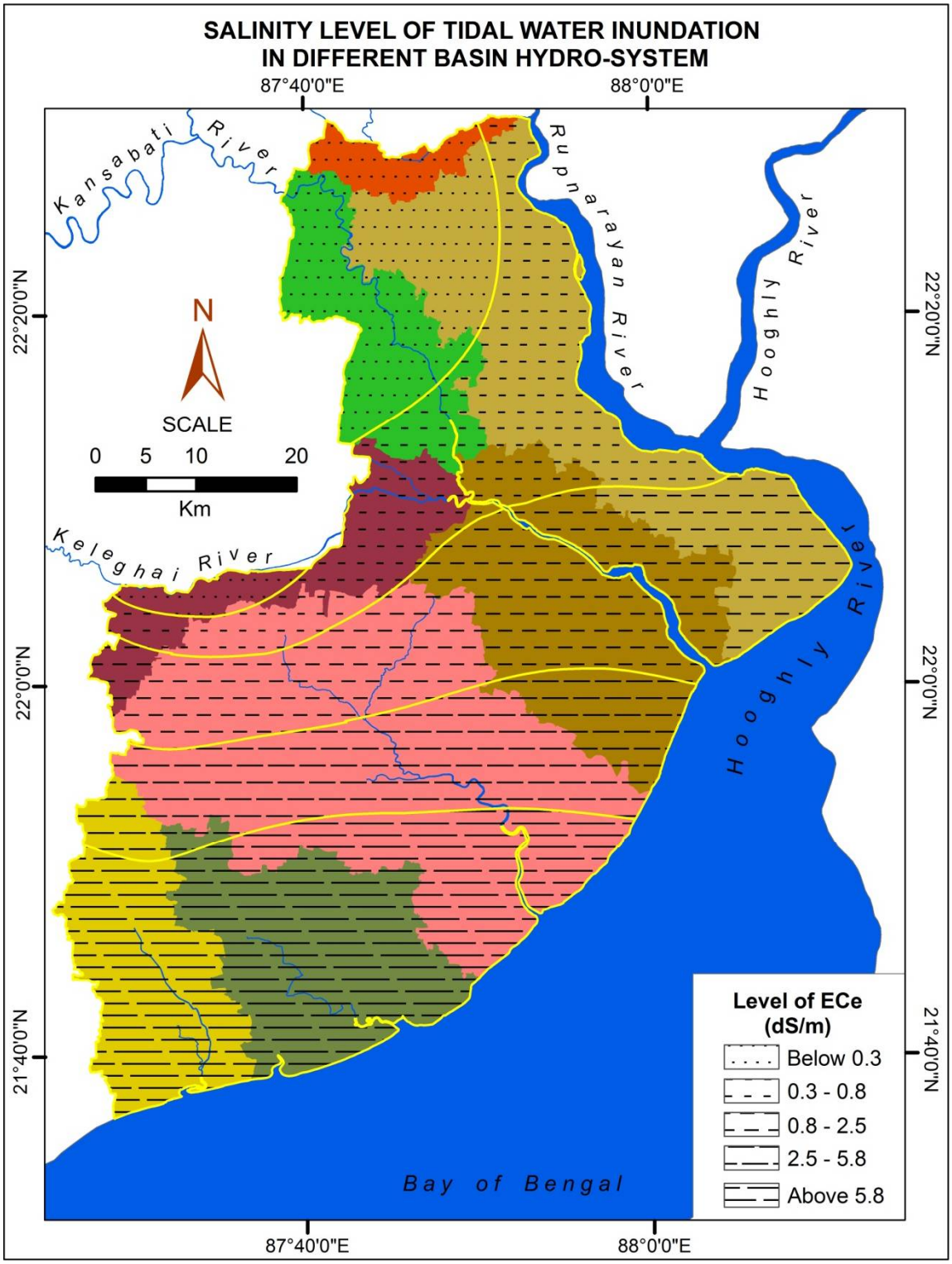

Fig. 5.5 Inundated area of basin hydro-system by different salinity level of tidal water.

Salient features of different basin hydro-system in relation to agro-natural resources

Characteristics of different basin hydro-system are shown in different table and corresponding diagram. Here the amount of cultivated land, nature of cultivated landuse, agricultural importance, fishery and nature of vegetation in different basin has been discussed.

a. Cultivated land area

All the basins have cultivated land above 50 percent of their total land (Table 5.2). Rasulpur basin hydro-system has the highest cultivated land and downstream sub-basin of Kangsabati river has the lowest amount of cultivated land such as 78.50 percent and 54.14 percent respectively. The diagram (Fig. 5.6) shows the basin wise amount of cultivated land.

b. Nature of cultivated land use

Every basin has maximum cultivated land but use of cultivated land is varied in different basin in different seasons (Table 5.3). The diagram (Fig. 5.7) shows the basin wise use of cultivated land in different seasons. The maximum cultivated land is used in each basin during kharif crop season, but large amount of cultivated land is unploughed during rabi and zaid crop season in all basin except downstream sub-basin of Kangsabati river and Durbachati sub-basin hydro-system.

Table 5.2 Basin wise amount of cultivated land

Sl No	Name of Basin Hydro System	Total Basin Area (hect.)	Area of Cultivated land (hect.)	% of Cultivated Land
1	Downstream Sub-basin of Rupnarayan-Hooghly River	70726.27	47235.02	66.79
2	Durbachati Sub-basin Hydro-system	7707.30	5921.04	76.82
3	Downstream Sub-basin of Kangsabati River	29312.67	15871.00	54.14
4	Downstream Sub-basin of Keleghai - Chandia River	25332.79	17206.06	67.92
5	Haldi Sub-basin Hydro-system	58889.04	42297.05	71.82
6	Rasulpur Basin Hydro-system	117555.16	92284.84	78.50
7	Pichaboni Basin Hydro-system	44529.26	33228.35	74.62
8	Champa Basin Hydro-system	36751.01	27888.99	75.89

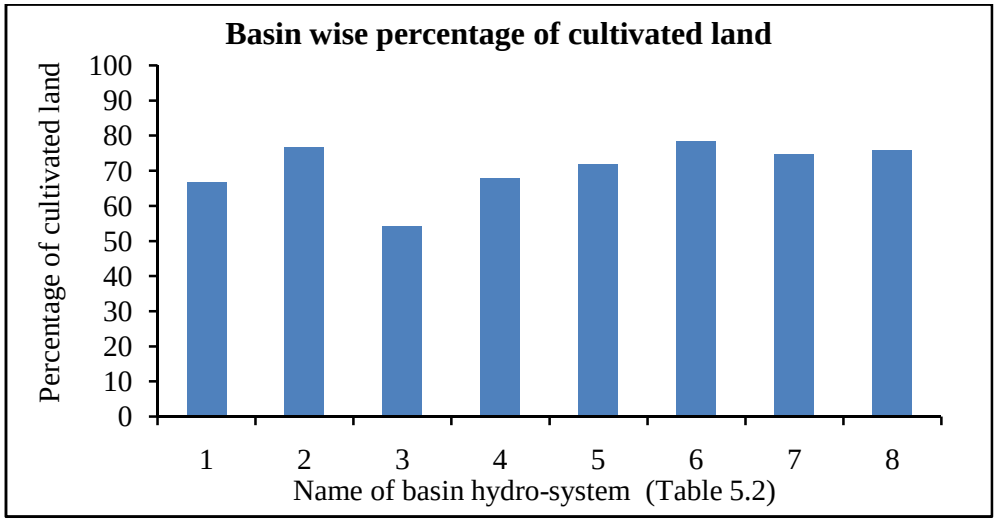

Fig. 5.6 Amount of cultivated land in different basin.

Table 5.3 Basin wise percentage of non ploughed arable land in different season

Sl No.	Name of Basin Hydro System	% Of non ploughed arable land in Kharif crop season	% Of non ploughed arable land in Rabi crop season	% Of non ploughed arable land in Zaid crop season
1	Downstream Sub-basin of Rupnarayan-Hooghly River	13.47	89.70	33.35
2	Durbachati Sub-basin Hydro-system	9.78	48.45	25.78
3	Downstream Sub-basin of Kangsabati River	12.20	52.53	38.86
4	Downstream Sub-basin of Keleghai - Chandia River	9.65	95.96	71.58
5	Haldi Sub-basin Hydro-system	15.19	83.95	42.53
6	Rasulpur Basin Hydro-system	15.37	89.93	80.68
7	Pichaboni Basin Hydro-system	24.80	92.26	76.26
8	Champa Basin Hydro-system	10.99	93.76	59.59

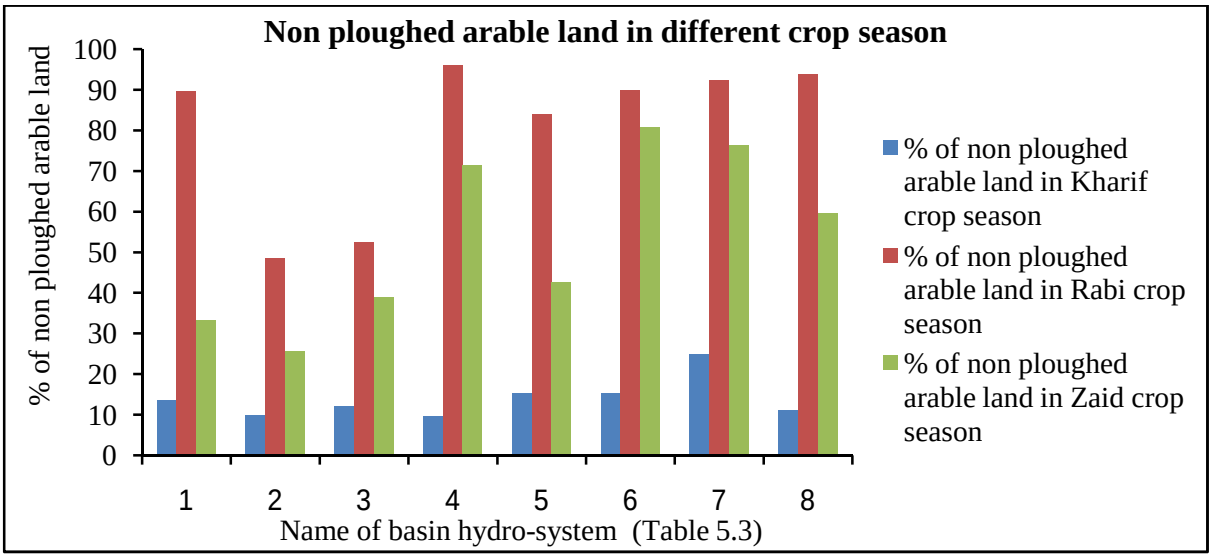

Fig. 5.7 Basin wise amount of non ploughed arable land in different season.

c. Cropping Intensity

The nature of cropping intensity is different in each basin (Table 5.4). Cropping intensity is high in downstream sub-basin of Rupnarayan-Hooghly river, Durbachati sub-basin hydro-system and downstream sub-basin of Kangsabati river where the cropping intensity of most villages is above 150 percent such as 73 percent, 84 percent and 100 percent villages of respective basins. The diagram shows the basin wise number of villages in different category of cropping intensity (Fig. 5.8).

Table 5.4 Basin wise number of village in different classes of cropping intensity

Sl No	Name of Basin Hydro System	Total Village	Number of village and percentage					
			Below 100	% of village	100 to 150	% of village	Above 150	% of village
1	Downstream Sub-basin of Rupnarayan-Hooghly River	491	25	5	108	22	358	73
2	Durbachati Sub-basin Hydro-system	62	0	0	0	0	62	100
3	Downstream Sub-basin of Kangsabati River	249	21	8	20	8	208	84
4	Downstream Sub-basin of Keleghai - Chandia River	187	14	7	141	76	32	17
5	Haldi Sub-basin Hydro-system	322	225	70	12	4	85	26
6	Rasulpur Basin Hydro-system	933	178	19	528	57	227	24
7	Pichaboni Basin Hydro-system	442	205	46	188	43	49	11
8	Champa Basin Hydro-system	308	68	22	186	60	54	18

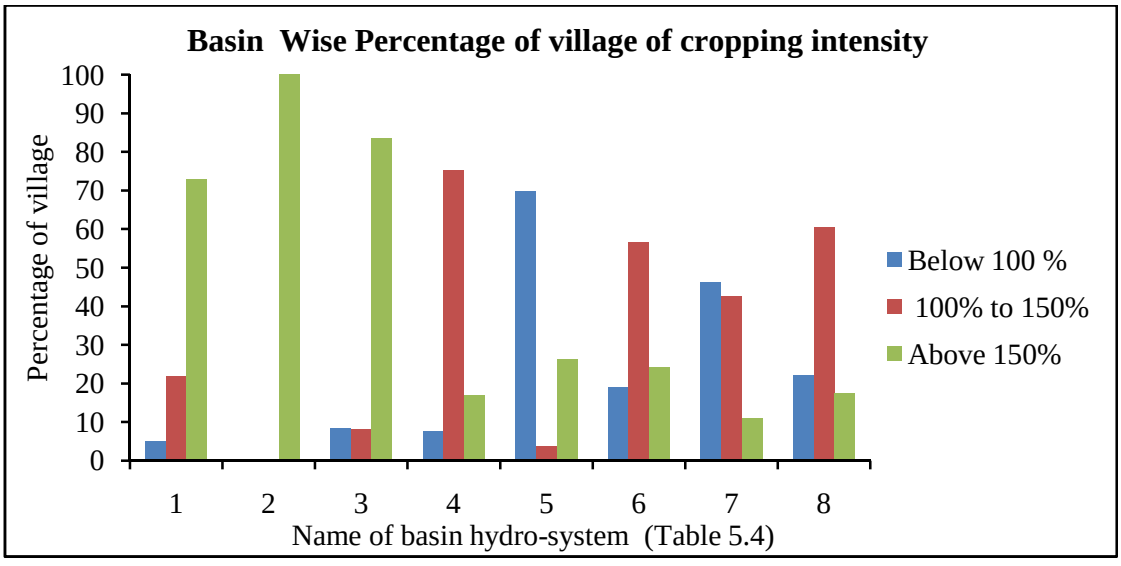

Fig. 5.8 Basin wise percentage of village in different classes of cropping intensity.

d. Crop Combination

Crop combination is most important in Durbachati sub-basin hydro-system and downstream sub-basin of Kangsabati river, where respectively 66 percent and 47 percent villages is under the four crop combination zone, even 24 percent villages of downstream sub-basin of Kangsabati river is under the five crop combination zone. Near about 50 percent villages of other basins are under minimum of three crop combination zone. The table (Table 5.5) and related diagram (Fig. 5.9) shows the basin wise percentage of village in different category of crop combination.

Table 5.5 Basin wise number of village in different crop combination zone

Sl No	Name of Basin Hydro System	Total Village	Number of village and percentage									
			One Crop	% of Village	Tow Crop Combination	% of Village	Three Crop Combination	% of Village	Four Crop Combination	% of Village	Five Crop Combination	% of Village
1	Downstream Sub-basin of Rupnarayan-Hooghly River	491	5	1	155	32	236	48	80	16	15	3
2	Durbachati Sub-basin Hydro-system	62	0	0	3	5	15	24	41	66	3	5
3	Downstream Sub-basin of Kangsabati River	249	0	0	11	4	61	25	117	47	60	24
4	Downstream Sub-basin of Keleghai - Chandia River	187	6	3	76	41	70	37	17	9	18	10
5	Haldi Sub-basin Hydro-system	322	2	1	87	27	144	45	76	23	13	4
6	Rasulpur Basin Hydro-system	933	17	2	361	39	411	44	121	13	23	2
7	Pichaboni Basin Hydro-system	442	7	2	94	21	286	64	34	8	21	5
8	Champa Basin Hydro-system	308	59	19	76	25	91	30	59	19	23	7

e. Crop Diversification

From the table (Table 5.6) and related diagram (Fig. 5.10), it is found that the crop diversification is also greater in Durbachati sub-basin hydro-system and downstream sub-basin of Kangsabati river, where respectively 95 percent and 93 percent villages of that basin

are under the high level of crop diversification which is above 0.6. The crop diversification of near about 50 percent villages in other basins is of medium type.

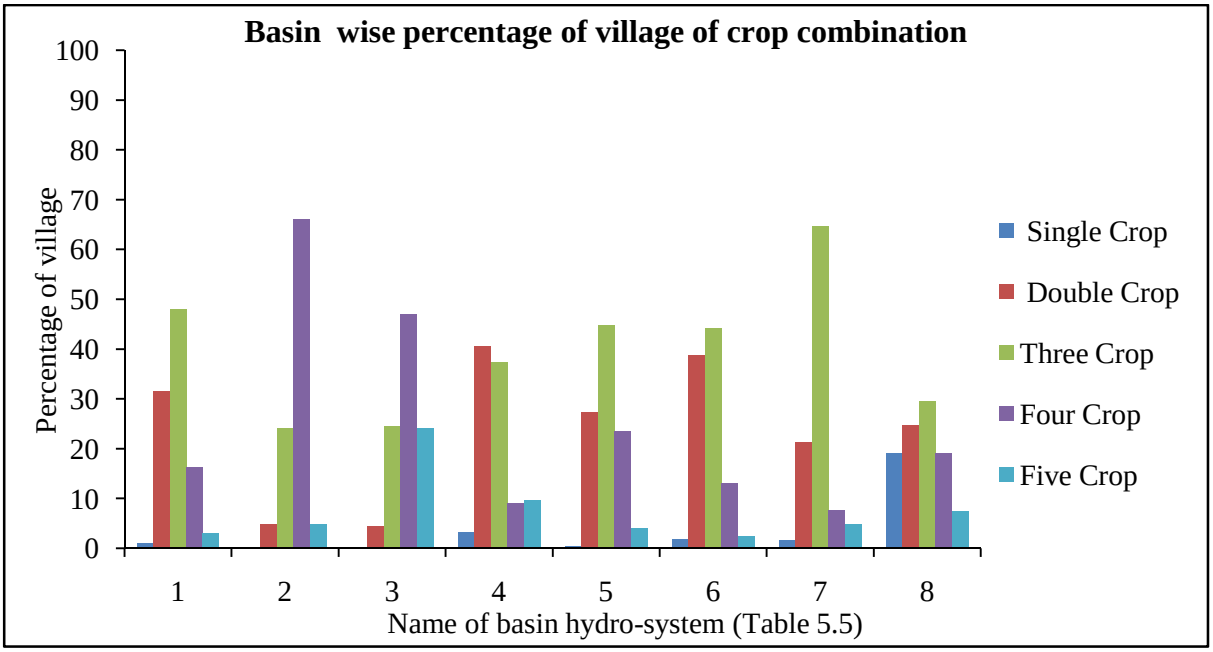

Fig. 5.9 Basin wise percentage of village in different crop combination zone.

Table 5.6 Basin wise number of village in different classes of crop diversification

Sl No	Name of Basin Hydro System	Total Village	Number of village and percentage					
			Below 0.3	% of village	0.3 to 0.6	% of village	Above 0.6	% of village
1	Downstream Sub-basin of Rupnarayan-Hooghly River	491	8	2	226	46	257	53
2	Durbachati Sub-basin Hydro-system	62	1	2	2	3	59	95
3	Downstream Sub-basin of Kangsabati River	249	2	1	17	7	230	92
4	Downstream Sub-basin of Keleghai - Chandia River	187	43	23	118	63	26	14
5	Haldi Sub-basin Hydro-system	322	15	5	194	60	113	35
6	Rasulpur Basin Hydro-system	933	143	15	578	62	212	23
7	Pichaboni Basin Hydro-system	442	32	7	227	51	183	42
8	Champa Basin Hydro-system	308	85	28	118	38	105	34

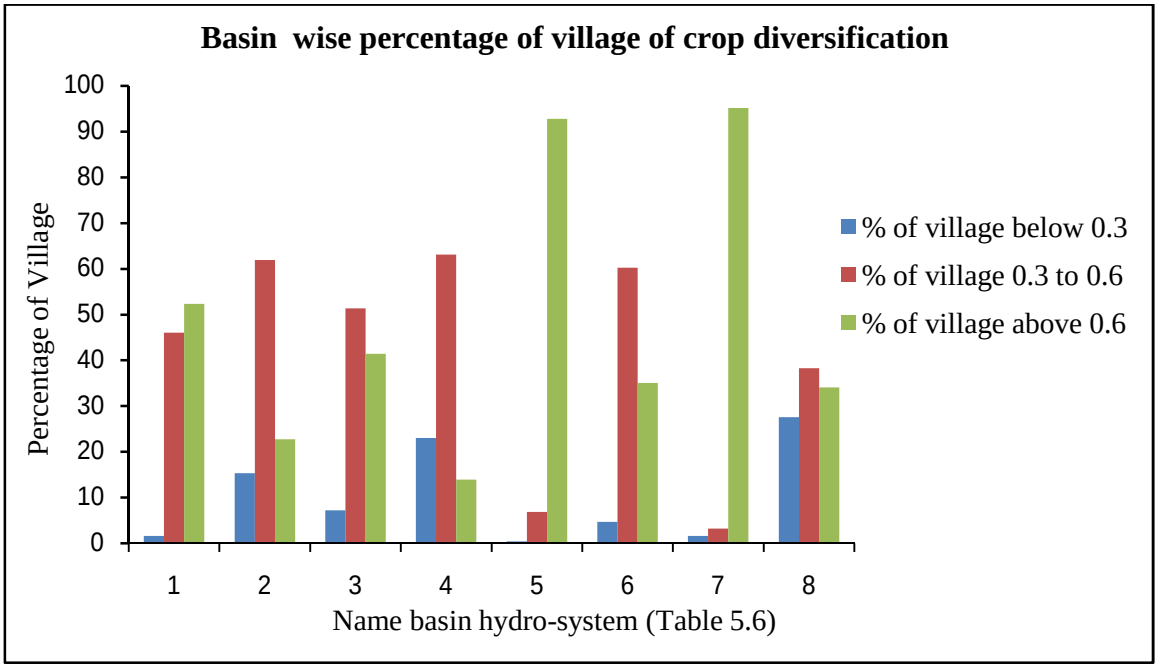

Fig. 5.10 Basin wise percentage of village in different classes of crop diversification.

f. Amount of vegetation

The table (Table 5.7) and diagram (Fig. 5.11) shows the basin wise amount of forest cover area. Durbachati sub-basin hydro-system and Champa basin hydro-system has the largest forest cover area like 30.30 percent and 30.65 percent respectively out of total land. All other basins have above minimum 15 percent forest cover area out of total land. The table (Table 5.8) and diagram (Fig. 5.12) also shows the basin wise amount of different types of forest such as forestry by farmer and forestry by government and semi-government organization. From the diagram it is found that the forest planted by farmer is comparatively larger in Rasulpur basin hydro-system, Pichaboni basin hydro-system and Champa basin hydro system than other basin, but forest planted by government and semi-government agencies is less from other basin.

g. Amount of fishery

Fishery has more developed in downstream sub-basin of Kangsabati river, where 21.47 percent land out of total land is fishery. In other basins except Durbachati sub-basin hydro-

system and Champa basin hydro system more or less has also found. Basin wise amount of fishery is shown in the table (Table 5.9) and diagram (Fig. 5.13) below.

Table 5.7 Basin wise amount of forest cover area

Sl No	Name of Basin Hydro System	Total Basin Area (hectare)	Total Forest (hectare)	% of forest area
1	Downstream Sub-basin of Rupnarayan-Hooghly River	70726.27	17543.87	24.81
2	Durbachati Sub-basin Hydro-system	7707.30	2335.37	30.30
3	Downstream Sub-basin of Kangsabati River	29312.67	7850.43	26.78
4	Downstream Sub-basin of Keleghai - Chandia River	25332.79	4557.63	17.99
5	Haldi Sub-basin Hydro-system	58889.04	9315.98	15.82
6	Rasulpur Basin Hydro-system	117555.16	19567.3	16.65
7	Pichaboni Basin Hydro-system	44529.26	7683.78	17.26
8	Champa Basin Hydro-system	36751.01	11265.55	30.65

Table 5.8 Basin wise amount of different category of forest cover area

Sl No	Name of Basin Hydro System	Total Forest (hectare)	Area of Agro Forest by Farmer (hectare)	% of Agro-Forest planted by farmer	Area of Agro-forest by govt/semi-govt. agencies (hectare)	% of Agro-forest by govt/semi-govt. agencies
1	Downstream Sub-basin of Rupnarayan-Hooghly River	17543.87	15487.31	88.28	2056.56	11.72
2	Durbachati Sub-basin Hydro-system	2335.37	2089.64	89.48	245.73	10.52
3	Downstream Sub-basin of Kangsabati River	7850.43	6863.21	87.42	987.22	12.58
4	Downstream Sub-basin of Keleghai - Chandia River	4557.63	4006.14	87.90	551.49	12.10
5	Haldi Sub-basin Hydro-system	9315.98	8367.14	89.81	948.84	10.19
6	Rasulpur Basin Hydro-system	19567.3	18091.21	92.46	1476.09	7.54
7	Pichaboni Basin Hydro-system	7683.78	7164.57	93.24	519.21	6.76
8	Champa Basin Hydro-system	11265.55	10511.25	93.30	754.3	6.70

Table 5.9 Amount of fishing ground in different basin hydro-system

Sl No	Name of Basin Hydro System	Total Basin Area (hectare)	Area of Fishery (hectare)	% of Fishery Land
1	Downstream Sub-basin of Rupnarayan-Hooghly River	70726.27	7881.27	11.14
2	Durbachati Sub-basin Hydro-system	7707.30	122.07	1.58
3	Downstream Sub-basin of Kangsabati River	29312.67	6293.40	21.47
4	Downstream Sub-basin of Keleghai - Chandia River	25332.79	2519.10	9.94
5	Haldi Sub-basin Hydro-system	58889.04	5647.50	9.59
6	Rasulpur Basin Hydro-system	117555.16	8957.87	7.62
7	Pichaboni Basin Hydro-system	44529.26	4668.65	10.48
8	Champa Basin Hydro-system	36751.01	962.89	2.62

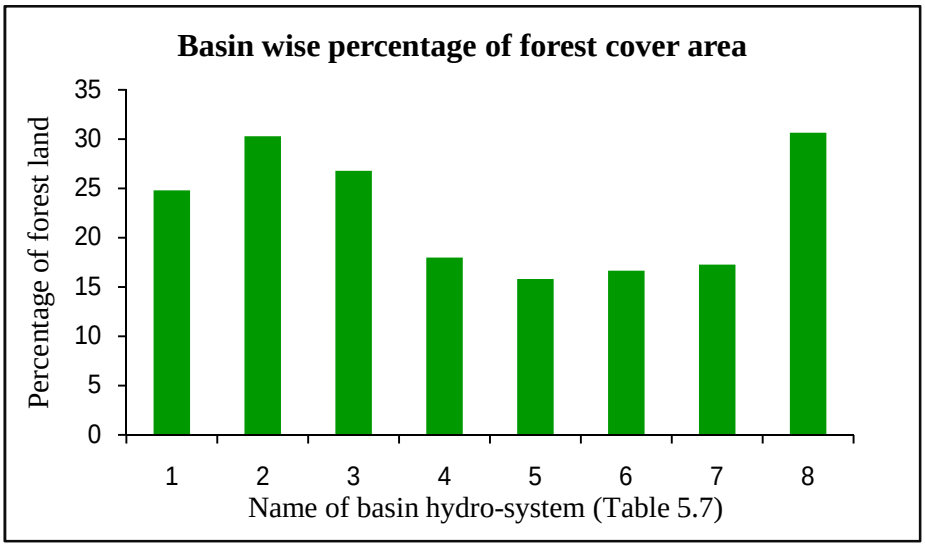

Fig. 5.11 Basin wise percentage of forest covers land out of total area.

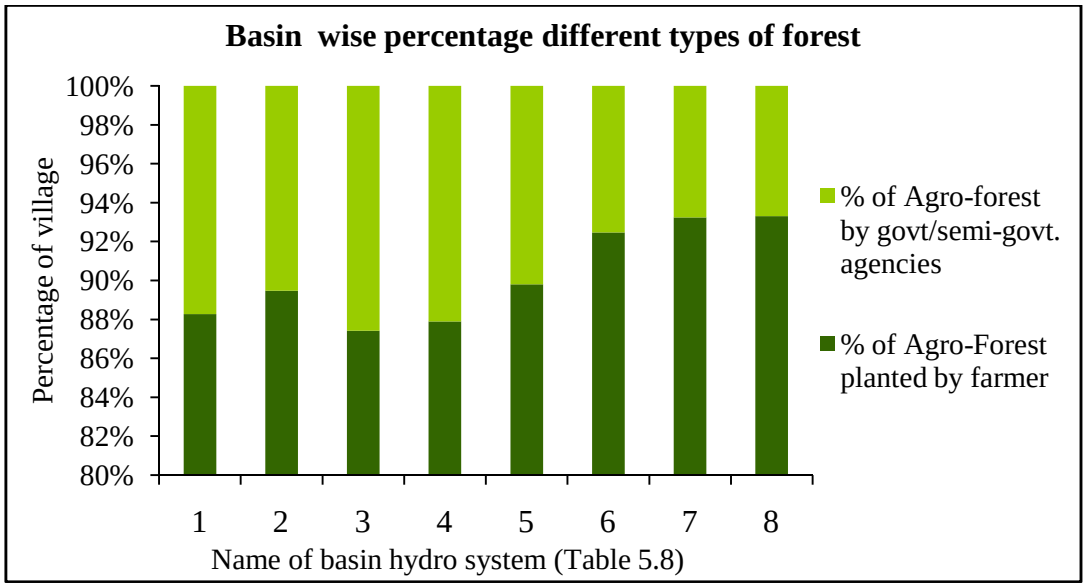

Fig. 5.12 Basin wise different types of forest.

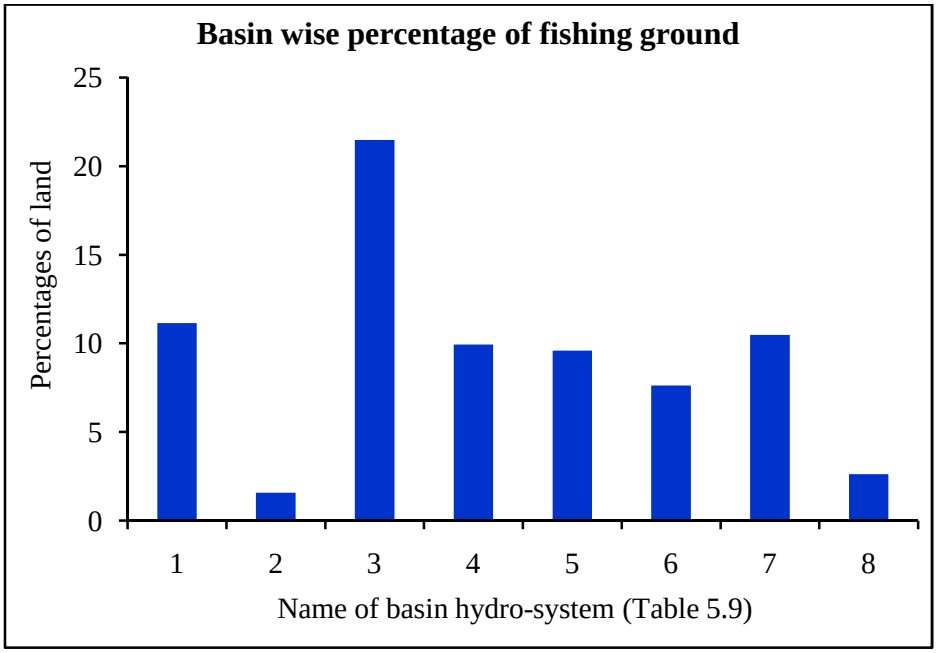

Fig. 5.13 Basin wise percentage of fishing ground out of total area.

5.3 Agricultural landuse management

In Purba Medinipur district, the amount of cultivated land is higher than other districts of West Bengal. This cultivated land is conducive to agriculture. Quantitative and qualitative characteristics of different components in the soil have made this region rich in agriculture (Sahu, 2014). Nevertheless, a large amount of this cultivated land is left vacant in rabi and zaid crop season. Only during the kharif crop season, almost the entire part is cultivated because of availability of rain water. The main reason for the cultivated land being vacant mostly in rabi and zaid crop season is the lack of adequate fresh water. Although there is a system of ground water supply in agriculture but it is less than necessary. Even in many places this system has stopped. In addition, there are also restrictions on ground water abstraction.

It has already been discussed that the intense drainage system with rivers, tributaries and canal has developed in this district. As the Bay of Bengal is situated to the south of the district, the tidal water enters into the interior of the district through various watercourses and it has been observed that almost the entire part of this district is inundated by tidal water. But

the main problem of tidal water is that it is saline in nature which is not conducive to conventional agricultural crops of the district. However, the salinity of tidal water gradually decreases towards the interior. The northern block of the district, like Panskura, Kolaghat, Sahid Matangini, Tamluk and Moyna etc. is not affected by the salinity of tidal water. Besides, another obstacle of agriculture in the district is the salinity of soil. Although this problems is especially observed in coastal areas.

So, if tidal water can be used in agriculture, then non ploughed arable land will be suitable for proper use even in rabi and zaid crop season. In that case it is necessary to cultivate agricultural crops based on the nature of saline water. Proper choice of crops for vultivation can result in good returns. But at the same time the drainage system and soil permeability are also important. The map (Fig. 5.14) shows the categorization of all villages of the district according to tidal water salinity zone and the number of villages under different tidal water salinity zone is shown in the table 5.10. Villages along the boundaries of the zones are included within the zone in which they have the largest share. So, from the map it is clear that most of all such as 1013 villages of the southern part of the district are inundated by extremely high saline tidal water. Mainly, all the villages of Ramnagar-I and II, Contai-I, Desopran and some villages of Khejuri-II, Contai-II, Egra-I and II blocks belong to this zone. The salinity level of inundated tidal water in these villages is above 5.8 dS/m. About 379 villages of the district are inundated by very high saline tidal water with salinity level of 2.5 to 5.8 dS/m. All the villages of Nandigram-I, Khejuri-I and some villages of Nandigram-II, Khejuri-II, Contai-III, Bhagawanpur-II, Patashpur-II, Egra-I and II blocks belong to this zone. Beside, 615 villages are inundated by high saline water with salinity level of 0.8 to 2.5 dS/m which includes all the villages of Haldia, Sutahata, Chandipur and some villages Mahisadal, Bhagawanpur-I and II, Nandigram-I and II, Patashpur-II, Egra-I and II blocks. About 565 villages of Sahid Matangini, Tamluk, Nandakumar, Mahisadal, Moyna,

Bhagawanpur-I and Patshpur-I is inundated by medium saline water with salinity level of 0.3 to 08 dS/m. The salinity of tidal water is low in about 427 villages of Kolaghat, Panskura, Moyna, Sahid Matangini, Tamluk and Patashpur-I such the salinity level below 0.3 dS/m (Annexure 11). The map (Fig. 5.15) also shows the categorization of all villages of the district according to soil salinity zone and the table (Table 5.11) represents the number of villages under different soil salinity zone. The map depict that the soil salinity of 1117 villages is below 2 dS/m which is no saline (S0) in nature according to indicator. This zone includes the all villages of Pankura, Kolaghat, Sahid Matangini, Tamluk, Mayna, Nandakumar, Patashpur and some villages of Egra-I, Patashpur-II, Mahishadal and Bhagawanpur-I. The soil characteristic of 477 villages is slightly saline (S1) in nature and salinity level 2.0 to 4.0 dS/m which belongs to the block of Mahishadal, Haldia, Chandipur, Bhagawanpur-I and II, Patashpur-II and Egra-I. The soil salinity of 1302 villages is of medium nature (S2) with salinity level 4.0 to 8.0 dS/m. This types of villages belong to the block of Sutahata, Haldia, Nandigram-I and II, Khejuri-I and II, Desopran, Contai-I and III, Ramnagar-I and II, Egra-I and II. There are also 103 villages whose soil salinity is high (S3) which is located along the coastal blocks like Ramnagar-I and II, Contai-I, Desopran and Khejuri-II. The soil salinity of the villages is above 8.0 dS/m (Annexure 12).

From the map (Fig. 5.14 & 5.15) it is very much clear that different villages of this district have different salinity soil and various nature of saline water enters the villages through tide. Since, the salinity controls the production of agricultural crops, therefore, not all villages are suitable for cultivation of all types of crops. Crops should be selected for cultivation depending on the salinity nature of the soil. If tidal water is used for crop cultivation, the salinity nature of tidal water must be judged along with the salinity of soil to crop selection. In this context, there is a universal crop selection criteria given by different research organization where shown that what type of crop should be selected in what nature

of salinity. Table (Table 5.12) shows the plant suitability in different ranges of water salinity according to Victorian Irrigation Research and Advisory Committee, 1980. The table (Table 5.13) also shows the crop response in different nature of soil salinity according to United States Department of Agriculture (USDA), November, 1955.

Now a map (Fig. 5.16) has been prepared where the salinity of the soil and the salinity of tidal water are shown together of each villages. In this case, salinity level has been categorised by uniting the class division of both the criteria. For example, the salinity of a village is No Saline Soil (NSS) with Low Saline Water (LSW). According to this, all the villages have been divided into 14 categories. The table (Table 5.14) shows the 14 categories of salinity level of the district and the number of village in each category. This map has been made by superimposition of both layer such as soil salinity zone and tidal water salinity zone. This map will give an idea of the salinity level in soil and tidal water of a village at a glance and which will help in selecting the suitable crop for cultivation. From this map, it is observed that most of the villages of the district fall into three categories, like Medium Saline Soil with Extremely High Saline Water (MSS_ EHSW), No Saline Soil with Medium Saline Water (NSS_MSW) and No Saline Soil with Low Saline Water (NSS_LSW). There are 844 villages of the district under the category of MSS_ EHSW belongs to the block of Ramnagar-I and II, Contai-I and III, Desopran, Khejuri-II, Egra-I and II. About 481 villages are under the category of NSS_MSW which belongs to the Sahid Matangini, Tamluk, Nandakumar,Mayna, Kolaghat, Bhagwanpur-I, Patashpur-I and Mahisadal blocks. There also 426 villages are under the category of NSS_LSW which are located in Panskura, Kolaghat, Tamluk, Patashpur-I and Moyna. Apart from, there are three categories i.e. Slightly Saline Soil with High Saline Water (SSS_HSW), Medium Saline Soil with High Saline Water (MSS_HSW) and Medium Saline Soil with Very High Saline Water (MSS_VHSW) which includes 243, 230 and 222 villages of the district respectively (Annexure 13).

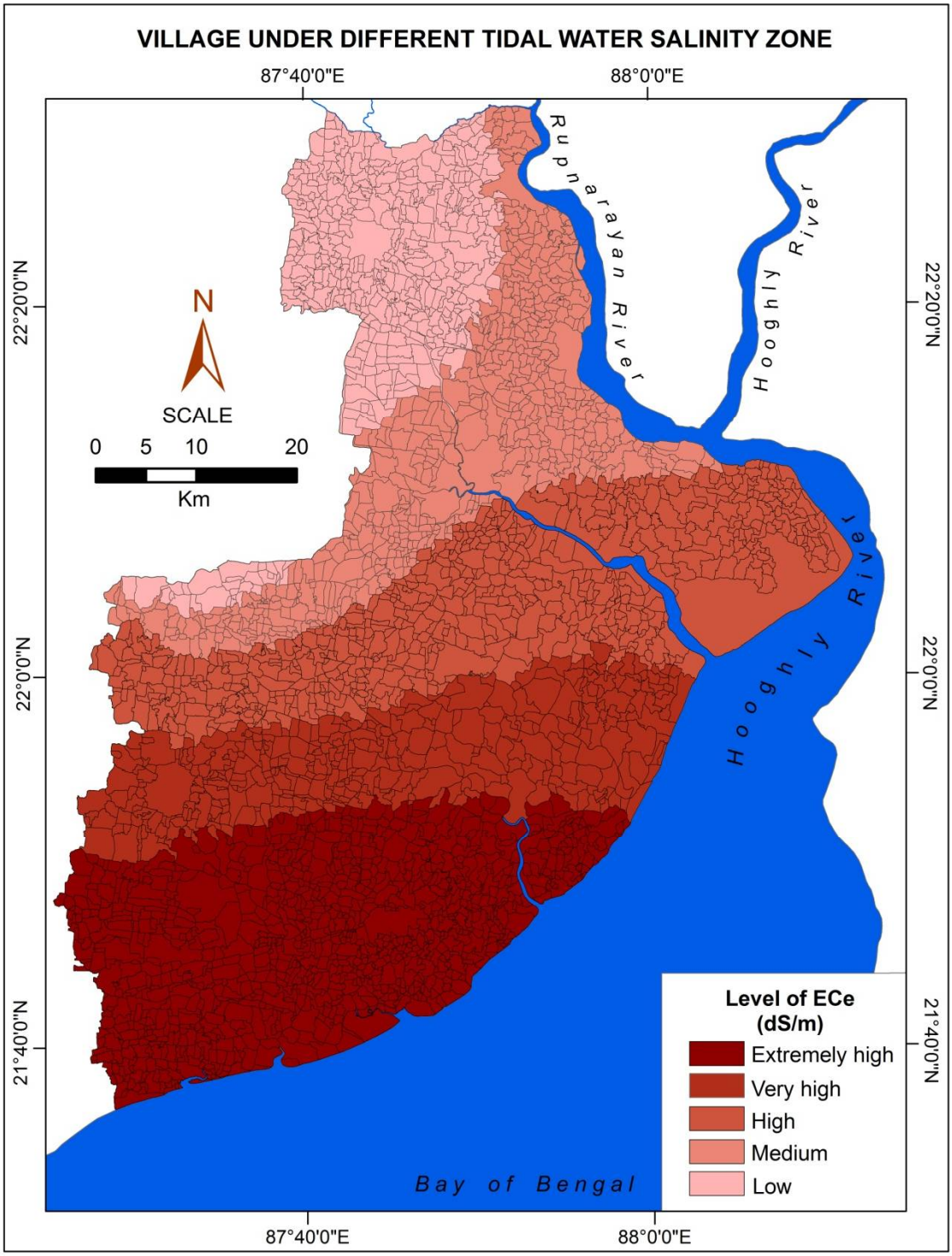

Fig. 5.14 Number of village in different tidal water salinity zone.

Table 5.10 Number of village in different categories of inundated tidal water salinity zone.

EC (dS/m)	Water Salinity Class	Number of village
Below 0.3	Low salinity water	427
0.3 – 0.8	Medium salinity water	565
0.8 – 2.5	High salinity water	615
2.5 – 5.8	Very high salinity water	379
Above 5.8	Extremely high salinity water	1013

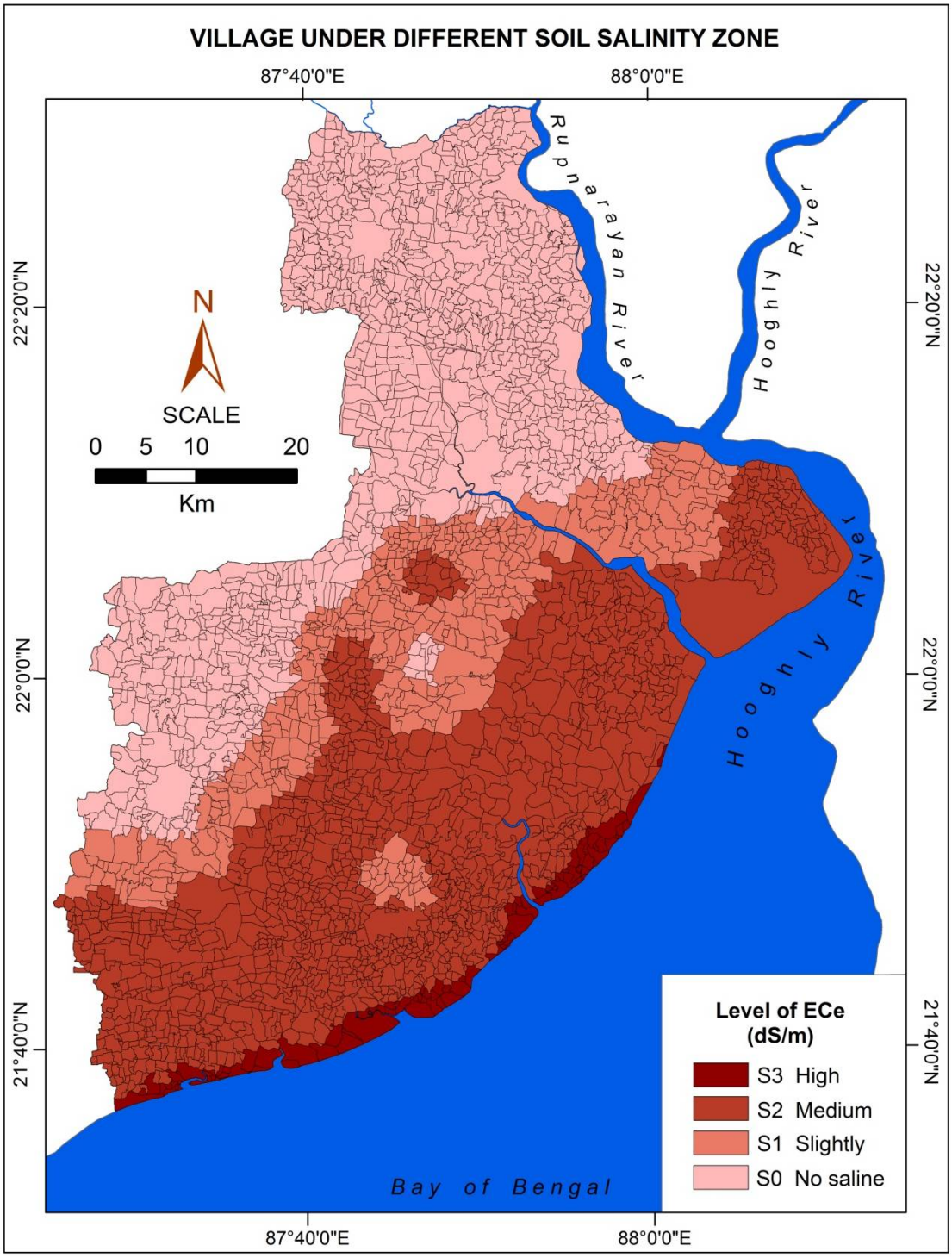

Fig. 5.15 Number of village in different soil salinity zone.

Table 5.11 Number of village in different categories of soil salinity zone

EC (d/S/m)	Soil Salinity Class	Number of village with municipality
Below 2	S0 - No Saline	1117
2 – 4	S1 - Slightly Saline	477
4 – 8	S2 - Moderately Saline	1302
8 – 16	S3 - High Saline	103
Above 16	S4 - Extremely High Saline	0

Table 5.12 Plant suitability in different saline water with proper method

EC (dS/m)	Water Salinity Class	Plant Suitability
Below 0.3	Low	Can be used for most crops on most soils with all methods of water application.
0.3 – 0.8	Medium	Plant with a medium salt tolerance can be grown, usually without special practices for salinity control.
0.8 – 2.5	High	Restricted yields of the more sensitive crops. Adequate drainage and special management for salinity control may be required.
2.5 – 5.8	Very high	Yield of many crops restricted. Salt tolerant crop should be selected and use soils must be permeable with very good drainage.
Above 5.8	Extremely high	Only a few very salt tolerant crops can be produced. Occasional emergency use for salt tolerant crops on permeable well drained soils under good management.
Source: Water salinity classes, ranges and plants suitability are adapted from Victorian Irrigation Research and Advisory Committee, 1980, Quality aspects of farm water supplies.		

Table 5.13 Crop response in different level of soil salinity

EC (d/S/m)	Soil Salinity Class	Related crop response
Below 2	S0 - No Saline	Salinity effects mostly negligible
2 – 4	S1 - Slightly Saline	Restricted yields of the more sensitive crops,
4 – 8	S2 - Moderately Saline	Yields of many crops restricted
8 – 16	S3 - High Saline	Only salt-tolerant crops yield satisfactory. Well drainage is required.
Above 16	S4 - Extremely High Saline	Satisfactory yields from only a few very salt-tolerant species. Well drainage is required.
Source: Soil salinity classes and ranges are adapted from United States Department of Agriculture (USDA), November, 1955.		

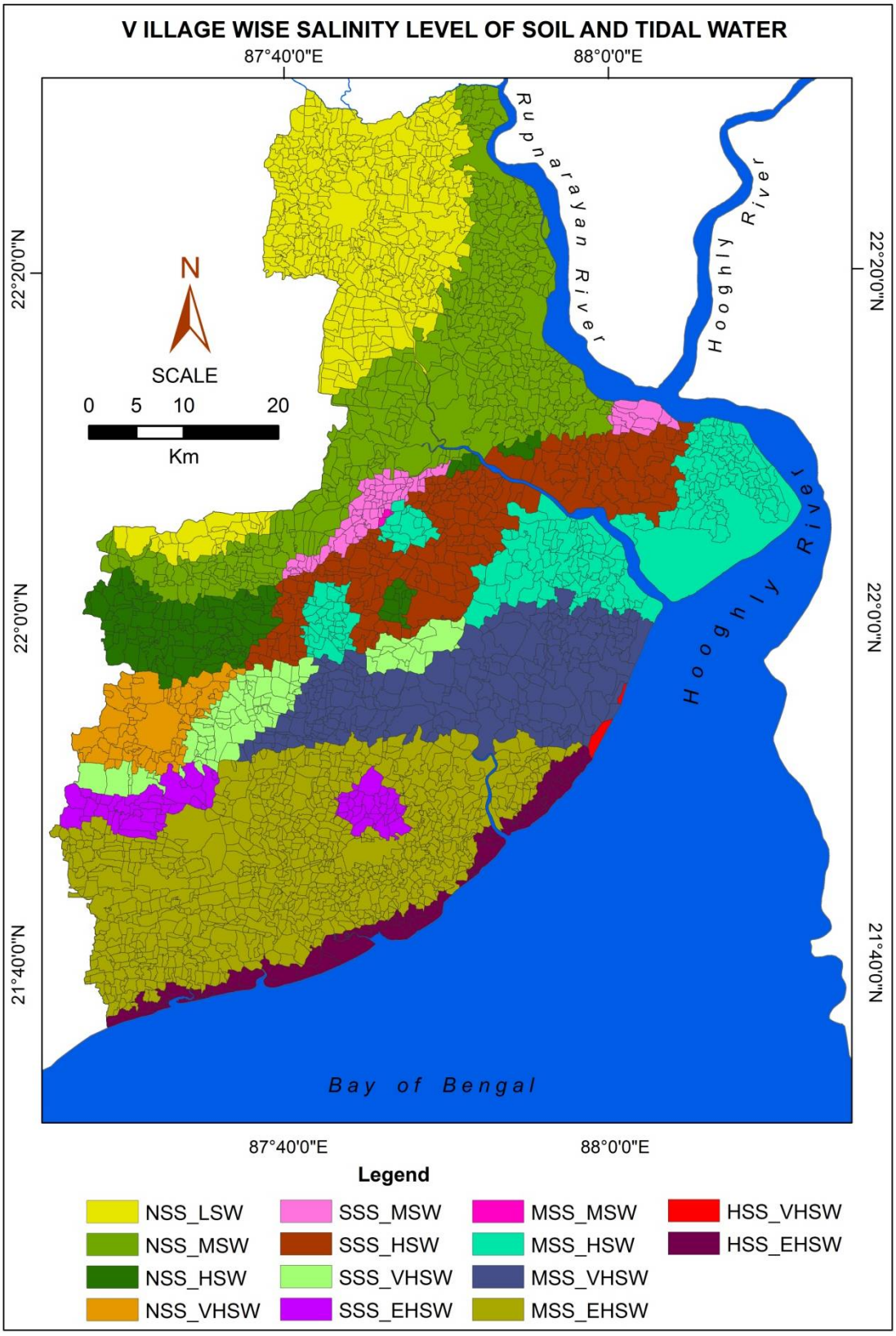

Fig. 5.16 Salinity level of soil and inundated tidal water in each village.

NOTE:
NSS= No Saline Soil, SSS= Slightly Saline Soil, MSS= Medium Saline Soil, HSS= High Saline Soil, LSW= Low Saline Water, MSW= Medium Saline Water, HSW= High Saline Water, VHSW= Very High Saline Water, EHSW= Extremely High Saline Water

Table 5.14 Number of village in different categories of salinity level

Sl no	Category of Salinity	Number of Village
1	NSS_LSW	426
2	NSS_MSW	481
3	NSS_HSW	140
4	NSS_VHSW	69
5	SSS_MSW	84
6	SSS_HSW	243
7	SSS_VHSW	87
8	SSS_EHSW	66
9	MSS_MSW	3
10	MSS_HSW	230
11	MSS_VHSW	222
12	MSS_EHSW	844
13	HSS_VHSW	2
14	HSS_EHSW	102

5.4 Landuse in terms of Fishery

From the locational point of view, Purba Medinipur district is very conducive to the development of commercial fish farming. Fishery is an important way to make good use of vacant land. In the villages where most of agricultural land is lying vacant, it is possible to make proper uses of the land by development of fishery. It is a profitable economic activity. In this case, it is necessary to dig a large area of land and needs to be done in a scientific way. However, at present, the commercial fishery has developed in some part of the district. The traders are farming the fish in a modern technique by renting the land from the farmers. As a result, farmers earn money from their land as well as work in the fisheries. In addition, due to the commercial fish farming, the supply of fish in the local market is continued. As a result, the demand for fish of the local people is within their purchasing power.

The present study depicts the suitability of fisheries development in the district of Purba Medinipur. The development of fishery in any places depends on some factors, such as ecological factors, economical factors and location factors. Location factors are most important among these. It should be mentioned that the climate is most favourable to fish

farming in the district. So other ecological factors can be controlled today with the help of advance technology. On the other hand, economic factors are usually controlled by government policies. Therefore, the suitability of villages for fishery development in the district has been determined only by the location factor. Here, the selected location factors are the amount of land, drainage density, road density, population density and working population. It should be noted that fisheries have been developed in some villages of the district based on such location factors. For example, in 348 villages of the district where above 21 percent of total land area is under fishery and the amount of gross non cultivated arable land, drainage density, road density and amount of worker population is moderate to high and population density is low according to previous discussion. However, all these factors for the development of fishery are not equally important. The importance of all these parameters is discussed below.

Land:

Land is most important than other factors for fishery. Suitable land is required for preparing the fishery. It is not advisable to acquire the lands for fishery which produce the crops several times in a year. Fishery should be set up where vacant land is available. In Purba Medinipur district, there are many villages where crops are produced once a year or very small amount of cultivated land is ploughed in different seasons. That means the amount of non ploughed arable land is more in these villages. So, these villages are most suitable for fishery. Here, gross non ploughed arable land has been considered as the land parameter.

Drainage density:

The second most important factor for development of fishery is drainage. Fisheries need water supply and discharge of water time to time. Therefore, a proper drainage system is required.

Population density:

A third important factor is population density. Where the population density is high, the population pressure on land is high and intensive agriculture has developed there. Therefore, it is helpful to build fisheries where the population density is low.

Road density:

The fourth important factor for fishery is road density. Fish is a perishable substance. Therefore, proper transport system is needed to supply the fish quickly. Beside, good transport is needed for transportation of necessary equipment, food items etc in the fishery.

Working population:

Another important factor is number of working population. Commercial fishery requires a large number of workers. Local workers are profitable in fishery. So, fish farming is profitable where working population is more.

The suitability level for fish farming in different villages of Purba Medinipur district has been analyzed by the above mentioned factors. Since, not all the factors are equal important to build the fishery. So, different weighted values have been assigned for each factor manually. In this case, the total weighted value has been taken to be 100 percent. Then it is distributed into different factors according to their importance. Such as 50 percent weighted has been assigned to land, 20 percent to water, 15 percent to population density, 10 percent to road density and 5 percent to working population. Again the total weighted value of land has been divided based on the amount of gross non ploughed arable land in each village out of total and the divided values are then ranked in four classes. In this way all weighted value for the factors has been divided according to their nature in each village and ranked it. The rank of factors has been made in descending order, that means higher the value higher the rank and lower the value lower rank. Then the all rank values of all factors in each village have been summed and finally, it also ranked in four classes for identifying the suitability level. Here, higher value indicates the higher rank and high suitability and lower

value indicates the lower rank or low suitability. On the basis of the calculated rank value, a village wise suitability map (Fig. 5.18) for fish farming has been prepared. All the classes have been done at equal intervals of the values. The table 5.15 shows the calculation of suitability with a sample of few villages.

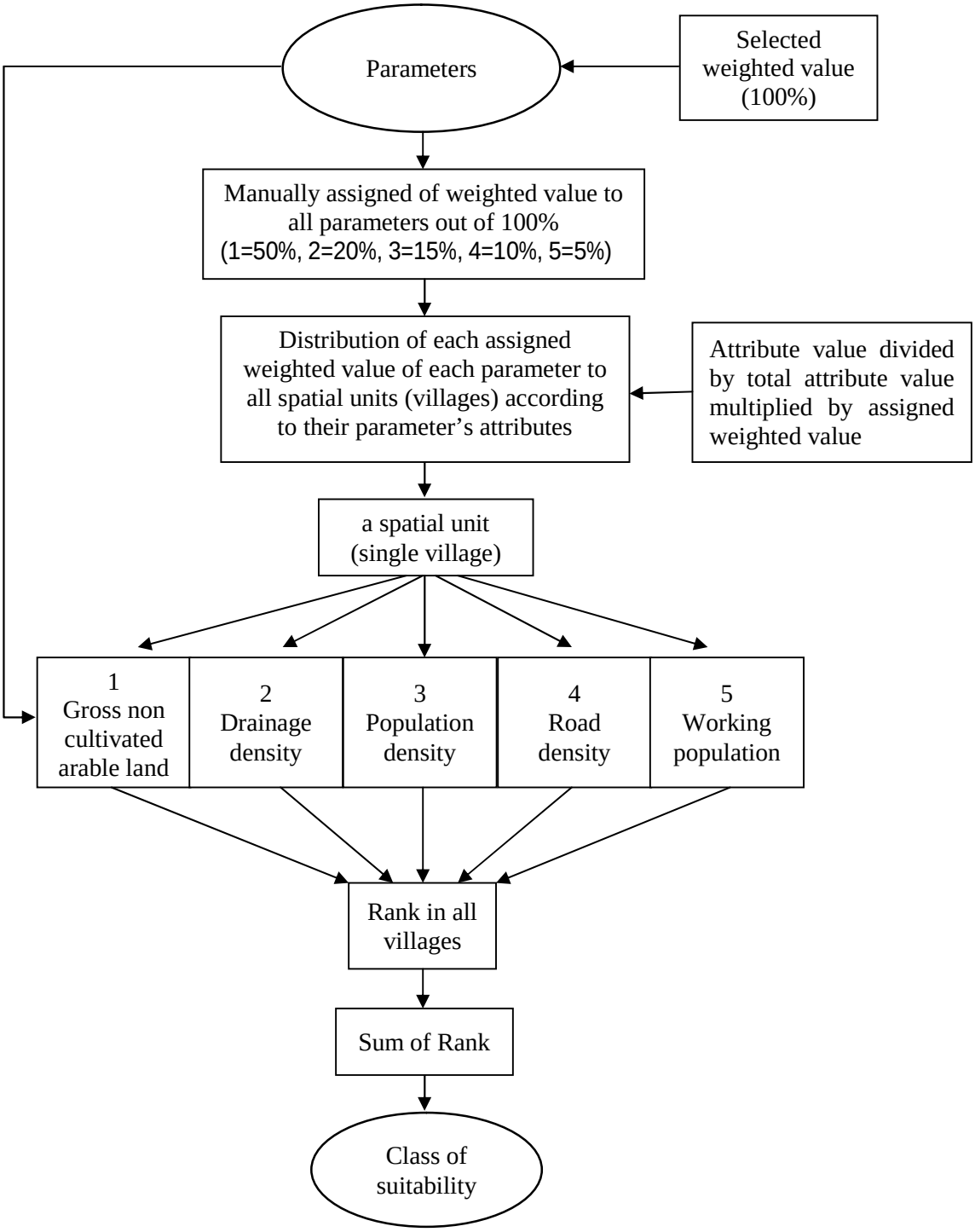

Fig. 5.17 Flow chart showing the suitability analysis for fishery.

Table 5.15 Calculation table for suitability of fishery.

Name of Village	Non ploughed arable land (hectare)	Distribution of assigned weighted value out of 50%	Rank	Drainage density (km/sq.km)	Distribution of assigned weighted value out of 20%	Rank	Population density (person/sq.km)	Distribution of assigned weighted value out of 15%	Rank	Road density (km/sq.km)	Distribution of assigned weighted value out of 10%	Rank	Number of worker population	Distribution of assigned weighted value out of 5%	Rank	Sum of Rank	Suitability
Kalaguchia	152.65	0.0160	2	3.07	0.0239	2	2102	0.0074	3	3.11	0.0036	1	61216	0.1622	2	10	Moderate
Machinan	208.75	0.0218	3	1.31	0.0102	1	2447	0.0086	3	3.03	0.0036	1	30215	0.0801	2	10	Moderate
Jashar	13.40	0.0014	1	2.15	0.0167	1	6185	0.0218	1	5.55	0.0065	2	22929	0.0608	2	7	Low
Kulhanda	28.10	0.0029	2	1.63	0.0127	1	2413	0.0085	3	4.63	0.0054	2	19822	0.0525	2	10	Moderate
Saluka	132.25	0.0138	2	1.96	0.0153	1	2689	0.0095	2	1.79	0.0021	1	10254	0.0272	2	8	Low
and so on... (total village with municipality 2999)																	
Total	473210.19			2571.43			4247715			8525.60			1886868				

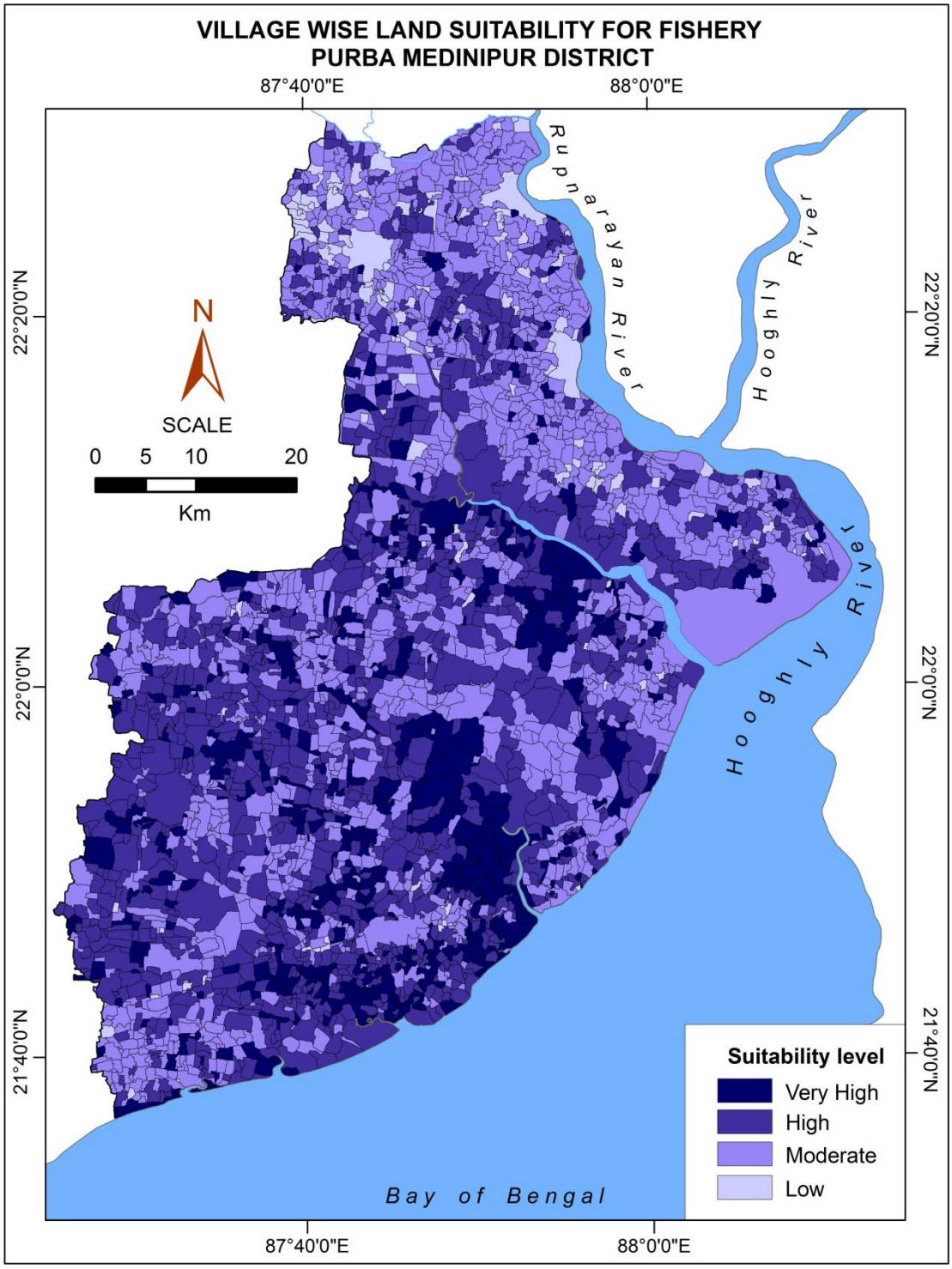

Fig. 5.18 Village wise land suitability for fishery.

Table 5.16 Number of village in different suitability level of fishery

Suitability level	Number of Village
Very High Suitable	568
High Suitable	1049
Moderate Suitable	1243
Low Suitable	139

There are four suitability classes such as very high, high, moderate and low suitability. Very high suitability indicates the very good location for fish farming and low suitability indicates the inappropriate location. The table 5.16 shows the different suitability classes and the number of villages within it. Near about 19 percent villages of the district is very highly suitable, 35 percent high suitable, 42 percent is moderately suitable and 4 percent is low suitable for fish farming (Annexure 14).

The chapter has proposed some process for sustainable management of agro-natural resources of Purba Medinipur district. Physiographic micro-zonation of the district is most important. The district has been divided into 8 micro zones on the basis of drainage basin area. An appropriate management, proper planning and decision making can be adopted by identifying the local resources in each zone. In addition, a map has been prepared for agricultural landuse management which reveals that the crop needs to be selected for cultivation by judging the nature of the soil and tidal water. Another important map is land suitability for fishery which represents the level of suitability of each village of the district for the development of fishery. The map reveals that the fishery will be profitable to build where it is suitable and it also indicates the proper use of land resource.