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Agricultural Climatology with special reference to Cropping Pattern of North 24-Parganas

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Abstract:
Background: *Agricultural Climatology, often also referred to as Agro-climatology, is a field in the interdisciplinary science of agro-meteorology, in which principles of climatology are applied to agricultural systems. The present article analyses the interaction between climatological and hydrological factors and their impact on agriculture and the nature of crop diversification in terms of the changes in cropping pattern concerning acreage and production distribution of North 24-Parganas district.*
Materials and Methods: *Primary data has been generated through surveys and some conversations with the agricultural workers and secondary data were collected from the websites of Agriculture and Weather Department, Government of West Bengal, and Department of Agriculture, Cooperation and Farmers welfare. All charts and diagrams were prepared using Microsoft Excel 2016, QGIS 3.14, and ArcGIS 10.6 software.*
Results: *From both the aspects of the area and production it is observed that for three decades the cropping pattern of North 24-Paranas is increasingly dominated by paddy, oilseeds (including, rapeseed and mustard) flowers, and vegetables. Pulses, as a whole, have lost both in terms of acreage and production in North 24-Parganas. The indices of diversification mostly indicate an increasing degree of crop diversification over time.*
Conclusion: *The soil is very fertile and neutral pH in nature but the agricultural production is not sufficient to compare to the soil. Growing urbanization and gradual conversion of land for non-agricultural purposes is a major problem. To get a better production government should take proper initiatives in favor of farmers otherwise farmers will lose interest in agriculture and choose other professions that are not suitable for the economy.*
Key Words: *Agricultural Climatology, Cropping pattern Crop calendar, Cropping intensity*

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I. INTRODUCTION

With the diversification of the Indian economy after post-independence, agriculture has changed. Over the past 50 years, the North 24-Parganas district occupies a prominent place in the agriculture as well as the industry-based economy of West Bengal. The district is situated in the southeastern part of the State bordering Bangladesh and covering the geographical area of 4094 sq. km. It is the most populous district in the State with a total population of 100.82 lakh and a density of population 2500 per sq. km. The net sown area in the district is 225000 ha and cropping intensity is about 225%. The net irrigated area of the district is 154311 ha. Agriculture and allied activities are one of the backbones of the economy of the district. The major crops grown in the district are Paddy, Jute, vegetables, and Oilseeds. Agricultural development goes hand in hand in the district. The farm sizes have decreased over time, the number of farmers and those employed in farming have increased over time, and as the economy has grown the relative contribution of agriculture to the total economy has increased due to increasing demand and production in food. Large parts of Barasat and Barrackpore sub-divisions depict a high level of industrial development in small, medium, and large-scale sectors, which provide employment to the increasing population and decrease the employment pressure on agriculture. The main industries like Jute, Cotton, Textile, Handicrafts, and Engineering employ a few lakh workers.

II. MATERIAL AND METHODS

***Study Design*:**

The study is principally based on various climatic and agricultural data, both qualitative and quantitative. Data on different climatic parameters and data on area, production, and yield rate of the principal crops in North 24-Parganas as well as West Bengal have been drawn upon from different Socio-Economic and Evaluation Branch of various Journals, Agriculture Contingency Plan for North 24-Parganas district, and Board of WB State Marketing, Govt. of West Bengal. Data on weather parameters like monthly and weekly rainfall,

monthly and weekly relative humidity, and monthly and weekly temperature have been collected from the records available at the State Department of Agriculture. After collecting the data and other information it is compiled, analyzed, and synthesized using appropriate modern techniques like GIS, standard statistical methods, and various diagrams to carry out our present study.

***Study Location*:**

North 24-Parganas is a district in southern West Bengal, of eastern India. North 24-Parganas extends in the (tropical zone) from latitude 22º11'6" north to 23º15'2" north and from longitude 88º20' east to 89º5' east. It is bordered by Nadia district to the north, Bangladesh (Khulna Division) by north and east, South 24-Parganas and Kolkata by south, and Kolkata, Howrah, and Hooghly district by the west. Barasat is the district headquarters, and it is also West Bengal's most populous district after Kolkata city.

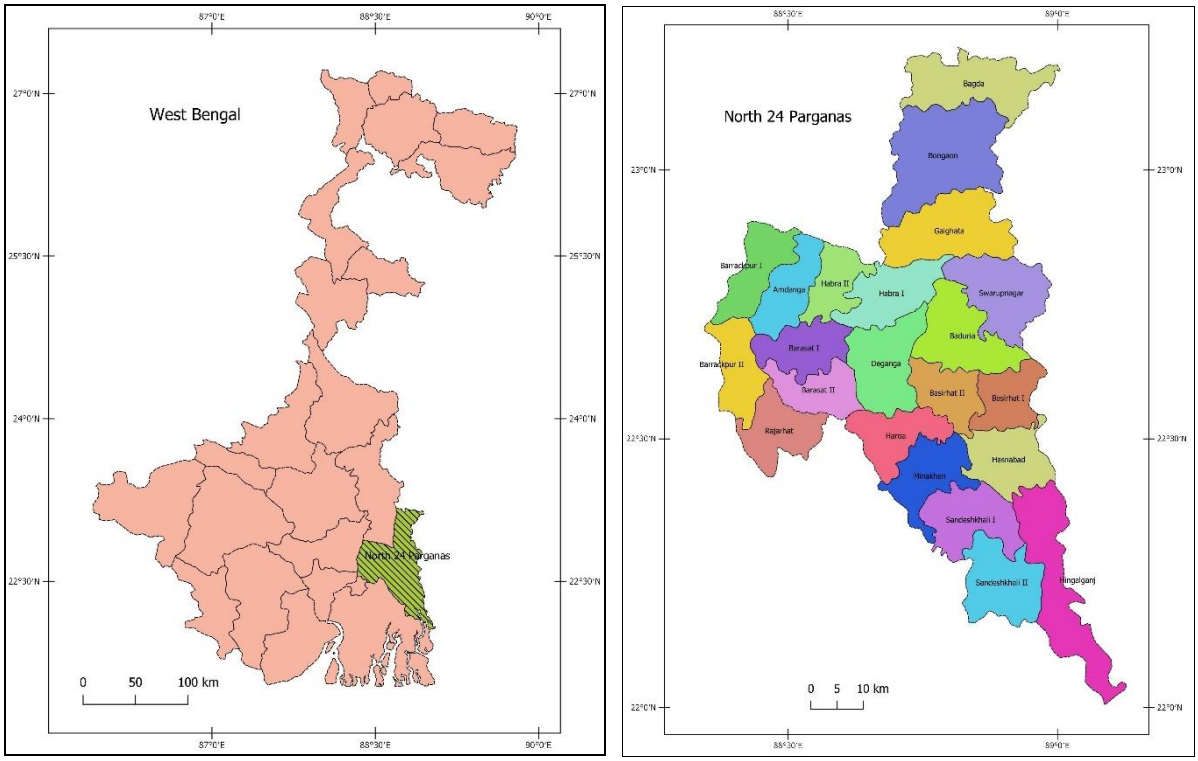

Figure 1: Location of the Study Area.

***Climate*:**

Climate plays an important role in agriculture. Different parameters of climate like the rainfall cycle, magnitude, and the timing of rainfall, temperature balance, relative humidity, evapotranspiration rates all play an important role in seeds germination, roots development, plant growth and crop production. The climate of North 24-Parganas is sub-tropical and normally hot and humid, lies just south of the tropic of cancer. It is also characterized by the Monsoon dominates during the period mid-June to mid-October because of the district's proximity towards the Bay of Bengal, which lasts from early June to mid-September. The weather remains dry during the winter (mid-November to mid-February) and humid during summer.

Table 1: Five years' average of seasonal variation in Rainfall (2015 – 2019) of North 24-Parganas*

Season / Month	Amount of Rainfall in (mm)	Amount of Rainfall in %
SW monsoon (June-Sep)	986.9	69
NE Monsoon(Oct-Dec)	213.9	15
Winter (Jan- March)	70.5	5
Summer (Apr-May)	153.6	11
Annual	1424.9	100

Table 2: Five years' monthly Rainfall in millimeter (2015 – 2019) of North 24-Parganas*

Month	2015	2016	2017	2018	2019
January	60	-	-	-	41
February	29	1	1	2	10
March	26	60	1	45	9
April	55	-	34	62	83
May	98	182	170	118	43
June	181	87	205	344	180
July	303	257	181	321	262
August	179	457	215	488	208
September	290	290	241	264	224
October	128	59	107	25	92
November	-	18	4	-	46
December	-	-	21	-	10
Annual	1349	1411	1180	1669	1208

Table 3: Five years' Max. (▲) Min. (▼) temperature in degree Celsius (2015 – 2019) of North 24-Parganas*

Month	2015		2016		2017		2018		2019	
	▲	▼	▲	▼	▲	▼	▲	▼	▲	▼
January	30	12	29	11	29	10	28	10	29	12
February	34	12	35	15	33	15	34	15	33	14
March	35	17	37	22	35	18	36	20	36	16
April	37	22	41	26	38	23	39	21	38	20
May	39	24	40	22	38	23	38	22	40	24
June	38	24	40	21	38	25	40	25	38	23
July	36	25	35	26	35	25	36	29	37	26
August	35	25	36	25	36	26	36	25	35	25
September	37	25	35	25	36	25	36	25	35	24
October	35	21	35	23	35	21	36	20	34	21
November	32	18	32	16	32	14	33	18	31	18
December	31	11	29	10	30	14	34	9	29	12
Average	35	20	35	20	35	20	36	20	35	20

*Source: Meteorological Department, Govt. of India

The average annual rainfall of the district varies from 1200 mm to 1500 mm. The span of winter is not prolonged as compared to other north and south Eastern states. The average minimum temperature varies from 18 to 20 °C and the maximum temperature varies from 30 to 32 °C. The maximum temperature recorded around 41 °C in May and the minimum 10 °C recorded in January 2020. The cold spell prevails from November to mid-February. Since subtropical humid climate prevails in this district, humidity is a major concern, and as far as infestations of pests and disease are concerned on crops. Relative Humidity prevails in the district between 50% in March and 90% in July. Maximum rainfall (more than 50%) occurs in the periods between June to September by the south-west monsoon which necessary for the growth of the Kharif crops. In winter periods the retreat monsoonal wind also results in some low amount of rainfall which is favorable for the growth of Rabi crops.

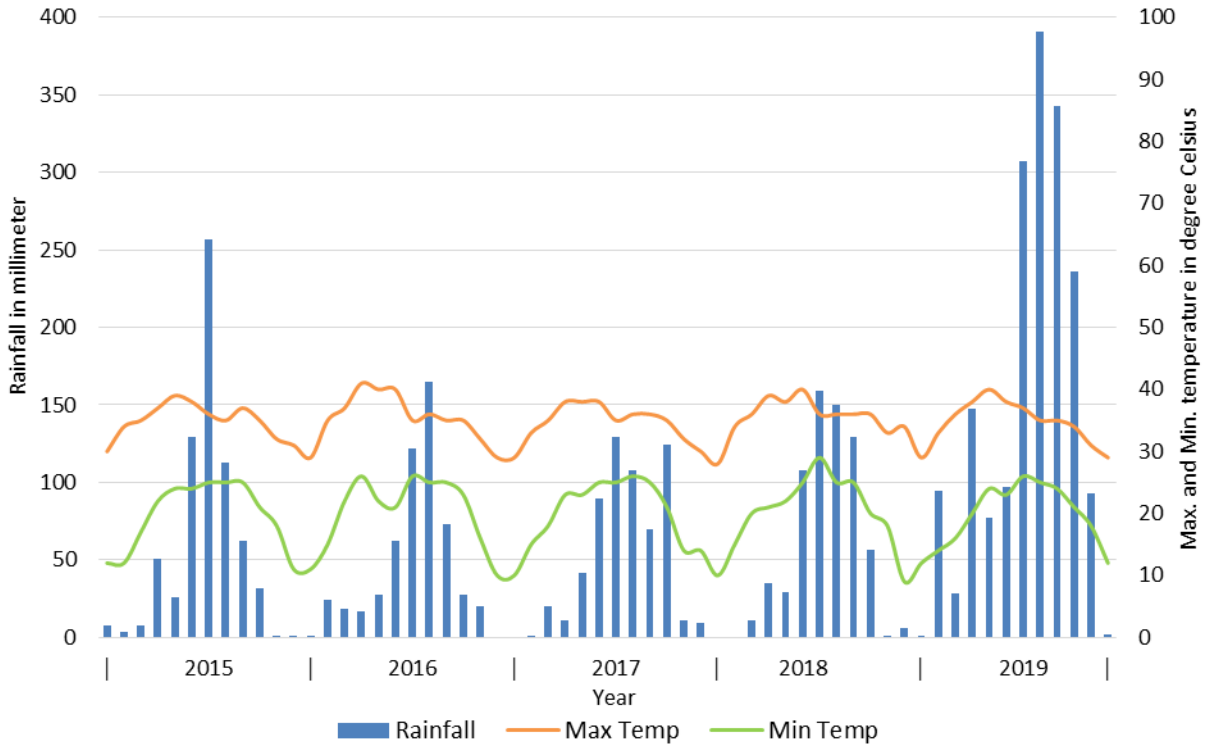

Figure 2: 5 Years' Rainfall and Temperature Graph

***Agricultural climatology and its Parameters*:**

Agricultural climatology is the study of climate as it relates to the agricultural sector. Preparation on the explanation of climate given above, the agricultural climate is characterized or described by different parameters related to Agricultural Climatology in a broad sense that portrays the climate resources and risks concerning producing crops and livestock of North 24-Parganas.

***i. Solar Radiation*:** Solar radiation is the principal energy source for organic life on earth. Agricultural production is very much related to solar radiation. Very effective solar radiation as well as very low solar radiation is not suitable for agricultural production. Due to its location in a sub-tropical climatic zone, the entire area receives sufficient solar radiation. The amount of incoming solar radiation receives approx. 300 Watt/m^2 varies seasonally. Generally, three broad spectra of solar energy are significant to plant life. (i) The shorter-than-visible wavelength; (ii) Solar radiation in the higher-than-visible; (iii) The third spectrum, lying between the ultraviolet and infrared (Rodriguez et al., 1999).

***ii. Environmental Temperature*:** Environmental temperature is the intensity aspect of heat energy, and it has foremost importance for organic life. Temperature regulates the physical and chemical processes that control biological reactions within plants. If the crop is sensitive to high-temperature stress, we need to plan to reduce the risk of high-temperature stress, and based on the temperature the crops are selected whether they are planted in the summer or winter season. (Pallais, 1995)

***iii. Soil Temperature*:** Soil temperature is important for the vegetative growth of crops. Soil temperatures influence the germination of seeds, the functional activity of the root system, the incidence of plant diseases, and the rate of plant growth (Singh and Rao, 1998). When the soil temperature is warm, the water is held in the form of moisture. In arid regions, soil moisture gets evaporated fast leaving less water for crop production.

***iv. Precipitation*:** Agricultural productivity is closely related to rainfall. It is important for fixing cropping patterns, operating irrigation projects, preparing schedules of agriculture, designing drainage projects, planning soil and water conservation programs, and classifying agricultural regions climatologically.

***v. Atmospheric Pressure*:** The lower atmospheric pressures experienced as altitude increases have important consequences for plant life at high altitude. At high altitude and low atmospheric pressures, the solubility of carbon dioxide and oxygen in water is reduced. Some plants show stunted growth at higher altitudes as concentrations of oxygen and carbon dioxide reach low levels. But plants with strong root systems and tough stems can live under increased wind speeds at low pressures in high altitude areas.

***vi. Humidity*:** Humidity is closely related to rainfall, wind, and temperature. Humidity related parameters such as relative humidity; dew point plays a significant role in crop production and strongly determines the nature of crops grown in a particular region.

***vii. Evapotranspiration*:** Evapotranspiration is defined as the evaporation of the soil-air interface, and the transpiration of plants, under existing conditions of soil moisture. A Pan Evaporation measurement helps farmers and ranchers to understand how much water is needed for their crops. Forecast of evapotranspiration also can be important to improve knowledge of the water status of crops. (Hubbard, 2007)

***viii. Growing degree-days*:** Growing degree-days (GDD), also called effective growth units, are a simple means of relating plant growth, development, and maturity to air temperature. Degree-day units are often used in agronomy to estimate the lengths of the different phases of development in crop plants (Bonhomme, 2000).

Table 4: Five years' Solar Radiation data (2015 – 2019) of North 24-Parganas*

Month	2015		2016		2017		2018		2019	
	Sun Hours	Sun Days	Sun Hours	Sun Days	Sun Hours	Sun Days	Sun Hours	Sun Days	Sun Hours	Sun Days
January	225	28	229.5	29	231	31	232.5	31	231	30
February	211	24	215.5	20	215	26	207	28	181	18
March	295	22	305.5	22	303	22	305.5	25	287.5	21
April	279	10	285	16	279.5	18	285	11	297.5	15
May	363.5	13	365	11	373	19	363	14	361.5	21
June	285.5	7	324.5	9	315.5	6	291	9	309	12
July	238.5	1	223.5	2	262.5	5	247.5	1	208.5	2
August	284	3	278	7	289	1	305.5	3	183	1
September	236	12	231.5	5	237.5	6	250.5	10	144.5	1
October	286	17	279	20	259.5	15	285.5	22	230.5	12
November	286	29	283	25	273	26	288.5	27	277.5	27
December	223.5	29	232.5	31	216.5	29	221.5	29	223	30
Annual	3213	195	3252.5	197	3255	204	3283	210	2934.5	190

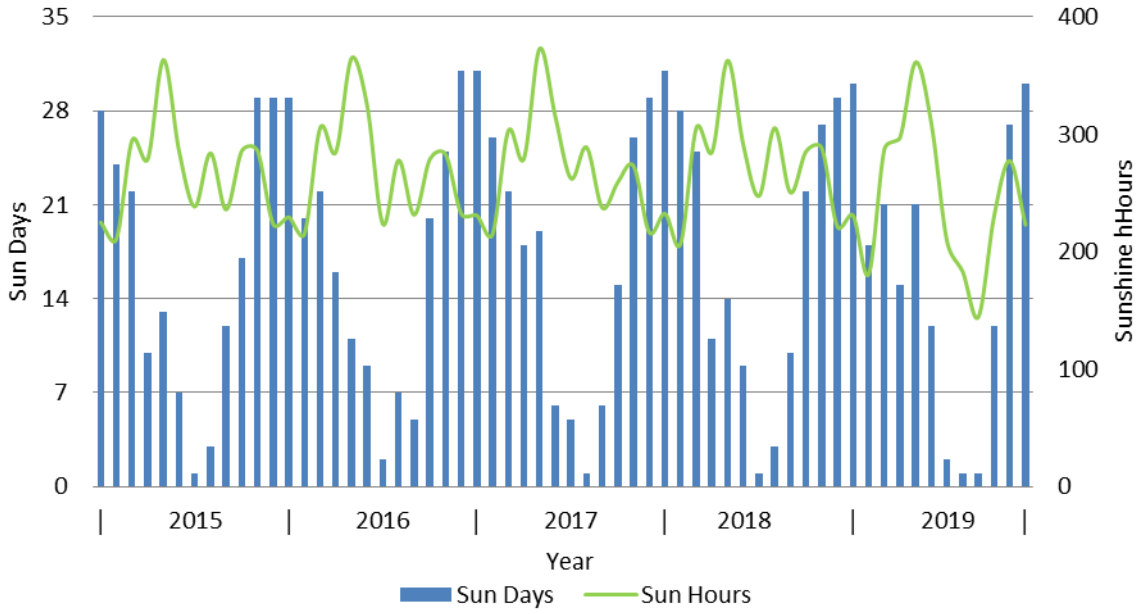

Figure 3: 5 Years' Solar Radiation Graph

*Source: Meteorological Department, Govt. of India

Table 5: Five years' monthly Humidity and Cloud cover in percentage (2015 – 2019) of North 24-Parganas*

Month	2015		2016		2017		2018		2019	
	Humidity	Cloud	Humidity	Cloud	Humidity	Cloud	Humidity	Cloud	Humidity	Cloud
January	47	9	43	6	40	3	37	0	39	5
February	45	8	49	13	41	5	38	3	43	21
March	45	14	50	11	57	13	44	9	49	18
April	58	24	55	21	65	30	58	27	54	18
May	61	27	59	23	61	21	63	26	58	16

June	65	43	63	34	67	38	60	40	62	37
July	76	57	73	55	71	52	73	53	68	60
August	76	45	77	46	73	44	76	42	78	62
September	71	39	80	39	74	38	74	34	81	61
October	65	22	70	20	74	26	63	17	72	39
November	53	9	57	11	55	13	53	8	61	10
December	47	20	46	3	51	9	46	13	47	15
Average	59.083	26.417	60.167	23.500	60.750	24.333	57.083	22.667	59.333	30.167

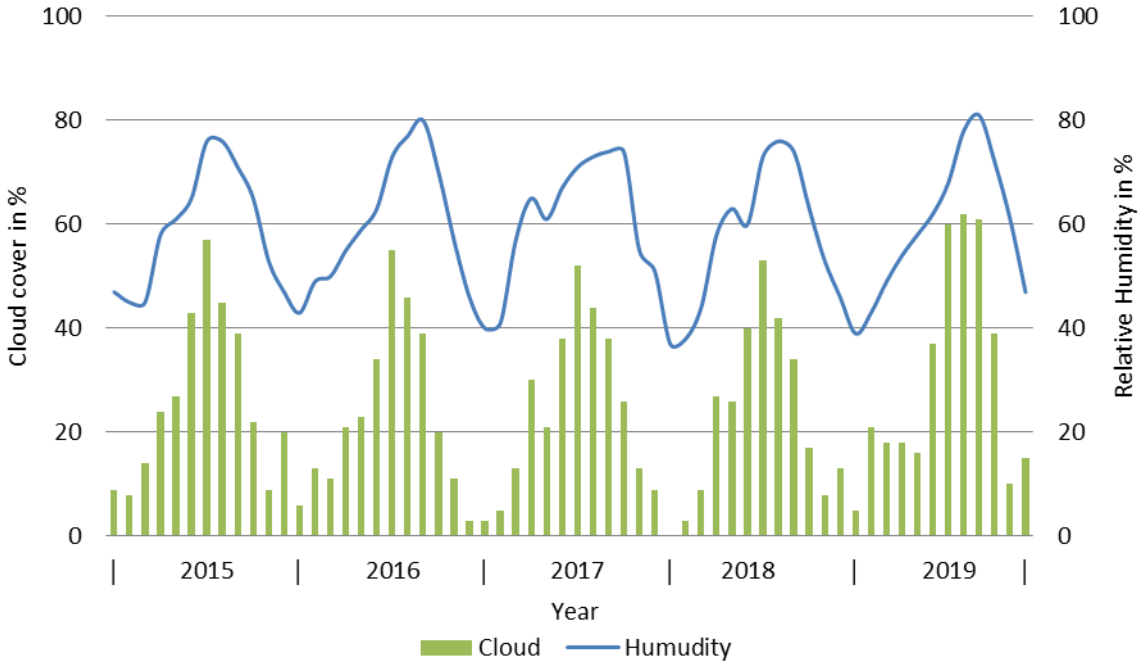

Figure 4: 5 Years' Cloud cover and Relative Humidity Graph
*Source: Meteorological Department, Govt. of India

***Agro-climatic Zones*:**

The soils of West Bengal were first classified during the middle of the 20th century by the West Bengal Department of agriculture in collaboration with ICAR by the rapid reconnaissance survey based on 9.6 km. grid system. According to that classification, the soils of the state were broadly sub-divided into seven units viz.

i. Gangetic alluvium;
ii. Vindhya alluvium;
iii. Terai and Teesta alluvium;
iv. Coastal;
v. Laterite;
vi. Red gravely and:
vii. Brown forest

And thereafter, considering the minimum variability in rainfall, temperature, soil types, and topography of lands, West Bengal is broadly categorized into the following six agro-climatic zones by NARP.

i. Northern Hill zone (Darjeeling and northern fringe of Jalpaiguri);
ii. Terai-Teesta Alluvial zone (Jalpaiguri and Cooch Bihar, Siliguri sub-division of Darjeeling and Islampur sub-division of North Dinajpur);
iii. Old alluvial zone (western part of Murshidabad and Hooghly, eastern part of Birbhum and Bankura, central part of Burdwan and Midnapore, and northern part of Howrah);
iv. New alluvial zone (Nadia district and parts of Malda, West Dinajpur, Murshidabad, Burdwan, Hooghly and northern part of North and South 24-Parganas);
v. Red and Lateritic (Purulia, Birbhum, Bankura and western part of Burdwan and Midnapore); and
vi. Coastal saline zone (southern part of North and South 24-Parganas, and the parts of Howrah and Midnapore)

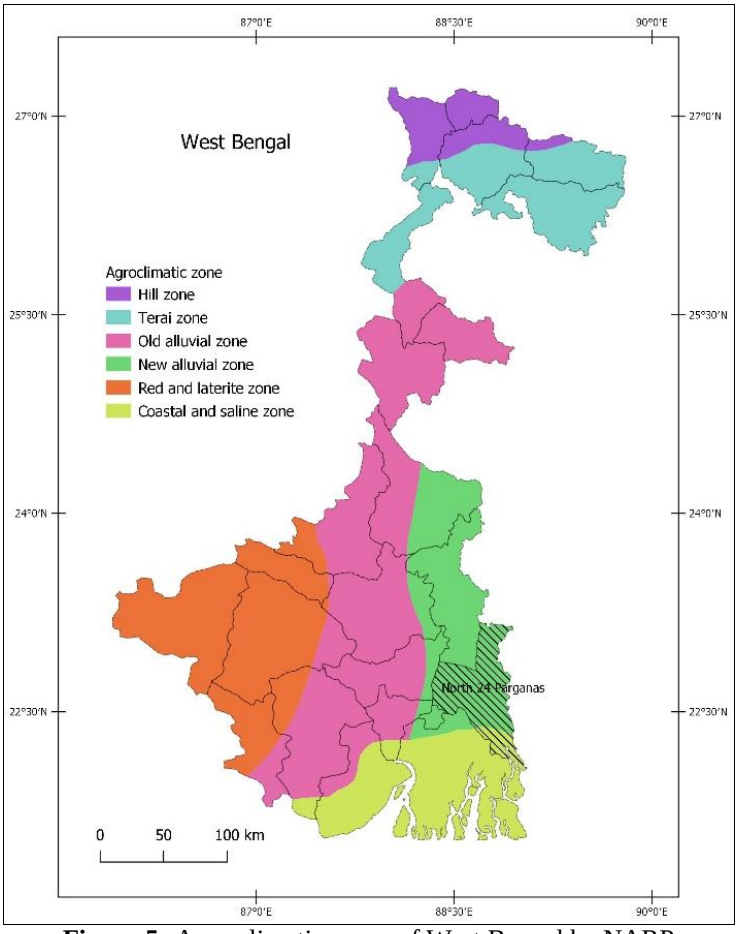

Figure 5: Agro-climatic zones of West Bengal by NARP

The classification of ICAR and NARP showing the geographical area of agro-climatic zones which helps to understand a gross demarcation of the agro-climatic zones. This demarcation has been made based on an administrative unit of the geographical area which is not following the classification of the planning area. So, it is very difficult to understand accurately the variability in and cropping pattern and crop diversification between two zones and also the same within a particular zone itself at a particular point of time just by using the data which is available only for an administrative demarcated area like a district. These studies can be considered as elicited of cropping system and cropping pattern within a zone and its inter-zonal variability by using widely classified district-level data.

The above map of West Bengal (Figure 5) showing the classification of agro-climatic zones by NARP along with district boundary as an administrative unit. It can be shown that North 24-Parganas lies within two agro-climatic zones; the maximum area from the northern part is under the New alluvial zone (WB-iv) and a smaller area from the southern part is under Coastal Saline Zone (WB-vi). Planning Commission of India comprises the district North 24-Parganas into the New alluvium sub-region of the Lower Gangetic Plain Region.

III. FINDINGS

***Topography and Agro Climatic Characteristics*:**

North 24 Parganas district lies within the Ganges-Brahmaputra delta. It comprises the moribund delta in the north, the matured delta in the middle, the active delta in the south, and a depressed zone of brackish water and salt marshes between the active and mature part of the delta. The river Ganges flows along the western border of the district. There are many other rivers, which include the Ichhamati, Jamuna, and Bidyadhari. The physiographic structure of the district is mostly plain land is low and swampy and the type of soil varies widely from alluvial to clay loam, and sandy. Most of the soils derived from alluvium deposits are azonal in nature with weak profile development. Clayey-loam is the predominating type, clays with or without muck soils occur in swamps and alluvial lakes which have been formed from deposits brought by tidal currents.

The active delta is still growing southwards as a system of innumerable tidal rivers, canals, creeks, saline marshes, and swamps. A part of this active delta region contains Sunderbans reserve forests. Although it is a reserve forest, quite a large part of Sunderbans has been brought under cultivation. Around 1629 sq. km. the area of Sunderbans used as agricultural practices in 24 Parganas (both north and south). All the mangroves protect the shore from erosion and aid in the accumulation of deposits of peat and mud. Snails, crabs, and other marine species usually populate heavily beneath mangroves.

Two distinct agro-climatic ambiances are prevailing in the district– Gangetic alluvial zone and coastal alluvial zone. Gangetic alluvial zone comprised of 16 blocks spread over entire Barasat, Barrackpore, and Bongaon subdivisions and only 4 blocks of Basirhat Sub-division. Gangetic alluvial regions have been further sub-divided into two regions for better application of location specific technologies. One is the Icchamati basin comprising Bongaon, Bagdah, Gaighata, and Swarupnagar block, the other one is Gangetic Plains comprising all blocks of Barasat-Barrackpore Sub-division and 4 blocks of Basirhat Sub-division i.e. Basirhat - I & II, Baduria and Swarupnagar. Coastal alluvial zone comprised only 3 blocks of Bashirhat sub-division i.e. Sandeshkhali - I and II and Hingalganj. Each of such regions has distinct agro-climatic features that need to be considered during planning interventions.

***Agro-climatic conditions and its relation with crops*:**

Soils and climate are the two major important natural factors in explaining the natural advantages or disadvantages of the production of crops in a particular area. The soil includes physical properties like texture (the composition of sand, silt, and clay in soil) and the climate includes rainfall, temperature, relative humidity, solar radiation (sunshine hour), and a host of other parameters.

Table 6: Major Soils of Cultivable Area 2,61,070 Hectares*

Soils	Area in '000 Hectares	Percentage (%)
Clayey	42.08	16
Clayey – Loamy	62.82	24
Loamy	156.14	60
Total	261.07	100

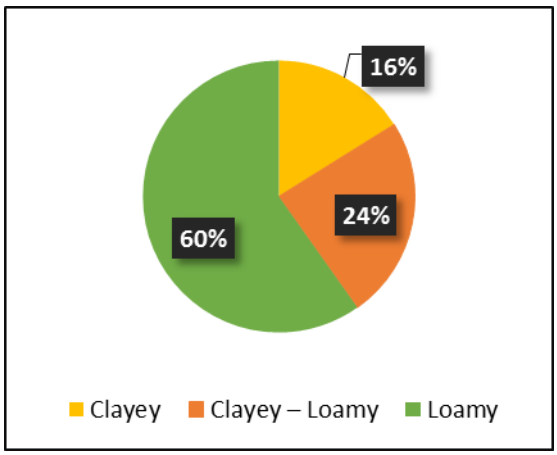

Figure 6: Percentage of Major Soils of Cultivable area; North 24-Parganas
*Source: Agriculture Contingency Plan, West Bengal

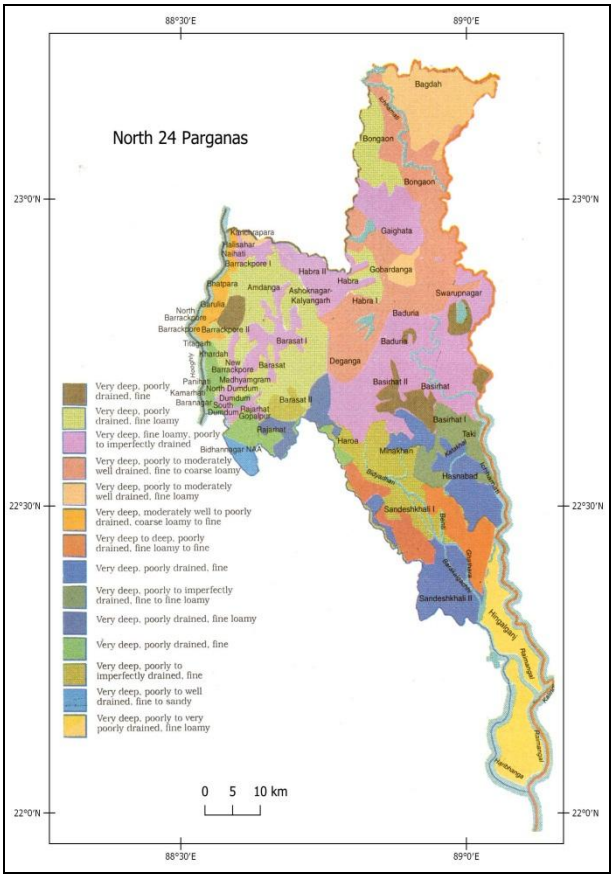

Figure 7: Soils; North 24-Parganas

The soils of the district belong within the new alluvium sub-region of the lower Gangetic Plain and are considered to be most fertile for crop production. The soil type varies from sandy to clay sandy loam. The soil of the northern part of the district is sandy, in the central middle part it is sandy with clay loam and on the southern side, it is clay loam. Clayey loamy soil is used for both Kharif and rabi crops. The elevated lands surrounding village sites, come under this category. Being generally highly manured, they are devoted to rice,

sugarcane, tobacco, pulses, and vegetables. Sandy loam is suitable for Potato, Tobacco, Paddy (Aus), and Pulses. Clayey soils are subdivided into two varieties called black clay and red clay. Black clay is stiff black clay of great natural fertility, on which all kinds of crops can be grown. Red clay is reddish, it cracks in the dry season and sinks into holes in the rains. It is well suited for winter rice, and on higher levels can be used for the cultivation of jute and other crops.

In the North 24-Parganas district as a whole, cultivation suffers far more frequently from excessive, than from deficient, rainfall, for, except for stripes of high land along the banks of the rivers, the land is low and swampy and tends to become waterlogged whenever there is heavy rainfall. This is especially the case with the great basin shut in between the Eastern Bengal Railway and the Hooghly embankments. In this case, the natural drainage channels are inadequate to remove the volume of water that accumulates after heavy precipitation in rain. In these circumstances, there is little necessity for artificial irrigation. It is, in fact, only resorted to for the cultivation of sugarcane and garden crops, for which water is raised from tanks and ditches.

IV. RESULTS AND DISCUSSION

Land use pattern and land holdings:

The total geological area of this North 24-Parganas is 4,09,400 hectares of which 2,61,040 hectares (63.76%) is under cultivation. Out of the total cultivated area, 73.07% area is facilitated by irrigation. Although there are no major irrigational projects like canals, so that, farmers are mainly dependent on groundwater as the main source of irrigation. According to the Agricultural Census of 2010, there are 3,75,235 numbers of farming families, of which 2,31,690 families belong to the marginal category; 1,40,361families belong to the small category, and the rest 2184 families belong to the big farmers' category. Since the area of the agricultural field is not so much larger, it becomes difficult for the application of advanced machine tools and technology in the field. The information on the land use pattern of the district is given below.

Table 7: Land use pattern of by North 24-Parganas (2017 - 18)*

Land use pattern	Area in '000 Hectares	Area in %
Cultivable area	261.04	63.76
Land under non-agricultural use	121.92	29.78
Cultivatable wasteland	7.19	1.76
Land under Miscellaneous crops and groves	10.41	2.53
Fallow land	8.84	2.17
Total Geographical area	409.4	100

Table 8: Irrigational area of the by North 24-Parganas (2017 - 18)*

Irrigational types	Area in '000 Hectares	Area in %
Area under net irrigation	200.56	76.83
Rain fed area	60.48	23.17
Total Cultivable area	261.04	100

Table 9: Irrigational structure of the by North 24-Parganas (2017 - 18)*

Sources of Irrigation	Number	Area in '000 Hectares	Area in %
Canals	-	7.5	3.74
Tanks	45063	15.1	7.52
Bore Wells	68914	-	-
Lift irrigation schemes	-	174.27	86.89
Other sources	-	3.69	1.85
Total	113977	200.56	100

*Source: Agriculture Contingency Plan, West Bengal

Paddy is the major crop of this district which covers an area of 75% of the total cultivated area of the district during Kharif season. Other major crops are Jute, vegetables, Oilseeds like Rapeseed and Mustard, Sesame, Groundnut, Wheat, Pulses like Gram, Mung, Musur khesari, etc. The major cropping pattern of the district is Jute-Paddy(Aus)-vegetables; Paddy(Aman)-vegetables(rabi)-Oilseeds; Pulse-Paddy(Boro)-vegetables. Due to high dependence on chemical fertilizer and unscientific cropping system, soil fertility is deteriorating day by day. On the other hand, contamination of chemicals on all agri-produce and living organisms is a serious concern. To overcome these problems, several programs like, organic farming, Bio-village, Soil health management, etc., and massive training programs at different levels with the small and marginal farmer are taken in the proposed strategic plan from the Krishi Vigyan Kendra and other departments of the district.

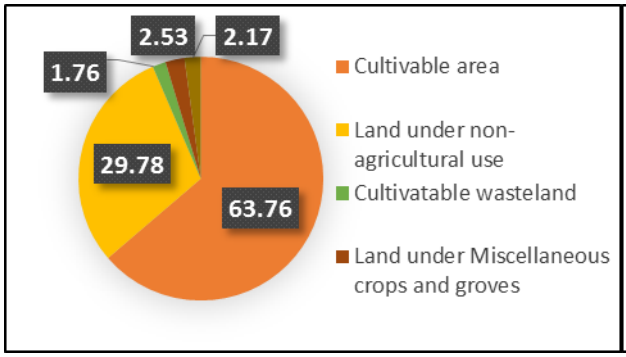

Figure 8: Land use pattern of North 24-Parganas (2017 - 18)

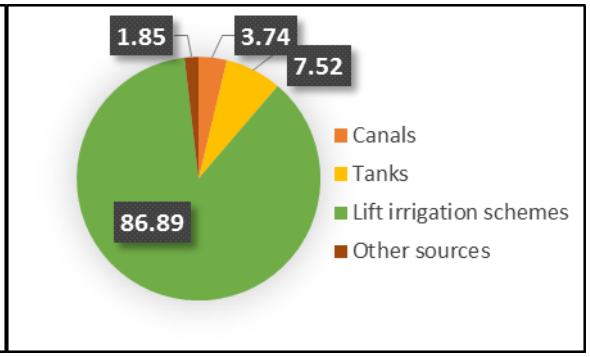

Figure 9: Irrigational structure of North 24-Parganas (2017 - 18)

***Cropping Pattern of North 24-Parganas*:**

As the growth and development of crops and cropping pattern in a particular region concerning other regions largely relies on the agro-climatic condition of the area. At present, the Agro-climatic study deals with the question of variation in the cropping system and cropping pattern between different agro-climatic zones. West Bengal also has a variability of the pattern over the period within each zone. By considering the natural advantages and disadvantages of different crops caused by soil and climatic factors the North 24-Parganas has an edge over other zones of the State in growing rice, potato, cabbage, cauliflower, tomato, and chili while this zone is disadvantageous for wheat and cotton cultivation. As the district has a growing consumption demand of cereals has also played a prime role in increasing allocation of land over time under cereal crops like winter rice and wheat are visualized in some parts of the district. Here also twin objective of meeting increasing consumption demand of cereals by bringing in more area under the aforesaid cereal crops and increasing farm income by allocation of more land under Horticulture has been addressed.

Table 10: Block wise land use pattern of North 24-Parganas (2017 – 18)**

Name	Net area under Cultivation	Area under orchard farming	Cultivatable wasteland	Area cultivated more than 1	Gross cropped area	Total cropped area	Cropping intensity
Amdanga	9.00	0.18	0.14	7.15	24.74	41.20	275.0
Baduria	12.39	1.26	0.21	11.47	35.22	60.55	284.2
Bagda	17.75	1.08	0.05	13.58	36.37	68.83	204.8
Barasat I	6.32	0.31	0.16	5.99	15.17	27.94	240.0
Barasat II	9.73	0.25	0.15	7.52	21.87	39.52	224.7
Barrackpur I	5.34	0.22	0.27	5.13	14.74	25.70	275.8
Barrackpur II	2.23	0.09	0.10	1.68	15.18	19.27	232.4
Basirhat I	7.40	0.83	0.39	5.62	15.84	30.06	213.9
Basirhat II	8.60	0.53	0.05	7.62	24.39	41.19	283.8
Bongaon	22.94	2.12	0.08	17.85	58.60	101.58	255.4
Deganga	12.00	1.13	0.03	10.69	31.35	55.20	261.2
Gaighata	15.91	0.58	0.03	14.20	42.70	73.42	268.3
Habra I	8.81	1.11	0.05	7.47	12.13	29.57	251.2
Habra II	8.00	1.15	0.10	6.57	19.32	35.13	241.4
Haroa	9.10	0.25	0.05	5.97	16.87	32.23	185.3
Hasnabad	11.02	1.03	0.24	6.88	19.88	39.04	180.3
Hingalganj	14.20	0.09	0.08	4.21	20.26	38.84	142.6
Minakhan	11.40	0.02	0.35	3.18	16.70	31.64	146.4
Rajarhat	3.96	0.46	0.02	2.36	10.67	17.46	269.5
Sandeshkhali I	8.06	0.15	0.35	3.13	12.64	24.32	156.8
Sandeshkhali II	7.73	0.09	0.16	3.41	12.25	23.64	158.4
Swarupnagar	13.12	0.66	0.24	8.44	26.58	49.04	202.6
Total cropped area	225.00	13.56	3.28	160.07	503.44	905.36	225.18

**Source: Directorate of Agricultural Evaluation, West Bengal

**Area in '000 Hectares; Cropping intensity in Percentage

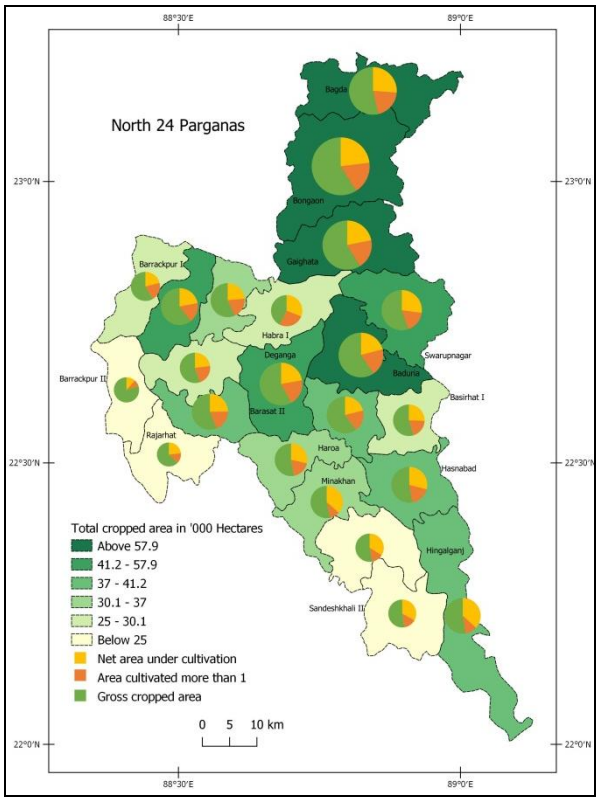

Figure 10: Different cultivable area (2017 - 18)

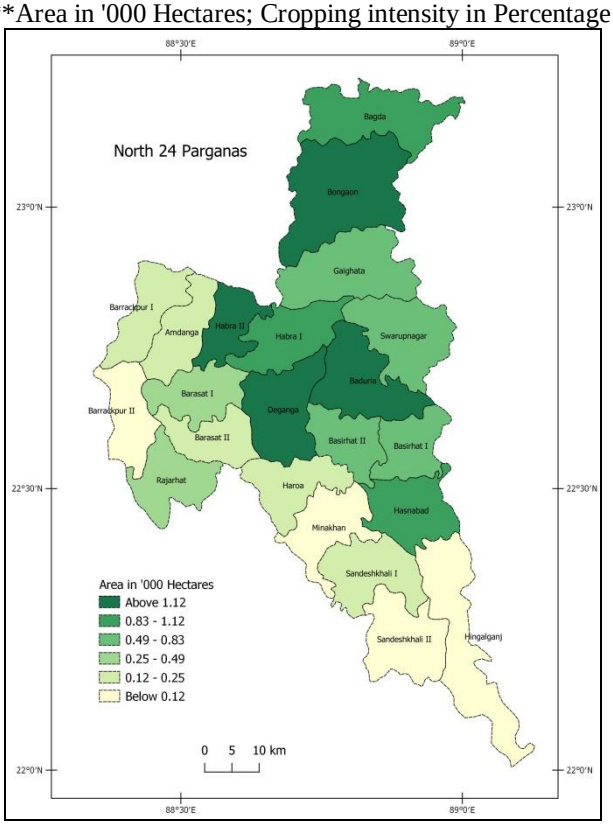

Figure 11: Area under orchard farming (2017 - 18)

Table 11: Area under Principle Crops by North 24-Parganas in '000 Hectares (2017-18)*

Total Cereal Crops	280.5	Rice	273.6	Aus	21.6
				Aman	159.9
				Boro	92.1
		Wheat	6.9		
Total Pulses	9.2	Gram	0.8		
		Mung	0.7		
		Musur	4.6		
		Khesari	0.9		
		Other Pulses	2.2		
Total Oil seeds	48.8	Rape seed & Mustard	33.6		
		Lin seed	2.5		
		Til	7.9		
		Other Oil Seeds	4.8		
Miscellaneous crops	16.1	Sugarcane	0.6		
		Potato	10.7		
		Chilli	4.3		
		Ginger	0.5		
Vegetables	71.8	Tomato	4.0		
		Cabbage	5.0		
		Cauliflower	5.1		
		Peas	1.3		
		Brinjal	10.4		
		Onion	1.4		
		Cucurbits	8.5		
		Ladies Finger	4.8		

		Radish	1.9
		Other Vegetables	29.4
Fruits	20.4	Mango	7.2
		Banana	6.7
		Pineapple	0.4
		Papaya	1.9
		Guava	0.9
		Jackfruit	1.4
		Litchi	0.7
		Sapota	0.3
		Other Fruits	0.9
Total Fibers	56.2	Jute	55.3
		Mesta & Other Fibers	0.9

*Source: Agriculture Contingency Plan, West Bengal

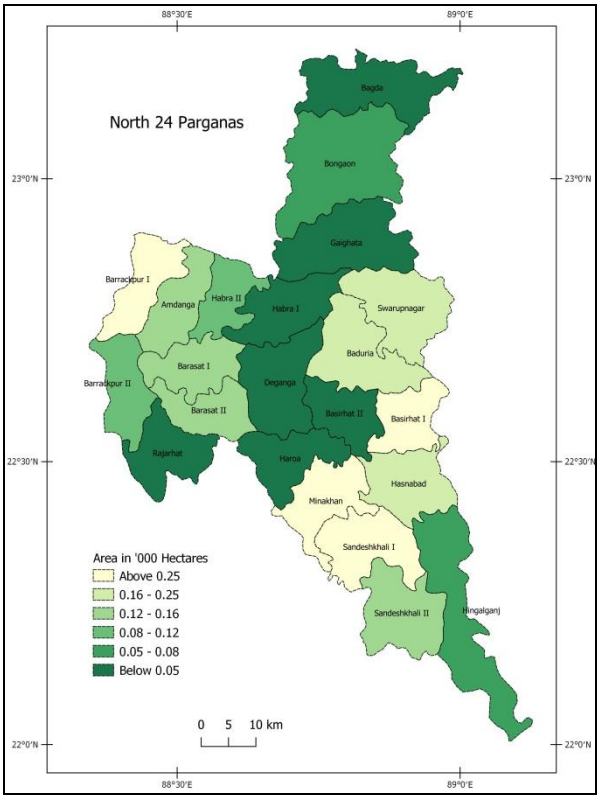

Figure 12: Cultivable wasteland (2017 - 18)

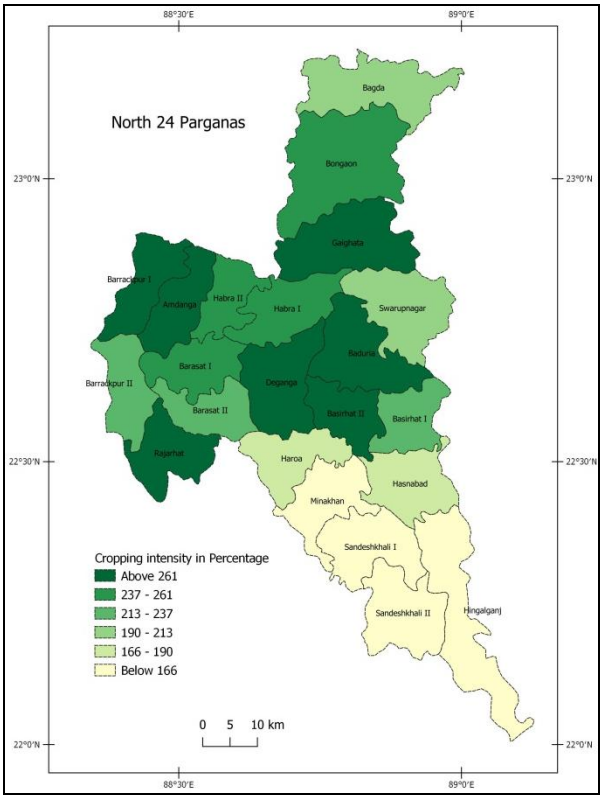

Figure 13: Cropping intensity (2017 - 18)

From the above analysis of the agro-climatic condition and the cropping pattern of North 24-Parganas, it is found that the district has a well-balanced cropping system that contributes significantly to employment for the people who are largely dependent on the agricultural sector. The cropping pattern of North 24-Parganas in terms of allocation of the acreage has been skewed towards Aman and Boro paddy, Jute, Potato, and Oilseeds (especially, rapeseed and mustard). These are marked as the important emerging remunerative crops during the last few decades. Net sown area (or actual area under cultivation) predominates higher in the northern and southern blocks and lower in Barasat, Barrackpore, and Amdanga blocks because these blocks are more urbanized, on the other side the share of cultivatable wasteland in North 24-Parganas is very low (less than 5000 hectares) concentrated only Amdanga, Bashirhat, and Sandeshkhali.

As regards fruits and vegetables, the district enjoys a very comfortable position over the state. Throughout the whole year winter, rainy and summer fruits and vegetables grow substantially. Mango, Banana, Pineapple, Jackfruit, Cauliflower, Cabbage, Tomato, Brinjal, Ladies-finger are the major fruits and vegetables produce in North 24-Parganas. Expect the fruits and vegetables; the agro-climatic conditions of the district are

suitable for Jute cultivation which regards as major fiber crops and comprise over 50 thousand hectares area next to paddy cultivation.

The average Cropping intensity is 225%, one of the highest in West Bengal comparative to other districts. The blocks situated in the southern part of the district (Minakhan, Sandeshkhali, and Hingalganj) experienced lower Cropping intensity because these blocks are parts of the Coastal saline zone (Sundarban area) and the agro-climatic conditions are not suitable for the growth of cereal crops or fruits-vegetables. The local people of these blocks engage themselves in aquaculture and shrimp cultivation as the soil with the saline water intrusion and several tidal creeks facilitating this activity.

Crop-Calendar of North 24-Parganas

			Sowing time				Harvesting time				Growth period			
Season			Kharif				Rabi				Zaid			
			Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Cereal Crops	Rice	Aus	G	G	H	H							S	S
		Aman	S	S	G	G	G	H	H					S
		Boro						S	G	G	G	H	H	
	Wheat							S	S	G	G	G	H	H
Pulses	Musur						S	S	G	G	G	G	H	H
	Pea					S	S	G	G	G	H	H		
Oilseeds	Mustard						S	S	G	G	H	H		
	Sesame (Til)		G	H	H					S	S	G	G	G
Other Crops	Sugarcane		G	G	G	G	H	H		S	S	S	G	G
	Potato			S	S	G	G	G	H	H				
Fruits	Banana		G	G	G	G	H	H					S	S
	Mango		G	H	H							S	S	G
	Pineapple		G	G	H	H					S	S	G	G
Rabi	Vegetables						S	S	G	G	H	H		
Re-creational	Tobacco				S	S	S	G	G	H	H			
	Betel Leaf (Pan)		H	H							S	S	G	G
Fibers	Jute		G	G	H	H							S	S

Source: Bengal District Gazetteers, 24-Parganas

V. CONCLUSION

The present study aims to examine the variation in cropping patterns of North 24-Parganas by analyzing the agro-climatic condition of the district. The variation within the agro-climatic zone itself has also been dealt with in this study. As the growth and development of crops in a particular area largely confide upon different agro-climatic parameters of the area under consideration, the aspects of natural advantage by considering the agro-climatic parameters have been examined in explaining the variation in cropping pattern of the district. Enormous monsoonal precipitation in this district favors the growing of Paddy, Jute, and other summer vegetables with minimum irrigational cost compare to other agro-climatic zones. This prolonged precipitation from June to September maintains the high soil moisture content and retains it up to the end of November. This condition favors the sowing of wheat without any pre-sowing irrigation but some years it has been experienced that extreme rainfall with very high soil moisture content inhibits the timely sowing of Mustard crops. From the study of the monthly rainfall, minimum-maximum temperature, solar radiation, and humidity of North 24-Parganas, it is noted that the interval of growth periods are seven months extending from October to April for the thermosensitive crops like Wheat, Potato, Tomato, Brinjal, Chilli, Radish, Cabbage and Cauliflower while it is generally five months in the other agro-climatic zones. On contrary, the advancement of

comparatively high relative humidity in this agro-climatic zone favors the occurrence of some crop diseases and insect-pests which causes loss of some important crops like Paddy, Mustard, Potato, Tomato, Brinjal, and Chilli. The soils of North 24-Parganas (alluvial with sandy loam to loam texture) having moderate porosity help to the presence of evapotranspirative water in the rhizosphere (the narrow region of soil or substrate that is directly influenced by root secretions) which helps growing of Wheat, Mustard, Pulses and all winter vegetable crops with minimum irrigation or in some cases without any irrigation during the dry months (November to March).

Although 60 percent of land holdings belong to marginal and small category farmers in so far as operational landholdings are concerned, it is nearly 40 percent of landholdings are medium, semi-medium, and large category. There seems to be a tendency for large operational landholdings to keep increasing which will favor farm mechanization. There are also enormous water resources and rainfall distribution available in the district. The government should have to make concerted efforts to bring more and more area under irrigation. An increase in the irrigated area will require farm equipment to enhance the capacity of operations. There is a big potential to enhance the yield levels of Paddy, vegetables, fruits, and other horticultural crops. Mechanization of different farm operations will surely support in achieving these goals.

The land of the district falls in the most fertile tract of the state with neutral soil and there is no major constraint on higher productivity. As desired by the agricultural department of the Planning Commission; they have taken up the task of operationalization of the agro-climatic regional planning for agriculture but the government policy on farm mechanization is nonchalant. The main problems which hinder the development of farming in this district are small landholdings, the resurgence of insects, pests, poor marketing facilities and on and often natural calamities like drought, flood, hailstorm, and breach of the embankment of rivers in coastal areas and overall huge population growth, etc. A large portion of the unemployed population of the district provides cheap labor that discourages the mechanization process. The economic conditions of the farmer do not favor investment in high-value equipment because; there is a lack of credit facilities available to the farmers. Besides this growing urbanization and gradual conversion of land for non-agricultural purposes is also a major problem. Apart from that, the low literacy rate, traditional knowledge, and ignorance of the farmers are the basic reasons which hindrances the development of agriculture in North 24-Parganas.

By considering the natural advantages and disadvantages of different crops caused by different agro-climatic parameters this district should require more and more area is being covered by assured irrigation facility. This will improve the cropping intensity and resultant farm mechanization. An increase in the size of operational landholdings has been observed in recent past years, which is a helpful indicator for the higher levels of farm mechanization. The government has unwavering plans to make different agro-based industries in the district to employ the peoples. The district has a dominant role over the other districts of the state in growing Paddy, Potato, Cabbage, Cauliflower, Tomato, Brinjal, and Chilli while this zone is disadvantageous for Wheat, Pulses, and Onion crops. The growing consumer demand for cereal crops has also played a prime role in increasing allocation of land over time under cereal crops like Paddy (both Kharif and Rabi) are visualized. But at present, there is a substantial gap between the demand and production of Paddy, Pulses, Onion, and Oilseeds, therefore the farm mechanization process will be necessary to increase the production to achieve the targets. New developments of Jute technology are promising to raise production of Jute in this agro-climatic zone which will employ jute based agro-industries. The agro-climatic conditions are also favorable to promote invasive diversification of aquaculture, shrimp cultivation and poultry farming.

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