Agriculture is not limited to merely the growing of crops, it is more than that i.e. it is also a form of applied ecology. Man's agricultural activities depend on the physical environment within which one lives, although man has often tried to minimise the restriction. To make a scientifically viable enquiry into agricultural phenomena one must pay particular attention to their basic sets of relationships i.e. those between the intricately related quadruplet a complex environment viz. the land, the climate, the soils and water resources and agricultural operation etc. i.e. the complex situation between the man and the environment. Such a study determines the extent and magnitude of usefulness of arable land for different agricultural purposes. Like spatial distribution of HYV rice, crop landuse is directly depend on the immediate natural environment which can be changed only at heavy cost, initially, agricultural systems are imposed by the physical condition till the later are modified. West Bengal as a whole and Malda District in particularly reveals regional contrasts in agricultural attributes, largely because of differences in environment. The diversities in relief, climate, soil and water resources within Malda must therefore be investigated at the out-set because they combinedly constitute a major factor in describing and interpreting the pattern of agricultural formations. In addition the role of
socio-economic factors can never be underestimated. These aspects have been dealt within Chapter V and VI.

Physical factors affecting agriculture may be divided into geology, topography, climate, soil, drainage and hydrology, although they are clearly interrelated. Climate is modified by altitude and slope aspects, soils by evapotranspiration, human activities etc. Thus the role of these factors in the areal agricultural complex is undeniable.

A long list of geographers, analysing the influence of terrain upon agriculture is on record, although some parent ones are much less inclined to record that terrain throws powerful illumination on landuse and on the growth and distribution of crops in areas where relief encompasses complex and diverse lithology, (Singh, 1971)\textsuperscript{86}. Physiography exercises a direct influence on landuse particularly through elevation, ruggedness, the slope, whilst in lower ground it affects flooding. It also influences farming by modifying the climate and affecting the case of cultivation and in the degree of accessibility. The flood plain thus formed by the alluvial parent materials have been conducive for cultivating rice including HYV.

(i) **Geology** : The making of the lower Ganga plain in general and the Malda district in particular is a product of fluvial action, the platform for this section was set through the
tectonic activities associated with the recent phase (Tertiary) of the earth's orogenic epoch resulting in the formation of the Trans-Eurasian mountain chains. The region has been reclaimed from the sea at a late date in the history of India by the rapid southward advance of the Ganges and Brahmaputra delta through the deposition of enormous load of silt.

The entire area in the district is covered by alluvium of two different ages displaying different physical and physiographic characteristics. The Barind area is covered by old alluvium deposits of pleistocene period. The recent alluvium found in the western part of the district is typically dark, loosely compacted with a high water and organic material content. A part of the Tal depression on the West of Mahananda upto the Kalindri have the same formation. These indicate that the present surface of the district is the result of partial denudation of the old alluvium of northern Bengal, between this alluvium plain and the Rajmahal hills, the Ganga and other Himalayan rivers flow down slope.

(ii) **Topography**: The two most aspects of topography namely, altitude and slope exercise both a direct and indirect influence on agricultural land use and specially High Yielding rice cultivation. These two factors determine the pace of diffusion of a new innovation, extent of farm mechanization and the degree of accessibility.
Topographic expressions in the region hardly speak of any well-defined stage of their evaluation. The monotonous surface is dissected frequently by the channels of the tributaries of distributaries of the main streams, i.e. the Ganga and the Brahmaputra.

The district is a triangular shaped region, through which flow a number of rivers from north to south. All of them, except the Mahananda rise in the plains, which are fed mainly by seepages from old alluvial banks, usually they have highly meandering courses, slightly incised in the old alluvial deposits. Physiographically the district may be divided into (a) Rahr (West) and (b) Barind (East). The Rahr again is sub-divided into (i) Tal (North) and (ii) Diarah (South).

The river Mahananda is flowing north and south roughly divides into two equal parts, corresponding by local traditions to the old boundary line of the Rahr and Barendra. The country to the east of the Mahananda is called the Barind.

Its characteristic feature is the relatively high land of the red clay soil of the old alluvium. The tract extends over a wide area in the districts of Malda in West Bengal and Rajsahi, Bogra and Dinajpur in Bangladesh. The characteristic feature of this region is wild undulations with successive ridges and depressions seamed with small water
course in the valley and practically devoid of shade except for the village sites and small patches of sal forest. The barind tract comprises an area of 1,32,761 hectare. West of the Mahananda the country is again divided into two well defined parts by the Kalindi river flowing west to east from the Ganges. North of the Kalindi the distinguishing natural feature is the Tal land, it is low lying area the name applied to the land which floods deeply as the rivers rise and drains by meandering streams into swamps or into the Kalindi. The Tal area gradually slopes South of the Kalindi down towards the south and west. The area under the Tal lies in the most populous portion of the district is 1,14,100 hectare. The most striking feature in the continuous line of islands and accretion formed in the bed of the Ganges by its everchanging currents and known as the Diarah. The Diarah consists of a strip roughly eight miles in width along the western and southern side of the district. Its formation is the result of centuries of fluvial action by the Ganges, the old channels of which can still be traced. The area under this tract is 1,09,493 hectare.

There are no uplands in the district excepting a few elevated tracts in the Barind area, parts of these uplands, have an elevation ranging from 17 to 30 meter, above the level of Ganges. Apart from these undulations, the region is a low lying plain, covered with a succession of village sites with their adjacent fields and swampy tracts.
The district slopes generally from the North to the South. The highest elevation in the district above sea level is 39.7 metres and is situated in the police station of Gazole. Elevation ranging between 30 and 39 meters above sea level are found in Bamongola and Habibpur blocks where the elevation is a little above 38 metres. The slope is gradual as is proved by the meandering course taken by the rivers flowing through the district. From the above discussion it is quite evident that the district is almost lowlying and provided favourable conditions for HYV rice cultivation excepting the Barind tract.

(iii) **CLIMATE** : There always exists a significant relationship between climate and crops because of the limits imposed on crop growth by the existing broad natural climatic condition which in a way determine the patterns of farm activity and crop production. In the case of High yielding varieties the effect of climate is very significant. It is absolutely essential to understand the elements of climate, especially rainfall, solar radiation, temperature and relative humidity of a region where diffusion of agriculture is taking place (De Dutta, 1981)\(^27\).

The district experiences a hot and humid monosonal climate. the proximity to the Bay of Bengal in the south, the alignment of the Himalaya in the North and that of the Meghalaya plateau in the north-east determine largely the climatic character, i.e. the distribution of the climatic
elements with respect to time and space. Irrespective of the general vagaries and mechanism of the monsoon, the spatial and seasonal distribution of the elements such as temperature, rainfall and relative humidity are too uneven. (Singh, 1971) 88.

The climate of the district is characterised by a hot and oppressive summer season, plentiful rain and moisture in the air throughout the year. The climate of this district is mainly governed by the following five factors:

a) the orography,
b) the alternative pressure cells of the north east India and the Bay of Bengal,
c) the predominance of maritime tropical airmass,
d) the local valley winds,
e) the periodic western disturbances.

On the basis of temperature variation, rainfall humidity and winds, four well defined seasons are observed in the district.

Winter Season - December to February
Summer Season - March to May
Monsoon Season - June to September
Retreating Monsoon - October and November.

The winter season starts from December and ends in February. The main characteristic phenomena of this season are
cool weather, frequent morning fog, average monthly temperature above 12.8°C, mean rainfall amounting to an average of 1140 mm., January is the coldest month.

The summer season starts from March and ends in first half of June. The season is characterised by a rise in temperature, increase in the amount and frequency of rainfall with the advance of the season, decrease in diurnal range of temperature. The total average rainfall during the season is recorded as 308.7 mm. and the region experiences and average temperature of 28°C and average diurnal range of about 6°C. The mean annual temperature varies between as low as 24.30°C to as high as 26.35°C for Chanchal and Habibpur respectively (appendix-1).

Monsoon season in the valley starts from June and ends of September. The low pressure through this being created in the plain as a result of which monsoon currents pass through it. The seasonal characteristics include weak surface winds, cloudy sky, high humidity and sultry weather.

With the withdrawal of the south-west monsoon by about the first week of October both day and night temperature drop steadily. Summing up the whole climatic phenomena in general it could be concluded that though there prevails a homogeneous climate in the plain, nevertheless, a little heterogeneity in climatic conditions within and between
different parts of the district in terms of variation in rainfall and range of temperature etc. prevails. Thirty years average of rainfall indicates a little difference between the North Western and South Western part of the district and as far as the temperature is concerned a spectacular differences exist between the Northern and Southern part. The North and North Western part of the district get high amount of rainfall and has a low range of temperature whereas in the Southern and South Eastern part experiences relatively less rainfall and a higher range of temperature.

Though the present study is confined to an area of the district of Malda in North Bengal, a micro region, an attempt has been made to analyse the spatial distribution of temperature rainfall and relative humidity. These three variables - temperature, rainfall and relative humidity have a close bearing on the productivity of new seeds of rice. Such factors directly affect the physiological process involved in grain production i.e. vegetative growth development of spikelets and grain filling. Indirectly the grain yield is affected by them through incidence of plant diseases and insects (IRRI, 1988).

**RAINFALL EFFECTIVENESS**

At a glance to the 20 years normals of monthly rainfall total and annual mean from 4 meteorelogical stations
and 2 Agricultural research Stations Farm data (English Bazar, Harishchandrapur, Chanchal, Gazole, Habibpur, Kaliachak-I and Kaliachak-III). It is distinct that the rainfall (20 years average) have been plotted (appendix-1) varies from North to South direction, between 1843.51 mm. and 1738.03 mm as the highest and lowest for Harishchandrapur and Habibpur respectively. Habibpur located in the extreme south eastern part of the district, received lowest rainfall i.e. 1738.03 mm.

70 to 80 percent of the average annual rainfall is recorded during the month of May to September.

**INTENSITY**: From the High yielding point of view it is the timely distribution of rainfall which is more important and not the seasonal average. Infact, heavy rainfall in one week followed by long interval of dry weather may affect the HYV of rice adversely.

The precipitation and the number of rainy days may be sufficient to meet the requirements of different crop production in general and HYV rice in particular, but successful harvest is noticed only when the rainfall is timely and well distributed over the rice growing period. So the concentration of rainfall over few months decreases its usefulness. In 1987 it so happened that the transplantation of HYV rice was carried on without rain because of the late arrival of monsoon in many blocks of Malda District.
It would be worthwhile if the intensity of rainfall is studied for the selected sections of the district which explain the intensity per 24 hour period. The intensity of rainfall is calculated with the help of the following formula.

\[ I (\text{Intensity}) = \frac{\text{Total Monthly rainfall}}{\text{Number of rainy days}} \]

It will be seen from Table II.2 that in English Bazar, June and January have the highest and the lowest intensity of rainfall being 26.09 mm. and 9.69 mm. per rainy day respectively. But in Harishchandrapur the highest intensity was observed in the month of June. Gazole experiences high intensity of rain in August and low in December. As evident from Fig.-3. Habibpur, located in extreme South Eastern part of the district, has the highest intensity of rain in July and lowest in December. So the highest - rainfall intensity throughout the district from North to South is observed in the months of June, July, June, July, August and July for the stations such as English Bazar, Harishchandrapur, Chanchal, Gazole, Habibpur and Kaliachak respectively. Similarly lowest intensity of rainfall at most of the rainfall recording stations is seen in the month of December and January.

Apart from temperature and amount of rainfall the
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<tr>
<td>Gazole</td>
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<td>10.17</td>
<td>12.71</td>
<td>15.17</td>
<td>18.12</td>
<td>20.10</td>
<td>21.23</td>
<td>23.07</td>
<td>20.00</td>
<td>19.00</td>
<td>7.67</td>
<td>9.2</td>
<td>15.48</td>
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<td>Habibpur</td>
<td>14.00</td>
<td>11.00</td>
<td>16.18</td>
<td>19.02</td>
<td>21.02</td>
<td>20.21</td>
<td>24.18</td>
<td>20.09</td>
<td>20.07</td>
<td>17.01</td>
<td>11.00</td>
<td>10.0</td>
<td>15.40</td>
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<tr>
<td>Kaliachak</td>
<td>13.27</td>
<td>13.97</td>
<td>14.48</td>
<td>20.20</td>
<td>28.28</td>
<td>28.28</td>
<td>22.58</td>
<td>23.31</td>
<td>22.21</td>
<td>20.00</td>
<td>11.08</td>
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<td>17.18</td>
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relative humidity has also a close bearing on the outputs of High Yielding varieties of rice. The district experience a humid climate, the mean annual relative air humidity exceeding 70 percent in each of the rainfall recording station. The data relates to 20 years average for each month from 1971-1990. In the North-West and central part of the district Harishchandrapur, Chanchal and English Bazar have more than 75 percent relative humidity in air. However, in the South Eastern part of the district the same has a range between 70 to 74 percent. So far as the relative humidity is concerned there appears not much variation between Northern and Southern part of the districts. But the slight variation in the Southern part is due to high temperature range in its air.

Coming to the relative humidity in the monsoon season it is observed that more than 80 percent humidity is experienced in every part of the district excepting in Habibpur Block (appendix-1).

It is observed that there is a spectacular difference in the range of temperature during the kharif and rabi season. Stations falling in the lower part of the district show a higher range of temperature than the upper, which is normally more than $24^\circ$C. Hence, because of high range of temperature during the ripening stage the sensitive high yielding varieties of rice crops may be more prone to failure and low yield. Matsushima and Manaka (1977) hence, are of
opinion that $22^\circ$C the optimum temperature for ripening stage of rice and temperature higher than $25^\circ$C adversely affects ripening of rice grains. On the contrary, it has also be found that temperature and yield rate are positively correlated. De Datta and Zarati (1979) failed to find out the negative influence of temperature on the yield of Indian varieties sown every month during the year in Indian Rice Research Institution (IRRI) at Cuttack. It is because, higher the temperature, higher is the solar radiation which is associated with higher yield. In the present study it will however, be discussed in the chapter IV as to whether temperature is positively or negatively related with the yield of HYV of rice in the Malda District.

(iv) **DRAINAGE** : The principal rivers of the district enumerating from the east are the Punarbhaba, the Tangon, the Mahananda, the Kalindi and the Ganges. In fact the Ganges, which form the South Western boundary of the district, is being enriched by discharges from all the other rivers.

The Punarbhaba leaves the district of South Dinajpur and forms the boundary between the Police Stations of Tapan (South-Dinajpur) and Bamongola (Malda). It is a tributary of Mahananda. It flows within the district for about 64 km.

The Tangon forms the boundary between Gazole and Bamongola blocks. It joins Mahananda in the Police Station of
Habibpur. A branch of it named Mara Tangon, flows several kilometer through the Police Station of Gazole and joins the present river in Bamongola Police Station. The length of this river in the district is nearly 64.4 km. Floods in this river are also associated with floods in the Mahananda.

The Mahananda enters the district from the North. The actual entry is made at the trijunction point of the blocks of Chanchal, Ratua and Gazole. It joins the Ganges through Bangladesh. The river runs for about 88.6 km. in the district. The maximum discharge observed in the flood season in 1992 amounted to 1,53,329.00 cusecs (1992) and in the dry season 665 cusecs (1992) at Kaliachak.

The Kalindi is taken as an offshoot of the Eastern branch of the Ganges but actually it is branch of the river Mahananda and renamed as Phullar in the district of Purnea. It enters the district of Malda near Mihaghat from where it is known as the Kalindi. It is flowing mainly in the South Eastern direction to its meeting point with the Mahananda.

The Ganges forms the South-Western boundary of the district. There is a big 'Char' in its bed near the point where she first enters the district. This char is 18 km. in length and is known as Bhutni Diara. The river flows in two channels north and south of the Char island. The river is in the process of shifting towards the easterly direction. This
continuous easterly movement of the river is causing concern as it is endangering the left bank and affecting the proper functioning of the Farakka Barrage. Moreover, in this part of the river the meander pattern is also shifting. Now because of changed meander pattern the whole of left bank from Manickchak to Tofi is facing severe erosion problem. The deep water channel of the river which is only about 500 m. width carries about 75 percent of the total discharge hugging its left bank from Manikchak to Tofi. After Khejuria near Farakka Barrage is the river has shifted its course towards west recently and is caused a serious havoc on its right bank in Murshidabad district.

(v) **SOIL**: Rice is grown on a variety of soil ranging from water logged and poorly drained to well drained. It is also grown under many different climatic and hydrologic conditions. Consequently there is a considerable range in pedogenetic and morphological characteristics of rice growing soils. Geographical investigation of soil characteristics is of great significance to agricultural geographers. Soil Characteristics, help us to know the distribution of crops and the selection for specific varieties, this may be called the selective, rather than the prohibitive influence of the soil. Mahsuri a very common variety of rice had a very little success in yield, has been replaced by IET 2815 (another variety of HYV rice) in many parts of West Bengal due to non suitable soil
condition. (Chang and Vegara, 1972) arrived at the conclusion that alluvium plain of Korea, with moderate drainage responded better yield than poorly drained soil.

The soils of Malda district are more or less uniform in nature. But it is quite probable from theoretical considerations that truely genetic variants may occur, depending upon micro-relief, ground water condition etc. The district is enriched with alluvial soil (the Ganges silt).

Northern parts of the district are occupied by older alluvial soil and the southern parts are occupied by deep to very deep newer alluvial soil which is comparatively more fertile in the district. Both these areas are intensively cultivated. The soils of the district are locally classified as below:

1. The soils of Barind area, (old).
2. The soils of Tal area, (moderately new) and
3. The soils of Diara area, (new).

Soils of Barind Area: Barind tract (1,32,761 hectare) i.e. Gazole, Bamongola and Habibpur are under this soil. Barind soils are usually made up of massive argellaceous beds of a pale reddish brown colour. This old alluvial formation is considered to have formed in the pliestocene period. It is composed of stiff clay, containing iron and lime and becomes extremely hard in the cold weather. In this red-colour soil,
Aman is the main crop. But in low land areas rabi crops are
cultivated. Mustard seeds, Gram, Chhola are cultivated after
Aman. The soil is slightly acidic in nature and soil $p_H$ varies
from 6.2 to 7.0

**Soil of Tal Area**: It occupies an area of 1,14,100 hectares.
North of Mahananda river and middle portion of Kalindi river
are under this area. Ratua, Harishchandrapur and Chanchal are
under this soil. The soils are flooded during rainy season.
The soils are clay loam to sandy loam in texture. This soil is
light loam called do-ash. It is a later alluvial formation and
consists of an admixture of clay and sand. On the eastern side
the proportion of clay is greater, but further west towards
the Ganges the greater becomes the proportion of sand. This
soil is neutral in reaction and $p_H$ varies from 6.8 to 7.8.

**Soils of Diara**: It occupies (1,09,493 hectare) western parts
of the district i.e., English Bazar, Manikchak, Kaliachak and
parts of Ratua. This is the most fertile area, $p_H$ ranges from
6.5 to 8.0. It is most Intensively cultivated. Jute, Pulses
chhola, master seeds, wheat etc. are also cultivated widely.
These soils here are Ganges silt and alluvial soil which is of
very recent origin, and are admixture of sand and clay.

Considering soil as one of the major factor for the
growth and yield of any food or nonfood crop and for high
yielding varieties of rice in particular a thorough and
detailed discussion on this parameter has been done in Chapter-IV.

In general the fertility of the district differs according to its natural regions. East of Mahananda which is formed by older alluvium is most acidic in nature as a consequence it is mainly mono-cropped. Only on the northern part jute and rabi crops are grown on limited scale. Boro rice is restricted only in the 'Doba' area whereas in west of Mahananda formation of laterite has neutral reaction. Soil is fertile and produces mainly Amon and Boro paddy. On the other hand the Diarah is the highly fertile land in the district which is also favourable for HYV rice.

(vi) **UNDERGROUND WATER** :

Ground water table is very significant with regard to the genesis and properties etc. of the soil. The depth of the water table in any region is bound to various factors, such as -- physiography, climate, porosity of substraum. Water table in the district in the uplands and in the low-lands differs considerably. The depth of ground water table also depends on the distribution of moisture in the various soil horizons. The level of ground water depends to a great extent on the geological conditions. The height of the water table depends on the underground relief. The relief of the water table changes constantly in relation to the condition of
the water balance of soil and ground water. Ground water table is balanced by the amount of rainfall, rate of evaporation, rate of run-off and of the amount that percolates through the soil body. The conditions of ground water table of Malda district, both summer and rainy season are discussed below.

During summer the water table lies between 243 cm - 1554 cm. below the surface over the whole of the district. Major part of the ground water table lies between 609 cm - 1218 cm from the surface.

Water table remains at a greater depth (above 609 cm. from the surface) in Chanchal, Dakshinsahar, Malda, Sekpura, Betala, Harimkole, Gobindapur etc.).

In summer water table lies below on an average 365 cm. in Kaliachak Police Station and 609 cm. below the surface in Habibpur Police Station. In most of the area water table lies between 60.9 cm. - 1218 cm. covering the blocks of English Bazar, Gazole, Chanchal, Ratua, Harishchandrapur-I etc. The depth of the water table from the surface is highest 1218 cm. in Gazole Block of Barind area.

During rainy season ground water table lies between 91 cm - 762 cm. from the surface. Ground water table of the soil of the district lies nearer to the surface of the soil. But it is not continuous all over the district. On the southwest, east and in the middle of the district, water table lies
between 121 cm. to 182 cm. below the surface. In the northern part of the district water table lies below 91 cm. and more, from the surface. The general water table lies more or less nearer to the surface.

For High yielding varieties of rice, irrigation probably the most important factor. In this study it has been felt that extension and diffusion of HYV largely suffered for the lack of irrigation. In Barind area where hydrology or the ground water level is not favourable, river lift irrigation (RLI) is must to support HYV paddy. Gazole, Bamongola, Habibpur and Old Malda, the blocks of Barind area have drawn maximum R.L.I. water for these reason, whereas the Tal areas used mainly tube-well irrigation in a much more rational manner.