CHAPTER II

METEOROLOGY
1. INTRODUCTION

The study of this branch related with the chemical, physical and dynamical processes of the earth. Temperature, relative humidity and wind velocity, precipitation, sunshine, evaporation, evapotranspiration and water budgeting are the meteorological parameters described in this chapter with respect to HHB.

2. TEMPERATURE, WIND VELOCITY AND VAPOUR PRESSURE

The thermal state of an object which enables it to communicate heat to other objects is called TEMPERATURE. The daily maximum and minimum temperature data are collected and monthly mean maximum and minimum temperature value are calculated. Then the mean temperature of the month is determined by averaging maximum and minimum temperature for the different month. The average daily maximum and minimum temperatures for the years 1988 to 1995 are studied. The maximum temperature of 35.39°C was recorded in the month of April and minimum temperature of 17.40°C was recorded in the month of December which are given in Table 1.

Moving air is defined as WIND and the term is generally limited to air, moving horizontally or nearly so. Wind exerts a force or pressure against objects in its path, and that force is proportional to square of its velocity. WIND VELOCITY is a vector quantity and equals speed in a particular direction. The wind velocity of average of 8 years (1988-1995) in HHB area is given in Table 1. The wind velocity is maximum during May, June, July and August (10.54 to 12.75 Km/h) and minimum wind velocity is during January, February and October (8.09 to 8.14 Km/h).

When air is saturated no more moisture can be added to it without bringing on condensation or producing super saturation. When it is desired to discuss relative humidities between 0 - 100% it is necessary to bring a new concept of VAPOUR PRESSURE.
The SATURATION VAPOUR PRESSURE of pure water vapour is defined as the pressure of vapour when in a state of neutral equilibrium with a plane surface of pure water at the same temperature. It varies with temperature exactly as does the vapour tension of the water, so that the higher the temperature the greater the vapour pressure required for saturation. The saturation vapour pressure is independent of pressure of other gases at all atmospheric pressure. The saturation vapour pressure in HHB is given in Table 1. From the table it can be said that the saturation vapour pressure is 24.51 millibars in the month of June, 16.23 millibars in the month of February.

3. RELATIVE HUMIDITY, SUNSHINE AND EVAPORATION

Humidity is an important factor of climate, it plays a significant role in the growth and development of agriculture. The RELATIVE HUMIDITY refers to the degree to which the air is saturated with moisture. The relative humidity of dry air and saturated air has zero and 100% respectively. Relative humidity is necessarily an active factor in the precipitation that any area is likely to receive. The average mean relative humidity at 8.30 hours 51.20 to 92.35 per cent, and at 17.30 hrs. 26.10 to 84.85%. The average relative humidity varies from 48.82% to 80.42%. The relative humidity is low in January, February, March months (winter months) and high in June, July, August months (summer months).

A simple instrument recording SUNSHINE is a glass ball which focuses the Sun's rays on dialed paper, such that a charred trace is left at the surrey intervals. Sunshine also is closely related to temperature. In combination with atmospheric heat, the absorption of direct radiation can drive the temperature above the maximum limit permitted by moisture supply. In moderate intensity, radiation can stimulate plants to their optimum development. In the present study, the sunshine recorded in the Naviluteerth meteorological observatory Saundatti, Belgaum district is considered. The average daily sunshine of each month for 8 years is given in Table 1. The minimum sunshine of 183.09 min/day is in the month of July and 602.18 min/day in the month of February.
EVAPORATION is the process by which water precipitated on the earth's surface is returned to the atmosphere by vaporisation depending on the sunshine of the area. Quantitatively expressed is the depth of water vaporised from a unit surface in unit time i.e., mm/day, m/year. The rate of vaporisation depends on several factors. It increases with decrease in barometric pressure, increase in air and water temperature, sunshine wind velocity, dryness of the air and purity of water.

The daily evaporation data is collected from the Naviluteerth meteorological observatory and monthly average of 8 years is given in Table 1. The maximum evaporation of 256.51 mm during March and minimum evaporation of 100.10 mm during July are recorded.

4. EVAPOTRANSPIRATION AND RUNOFF

Thornthwaite (1948) suggested the term potential evapotranspiration which is defined as the total amount of water lost from the soil surface and through the Stromata of plant levels with ideal conditions provided by plenty of water in the soil and a complete vegetative cover. Since the potential evapotranspiration is determined by the atmospheric demand for moisture, it can be calculated from climatic data. The main climatic elements that affect the potential evapotranspiration are temperature, humidity, wind and radiation. There are many methods of estimating evapotranspiration and potential evapotranspiration, but no one method can be applied generally for all purposes.

In the present study the author has determined the evapotranspirations by different methods as follows:

THORNTHWAITE'S METHOD

Thornthwaite (1948) used mean monthly temperature to determine the potential evapotranspiration by the formula.
E = 16(10T/I)^a

where  
E = Monthly potential evapotranspiration in centimeter  
T = Mean monthly temperature in degree centigrade  
I = Head index, determined by Summing for 12 months,  
the expression \((T/5)^{1.514}\)  
a = 0.492 + 0.017911 - 0.00077112 + 0.000000675 I^3

Thus the computed potential evapotranspiration is adjusted for day length, which is determined by latitude of the station and given in the Table 2.

KHOSLA'S METHOD

Khosla (1949) gave a formula for computing monthly water losses \((L_m)\) based on monthly mean temperature \((T_m°F)\). His formula.

\[ L_m = \frac{T_m - 32}{95} \]

where  
\(T_m > 40°F\)

\(L_m\) = monthly water loss in inches.

The monthly water losses calculated according to this formula is given in the Table 2.

EAGLEMAN'S METHOD

Eagleman (1967) used the saturation vapour pressure and relative humidity to calculate maximum evapotranspiration rate by his formula.
\[ E_T = C(0.035 e_s)(100 - RH)^{1/2} \]

where

\( E_T \) = Maximum evapotranspiration in inches/month

\( e_s \) = Saturation vapour pressure in millibars

corresponding to the mean monthly temperature in Degrees Fahrenheit.

\( RH \) = Mean monthly relative humidity in percentage

\( C \) = is the factor related to vegetative cycle in turn related to mean monthly temperature (T) i.e. between 30 and 70°F, \( C = 0.20 + 0.0133T \).

If T < 30°F, \( C \) = constant value of 0.6, since there would not be further decrease in water loss rates as vegetative growth and other functions are reduced from the lower temperature. Above 70°F \( C \) = a constant value of 1.13, since no additional effect from increased
calculated maximum evapotranspiration is given in the Table 2. The average annual evapotranspiration is 125.71 mm.

**RUNOFF**

Runoff forms one of the basic components of hydrogeological cycle and it occurs when there is excess rainfall, minimum rate of infiltration and evaporation. The excess rainwater flows over the ground after depression filling. Runoff depends mainly upon the topography, surface slopes of the drainage basin and intensity of rainfall. It also depends upon the dimensions and configuration of the drainage basin, climatic condition of the area, soil, vegetation type, geology and ecological conditions.

The record of actual runoff of HHB is not available with Government departments, but runoff is estimated by indirect method given by Inglis (Raghunath 1990).

Inglis used the rainfall data for calculating the runoff by following empirical formula for a catchment.

\[ R = \frac{(P - 178)P}{254} \]

where  
R = runoff in cms  
P = rainfall in cms.

The author has used the Inglis formula for calculating the runoff by taking average annual rainfall of each rainguage station. The results are given in Table 3. The average annual runoff is 51.58 cms. approximately.
5. PRECIPITATION

The PRECIPITATION is the ultimate source of all surface water and groundwater. Intensity of precipitation is the rate of precipitation expressed in inches, cms. or mm. per minute, hour etc. Intensity of precipitation is of great importance in the study of groundwater, irrigation and for the use and regulation of water on the land. The HHB occupies an area of 150 Sq Kms. with only one raingauge station. Five more raingauge stations are taken up for the study, which are very near the periphery of HHB. The average monthly rainfall data was obtained for the year 1978 to 1995 (Table 5) and is studied with respect to following heads.

- Network design of raingauge station
- Seasonal variation of precipitation
- Distribution of precipitation
- Annual variation of precipitation
- Mean annual precipitation

The RAINGUAGE NETWORK plays a significant role in studying the aspects like distribution of rainfall, agriculture, planning, storm studies and water balance studies. The installation of raingauge depends on precipitation, topography, geology, soil type and land use etc. The Indian Meteorological Department (1972) has suggested the following pattern for raingauge network for different topographic features.
The Indian Standard Institute (ISI 1968), has suggested the formula to find the optimum number of raingage station for estimating the average precipitation in the area as

\[ N = \left( \frac{CV}{P} \right)^4 \]

where \( N \) = Optimum number of raingage station

\( CV \) = Coefficient of variation of rainfall values of the existing raingage stations.

\( P \) = Desired degree of percentage error in the estimate of the basin.

Calculation of "N" values is given below:

<table>
<thead>
<tr>
<th>Stations</th>
<th>Precipitation (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Munoli</td>
<td>557.92</td>
</tr>
<tr>
<td>2 Navilurth</td>
<td>646.54</td>
</tr>
<tr>
<td>3 Nesargi</td>
<td>543.28</td>
</tr>
<tr>
<td>4 Belavadi</td>
<td>403.90</td>
</tr>
<tr>
<td>5 Bailhongal</td>
<td>599.14</td>
</tr>
<tr>
<td>6 Murgod</td>
<td>600.63</td>
</tr>
</tbody>
</table>
Arithmetic mean  \( = \bar{x} = 558.57 \)

Standard deviation  \( = \sigma = 76.714519 \)

\[ CV = \frac{\sigma \times 100}{x} \]

If percentage of error \( P = 10 \)

Then optimum number of rainguage stations required  \( = N \)

\[ N = \left( \frac{CV^2}{P} \right) \]
\[ = 1.88 \]

The above calculations, the optimum number of rainguage stations required for HHB are 1.88 i.e. atleast two rainguage stations are required for the area under consideration. But at present there is only one rainguage station at Murgod one more rainguage station is proposed at Gontmar or Harugopa. The rainguage at Murgod should be maintained for its continued use.

SEASONAL VARIATION OF PRECIPITATION

Anantha Krishnan and Rajagopalachari (1963) have classified the calendar year into four seasons for the Indian conditions viz.,

* June to September - SW Monsoon
* October to November - NE Monsoon
* December to February - Winter
* March to May - Summer

On the basis of this classification the percentage of annual rainfall in each season has been calculated and presented in the Table 4. From the Table 4 it is clearly seen that a major portion of the rainfall is recorded during SW monsoon. i.e., 63.62% of total annual rainfall
occurs during this season and about 19.92% of total annual rainfall is recorded during NE Monsoon.

DISTRIBUTION OF PRECIPITATION

Sarma et al (1982) have calculated the coefficient of variation in order to study the distribution of precipitation. Five classes are identified based on the coefficient of variation and are given below.

<table>
<thead>
<tr>
<th>Precipitation distribution</th>
<th>Coefficient of variation CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniform</td>
<td>0-25</td>
</tr>
<tr>
<td>Normal</td>
<td>25-50</td>
</tr>
<tr>
<td>Medium scattered</td>
<td>50-75</td>
</tr>
<tr>
<td>Heavy (largely) scattered</td>
<td>75-100</td>
</tr>
<tr>
<td>Very very scattered</td>
<td>&gt;100</td>
</tr>
</tbody>
</table>

The coefficient of variation of rainfall data for the present study area has been calculated using 18 years rainfall data given in the Table 6. The Table 6 indicates that during the months of January, February, March & December, the distribution of rainfall is largely scattered (CV = 47.19 to 244.95) and during the rest of the months the rainfall distribution ranges from 0 to 255.56 mm (CV = 0 to 243.82).

ANNUAL VARIATION OF PRECIPITATION

To know the annual variation of precipitation, the author has constructed a variation diagram (Fig. 4). The figure indicates that the total annual precipitation for about 6 years above
normal and about 7 years the precipitation is below normal, for about 5 years the rainfall appears to be nearly normal. The figure 4 also reveals that in past 10 years (1981 to 1991) the deficit precipitation leading to severe drought in 1984 to 1986.

RELATION BETWEEN METEOROLOGICAL PARAMETERS

To study the relation between different meteorological parameters, the author has drawn the variation diagrams (Fig.5) using 8 years monthly average data (Table 1) of temperature (maximum and minimum) relative humidity, vapour pressure, wind velocity, evaporation, precipitation and sunshine. Figure 5 shows a sympathetic relation between the maximum temperature and evaporation i.e., when temperature is high, evaporation is also high, when temperature is low evaporation is also low. Sympathetic relation is also found between the vapour pressure and relative humidity. The relative humidity shows antipathical relation with temperature evaporation and sunshine. Sympathetic relation exist between wind velocity and vapour pressure. Antipathical relation exists between evaporation and precipitation.