

Practical Manual
B. Sc. (Hons.) Agriculture
Rainfed Agriculture and Watershed Management
Course No: ASAG 2211
Credit: 2(1+1)
Semester: 4th



Centurion
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*Shaping Lives...
Empowering Communities...*

Department of Agronomy

M. S. Swaminathan School of Agriculture
Centurion University of Technology and Management, Paralakhemundi
www.cutm.ac.in

December, 2022

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Certificate

Certified that this is a bonafide record of practical work done by

Mr./ Ms. _____

Regd. No. _____ in B. Sc. (Hons.) Agriculture degree programme,

Course No. ASAG 2211 entitled “Rainfed Agriculture and Watershed Management” during

4th semester of the academic year 2022-23.

Date:

Signature of Faculty In charge

Evaluation System
RAINFED AGRICULTURE & WATERSHED MANAGEMENT
Course No.: ASAG 2211

Sl. No.	Marks distribution*	Total marks	Marks obtained
1	Record	10	
2	Attendance	5	
3	Assignment	5	
4	Viva	5	
Total (25 marks)			

Signature of Faculty In-charge

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Studies on Climate Classification, Studies on Rainfall Pattern in Rainfed Areas of the Country and Pattern of onset and Withdrawal of Monsoons

The purpose of climate classification is to set up climatic types and climatic areas in global measure on the Earth as well as in particular geographical areas. There is interconnection between characteristics of the climate with latitude, georelief and the degree of continentality. *Climatic zones* lie in the direction along the parallel (zonally) and they are the base for climate classification.

Classification of dry climates:

1.1 Thornthwaite and Mather (1955)

They have taken the Moisture Index (Im) as the criteria for classification of dry climates

$$I_m = \frac{(P - PE)}{PE} \times 100$$

P = Precipitation, PE= Potential Evapo- transpiration

Table 1: Climate classification of Thornthwaite& Mather

I_m Quantity	Climate classification
100 & above	Per humid
20 to 100	Humid
0 to 20	Moist sub humid
-33.3 to 0	Dry sub humid
-66.7 to -33.3	Semi-arid
-100 to -66.7	Arid

Ex: Calculate I_m if P = 20mm & PE = 60mm?

$$I_m = \frac{(P - PE)}{PE} \times 100$$

$$I_m = \frac{(20 - 60)}{60} \times 100$$

$$= -66.66$$

Conclusion: Moisture index is -66.66 mm so it comes under the climatic classification of per semi-arid region.

Examples:

1. Calculate I_m , if $P = 35 \text{ mm}$ & $PE = 120 \text{ mm}$?

2. Calculate I_m , if $P = 20 \text{ mm}$ & $PE = 100 \text{ mm}$?

1.2 Troll (1965)

- ⊙ Based on thermal and hygric variables and number of humid months, climate is classified and said to be of agricultural use.
- ⊙ Humid month is one having mean rainfall exceeding the mean potential evapotranspiration. ICRISAT classified the Semi-arid tropics (SAT areas) in India by adopting this classification.
- ⊙ According to this classification, a climate which has 5 to 10 arid months(a month where precipitation is less than PET) or 2 to 7 humid months is called semi-arid tract (SAT), whereas humid climate will have 7 to 12 humid months and arid climate has less than 2 humid months.

Table 2: Climate classification of Troll

Humid months	Climate classification
12 to 9.5	Tropical rainforest
9.5 7.0	Humid savannah
7.0 4.5	Dry savannah
4.5 2.0	Thorn savannah
2.0 1.0	Semi desert
1.0 0.0	Desert

1.3 Papadakis (1961)

$$H = \frac{(P+W)}{E}$$

Where, P = Monthly precipitation, E = Monthly PET, W = Water stored from previous rainfall

Table 3: Climate classification of Papadakis

H Value	Climate
< 0.25	Arid
0.25 to 0.50	Dry
0.50 to 0.75	Intermediate
0.75 to 1.0	Intermediate humid
1.0 to 2.0	Humid
>2	wet

Moisture Index (H) based on precipitation, soil moisture storage and PET was developed.

Examples: Calculate moisture index (H) If P = 30mm, Evaporation of June = 60mm & water stored in root zone in May month = 5mm.

$$H = \frac{(P+W)}{E}$$

$$H = \frac{(30+5)}{60}$$

$$= 0.58$$

Conclusion: Moisture index is 0.58mm so it comes under the climatic classification of intermediate climate.

Examples:

1. Calculate moisture index (H) If P = 20mm, Evaporation of July = 100mm & water stored in root zone in June = 5mm.

3. Calculate moisture index (H) If P = 40mm, Evaporation of October = 100mm & water stored in root zone in September = 15mm.

1.4 Hargreaves (1971): Moisture Availability Index (MAI) is used for the classification. It is the ratio of dependable precipitation to potential evapotranspiration. It is a measure of adequacy of precipitation in supplying crop water demand.

Table 4: Climate classification of Hargreaves

MAI	Climate Classification
0 to 0.33 during all months	Very arid
>0.34 for 1-2 months	Arid
> 0.34 for 3-4 Consecutive months	Semiarid

Rainfall Pattern:

Rainfall varies both in time and space. Rainfall varies from season to season and year to year. Generally higher the rainfall less is the coefficient of variation. In other words without rainfall crop failures occurs mostly, in the regions of arid and semiarid regions. So rainfall pattern is so important in dryland areas to grow crops according to the season.

1. Amount of rainfall
2. Intensity of rainfall
3. Time of rainfall
4. Duration of rainy season
5. Distribution of rainfall
6. Onset of monsoon
7. Dry spell
8. Wet spells
9. Early withdrawal of monsoon

Amount of rainfall:

It varies from year to year. Generally yield levels are determined by amount of rainfall but, yields are not in direct proportion to amount of rainfall. Crop failure is more common.

Intensity of rainfall:

In most parts of India more than 50% rain is received in 3-5 days. High intensity causes loss of water through runoff. It also causes soil erosion.

Timing:

Rainfall is highly variable in time & space. Starting of rainy season is an important agro climate variable as rainfall is required initially for land preparation and sowing. It is also

possible to estimate distribution of the start of the rains commencing on different dates using historical weather data.

Duration of rainy season:

The length of growing season is limited by the duration of rainy season. It depends upon:

1. Starting of rainy season (Late onset)
2. Distribution of rainfall (Dryspell)
3. Ending of rainy season
4. Nature of soil with regard to water holding capacity

Distribution of rainfall:

There is a large variation in commencement of rainy season from year to year. The monsoon is not continuous. Dry spells interspecific with wet spells sometimes to a period of even one month. There is a large year to year variation in the dates of cessation of S.W monsoon. There is a variation in the quantum of rainfall received.

Onset of monsoon:

Long term data on onset of monsoon indicate that onset over Kerala state varies between 30 may to 2 June. It will extend all over India within 8-9 days. Delay in monsoon results in delay in sowing of crop. It also causes shifting of crops from commercial crops to pulse and other less remunerative crops.

Dry spells:

It is the number of continuous rainless days. It is a common feature of SW monsoon. A dry spell of round 10 days for sandy soils. 15 days for sandy loamy soils. 20 days or clay loams is critical. The no. of dry spells if more definitely affect the yield in dry lands.

Early withdrawal of monsoon:

Post rainy season crops fail due to less available soil moisture in the soil. It ultimately leads to poor grain yield. Cycles of periods of low rainfall alternating with periods of higher rainfall as symbolized.

Exercise:

1. Write in detail about troll's classification?

2. Write the rainfall pattern in India?

3. What is dry spell?

4. Write the limitations for climatic classifications?

1.5 Conclusion:

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Studies on Cropping Pattern of Different Dry Land Areas in the Country and Demarcation of Dry Land Area on Map of India

Cropping Pattern: Yearly sequence and spatial arrangement of crops on a given area. Means the proportion of area under various crops at a point of time in a unit area. This means the type and arrangement of crops in time and space.

2.1 Aim

- ❖ To acquaint with methodology to know about the cropping patterns in the country.
- ❖ To demarcate the dry land area on the maps for identification.

2.2 Materials required

1. Graph
2. Pencil
3. Data

The selection of crops and their varieties is to be made depending on the soil and rainfall situation in the rained areas. The photo insensitive crops and varieties with shorter duration should be chosen to escape drought of different intensities. There are wide variations, location to location in water availability periods in dry land areas. Thus depending upon water availability following are the different crops and cropping patterns to suit different climatic situations.

Table 1: Cropping pattern with varying rainfall and soil moisture storage capacity

Rain Fall (mm)	Storage Capacity Of Soil (mm)	Cropping Pattern
350-625	100	Single crop in <i>kharif</i>
650-750	100	Intercropping can be attempted
780-900	150	Sequential cropping is possible
900 and above	200	Sequential cropping is assured

Crop selection in Dry lands

Crop selection is very important in dry land areas. The selection should be done based on the following parameters.

Climate: Rainfall, temperature, humidity, sunshine are the main components of climate. However, rainfall is the main item considered for determining the effective cropping/growing

season of a dry area. The effective cropping season, often called as Length of growing period (LGP) of dry land area generally depends upon the natural moisture availability in the soil.

Length of Growing period	Cropping system that can be adapted
Less than 75 days	Perennial vegetation / mono cropping with short duration pulses
75 to 140 days	Monocropping
140 to 180 days	Inter cropping
More than 180 days	Double cropping

Table 2: Crops suitable for rained areas are:

Monoculture	Scarcity zone	Pearl millet, red gram, green gram, black gram, Horse gram, groundnut	
		Rabi : Jowar Safflower	
	Assured rainfall	Cotton, sorghum, red gram, black gram, green gram, soybean, sunflower	
Double cropping	Scarcity zone	Kharif crops Mung / Urid Mung / Urid Sunflower Bajra Bajra	Rabi crops Safflower Jowar Gram Gram Safflower
	Assured rainfall zone	Paddy Soybean Mung/Urid Mung/Urid Sunflower	Gram Safflower Jowar Safflower Gram
	Irrigated areas	Jowar Jowar Maize Grunt Grunt	Wheat Gram Wheat Jowar Sunflower

2.3 Grassland or pasture management

Most of the marginal lands are not able to sustain arable crops particularly during the drought years. Such lands can be developed into dependable pastures by following soil and water conservation measures like contour trenches and contour furrows. Controlled grazing may also help in building the forage resource.

In rained areas, different legumes from the genera Dolichos, Leucaena, Clitoria, Cassia and Stylosanthes have been found to do well with or without grasses like Cenchrus ciliaris but Stylosanthes has been found to be excellent in all situations with regard to persistence, nutritive value and palatability.

Different grasses from the genera *Dichanthium*, *Cenchrus*, *Lasiurus*, *Chloris*, *Urochloa*, *Panicum*, and *Pennisetum etc.* have been observed doing well. *Cenchrus ciliaris* has been found to be good in most of the situations.

The pastures are easily established if they are seeded at the beginning of rainy season. Seeds of *Cenchrus ciliaris* @ 1.0 Kg. *Stylo santheshamata* @ 4.0 Kg and *Stylo santhesscabra* @ 1.0 Kg per hectare may be used as seed moistures. The seed moisture may be broadcasted on a drizzling day. After that, light raking of the soil may improve germination chances considerably.

Exercise:

1. What is cropping system?

2. How you select the crops in dryland areas?

Demarcate the dry land areas in India map:



2.4 Conclusion

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Interpretation of meteorological data and scheduling of supplemental irrigation on the basis of evapo-transpiration demand of crops

The crop water need (ET crop) is defined as the depth (or amount) of water needed to meet the water loss through evapotranspiration. In other words, it is the amount of water needed by the various crops to grow optimally. The crop water need always refers to a crop grown under optimal conditions, i.e. a uniform crop, actively growing, completely shading the ground, free of diseases, and favorable soil conditions (including fertility and water). The crop thus reaches its full production potential under the given environment.

The crop water need mainly depends on:

Climate: in a sunny and hot climate crops need more water per day than in a cloudy and cool climate.

Crop type: crops like maize or sugarcane need more water than crops like millet or sorghum

Growth stage of the crop: fully grown crops need more water than crops that have just been planted.

To obtain the highest gain from gradually decreasing irrigation water resources and narrowing agricultural areas, one must obtain the highest yield with per unit water from a unit of area. Therefore, it is important to set up irrigation scheduling for optimum crop yield. Irrigation scheduling is one of the most effective tools to preserve water and it makes possible an increase in crop yield, water economy by better adjustment to the crop requirements during the growth season and energy savings by avoiding excessive water application. Crop evapotranspiration is an important component used in the planning, design, construction, operation and maintenance of irrigation systems. Because crop evapotranspiration largely depends on soil and climatic conditions, it must be determined for each crop in different regions.

This is due to identical effects of air temperature and solar radiation on both crop evapotranspiration and pan evaporation. In other words, climatic factors affecting evaporation also affect crop evapotranspiration and evaporation pans provide a measurement of the combined effect of temperature, humidity, wind speed and sunshine on the crop water consumption. Studies have shown that evaporation pans can be used in the irrigation programs and correlation between pan evaporation and crop evapotranspiration is higher than other empirical relationships. To schedule irrigations using the water budget method, the irrigation system manager must be able to measure or estimate the rate at which water is being

used by a crop. Evaporation pans can be used to indicate the rate of crop water use. An evaporation pan is an open pan of water that is subject to the same climatic conditions with a growing crop and from which water is evaporated as a result of the climatic conditions.

3.1 INFLUENCE OF CLIMATE ON CROP WATER NEEDS (ET_o)

Introduction

The major climatic factors which influence the crop water needs are:

- ❖ Sunshine
- ❖ Temperature
- ❖ Humidity
- ❖ Wind speed

Table 3.1: Effect of Major Climatic Factors on Crop Water Needs

Climatic Factor	Crop water need	
	High	Low
Temperature	Hot	cool
Humidity	low (dry)	high (humid)
Windspeed	Windy	little wind
Sunshine	sunny (no clouds)	cloudy (no sun)

The highest crop water needs are thus found in areas which are hot, dry, windy and sunny. The lowest values are found when it is cool, humid and cloudy with little or no wind.

The influence of the climate on crop water needs is given by the **reference crop evapotranspiration** (ET_o). The ET_o is usually expressed in millimetres per unit of time, e.g. mm/day, mm/month, or mm/season. Grass has been taken as the reference crop.

Definition: ET_o is the rate of evapotranspiration from a large area, covered by green grass, 8 to 15 cm tall, which grows actively, completely shades the ground and which is not short of water.

There are several methods to determine the ET_o. They are either:

1. Experimental, using an evaporation pan, or
2. Theoretical, using measured climatic data, e.g. the Blaney-Criddle method.

3.2 Methods to determine reference crop evapotranspiration:

3.2.1 Pan Evaporation Method: Evaporation pans provide a measurement of the combined effect of temperature, humidity, windspeed and sunshine on the reference crop evapotranspiration ET_o.

Many different types of evaporation pans are being used. The best known pans are the Class A evaporation pan (circular pan) (Fig. 8a) and the Sunken Colorado pan (square pan) (Fig. 8b).

The principle of the evaporation pan is the following:

1. The pan is installed in the field
2. The pan is filled with a known quantity of water (the surface area of the pan is known and the water depth is measured)
3. The water is allowed to evaporate during a certain period of time (usually 24 hours). For example, each morning at 7 o'clock a measurement is taken. The rainfall, if any, is measured simultaneously
4. After 24 hours, the remaining quantity of water (i.e. water depth) is measured
5. The amount of evaporation per time unit (the difference between the two measured water depths) is calculated; this is the pan evaporation: E_{pan} (in mm/24 hours)
6. The E_{pan} is multiplied by a pan coefficient, K_{pan} , to obtain the ET_o .

Formula:

$$ET_o = K_{\text{pan}} \times E_{\text{pan}}$$

ET_o : reference crop evapotranspiration

K_{pan} : pan coefficient

E_{pan} : pan evaporation

Determination of K_{pan}

When using the evaporation pan to estimate the ET_o , in fact, a comparison is made between the evaporation from the water surface in the pan and the evapotranspiration of the standard grass. Of course the water in the pan and the grass do not react in exactly the same way to the climate. Therefore a special coefficient is used (K_{pan}) to relate one to the other.

The pan coefficient, K_{pan} , depends on: The type of pan used, pan environment: if the pan is placed in a fallow or cropped area and the climate: the humidity and wind speed.

For the Class A evaporation pan, the K_{pan} varies between 0.35 and 0.85. Average $K_{\text{pan}} = 0.70$.

For the Sunken Colorado pan, the K_{pan} varies between 0.45 and 1.10. Average $K_{\text{pan}} = 0.80$.

Excercise:

1) Type of pan: Class A evaporation pan

Water depth in pan on day 1 = 150 mm

Water depth in pan on day 2 = 144 mm

Rainfall (during 24 hours) = 0 mm

$K_{\text{pan}} = 0.75$, Now calculate ET_o with the given data?

2) Type of pan: Sunken Colorado pan

Water depth in pan on day 1 = 411 mm

Water depth in pan on day 2 = 409 mm (after 24 hours)

Rainfall (during 24 hours) = 7 mm

K pan = 0.90, calculate E pan and ET_0 with the given data?

3) Type of pan: Sunken Colorado pan

Water depth in pan on day 1 = 380 mm

Water depth in pan on day 2 = 205 mm (after 24 hours)

Rainfall (during 24 hours) = 3 mm

K pan = 0.52, calculate E pan and ET_0 with the given data?

3. Draw the image of open pan evaporimeter?

3.3 Conclusion

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Critical analysis of rainfall and possible drought period in the country, effective rainfall and its calculation

There are several methods of assessing effective rainfall. Each method has certain merits and limitations. Some of the methods like

1. Soil Moisture Changes
2. Ramdas Method
3. Lysimeters
4. Empirical methods

Important methods are discussed below for the easy understanding and easy remembrance.

4.1 Soil Moisture Changes

Water in the root zone may be measured by sampling and oven-drying the soil before and after every shower of rain. The increase in soil moisture, plus evapotranspiration loss (ET_a) from the time the rain starts until the soil is sampled, is the amount of effective rainfall. After heavy rainfall evapotranspiration can be assumed to be at the potential rate during the short period from cessation of rainfall until the sampling time. This can be taken as 0.4 to 0.8 times the evaporation value of the Class A Pan as is given in FAO Irrigation and Drainage paper No. 24 (1974), or

$$ER = M_2 - M_1 + kpE_o$$

ER = effective rainfall

E_o = U.S. Class A Open Pan evaporation value or M₁ and

M₂ = moisture status in the effective root zone before and after rain, respectively

kp = pan coefficient

The method takes into account the soil and the crop characteristics. The determination is simple and accurate but it may involve errors due to soil variation; the sampling errors may range from 5 to 40 percent. The method is also laborious and time consuming. The use of neutron probes reduces the drudgery of periodic soil sampling, but these are costly methods for routine purposes and also subject to sampling errors.

4.2 Ramdas Method

Ramdas (1960) suggested a direct field method using a small portable device containing soil of the field, so eliminating the necessity of sampling.

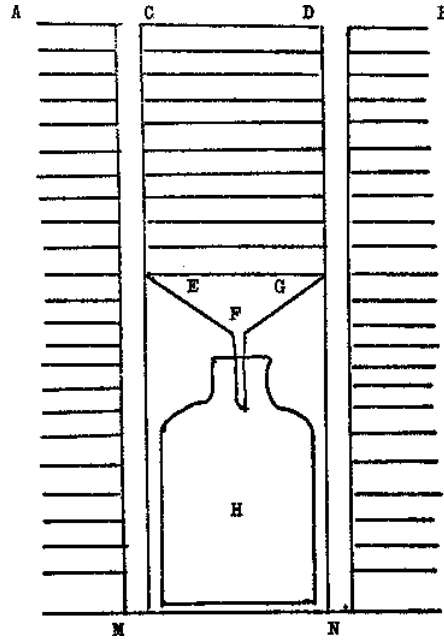


Fig 1: Ramdas Apparatus for Measuring Effective Rainfall

The apparatus as shown, consists of a cylinder (CD) of about 30 cm in diameter, with a perforated base (BO) and a funnel (F) leading into a receiver bottle (H). All these parts are enclosed in an outer cylinder (MN). The cylinder (CD) is filled with a representative soil with the same density as that of the field. The height is equal to the depth of the effective root zone of the crop.

The apparatus is installed in the field crop where the effective rainfall is to be measured. The crop in the container is irrigated along with the field crop. Excess rain or irrigation water drains in the receiver bottle H and is measured from time to time. The total rainfall minus the ineffective rainfall gives the value of effective rainfall. It is assumed that there is no surface run-off. Cylinders of different lengths are used consistent with the rooting depth of the different crops. With a suitable number of replications, the method is very useful. It is simple and practical and furnishes direct readings.

4.3 Lysimeters

Lysimeter is a method which provides complete information on all the components of water balance. Lysimeters can be used not only for measuring evapotranspiration but also for checking empirical formulae for computing ET. The method is similar to the Ramdas method, but is more elaborate, refined and gives a higher accuracy.

A lysimeter is a large container with soil in which crops are grown; water losses and gains can be measured. The container is fitted with suitable inlets for irrigation and outlets for drainage. The lysimeters are buried in the field and are surrounded by the same crop as is grown inside. The size of lysimeter varies from small oil drums. They can be either the non-weighing or weighing type.

Limitations

1. Lysimeters are the restricted root growth, the disturbed soil structure in the lysimeter causing changes in water movement and possibly the tank temperature regime, resulting in condensation of water on the walls of the container.
2. Other limitations include the 'bouquet effect' whereby the canopy of the plants grown in the lysimeter is above and extends over the surrounding crop, resulting in a higher evapotranspiration rate.
3. In spite of these limitations, it is the best technique for precise studies on evapotranspiration.

4.4 Empirical Methods

In cases where all the water needed for optimal growth of the crop is provided by rainfall, irrigation is not required and the Irrigation water need (IN) equals zero: $IN = 0$.

In cases where there is no rainfall at all during the growing season, all water has to be supplied by irrigation. Consequently, the irrigation water need (IN) equals the crop water need (ET crop): $IN = ET \text{ crop}$.

In most cases, however, part of the crop water need is supplied by rainfall and the remaining part by irrigation. In such cases the irrigation water need (IN) is the difference between the crop water need (ET crop) and that part of the rainfall which is effectively used by the plants (P_e). In formula: $IN = ET \text{ crop} - P_e$.

In summary

- If sufficient rainfall : $IN = 0$
If no rainfall at all : $IN = ET \text{ crop}$
If partly irrigation, partly rainfall : $IN = ET \text{ crop} - P_e$

Determination of the Effective Rainfall

The amount, the intensity and the distribution of rainfall is important.

1. When rain water falls on the soil surface, some of it infiltrates into the soil, some stagnates on the surface, while some flows over the surface as runoff.
2. When the rainfall stops, some of the water stagnating on the surface evaporates to the atmosphere, while the rest slowly infiltrates into the soil.
3. From all the water that infiltrates into the soil, some percolates below the root zone, while the rest remains stored in the root zone.

In other words, the effective rainfall is the total rainfall minus runoff minus evaporation and minus deep percolation.

$$EF = \text{Total rainfall} - \text{Runoff} - \text{Evaporation} - \text{Deep percolation}$$

Only the water retained in the root zone can be used by the plants, and represents what is called the effective part of the rainwater.

The term effective rainfall is used to define this fraction of the total amount of rainwater useful for meeting the water need of the crops.

Only 2 simple formulae are provided to estimate the fraction of the total rainfall which is used effectively. These formulae can be applied in areas with a maximum slope of 4-5% :

$$Pe = 0.8 P \text{ if } P > 75 \text{ mm/month}$$

$$Pe = 0.6 P \text{ if } P < 75 \text{ mm/month}$$

with P = rainfall or precipitation (mm/month)

Pe = effective rainfall or effective precipitation (mm/month)

NOTE: Pe is always equal to or larger than zero; never negative

Exercice

1. Calculate the effective rainfall for the following monthly rainfall figures: P = 35, 90, 116, 5, 260, 75 mm

2. Calculate the effective rainfall for the following months both in mm/month and in mm/day.

Month	Feb	Mar	Apr	May	June
ET crop (mm/month)	69	123	180	234	180
P (mm/month)	20	38	40	80	16

3. Calculate the irrigation water need, both in mm/month and mm/day, using the formula: $IN = ET_{crop} - P_e$
Ex: Feb: $IN = 60 - 5 = 50$ mm

	February	March	April	May	June
ET_o	60	100	160	220	160
P_e	5	10	10	30	0

4. Calculate the irrigation water need, both in mm/month and mm/day, using the formula: $IN = ET_{crop} - P_e$
Ex: Feb: $IN = 60 - 5 = 50$ mm

	February	March	April	May	June
ET_o	40	80	160	200	140
P_e	5	10	10	30	0

4.5 Conclusion

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Studies on Cultural Practices viz; Mulching, Plant Density, Thinning and Leaf Removal for Mitigating Moisture Stress

Improving soil moisture conservation is an ongoing goal in agricultural production, especially in India, where water resources are limited and regulated. One reason that there is a push to use less water in agriculture is because of increasing demand generated by the increasing population in India. The water demands of urban populations are essentially fixed and increase, so water availability for agricultural producers is constantly reduced. To address both of these issues, farmers are searching for new ways to improve soil moisture in drylands.

5.1 Aim

To know about different methods for reducing moisture stress.

5.2 Materials Required

1. Note book
2. Pen/ pencil
3. Any mulching materials like: straw, pebbles, husk etc.

5.3 Different methods for mitigating stress are

1. Mulching
2. Thinning
3. Depth of sowing
4. Leaf removal
5. Plant density

5.3.1 Mulching

It is one cultural practice which can be used to address this problem. Covering the ground with mulch saves water by preventing surface evaporation. The layer can also greatly reduce or eliminate weed propagation, which will also result in higher water use efficiency. Using certain agricultural byproducts as mulch is a sustainable practice which can reduce water use and provide other benefits as well. Wheat straw, grass clippings, and leaf debris are fairly abundant byproducts.

Mulching, the word mulch has probably been derived from the German word “molsch” meaning soft to decay, which apparently referred to the gardener’s use of straw and leaves as a spread over the ground as mulch. It consists of covering the soil surface with organic material and inorganic materials, is an age old practice and was used to control soil moisture, soil temperature, nutrient loss, salinity, erosion soil structure etc. However, with modern agriculture, this practice dwindled largely, but is now gaining importance once again in the context of sustainable agriculture. Various types of mulches have been demonstrated to reduce soil erosion by more than 90% compared to bare agricultural soil.

5.3.2 Plant Density

Plant density is very much important for getting good yields if irrigation is available properly. In drylands the irrigation is the most limiting factor so that yields are decreasing drastically in those areas. To get yields plant population should be lesser in dryland conditions than under irrigated conditions. The rectangular type of planting pattern should always be followed under dryland conditions. Under dryland conditions whenever moisture stress occurs due to prolonged dry spells, under limited moisture supply the adjustment of plant population can be done by

- Increasing the inter row distance: By adjusting more number of plants within the row and increasing the distance between the rows reduces the competition during any part of the growing period of the crop. Hence it is more suitable for limited moisture supply conditions.
- Increasing the intra row distance: Here the distance between plants is increased by which plants grow luxuriantly from the beginning. There will be competition for moisture during the reproductive period of the crop. Hence it is less advantageous as compared to above under limited moisture supply.

5.3.3 Thinning

Thinning is done to maintain optimum plant population so that the competition (for different sources like light, moisture, nutrients, CO₂) will be less in between the plants. This can be done by removing every alternate row or every third row which will save the crop from failure by reducing the competition if the crop is closely planted.

5.3.4 Leaf Removal

Normally the plants growing in irrigated conditions will grow vigourously because of the presence of sufficient amount of water and nutrients in the soil. So in these plants transpiration rate will be less compared to moisture stress conditions. Whereas, the plants growing in dryland areas shows wilting symptoms because of lack of moisture in the soil. So to reduce the wilting symptoms we can remove the leaves (No. of leaves will be reduced. Mostly the older 2 to 3 leaves will be removed) of the plant so that, the transpiration rate will be reduced and conserves the water. The removed leaves can be used as a mulching.

5.3.5 Depth of sowing

It also helps in mitigating moisture stress to plants. If plants are shallow planted due to lack of moisture the seed germination may be stopped. If seeds are sown very deep into the soil, seed maynot be germinated and shows dormancy. So optimum seed depth should be maintained around 3-4 cm depth based on diameter of the crop.

Exercise

- 1. Write the different mulching materials used to conserve moisture?**
- 2. Thinning should be done at how many days after sowing for crops?**
- 3. Reason for removal of older leaves?**
- 4. Increase of intra row/ inter row spacing increases plant survival, Justify the question?**

5.4 Conclusion

Signature of Faculty In-charge

Characterization and Delineation of Model Watershed

Imagine a watershed as an enormous bowl. As waterfalls onto the bowl’s rim, it either flows down the inside of the bowl or down the outside of the bowl. The rim of the bowl or the watershed boundary is sometimes referred to as the ridgeline or watershed divide. This ridge line separates one watershed from another.

Topographic maps created can help you to determine a watershed’s boundaries. Topographic maps have a scale of 1:24,000 (which means that one inch measured on the map represents 24,000 inches [2000’] on the ground). They also have contour lines that are usually shown in increments of ten or twenty feet. Contour lines represent lines of equal elevation, which typically is expressed in terms of feet above mean sea level. As you imagine water flowing downhill, imagine it crossing the contour lines perpendicularly.

6.1 Steps to Determine

Watershed:STEP 1

Use a topographic map(s) to locate the river, lake, stream, wetland, or other water bodies of interest. (See the example, West Branch of Big River, in Figure -1.)

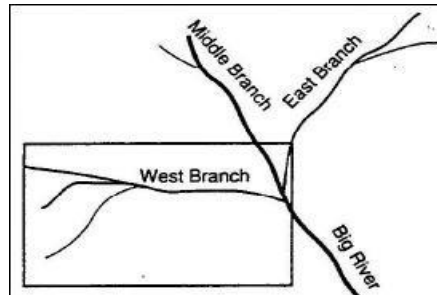


Fig 1: Map indicating rivers border

STEP 2

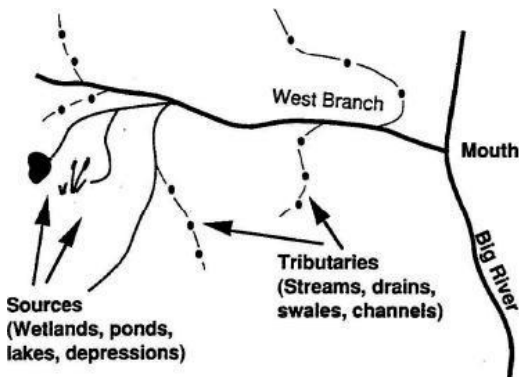


Fig 2: Map indicating rivers boundaries

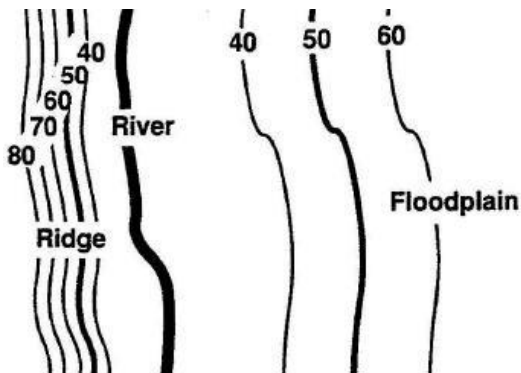
Trace the watercourse from its source to its mouth, including the tributaries (Figure-2). This step determines the general beginning and ending boundaries.

STEP 3

Examine the brown lines on the topographic map that are near the watercourse. These are referred to as contour lines. Contour lines connect all points of equal elevation above or below a known reference elevation. The dark contour lines (thick lines) will have a number associated with them, indicating the elevation.

The light contour lines (thin lines) are usually mapped at 10 (or 20) foot intervals, and the dark brown (thick) lines are usually mapped at 50 (or 100) foot intervals. Be sure to check the map's legend for information on these intervals. To determine the final elevation of your location, simply add or subtract the appropriate contour interval for every light brown (thin) line, or the appropriate interval for every dark (thick) line.

STEP 4



Contour lines spaced far apart indicate that the landscape is more level and gently sloping (i.e., they are flat areas). Contour lines spaced very close together indicate dramatic changes (rise or fall) in elevation over a short distance (i.e., they are steep areas)

Fig 3: Map indicating Contour lines

STEP 5: Check the slope of the landscape by locating two adjacent contour lines and determine their respective elevations. The slope is calculated as the change in elevation, along a straight line, divided by the distance between the endpoints of that line. A depressed area (valley, ravine, swale) is represented by a series of contour lines “pointing” towards the highest elevation (Figure - 4). A higher area (ridge, hill) is represented by a series of contour lines “pointing” towards the lowest elevation.

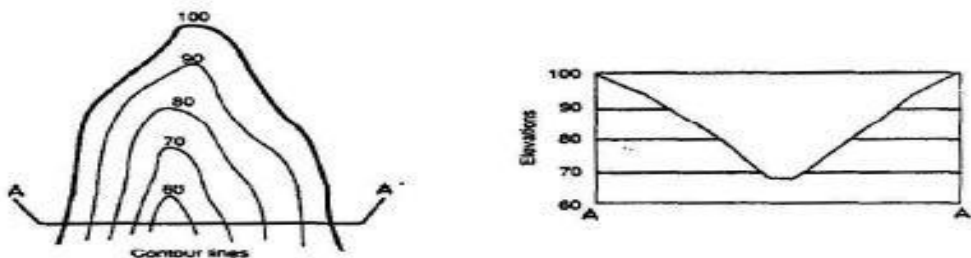


Fig 4: Map pointing out Contour lines towards higher

STEP 6

Determine the direction of drainage in the area of the waterbody by drawing arrows perpendicular to a series of contour lines that decrease in elevation. Stormwater runoff seeks the path of least resistance as it travels downslope. The “path” is the shortest distance between contours, hence a perpendicular route (Figure - 5). Mark the break points surrounding the waterbody. The “break points” are the highest elevations where half of the runoff would drain towards one body of water, and the other half would drain towards another body of

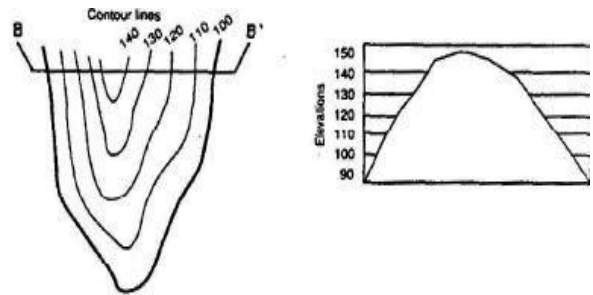


Fig 5: Image indicating the breakpoints

STEP 7

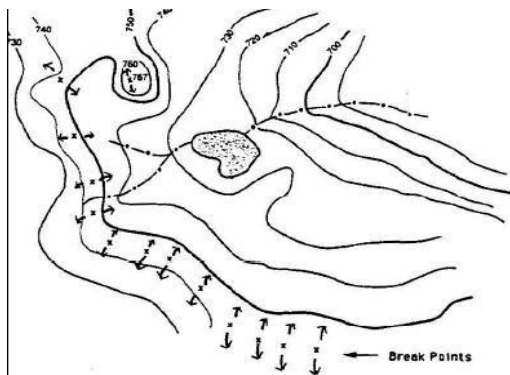


Fig 6: Connecting points with a lines

IDENTIFY BREAK POINTS: Connect the break points with a line following the highest elevations in the area. The completed line represents the boundary of the watershed (Figures - 6).

STEP 8

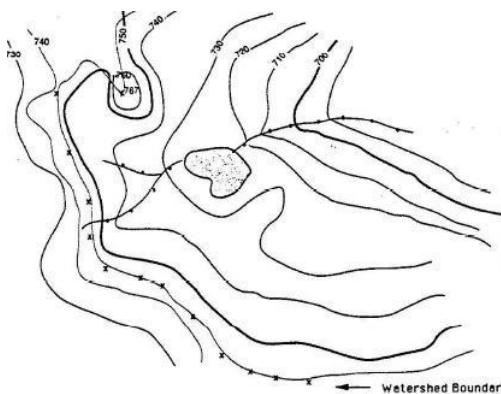


Fig 7: Imaginary boundary of watershed

Once you’ve outlined the watershed boundaries on your map, imagine a drop of rain falling on the surface of the map. Imagine the water flowing down the slopes as it crosses contour lines at right angles. Follow its path to the nearest stream that flows to the water body you are studying. Imagine this water drop starting at different points on the watershed boundaries to verify that the boundaries are correct.

STEP 9

Watersheds sometimes have what are termed subwatersheds within them. Rivers, large streams, lake, and wetland watershed often have more than one subwatershed (usually smaller tributary watersheds) within them. Generally, the larger the waterbody you are examining, the more subwatersheds you will find. Your watershed map can be further divided into smaller sections or subwatersheds if it helps organize your study better.

STEP 10

Once the watershed and subwatershed (optional) boundaries have been delineated on the map, we can verify them in the field, if necessary

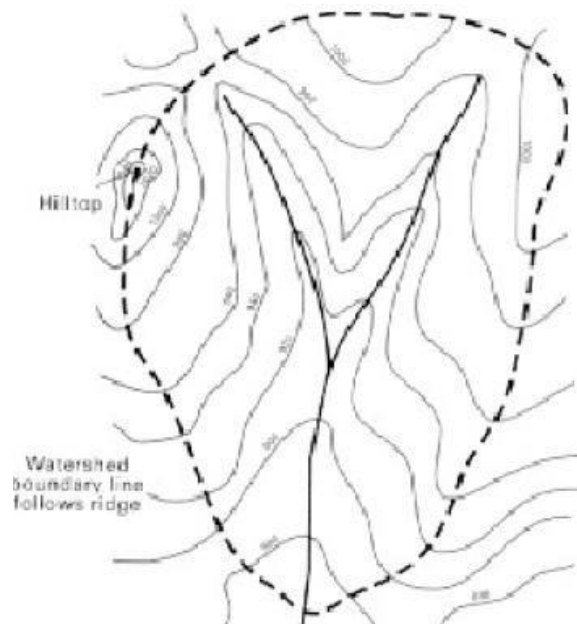


Fig 8: Complete Watershed Image

6.2 Watershed Characterization

It is a set of water and habitat assessments that compare areas within a watershed for restoration and protection value.

It is a coarse-scale tool that supports decisions regarding:

1. Where on the landscape should efforts be focused first?
2. What types of actions are most appropriate to that place?

It provides an initial filter for regional and local governments in landscape-level planning.

Results can identify areas of the landscape that are:

1. Priorities for acquisition (or protection via conservation easements)
2. More appropriate for restoration (mitigation/conservation banks)
3. Less likely to be damaged from development impacts.

This helps direct limited funds to areas with greater probability of successful protection and restoration of aquatic and terrestrial resources, while providing a predictable land use framework. Such a framework guides continuous land and water quality improvement leading to sustainable development within watersheds.

6.3 Purposes of Watershed Characterization in Land Use Planning

1. To sustain and restore aquatic resources.
2. To establish a common approach to coordinate planning efforts.
3. To involve the community in developing a green infrastructure plan.
4. To promote the integration of the Growth Management Act (GMA) and Shoreline Management Act (SMA).

Exercise

- 1. Imagine a watershed of different dimensions and create the watershed?**

2. What is watershed characterization?

3. Write the purposes of watershed characterization?

6.4 Conclusion

Signature of Faculty In-charge

Field Demonstration on Soil & Moisture Conservation Measures

7.1 Aim

To study the different soil and water conservation techniques
 To know how crops are grown even in difficult situations

7.2 Materials required

1. Hand hoe
2. Spades
3. Measuring tape
4. Observation book
5. Pen/pencil

Fertile soil and good quality water have become precious natural resources, their efficient and economical use is the first and foremost action to conserve them. The practical methods for soil and water conservation can be broadly divided into two classes.

Table 1: Different Soil and Water Conservation Measures

Agronomical Measures (Biological)	Engineering Practices
<p>1. Contour cultivation</p>	<p>1. Terracing</p> <p>a. Diversion terrace:</p> <ol style="list-style-type: none"> i. Magnum type. ii. Nicholas type. iii. Broad based type iv. Narrow based type <p>b. Retention Terrace</p> <p>c. Bench terrace</p>
<p>2. Strip Cropping</p> <ol style="list-style-type: none"> 1. Contour strip cropping 2. Field strip cropping 3. Buffer strip cropping 4. Wind strip cropping 	<p>2. Bunding</p> <ol style="list-style-type: none"> a. Contour bunding <ol style="list-style-type: none"> 1. Narrow based 2. Broad based b. Side bunds c. Lateral bund d. Supplemental bunds e. Marginal bund f. Shoulder bund

3. Tillage practices a. Mulch Tillage b. Vertical mulching c. Minimum tillage d. Conventional tillage e. Listening	
4. Soil management practices	
5. Supporting Practices (Interplanting, fertilizer application)	
6. Vetiver grass planting	

By following different practices we can reduce soil erosion, increase moisture holding capacity of soil and can minimize problems like water logging, soil salinization etc.

Exercise

1. Write about bench terracing?

2. Write the mulching and its types?

3. What is contour bunding?

4. What is contour strip cropping?

5. What slope should be there in soil to follow mechanical measures?

Draw the images for different moisture conservation measures:

Contour planting

Strip cropping

Vertical mulching

Contour bunding

Terracing

7.3 Conclusion

Signature of Faculty In-charge

Field Demonstration on Construction of Water Harvesting Structures

8.1 Aim

To study about the water storage structures

To get acquainted with different methods of water storage in different areas

8.2 Materials required

1. Spades
2. Hand hoes
3. Crowbar
4. Observation book
5. Pencil

The process of collection of runoff water during the peak periods of rainfall into storage tanks, ponds etc., is known as **water harvesting**. Water harvesting is done both in arid and semi-arid regions with certain differences. In arid regions, the collecting area or catchment area is substantially in higher proportion compared to command area.

8.3 Following are the several water harvesting structures

1. Wells
2. Percolation tanks
3. Farm ponds
4. Check dams/cement plug
5. Tanka/ Kundi
6. Underground bandharas/ Ground water dams

8.3.1 Wells: Hand dug wells have been used to collect and store underground water and this water is lifted for irrigation. The quality of water is generally poor due to dissolved salts.

8.3.2 Tanks: Runoff water from hill sides and forests is collected on the plains in tanks. The traditional tank system has following components viz., catchment area, storage tank, tank bund, sluice, spill way and command area. The runoff water from catchment area is collected and stored in storage tank on the plains with the help of a bund.

8.3.3 Percolation Tanks: Flowing rivulets or big gullies are obstructed and water is ponded. Water from the ponds percolates into the soil and raises the water table of the region. The improved water level in the wells lower down the percolation tanks are used for supplemental irrigation.

8.3.4 Farm Ponds: These are small storage structures for collection and storage of runoff water.

8.3.5 Tanka/ Kundi: Tanka is generally circular in shape and is constructed in stone masonry in 1:3 cement-sand mortar. While small Tankas of 3 to 4.22 m diameter and about 21-59 cum capacity are built by individual households, larger ones of 6 m diameter and 200 cum capacity are built for the village communities.

8.3.6 Check dams: These are constructed across small streams having gentle slope and are feasible both in hard rock as well as alluvial formations. The site selected for check dam should have sufficient thickness of permeable bed or weathered formation to facilitate recharge of stored water within short span of time. The water stored in these structures is mostly confined to stream course and the height is normally less than 2 m. These are designed based on stream width and excess water is allowed to flow over the wall. In order to avoid scouring from excess run off, water cushions are provided at downstream side.

Exercise

1. What is water harvesting?

2. Write the different lining materials used in constructing of checkdams?

3. Draw the water harvesting structures?

8.4 Conclusion

Signature of Faculty In-charge

Visit to rainfed research station/watershed

9.1 Aim

To know about the watershed.

9.2 Materials required

1. Observation book
2. Pen/ Pencil

A Watershed also called a drainage basin or catchment area, is defined as an area in which all water flowing into it and goes to a common point. People and livestock are integral part of watershed and their activities affect the productivity status of watershed and vice-versa.

Watershed is not simply the Hydrological Unit but also social, political, ecological entity which plays crucial role in determining food, social and economical security and also provides life-support services to rural people.

Place visited-

Catchment area of watershed-

Storage capacity-

Command area-

Lining materials used-

Description of watershed-

Uses-

9.3 Conclusion

Signature of Faculty In-charge