Rainfed Agriculture and Watershed Management

Practical Manual

Credit hour- 2(1+1)

Course code- CC-AGP 244

B. Sc. (Hons.) Agriculture

Prepared By

Dr. Tanuj Kumar Mandal

Assistant Professor

Department of Agronomy

School of Agriculture and Allied Sciences

The Neotia University

Jhinga, Sarisha, Diamond Harbour Road, South 24 Parganas,

West Bengal- 743368, INDIA

Content

Practical-1

Topic- Studies on climate classification

Aim- To study climate classification

Objective-

i. Know about the systematic way of defining climate of a region

ii. Know about the types of climatic classification

Introduction: Climate classifications, the formalization of systems that recognize, clarify, and simplify climatic similarities and differences between geographic areas in order to enhance the scientific understanding of climates. Such classification schemes rely on efforts that sort and group vast amounts of environmental data to uncover patterns between interacting climatic processes.

The earliest known climatic classifications were those of Classical Greek times. Such schemes generally divided Earth into latitudinal zones based on the latitudes, i.e. the Equator, the Tropics of Cancer and Capricorn, and the Arctic and Antarctic circles, respectively and on the length of day. Modern climate classification has its origins in the mid-19th century, with the first published maps of temperature and precipitation over Earth's surface, which permitted the development of methods of climate grouping that, used both variables simultaneously.

Materials required: Pencil, pen, India map etc.

Climate classification

Koppen's classification:

The most popular empirical classification is given by Wladimir Koppen, in 1900 and several revised versions thereafter. Koeppen's scheme used certain critical values of temperatures of the warmest and the coldest months and of rainfall of the wettest and the driest months. His climatic divisions generally coincide with vegetational divisions. Koppen (1936) divided the world climate into the following 5 principal groups.

Climatic regions of India as per Koeppen's scheme

Based on Koeppen's method, India has eight climatic regions as described in figure 1. Those are

1. Monsoon type with short dry season (Amw)

2. Monsoon type with dry season in summers (As)

3. Tropical savannah type (Aw)

4. Semiarid steppe climate (Bshw)

5. Hot desert type (Bwhw)

6. Monsoon type with dry winters (Cwg)

7. Cold humid winter type with short summers (Dfc)

8. Polar type (E)

Thornthwaite's rational classification

The main limitation of Koppen's classification is the lack of rational basis for selecting temperature and precipitation values for different climatic zones. Thornthwaite's (1948) improved the same by introducing water balance concept in his classification scheme. He compared the potential evapotranspiration, PET (defined as the amount of water that could evaporate and transpire from a vegetated landscape without restrictions other than the atmospheric demand) with precipitation and computed 'moisture index' which considers the water surplus (s) and water deficit (d) which occur in different seasons in most places. Water surplus means seasonal addition to sub soil moisture that is being used by the crop at a reduced rate of transpiration during deficit period.

Thus, the climate of a place is defined on the basis of (i) Potential evapotranspiration i.e. the combines loss of moisture from vegetation surface as evaporation and transpiration and (ii) Seasonal variation of effective moisture and (iii) Average annual thermal efficiency.

Table 1. Climate types and moisture index in Thornthwaite's classification

Symbol	Climate type	Moisture Index	Broad group
A	Pre humid	100 and above	Moist climate
B4	Humid	80 to 100	
B3	Humid	60 to 80	
B2	Humid	40 to 60	
B1	Humid	20 to 40	
C2	Moist sub-humid	0 to 20	
C1	Dry sub-humid	-20 to 0	Dry climate
D	Semi arid	-40 to -20	
E	Arid	-60 to -40	

Climatic regions of India as per Thornthwaite's scheme

On the basis of Thornthwaite's method, the climate of India falls under six different groups. Those are,

1- Perhumid (A),

2- Humid (B4 to B1),

3- Moist sub-humid (C2),

4- Dry sub-humid (C1),

5- Semiarid (D) and

6- Arid (E)

Exercise 1: Demarcate climatic divisions of India as per Koppen's classification on map

Exercise 2: Demarcate climatic divisions of India as per *Thornthwaite's* classification on map

Conclusion:

Video link: https://youtu.be/xhbUflzb9yU

Practical -2

Topic- Studies on rainfall pattern in rainfed areas of the country and pattern of onset and withdrawal of monsoons

Aim- To study the rainfall pattern, onset and withdrawal of monsoons in India.

Objective- To know the occurrence and distribution of rainfall in India.

Materials required: Pencil, pen, map of India etc.

Introduction- Rainfed areas currently constitute 55 per cent of the net sown area of the country and are home to two-thirds of livestock and 40 per cent of human population. Even after realizing the full irrigation potential, about 50 per cent of the cultivated area will remain rainfed.

Based on the percent rainfed area, districts were categorized into 3 classes i.e. <35% rainfed area, 35-70% rainfed area and > 70% rainfed area. Except for few districts in coastal areas of AP, Tamil Nadu and IGP, rest of the districts are having more than 35% area as rainfed. Most of the districts of Central India, parts of AP and Karnataka, are having more than 70% area under rainfed condition and also come under dry & moist semi-arid climate. Parts of Orissa, Chattisgarh, West Bengal having more than 70% rainfed areas come under moist sub-humid climate.

Monsoon

India's climate is dominated by monsoons. Monsoons are strong, often violent winds that change direction with the season. Monsoon winds blow from cold to warm regions because cold air takes up more space than warm air. Monsoons blue from land towards sea in winter and from sea to land in summer.

South West Monsoon

Southwest monsoon occur from June to September. Thar desert and adjoining areas of northern and central Indian subcontinent heats up considerably during hot summer. This causes a low pressure area over northern and central Indian subcontinent. To fill this void, moisture laden winds from Indian Ocean rush into the subcontinent. These winds, rich in moisture, are drawn towards Himalayas, creating winds blowing Storm clouds towards the subcontinent. Himalayas act like a high wall, blocking the winds from passing into Central Asia, thus forcing them to rise. With the gain in altitude of the clouds, temperature drops and precipitation occurs. Some areas of the subcontinent receive up to 10,000 mm of rain.

Southwest monsoon is, generally, expected to begin around start of June and fade down by the end of September or mid October. Moisture laden winds on reaching southernmost point of Indian peninsula, due to its topography, become divided into two parts: the Arabian Sea branch and the Bay of Bengal branch.

Arabian Sea branch of Southwest monsoon first hits the Western Ghats of coastal state of Kerala, thus making it as the first state in India to receive rain from southwest monsoon. This branch of monsoon moves northwards along Western Ghats with precipitation on coastal areas, west of Western Ghats. Eastern areas of Western Ghats do not receive much rain from this monsoon as the wind does not cross Western Ghats.

But the Bay of Bengal branch of Southwest monsoon flows over Bay of Bengal heading towards north east India and Bengal, picking up more moisture from Bay of Bengal. Winds arrive at Eastern Himalayas with large amounts of rain. Mawsynram, situated on southern slopes of Eastern Himalayas in Shillong, is one of the wettest places in the earth. After arrival at Eastern Himalayas, the wind turns towards west, travelling over Indo-Gangetic plain at a rate of roughly 1-2 week's part state, pouring rain all along its way. 1st June is recorded as the date of onset of monsoon in India, as indicated by the arrival of monsoon in southernmost state of Kerala.

Monsoon accounts for 80% of rainfall in India. Indian agriculture is heavily dependent on rains, for growing crops especially like cotton, rice, oil seeds and coarse grains. A delay by a few days in the arrival of monsoon can battery affect the economy, as evidenced in the numerous droughts in India in 1990s.

Exercise 1: Demarcate the direction of south west monsoon on map

Northeast monsoon

Around September, with the sun fast retreating south, northern land mass of Indian subcontinent begins to cool off rapidly. With this air pressure begins to build over Northern India, Indian Ocean and its surrounding atmosphere still holds its heat. This causes the cold wind to sweep down from Himalayas and Indo-Gangetic plain towards vast spans of Indian Ocean south of Deccan Peninsula. This is known as northeast monsoon or retreating monsoon.

While travelling towards Indian Ocean, the dry cold wind picks up some moisture from Bay of Bengal and pours it over Peninsular India and parts of Sri Lanka. Cities like Chennai, which get less rain from southwest monsoon, receive rain from this monsoon. About 50 to 60% of the rain received by the state of Tamil Nadu is from northeast monsoon. In southern Asia, northeastern monsoon take place from December to early March when the surface high pressure system is strongest.

Exercise 2: Demarcate the direction of north east monsoon on map

Conclusion:

Video link: https://youtu.be/Fo8nlearLZQ

Practical -3

Topic- Studies on cropping pattern of different rainfed areas in the country and demarcation of rainfed area on map of India

Aim: To study the cropping pattern of different rainfed areas in India.

Objective: To study the cropping pattern and demarcation of rainfed area on map of India.

Introduction: Rainfall in India is completely depends on the nature of monsoons, the annual rainfall is highly variable from year to year. Variability is high in the regions of low rainfall such as parts of Rajasthan, Gujarat and the leeward side of the Western Ghats. As such, while areas of high rainfall are liable to be affected by floods, areas of low rainfall are drought-prone.

Heavy rainfall region

Early in the season, the wind ward side of the Western Ghats receives very heavy rainfall, more than 200 cm. The maximum rainfall of this season is received in the north-eastern part of the country. Mawsynram in the southern ranges of the Khasi Hills receives the highest average rainfall in the world. Tropical moist deciduous forests can be seen in the region. Rice, tapioca and spices are cultivated in this region.

In north eastern hilly parts of India, the traditional farming involves jhum cultivation. Rice is the dominant crop grown in valleys. Rice, millets, maize and plantation crops (tea, coffee, rubber) and horticultural crops (oranges, pineapple) are cultivated on terraces of hills. Rains help in cultivation of rice and jute in particular.

Coconut, areca nut, oil palm, tapioca and pepper are the main plantation crops of Andaman and Nicobar Island and Lakshadweep. In Lakshadweep, rice is grown under lowland conditions.

Moderate rainfall region

Regions with 100- 200 cm of rainfall include major parts of Bihar, West Bengal, Orissa, Madhya Pradesh, Andhra Pradesh, and parts of other states. These areas fall under the Moderate Rainfall Region. Crops grown in this region in *kharif* season are Rice, maize, barley, soybean, groundnut, pigeonpea and jute. Gram, wheat and vegetables are grown with irrigation in *rabi* season.

Low rainfall region

Regions having low rainfall (50- 100 cm) include parts Maharashtra, Gujarat, Karnataka, Tamil Nadu, Andhra Pradesh, Madhya Pradesh, Punjab, Haryana and Western Uttar Pradesh. Crops commonly grown in this region are Sorghum, pigeon pea, maize, finger millet, green gram/ black gram and cotton. Where irrigation is available, sugarcane, mustard, wheat and gram are cultivated.

Scanty rainfall region

Regions having scanty rainfall (50 cm) include desert and semi-desert parts of Rajasthan, Gujarat and adjoining regions. The region experiences extremes of temperature (−2 to 48^{o}C), long day sunshine, high wind speed (35–40 km/h) and thus very high evaporation. Nearly 41–85% of ground water is saline. Rainfed mono-cropping is practised in this region. Rainy season crops of short duration, pearl millet, chari (fodder), cluster bean, mung bean and moth bean are major crops grown under rain-fed conditions.

Materials required: Pen/pencil, map of India

Exercise 1: Demarcate the rainfed area on map of India

Conclusion:

Practical -4

Topic-Studies on the agro-climatic zones of West Bengal

Aim: To study the agro-climatic zones of West Bengal

Objective: To know the area, soil type and rainfall pattern of the agro-climatic zones of West Bengal

Relevant information:

West Bengal is located between 21°31’ & 27°14’ North Latitude and 85°91’ & 89°53’ East Longitude. The tropic of Cancer passes through the middle of the state covering the district in the East, Nadia and Bardwan and in the West Bankura and Purulia. The state has occupied a geographical area of about 88,75,200 hectares sharing 2.7% land of the country but producing more than 8% of country’s food production and provideing space 7.6% of the country’s population. Total cultivable area of this state is about 56 lakh hectares which is 63% of it’s geographical area and having 62% irrigation area of Net cropped area. Gross cropped area is 94,58,675 hectares with cropping intensity (2012-13) of 182%.

West Bengal is broadly divided into six Agro-climetic Zones, which fall within three Agro-climetic Regions (Eastern Himalayan Region, Lower Gangetic Plain Region, Eastern Plteau & Hill Region) out of total 15 regions in India, as classified by the planning commission, Govt. of India.

Zone (Under Indian Agro Climatic Region)	**Soil Type & Area**	**Districts**	**Annual Rainfall** Max^{m}-Min^{m} Temp.	**Name of the Blocks**
Northan Hill Zone (Eastern Himalayan Region)	Brown Forest & Tarai Soil (3,68,642 ha)	Part of Darjeeling & Jalpaiguri 2500	2500-3500 mm. 19.5°C - 4.8°C	Darjeeling-Pulbazar, Rangali-Rangliot, Sukhiapokhri, Kalimpong-I, Kalimpong-II, Garubathan, Mirik, Kurseong
Teesta-Tarai Alluvial Zone (Eastern Himalayan Region)	Tarai Soil (11,45,443 ha)	Coochbehar, Part of Darjeeling, Jalpaiguri & U. Dinajpur	2000-3000 mm. 32.3°C - 12.8°C	Siliguri-Matigara, Naxalbari, Kharibari, Rajganj, Malbazar, Metiali, Nagrakata, Moynaguri, Dhupguri, Falakata, Madharihat, Kalchini, Alipurduar-I, Alipurduar-II, Kumargram, Haldibari, Mekhliganj, Mathabhanga-I, Mathabhanga-II, Coochbehar-I, Coochbehar-II, Tufanganj-I, Tufanganj-II, Dinhata-I, Dinhata-II, Sitai, Sitalkuchi, Chopra, Islampur, Goalpukur-I, Goalpukur-II, Karandighi
Gangetic Alluvial Zone (Lower	Ganga Alluvial (20,84,540	D. Dinajpur, Malda, Nadia, Part	1350-1650 mm. 35°C - 15.6°C	Raiganj, Kaliaganj, Hemtabad, Itahar, Ratua-I, Ratua-II, Harishchandrapur-I,

Gangetic Plain Region)	ha)	of U. Dinajpur, Murshidabad, N. 24 PGS, S. 24 PGS, Howrah, Hoogly & Birbhum		Harishchandrapur-II, Chanchal-I, Chanchal-II, Manikchak, old Malda, English Bazar, Kaliachak-I, Kaliachak-II, Kaliachak-III, Farakka, Samserganj, Suti-II, Raghunathganj-I, Raghunathganj-II, Sagardighi, Nabagram, Lalgola, Bhagawangola-I, Bhagawangola-II, Murshidabad-Jiaganj, Berhampur, Hariharpara, Raninagar-I, Raninagar-II, Jalangi, Domkal, Naoda, Beldanga-I, Beldanga-II, Santipur, Chakdah, Hanskhali, Ranaghat-I, Ranaghat-II, Haringhata, Kaliaganj, Krishnaganj, Karimpur, Nakashipara, Nabadwip, Chopra, Tehatta-I, Tehatta-II, Krishnanagar-I, Krishnanagar-II, Bagdah, Bongaon, Gaighata, Baduria, Habra-I, Habra-II, Barasat-I, Barasat- II, Amdanga, Deganga, Rajarhat, Bashirhat, Barrackpore, Baruipore, Bhangore-I, Bhangore-II, Bishnupur-I, Bishnupur- II, Sonarpur, Budge-budge-I, Budge-budge-II, Mahestala-Metiabaruz, Jadavpur-Behala, Ketugram-II, Katwa-I, Katwa-II, Purbasthali-I, Purbasthali-II, Kalna-I, Balagarh, Chinsurah-Mongra, Serampore-Uttar Para, Chanditala-I, Chanditala-II, Domjur, Jagatballavpur, Bali-Jagacha, Sankrail,Panchla
Vindhyan Alluvial Zone (Lower Gangetic Plain Region)	Vindhyan Alluvial (17,71,472 ha)	Part of Murshidabad, Howrah, Hoogly, Burdwan, Birbhum, Bankura, Paschim & Purba	1500-2000 mm. 35.5^{o}C - 15.1^{o}C	Gazole, Habibpur, Bamongola, Banshihari, Kushmandi Gangarampur, Kumargram, Tapan, Balughat, Hilli,Kandi, Bharatpur-I, Bharatpur-II, Burwan, Khargram, Burwan, Ausgram-I, Bhatar, Memari-I, Memari-II, Jamalpur, Raina-I, Raina-II, Khandaghosh, Galsi-I,

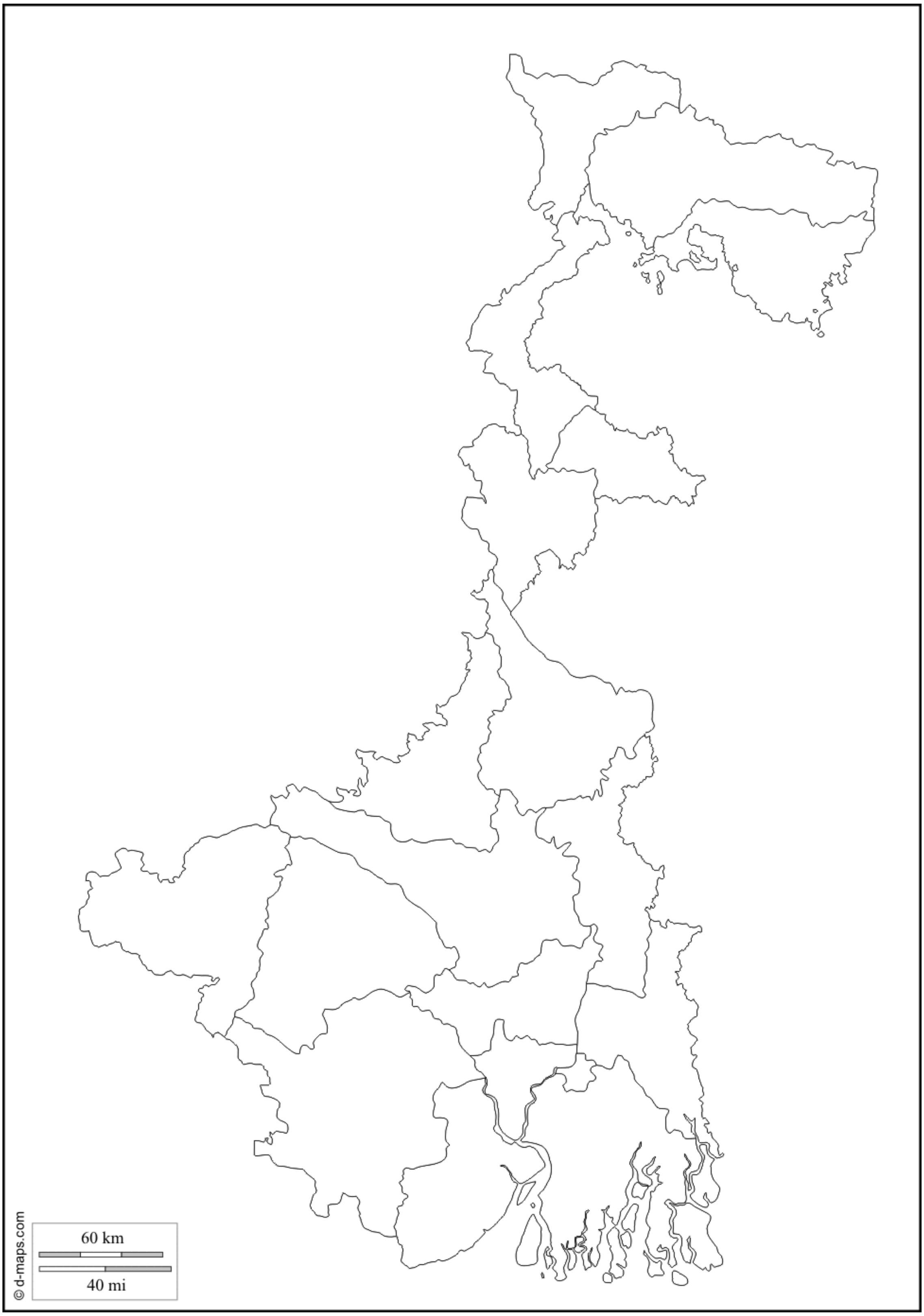
		Medinipur		Galsi-II, Kalna-II, Manteswar, Mangalkote, Ketugram-I, Arambagh, Khanakul-I, Khanakul-II, Purshurah, Goghat, Jangipara, Polba-Dadpur, Dhaniakhali, Pandua, Singur, Haripal, Tarakeswar, Uday Narayanpur, Amta-I, Amta-II, Labpur, Nanoor, Mayruswar-II, Nalhati-II, Rampurhat-II, Patrasayar, Kotolpur, Indus, Ghatal, Daspur-I, Daspur-II, Potashpur, Panskura-I, Panskura-II, Mayna, Debra, Pingla, Dantan-I, Dantan-II, Narayangarh, Mohanpur, Sabong,
Coastal Saline Zone (Lower Gangetic Plain Region)	Coastal Saline (13,19,466 ha)	Part of N. 24 PGs, S. 24 PGS, Howrah & Purba Medinipur	1600-1800 mm. 34^{o}C - 16^{o}C	Haroa, Minakhan, Swarupnagar, Hansabad, Hingalganj, Sandeshkhali-I, Sandashkhali-II, Bashirhat-II, Jaynagar-I, Jaynagar-II, Kultali, Canning-I, Canning-II, Basanti, Sagar, Falta, Magrahat-I, Magrahat-II, Kakdwip, Namkhana, Diamond-Harbour-I, Diamond-Harbour-II, Mathurapur-I, Mathurapur-II, Patharpratima, Mandirbazar, Kupli, Goshaba, Shyampur-I, Shayampur-II, Bagnan-I, Bagnan-II, Uluberia-I, Uluberia-II, Khejuri, Bhagabanpur-I, Bhagabanpur-II, Ramnagar-I, Ramnagar-II, Egra-I, Egra-II, Contai-I, Contai-II, Contai-III, Tamluk-I, Tamluk-II, Mahishadal-I, Mahishadal-II, Nandigram-I, Nandigram-III, Sutahata-I, Sutahata-II
Red & Laterite Zone (Eastern Plateau & Hill Region)	Red Soil (19,97,887 ha)	Puruliya, Part of Burdwan, Birbhum, Bankura & Paschim Medinipur	1100 - 1400 mm. 37^{o}C - 14.8^{o}C	Faridpur, Kanksa, Hirapur, Andal, Salanpur, Barabani, Raniganj, Kulti, Asansol, Jamuria-I, Jamuria-II, Aushgram-II, Nalhati-I, Muraroi-I, Muraroi-II, Mayureswar-I, Rampurhat-I, Mahamad Bazar, Sainthia, Bolpur, Dubrajpur, Nilambazar,

				Rajnagar, Suri-I, Suri-II, Khoyrasal, Hura, Puncha, Manbazar-I, Manbazar-II, Raghunathpur-I, Raghunathpur-II, Bagmundi, Arsha, Bunwan, Jhalda-I, Jhalda-II, Neturia, Kashipur, Sanpuri, Para, Purulia-I, Purulia-II, Balarampur, Jaipur, Barabazar, Sonamukhi, Jaipur, Bishnupur, Ranibandh, Gangajalhati, Barjora, Saltora, Onda, Taldangra, Simlipal, Mejhina, Raipur-I, Raipur-II, Chhatna, Indpur, Bankura-I, Bankura-II, Khatra-I, Khatra-II, Chandrakona-I, Chandrakona-II, Jhargram, Binpur-I, Binpur-II, Jambani, Nayagram, Sankrail, Gopiballavpur-I, Gopiballavpur-II, Keshiary, Salboni, Keshpur, Garbeta-I, Garbeta-II, Garbeta-III, Medinipur, Kharagpur-I, Kharagpur-II

Source: West Bengal Agriculture-an overview, (http://matirkatha.net)

Materials required: pen/pencil, map of West Bengal

Exercise1 - Demarcate the agro-climatic zones of West Bengal on map.



Conclusion:

Practical -5

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

Aim: To study the method of scheduling supplemental irrigation

Objective: To use meteorological data for scheduling supplemental irrigation

Introduction:

The crop water need (ET crop) is defined as the amount of water required to meet the water loss through evapotranspiration. The crop water need mainly depends on:

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

Crop type: Crops like maize, potato and sugarcane needs more water than crops like millet or sorghum.

Growth stage: Fully grown crops need more water than young crops that.

Crop evapotranspiration is an important components 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.

Influence of climate on crop water needs (ETo)

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

Sunshine, temperature, humidity and wind speed

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	cloudy

The highest crop water needs are thus found in areas with 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** (ETo). The ETo 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. ETo 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 ETo. They are either:

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

Materials required: Pan evaporation data, pen, pencil, record etc.

Methods to determine reference crop evapotranspiration:

Pan evaporation method: Evaporation pans provide a measurement of the combined effect of temperature, humidity, wind speed and sunshine on the reference crop evapotranspiration (ETo).

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

Procedure:

i. Install the pan in the field
ii. Fill the pan with a known quantity of water (the surface area of the pan is known and the water depth is measured)
iii. Allow the water is 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.
iv. Measure the remaining quantity of water after 24 hours (i.e. water depth)
v. Calculate the amount of evaporation per time unit (the difference between the two measured water depths); this is the pan evaporation: E pan (in mm/24 hours)
vi. Calculate the reference crop evapotranspiration by using the following formula.

ETo = K pan × E pan

Where,

ETo: Reference crop evapotranspiration, **K pan:** pan coefficient and **E pan:** pan evaporation

Determination of K pan

When using the evaporation pan to estimate the ETo, 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 pan = 0.70.

For the Sunken Colorado pan, the K pan varies between 0.45 and 1.10. Average K pan = 0.80.

Exercise 1: Schedule irrigation through IW:CPE by using the following data

Irrigation water to be applied = 7.0 cm

IW /CPE ratio = 0.9

Date of sowing of wheat = 15th November, 2018

Table 1: Pan evaporation data

Month	Date	Pan evaporation / day (mm)	Cumulative pan evaporation (mm)
November	15	2.5	2.5
	16	2.4	4.9

17	2.6	7.5
18	2.5	10.0
19	2.6	12.6
20	1.3	13.9
21	1.9	15.8
22	1.2	17.0
23	4.5	21.5
24	3.6	25.1
25	2.2	27.3
26	1.9	29.2
27	3.4	32.6
28	2.4	35.0
29	2.2	37.2
30	2.7	39.9
December 1	1.6	41.5
2	2.6	44.1
3	3.9	48.0
4	5.5	53.5
5	4.9	58.4
6	4.6	63.0
7	2.2	65.2
8	1.5	66.7
9	1.8	68.5
10	2.4	70.9
11	5.1	76.0
12	1.5	77.5
13	0.8	78.3
14	0.9	79.2
15	1.7	80.9
16	2.8	83.7

Solution:

Conclusion:

Video Link: https://youtu.be/f3ujoTLWqdk

Practical -6

Topic- Critical analysis of rainfall and possible drought period in the country

Aim- To study the annual rainfall and possible drought period in India

Introduction: Draught is a situation of significant water shortage. It may be due to insufficient rainfall or increase in water demand. Drought effects population spread over larger areas and longer period of time.

Types of drought:

Meteorological Drought:

When actual rainfall over an area is less than $3/4^{th}$ of the normal value i.e. the long term climatological mean then it is called meteorological drought.

Hydrological drought:

When there is marked depletion of surface water causing very low stream flow and drying of lakes, reservoirs and rivers. It may also result in recession of spring flows and glaciers due to insufficient regeneration of seasonal snow cover.

Agricultural Drought:

Agricultural drought means when soil moisture is inadequate to support healthy growth of crops resulting in very low yield. Water level goes lower and ground water is unable to meet the evapotranspiration demand of crop.

Materials required: pen/pencil, map of India

History of drought in India:

Period	Drought years	Number of drought
1801-1830	1801, 1804, 1806, 1812, 1819, 1825	6
1831-1860	1832, 1833, 1837, 1853, 1860	5
1861-1890	1862, 1866, 1868, 1873, 1877, 1883	6
1891-1920	1891, 1897, 1899, 1901, 1904, 1905, 1907, 1911, 1918, 1920	10
1921-1950	1939, 1941	2
1951-1980	1951, 1965, 1966, 1971, 1972, 1974, 1979	7
1981-2010	1982, 1987, 2002, 2009	4

Source: **http://www.editoria.u-tokyo.ac.jp/projects/awci/5th/file/pdf/091216_awci/4.3-3-1_CR_India1.pdf**

Early warning indicators:

i. Deficit rainfall

ii. Fall in ground water level

Occurrence of Meteorological Drought

Based on rainfall deficiency:

India Meteorological Department (IMD) defines Meteorological Drought on sub-division scale. The Meteorological Droughts are classified into 2 following categories:

A. **Moderate drought**: When seasonal rainfall deficiency falls between 26-50%.

B. **Severe drought:** When seasonal rainfall deficiency exceeds 50%.

Exercise 1: Demarcate drought prone areas of India on map

Conclusion:

Video link: https://youtu.be/YXddPLcMKZE

Practical -7

Topic- Effective rainfall and its calculation

Aim: To calculate effective rainfall

Objective: To study the methods for calculating effective rainfall

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

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

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 (ETa) 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
$ER = M_2 - M_1 + kpEo$
ER = effective rainfall
Eo = U.S. Class A Open Pan evaporation value
M_1 and M_2 = 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.

Materials required: Soil sampling augar, Hot air oven, soil moisture box and digital weight balance, wooden scale.

Procedure:

Collect the soil sample from effective crop root zone before rainfall.

Dry the soil sample in hot air oven at 105° C for 24 hours.

Calculate the moisture content of soil

Collect the soil sample from effective crop root zone after rainfall at field capacity.

Dry the soil sample in hot air oven at 105° C for 24 hours.

Calculate the moisture content of soil

Calculate the effective rainfall by using the following formula:
$ER = M_2 - M_1 + kpEo$
ER = effective rainfall
Eo = U.S. Class A Open Pan evaporation value
M_1 and M_2 = moisture status in the effective root zone before and after rain, respectively.

kp = pan coefficient

Observations to be recorded:

Soil moisture content at crop root zone before rainfall-

Soil moisture content at crop root zone after rainfall at field capacity-

Pan evaporation value-

Pan coefficient

Effective rainfall-

Conclusion:

Practical -8

Topic- Studies on cultural practices for mitigating moisture stress

Aim: To know about different methods for mitigating moisture stress.

Objective: To mitigate moisture stress.

Introduction:

Soil moisture conservation is an ongoing goal in agricultural production, especially in India, where water resources are limited. One reason that there is a push to use less water in agriculture is because of increasing water demand generated by the huge population in India. The water availability for agricultural producers is constantly reducing day by day. To address both of these issues, farmers are searching for new ways to improve soil moisture content for successful crop production.

Materials Required

i. Note book
ii. Pen/ pencil
iii. Mulching materials like: paddy straw, dry grass, dry leaf, husk, black polythene sheet (25-50 micron) etc.

Different methods for mitigating moisture stress are

i. Mulching
ii. Thinning
iii. Depth of sowing
iv. Leaf removal
v. Plant density

Mulching

It is one cultural practice which can be used to addresses 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 by products 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 by products.

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.

Planting Density

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

i. **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.
ii. **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.

Thinning

Thinning is done to maintain optimum plant population so that the competition (for different sources like light, moisture, nutrients, CO_2) 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.

Leaf Removal

Normally the plants growing in irrigated conditions will grow vigorously 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 rainfed areas shows wilting symptoms because of lack of moisture in the soil due to long dry spell. To reduce the wilting symptoms, older leaves should be removed (2 -3 older leaves will be removed) from the plant to reduce transpiration rate and conserve the water. The removed leaves can be used as a mulching.

Depth of sowing

It also helps in mitigating moisture stress to plants. If the seeds are shallow sown, due to lack of moisture the seed germination may be stopped. If seeds are sown very deep into the soil, seed may not be germinated. So optimum sowing depth should be maintained around 3-4 cm depth based on the type of crop.

Procedure

a) Sow the crop seeds at optimum depth based on the type of crop.
b) Remove excess seedling (Thinning) to maintain optimum plant population for minimizing competition.
c) Cover the soil surface by straw/ black polythene sheet or any other mulch material to reduce evaporation.
d) Remove older leaves of crop plants, if shows wilting symptoms.

Observations to be recorded:

Crop name-

Depth of sowing-

Date of thinning-

Type of mulching-

Date of mulching-

Amount of mulch material used-

Conclusion:

Video link: https://youtu.be/c-Xg1vfmhKo

Practical – 9

Topic-Use of anti-transpirants for mitigating moisture stress

Aim: To use anti-transpirants for mitigating moisture stress

Relevant information:

The adverse effects of moisture stress on crop growth can be mitigated by the application of anti-transpirants, which induce the plants to become adaptive to moisture stress situations for a specified period and the water requirement for such periods can be minimized or saved.

In India, about 90% of the land is under rainfed farming; therefore, it is very essential to manage every drop of water received through rains. Though various measures are adopted to conserve the rain water, yet rainfed farming is often subjected to drought. The severity of intermittent drought of 6-10 days during critical stages of the crop can reasonably be avoided by the use of anti-transpirants and thus crops can be saved. Anti-transpirants can effectively be used to the crop under water stress with adverse rainfall.

Classification of Anti-transpirants

I. Materials causing stomatal closure: Herbicides like 2, 4 – D, Phosphon D and Atrazine, Fungicides like Phenyl Mercuric Acetate (PMA), Metabolic inhibitors like hydroxy sulfonates, potassium metabisulphite etc., Growth hormones like ABA, Ethrel, TIBA, succinic acid, ascorbic acid and Cycocel (CCC).

II. Reflectant Types: Kaoline, China Clay, Calcium bicarbonate and Lime water

III. Thin-forming chemicals: Hexadecanol (Higher alcohols), Cetyl alcohol, Methanol, Paclobutrazol, Brassinolide and Resorcinol.

IV. Polyethylene materials forming thick films: Mobileaf, Folicot, Waxol, S- 800, Hico-110R.
(All the above chemicals are trade names given by the companies)

Materials required: Anti-transpirant, knapsack sprayer, water etc.

Procedure:

Select the plot for spraying anti-transpirant.

Select suitable anti-transpirant required for a specific crop.

Calculate the amount of chemical required for spraying.

Spray the chemical on the crop plant by using sprayer.

Observe the changes on crop plants.

Observations to be recorded:

Sl. no.	**Crop name**	**Growing season**	**Name of anti-transpirant**	**Type of anti-transpirant**	**Dose**

Conclusion:

Things to know

The purpose of anti-transpirants is to maintain the growth and productivity under stress conditions and it is never recommended for high productivity / unit area. It saves the crop and helps to get marginal yield when the expectations are zero.

Precautions:

a) Use recommended dose of anti-transpirant.

b) Use protective clothes viz. Hand gloves, face mask, cap, safety goggles etc.

c) Read instructions given on container lebel before use.

Practical – 10

Topic- Use of plant growth regulators (PGRs) for mitigating moisture stress

Aim: To use plant growth regulators for mitigating moisture stress

Relevant information:

Plant growth regulators are the chemical substances which are used to modify plant growth such as increasing branching, suppressing shoot growth, increasing return bloom, removing excess fruit, or altering fruit maturity. With the use of plant growth regulators, plants possessing moderate canopy development (moderate values for LAI), less reduction in photosynthesis, deeper root system, higher root / shoot ratio and delayed senescence will perform better under water stress conditions.

Toward this, application of some of the PGRs will prove beneficial for better crop growth and development when grown under water deficit situations. Some of the PGRs and their effects on crops in order to suit to the moisture stress conditions are:

Cycocel & Mepiquat chloride:

For promoting root growth (for more water absorption) and suppressing leaf area development (for reducing transpiration loss of water) and delaying on set of leaf senescence.

Cytokinins and Salicylic acid:

They delay the leaf senescence processes and also favour stem reserve utilization by the developing grains especially during the water defict situations.

Brassinolides:

These PGRs increase the photosynthetic activity of the plants.

Ascorbic acid:

Ascorbic acid acts as an anti-oxidant agent for scavenging Reactive Oxygen Species (ROS) accumulating under stress and thus avoiding membrane damage.

Pre-sowing hardening of seeds / plants:

Hardening of seeds / plants to required temperature / chemicals enables the plants to overcome the specific stresses. This process actually hardens the protoplasm (by osmoregulation), which enables the seeds to absorb more water under favourable situations to maintain its viability under unfavourable conditions.

Chemicals used for seed hardening process especially under rainfed conditions are: 1% KCl, 1% KH_2PO_4, 100 ppm Succinic acid, 0.5% NaCl, 100 ppm $ZnSO_4$, 100 ppm $MnSO_4$, 100 ppm Ascorbic acid, 250 ppm Cycocel and 0.5% $MgSO_4$.

These chemicals / PGRs could serve as boon to the frustrated farmers of rainfed areas, if rightly adopted with perspective vision to have food security.

Materials required: Plant growth regulators/ chemicals, knapsack sprayer, water, crop seed, beaker, measuring cylinder, weight balance etc.

Procedure:

Pre sowing seed hardening

a) Take required quantity of chemical.

b) Prepare solution of required concentration by dissolving required quantity of chemical in water.

c) Put the crop seeds in the prepared solution for soaking.

d) Remove the seeds from the solution after soaking.

e) Sow the seeds in field.

Observations to be recorded:

Crop name	Name of the chemical	Concentration	Amount of chemical required	Amount of water required	Soaking time

Conclusion:

Practical – 11

Topic- Nutrient management for mitigating moisture stress

Aim: To use plant nutrients for mitigating moisture stress

Relevant information:

Among the major nutrients, potassium and magnesium are found to be highly deficient due to water deficit conditions. Therefore, application of potassium enhances the water uptake as well as the water relations in the plant tissues by osmoregulation processes, by acting as a potent osmoregulator (osmolyte), thereby the solute potential is reduced. Besides, potassium nutrition also helps in the favourable stomatal regulatory mechanisms, which regulate the water balance of the plants. This has also resulted in the increased WUE of the plants. Similarly, magnesium is component of chlorophyll, its content and uptake is drastically reduced due to the water stress effect. This is most prominent in Mg-loving crops like cotton.

Besides macronutrients, deficiencies of micronutrients also appear under water deficit situations due to the following reasons:

1. Depletion due to erosion and leaching. In India, annual soil loss is estimated to be about 6000 Metric tons and obviously due to loss through runoff water and soils
2. Continuous use of micronutrients free NPK fertilizers in dryland agriculture and diminishing the use of organic matter, FYM, compost and green / green leaf manures.
3. Use of high-yielding varieties (HYVs), adoption of intensive systems of farming and cropping and use of heavy doses of fertilizers, increased proportionately the mining of micronutrients from the soil
4. Since increased crop production arising from the heavy demand of the nutrients in rapid depletion of macro and micro-nutrients unless regularly replenished. Consequently, the deficiencies of micro-nutrients in general and that of Zn, Fe and B in particular are widely spread under stress conditions.

In general, foliar application of the following nutrients are effective for mitigating moisture stress

1) 2 % DAP
2) 0.5 to 1 % potassium chloride (KCl)
3) 0.5 % Zinc sulphate
4) 0.5 – 1.0 % Ferrous sulphate + 1 % urea
5) 0.3 % Boric acid

Materials required: Diammonium phosphate (DAP), Potassium chloride (KCl), Zinc sulphate, Ferrous sulphate, Urea and Boric acid

Procedure-

a) Identify the plant nutrient deficiency by observing nutrient deficiency symptoms.
b) Prepare spray solution in suitable concentration.
c) Spray the nutrient solution on plants.
d) Observe the changes on plant growth and development.

Observations to be recorded:

Crop name	Type of nutrient deficiency	Deficiency symptoms	Fertilizer applied	Dose	Changes on plants

Conclusion:

Practical – 12

Topic- Characterization and delineation of model watershed

Aim: To understand the characters of a model watershed

Introduction:

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.

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.)

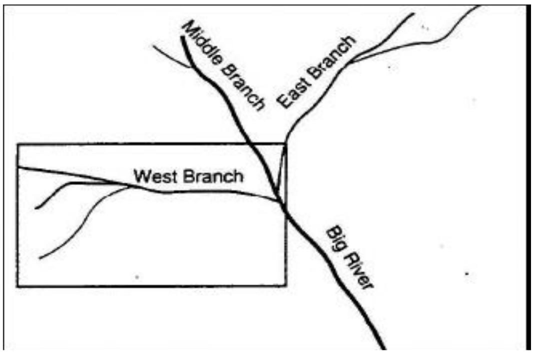


Fig 1: Map indicating rivers border

STEP 2

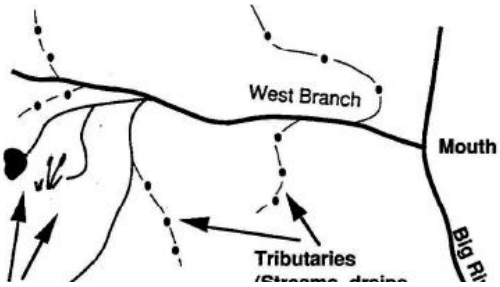


Fig 2: Map indicating rivers boundaries

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

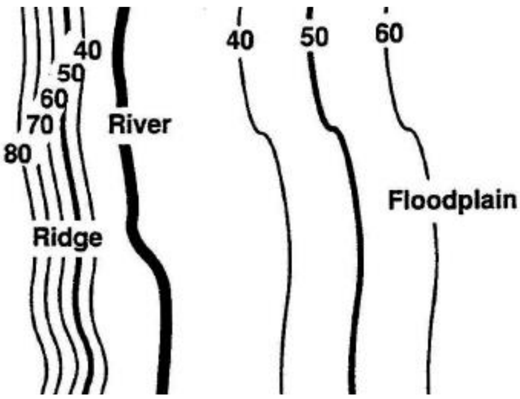


Fig 3: Map indicating Contour lines

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) (Figure -3).

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 and 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.

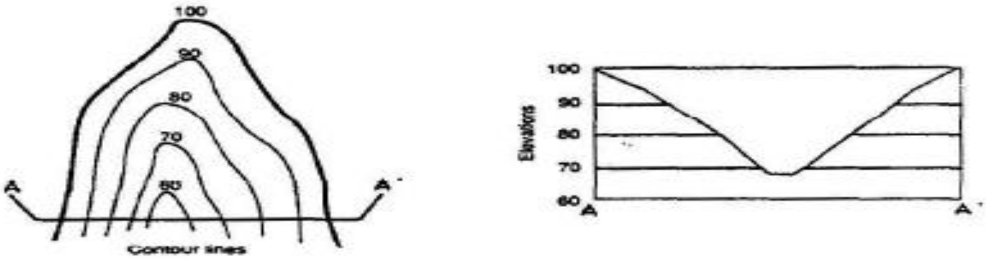


Fig 4: Map pointing out Contour lines towards higher

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 water.

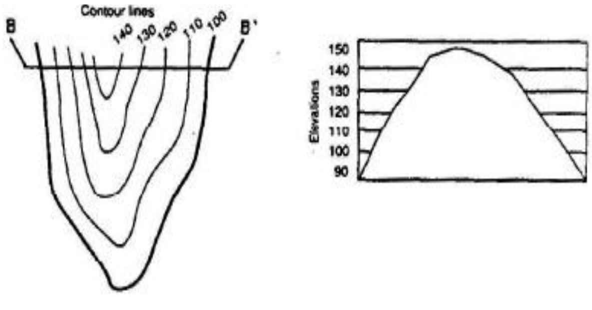
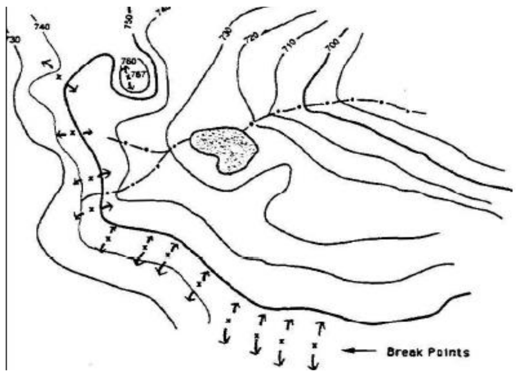


Fig 5: Image indicating the breakpoints

STEP 7



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).

Fig 6: Connecting points with a lines

STEP 8

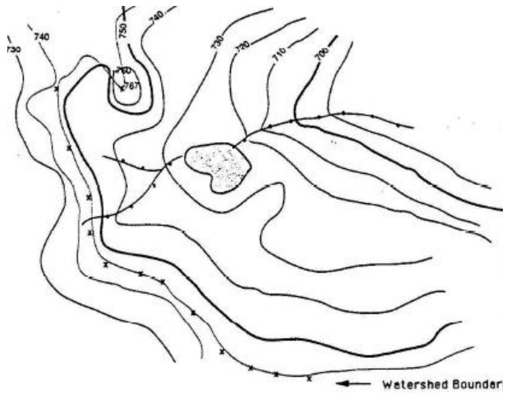


Fig 7: Imaginary boundary of watershed

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.

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

STEP 10

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

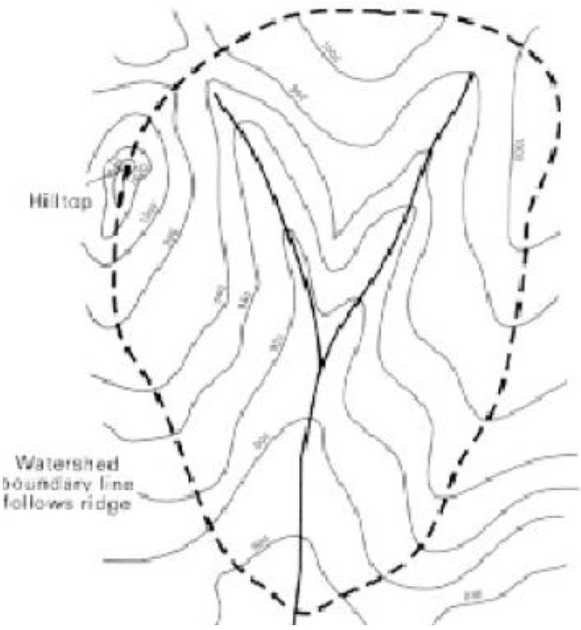


Fig 8: Complete Watershed Image

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.

Conclusion:

Video link: https://youtu.be/EJE-Y_K_j9E

Practical -13

Topic- Field demonstration on soil and water conservation measures

Aim: To study the different soil and water conservation techniques

Objective: To conserve soil.

Relevant information-

Soil and water are critical natural resources that must be kept in harmony with the environment for agro-ecosystems to be sustainable. In India, droughts, famines and floods cause crop damage almost every year. Soil conservation practices will not only increase crop yields but also prevent floods and further deterioration of land. The methods used for controlling soil erosion are described below-

Surface cover- Use of surface cover to control wind erosion may be either vegetative or non-vegetative. Protection of the land surface through vegetative surface cover of grasses or crops is perhaps the most effective, easy and economical method. In addition to the standing vegetation, crop residues are often placed artificially on the soil to provide temporary cover until establishment of permanent vegetation.

Crop Management- Generally, crops grown at close spacing are more effective in controlling wind erosion than at wider spacing. The direction of crop rows with reference to prevailing wind direction has effects on wind erosion. It is recommended to align crop rows perpendicular to the prevailing erosive wind direction, to protect top-soils in inter-row areas from erosion.

Tillage- Tillage operations in arid lands control wind erosion mainly through creating rough surfaces and by bringing clay-rich subsoil to the surface and thus increasing the size and strength of clods. Normal tillage practises make ridges and furrows in the field and thus create rough surfaces. However, roughening the surface is effective only when the roughness elements are non-erodible clods. During tillage operations, it is always better to orient the ridge and furrow across the prevailing wind direction. Repeated or excessive tillage pulverizes the soil, which is more prone to erosion and hence should be avoided on drylands. Stubble mulch tillage is also very effective for conserving soil and water.

Broad-Bed, Furrow System and Conservation Furrow System

On black soils, water-logging and water scarcity normally occur during the same cropping season. Hence, in situ soil and water conservation and proper drainage technologies are required. The "broad-bed and furrow" (BBF) system has proved satisfactory for achieving these goals. Conservation furrows is a promising technology in red soils with moderate slopes (0.2%–0.4%), receiving 500–600 mm rainfall.

Contour Bunding- Contour bunding is recommended for medium to low rainfall areas (<700 mm) and on permeable soils with <6% slope. The bunds consist of series of narrow trapezoidal embankments along the contour. The bunds decrease runoff and hence promote runoff retention within field.

Vegetative Barriers- Vegetation that can form a thick hedge established along contours can obstruct the flow of surface water. As a result, soil particles settle on the upstream side and filtered relatively clear water oozes through the barrier more uniformly across the field at decreased velocity.

Vertical Mulching- Vertical mulching is the creating of holes around the base of a tree or shrub that is stressed. The holes are filled with a mixture of organic material. This type of mulching is useful for conserving soil moisture.

Plantation of vetiver grass- Vetiver grass plantation is a very effective low cost technology for soil and water conservation. Plantation of vetiver grass can reduce surface runoff and soil erosion. Plantation of single or multiple rows of vetiver grass on the contour forms a protective barrier across the slope.

Materials required

1. Hand hoe
2. Spades
3. Measuring tape
4. Tractor with ridge maker
5. Observation book
6. Pen/pencil

Procedure

Tillage-Plough the land and make ridge and furrow with larger soil clods.
Surface cover- Place crop residues on the soil surface to provide temporary cover.
Broad-bed and furrow- Prepare broad-bed and furrow of suitable size.
Contour bunding- Prepare contour bunds across the slope of the land by using hand hoe.
Vertical Mulching- Dig holes (5-7.5 cm wide and 20-25 cm deep) near to the root zone of tree.
Fill the hole with manure and any organic mulch material.
Vetiver grass plantation- Plant vetiver grass on the contour by maintaining proper spacing.

Observations to be recorded

Size of broad-bed and furrow-

Size of contour bund-

Type of mulch material used-

Spacing of vetiver grass-

Conclusion:

Practical -14

Topic- Soil and water conservation through land shaping techniques in coastal regions

Aim: To study the land shaping models for soil and water conservation.

Objective: To conserve soil and water

Relevant information:

Rain-water harvesting in farm pond with suitable land shaping (farm pond technique) was developed at CSSRI, Regional Research Station (RRS), Canning Town, West Bengal, under the leadership of Dr K.V.G.K. Rao during the 1980s. The technique improves the productivity of salt-affected coastal soils using integrated agriculture-aquaculture farming. The research work in the Sundarbans Region showed that digging a farm pond in the 1/5th area of the farm pond and using the excavated soil for raising the remaining the land can facilitate the transformation of mono-cropped coastal land to multi-cropped land with diversified crops.

Farm Pond- About 20% of the farm area is converted into on-farm pond of 3 m depth to harvest excess rain-water. The dug-out soil is used to raise the land to form high land/dike and medium land situations besides the original lowland situation in the farm for growing multiple and diversified crops throughout the year, instead of mono-cropping with rice in the *kharif* season. The upper land is free from water-logging in the *kharif* season, with less salinity accumulation in dry seasons and thus can be used for multiple and diversified crop cultivation throughout the year.

Deep furrow and high ridge- About 50% of farm land is shaped into alternate ridges (1.5 m top width × 1.0 m height × 3 m bottom width) and furrows (3 m top width × 1.5 m bottom width × 1.0 m depth). These ridges remain free of water-logging during the *kharif* season, with less soil salinity accumulation in dry seasons (due to higher elevation and the presence of fresh rain-water in furrows). The remaining farmland, including the furrows, is used for growing more profitable paddy and fish cultivation in the kharif season. The rain-water harvested in furrows is used for irrigation

Paddy-cum-fish cultivation- Trenches (3 m top width × 1.5 m bottom width × 1.5 m depth) are dug around the periphery of farm-land, leaving 3.5 m wide land to the outer boundary. The dug-out soil is used for making dikes (1.5 m top width × 1.5 m height × 3 m bottom width) to protect free flow of water from the field and harvesting more rain-water in the field and trench. A small ditch is dug out at one corner of the field as a reserve for fish when water in trenches dries out.

Materials required: Measuring tape, pen/pencil, note book etc.

Procedure:

Measure the size of land (length, width) by using measuring tape.

Measure the size of pond/ trench/ high ridge and deep furrow (length, width and depth)

Observations to be recorded:

Type of structure	Length (m)	Width (m)	Depth (m)	Total area (m)	Type of crop grown

Conclusion:

Video link: https://youtu.be/89sLAwXV1rY

Practical -15

Topic- Field demonstration on construction of water harvesting structures

Aim: To study about the water storage structures
To get acquaint with different methods of water storage in different areas

Objective: Construction of water harvesting structures.

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.

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

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.

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.

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.

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

Tanka/ Kundi: Tanka is generally circular in shape and is constructed in stone masonry in 1:3 cement-sand. 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 cm capacity are built for the village communities.

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.

Conclusion:

Video link: https://youtu.be/GgI6TkLBUk0

Practical - 16

Topic- Visit to a watershed

Aim- To visit a watershed.

Objective- To know about the watershed.

Materials required

1. Observation book
2. Pen/ Pencil

Introduction:

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-

Type of watershed (macro/sub/ milli/ micro)-

Storage capacity-

Command area-

Lining materials used-

Description of watershed-

Uses-

Conclusion

References

http://matirkatha.net/wp-content/uploads/2016/07/West-Bengal-Agriculture-an-Overview.pdf

http://www.editoria.u-tokyo.ac.jp/projects/awci/5th/file/pdf/091216_awci/4.3-3-1_CR_India1.pdf