

Theory notes on

Course No. AGRO-235 (1+1=2)

Rainfed Agriculture and Watershed Management

Krusha Sutra App

Teaching Schedule

Sr. No.	Topic	Page No.
1	Rainfed agriculture: Introduction, types, History of rainfed agriculture and watershed in India	
2	Problems and prospects of rainfed agriculture in India	
3	Soil and climatic conditions prevalent in rainfed areas	
4	Soil and water conservation techniques	
5	Drought: types, effect of water deficit on physio-morphological characteristics of the plants	
6	Crop adaptation and mitigation to drought	
7	Water harvesting: importance, its techniques, Efficient utilization of water through soil and crop management practices	
8	Management of crops in rainfed areas	
9	Contingent crop planning for aberrant weather conditions	
10	Concept, objective, principles and components of watershed management	

REFERENCE BOOKS

1. Principles of Agronomy : S. R. Reddy
2. Sustainable Development of Dryland Agriculture in India. : R.P.Singh
3. Dry farming technology in India. : P.Rangaswamy
4. Dryland Resources and Technology, Vol. 8 L.L.Somani, W.Kausal
5. Physiological aspects of dryland farming. U.S. Gupta
6. Dry farming in India. N.V. Kanitkar, S.R. Sirur and Gokhale Agronomy by S.C. Panda 2006. Agrobios Publication, New Delhi.
7. Guide for competitive agriculture by R.K. Sharma, N. Pandey, A.P. Singh, R.S. Maitry
8. A Lecture note on Dryland farming and watershed management by Dr. T.Y. Reddy and Dr. G.P. Reddy, ANGARU, Hyderabad

1. Rainfed agriculture: Introduction, types, History of rainfed Agriculture and Watershed in India

Introduction

Dryland agriculture has a distinct place in Indian agriculture, occupying around 67 % of the cultivated area, contributing to nearly 44 % of foodgrains and supporting 40 % of human and 60 % of livestock population. Most (80-90 %) of the pulses, oilseeds and millets are confined to dryland ecosystems.

Dryland Agriculture refers to growing of crops entirely under rainfed conditions .

Based on the amount of rainfall received, dryland agriculture can be grouped into three categories:

1. **Dry Farming:** Cultivation of crops in areas where average annual rainfall is less than 750 mm per annum. Crop failure is most common due to prolonged dry spells during the crop period. These are arid regions with a growing season (period of adequate soil moisture) less than 75 days. Moisture conservation practices are necessary for crop production.

2. **Dryland Farming:** Cultivation of crops in areas receiving rainfall from 750 to 1150 mm per annum. In spite of prolonged dry spells crop failure is relatively less frequent. These are semi arid tracts with a growing period between 75 and 120 days. Moisture conservation practices are necessary for crop production. However, adequate drainage is required especially for vertisols or black soils.

3. **Rainfed Farming :** Cultivation of crops in regions receiving more than 1,150 mm per annum. Crops are not subjected to soil moisture stress during the crop period. Emphasis is often on disposal of excess water. These are humid regions with growing period more than 120 days.

Dry Farming, Dryland Farming and Rainfed Farming

Particular	Dry Farming	Dryland Farming	Rainfed Farming
Rainfall/annum (mm)	< 750	750 - 1150	> 1150
Moisture Availability	Acute shortage	Shortage	Enough
Crop growing season	< 75 days	75 – 120 days	> 120 days
Growing region	Arid	Semi arid	Humid
Cropping systems	Single crop/ Inter cropping	Single crop/ multi cropping	Inter cropping/ double cropping
Dry spells	Most common	Less frequent	No occurrence
Crop failure	More frequent	Less frequent	Rare
Constraints	Wind erosion	Wind erosion/ water erosion	Water erosion
Measures required	Moisture conservation practices	Moisture conservation	Proper drainage
		Practices & drainage	require
		for vertisols	

The chronology of events in dryland agricultural research in India is as follows.

Year	chronology of Events
1920	Scarcity tract development given importance by the Royal Commission on Agriculture
1923	Establishing Dryland Research Station at Manjri (Pune)
1933	Research Stations established at Bijapur and Solapur
1934	Research Stations established at Hagari and Raichur
1935	Research Station established at Rohtak (Punjab)
1944	Monograph on dry farming in India by N.V. Kanitkar, Bombay, Hyderabad
1953	Establishing Central Soil Conservation Board
1954	Establishing Soil and water conservation research institute at Dehradun, with Soil Conservation Centres
1959	Central arid zone research institute (CAZRI), Jodhpur
1970	Research Centres established under AICRPDA in 23 locations
1972	Establishment of ICRISAT, Hyderabad
1976	Establishment of Dryland Operational Research Projects
1983	Starting of 47 model watersheds under ICAR
1985	Central Research Institute for Dryland Agriculture (CRIDA) at Hyderabad
1990	National watershed development project for rainfed agriculture (NWDPA)
2006	National Rainfed Area Authority (NRAA)

2. Problems and prospects of rainfed agriculture in India

Problems or constraints for crop production in dry farming regions Most of the cropping in the arid and semi arid regions continues to be under rainfed conditions. A majority of the farmers are small farmers with meager resources. The poor resource base permits only low input subsistence farming with low and unstable crop yields. The low productivity of agriculture in dry farming regions is due to the cumulative effect of many constraints for crop production. The constraints can be broadly grouped in to

1) Inadequate and Uneven Distribution of Rainfall

In general, the rainfall is low and highly variable which results in uncertain crop yields. Besides its uncertainty, the distribution of rainfall during the crop period is uneven, receiving high amount of rain, when it is not needed and lack of it when crop needs it.

- (a) Cultivation of low water required crops
- (b) Short duration crops grown
- (c) Providing life saving irrigation

2) Long Gap in Rainfall

- (a) Increase in seed rate to obtain more population
- (b) Spraying of urea solution
- (c) Providing life saving irrigation at critical growth stages
- (d) Weeding and intercultural operations

3) Early Onset of Monsoon

- (a) Cultivate Pearlmillet, Sesamum etc.

4) Late Onset of Monsoon

Due to late onset of monsoon, the sowing of crops are delayed resulting in poor yields.

- (a) Alternate crop & varieties: Castor (Aruna), greengram, cowpea, sunflower
- (b) Dry sowing

- (c) Pre sowing
- (d) Seed soaking/treatment
- (e) Transplanting of one month old Bajra seedlings.
- (f) Complete weed control
- (g) Grow legumes/oilseed crops in place of cereals
- (h) Most suitable crop for this condition is Sunflower.

5) Early Cessation of Rains

Sometimes the rain may cease very early in the season exposing the crop to drought during flowering and maturity stages which reduces the crop yields considerably

- (a) Select short duration varieties
- (b) Using mulching/mulches
- (c) Life saving irrigation applied
- (d) Decrease in plant population

6) Prolonged Dry Spells

Long breaks in the rainy season is an important feature of Indian monsoon. These intervening dry spells when prolonged during crop period reduces crop growth and yield and when unduly prolonged crops fail.

- (a) If dry spell in 10 days of sowing, resowing
- (b) If mild moisture stress at 30-35 days after sowing, thinning of alternate rows of Sorghum and Pearl millet
- (c) If severe moisture stress at 30-35 days after sowing, cutting of sorghum and Pearl millet and rationing
- (d) If moisture stress at blooming stage, cutting of sorghum and Pearl millet and rationing
- (e) Breaking of monsoon for short while, shallow inter cultivation for eradicating weeds/soil mulch
- (f) Wider spacing for moisture conservation

(g) Spray of 2 per cent urea after drought period is useful for indeterminate crops like castor, pigeonpea and groundnut.

(h) Soil mulching to reduce evaporation losses

(i) *In situ* water harvesting

(j) Life saving irrigation

(k) Weed control to save water, nutrients etc.

7) Low moisture retention capacity

The crops raised on red soils, and coarse textured soils suffer due to lack of moisture whenever prolonged dry spells occur due to their low moisture holding capacity. Loss of rain water occurs as runoff due to undulating and sloppy soils.

8) Low fertility of soils

Soil fertility has to be increased, but there is limited scope for extensive use of chemical fertilizers due to lack of adequate soil moisture.

Krushi Sutra App

3. Soil and climatic conditions prevalent in rainfed areas

1) Soils: - Out of total cultivable land in M.S. 87 per cent area comes under rainfed. Soils of drought prone areas of M.S. area derived from the basic igneous rock Basalt commonly known as Deccan trap. The colours of soil vary from reddish brown to dark gray black and are called verti. The soils exhibit a definite to presence of ridge medium deep (122 - 90 cm depth) soils on sloped land deep soils (more than 90 cm deep) end of watershed. The distribution of very shallow, shallow, medium deep and deep soils in drought prone areas of M.S. is about 10,20,45 and 25% respectively. They usually under lined partially decomposed rock locally known as murum which overlies parent material. On account of more or less complete absence of leaching the soils are base saturated. The exchangeable calcium is predominant cation. The free lime is reserve is fairly high (3 to 10%) and at places excessive quantities of iron nodules accumulate. The problematic soils viz. saline, saline sodic land sodic soils do occur in patches in low lying areas.

As regards the fertility status, the soils are generally low in organic carbon (0.35 to 0.5%) total nitrogen (0.03 to 0.05%) low to medium available phosphate (10 to 30 kg p₂O₅/ha) and high available potash (300 to 750 kg K₂O/ha). Usually micro-nutrient deficiencies are not observed in dry land crops. However in eroded soils, crop like groundnut have shown some response to boron application. Cereal crops give fairly good response to nitrogenous fertilizers while oilseeds and legumes give good response to phosphatic fertilizers.

Soils exhibit adverse physical characters because of high clay content (35 to 65%) of type clay mineral. The soils exhibit high volume expansion when moist and shrink when dry. The infiltration rate of soils is moderately slow (0.5 to 0.9 cm/hr). During the process of shrinkage, wide land deep cracks are developed even up to Murum strata in medium deep soils. The crack development accelerates the soil moisture loss from the deeper layers (phases). Further soils exhibit varying degree of erosion depending on the slope, tillage operations and cropping season. The soils classed as moderate to high erodible. Hence soil and water conservation is a pre-requisite for successful cropping. Limited soil depth puts limitations on availability of water and nutrients for cropping intensity. Usually soils having less than 45 cm depth are useful for *Kharif* crops as they are unretentive of soil moisture. Intermittant wetting due to frequent rainfall during June to Aug helps to mature crops on such soils. Soils having depth more than 45 cm have high moisture storage and retentive capacity. Under dry land to bring the soil moisture in the available range (i.e. above PWP) the rainfall required is quite high since the precipitation in the early part of monsoon is quite inadequate the medium deep soils (beyond 45 cm deep) usually do not have adequate moisture for sowing. It is only due to receipt of about 200 mm of rains during September the medium deep and deep soils are adequately moistened for Rabi cropping. Hence Rabi cropping is predominant and medium deep and despoils one grown with Rabi crops.

The moisture storage capacity of soil mainly depends on clay content and soil depth. However, clay content is generally above 45 percent in medium deep and deep soil the moisture depletion of soil depends on the moisture held in the soil at different tensions. The soil moisture is always below the moisture at 15 bar (PWD) which ultimately results in failure of crops in dry land agriculture.

II) Climate: Weather, which is part of climate, plays an important role in crop planning in dry farming area. Out of the several elements of weather, rainfall has key position in success of dry farming.

In dry land areas, South West Monsoon brings the bulk of rainfall. The South West Monsoon is followed by North East Monsoon which supplements to South West Monsoon are the main source of rainfall. There are four types of rainfall characterized by the nature in different parts of India. Generally, the rainfall is scanty, erratic and ill distributed. The draught prone area in Maharashtra State covers about 1/3 of the total area of the state. The climate in this is usually hot and PE (Potential Evaporation) is for in excess of the precipitation is classified as semiarid e.g. Annual precipitation at Solapur is about 722 mm. but PE is about 1300 mm annually resulting in deficient 60%.

III) Rainfall features :- The annual Average rainfall varies from 400 mm to 700 mm. Year to year fluctuations are so much that there is no guaranteed of fixed quantity of rainfall. Uncertain and ill distributions of rainfall are two qualities which makes the Rainfed farming difficult. Rainfall starts in late June to Early July.

There is depression during late July and early August. Again there is good rainfall in late August and September. The rainfall totally recedes by mid October. The probability of rainfall is more than half of the normal fairly good ($P = 0.58$) during September.

M) Dry spells: - It is another rainfall feature. Breaks in monsoon are normally experienced (observed) during late July and August. They may extend by 2 weeks to 13 weeks at a stretch. A break is defined as period receiving less than 15 mm rainfall in consecutive weeks. The normal rainfall during the week being more than 50 mm. A duration of break more than 4 weeks and frequently more than 3 times usually results in failures of crops.

Variation in the rainfall within the district is also observed. In Solapur, particularly variation in annual precipitation is noticed from 500 mm in western part to about 700 mm in eastern parts.

V) Water availability period: - Water availability depends on rainfall and PE. Humid (when rainfall exceeds PE) and moist (when rainfall is less than PE but exceeds PET) period together provides congenial weather for active crop growth.

VI) Wind velocity: - Wind velocity is generally high during July and August. If wind velocity exceeds 18 - 20 km./hr. Such period coincided with dry spell. Hence Evapotranspiration is at high degree. If velocity is low the lowest evaporation rates are observed during November and December.

VII) Bright sunshine hours: - Bright sunshine is usually experienced during months of Jan. and Feb. At Solapur it is about 8 to 9 hours. During April and May the sky is usually hazy with more dust particles, lowest bright sunshine is noticed during Aug. (4 to 5 hours). This indicates the cloudy weather but no rainfall.

VIII) Humidity: - Humidity is high during July and Sept. During Feb. to May it is low. During dry spell, less relative humidity is noticed. Evaporation demands are also accelerated with high temperature and low humidity.

IX) Temperature: - a Maximum temperature exceeds 41°C during late April and early May. Minimum temp. is noticed during December. Lowest weekly minimum temperature is about 14 to 15°C. Generally climate is semi arid with mild winter and hot summer. Crop like wheat and gram requiring longer cool period hence do poor while prolonged cold weather however, Jowar suffers considerably.

4. Soil and water conservation techniques

Broadly speaking, the practical methods of soil and water conservation fall into two important classes, viz. Agronomic measures and Engineering measures.

A) AGRONOMIC MEASURES

Agronomic practices for soil and water conservation help to intercept rain drops and reduce the splash effect, help to obtain a better intake of water rate by the soil by improving the content of organic matter and soil structure, help to retard and reduce the overland run-off through the use of contour cultivation, mulches, dense-growing crops, strip-cropping and mixed cropping. **Agronomical measures are adopted where land slope is <2 per cent**, which are followings:

1. Conservation Tillage
2. Deep tillage
3. Conservation Farming
4. Contour Farming
5. Mulching
6. Growing of cover crops
7. Strip cropping
8. Mixed cropping

1) CONSERVATION TILLAGE

- ✓ This umbrella term can include reduced tillage, minimum tillage, no-till, direct drill, mulch tillage, stubble-mulch farming, trash farming, strip tillage, plough-plant.
 - ✓ With advanced soil conservation programmes, the concept of conservation tillage is the main theme of the recommendations for cropland.
 - ✓ The application is mainly in mechanized high production farming with good rainfall, or for the control of wind erosion where there is large-scale mechanized cereal production.
 - ✓ It is less applicable to low input level crop production, or subsistence agriculture.
- The principles are equally effective in any conditions - to maximize cover by returning crop residues and not inverting the top soil, and by using a high crop density of vigorous crops.

✓ Conservation tillage also has the advantage of reducing the need for terraces or other permanent structures. However there are several disadvantages which hinder the application of conservation tillage in semi-arid conditions:

✓ Dense plant covers may be incompatible with the well-tested strategy of using low plant populations to suit low moisture availability;

✓ Crop residues may be of value as feed for livestock;

✓ Planting through surface mulches is not easy for ox-drawn planters although there may be no problem with hand job planters.

2) DEEP TILLAGE

✓ One of the reasons for low yields in semi-arid areas is the limited amount of moisture available to crop roots.

✓ The available moisture will be increased if the rooting depth is increased and it has been shown that in some cases deep tillage can help, for example on the dense sandy soils.

✓ Deep tillage is beneficial for some crops but not all, and on some soils but not all.

✓ Deep tillage requires greater draught power which is usually in short supply in semi-arid areas.

✓ Ripping or subsoiling can be beneficial, either to increase the porosity of the soil, or to break a pan which is reducing permeability.

✓ The deep placement of fertilizer can also be used to encourage more rooting at depth, but again the application of this technique to subsistence farming will be difficult.

3) CONSERVATION FARMING

✓ It includes any farming practice which improves yield, or reliability, or decreases the inputs of labour or fertilizer, or anything else leading towards improved land husbandry, which we have defined as the foundation of good soil conservation.

✓ It includes strip cropping, crop rotations, alternate cropping, mixed cropping and interplanting, surface and mulching, organic mulches, deep planting of varieties, dry seeding etc.

4) CONTOUR-FARMING

✓ During intense rain storms, the soil cannot absorb all the rain as it falls. The excess water flows down the slope under the influence of gravity. If farming is done up and down the slope, the flow of water is accelerated, because each furrow serves as a rill. The major part of the rain is drained away without infiltrating into the soil. The top fertile soil, along with plant nutrients and seeds, is washed off. All this results in a scanty and uneven growth of a crop.

✓ —A simple practice of farming across the slope, keeping the same level, as far as possible is technically called contour-farming .



Advantages: 1) Contour-farming reduces run-off and prevents soil erosion as compared with the up and down cultivation in the major groups of soils in India, viz. Alluvial soils, black soils and deep lateritic soils. 2) Contour-farming conserves soil fertility and increases crop yields.



Counter cultivation

5) MULCHING



Surface mulches are used to prevent soil from blowing and being washed away, to reduce evaporation, to increase infiltration, to keep down, to improve soil structure and eventually to increase crop yields.



Inter-culture kills weeds and produces five or seven cm thick soil mulch which helps to reduce evaporation from the top soil.



It also breaks the surface crust which forms after each downpour.



6) GROWING OF COVER CROPS

- ✓ Cultivated legumes, in general, furnish a better cover and hence better protection to cultivated land against erosion than ordinary cultivated crops.
- ✓ The crops and the cropping systems will naturally vary from region to region, depending on the soil and climatic conditions.
- ✓ The mostly preferred cover crops are green gram, black gram, cowpea, groundnut etc.

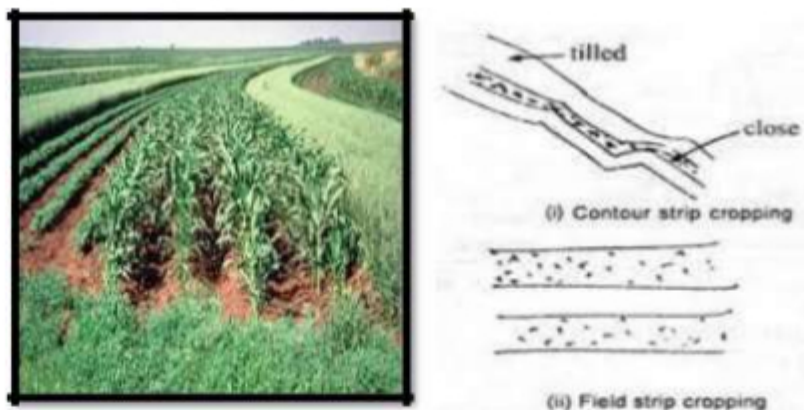
7) STRIP CROPPING

Strip cropping is the system of growing alternate strips of erosion permitting crops (row crop such as maize, jowar, bajra, cotton etc) and erosion resisting crops (close growing crops such as green gram, black gram, moth, groundnut etc.) in the same field. This practice reduces the velocity of runoff and checks the eroded soil from being washed away.

- ✓ Strip cropping is essentially for controlling the run-off erosion and thereby maintaining the fertility of the soil is now universally recognized. Strip cropping, in effect, employs several good farming practices, including crop rotation, contour cultivation, proper tillage stubble mulching, cover cropping, etc.

✓ Strip cropping is of the following different forms :

- (i) Contour strip cropping
- (ii) Field strip cropping
- (iii) Wind strip cropping
- (iv) Permanent or temporary buffer strip cropping



(i) Contour Strip Cropping



Contour strip cropping is the growing of soil exposing and erosion permitting crops in strips of suitable widths and placed across the slopes on contour, alternating with strip of soil protecting and erosion resisting crops.



Contour strip cropping shortens the length of the slope, checks the movement of runoff water, helps to desilt it and increases the absorption of rainwater by the soil.



Further, the dense foliage of the erosion resistant crops prevents the rain from beating the soil surface directly.



It is advisable to rotate the strip planting by sowing a non-resistant crop, following an erosion resistant crop and *vice versa*.

(i) Groundnut, Moth bean (*Phaseolus acontifolius*) and Horse gram (*Dolichos biflorus*) are the most efficient and suitable crops for checking erosion.

(ii) The normal seed-rates of leguminous crops, other than groundnut, do not give sufficiently dense canopies to prevent rain drops from beating the soil surface in many cases. The seed rate should be trebled.

(iii) The most effective width of the contour strips for cereals, such as Jowar and Bajra, is 21.6 m and for the intervening legume, it is 7.2 m.

Strip Widths as Suitable for Erosion Permitting and Resistant Crops on Different Slopes

<i>Slope</i>	<i>Width of Erosion-Permitting Crops</i>	<i>Width of Erosion-Resistant Crops</i>
1/2 per cent and below	45.0 m	9.0
Between 1 and 2 per cent	24.0	6.0
Between 2 and 3 per cent	13.5	4.5

(ii) Field Strip Cropping

It is the planting of field crops in more or less parallel strips across fairly uniform slopes, **but not on exact contours**. This system is useful on regular slopes and with soils of high infiltration rates.

(iii) Wind Strip Cropping



It consists of planting **tall growing crops such as jowar, bajra, maize, and short growing crops in alternately arranged** straight and long, but relatively narrow, parallel strips laid out right across the direction of the prevailing wind, regardless of the contour.

(iv) Permanent or Temporary Buffer Strip Cropping



In the case of permanent or temporary buffer strip cropping, permanent strips of grasses or legume or mixture of grass and legume are laid either in badly eroded areas or in areas that do not fit into a regular rotation, *i.e.* steep or highly eroded, slopes in fields under contour strip cropping.



These strips do not form part of the rotation practiced in normal strip cropping and they are generally planted with perennial legumes, grasses or shrubs on a permanent or temporary basis.

8) MIXED CROPPING



Mixed cropping is the growing of 2 or more crops simultaneously in the same field without any definite row pattern. This is done by mixing their seeds.



Important objectives of mixed cropping are a better and continuous cover of the land, good protection against the beating action of the rain, almost a complete protection against soil erosion and the assurance of one or more crops to the farmer.



Mixed cropping

B) ENGINEERING MEASURES

Engineering/Mechanical measures are construction of mechanical barriers across the direction of the flow of water to retain the runoff for reducing soil and water loss. They play a very vital role in controlling erosion on agricultural land. **They are generally adopted where land slope is >2 per cent** and to supplement the agronomical practices when the later alone are not adequately effective. These measures include:

1. Bunding
2. Terracing
2. Trenching
3. Basin-listing
4. Subsoiling

The main objectives of the mechanical measures for controlling erosion are:

- (i) To increase the time of concentration by intercepting the run-off and thereby providing an opportunity for the infiltration of water, and
- (ii) To divide a long slope into several short ones so as to reduce the velocity of the run-off and thus prevent erosion.

1) BUNDING

Bund is an earthen embankment constructed to control runoff and minimize soil erosion by reducing the length of slope.

(a) Contour Bunding



Contour bunding is most popular mechanical measure to control soil erosion and conserve moisture in arid and semi-arid areas with high infiltration and permeability.



This practice consists in making a comparatively narrow-based embankment at intervals across the slope of the land on a level that is along the contour.



It is commonly adopted on agricultural land up to a slope of about 6 per cent and in areas where average annual rainfall is < 600 mm.



Contour Bunding

(b) Graded Bunding/Channel Terraces

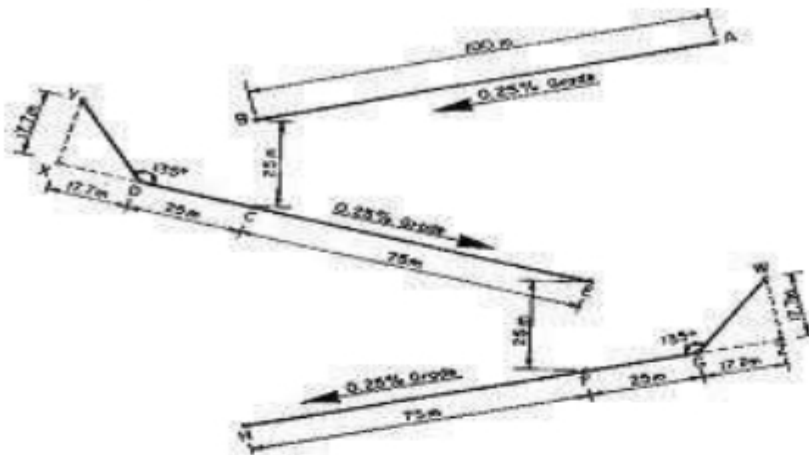


In graded bunding water flows in graded channels constructed on up-stream side of bunds and leads to safe outlet on grassed water ways.



Graded bunds may be narrow-based or broad-based. A broad-based graded terrace consists of a wide-low embankment constructed on the lower edge of the channel from which the soil is excavated. The channel is excavated at suitable intervals on a falling contour with a suitable longitudinal grade.

- It is adopted at about 2-10 per cent land slope and in areas where average annual rainfall is > 600 mm.



Graded Bunding

Grassed Waterways

- Grass waterways are natural or constructed watercourses covered with erosion resistant grasses and are used to dispose surface water from the crop land. They are constructed along the slope of the land.
- Grassed waterways are associated with channel terraces for the safe disposal of concentrated runoff, thereby protecting the land against rills and gullies.
- Grass waterways are also used to handle natural runoff or to carry the discharge from contour furrows, diversion channels or to serve as emergency spillway in farm ponds.
- The suitability of a grass was based on the cover it gave, the ease with which it was established and the forage yield obtained from it.
- *Panicum repens* was the best suited grass, followed by *Brachiara mutica*, *Cynodon plectostachyus*, *Cynodon dactylon* and *Paspalum notatum*.

2) TERRACING

A terracing is a combination of ridge and channels built across the slope. This is generally practiced in steep hill slope.



(a) Bench Terracing

- Bench terrace consists of construction of step like fields along the contour by half cutting and half filling. Original slope of the land is converted into level fields and thus all hazards of erosion are eliminated.
- The vertical drop may vary from 60 to 180 cm, depending upon the slope and soil conditions, as also on the economic width required for easy cultural operations.
- The material excavated from the upper part of the terrace is used in filling the lower part.
- A small 'shoulder' bund of about 30 cm in height is also constructed along the outer edge of the terrace.
- It is generally practiced on steep sloping (16-33 per cent) and undulated land.
- It helps to bring sloping land into different level strips to enable cultivation.
- Bench terraces may be 'table top' or sloping outward or inward with or without a slight longitudinal grade, according to the rainfall of the tract - medium, poor or heavy, and the soil and the subsoil are fairly absorptive or poorly permeable

(i) **Table top (level)**: adopted in medium rainfall (750 mm) areas, permeable soils and ideal where irrigation facility is available.

(ii) **Sloping inward**: adopted in heavy rainfall (>750 mm) areas

(iii) **Sloping outward**: adopted in low rainfall (<750 mm) areas

(b) Zing Terracing

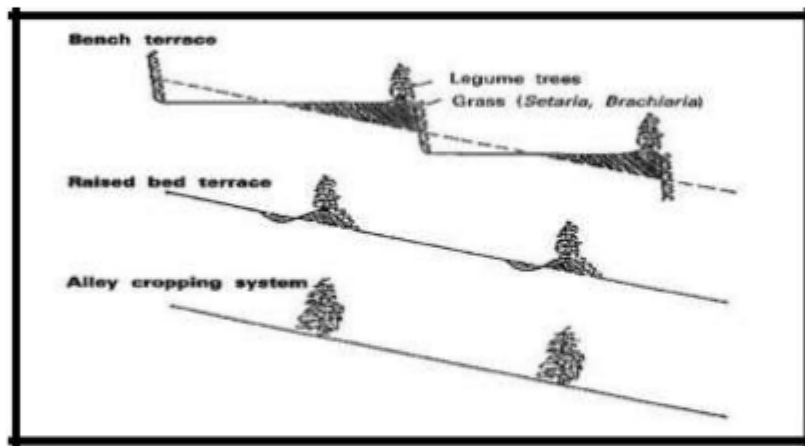
- ❑ Zing terracing is adopted in 3-10 per cent land slope.
- It is constructed in medium to deep soils in high rainfall areas.

- The aims of constructing zing terracing is:
 - ❑ To cut down the length of slope
 - ❑ To harvest the runoff from upper areas for the benefits of crops grown in lower areas.

3) TRENCHING

Trenching is made along the contour for soil & moisture conservation and afforestation purpose.

- The size of trenches – 60cm x 48cm
- Spacing between trenches – 10-30 meter
- Trenches are half refilled with excavated materials and remaining half of the soil forms the spoil bank.
- The remaining water in the trenches help in conserving the moisture and provides benefits for sowing and planting.



Trenching

4) BASIN-LISTING

Basin-listing consists in making of small interrupted basins along the counter with a special implement, called a **basin lister**. Basin-listing helps to retain rainwater as it falls and is specially effective on retentive soils having mild slopes.



5) SUBSOILING

This method consists of **breaking the hard and impermeable subsoil with a subsoiler to conserve more rainwater** by improving the physical conditions of a soil. This operation, which does not involve soil inversion and promotes greater moisture penetration into the soil, reduces both run-off and soil erosion. The subsoiler is worked through the soil at a depth of 30-60 cm at a spacing of 90-180 cm. Sub soiling by tractor drawn chisel plough at 2 m horizontal interval is the most effective insitu soil and water conservation practice for early establishment and improving the pasture. It will also increase the efficiency of work and a large area can be covered in a few cost and limited time.



MICROCATCHMENTS FOR SLOPING LANDS

It is useful for in-situ moisture conservation and erosion control for tree crops.

MICROCATCHMENTS

Salient Features

- Slope ranges from 2 –8 per cent
- Around 16 m² area surrounded by 15-20 cm dirtwall
- Bund height - 30 to 45 cm.
- Soil type - Light to moderate texture
- *In situ* moisture conservation with staggered planting
- Suitable for dry land Horticulture & Agroforestry



Microcatchment

CHECK DAM

- A low weir normally constructed across the gullies.
- Constructed on small streams and long gullies formed by erosive activity of flood water.
- It cuts the velocity and reduces erosive activity.
- The stored water improves soil moisture of the adjoining area and allows percolation to recharge the aquifers.
- Spacing between the check dams water spread of one should be beyond the water spread of the other.



Height depends on the bank height, varies from a metre to 3 metre and length varies from less than 3m to 10m.



Fig.12. Check dam

PERCOLATION POND: To augment the ground water recharge

Salient Features

- Shallow depression created at lower portions in a natural or diverted stream course.
- Preferable under gentle sloping stream where narrow valley exists.
- Located in soils of permeable nature.
- Adaptable where 20-30 ground water wells for irrigation exist within the zone of influence about 800 – 900m.
- Minimum capacity may be around 5000 m³ for the sake of economy.
- Also act as silt detention reservoir.



Fig.13. Percolation tank

BROAD BEDS AND FURROWS

The broad bed and furrow system is laid within the field boundaries. The land levels taken and it is laid using either animal drawn or tractor drawn ridgers.

Maize/Sorghum is grown in beds and rice in furrows.

Salient Features

- Conserves soil moisture in Dryland.
- Controls soil erosion.
- Acts as a drainage channel during heavy rainy days.



Classification of Gullies

Any system of gullies has an independent catchment, with a regular stream which has been termed the —drainage system . In each drainage system, it has been observed that gullies with defined side slopes, bed width and depths occur in a regular order. In the upper reaches of the drainage system, the gullies are wide and shallow, with varying side slopes. The middle part of the drainage system is usually deeper, wider and has uniform side slopes normally up to about 15 per cent. The lower portion of the drainage system which is nearer to the main river is usually very deep, has steep side slopes and is associated with intricate branch gullies.

The gullies have been classified as follows:

Symbol	Description	Specifications
G1	Very small gullies	Up to 3 m deep and bed width 18 m.
G1	Small gullies	Up to 3 m deep and bed width >18 m.
G1	Medium gullies	Depth between 3-9 m and bed width > 18 m
G1	Deep and narrow gullies	m deep with < 18m bed width

UNIVERSAL SOIL LOSS EQUATION

$$A = RKLSCP$$

where,

A: Predicted soil loss (tonne/acre/year)

R: Rainfall and runoff factor

K: Soil erodibility

S: Steepness (land slope)

C: Soil cover management

P: Erosion control practices

Design of Composite Check Dams

The design discharge (maximum run-off) through the drainage channel is computed from the empirical formula

$$Q = 0.0028 C.I.A.$$

where,

Q: Run-off in cubic metres per second (m³/sec).

C: Run-off coefficient (a value calculated by constants of slope and soil type).

I: Rainfall intensity in mm/hr.

A: Watershed area in hectare.

The length of the spillway is determined from the formula:

$$Q = 1.70 LH^{3/2}$$

where,

Q: Run-off in cubic metres per second (m³/sec).

L: Length of the weir notch in metres.

H: Height in metres of water flow above the spillway level.

Institute Involved in Soil and Water Conservation

1. Central Soil and Water Conservation Research and Training Institute (CSWCRTI), Dehradun, Uttarakhand.
2. Soil Conservation Research Demonstration and Training Centre, Hyderabad (AP).

In situ soil moisture conservation

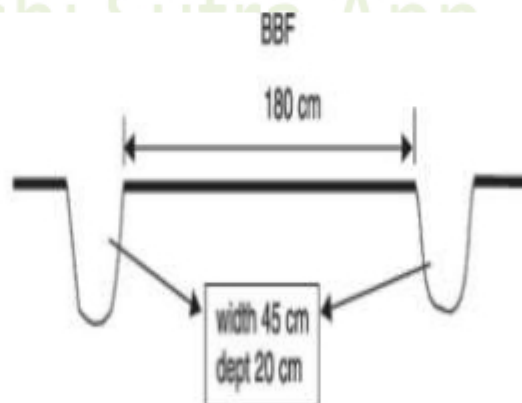
Storage of rainfall or rain water at the place where rainfall occurs for its effective usage is known as in situ moisture conservation. This can be achieved by different measures. Improving the soil surface conditions to increase infiltration of rainfall and reduction of runoff are the two basic requirements in dry lands. Hence land configuration determines the ease with which water can enter the soil. The different in situ moisture conservation practices which result in changed land configuration are as follows.

Ridges and furrows: The field must be formed into ridges and furrows. Furrows of 30-45 cm width and 15-20 cm height are formed across the slope. The furrows guide runoff water safely when rainfall intensity is high and avoid water stagnation. They collect and store water when rainfall intensity is less. It is suitable for medium deep to deep black soils and deep red soils. It can be practiced in wide row spaced crops like cotton, maize, chillies, tomato etc. It is not suitable for shallow red soils, shallow black soils and sandy/gravelly soils. It is not suitable for broadcast sown crops and for crops sown at closer row spacing less than 30 cm. Since furrows are formed usually before sowing, sowing by dibbling or planting alone is possible.

Tied ridging: It is a modification of the above system of ridges and furrows wherein the ridges are connected or tied by a small bund at 2-3 m interval along the furrows to allow the rain water collection in the furrows which slowly percolated in to the soil profile



Broad bed furrows (BBF): This practice has been recommended by ICRISAT for vertisols or black soils in high rainfall areas (> 750 mm). Here beds of 90-120cm width, 15 cm height and convenient length are formed, separated by furrows of 60 cm width and 15 cm depth. When runoff occurs, its velocity will be reduced by beds and infiltration opportunity time is increased. The furrows have a gradient of 0.6%. Crops are sown on the broad beds and excess water is drained through number of small furrows which may be connected to farm ponds. It can be formed by bullock drawn or tractor drawn implements. Bed former cum seed drill enables BBF formation and sowing simultaneously, thus reducing the delay between receipt rainfall and sowing.

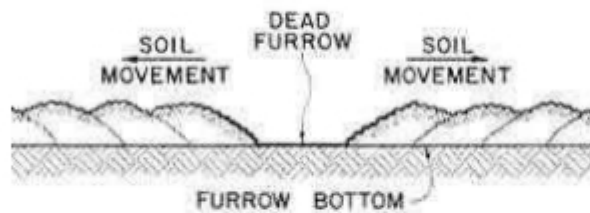


Broad bed furrow has **many advantages** over other methods.

- It helps in moisture storage
- Safely dispose off surplus surface runoff without causing erosion
- Provide better drainage facilities
- Facilitate dry seeding

- It can accommodate a wide range of crop geometry i.e. close as well as wide row spacing.
- It is suitable for both sole cropping and intercropping systems.
- Sowing can be done with seed drills.

Dead furrows: At the time of sowing or immediately after sowing, deep furrows of 20 cm depth are formed at intervals of 6 to 8 rows of crops. No crop is raised in the furrow. The dead furrows can also be formed between two rows of the crop, before the start of heavy rains (Sep – Oct). It can be done with wooden plough mostly in red soils. The dead furrows increase the infiltration opportunity time.



Compartmental bunding: Small bunds of 15 cm width and 15 cm height are formed in both directions to divide the field into small basins or compartments of square or rectangular shape of 6 x 6 m to 10 x 10 m size using bund former. They are useful for temporary impounding of rain water which facilitates high infiltration resulting in high moisture storage in the soil. Recommended for black soils with a slope of 0.5 to 1%. Maize, sunflower, sorghum perform well in this type of bunding.



Scooping: Scooping the soil surface to form small depressions or basins help in retaining rain water on the surface for longer periods. They also reduce erosion by trapping eroding sediment. Studies have shown that runoff under this practice can be reduced by 50 % and soil loss by 3 to 8 t /ha.

Inter plot water harvesting: Water is drawn from part of a small catchment and used in lower portion for crop production. There may be 1: 1 cropped: catchment

area or 1:2 catchment: cropped area.

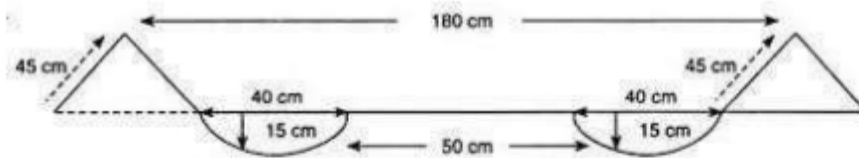


Fig. 5.5. Inter-plot or micro-plot water harvesting for field crops.

Zingg terracing or conservation bench terracing: These are developed by A.W.Zingg, in USA. Zingg terracing is practiced in low to medium rainfall areas in black soils with contour bunds. It is a method of land shaping where lower one third portion of the land adjacent to the contour is leveled to spread to the runoff water coming from the remaining two third portion of the field .This rainfall multiplication technique ensures at least one good crop in one third area even in low rainfall years. Usually during medium rainfall years water intensive crops (like paddy) are cultivated in the levelled portion (receiving area) while dry crops are cultivated in the unlevelled (donor) area.

Krushi Sutra App

5. Drought: types, effect of water deficit on physio-morphological characteristics of the plants

Introduction

Low rainfall or failure of monsoon rain is a recurring feature in India. This has been responsible for droughts and famines. The word drought generally denotes scarcity of water in a region. Though, aridity and drought are due to insufficient water, aridity is a permanent climatic feature and is the culmination of a number of long term processes. However, drought is a temporary condition that occurs for a short period due to deficient precipitation for vegetation, river flow, water supply and human consumption. Drought is due to anomaly in atmospheric circulation.

Aridity Vs. Drought

Particulars	Aridity	Drought
Duration	Permanent feature	Temporary condition of scarcity of varying duration
Factors	Culmination of many long term processes , considers all climatic features	Caused by deficient rainfall
Aspect described	Description of Climate	Description of Water availability

Definition of drought

There is no universally accepted definition for drought.

- a) Early workers defined drought as prolonged period without rainfall.
- b) According to Ramdas (1960) drought is a situation when the actual seasonal rainfall is deficient by more than twice the mean deviation.
- c) American Meteorological Society defined drought as a period of abnormally dry weather sufficiently prolonged for lack of water to cause a severe hydrological imbalance in the area affected.

Classification of drought:

Drought can be classified based on duration, nature of users, time of occurrence and using some specific terms.

1. Based on duration

a. Permanent drought: This is characteristic of the desert climate where sparse vegetation growing is adapted to drought and agriculture is possible only by irrigation during entire crop season.

b. Seasonal drought: This is found in climates with well defined rainy and dry seasons. Most of the arid and semiarid zones fall in this category. Duration of the crop varieties and planting dates should be such that the growing season should fall within rainy season.

c. Contingent drought: This involves an abnormal failure of rainfall. It may occur almost anywhere especially in most parts of humid or sub humid climates. It is usually brief, irregular and generally affects only a small area.

d. Invisible drought: This can occur even when there is frequent rain in an area. When rainfall is inadequate to meet the evapo-transpiration losses, the result is borderline water deficiency in soil resulting in less than optimum yield. This occurs usually in humid regions.

2. Based on relevance to the users (National Commission on Agriculture, 1976)

a) Meteorological drought: It is defined as a condition, where the annual precipitation is less than the normal over an area for prolonged period (month, season or year).

b) Atmospheric drought: It is due to low air humidity, frequently accompanied by hot dry winds. It may occur even under conditions of adequate available soil moisture. It refers to a condition when plants show wilting symptoms during the hot part of the day when transpiration exceeds absorption temporarily for a short period. When absorption keeps pace with transpiration the plants revive. (Mid day wilt).

c) Hydrological drought: Meteorological drought, when prolonged results in hydrological drought with depletion of surface water and consequent drying of reservoirs, tanks etc. It results in deficiency of water for all sectors using water. This is based on water balance and how it affects irrigation as a whole for bringing crops to maturity.

d) Agricultural drought (soil drought): It is the result of soil moisture stress due to imbalance between available soil moisture and evapotranspiration of a crop. It is usually gradual and progressive. Plants can therefore, adjust at least partly, to the increased soil moisture stress. This situation arises as a consequence of scanty precipitation or its uneven distribution both in space and time.

3. Based on time of occurrence

a) Early season drought: It occurs due to delay in onset of monsoon or due to long dry spells after early sowing

b) Mid season drought: Occurs due to long gaps between two successive rains and stored moisture becoming insufficient during the long dry spell.

c) Late season drought: Occurs due to early cessation of rainfall and crop water stress at maturity stage.

4. Other terms to describe drought

a) Relative drought: The drought for one crop may not be a drought situation for another crop. This is due to mismatch between soil moisture condition and crop selection. Eg. A condition may be a drought situation for growing rice, but the same situation may not be a drought for growing groundnut.

b) Physiological drought: Refers to a condition where crops are unable to absorb water from soil even when water is available, due to the high osmotic pressure of soil solution due to increased soil concentration, as in saline and alkaline soils. It is not due to deficit of water supply.

Important causes for agricultural drought are

- Inadequate precipitation
- Erratic distribution
- Long dry spells in the monsoon
- Late onset of monsoon
- Early withdrawal of monsoon
- Lack of proper soil and crop management

Effect of drought on crop production

a) Water relations: Alters the water status by its influence on absorption, translocation and transpiration. The lag in absorption behind transpiration results in loss of turgor as a result of increase in the atmospheric dryness.

b) Photosynthesis: Photosynthesis is reduced by moisture stress due to reduction in Photosynthetic rate, chlorophyll content, leaf area and increase in assimilates saturation in leaves (due to lack of translocation).

c) Respiration: Increase with mild drought but more severe drought lowers water content and respiration.

d) Anatomical changes: Decrease in size of the cells and inter cellular spaces, thicker cell wall, greater development of mechanical tissue. Stomata per unit leaf tend to increase.

e) Metabolic reaction: All most all metabolic reactions are affected by water deficits.

f) Hormonal Relationships: The activity of growth promoting hormones like cytokinin, gibberlic acid and indole acetic acid decreases and growth regulating hormone like abscisic acid, ethylene, etc., increases.

g) Nutrition: The fixation, uptake and assimilation of nitrogen is affected. Since dry matter production is considerably reduced the uptake of NPK is reduced.

h) Growth and Development: Decrease in growth of leaves, stems and fruits. Maturity is delayed if drought occurs before flowering while it advances if drought occurs after flowering.

i) Reproduction and grain growth: Drought at flowering and grain development determines the number of fruits and individual grain weight, respectively. Panicle initiation in cereals is critical while drought at anthesis may lead to drying of pollen. Drought at grain development reduces yield while vegetative and grain filling stages are less sensitive to moisture stress.

j) Yield: The effect on yield depends hugely on what proportion of the total dry matter is considered as useful material to be harvested. If it is aerial and underground parts, effect of drought is as sensitive as total growth. When the yield consists of seeds as in cereals, moisture stress at flowering is detrimental. When the yield is fibre or chemicals where economic product is a small fraction of total dry matter moderate stress on growth does not have adverse effect on yields.

6. Crop adaptation and mitigation to drought

Crop Adaptation:

The ability of crop to grow satisfactorily under water stress is called drought adaptation.

Adaptation is structural or functional modification in plants to survive and reproduce in a particular environment.

Crops survive and grow under moisture stress conditions mainly by two ways:

- (i) Escaping drought and (ii) drought resistance

1. Escaping Drought

Evading the period of drought is the simplest means of adaptation of plants to dry conditions. Many desert plants, the so called ephemerals, germinate at the beginning of the rainy season and have an extremely short life period (5 to 6 weeks) which is confined to the rainy period. These plants have no mechanism for overcoming moisture stress and are, therefore, not drought resistant. Germination inhibitors serve as safety mechanism.

In cultivated crops, the ability of a cultivar to mature before the soil dries is the main adaptation to growth in dry regions. However, only very few crops have such a short growing season to be called as ephemerals. Certain varieties of pearl millet mature within 60 days after sowing. Short duration pulses like cowpea, greengram, blackgram can be included in this category. In addition to earliness, they need drought resistance because there may be dry spells within the crop period of 60days. The disadvantage about breeding early varieties is that yield is reduced with reduction in duration.

2. Drought Resistance

Plants can adopt to drought either by avoiding stress or by tolerating stress due to different mechanisms. These mechanisms provide drought resistance.

3. Avoiding Stress

Stress avoidance is the ability to maintain a favourable water balance, and turgidity even when exposed to drought conditions, thereby avoiding stress and its consequences. A favourable water balance under drought conditions can be achieved either by: (i) conserving water by restricting transpiration before or as soon as stress is experienced; or (ii) accelerating water uptake sufficiently so as to replenish the lost water.

Strategies for drought management

The different strategies for drought management are discussed under the following heads.

1. Adjusting the plant population: The 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

a) 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.

b) 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.

2. Mid season corrections: The contingent management practices done in the standing crop to overcome the unfavourable soil moisture conditions due to prolonged dry spells are known as mid season conditions.

a) Thinning: This can be done by removing every alternate row or every third row which will save the crop from failure by reducing the competition

b) Spraying: In crops like groundnut, castor, redgram, etc., during prolonged dry spells the crop can be saved by spraying water at weekly intervals or 2 per cent urea at week to 10 days interval.

c) Ratooning: In crops like sorghum and bajra, ratooning can be practiced as mid season correction measure after break of dry spell.

3. Mulching: It is a practice of spreading any covering material on soil surface to reduce evaporation losses. The mulches will prolong the moisture availability in the soil and save the crop during drought conditions.

4. Weed control: Weeds compete with crop for different growth resources are seriously under dryland conditions. The water requirement of most of the weeds is more than the crop plants. Hence they compete more for soil moisture. Therefore the weed control especially during early stages of crop growth reduce the impact of dry spell by soil moisture conservation.

5. Water harvesting and life saving irrigation: The collection of runoff water during peak periods of rainfall and storing in different structures is known as water harvesting. The stored water can be used for giving the life saving irrigation during prolonged dry spells.

6. Use of wind breaks and shelterbelts: Wind breaks are any structures that obstruct wind flow and reduce wind speed while shelterbelts are rows of trees planted for protection of crops against wind. The direction from which wind is blowing is called windward side and direction to which wind is blowing is called leeward side. Shelterbelts are planted across the direction of wind. They do not obstruct the wind flow completely. Depending upon their porosity, certain amount of wind passes through the shelterbelts while the rest deflects and crosses over the shelterbelts. It thus reduces wind speed without causing turbulence. The protection offered by the shelterbelts is dependent on the height of central tree row in the shelterbelts. Generally, shelterbelts give protection from desiccating winds to the extent of 5 to 10 times their height on windward side and up to 30 times on leeward side. Due to reduction in wind speed, evaporation losses are reduced and more water is available for plants. The beneficial effects of shelterbelts are seen more clearly in drought years. In addition, shelterbelts reduce wind erosion.

Krushi Sutra App

7. Water harvesting: importance, its techniques, Efficient utilization of water through soil and crop management practices

Introduction

Rainwater is the key input in dryland agriculture. In a tropical country such as India which experiences extreme variation in rainfall both in space and time, rain water management assumes vital importance in cutting down risks and stabilizing crop production in dry areas. When rains are received with an intensity far reaching infiltration rate, runoff is inevitable. It varies from 10 to 40% of total rainfall. Of this at least 30% can be harvested into water storage structures.

Water Harvesting

The process of runoff collection during periods of peak rainfall in storage tanks, ponds etc., is known as water harvesting. It is a process of collection of runoff water from treated or untreated land surfaces/ catchments or roof tops and storing it in an open farm pond or closed water tanks/reservoirs or in the soil itself (in situ moisture storage) for irrigation or drinking purposes.

Runoff farming and rainwater harvesting agriculture are synonymous terms, which imply that farming is done in dry areas by means of runoff from a catchment. Runoff farming is basically a water harvesting system specially designed to provide supplemental or life saving irrigation to crops, especially during periods of soil moisture stress.

Collecting and storing water for subsequent use is known as water harvesting. It is a method to induce, collect, store and conserve local surface runoff for agriculture in arid and semiarid regions. All water harvesting systems have three components viz., the catchment area, the storage facility and the command area. The catchment area is the part of the land that contributes the rain water. The storage facility is a place where the runoff water is stored from the time it is collected until it is used. The command area is where water is used.

Methods of Water Harvesting

The different methods of water harvesting that are followed in arid and semiarid regions are discussed separately.

Arid Regions

The catchment area should provide enough water to mature the crop, and the type of farming practiced must make the best use of water. In general, perennial crops are suitable as they have deep root systems that can use runoff water stored deep in the soil which is not lost through evaporation.

Water Spreading: In arid areas, the limited rainfall is received as short intense storms. Water swiftly drains into gullies and then flows towards the sea. Water is lost to the region and floods caused by this sudden runoff can be devastating often to areas otherwise untouched by the storm. Water spreading is a simple irrigation method for use in such a situation. Flood waters are deliberately diverted from their natural courses and spread over adjacent plains. The water is diverted or retarded by ditches, dikes, small dams or brush fences. The wet flood plains or valley floods are used to grow crops.

Microcatchments: A plant can grow in a region with too little rainfall for its survival if a rain water catchment basin is built around it. At the lowest point within each microcatchment, a basin is dug about 40 cm deep and a tree is planted in it. The basin stores the runoff from microcatchment.

Semiarid Regions

Water harvesting techniques followed in semi-arid areas are numerous and also ancient.

Dug 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. To avoid the breaching of tank bund, spillways are provided at one or both the ends of the tank bund to dispose of excess water. The sluice is provided in the central area of the tank bund to allow controlled flow of water into the command area.

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. There are three types of excavated farm ponds – square, rectangular and circular.

Circular ponds have high water storage capacity. Farm ponds of size 100 to 300 m³ may be dug to store 30 per cent of runoff. The problem associated with farm ponds in red soils is high seepage loss. This can be reduced by lining walls. Some of the traditional methods for seepage control are the use of bentonite, soil dispersants and soil-cement mixture. Bentonite has excellent sealing properties if kept continuously wet, but cracks develop when dried. Soil-cement mixture can be used. A soil-cement lining of 100 mm thickness reduces seepage losses up to 100 per cent. The pit lined continuously develops cracks but no cracks develop when applied in blocks. The other alternative sealant for alfisols is a mixture of red soil and black soil in the ratio of 1: 2. In arid and semi-arid regions, rains are sometimes received in heavy down pours resulting in runoff. The runoff event ranges from 4 to 8 during the rain season in arid and semi-arid region. The percentage of runoff ranges from 10 to 30% of total rainfall. The size of the farm pond depends on the rainfall, slope of the soil and catchment area. The dimensions may be in the range of 10 m x 10 m x 2.5 m to 15 m x 15 m x 3.5 m. The side slope 1.5: 1 is considered sufficient. A silt trap is constructed with a width of slightly higher than the water course and depth of 0.5 to 1 m and with side slope of 1.5: 1.

Krushi Sutra App

Tillage

The mechanical manipulation of soil with tools and implements for obtaining conditions ideal for seed germination, seedling establishment and growth of crops is known as tillage. Tillage may be described as the practice of modifying the state of

the soil in order to provide conditions favourable to crop growth, The objectives of tillage in drylands are

- ❑ Develop desired soil structure for a seed bed which allows rapid infiltration and good retention of rainfall.
- ❑ Minimize soil erosion by following practices such as contour tillage, tillage across the slope etc.
- ❑ Control weeds and remove unwanted crop plants.
- ❑ Manage crop residues
- ❑ Obtain specific land configurations for in- situ moisture conservation, drainage, planting etc.
- ❑ Incorporate and mix manures, fertilizers, pesticides or soil amendments into the soil.
- ❑ Accomplish segregation by moving soil from one layer to another, removal of rocks or root harvesting.

Hence, attention must be paid to the depth of tillage, time of tillage, direction of tillage and intensity of tillage.

Seeding practices**Establishment of optimum population**

Poor or suboptimal population is a major reason for low yields in rainfed crops. Establishment of an optimum population depends on

- a) Seed treatment
- b) Sowing at optimum soil moisture
- c) Time of sowing
- d) Depth of sowing
- e) Method of sowing
- f) Crop geometry

Seed treatment

Seed treatment is done for many purposes such as protection against pests and diseases, inoculation of bio-fertilizers and inducing drought tolerance.

Seed hardening

It is done to induce drought tolerance in emerging seedlings. It is the process of soaking seeds in chemical solution and drying to induce tolerance to drought. Soil moisture stress immediately after sowing affects germination and establishment. Seed hardening enables seedlings to survive this early moisture stress. During seed hardening, seeds are subjected to partial hydration followed by dehydration before sowing. Seeds are soaked for specified time in chemical solutions of prescribed concentration. Soaked seeds are then dried in shade back to original moisture content. During soaking, seeds imbibe water and germination process is started but not completed. The hardened seeds are thus in a ready state for germination. When sown in moist soils, seeds germinate immediately. Such early germination helps in seedling emergence before surface soil dries up.

Sowing at optimum soil moisture

An effective rainfall of 20-25 mm which can wet a depth of 10-15 cm is needed for sowing. Moisture stress at or immediately after sowing adversely affects germination and establishment of seedlings. To ensure adequate soil moisture at sowing, sowing has to be done as early as possible after soaking rainfall is received. Sowing methods and implements play a crucial role in this regard.

Time of sowing

Optimum time of sowing is indicated by adequate rainfall to wet seedling depth and continuity of rainfall after sowing. The probable sowing time in a rainfed area is the week which has a rainfall of not less than 20 mm with coefficient of variability less than 100% and the probability of a wet week following wet week. Timely sowing ensures optimal yield besides it may also help pest avoidance. In Maharashtra kharif sorghum cultivated in 30 lakh hectares and more than 70% under hybrid prone to shoot fly. If sown at early July, the pest incidence can be avoided.

Optimum depth of sowing

When seeds are sown on surface or at very shallow depth, germination and seedling growth are affected when surface soil moisture dries up. Sowing at a depth where soil moisture availability is adequate, ensure early and uniform germination and seedling establishment. Optimum depth of sowing varies with crop, especially seed size and penetration power of plumule.

Crop	Depth of sowing (cm)
------	----------------------

Sesamum	1-2 cm
Pearl millet and minor millets	2-3 cm
Pulses, sorghum, sunflower	3-5 cm
Cotton, maize	5 cm

Method of sowing:

In dry lands, it is important to sow the seeds in moist soil layer to ensure proper germination and seedling emergence. It is therefore necessary to sow immediately after rainfall to avoid sowing in dry soil. It is also important to sow the seeds at correct depth, neither on the surface nor too deep. Establishment of an optimum population also depends on proper spacing between plants. The density, geometry, and depth of sowing are dependent on method of sowing. The sowing methods usually adopted in dry lands include broadcasting, sowing behind plough and sowing by seed drills. Dibbling of seeds and planting of seedlings are also adopted for some crops (Cotton, tobacco, chillies). Each method has advantages as well as limitations. The choice of sowing method depends on seed size, soil condition, time available, cropping system, crop geometry, sowing depth, source of power, cost of sowing, etc.

Crop geometry:

Crop geometry refers to the shape of land occupied by individual plants as decided by spacing between rows and between plants. It depends on the root spread and the canopy size of the crop and the cropping system.

Anti-transpirants

Any material that is applied on transpiring plant surface for reducing water loss is called antitranspirants. The antitranspirants are also known as transpiration suppressants. The best anti transpirants reduce transpiration losses up to 30-40%. There are four types of anti transpirants.

a. Stomatal closing type: Transpiration mostly occurs through stomata on the leaf surface. Some fungicides like PMA (phenyl mercuric acetate) and herbicides like atrazine in low concentrations serve as anti transpirants by closing of stomata. PMA is known to inhibit mesophyll photosynthesis. Though the success was reported from glasshouse studies, their effectiveness under field conditions is limited.

b. Film forming type: The plastic and waxy materials, which form a thin film on the leaf surface, retard the escape of water due to formation of physical barrier. The

success of these chemicals is limited since they also reduce photosynthesis. The desirable characteristics of film forming type of antitranspirants are: they should form a thin layer, they should be more resistant to the passage of water vapour than carbon dioxide and

the film should maintain continuity and should not break. These film forming anti transpirants may be of either thin film or thick film.

Thin film forming type: Hexadeconol

Thick film forming type: Mobileaf, Polythene S-60

c. Leaf reflectant type: These are the white materials, which form a coating on the leaves and increase leaf reflectance (albedo). By reflecting the radiation they reduce leaf temperatures and vapour pressure gradient from leaf to atmosphere and hence reduces transpiration. About 5% of kaolin spray reduces the leaf temperature by 3-4°C and decrease in transpiration by 22 to 28 per cent. Celite and hydrated lime are also used as reflectant type of anti transpirants.

d. Growth retardant type: These chemicals reduce shoot growth and increase root growth and thus enable the plants to reduce transpiring surface and resist drought conditions. They increase root/shoot ratio.

Eg : Cycocel – (2-chloroethyl) Trimethyl ammonium chloride (CCC), Phosphon– D, Maleic Hydrazide (MH)

Antitranspirants generally reduce photosynthesis. Therefore, their use is limited to save the crop from death under severe moisture stress. If crop survives, it can utilise the rainfall that is received subsequently. Antitranspirants are also useful for reducing the transplantation shock of nursery plants. They have some practical use in nurseries and horticultural crops. Waxy materials are used for reducing post harvest shrinkage of fruits.

Evapotranspiration

Definition:

Under dry land conditions soil moisture is the most limiting factor for crop production. It is lost as evaporation from soil surface and as transpiration from the plant surfaces. The combined loss of moisture through these two processes is known as evapotranspiration.

Methods to reduce evaporation:

There are three principles of evaporation control under field conditions.

Krushī Sūtra App

layer of a treated soil dries out more rapidly than that of untreated soil, creating a diffusional layer to evaporation.

e. Vertical mulching: It is a technique wherein trenches of 40 cm wide, 15 cm deep are dug at 2 to 4 m interval across slope and filled with stubbles or organic wastes to a height of 10 cm above soil surface. Runoff is checked, collected in the shallow trenches and redistributed to adjoining soil layers and infiltration is increased in black soils.

f. Live mulching: Is the term used to describe the covering of soil surface through the plant canopy in intercropping system. Eg. Sorghum + forage cowpea, sorghum + sword bean

g. Pebble mulch: Where small pebbles like stone are placed on the soil surface. This mulching will be successful in dryland fruit tree culture. The pebbles placed on the basins of trees not only reduce evaporation but also facilitate infiltration of rain water into the basin. Mulching is more advantageous during rabi/summer months than in kharif season. Organic mulches particularly under receding soil moisture conditions increase crop growth by conserving soil moisture.

Effect of mulches on soil properties

1. Soil structure: Surface mulches reduce the impact of falling raindrops, thus reducing dispersion and sealing of soil pores leading to crust formation. Hence the soil structure is protected. The mulches also improve soil structure due to decomposition of mulch.

2. Soil salinity: Under dry land conditions due to limited precipitation, soluble salts move only to a limited depth and readily return to the surface as the soil water evaporates. Due to salt accumulation in surface layers the germination and seedling establishment may be adversely affected. Hence, mulches will reduce soil salinity problem by increasing infiltration and reducing evaporation.

3. Soil water: The soil moisture content is improved by induced infiltration, reduced evaporation and reduced transpiration by weeds. Surface mulches also obstruct the free exchange of water vapour from soil surface into the atmosphere and hence increase soil water content.

4. Soil temperature: The effects of mulches on soil temperature are highly variable and depend up on the type of mulch material. White or reflective type of plastic mulches generally decrease soil temperature, while black plastic mulches may increase soil temperature. Crop residues moderate temperature by decreasing it in summer and by increasing in winter season. This is due to combined effect of

Krushī Sūtra App

radiation interception and evaporative cooling. The sugarcane trash mulch will enhance the germination of sugarcane setts during summer by temperature reduction.

5. Soil erosion: The ease by which soil particles are moved by wind and water is related to size of soil particles and wind and water velocity. The particles of size greater than 0.84 mm in diameter are generally not eroded by wind but they are easily eroded by water. The mulches reduce the direct impact of falling raindrops on soil, thereby preventing soil dispersion and consequent sealing of soil pores leading to reduced soil erosion.

Reducing losses due to transpiration

Nearly 99% of water absorbed by the plant is lost in transpiration. Hence transpiration reduction is needed for maintaining favorable water balance in the plants. Transpiration has become unavoidable evil as the stomata, which allow CO₂ exchange also allows water vapour transfer into the atmosphere.

There are four principles of transpiration control

- a. By increasing leaf resistance to water vapour transfer by application of materials, which tend to close or cover stomata (ex: both stomatal closing and film forming type of antitranspirants).
- b. By reducing amount of energy absorbed by leaf surface (Eg: leaf reflectants)
- c. By reducing top growth of plants (Eg: Growth retardants)
- d. By increasing air resistance to water vapour transfer by shelter belts/ wind breaks

The transpiration losses can be controlled by use of antitranspirants, use of wind breaks/shelter belts and efficient weed control

9. Contingent crop planning for aberrant weather conditions

Effect of aberrant weather conditions on crops Rainfall behaviour in dry farming areas is erratic and uncertain. The deviations in rainfall behaviour commonly met with in dry areas include delayed onset, early withdrawal and intermediary dry spells during rainy season. The adverse effect of these rainfall aberrations on crop growth vary with the degree of deviation and the crop growth stage at which such deviations occur. Suitable manipulations in crop management practices are needed to minimize such adverse effects of abnormal rainfall behaviour. These management decision, constitute contingency planning. Such management practices done after crop establishment and in the middle of crop growth are called mid season or mid term corrections.

Rainfall aberration	Effect on crops	Midterm correction
Delay in onset of rainfall	Length of cropping season or cropping duration is reduced - crop sowing is delayed	Alternate crops of short duration to be sown
Early withdrawal or cessation of Rainfall	Moisture stress at maturity grain filling is affected (terminal stress)	Antitranspirant spray, harvesting for fodder (millets), harvesting at physiological maturity
Intermediate dry spells		
Immediately after sowing	Germination will be affected, plant population will be reduced	Gap filling with subsequent rains if stand reduction is less than 20%. Re-sowing if stand reduction is more than 20%, mulching between crop rows. Stirring soil surface to create dust mulch to reduce evaporation
At vegetative phase	Affects stem elongation, leaf area expansion, branching or tillering	Mulching, antitranspirant spray, spraying potassium chloride, thinning of 33-50 % population
At flowering	Affects anthesis and pollination, grain / pod number is reduced	Antitranspirant spray, harvesting for fodder and ratooning with subsequent rains in millets (e.g sorghum)
At ripening	Grain filling and grain size	Antitranspirant spray,

	reduced	harvesting for fodder, Harvesting at physiological maturity
--	---------	---

Contingency cropping is growing of a suitable crop in place of normally sown highly profitable crop of the region due to aberrant weather conditions. In dryland agriculture, contingency of growing another crop in place of normally grown crop arises due to delay in the onset of monsoon. Depending upon the date of receipt of rainfall, crops are selected. It is assumed that the rainfall for the subsequent period is normal and depending upon the economic status of the farmer, certain amount of risk is taken to get good profits if season is normal or better than normal. Contingency cropping is highly location specific due to variation in amount and distribution of rainfall. Especially in arid regions, the spatial distribution of rainfall is highly variable. It is common to observe that rainfall received varies from field to field in the same location. Temperature gradually falls from August onwards reaching minimum in November and December. Contingency plan and midterm corrections vary with the type and time of occurrence of rainfall aberration.

Crops have to be selected with suitable crop duration to coincide with the length of the growing season. Generally short duration pulses like greengram, blackgram and cowpea may suit the situation. However if the monsoon turns to be extraordinarily good, opportunity is lost if only short duration crops are sown. Farmers with economic strength and motivation for high profits with some amount of risk can go for crops of long duration. The long duration crops with flexibility or elasticity in yield are more suitable. For example, pearl millet, and sorghum can be ratooned if monsoon extends. Sunflower can be introduced for higher profits with certain amount of risk. Crops like sorghum, pearl millet, can be grown for grain if monsoon extends and if not, fodder can be obtained.

Sr.No.	Onset of rains	Suitable crops for sowing	Unsuitable crops
1	15 June to 30 July	All <i>Kharif</i> crops	---
2	1 July to 7 July	All <i>Kharif</i> crops	---
3	8 July to 15 July	Cotton, Sorghum, Pearl millet, Soybean, Pigeonpea, Sesamum, Sunflower	Groundnut, greengram and black gram
4	16 July to 31 July	Pearl millet, Sunflower, Soybean+Pigeonpea, Pearl millet + Pigeonpea, Castor + Fenugreek, Castor + Pigeonpea	Cotton, Sorghum, Groundnut

5	1 August to 15 August	Castor , Sesamum, Pearl millet, Sunflower, Castor + Fenugreek, Castor + Pigeonpea	Cotton, Sorghum, Groundnut
6	16 August to 31 August	Sesamum, Pearl millet, Sunflower, Castor + Fenugreek, Castor + Pigeonpea and Fenugreek	Cotton, Sorghum, Groundnut, Sesamum
7	20 September to 30 September	Rabi sorghum, Safflower, Sunflower	Gram, Wheat and Linseed
8	1 October to 15 October	Rabi sorghum, Safflower, Linseed	Sunflower, Wheat
9	16 October to 1 November	Gram, Safflower, Wheat and Linseed	<i>Rabi</i> sorghum, Sunflower

Krushi Sutra App

10. Concept, objective, principles and components of watershed management

Introduction

Soil, water and vegetation are the three important natural resources. As these resources are interdependent there is a need to have a unit of management for most effective and useful management of these resources. In this context, watershed is an important unit for the management of the natural resources.

Concept of watershed management

A watershed is defined as any spatial area from which runoff from precipitation is collected and drained through a common point or outlet. In other words, it is a land surface bounded by a divide, which contributes runoff to a common point (Fig.). It is defined as unit of area, which covers all the land, which contributes runoff to a common point. It is synonymous with a drainage basin or catchment area. The basic unit of development is a watershed, which is a manageable hydrological unit. The watershed is also known as ridgeline in U.K.

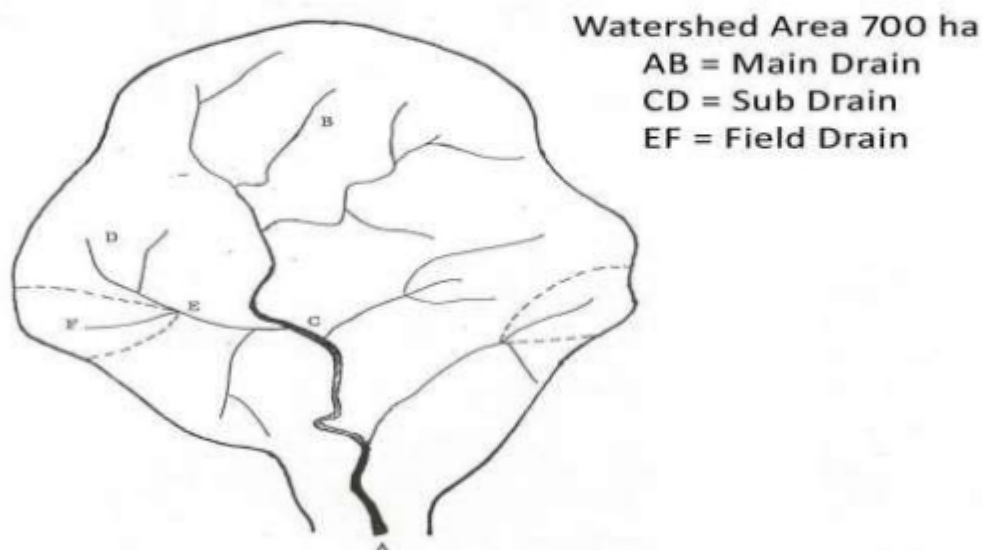


Fig. watershed with main and sub drains

Watershed management implies the wise use of soil and water resources within a given geographical area so as to enable sustainable production and to minimize floods.

Watershed management is the rational utilization of land and water resources for optimum production with minimum hazard to natural resources.

Principles of watershed management

- Utilizing the land based on its capability
- Protecting the fertile top soil
- Minimizing the silting up of the reservoirs and lower fertile lands
- Protecting vegetative cover throughout the year
- Insitu conservation of rain water
- Safe diversion of surface runoff to storage structures through grassed water ways
- Stabilization of gullies and construction of check dams for increasing ground water recharge.
- Increasing cropping intensity through inter and sequence cropping.
- Alternate land use systems for efficient use of marginal lands
- Water harvesting for supplemental irrigation
- Ensuring sustainability of the ecosystem
- Maximizing farm income through agricultural related activities such as dairy poultry, sheep, and goat farming
- Improving infrastructural facilities for storage transport and agricultural marketing
- Setting up of small scale agro industries and
- Improving socio-economic status of farmers.

Objectives of watershed management

The term watershed management is synonymous with soil and water conservation with the difference that emphasis is on flood protection and sediment control besides maximizing crop production. The watershed aims ultimately at improving standards of living of common people in the basin by increasing their earning capacity, by offering facilities such as electricity, drinking water, irrigation water, freedom from fear of floods, drought etc.

The objectives of watershed management programme can also be described in symbolic form by the expression: **POWER**. Here the letters symbolize the following:

P = Production of food-fodder-fuel-fruit-fibre-fish-milk combined on sustained basis

- Pollution control
- Prevention of floods

O= Over exploitation of resources to be minimized by controlling excessive biotic interferences like over grazing

- Operational practicability of all on farm operations and follow up programmes including easy approachability to different locations in watershed

W = Water storage at convenient locations for different purposes

- Wild animal and indigenous plant life conservation at selected places

E = Erosion control

- Ecosystem safety
- Economic stability
- Employment generation

R = Recharge of ground water

- Reduction of drought hazards
- Reduction of siltation in multipurpose reservoirs
- Recreation

Components of watershed management:

The main components of watershed programme are:

1. Soil and water conservation
2. Water harvesting
3. Crop management and
4. Alternate land use systems

1. Soil and water conservation measures

These measures coupled with water harvesting help to improve the moisture availability in the soil profile and surface water availability for supplemental irrigation. Based on the nature and type of hydraulic barriers and their cost the conservation measures in arable lands can be divided into three categories:

Permanent treatments (Hardware treatments)

Semi permanent treatments (medium software treatments) and

Temporary treatments (software treatments).

a. Permanent measures: These measures are provided for improvement of relief, physiography and drainage features of watershed, aimed at controlling soil erosion, regulating surface runoff and reducing peak flow rates. Bunds, terraces and waterways are the permanent measures in watershed management.

Waterways: both with and without vegetation- grassed waterways for safe disposal of runoff water.

Bunds: contour bunds –Suitable for low rainfall areas (< 600 mm) and in permeable soils having slope up to 6%.

Graded bunds – Suitable for high rainfall areas (> 600 mm) and for poor permeable soils having 2-6% slope.

Terraces: Bench terracing: suitable for soils having slopes 16 to 33%. Bench terraces reduce both slope length and degree of slope.

b. Semi permanent measures: These are usually interbund treatments where field sizes are large in conventionally banded area. They are adopted to minimize the velocity of overland flow. These measures may last for 2 to 5 years.

i. **Small section / key line bunds:** A small section bund may be created across the slope at half of the vertical bund spacing, which needs to be renovated at an interval of 2-3 years.

ii. **Strip Levelling:** Levelling of about 4 to 5 m strips of land above the bund across the major land slope help in reducing the velocity of surface flow. Strip levelling can be done by running blade harrow at an interval of 2 to 4 years.

iii. **Live beds:** One or two live beds of 2-3 m width on contour or on grade also serve the purpose. The vegetation on the beds may be annual or perennial or both.

iv. **Vegetative or live barriers:** One or two barriers of close growing grasses or legumes along the bund and at mid length of slope can filter the runoff water or slow down over land flow. Khus grass is widely recommended as vegetative barrier.

c. Temporary measures (Software treatments): These are simple treatments for in situ moisture conservation and needs to be remade or renovation every year.

Simple practices like contour farming, compartmental bunding, broad bed and furrows, dead furrows, tillage and mulching have gained wide acceptance in the recent past.

2. Water harvesting: The water harvesting structures and the use of harvested water for life saving irrigation in watershed areas.

3. Crop management

Location specific package of practices for dryland crops have been developed by dryland research centres and state agricultural universities for all the crops and cropping systems which include.

- a) Selection of crops and cropping systems to suit length of growing season
- b) Optimum sowing time
- c) Fertilizer schedules and balanced use of plant nutrients for crops and cropping systems
- d) Weed management and package of practices for aberrant weather
- e) Contingent cropping

4. Alternate land use systems: A pattern of land use that is different from the existing or the conventional can be described as an alternative land use system. The term alternate land use is applicable to all classes of land to generate assured income with minimum risk through efficient use of available resources.

The advantages of alternative land use systems are

- Optimizing resource use by enhancing biological productivity and profitability,
- Conserving and enhancing the quality of resource base,
- Integrating crops (arable and pastoral) and livestock,
- Making agriculture less dependent on off-farm inputs,
- Generating employment potential, and
- Improving overall quality of farm life.

Commonly known alternate land use systems are agroforestry (agrisilviculture, silvipasture, agrihorticulture and alley cropping), tree farming and ley farming.

5. LAND CAPABILITY CLASSIFICATION

Land-capability classification: Any soil and water-conservation project includes two distinct sets of operations, *viz.*

1. The mapping of land for classification according to its capability, and
2. Planning and executing measures to check erosion, improve land productivity and reclaim wasteland.

The farm plans for effective soil and water conservation are based largely on the capability of the land. The land-capability classification map is normally prepared by interpreting a standard soil-survey map.

“Land-capability classification is a systematic arrangement of different kinds of lands according to those properties that determine the ability of the land to produce crops on a virtually permanent basis.”

The factors determining land-capability: There are the major soil characteristics of the land, *e.g.* the texture of the top soil, its effective depth, permeability of the top soil and subsoil, and associated land features, *e.g.* the slope of the land, the extent of erosion, the degree of wetness and susceptibility to overflowing and flooding. The grouping of soils into capability classes is done primarily on the basis of their capability to produce common cultivated crops and pasture plants without deterioration over a long period.

Land-capability Classes

The land-capability classes are based on the intensity of hazards and the limitations of use. The land-capability classes range from the best and most easily farmed land to that which has no value for cultivation, grazing or forestry, but which may be suited to wild-life, recreation or for watershed protection. They are fall into 2 broad groups: one suitable for cultivation and other land uses, and the other not suitable for cultivation, but suitable for other land uses.

LAND SUITABLE FOR CULTIVATION

CLASS I (Green Color)



Soils in class I have very few or no limitations that restrict their use.



This type of land is nearly level (1 per cent land slope) and the erosion hazard is low.



The soils are deep, well-drained, easily worked, hold water well and are either fairly well supplied with plant nutrients or highly responsive to the application of fertilizers.

- ☐ The soils are not subject to damage because of overflow.
- ☐ The local climate must be favorable for growing many of the common field crops.
- ☐ In irrigated areas, the soils may be in class I, if the limitation of the arid climate has been removed by relatively permanent irrigation works.
- ☐ These soils need ordinary management practices to maintain productivity. Such practices may include the use of one or more of the following: fertilizers, lime, cover and green-manure crops, conservation of crop residues and crop rotations.
- ☐ Soils in this class are suited to a wide range of plants, may be used for cultivated crops, pastures, forests, and wildlife, food and cover.

CLASS II (Yellow Color)

- ☐ Soils in class II have some limitations which reduce the choice of plants or require simple conservation practices.
- ☐ The limitations of soils in class II may result from the effects of one or more of the following factors: (i) a gentle slope, (ii) a slight susceptibility to erosion, (iii) less than ideal soil depth, (iv) occasional damaging overflow, (v) wetness which can be corrected by drainage, but existing permanently as a moderate limitation, (vi) slight to moderate salinity or sodium, easily corrected but likely to recur, and (vii) a slight climatic limitation on soil use and management.
- ☐ The length of slope of land is 1-3 per cent and the depth of soil is from 22.5 to 45cm.
- ☐ These soils require careful management. The limitations are only a few and the practices are easy to apply.
- ☐ They may need one or more of the following practices: terracing, strip cropping, contour cultivation, water disposal area, covered with vegetation crop rotation, cover and green-manure crops, stubble mulching, use of fertilizers, manure and lime.
- ☐ These soils may be used for growing cultivated crops, Agri-horticulture, Alley cropping, raising pastures, forests, and for wild-life, food and cover.

CLASS III (Red Color)

- ☐ Soils in class III have moderate limitations which reduce the choice of plants or require special conservation practices.
- ☐ The length of slope of land is 3-5 per cent.
- ☐ Soils in class III have more restrictions than those in class II and, when used for cultivated crops, the conservation practices are usually more difficult to apply and to maintain.

Limitations of soils in class III may result from the effects of one or more of the following factors: (i) a moderately sloping land, (ii) moderately susceptibility to water or wind erosion, (iii) frequent overflow accompanied with some crop damage, (iv) very slow permeability of the sub-soil, (v) wetness or continuing water-logging after drainage, (vi) shallow soil depth up to the bed-rock, hard-pan or clay-pan which limits the rooting-zone and water storage, (vii) low moisture-holding capacity, (viii) moderate salinity or sodium, and (ix) moderate climatic limitations.



These soils may be used for Agri-horticulture and Alley cropping.

CLASS IV (Blue Color)



Soils in class I V have severe limitations that restrict the choice of plants and require careful management.



The length of slope of land is 5-10 per cent.



The restrictions in the use of these soils are greater than those in class III and the choice of plants is more limited. When these soils are cultivated, very careful management is required and the conservation practices are more difficult to apply and to maintain.



The use of these soils for cultivated crops is limited as a result of the effect of one or more of the permanent features, such as (i) steep slopes, (ii) severe susceptibility to water or wind erosion, (iii) severe effect of past erosion, (iv) shallow soil, (v) low moisture-holding capacity, (vi) frequent overflow accompanied with severe crop damage, (vii) excessive wetness or continuing hazard of water-logging after drainage, (viii) severe salinity or sodium, and (ix) moderately adverse climate.



These soils can be used for close growing crops, forage cultivation, Agri-Silviculture, Agri-Horticulture, fish culture, pastures, forests, and wild-life food and cover.

LAND NOT SUITABLE FOR CULTIVATION

CLASS V (Dark Green)



Soils in class V have little or no erosion hazard, but have other limitations, the removal of which is not practicable. They are used largely for pastures, forests, and wild-life food and cover.



The length of slope of land is 10-15 per cent.



Such land is nearly level and is not subject to more than slight wind or water erosion.

?

Cultivation is not feasible because of one or more limitations, such as overflow, stoniness, steep slope, wetness or severe climate. Examples of class V land are (i) soils of lowlands subject to frequent overflows which prevent the normal production of cultivated crops, (ii) nearly level soils with growing season that prevents the normal production of cultivated crops, (iii) the level or nearly level stony or rocky soils, and (iv) ponded areas where drainage for cultivated crops is not feasible but where soils are suitable for grasses or trees.

?

Soils in class V are not suitable for raising cultivated crops, but are suitable for perennial vegetation (silvipasture). Pastures can be improved, and benefits from proper management can be expected. Physical conditions of soils are such that it is practicable to apply pasture improvements, if needed, such as seeding, liming, fertilizing, and water control with contour furrows, drainage ditches, diversions of water spreaders.

CLASS VI (Orange Color)

?

Soils in class VI have severe limitations that make them unsuitable for cultivation and limit their use largely for pastures, or forests, or wild-life food and cover.

?

The land slope varies from 15-25 per cent.

?

Soils in class VI have continuing limitations which cannot be corrected, such as (i) steep slope, (ii) very severe erosion hazard, (iii) very severe effect of past erosion (iv) stoniness, (v) shallow rooting-zone, (vi) excessive wetness or overflow, (vii) low moisture capacity, (viii) salinity or sodium, and (ix) severe climate.

?

Soils in this class are subject to moderate limitations under grazing or forestry use.

CLASS VII (Brown Color)

?

Soils in class VI I have very severe limitations that make them unsuitable for cultivation and restrict their use largely to grazing, or forestation, or wildlife food and cover.

?

The land slope varies from 25-33 per cent.

?

The soils in this class are subject to dry and marshy conditions, eroded and undulated land and steep slope.

?

After well care, the soils of this class can be used for forestry and pasture.

CLASS VIII (Purple Color)

?

Soils and land forms in class VIII have limitations that preclude their use for commercial plant production and restrict their use to recreation, wild-life

food and cover or to water-supply, water shed protection or for aesthetic purposes.

☒ The land have highly steepness (>33 per cent).

☒ Limitations which cannot be corrected may result from the effects of one or more of the following factors: (i) erosion or erosion hazard, (ii) severe climate, (iii) wet soil, (iv) stones, (v) low moisture capacity, (vi) salinity or sodium.

☒ Bad lands, rock outcrops, sandy beaches, marshes, deserts, river wash, mine tailings and other nearly barren lands are included in class VIII in order to protect other more valuable soils to control water or for wild-life or for aesthetic reasons.

Steps in watershed development:

Step 1. Identification and selection of watershed

The boundary of the watershed has to be marked by field survey starting from the lowest point of the water course and proceeding upwards to the ridge line. The area may vary as low as 100 ha to as high as 10,000 ha.

Step 2. Description of watershed

Basic information has to be collected on—

- ☒ Location
 - ☒ Area, shape and slope
 - ☒ Climate
- ☒ Soil—geology, hydrology, physical, chemical and biological properties, erosion level
- ☒ Vegetation—native and cultivated species
- ☒ Land capability
- ☒ Present land use pattern
- ☒ Crop pattern, cropping system and management
- ☒ Farming system adopted
- ☒ Economics of farming
- ☒ Manpower resource
- ☒ Socio economic data
- ☒ Infrastructural and institutional facilities

Step 3. Analysis of problems and identification of available solutions

Step 4. Designing the technology components

- o Soil and moisture conservation measures
- o Run off collection, storage and recycling
- o Optimal land use and cropping system
- o Alternate land use system and farming system
- o Other land treatment measures
- o Development of livestock and other allied activities
- o Ground water recharge and augmentation

Step 5



Preparation of base maps of watershed incorporating all features of geology, hydrology, physiography, soil and proposed development measures for each part of watershed.

Step 6



Cost-benefit analysis to indicate estimated cost of each component activity, total cost of project and expected benefit.

Step 7



Fixing the time frame to show time of start, duration of project, time frame for completion of each component activity along with the department/agency to be involved in each component activity.

Step 8



Monitoring and evaluation to assess the progress of the project and to suggest modification if any

Step 9



On-farm research to identify solutions for site-specific problems.

Problems of watershed:

Physical problems: Steep slopes, bad lands, weak geological formations etc., can be found by observation of the existing maps. Problems such as heavy and intense rainfall, excessive runoff and strong winds can be identified from the weather and hydrological data.

Resource use problems: Problems such as shifting cultivation, forest destruction, fire, over grazing, poor road construction and uncontrolled mining should be identified.

End problems: The final effects of watershed degradation i.e. soil erosion, land slides, heavy sedimentation, water pollution, floods and droughts must be identified as quickly

as possible. By analyzing the information like history, frequency and extent of these problems can be determined.

Socio economic and other problems: Serious socio economic problems can be major obstacles in carrying out watershed work. Any serious problem should be identified at the beginning of the stage. These may include land tenure, poverty, lack of education, low acceptance of innovations, seasonal shortage of labour etc.

Krushī Sūtra App

