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A Water Conservation Technique: Continuous Contour Trenches

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Abstract-As agriculture is traditionally the major economic activity in Maharashtra, soil and water are two basic essentials for agriculture**.** Maharashtra is the third largest State in Union of India considering population as well as area. The rainfall varies from 400 mm to 6000 mm. The agriculture suffers due to vary of monsoon. Nearly 82% area under Maharashtra state is a drought prone area, especially Vidharbha and Marathwada regions. Because of the continuous negligence of water and soil conservation practices by people and society, the intensity of drought is becoming more and more severe with every passing year. At the end of 20th century new water conservation technique known as continuous contour trenches (CCT) is introduced, accepted, popularized and practiced in Maharashtra. Few micro watersheds are treated with integrated watershed management measures where CCT is widely used. This technique should be given more focus as it is ideal for increase in infiltration of rain water, reduces runoff, reduces the soil loss and increase the ground water level. This is useful for increasing agriculture productivity and solving the problem of shortage of water availability. Also due to construction of CCTs at areas of low rainfall or high rainfall areas, water is conserved at large amount by one CCT. It will help in increase of groundwater level.

Keywords- Water Conservation, drought, continuous contour trenches, Jalyukta Shivar Abhiyan

I. INTRODUCTION

As agriculture is traditionally the major economic activity in Maharashtra, soil and water are two basic essentials for agriculture**.** Maharashtra is the third largest State in Union of India considering population as well as area. The population of the state is about 112 million. Nearly 58% of population lives in rural area which depends largely on agriculture for their livelihood. The rainfall varies from 400 mm to 6000 mm. The agriculture suffers due to vary of monsoon. In Maharashtra state nearly 82% area under Maharashtra is a drought prone area, especially its region of Vidharbha and Marathwada. Maharashtra is one of the most drought prone states in India. In Maharashtra water is consider more valuable than soil [1].

Due to soil erosion, water logging and other deteriorating factors nearly 50% of our cultivable land suffers from land degradation at various stages. If it is not checked the land will become waste land and unfit for cultivation. The degraded lands which have reached to severe stage of degradation are not under cultivation. If these lands are not treated immediately they will turn into waste land. Water conservation structures like Nala bunds, which serve as percolation reservoirs in the upper catchment. These are to be located on pervious strata to improve vertical percolation, Gabian structures where velocity and volume of peak run-off is too high for loose boulder structures, Farm ponds to harvest runoff and many more and amongst these all water conservation structures, for the present study Continuous contour trench (CCT) is considered as one of the water conservation structure.

CCT are excavating continuous trenches (60 cm wide x 30 cm. deep) on continuous contour lines which are mark, prepared with the help of contour marker. Trenching was started from top to bottom. Distance between two trenches is depends upon the slope as well as availability of time and resources. At its simplest, contour trench construction is an extension of the practice of plowing fields at a right angle to the slope. CCT is the best suitable technique for low rainfall, hilly and undulating terrain areas. Contour trenches are ditches dug along a hillside in such a way that they follow a contour and run perpendicular to the flow of water. The soil excavated from the ditch is used to form a berm on the downhill edge of the ditch. The berm is planted with permanent vegetation (native grasses, legumes) to stabilize the soil and for the roots and foliage in order to trap any sediment that would overflow from the trench in heavy rainfall events [1]. Fig. 1 shows the profile of Contour trenches.

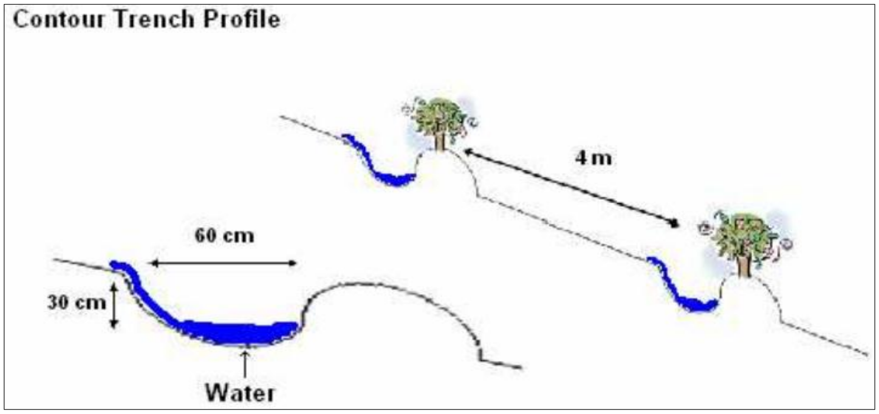

Figure 1. Contour trenches profile [2]

A. *Functions of Continuous Contour Trenches (CCT)*

The major functions of using CCT technique are as follows:

- Construction of CCT helps to stop the soil loss.
- Constructing CCT reduces the rate of runoff and thus results in increase in percolation rate.
- Due to construction of CCT, increase in the ground water level has been noticed.
- Increase in groundwater level helps in increase the green cover over the area and soil quality.
- An increase in the availability of drinking water, agriculture development and employment has been noticed.
- Overall CCT helps indirectly in increasing the soil moisture to vegetation and develop the degraded lands.

B. *Construction norms of CCT*

1) *Design consideration:* Table I provides guidelines for how much space to allow between trenches based on slope percentage.

TABLE I
DISTANCE BETWEEN TRENCHES ACCORDING TO SLOPE [2]

Hill slope (%)	Distance between trenches(m)
0 to 4	10 to 12
4 to 8	8
8 to 15	6
2) o 33	4

2) *Types for selection:*

- Continuous contour trenches (CCT): Uniform slopes, steep slopes, high rainfall.
- Staggered Contour trenches (SCT): Dissected slopes, gentle slopes, low to medium rainfall.

3) *Surveying and mapping:*

- Land slope by dumpy level.
- Soil texture analysis.

4) *Design [2]:*

- The cross sectional area of the trenches is designed to collect the runoff from intense storms at recurrence intervals of 5-10 minutes.
- Protective bunds stabilized by fast growing tress, species and grasses.
- Due to the flow of water through the trenches, slight deviation of the trench from contour lines can create a gully. So in case of CCT, to avoid such situations, continuity should be broken by providing ribs of 0.3 m width in the trenches at an interval of 3-4 m.

5) *Construction process:*

- Once the contours have been marked the farmers can begin to excavate the trench.
- To maintain structural rigidity on the uphill slope of the hill, the shovel should be applied to the contour with the user facing downhill, not along the contour, so that the uphill face of the trench is not structurally compromised.
- Place the excavated soil down slope along the edge of the trench.
- Pack excavated soil to create a berm on the downhill border of the trench.
- Plant native grasses, legumes, or perennials on the berm. These varieties have a root system capable of providing adequate structure to the berm.

- Apply mulch to berm to prevent erosion while the plants take root.
- If possible, trenches should be dug in the dry season so that the rain does not destabilize or wash away the berm before vegetation's can provide stabilization.

II. TECHNICAL PRINCIPLES [3]

A. *Site Location:*

- Mainly in the upper reaches of watershed.
- Where there is sloppy land/ hill slopes.
- Degraded/ Waste lands.
- At the foothills of small hills with other interventions above.
- Without treating the upper regions of watershed with other treatment options (Staggered Trenches, Tree Plantation, etc), CCTs alone should not be constructed.

B. *Design Components:*

Design process of CCTs involves finding of the following specifications.

- Horizontal and vertical interval between two CCTs. (spacing between two CCTs).
- Cross Section of CCTs (Top Width, Bottom Width and Depth).
- Choice of Plant Species.

C. *Design Principles:*

Main principles for designing CCTs are as follows:

- To make specifications site specific.
- Flexibility in practice.
- Smaller sections.

D. *Design Parameters:*

The designing of CCT is a function of/ dependent on the following design parameters.

- Rainfall in that given area (High, Medium or Low).
- Soil Type (Soil Infiltration Levels – Low/ Average and above / Medium)
- Slope of the land.
- Tree canopy planned/ exists in that region.

E. *Design Steps / Formulae:*

The following Steps need to be followed for designing/ arriving at the specifications of the CCTs in a given site. Step 1: Finding Out Vertical Intervals (VI):

The following formula is used for finding out Vertical Intervals VI: 0.305 (X S + Y) (1)

Where,

S = Slope of the land in %.

X = Rain Fall Factor (Refer Table No.1) & Y = Factor due to soil and type and canopy

Table 2 shows the rainfall factor. Table 3 shows the value of factor due to soil and type and canopy.

TABLE II
RAINFALL FACTOR X [3]

Rainfall (In mm)	Value of X
Below 625	0.8
625 – 875	0.6
More than 875	0.4

TABLE III
VALUE OF Y [3]

Soil Infiltration	Crop Canopy cover during erosive rain	Value of Y
Low (Heavy Soils)	Low	1.0
Average and above	Good	2.0
Medium	Medium	1.5

Step 2: Finding out Horizontal Interval (HI):

After determining the Vertical Interval (VI) from Step No.1, use the following formula for deriving HI.

$$HI = (100 \times VI) / S \quad (2)$$

Step 3: Determining Dimensions of Trench: (Cross Section of Trench)

During this stage, the Cross Section of the Trench is to be determined keeping in view the runoff from the catchments of each trench and required storage capacity.

- Finding out Catchment of each CCT:

  Area drained (between two trenches) = A, that is

$$A = (\text{Average width between two trenches x Length of Trench}) \quad (3)$$

- Finding out Peak Runoff:

  Using Rational Formula as

$$Q = (CIA/360) \quad (4)$$

Where,

Q = Peak rate of runoff in Cumec/ sec for the given frequency of rainfall.

C = Rational runoff coefficient having values ranging from zero to one depending upon watershed conditions

I = Intensity of rain fall (in mm per hour for design frequency and for duration equal to time of concentration.

A = Catchment area for trench.

- Fixing up Dimensions for CCTs:

Dimensions of Trench can be either Rectangular or Trapezoidal, depending on the nature of soil. Most generally adopted practice is to keep these sections small, as the main objective is to retain sufficient moisture in the soil to regenerate natural vegetation.

The following formula is used for determining the dimensions of the Trench.

$$Q = (W \times D) / (100 \times HI) \quad (5)$$

Where

Q = Depth of Runoff from catchment area of trench in Cm.

W = Width of trench in cm

D = Depth of trench in cm

HI = Horizontal Interval in meters

Normal practice is use square cross sections ranging from 30 X 30 to 50 X 50 cm. In case of trapezoidal section, the side slopes are generally 1:1.

- Fixing up Dimensions for Staggered Trenches:

Dimension for Staggered Trench is fixed, using the following formulae.

Case 1: With Gap in between trenches equal to length of trench:

$$Q = (W \times D) / (100 \times HI) \quad (6)$$

Case 2: With Gap in between trenches not l to length of trench:

$$Q = (W \times D) / [(100 \times HI) \times (1+X/L)] \quad (7)$$

Where,

X = gap between trenches

L = Length of the trench

III. JALYUKTA SHIVAR ABHIYAN (JSA), GOVT. OF MAHARASHTRA

The Maharashtra government in India has launched a water management program named Jalyukta Shivar Abhiyan to make Maharashtra state drought free state by 2019.The project was launched on 26 January 2016.The program aims to make 5000 villages free from water shortage every year. Under this program, the micro irrigation systems would be encouraged for proficient use of water, hence increasing the irrigated land. Several parts of Maharashtra are still facing the shortage of water problem. The project involves deepening and widening of streams, construction of cement and earthen stop dams, works on nallahs and digging of farm ponds. The scheme has objective to store and manage water resources and use them on those areas where farmers suffering from low rainfall and irrigation problem [4].

A. *Benefits of JSA:*

- The state of Maharashtra has been suffering from drought and water shortage from past few years. JSA has aim to make Maharashtra drought free by 2019. This directly helps beneficiary and the farmers who live on agriculture.
- JSA is a massive water conservation program in the state. This program generates thousands of jobs in Maharashtra state and employed on various works under the scheme.
- JSA helps to stop farmer's suicide in Maharashtra state because of water problem.

B. *Works to be done under JSA:*

- The work is to broadening and deepening river base.
- Removing silt from lakes, farm ponds, and canals which prevents water percolation.
- Building check dams, canals, small ponds, and wells for individual and community.
- Tree plantation for better conservation of water in soil.

C. *Objectives of JSA:*

- To arrest Maximum runoff in the Village area.
- To create decentralized water bodies.
- To increase ground water level in Drought prone areas.
- To encourage people for Tree Plantation.
- To create new structures of Water conservation in the State.
- To create awareness and encourage People for efficient use of water for farming.

D. *Study Area:*

JSA is carried out in Pune district. This study is considered of 4 talukas namely Maval, Khed, Ambegaon and Junnar in Pune district. Various works such as Cement Nala Bund (CNB), Recharge shaft, Continuous Contour Trench (CCT), Earthen Nala Bund (ENB), Farm Pond (Shet tale), Percolation Tank, Sediment Removal, Compartment Bunding, Forest Pond (Vantale), Nala deepening and widening are carried out. CCT constructed in different villages in Pune division are shown in fig. 2 to fig. 7.

Figure 2. CCT at Nalawane, Tq. Junnar, Dist. Pune

Figure 3. CCT at Nalawane, Tq. Junnar, Dist. Pune

Figure 4. CCT at Shirdale, Tq. Ambegaon, Dist. Pune

Figure 5. CCT at Shirdale, Tq. Ambegaon, Dist. Pune

Figure 6. CCT at Vadgaopir, Tq. Ambegaon, Dist. Pune

Figure 7. CCT at Mandalewadi, Tq. Ambegaon, Dist. Pune

E. *Impact of Jalyukta Shivar Abhiyan:*

1) Increase in Ground Water level: The Water harvesting structures play a key role by storing water and allow sufficient time for water to percolate into ground. Therefore, Increase in ground water table in Drought Prone area in measurable indicator of Successful of JSA.
2) Soil Erosion Reduction: The Soil Erosion was reduced more than 50% in the Jalyukta Shivar Abhiyan Implanted Area Because of compartment bunding, CCT and Deep CCT and Graded Band.

3) Run-off Reduction: With Regards to Run-off reduction it was observed that the Program is successful in achieving this goal. According to the JSA Beneficiaries this has been possible because of the contour bunding or Field bunding which has also in checking the run-off of Rain water resulting in Soil Moisture Retention.
4) Increase in Agriculture Productivity: Result of JSA increase in Agricultural Productivity also Fodder production increased due to this milk Production also increased.
5) Employment Generation: According to the Watershed Guidelines, the Under the Study, Additional employment is generated due to JSA. It was reported that during the implementation of JSA's Earthen Nala, Bunding, K.T. Weirs Employment have been generated.

IV. CONCLUSIONS

From the above study it can be concluded that:

- Construction of CCT helps in increasing the groundwater level and water level in nearby wells situated at the downhill where CCT are constructed.
- It is noticed that there is increase in water storage capacity in the village due to Jalyukta Shivar Abhiyan works. Due to assured water availability, now farmers are able to take many crops other than traditional crops.
- CCT technique should be used on large scale at wider part of Maharashtra to solve the soil and water conservation.

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