59. Sustainable Watershed Development by Refilled Continuous Contour Trenching Technology"

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ABSTRACT

Environment has been considered as the aggregate of all external conditions and influences affecting the life and development of an organism. Development without regard to the ecological equilibrium has led to an environmental crisis in the recent past. About 2.7 per cent of the total water available on the earth is fresh water of which about 75.2 per cent lies frozen in Polar Regions and another 22.6 per cent is present as ground water. Based on per capita renewable water availability, India—the second most populous country in the world—has water enough to meet its people's needs. But despite an estimated 2,464 cubic meters per person per year, many of its nearly 900 million people suffer severe water shortages, in part as a result of uneven availability of water. Sustainable development of watershed area is the need of the hour not only for soil conservation, ground water conservation but it also has impact on national economy and solution for employment problem. For balancing of the balance of the VASUNDHARA, it is necessary to maintain at least 33% forest coverage of the available land in each country. In draught prone area, there are two critical factors: water and soil. So in such areas main objective is to conserve the soil and conserve water. Once soil and water conserved, vegetative growth sustain easily. For the same to satisfy this objective economically and efficiently, REFILLED CONTINUOUS CONTOUR TRENCHING (RCCT) Technology is the solution for sustainable watershed development.

INTRODUCTION

Based on per capita renewable water availability, India—the second most populous country in the world—has water enough to meet its people's needs. But despite an estimated 2,464 cubic meters per person per year, many of its nearly 1 billion people suffer severe water shortages, in part as a result of uneven availability of water. Most rainfall comes during the monsoon season, from June to September, and levels of precipitation vary from 100 millimeters a year in the western parts of Rajasthan to over 9,000 millimeters in the northeastern state of Meghalaya. Floods and droughts are both common throughout the country. While the number of people with access to safe drinking water and adequate sanitation increased between 1980 and 1990, population growth erased any substantial gain, especially in urban areas. Between 1990 and 2000 an additional 900 million people are projected to be born in regions without access to safe water and sanitation. India's vulnerability to regional water scarcity is well illustrated by the case of Rajasthan, a state in northwest India. Situated in one of the most inhospitable arid zones in the world, Rajasthan's northwest corner extends into the vast Thar Desert. With a wide range of temperatures and an unpredictable monsoon climate, drought and desertification are common, and water is a scarce commodity. Even those who live in areas of high rainfall in India often face drought because landscapes have been denuded. Soil is compacted

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and most rainfall runs off before it can sink into the ground, increasing flooding. The region of Cheerapunji in Meghalaya, for example, receives among the highest levels of mean rainfall recorded in the world. Yet because of intense seasonal rainfall and the fact that the area's forests have been cleared in the past few decades to meet growing demands for agricultural land and housing, much of the runoff cannot be captured. The region now suffers from excessive flooding for three or four months and frequent droughts the rest of the year.

NATIONAL WATER RESOURCES AT A GLANCE

	Quantity (Cu.Km)
Precipitation Volume (Including snowfall	4000
Annual Potential flow in Rivers	1869
Water Availability (1997)	1967
Utilizable Water Resources	1122

After decades of work by governments and organization to bring potable water to poorer people of the world, the situation is still dire. The reasons are many and varied. The poor of the world cannot afford the capital intensive and technically complex traditional water supply systems which are widely promoted by government and agencies throughout the world. Water is the key of life, presence of water and its absence determine the fertility of the bareness of the land and the ecosystem that surrounds it. Soil erosion takes place on steep slope because no obstruction to flowing water. "Water is explosive; not to shunt loose"

In degraded watershed, which lacks forests and cropland conservation measures, water running downhill too fast erodes soils and washes out crops. It pollutes streams or fills lakes with sediment. It causes frequent flash floods and contributes to bigger floods downstream. In a well managed watershed, most of the storm water soaks into the soil, increasing groundwater supplies and providing crops, pastures and trees with needed moisture. Floods are controlled. The overall objectives of all watershed management programmes are:

- To increase infiltration into soil
- To control damaging excess runoff
- To manage and utilize runoff for useful purposes

In India out of about 328 million hectares, about 175 million hectares of land is classified as wasteland. Most of this wasteland can be transformed into a precious and bountiful natural capital in order to overcome this water crisis. The denuded forestlands have great potential for producing fodder, fuel and low quality timber. To achieve this, it is necessary to adopt the different soil and water conservation engineering measures, supplemented with proper afforestation techniques, grassland development. In the top portion of catchment area, Contour trenches are excavated all along a uniform level across of the slope of the land. Bunds are formed downstream along the trenches with material taken out of them to create more favourable moisture conditions and thus accelerate the growth of vegetation. Contour trenches break the velocity of runoff. The rainwater percolates through the soil slowly and travels down and benefits the better types of land in the middle and lower sections of the catchments REFILLED CONTINUOUS CONTOUR TRENCHING (RCCT) method is the solution for watershed management: soil conservation and water conservation.

WHAT IS REFILLED CONTINUOUS CONTOUR TRENCHING TECHNOLOGY?

The RCCT work starts from top to the bottom of the hill, so that total area is covered with not only retention of soil in it's own place but also arrests every drop of water and infiltrate into the subsoil instead of flowing as surface water with evaporation losses making soil erosion. It recharges downstream water sources e.g. nalla, dug wells, tube wells etc. This particular technique has proved most effective. Principle behind this technique can be narrated as

"ONE WHICH IS RUNNING, MAKE IT TO WALK;
ONE, WHICH IS WALKING, MAKES IT TO STOP;
ONE WHICH IS STOPPED, LET IT BE ABSORB IN SUBSOIL"

When rainwater is in excess, allow it to pass through subsoil to down below drains. This gives desired effect of zero to minimum soil erosion and

once subsoil water starts draining due to obstruction, moisture detain for more period which is in term available for plant growth. This RCCT Technology reduces soil erosion to minimum level and the plant growth on such trenches is very promising with 90% to 95% survival rate with increase in height of plant from 45 cm basic height to 2m within only 6 months. This method can be adopted in low rainfall area to high rainfall area up to 3200mm and from flat area to hilly area with 65% steep slope. This method is suitable for plantation of all species and easy, simple for laborers and comparatively less record keeping. The most advantage of this method is easy and detail checking is possible at a glance.

RCCT has proven that the wasteland can be transformed into natural capital at very low cost, within a short span of time and with guaranteed and instantaneous results. RCCT is proven to be applicable to diverse agro-climatic zones for watershed development, soil conservation and forestation. RCCT isbased on knowkedge input as against costly material and capital inputs used in other conventional techniques of watershed development.

In Maharashtra state (INDIA), within last eight years 30,000 hectares forest area is covered with this RCCT Technology. The average length of RCCT is 1200m per hectare. The number of plants actually planted in the above mentioned area is 540 lakhs with average survival rate 94.25%. The rainfall ranges from 200 mm to 3200 mm. The approximate quantity of water conservation is 89.155 million cubic meters. Considering 50% evaporation and other losses, 44.58 million cubic meter is infiltrated into the soil strata.

METHODOLOGY

Assumption :

For the watershed area with soil cover more than 30 cm to be treated, average length of CCT per hectare is 1200 meter gives good result. Similarly for soil cover in between 10 cm to 30 cm, average length of CCT per hectare is 1060 meter and for the area with soil covers less than 10 cm, average length of CCT is 200 meter assumed.

Collection Of Data :

After selection of area where afforestation activity to be carried out, first of all detail inspection of the total area is necessary for collection of data about

1. Available depth of soil cover
2. Width and length of the streams in selected area
3. Area and definate boundary marking
4. Ground levels at bottom and top of the hills,
5. Horizontal distance between bottom and top of the hill

Theory :

1. From the collected data and map of the area, total work to be carried out can be worked out. Similarly possible minimum and maximum length of CCT can be worked out.
2. From that data, average length of the trench can be calculated.
3. umber of CCT line is calculated by using the relation,
   No. of CCT line == Total work to be done / average length of CCT
4. Hight difference between top and bottom of the hill is calculated by using the collected data.
5. Contour interval can be calculated by using the relation,
   Contour interval == Total height difference / no. of CCT line.

Instruments : Following equipment are used

1. CONTOUR MARKER: Contour marker consists of two staff members of 1meter to 1.50 meter height with piezometric transparent tube of 12 meter length to show the level difference between two points. Every staff member consists of scale of 1meter or 1.50 meter. Each centimeter of scale is divided into four parts with accuracy of 0.25 cm. This instrument is used for finding out contour interval as well as to lay out the contour.
2. CENTRELINE MARKER: Centerline marker is simple instrument having two edges about 35 cm apart with handle at center. Centerline of CCT is marked with the help of centerline marker.
3. SPACEMENT MARKER is the instrument used for marking position of plantation at specified spacing. The instrument consists of three pegs at equidistant at specified spacing of plantation with handle at center. The spacement marker is operated across the centerline starting

from one end with reference to the last point as first point for the next position. The point where cross line matches to the centerline, point is for plantation.

Process of Laying Out Contour :

The process starts from top of the hill. Contour marker is the instrument for laying of contour and marking of contour lines at calculated contour interval. One staff member at one point and another staff member at fullest length which is roughly 12 meter. Once reading is same at both points, two points are marked. First person with staff or follower has not to move till the contouring between two points is completed. Once farthest two points marked, person "LEADER" again come back close to follower & goes on selecting & fixing points of equal height till he reaches to the original farthest point. This method of measurement is called " Whole to Part". In this method, error is minimized or avoided completely and check is obtained. Once LEADER reaches his original point, then follower becomes LEADER. The process continues till completion of that particular CCT line. For change in CCT line, contour interval is taken into consideration. Similarly the total CCT lines are marked.

Simultaneously, number of CCT lines can be operated for speedy completion of work. All spots are marked with lime or by putting a small stone to avoid confusion. Once lines are marked, digging of trench operation is started. To maintain accuracy in digging original marking is kept untouched & about 5cm apart . Size of trenches is 60 cm * 30 cm. Upper fertile layer of soil is deposited on uphill side of the trench & remaining material like murum, boulder of size more than 20 cm on downhill side. Wherever plenty of stones are available, contour bunds are constructed on downhill side in advance and then digging of trench is started on up hillside of bund. Trenches are kept expose to weather for about two months. After this operation, refilling operation starts. In this operation, for refilling good quality comparatively fertile soil, which is stored on uphill with topsoil layer upto 1meter width of that area, is utilized. It is necessary to develop the perfect shape with 55cm to 60cm central depths as shown in figure no.3.

During transportation of plants from nursery, it is necessary to provide cushion layer of grass to avoid damage to the plants due to shocks. The plants should be arranged in vertical position in two layers maximum. At the time of unloading, it is necessary to take utmost care of seedlings so that minimum damages or injury to the plants. Plants are to be unloaded at convenient places where from transport to actual planting site is easy. They should be arranged in upright position.

Plantation Procedure:

In draught prone area, Nature is very tricky; it may rain torrential or may not at all for longer period. And even it rains, there is large dry spell. This is the most critical point to be thought at the time of planting. In order to have success, it is essential to protect the plant at initial stage of transplantation during dry spells.

The plantation operation is carried out with optimum management of man power and time. The plantation team consists of 15 persons with plantation of 750 plants/day. The plantation operation is divided in following stages;

Centerline marker	1	To mark the centerline
Spacement marker	1	To mark the cross line
Digger	1	For digging polypot
Excavator	3	For removing the soil from polypot
Fertiliserer	1	For specified dosing of fertilizer
Cutter	1	For taking cut from the top to centerline of bottom of one side of polybag
Planter	3	For plantation of plants by removing the plastic polybag Taking the plant on forearm and gently put in polypot pit filling the vacuum with adjoining soil and gentle press is given with hands
Porter	3	For transportation of plants to actual plantation site
Drainer	1	For wetting the plants till it is saturated

The plantation process starts with formation of groups of 15 persons in each group. The plantation area is distributed in the formed groups. After draining of seedlings, every person transports the plants to plantation site while proceeding for on site. Then three persons are allotted separately for transportation of plants. In order to have success, it is essential to protect the plant at initial stage of transplantation during dry spells. For that the poly plants is fully drained with water till all air bubbles from bag are out and the surrounding soil is fully saturated. The excess water from polybag is removed.

Centerline of CCT is marked with the help of CENTERLINE marker. The SPACEMENT marker is operated across the centerline starting from one end with reference to the last point as first point for the next position. The point where cross line matches to the centerline, that point is for plantation. Simultaneously drained seedlings are transported and laid all along ridge of the contour on the upper side of the cross, which is actual plantation spot. The digger digs it to the specified size followed by the excavator. Excavator excavate the pit to the size required for plantation followed by cutter, who is taking cut from the top to centerline of bottom of one side of polybag. Fertiliserer, who is spreading the specified dose of fertilizer in the pit, follows cutter. Then planter is planting the plants by removing the plastic polybag and taking the plant on forearm and gently put in polypot pit. Filling the vacuum with adjoining soil and gentle press is given with hands. This process continues till completion of plantation.

The economics of this RCCT technology is very interesting. One milliliter rainfall in one hectare area in which RCCT works are completed collects 10,000 liter water. If the annual average rainfall in that area is 500 milliliter and considering 50% evaporation losses, 2.5 million liters of water is infiltrated in subsoil to recharge down below water sources. Now a day in hilly areas, drinking water problem is so sever that water tanker supply is compulsory for survival of people. Considering capacity of tanker 10,000 liter and cost of one trip from water source to needy area is Rs. 500 per trip average, RCCT works supply 250 tanker/hectare/ year worth cost Rs. 1,25,000. The expenditure for one hectare is approximately Rs. 30,000 in four

Human resources per hectare :

Sr No	Description	Man days
1	Laying contours	8-10
2	Digging contours	200
3	Raising seedling in the nursery	30
4	Refilling contours and planting	175
5	Maintaining plantation	60 + 25 + 15 +10

Cost structure per hectare :

Sr No	Description	Cost per hectare
1	Development cost per labourers	Rs. 31500.00
2	Seeds, jute bags & soil mixture	Rs. 600.00
3	contengencies	Rs. 948.00
4	Labour amenities	Rs.1264.00
5	overheads	Rs.5688.00
6	Total cost	Rs. 40000.00

years. So that benefit cost ratio comes 4.17 from indirect benefits for one year only. The cost of water conservation for RCCT is Rs.6.00/M3 comparing with percolation tank, Rs.25/ M3 and major irrigation project RS.35/ M3.There is no displacement of tribal, no water logging problem, no mosquito breeding site created, no pumping required, less water treatment require. This is decentralized water conservation technique. Considering the micro watershed, necessary treatment is applied. This removes root cause of soil erosion and depleting ground water levels. The production of grass in one hectare is approximately 2 to 3 MT/hectare costing Rs. 1000/MT and thinning operation gives firewood and other products of worth cost approximately Rs. 6400/hectare. Appreciation of land due to his woks increases in three fold because the no irrigated land gets converted into well irrigated land. Farmers are taking double season cash crops in place of single crop.

ADVANTAGES

1. Barren land gets permanent biomass cover and soil protection
2. Soil loss in cultivable area becomes nil
3. Every drop of rain is held in situ
4. Augmentation of ground water without grouting
5. Good soil moisture and good ground water available in the wells, tube wells and tanks
6. Increase in life of dams, prevention of floods by avoiding silting
7. No displacement of communities or creation of environmental refugees and hence no rehabilitation costs
8. No migration of villagers to cities as the local water availability ensures livelihood sustainability
9. Decentralized and democratic water management
10. Evaporation losses are negligible as compared to tanks and dams
11. No separate nullah bunding, gully plugging and such other civil structures
12. Accelerates soil formation and natural succession dramatically
13. Increases fodder resources for feeding cattle and livestock
14. Increased agricultural and biomass production
15. Guaranteed mass employment generation to rural people at their doorstep
16. Land value increases significantly
17. Increases crop intensity and biodiversity
18. Women free from the drudgery of finding and fetching water, fuel and fodder from distant places
19. Clean water for drinking purposes.

DISADVANTAGES :

1. Very tedious and laborious for alignment
2. Time consuming
3. Requirement of accuracy skilled labours and instruments like contour marker.
4. There is potential danger of water flowing along the upper edge in case the trench breaks.

CASE STUDY : Dolasane, Tal. Sangamner, Dist. Ahmednagar (Maharashtra) India

Dolasane village has an forest area of 524.40 ha. Total 145 ha. Area was treated with RCCT method.

The impact of RCCT work on village has been clearly indicated;

- Agriculture: yield per acre increased from 50 kg to 500 kg per acre of bajra and wheat.
- Irrigation : 95% agriculture is rainfed has changed to well irrigated due to increase in water level of wells.
- Grazing :cattle population is reduced from 6358 to 1115 with increase in milk production.
- Control of soil erosion & flash floods
- Income generation: farmers with four acre land can make a profit of Rs. One lakh minimum per year.

No.	Description	Data
1	Name of village	Dolasane
2	Village area	1185 ha
3	Number of households	271
4	Annual rainfall	293 mm
4	Average number of members	05
5	Total population	1356
5a	Men	533
5b	Women	434
5c	Children	389

DOLASANE , SANGAMNER RANGE I, SANGAMNER SUBDIVISION, AHMEDNAGAR DIVISION

1	Name of the work	WGS Scheme
2	Year of plantation	1995-96 (soil treatment work 1994-95)
3	Location	FS no.208 Nasik—Pune Highway
4	Area in hectares	40
4A	zone I Soil layer <10cm	9
4B	zone II Soil layer 10 cm	13
4C	zone III Soil layer . 25 cm	18
5	Average slope = col.4 / col.5	45%
6	Average rainfall	317mm (1997)310mm (1997) 250mm in1998
7	Temperature	22 - 41 C
8B	Time duration	36 days
9	Type of rock &soil	Trap basalt rock with reddish murum soil
9A	% of soil erosion	93%
10	Total trench work	35458 m
10A	zone I—09 ha	———
10B	zone II—13 ha *1066	13858 m
11	WAT length (size 0.60*0.30m)	1800 m
12	Grass bed	800 no.
13	Length of CCT per hectare =35458/31	1143.80 m
14	Minimum CCT length	3120 m
15	Maximum CCT length	415 m
16	nalla bundings	175 cu.m
17	TCM length (1.90*0.60m)	1940 cu.m
18	Size of CCT	0.60 * 0.30 m
19	Number of wells in downbelow area	11
20	Land in downbelow area in hectare	80
21	Expenditure for the work	Rs.527275.60
22	Expenditure for CCT work	Rs.216196.00
23	Expenditure for plantation	Rs.190568.00
24	Capacity of CCT for collection of water	6382.44 cu.m
25	Collection of water in CCT throughout year	117200 cu.m
26	Evaporation losses	50%
27	Surface water flow	nil
28	Infiltration of water into subsoil throughout Year	58600 cu.m.
29	Soil conservation area	40 hectare
30	Forest coverage area	40 hectare
31	Water conservation quantity	117200 cu.m
32	Total expenditure for the work	Rs. 527275.60
33	Survival rate Oct.1998	96%
34	Survival rate Oct.2000	79%

PLANTATION DETAILS :

Sr	DESCRIPTION	DETAILS
1	Original habitant species/trees/bushes	Tarvad (Cassia auriculata),babhul (Acacia nilotica spp. indica), henkal (Gymonsporia montana)
2	Presence of natural forest/trees/bushes in past	Yes
3	Approximate years of deforestation	25 years
3A	Reason for deforestation	Heavy grazing & illicit cutting
4	Selected species for plantation	GIRTH HIGHT SURVIVAL
4A	Neem(Azadirachta indica) —17729	4/5cm 2.50m 100%
4B	Sisso(Dalbergia sissoo) —4629	4/5cm 2.00m 100%
4C	Siras(Albizia lebbek)—3175	2/3cm 1.00m 50%
4D	Bor(Zizyphus mauritiana)—3175	2/3cm 1.00m 50%
4E	Subabhul(Leucenia lucocephala)— 17729	6cm 4.00m 100%
4F	Sitaphal(Anona squamosa)—1550	3/4cm 0.60m 50%
4G	A.Tortolis—4700	4/5cm 2.00m 100%
4H	Nilgiri (Eucalyptus)—500	6/7cm 4.00m 100%
5	Spacing for plantation	0.67m
6	Total number of plants	53187
7	Total number of plants/hectare	1715
8	Grass plantation	Dinanath 30kg, hemata-25kg,ber-10kg, shed-15kg

Details of Water Levels in Wells Downstream Of the Area Where RCCT Work Is Carried Out

Name of farmer	Village	Depth of well in m	Water level in m				
			01.05.97	01.10.97	01.03.98	01.05.98	01.07.98
S.R.Jadhav	Dolasane	6.6	0.9	3.5	4.5	1.4	4.5
R.S.Gadekar	Dolasane	10.5	150	9	6	5	8
R.L.Vajhe	Dolasane	10.5	1.5	5.3	6	5.1	6.5
S.B.Kadone	Chandanapuri	17	—	—	5	1.7	7
R.V.Rahane	Chandanapuri	18	—	—	5	2	9
S.V.Rahane	Chandanapuri	20	—	—	2.7	1.1	10
V.M.Momin	Varude	12	5.5	10	6.5	5.5	5.5
B.S.Bhagwan	Varude	12	1.8	11	8.5	8.1	8.15
B.S.Jadhav	Karjule	11	3.6	7.1	7	6	7.2

CONCLUSION

The CCT helps to increase the water levels in the surrounding areas/ dug wells and tube wells which increases the yield of farms due to change in crop pattern from food grains to cash crops. This will also avoid loss of soil due to erosion , increase the grass coverage which will helpful for soil stabilization. Due to CCT tree development is better than any other type of trenching.

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