*International Journal of Current Research in Multidisciplinary (IJCRM)* *ISSN: 2456-0979*
Vol. 5, No. 8, (August'20), pp. 12-17

# QUALITATIVE PERFORMANCE OF SOIL AND WATER CONSERVATION MEASURES AT MANDAKHALI WATERSHED, MAHARASHTRA

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***ABSTRACT***
*The study was conducted at Mandakhali Watershed in Parbhani District of Maharashtra State in the year of 2017-18.. The Soil and Water Conservation Works (SWC) were undertaken in 2014-15 by Department of Agriculture, Government of Maharashtra under Jalyukt Shivar Abhiyan. Representative SWC measures were selected for evaluation. The existing dimension of the structures were measured and compared with the designed dimensions for determining the percent change in dimensions. Depth of silt deposited were measures. Volume of silt deposited at each structure was determined by multiplying the silt deposited area and depth of silt deposited. Weight of silt deposited was calculated by multiplying the volume of deposited silt to the bulk density of silt. On an average reduction in cross sectional area of graded bund was found to be 26.70 percent and total 686.11 tonnes silt was deposited at all seven graded bunds over a period of three years after their construction. In case of CCT, an average 21.13 per cent reduction in volume has been noticed and total 1215.18 tonnes silt was deposited in selected ten CCTs over a period of three years after their construction. The total silt deposited in all cement nala bunds was found to be 79.53 tonnes over a period of three years after their construction. Weight of silt deposited from three selected farm ponds was worked out to be 707.17 tonnes over a period of three year after their construction.*

***KEY WORDS**: SWC Measures, Gaded bund, CCTs , CNBs, Farm Pon.,*

## INTRODUCTION

Soil and water are the two most important natural resources required for the survival of living things on the earth. The basis source of water is rainfall. In India rainfall is uneven, erratic and varies from place to place and from year to year. The countries average annual rainfall is about 1194 mm with average rainy days of 130 in a year. In case of India's total geographical area 326.8mha, about 81 million hectare land is affected by erosion, in other terms, Out of net cultivated area of 185.8mha, 56.7mha land is suffering from erosion, either due to water or wind. Out of these (56.7mha) 40mha, land is severely affected and needed immediate control measures. On an average soil due to erosion in the country is 16.4tonnes per hectare per year.(Mittal et al.,1986, Abuj et al.,2010)

Watershed management is a holistic approach arrived at optimizing the use of land, water and vegetation in an area and thus providing solution to alleviate drought, moderate floods, prevent soil erosion, improve water availability and increase fuel, fodder and agriculture production on sustained basis. A watershed is the total land area above a given point on a water way that contributes a runoff to the flow at that point. In planning watershed development programme various types of soil and water conservation works such as bunding, terracing, nala bunding, underground diaphragms, diversion ditches, vegetative waterways are taken according to the availability of site, location and land capability classification. Conservation structures not only control the erosion and conserve water but also help in meeting the socio-economic demand in various ways. It is therefore, important to plan

the watershed on sound technical knowledge to save the land from erosion and degradation, to conserve water and improve soil for maximum production in the interest of the nation as well as individual farmer.

## METHODOLOGY

Mandakhali watershed is situated in Parbhani District of Maharashtra State. It is located 16 km towards West from District headquarters. The jurisdiction of Mandakhali encompasses watershed $19^{o}14'$N latitude and $76^{o}38'$E longitude at 400 m from mean sea level. The watershed comes under assured rainfall zone. The total geographical area of Mandakhali watershed was 2167.03 ha, out of that 1920 ha area was under cultivation. The topography was flat to undulating. The general slope of cultivable land ranges from 1 to 3 per cent while slope of non-cultivable land ranges from 3 to 15 per cent. The average annual rainfall ranges from 750-800 mm, which is uneven, erratic and varies from year to year. South-West monsoon is the major source of rainfall and about 90 per cent rainfall receives during monsoon season i.e. from the month of June to October. The cropping pattern followed during Kharif: cotton, soybean, green gram, pigeon pea, black gram, sorghum etc and Rabi: wheat, gram, rabi jowar, safflower.

**Details of Soil and Water Conservation Structures:**

The various soil and water conservation structures undertaken at Mandakhali village are listed in Table 1.

**Table 1: Soil and Water Conservation Structures at Mandakhali village**

| Sr. No. | Name of SWC Structures | No. of structures or Area | No. of Structures under study |
|---|---|---|---|
| 1. | Graded Bunds | 250 ha | 50 ha |
| **2.** | Farm Ponds | 15 No. | 3 No. |
| 3. | Deep Continuous Contour Trenches | 66 ha | 66 ha |
| 4. | Cement Nala Bunds | 9 No. | 4 No. |

**Graded bunds:**

In Mandakhali watershed the graded bunds were constructed in 250 ha area having the slope of 0-4 %. Graded bunding involves the construction of earthen bund having section near about 2.30 x 0.50 $m^2$ along the longitudinal slope. For study 50 ha area was selected..

**Farm ponds:**

There were 15 farm ponds constructed in Mandakhali village watershed. Three unlined farm ponds were selected for the study.

**Table 2: Details of unlined farm ponds**

| Farm Pond No. | Survey No. | Size of the Farm Pond (m x m x m) |
|---|---|---|
| 1. | 60 | 16×16×3 |
| 2. | 83 | 30×30×3 |
| 3. | 146 | 24×24×3 |

Storage volume of farm pond was calculated on fortnight basis. The volume with respect to particular depth was computed by using 'Trapezoidal formula' as follows

$$\boldsymbol{V = \frac{A_o + A}{2} X\, h}$$

In which,

V = Storage volume of farm pond with respect to h, $m^3$

$A_0$ = Bottom area of farm pond, $m^2$
$A_1$ = Top area of farm pond at depth h, $m^2$
h = Depth of Water, m

**Cement nala bund**:

In Mandakhali watershed nine cement nala bunds were constructed. From which four cement nala bunds were selected for the tudy.

**Continuous Contour Trenches (CCTs):**

CCT work was undertaken on 66 ha area at upper ridge of catchment area having slope ranges 12-14 % to control runoff and soil erosion. The dimensions of CCTs 20 m x 1m x 1m. The horizontal interval of trenches was in the range of 15.

## RESULTS AND DISCUSSION

The results obtained from the present investigation are summarized below,

**Table 3: Design and present dimensions of graded bunds**

| GB Line No. | Design dimensions (2014-2015) | | | | Present dimensions (2017-2018) | | | | Percent reduction in c/s area (%) |
|---|---|---|---|---|---|---|---|---|---|
| | TW (m) | BW (m) | Ht (m) | c/s area ($m^2$) | TW (m) | BW (m) | Ht (m) | c/s area ($m^2$) | |
| 1. | 0.50 | 2.30 | 0.75 | 1.05 | 0.75 | 2.30 | 0.55 | 0.84 | 20.00 |
| 2. | 0.50 | 2.30 | 0.75 | 1.05 | 0.74 | 2.30 | 0.46 | 0.70 | 33.33 |
| 3. | 0.50 | 2.50 | 0.75 | 1.05 | 0.83 | 2.50 | 0.56 | 0.87 | 17.15 |
| 4. | 0.50 | 2.30 | 0.75 | 1.05 | 0.82 | 2.30 | 0.50 | 0.78 | 25.72 |
| 5. | 0.50 | 2.30 | 0.75 | 1.05 | 0.76 | 2.30 | 0.54 | 0.82 | 21.90 |
| 6. | 0.50 | 2.30 | 0.75 | 1.05 | 0.70 | 2.30 | 0.45 | 0.67 | 36.20 |
| 7. | 0.50 | 2.30 | 0.75 | 1.05 | 0.75 | 2.30 | 0.47 | 0.71 | 32.62 |
| | | | | | | | | **Average** | **26.70** |

The results presented in Table 3 indicates that for all selected graded bund top width is increased while the height is reduced as compared to design dimensions. Also it was observed that there is no change in design and present bottom width of all graded bunds. Increase in top width and reduction in height might be due to compaction of bunds. It is clear that per cent reduction in designed cross sectional area of graded bunds ranges between 17.15 to 36.20 per cent over a period of four years after their construction.

**Silt deposition at graded bunds:**

The data on volume and weight of silt deposited on upstream side of selected graded bunds is presented in Table 4.

**Table 4: Silt deposition at graded bunds**

| GB Line No. | Length of G.B. (m) | Area of silt deposition ($m^2$) | Average depth of silt deposition (m) | Volume of silt deposition ($m^{3)}$ | Weight of silt deposition (tonnes) |
|---|---|---|---|---|---|
| 1. | 160 | 368.00 | 0.25 | 92.00 | 118.80 |
| 2. | 145 | 333.50 | 0.20 | 66.70 | 88.04 |
| 3. | 150 | 345.00 | 0.22 | 75.90 | 100.18 |
| 4. | 157 | 361.10 | 0.25 | 90.27 | 119.15 |

| | | | | | |
|---|---|---|---|---|---|
| 5. | 138 | 317.40 | 0.23 | 73.00 | 96.36 |
| 6. | 135 | 312.80 | 0.18 | 56.30 | 74.32 |
| 7. | 140 | 322.00 | 0.21 | 67.62 | 89.26 |
| **Total silt deposition at graded bunds** | | | | | **686.11** |

From Table 4, it can be seen that average depth and area of silt deposition at various graded bunds ranges between 0.18 to 0.25 m and 312.80 to 368.00 $m^2$ respectively while weight of silt deposited at different graded bunds ranges from 88.04 to 119.15 tonnes. Total 686.11 tonnes silt was deposited at all seven graded bunds over a period of three years after their construction. From the results obtained, it is could be concluded that the graded bunds have helped in arresting the silt on their upstream side and helped in reducing the soil loss. The Details and storage capacity of farm ponds are presented in Table 5.

**Table 5: Storage capacity of farm ponds**

| Farm Pond No. | Survey No. | Type of the Farm Pond | Size of the Farm Pond (m x m x m) | Storage capacity ($m^3$) |
|---|---|---|---|---|
| 1. | 60 | Unlined | 16×16×3 | 534 |
| 2. | 83 | Unlined | 30×30×3 | 2214 |
| 3. | 146 | Unlined | 24×24×3 | 1350 |

Table 5 shows that Farm pond No.2 have a highest storage capacity whereas the farm pond No.1 have a lowest storage capacity i.e. 534 $m^3$.

**Silt deposition in farm ponds:**

The data on volume and weight of silt deposited at different farm ponds is presented in Table 6.

**Table 6: Silt deposition in farm ponds**

| Farm Pond No. | Average depth of silt deposition (m) | Area of silt deposition ($m^2$) | Volume of silt deposition ($m^{3)}$ | Weight of silt deposition (tonnes) |
|---|---|---|---|---|
| 1. | 0.40 | 130.00 | 54.60 | 72.07 |
| 2. | 0.48 | 648.00 | 311.04 | 410.57 |
| 3. | 0.45 | 378.00 | 170.10 | 224.53 |
| **Total silt deposition in farm ponds** | | | | **707.17** |

From Table 6, it is clear that average depth of silt deposited and weight of silt deposited in selected farm ponds ranged between 0.40 to 0.48 m and 72.07 to 410.57 tonnes respectively. The weight of silt deposited at all selected farm ponds has been worked out as 707.17 tonnes over a period of three year after their construction.

**Change in dimensions of CCTs:**

The design and present dimensions of CCTs are presented in the Table 7.

**Table 7: Design and present dimensions of CCTs**

| CCT Line No. | Design dimension | | | | | Present dimension | | | | | Per cent reduction in $Vol^m$ (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | TW (m) | BW (m) | H (m) | L (m) | Vol. of Trench($m^3$) | TW (m) | BW (m) | H (m) | L (m) | Vol. of Trench ($m^3$) | |
| 1. | 1 | 1 | 1 | 20 | 20 | 1.20 | 1 | 0.75 | 20 | 16.50 | 17.50 |
| 2. | 1 | 1 | 1 | 20 | 20 | 1.15 | 1 | 0.75 | 20 | 16.20 | 19.00 |
| 3. | 1 | 1 | 1 | 20 | 20 | 1.18 | 1 | 0.70 | 20 | 15.26 | 23.70 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 4. | 1 | 1 | 1 | 20 | 20 | 1.14 | 1 | 0.72 | 20 | 15.40 | 23.00 |
| 5. | 1 | 1 | 1 | 20 | 20 | 1.22 | 1 | 0.70 | 20 | 15.54 | 22.30 |
| 6. | 1 | 1 | 1 | 20 | 20 | 1.18 | 1 | 0.71 | 20 | 15.48 | 22.60 |
| 7. | 1 | 1 | 1 | 20 | 20 | 1.16 | 1 | 0.75 | 20 | 16.20 | 19.00 |
| 8. | 1 | 1 | 1 | 20 | 20 | 1.17 | 1 | 0.76 | 20 | 16.56 | 17.20 |
| 9. | 1 | 1 | 1 | 20 | 20 | 1.12 | 1 | 0.71 | 20 | 15.05 | 24.75 |
| 10. | 1 | 1 | 1 | 20 | 20 | 1.15 | 1 | 0.72 | 20 | 15.55 | 22.25 |
| | | | | | | | | | | **Average** | **21.13%** |

Data presented in Table 7 indicates that for all selected CCTs top width has increased, while bottom width remains constant and depth has reduced over a period of three years after their construction. Increase in top width of CCT's might be due to inflow of water from upstream side while reduction in depth is due to the deposition of silt. Table 7 shows that per cent reduction in volume of CCTs is in the range between 17.20 to 24.75 per cent.

**Silt deposited at CCTs:**

The data on volume and weight of silt deposited at selected CCTs is presented in Table 8.

**Table 8: Silt deposited at continuous contour trenches**

| CCT Line No. | Length of trench (m) | Average depth of silt deposited (m) | Area of silt deposition ($m^2$) | Vol. of silt deposition ($m^{3)}$ | No. of Trenches (no.) | Weight of silt deposition (V×VI×B.D.) (tonnes) |
|---|---|---|---|---|---|---|
| 1. | 20 | 0.25 | 20 | 5.0 | 19 | 125.40 |
| 2. | 20 | 0.25 | 20 | 5.0 | 20 | 132.00 |
| 3. | 20 | 0.30 | 20 | 6.0 | 23 | 182.16 |
| 4. | 20 | 0.28 | 20 | 5.6 | 16 | 118.27 |
| 5. | 20 | 0.30 | 20 | 6.0 | 18 | 142.56 |
| 6. | 20 | 0.29 | 20 | 5.8 | 22 | 168.43 |
| 7 | 20 | 0.25 | 20 | 5.0 | 19 | 125.40 |
| 8. | 20 | 0.24 | 20 | 4.8 | 17 | 107.71 |
| 9. | 20 | 0.29 | 20 | 5.8 | 9 | 68.90 |
| 10. | 20 | 0.28 | 20 | 5.6 | 6 | 44.35 |
| Total silt deposition at continuous contour trenches | | | | | | 1215.18 |

From Table 8, it can be seen that average depth of silt deposited and area of silt deposited in CCTs ranged between 0.24 to 0.30 m and 20 $m^2$ respectively while weight of silt deposited in different CCTs ranged from 44.35 to 182.16 tonnes. Total 1215.18 tonnes silt has deposited in selected ten CCTs over a period of three years after their construction. From these results, it was found that CCTs have helped in arresting the soil and thereby reducing the soil erosion. The deposition of silt and conservation of the moisture in CCTs created a favourable condition to stand good grass and vegetative cover on the bunds formed on downstream side of CCTs.

**Volume of water stored at cement nala bunds:**

The Volume of water stored at cement nala bunds is presented in Table 9.

**Table 9: Volume of water stored in cement nala bunds:**

| Sr. No. | Water spread length (m) | Width of CNB (m) | Avg. depth of water impounded (m) | Volume of water stored ($m^3$) |
|---|---|---|---|---|
| CNB 1 | 250.00 | 10 | 0.50 | 1250.00 |

| | | | | |
|---|---|---|---|---|
| CNB 2 | 125.00 | 10 | 0.40 | 500.00 |
| CNB 3 | 140.00 | 10 | 0.50 | 700.00 |
| CNB 4 | 115.00 | 10 | 0.65 | 747.50 |
| Total volume of water stored at CNBs | | | | 3197.50 |

The length and average depth of water impounded at CNBs ranges between 115 to 250 m and 0.40 to 0.65 m respectively. CNBs have helped in storing runoff water on their upstream side.

**Silt deposition at cement nala bunds:**

The data on volume and weight of silt deposited at different cement nala bunds is presented in Table 10.

**Table 10: Silt deposition at cement nala bunds**

| CNB No. | Area of silt deposition ($m^2$) | Avg. depth of silt deposited (m) | Volume of silt deposition ($m^3$) | Weight of silt deposition (tonnes) |
|---|---|---|---|---|
| 1. | 69.00 | 0.20 | 13.80 | 18.216 |
| 2. | 66.00 | 0.17 | 11.22 | 14.810 |
| 3. | 84.00 | 0.18 | 15.12 | 19.958 |
| 4. | 87.50 | 0.23 | 20.12 | 26.565 |
| Total silt deposition at cement nala bunds | | | | 79.530 |

Table 10 shows weight of silt deposition at each CNBs and total silt deposited in selected four CNBs was found to be 79.53 tonnes over a period of three years after construction.

## CONCLUSIONS

The overall soil and water conservation measures undertaken at Mandakhali watershed through Jalyukt Shivar Abhiyan were found beneficial in arresting silt, storing excess runoff water and controlling soil erosion.

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