P-4: REHABILITAITON OF AREAS AFFECTED BY MASS EROSION

4.1 Development and refinement of technologies for rehabilitation of ravines, landslide, mine spoils, riverbed mining, stream banks, torrents etc.

Assessment of impact of extraction of RBM (river bed material) on physiography of stream flow courses of Himalayan foot hill streams (S.S. Shrimali, C. Jana and D. Mandal) - Dehradun)

The mountain rivers, specially of Himalayas/ Shiwalik foothills, bring down huge quantity of land mass broken into clay, silt, sand and boulders of various sizes while flowing with high velocity on the steep slopes of the streambed. The heavy course material when gets deposited in the foothills. It obstructs the subsequent flow of water carrying more fluvial debris. This results in change of river course to the sides.

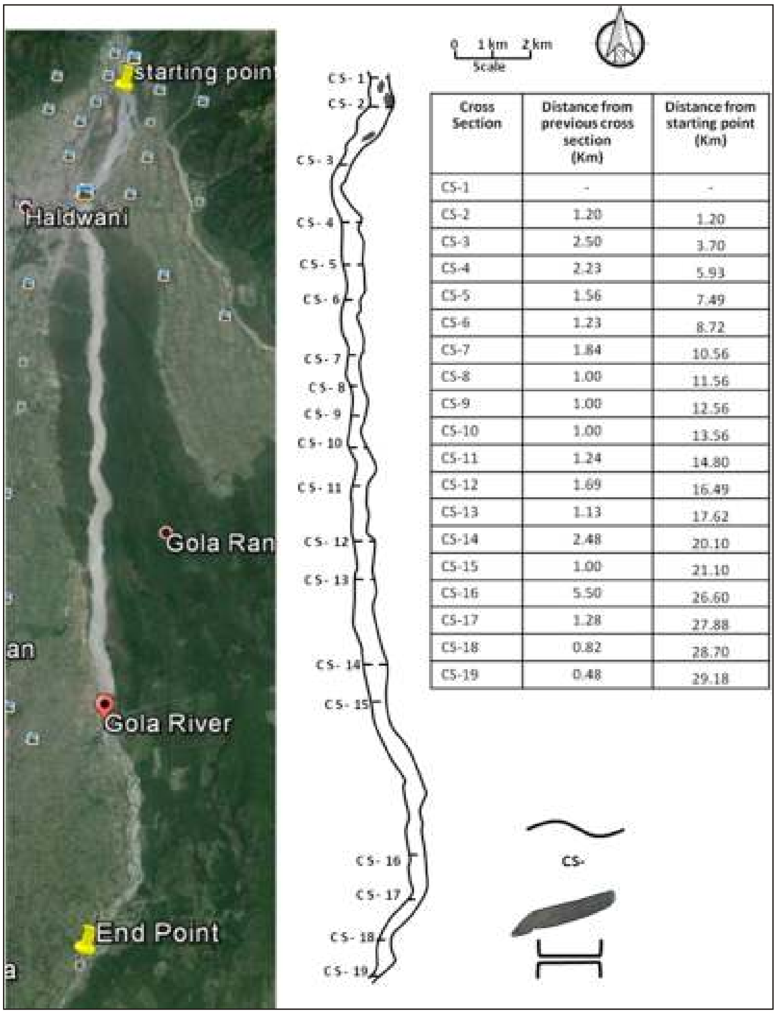
This process continues and the river encroaches to either side of the river thus increasing the total width of the river though the actual flow width is much less. Further the encroachment on either side also damages/destroys the valuable property/ plantation/ agriculture lying there and hence needs some management practices to avoid such phenomena .User agencies have been carrying out the RBM extraction based on the out sourcing the extraction activities among diverse agencies. A study was initiated in year 2014 to evaluate post extraction impact of the stream courses to further refine the extraction strategies without adverse impacts.

During the year the study area has been selected a stretch of *Gaula river* near Haldwani which is under mining activity. Twenty nine km long river reach has been marked and benchmarks have been established (Fig. 4.1). Periodic Longitudinal and cross section survey of the river reach is proposed to be carried out to monitor the impact.

Prototype field study on application of potentially important jute geo-textiles for hill slope stabilization (S. Manivannan, O.P.S. Khola, K. Kannan and K. Rajan) - Udagamandalam

A field study was conducted for evaluating different Jute Geo-Textiles (JGT) on Nilgiris hill slopes at Research Centre, Udhagamandalam, with the objective to assess the effect of various JGT on runoff, soil loss, nutrient loss and growth of tea and grasses.

In 2014, minimum runoff (57.13 mm) was recorded from 700 GSM JGT, followed by 69.52 mm from 600 GSM JGT, and 164.33 mm from control plots. Soil loss was minimum (0.2 t $ha^{-1}yr^{-1}$)



Cross Section	Distance from previous cross section (Km)	Distance from starting point (Km)
CS-1	-	-
CS-2	1.20	1.20
CS-3	2.50	3.70
CS-4	2.23	5.93
CS-5	1.56	7.49
CS-6	1.23	8.72
CS-7	1.84	10.56
CS-8	1.00	11.56
CS-9	1.00	12.56
CS-10	1.00	13.56
CS-11	1.24	14.80
CS-12	1.69	16.49
CS-13	1.13	17.62
CS-14	2.48	20.10
CS-15	1.00	21.10
CS-16	5.50	26.60
CS-17	1.28	27.88
CS-18	0.82	28.70
CS-19	0.48	29.18

Fig. 4.1: Location of bench marked sites at a stretch of Gaula river near Haldwani
चित्र 4.1: हल्दवानी के निकट ग्वाला नदी के एक खंड में बेंचमार्क साइट स्थल

from 700 GSM JGT, followed by 0.3 t ha^{-1} yr^{-1} from 600 GSM and 0.4 t ha^{-1} yr^{-1} from 500 GSM against 1.1 t ha^{-1} yr^{-1} from the control plot.

Among the treatments, 700 GSM JGT showed lowest nutrient loss of 60.0 kg ha^{-1} yr^{-1}, followed by 600 GSM JGT and 500 GSM JGT with the nutrient loss of 65.3 and 67.0 kg ha^{-1} yr^{-1}, respectively.

Though the runoff, soil loss and nutrient loss reduced by the application of 700 GSM JGT, the growth of tea plant was affected by weeds and other vegetations which is evidenced from the highest dry matter productivity (610 kg ha^{-1}) in the 700 GSM JGT treatment.

In another study, 500 GSM non-woven JGT and 500 GSM open weave JGT were evaluated in two slope categories (60 and 90%) with the test crop *Eragrostis curvula*. In the second year (2014) of this study, minimum runoff of 185.1 mm and 197.8 mm was recorded in open weave JGT and non-woven JGT, respectively in 90% slope against 221.2 mm in synthetic textiles and 253.58 mm in control plot. The highest grass height (128.4 cm) was observed in 500 GSM open weave JGT and followed by non-woven JGT (120.4 cm) and synthetic textiles (119.8 cm) in 60% slope; and the least grass height (79.5 cm) was observed in control plot. Tillers per clump of grass and biomass were highest in 500 GSM open weave JGT followed by 500 GSM non-woven JGT and 500 GSM synthetic geo-textiles. The surface area protected by the grass was more in 500 GSM open weave JGT plot followed by 500 GSM non-woven JGT. In 90% slope, a clear-cut trend among the various jute geo textiles was observed. The 500 GSM open weave JGT manifested with the highest surface area protection.

Both 700 & 600 GSM open weave JGT were found to be more effective on reducing runoff, soil and nutrient losses and increased soil moisture retention. However, the height and growth of tea plants were better under 500 GSM JGT.

Cost effective conservation measures for management of medium and deep ravine lands

(Shakir Ali, A.K. Parandiyal, Ashok Kumar and R.K. Singh) - Kota

The project was initiated during 2004 for identifying cost effective conservation measures for managing medium and deep ravine lands. Four ravine watersheds, *viz;* RW_1 (0.4 ha), RW_2 (1.4 ha), RW_3 (1.1 ha) and RW_4 (1.0 ha) at the Chambal ravine in South-eastern Rajasthan were calibrated with control (no trenched micro-watershed) during 2004 and 2005. These micro-watersheds were treated with the three different trenching densities for trapping 25, 50 and 75% of potential runoff. Uniform land management systems i.e. ravine humps with Aonla, ravine bottom with bamboo and interspaces with *Dhaman* grasses were imposed with recommended package of practice since 2006. During 2014, the area received a total of 632.3 mm rainfall in 25 events. Rainfall of 481.2 mm through 9 events produced runoff of 15.9, 10.8, 5.6 and 1.9% of rainfall and sediment yield of 7.29, 4.56, 2.02 and 0.6 t ha^{-1} yr^{-1} from RW_1, RW_2, and RW_3, respectively (Table 4.1). Results showed that runoff conserved in the RW_2, RW_3 and RW_4 over the RW_1 micro-watershed was respectively, 32.9, 54.1 and 82.0%, and retained sediment nearly 35.4, 69.4 and 103.2% over control, which reflect the significant impact of the trenching and its density on the natural resource conservation measures over the untrenched area. There was no significant difference in soil physio-chemical properties observed during the period of experimentation. The total productivity of *aonla* and grass in the ravine lands were recorded, respectively 2.878, 5.152, 7.199 & 7.880 t ha^{-1} yr^{-1}; and 3.988,

Table 4.1 : *Hydrological behaviour, productivity and production potential of the ravine watersheds in the medium and deep ravine lands of the Chambal catchment*

तालिका 4.1 : चंबल जलग्रहण क्षेत्र के मध्यम एवं गहरी बीहणयुक्त भूमियों में बीहणयुक्त जलागम का जलविज्ञानी व्यवहार, खड्ड की उत्पादकता एवं उत्पादन क्षमता

Micro-watershed	Runoff		Sediment		Aonla	Bamboo	Grass
	Rainfall gener ating runoff (%)	Conserved (%)	Yield (t ha^{-1} yr^{-1})	Retained (%)	(t)	(clums)	(t)
RW_1	15.9	Control	7.29	Control	2.878	12	3.988
RW_2	10.8	32.9	4.56	35.4	5.152	19	4.441
RW_3	5.6	54.1	2.02	69.4	7.199	22	5.228
RW_4	1.9	82.0	0.60	103.2	7.880	27	5.972

4.441, 5.228 & 5.972 under the RW_1, RW_2, RW_3 & RW_4 respectively (Table 4.1). It is concluded that the protective medium and deep ravines could be economically and environmentally converted into productive system with the adaptation of suitable soil and water conservation measures as the adoption of trenching and planting of suitable perennial economically marketable plants.

Field evaluation of design of trenches under different agro-ecological regions

A. Vasad (R.S. Kurothe, V.C. Pande and Gopal Kumar)

Contour trenches are rainwater harvesting structures, which can be constructed on hill slopes as well as on degraded and barren waste lands in both high and low rainfall areas. The size and number of trenches are worked out on the basis of the rainfall proposed to be retained in the trenches. Valuable information is available on their design, layout, construction and performance of various land uses in different regions of our country and abroad. However, an optimum option considering size, intensity, cost and performance needs to be identified under various land uses and edaphic and climatic conditions. A core project has been started during 2011-12 at regional centres of the institute to cover different agro-climatic regions of the country with objectives: (a) to identify design storm, size and trenching intensities, (b) to quantify resources conserved, and (c) to suggest optimum options by devising a DSS.

The design storm has been identified after analysis of maximum daily rainfall data. Three treatments of 30, 50 and 80% retention of runoff from design storm will be done in staggered trenches. One watershed will be kept as control for comparison. Accordingly size and intensities of the trenches will be decided. Rainfall, runoff, breach patterns, soil loss, moisture distribution, input costs, growth parameters, yields etc. will be recorded.

A preliminary linear relationship was developed during 2011 from 10 events data. However, in the year 2012 rainfall-runoff data (10 events) is more scattered and has no trend at all. In the year 2013 also 16 events recorded has scattered data. Seven storms recorded in 2014 also show scatter. As a result rainfall-runoff relationship could not be established even with all the events from 2011 to 2014. Since many events produced zero runoff, the linear regression fitting gave a very low R^2. As an alternative, regression was performed on 10 extreme events. This data give a better fit for W_2, W_3 & W_4 watersheds {$Y=-15.476+0.392X_{W2}$; ($R^2=0.596$), $Y=-19.850+0.4377X_{W3}$; ($R^2=0.700$) & $Y=-21.796+0.4228X_{W4}$; ($R^2=0.656$)}. The data of control watershed (W_1) do not give a better fit {$Y=1.9174+0.037X_{W1}$; ($R^2=0.069$)}.

The relationship of runoff from W_1 watershed and other watershed runoff (W_2, W_3 & W_4) could not be established from pooled data 2011-14

$Y_{W2} = 4.352+1.677X_{W1}$; ($R^2=0.214$),

$Y_{W3}=2.347+2.025X_{W1}$; ($R^2=0.324$); and

$Y_{W4}=2.371+1.873X_{W1}$; ($R^2=0.313$).

However, runoff from W_2-W_3 ($Y_{W3}=-0.3684+0.8763X_{W2}$; $R^2=0.795$) and W_2-W_4 ($Y_{W4} = 0.6878 + 0.8424X_{W2}$; $R^2=0.793$) gave better relationships.

The control watershed runoff behaviour is not predictable so paired watershed technique may not be useful in this case. The treatments will be imposed and comparison will be made from before and after treatment data. Relationships (W_2-W_3 and W_2-W_4) may be used for inter-comparison.

Vegetation composition: During the current year, *Azadirachta indica* plantation was done in the month of July 2014. The trench density in different catchments was estimated from the DSS software developed at the centre. The tree survival and green biomass measured in December 2014 (Fig. 4.2).

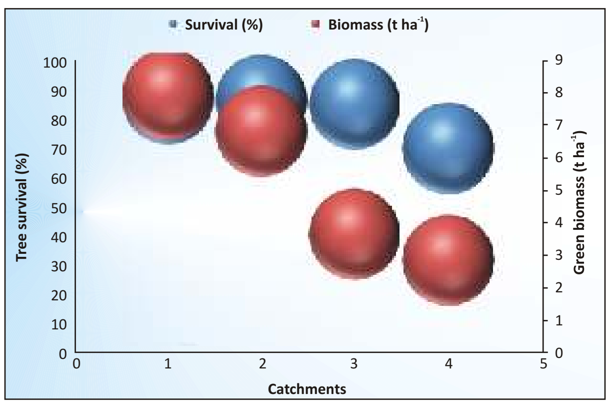


Fig. 4.2 : Tree survival and green biomass in different catchments
चित्र 4.2 : विभिन्न जलग्रहण क्षेत्रों में वृक्ष जीवितता एवं हरा जैवभार

Watershed (W_1) was dominated by green biomass of *Ocimum sanctum* (330 gm m^{-2}) followed by *Eclipta alba* (310 gm m^{-2}) and *Achyranthes aspera* (130 gm m^{-2}). In W_2, similarly, highest biomass was observed for *Ocimum sanctum* (163 gm m^{-2}) followed by *Spermacoce hispida* (90 gm m^{-2}), *Desmostachya bipinnata* (88 gm m^{-2}) and *Pulicaria wightiana* (85 gm m^{-2}). W_3 had maximum biomass *of Securinega virosa* (105 gm m^{-2}) followed by *Desmostachya bipinnata* (65 gm m^{-2}). W_4, on the other hand, had maximum biomass of *Apluda mutica* (50 gm m^{-2}) followed by *Ocimum sanctum* and *Grewia pilosa* (45 gm m^{-2}) (Fig. 4.3).

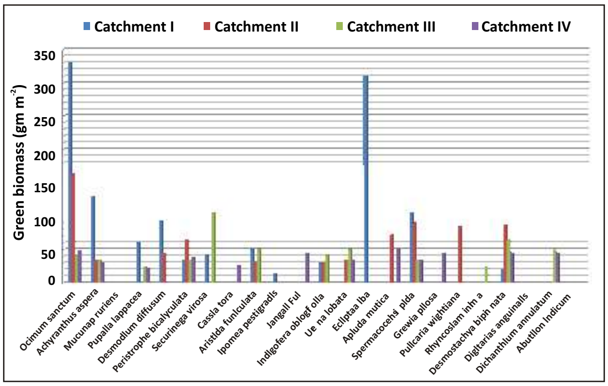


Fig. 4.3 : Species-wise distribution of species in different catchments
चित्र 4.3: विभिन्न जलग्रहण क्षेत्रों में प्रजातियों की प्रजातिवार वितरण

B. Chandigarh (A.K. Tiwari, Pankaj Panwar, V.K. Bhatt and Sharmistha Pal)

Study is being conducted in four micro hilly watersheds located within the research farm of Centre. Land use of these watersheds is sparse mixed deciduous forest. Slope of these micro watersheds varied from 35.8 to 52.5%. These micro-watersheds are equipped with gauging structures and recorder houses. Runoff is being gauged through 0.3 m deep 90° sharp crested weirs supported with water stage recorders. Presently all the micro watersheds are being calibrated for runoff. Runoff was recorded during monsoon season of 2014. There were total 10 runoff causing storms (from July to Sept.2014) varying from 14 to 86 mm. Maximum 5 storms occurred in the month of July 2014. Highest rainfall was 92.2 mm on 02.07.2014. There was only one runoff causing rainfall during the month of September.

Runoff and soil loss analysis indicate that runoff varied from 3.89 to 14.93% and soil loss varied from 3.5 to 18.6 kg ha^{-1} (Table 4.2). Bed load i.e. deposited silt in the approach channel and debris basin was also measured which ranged from 11.3 to 29.4 t ha^{-1} (Table 4.2).

On the basis of data of calibration period (2013 and 2014), runoff from each of the three micro watersheds MWS-37, MWS-38 and MWS-39 was calibrated with respect to runoff from MWS-36 (control watershed). Polynomial type equations fitted well for calibration as under:

$$R_{37}=-0.0154(R_{36})^2+0.8764R_{36}-0.0084 \quad (n=28, r=0.99) \quad ...1$$
$$R_{38}=-0.0108(R_{36})^2+0.4316R_{36}+0.0627 \quad (n=28, r=0.98) \quad ...2$$
$$R_{39}=-0.0431(R_{36})^2+1.6314R_{36}-0.2277 \quad (n=28, r=0.97) \quad ...3$$

where, R_{36}, R_{37}, R_{38} and R_{39} are runoff in mm from micro watersheds MWS-36, MWS-37, MWS-38 and MWS-39, respectively.

Soil moisture measurement was done in 4 experimental micro watersheds. In the surface soil layer (0-15 cm), it varied from 1.22 to 8.04%, 1.64 to 10.72%, 2.26 to 9.23% and 2.01 to 22.9% in MWS-36, MWS-37, MWS-38 and MWS-39, respectively over a period from February to December, 2014. In the lower soil layers, the moisture content ranged from 1.2 to 7.9%, 4.1 to 11.56%, 1.2 to 9.3% and 3 to 25%, in MWS-36, MWS-37, MWS-38 and MWS-39, respectively.

Table 4.2 : *Rainfall, runoff and soil loss from all the four micro watersheds during 2014*
तालिका 4.2 : वर्ष 2014 के अंतर्गत सभी चार सूक्ष्म जलागमों में वर्षा, अपवाह एवं मृदा ह्रास

Month	Rainfall (mm)	Runoff (mm)				Month	Soil loss (kg ha^{-1})			
		MWS 36	MWS 37	MWS 38	MWS 39		MWS 36	MWS 37	MWS 38	MWS 39
July	246.5	22.92	13.43	9.36	28.25	July	0.4	0.4	0.7	0.4
August	196.2	48.9	26.01	9.56	26.14	August	3.1	27.5	5.5	18.2
September	54.2	2.39	1.17	0.4	0.49	September	0	0	0	0
Total	***496.9***	***74.21***	***40.61***	***19.32***	***54.88***	***Total***	***3.5***	***27.9***	***6.2***	***18.6***
	%	**14.93**	**8.17**	**3.89**	**11.04**	**Bed load (t ha^{-1})**	**29.4**	**22.60**	**11.30**	**12.80**

C. Udhagamandalam (S. Manivannan, K. Kannan and K. Rajan)

Experimental plots of the project were still under calibration (i.e. 3rd year), and runoff, soil and nutrient losses, soil physical properties (infiltration rate, bulk density and soil moisture) were monitored. An amount of 1098.4 mm rainfall was recorded in the experimental site which was 8.5% less than normal rainfall (1200 mm). Annual runoff depth in all four plots varies from 34 to 142 mm which was large variation due to variation in infiltration rates (1.2 to 2.7 cm hr^{-1}). Soil losses ranged from 0.2 to 2.1 t ha^{-1} yr^{-1} which was due to wide variation in infiltration rates (Table 4.3). Similar trend was observed in case of nutrient losses.

Soil moisture in the profile was lowest in March and highest during September - October (Fig. 4.4). From April, the moisture status of the soil is increasing till October. During dry and wet period, the highest soil moisture was found in T_3 followed by T_2 and T_4. The lowest soil moisture was recorded in T_1. Soil reaction was acidic ranged from 4.9 to 5.7. Solute concentration in the soil varied from 0.02 to 0.04 dSm^{-1}. Organic carbon of all the soils falls in higher rating and means' value is varying from 14.8 to 17.3 g kg^{-1} of soil. Available soil nitrogen ranged from 176 to 245 kg ha^{-1}. Available phosphorus ranged from 14.1 to 16.6 kg ha^{-1} and rated as medium to high. Available potassium ranged from 139 to 202 kg ha^{-1} (Table 4.3).

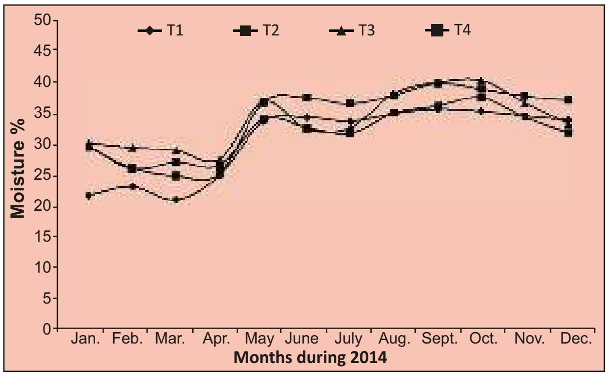


Fig. 4.4 : Annual soil moisture dynamics in the experimental plots

चित्र 4.4 : प्रयोगात्मक भूखंडों में वार्षिक मृदा नमी गतिशीलता

The grass dry matter production recorded during 2014-15 before implementation of the treatment was higher in the plots earmarked for 80% runoff retention (2.472 t ha^{-1}) and 2.250 t ha^{-1} in the plots earmarked for control followed by 1.561 t ha^{-1} (30% runoff retention) and 1.270 t ha^{-1} (50% runoff retention).

D. Agra (S. Kala, A.K. Singh and R.B. Meena)

During 2014-15, study focused on rainfall distribution and runoff calibration from selected watersheds. Four watersheds were identified and selected having an area of 0.206, 0.290, 0.197 and 0.155 ha under degraded Yamuna ravines with slope ranges from 8.5 to 15.4% at Research Farm of the Centre. Refinement of four gauging structures have been completed before monsoon for calibrating runoff and soil loss.

This year was drought year and no runoff producing rain event was recorded from any selected watershed. The total monsoon rainfall received during this year was 170 mm only. There was not a single storm during monsoon season having rainfall more than 40 mm. The 80% rainfall received during this year having rainfall amount less than 10 mm (Table 4.4).

The trenching work were completed at different intensity of trenches (0%, 30%, 60% and 80%) on experimental site with aim to identify design storm, size and trenching intensity, to quantify resources conserved, to suggest optimum option by devising a DSS and to promote better design of trenches and

Table 4.3 : *Annual runoff, soil loss and soil fertility status in the experimental plots during the year 2014*

तालिका 4.3 : वर्ष 2014 के अंतर्गत प्रायोगिक भूखंडों में वार्षिक अपवाह, मृदाह्रास एवं मृदा उर्वरता स्थिति

Treatment	Rainfall (mm)	Runoff (mm)	Percentage of runoff	Soil loss (t ha^{-1} yr^{-1})	pH	EC (dS m^{-1})	OC (g kg^{-1})	Avail. N (kg ha^{-1})	Avail. P_2O_5 (kg ha^{-1})	Avail. K_2O (kg ha^{-1})
T_1: : 30% of runoff retention	1098.4	54.6	5.0	0.4	4.9	0.04	15.6	213	16.6	202
T_2: : 50% of runoff retention	1098.4	34.9	3.2	0.2	5.7	0.04	15.7	203	15.1	183
T_3: : 80% of runoff retention	1098.4	141.7	12.9	2.1	5.0	0.02	14.8	184	14.1	139
T_4: : Control	1098.4	87.0	7.9	0.8	4.9	0.03	14.2	183	14.4	152

transfer it to field (Photo 4.1). The details about the trenching, volume of earth work and cost of work at four ravine watersheds of AGA FS-10, AGA FS-11 and AGA FS-12 are presented in Table 4.5. Karanj (*Pongammia pinnata*) species selected for trench project under Yamuna ravine catchments and it is hardy species and suitable for this agro climatic condition. This species planting programme will be initiated during the monsoon of the year 2015. The selected spacing of 5x5 m will be given between row to row and plant to plant in three watersheds for field evaluation.

Photo 4.1 : Trench lay out, renovated gauging structures and soil profile studies at watersheds

फोटो 4.1 : जलागमों में खन्दक लेआउट, पुनर्निर्मित अपवाह मापक संरचनाएं एवं मृदा रूपरेखा अध्ययन

Status of pre-monsoon and post monsoon soil basic properties were assessed at four watersheds. Basic soil fertility data of the experimental site is presented in Table 4.6. Result showed that EC varied from 0.13 to 0.22 ds m^{-1} 0.13 to 0.43 ds m^{-1} and 0.16 to 0.36 ds m^{-1} at top, middle and bottom, respectively. Similarly, pH of experimental site was found normal and ranged from 8.03 to 8.54 whereas organic carbon ranged from 0.28 to 0.78%. Available nitrogen, phosphorus and potassium were recorded 87.81 to 175.62 kg ha^{-1}, 3.25 kg ha^{-1} to 14.48 kg ha^{-1} and 145.60 to 268.80 kg ha^{-1}, respectively.

Pre- and post- monsoon soil moisture status were recorded from different sections (top and bottom) at two different depths of each watershed (Table 4.6) and observed that the soil moisture content ranged from 2.40 to 4.35% (0-30 cm) and 3.41 to 4.70% (30-60 cm) depths on top of the watersheds and 2.96 to 4.72% (0-30 cm) and 2.19 to 4.29% (30-60 cm) depth on bottom of the watersheds, respectively, in the pre-monsoon season, whereas in post-monsoon season the soil moisture ranged from 6.56 to 7.18% (0-30 cm) and 5.92 to 10.56% (30-60 cm) depth on top of the watersheds and 6.33 to 11.04% (0-30 cm) and 6.41 to 10.97% (30-60 cm) depth on bottom of the watersheds, respectively. The moisture content at top was low because water flow towards bottom and same time bottom also accumulate the organic matter which increased soil moisture holding capacity of the soil. At bottom organic matter accumulation was more at surface as compared to sub-surface, therefore, moisture content was high at 0-30 cm as compared to 30-60 cm depth.

Table 4.4 : *Rainfall distribution during monsoon 2014*

तालिका 4.4 : मानसून वर्ष 2014 के दौरान वर्षा वितरण

Months	Rainfall (mm)	Rainfall storm (mm)			
		> 10	> 20	> 30	> 40
July	32.1	21.0	21.0	0.0	0
August	93.3	84.4	65.4	65.4	0
September	44.3	30.2	0.0	0.0	0
Total	**169.7**	**135.6**	**86.4**	**65.4**	**0**

Table 4.5 : *Details of design of trench work at watersheds*

तालिका 4.5 : जलागमों में खन्दक कार्यों के डिजाइन का विवरण

Particulars	Trenching study watershed -Agra			
	FS-9	FS-10	FS-11	FS12
Slope (%)	9	8.5	15.4	8.4
Area (ha)	0.206	0.290	0.197	0.155
Length (m)	50	64	54	61
Width (m)	41	45	36.5	25.4
Runoff to be trapped (%)	Control	30	60	80
Trench Horizontal Interval(m)	Control	5.98	2.79	2.24
Trench Vertical Interval (m)	Control	0.51	0.43	0.19
No. of trench (ha^{-1})	Control	241	353	173
Volume of earth work (cu-m)	Control	56.94	83.4	81.74
Cost of earth work (₹)	Control	10249	15011	14714
Cost (₹ ha^{-1})	Control	35,587	76,159	94,966
Species - *Pongamia pinnata* (Spacing 5x5 m)	Control	116	79	62

Table 4.6 : *Basic fertility status and pre and post monsoon moisture status of experimental site*

तालिका 4.6 : प्रारम्भिक उर्वरता स्थिति और प्रायोगात्मक स्थल की मानसून पूर्व एवं उपरान्त नमी स्थिति

Watershed	Section	Soil parameters						Moisture status (%)			
		EC (dS m^{-1})	pH	OC (%)	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Pre-monsoon		Post-monsoon	
								0-30 cm	30-60 cm	0-30 cm	30-60 cm
AGA FS-9	Top	0.22	8.22	0.28	100.35	10.58	145.60	4.24	4.60	6.56	6.42
	Middle	0.43	8.10	0.38	100.35	10.58	168.80				
	Bottom	0.17	8.21	0.47	175.62	14.48	182.20	4.45	4.29	11.04	10.97
AGA FS-10	Top	0.21	8.03	0.44	87.81	4.25	232.16	2.40	3.41	7.07	7.00
	Middle	0.13	8.19	0.47	125.44	3.58	236.28				
	Bottom	0.36	8.12	0.78	137.98	4.92	238.20	2.96	2.19	6.33	7.13
AGA FS-11	Top	0.13	8.32	0.28	87.81	6.50	215.00	4.35	4.70	7.18	10.56
	Middle	0.15	8.32	0.28	87.81	6.20	216.00				
	Bottm	0.16	8.37	0.38	150.88	6.44	255.36	4.15	3.95	10.27	8.63
AGA FS-12	Top	0.16	8.41	0.16	87.81	3.25	282.24	3.55	4.23	7.16	5.92
	Middle	0.13	8.49	0.31	137.98	6.27	268.00				
	Bottom	0.18	8.54	0.24	113.25	4.25	268.80	4.72	3.95	7.56	6.41

E. Kota (Shakir Ali, Ashok Kumar and A.K. Parandiyal)

The project was initiated in April 2011 with the objectives of identifying design storm, size and trenching intensity; quantifying resources conserved; and suggesting optimum option by devising a decision support system (DSS). The three micro-watersheds namely; W_1 W_2, W_3 and W_4 located in Dhoti watershed was monitored hydrologically for the calibration purpose. The area of the watersheds W_1, W_2, W_3 and W_4 are 0.75, 0.50, 0.45 and 1.00 ha. The relief of the micro-watersheds varies between 2.21 (W_3 and W_4) and 2.51 m (W_1) and 2.24 m for the micro-watershed W_2. The slope of the micro-watersheds ranged from 2.51 to 3.58%. During the year under report, the area received 859.0 mm rainfall through 31 events. Runoff producing events were recorded 11 with rainfall amount of 505.8 mm. The runoff generating potential of the W_1, W_2, W_3 and W_4 micro-watersheds was recorded of 16.8, 14.7, 18.1 and 15.2% of monsoon rainfall and sediment yields was of 15.010, 14.208, 16.740 and 13.839 t ha^{-1} yr^{-1}, respectively. The calibration prediction equations for runoff and soil loss were established. The plantation of *Acacia nilotica* has been completed in the month of Sept., 2014. The approved trenching densities treatments for trapping 30, 60 and 80% of potential runoff would be imposed before the monsoon season 2015.

F. Datia (Monalisha Pramanik and S.P. Tiwari)

As an Institute's core project this study was initiated in 2010 to determine optimum design of trenches in soil-agro-climatic conditions of Bundelkhand region. One day maximum rainfall of five years return period was, computed, for the purpose, to decide the design storm for size and trenching intensity. Experimental site consist of four micro catchments, W_1, W_2, W_3 and W_4 of sizes 0.7 ha, 0.23 ha, 0.27 ha and 0.40 ha, respectively. Average soil loss, total rainfall and runoff for the monsoon period of 2014 are shown in Table 4.7. It revealed that runoff and soil loss were maximum in W_2 (180.69 mm & 1.61 t ha^{-1}) and minimum in W_3 (111.46 mm & 0.93 t ha^{-1}).

The infiltration rate of soil and land slope might have major influence on the runoff. Event wise rainfall and runoff under different watersheds is depicted in Fig. 4.5. Rainfall runoff relationships for different watershed revealed a good relationship (R^2 > 0.8) exist between rainfall and runoff of each micro-watershed (Fig. 4.6).

Design and numbers of the trenches was worked out using 'Trench software' provided by the PI for plantation of 'Karanj' (*Pongamia pinnata*) species

Table 4.7 : *Annual rainfall, runoff and soil loss in four different micro catchments - 2014*

तालिका 4.7: वर्ष 2014 में चार विभिन्न जल ग्रहण क्षेत्रों में नापी गई वर्षा, अपवाह एवं मृदा हानि

Watershed	Catchment Area (ha)	Runoff (mm)	Runoff (%)	Soil loss (t ha^{-1})
W_1	0.70	94.89	21.39	1.19
W_2	0.23	180.69	40.73	1.61
W_3	0.27	111.46	25.13	0.93
W_4	0.40	157.43	35.49	1.60

Note: Rainfall during the monsoon season 2014: 443.6 mm.

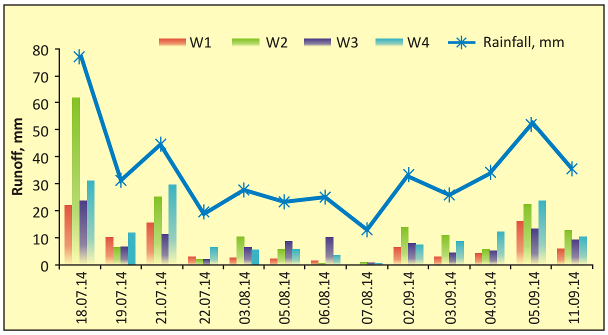


Fig. 4.5 : Event wise rainfall and runoff recorded in different micro- catchments during 2014

चित्र 4.5 : वर्ष 2014 में दतिया के चार विभिन्न जल ग्रहण क्षेत्रों में नापी गई वर्षा एवं अपवाह

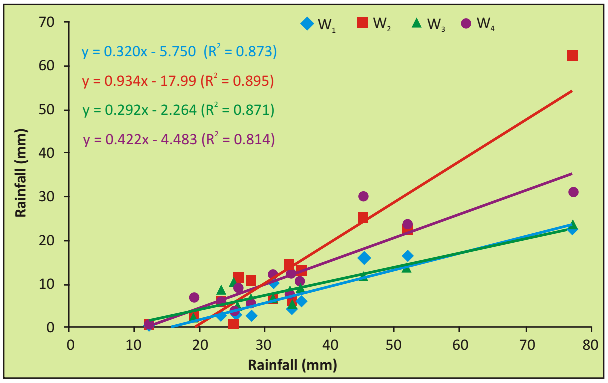


Fig. 4.6 : Rainfall-runoff relationship of different watershed for the year 2014

चित्र 4.6 : वर्ष 2014 में दतिया के चार विभिन्न जलागमों हेतु विकसित वर्षा–अपवाह संबंध

considering its suitability in the region being hardy, less-browsed by wild life/cattle etc. Accordingly a number of 63, 148, 220 trenches of appropriate size to retain 30%, 50% and 80% runoff will be imposed in W_2, W_3 and W_4 micro-catchments, respectively keeping W_1 as control (without trenching treatment) with plantation of Karanj during ensuing rainy season.

G. Koraput (D.C. Sahoo, M. Madhu and P.P. Adhikary)

This study was undertaken at ICAR-IISWC, Research Farm, Semliguda, Koraput. The design storm has been analyzed for maximum daily rainfall data of Research Farm. Maximum daily rainfall for 2 and 5 year return period was worked to 109 and 152 mm, respectively. An experimental site consisting of four watersheds was selected having an area of 0.1708, 0.1748, 0.1722 and 0.1702 ha in the degraded land having an average slope of 8%. Four gauging stations were constructed during 2012 and hydrological data were monitored. All the watersheds were under calibration for a period of two years (2012 & 2013). *Acacia mangium* was planted during the monsoon of 2014 in all the watersheds and three treatments, *viz*; 30, 50 and 80% retention of runoff from the design storm for two years return period were imposed during 1st week of September and one watershed kept under control for comparison.

Acacia mangium was planted at 1.5 m plant to plant and 3.0 m row to row spacing during monsoon and observed a survival percent of more than 95%. Contoured Staggered Trenching with dimension of 2x0.5x0.45 m^3 (LxWxD) was carried out during the monsoon to harvest and store the excess runoff within the trenches (Photo 4.2). For 80, 50 and 30% runoff retention, 187, 132 and 88 number of trenches were taken in watersheds W_1, W_2, W_3, respectively and W_4 was kept as a control with only plantation and without trenches.

Initial growth parameters (plant height and basal diameter) of *Acacia mangium* was observed randomly from 15 plant three months after plantation and after executing the treatments of runoff retention through trenches. Better height and diameter was found in the watershed with 80%

Photo 4.2 : Plantation of *Acacia mangium* and trenching in different watershed

फोटो 4.2 : विभिन्न जलागमों में बबूल रोपण एवं खंती निर्माण

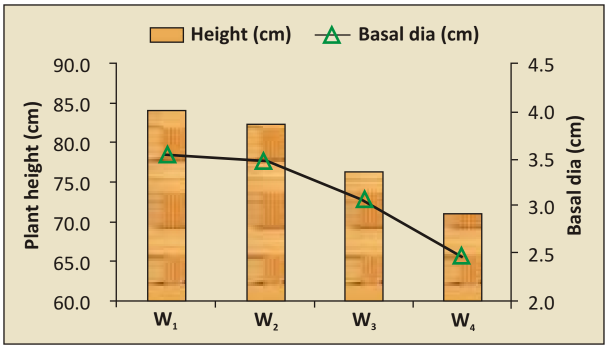


Fig. 4.7 : Plant height and basal dia. of *Acacia mangium* in different watersheds

चित्र 4.7 : विभिन्न जलागमों में बबूल पौधों की ऊंचाई एवं तना व्यास

runoff retention followed by 50% and 30% retention (Fig. 4.7). However, because of initial reading, no conclusion was drawn with respect to the trend in height and diameter.

Total runoff producing rainfall was 1072 mm during the year 2014 from 32 rainfall events. Event wise runoff was analyzed with respect to the corresponding rainfall before and after the execution of trenching. Runoff (percent to the runoff producing rainfall) is 18.6%, 20.3%, 24.2% and 21.3% before trenching but after the imposition of treatments i.e., trenching it was 4.3%, 8.7%, 12.8% and 21.0% under W_1, W_2, W_3 and W_4 watershed, respectively. The reduction in runoff was 76.6%, 57.2% and 47.2% after trenching in W_1, W_2 and W_3, respectively over before trenching in respective treatments. Total soil loss for the year from all the rainfall events was 1.24, 1.48, 1.58 and 1.41 t ha^{-1} from W_1, W_2, W_3 and W_4, respectively.

Enhancing productivity of ravine lands by plantation of A. sapota with intercropping systems (Raj Kumar, B.K. Rao, Gopal Kumar and V.C. Pande) - Vasad

A study was initiated in 2008 to enhance the productivity of ravine land by plantation of Sapota (*Acorus sapota* L.) with intercropping. Five treatments, namely; T_1 (Cowpea+castor in bench terrace); T_2 (Cowpea+castor+sapota in bench terrace); T_3 (Sapota plantation in bench terrace); T_4 (Sapota + staggered trench) and T_5 (Pure sapota) was imposed to assess impact on crop/tree growth and yield, runoff and soil loss. During 2014 results showed that Cowpea (green pod - 217 kg ha^{-1}) and straw yield (515 kg ha^{-1}) in T_1 were higher than T_2 (green pod - 193 kg ha^{-1} and straw yield - 435 kg ha^{-1}). The low yield of Cowpea was obtained due to heavy rainfall (335 mm in three days) just after sowing. Effect of different treatments on growth of Sapota depicted that height and diameter were higher in T_3 and lower in T_2.

The rainfall, runoff and soil loss data from various treatments were collected and analysed. The monsoonal rainfall in 2014 was 1221 mm and rainy days were 36. Among the treatments the lowest runoff (186 mm) and soil loss (4.89 t ha^{-1}) were recorded from T_3 (Fig. 4.8). The terraced treatment in undisturbed land condition reduced the runoff and soil losses. The highest runoff (364 mm) was occurred in the T_5 treatment but highest soil loss (9.02 t ha^{-1}) was registered in T_1 treatment. Possibly tillage and other crop operations caused more soil loss.

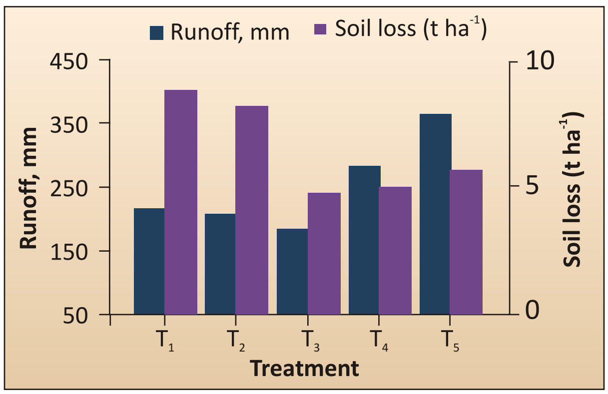


Fig. 4.8 : Runoff and soil loss from different treatments

चित्र 4.8 : विभिन्न उपचारों से अपवाह एवं मृदाह्रास