EFFECT OF VEGETATION AND ENGINEERING CONTROL STRUCTURES ON SURFACE RUNOFF AND SEDIMENT YIELD AT FIZAGAT, SWAT.

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Abstract

This study was conducted to evaluate the effect of different soil conservation measures, both biological and engineering on surface runoff and sediment yield in five contiguous small catchments having almost similar slopes and soil characteristics. Different treatments namely; mix plantation with engineering techniques, mix plantation, pure chir pine plantation with engineering techniques and Pure chir pine plantation with range land improvement practices were randomly applied to four sub-catchments, while the 5th one was kept untreated and open to grazing.Nine year's (1986-1995) average data showed that both the hydrologic response and sediment yield from the catchment treated with mix plantation and engineering technique was less than half as compared to other treatments.This response was much higher in the catchment untreated and kept open to grazing. The analysis of variance showed that hydrological response and sediment concentration was significant and non significant at 5% level,respectively.

Introduction

Several watershed management programmes have been implemented in Pakistan in the past decades. These programmes were carried out to rehabilitate the severely deteriorated catchments of the existing Tarbela and Mangla reservoirs and the proposed dam at Kalabagh. Biological and engineering control measures have been used in an attempt to control erosion in mountain watersheds of the country.However, no assessment of the effectiveness of these projects has been conducted.

This study was designed to investigate the effects of biological and engineering control measures on surface runoff and sediment yield in the

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catchment of the River Swat, a tributory of the River Indus. The study was established in cooperation with the NWFP Forest Department under the FAO/UNDP/Pak/78/036 Project in 1985 at Fiza Gat,Swat.

The main objective of the study was to determine the effect of reforestation and exclusion of grazing on annual streamflow and sediment production.

Materials and Methods

1.Study site

The study site is located at Fizagat near Saidu Sharif in Swat District, NWFP. The area includes a catchment with five contiguous sub-watersheds. The sub-watersheds range in size from 4 to 20 hectares. The catchment have steep slopes with channels that have cut to bedrocks. The elevation above sea level ranges from 914 to 1341 m. The soil consists of shallow remanent of sandy loams overlying sandstone with intrusions of quartzite and schist (Table 1).Exposed bedrock is prevalent on the watershed surface. The vegetation at the beginning of the study consisted of a sparse cover of overgrazed grasses and shrubs.

The catchment has western aspect. All the sub-catchments have a common channel which drains directly into the Swat River. The streamflow is mostly ephemeral with intermittent flow during February and March.

Table 1. Physical Characteristics of the sub-catchments at Fiza Gat (Swat)

Sub-catchment	Area (ha)	Channel Length (m)	Elevation (m)	Aspect	Soil
SW1	20	898	914-1341	Western	Sandy loam
SW2	13	891	945-1250	"	"
SW3	13	634	945-1189	"	"
SW4	4	414	945-1158	"	"
SW5	6	500	945-1158	"	"

2. Procedures

Biological and engineering control structures selected for the sub-catchments were similar to that being used in the watershed programmes by the Forest Department, NWFP in Swat district.

Treatments given to SW1 sub-catchment were mix plantation of *Pinus roxburghii* (Chir pine) and broad leaved species with a spacing of 3 x 3 m each. Broad leaved species included *Eucalyptus camaldulensis, Robinia pseudoacacia* and *Ailanthus altissima*. Pits were used for planting of seedlings of all species. Seedlings of chir pine were planted on the ridges. Loose stone check dams were constructed at specified location in the main channels. Grazing was excluded. Sub-catchment SW2 was without engineering control structures, however its biological treatments and protection from grazing was just similar to SW1. Both SW3 and SW4 were treated with pure chirpine plantation in combination with engineering control structures to the former and rangeland improvement practices to the later. Rangeland improvement practices in SW4 consisted of interseeding with grasses/forbs species including *Medicago sativa, Chrysopogon aucheri, Onobrychus sativa* and *Bothriochloa pertusa*. Grazing was excluded in both the catchments. Sub-catchment SW5 was open to grazing and no biological or engineering soil conservation treatments were given to it (Anon,1987).

A meteorological observatory was established within the research area near SW1 at an elevation of 914 m with coordinates of latitude N 34° 45' and longitude E 72° 22'. The parameters measured were daily temperature, reletive humidity, wind velocity, rainfall, evaporation and solar radiation. Average of nine years meteorological data are given in Table 5.

Eight standard rain gauges were placed,four on the ridges of the sub-catchments and four in the lower elevations near the streamflow measurement stations, to measure the spatial distribution of rainfall over the experimental area. Rainfall accumulation was recorded after each rainfall event.

The modified San Dimas flumes were constructed for the measurement of surface runoff and sediment concentration at the outlet of each sub-catchment. Stilling wells were provided for fixing Automatic stage recorders. For manual observation staff gauges were also attached in each flume. Sediment load determination was conducted on yearly basis from each individual storm event

and for each sub-catchment, using laboratory facilities at PFI. The Hydrological Respons and sediment yield for each year are given in Table 4. Collection of data on total forage production, cover percentage and percentage of different surface materials were regularly performed once in a year. Average weight of dry forage production and percentage cover are shown in Table 3 (Tennyson,1986).

Results

The results on surface runoff and sediment yield indicated that highest average hydrological response of 27% and sediment yield of 295 kg/ha/year were for sub-watershed SW5 (kept as untreated), while the lowest average hydrological Response of 10% and sediment yield of 58 kg/ha/year were for SW1, Subwatershed treated with plantation of *Pinus roxburghii*, broad leaved Tree species and Technical soil conservation measures. The results are given below in Table 2.

Table 2. Hydrological response & sediment yield of Different sub-watersheds.

Subwatershed	Treatment	Hydrological Response (%)	Sediment yield Kg/ha/year
SW1	Mix plantation + Engineering Techniques	10	58
SW2	Mix plantation + No Engineering Techniques	19	90
SW3	Pure pine + Engineering Techniques	20	112
SW4	Pure Pine + Range improvement Measures	21	135
SW5	Control (open to grazing)	27	295

Analysis of variance (ANOVA) of hydrological response by treatments was conducted. The hydrological response was significant at about 5% level. The L.S.D. test was also applied which revealed that there are two sets of treatments which are mutually non-significant. The two sets of treatments are shown below.

		Sub set I		
Groups	1	2	3	4
Mean	10.011	16.800	20.022	21.044

Non significant

		Sub set II		
Groups	2	3	4	5
Mean	16.800	20.022	21.044	27.056

Non significant

Analysis of variance of sediment concentration was also conducted. The analysis showed that the treatments were not significant at 5% level and were mutually non-significant.

Though the highest average yield of dry forage production of 3666 kg/ha and vegetation cover percentage of 80 were found in SW4 sub-catchment treated with pure chir pine plantation and range improvement practices (Table 3), however, its hydrological response and sediment yield, 21% and 135 kg/ha/yr respectively (Table 2) were found higher as compared to SW1.

Table 3: Average dry forage production and vegetation cover percentage

Sub-catchment	Average forage production kg/ha	Average cover percentage
SW1	3221	79
SW2	3115	77
SW3	3283	74
SW4	3666	80
SW5	1795	56

Conclusions

The result of the study indicated that for the rehabilitation of denuded watersheds *Pinus roxburghii*, with broad-leaved mix plantation and loose stone massonary check dams were quite effective to reduce surface run-off and soil erosion. The study further proved that if range improvement practices were combined with the above soil conservation treatments,it will be more effective measures to rehabilitate the degraded watersheds.

Table 4. Summary of Hydrological responses and sediment yields of different catchments at Fizagat, Swat (1987-1995)

Year		SW1	SW2	SW3	SW4	SW5
1987	a	7.0	30.4	27.3	13.2	17.7
	b	24.0	55.0	91.0	89.0	85.0
1988	a	7.4	13.4	5.8	6.5	26.8
	b	31.0	6.0	6.0	32.0	20.0
1989	a	7.2	9.1	12.3	13.9	14.5
	b	58.0	90.0	100.0	217.0	215.0
1990	a	12.5	28.4	22.5	49.6	53.3
	b	100.0	310.0	230.0	550.0	580.0
1991	a	12.9	25.0	45.1	37.4	36.1
	b	58.0	197.0	235.0	81.0	1091.0
1992	a	5.8	10.4	8.2	4.8	10.3
	b	110.0	39.0	126.0	30.0	410.0
1993	a	12.6	24.9	30.1	30.8	36.0
	b	70.0	80.0	120.0	130.0	200.0
1994	a	13.2	-	16.0	17.5	23.2
	b	30.0	-	50.0	36.0	58.0
1995	a	11.5	9.6	12.9	15.7	25.6
	b	40.0	31.0	52.0	48.0	95.0
Average	a	10.0	19.0	20.0	21.0	27.0
	b	58.0	90.0	112.0	135.0	295.0

a. Hydrological response (Percent)
b. Sediment yield (kg/ha)

Table 5. Meteorological data of Fizagat, Swat (average of nine years, 1986-95)

Month	Air Temp (°C)		Evaporation (mm)	Rainfall (mm)	Wind vilocity (km/hr)		Soil Temp (°C)		Sunshine duration	
	Max	Min			at 2'	at 8'	Surface	at 4'Depth	Hrs	Min.
January	13.1	2.0	1.7	56.0	30.34	49.7	2.5	4.5	3	33
February	14.5	4.8	2.7	83.0	38.48	60.0	3.6	5.8	3	16
March	18.7	8.5	3.6	165.0	42.28	68.3	7.9	9.8	4	06
April	23.5	14.2	5.2	117.2	42.30	71.7	14.8	15.5	7	55
May	28.5	16.3	7.2	49.3	40.42	74.5	20.8	21.6	9	48
June	36.0	21.2	8.1	34.2	74.07	72.6	27.5	28.8	9	08
July	34.0	22.4	7.8	196.2	20.99	48.7	24.4	27.8	9	02
August	31.1	20.3	6.4	95.4	17.69	40.4	23.0	26.9	8	00
September	30.8	15.5	5.3	70.5	22.03	44.3	19.5	22.1	8	42
October	22.0	10.4	3.3	56.6	21.03	35.8	11.2	12.3	4	34
November	18.5	5.7	1.5	15.6	11.38	19.4	4.0	5.2	3	16
December	12.6	2.5	1.1	26.9	7.77	10.1	2.6	3.8	1	50

References

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