STATUS OF SOIL TEXTURE AND REQUIRED ASSOCIATED SOIL CONSERVATION MEASURE OF RIVER SWAT CATCHMENTS AREA, NWFP, PAKISTAN

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ABSTRACT

This study was conducted during 2002-06 with an attempt to know about the status of soil texture of River Swat catchment area, also called Swat Valley. In total, 212 soil samples were collected twice (2005 and 2006) from 100 villages and were analyzed for soil texture. For water quality, river Swat water samples (three samples per month for the year 2006) were analyzed for suspended load. Slope was calculated in 100 different regions with the help of Global Positioning System (GPS). River Swat catchment is mountainous and the soil is mostly of sandy nature, presenting fragile picture of soil. The average forest cover is 17% with a range varying from 5% in lower Valley to 25% in the upper parts. Besides, of forestland has been acquired as agricultural lands making soil more susceptible to erosion. The seasonal fluctuation of suspended load of River Swat during 2001-2004 was from 19 to 116 mg/l during low flow season (October -March) and from 137 and 692 mg/l in high flow season (April-September). The field observation shows that the intensity of erosion is comparatively higher in rain-fed area. The paper suggests encouragement of agro-forestry through awareness campaign and technical assistance.

Key words: Soil texture, Soil slope, Water erosion, Soil conservation, Swat Valley, Pakistan

INTRODUCTION

Swat valley situated in the Hundukush mountain ranges of Northern NWFP is a combination of three districts, namely Upper Malakand (Tehsil Swat Ranizai), Lower Dir (Tehsil Adenzai) and Swat District (all six sub-Tehsil, namely Kalam, Bahrain, Kwazakhala, Matta, Mingora, Kabal, and Barikot) that collectively form River Swat Watershed. District Swat makes 80.81%, Lower Dir 11.98% and Malakand 7.21% of the watershed (Fig. 1). The watershed presents a scenic view and is a source of tourist attraction (Inam-ur-Rahim and Alain, 2002). The study area comprise of the entire watershed located at 34° - 36° North Latitude and 71° - 73° East Longitude (Govt. of Pak, 1985) surrounded by mountains with an elevation ranging from 390-650 m above MSL (Mean Sea Level) and extends over a total area of 6288 Km^2 (Swat 5337 Km^2, Lowe Dir: 475 Km^2 and Malakand 476 Km^2) (Govt. of Pak, 2002). The drainage area of the watershed has a complex geological history of organic disturbances and erosion and depositional cycle. The result is an extremely varied nature of landforms comprising mountain, disserted loebs plains, outwash aprons and alluvial plains. Some major landforms of the area are: i) Residual and alluvial lopes ii) loess plains and iii) alluvial plains. Average annual rainfall ranges form 800-1200 mm. A minor proportion of water is also diverted from streams and the river for irrigation at suitable locations. The major crops grown in the area include wheat, rice, potatoes, fodder and maize (Survey of Pakistan, 1986). Major portion of rainfall is received during the monsoon season (June to September). According to meteorological data (Weather station Saidu Sharif) the minimum and maximum temperature varies in the range of -0.5^0C to 39^0C (Rashid, *et al* 1999). The mean relative humidity varies from a minimum of 40% in April to a maximum of 85% in the month of July. The overall climate of the area can be classified as sub tropical in the Southern part and Mediterranean in the northern parts (Aslam, *et al* 1991). The soil is mainly sandy loam type occupying the maximum area with a land slope varying from 0 to 8 %, maximum slope of some hilly parts of the watershed is up to 22% and the soil depth ranges from 0 to 45 cm (Rashid, *et al* 1999). It is observed that the area exhibit high erosion rate, especially in the areas where vegetation covers is less. These areas include lower Swat situated in the area of Lower Dir and Upper Malakand. In this study an attempt has been made to find out the various contributing causes, effects and possible remedial measures for erosion control.

MATERIALS AND METHODS

Sampling

Selection of Sample points

Prior to sample collection the whole area, from Kalam to Totakan was visited twice to identify and select major land types and sampling points. The criteria adopted for site selection was, that sample should cover maximum area, must be accessible and representative. The total numbers of main villages in the valley are 150 as identifies from the data base developed by Falling Rain Genomics, Inc. 1996-2004, out of which 100 villages (75%) were selected for initial tests.

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The total number of sample (212) cover an area of about 1000 Km^2,16% of the total River Swat Watershed (6628 Km^2) and 75% of the agriculture land. 73.58% of the sampling points fall in Swat district with 8.96% in upper mountainous area, 64.62% in the middle portion (33.96 North and 30.66% in south Bank of River Swat) and 26.42% fall in lower Swat region (11.79% upper Malakand and 14.63% lower Dir) according to their proportional contribution to the watershed.

Sample collection and storage

A systematic composite soil samples from 0-30 cm depth were collected from selected fields during two seasons i.e., June and July (summer season), and November, December (winter season). The Kalam area was not accessible during winter and hence was sampled in summer only.

For detail Physico-chemical analysis a representative portion (2-3Kg) was packed in plastic bag (reference for in the field sampling). The arable lands in 51 villages were clearly divided into *Shoulgar* (irrigated), *Jewardara* (Semi irrigated) and *Daman* (rain-fed). Hence triplicate samples from each category of agricultural field were separately collected. In upper mountainous region where no such categorization exists, one sample was collected from each village. These include 7 villages in Kalam side, 16 in Matta area, 3 in Mingora area, 5 Malakand area and 8 in Lower Dir area. In some area the land is divided into irrigated and rain fed, two samples were collected from each village. These include 3 villages in Kalam area, 1Matta, 1 Mingora, 1 in Malakand area and 4 in Lower Dir area. In each agriculture field, four points were selected for sample collection. These samples were then mixed in a plastic basket. The samples were labeled, dried at room temperature and stored in Plastic containers for further evaluation.

Sample analysis

Soil texture was tested in the field by feel method (Plaster, 1992), which was latter on conformed in the laboratory. For clay and silt wet method (pipit gravimetric method) and for sand dry sieve method was followed (Rowell, 1994 and Kettler *et al*, 2001). To summarize the results a sample statistics were applied (Table I)

Physical features

Soil Slope

Soil slope was measured in 76 sites (35 villages). GPS (Global Positioning System) was used for slope estimation. For which a particular field was measured along the direction of water flow and an average slope was calculated by using GPS (Magellan color-trak, Made in USA). For maximum accuracy the results were cross-checked with Google Earth facilities.

Water Quality

In River Swat for determining suspended load, Chakdara Bridge was selected for sample collection. Per month three samples were taken and were analyzed for one year by following standard method (Arnold *et al*, 1992). For this purpose flow data of River Swat was collected form WAPDA Lahore office for the year 2004.

Forest cover

To know about the situation of forest cover, data was collected form Forest Management Center (FMC) Peshawar. For vegetative remedial measures detail literature survey was conducted. To known about different associated problems in aforestation and reforestation field observations and interviews with farmers, forest department agriculture department were conducted, which was supplemented with participatory Rural Appraisal (PRA) techniques, like time line, transit walk and seasonal map.

RESULT AND DISCUSSION

Soil Texture

Erosion affects soil texture, by washing clay contents, which in turn further accelerate erosion process. Sand is the dominant feature of all soil in Swat Valley. The percentage sand contents decrease down stream River Swat. At Kalam it is high (above 80%) with only 20% clay and silt. At Totakan the sand contents comes down to about 40%. Besides, the valley is divided into small valleys and sub-valleys. Variation was found in side the valleys also. Near the *Khwar* (Natural wet/dry water stream) joining River Swat directly, it is high, but some time only sand is there in and near the floodplain. Going on either side of the *Khwar*, there is increase in soil thickness and decrease in sand contents.

On the basis of texture the whole watershed can be classified into six major categories, as Loamy sand, sandy loam, sandy clay, sandy clay loam, loam and silt loam. More than seventy percent the soil was sandy loam (62.26%) and loamy sand (8.01%) (Table I), and that is why the water holding capacity if the soil is low.

Sandy loam, (where the sand percentage ranges from 50 to 75 %, clay ranges form 10 to 20% and silt 20 to 30%) is the largest class in Swat valley, occupying 60 % of the irrigated land (*Shoulgar*). 10% rain-fed (*Damani*) lands and 40 % irrigated lands in areas like

Rangmala, Piran, Nul, Gunyar in the lower Swat also have sandy loam soils.

12.26 % samples were of loamy soil type (also called medium loam explain the composition like previous Sandy loam) and were predominantly from lower part (Malakand and Lower Dir) and part of southern strip of River Swat. This is considered as the most fertile strip with irrigation water, available from River Swat.

10.84 % samples were of Sandy clay loam soil types (explain the composition like previous Sandy loam) mostly of the area is situated in the Matta side (Northern strip of River Swat) and the surrounding of Mingora (southern strip of River Swat). Other parts include the Tutano-Bandai area in Kabal valley and middle part of Adenzai Tehsil in Lower Dir, mostly used for horticultural purposes in case of irrigation possibilities.

Loamy sand class appeared 4th in river Swat watershed. A strip of 50 to 300 meters is stretched through the entire length of River Swat on its both banks. Loamy sand also found in the villages situated in the foothill, such as Landakai where the sand percentage is above 80%. Other areas include part of Lower Dir situated along river Swat. Main villages include Chakdara, Badwan, Mian-barangola, Tiroona and Kamala, where both irrigated and rain-fed land is of this class.

Other categories with high contents of clay or silt including sandy clay and silt loams are rarely found in the study area.

Soil Slope

In Swat valley the height from the mean sea level is 567 meters at Kalangai that go up to 2969 meters at Kalam after covering a distance of 120.36 km. The total difference comes out as 2402 meters. In this way average increase per kilometers is 19.96 meters. If we divide the area into three segments the situation becomes clear. First segment stretched from Kalam to Fatehpur, where the average height increase is 24 meter per kilometers. Second segment is from Fatehpur to Mingora, where the average increase is 21 meters per kilometers and the third segment stretched from Mingora to Kalangai (end point of Swat Valley) and the average increase is 2 meters per Kilometers when going along river Swat.

The valley is broader to the south and it narrows down to the north with gradual rise in elevation as well. The irrigated area from Mingora to Kalangai appears nearly level. But as the texture ranges form sandy (in the river flood plain) to loamy sand and loam (in semi irrigated called *Jewardara* in local language) the area appears susceptible to erosion in flood season (June to August). Because of limited agricultural land availability the farmers are obliged to take the risk for using the flood plain for agriculture that is always endangered with flushing away through gully erosion. The irrigated and semi irrigated agricultural land from Mingora to Fatehpur and Fathepur to Kalam can be categorized as very steep. The rain-fed area from Fathepur till Kalangai is categorized as strongly sloping land as slope increases moving in the left and right direction form the River Swat. The area of Matta and Kabal Valley and foothill from Fathehpur till Kalangai is categorized as steep, where the slope is ranging from 25 to 60%. The area of Lower Dir situated in watershed of Chakdara Khwar (Sub watershed of River Swat) is categorized as strongly sloping with some plain area in the middle of the valleys. But most of the former practicing agriculture in the mountains area where the land consists of gravel and maximum sand contents (Fig. 2).

At present various measures have been adopted by the farmers, such as plantation, protection walls and leveling etc. For example in Matta Valley more than 60% agricultural fields have trees or fruits plants surrounding agricultural field, which is coming under the definition of farm forestry (Zubair, 2006). Besides, terracing is also practiced, by growing weeds in the cracks of the walls that give support to the wall during rain and reduce runoff. But besides terraces other supportive measures are also recommended to respond effectively to the problem of water erosion. The reducing vegetation cover particularly on sloping and sandy soils predisposes the soil to erosion (Hao C. and Qiangguo , 2006) and warrants promotion of agro-forestry. While in the northern mountainous area there is a need to create spaces for forest regeneration activity through community support

Impact on Water Quality

For soil quality River Swat water was analyzed for suspended load. In low flow season (October-March) suspended load fluctuates between 19 and 116 mg/l while in high flow season (April-September) the suspended load fluctuates between 137 and 692 mg/l. According to our estimation (with out flood event) the average annual suspended load was 0.855 tones/acre/year for the year 2004 (Fig. 3). This figure shoots up to 1.628 tons/acre/year with flood events (Table II).

To cope with this heavy soil loss, there is also lack of attention from Agriculture Department as well as

Forest Department. Both the departments should focus on agronomic measures, aforestation and especially agroforesty to control land degradation of the river Swat catchments area.

Forestation/ Forest regeneration as a remedial measure

River Swat catchments is mostly mountainous (75%) and forest cover is decreasing. According to Hao and Qiangguo 2006, forest cover directly affects soil quality in terms of erosion and nutrients loss. Total forest cover in Pakistan is 4.8% (4.224 mha) of the total area (Qiang, 1999) and considered as poor. For better economy and balance ecology an area must have at least 20-25% in forest cover (Anwar. 2002). Comparatively North West Frontier Province (NWFP) appeared lucky in terms of forest cover 17% (Yar and Rafiq, 1997). In NWFP, an estimated 6% of the total forest area of the province comprises reserved forests owned by the government. Forestry Department had initiated various aforestation projects on private and communal land predominantly for watershed management and as part of social forestry projects (Iqbal, 2003).

In Swat valley the forest is protected forest and under the de-jure control of forest department subjected to the payment of royalty (share payable to local residents) ranging from 60 to 80%. The forest resources of the study area are under severe pressure. It is used as fuel, as well as, as a livelihood. To decrease pressure on forest resources, alternative fuel sources, such as fuel gas (Liquid Petroleum Gas LPG) and in some area Natural Gas have been provided. The Participatory Rural Appraisal (PRA) survey revealed that in upper Malakand the deciduous forest is decreased by 65% in Lower Dir by 55% and in Swat by 35% in the last 30 years. Now Malakand district appeared the most poor when compared with other three districts, where only 5% of mountain has got scattered forest. The figure for forest in lower Dir is 10% and in Swat 20%. In Swat 50% of the timber forest is converted into rangeland in the last 30 years. It is still on the way toward decline, which is a serious threat to soil resources of the area.

According to our estimate, as calculated from Satellite Imagery, almost 30% area of the lower Swat is covered by mountains and is considered as common property or state property. In this way no one is taking care,. One of the reasons of degradation may be the tenure disputes, as in some areas where mountainous area has been acquired as individual property, dense plantation was observed. These areas include Amandara, Dahdara, Khairabad etc. But in upper Swat such as Miandam and Sarai, people are hesitant to go for plantation and preferring to use it as agricultural land. The reason behind that is, that tree is considered as state property and agriculture products are considered as individual property, as they can use tree for their personal use, but cannot cash it in the market.

Secondly commercial and unscientific forest harvesting is one of the big drains toward deforestation. Forest in the Swat Valley is used as revenue. According to forest department in 1984-85, 38.166 million rupees were generated, which was increased to 461.580 million rupees in 1995-96.

The third reason is subsistence agriculture, which has linkage with population increase. The rain fed area where slope is above 20%, and in many cases go beyond 40%, is used for agriculture. The dominant area includes upper Swat, especially Matta Valley, where 70% of the rain-fed land is used for agriculture. In the lower Swat 30% of the rain-fed land has got high slope and is not suitable for agriculture. People are behind encroachment to acquire land for houses and agriculture activities. Un-employment and lake of education in the rural community is another reason. Because of which illegal cutting is there. Proper awareness may work, but will take time.

Other reason includes, forest fire, land sliding, non-participatory approach of forest department that need proper attention.

Possibility and need of Agro-forestry

Agroforestry is combinations of trees, crops, and/or livestock are intentionally designed, established, and/or managed to work together and yield multiple products and benefits, rather than as individual elements which may occur together but are managed separately (Uni. of Missouri, 2006). Agroforestry is neither mono-culture farming, nor a mixture of monocultures. Looking into Swat Valley in this prospective, part of irrigated area is used for Agroforestry in the form of crops and horticulture only. These areas are mostly situated in upper and middle Swat. In upper Malakand the horticulture is discouraged by land tenure system. These areas include class-I and Class-II of the land capability classes (Table. III). But these are not contributing to fuel-wood or construction wood directly. Therefore, it is required to add its utility for fuel-wood and construction wood. Class-III and IV (rain-fed areas) are the areas, which are not properly managed. In most cases, especially in the Lower Dir and Upper Malakand mono culturing is practiced and needed to be used for agro-forestry. The only limitation is the

availability of irrigated water. This can be provided in the form of canal to be diverted from River Swat and/or tube-well. For this awareness, training and financial assistance is required. In this regards Forest department and agriculture department are required to work together and help the farmers. Class-V to VII are purely mountainous areas and required to be used for forestry. This will provide help in terms of providing wood for fuel and construction. As most of the area is encroached, therefore, the concept of Guzara forest (privately owned) or social forestry is required to be introduced in these areas.

CONCLUSION

Looking into the deforestation in the mountainous area, textural classes and slope of the soil, the Swat Valley needs a good forest cover. The concerned departments are required to encourage plantation on mountainous areas and land management practices and agricultural crops on low sloping areas. For agricultural land, other than mountainous, the agriculture department should encourage farm forestry and agroforestry. At present only irrigated agricultural land is used for multi purposes, such as production of cereal crop, fruits, vegetable and fuel wood. The remaining area including rain-fed and mountainous are poorly managed. It is therefore, recommended that:

i. The rain fed areas need attention of agriculture department to initiate agroforestry. The department is required to plan awareness, training, loan, and irrigation water.
ii. Mountainous areas must be used for forestry and agro-forestry for which forest department is required to show flexibility in forest policy and provide market facility to the farmers using mountainous area for forestry and agro-forestry.

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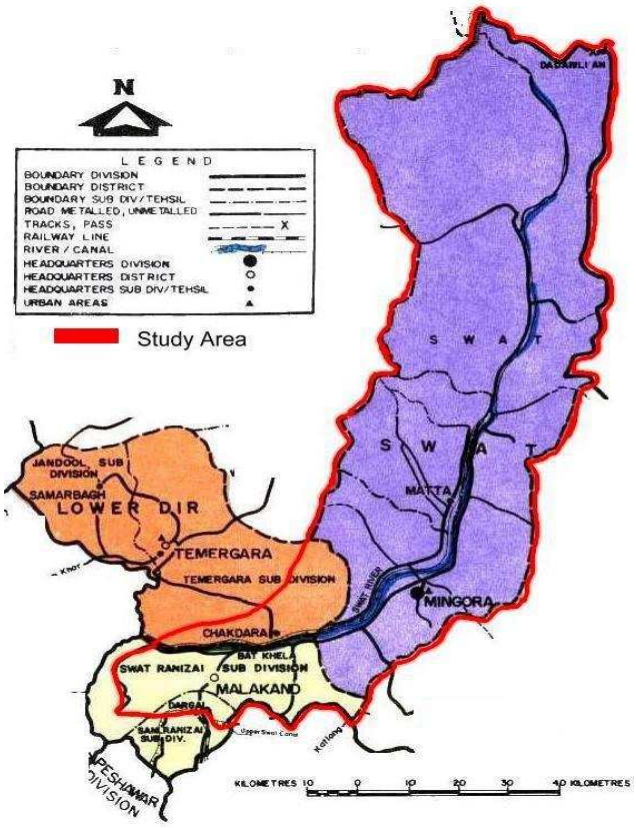

Fig.1: - Map of the Study Area (After Survey of Pakistan)

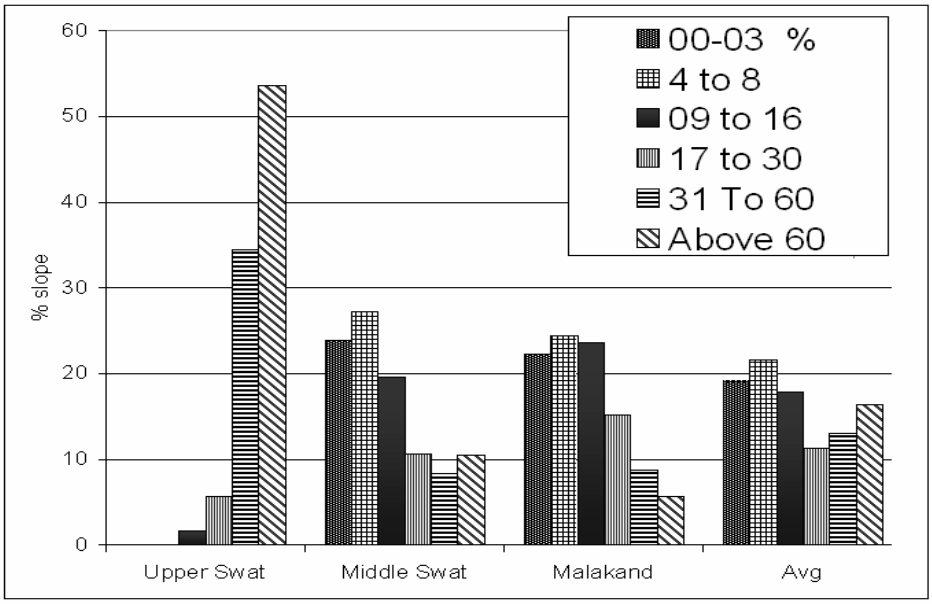

Fig.2: - Graph showing comparison of average slope for different regions of Swat Valley

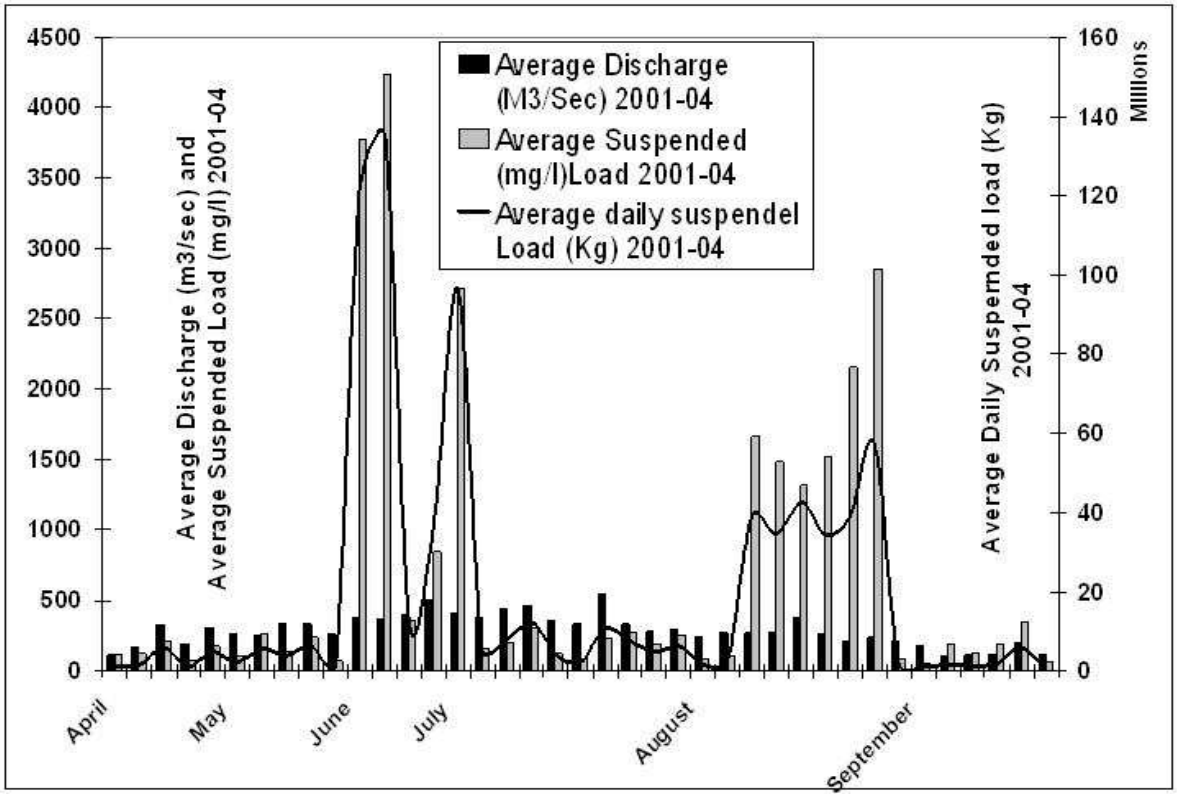

Fig.3: - Average Discharge (m^3/Sec), suspended load (mg/l) and daily-suspended load (kg/day) of river Swat during High Flow Season along with flood events 2001-04

Table I ***Soil texture of selected sample collected form River Swat catchments area.***

Region (%age of the total)	Textural Classes	No of Samples	Sand (%)			Silt (%)			Clay (%)		
			Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Upper Swat (8.96%)	Loamy Sand	10	76.28	84.62	80.70	4.40	14.87	10.34	06.96	12.90	8.96
	Sandy Loam	9	59.49	77.61	67.44	7.13	30.36	20.66	06.61	17.90	11.90
Middle Swat Northern side of River Swat (33.96)	Sandy loam	59	54.22	79.92	68.06	4.29	33.37	17.86	05.81	21.64	14.08
	Sandy clay	2	47.49	52.26	49.87	11.39	16.20	13.79	36.32	36.36	36.34
	Sandy clay loam	9	53.43	71.79	64.54	6.11	20.42	13.53	19.32	26.16	21.94
	Loamy sand	2	81.89	84.22	83.05	08.50	08.87	8.68	07.28	9.25	8.26
Middle Swat Southern side of River Swat (30.66)	Sandy clay	2	48.98	52.00	50.49	11.54	14.75	13.14	36.28	36.46	36.37
	Sandy clay loam	6	46.40	69.45	52.86	8.15	38.18	23.27	15.43	27.10	23.87
	Loam	8	34.18	51.81	44.52	32.77	49.13	38.67	10.81	22.05	16.83
	Sandy loam	36	52.61	73.74	61.48	12.12	37.56	25.65	07.11	17.49	12.87
	Loamy sand	5	76.03	78.50	77.06	14.76	17.12	16.16	06.51	07.10	6.78
	Silt loam	8	29.42	43.94	37.68	49.22	57.49	52.90	06.01	13.10	9.43
Lower Swat Northern Side of River Swat (11.79%)	Sandy loam	14	52.66	74.53	61.48	14.22	40.27	24.88	07.08	17.78	13.05
	loam	6	29.48	48.95	38.90	33.44	47.58	42.07	11.41	24.68	19.03
	Sandy clay loam	5	47.09	50.49	48.69	22.59	27.54	24.08	21.98	31.54	27.22
Lower Swat Southern Side of River Swat (14.63)	Sandy clay loam	3	50.02	58.44	53.31	16.88	28.47	23.08	21.51	24.69	23.61
	Silt loam	2	23.31	34.43	28.87	51.62	52.66	52.14	13.96	24.04	19.00
	Sandy loam	14	53.45	72.76	59.25	10.35	46.08	28.96	07.24	16.90	11.80
	Loam	12	37.72	52.11	45.73	32.72	46.25	38.43	10.05	22.12	15.84

Table II: ***Average Discharge (m^3/sec), Suspended Load (mg/l) and daily suspended load (Kg/day) of River Swat during Normal Flow, 2004***

	Discharge m3/s 2004	SS (mg/l)	Load (Kg/day)		Discharge m3/s 2004	SS (mg/l)	Load (Kg/day)
October	94.95	116.00	951626.88	April	101.7	137.70	1209953.376
	166.4	97.00	1394565.12		157.8	184.00	2508641.28
	143.9	108.00	1342759.68		169.4	243.00	3556586.88
November	122	89.00	938131.2	May	219.1	298.00	5641211.52
	101.2	74.00	647032.32		229	360.00	7122816
	93.75	69.00	558900		349.8	453.00	13690892.16
December	92.89	72.00	577850.112	June	304.3	415.00	10910980.8
	72.72	55.00	345565.44		390.6	603.00	20349947.52
	79.55	43.00	295544.16		526.1	692.00	31454887.68
January	34.21	22.00	65026.368	July	442.7	667.00	25512269.76
	30.89	22.00	58715.712		437.3	620.00	23425286.4
	32.31	19.00	53040.096		212.4	369.00	6771651.84
February	34.4	34.90	103728.384	August	295.9	438.00	11197802.88
	135	96.00	1119744		228.4	375.00	7400160
	89.76	82.00	635931.648		283.4	433.00	10602334.08
March	77.66	91.00	610593.984	Septembe r	166	340.00	4876416
	93.47	85.00	686443.68		176.8	275.00	4200768
	131.7	114.00	1297192.32		148.1	238.00	3045409.92

Table III: - ***Pakistan land capability classes in comparison of North West Frontier Province and Swat Valley***

Land Class		Pakistan		NWFP 9139		Swat Study area	
		Area in million hectares	%age Area	Area in Thousands hectares	%age Area	Area in hectares	%age Area
I	Very good agriculture land	5.24	8.46	187.3	2.05	32252	5.03
II	Good Agriculture Land	6.98	11.28	524.4	5.74	59413	9.26
III	Moderate Agriculture Land	4.87	7.86	665.8	7.29	68619	10.70
IV	Poor (marginal) agriculture Land	2.99	4.83	581.6	6.36	43962	6.86
V	Good forest or rangeland	0.17	0.25	70.1	0.77	135400	21.11
VI	Moderate forest or rangeland	1.27	2.05	827	9.05	23209	3.62
VII	Poor forest or rangeland	15.41	24.91	2603.8	28.49	34685	5.41
VII I	Non Agriculture land	23.2	37.51	2974	32.54	NA	NA
XI	Unclassified	1.78	2.85	704.9	7.71	243761	38.01
			100		100	664487	100

Data Source for Pakistan and NWFP: Govt of Pakistan and IUCN National Conservation Strategy, 1993 (Alim M., and Yasin J. M. M) for Swat, Nafees, 2007

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