

**MODELING RISK OF SOIL EROSION IN SIMLY
WATERSHED, POTHWAR REGION**



BY

RABIA MUKHTAR

**Department of Earth and Environmental Sciences,
Bahria University, Islamabad**

2014

ABSTRACT

Soil erosion is indicating as a critical device for assessment of soil loss procedures and elaboration of soil erosion risk maps, which are valuable references for arranging future exercises, thus diminishing current erosion impacts and additionally forestalling declining scenarios. Soil erosion is a major problem effecting agriculture and water resource development in the pothwar region of Pakistan. The main objective of this study is to map the areas exposed to water erosion risks in the Simly dam watershed. The results of the study reveal an average rate of about 14 tons/ha/yr soil erosion in the Simly watershed. The very low risk zone (0 - 1 tons/ha/yr) possesses the maximum coverage i.e about 41% while the very high risk zone (> 100 tons/ha/yr) the minimum coverage i.e 1.2% in the watershed. The agricultural land indicated erosion at an average rate of about 120.16 tons/ha/yr while rangeland at an average rate of about 27.51 tons/ha/yr. The soil erosion was found maximum under steep slopes (> 30 deg) followed by gentle slopes (5-15 deg). The percentage coverage of different scenarios was helpful for evaluating the risk of soil erosion i.e In scenario 1, all the scrub forest is assumed to be converted into range land, so in this case the soil erosion increases to about 70.7% from the base landuse of 2013. In scenario 2 the all the rangeland is assumed to be converted into agriculture land so the agricultural land is increased to about 11% under this scenario. In scenario 3, all the rangeland of base landuse of 2013 is assumed to be converted into scrub forest (afforestation case). The soil risk indicated a decrease of about 16.4% from that of base landuse in this scenario. The findings of study can provide base for planners and decision makers to organize better soil and water conservation plans for agriculture and water resource development in the target area in future.

ACKNOWLEDGEMENTS

I am really grateful for those persons who helped me a lot and provided me possibility to complete this master thesis: To my supervisor, Assistant Professor, Muhammad Khubaib Abuzar, Department of Earth and Environmental Science, Bahria University, Islamabad who guided me, gave me constructive suggestions during the whole process and improving the report and helped me solve problems carefully and patiently through the whole thesis work as I wished and believing in my capabilities.

My sincere appreciation also goes to my Co-supervisor Scientific Officer Dr. Mohammad Arshad Ashraf (Principal Scientific Officer at Climate Change, Alternate Energy and Water Resource Institute (CAEWRI), National Agricultural Research Center (NARC) Islamabad) for his cooperation and valuable suggestions in executing this project. I really thanks to him for giving me a head start in this task by guiding me and support.

I am also grateful to Assistant professor Asif Javed, Department of Earth and Environmental Sciences, Bahria University, Islamabad to review my thesis and furnish me with fruitful suggestions and feedback and my gratitude also goes to Dr. Muhammad Zafar, Head of Earth and Environmental Sciences Department, Bahria University, Islamabad for his moral support and encouragement towards my research work.

Whenever I thought this would never reach an endpoint especially thanks to my loving father, mother, brother and sister for their generous support, prayers and encouragement. I would like to acknowledge Javeria Akbar, Samiya Ghazal who deserves to be thanked for being there for supporting me, prayed for me and especially thanks to my dear friend Sunaina Abbas for helping me and advising me in different components of this task and mostly giving me much needed moral support in stressful times throughout the research time period

ABBREVIATIONS

BGI	Bagnouls-Gaussen aridity Index
CORINE	Coordination of Information on the Environment
DEM	Digital Elevation Model
ETM	Enhanced Thematic Mapper
GIS	Geographic information system
GPS	Global Positioning
IDW	Inverse Distance Weighted
LCTA	Land Condition Trend Analysis
LULC	Landuse and Landcover
MFI	Modified Fournier Index
MODIS	Moderate resolution imaging spectroradiometer
MUSLE	Modified Universal Loss Equation
NDVI	Normalized Difference Vegetation Index
PMD	Pakistan Meteorological Department
RS	Remote sensing
RUSLE	Revised Universal Soil Loss Equation
USLE	Universal Soil Loss Equation
UTM	Universal Transverse Mercator
WAPDA	Water and Power development authority

CONTENTS

	Page
ABSTRACT	i
ACKNOWLEDGEMENTS	ii
ABBREVIATIONS	iii
FIGURES	vii
TABLES	x

CHAPTER 1

INTRODUCTION

1.1	Introduction	01
1.2	Objective and Scope	05
1.3	Significance of the study	05
1.4	Study area	06
1.4.1	Topography	07
1.4.2	Climate	09
1.4.3	Surface hydrology	10
1.4.4	Geology	10
1.5	Literature review	13

CHAPTER 2
METHODOLOGY

2.1	Data used	41
2.2	Software's tools used	41
2.3	Preparation of base map	42
2.4	Digital Image Processing and Analysis	42
2.5	Supervised Classification of Satellite Data	43
2.5.1	Feature Space Image	43
2.5.2	Defining Training Areas	44
2.5.2.1	Non- Parametric Signatures	45
2.5.2.2	Class Credibility	45
2.6	Spectral signatures	46
2.6.1	Maximum likelihood classifier	46
2.7	Accuracy Assessment	47
2.8	Measurement of Soil Erosion	47
2.9	Soil Erosion Rates and Potential Erosion	50
2.9.1	Class 1 (Very low)	50
2.9.2	Class 2 (Low)	50
2.9.3	Class 3 (Moderate)	50
2.9.4	Class 4 (High)	51
2.9.5	Class 5 (Severe)	51

2.10	RUSLE factor generation	51
2.10.1	R-Factor (Erosivity)	52
2.10.2	K-Factor (Erodibility)	53
2.10.3	L-S Factor (Length slope)	53
2.10.4	C-Factor (Cover management)	54
2.10.5	P-Factor (Conservative practice)	55
2.11	Erosion risk	55

CHAPTER 3

RESULTS

3.1	Spatial distribution of annual rainfall in the study area	56
3.2	Estimation of erosivity factor (R)	59
3.3	Estimation of erodibility Factor (K)	61
3.4	Estimation of length-Slope factor (LS)	62
3.5	Estimation of Cover management factor (C)	64
3.5.1	Accuracy Assessment	65
3.6	Estimation of conservation practice factor (P)	68
3.7	Assessment of Soil Erosion and Risk mapping	69
3.8	Land use Change Scenarios	79
3.8.1	Scenario 1	81
3.8.2	Scenario 2	81
3.8.3	Scenario 3	81

CHAPTER 4

DISCUSSION AND CONCLUSIONS

4.1	Discussion	83
4.1.1	Strategies for risk mitigation of soil erosion	84
4.1.1.1	Measures in high & very high risk zones	84
4.1.1.2	Measures in Medium Risk Erosion	85
4.1.1.3	Measures in Low Risk zone	85
	CONCLUSIONS	86
	RECOMMENDATIONS	87
	REFERENCES	88

FIGURES

	Page
Figure 1.1. Areas of serious concerns for soil degradation	03
Figure 1.2. Causes of soil degradation all over the world	04
Figure 1.3 An overview of Simly watershed boundary	07
Figure 1.4. Elevation declines towards North-West in the study area	08
Figure 1.5. Monthly-accumulated Rainfalls in the Study Area Islamabad	09
Figure 1.6. Monthly-accumulated Rainfalls in the Study Area Murree	09
Figure 2.1 Land cover feature space images	44
Figure 2.2 Spectral Signatures of Land cover classes	46
Figure 2.3. Conceptual diagram of methodology followed in the study	49
Figure 3.1. Mean monthly rainfall pattern	57
Figure 3.2. Monthly Rainfall Maps of the study area	58
Figure 3.3. Areal distribution of annual rainfall in the study area	59
Figure 3.4. Monthly R- Factor Maps of the study area	60
Figure 3.5. Spatial distribution of annual R- factor in the study area	61
Figure 3.6. Soil erodibility map	62
Figure 3.7. Slope steepness factor (LS)	63
Figure 3.8. Slope length map	64
Figure 3.9. Extent of various types of landuse/landcover	66
Figure 3.10. Percentage share of landuse/landcover in the study area	67
Figure 3.11. C-factor Map	68
Figure 3.12. Monthly Soil Erosion Risk Maps of the Study Area	70

Figure 3.13.	Soil erosion risk map of Simly watershed area	71
Figure 3.14.	Mean soil erosion	72
Figure 3.15.	Soil erosion under various landuse/landcover classes	73
Figure 3.16.	Average erosion rates in slopes	74
Figure 3.17.	Percentage coverage of five erosion risk zones.	75
Figure 3.18.	Percentage risks zone in different months	77
Figure 3.19.	Detailed of soil erosion intensities and associated risk zones	77
Figure 3.20.	Erosion rate at different slopes under different erosion classes	78
Figure 3.21.	Land distribution and their different scenarios	80
Figure 3.22.	Percentage coverage of landuse in different scenarios	82

TABLES

		Page
Table 1.1.	Annual losses due to land degradation in Asia	03
Table 1.2.	Human-induced Soil Degradation in Europe1 (M ha)	30
Table 2.1.	Guidelines for Assessing Potential Soil Erosion Classes	50
Table 2.2.	Soil loss tolerance levels	51
Table 3.1.	Mean monthly rainfall of Islamabad and Muree	57
Table 3.2	Error matrix for the landcover classification showing accuracy, assessment of the results in terms of user accuracy, producer accuracy and overall accuracy	65
Table 3.3.	Statistics of landuse/landcover coverage	66
Table 3.4.	Details of cover management factor used	67
Table 3.5.	Mean Monthly Soil Erosion	72
Table 3.6.	Soil erosion under various slope classes (Area in sq km)	73
Table 3.7	Erosion rate in different slope (degrees)	73
Table 3.8	Risk of soil erosion predicted in Simly watershed area	74
Table 3.9	Percentage coverage of soil erosion risk in different months	76
Table 3.10	Area coverage under erosion classes at different landuse in tons/ha/yr	77
Table 3.11	Area coverage under erosion classes at different slopes	78
Table 3.12	Coverage area for different landuse classes under scenario	81