



Lulseged Tamene Desta (Autor)
Reservoir siltation in Ethiopia:
Causes, source areas, and management options

Ecology and Development Series

No. 30, 2005

Lulseged Tamene Desta

Reservoir siltation in Ethiopia:
Causes, source areas,
and management options



Zentrum für Entwicklungsforschung
Center for Development Research
University of Bonn

ZEF Bonn

<https://cuvillier.de/de/shop/publications/2414>

Copyright:

Cuvillier Verlag, Inhaberin Annette Jentzsch-Cuvillier, Nonnenstieg 8, 37075 Göttingen, Germany
Telefon: +49 (0)551 54724-0, E-Mail: info@cuvillier.de, Website: <https://cuvillier.de>

TABLE OF CONTENTS

1	INTRODUCTION	1
1.1	General.....	1
1.2	Main objectives.....	4
1.3	Organization of the thesis	4
2	THE STATE OF THE ART.....	5
2.1	Water harvesting as a means to improve food security	5
2.2	Water harvesting in Tigray: potentials and problems.....	7
2.3	Soil erosion and its impacts	10
2.4	Approaches to siltation assessment	13
2.5	Approaches to soil erosion modelling	15
2.6	Spatial simulation for site-specific land management options	18
3	STUDY AREA AND METHODOLOGY.....	19
3.1	Study area	19
3.1.1	Ethiopia: physical attributes and resource potential	19
3.1.2	Tigray: physical attributes and resource potential	22
3.2	Methodology.....	23
3.2.1	Site selection	23
3.2.2	Constructing Digital Elevation Models (DEMs)	26
3.2.3	Deriving land-use and land-cover (LUC) types.....	28
3.2.4	Field-based catchment characterization.....	29
3.2.5	Reservoir survey	29
3.2.6	Modelling spatial patterns of erosion/deposition processes.....	30
3.2.7	Simulation based on LUC redesign approach.....	31
4	RESERVOIR SILTATION: RATE OF SEDIMENT YIELD AND ITS RELATION WITH CATCHMENT AREA	32
4.1	Introduction	32
4.2	Study area and site characteristics	34
4.2.1	Site selection	34
4.3	Materials and methods.....	35
4.3.1	Assessment of reservoir siltation	35
4.3.2	Estimating reservoir sediment deposit based on sediment pit data.....	36
4.3.3	Estimating reservoir sediment deposit based on bathymetric survey	37
4.3.4	Determining dry-bulk density of reservoirs.....	39
4.3.5	Estimating trap efficiency of reservoirs.....	39
4.3.6	Calculating sediment yield to reservoirs.....	40
4.4	Results	41
4.4.1	Sediment deposition in reservoirs.....	41
4.4.2	Rate of sediment yield as compared to results of other studies	43
4.5	Discussion.....	46
4.5.1	Factors influencing sediment yield estimation	46
4.5.2	Sediment yield and its relation with catchment area	49
4.6	Conclusion.....	53

5	ANALYSES OF FACTORS DETERMINING SEDIMENT YIELD VARIABILITY	55
5.1	Introduction	55
5.2	Study area and site characteristics	56
5.2.1	Site selection	56
5.3	Materials and methods.....	57
5.3.1	Data on sediment yield to reservoirs.....	57
5.3.2	Morphometric properties of catchments	58
5.3.3	Statistical analysis.....	62
5.4	Results	62
5.4.1	Sediment deposition in reservoirs.....	62
5.4.2	Morphometric properties of catchments	62
5.4.3	Correlation analysis	63
5.4.4	Principal component analysis (PCA).....	68
5.4.5	Multiple regression analysis	73
5.5	Discussion.....	75
5.6	Conclusion.....	79
6	MODELLING LANDSCAPE SUSCEPTIBILITY TO EROSION AND POTENTIAL SEDIMENT SOURCE AREAS.....	81
6.1	Introduction	81
6.2	Study area and methodology	84
6.2.1	Site selection	84
6.2.2	Materials and methods	85
6.3	Derivation of the major erosion parameters (factors).....	86
6.3.1	Rainfall erosivity (R) factor	86
6.3.2	Soil erodibility (K) factor.....	88
6.3.3	Cover-management (C) factor	88
6.3.4	Support practice (P) factor	89
6.3.5	Slope length and steepness (LS) factor.....	90
6.4	Model description.....	91
6.4.1	The Sediment Transport Capacity Index (STCI) Model.....	91
6.4.2	The USLE2D model	93
6.4.3	The Unit Stream Power based Erosion/Deposition (USPED) model	94
6.5	Sediment delivery ratio (SDR) estimation.....	96
6.6	Data collection to evaluate model results	98
6.6.1	Caesium-137 data collection and analysis	99
6.6.2	Soil profile data.....	101
6.6.3	Similar Erosion Risk Potential Units (SERPUs)	102
6.6.4	Catchment characterization based on erosion sensitivity scores	110
6.7	Results	111
6.7.1	Annual soil loss rate.....	111
6.7.2	Spatial patterns of erosion/deposition.....	116
6.8	Evaluation of model results	123
6.8.1	Results of models related to sediment yield to reservoirs.....	123
6.8.2	Results of models related to ¹³⁷ Cs data	124
6.8.3	Results of models related to soil profile data.....	130

6.8.4	Results of models related to the SERPUs	134
6.8.5	Results of models related to field-based erosion sensitivity scores	137
6.9	Discussion.....	138
6.9.1	Modelling soil loss rate: potentials and challenges.....	138
6.9.2	Spatial patterns of erosion/deposition and sediment source areas	141
6.10	Conclusion.....	147
7	GIS-BASED SEDIMENT YIELD SIMULATION OF LUC-REDESIGN SCENARIOS	149
7.1	Introduction	149
7.2	Study area	151
7.3	Methodology.....	151
7.3.1	Model description and input	151
7.3.2	Scenario description.....	152
7.3.3	Scenario simulation.....	156
7.4	Results	156
7.5	Discussion.....	163
7.6	Conclusion.....	168
8	SUMMARY AND CONCLUSION.....	171
8.1	How severe is the siltation problem?.....	171
8.2	What are the determining factors of siltation?.....	171
8.3	Where are the major sediment source areas?.....	172
8.4	What is the appropriate solution to reduce siltation?	172
8.5	Research and policy implications	175
9	REFERENCES.....	179

ACKNOWLEDGEMENTS