

TABLE OF CONTENTS

1	INTRODUCTION	1
1.1	Background.....	1
1.2	Objectives	3
1.3	Outline of the study	4
2	LITERATURE REVIEW	5
2.1	Characteristics of groundwater with emphasis on (semi-)arid zones	5
2.2	Interaction of GW – surface water	8
2.3	Spatial and temporal aspects of GW table and salinity	9
2.4	Features of GW table and salinity in the Khorezm region	13
3	MATERIALS AND METHODS	17
3.1	Area description.....	17
3.1.1	General information	17
3.1.2	Location	17
3.1.3	Climate	18
3.1.4	Relief, geology and geomorphology.....	20
3.1.5	Hydrogeology	21
3.1.6	The Amu-Darya River	22
3.1.7	Soils	24
3.1.8	Crops	26
3.1.9	Farming system.....	26
3.1.10	Irrigation network and method of irrigation	27
3.1.11	Drainage network.....	29
3.2	Data collection and statistical analysis	30
3.2.1	GW table and salinity.....	31
3.2.2	Amu-Darya River runoff and salinity	32
3.2.3	Drainage discharge and salinity	33
3.2.4	Soil salinity	33
3.2.5	Irrigation water use and salinity.....	34
3.2.6	Irrigation/drainage network	35
3.2.7	Soil lithology.....	35
3.3	Analysis	35
3.4	Data processing and methods	36
3.4.1	Elevation data and DEM construction	36
3.5	(Geo)-statistical analysis.....	38
3.5.1	Exploratory data analysis	38
3.6	Methods of interpolation	39
3.6.1	Kriging	39
3.6.2	Inverse Distance Weighted method	42
3.6.3	Spline	42
3.6.4	Triangulated irregular networks.....	43
3.6.5	Validation.....	44

3.6.6	Time series analysis	44
3.6.7	Groundwater recharge.....	45
3.6.8	Change detection method.....	46
4	TEMPORAL DYNAMICS OF GROUNDWATER TABLE AND SALINITY .	48
4.1	Introduction	48
4.1.1	Quality of groundwater salinity readings.....	50
4.1.2	Quality of groundwater table readings.....	52
4.2	Characteristics of groundwater table and salinity in Khorezm.....	54
4.2.1	Seasonal dynamics of groundwater table.....	54
4.2.2	Seasonal dynamics of groundwater salinity.....	57
4.3	Temporal dynamics of groundwater table and salinity	59
4.3.1	Groundwater table changes.....	59
4.3.2	Groundwater salinity changes.....	63
4.3.3	Groundwater salinity and soil salinity changes	66
4.4	Causes of groundwater table change in April and July	67
4.4.1	The Amu-Darya River runoff change	67
4.4.2	Drainage discharge.....	70
4.5	Causes of groundwater table change in October	73
4.6	Causes for groundwater salinity changes	75
4.6.1	Water supply and salinity.....	75
4.6.2	Drainage salinity	77
4.6.3	Groundwater table in districts.....	79
4.7	Discussion.....	80
4.7.1	Temporal dynamics of groundwater table and salinity.....	80
4.7.2	Increased diversion and water use	81
4.7.3	Temporal groundwater table and salinity changes.....	81
4.8	Conclusion.....	83
5	SPATIAL DYNAMICS OF GROUNDWATER TABLE AND SALINITY	86
5.1	Introduction	86
5.2	Spatial analysis of groundwater table.....	87
5.2.1	Kriging	87
5.2.2	Inverse Distance Weighted method	99
5.2.3	Spline	102
5.2.4	Comparison of kriging, IDW and spline methods for estimating groundwater table.....	105
5.2.5	Triangulated irregular networks (TIN)	106
5.3	Spatial analysis of groundwater salinity.....	107
5.3.1	Kriging	107
5.3.2	Inverse Distance Weighted	118
5.3.3	Spline	121
5.3.4	Comparison of kriging, IDW and spline methods for estimating groundwater salinity.....	124
5.4	Estimation of groundwater table and salinity using cokriging.....	125
5.5	Summary: Selection of the best-performing method.....	126
5.6	Assessment of areas at risk from shallow saline groundwater	126

5.7	Factors influencing spatial distribution of groundwater tables in Khorezm	129
5.7.1	Ancient Amu-Darya River beds.....	130
5.7.2	Influence of lithology on spatial groundwater table	131
5.7.3	Drainage network efficiency.....	133
5.7.4	Digital elevation model and topographic indices.....	136
5.7.5	Effects of other possible factors on GW table dynamics.....	140
5.8	Factors influencing spatial groundwater salinity distributions.....	140
5.8.1	Ancient Amu-Darya River beds.....	140
5.8.2	Soil lithology.....	141
5.8.3	Irrigation network	141
5.8.4	Topography	143
5.9	Identification of spatial patterns of groundwater salinity.....	144
5.10	Discussion.....	148
5.10.1	Introduction.....	148
5.10.2	Quality of interpolation.....	148
5.10.3	Soil lithology.....	151
5.10.4	Drainage network efficiency.....	153
5.10.5	Digital elevation model.....	154
5.10.6	Irrigation water salinity.....	155
5.10.7	Hotspot identification.....	156
5.11	Conclusions	157
6	GENERAL DISCUSSION	161
6.1	Introduction	161
6.2	Assessment and implications of groundwater table and salinity dynamics in Khorezm.....	161
6.3	Temporal seasonal and annual changes in groundwater table and salinity and soil lithology	162
6.4	Hotspot identification	164
6.5	Summary.....	164
7	RECOMMENDATIONS	166
7.1	Introduction	166
7.2	Spatial distribution of groundwater table and salinity.....	167
7.3	Hotspot areas	169
7.4	Summary.....	169
8	REFERENCES.....	171
ACKNOWLEDGEMENTS		