TABLE OF CONTENTS

CERTIFICATE	iii
DECLARATION BY THE CANDIDATE	v
COPY RIGHT TRANSFER CERTIFICATE	vii
ACKNOWLEDGEMENT	ix
TABLE OF CONTENTS	xiii
LIST OF FIGURES	xix
LIST OF TABLES	xxiii
LIST OF ABBREVIATIONS	xxv
LIST OF SYMBOLES	xxvii
PREFACE	xxix
CHAPTER 1 INTRODUCTION	1-24
1.1 REMOTE SENSING AN OVERVIEW	1
1.1.1 Passive remote sensing	2
1.1.2 Active remote sensing	3
1.2 ELECTROMAGNETIC WAVES USED IN THE REMOTE	4
SENSING	
1.3 SPECTRAL REFLECTANCE AND EARTH SURFACE	5
INTERACTION	
1. 4 RESOLUTIONS IN THE REMOTE SENSING	6
1.4.1 Spatial resolution	6
1.4.2 Spectral resolution	6
1.4.3 Radiometric resolution	7
1.4.4 Temporal resolution	7
1.5 ATMOSHPHERIC EFFECT AND ITS CORRECTION	
1.6 NEED OF CROP GROWTH MONITORING	8
1.7 CROP GROWTH MONITORING	8
1.7.1 Crop classification and mapping	8
1.7.2 Crop growth parameters estimation	9
1.8 THE ROLE OF REMOTE SENSING IN CROP GROWTH	10
MONITORING	10
1.8.1 Role of optical remote sensing	10
1.8.2 Role of microwave remote sensing	10

1.9 NEED OF SOIL MOISTURE RETRIEVAL	
1.10 SOIL MOISTURE RETRIEVAL	11
1.11 THE ROLE OF REMOTE SENSING IN SOIL MOISTURE	12
RETRIEVAL	12
1.12 LITERATURE REVIEW	
1.13 MOTIVATION	13
1.14 ORGANIZATION OF THE THESIS	22
CHAPTER 2 STATISTICAL SIGNIFICANCE IN THE CROP	23 25-46
CLASSIFICATION ACCURACY USING DIFFERENT	43-40
ALGORITHMS	
2.1 INTRODUCTION	25
2.2 STUDY AREA AND MATERIALS	28
2.3 METHODOLOGY	29
2.3.1 Image pre-processing and data preparation	29
2.3.2 Spectral separability	30
2.3.3 Support vector machines based classification	31
2.3.4 Maximum likelihood based classification	33
2.3.5 Normalized difference vegetation index based classification	34
2.3.6 Classification accuracy	35
2.3.7 Statistical significance of classifiers performance	36
2.4 RESULTS AND DISCUSSION	37
2.4.1 Assessment of classification accuracies using different algorithms	37
2.4.2 Test for statistical significance in the classification accuracy	44
2.5 CONCLUSION	46
CHAPTER 3 PERFORMANCE ANALYSIS OF SUPERVISED	47-72
ALGORITHMS FOR THE LAND FEATURES CLASSIFICATION	
.1 INTRODUCTION	47
.2 DESCRIPTION OF THE STUDY AREA AND MATERIALS	50
.3 METHODOLOGY	51
3.3.1 Image processing of satellite data	51
	51
3.3.2 Image pre-processing	52
3.3.3 Separability analysis	54
3.3.4 Image classification	

3.3.5 Selected measures	57
3.4 Statistical significance of classification accuracy by Z-test	58
3.5 RESULTS AND DISCUSSION	59
3.5.1 Support vector machines based summary of classification	62
accuracy	
3.5.2 Artificial neural network based summary of classification	65
accuracy	
3.5.3 Random forest based summary of classification accuracy	67
3.5.4 Post-processing summary of classification accuracy	68
3.5.5 Analyses of statistical significance in the classification accuracy	70
between two algorithms	
3.6 CONCLUSION	70
CHAPTER 4 ARTIFICIAL NEURAL NETWORK WITH	73-86
DIFFERENT LEARNING PARAMETERS FOR CROP	
CLASSIFICATION USING MULTI-SENSOR SATELLITE DATA	
4.1 INTRODUCTION	73
	74-82
PART A 4.2 DESCRIPTION OF THE STUDY AREA	74
4.2 DESCRIPTION OF THE STORY 4.3 MATERIALS AND METHODOLOGY	74
4.3 MATERIALS AND INDITION 4.3.1 Ground reference data collection	74 75
4.3.1 Ground reference data 4.3.1 Ground reference data 4.3.2 Remotely sensed data collection	75
4.3.2 Remotely sensed data 4.3.3 Image processing of remotely sensed data	76
4.3.3 Image processing of 4.3.4 Creation of region of interest files	76
4.3.4 Creation of region of the	77
4.3.5 Image classification	81
4.4 RESULTS AND DISCUSSION	82-85
4.5 CONCLUSION	82
PART B	83
4.6 STUDY AREA AND DATA-SETS	83
4.7 METHODOLOGY	83
4.7.1 Image processing	83
4.7.2 Separability analysis 4.7.3 Artificial neural network based Classification 4.7.3 Artificial neural network based Classification	84
4.7.3 Artificial neural Idea	
4.7.3 ARTHUMAN AND DISCUSSION	

4.9 CONCLUSION	1
CHAPTER 5 ESTIMATION OF WINTER WHEAT CROP	87-10
GROWTH PARAMETERS USING SENTINEL-1A SAR DATA	
5.1 INTRODUCTION	8
5.2 WINTER WHEAT CROP GROWTH STAGES	9
5.3 MATERIALS AND METHODOLOGY	9
5.3.1 Study area	9
5.3.2 Measurements of winter wheat crop growth parameters	92
5.3.3 Satellite data collection and processing	93
5.3.4 Random forest regression algorithm	93
5.3.5 Support vector regression algorithm	94
5.3.6 Artificial neural network regression algorithm	95
5.3.7 Linear regression algorithm	95
5.3.8 Validation	96
5.4 RESULTS AND DISCUSSION	96
5.5 CONCLUSION	107
CHAPTER 6 ESTIMATION OF CORN CROP GROWTH	109-116
PARAMETERS BY WATER CLOUD MODEL USING SAR DATA	
6.1 INTORDUCTION	109
6.2 MATERIALS AND METHODOLOGY	110
6.2.1 Corn crop growth stages	110
6.2.2 Leaf area index measurements	111
6.2.3 Satellite data collection and processing	111
6.2.4 Water cloud model	112
6.2.5 Estimation of crop growth parameters	113
6.3 RESULTS AND DISCUSSION	114
6.4 CONCLUSION	116
CHAPTER 7 COMPREHENSIVE EVALUATION OF SOIL	117-136
MOISTURE RETRIEVAL MODELS UNDER DIFFERENT CROP	
COVER TYPES USING SENTINEL-1A DATA	
7.1 INTRODUCTION	117
7.2 MATERIALS AND METHODOLOGY	119
7.2.1 Ground soil samples collection	119

7.2.2 SAR data collection and processing	
7.2.3 Random forest regression model	121
7.2.4 Support vector regression model	121
	122
7.2.5 Artificial neural network regression model	123
7.2.6 Performance indicators	123
7.3 RESULTS AND DISCUSSION	124
7.3.1 Retrieval of wheat crop covered soil moisture using RFR, SVR	125
and ANNR models	
7.3.2 Retrieval of barley crop covered soil moisture using RFR, SVR	125
and ANNR models	
7.3.3 Retrieval of corn crop covered soil moisture using RFR, SVR	131
and ANNR models	
7.4 CONCLUSION	135
CHAPTER 8 SUMMARY AND CONCLUSIONS	137-140
	135
8.1 SCOPE FOR FURTHER WORK	141
REFERENCES	161
LIST OF PUBLICATIONS	

1 2 13