CONTENTS

LIST OF SYMBOLS……(XIV-XVI)
LIST OF FIGURES…….(XVII-XIX)
LIST OF TABLES…….(XX-XXI)
PREFACE…….(XXII-XXIV)

CHAPTER – 1: INTRODUCTION AND LITERATURE OF REVIEW.....(1-29)

1.1 REMOTE SENSING.....1

1.2 BRIEF HISTORY OF REMOTE SENSING.....1

1.3 TYPES OF REMOTE SENSING.....3

1.3.1 ACTIVE REMOTE SENSING.....3

1.3.2 PASSIVE REMOTE SENSING.....3

1.4 DIFFERENT KINDS OF REMOTE SENSING DATA.....4

1.5 ATMOSPHERIC AFFECT.....4

1.5.1 RAYLEIGH SCATTERING.....5

1.5.2 MIE SCATTERING.....5

1.5.3 NON-SELECTIVE SCATTERING.....6

1.6 USEFUL FREQUENCY SPECTRUM AND THEIR APPLICATIONS USED IN REMOTE SENSING.....6

1.6.1 ATMOSPHERIC WINDOW.....6

1.6.2 FREQUENCY BANDS AND THEIR USES.....8

1.6.3 FREQUENCY BANDS USEFUL IN MICROWAVE REMOTE SENSING.....8

1.7 MICROWAVE SENSORS.....9

1.7.1 PASSIVE SENSOR.....9

1.7.2 ACTIVE MICROWAVE SENSOR.....10

1.8 REVIEW OF LITERATURE.....11

1.9 STATEMENT OF THE PROBLEM.....26

1.10 ORGANIZATION OF THESIS.....28

CHAPTER – 2: EXPERIMENTAL DETAILS.....(30-41)

2.1 BISTATIC SCATTEROMETER MEASUREMENT 30

2.2 SOIL SURFACE PARAMETERS MEASUREMENT 34

2.2.1 SOIL MOISTURE CONTENT MEASUREMENT 34

2.2.2 SURFACE ROUGHNESS MEASUREMENT 37

2.3 CROP VARIABLES MEASUREMENT.....39

2.3.1 VEGETATION WATER CONTENT (VWC) MEASUREMENT.....39

2.3.2 LEAF AREA INDEX (LAI) MEASUREMENT 40

2.3.3 PLANT HEIGHT MEASUREMENT 41

2.3.4 SPAD VALUE MEASUREMENT 41

2.3.5 LEAF LENGTH AND LEAF WIDTH MEASUREMENT 41

CHAPTER – 3: ESTIMATION OF SOIL MOISTURE BY GROUND BASED BISTATIC SCATTEROMETER DATA AT X-BAND .....(42-62)

3.1 INTRODUCTION.....42

3.2 EXPERIMENTAL DETAILS.....44

3.3 DESCRIPTION OF DIFFERENT KIND OF ARTIFICIAL NEURAL NETWORK MODELS 44

3.3.1 BACK PROPAGATION ARTIFICIAL NEURAL NETWORK (BPANN).....45

3.3.2 RADIAL BASIS FUNCTION ARTIFICIAL NEURAL NETWORK (RBFANN) 46

3.3.3 GENERAL REGRESSION ARTIFICIAL NEURAL NETWORK (GRANN) 48

3.3.4 LINEAR REGRESSION MODEL (LRM).....50

3.4 PERFORMANCE INDICES.....50

3.5 RESULTS AND DISCUSSION 51

3.5.1 MICROWAVE RESPONSE OF SOIL MOISTURE IN SPECULAR DIRECTION AT X- BAND.....51

3.5.2 EVALUATION OF DATA 52

3.5.3 ESTIMATION OF SOIL MOISTURE USING THREE DIFFERENT ARTIFICIAL NEURAL NETWORK ARCHITECTURES AND LINEAR REGRESSION MODEL 54

3.6 CONCLUSIONS 62

CHAPTER – 4: ESTIMATION OF RICE CROP VARIABLES USING BISTATIC SCATTEROMETER DATA AND ARTIFICIAL NEURAL NETWORKS .....(63-80)

4.1 INTRODUCTION 63

4.2 DIFFERENT GROWTH STAGES OF RICE CROP 64

4.3 METHODS AND OBSERVATIONS 65

4.3.1 BISTATIC SCATTEROMETER MEASUREMENT 65

4.3.2 RICE CROP VARIABLES MEASUREMENT 66

4.4 PROCEDURE FOR THE ESTIMATION OF RICE CROP VARIABLES . 66

4.4.1 POLYNOMIAL REGRESSION ANALYSIS 67

4.4.2 FEED FORWARD BACK PROPAGATION ARTIFICIAL NEURAL NETWORK (FFBPANN) 67

4.4.3 DATA PREPARATION 68

4.4.4 CREATION OF FFBPANN MODELS 69

4.5 RESULT AND DISCUSSIONS 73

4.5.1 POLYNOMIAL REGRESSION ANALYSIS FOR SELECTING THE SUITABLE SCATTEROMETER SYSTEM CONFIGURATION 75

4.5.2 FEED FORWARD BACK PROPAGATION ARTIFICIAL NEURAL NETWORK (FFBPANN) FOR THE ESTIMATION OF RICE CROP VARIABLES 76

4.6 CONCLUSIONS 79

CHAPTER – 5: ESTIMATION OF CROP VARIABLES USING BISTATIC SCATTEROMETER DATA AND ARTIFICIAL NEURAL NETWORK TRAINED BY EMPIRICAL MODELS .....(81-99)

5.1 INTRODUCTION....81
5.2 METHOD AND OBSERVATIONS....83
5.3 STATISTICAL ANALYSIS....83
5.4 MODELLING APPROACH....83
5.4.1 MULTIPLE REGRESSION ANALYSIS....83
5.4.2 FITTING OF CROP VARIABLES WITH DIFFERENT AGE OF KIDNEY BEAN CROP....85
5.5 ARTIFICIAL NEURAL NETWORK....86
5.6 RESULT AND DISCUSSIONS....88
5.6.1 ANGURAL VARIATION OF BISTATIC SCATTERING COEFFICIENT....88
5.6.2 RETRIEVAL ALGORITHM FOR THE CROP VARIABLES OF KIDNEY BEAN....94
5.7 CONCLUSIONS....98
CHAPTER – 6: ESTIMATION OF WHEAT CROP VARIABLES USING BISTATIC SCATTEROMETER DATA AND ARTIFICIAL NEURAL NETWORK……..(100-116)
6.1 INTRODUCTION....100
6.2 METHODS AND OBSERVATIONS....101
6.3 ARTIFICIAL NEURAL NETWORK....105
6.4 RESULT AND DISCUSSIONS....107
6.4.1 TEMPORAL VARIATION OF BISTATIC SCATTERING COEFFICIENTS....107
6.4.2 ESTIMATION OF WHEAT CROP VARIABLES....108
6.5 CONCLUSIONS....116
CHAPTER – 7: ESTIMATION OF CHICKPEA CROP VARIABLES USING BISTATIC SCATTEROMETER DATA AND ARTIFICIAL NEURAL NETWORK……..(117-130)

7.1 INTRODUCTION....117
7.2 METHODS AND OBSERVATIONS....118
7.3 LINEAR REGRESSION ANALYSIS....119
7.4 RESULT AND DISCUSSIONS....122
7.4.1 TEMPORAL VARIATION OF BISTATIC SCATTERING COEFFICIENTS....122
7.4.2 ESTIMATION OF CHICKPEA CROP VARIABLES....124
7.5 CONCLUSIONS....130
CHAPTER – 8: CONCLUTIONS AND RECOMMENDATIONS…….(131-135)
8.1 ADVANTAGES AND DISADVANTAGES OF BISTATIC SCATTEROMETER DATA OVER THE MONOSTATIC SCATTEROMETER DATA 132
REFERENCES …….(136-148)