LIST OF FIGURES

Figure No.	Description Page 1	age No.
1.1	Remote sensing imaging process of Earth targets	2
1.2	Remote sensing illuminating process (Passive and Active remote sensi	ng) 4
1.3	Atmospheric transmittance (atmospheric window)	6
1.4	The location of Banaras Hindu University campus at 5.8 m,	9
	30 m and 56 m spatial resolution	
1.5	Spectral reflectance curve for vegetation, soil and water	12
1.6	The spectral reflectance of vegetation leaves for healthy,	13
	sick and dead conditions	
1.7	Scattering mechanism from smooth and rough surfaces	15
1.8	Illustration of synthetic aperture radar (SAR) imaging geometry	17
1.9	SAR backscattered signal toward the sensor from the vegetation	18
1.10	Microwave frequency bands and their application	20
1.11	Electric wave signal interaction at the Earth target with	21
	horizontal (H) and vertical (V) polarization of EMW	
1.12	SAR looking incidence angle	22
1.13	Classification of backscattering coefficient (σ^0) for various features	23
	at the Earth surface	
1.14	Illustration of optical and microwave remote sensing applications	25
2.1	The detailed pre-processing workflow for Sentinel -1A synthetic	46
	aperture radar (SAR) satellite data	
2.2	Leaf Area Index (LAI)-2200C Plant Canopy Analyzer	51
2.3	Metallic plate (1 meter long) used for the measurement of	55
	soil surface roughness	
2.4	The surface roughness profile drawn on the metallic plate using	55
	ink marker	
2.5	The schematic flowchart of the methodology for present	56
	research work	

2.6	The SAR backscattering phenomenon over the vegetation	58
	and soil layers	
2.7	Flowchart for the computation of dual polarimetric radar vegetation	61
	index using ALOS -2 SAR satellite data at HH and HV polarization	
2.8	Flowchart for the computation of dual polarimetric radar vegetation	63
	index using Sentinel -1A SAR satellite data at VV and VH polarizations	
2.9	NDVI value for healthy and stress vegetation	65
2.10	Spectral reflectance curve for healthy and stress plant and	65
	Red - Edge (RE) region	
3.1	The location map of study region	68
3.2	Assessment of forward modeling simulation computed by using the	79
	vegetation descriptors (NDVI $_{RE}$, MSR $_{RE}$, CI $_{RE}$, NDVI and LAI) in	
	MWCM at VV polarization	
3.3	Comparative analysis of (a) $NDVI_{RE}$, (b) MSR_{RE} , and (c) CI_{RE} with	81
	Sentinel- 1A SAR derived $\sigma^0(dB)$ at VV polarization	
4.1	The location of study area and sampling fields	86
4.2	Temporal variation of backscattering coefficient of wheat crop at	94
	VV and VH polarizations	
4.3	Comparison between SAR observed and simulated backscattering	94
	coefficient computed at VV polarization by (a) MWCM (b) WCM	
4.4	Comparison between SAR observed and simulated backscattering	95
	coefficient computed at VH polarization by (a) MWCM (b) WCM	
4.5	Comparison between observed and estimated LAI computed at	96
	VV polarization by (a) MWCM (b) WCM	
4.6	Comparison between observed and estimated LAI computed at	97
	VH polarization by (a) MWCM (b) WCM	
5.1	Geo-location of study region with different sampling points	101
	(March 08, 2018 at VV channel)	
5.2	Correlation matrix for in-situ measurements	108
5.3	Comparison between SAR and simulated backscattering coefficient at	110
	the (a) VV and (b) VH polarization for forward modelling	

5.4	Comparison between in-situ and retrieved LAI by the modified model	112
	at (a) VV and (b) VH polarization	
5.5	Comparison between in-situ and retrieved LAI by the	113
	(a) PROBA-V (b) MODIS global satellite product	
5.6	Comparative analysis of retrieved LAI using Taylor plot	114
6.1	Location map of the study area	120
6.2	The temporal variation of SM, LAI and σ^0 (dB) in region 1	124
	with correlation matrix	
6.3	The temporal variation of SM, LAI and σ^0 (dB) in region 2	125
	correlation matrix	
6.4	Methodology flow chart for the retrieval of SM using MWCM	126
6.5	Linear regression between Sentinel-1A (SAR) observed	133
	backscattering coefficient and retrieved soil moisture through	
	MWCM at VV polarization	
6.6	Temporal SM mapping for region1 (sparse vegetated soil fields)	135
6.7	Temporal SM mapping for region 2 (vegetated soil fields)	136
6.8	Temporal analysis between retrieved SM through MWCM and	137
	in-situ SM in region 1	
6.9	Temporal analysis between retrieved SM through MWCM and	139
	in-situ SM in region 2	
6.10	Temporal comparison of coefficient of determination (R ²)	140
	in region 1 and region 2	
6.11	Comparative analysis of RMSE values in region 1 and 2 for	141
	robustness of the MWCM performance	
6.12	Comparative analysis of NSE values in regions 1 and 2 for	142
	evaluation of the MWCM performance	
6.13	The overall comparison between retrieved SM and in-situ SM	143
	through (a) MWCM (b)WCM in region 1 and region 2	
7.1	Sentinel -1A SAR RGB (R -VV, G – VH and B – VV/VH) image	149
	of the study location	

7.2	Illustration of general work flow for the appraisal of dual	151
	polarimetric radar vegetation index	
7.3	Parametrization work flow of Genetic algorithm for model optimization	156
7.4	Computed map of (a) D _p RVI, (b) PRVI and (c) RVI from	160
	ALOS-2 (L- band) satellite data	
7.5	Computed map of (a) D _p RVI, (b) PRVI and (c) RVI from	162
	Sentinel -1A (C- band) satellite data	
7.6	Comparative analysis between simulated and Sentinel -1A	164
	backscattering coefficient using vegetation descriptors (a) D _p RVI,	
	(b) PRVI and (c) RVI at HH + HV polarization	
7.7	Comparative analysis between simulated and Sentinel -1A	166
	backscattering coefficient using vegetation descriptors (a) D _p RVI,	
	(b) PRVI and (c) RVI at VV + VH polarization	