Upscaling cover management factor for different land use types in semi-arid agro-ecosystems

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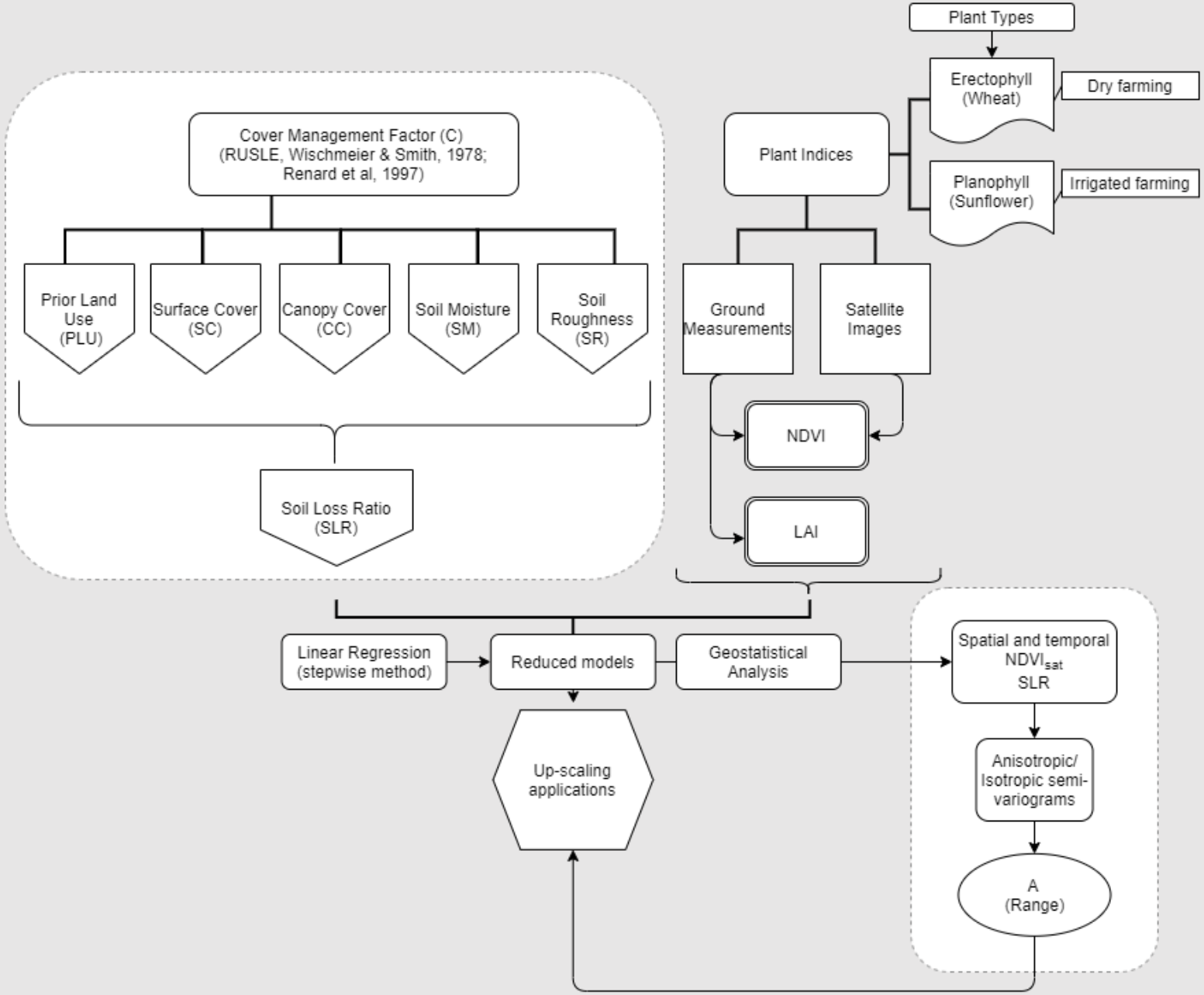
Objective

Investigating

- relationships between RUSLE-C/sub-factors and plant indices (NDVI & LAI) in different land uses (dry and irrigated farming) and
- the effects of cover management practices on soil loss and

assessing the effect of management options on soil conservation plans and upscaling methods.

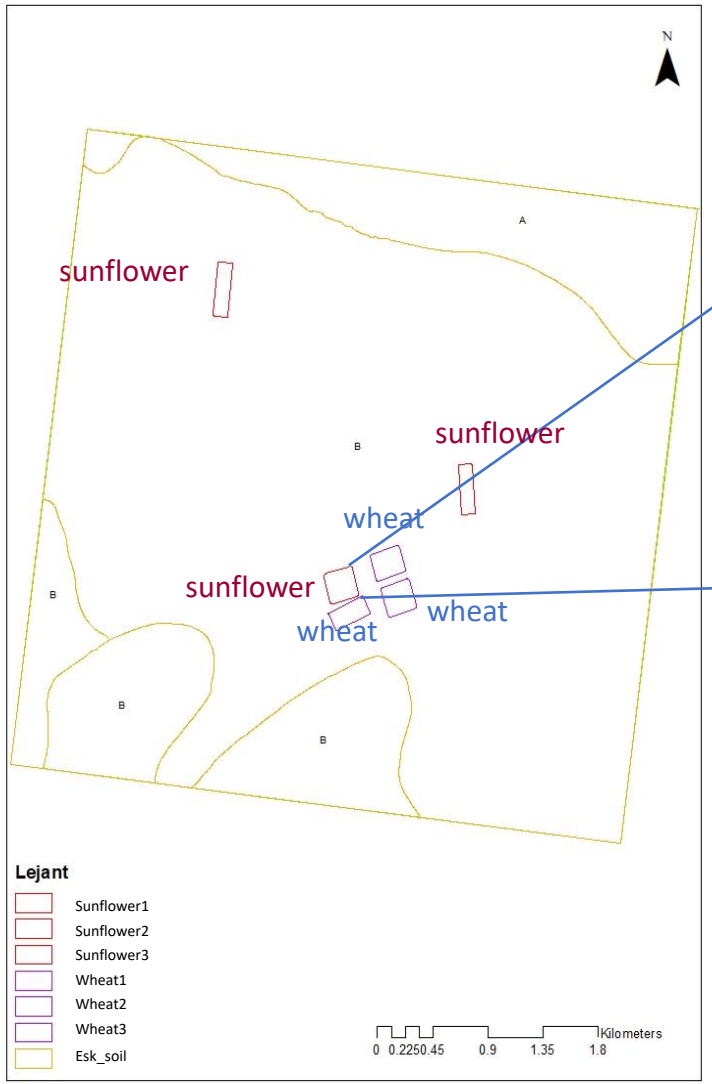

Plant Types
Erectophyll (Wheat)
Dry farming
Plant Indices
Planophyll (Sunflower)
Irrigated farming
Cover Management Factor (C) (RUSLE, Wischmeier & Smith, 1978; Renard et al, 1997)
Prior Land Use (PLU)
Surface Cover (SC)
Canopy Cover (CC)
Soil Moisture (SM)
Soil Roughness (SR)
Ground Measurements
Satellite Images
NDVI
LAI
Soil Loss Ratio (SLR)
Linear Regression (stepwise method)
Reduced models
Geostatistical Analysis
Spatial and temporal $NDVI_{sat}$ SLR
Anisotropic/ Isotropic semi-variograms
A (Range)
Up-scaling applications

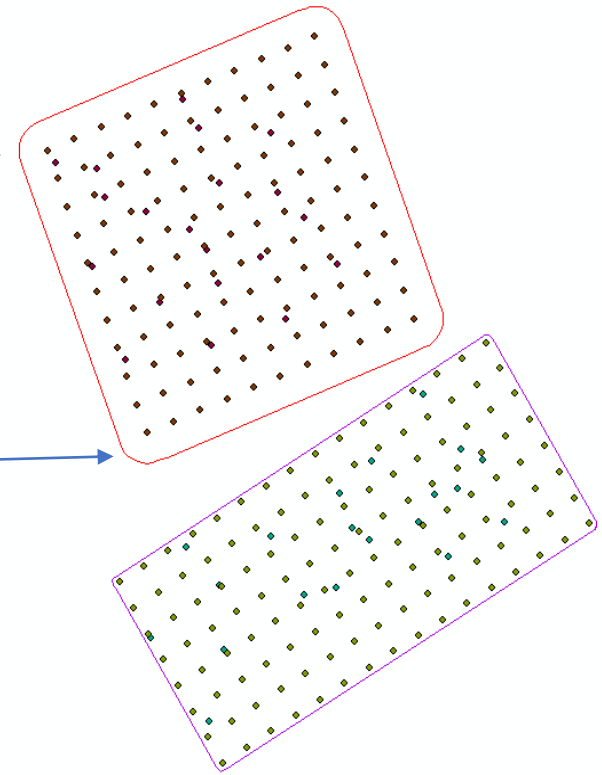
flowchart

Materials & Methods

Site description

Climate (terrestrial)
Minimum: 0 - 20° C
Maximum: 30 - 38° C
Precipitation (annual): 410 mm
Elevation :700m
Soil & Land classification
Brown soils with moderate depth, mostly C and CL texture
Land capability class II





Study area is located in Alpu, approximately 40 km East of Eskişehir which is a part of the Porsuk Stream Sub-basin.

20m × 20m grid sampling method
140 systematic,
20 random points for each plot

wheat






sunflower

USLE crop-stage periods - sunflower (Wischmeier and Smith, 1978)

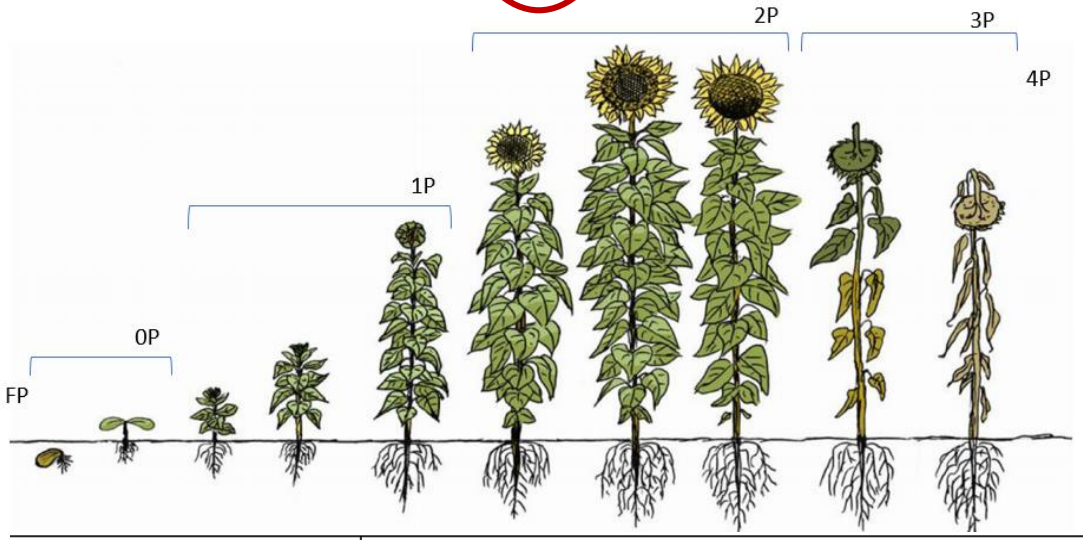
Fieldworks and dates of satellite images

	FP			1P		3P	
3P	B-1	18/09/2015 22/09/2015	B-1	13/11/2015 07/12/2015	B-1	14/04/2016	B-1	11/07/2016
4P	B-2	19/09/2015 23/09/2015	B-2	11/11/2015 21/11/2015	B-2	22/04/2016	B-2	12/07/2016
4P	B-3	17/09/2015 01/10/2015	B-3	12/11/2015 22/11/2015	B-3	01/06/2016 02/06/2016	B-3	13/07/2016
		0P		2P				

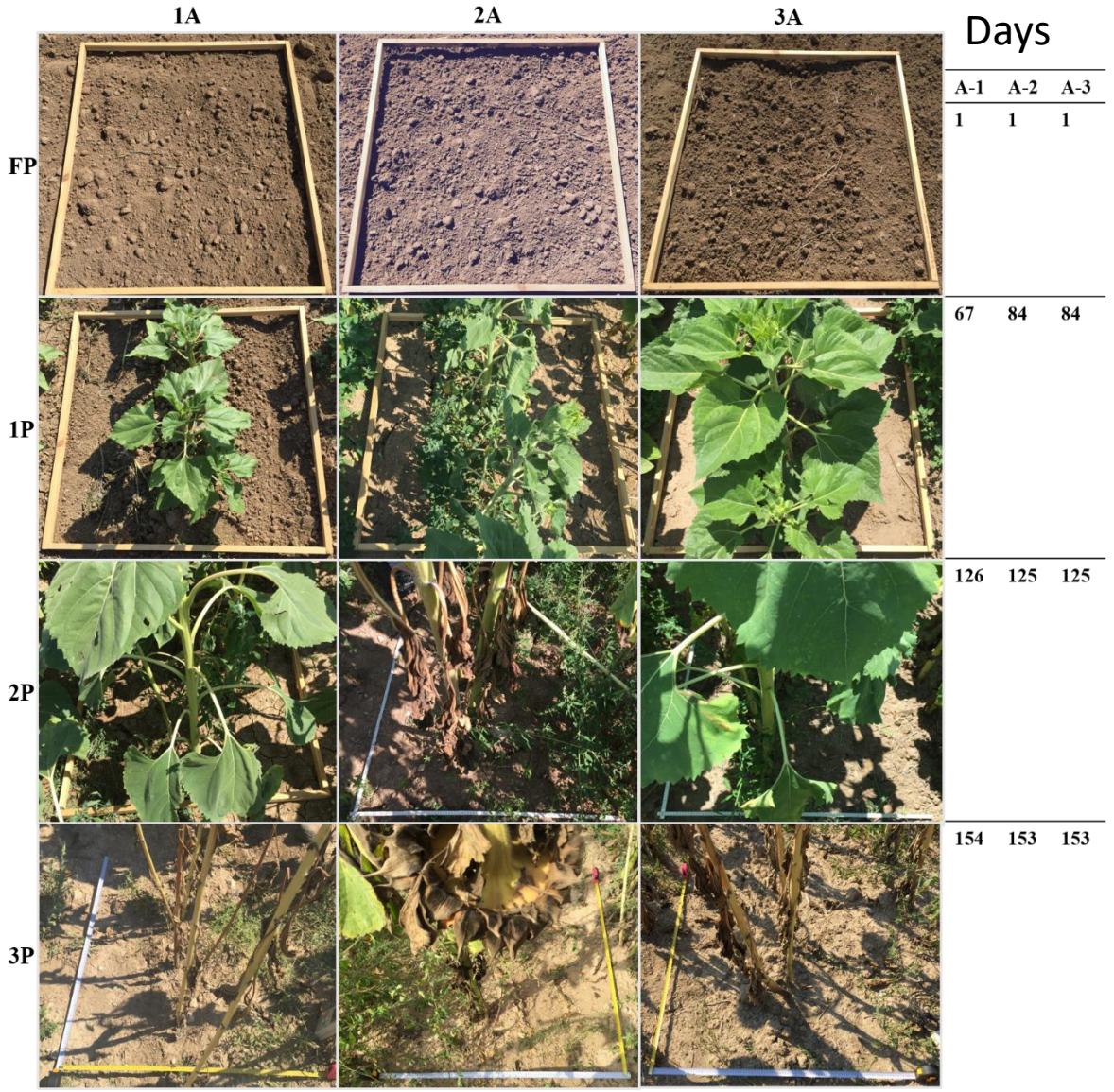
Data used for Upscaling

18/09/2015 (PHR1A)	11/11/2015 (PHR1B)	07/04/2016 (PHR1B)	25/06/2016 (PHR1A)	08/08/2016 (PHR1B)	16/09/2016 (SPOT7)

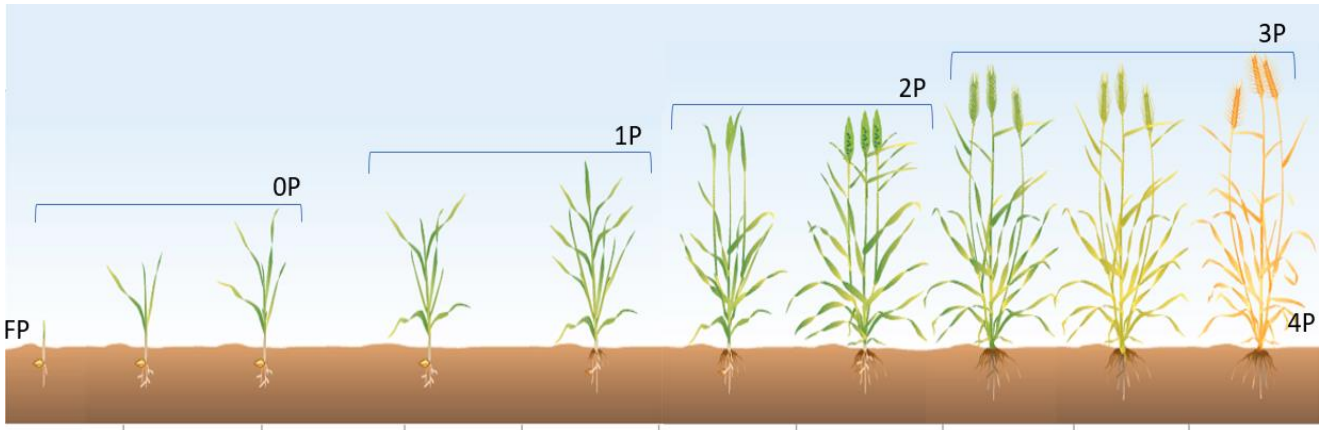
A-1	05/04/2016	A-1	10/06/2016 17/06/2016	A-1	08/08/2016	A-1	05/09/2016
A-2	06/04/2016	A-2	28/06/2016	A-2	08/08/2016	A-2	05/09/2016
A-3	07/04/2016	A-3	29/06/2016	A-3	09/08/2016	A-3	06/09/2016
FP		1P		2P		3P	



Vegetative stages		Reproductive stages		
Emergence	Growing stage		Flowering	Achene development	Physiological maturity
	Slow	Accelerated			

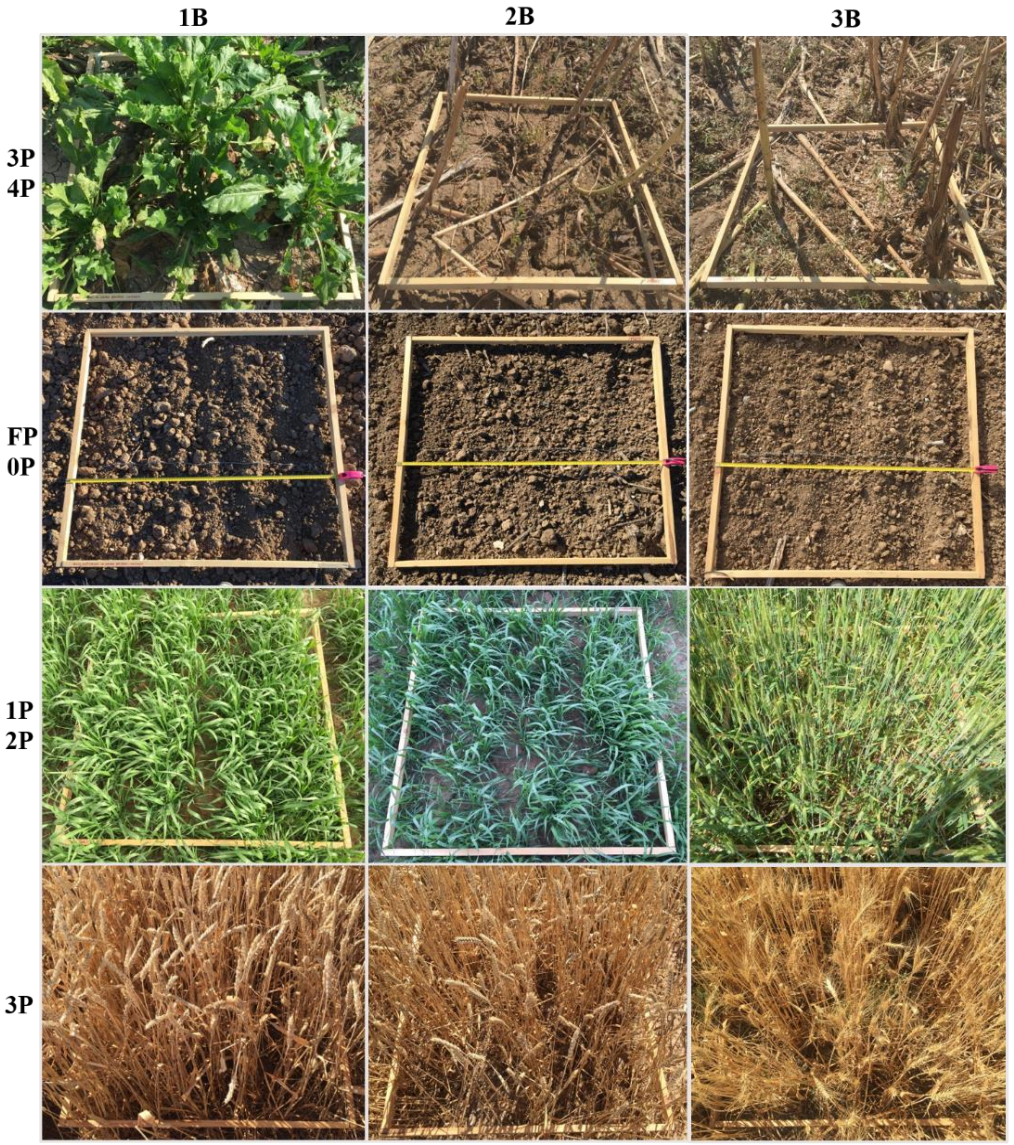


USLE crop-stage periods - wheat (Wischmeier and Smith, 1978)



GD 00-09	GD 10-19	GD 20-29	GD 30-39	GD 40-49	GD 50-59	GD 60-69	GD 70-79	GD 80-89	GD 90-99
Germination	Seedling growth	Tillering	Stem Elongation	Booting	Ear emergence	Flowering	Milk development	Dough development	Ripening

- *Period F (Rough falllow): Inversion plowing to secondary tillage*
- *Period SB (0, seedbed): Secondary tillage – 10% canopy cover*
- *Period 1 (establishment): End of SB - 50% canopy cover*
- *Period 2 (development): End of 1 – 75% canopy cover*
- *Period 3 (maturing crop): End of 2 - harvest*
- *Period 4 (residue or stubble): Harvest – plowing/new seeding*



Days		
B-1	B-2	B-3
1	1	1
81	64	67
210	217	260
298	298	301

Measuring vegetation indices

LAI – LP-80 Ceptometer, Decagon Inc. $LAI = \frac{\left(\left(1-\frac{1}{2K}\right)\cdot f_b - 1\right)\ln\tau}{A(1-0{,}47 f_b)}$

NDVI – GreenSeeker, Trimble Inc. $NDVI = \frac{(NIR-Red)}{(NIR+Red)}$

Satellite images*

Pleaides PHR1A and 1B

(Resolution: 0.5m panchromatic, 2m multispectral

Band: Panchromatic; 4 multispectral bands

(Red, Green, Blue & NIR))

Spot -7

(Resolution: 1.5m panchromatic, 6m multispectral

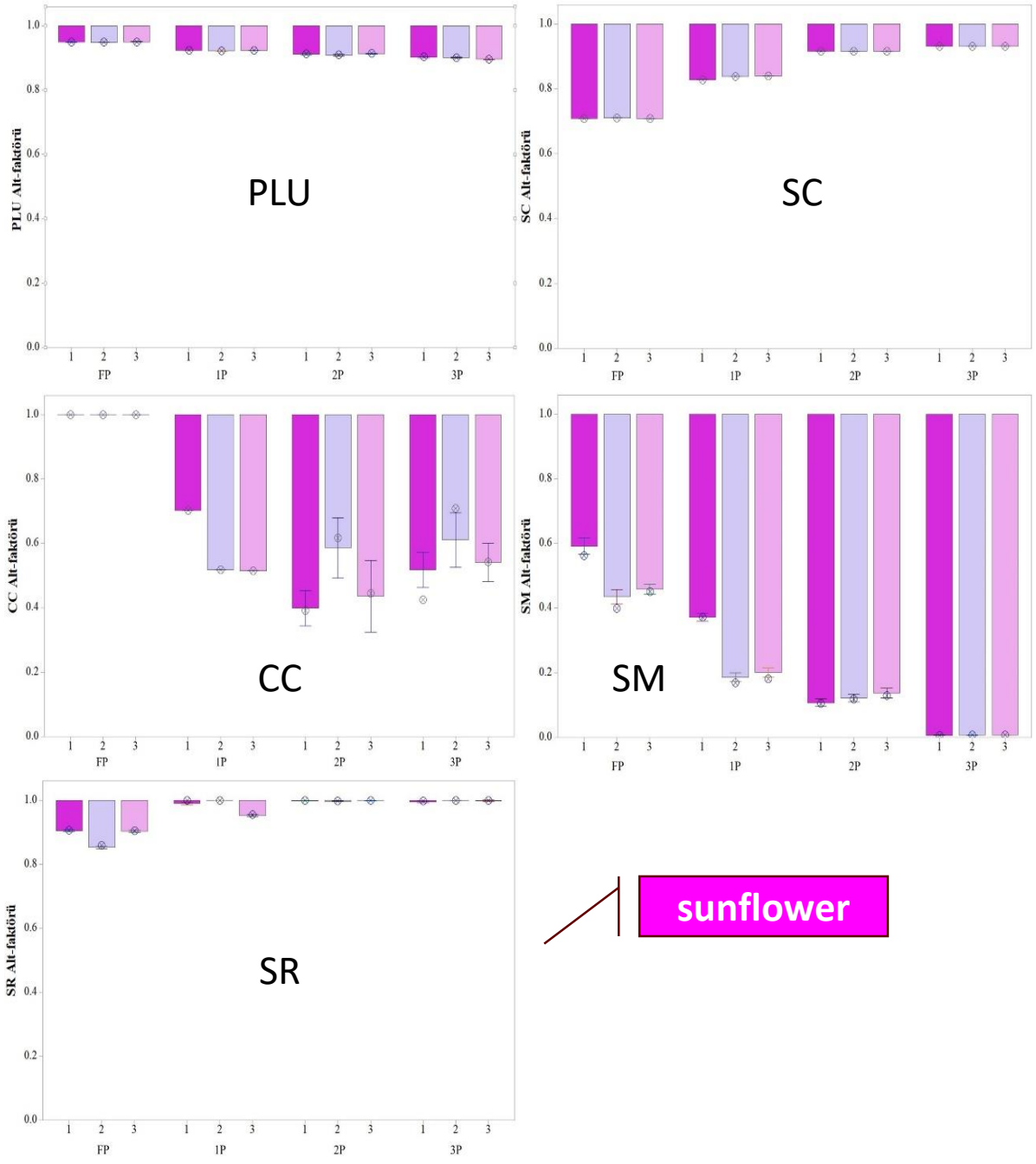
Band: Panchromatic; 4 multispectral bands

(Red, Green, Blue, & NIR))

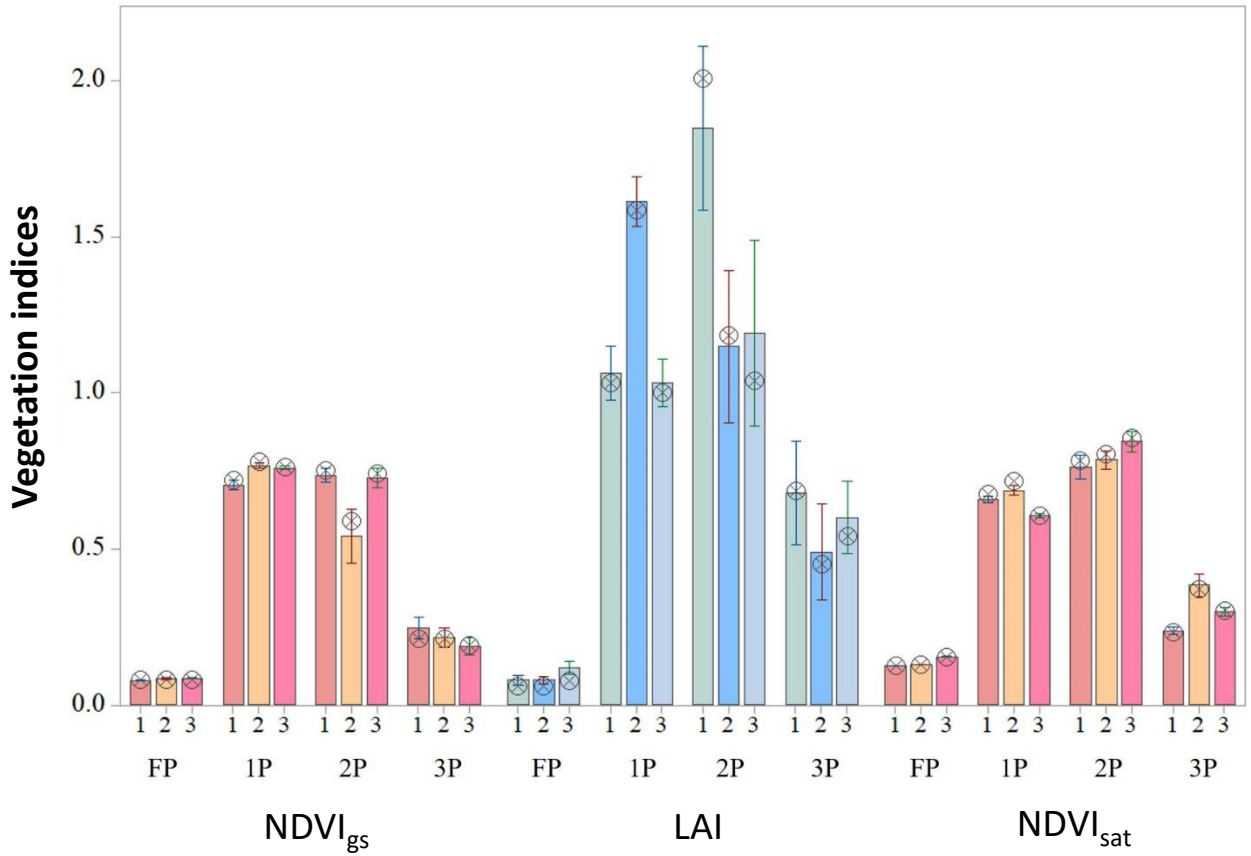
Image processing – PCI Geomatics/ATCOR and ArcGIS

* They are operated on the same orbit as a 4-satellite constellation)

Results & Discussion

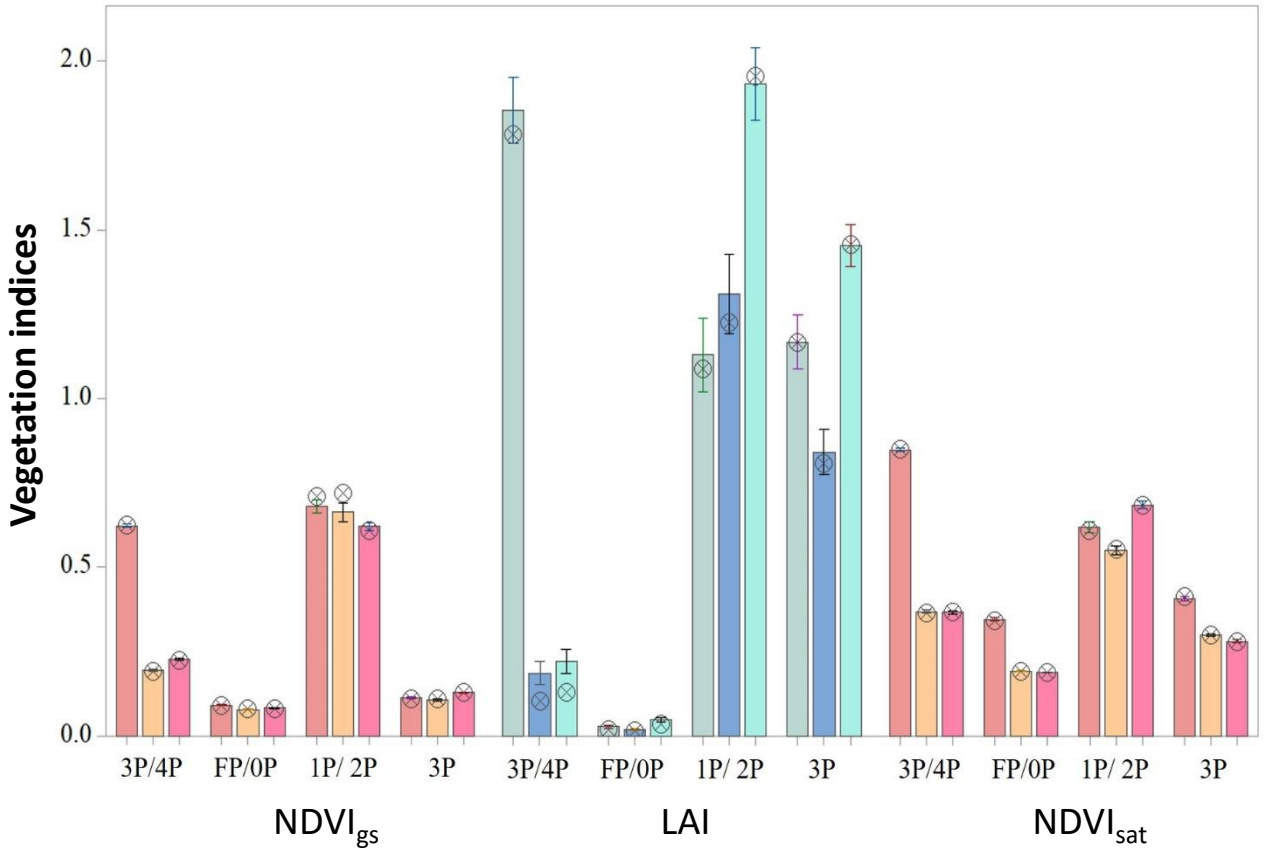


sunflower



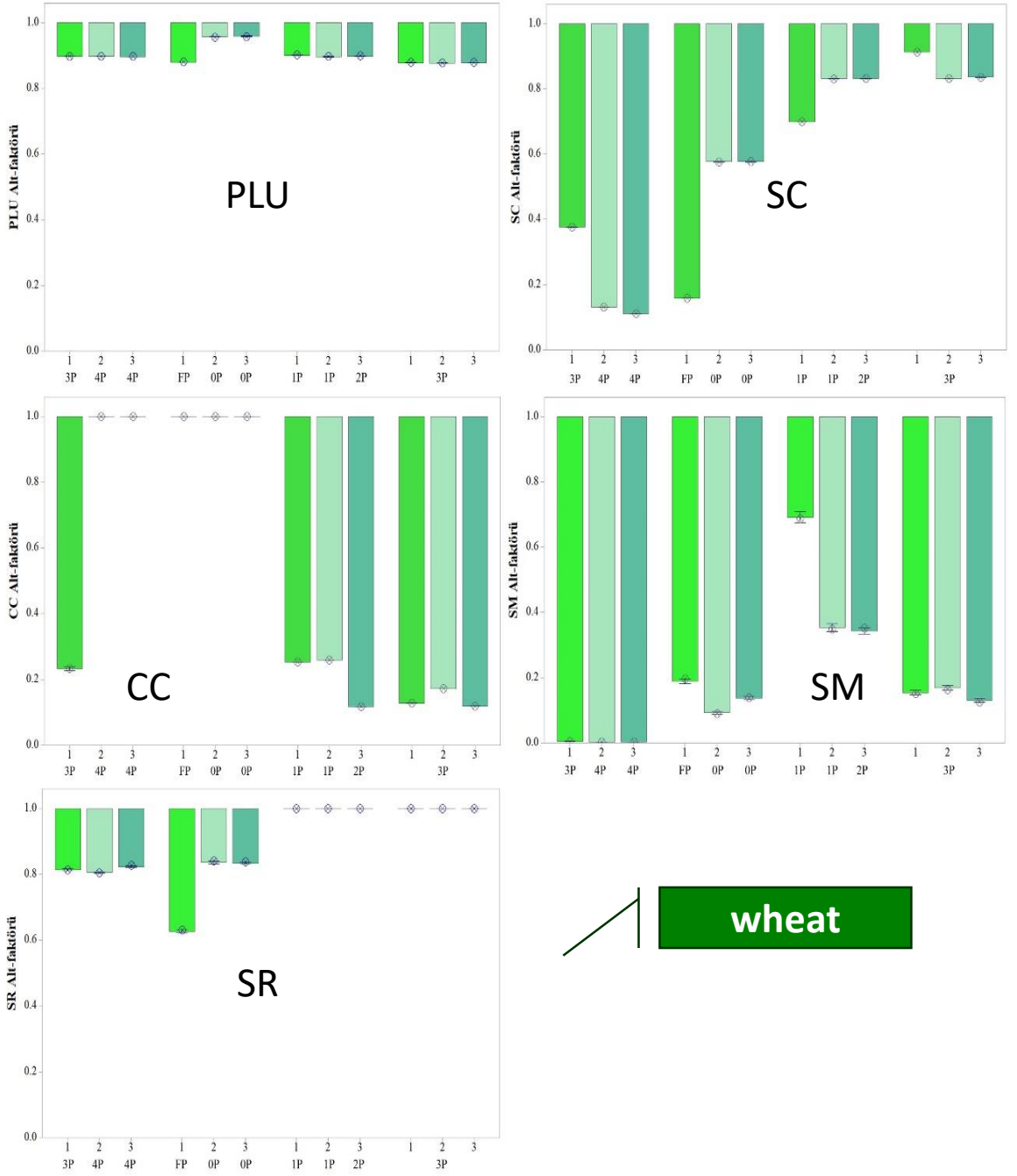
Sunflower

Temporal variations of NDVI & LAI along with the development periods



Wheat

Temporal variations of NDVI & LAI along with the wheat development period



sunflower

Mean of the plots	df	Adj SS	Adj MS	F-value	P-value
Regression	3	0.302	0.101	293.67	**0.000**
$NDVI_{sat}$	1	0.003	0.003	8.18	**0.012**
Period	2	0.239	0.120	349.11	**0.000**
Error	158	0.054	0.000		
Total	161	0.356			

Model R^2 = 0.8495

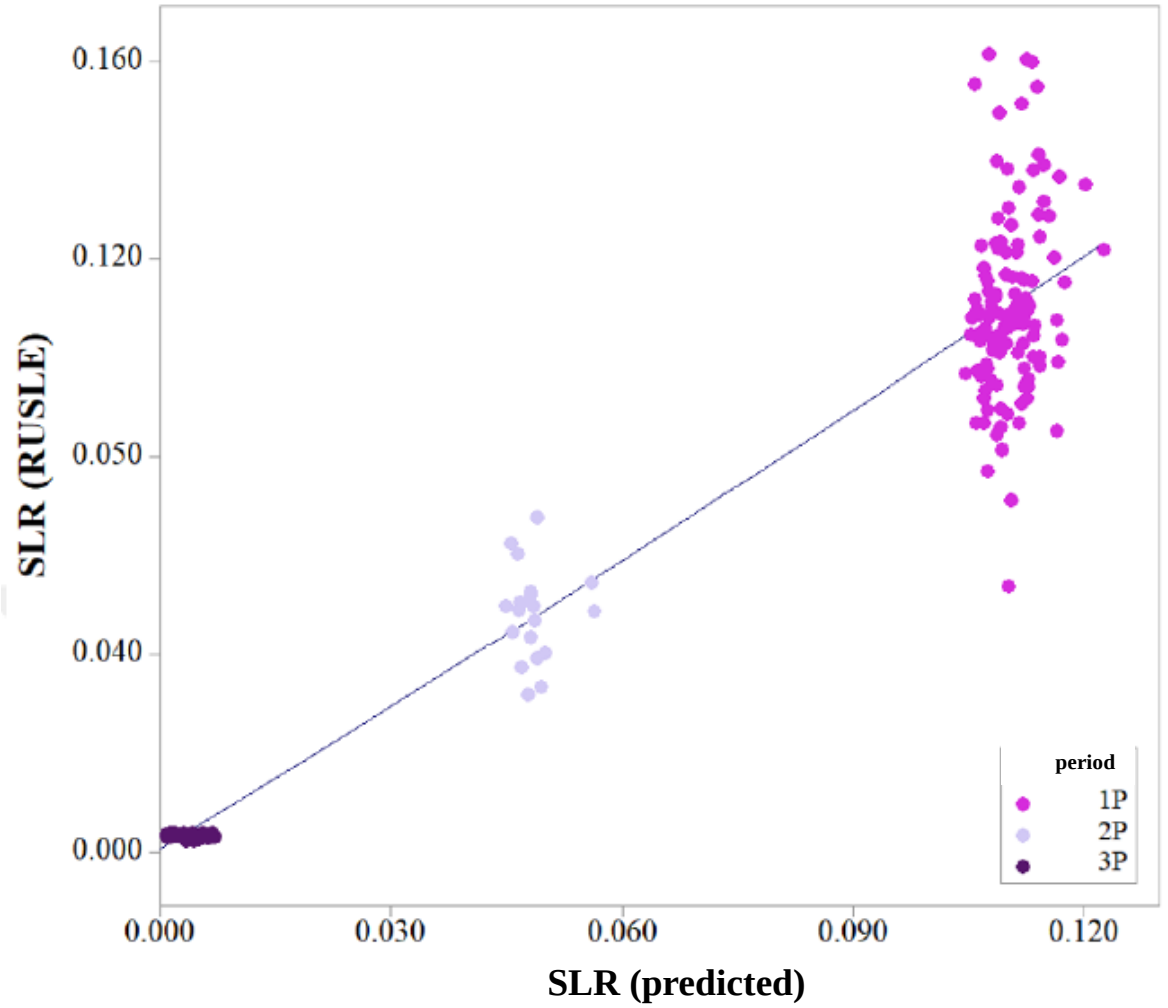
Periodic regression equations – reduced models*

$\underline{1}: SLR = 0.167 - 0.0872NDVI_{sat}$

$\underline{2}: SLR = 0.1194 - 0.0872NDVI_{sat}$

$\underline{3}: SLR = 0.030 - 0.0872NDVI_{sat}$

$SLR_{RUSLE} = 0.8574SLR_p^{0.9458}$ $R^2 = 0.9346$ RMSE = 0.098



*Period F is not included

Wheat

Mean of the plots	df	Adj SS	Adj MS	F-value	P-value
Regression	3	0.190	0.063	1785.52	**0.000**
$NDVI_{sat}$	1	0.000	0.000	4.74	**0.030**
Period	2	0.096	0.048	1346.00	**0.000**
Error	395	0.014	0.000		
Total	398	0.204			

Model R^2 = 0.9313

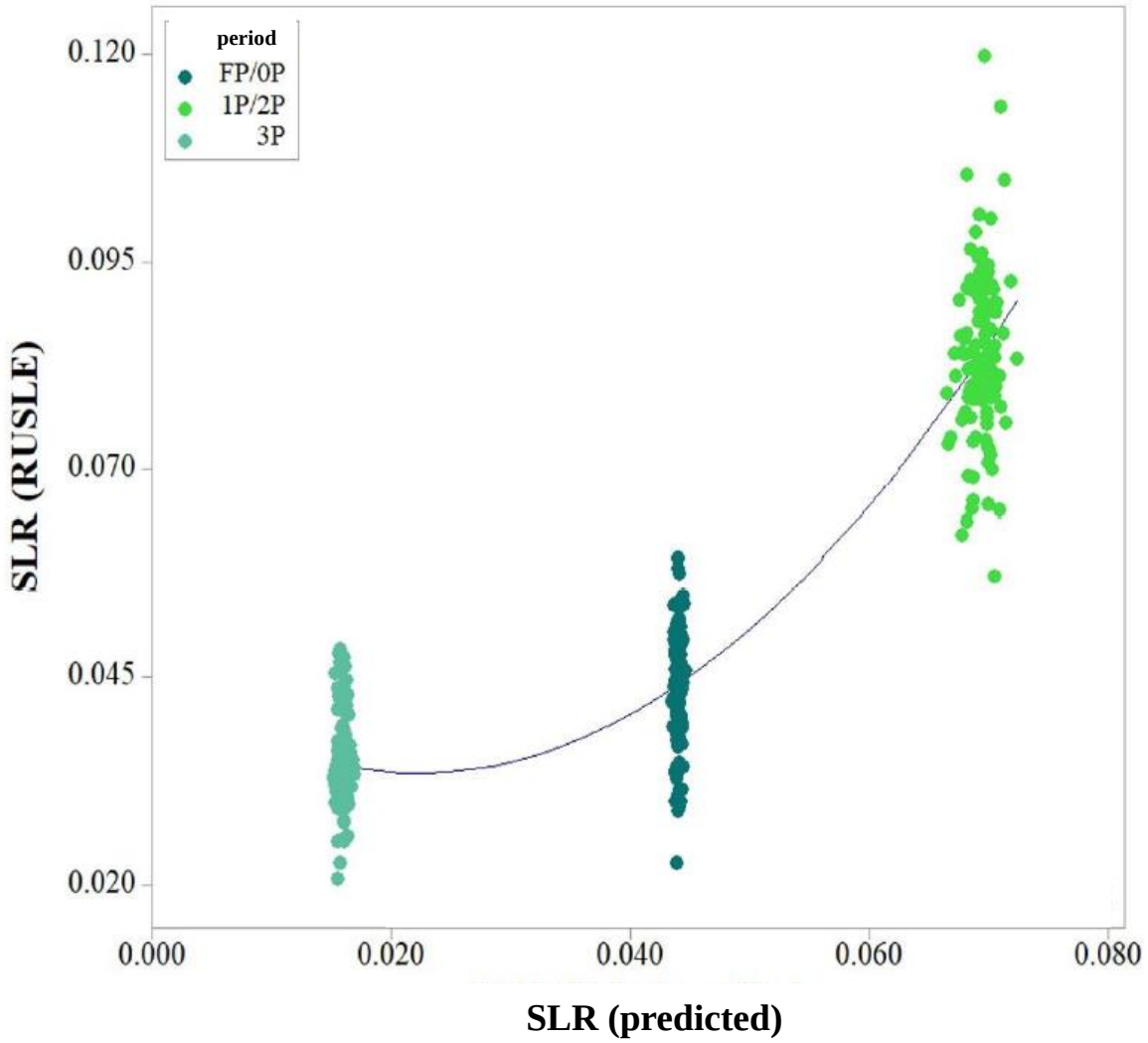
Periodic regression equations – reduced models

F-0: $SLR = 0.3895 + 0.02101NDVI_{sat}$

1-2: $SLR = 0.05645 + 0.02101NDVI_{sat}$

3: $SLR = 0.0090 + 0.02101NDVI_{sat}$

$SLR_{RUSLE} = 0.0243^{16.583SLRp}$ $R^2 = 0.8117$ RMSE = 0.006



June 2016

SLR – sunflower period 1 ($SLR = 0.167 - 0.0872NDVI_{sat}$)

6m × 6m

23m × 23m
(for SLR)

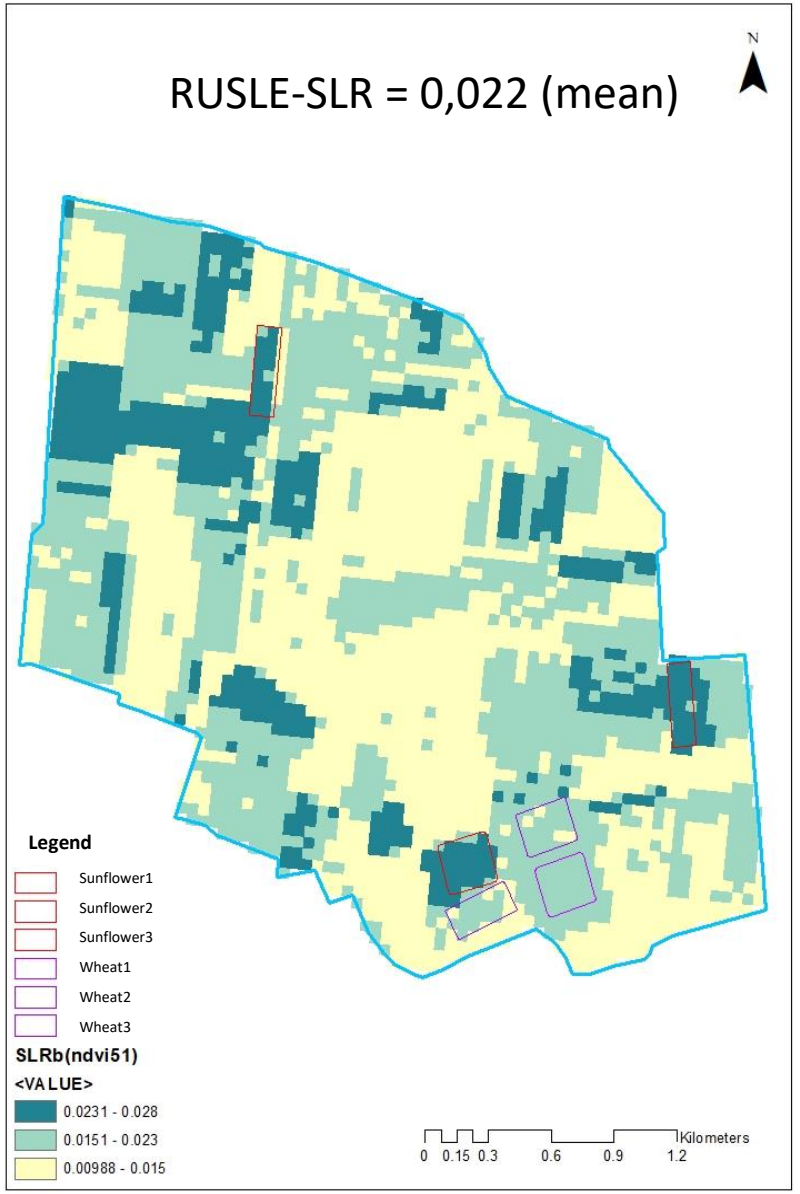
31m × 31m
(for $NDVI_{sat}$)

June 2016

SLR – wheat period 3 (SLR = 0.009 + 0.02101NDVI$_{sat}$)

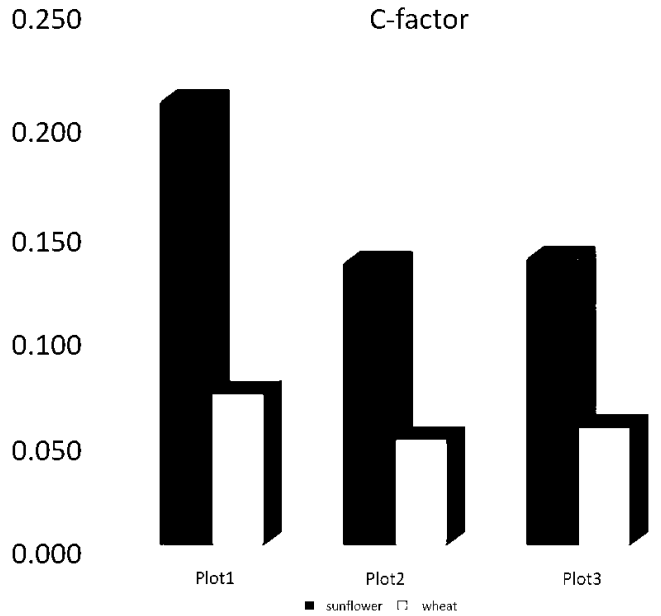
6m × 6m

20m × 20m
(for SLR)



51m × 51m
(for NDVI$_{sat}$)

Conclusion



- Since heavy soil cultivation activities were caried out, it cannot be mentioned about the effectiveness of PLU, SC and SR sub-factors. CC and SM sub-factors were increased starting with germination as it is expected and due to the clay-textured soil, moisture was preserved when there was no precipitation.
- Sub-factors calculated from the sunflower plots were generally found to be highly or very highly correlated both with each other and VIs due to its planophile structure (proportional growth). Considering the relationships between NDVI and LAI, higher determination coefficient values were obtained for sunflower than wheat which shows low NDVI values due to the yellowing in the ripening period, it does not lose much volume and exhibit a behavior in parallel with LAI values because of its erectophile physiology.
- As the sunflowers entered the maturation period, spaces between rows and plants increased considarebly and soil surface became bare for the potential runoff threats. Since the wheat is a herbaceous plant, its covering provided protection for the soil surface. This is also evident from the average C-factors of the plots. Although both the periodic and average values of the C-factor of the plots were significantly high, the soil surface was vulnerable to the erosion until the plant showed its own efficiency.
- This study shows that mathematical models such as RUSLE can be used in a practical way for dry and irrigated farming areas where the topography is not variable and certain agricultural crops are cultivated.

Thank you!

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https://arastirma.tarimorman.gov.tr/gktaem/