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Research Paper

Recognition of different yield potentials among rain-fed wheat fields before harvest using remote sensing

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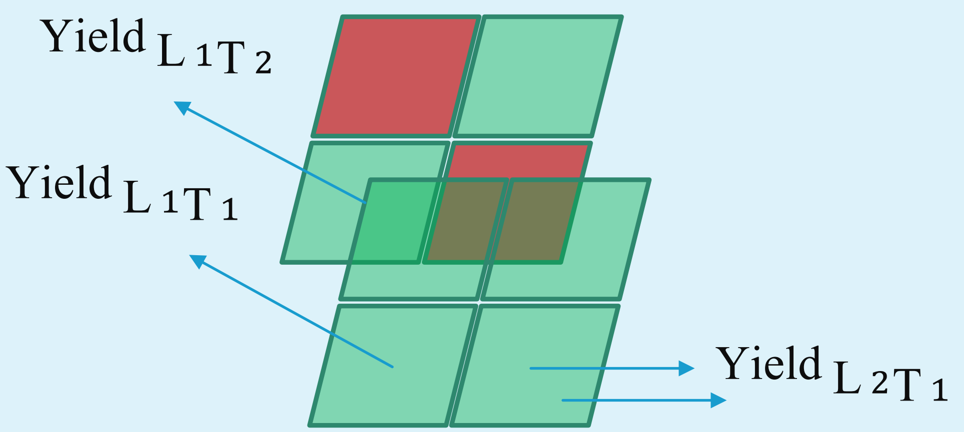
Outline



Scope of improvement

- Location: $\Delta Yield = Yield_{L1T2} - Yield_{L2T2}$
- Time: $\Delta Yield = Yield_{L1T2} - Yield_{L2T2}$

Using RS, various methods have been developed to **estimate crop yield**, which allows the comparison of yield values in different pixels and also in one pixel in different growth periods.

If the same crop is grown on different pixels or if the same crop is grown in one pixel in different growth periods, the **difference in the amount of yield** can be considered as a yield gap caused by different factors.

By identifying these reducing factors and if measures are taken to mitigate them, the amount of yield gap that can be closed is called the **scope of improvement**.

An strategy along with **food security** can be based on estimating this scope of improvement and setting a sort of best practices to achieve it.

Outline

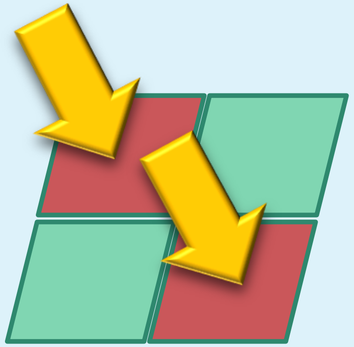
Determination of the scope of improvement after harvest (Zwart et al., 2010) can provides useful information about agricultural fields indicating that in which area **best practices** must be focused to close the yield gap for the next season.

It will be more desirable if these area can be recognized before harvest in an **early time**, when it is still possible to mitigate the gap by implementing quick actions such as supplementary irrigation (if the reduction factor refers back to lack of water) and agricultural inputs.

Before harvest

After harvest

Detection of noncompliance pixels → Why productivity is low in these pixel ? → How it can be improved?



Easy and quick observation of any sign that can provide on-time information on occurrence of yield gap before harvest can be an utmost important for production systems.

Assumption

The sensitivity of wheat in the anthesis stage to factors such as water stress has been investigated before (Huang et al., 2015 and Singh and Malik, 1983)

Idea

This research used the **anthesis stage** of the rain-fed wheat as a pre-harvest stages to detect an early and easy sign using remote sensing to predict relatively high-productive and low-productive pixels.

Assumption

It was investigated if ET in a wheat pixel in the anthesis stage is less than the ET with the highest frequency in a plain (with a uniform climate), then it is a sign of a relative yield gap. In another word, if ET in the anthesis stage is less than a **threshold value** then the yield gap can be expected.

Steps and Methods

Steps	Methods	Verification
The attepnt in this research was on proceedeing all the steps using remote sensing		
• Wheat area mapping	**Elimination process** of non-wheat pixels	Surveyed plots & Census data
• Estimation of ETa at the anthesis stage	**SEBAL** algorithm	**Eagleman-Affholder method** MOD16A2 products
• Determination of ET threshold value	Frequency analysis	Iranian National Water Document Wheat water requirement
• Recognition of high and low-productive pixels	Classification	
• Estimation of yield values	The **LUE** model	Provincial census data
• Determination of yield gap	Subtracting mean yield values in the two classes	if $\text{Yield}_{LP} < \text{Yield}_{HP}$?

Steps and Methods

Estimation

ET

SEBAL ▶ $\lambda LE = R_n - G - H$

latent heat flux

net radiation

soil heat flux

sensible heat flux

Verification

ET

Eagleman-Affholder method ▶

$$ET_a = f\ (ET_{FPM}\ , MR)$$

$$MR = R/AWC$$

Rainfall & Available water capacity

Yield

LUE ▶ $\mathrm{DM} = \mathrm{APAR}.\varepsilon$

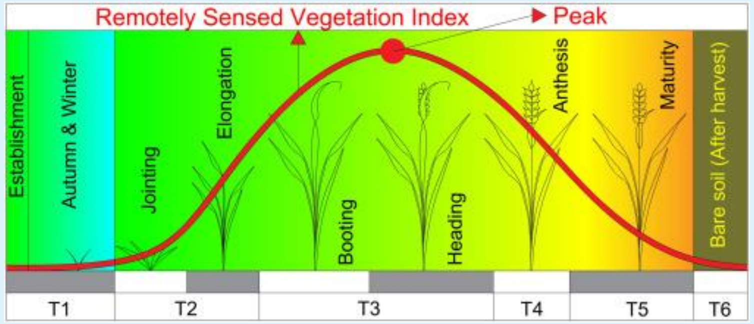
Absorbed Photosynthetically Active Radiation

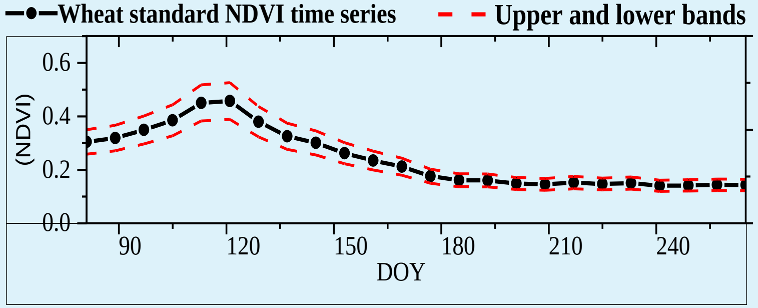
Light use efficiency

Wheat area mapping

MODIS :

- Produce wheat standard NDVI time series
- The NDVI values of each pixel is observed during growth season, and at any stage violation from the standard NDVI curve leads to eliminate that pixel from the rest of process. At the end only wheat pixels with 250 m spatial resolution remain.

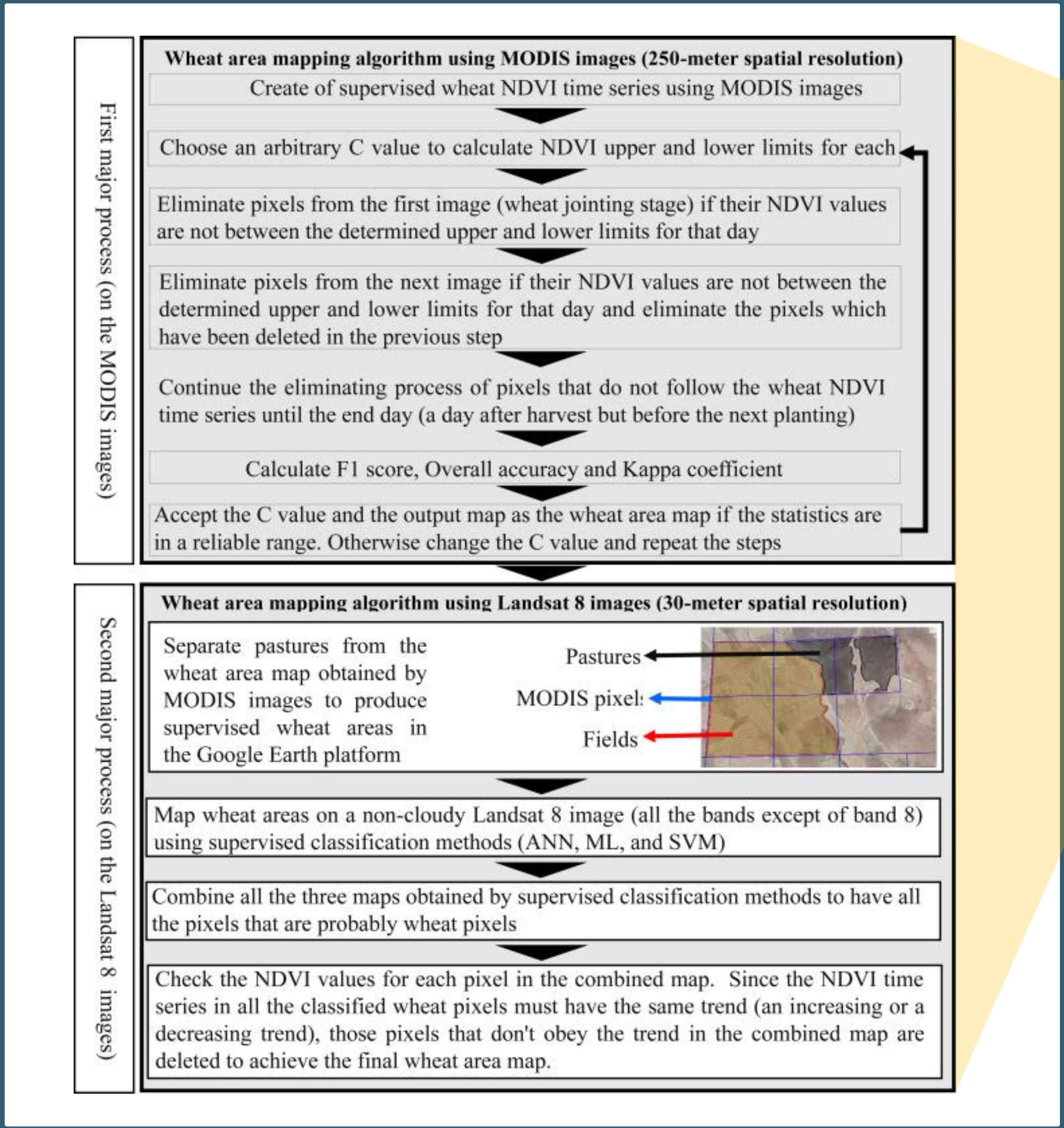




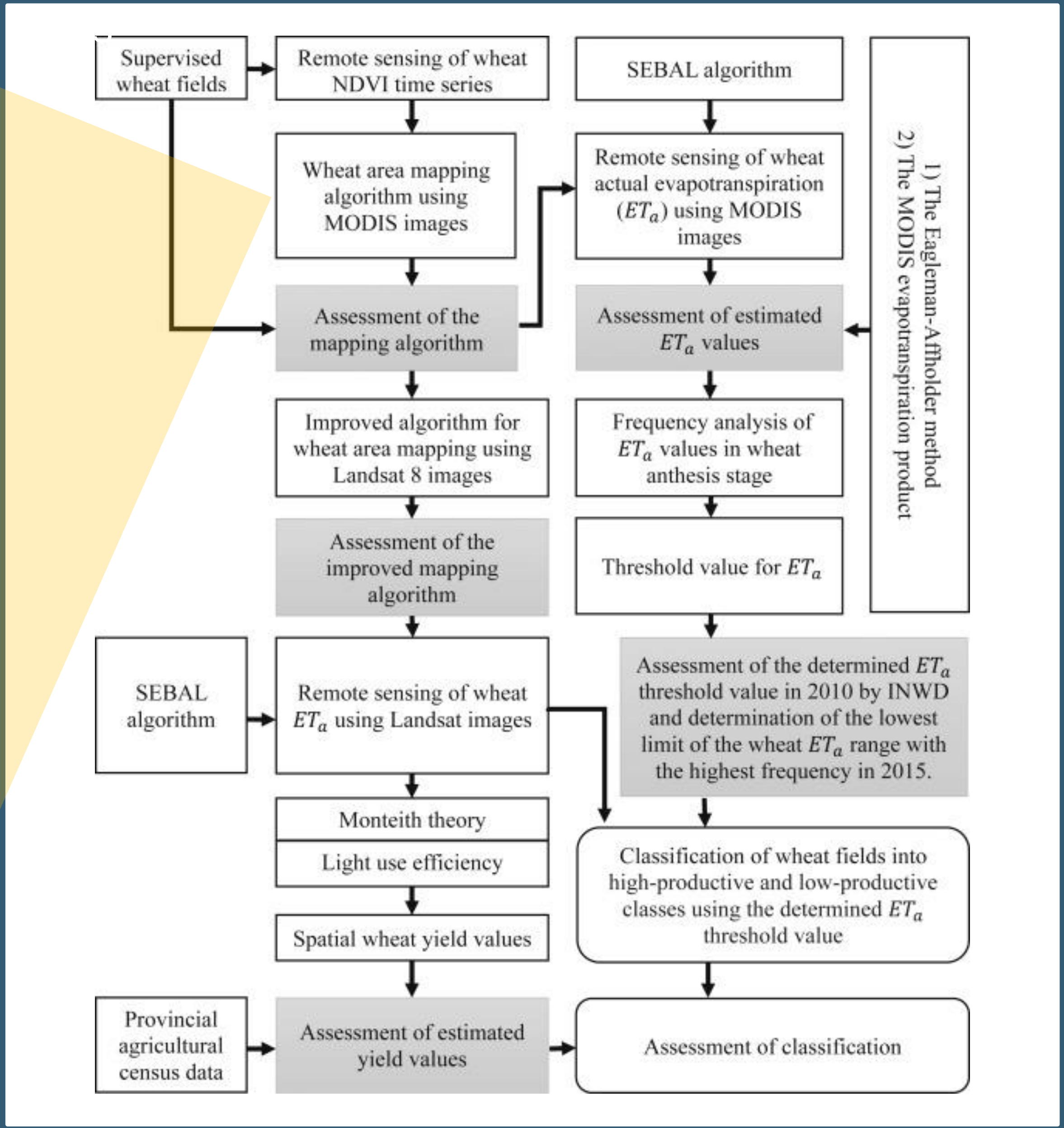
Landsat 8 :

- The 250 m rainfed wheat map is used to train supervised classification models (ML methods) on a Landsat 8 images. The output of the classification contains all possible 30 m pixels that can be considered as wheat pixel knowing that there are impurities. To remove these impurities, NDVI is calculated on 3 Landsat 8 images in descending arm of the wheat NDVI time series. For all the detected 30 m pixels the descending trend of NDVI is tested and violating pixels are removed to achieve the pure 30 m wheat map.

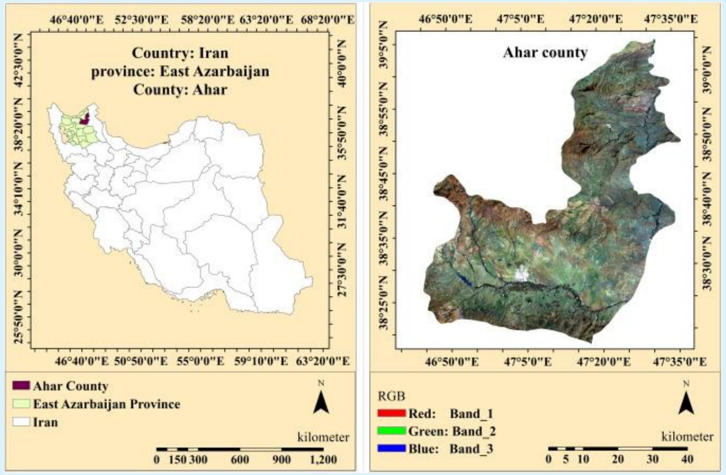
Wheat area mapping algorithm



Recognition of high and low-productive



Results



Iran, East Azarbaijan province, Ahar county

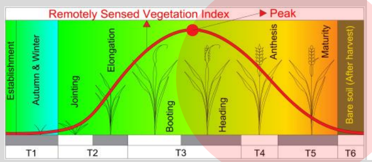
11 surveyed plots = 20 ha

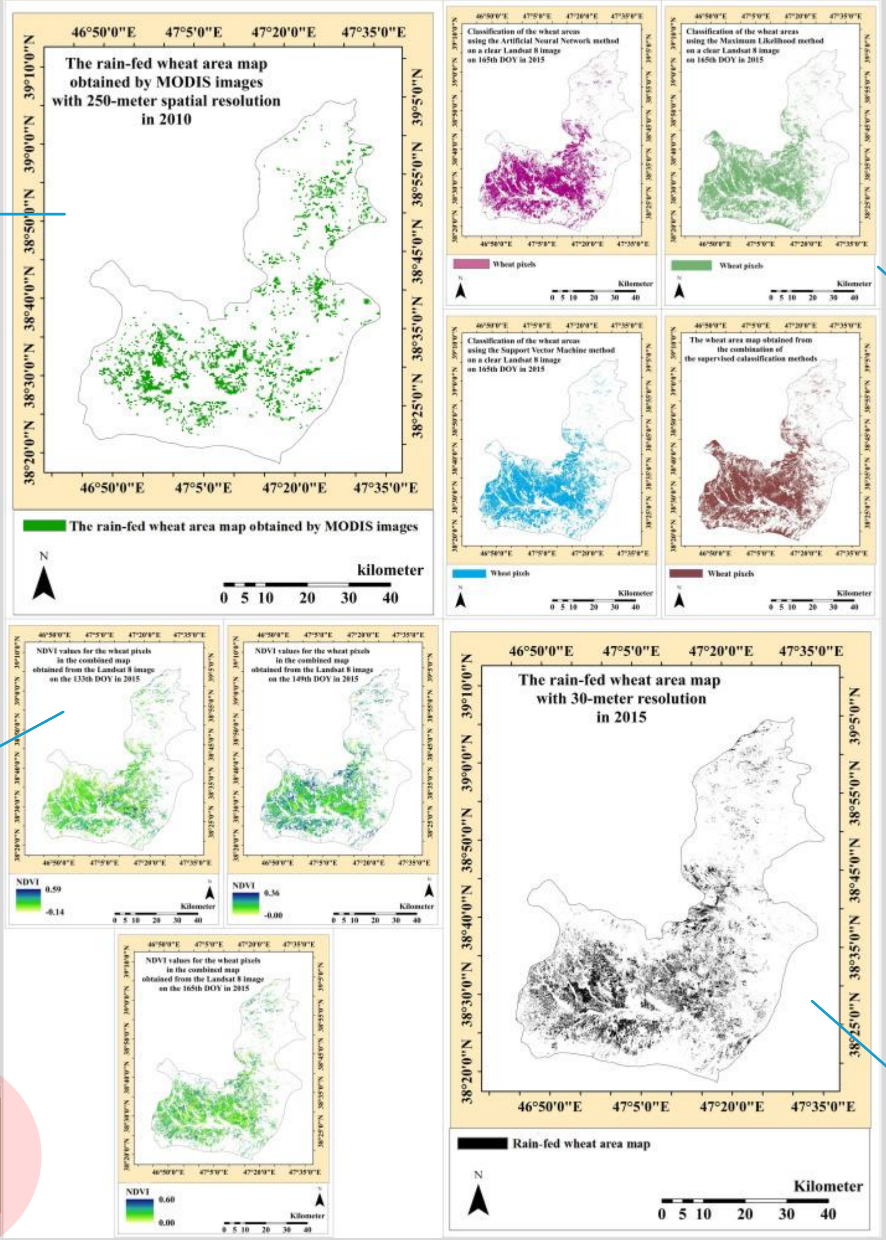
Total wheat area in 2015 were 37,745 ha in the 30-m resolution map showed 20% difference in comparison with censuses data

	Overall accuracy	Kappa coefficient	F1 score
30 m map	92	0.68	0.77

Wheat area map 250 m resulation

NDVI values in 3 landsat images corresponding to descending arm of the wheat NDVI time series



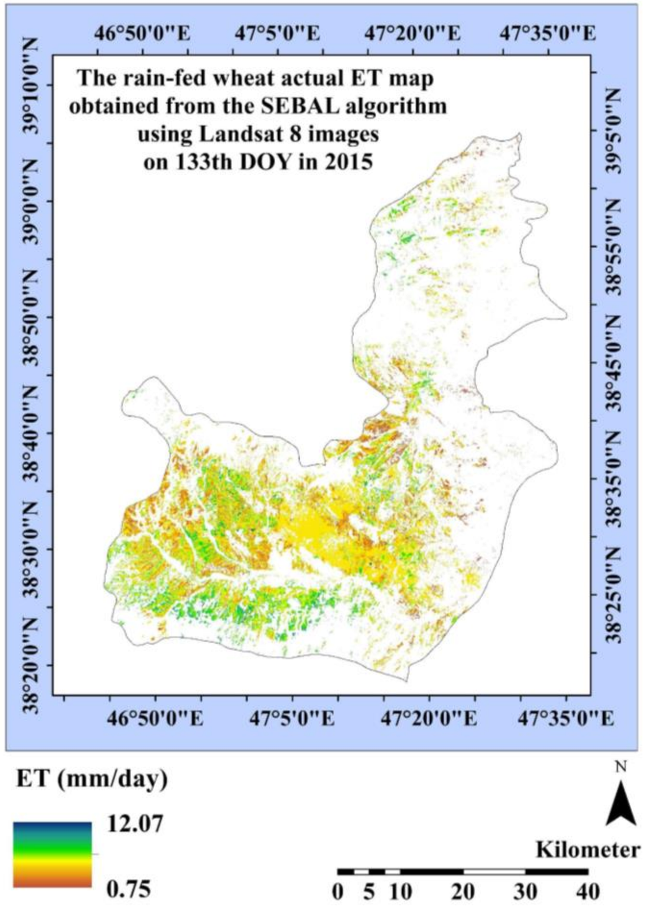


Impure wheat pixels

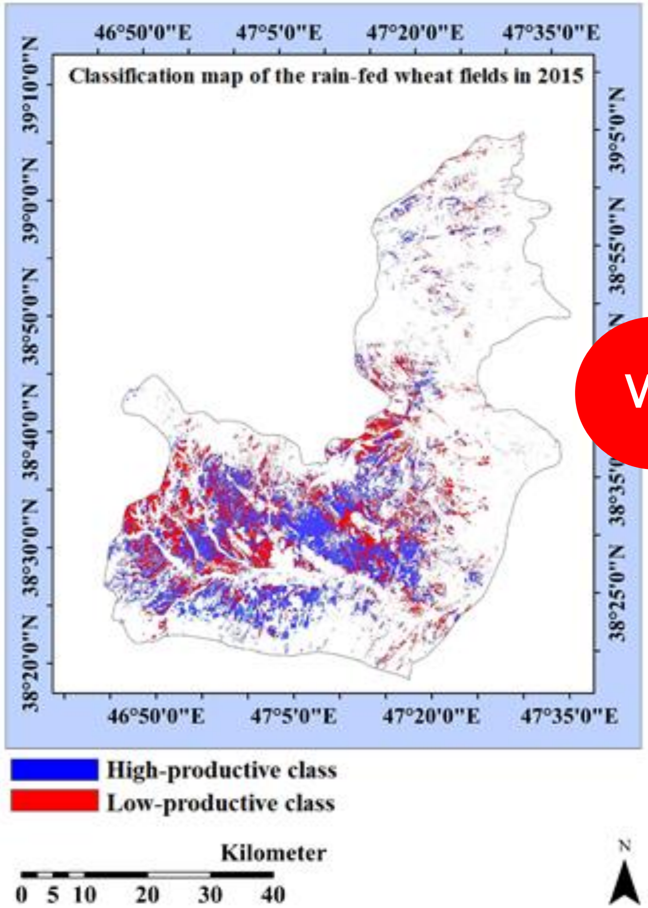
Wheat area map 30 m resulation

Results

ET (mm/day)	NDVI 0.3	0.4	0.5	0.6	Total frequency %
$0.7 \le ET < 2$	10.5	12.5	0	0	23
$2 \le ET < 3$	20.5	40.5	5.5	1.5	68
$3 \le ET \le 4.2$	1	7.5	0.5	0	9
Total frequency %	32	60.5	6	1.5	100



Mean of the yield value (kg/ha)	*During the growing season by LUE model*		*Provincial agricultural census data*	*Absolute error*
	704		783	79
	High-productive class	*Low-productive class*	*The difference in the average yield values between the two classes*	
	815	544	271	



Vs.