Mapping Cropped Area of Smallholder Farms in South Asia

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MAIN QUESTION

What is the most accurate method to map cropped area of smallholder farms using readily-available MODIS data?

Motivation

- Mapping cropped area of smallholders is difficult; farms are smaller than the resolution of readily-available imagery
- Scaling MODIS EVI based on Landsat accurately maps cropped area of farms (R^2 up to 0.97; Jain et al. *in press*)
- This method is difficult to use over large scales because Landsat data are often unavailable

Study Goal

- We assess 3 methods to quantify cropped area that use only MODIS EVI data:
  - Relative scaling
  - Peak
  - Temporal mixture analysis (TMA) (Small 2012)
- Landsat and Quickbird imagery are used for validation

Study Area

- Validation will be conducted in 5 regions in India (Fig. 1)
- Regions represent a range in precipitation, soil type, crop type, and market access
- Gujarat winter and summer season results for 2009-2010 are presented. Monsoon season results are not presented - we assume 100% of farms are cropped during this season.

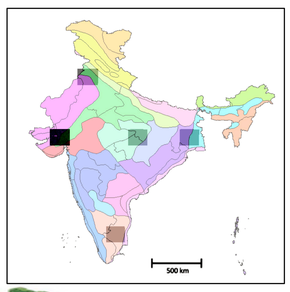


Figure 1. Current study region highlighted in black (Gujarat scene) and future study regions highlighted in gray. Colors represent different agro-ecological zones.

Methods

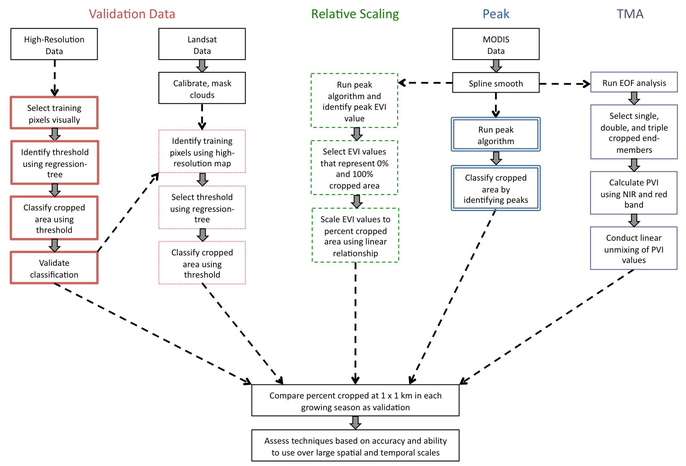
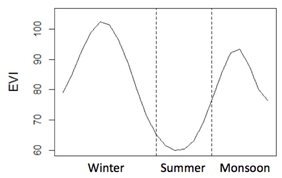


Figure 2. Work-flow diagram for each of the 3 methods used in our analyses.

- **Validation (Fig. 2)**: uses an NDVI threshold to classify cropped pixels
- **Peak (Fig. 2)**: identifies pixels with a peak in EVI during the growing season (Fig. 3) as 100% cropped
- **Relative scaling (Fig. 2)**: quantifies percent cropped area by scaling peak EVI values (Fig. 3) between 0 to 100%
- **TMA (Fig. 2)** uses empirical orthogonal fractions (EOFs) to select single and double crop phenologies that are used in a TMA

Figure 3. EVI phenology for an agricultural pixel in 2009-2010. Cropped areas are defined as those that have a peak in EVI phenology during the specified growing season. The maximum EVI value of the peak is used in the relative scaling analysis. Data were smoothed using a B-spline curve.



Results

- The relative scaling technique has the highest accuracy (Fig. 4)
- Accuracy is similar for both winter and summer seasons (Table 1)

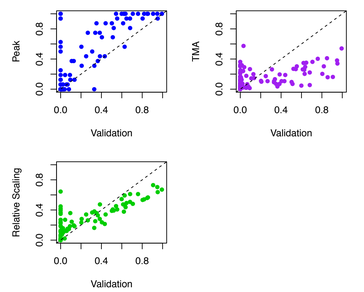


Figure 4. Predicted cropped areas at 1 x 1 km for each of the three methods during the winter season, plotted against validation data derived from higher resolution imagery. The one-to-one line is represented with a dashed line.

Season	Method	Peak	TMA	Relative Scaling
Winter	Adj R2	0.66	0.25	**0.68**
	RMSE	0.29	0.27	**0.18**
	Sp. Corr	0.72	0.50	**0.76**
Summer	Adj R2	0.00	-	**0.74**
	RMSE	0.32	-	**0.18**
	Sp. Corr	0.20	-	**0.75**

Table 1. Adjusted R^2, RMSE, and Spearman rank correlation coefficient for each of our three methods when validated with higher resolution imagery. The most accurate method is bolded.

Discussion and Conclusion

- It is possible to map cropped area of smallholder farms using the relative scaling technique of MODIS data at a scale of ≥ 1 x 1 km
- Future analyses will assess whether this method accurately maps cropped area in different agro-ecological zones (Fig. 1) and through time
- We will then assess the climate and irrigation drivers of cropped area from 2000 to 2013 across all of India

MAIN CONCLUSION

The relative scaling method most accurately maps smallholder cropped area

Acknowledgements and References

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- Small, C. (2012). Spatiotemporal dimensionality and time-space characterization of multitemporal imagery. *Remote Sensing of Environment,* 124, 793-809.