

1 **Observational Evidence that agricultural Intensification and land use change may**
2 **be reducing the Indian Summer Monsoon Rainfall**

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9 **Abstract :** Using gridded daily rainfall observations, and monthly satellite land surface
10 datasets, the connection between land use change and monsoonal rainfall climatology is
11 analyzed. A combination of statistical analysis involving genetic algorithm (GA),
12 Empirical Orthogonal Function (EOF), and causal discovery algorithms (CDA) are used.
13 Study objectives are to (i) identify regional trends in the observed precipitation data over
14 the Indian summer monsoon region, (ii) investigate the relation between land use change/
15 agriculture intensification and changes in rainfall, and (iii) explore whether land use
16 change and agricultural intensification has *caused* change in the rainfall climatology.
17 The satellite based vegetation dataset shows significant agricultural intensification over
18 northern India. For the period just before start of the summer monsoon season (April and
19 May), the normalized differential vegetation index (NDVI) shows an increase only over
20 Peninsular India. The EOF and GA based analysis identified the strongest climatic signal
21 for monsoon rainfall with an increasing trend over the east-central regions of India and a
22 decreasing trend in monsoon seasonal precipitation over north/north-west India. The
23 areas of decreasing rainfall coincided with regions of agricultural intensive land use, and
24 are analyzed further. The correlation and the causal data analysis suggest that
25 premonsoon (March-April) vegetation affects July month precipitation over peninsular
26 India. In particular, a negative relationship exists between them. The results are more
27 robust over Peninsular and northern India indicating that an increase in NDVI has
28 possibly weakened the early monsoon rainfall in this region. The results of this study
29 suggest that land use change associated with agricultural intensification could be
30 reducing the summer monsoon rainfall over certain regions of India.

31 **Keywords:** Land use land cover change, Indian monsoon, Agricultural Intensification,
32 irrigation, Causal Analysis, Genetic algorithms, soil moisture, NDVI.