

A National Level Collaborative Indian Mapping Event

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DETAILS OF TEAM

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TEAM NAME : TEAM SWATH (Stubble Wildfire Assessment and Evaluation Towards better Habitat)

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TITLE OF THE PROJECT : A Remote Sensing Based Approach for mapping of Stubble Burning in the districts of Punjab and Haryana and its impact on pollution in the Delhi-NCR region, India

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A Remote Sensing Based Approach for mapping of Stubble Burning in the districts of Punjab and Haryana and its impact on pollution in the Delhi-NCR region, India

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1. INTRODUCTION AND OBJECTIVE OF THE STUDY :

Punjab and Haryana (will be referred as PH in this text) are the two major agriculturally developed states of India. Agriculture is the principal activity of production, which serves as a support for both secondary and tertiary activities in the states. The major crops grown in this region are Rice and Wheat. In Punjab, the rice is sown in May- August and harvested during the period of September –November. Wheat is sown in October-November and harvested during April-May. Since there is very little time left during harvest of rice and sowing of wheat, the crop residues are often burned (often termed as stubble burning) to facilitate the sowing process. This in turn further degrades the ambient air quality and results in emitting heavy aerosol and gaseous pollution in NCR regions of Delhi. It has to be mentioned that it is very difficult to manually analyze the areas that are burned, the propagation of smoke, pollution level, and the relationship between them.

Thus, the main objective of the study is to map and estimate the stubble burned area of Punjab and Haryana districts applying by using remote sensing approach. In this study, we basically focus on post monsoon season (i.e., October –November), since the number of burning episodes are found highest during this period. Importantly, we have also tried to find the impact of stubble burning and its impact on pollution in the Delhi-NCR region.

2. DATA USED :

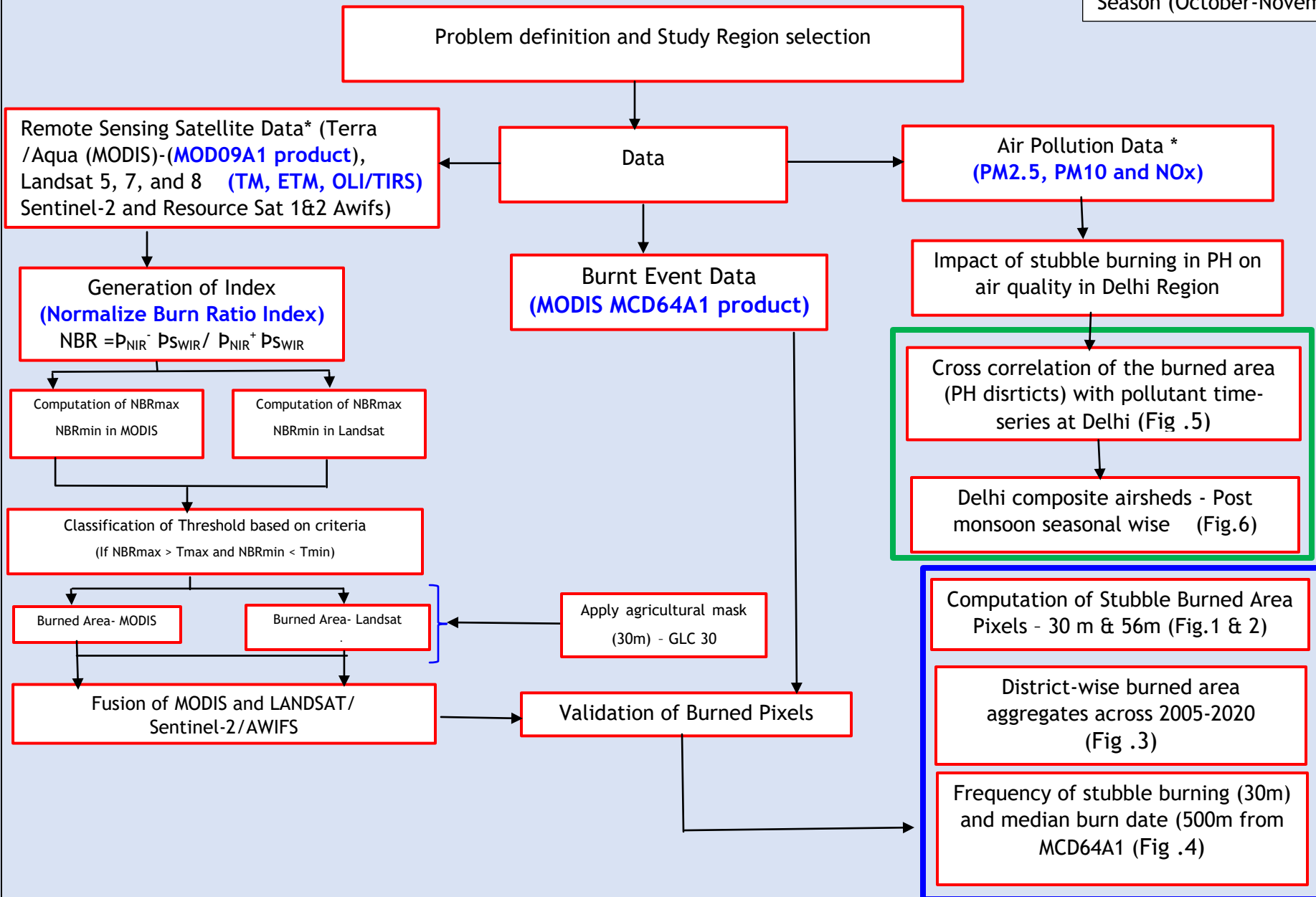
The following are the data used in the study. All MODIS-derived products obtained are from the Collection 6 suite. We have used Google Earth Engine (GEE), a cost-free, petabyte-scale cloud computing platform, to retrieve datasets and for geospatial analysis (Gorelick et al 2017).

Table 1. Satellite-derived products used in this study

Name of the satellite/product	Description and Project code	Resolution		Year of Available Data	Source
		Spatial	Temporal		
Landsat 5, 7 and 8 (Sensor : TM/ETM, OLI/TIRS)	Surface Reflectance (SR)	30	every 16 days	1984-2013,1999 onwards, 2013 onwards	Google Earth Engine
Terra/Aqua (Sensor : MODIS)	Active Fires (MCD14ML)	1 km	Daily	Terra: from 2000 Aqua: from 2002	
	Burned Area (MCD64A1)	500 M	Monthly		
Global Fire Emissions Database	GFEDv4s	0.25°	Monthly	from 1997	
			3-hourly	from 2003	
Suomi NPP (Sensor : VIIRS)	Active Fires (VNP14IMGML)	375 m	Daily	From 2012	
INSAT3D (Sensor : Imager)	Active Fires (L2P-FIR)	4 km	Every 30 min	From 2013	
Sentinel-5P (Aerosol Optical Depth (AOD :Offline UV Aerosol Index)		10 km	Daily	2018, 2019	
Resourcesat 1&2 (Sensor : AWifs)		56 m		24 October, 22 November 2017	https://bhuvan.nrsc.gov.in/
GlobeLand30		30 m		2010,2020	http://www.globallandcover.com/
ERA5 Reanalysis Data	For computing wind speed and direction	25 km	Monthly	2018-2019	Google Earth Engine
Air pollution data	PM10, PM2.5,NOX		Daily	October to December 2016-2019	CCR (cpcbcr.com)
Crop production statistics	Validation of Burned area estimates	istrictwise	Annual	2011-2019	https://aps.dac.gov.in/APY/Public_Report1.aspx
India states and Districts .shp					https://static.fossee.in/mapathon/Mapathon2020_Data/

3. METHODOLOGY :

* Acquired for Post Monsoon Season (October-November)



It is a known fact the agricultural lands in India are small and fragmented. Therefore, for accurate estimation of burned areas one needs satellite products of finer spatial resolution. However, the fine spatial resolution products from Landsat, Sentinel are available only twice in a month. On the other hand, coarser spatial resolution satellite imagery from MODIS are available at daily scale. Hence, in this method finer (Landsat, Sentinel) and coarser (MODIS) products are fused to compute the stubble burned areas. The methodology adopted in this study is based on Liu et al. (2019). The method includes the following processing steps, namely, image preprocessing, compositing cloud-free scenes, definition of threshold based on quantile intersection of Normalized Burned Ratio (NBR), derive burned areas from MODIS and Landsat separately, merge them and apply agricultural mask from GLC30. We have refined the method to process Sentinel images so as to extend the applicability of the algorithm.

We have acquired pollution level time series (<https://app.cpcbcr.com/ccr/#/caaqm-dashboard-all/caaqm-landing/caaqm-data-availability>) for Delhi (PM 2.5, PM 10 and NO_x) and correlated with the burned areas time series of each district in PH. Also, we have analyzed the implication of wind on dispersion of the pollutants from the source of stubble burned regions to Delhi region.

4. **CONCLUSION AND INFERENCES FROM THIS STUDY :**

- (i) Fig.1 shows the stubble burned areas from 2003 to 2020. It can be seen that the accumulated burned areas for the 2016 - 2020 are greater than for the period 2003-2005.
- (ii) Table 2 shows the comparison of computed burned areas for Punjab and Haryana from the methodology mentioned above with that from the MODIS64A1 product.

Table 2 . Comparison of burned areas for Punjab and Haryana from the methodology mentioned above with that from MODIS64A1

Name of the District	MCD64A1 (Sq.km)	Derived Product (Sq.km)
Punjab	12920.7	17043.9
Haryana	2265.3	5511.7

Table 3 shows the comparison of computed burned areas for the Patiala and Ludhiana districts in Punjab with that from the AWiFS product.

Table 3 . Comparison of burned areas for Punjab and Haryana from the methodology mentioned above with that from AWiFS

Name of the District	MCD64A1 (Sq.km)	Derived Product (Sq.km)	Awifs (Sq.km)
Patiala	1346.508	1497.088	845.6444
Ludhiana	698.2029	1491.183	1369.388

(ii) The methodology adopted for computation of stubble burned areas can be applied to any Indian Satellite products. We tried to experiment it using Resourcesat 1&2, Awifs data for November 2017 (Fig. 2)

(iii) From the district-wise annual burned areas (2005, 2010, 2015 and 2020) map, it can be seen that the districts of Punjab namely, Sangrur, Firozpur, Ludhiana and Moga report more stubble burning in PH region. The stubble burning areas are on a decreasing trend from 2010 (Fig. 3).

(iv) Fig. 4 shows the frequency/number of times the area has been burned and median burned date for each pixel area for the period (2003-2020). It can be seen that the districts of Punjab namely, Moga, Ludhiana, Sangrur and Patiala show burning almost every year. The likely burn date lies in the first week of November.

(v) Cross-correlation analysis was performed for the burned area time series for each district against the pollutant time series in Delhi to get a rough idea of the likely contributing districts (Fig. 5). In that regard, pollutants Pm 2.5, pm 10 and Nox profiles for the years 2018 and 2019 were considered for the Post Kharif season months of October and November. For the year 2018, the pollution levels in Delhi was greater than that of 2019 and PM 2.5 reported greater correlation with burned areas than PM 10 and Nox. The PM 2.5 2018

map shows that districts that reported higher amounts of burned area (Fig. 3), report high correlation with a lag of around 5 – 10 days. While the pollutants PM 10 report moderate correlation with the burned areas and the pollutant NO_x even lesser.

(vi) For the year 2019, though the correlation between the pollutant PM 2.5 and 10 is lesser in comparison to that of the year 2018, the lag in maximum correlation is reduced and is around 0 – 1 days (Fig. 5). A common observation is that the districts that are located farther away from Delhi exhibit a more delayed maximum correlation with the pollutant levels at Delhi, as one would expect. Wind speed and direction is an obvious causative factor that effects the degree to which the stubble burning in PH districts and the pollutions levels in Delhi are related. Due to the prominent direction towards Delhi and greater wind speed in 2019, the lag in maximum correlation is lesser than the year 2018 (Fig. 6).

Figure	Title	Description
Fig. 1	Stubble Burned Area Map at 30 m	Computed from the suggested method and shows the pixel wise burn details across 2003-2020
Fig. 2	Stubble Burned Area map prepared from AWiFS	The suggested method is applied to available AWiFS images of 2017 and the stubble burn is mapped
Fig. 3	District-wise burned area aggregates across 2005-2020	Aggregated maps showing burn statistics across 2003-2020
Fig. 4	Burn Frequency and Median Burn Date Maps	The burn frequency of each pixel across 2003-2020 is calculated at 30 m. The median map shows the median burn week across 2003-2020
Fig. 5	Cross-correlation maps between burned area and pollutants across districts (2018-2019)	Cross-correlation is attempted between pollutants and burned area at district level for 2018-2019 to find the highly correlated districts and the time lag (in days) the correlation is highest
Fig. 6	Post-Monsoon burn area and aerosol index map (2018-2019)	This map is a representative map which shows the burn area extent for 2018-2019, averaged wind direction and speeds across the Delhi-NCR airshed. The aerosol index and the monthly pollutant load at Delhi air-monitoring station shows the impact of burning during Post-monsoon period.

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