GAU Research Journal **45** (4) : 179-188 (October 2020)

Status and policy analysis of stubble burning in North-Western India

ANSHU SIWACH[1*], DIVYA[2], AND NITIN KUMAR[3]

Department of Geography, Pt. N. R. S. Government College, Maharishi Dayanand University Rohtak, Haryana -124001 [INDIA]

Received: 08 June, 2020

Accepted: 01 September, 2020

ABSTRACT

The study highlights the status of crop residue burning in north-western India along with the assessment of government policies in combating it, the role of private sector and numerous startups in utilizing the straw as a resource. The study used Landsat-8 images of three months from October to December 2018 and 2019 to show the burn severity maps of Haryana and Punjab region. Here, Normalized Burn Ratio (NBR) index was applied to determine the burned area in an image and obtain the burn severity map. Delta NBR (dNBR) was used to validate the result. Our result shows that burn severity in Punjab is higher than that of 2018 while in Haryana it shows less burn severity in 2019 as compare to 2018.

Keywords: Stubble Burning, Burn Severity, NBR Index, Paddy Straw, Environment policies

Stubble burning is one of the many challenges the agricultural sector is facing. Stubble burning is the practice of turning up the crop residue into ashes in order to clear up the fields for next sowing. Ever since the advent of green revolution and the resultant mechanization, combine harvesters were used to harvest the crop and trash, thus separating the grain, but these do not cut close enough to the ground and hence leaves residue behind (Saini *et al.*, 2019). It is also estimated, that burning of paddy straw results in loss of nutrients, some soil properties like soil temperature, pH, moisture, available soil organic matter which governs microbial population of soil (Mandal *et al.*, 2004).Greenhouse gases like CH_4, N_2O, CO_2 along with particulate matter and smoke are also released in the atmosphere contributing to global warming (Jain *et al.*, 2014, Badarinath *et al.*, 2006). Residue burning emits pollutants like RSPM, NO_x and SO_2, impacting air quality and decreasing the visibility. According to Ministry of New and Renewable Energy, on an average India generates 500 million tonnes of crop residue (Bhuvaneshwari *et al.*, 2019). Haryana and Punjab generates 27.83 million tonnes and 50.75 million tonnes of residue respectively of which 9.08 million tonnes and 19.65 million tonnes of residue was burnt in these respective states (NPMCR, 2014). A total of 79.31 lakh million tonnes quantity of paddy straw was generated during year 2018-2019 in Haryana out of which 1.34 million tonnes was burnt. Whereas in Punjab 201.70 lakh million tonnes paddy residue was generated out of which 99.6 lakh million tonnes was burnt (MoA&FW 2019).The present study was undertaken to identify the areas of intensity and spread of stubble burning in north-west India and to find out the measures initiated by government agencies and private entrepreneurs to control these stubble burning. Also, the study involved evaluation of initiatives taken for alternative approaches to curb stubble burning by the private sectors.

[1]Department of Geography, Pt. N. R. S. Government College, Maharishi Dayanand University, Rohtak, Haryana -124001 [INDIA]
*Email: anshusiwach96@gmail.com

MATERIALS AND METHODS

For the present study, secondary sources of data have been used, based on information available from published reports of various ministries (particularly Ministry of Agriculture and Farmer Welfare), newspapers and various research publications. The Landsat 8 images were used to show the burn severity map of the region of Haryana and Punjab. Images were retrieved during the period of 1st October 2018 to 25th December 2018 and 1st October 2019 to 25th December 2019 for the study area.

Study Area

The study mainly focused on the two north western states of India namely Punjab (29°54'N-32°57'N and 73°88'E-76°93'E) and Haryana (7428E-7735E and 2739N-3056N). Punjab covers 1.53% of total geographical area of India with 22 districts. Haryana

has an area of 44,212 km sq with 22 districts. These are the states where paddy (Kharif crop) is sown in end of May and starting of June and its harvesting start from the first week of October till mid of November every year.

Image Processing

Landsat 8 OLI_TIRS images were procured from the USGS Glovis website. These Geo tiff Images were stacked and clipped according to the study region for paddy crop. QGIS 3.12 Bucuresti was used as a tool to process the images. In Landsat 8, band 5(NIR) has a wavelength of 0.85-0.88µm and a resolution of 30m and in band 7 (SWIR) short wave infrared has a wavelength of 2.11- 2.29µm and a resolution of 30m. Normalized Burn Ratio was computed for each scene in Landsat 8 as (Saulino *et al.*, 2020):

$$NBR = \frac{[Band5(NIR) - Band7(SWIR)]}{[Band5(NIR) + Band7(SWIR)]}$$

Identification of Burn Area

For identification of stubble burn area, Normalised Burn Ratio (NBR) has been used. The Normalised Burn Ratio is used to process the burned areas in the region. Once the pre-fire and post-fire NBR images are created, the post-fire images are subtracted from the pre-fire to create a differenced (delta) NBR (dNBR) images. dNBR is then used for burn severity assessment after it is being classified according to the burn severity ranges [United States geological survey (USGS)]. This index can show map burned area of different landscapes.

To obtain dNBR:

$$dNBR = prefireNBR - postfireNBR$$

Then the raster histogram was used for Punjab and Haryana, separately for year 2018 and 2019, to identify the pixel values and their frequencies, where the lower pixel values shows low burn severity and as the pixel values increases it shows higher burn severity according to their frequency.

RESULTS AND DISCUSSION

Punjab Region 2018 and 2019:

For analysis of Punjab Region, it was divided into two regions i.e. Northern and southern regions. The northern region (74°50′E-76°63′E and 31°09′N-32°57′N) of Punjab witnessed a surge in the burning events particularly in Tarn Taran and Kapurthala districts (CREAMS, 2019). Analysis of raster histogram of northern region of Punjab showed that the graph of frequency from pixel values 0.5 to 0.8 was high in 2019 while in 2018 this was much lower, frequency at value 0.5 was 400 in 2019 while in 2018 it was just 50.

In southern region of Punjab (73°88′E-76°93′E and 29°54′N-31°09′N) burning events decreased marginally except in Fazilka where the burning events surged. However, Faridkot registered a gradual decrease in the number of cases from 2018 (Figure 1). In the raster histogram of southern region of Punjab, the line of frequency in 2019 at pixel value of 0.5 was 1000 but in 2018 it was 150 only. The burn severity in the both regions showed a surge. Analysis of raster histograms of the state of Punjab (2018 and 2019) revealed that the graph of frequency from pixel values 0.5 to 1 is higher in 2019. Values in this range showed higher burn severity in NBR index. Comparing the pixel value 0.5 for year 2018 and 2019 it shows that the frequency is very high (approximately 1300) for 2019 and only 130 for the year 2018(Figure 3A-B). And instead of decrease in the cases in the state, some districts had shown a steep increase in the number of burning events in the year 2019. The last week of October and first week of November in 2019 showed higher number of burning incidents. A steep increase in the number of cases in comparison to 2018 was observed (CREAMS, 2019). The raster histogram and the burn severity map of Punjab showed an increase in burning incidents which was then finally concluded through higher values in NBR index (Figure 2A-B, 3A-B respectively). In 2019 it was seen that south-west region and districts of Amritsar and Tarn Taran of Punjab showed higher burn severity compared to rest of the state (Figure 4A-B).

Haryana Region 2018 and 2019

Haryana was divided into three regions to study the burn severity: (i) northern Haryana (7534E-7735E and 2919N-3056N) (ii) west Haryana (7428E-766E and 2828N-2959N) (iii) central, eastern and southern part of Haryana (7534E-7732E and 2739N-2919′N). Raster histograms of these regions were studied separately for both years 2018 and 2019.

From the districts like Panchkula, Ambala, Kurukshetra, Kaithal, and Karnal in the north, only Kaithal showed a decrease in burning events in 2019 in this region (CREAMS, 2019). Raster histogram of the north Haryana showed that the pixel values from 0.5 to 1 indicated surge in frequency especially at the value of 0.5044 and 0.516, frequency near the 32 in 2019 while in 2018 frequency at these values reached up to 16. This depicted that the northern region of Haryana showed high burn severity in 2019 than 2018, whereas in the western region of Haryana burning events especially in Sirsa and Fatehabad decreased drastically in 2019. Continuous dip in the frequency of pixel values from 0 to 0.5 could be seen

in 2019. Values from 0.5 to 1 had some spikes but in 2019 the frequency was near to 0 and there were no points of high burn severity in this region. In the central, eastern and southern region events of burning had decreased in 2019. However, Palwal was an exception, where events surged from 2018 but in 2019(Figure 5) this region showed that burn severity decreased as graph of frequency of pixel values from 0.5 to 1 showed a dip in 2019. Frequency of these values ranges somewhere in between 0 to 200 in 2018, but in 2019 this was from 0 to 50 only, which showed that there were fewer areas of severe burns in this region of Haryana.

In histogram of years 2018 and 2019, the lines of frequency of pixel value 0.0729 (lies in between moderate severity and moderate-high severity), touched a mark of 1600 in 2018 but in 2019 the value was down to somewhere 1000. Frequency of value -0.12708 (lies in between moderate low severity and moderate severity) touched a mark of 2100 and values from 0.5 to 1, indicating a downfall in the frequency 2019. The frequency ranges from 0 to 220 (0 near 1 and 220 at 0.5) in 2018 while in 2019 it was from 0 to 70 (0 near 1 and 70 near 0.5)(Figure 7A-B). Both histograms depict that there is less burn severity in Haryana in the year of 2019 however northern region of Haryana showed marginal increase in the burn severity and showed a very high burn severity in 2019. It was observed that first week of November in 2019 showed marginal increase in the number of burning events (CREAMS, 2019). The burn severity map of Haryana showed us number of points of very high burn severity cases in northern region of Haryana in 2019(Figure 6A-B) and at the same time in 2018 there was no point of very high burn severity in the northern Haryana(Figure 8A-B).

Analysis of government policies

The wasteful practice of stubble burning requires counter-action from the government through awareness campaigns, community mobilization, media and various effective policies. Numerous awareness programs are conducted from time to time in order to educate the farmers about possible best practices to deal with crop residue (Rajya sabha unstarred question, 2020).Some laws and policies framed to tackle crop residue burning are: -i) Sec 144 of civil procedure code, ii) environment protection act 1896, iii) the air prevention and control of pollution act 1981, iv) then national tribunal act 1995 and v) the national environment appellate authority act 1997.

National Initiatives

National policy for management of crop management formulated by the Department of Agriculture has laid various objectives to manage and diversify the usage of crop residue (NPMCR 2014). EPCA (Environmental Pollution Control Authority) collaborated with Punjab Pollution Control Board to increase aerial surveillance in detection of crop residue burning in Punjab region (Bhuvaneshwari *et al.*, 2019). National Green Tribunal ordered a ban on stubble burning in 2015. To prevent burning of paddy, a fine was imposed on farmers (Jain, 2015).Central sector scheme "Promotion of agriculture mechanization for *in-situ* management of crop residue in state of Punjab, Haryana, Uttar Pradesh and NCT of Delhi" was implemented to tackle air pollution and to subsidize machinery required for *in-situ* management of crop residue.

Initiatives by Haryana government

Chaudhary Charan Singh Haryana Agriculture University, Hisar and the Finnish firm Fortum signed MoU to use paddy straw in making textile fibers and other chemicals which will be utilized further for bio plastic industry and bio refineries (Anonymous, 2019).Haryana government directed gram sabhas and panchayats to understand stubble burning as a behavioral problem (Kapil, 2019).Haryana bioenergy policy (2018) promotes the generation of bioenergy from agricultural residue. It also promotes production of bio energy/electricity/Bio-CNG/ bio manure/ bio fuel from surplus biomass (HAREDA.gov.in). A target of 150 MW biomass-based power generations is proposed to be achieving by 2022. Few paddy straw-based power plants are mentioned in Table 1. Crop residue burning is a criminal offence under the sec 188 of Air pollution act 1981, the code of criminal procedure 1973 and other acts. In addition, a penalty is being imposed on those who practice it.

Initiatives by Punjab Government

Since 2008 awareness programmes regarding stubble burning have been initiated (LokSabha, 2008). About 29 power projects with an installed capacity of 330 MW have been facilitated by Punjab Pollution Development Authority (PEDA). This project will be set up by private developers who will design power plants to process paddy straw or other agricultural residue into energy. Also, Punjab University is developing agricultural technologies like happy seeder machines, straw collectors and balers (Kumar *et al.*, 2015). Punjab government has incentivised small and marginal farmers with Rs 2500 per acre for not burning paddy straw (Krar, 2019).Five bio refineries each of capacity of 75,000 kiloliters per year is proposed to be set up. These will produce cellulosic ethanol using paddy straw as feed stock (India-Sweden TERI report, 2018).

Role of Private Sector

Along with government initiatives, there has also been the presence of private sector in combating burning of crop residue. Private players are coming forward in collaboration with the government entities; various startups to bring about a technological revolution in farm mechanisation and handling the farm waste. Some of the private players are: Praj industries are the main technology provider for second generation ethanol to Indian companies including IOCL, BPCL, HPCL and MRPL who are setting up units in Punjab and Haryana (Krar, 2019). Detailed design and engineering work have been completed for four commercial scale smart bio-refineries based on in-house second-generation technology to convert biomass to ethanol. A subsidy of Rs 7 crore to catalyze investment for paddy straw-based project was announced along with an offer of Rs 46 per kilograms of CNG to be produced from paddy stubble. Mahindra and Mahindra subsidiary swaraj tractors and Germany based verbio space vereingite bioenergie AG are in process of collaborating to set up bio CNG plants in Punjab. Tableware and packaging material produced from plant remnants as raw material and it is paid by bio-lutions, a German based company. This factory came up in Bengaluru in 2018(Anonymous, 2019). A technology business incubator in the name of kriya labs is developed at IIT Delhi that can covert paddy straw into pulp using sustainable technology. The pulp is used to make various products like paper, plates and cups which are cheaper than similar plastic products and are biodegradable (Pal, 2018). Ajay bio-energy Pvt ltd has set up a unit under SATAT scheme and will come up by 2022. It will have capacity of using 40000 tonnes of paddy straw annually and will produce bio-manure as a byproduct (Anonymous, 2019). A Chennai based firm, Neway Engineers Private Limited, had signed a MoU of setting up 400 processing plants with Punjab government to utilize 20 million tonnes of stubble (Sharma and Kumar, 2019).

CONCLUSION

This study analysed the steps taken by government and private sector to find sustainable alternatives for converting crop residue into a resource. The above study revealed that the burn severity has increased in Punjab in 2019 and cases in some districts also increased from 2018. Haryana witnessed an overall decline in burn frequency however few regions especially in the northern Haryana recorded a spike. The crop residue burning in north-western India recorded a decrease in the number of cases marginally but few districts in both states showed increase in burn events.

Government has taken numerous sustainable solutions from farmer incentivisation to converting stubble into energy. However, from above image analysis and data interpretation, it is clear that though stubble burning cases have reduced but their frequency at certain days of the month registered a sudden increase. This may be due to farmer's reluctance in adapting to newer methods of harvesting or loopholes arising out in government policies and schemes. Laws to combat stubble burning exist but their implementation is poor. Collaboration with private sector has increased but they are not yet functional. Delay in the projects leaves the farmer with no other option than burning. Start-ups have shown interest to collaborate and help in managing crop residue. However, lack of funding and approval delays is making them non-functional causing the projects to remain stagnant. The power plants producing renewable energy use numerous varieties of waste but use of crop residue in energy generation is still meagre. From the analysis of Rajya sabha unstarred question no. 1765, dated 06 March 2020,it is observed that the awareness programs, Kisan Melas, articles in newspapers, posters/ banners at various places have registered a downfall. This is indicative of the harsh fact that government although is making efforts by numerous projects but doing little to install a behavioural change in the farmers. Lack of farmer awareness about alternatives to stubble burning may not prompt them to use innovation or sustainable technology available at hands. Stubble burning is a criminal offence and numerous FIRs have been filed along with penalty on the farmers but a poor farmer because of the paucity of resource is left with no other alternative but burning. There is thus a need for technological rejuvenation to make technologies adaptive for the usage of farm residue. This problem is in the need of real, cost effective, efficient and sustainable alternatives that will help conserve soil, water, environmental health along with public health. Managing crop residue by use of the happy seeder technology, promoting *in-situ* residue management, promote crops other than wheat and rice (e.g. Pulses), on field collection of crop residue and its further use in producing bio power, bio CNG, bio gas or pelletising plants etc. Private sector, cooperative societies, custom hiring centres (CHCs) and start-ups should be encouraged to find innovative solutions of such farm problems. For example, the CHCs of government of Haryana is supporting the farmers with technological infrastructure in crop residue management. Remote sensing and GIS can be used in monitoring the fire

CONFLICT OF INTEREST : NIL Table 1 Renewable Energy Power Projects under Execution

S. No.	Name of firm	Capacity
1	M/s The Hind Samachar Ltd. in Kurukshetra District	15 MW
2	M/s Jind Bio Energy LLP in Jind District	9.9 MW
3	M/s Sukhbir Agro Energy Ltd. in Kaithal District	15 MW
4	M/s Fatehabad Bio-Energy LLP in Fatehabad District	9.9 MW
	Total	49.8 MW

(Source: Status of Biomass Projects in Haryana Dated 31.07.2019)

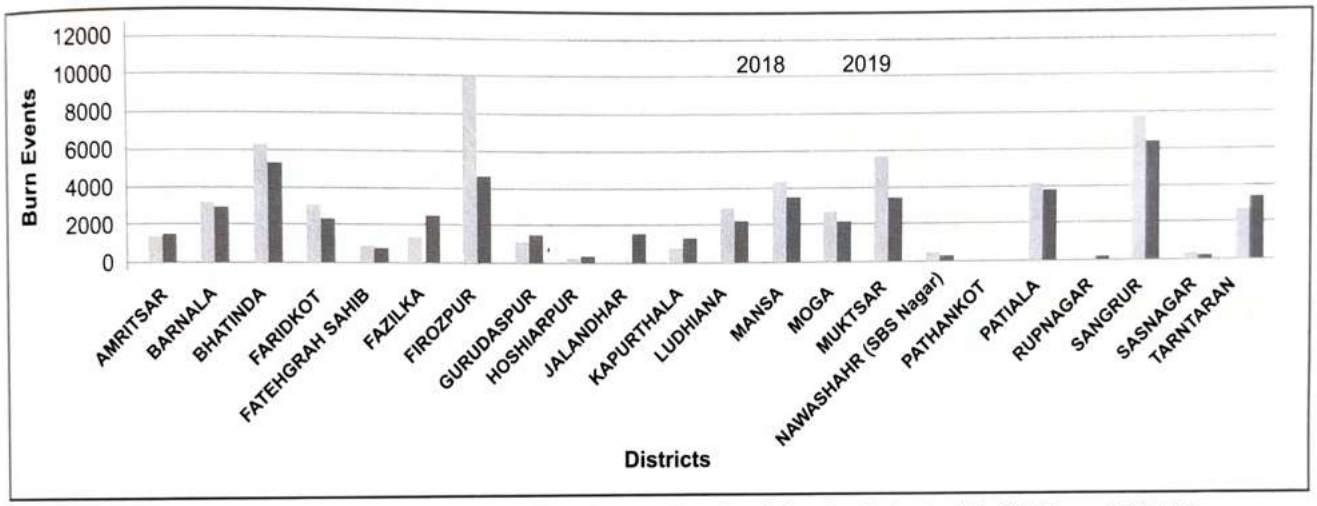

Figure 1 District-Wise Cumulative Number of Residues Burning Events Detected in 2018 and 2019 in Punjab (Period: 01-Oct to 23-Nov).

Source: CREAMS Laboratory - Indian Agricultural Research Institute, New Delhi (2019)

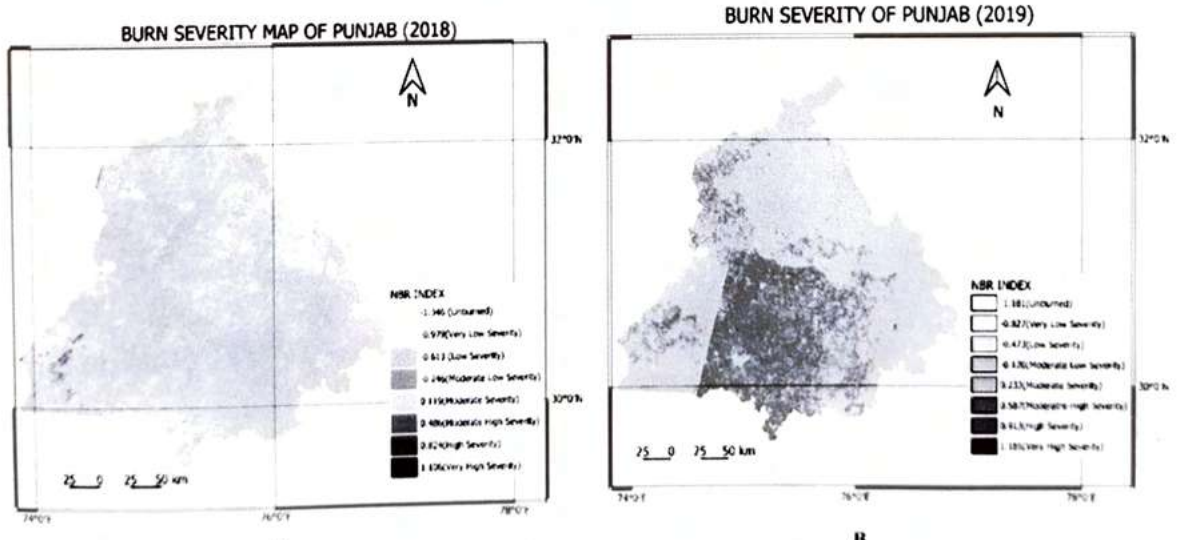

Figure 2 A-B.Landsat 8 images of burn severity of Punjab region during the study period 2018 (A) and 2019(B)

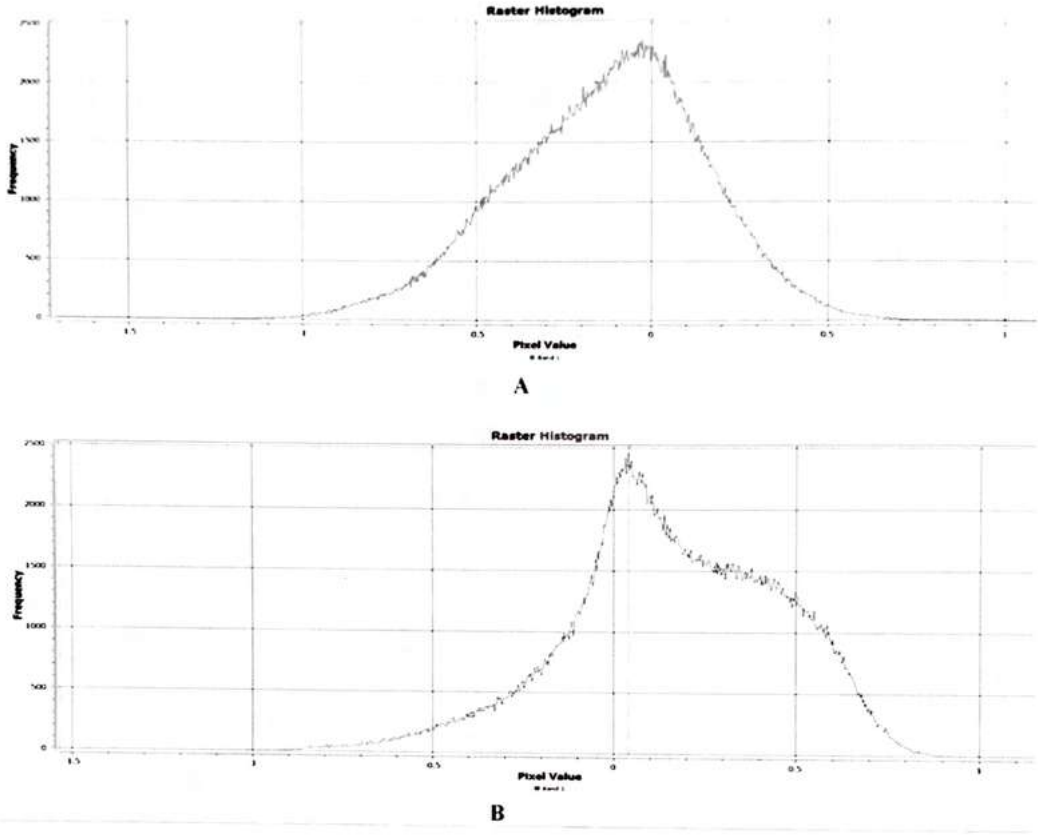

Figure 3 A-B.Raster histogram of Punjab 2018(A) and 2019(B)

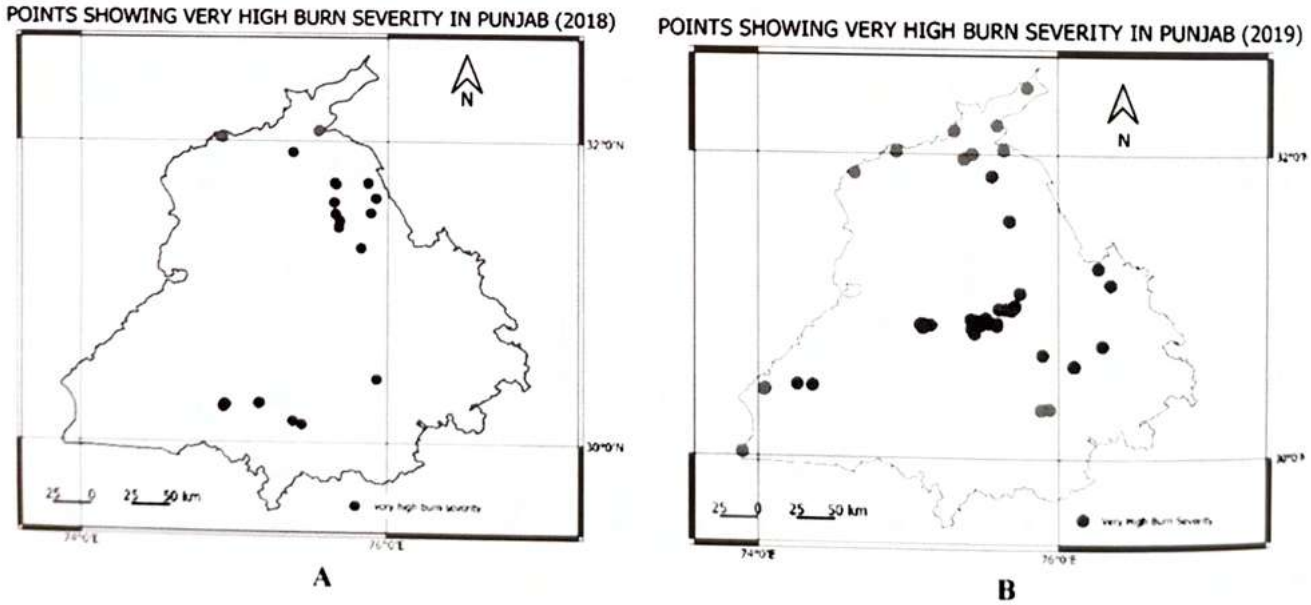

Figure 4 A-B.Points showing very high burn severity in Punjab 2018(A)and 2019(B)

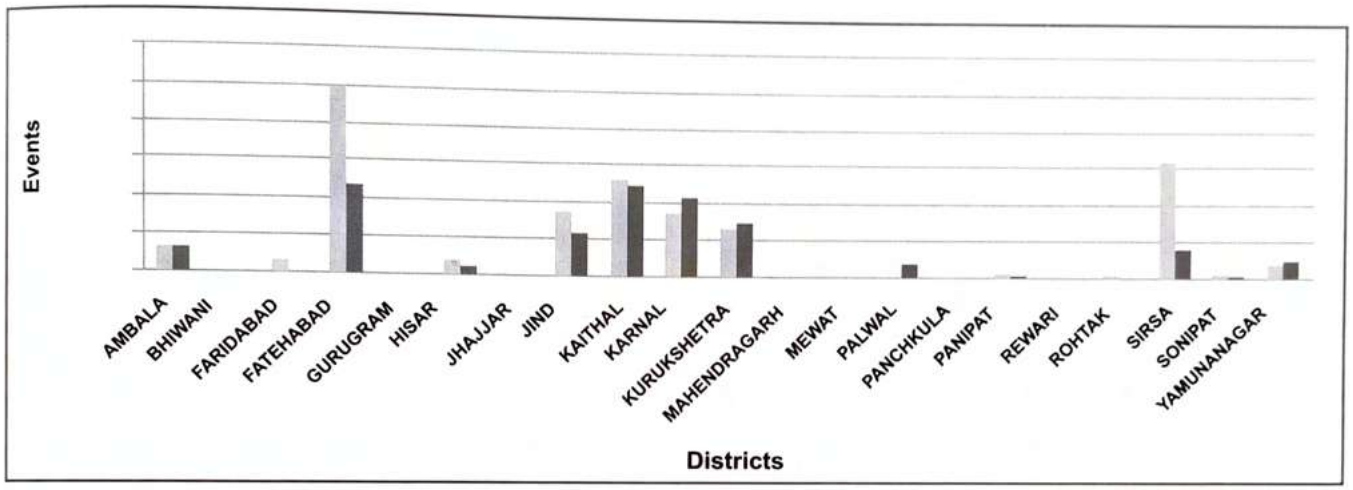

Figure 5. District-Wise Cumulative Number of Residues Burning Events Detected in 2018 and 2019 in Haryana (Period: 01-Oct to 23-Nov)

Source: CREAMS Laboratory - Indian Agricultural Research Institute, New Delhi (2019)

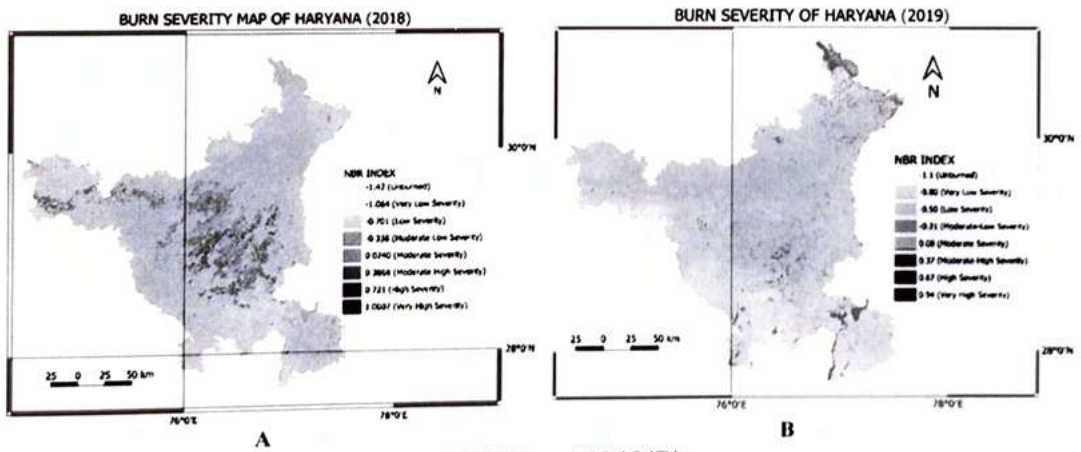

Figure 6 A-B.Burn severity map of Haryana 2018(A) and 2019(B)

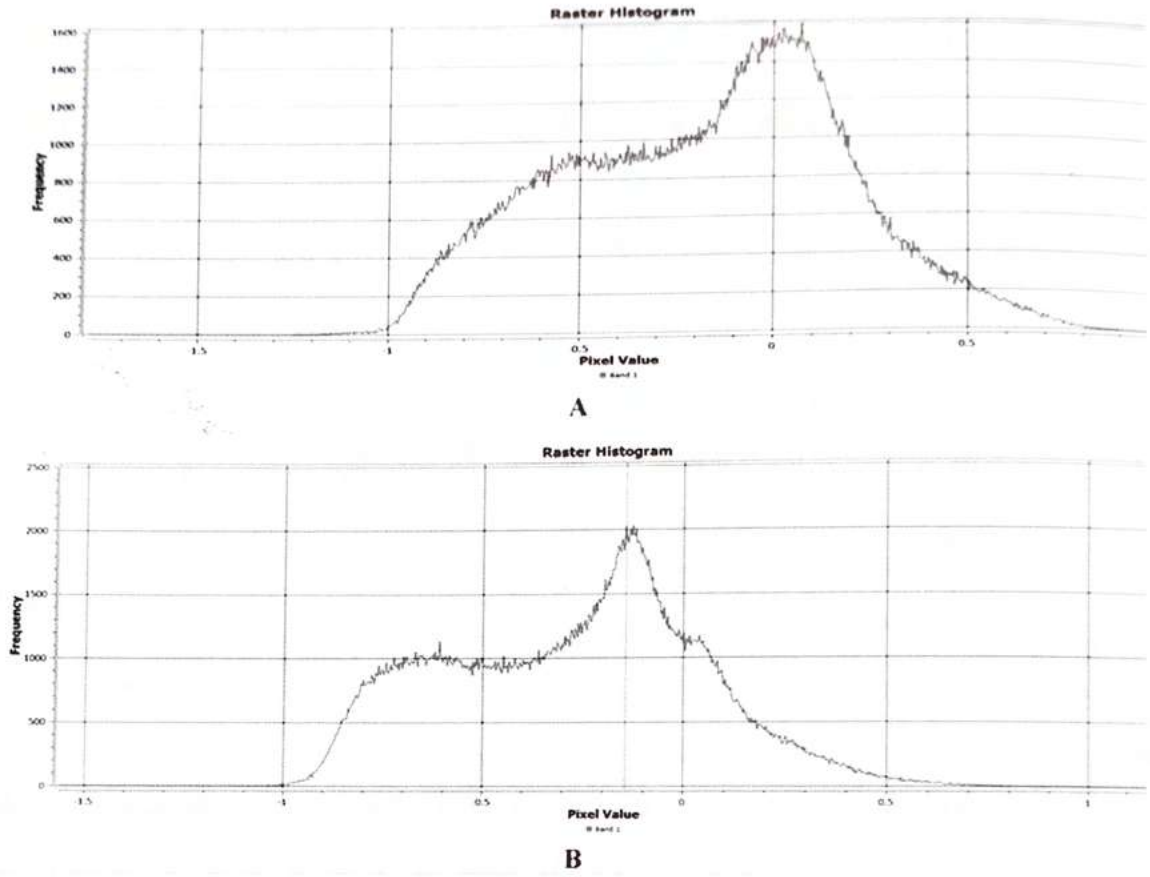

Figure 7 A-B. Raster histogram of Haryana 2018(A) and 2019(B)

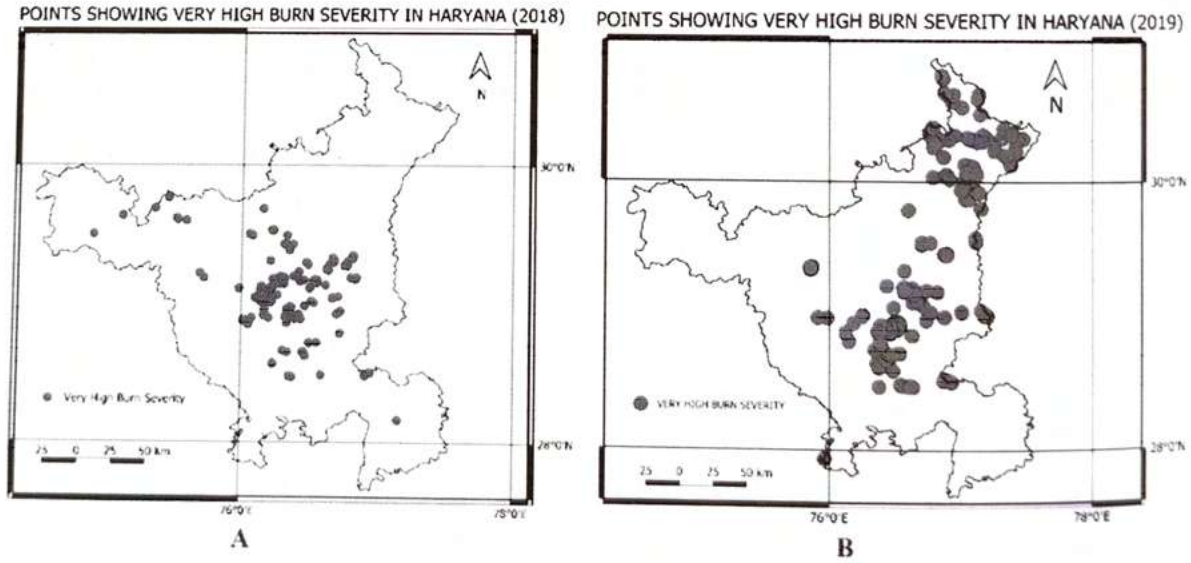

Figure 8 A-B.Points showing very high burn severity in Haryana 2018(A) and 2019(B)

incidents. The farmers need to be educated about this evil and wasteful practice and they need to be made aware about sustainable alternatives to manage with the stubble.

REFERENCES

Anonymous. 2019. BIO-LUTIONS International AG. https://www.bio-lutions.com/bio-lutions-india/

Anonymous. 2019. Fortum, Haryana University to make textile fibre from paddy straw. *The Economic Times* https:// economictimes.indiatimes.com/news/ economy/agriculture/fortumharyana-university-to-make-textile-fibre-from-paddy straw/articleshow/71013352. cms?from=mdrAnonymous. 2019. KFW Bank aus Verantwortung. KfW Stories. Disposable tableware without Plastic.https:// www.kfw.de/stories/environment/nature-conservation/biolutions/

Badarinath, K., Chand, T., and Prasad, V. 2006. Agriculture crop residue burning in Indo-Gangetic plains- A study using IRS-P6 AWiFS Satellite data. *Current Science*.**91** (8), 10851089.www.jstor.org/stable/24093988

Bhuvaneshwari, S.; Hettiarachchi, H.; Meegoda, J.N. Crop Residue Burning in India: Policy Challenges and Potential Solutions. *Int. J. Environ. Res. Public Health***2019**, *16*, 832.

Chawala, P., and Sandhu, H. 2020. Stubble burn area estimation and its impact on ambient air quality of Patiala & Ludhiana district, Punjab, India. *Heliyon*, *6*(1).https://doi.org/10.1016/j.heliyon.2019.e03095

CREAMS Laboratory.2019. Monitoring Paddy Residue burning in North India using Satellite Remote Sensing during 2019.*ICAR-IARI.*Bulletin no 41.New Delhi.http://creams.iari.res.in/pdf/bulletin19/26.RiceResidueFire Bulletin_26Oct_2019_ICAR.pdf

ICAR-IARI. 2019. Monitoring paddy residue burning in north India using satellite remote sensing during 2019. CREAMS Laboratory, ICAR-IARI, bulletin no. 54, New Delhi.

https://krishi.icar.gov.in/jspui/bitstream/123456789/25254/1/54.RiceResidueFireBulletin_23Nov 2019_ICAR.pdf IFPRI. 2019. New Study: Air pollution from India's stubble burning leads to USD 1.5 billion economic losses, poses significant health risk. https://www.ifpri.org/news-release/new-study-air-pollution-indias-stubble-burning-leads-usd-15-billion-economic-losses.

Jain, A. 2015.NGT says no to age old practice of straw burning. *The Hindu*.https:// www.thehindu.com/news/cities/Delhi/ngt-says-no-to-ageold-practice/article7843676.ece

Jain, N., Bhatia, A., Pathak, H. 2014. Emission of air pollutants from crop residue burning in India. *Aerosol and Air Quality Research* (14): 422–430

Kapil, S. 2019. How Haryana cut stubble burning this season. *Down to Earth.* https://www.downtoearth.org.in/news/agriculture/how-haryana-cut-stubble-burning-this-season-67726

Krar, P. 2019. Paddy Stubble to drive biofuel production in Punjab Haryana. *The Economic Times.* https://economictimes.indiatimes.com/industry/energy/oil-gas/paddy-stubble-to-drive-bio-fuel-production-in-punjab-haryana/articleshow/71984431.cms?from=mdr

Krar, P. 2019. Punjab announces RS 2500 per acre for not burning stubble .*The Economic times*.

https://economictimes.indiatimes.com/news/economy/agriculture/punjab-announces-rs-2500-per-acre-for-not-burning-stubble/articleshow/72044065.cms?from=mdr

Mandal, K.G., Misra, Arun., Hati, Kuntal., Bandyopadhyay, Kali., Ghosh,Prabir and Mohanty, Manoranjan. 2004. Rice Residue-Management Options and Effects on soil Properties and Crop Productivity. *Food, Agriculture and Environment*.22. 224-231

MoA&FW. 2019. Report of the committee on Review of the scheme "Promotion of Agricultural Mechanisation For in-situ Management of Crop Residue in States of Punjab, Haryana, Uttar Pradesh and NCT of Delhi". Dept.of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture and Farmers Welfare, GOI.

NPMCR.2014. http://agricoop.nic.in/sites/default/files/NPMCR_1.pdf.

Pal, S. 2018. Biodegradable paper from Paddy straw? This project by IIT Delhi is doing it! *The Better India*.https://www.thebetterindia.com/141523/iit-kriya-labs-biodegradable-paper-paddy-straw/

Sai, N.K. 2008.Unstarred question no. 1529.Ministry of Environment and Forests. Lok Sabha. Government of India.

Saini K. D., Singh K. V., and Kumar A. 2019. Stubble Burning: either farmers to be punished or

technology need to be improved?. *Biomolecule Reports- An international eNewsletter*

Saulino, L.; Rita, A.; Migliozzi, A.; Maffei, C.; Allevato, E.; Garonna, A.P., andSaracino, A. 2020. Detecting Burn Severity across Mediterranean Forest Types by Coupling Medium-Spatial Resolution Satellite Imagery and Field Data. *Remote Sens. 12*, 741.

Sharma, N., Kumar, S. 2019.2 years on, Punjab's ambitious project to tackle stubble trouble fails to take off. *The Hindustan Times*.https://www.hindustantimes.com/cities/2-years-on-punjab-s-ambitious-project-to-tackle-stubble-trouble-fails-to-take-off/story-cQUZy8Y9oa05wX54CoZE4N.html

TERI 2018. India-Sweden strategic approach to integrated management of bio-waste and non-ozone depleting substance – non-HFC alternatives. New Delhi. The Energy and Resources institute. 54pp. Project report no. 2018RT08