

Brick kiln detection around New Delhi using Sentinel 2 with Deep Learning: Distribution and Drivers

Prakhar Misra, *Post-doc*

Wataru Takeuchi, *Professor*

Institute of Industrial Science, The University of Tokyo,

24 July, 2019 Johor Bahru, Malaysia



東京大学
生産技術研究所
Institute of Industrial Science,
The University of Tokyo



Fired bricks are historically important in Indian subcontinent

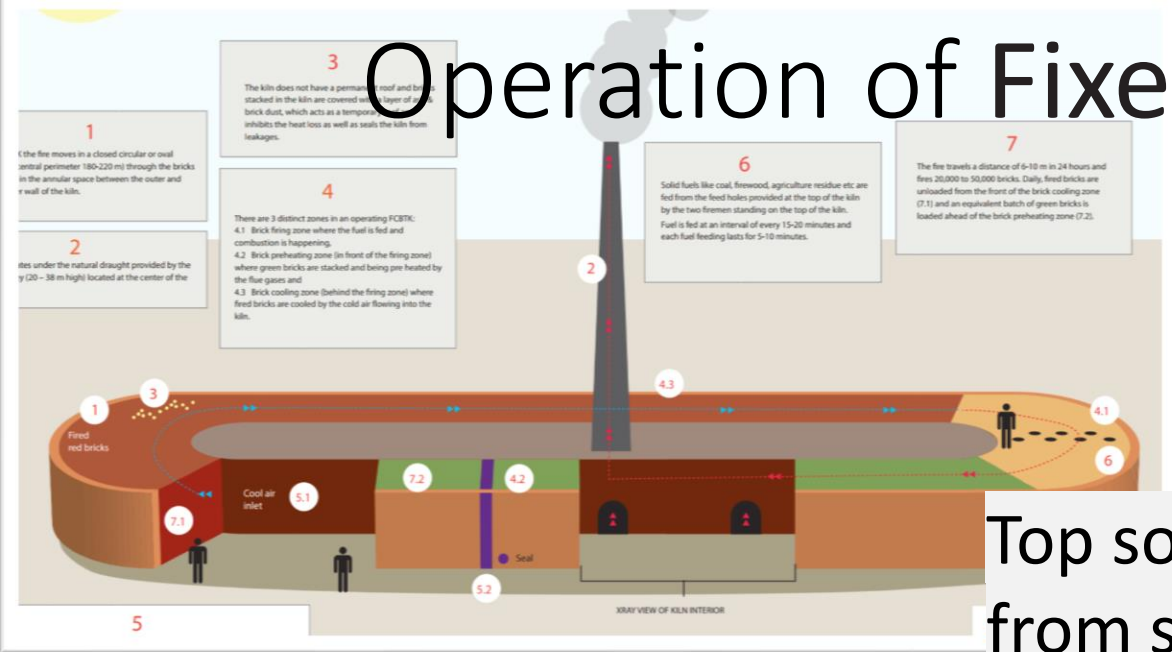


2500 B.C : Brick houses in Indus Valley Civilization (dfindout.com)



400 A.D: brick based Bhitargaon Temple:
(commons.wikimedia.com)

Operation of Fixed Chimney Bull's Trench Kiln



New constructed brick kiln

Top soil excavated from surrounding fields

Maithel et al



Raw (green) clay bricks made from top soil



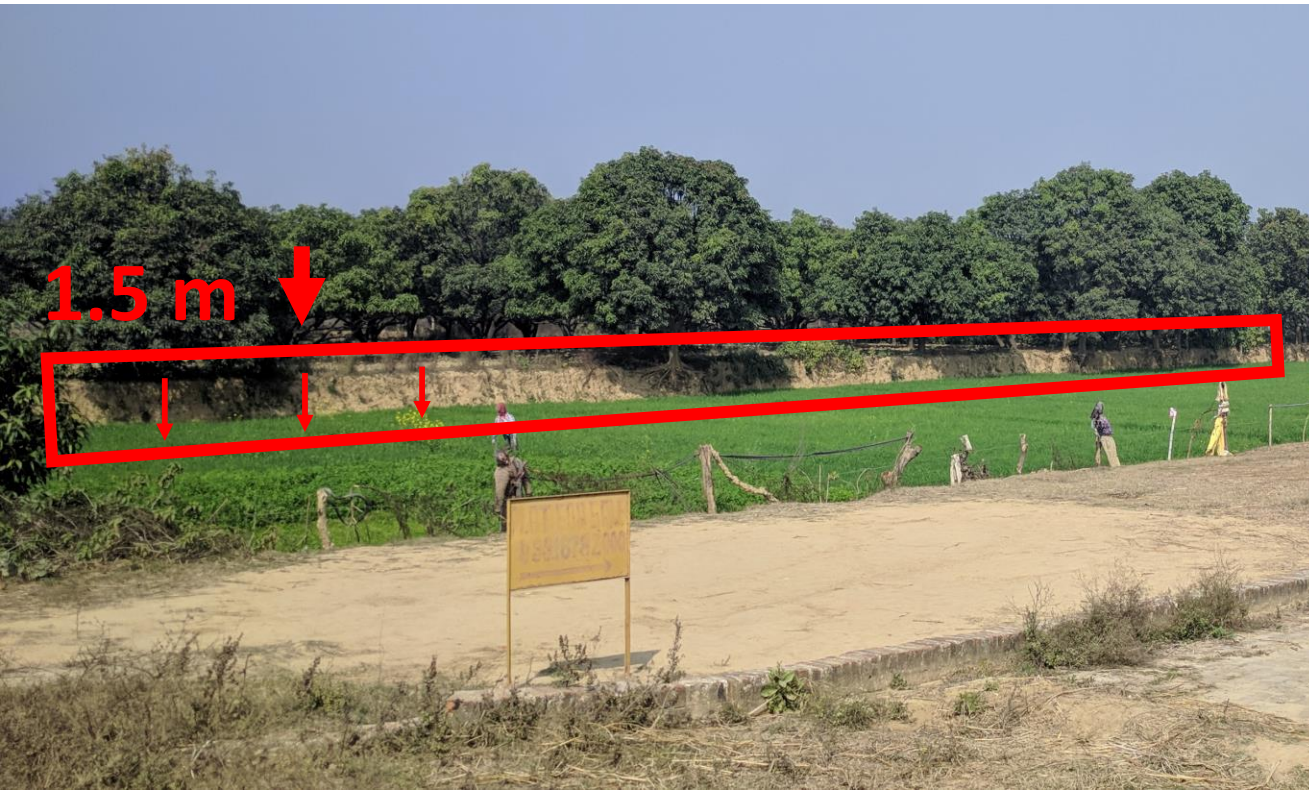
Loss of fertile top soil after excavation

3kg soil/brick needed, **4 million bricks/year**

Surrounding fields become low-lying, vulnerable to flooding

Low-lying land used again for farming, residential plot

Loss of soil carbon



“Double punch emission”,
chopped wood as fuel, modern slavery

Consumption: **600-ton coal/year**

Season: Dry season (onset, offset uncertain)





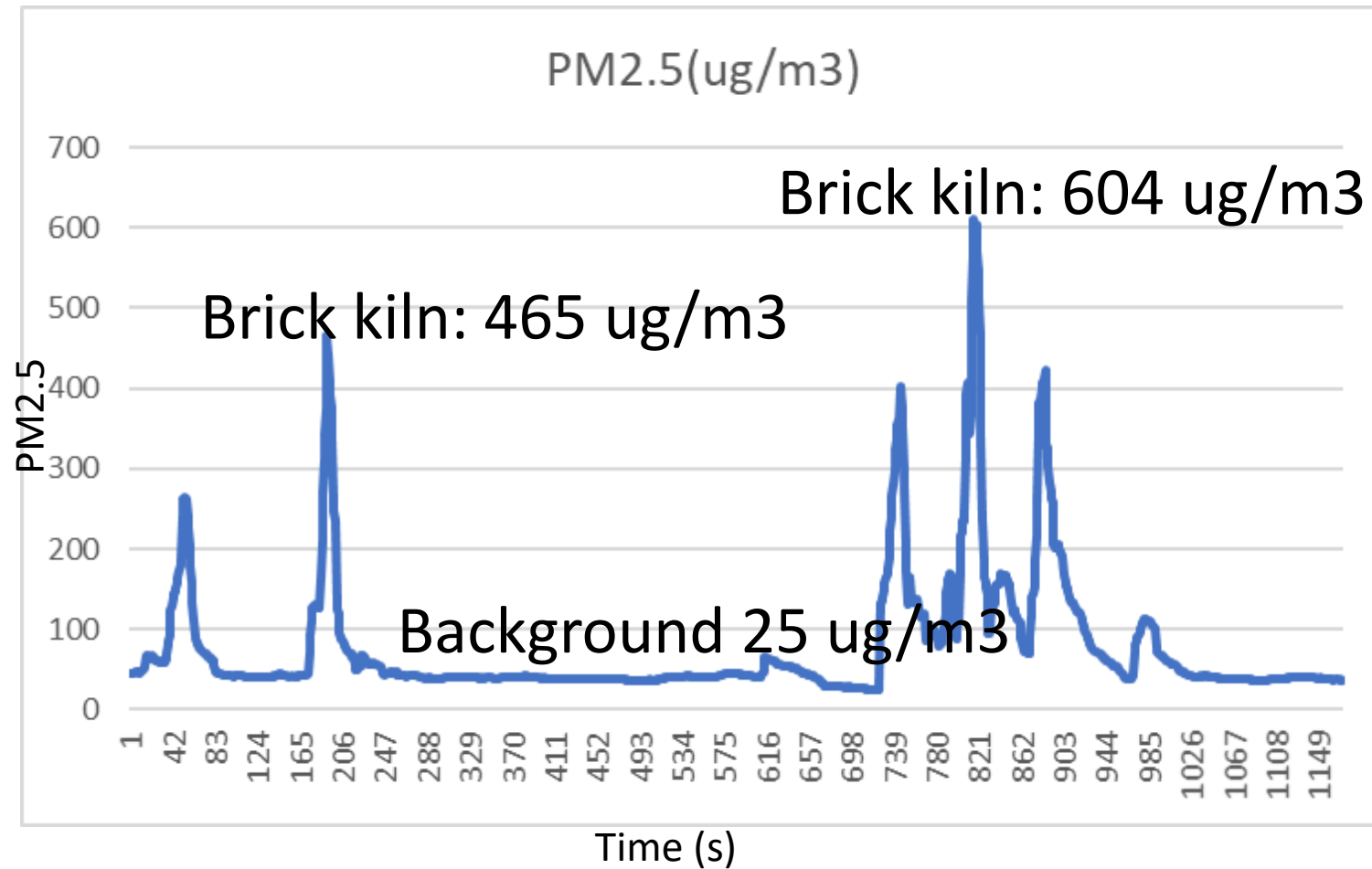
Feb, 2019
(season start)



Jun, 2019
(peak season)

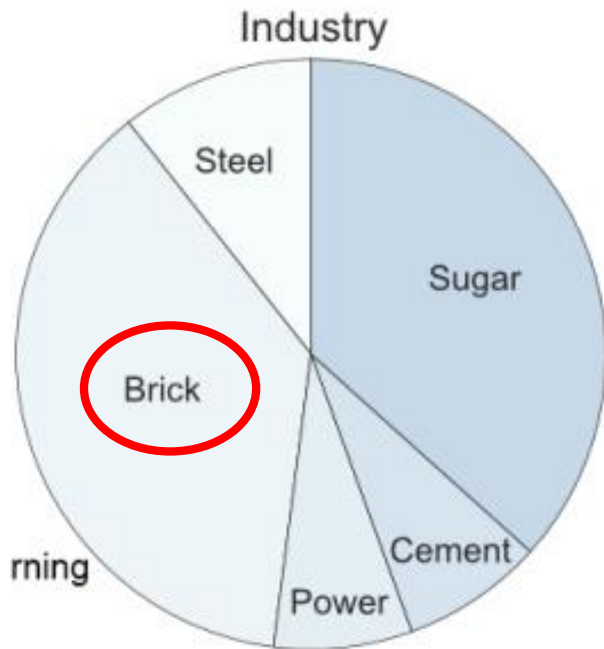
Stage of fuel determines emission type

PM2.5 emissions affect crops yield, pest vulnerability

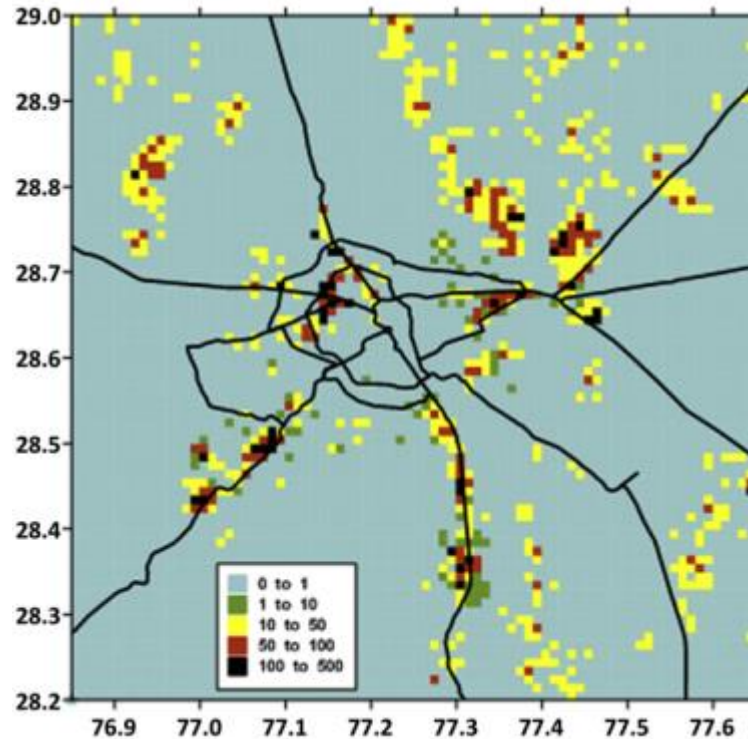


Emissions affect urban air quality up to 50 km far

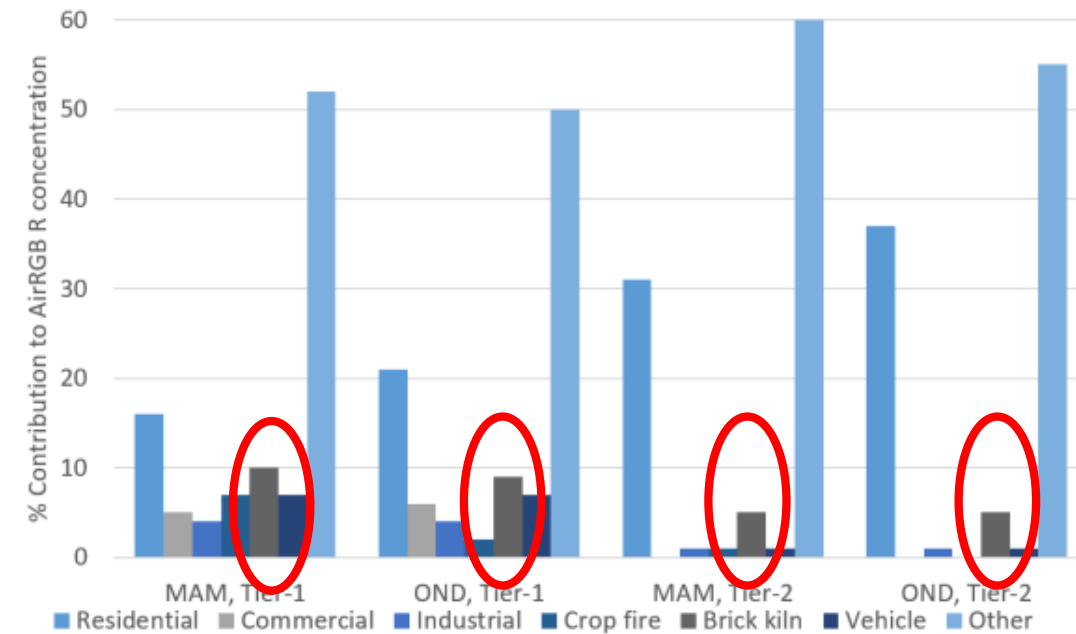
Statistical approach



Statistical, remote sensing, survey



Remote sensing approach

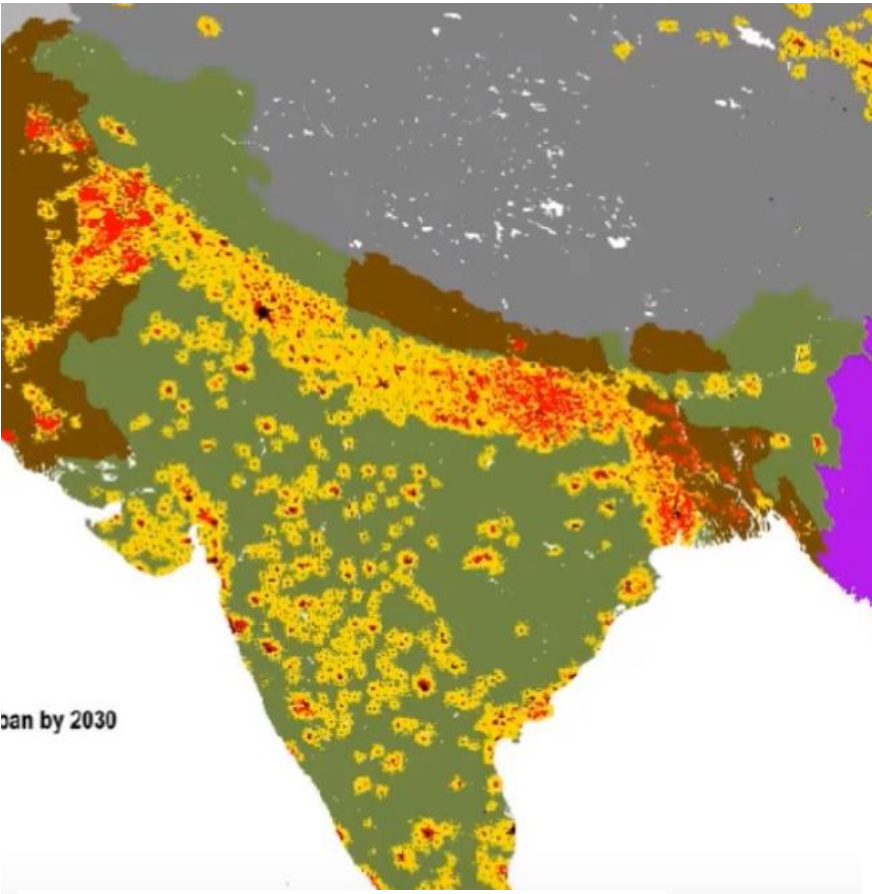


Paliwal, et al., *Atmos. Chem. Phys.* (2016)

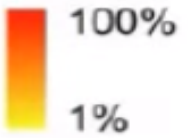
Guttikunda and Calori, *Atmospheric Environment* (2013)

Misra et al., (2019) *Atmosphere* (submitted)

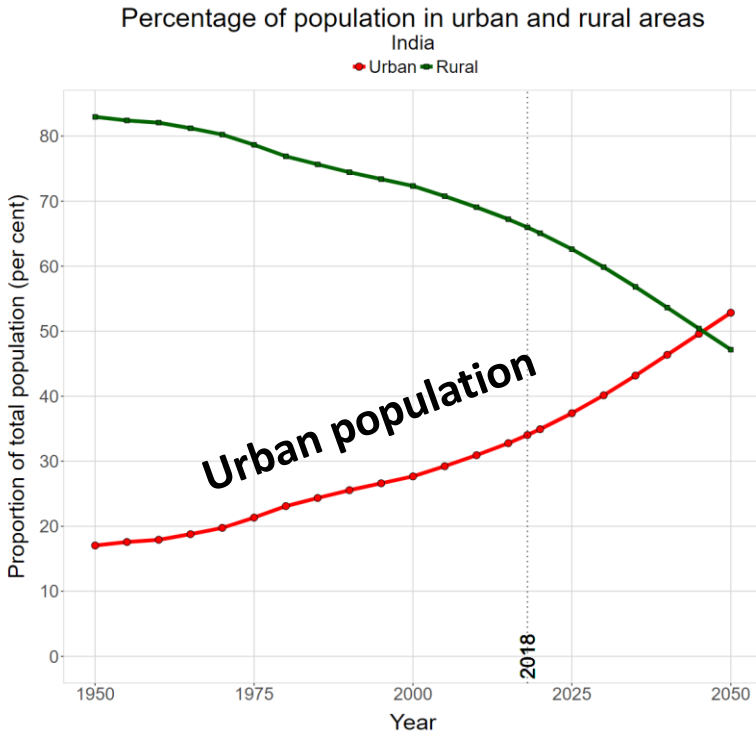
'Housing for All', urbanization policy in Indian subcontinent implies brick kiln count rise



Likelihood to become urban by 2030



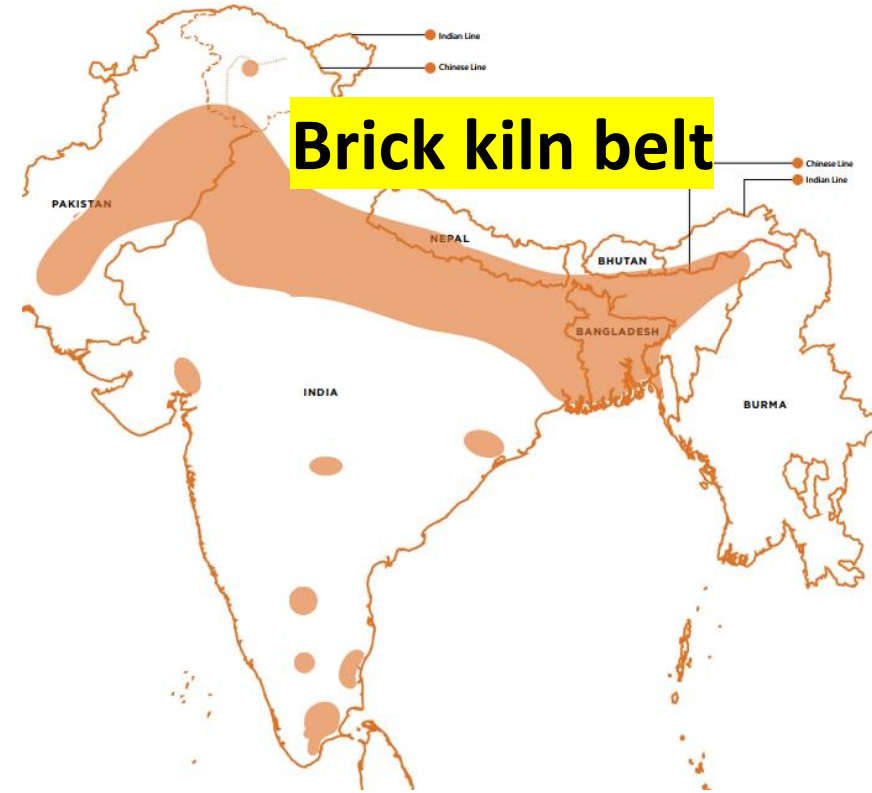
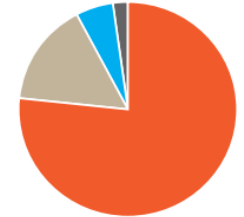
Adapted from Seto, et al (2012)



NUMBER OF OPERATIONAL ENTERPRISES AND TOTAL PRODUCTION*

Country	Number of enterprises	Total production billion bricks/year
India ^{2,3}	35,000	185
Pakistan ⁴	11,500	56
Bangladesh ⁵	4,500	17.4
Nepal ⁶	450	2.3
Total	51,450	260.7

*Numbers are estimates only



Fixed Chimney Bull's Trench Kiln mostly in North India

Adapted form Maithel, et al (2014)

Needed - Brick kiln location open data

70% kilns illegal

Brick kiln count **believed** to be 125,000 in India



केन्द्रीय प्रदूषण नियंत्रण बोर्ड
CENTRAL POLLUTION CONTROL BOARD
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय भारत सरकार
MINISTRY OF ENVIRONMENT, FOREST & CLIMATE CHANGE GOVT. OF INDIA

Fax/ Speed Post

IPC-V(SS1)/Brick Kiln/2017

October 24, 2017

12613

WHEREAS, on the basis of the data collected by the CPCB during July 2017 from UP State Board regarding types and consent status of Brick Kiln operating in the NCR, indicated that there are total 2125 nos of Brick Kilns operated in the 07 NCR Districts of Uttar Pradesh. Among these 1728 nos (81%) of Brick Kilns are operating without consent; and

WHEREAS, in Bagpat District of NCR, total 525 nos of Brick Kilns are being operated as per list of Brick Kilns enclosed herewith and among these 366 nos (70%) of Brick Kilns S. No. 1 to 366 are operating without consent; and

WHEREAS, the Hon'ble High Court of Judicature, Delhi vide its order dated 25th August, 1999 in CWP No. 2145/99 Centre for Public Interest Litigation, Delhi v/s Union of India directed that the Central Government to publish the final notification in respect of fly ash on or before 26th October, 1999; and

A handwritten signature in blue ink is located at the bottom center of the page.

Needed - Brick kiln location open data

Brick kiln count **believed** to be 125,000 in India



केन्द्रीय प्रदूषण नियंत्रण बोर्ड
CENTRAL POLLUTION CONTROL BOARD
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय
MINISTRY OF ENVIRONMENT, FOREST & CLIMATE CHANGE

Remote Sens. 2019, 11(3), 266; <https://doi.org/10.3390/rs11030266>

Open Access

Article

Earth Observation and Machine Learning to Meet Sustainable Development Goal 8.7: Mapping Sites Associated with Slavery from Space

Giles M. Foody ^{1,2,*} , Feng Ling ³ , Doreen S. Boyd ^{1,2} , Xiaodong Li ^{1,3} and Jessica Wardlaw ^{1,2}

IPC-V(SS1)/Brick Kiln/2017

Fax/ Speed Post

October 24, 2017

12613

WHEREAS, on the basis of the data collected by the CPCB during July 2017 from UP State Board regarding types and consent status of Brick Kiln operating in the NCR, indicated that there are total 1728 nos of Brick Kilns operated in the 07 NCR Districts of Uttar Pradesh. Among these 1728 nos (81%) of Brick Kilns are operating with consent; and

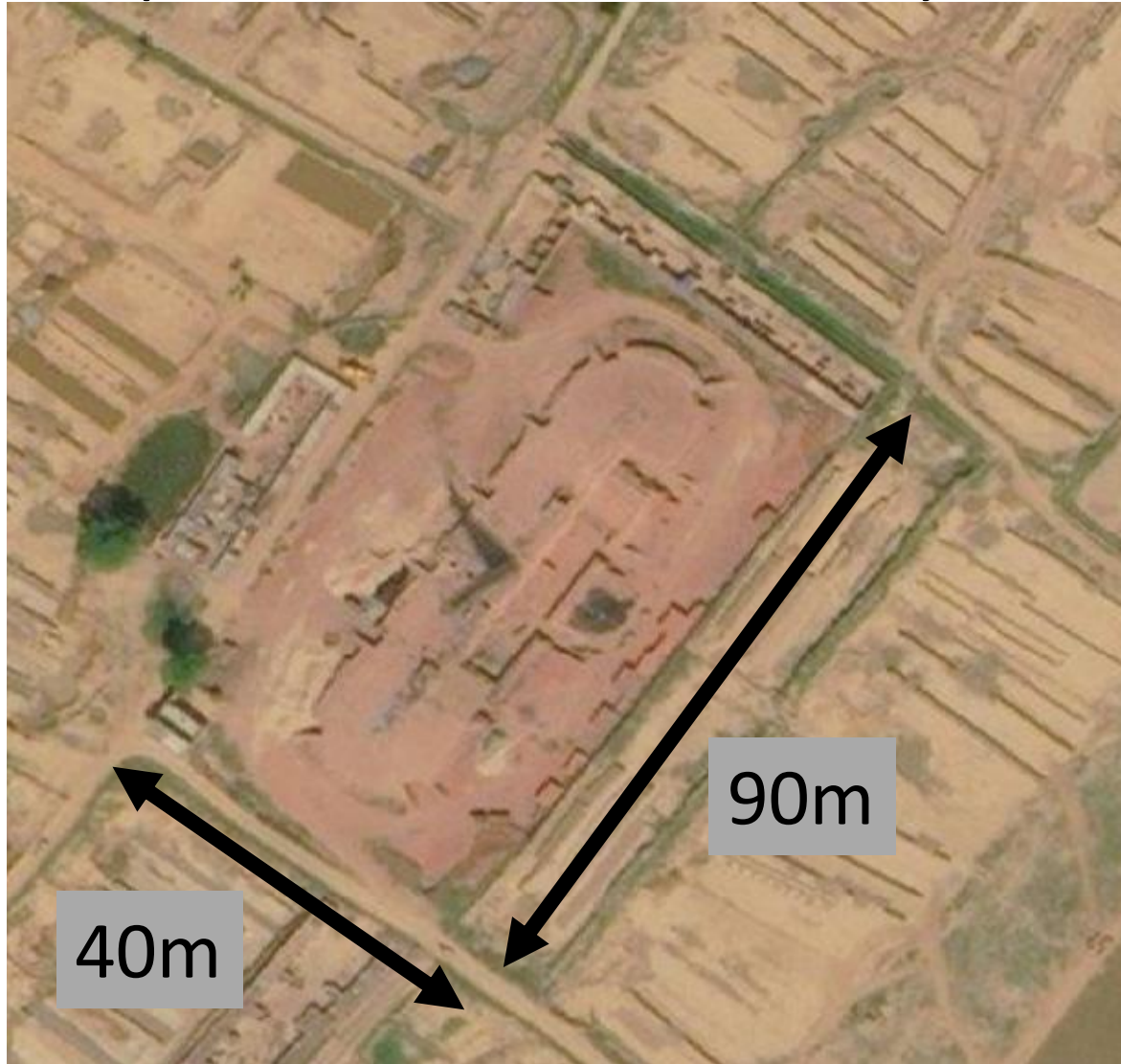
WHEREAS, in Bagpat District of NCR, total 525 nos of Brick Kilns are being operated as per list of Brick Kilns enclosed herewith and among these 366 nos (70%) of Brick Kilns S. No. 1 to 366 are operating without consent; and

WHEREAS, the Hon'ble High Court of Judicature, Delhi vide its order dated 25th Aug 1999 in CWP No. 2145/99 Centre for Public Interest Litigation, Delhi v/s Union of India directed that the Central Government to publish the final notification in respect of fly ash or before 26th October, 1999; and



Using data from Google Earth

Brick kilns appear reddish having round or ellipse shape with a chimney shadow



Reference Image DG Google Earth

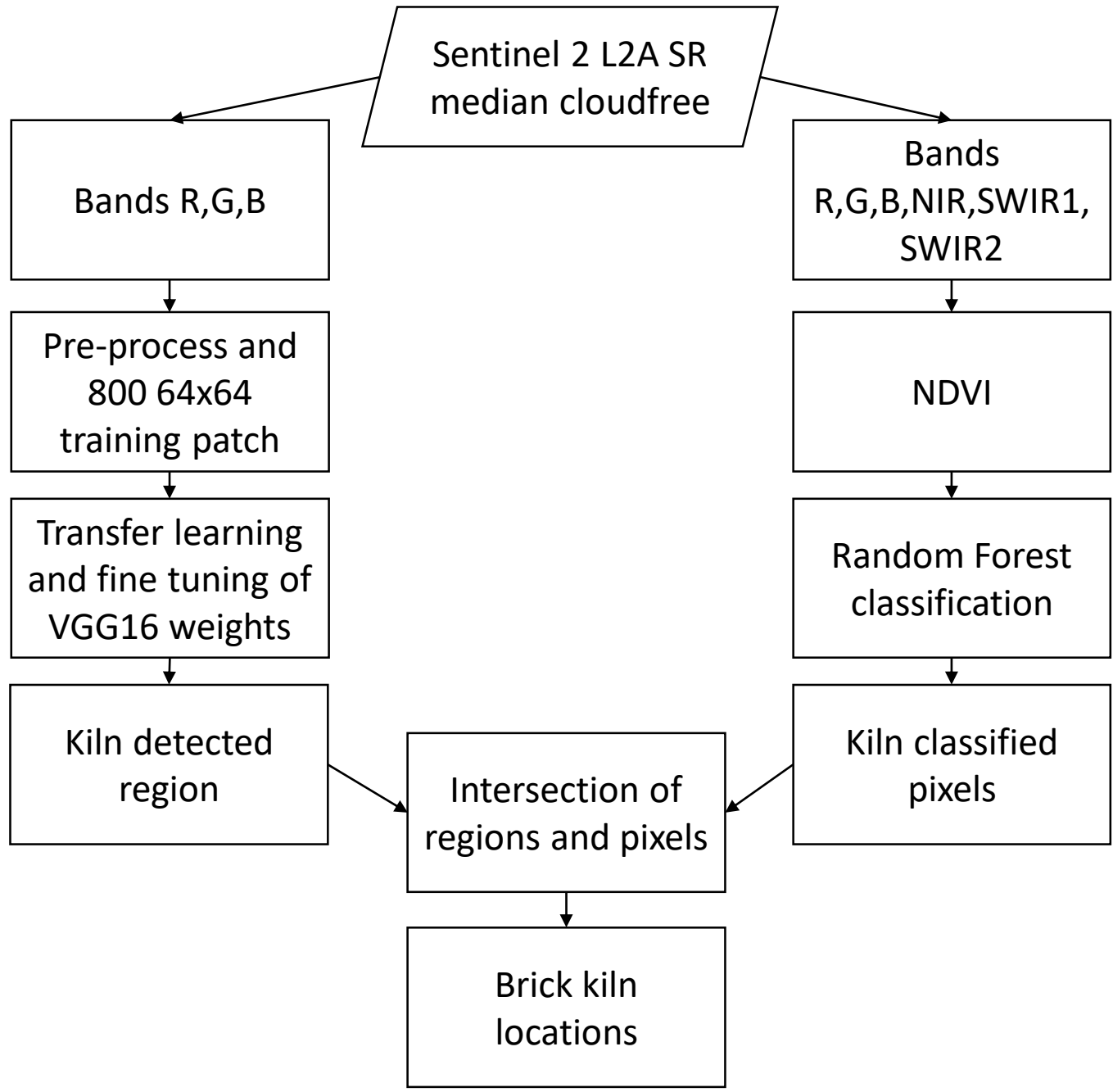


Sentinel 2



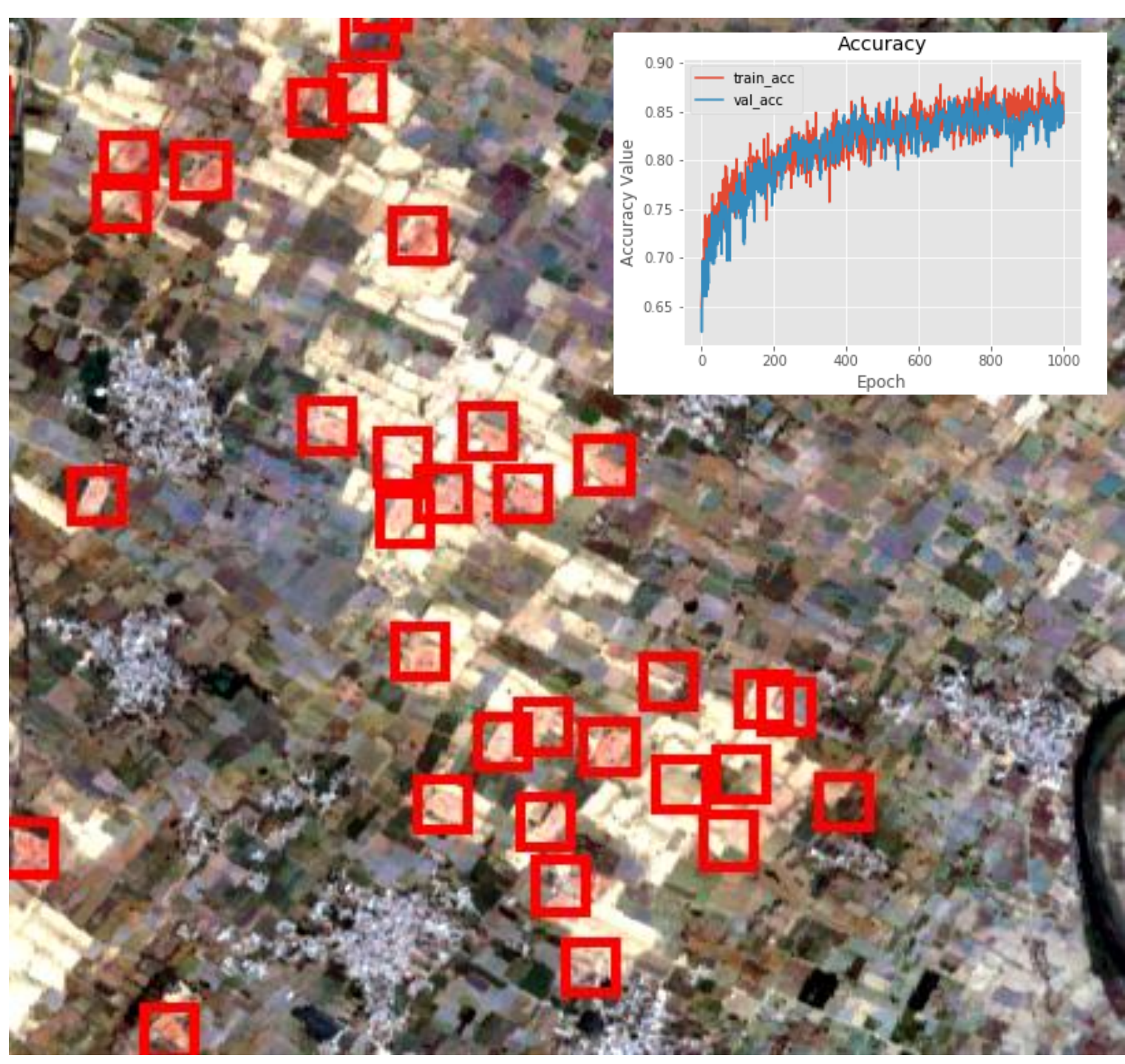
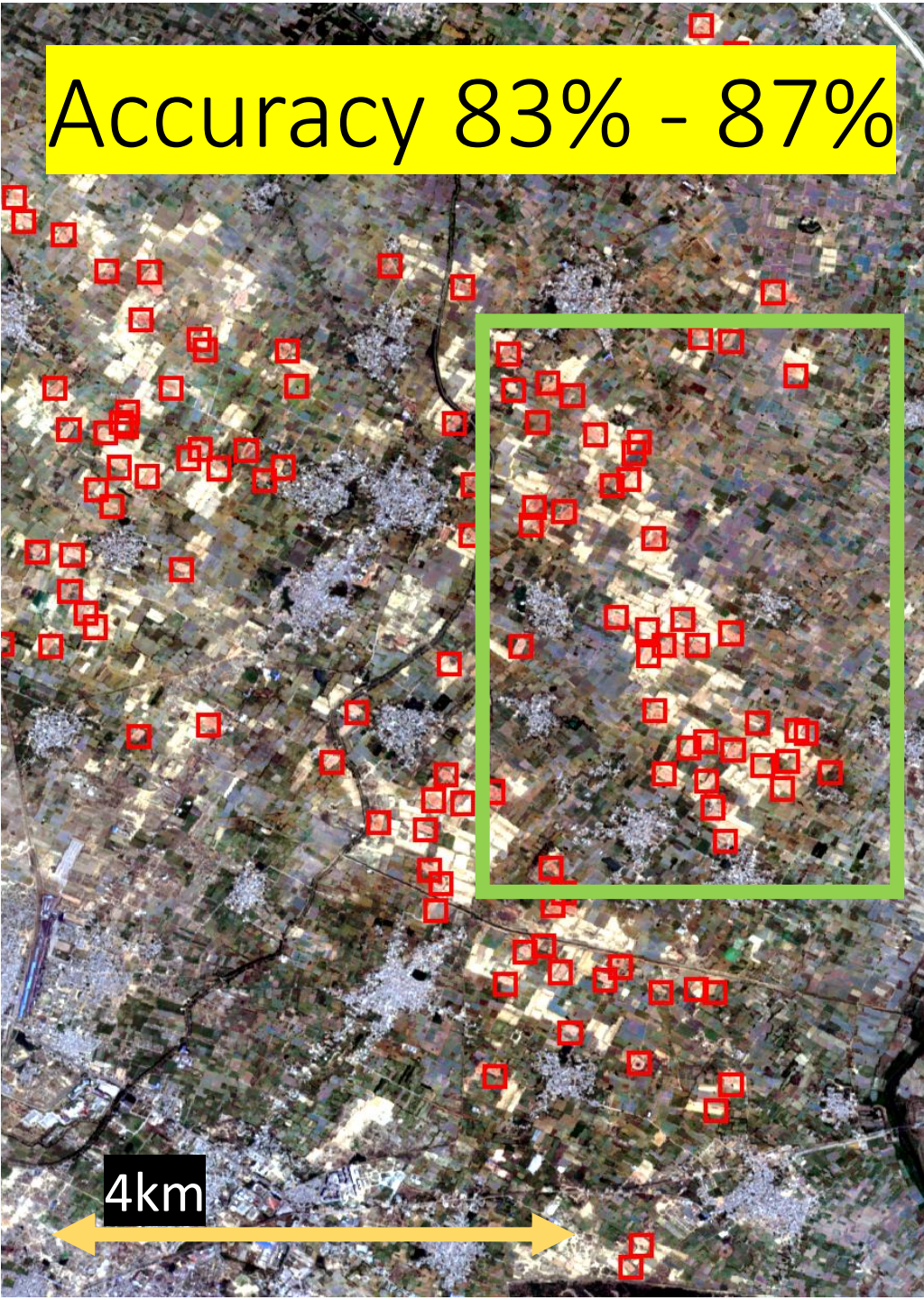
Flowchart

Texture and geometry
object detection
Deep Neural Network

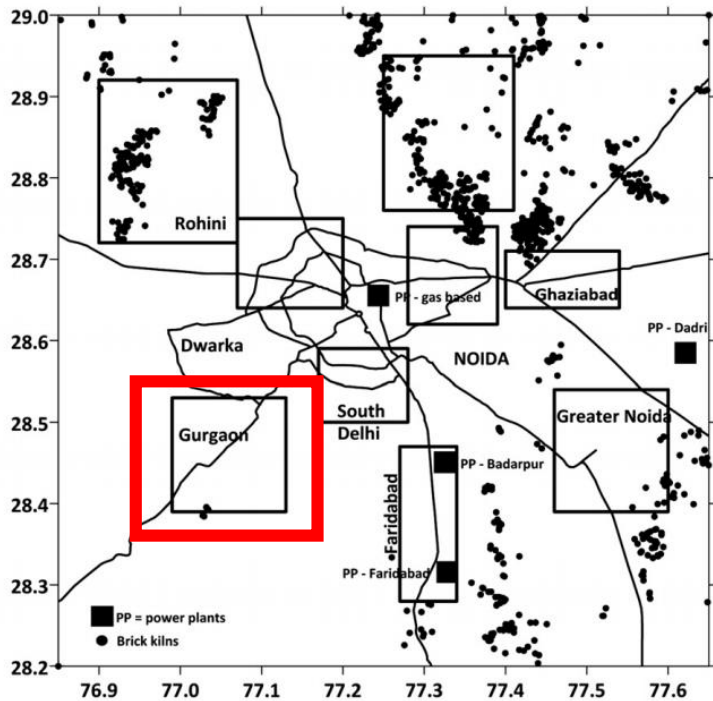


Spectral **pixel classification**
Random Forest

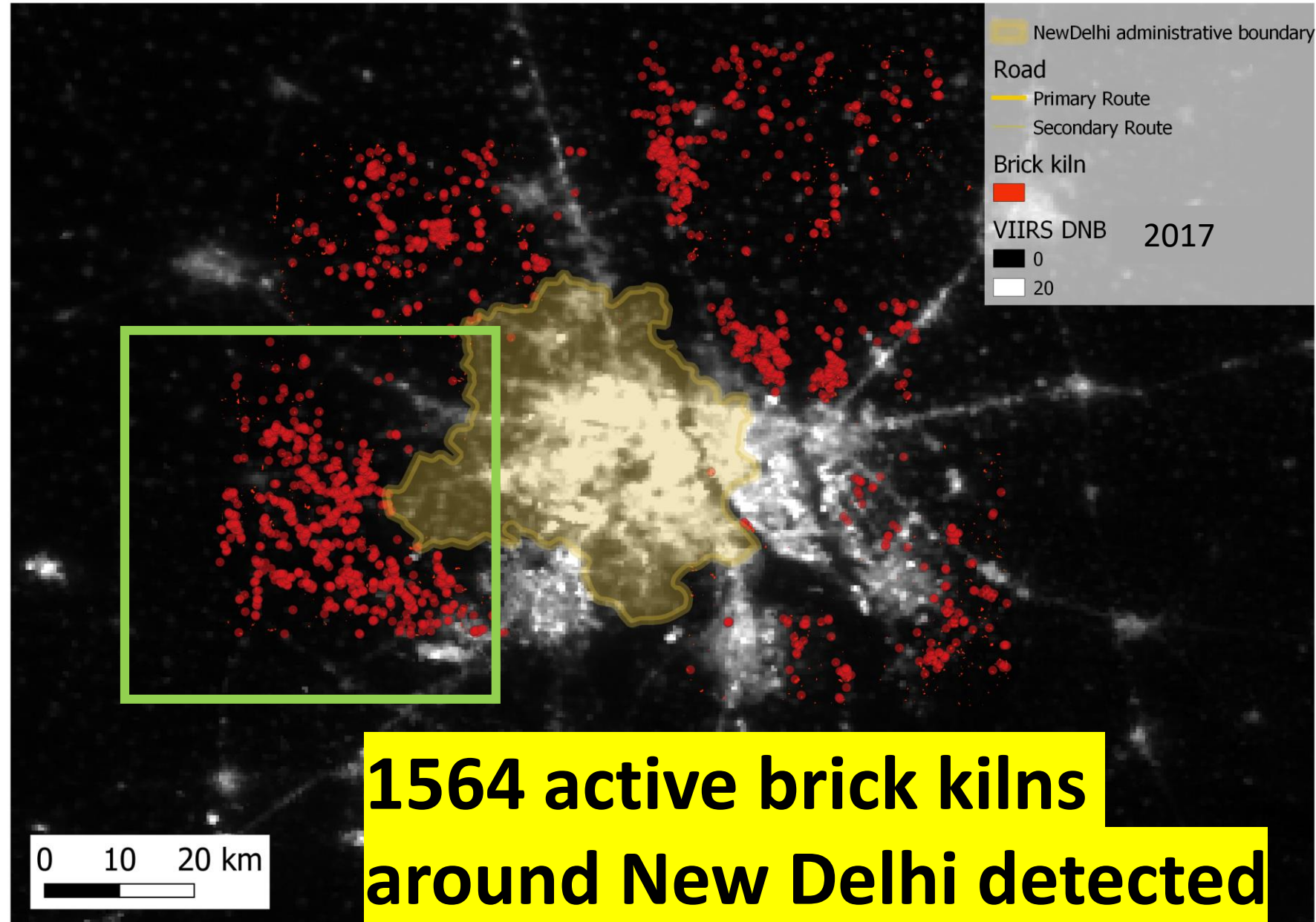
Accuracy 83% - 87%



Kiln clusters correspond to previous location inventory

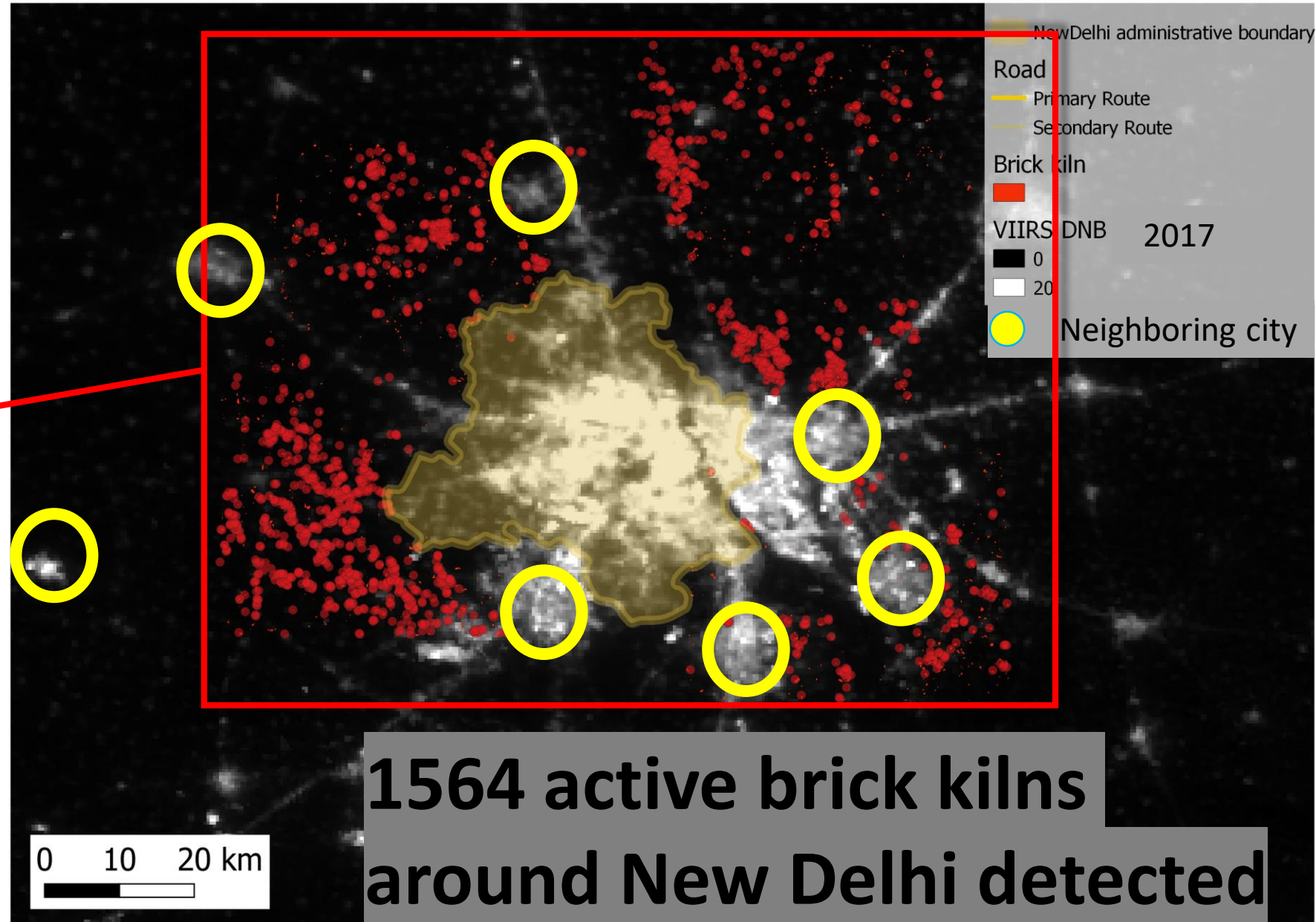


Guttikunda and Calori (2013) found about 1000 kilns manually for inventory but missed a major portion



1564 active brick kilns around New Delhi detected

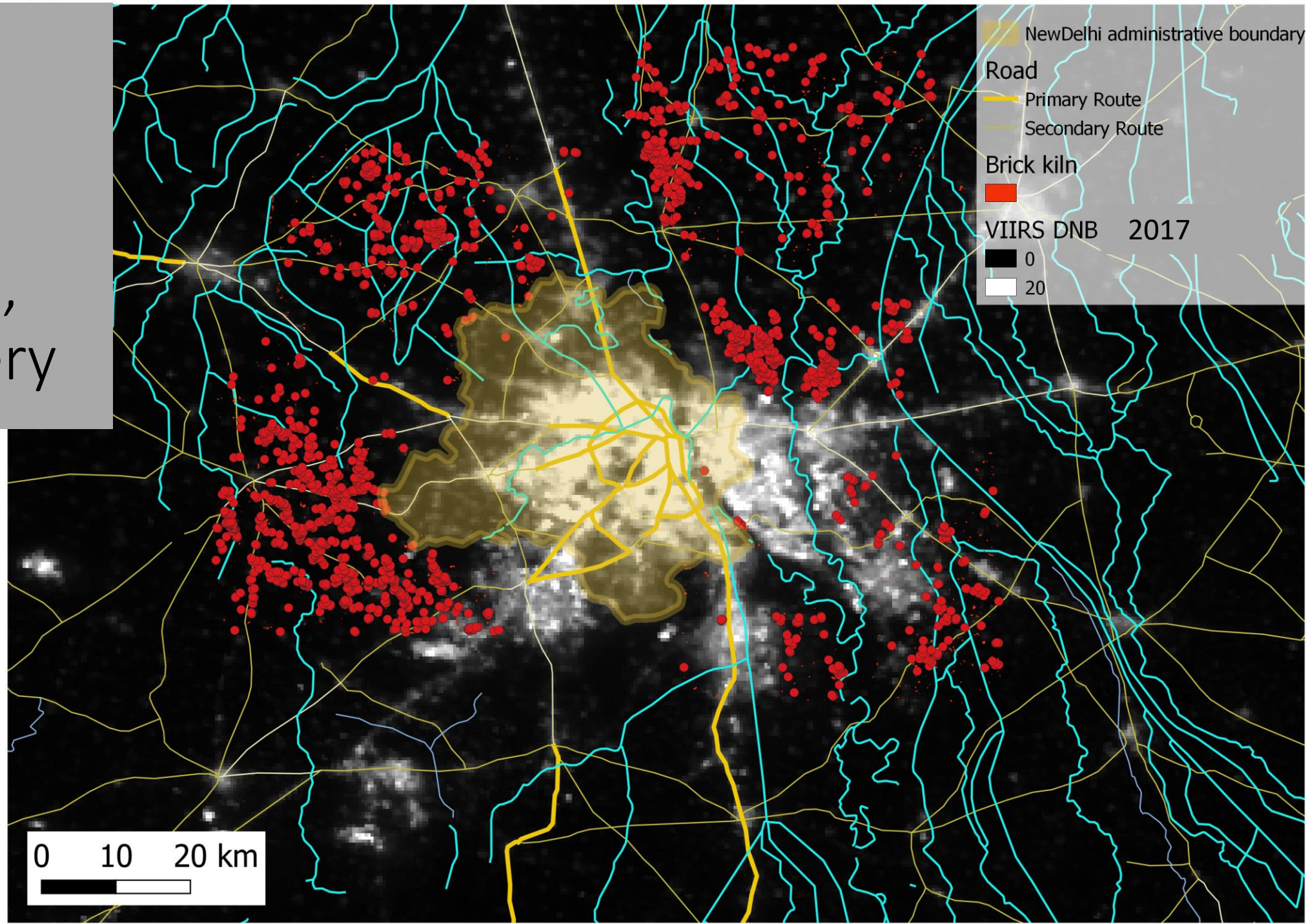
Kiln located in 6 clusters, between upcoming satellite cities



Domain of kiln detection

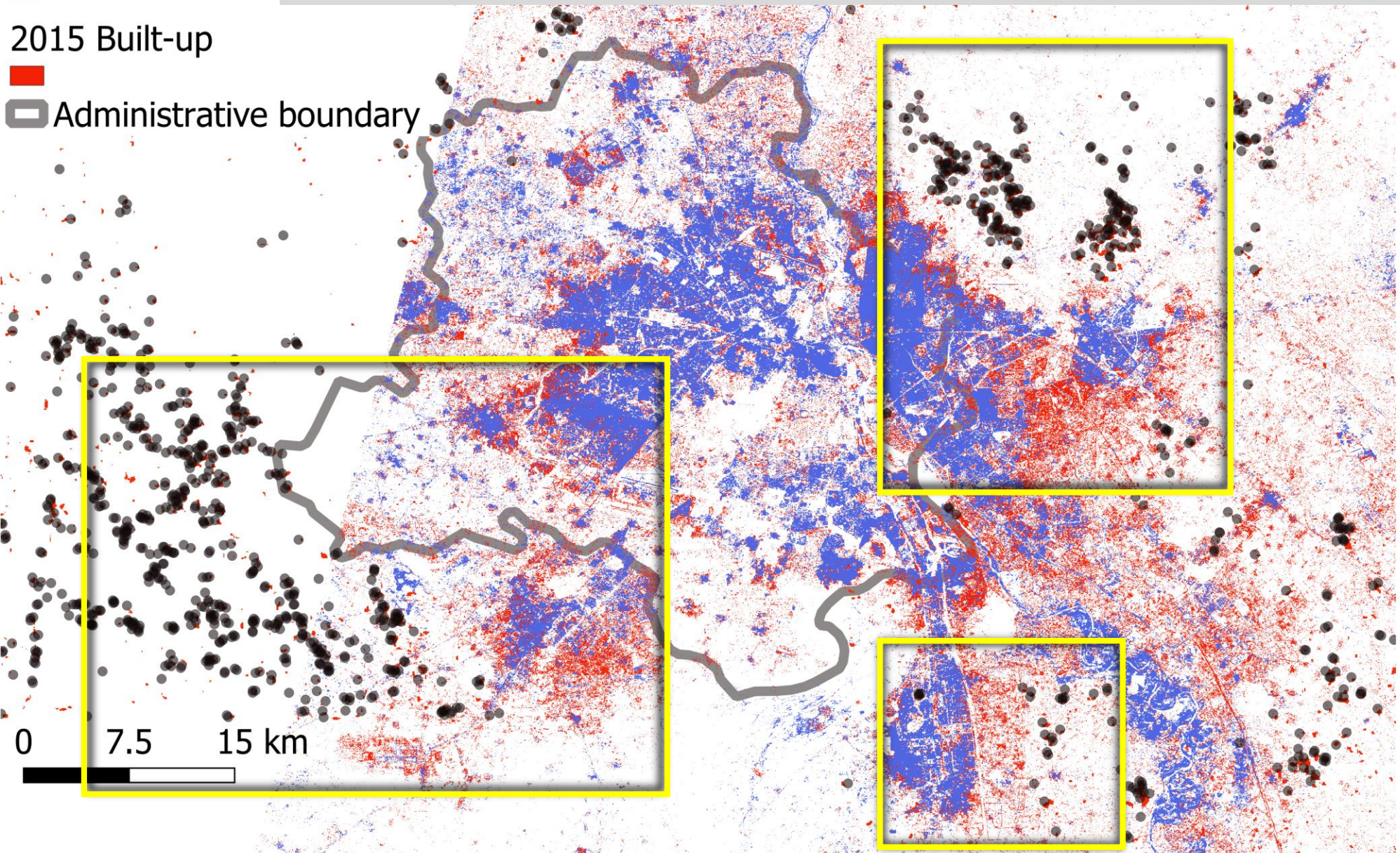
1564 active brick kilns around New Delhi detected

Suitability:
riverbed,
road-access,
city periphery

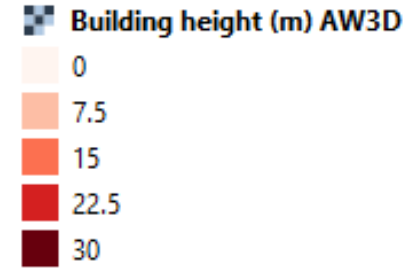
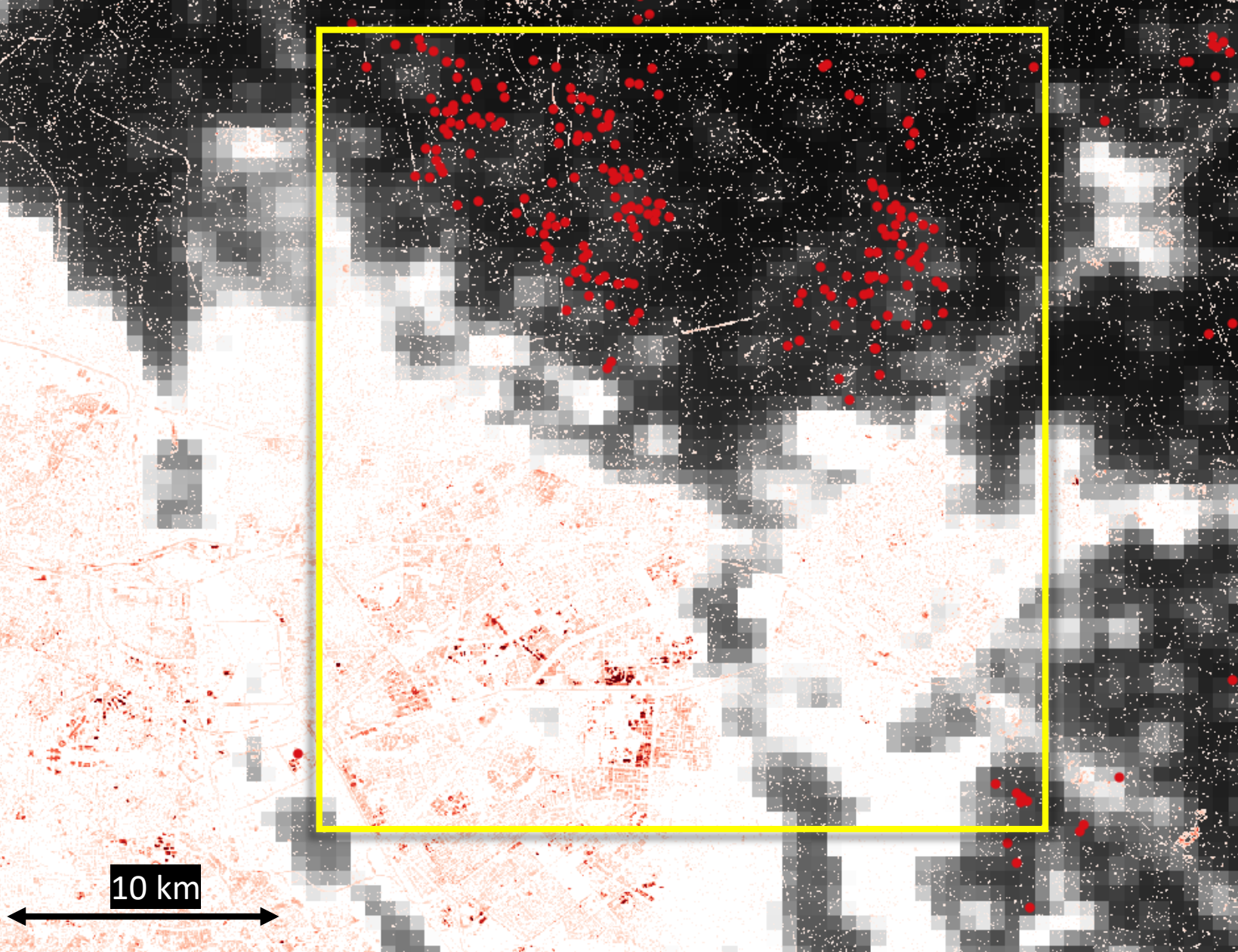


Kilns active near peripheral horizontal expansion

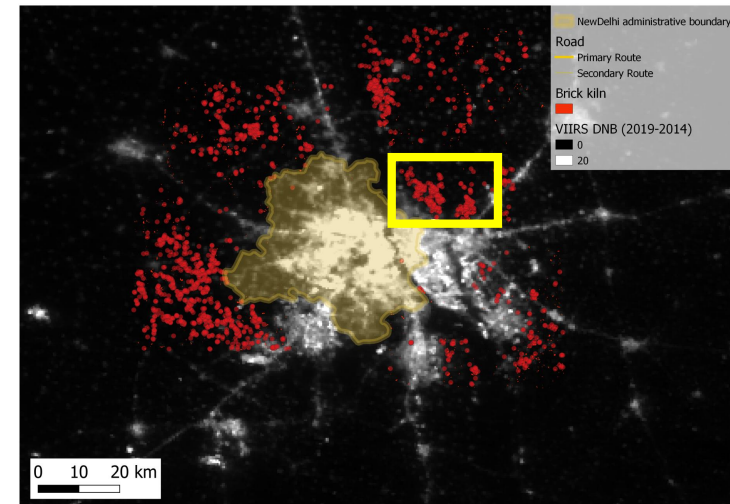
- Brick kiln
- 2001 Built-up
- 2015 Built-up
- Administrative boundary



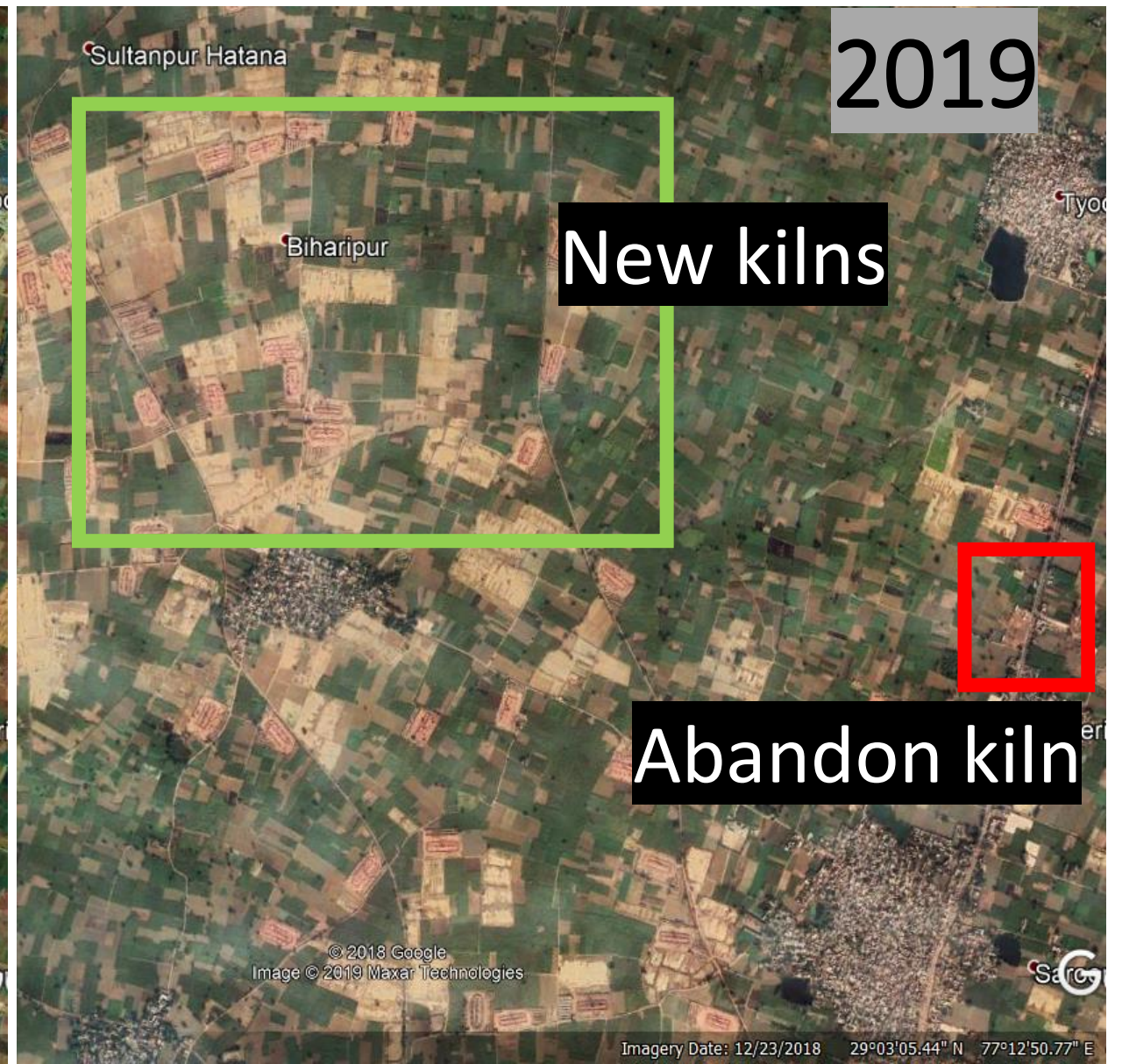
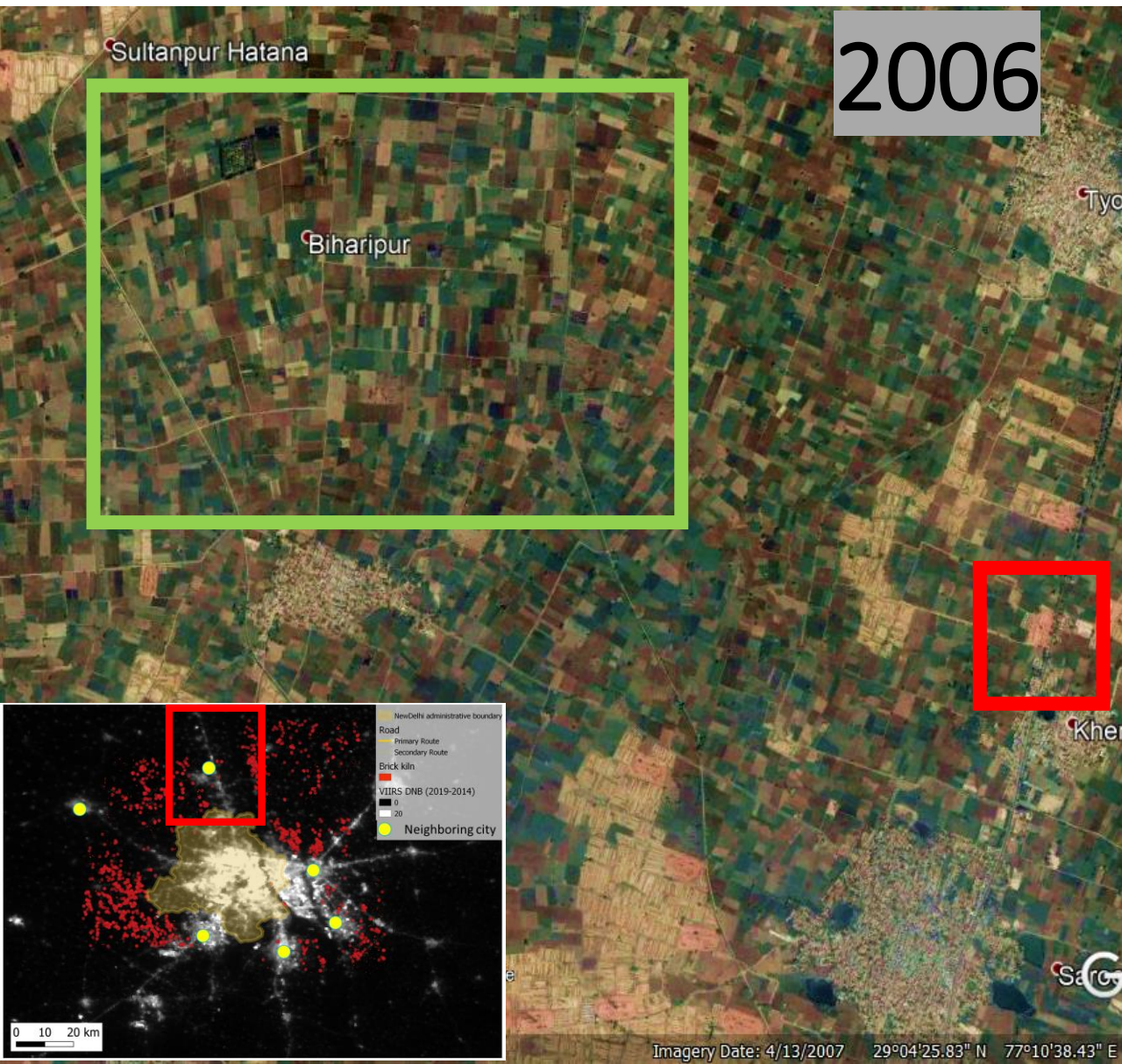
Kilns also related with high-rise constructions



Building heights from
Misra et al., *Remote Sensing* (2018)

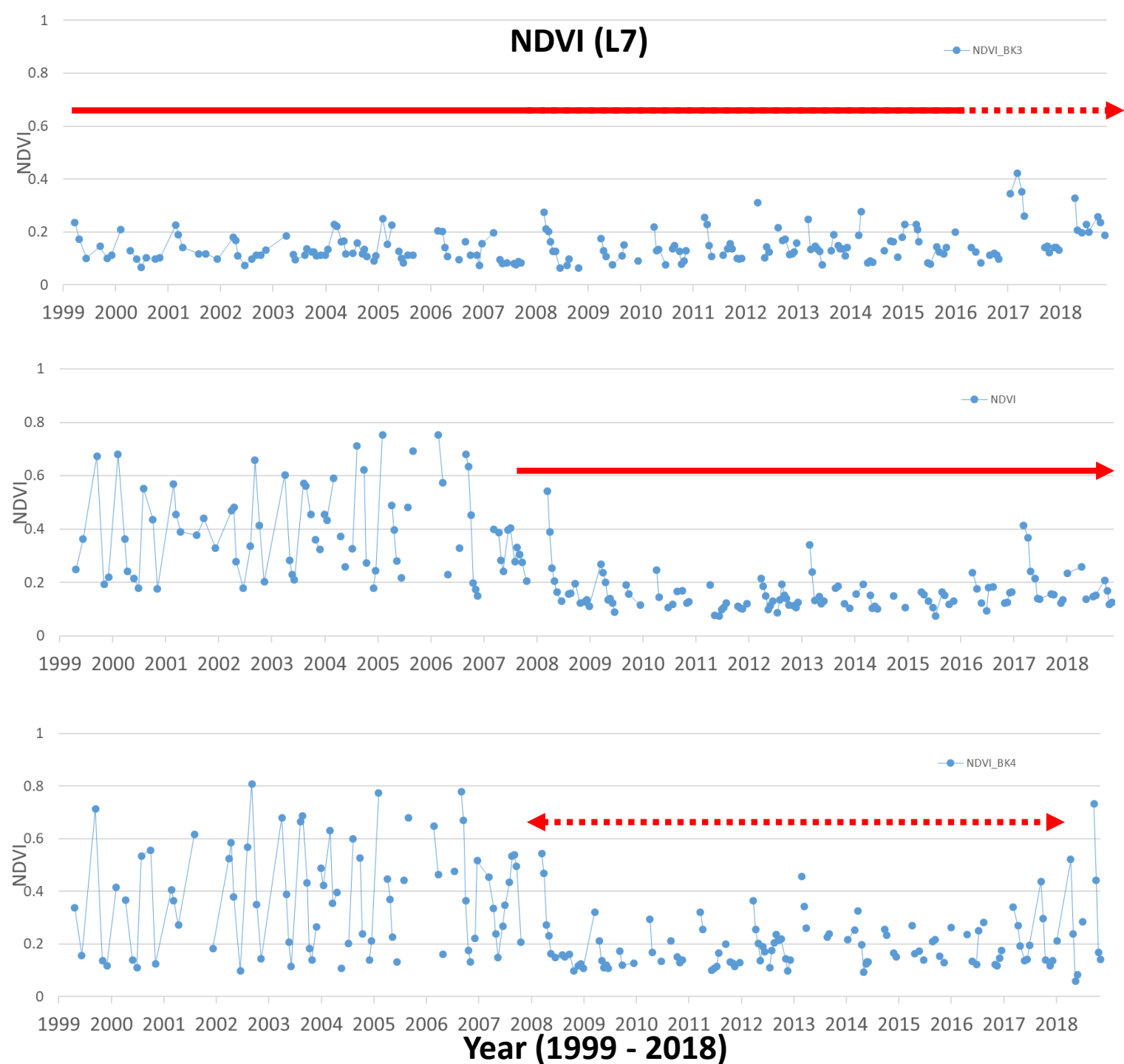


New and abandoned kilns with time

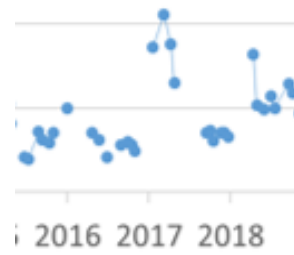


NDVI reveals age of operation

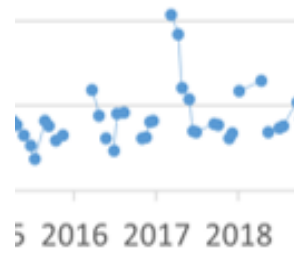
1. Most built around 2009
2. Young brick kilns are further away from suburb
3. Some converted to field while some lie fallow (these were missed in our dataset)



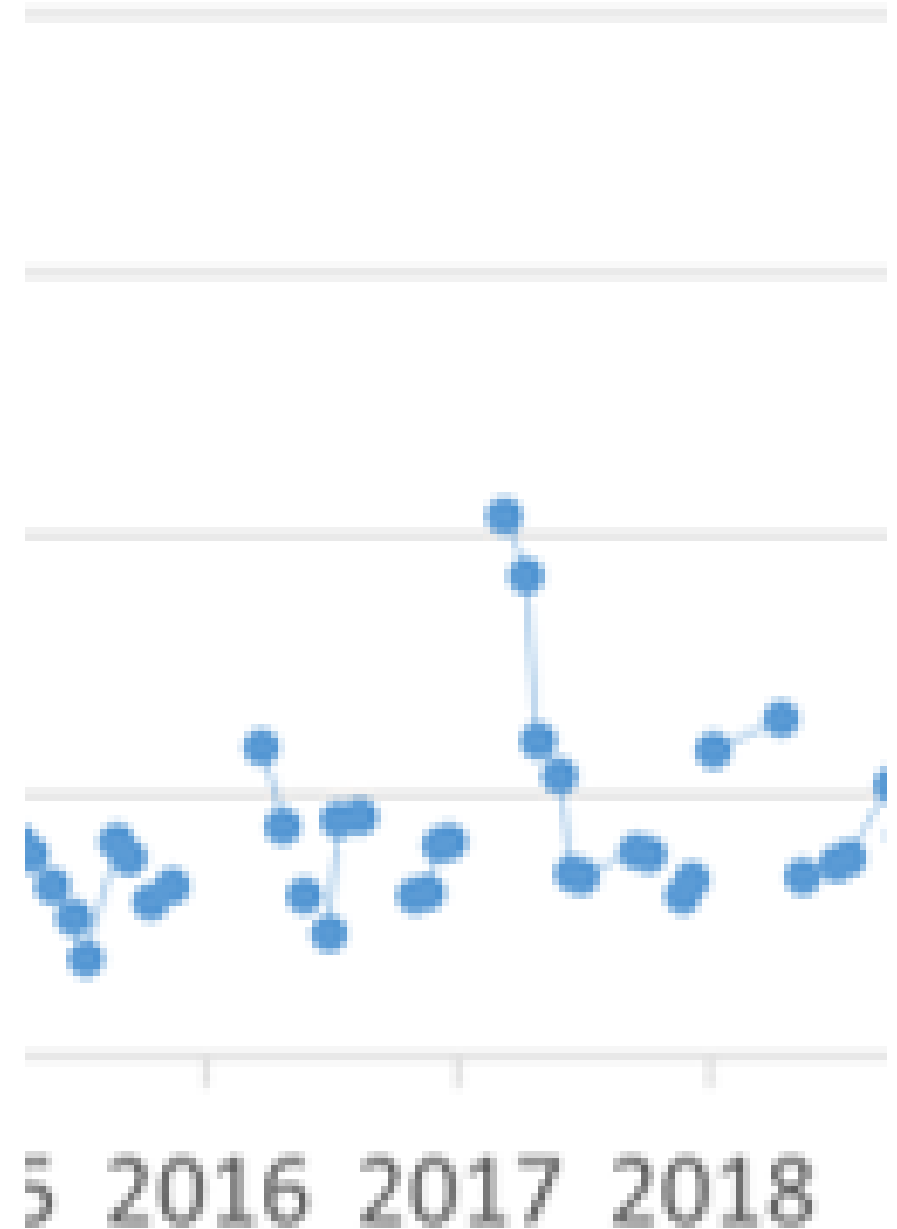
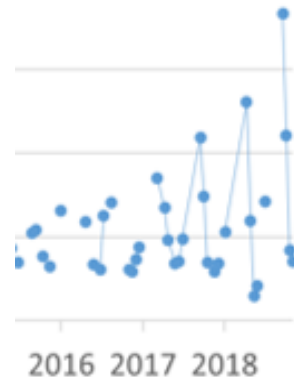
Kiln operation vs. demonetization policy



NDVI



NDVI_BK4



Conclusion

- First open data Brick Kiln location product, accuracy between 83% – 87%.
- Located where clay, water and construction along non-highway roads, less than 20 km from urban.
- Emission inventory underestimated, operation age important for historic emissions.
- Product will be extended to the brick belt and released.
Open to collaborate.

Beehive Brick kiln in Vietnam, Cambodia



Rạch Cai Thây, Vietnam



Mekong river, Vietnam



Co Chien River in Vinh Long, Vietnam



West Bengal,
India

Bangladesh

Thank you for kind attention
mprakhar@iis.u-tokyo.ac.jp