

1. Motivation

- 24.9 million people trapped in forced labour world wide
- 12.7 million people reside in Brick Kiln belt of South Asia
- UN Sustainable Development Goal 8.7: Eradicate forced labour by year 2025

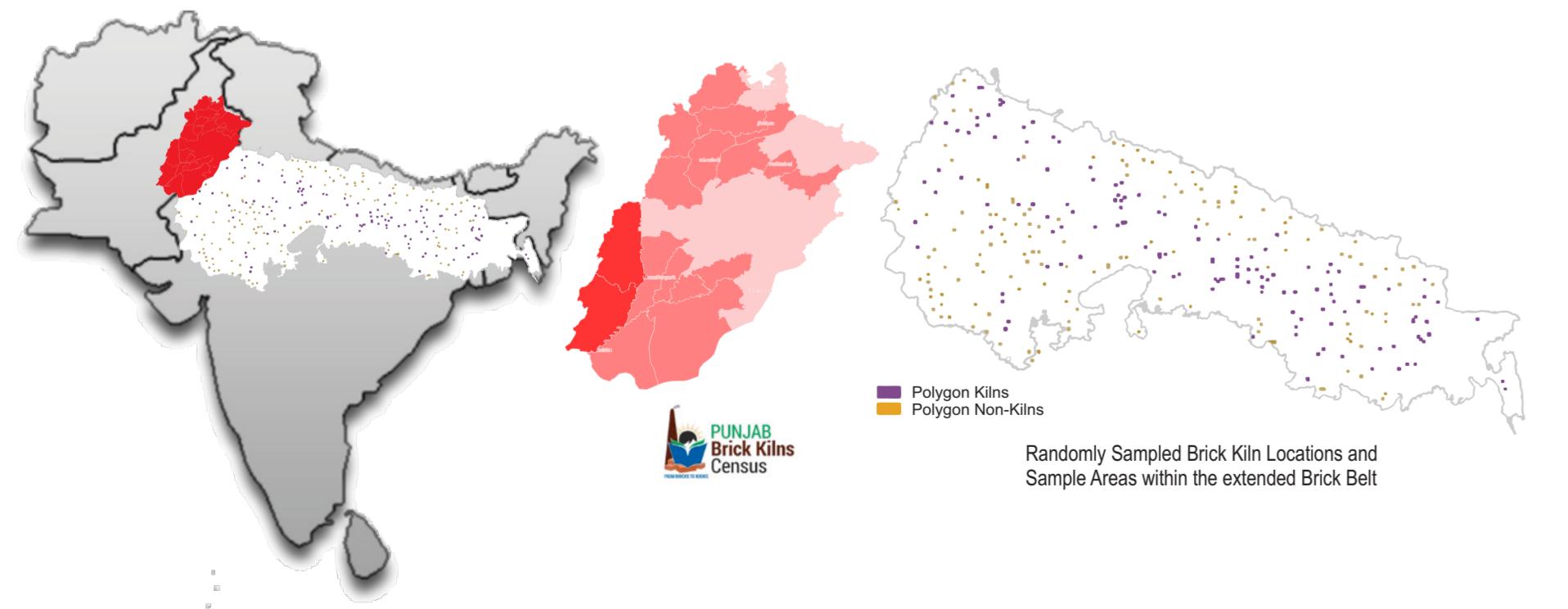
2. Challenges

- Bottleneck: Absence of spatially explicit data
- Huge variations in satellite imagery



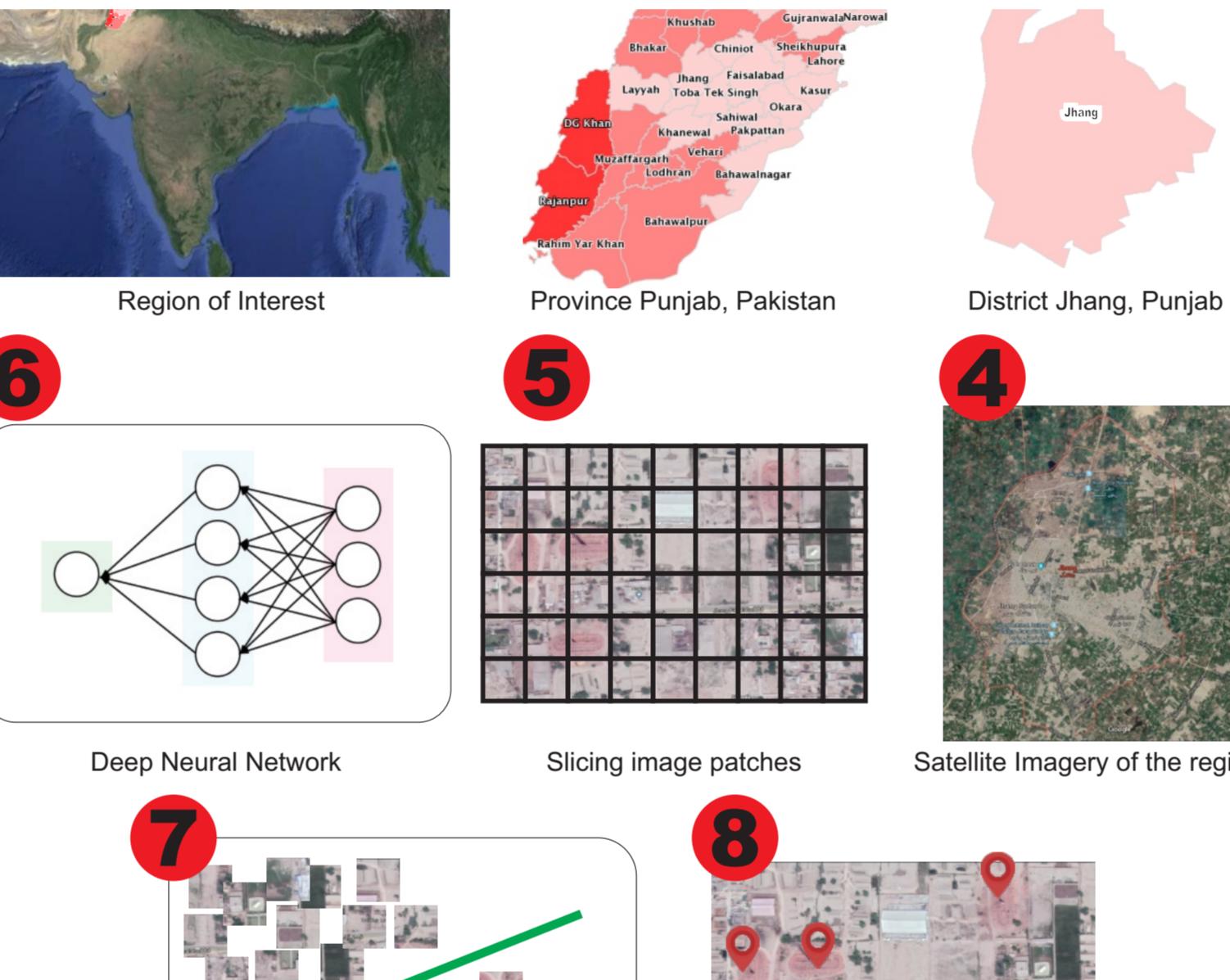
3. Existing Strategies & Limitations

- Field surveys and manual localization are both tedious and lack scalability [2]
- Data obtained manually from satellite imagery is very sparse (320 kilns only) [3]



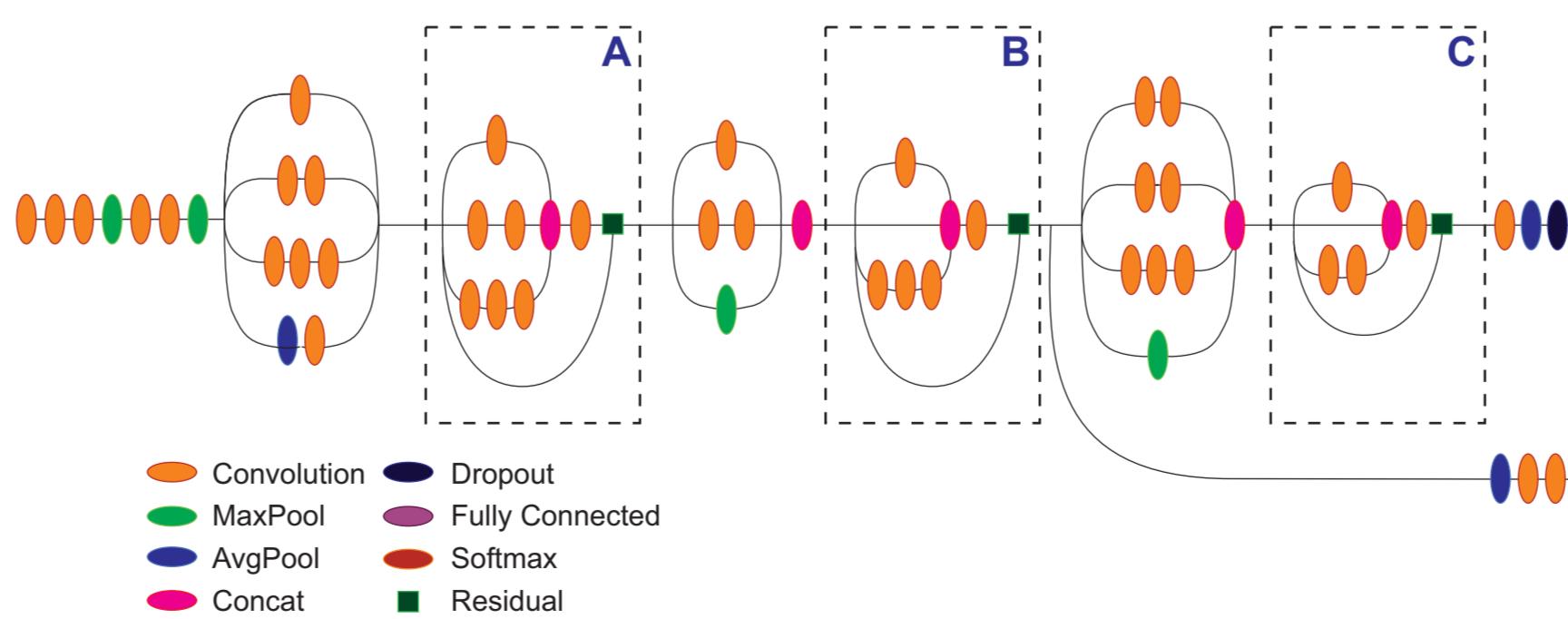
4. Proposed Framework

- Proposed efficient solution to locate brick kilns from remote sensing data



5. Tiny-Inception-ResNet-v2

- Inception-ResNet-v2 contains 11 A-blocks, 20 B-blocks, and 10 C-blocks [1]
- Our best performing tiny version only contains 10 A-blocks, 3 B-blocks, and 3 C-blocks



6. Quantitative Results on Pilot Dataset

- Network trained on 782 images of Lahore, Pakistan at zoom-level 20
- Validated on the images of whole South Asia at zoom-level 17

$$\text{Precision} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Positives}} \quad \text{Recall} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Negatives}}$$

$$F1 \text{ Score} = \frac{2}{\frac{1}{\text{Precision}} + \frac{1}{\text{Recall}}}$$

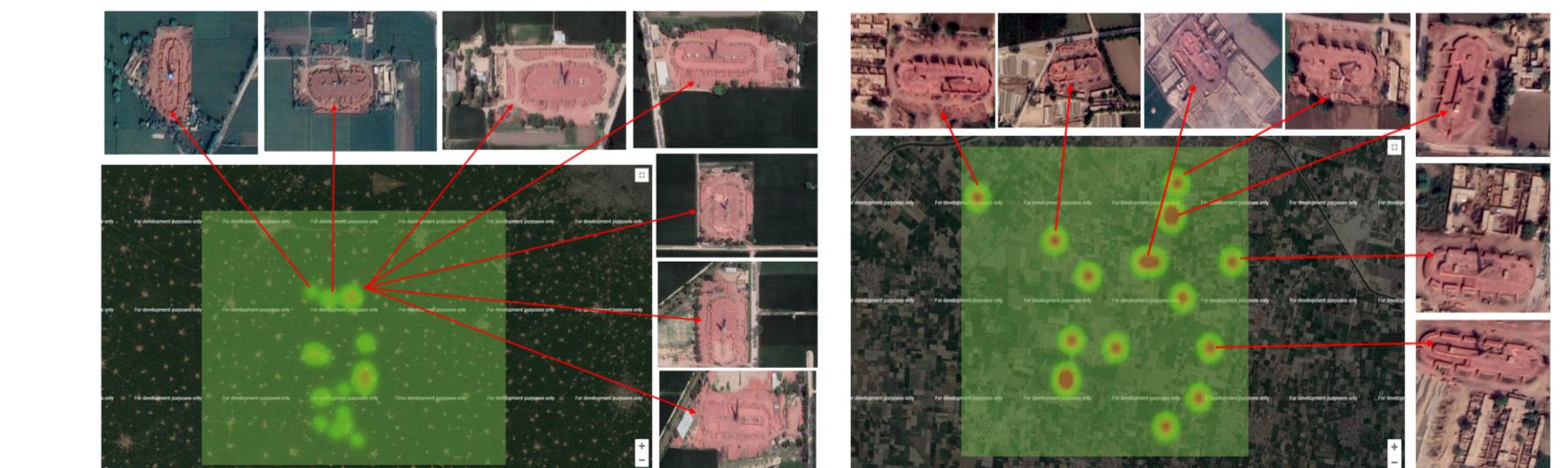
Table 1. Evaluation of the proposed network with state-of-the-art architectures

Network Architectures	Precision	Recall	F1 Score	Parameters (Million)
ResNet-152	0.99	0.81	0.89	41
ResNet-50	0.99	0.84	0.91	21
ResNet-34	0.98	0.88	0.93	21
Inception-v3	0.98	0.74	0.84	21
Inception-ResNet-v2	0.99	0.85	0.92	54
Tiny-Inception-ResNet-v2 (Proposed)	0.98	0.90	0.94	19

Table 2. Comparison between different versions of Inception-ResNet-v2

A-block	B-block	C-block	Val. Loss	Precision	Recall	F1 Score	Parameters (Million)
11	20	10	0.00037	0.99	0.85	0.92	54
20	5	5	0.00016	0.99	0.29	0.45	27
10	3	3	0.00022	0.98	0.90	0.94	19
10	1	1	0.00041	0.99	0.31	0.47	13

7. Qualitative Results



References

- [1] Szegedy, Christian, et al. "Inception-v4, Inception-ResNet and the Impact of Residual Connections on Learning." Thirty-First AAAI Conference on Artificial Intelligence. 2017.
- [2] Punjab Brick Kiln Census, URL: http://202.166.167.115/brick_kiln_dashboard/
- [3] Boyd, Doreen S., et al. "Slavery from Space: Demonstrating the Role for Satellite Remote Sensing to Inform Evidence-Based Action related to UN SDG number 8." ISPRS Journal of Photogrammetry and Remote Sensing 142. (2018): 380-388.