



Land Use Land Cover change assessment of Sundarbans using a multimodal Super-Resolution approach



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Objectives

The key objectives of this study are as follows:

- To conduct a comparative assessment of land use/land cover (LULC) changes in the Indian and Bangladesh parts of the Sundarbans from years 1995 to 2025 and evaluate the extent of vegetation changes over time.
- To evaluate the impact of anthropogenic and climatic factors on the spatial and temporal dynamics of mangrove forest, barren land, urban areas and water bodies, aiming to support sustainable forest management policies.
- To develop a novel classification framework by integrating superpixel segmentation with Generative Adversarial Networks (GANs) for improved remote sensing image classification.
- To enhance spatial feature representation by incorporating superpixel-based spectral-spatial information, which helps preserve object boundaries and structural details in remote sensing images.
- To validate the proposed method's performance by comparing it with existing classification techniques on benchmark datasets, demonstrating improvements in classification accuracy and visual quality.

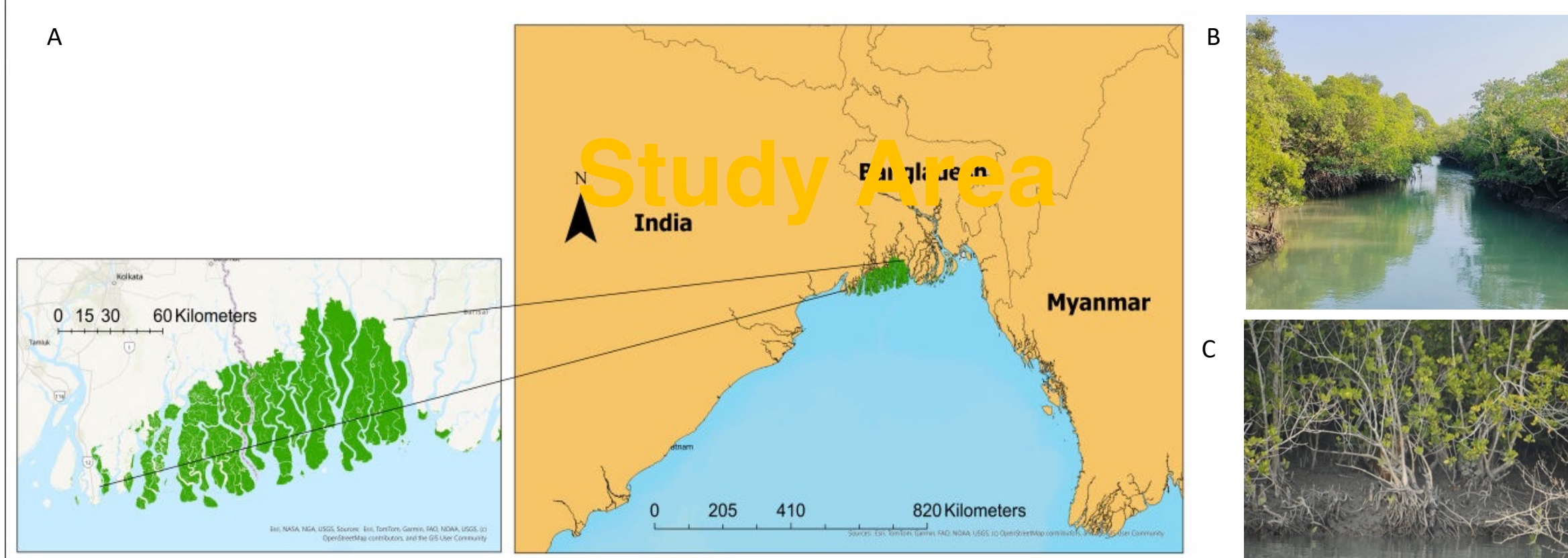


Figure 1: A. Extent of Sundarbans Mangrove forest in India and Bangladesh. B. Mangroves growing on the banks of River Hooghly, India. C. Endangered Bengal tiger camouflage in the Sundarbans .

Methods

- Our study area comprises of the Sundarbans mangrove forests (covering Bangladesh and India), lies between 21°32' and 22°40' N and 88°05' and 89°51' E as shown in Figure 1 with sensor details in Table 1.
- Figure 2 shows the detailed methodology used to correlate LULC change with Normalized Difference Vegetation Index (NDVI) and Land Surface Temperature (LST).
- Super-Resolution, Domain Translation and Generative Adversarial Network (SR-DT GAN) models were applied to sentinel images to increase image resolution by three-fold.

Year	Date and time	Satellite and sensor	Path	Row	Bands	Cloud cover
1995	11/28/1995	Landsat 5 TM	138	45	7	0
	1/28/1995	Landsat 5 TM	138	44	7	0
	1/5/1995	Landsat 5 TM	137	44	7	0
2000	11/26/2000	Landsat 7 ETM +	137	44	7	0
	11/17/2000	Landsat 7 ETM +	138	44	7	0
2005	1/16/2005	Landsat 5 TM	137	44	7	0
	1/7/2005	Landsat 5 TM	138	44	7	0
2010	12/23/2010	Landsat 5 TM	138	45	7	0
	12/16/2010	Landsat 5 TM	138	45	7	0
2015	1/30/2010	Landsat 5 TM	137	44	7	0
	3/8/2015	Landsat 8 OLI	138	45	7	0
2019	12/19/2019	Sentinel-2 MSI	NA	NA	13	0
	12/27/2020	Landsat 8 OLI	138	45	7	0
2020	12/18/2020	Landsat 8 OLI	137	44	7	0
	12/18/2024	Sentinel-2 MSI	NA	NA	13	0
2025	2/24/2025	Landsat 8 OLI	138	45	7	0
	2/16/2025	Landsat 9 OLI-2	137	44	7	0

Table 1. Source and specification of satellite images used in the study.

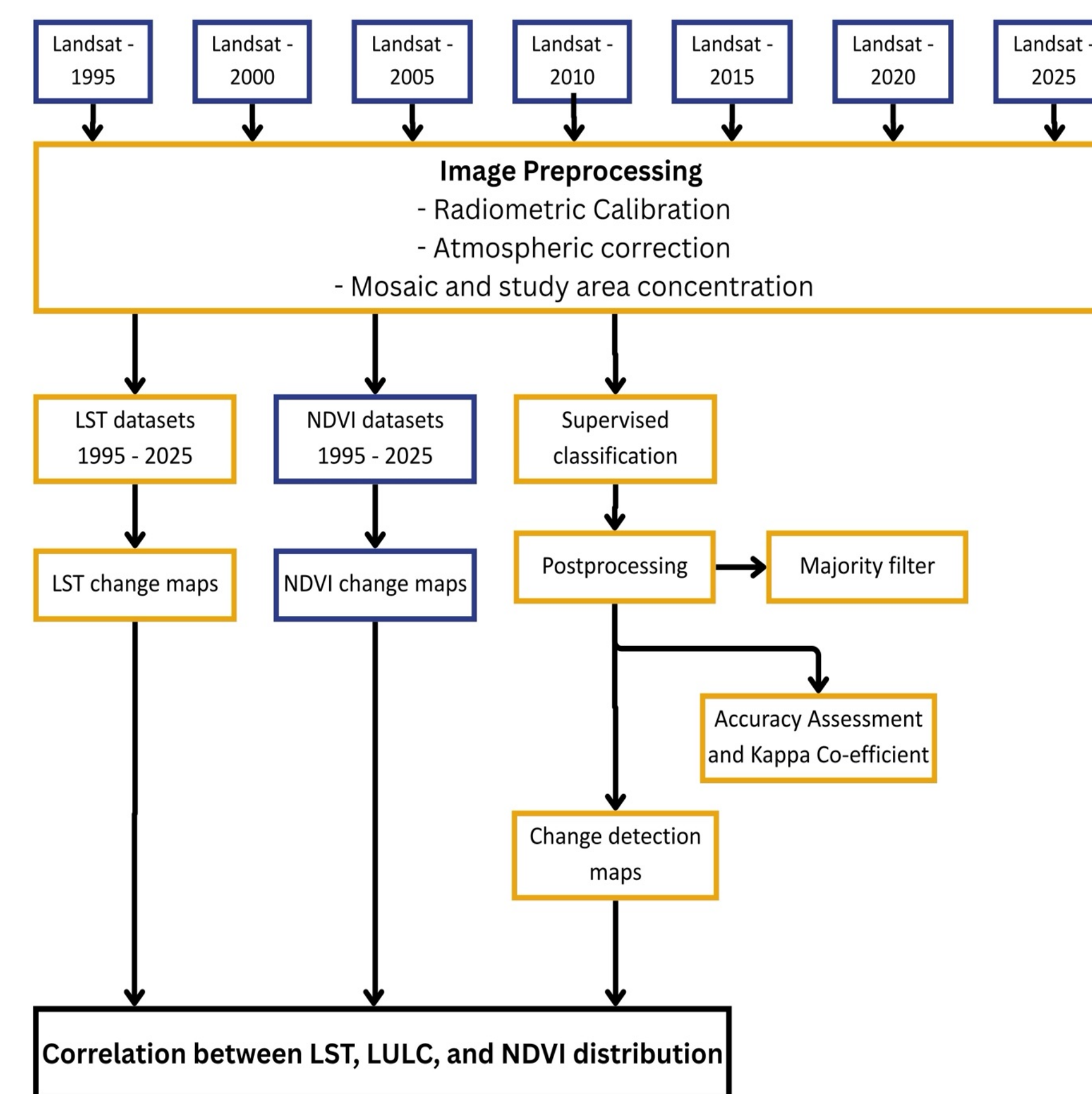


Figure 2: Flowchart of methodology

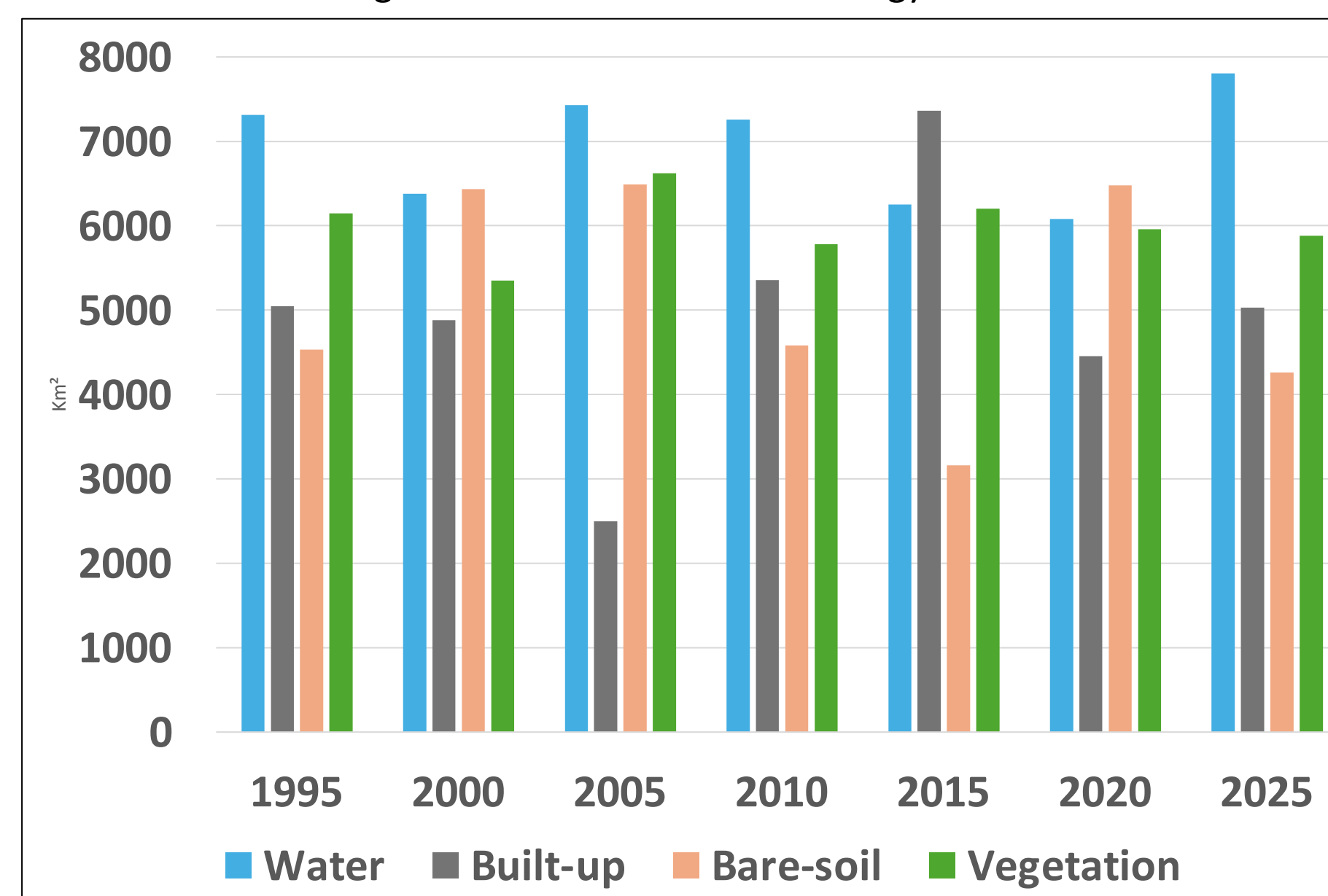


Figure 4: LULC change in kilometer squared for year 1995 – 2025.

Discussion

- Image classifications for each year in Figure 3a, showing change spatially from year 1995 to 2025 revealed mangrove forest reduction and change to built up areas in the recent years shown in Figure 4.
- Overall accuracy ranges were 84.8% to 90.1% from 1995 to 2025.
- Mean NDVI values in Figure 3b have declined from 0.45 and above to 0.21 in 2015, indicating declining healthy forests to bare soil.

Future Work

- Preliminary results for SR-DT GAN, the super-resolved 240x240 patch produced by our deep transformer GAN, successfully recovered finer spatial structure absent in original Landsat.
- Flowchart shown in Figure 5 will be used to test its efficacy
- Some preliminary outputs from DT-GAN shown in Figure 6

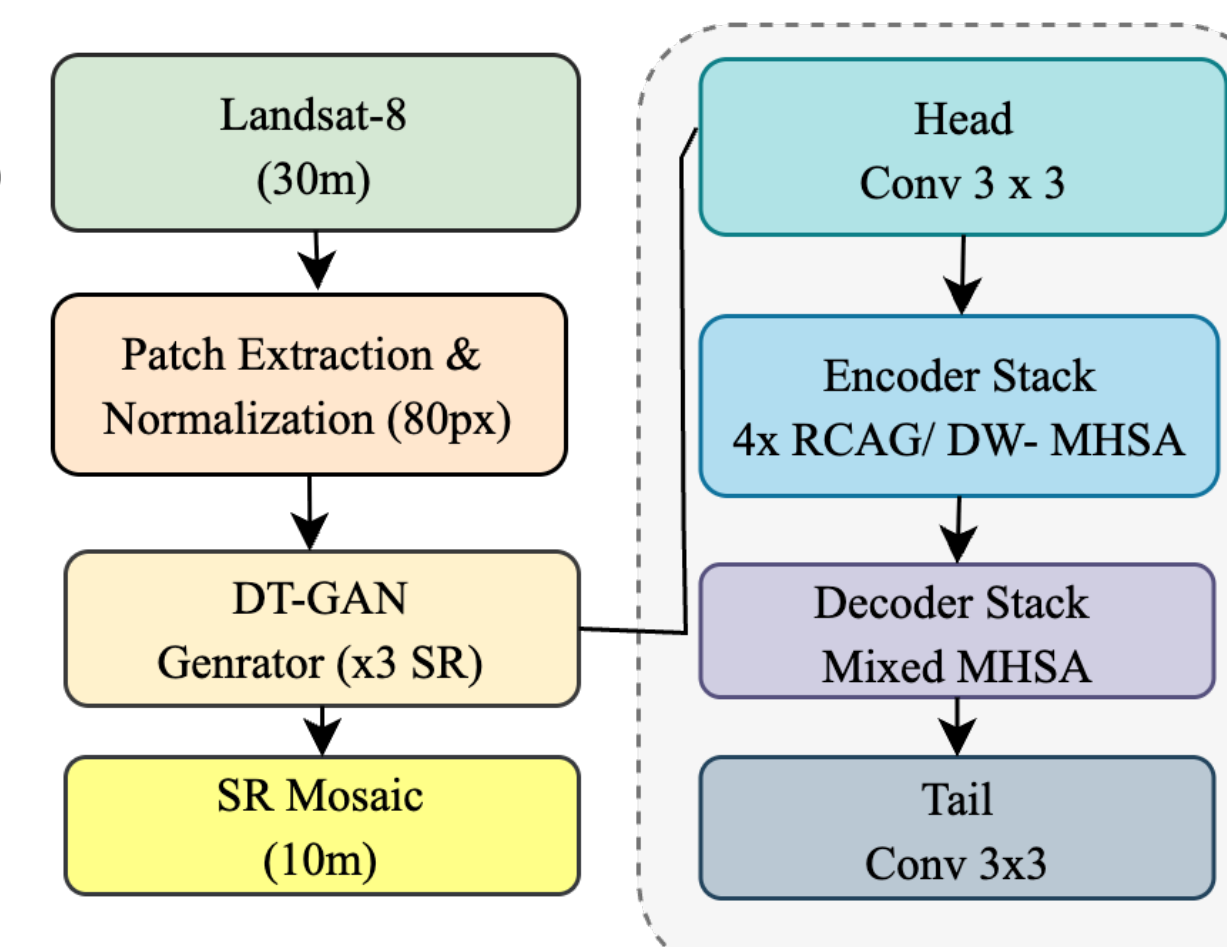


Figure 5: Flowchart of methodology

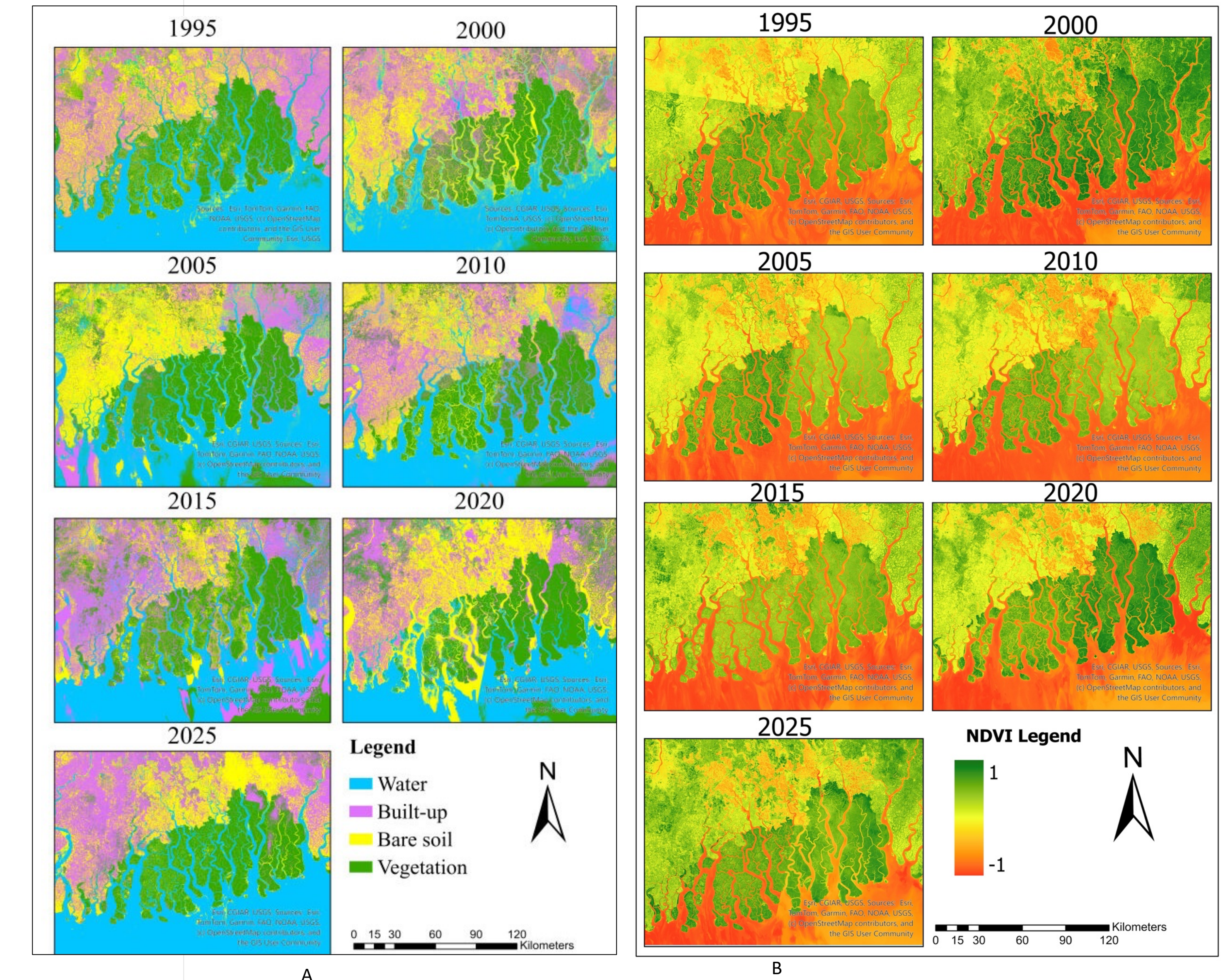


Figure 3: A. LULC change from year 1995 – 2025. B. NDVI change from year 1995 – 2025.

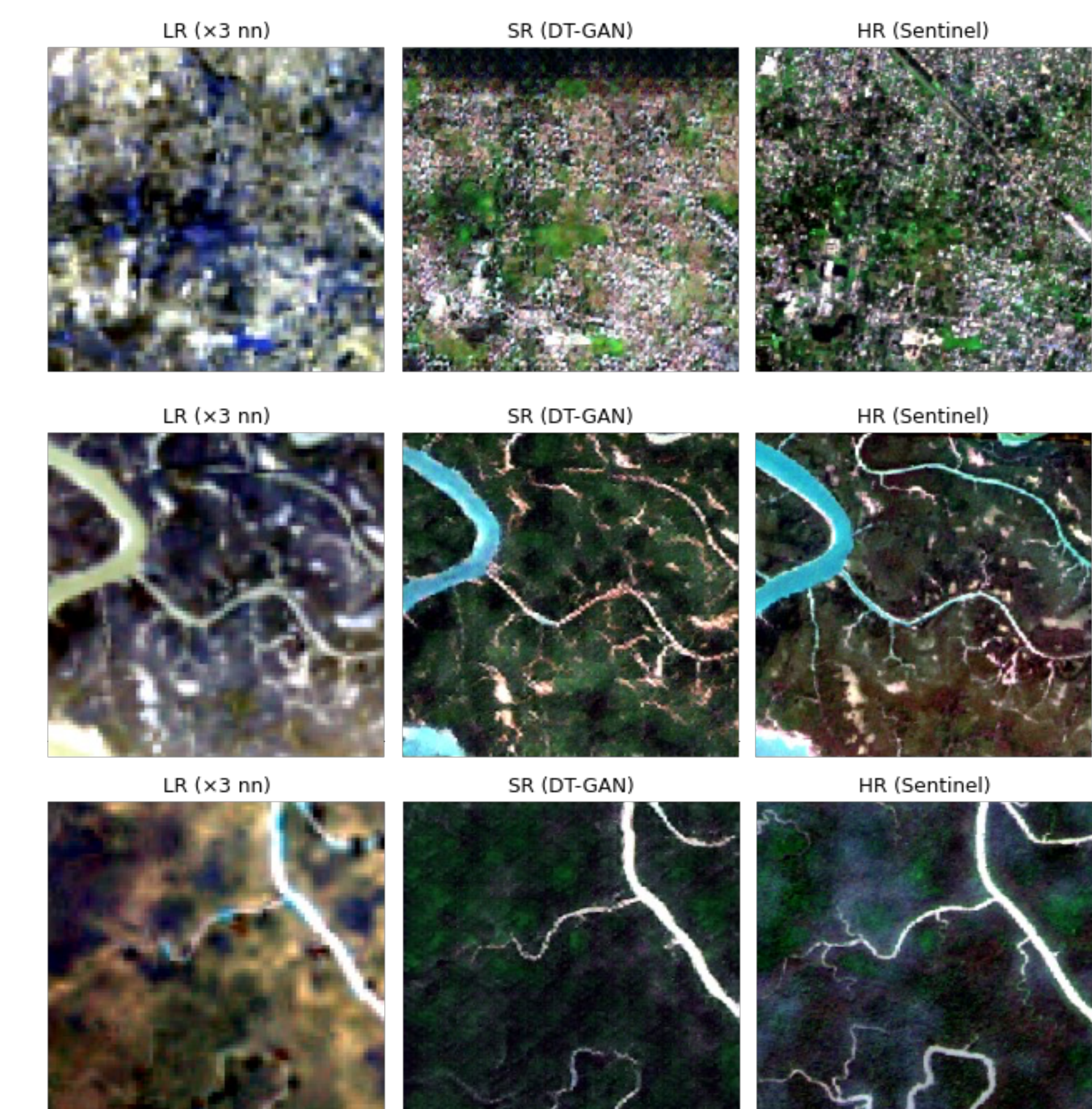


Figure 6: Results of DT-GAN Model on Imagery

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