Urban Morphology Identification using Digital Surface Model (DSM) over Indian Cities

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SUSTAINABLE DEVELOPMENT GOALS

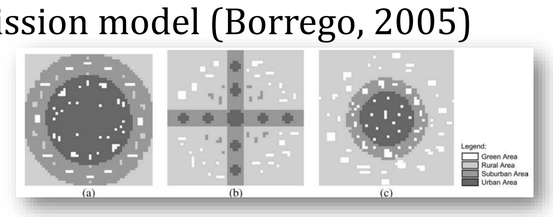
11 SUSTAINABLE CITIES AND COMMUNITIES

11.6: "Reducing impact of adverse air quality on environment"

1. INTRODUCTION: Previous researches have indicated that growth in built-up urban area and air pollution for Indian cities are correlated. Characterization of urban regions into residential, commercial and industrial zones can throw further light on nature of air quality growth and emission factors of these zones. For this, we investigate the possibility of using freely available coarse resolution satellite derived digital surface model (DSM) to estimate building height. The most recent DSMs at global scale are those provided by ASTER GDEMv2 and ALOS World 3D (AW3D) datasets and are distributed freely at 30m resolution. Since nightlight observed from space are reliable indicator of ground human activity, it is hypothesized that using structure height in conjunction with nightlight can reveal characterization of urban areas. We consider an urban region (Kanpur city) in India for comparing the performance of DSM to derive built structure heights. Our results indicate better performance of AW3D datasets to find built structure heights. Our objective is to investigate freely available satellite datasets for building height estimation. Thereafter urban morphology is identified in terms of: residential, commercial and industrial areas

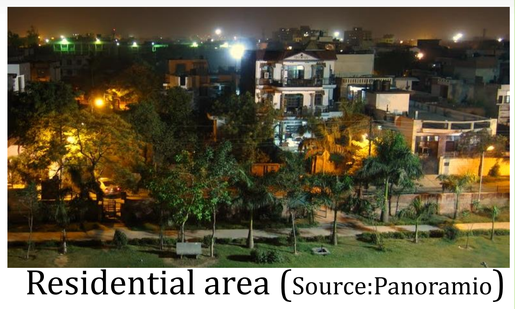
2. BACKGROUND

- Air pollution in Indian cities (aerosol and NO2) is correlated with built-up area and population
- Construction and industrial time series GDP statistically cause air pollution
- Spatial urban structure determines emissions through a landuse-transport-emission model (Borrego, 2005)



How urban morphology (residential, commercial, industrial) and its spatial layout determines urban air pollution?

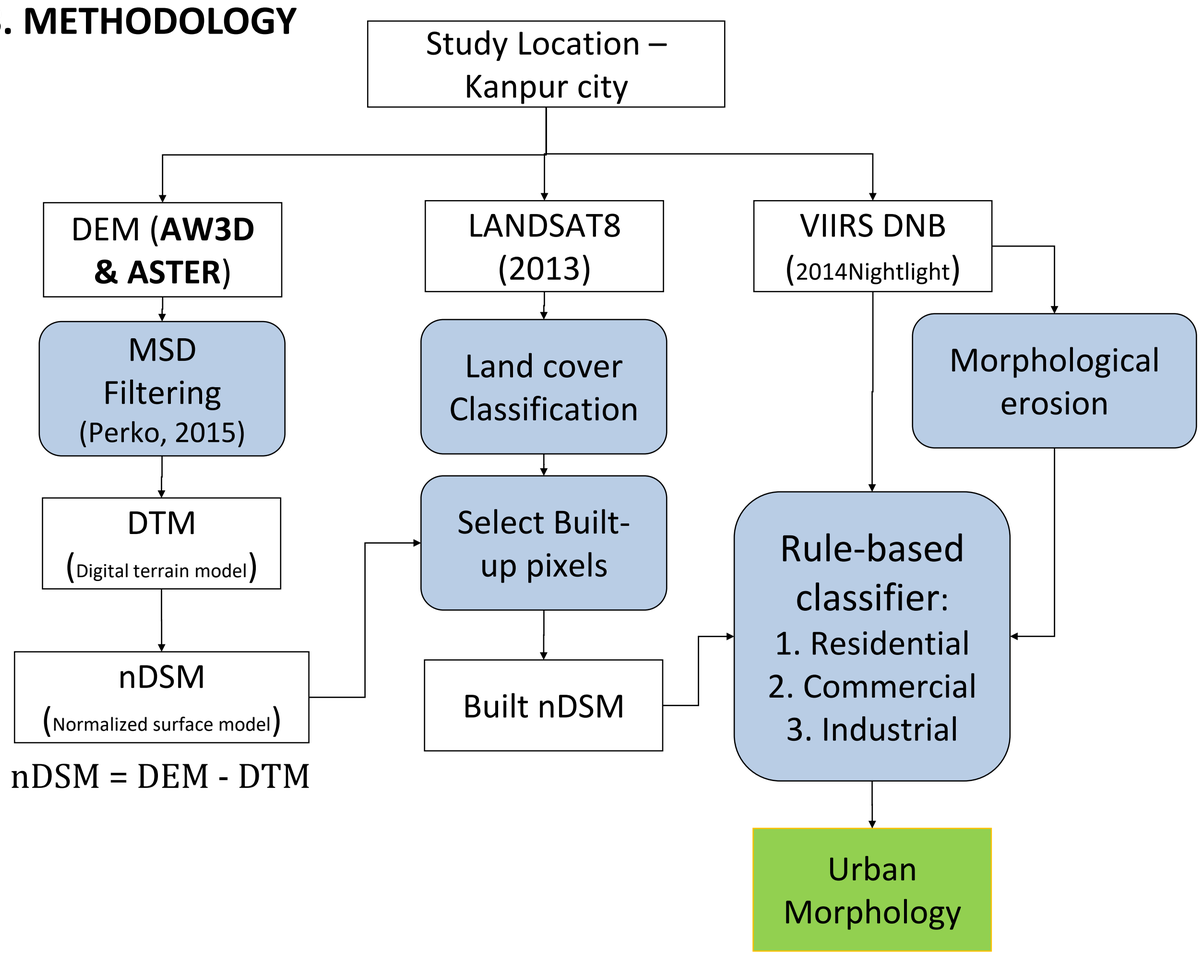
Objective: to identify urban morphology in Indian cities


Residential area (Source:Panoramio)

Commercial area (Source:Flickr)

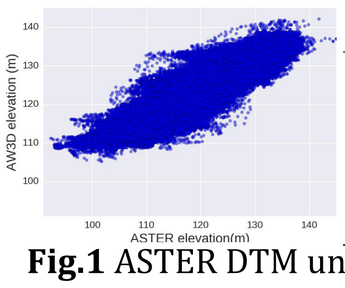

Industrial area (Source:Topcem)

3. METHODOLOGY



nDSM = DEM - DTM

4. RESULTS



Statistic	NCR	
	AW3D(m)	ASTER(m)
Mean	218.3	215.8
StdDev	18.9	19.7
Min	186.4	146.0
Max	341.2	342.5
Skew	2.22	1.80
Kurtosis	6.53	4.96
Corr.	0.97	
RMSE	4.8	

Fig.1 ASTER DTM underestimates

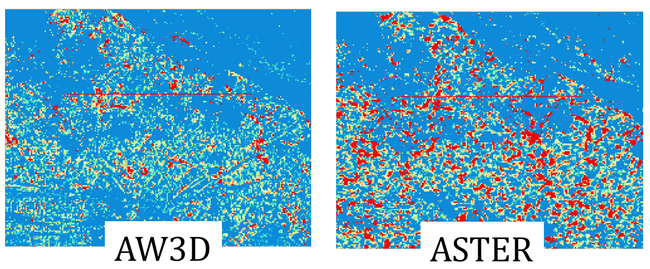


Fig.2 Comparison of nDSM

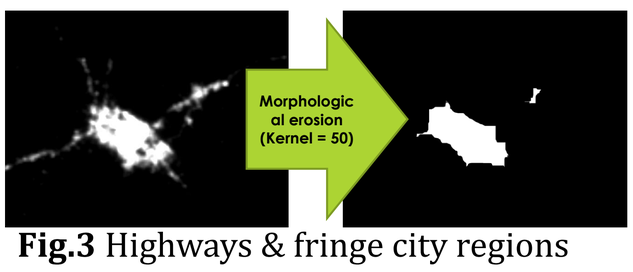


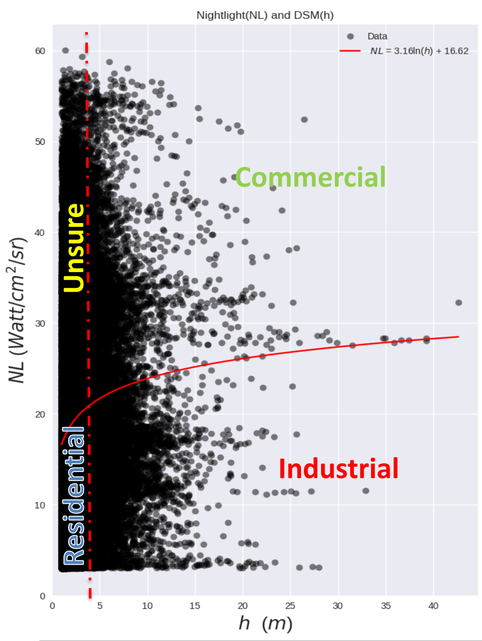
Fig.3 Highways & fringe city regions are removed while estimating 'core'.

Thresholds:
h > = 4m
NL >= NL'

Fig.4 Height threshold is based on uncertainty of AW3D DSM and local municipal law.

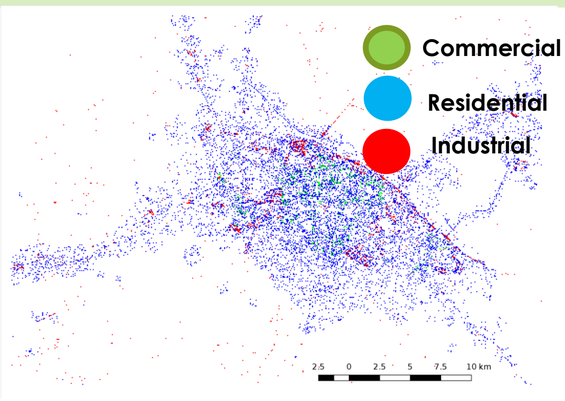
Table 1 Classification rules based on **Fig4.** and **Fig3** threshold. 1 indicate TRUE.

Height	NL	Core	Class
0	0	0	Residence
1	0	0	Industry
1	1	0	Industry
0	0	1	Residence
0	1	1	Unsure
1	0	1	Industry
1	1	1	Commercial



Regression relationship:
NL' = f(h) = 3.16ln(h) + 16.62

Fig.5 Regression relationship between nightlight (NL) and AW3D nDSM (h).



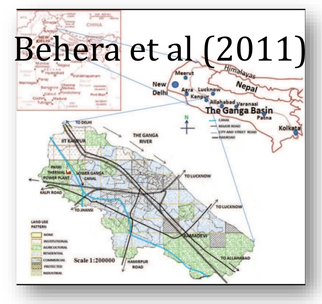


Fig.6 Urban morphology of Kanpur city

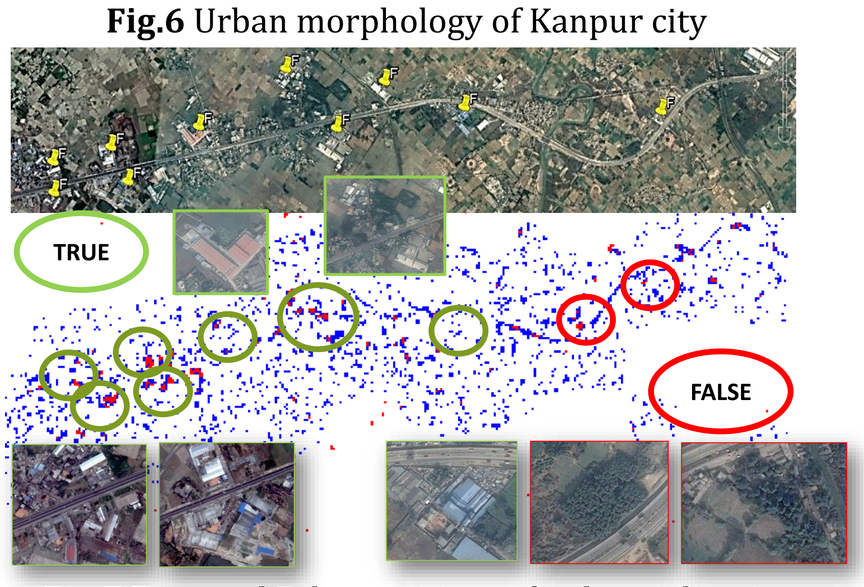


Fig.7 True and False positives of industrial regions

5. DISCUSSION

- AW3D is suitable for structure height extraction while ASTER needs error correction or uncertainty estimation. However ASTER can also be used for urban morphology.
- Nightlight shows correlation with structure heights and estimated urban morphology appears similar to known map.
- Needs processing to get rid of tall vegetation more accurately, possibly using NDVI index.
- Ground truth data to resolve 'unsure' region. Overpasses, bridges, military bldg. identified as industry/commercial. Using road from OSM to increase DTM accuracy.
- Future step: Estimate emission factors of different morphology based on spatial distribution for air pollution studies.

6. REFERENCES

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2) Misra Prakhar and Takeuchi Wataru. Analysis of Air Quality in Indian Cities Using Remote Sensing and Economic Growth Parameters. *36th Asian Conference of Remote Sensing, Manila*, 2015
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