Remote Sensing Concepts and Applications

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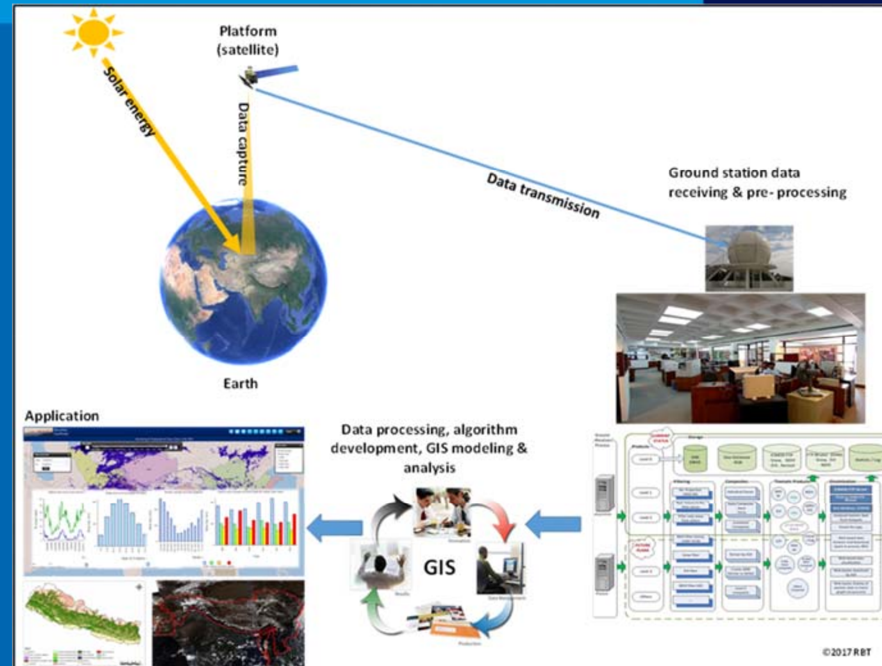
Remote Sensing Concepts



Remote Sensing Concepts

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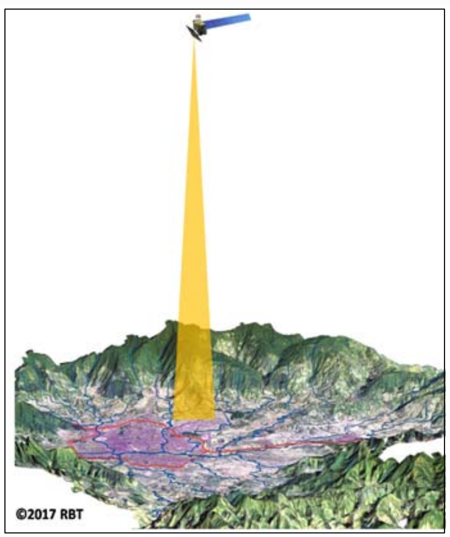
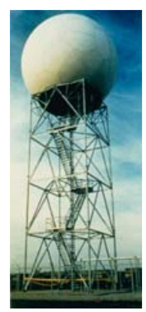


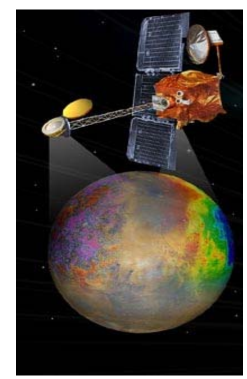
Fig. 2. Satellite remote sensing

- **Remote sensing is the science for collecting and interpreting information on targets (objects or areas) without being in physical contact with them.**
- **It employs electromagnetic energy in the form of radio waves, light, and heat as a means of detecting and measuring target characteristics.**
- **Remote sensing gathers information about the Earth from a distance, usually from aircraft or satellites**

Modern Remote Sensing Platforms


Ground-based


Aerial-based


Satellite-based

Components of Remote Sensing

- **Energy source:** Sun, irradiance from earth's materials which is used in passive remote sensing; RADAR, irradiance from artificially-generated energy sources, which is used in active remote sensing)
- **Platforms**: The vehicle which carries a sensor, i.e., balloon, aircraft, space shuttle, satellite, international space station, etc.
- **Sensors**: Device that receives electromagnetic radiation and converts it into a signal that can be recorded and displayed as either numerical data or an image (camera, scanner, radar, etc.).
- **Processing**: Handling remotely sensed signal data, i.e., photographic, digital, etc.
- **Institutionalization**: Organization for execution at all stages of remote-sensing technology.

Remote sensing work-flow

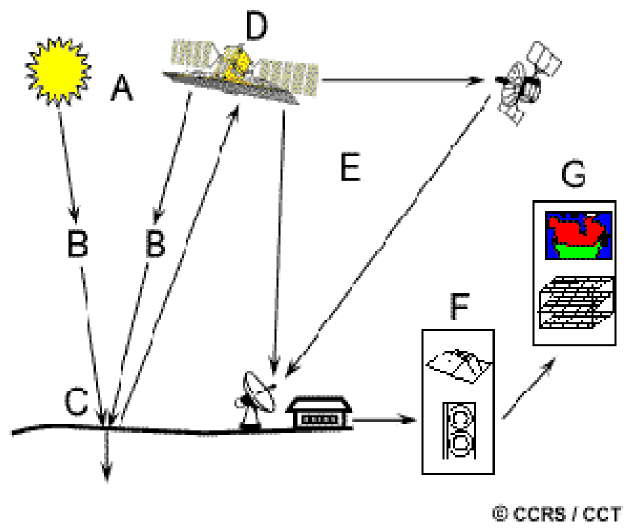
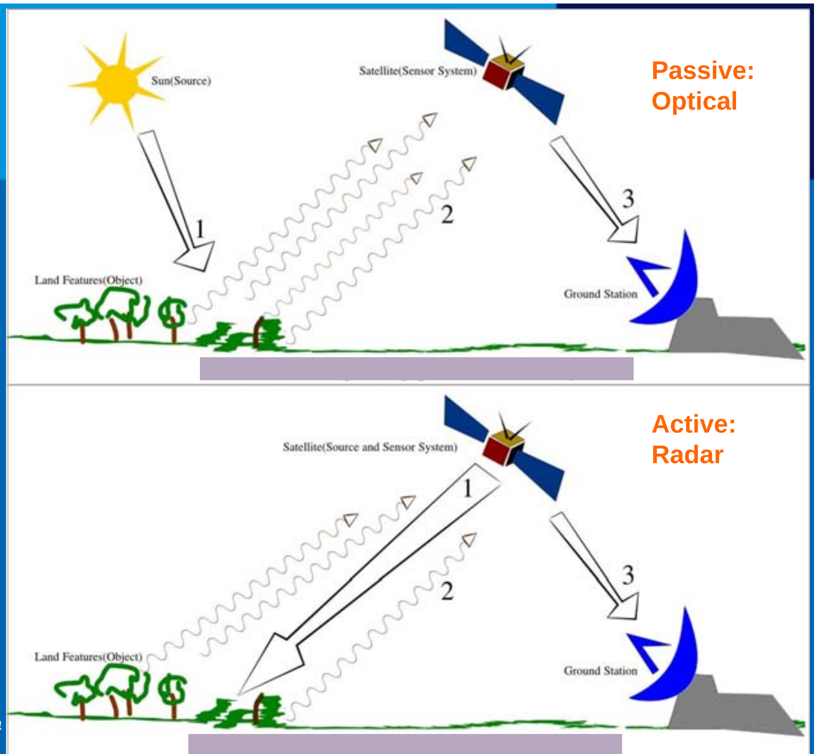


Fig. 3. Remote sensing process (A. Energy source; B. Radiation and the Atmosphere; C. Interaction with the target; D. Recording of energy by the sensor; E. Transmission, reception, and processing; F. Interpretation and analysis, G. Application). Source: CCRS.

Basics of RS System: PASSIVE/ ACTIVE



Source: Wikipedia

RS sensors/platforms …

Passive satellite/sensors (OPTICAL): ALOS AVNIR-2, PRISM; Landsat TM, ETM; AVHRR, Spot, MODIS, IKONOS, Quickbird, Worldview, etc.

Active satellite/sensors (RADAR): ALOS PALSAR, ALOS-2 PALSAR-2, RADARSAT, TanDEM-X, TerraSAR-X, etc.

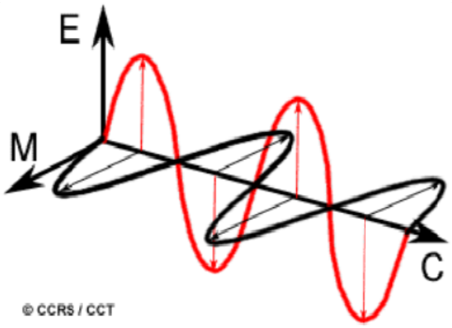
A list of satellites @ http://www.itc.nl/research/products/sensordb/AllSatellites.aspx

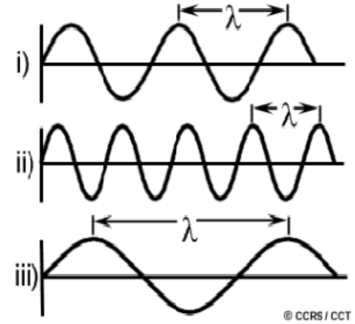
There are also some airborne sensor, such as PiSAR, PiSAR-L2, LiDAR, etc. Recently UAVs are also getting popular

Satellite height: 300~36000 km; Airborne: ~12 km

Electromagnetic Radiation

Energy from any sources comes in the form of electromagnetic radiation





ER consists of Electrical field (E) and Magnetic field (M), travel at the speed of light (C).
Wavelength and Frequency. The wavelength is the length of one wave cycle, which can be measured as the distance (in m, cm, mm, and nm) between successive wave crests. Frequency refers to the number of cycles of a wave passing a fixed point per unit of time. Frequency is normally measured in hertz (Hz), equivalent to one cycle per second, and various multiples of hertz.

These two are inversely related to each other. The shorter the wavelength, the higher the frequency and vice-verse.

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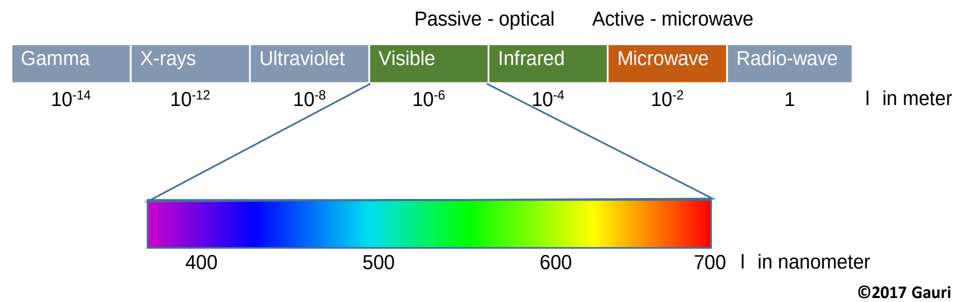
Electromagnetic Spectrum

From very short Gamma rays to very long radio waves



blue (400 – 500), green (500 – 600) and red (600 – 700) bands

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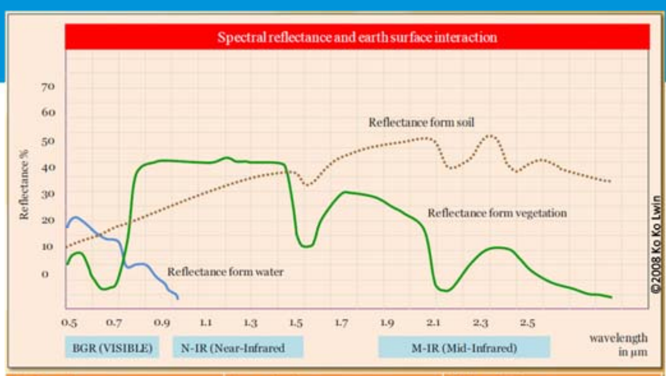
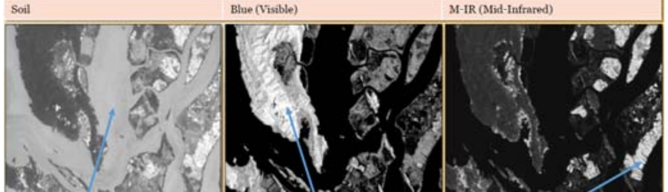
Spectral Properties of Objects



Surface category	Low reflectance	High reflectance
Water	N-IR (Near -Infrared)	Blue (Visible)
Vegetation	M-IR (Mid-Infrared)	N-IR (Near-Infrared)
Soil	Blue (Visible)	M-IR (Mid-Infrared)



TM B1: High reflectance in water TM B4: High reflectance in vegetation TM B7: High reflectance in bare soil

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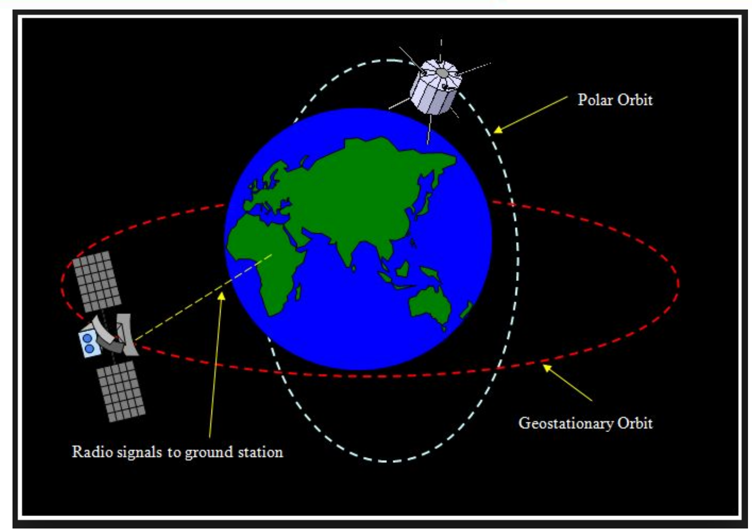
Types of Remote Sensing Images

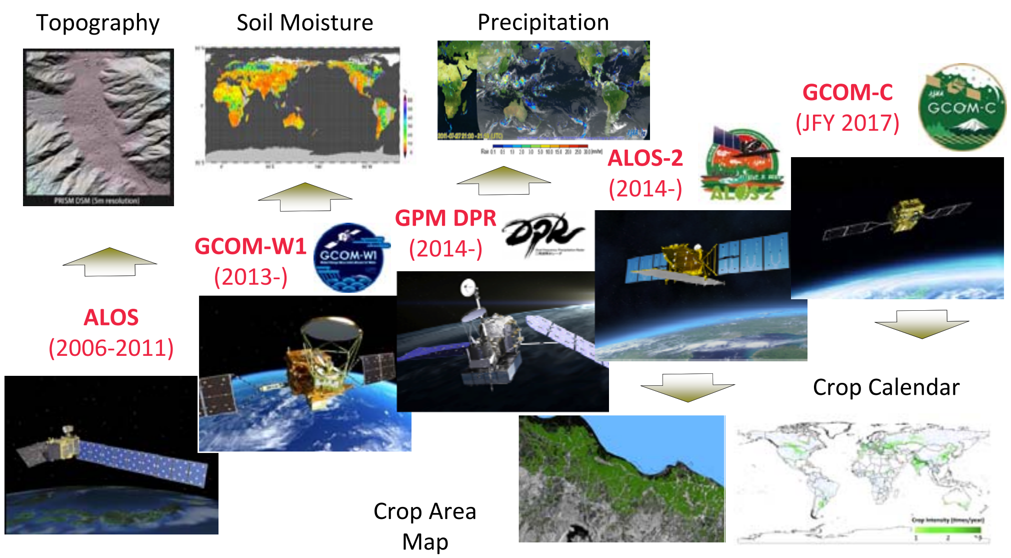
Polar orbit (sun-synchronous), earth resources satellites, Landsat, SPOT, ALOS, IKONOS, QuickBird, etc.

Geostationary orbit, directly over equator at very high altitudes and revolves in the same direction that the earth rotates (west to east), used in metrological, communication and broadcasting applications (e.g., GEOS, Meteosat, EDUSAT, GALAXY-27, KALPANA-1, etc.).



Types of information from remote sensing…

- ❖ Field survey, Field sensor, UAV, Airplane, Satellite …
- ❖ Satellite Sensors: Optical, RADAR, MWR, LiDAR etc.



NASA Fleet - 2015

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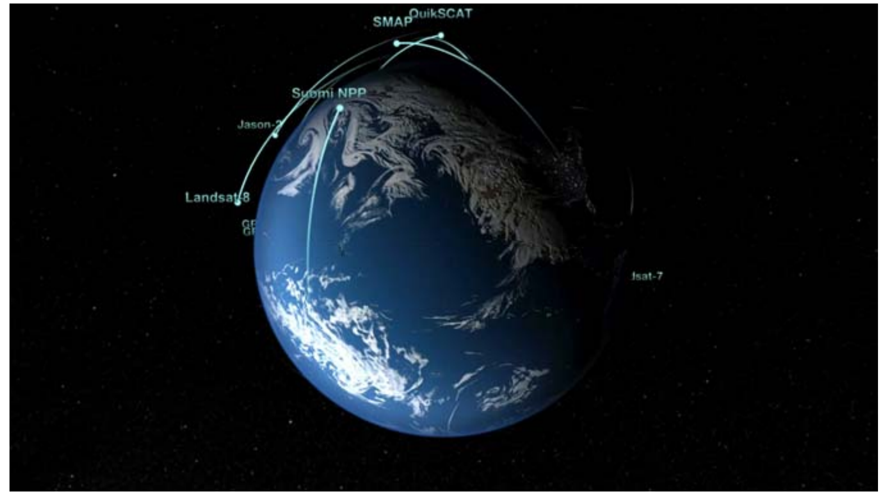

Nadir vs Oblique viewing

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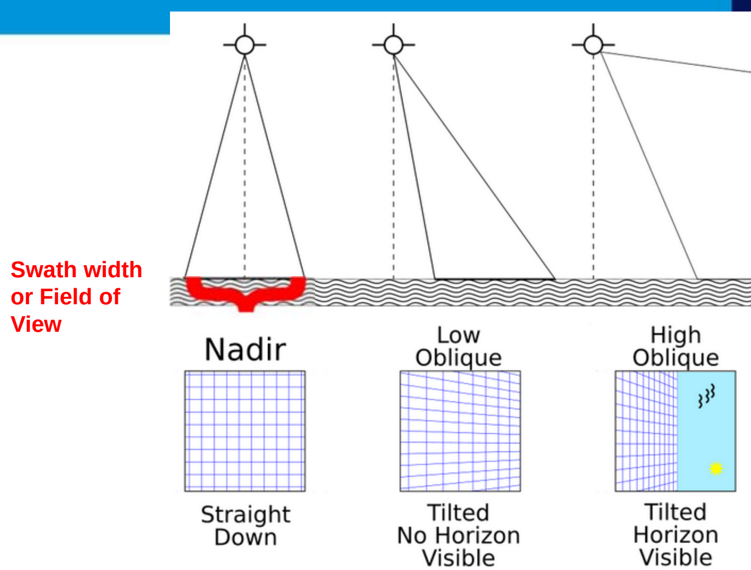

Nadir vs Oblique viewing

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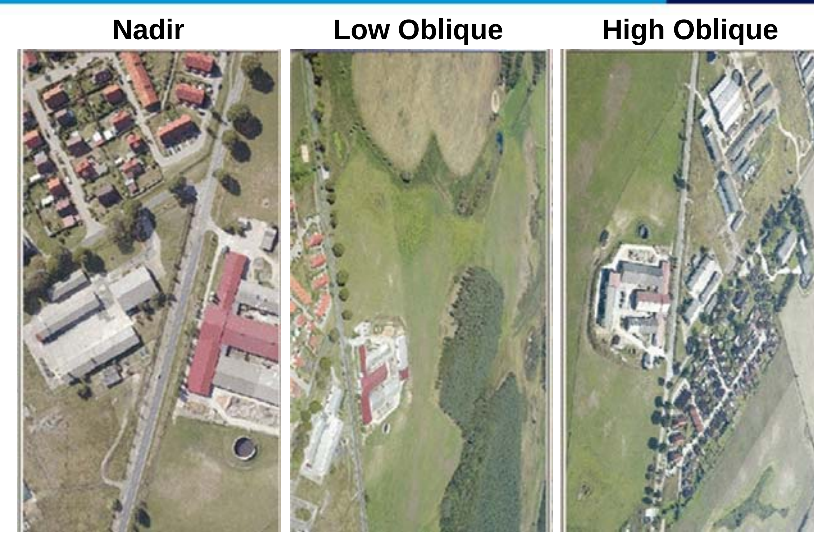


Characteristics of Remotely Sensed Imagery

Remote sensing systems differ in the level of detail or resolution they can capture and data are available at a variety of resolutions, we will cover four types of satellite resolution:

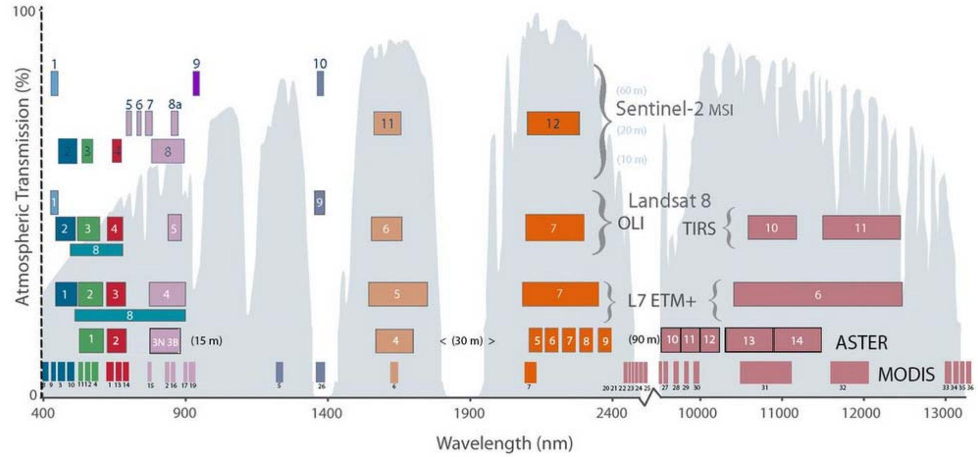
1) **Spectral Resolution – refers to the degree to which a satellite sensor can distinguish or resolve features of the electromagnetic spectrum**

2) **Radiometric Resolution – refers to the number of quantized bits that are used for recording the reflected electromagnetic energy.**

3) **Spatial Resolution – refers to the number of pixels utilized in construction of a digital image. Images having higher spatial resolution are composed of a greater number of pixels than those of lower resolution.**

4) **Temporal Resolution – refers to the frequency of a measurement with respect to time. Often there is a trade-off between temporal and spatial resolution.**

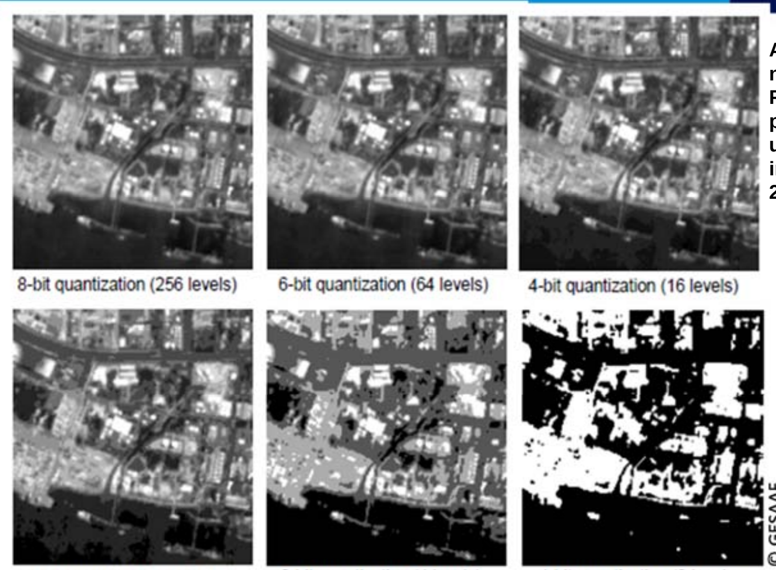
Spectral Resolution



Spectral Bands Commonly Used in Remote Sensing

Spectral bands (µm)	Applications
Blue (0.45 – 0.52)	analysis of water characteristics, water depth, and the detection of subsurface features
Green (0.52 – 0.60)	water quality studies measuring sediment and chlorophyll concentration
Red (0.63 – 0.69)	discriminating vegetation types, assessing plant condition, delineating soil and geologic boundaries, and identifying cultural features
Panchromatic (0.50 – 0.90)	digitally combined with two or three of the multispectral bands to produce color images with spatial detail of the panchromatic image and the spectral detail of the multispectral bands
Near Infrared (0.7 – 1.0)	useful for vegetation mapping, crop condition monitoring, biomass estimation, and soil moisture assessment
Shortwave Infrared (1.0 – 3.0)	useful for analyzing moisture levels in soil and for monitoring plant vigor and crop condition, distinguishing clouds from snow and ice
Medium wave (3.0 - 8) and Long Wave Infrared (8 – 14)	useful to measure the temperature of features such as industrial sites, pipelines carrying heated materials, geothermal sites, and thermal pollution, also useful for the analysis of vegetation stress, soil moisture, and geology
Microwave region (radar)	useful for mapping of vegetation structure and biomass, flooding, geological sites, etc.

Radiometric Resolution



8-bit quantization (256 levels) 6-bit quantization (64 levels) 4-bit quantization (16 levels)
3-bit quantization (8 levels) 2-bit quantization (4 levels) 1-bit quantization (2 levels

A bit is a binary number that is 0 or 1. For computer processing, the byte unit (1 byte =8bits; integer value 0-255; 256 grey levels)

Spatial Resolution

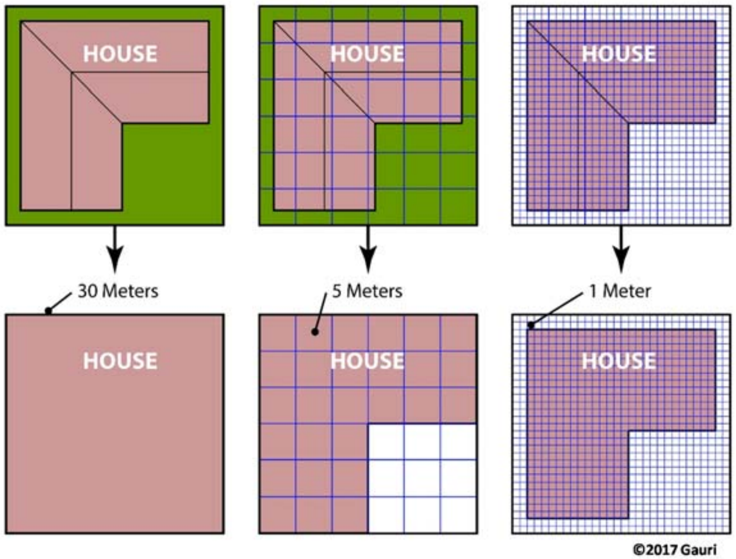


Fig. 8. Impact of spatial resolution

Spatial Resolution

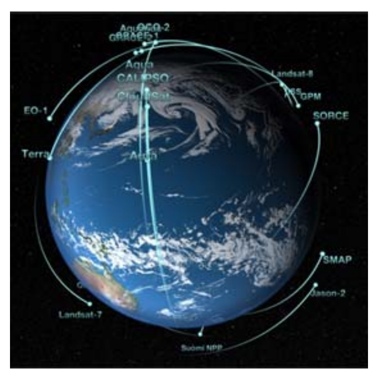
Fig. 9. Spatial resolution: Landsat 8, 30m (left) and World View-2, 0.5m (Image source: Google Earth)

Spatial resolution: Satellites…

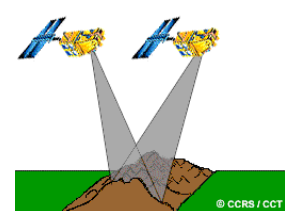
Geoeye: 0.41m	**Rapid Eye: 5m**
Worldview 1,2 : 0.46m	**ALOS: 2.5m~100m**
Pleiades-1A: 0.5m	**ALOS 2: 3m~100m**
Quickbird: 0.61m	**Sentinel 1: 5m~100m**
Ikonos: 0.82m	**Sentinel 2: 10m~60m**
SPOT6: 1.5m	**ASTER: 15m**
Spot5: 2.5m/5m	**LANDSAT: 15m~60m**
	MODIS 250~1000m

Temporal Resolution

The temporal resolution specifies the revisiting frequency of a satellite sensor for a specific location.



High temporal resolution: < 24hours – 3days
Medium temporal resolution: 4-16 days
Low temporal resolution: > 16 days



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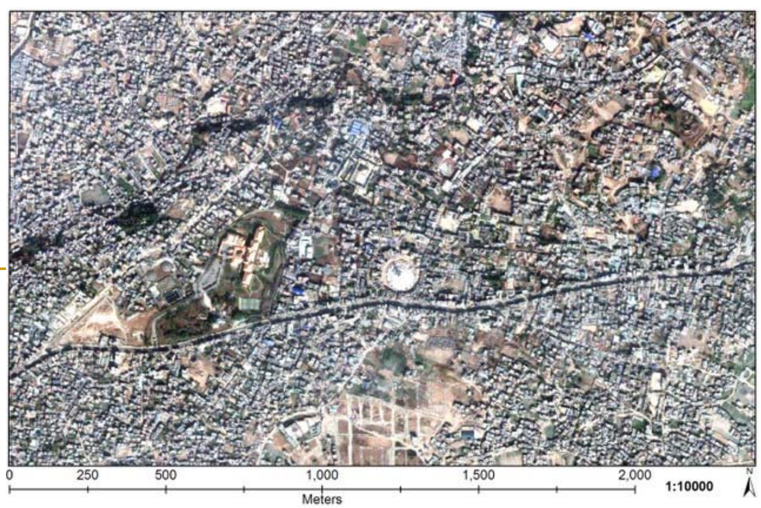
Remote Sensing Applications

Kathmandu landscape

Kathmandu: Baudhanath area in 2010

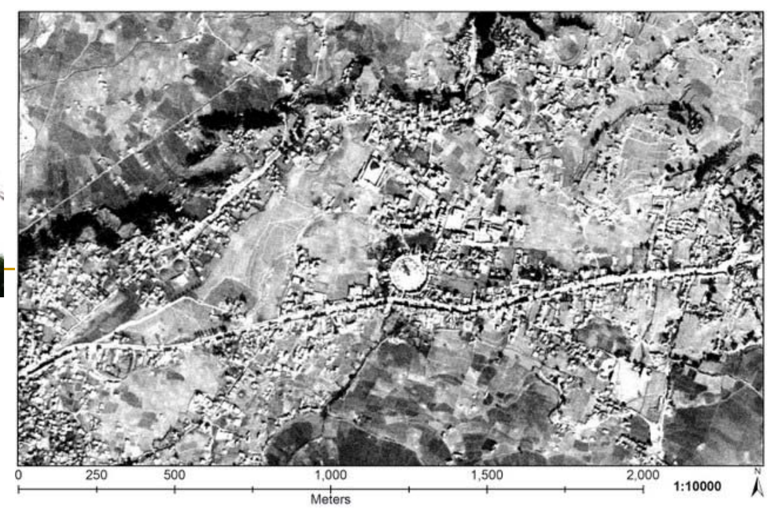
Landmark:
Baudhanath Temple
(*World Heritage Site*)



GeoEye Satellite Imagery, Jan 23, 2010

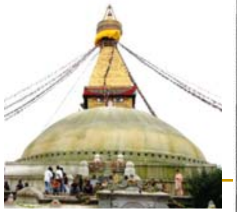
Kathmandu: Baudhanath area in 1991

Landmark:
Baudhanath Temple
(*World Heritage Site*)

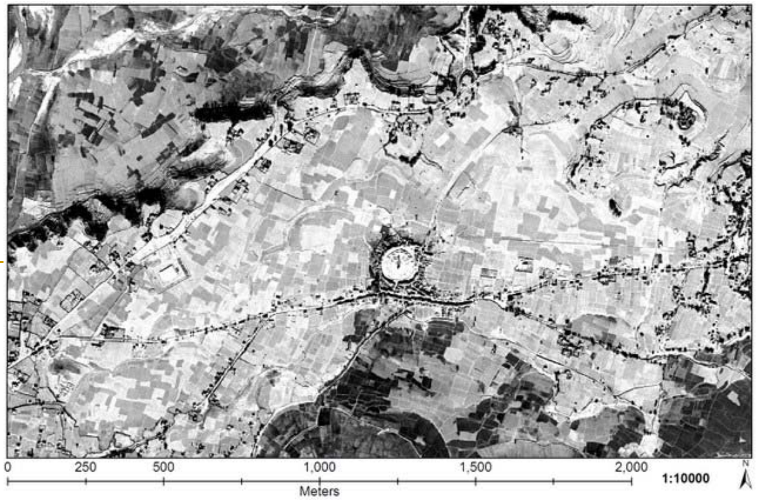


SPIN-2 Satellite Imagery, Feb 5, 1991

Kathmandu: Baudhanath area in 1967

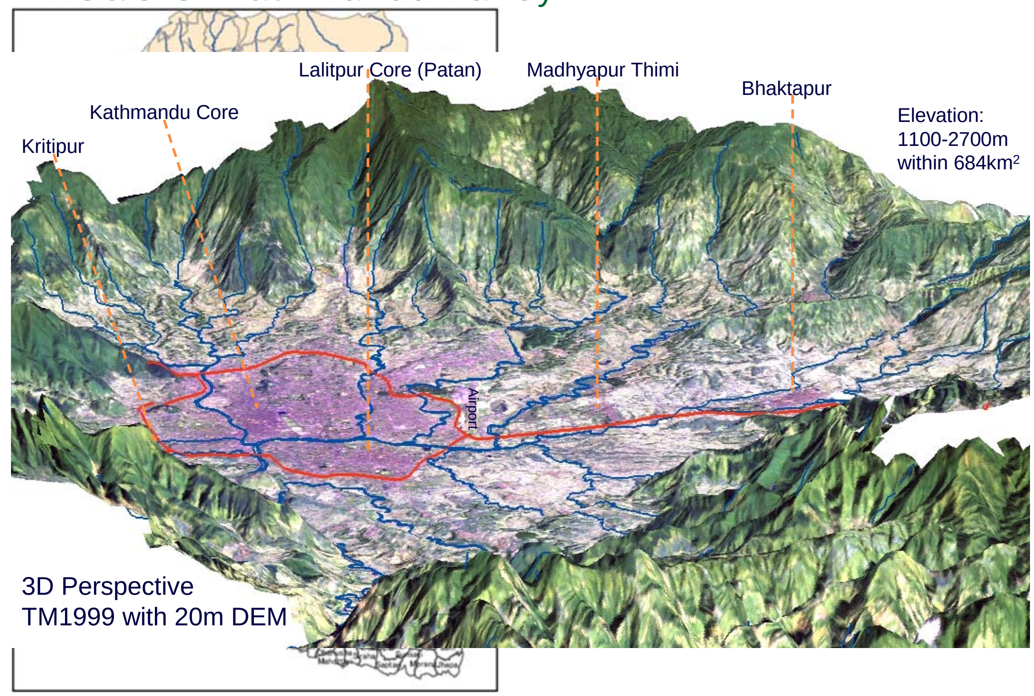


Landmark:
Baudhanath Temple
(*World Heritage Site*)



CORONA Satellite Imagery, Feb 5, 1967

RS&GIS: Kathmandu Valley



Land use analysis at micro level – fringe area

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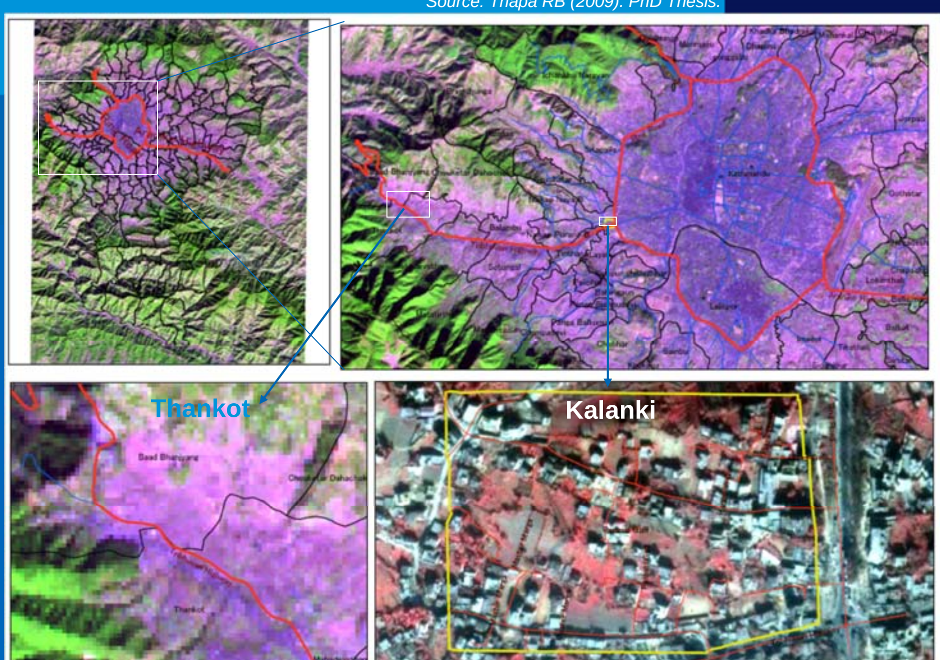
Source: Thapa RB (2009). PhD Thesis.



Land use analysis at micro level: study area - Kalanki – from satellite

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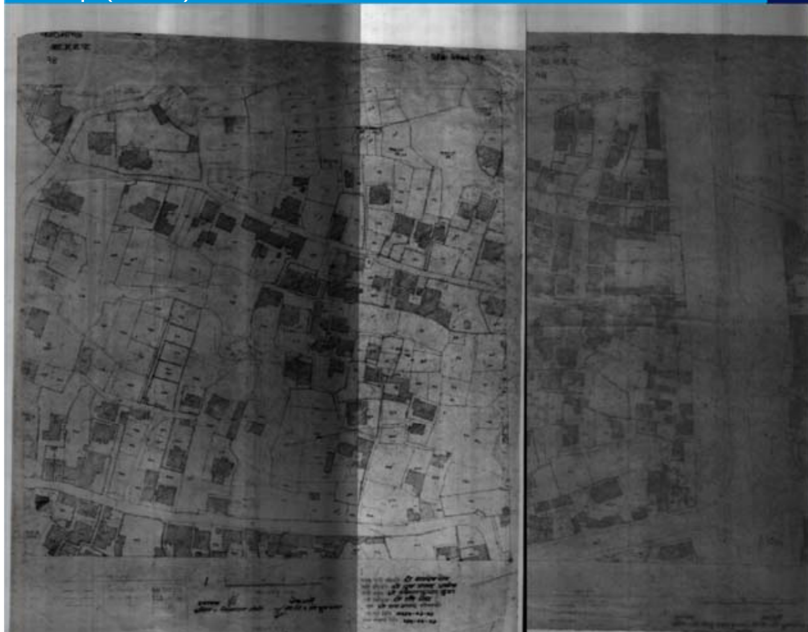
Source: Thapa RB (2009). PhD Thesis.

Land use analysis at micro level – study area -cadastral map (1:500)

Source: Thapa RB (2009). PhD Thesis.



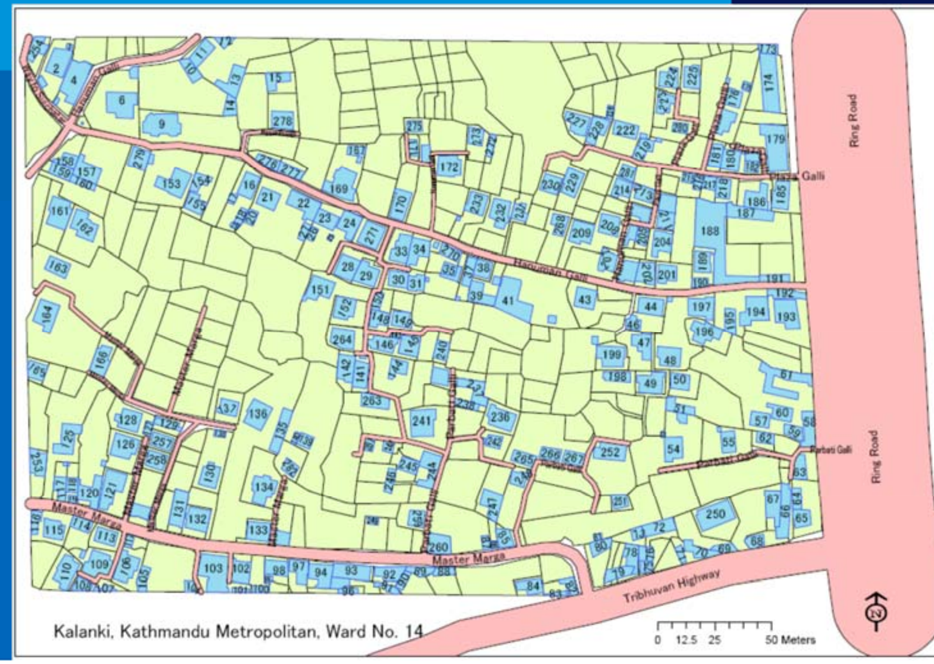
Process:
-Scanned the paper maps

-Geometry correction in real coordinate system

-Digitizing land parcels, house parcels and roads

Land use map at micro level

Source: Thapa RB (2009). PhD Thesis.



Land use analysis at micro level – cadastral map overlay with satellite imagery

Source: Thapa RB (2009). PhD Thesis.

Land use analysis at micro scale: initial results

Source: Thapa RB (2009). PhD Thesis.

Land use change analysis at micro scale to be continued…

Key statistics:

Cadastral maps (Yr. 2002) = 2 sheets

Total houses derived from the cadastre = 240

Total houses after updating the maps using field work information = 268 (as of Yr. 2007)

Current state of house use		
Purpose	N	Percentage
Business	33	12.31%
Business/Residence	26	9.70%
Residence	178	66.42%
School	7	2.61%
Temple	2	0.75%
Unknown	22	8.21%
Total observation	268	100.00%

Land use changes… Micro case study: Kalanki

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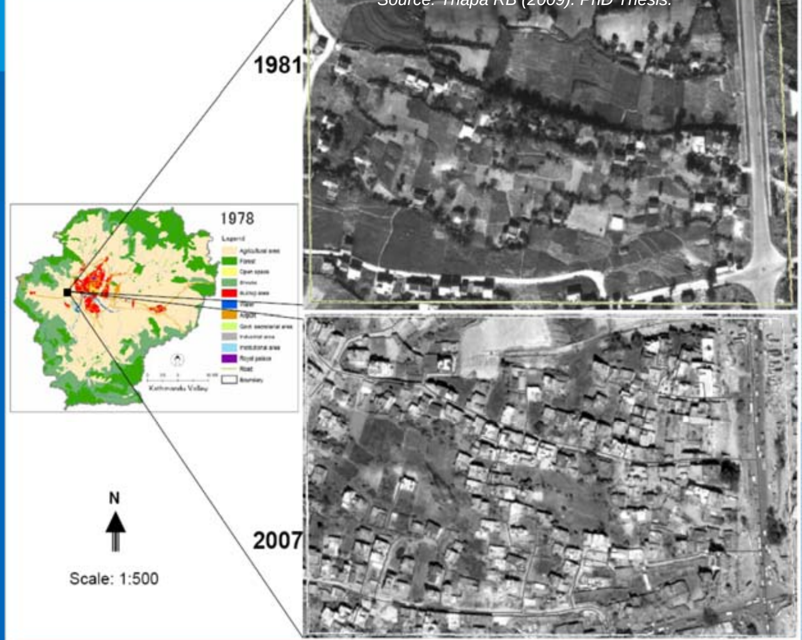
Source: Thapa RB (2009). PhD Thesis.



Land use changes… at micro case

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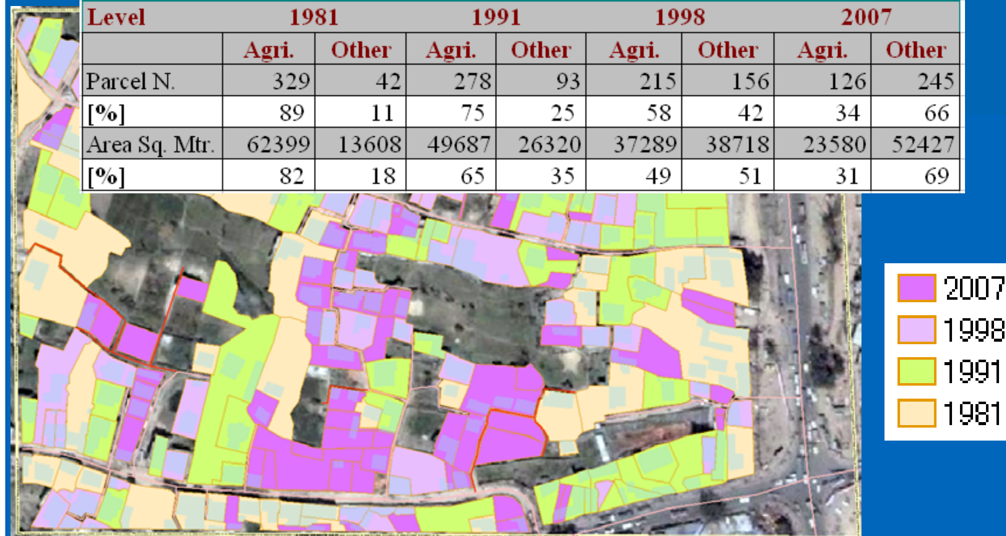
Source: Thapa RB (2009). PhD Thesis.

Agricultural area transformation to other uses

Level	1981		1991		1998		2007	
	Agri.	Other	Agri.	Other	Agri.	Other	Agri.	Other
Parcel N.	329	42	278	93	215	156	126	245
[%]	89	11	75	25	58	42	34	66
Area Sq. Mtr.	62399	13608	49687	26320	37289	38718	23580	52427
[%]	82	18	65	35	49	51	31	69



Land use … at micro case (2007)

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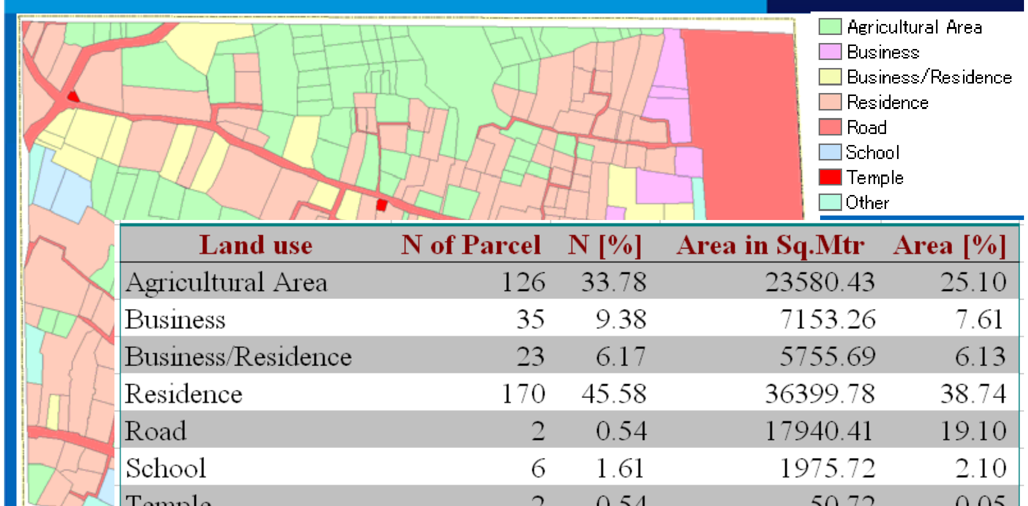
Source: Thapa RB (2009). PhD Thesis.



Land use	N of Parcel	N [%]	Area in Sq.Mtr	Area [%]
Agricultural Area	126	33.78	23580.43	25.10
Business	35	9.38	7153.26	7.61
Business/Residence	23	6.17	5755.69	6.13
Residence	170	45.58	36399.78	38.74
Road	2	0.54	17940.41	19.10
School	6	1.61	1975.72	2.10
Temple	2	0.54	50.72	0.05
Other	9	2.41	1091.33	1.16
Grand Total	373	100.00	93947.34	100.00

Land use changes… at micro case

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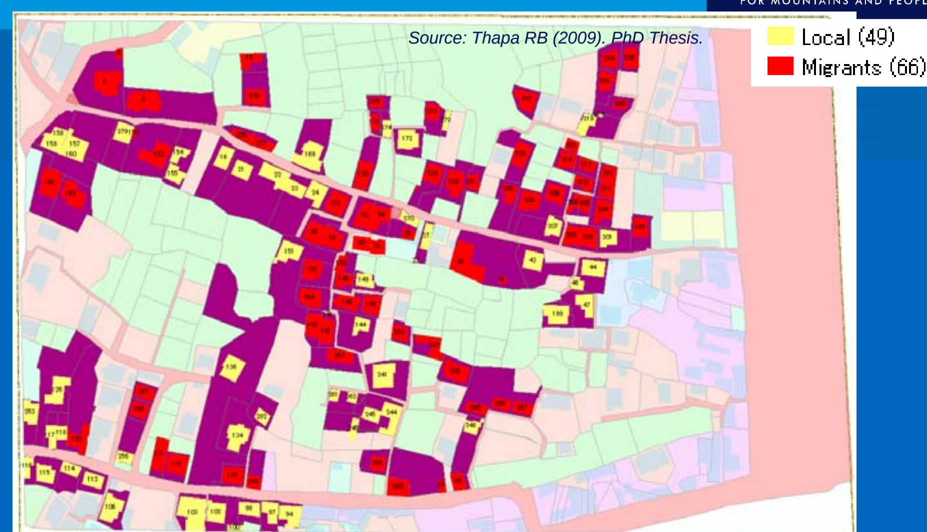
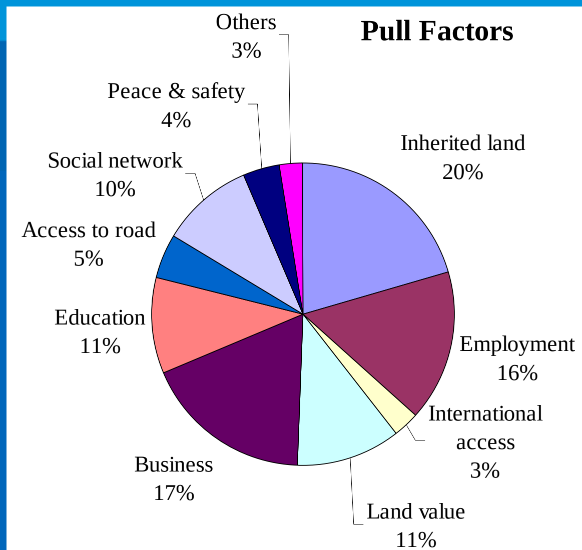
Respondents' location and composition

Source: Thapa RB (2009). PhD Thesis.

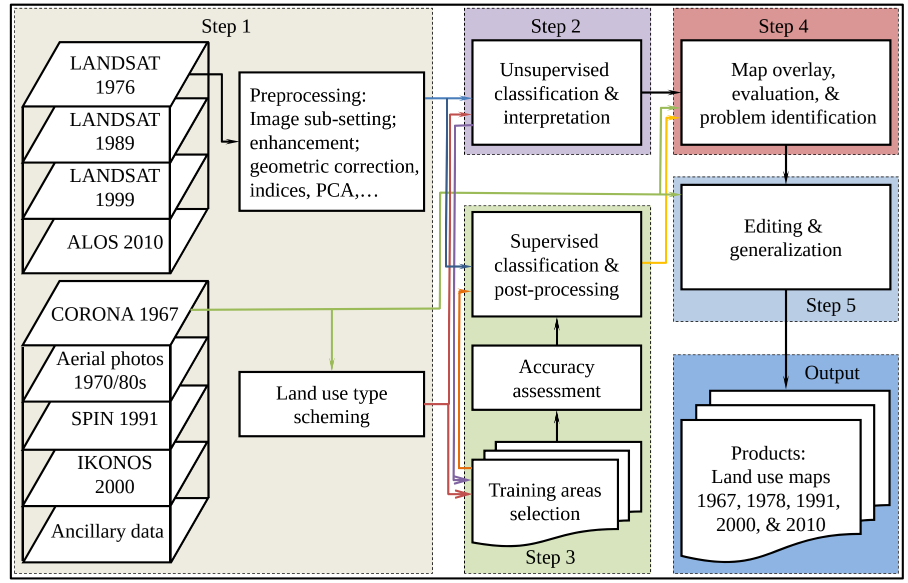


Land use changes… factors at micro case

Source: Thapa RB (2009). PhD Thesis.



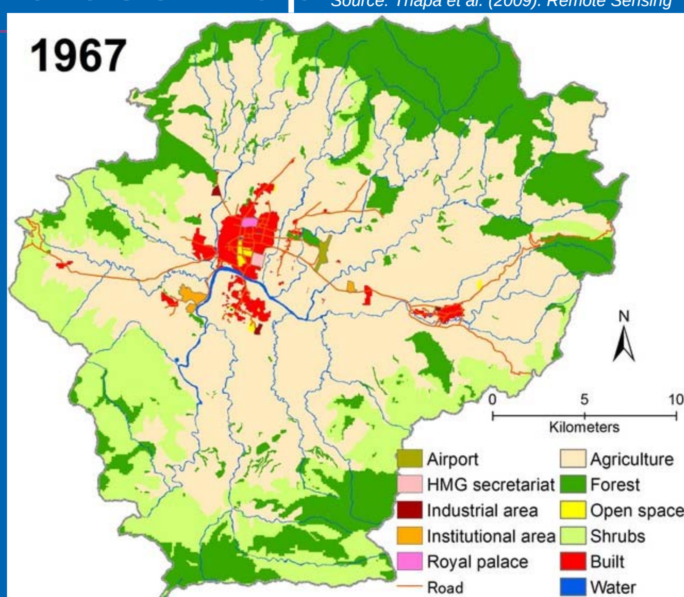
Methodology: Land use mapping…image processing



Thapa 2012, SPIE Proceedings

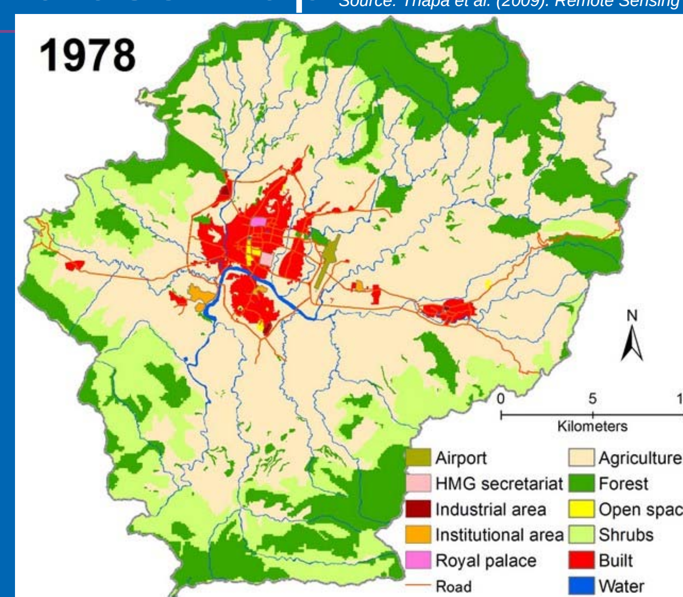
Land use map

Source: Thapa et al. (2009). Remote Sensing



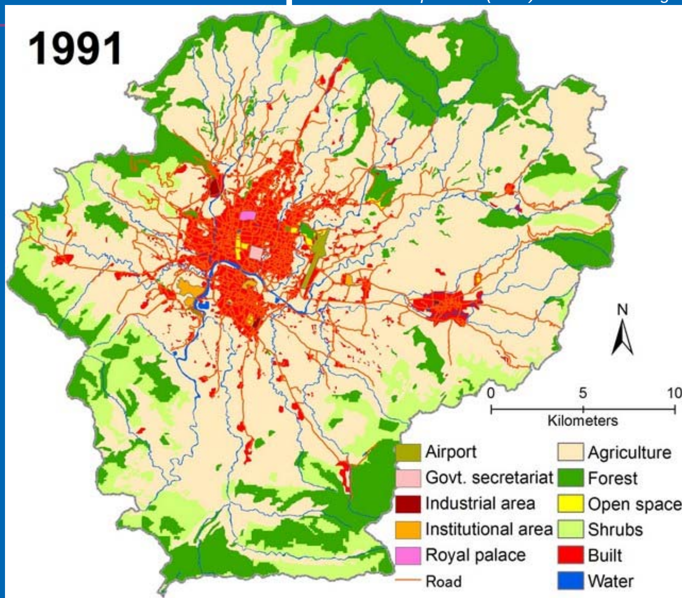
Land use map

Source: Thapa et al. (2009). Remote Sensing



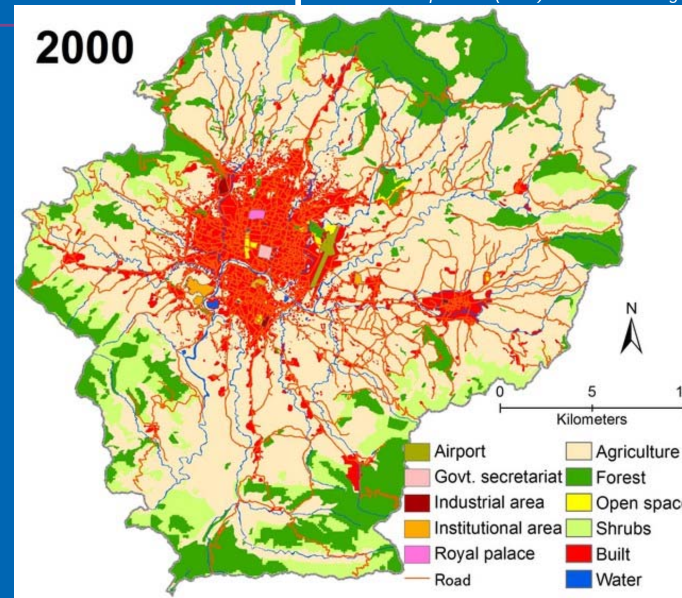
Land use map

Source: Thapa et al. (2009). Remote Sensing



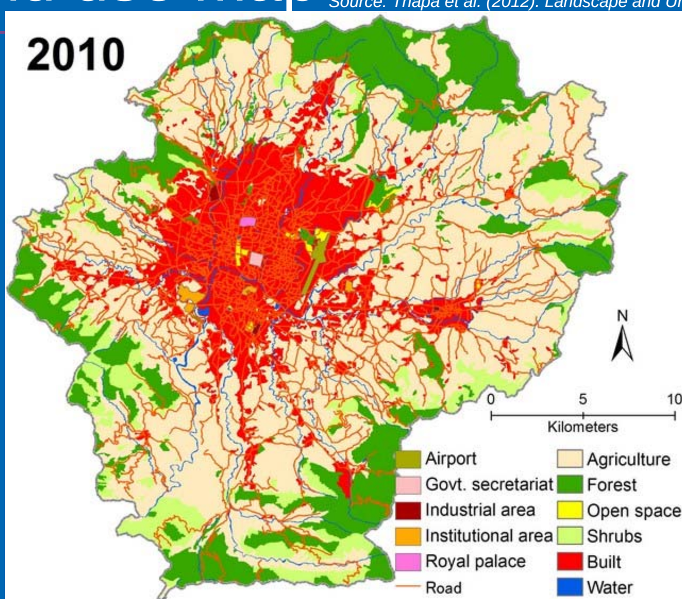
Land use map

Source: Thapa et al. (2009). Remote Sensing

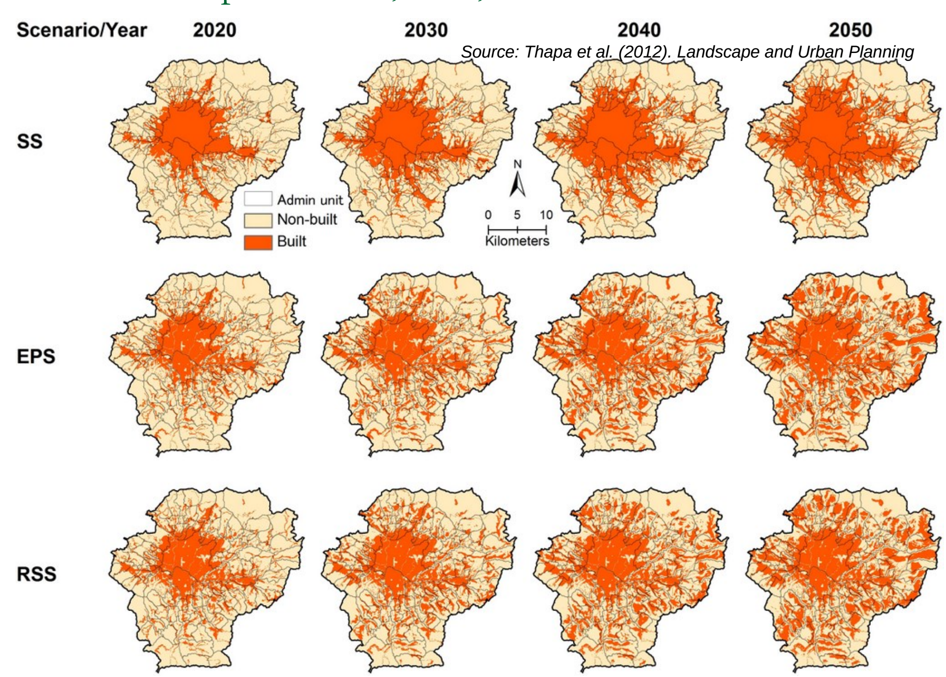


Land use map

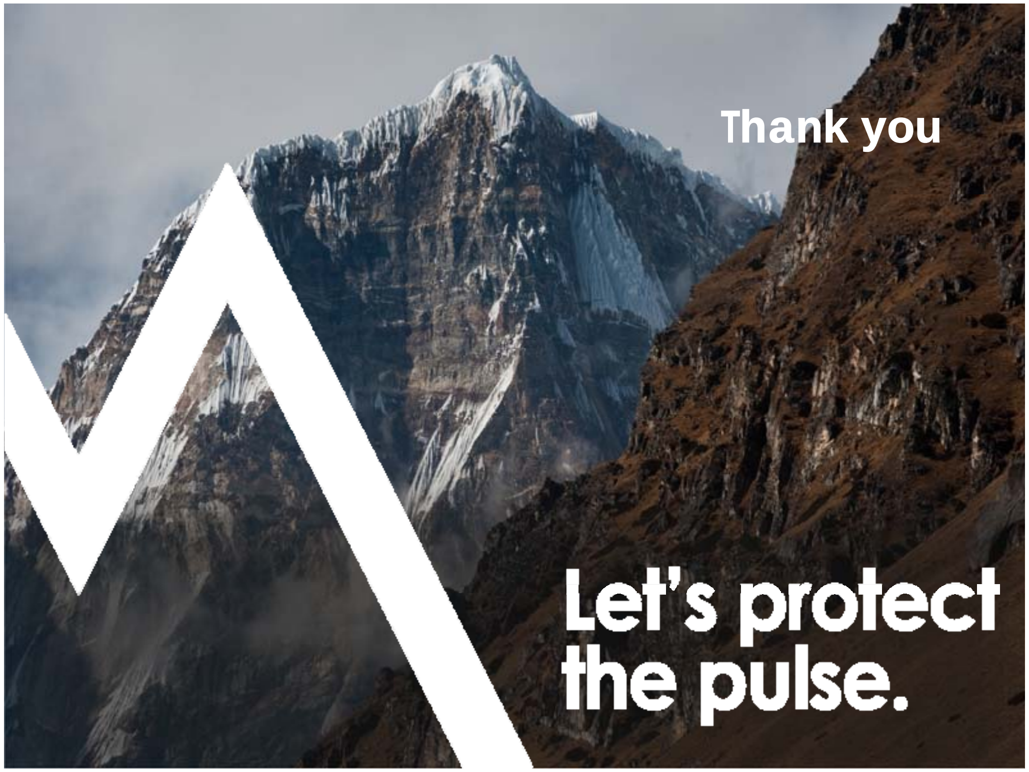
Source: Thapa et al. (2012). Landscape and Urban Planning



Scenarios Comparison: SS, EPS, and RSS



Source: Thapa et al. (2012). Landscape and Urban Planning


Thank you
Let's protect
the pulse.