MG X
PENGANTAR EKOLOGI LANSKAP ARL 230: 2 [2-0]

# MESO SCALE

Dr. Kaswanto Thursday, May 03, 2018

www.kaswanto.staff.ipb.ac.id

## 1. INTRODUCTION

- It is important to immediately clarify that the study of the landscape requires **metrics** but also **additional tools** like **Databases**, **Spatial Statistics**, **Geographic Information Systems**, **Remote Sensing Techniques and Global Positioning Systems**, **that are used in many other circumstances.**
- These methodologies are applied in **geology, geography, navigation, agronomy, climatic economics and social sciences, forecasting,** etc.
- At least 4 **methodological approaches** to study landscape metrics: 1) **numerical analysis,** 2) **spatial analysis,** 3) **multiscalar analysis** and 4) **spatial modeling analysis.**

## References:


1. Principles and Methods in Landscape Ecology → **Almo Farina**
2. Landscape ecology principles in Landscape Architecture and Land use Planning → **Wenche E. Dramstad, James D. Olson, Richard T.T. Forman**
3. International Journals


**PPT would be uploaded to the BLOG**

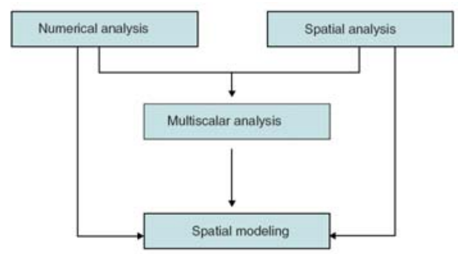




*Figure 8-1.* The principal approaches to landscape metrics (from Farina 2000, with permission).

## MINGGU XI

## MESO SCALE

Outline:

1. **Introduction**
2. **Fractal Dimension**
3. **Geographic Information Systems (GIS)**
4. **Remote Sensing (RS)**
5. **Case Studies**

Landscape analysis can be performed on at least at four levels of spatial resolution: **individual**, **patch**, **mosaic** and **landscape** (Figure 8.2).

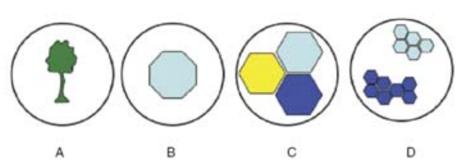
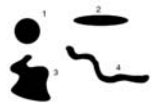


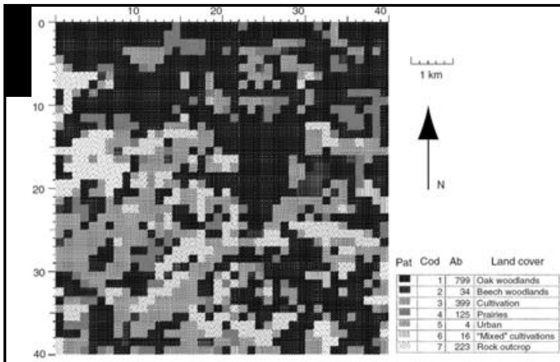

*Figure 8-2.* Metrics in landscape ecology can be applied at individual (A), patch (B), mosaic (C) and finally, at landscape scales (D) (from Farina 2001, with permission).

# Patch Shape Metrics

*Table 8-3*. Some patch shape measures applied to four types of patches (1,2,3,4)
#patch= Patch Identifier
S= Area (Patch size, in pixel)
L= Perimeter (Patch edge, in pixel)
S/L = Ratio Area/Perimeter
CORR (Corrected Perimeter-Area) = .282*L/√S
RCC (Related Circumscribing Circle) = 2*(S/π)1/2)/longest-axis
Long-Axis (Longest Axis)
Data have been processed using the routine basic MPC of Box 6.1




| *#patch* | *S* | *L* | *S/L* | *CORR* | *RCC* | *Long-Axis* |
|---|---|---|---|---|---|---|
| 1 | 4838 | 259.52 | .054 | 1.052 | .994 | 79.010 |
| 2 | 4235 | 356.27 | .084 | 1.544 | .451 | 162.720 |
| 3 | 11055 | 521.24 | .047 | 1.398 | .867 | 136.900 |
| 4 | 5639 | 662.32 | .117 | 2.487 | .448 | 189.090 |




| Pat | Cod | Ab | Land cover |
|---|---|---|---|
| | 1 | 799 | Oak woodlands |
| | 2 | 34 | Beech woodlands |
| | 3 | 399 | Cultivation |
| | 4 | 125 | Prairies |
| | 5 | 4 | Urban |
| | 6 | 16 | "Mixed" cultivations |
| | 7 | 223 | Rock outcrop |

*Figure 8-7*. Subset of 8x8 km, 200x200 m cells, of a GIS ( Routine MacGIS (Hulse & Larsen 1989)), across the northern Apennines (from Nardelli 1995). The mosaic is composed of 7 mainland covers. Pat=Graphic Pattern, Cod= Land cover code, AB= Number of cells.

# Patch Distance

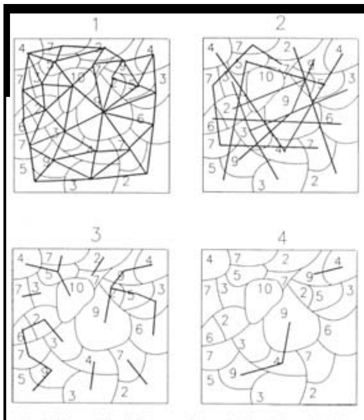


*Figure 8-5*. Four possible methods to measure distance. 1,2,3,4 see text for explanation (from Baker & Cai 1992, with permission).

The measurement of distances can be done according to a selection of possibilities:

1. from each patch to all the adjacent neighbors of each patch.
2. from a patch to all others of the same group,
3. from each patch to the single nearest patch of a different group,
4. from a patch of a specific group to another patch of a specific group (Figure . 8.5 and Table 8.6).

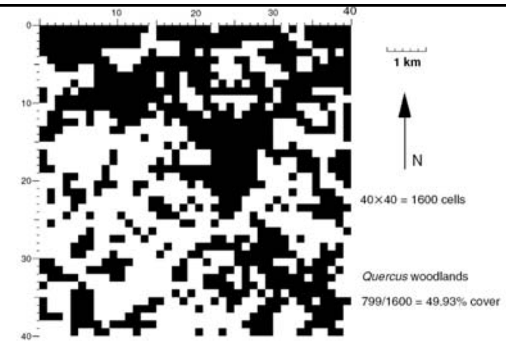



*Figure 8-8*. Example of landscape analysis using a single land cover, in this case the oak woodlands cover (source from Nardelli 1995) see also Fig. 8.7 for the complete mosaic.
From this image it is possible to measure:
No. Patch, Area, Perimeter, Shannon diversity of patch size, Shannon diversity of patch edge, Max., Min., Patch size and Patch edge.

# Patch Co-occurance

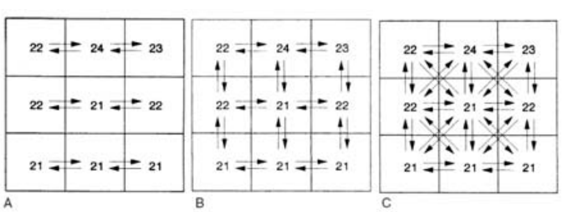



*Figure 8-6*. Three possibilities to calculate the co-occurrence probability p(i,j,d,q) between cells or pixels of a matrix. The number in the cells indicates the type of attribute, maybe a land-cover or vegetation or color attribute. In case A the co-occurrences have been measured only along the horizontal axis (q=0°), in B according to the four perpendicular directions (q=0°,90°) and C in all directions(q=0°,45°,90°,135°) at a distance d=1 (from Musick & Grover 1991, modified, with permission).

# 2. FRACTAL DIMENSION

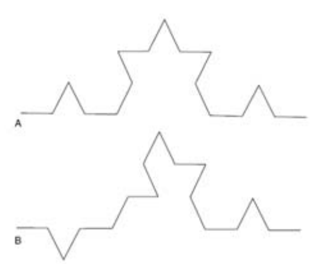



*Figure 8-11*. Example of regular (A) and a randomized (B) Koch snowflake.

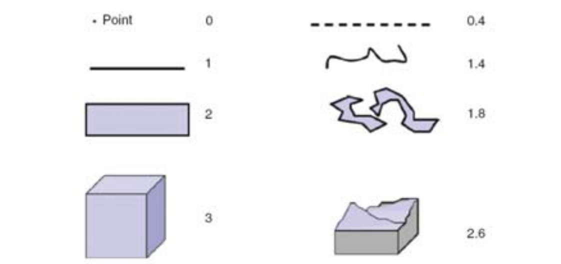



*Figure 8-12.* Comparison between Euclidean dimensions (left) and fractal dimensions (right).

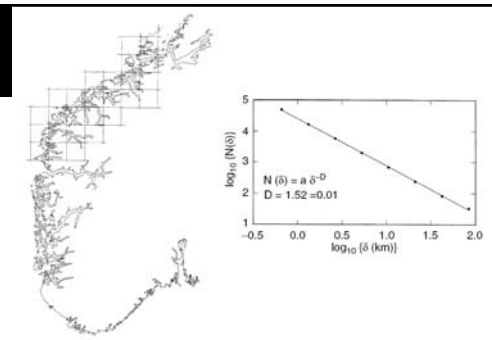



*Figure 8-15.* Example of application of fractal geometry to the computation of the complexity of an edge. The coast of southern Norway with a superimposed square grid of δ˜ 50 Km and the log-log plot of $N(\delta) = a\delta^{-D}$. Changing the value of δ, and regressing the number of boxes N(δ) of d dimension that cover the coast line with the value of δ, the fractal dimension D is the (-1) times the slope of the regression. This method is applied in Box 6.7 (from Feder 1988, with permission).

## The Fractal Dimension of the Edges

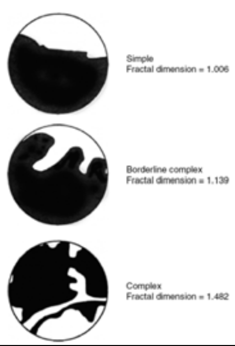



*Figure 8-13. Example of different complexity of a vegetation border expressed by the* fractal dimension D, note that the increase of edges is equivalent to the increase of fractal dimension (from Hees 1994, with permission).

## 3. GIS

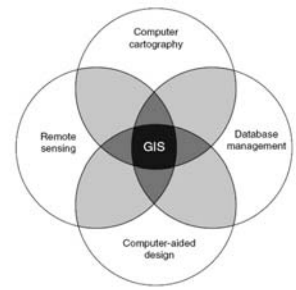



*Figure 8-21.* GIS is the combination of different procedures and methodologies (from Maguire 1991, with permission).

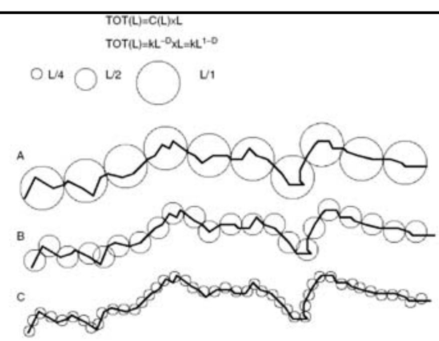
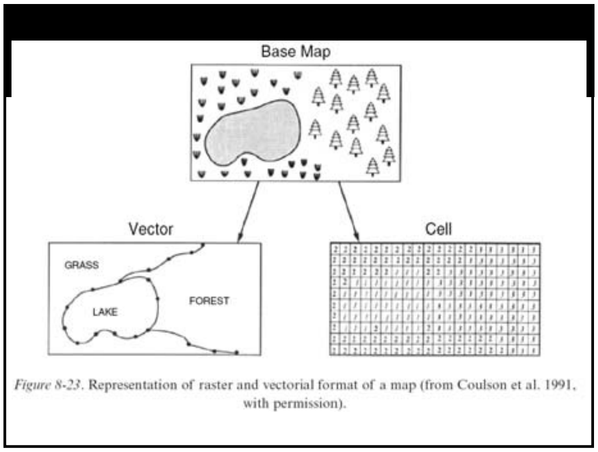
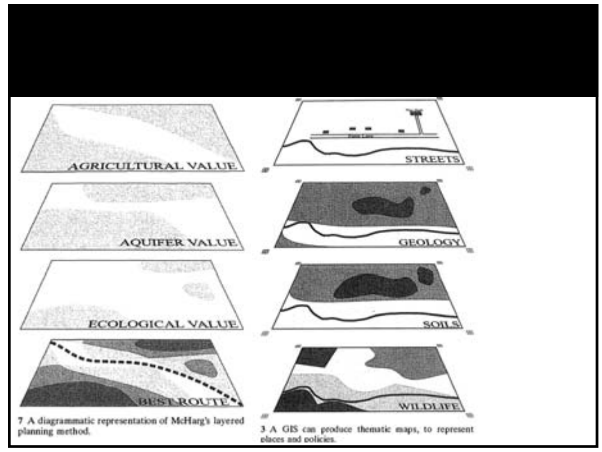


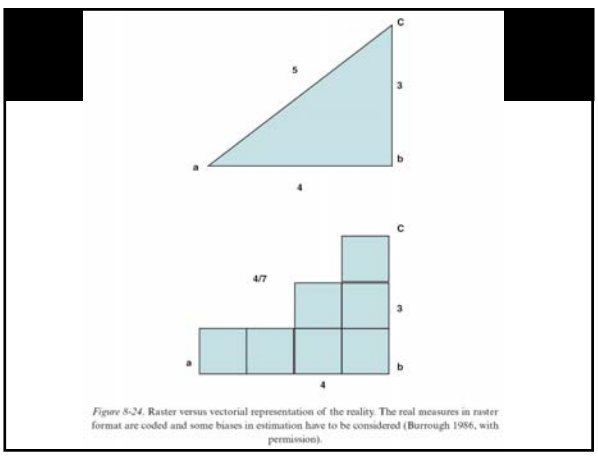

*Figure 8-14.* The irregularity of a border can be estimated by calculating the fractal dimensions applying the caliber method. In this case, the total length of the border decreases with the increase of the caliber size. In A the caliber is L/1, the number of steps C(L)=10, the total length TOT(L)=10x1=10; in B L/2, C(L)=22, TOT(L)=22x1/2=11, in C L/4, C(L)=47, TOT(L)=47x1/4=11.75. The shorter the caliber the more border will be measured, see text for the calculation of the fractal dimension (from Farina 2001, with permission).

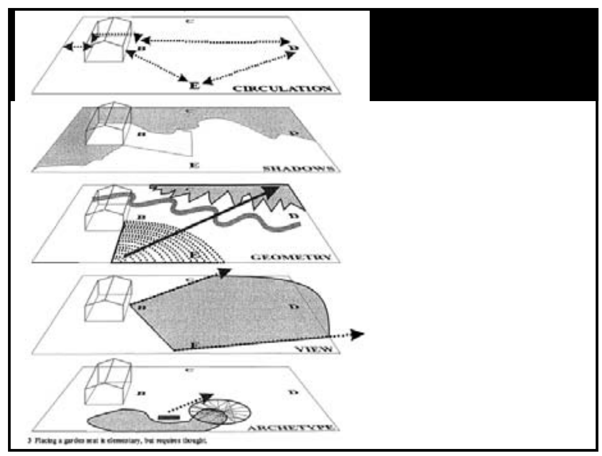
The GIS appears indispensable for most landscape investigations like:

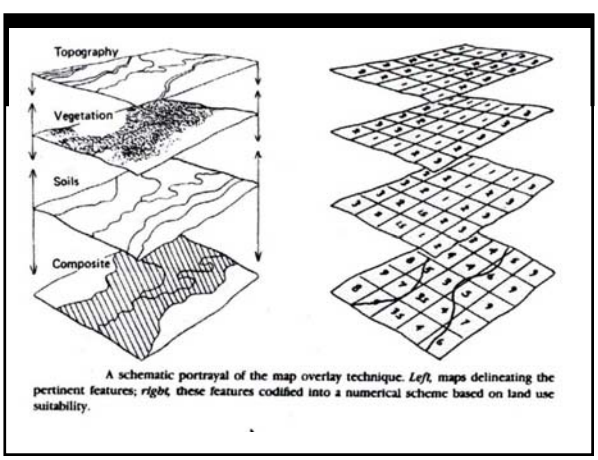
- Land use change
- Vegetation patterning
- Animal distribution across the landscape
- Linking remote sensing with topography
- Modeling processes across the landscape

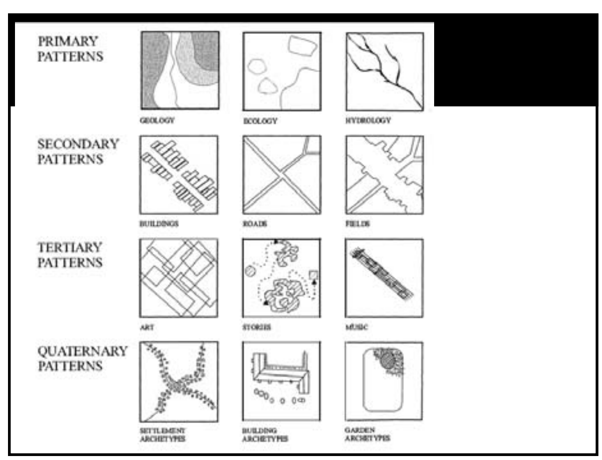

Base Map
Vector
Cell
GRASS
LAKE
FOREST
Figure 8-23. Representation of raster and vectorial format of a map (from Coulson et al. 1991, with permission).

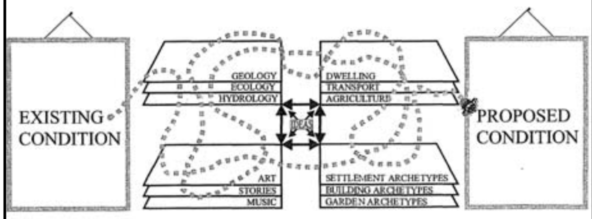

AGRICULTURAL VALUE
AQUIFER VALUE
ECOLOGICAL VALUE
BEST ROUTE
STREETS
GEOLOGY
SOILS
WILDLIFE
7 A diagrammatic representation of McHarg's layered planning method.
3 A GIS can produce thematic maps, to represent places and policies.


c
5
3
a
b
4
4/7
Figure 8-24. Raster versus vectorial representation of the reality. The real measures in raster format are coded and some biases in estimation have to be considered (Burrough 1986, with permission).


CIRCULATION
SHADOWS
GEOMETRY
VIEW
ARCHETYPE


Topography
Vegetation
Soils
Composite
A schematic portrayal of the map overlay technique. Left, maps delineating the pertinent features; right, these features codified into a numerical scheme based on land use suitability.


PRIMARY PATTERNS
GEOLOGY
ECOLOGY
HYDROLOGY
SECONDARY PATTERNS
BUILDINGS
ROADS
FIELDS
TERTIARY PATTERNS
ART
STORIES
MUSIC
QUATERNARY PATTERNS
SETTLEMENT ARCHETYPES
BUILDING ARCHETYPES
GARDEN ARCHETYPES



Ideas are at the heart of the design process.

## The use of GPS in landscape ecology

- Bird community ecology
- Rectify aerial photographs
- Low-altitude oblique photographs
- mapping vegetation patches on the ground with an accuracy of 5m after differential correction.

## 4. REMOTE SENSING

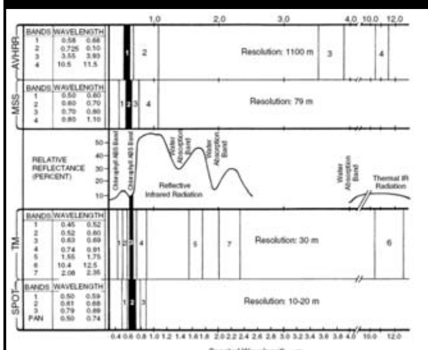



*Figure 8-29. Spectral and spatial resolution for the commonest civilian satellites: AVHRR,* MSS, TM and SPOT, and the electromagnetic spectral response curve for green vegetation (Iverson et al. 1989).

## CASE STUDIES

1. AEZ
2. UHI
3. LUCC
4. Carbon Stock
5. Water Quality

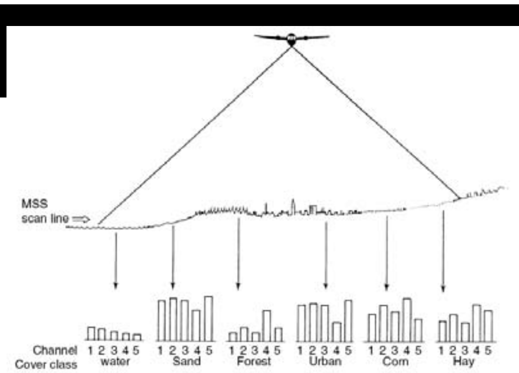
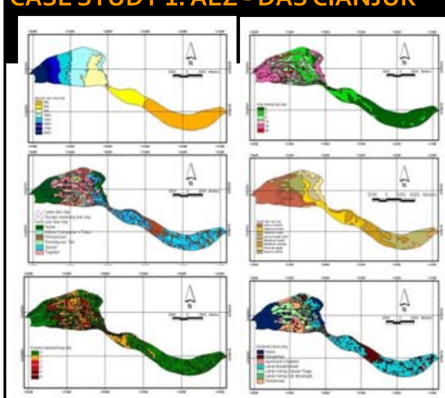



*Figure 8-31.* Spectral attributes belonging to different land cover types. Band 1, blue; band 2, green; band 3, red; band 4, near-infrared, band 5, thermal-infrared (from Lillesand & Kiefer 1987, with permission).

## CASE STUDY 1: AEZ - DAS CIANJUR



Distribusi Klas Elevasi (atas kiri), Klas Kemiringan Lereng (atas kanan)

Existing Tataguna Lahan (tengah kiri), Jenis Tanah (tengah-kanan)

Bahaya Erosi (bawah kiri), dan usulan tata guna lahan ekologis (bawah kanan)

BACK

DAS Cianjur – Sub-DAS Citarum ( Saroinsong, Arifin, Gandasasmita & Takeuchi, 2003)

## CASE STUDY 2: UHI - BEIJING

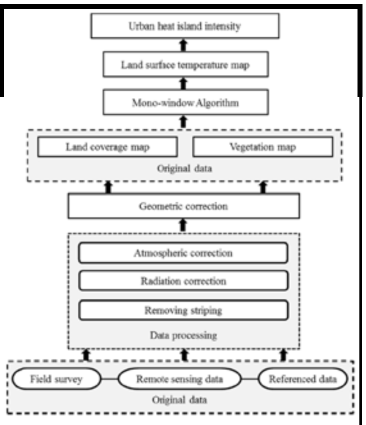


Figure 3 - 3 Flowchart of Methodology in this research

### 2. The Annual Rate of Change

The annual rate of change for forest was calculated with the formula proposed by Puyravaud (2003):

$$P\,(\%/year) = \frac{100}{t_2 - t_1} ln \frac{A_2}{A_1}$$

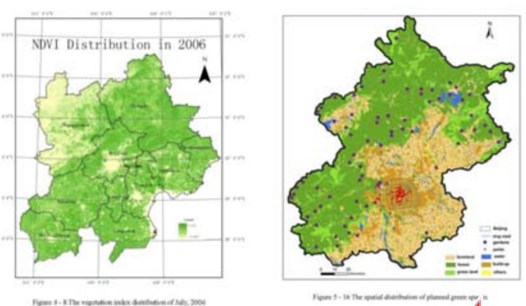
$A_2$ and $A_1$ = the forest cover areas at the end and the beginning, respectively, of the period being evaluated.
$t_1$ and $t_2$ = the numbers of years spanning on that period.

### 3. The Driving Factors of Change

$$log\left(\frac{Pi}{1 - Pi}\right) = \beta_0 + \beta_1 X_{1,i} + \beta_2 X_{2,i} + \cdots + \beta_n X_{n,i}$$

$P_i$ = the probability of a grid cell for the occurrence of land use type.
X's = the driving factors.
$B_i$ = the coefficient of each driving factor in the logistic model.

34

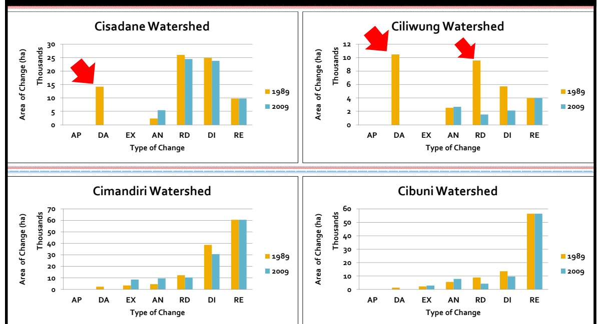



(Wang et al, 2012)

BACK

## Results

### Changes in the areas of the various types of forests pattern




**AP**: Appearance, **DA**: Disappearance, **EP**: Expansion, **AN**: Annexation, **RD**: Reduction, **DI**: Division, **RM**: Remain

## Methods

LANDSAT Satellite Images (1989, 2001 and 2009)

Land Use and Cover Classification

**1. Type of land use pattern change**
- Appearance
- Disappearance
- Expansion
- Annexation
- Reduction
- Division
- Remain

**2. Forest Annual Rate Change**

Calculated with the formula proposed Puyravaud (2003):

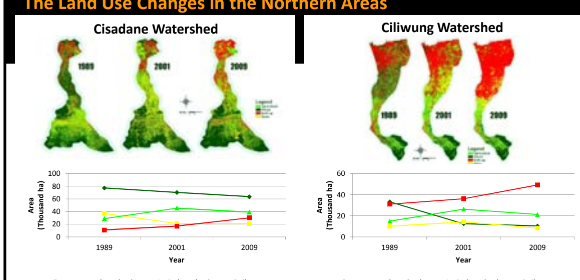
$$P\,(\%/year) = \frac{100}{t_2 - t_1} ln \frac{A_2}{A_1}$$

**3. The Driving Factors of Change**
- Altitude
- Slope
- Population density
- Distance to major road
- Distance to river
- Distance to urban area
- Soil drainage

**Impact of land use changes on spatial pattern of landscape**

33

### The Land Use Changes in the Northern Areas



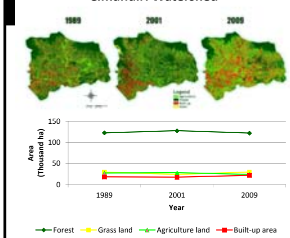

| Variables | Northern F | Northern G | Northern A | Northern B |
|---|---|---|---|---|
| Altitude | 0.0012 | 0.0054 | - 0.0089 | - 0.0074 |
| Slope | 0.0302 | 0.0323 | - 0.0002 | 0.0098 |
| Population density | - 0.0003 | - 0.0001 | - 0.0007 | - 0.0002 |
| Distance to major road | 0.0261 | 0.0098 | 0.0021 | - |
| Distance to river | 0.0043 | 0.0001 | 0.0001 | - |
| Distance to urban area | - 0.0584 | - 0.0691 | 0.0021 | - 0.0012 |
| Soil drainage | 0.0745 | 0.0689 | - 0.0891 | 0.0025 |

| Variables | Southern F | Southern G | Southern A | Southern B |
|---|---|---|---|---|
| Altitude | 0.0032 | 0.0010 | - 0.0198 | - 0.0074 |
| Slope | 0.0502 | 0.0356 | - 0.0112 | 0.0058 |
| Population density | - 0.0653 | - 0.0001 | - 0.0001 | - 0.0001 |
| Distance to major road | 0.0037 | 0.0043 | 0.0163 | - |
| Distance to river | 0.0083 | 0.0163 | 0.0653 | - |
| Distance to urban area | - 0.9834 | - 0.0451 | 0.0001 | - 0.0002 |
| Soil drainage | 0.0519 | 0.0889 | - 0.0341 | 0.0001 |

36

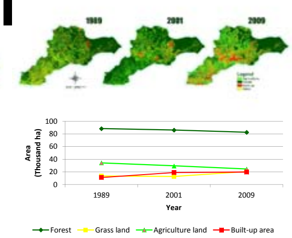
## The Land Use Changes in the Southern Areas

Cimandiri Watershed




| Variables | Southern | | | |
|---|---|---|---|---|
| | F | G | A | B |
| Altitude | 0.0010 | 0.0098 | 0.0001 | - 0.0274 |
| Slope | - 0.0282 | 0.0093 | - 0.0072 | 0.0738 |
| Population density | - 0.0001 | - 0.0001 | - 0.0001 | 0.0051 |
| Distance to major road | 0.0056 | 0.0043 | 0.0025 | - |
| Distance to river | 0.0098 | 0.0001 | 0.0002 | - |
| Distance to urban area | - 0.0025 | - 0.0001 | 0.0001 | - 0.0009 |
| Soil drainage | 0.2378 | 0.7629 | - 0.0091 | - 0.0001 |

Cibuni Watershed




| Variables | Southern | | | |
|---|---|---|---|---|
| | F | G | A | B |
| Altitude | 0.0012 | 0.0014 | 0.0001 | 0.0024 |
| Slope | 0.0302 | 0.0413 | - 0.0112 | 0.0138 |
| Population density | - 0.0003 | - 0.0001 | - 0.0001 | 0.0091 |
| Distance to major road | 0.0098 | 0.0014 | 0.0021 | - |
| Distance to river | 0.0024 | 0.0084 | 0.0174 | - |
| Distance to urban area | - 0.0064 | 0.0001 | 0.0001 | - 0.0292 |
| Soil drainage | 0.0519 | 0.8689 | 0.0641 | 0.0009 |

BACK

## THE SCALING UP

*Short Explanation*

| | Scale | Short Explanation |
|---|---|---|
| 1 | • Tree scale<br>• Crops scale | C ~ Plant |
| 2 | • Plot scale<br>• Quadrant scale | C ~ Plot |
| 3 | • Landscape scale<br>• Land use scale | C ~ Land use |
| 4 | • Watershed Scale<br>• Regional Scale | C ~ Watershed |

40

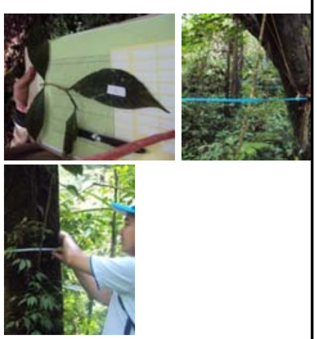
Carbon Stock Estimation

## CASE STUDY 4: Carbon Stock Estimation

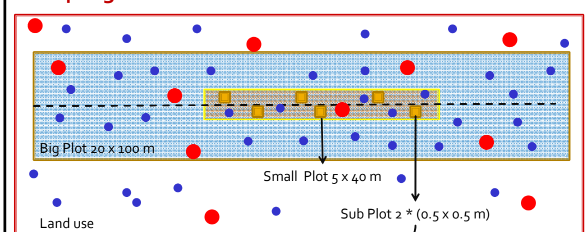
**Carbon at Agro-forestry Landscapes**
- Biomass
- Necromass
- Soil Organic Matter

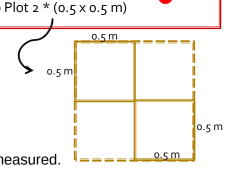
**Above Ground**
- Trees Biomass
- Understorey plants
- Necromass
- Litter

**Below Ground**
- Soil Organic Matter



## Sampling Plot Procedure




Note:
- Tree with dbh > 30 cm
- Tree with dbh < 30 cm
- Understorey and Litter

1 land utilization type → 3 sampling plots.
1 watershed → 16 type of land utilizations.
1 watershed → 48 plots, in total 192 plots were measured.

41

Carbon Stock Estimation

## Methods

LANDSAT image
↓
LULC classification
↓
Sampling plot in each land use
↓

| Plants Biomass | Necromass | Soil Organic Matter |
|---|---|---|
| •Trees<br>•Root<br>•Understorey | •Wooden<br>•Non-wooden | • Depth 0 -5, 5-15, &15-30 cm |

↓
Calculating C stock in each land use

39

Water Resources Management

## CASE STUDY 5: Water Quality

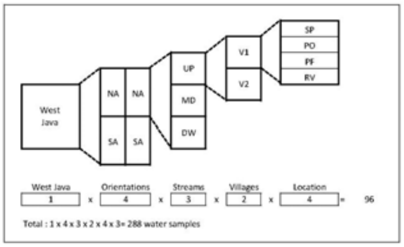
- ❑ Based on result from preliminary research, the water quality was measured through **11 parameters**.
- ❑ Those are (1) Dissolved Oxygen: **DO**, (2) Biological Oxygen Demand: **BOD**, (3) Chemical Oxygen Demand: **COD**, (4) Ammonium: **$NH_4$**, (5) Nitrate: **$NO_3$**, (6) Nitrite: **$NO_2$**, (7) Phosphate: **$PO_4$**, (8) Acidity: **pH**, (9) Alkalinity: **$OH^-$**, (10) Bacteria ***Escherichia coli***, and (11) **General Bacteria** - others than *E. coli*.

42

Water Resources Management

**11 Parameters:**

- DO
- COD
- BOD
- Nitrite
- Nitrate
- Ammonium
- Phosphate
- Alkalinity
- Acidity
- *Escherichia coli*
- General Bacteria




# TERIMA KASIH

PENGANTAR EKOLOGI LANSKAP

Contact Address:
kaswanto@apps.ipb.ac.id
www.kaswanto.staff.ipb.ac.id

FB : Regan Leonardus Kaswanto
Instagram : Regan_Kaswanto