

Determining Formalities Of Settlement Clusters Using Fractal Dimensions

Florence GALEON
Philippines

1

Outline

- I. Introduction
- II. Significance of the Study
- III. Study Area and Datasets
- IV. Methodology Flow Diagram
- V. Settlement Type Categories
- VI. Fractals and Fractal Dimensions
- VIII. Results and Discussions
- IX. Recommendations

2

Introduction

- Urban areas in the world are the most dynamic regions on earth and have become the densest populated regions in the world over the past few decades.
- Based on the final report of the Metro Manila Urban Services for the Poor Project (MMUSP) in 2002, there were 3.5 million residents living in depressed neighborhoods across the National Capital Region.
- In UP Diliman, the estimation from the 2004 QuickBird Satellite Image is that around 16% of the total 493 hectares UP Diliman property or roughly 79 hectares may be labeled as informal settlements .

3

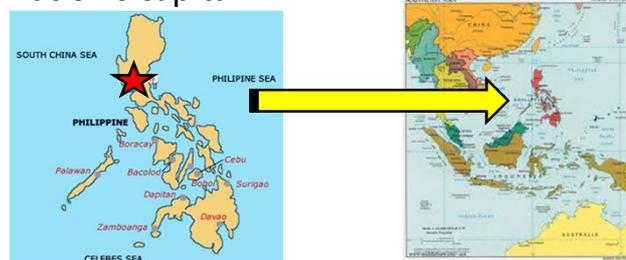
Significance of the Study

- With the advent of high resolution satellite imagery, the need for context-based algorithms and other image processing methods applicable for mapping must be developed.
- Fractals and fractal dimensions may provide another way of identifying and mapping settlement categories particularly informal settlements and when used in complement with other techniques may increase mapping accuracy.

4

Study Area

- The study area is the University of the Philippines in Diliman which is the flagship campus and the largest constituent university of the University of the Philippines System.
- It is located in Quezon City, the most populated city in the nation's capital.



5

Dataset

Spatial and Spectral Resolution					
Spectral Characteristics	Panchromatic	Multispectral			
	Black & White	Blue	Green	Red	Near IR
	450 to 900-nm	450 to 520-nm	520 to 600-nm	630 to 690-nm	760 to 900-nm
Pixel Resolution	61-cm to 72-cm (2 to 2.4-ft)	2.44 to 2.88-m (8 to 9.4-ft)			
Scene Dimensions	27,552 x 27,424 pixels	6,888 x 6,856 pixels			
Scene Size	16.5-km ² (nadir) to 20.8-km ² (25° off-nadir) 10.3 to 12.9-mi ²				

QuickBird Satellite Data Specifications

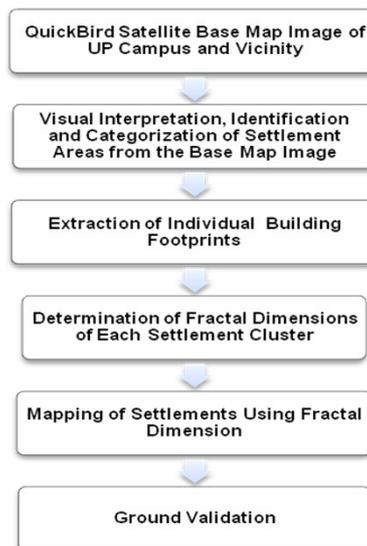
6

UP Campus Base Map Image



7

Methodology Flow Diagram



8

Settlement Type Categories for this Study

1. Informal/Slum Type
2. Semi-formal Type
3. Formal Type

9

Definition of Slum

- Encyclopedia Britannica defines a slum as "...a residential areas that are physically and socially deteriorated and in which satisfactory family life is impossible. Bad housing is a major index of slum conditions. By bad housing is meant dwellings that have inadequate light, air, toilet and bathing facilities; that are in bad repair, dump and improperly heated; that do not afford opportunity for family privacy; that are subject to fire hazard and that overcrowd the land, leaving no space for recreational use....."

10

Informal/Slum Type

- They are characterized by the Metro Manila Urban Services for the Poor Project (MMUSP) to have lack of spatial pattern, smaller structures, irregular boundary demarcation, clustering and uneven spread, different reflectance and locational attributes.
- These settlements are considered to be the miserable or depressed areas, normally lacking in basic services such as electricity, water, and communication lines.

11

Sample Slum Type



Sample Slum Type



13

Semi-formal Type

- They are characterized by a more decent neighborhood similar to a low-cost housing with provisions of the basic services and amenities.
- These settlements, although not physically informal, lack necessary tenure or permit to legally occupy the property.

14

Sample Semi-formal Type



15

Formal Type

- They are products of well-planned subdivisions characterized by well organized road network and facilities with complete provisions of not only the basic services and amenities but the more luxury ones.
- These settlements are titled properties that have the necessary legal tenure.

16

Sample Formal Type



17

Fractal

- An irregular geometric object with an infinite nesting of structure at all scales.
- Uses dimension determination techniques (Falconer, 1990)
- Analyzes surface coverage (Frankhauser, 1994)
- Focused on the spatial arrangement of the settlement structures (Thomas, 2007)

18

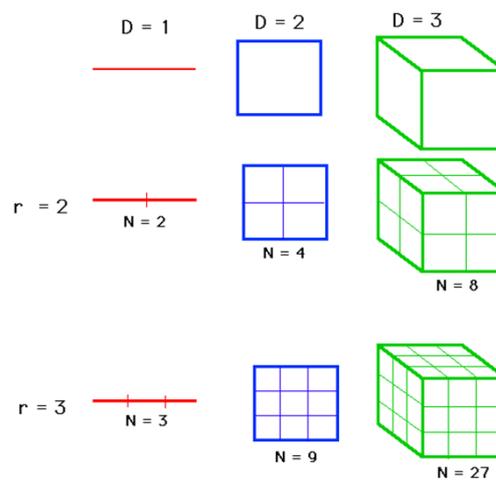
Why do we care about fractals?

- Natural objects are fractals.
- Chaotic trajectories (strange attractors) are fractals.
- Assessing the fractal properties of an observed time series may be informative.

19

Fractal Dimension

In fractal geometry, the fractal dimension, D , is a statistical quantity that gives an indication of how completely a fractal appears to fill space, as one zooms down to finer and finer scales.



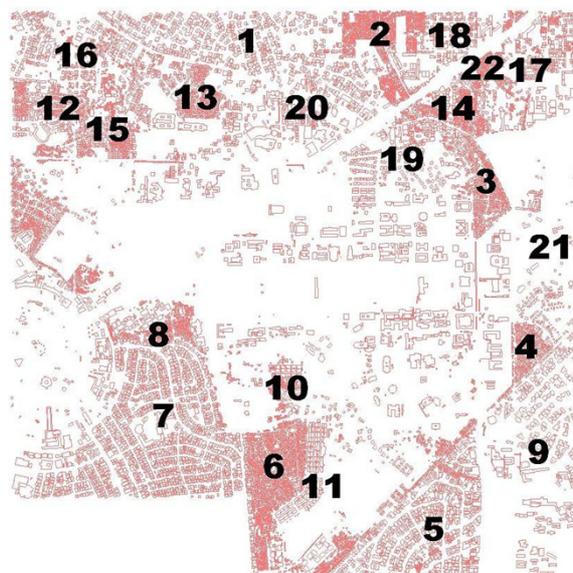
20

Fractalyse

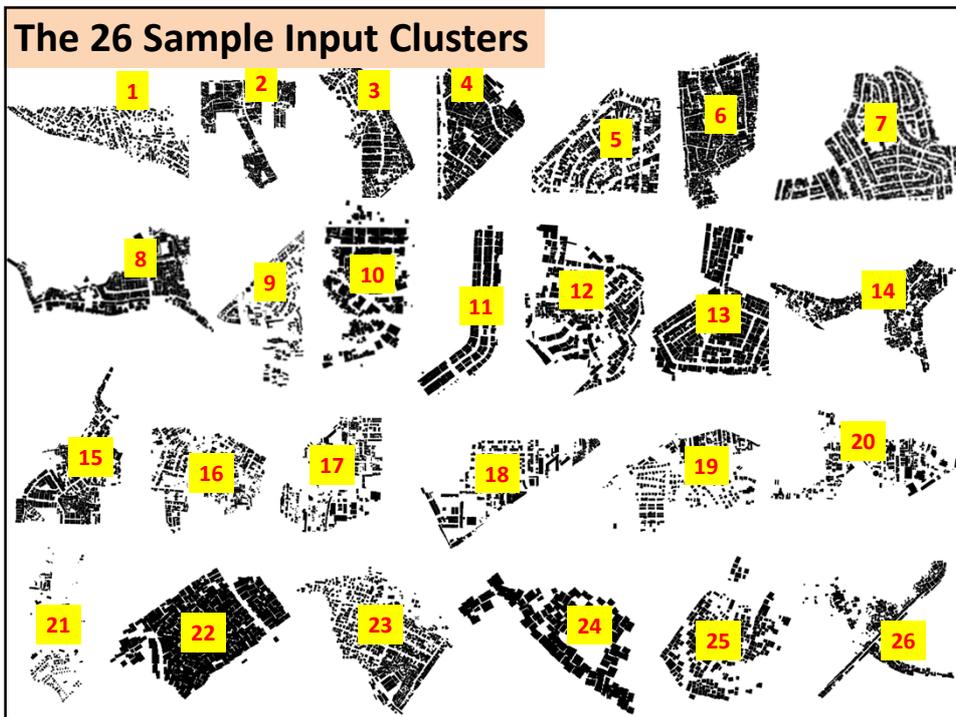
- Fractalyse is a fractal analysis software developed by the research team **“City, mobility, territory”** of the research center, **“TheMA”**
- Fractalyse needs TIFF or BMP image file format in Black and White because the software determines the fractal dimension by counting the black pixels of a selected area or the entire image.

21

Location Map of the 26 Sample Settlement Clusters



22



Cluster	Fractal Dimension	Actual Settlement Type
1	1.699	Formal
2	1.562	Informal
3	1.679	Informal
4	1.752	Semi-formal
5	1.82	Formal
6	1.722	Semi-formal
7	1.808	Formal
8	1.68	Informal
9	1.651	Formal
10	1.746	Semi-formal
11	1.875	Formal
12	1.735	Formal
13	1.768	Semi-formal
14	1.661	Informal
15	1.658	Informal
16	1.73	Semi-formal
17	1.695	Informal
18	1.679	Informal
19	1.691	Formal
20	1.692	Formal
21	1.456	Formal
22	1.802	Informal
23	1.818	Semi-formal
24	1.577	Informal
25	1.663	Informal
26	1.304	Informal

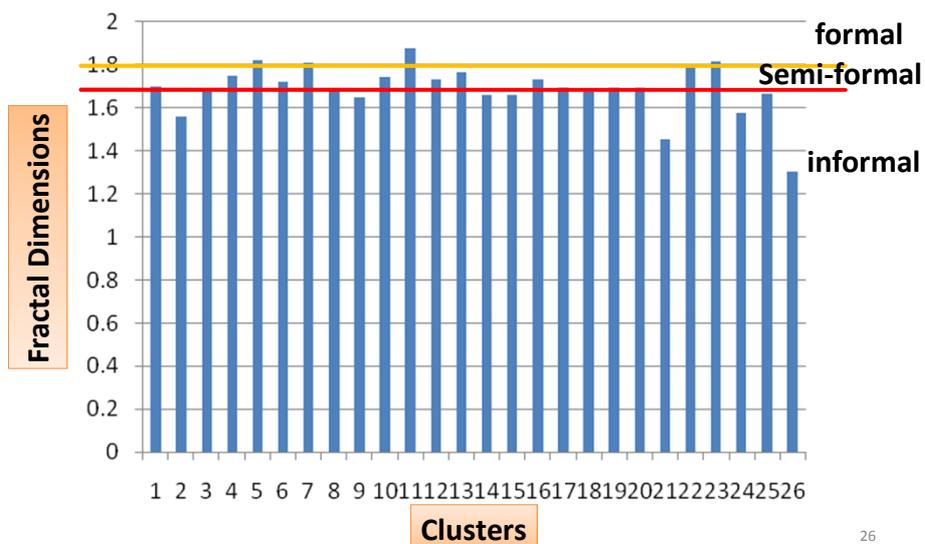
The Generated Fractal Dimensions and Actual Category Type

Summary of Results

Settlement Category	Fractal Dimension Range
Informal	1.304 to 1.695
Semi-Formal	1.722 to 1.818
Formal	1.456 to 1.875

25

Fractal Dimensions Computed for the Sample Clusters



26

UP Campus & Vicinity Settlement Map Using Fractal Dimensions



Some Interesting Findings

- Cluster 9, $D = 1.651$, Loyola Heights
Formal but categorized Informal



28

Some Interesting Findings

- Cluster 21, $D = 1.456$, located in Balara, Formal but categorized Informal



29

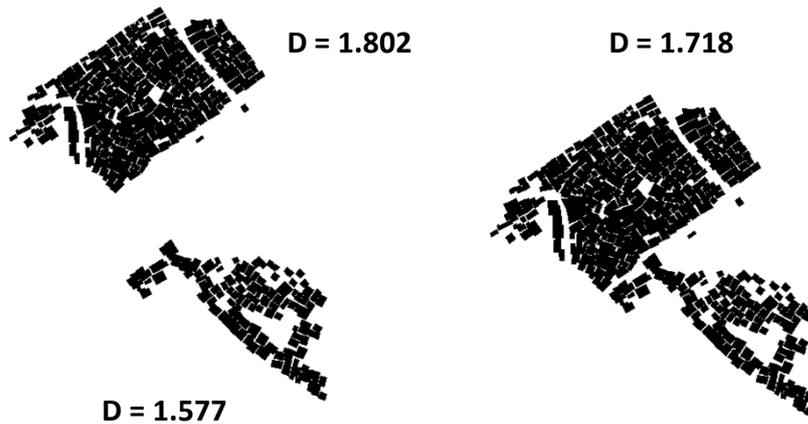
Some Interesting Findings

- Cluster 22, $D = 1.802$, located near the Iglesia Ni Kristo, Informal but categorized Formal



30

Effect of Combining or Separating Clusters



31

CORRELATION DIMENSION AND BOX COUNTING DIMENSION COMPARISON



Pook Ricarte, Dagohoy, Palaris

$D = 1.679, 1.697$



UP Village

$D = 1.808, 1.713$



near UP Wet & Dry Market

$D = 1.663, 1.643$



Xavierville

$D = 1.82, 1.717$



San Vicente

$D = 1.68, 1.596$



Culiat, Tandang Sora Avenue

$D = 1.699, 1.713$



Krus na Ligas

$D = 1.722, 1.783$

Conclusions

- The informal settlement clusters can be identified from the other settlement categories in a QuickBird satellite image using fractal dimensions.
- Interesting associations are found between the fractal dimensions and settlement categories, that is, higher fractal dimensions indicate more formality and lower numbers indicate informality.
- Despite its limitations, fractal analysis seems to be a promising tool for describing the morphology of settlements.

33

Recommendations

- Fractal dimensions and other landscape metrics must be tried and tested in a wider area like Metro Manila to refine further characterization of different formalities and later help identify and map the extent of informal settlements and other settlement categories.
- Different estimation techniques lead to slightly different values of fractal dimensions, therefore further studies using these other estimation techniques may be warranted.

34

Maraming Salamat!

35