United Nations/Morocco/European Space Agency International Workshop

APPLICATION OF SLEUTH MODEL IN ANTALYA, TURKEY

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&

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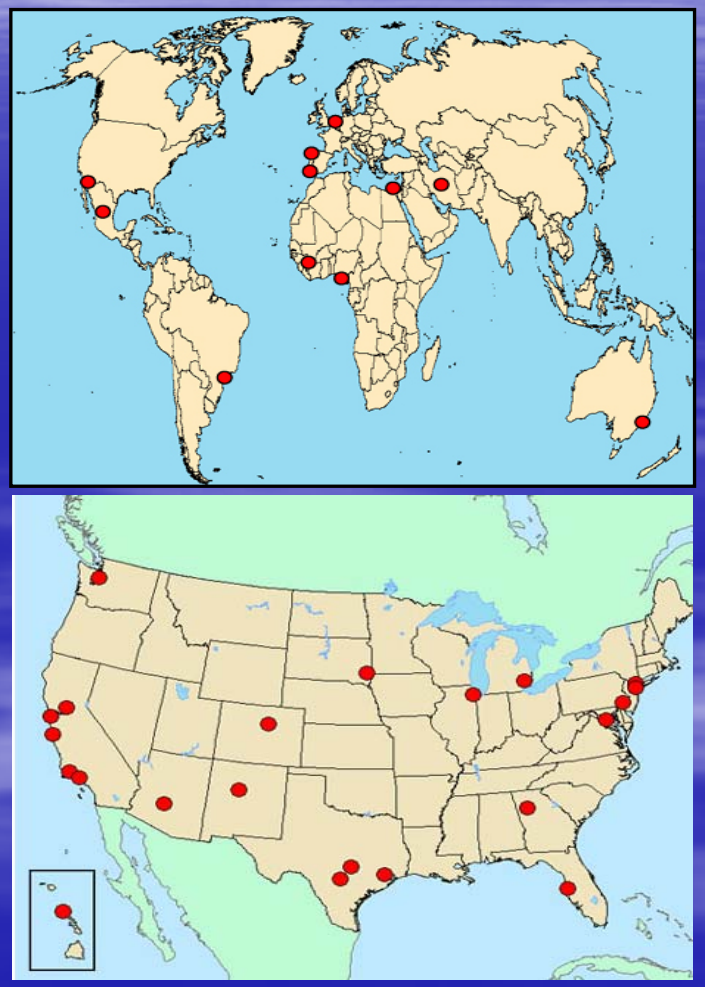
1. INTRODUCTION

- In this study, an urban growth model SLEUTH integrated with Remote Sensing (RS) and Geographical Information Systems (GIS) are used to simulate urban growth within the frame of Sustainable development in 2025 in the Antalya. It is the fastest growing metropolis in Turkey with a population growth of 41, 79‰ although Turkey's growth is 18, 28‰ for the last decade.



2. MATERIALS AND METHODOLOGY

2.1. Definition of the Study Area

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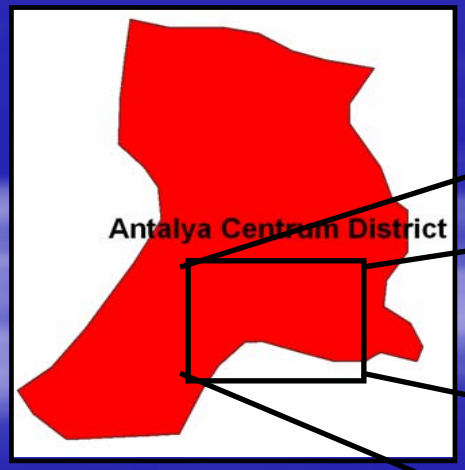
2.1. Definition of the Study Area



2.2. Data Used in the Study

List of the Model Input Data, Naming Format

Theme	Year	Source	Format	Naming Format for the model
Urban Extent	1987	Classified from 1987 Satellite Image (Landsat TM30m)	Raster	antalya.urban.1987.gif
	1992	Digitized from 1992 Air photos	Rasterized	antalya.urban.1992.gif
	1996	Classified from 1996 Satellite Image (Spot 20m)	Raster	antalya.urban.1996.gif
	2002	Classified from 2002 Satellite Image (Landsat ETM 30m)	Raster	antalya.urban.2002.gif
Roads	1995	Digitized from Antalya Transportation Map and Satellite Image of 1996	Rasterized (originally cad data)	antalya.road.1995.gif
	2003	Digitized from DAMPO Planning, 1/5000 Development Plan and Satellite Image of 2002	Rasterized (Originally cad data)	antalya.road.2003.gif
Slope	1996	Computed from SRTM 90m DEM	Raster	antalya.slope.gif
Excluded Areas	2003	Digitized from 1/5000 Development Plan	Rasterized (Originally cad data)	antalya.excluded.gif
Hill shade	1996	Computed from SRTM 90m DEM	Raster	antalya.hillshade.gif

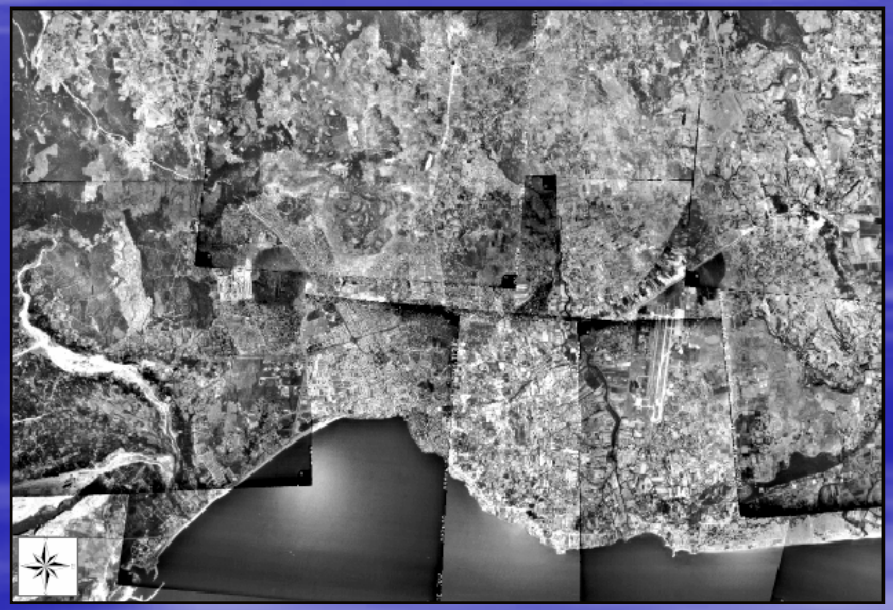
2.2. Data Used in the Study

1987 Landsat TM satellite imagery
of the study area with 30 m resolution

1996 SPOT satellite imagery
of the study area with 20 m resolution

2.2. Data Used in the Study

2002 Landsat ETM satellite imagery of the study area with 30-meter spatial resolution.



1992 Aerial photograph mosaic of the study area with a scale of 1/40.000

2.2. Data Used in the Study

- The road layer of the year 1995 is digitized as the 4 degrees from the Antalya Transportation Plan of the year 1995 prepared by Elker and the road layer of the year 2003 is digitized from the transportation plan of Antalya of the year 2003 prepared by DAMPO Planning

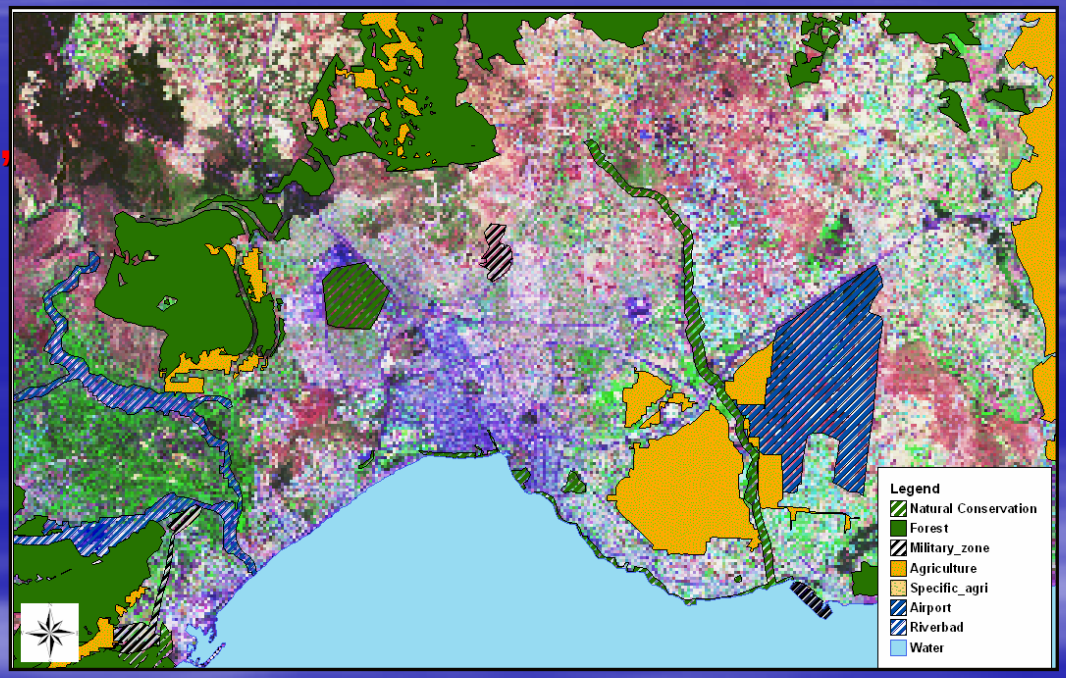
Road Data for the Year 1995

Road Data for the Year 2003

2.2. Data Used in the Study

The vector layer of the excluded areas is produced from the Antalya 1/5000 Development Plan which is

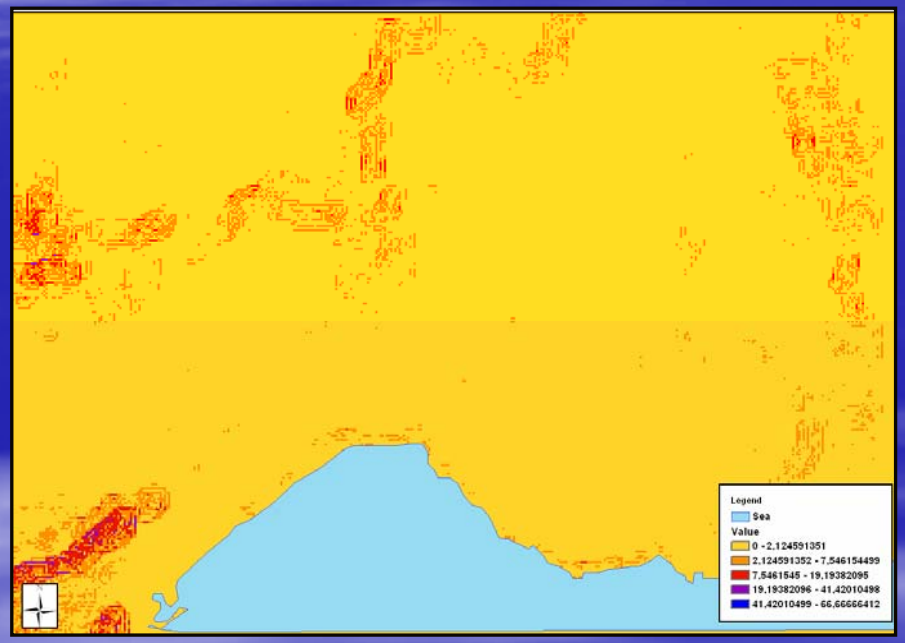
-natural conservation areas,
-forest covered areas,
-military zones,
-first and second-degree productive agricultural areas,
-airport,
-riverbeds,
-Mediterranean Sea



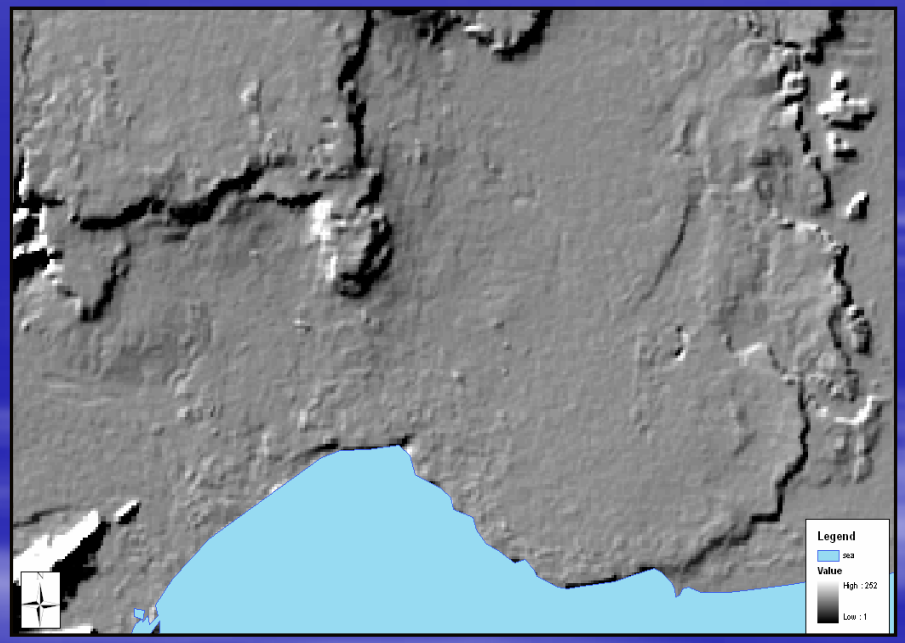
The Layer of Excluded Areas (unresidential areas)

2.2. Data Used in the Study

The **slope** and **hillshade** layers are produced from the SRTM 90 meter DEM data.

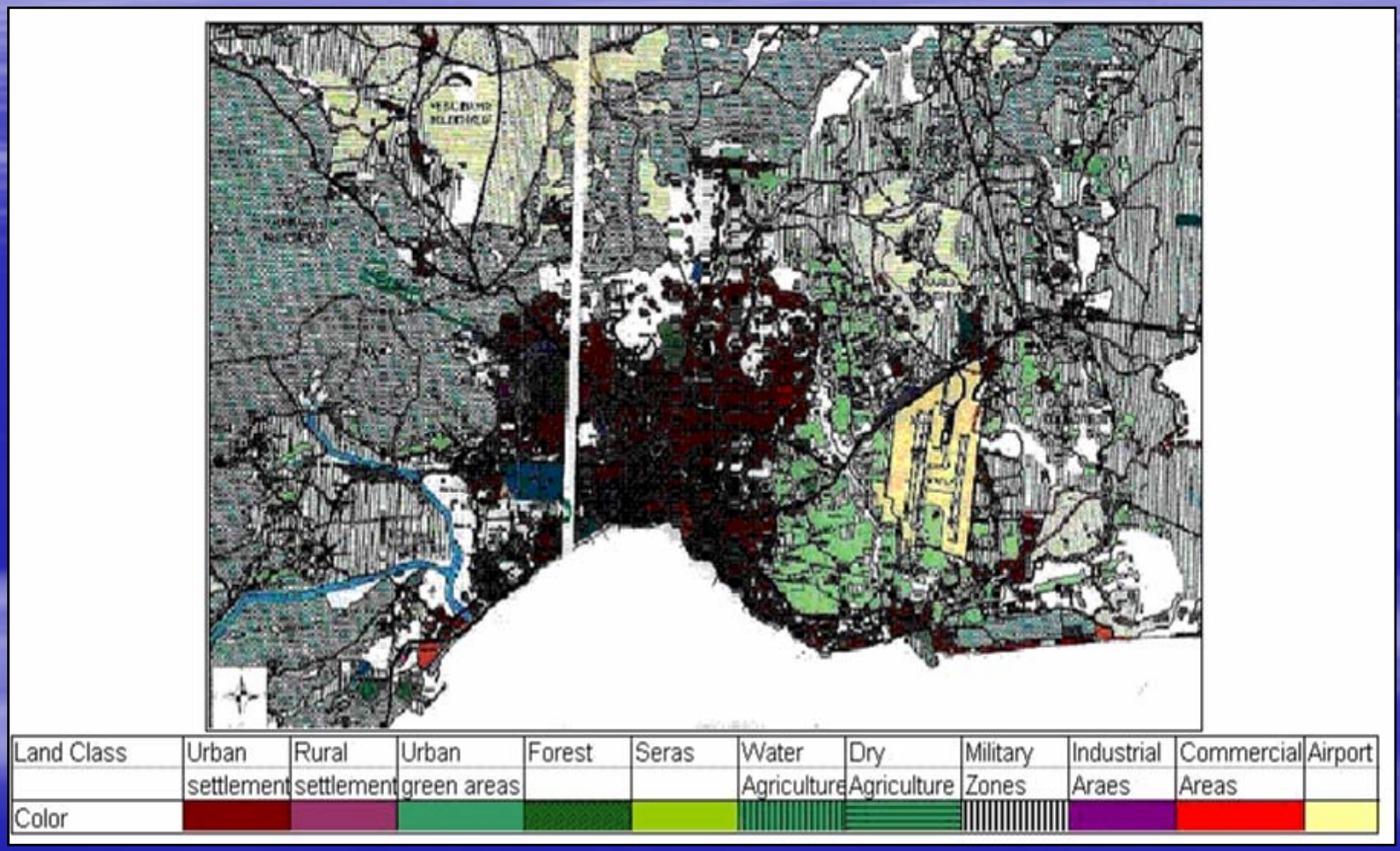


The Layer of Terrain Slope



Layer of the Hillshade

2.2. Data Used in the Study

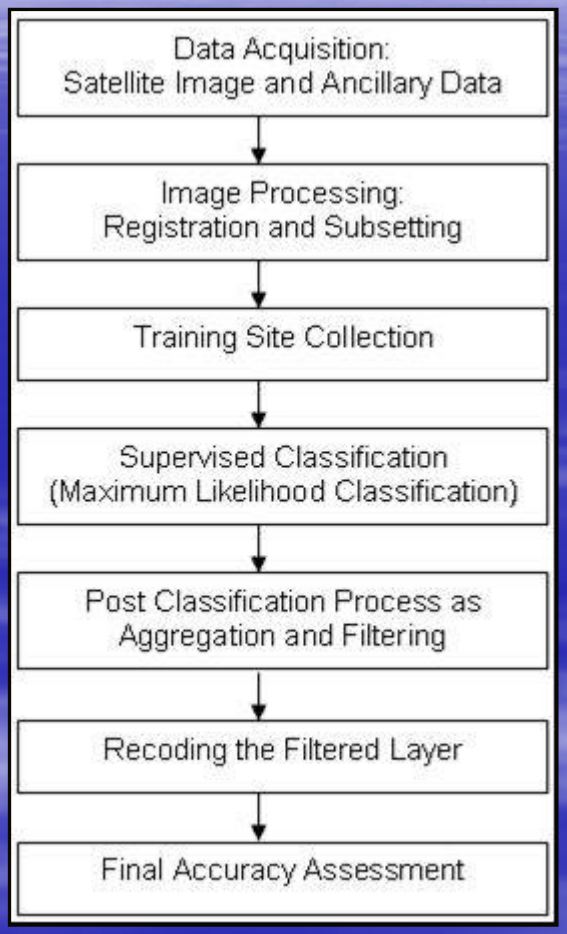


Land Class	Urban settlement	Rural settlement	Urban green areas	Forest	Seras	Water Agriculture	Dry Agriculture	Military Zones	Industrial Araes	Commercial Areas	Airport
Color											

Land Use Data of Antalya for the year 2002

2.3. Analyses of the Satellite Images

- After the Data Preparation and Registration the urban extent input layers of the years 1987, 1996 and 2002 are obtained by means of the training area collection then, the classification analyses.
- Following the classification, post classification analyses of aggregation and filtering and then the rule application are done to improve the result of accuracy assessment.
- Then, they are recoded.
- Finally, Accuracy Assessment is done



The Flowchart of the Methodology of the Classification Analysis

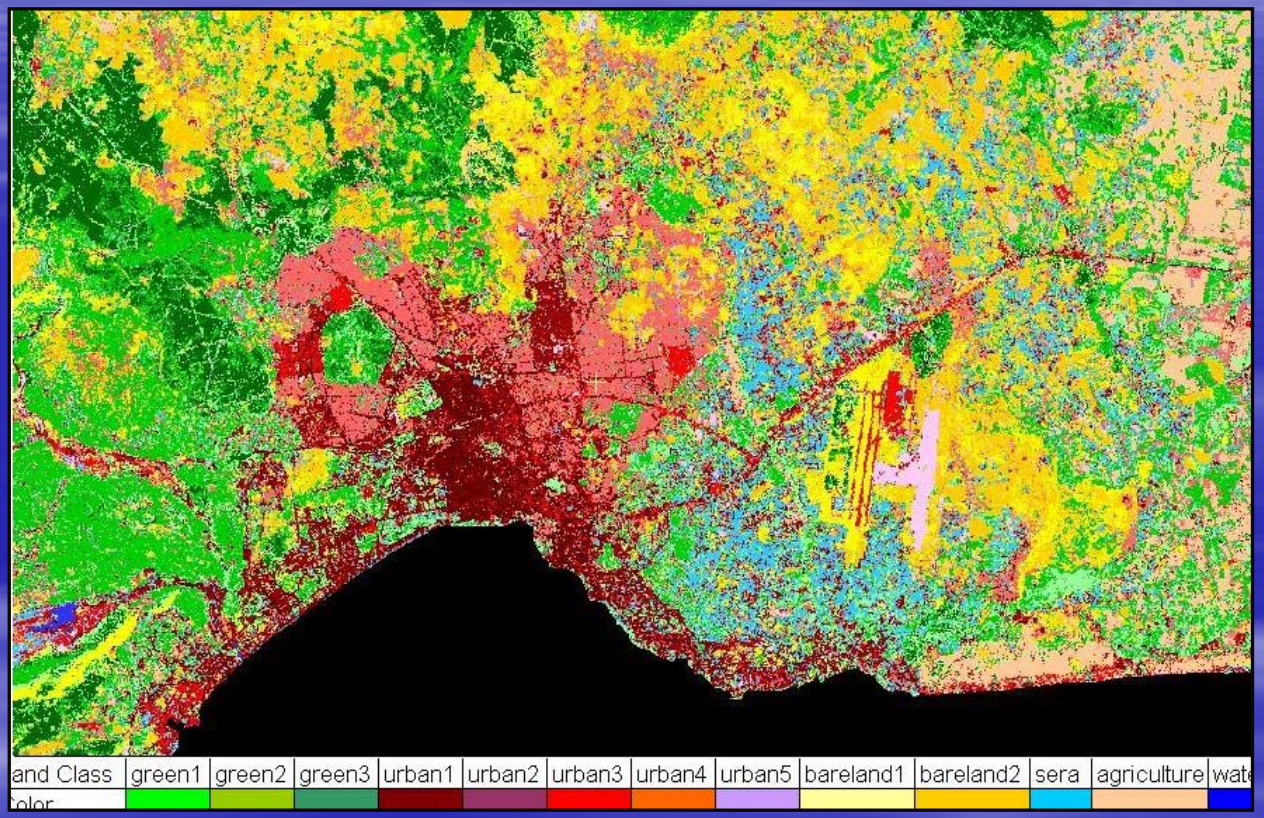
2.3.1. Classification Analyses of the Satellite Image of the Year 2002

- First, the satellite image of the ending year of 2002 is classified. Because the only obtained land use data is the 2002 land use data for the accuraccy assessment.

	Value	Name	Color
1	1	green_1	
2	2	green_2	
3	3	green_3	
4	4	urban_1	
5	5	urban_2	
6	6	urban_3	
7	7	urban_4	
8	8	bareland1	
9	9	bareland2	
10	10	sera	
11	11	agriculture	
12	12	water	
13	13	urban5	

The Classification Classes of the Landsat 2002 Image

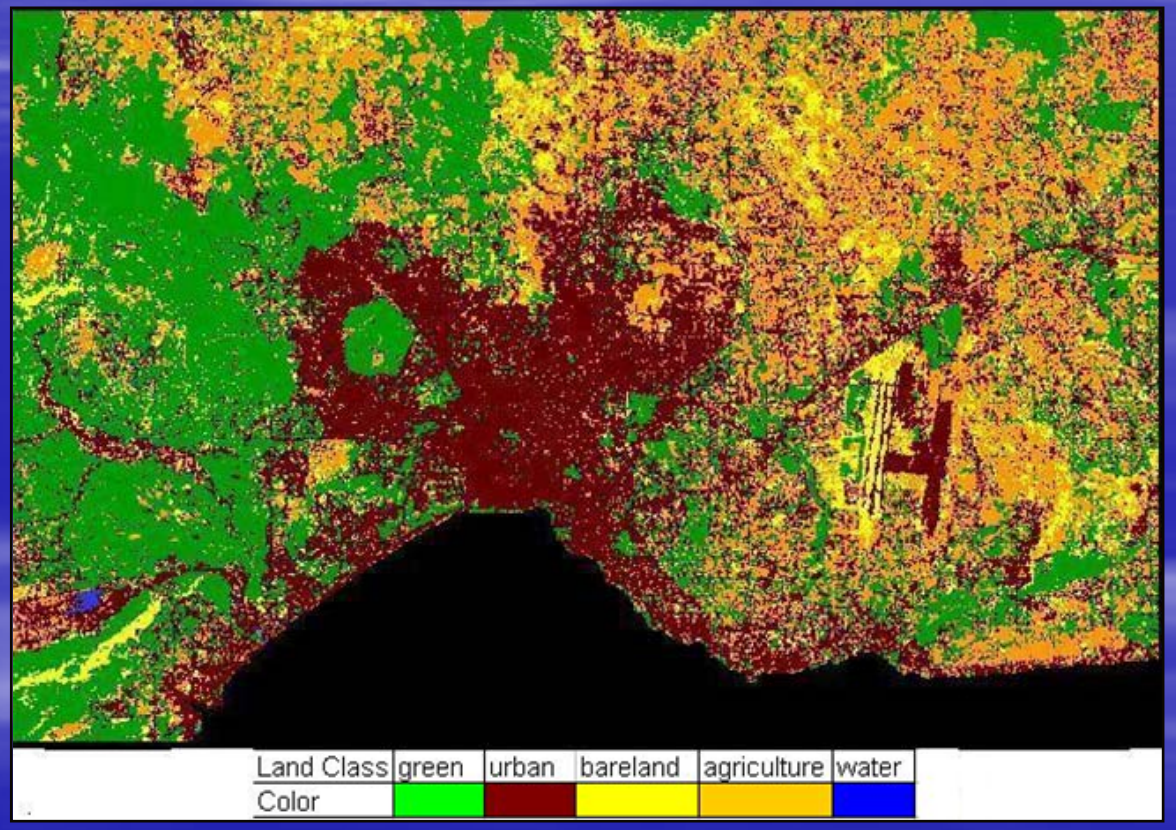
2.3.1. Classification Analyses of the Satellite Image of the Year 2002



The Result Thematic Map of the Supervised Maximum Likelihood Classification Analysis of the Year 2002.

i. Post Classification Analyses of the Year 2002

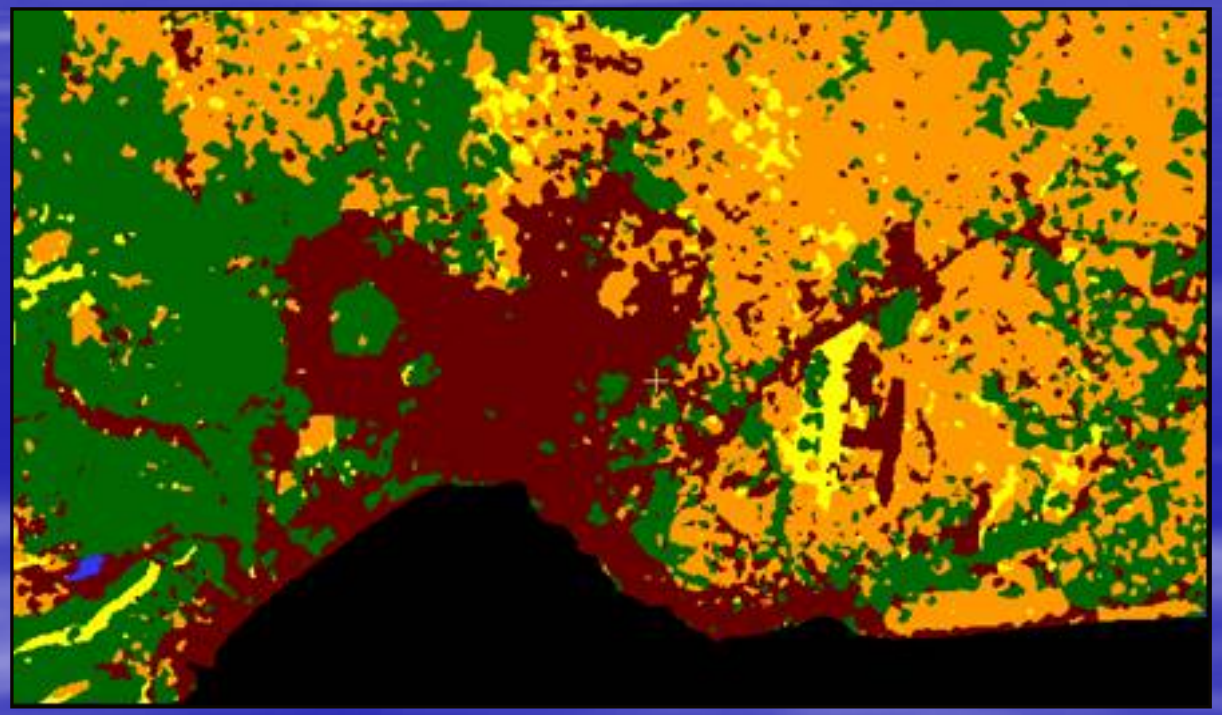
- **The 13 classes are aggregated as a post classification method in PCI**



Aggregation of the Maximum Likelihood Classification for the year 2002.

i. Post Classification Analyses of the Year 2002

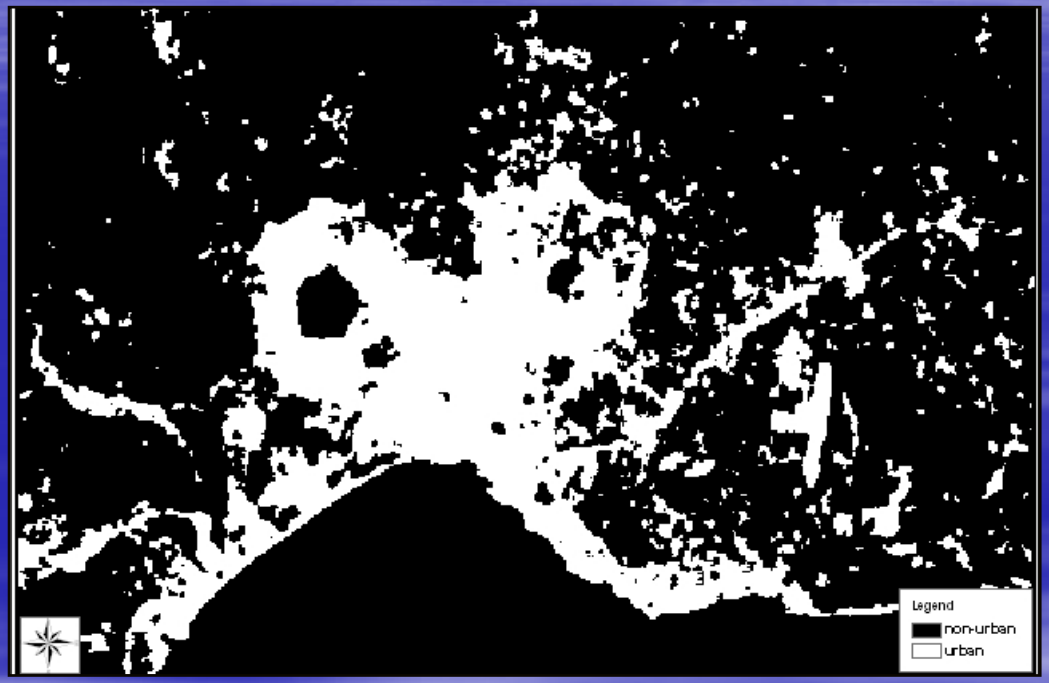
A low pass mode filter with a window of 7 x 7 is applied to the aggregation result to obtain the integrity of the classes:



Mode 7 x 7 Filter Application to the Aggregation Result of the year 2002.

ii. Recoding of the Raster Layer of the Year 2002

- The model requires the urban extent layer as urban and non-urban binary layer. Therefore, they are converted to raster imagine format.



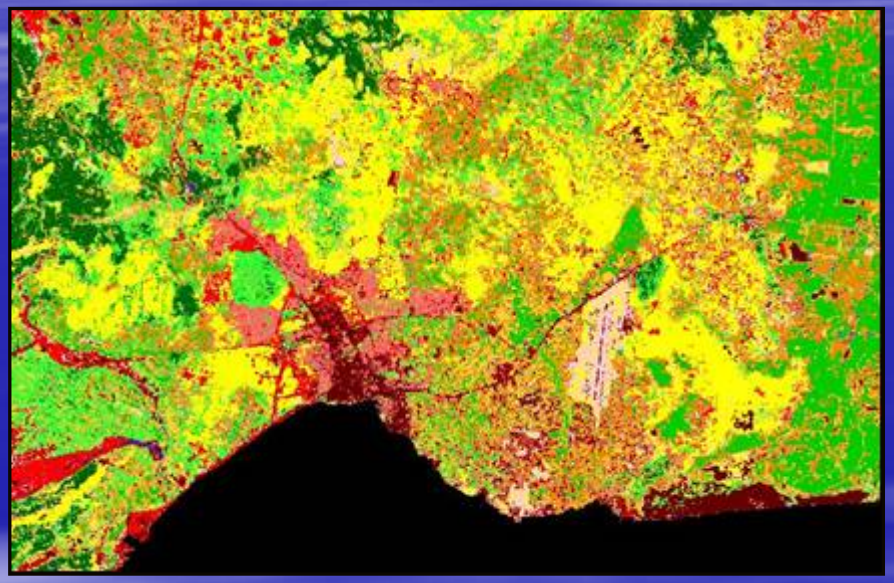
2002 Urban Extent Layer after Recoding the Mode Filtered 2002 Image (white is urban, black is non-urban pixels).

i.i.i. Accuracy Assessment of the Classification Result of the Year 2002

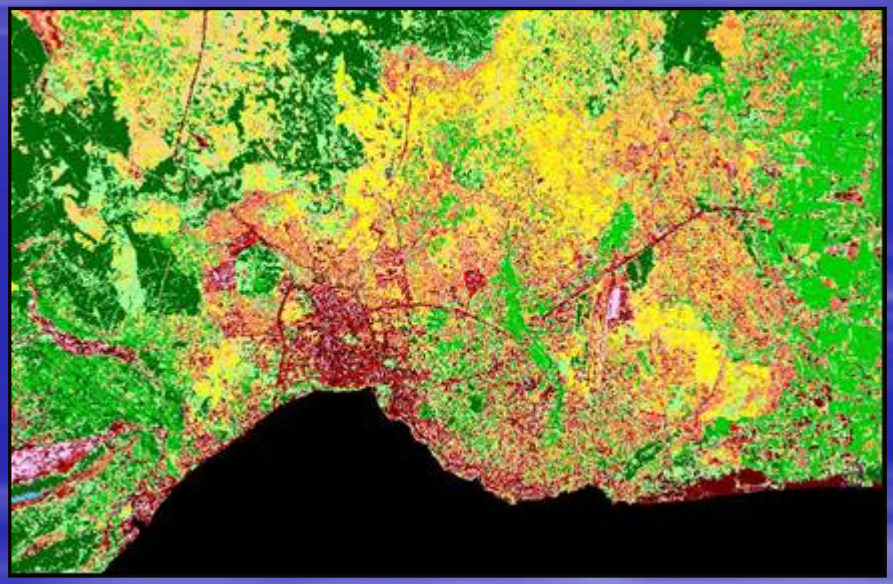
- The overall accuracy is obtained as 91.720%

- The producer's accuracy is obtained as 92.4% for non-urban areas, 88.8% for the urban areas.

2.3.2. Classification of the Satellite Images of the Year 1987 and 1996



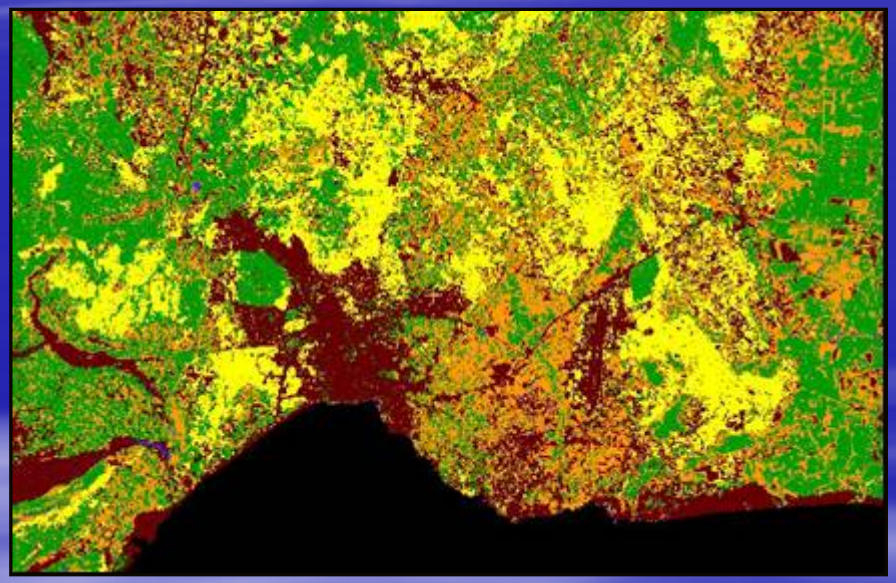
The Result Thematic Map of the Supervised Maximum Likelihood Classification Analysis of the Year 1987



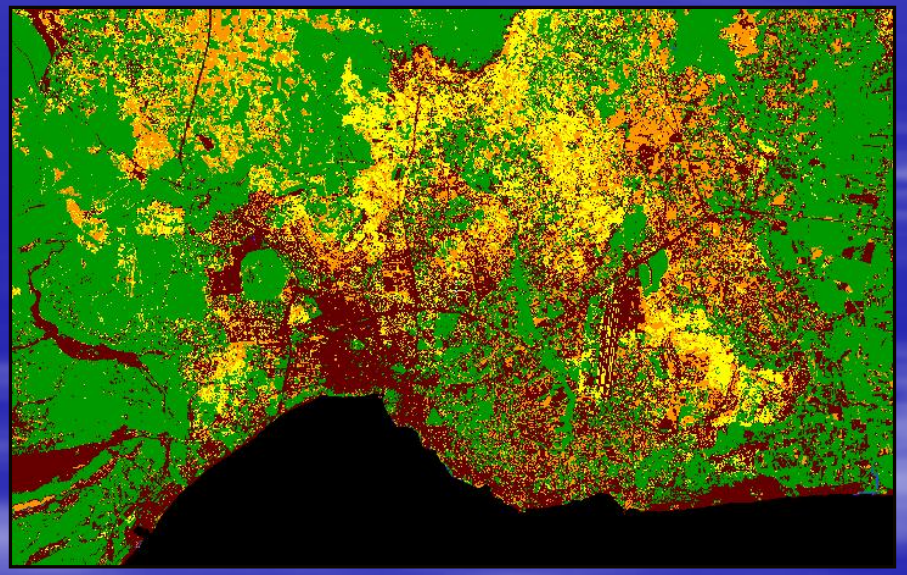
The Result Thematic Map of the Supervised Maximum Likelihood Classification Analysis of the Year 1996

i. Post Classification Analyses of the Years 1987 and 1996

After the classification analysis, the post classification steps of aggregation for these two years are realized



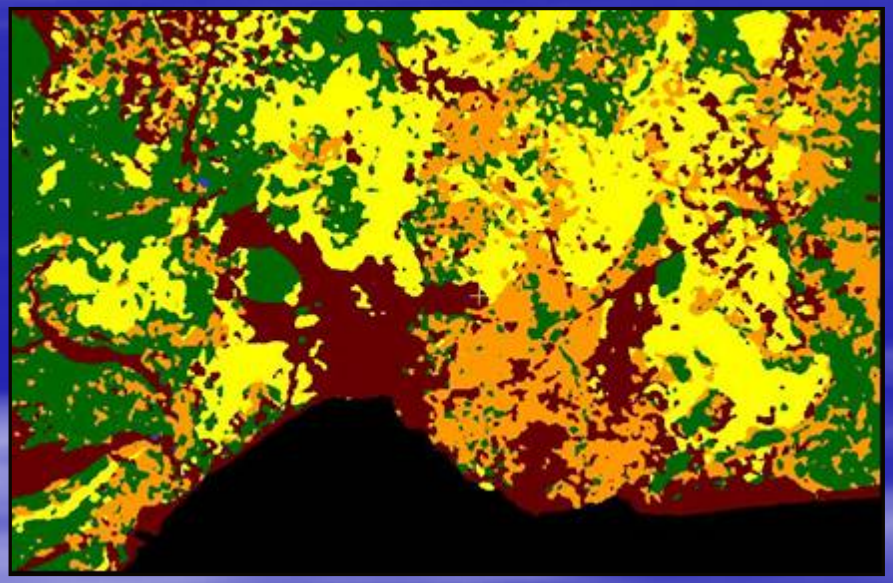
Aggregation of the Maximum Likelihood Classification for the year 1987.



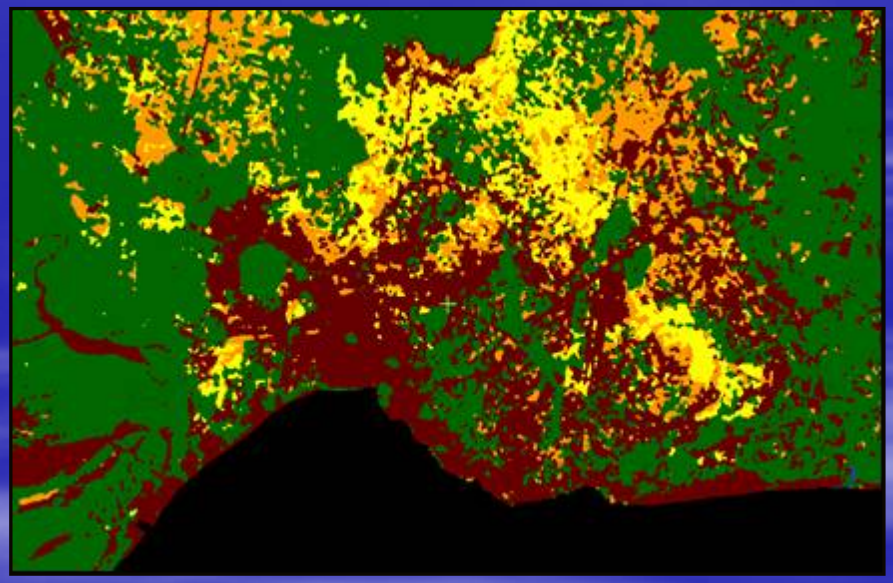
Aggregation of the Maximum Likelihood Classification for the year 1996.

i. Post Classification Analyses of the Years 1987 and 1996

- For the integrity of the classification classes of these two years, the next post classification step of filtering is produced; low pass 7 x 7 pixel window filter is applied in PCI V9.1

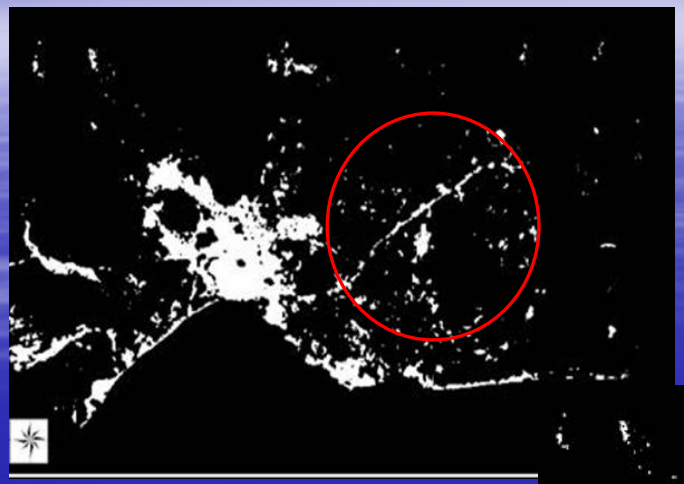


Mode 7 x 7 Filter Application to the Aggregation Result of the year 1987.

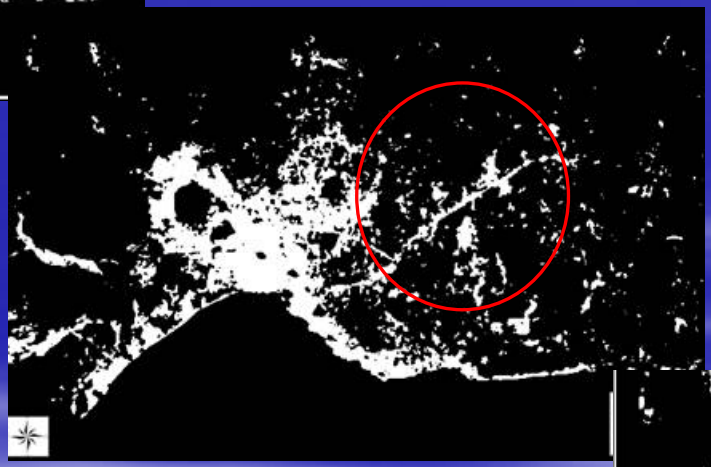


Mode 7 x 7 Filter Application to the Aggregation Result of the year 1996.

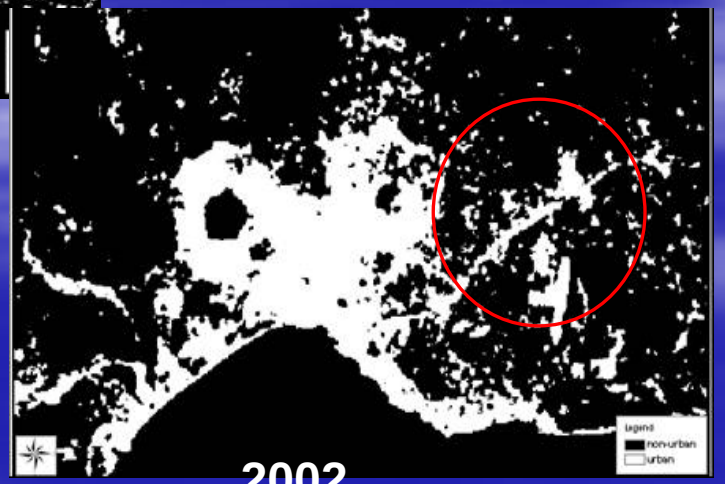
In turn in order, 1987, 1996, and 2002, Urban Extent Layers



1987



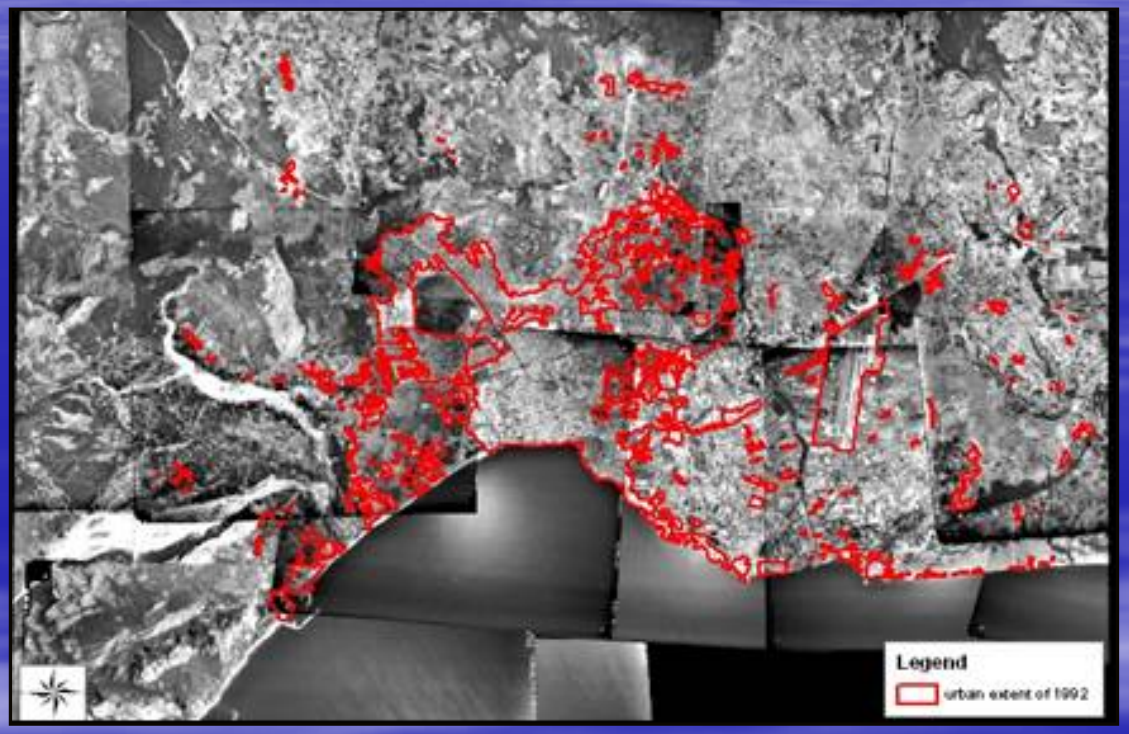
1996



2002

2.4. Analyses of the 1992 Aerial Photographs

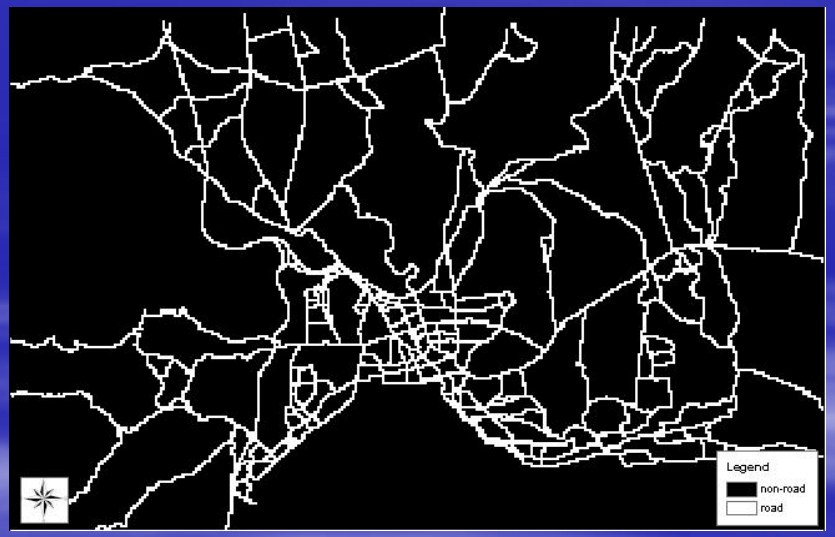
- For urban extent of the year 1992, the satellite images could not be found. Therefore, aerial photographs of the study area are obtained



The Layer of the Urban Extent of the Year 1992

2.5. Analyses of the Roads Layer

- The digitized road layers are converted to raster imagine format
- The road pixels are recoded as one and the non-road pixels are recoded as zero



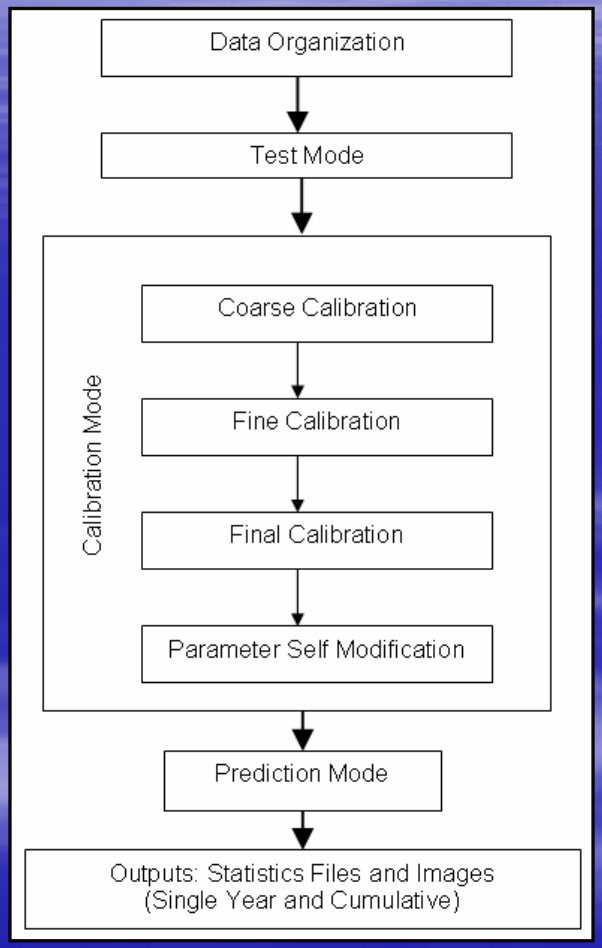
The Recoded Road Layers of the Years 1995 and 2003

2.6. Analyses of the Excluded Areas Layer

- **The excluded area layer is converted to raster imagine format and recoded**

The Recoded Excluded Area Layer of the Year 2003

2.7. Methodology of the Study



General outline of a Sleuth Model run examined in this study

3.URBAN GROWTH ANALYSES

- The structure of the model run and the required coefficients, adapted to Antalya are explained.

3.1. Calibration Analyses

Coefficients start-step-stop values	Test Run	Coarse Cal.	Fine Cal.	Final Cal.	Forecast Run
CALIBRATION_DIFFUSION_START	25	0	0	1	1
CALIBRATION_DIFFUSION_STEP	1	25	5	1	1
CALIBRATION_DIFFUSION_STOP	25	100	20	5	1
CALIBRATION_BREED_START	10	0	0	10	20
CALIBRATION_ BREED_STEP	1	25	5	2	1
CALIBRATION_ BREED_STOP	10	100	20	20	20
CALIBRATION_SPREAD_START	30	0	20	27	32
CALIBRATION_ SPREAD_STEP	1	25	5	1	1
CALIBRATION_ SPREAD_STOP	30	100	40	32	32
CALIBRATION_SLOPE_START	70	0	75	75	78
CALIBRATION_SLOPE_STEP	1	25	5	3	1
CALIBRATION_SLOPE_STOP	70	100	100	90	78
CALIBRATION_ROAD_START	100	0	25	23	24
CALIBRATION_ROAD_STEP	1	25	5	1	1
CALIBRATION_ROAD_STOP	100	100	50	28	24
Self Modification Constraints					
Critical High	1.500	1.500	1.500	1.500	1.500
Critical Low	0.050	0.050	0.050	0.050	0.050
Boom	1.010	1.010	1.010	1.010	1.010
Bust	0.090	0.090	0.090	0.090	0.090
Critical Slope	21	21	21	21	21
The number of Monte Carlo com	2	100	100	100	100
The Calibration Start Date	1987				
The Calibration Stop Date	2003				

Parameters of the Test Run and the Calibration Runs

ii. Result of the Calibration Analyses

Result Parameters of the Coarse Calibration

LeeSallee	Diffussio	Bread	Spread	Slope	RoadGravity
0.46756	1	1	25	100	100
0.46756	1	1	25	100	75
0.46751	1	1	25	100	50
0.4674	1	1	25	75	25
0.4674	1	1	25	75	1
New Parameters For the next calibration	{0-20, 5}	{0-20, 5}	{20-40, 5}	{75-100, 5}	{25-50,5}

Result Parameters of the Fine Calibration

LeeSallee	Diffussio	Bread	Spread	Slope	RoadGravity
0,48995	1	15	30	85	100
0,48992	1	20	30	80	75
0,48992	1	10	30	85	50
0,48987	1	20	30	75	25
0,48987	1	15	30	90	1
New Parameters For the next calibration	{1-5, 1}	{10-20, 2}	{27-32, 1}	{75-90, 3}	{23-28,1}

Result Parameters of the Final Calibration

LeeSallee	Diffussion	Bread	Spread	Slope	RoadGravity
0,50298	1	20	32	78	24
0,50294	1	20	32	78	26
0,50289	1	18	32	78	27
0,50289	1	12	32	84	24
New Parameters For the next step	{1-1, 1}	{20-20, 1}	{32-32, 1}	{78-78, 1}	{24-24,1}

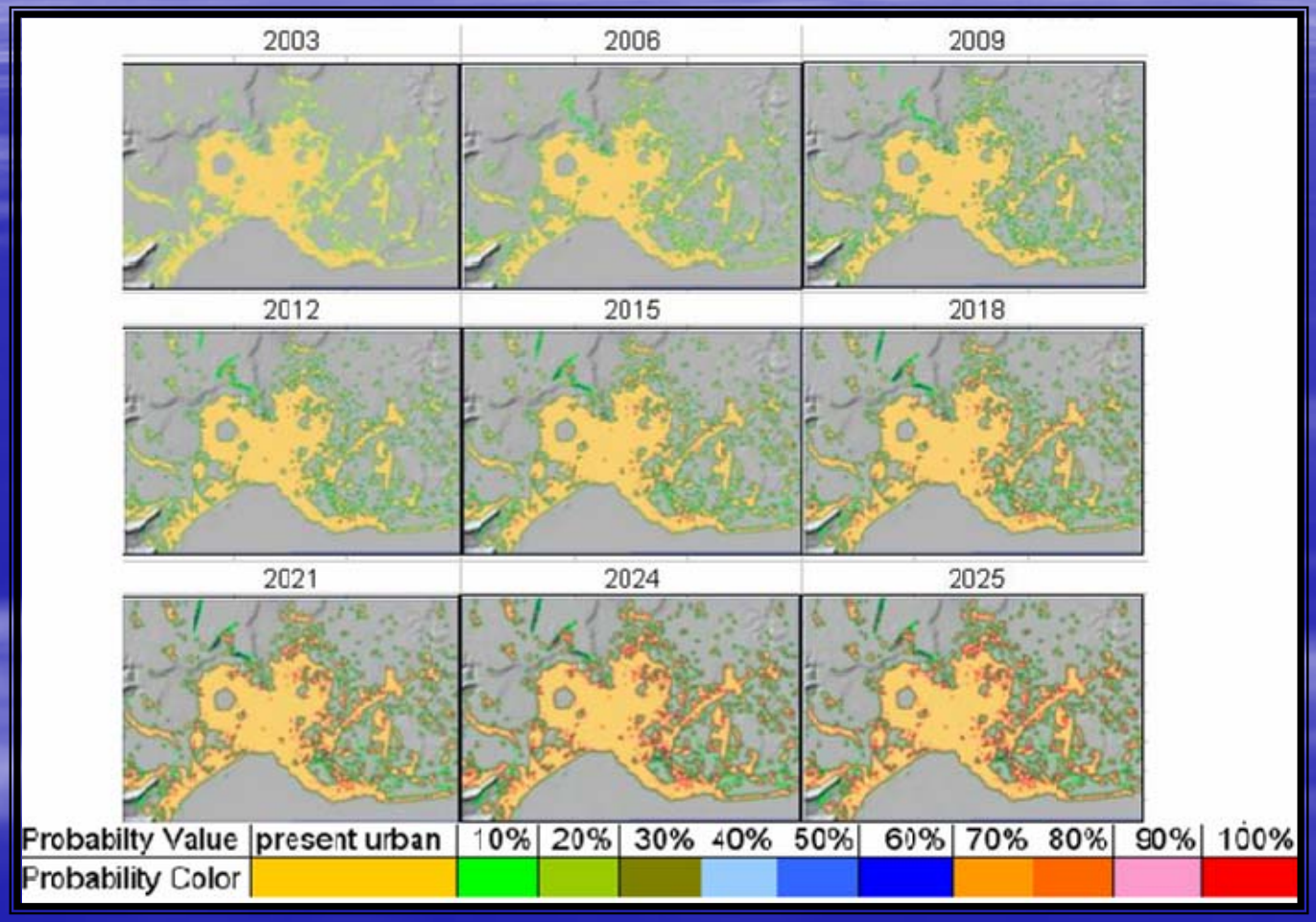
3.2.Urban Growth Prediction Run

In the prediction scenario file;

- **PREDICTION START DATE = 2002**
- **PREDICTION STOP DATE = 2025**

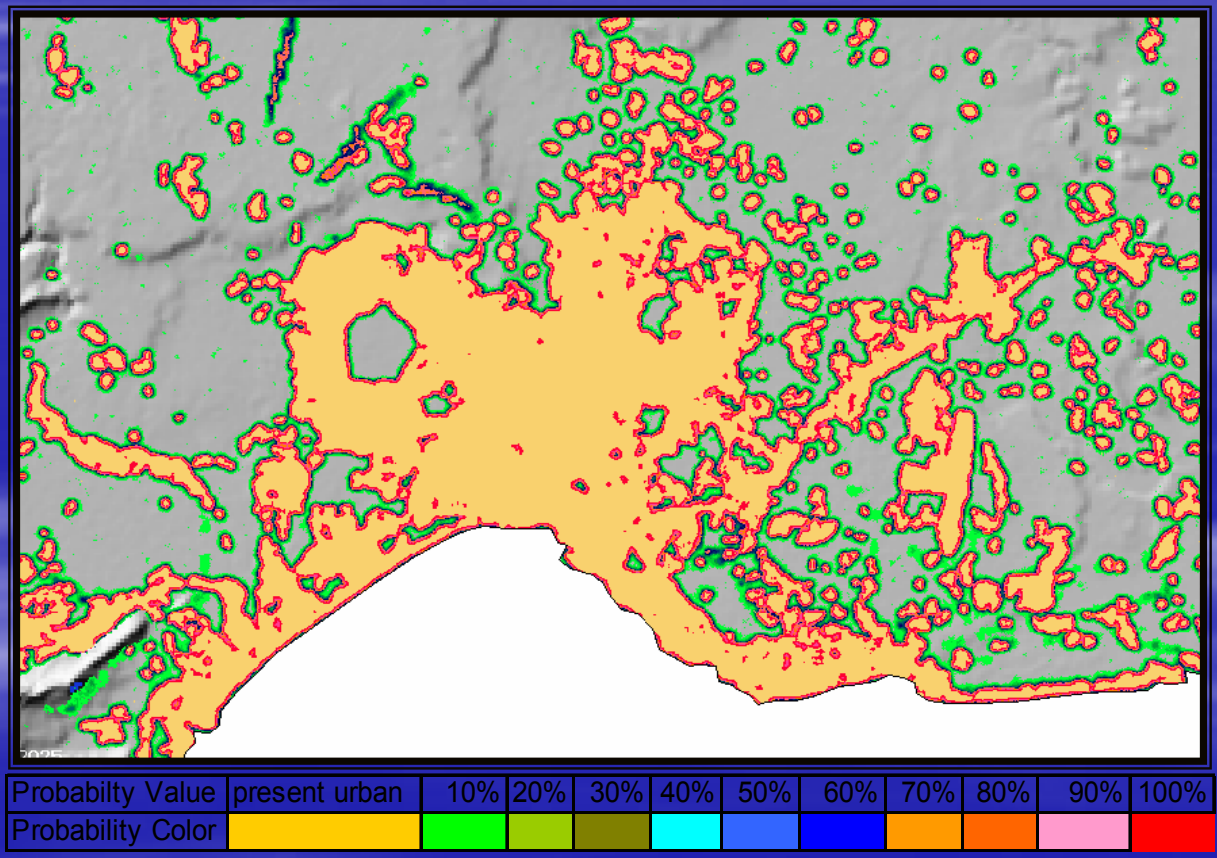
As a result, the urban growths of the years from 2003 to 2025 within the environmental protective frame are created in the prediction output file.

4.RESULTS AND DISCUSSIONS



4.RESULTS AND DISCUSSIONS

- Each year's growth probability pixels are colored. The higher the probability value, the more likely urbanization is.



Urban Growth Prediction of the year 2025 with the Probability Colors

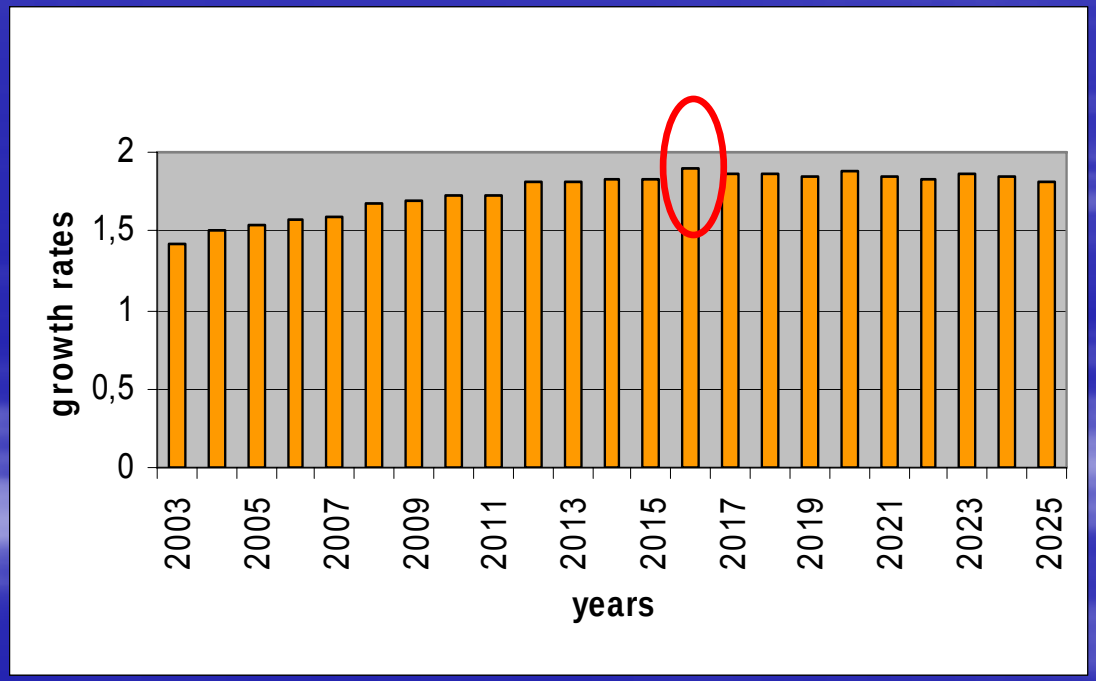
4.RESULTS AND DISCUSSIONS

- Comparison of the Selected Statistical Measures of the Years 2002 and 2025.
- The reason of this decrease is the maximum protection of the forest areas, agricultural areas, and natural conservation areas in this study.

Statistical Measures	2002	2025
sng	5,78	5,26
og	2801	3621,26
rt	13,07	28,48
pop	92738,64	201894,3
area	92738,64	201894,3
edges	20731,95	32667,84
clusters	1362,68	1895,96
rad	171,81	253,51
slope	0,73	0,69
diffusion	1,15	1,24
spread	36,78	28,63
breed	22,99	46,05
road_gravity	26,59	37,74
percent_urban	21,8	56,05
growth_rate	3,04	1,81
growth_pixels	2822,23	3659,33

4.RESULTS AND DISCUSSIONS

- The scenarios for Antalya embodies an anti-growth strategy, which requires slowing down the growth rate.



Urban Growth Rates through the Year 2025

5.CONCLUSION AND RECOMMENDATIONS

As a conclusion:

- **RS and GIS based dynamic growth modeling improves the understanding of the urban growth variations, and facilitates the urban and environmental management within a balance for a sustainable development.**

- **Different growth scenarios as slow, fast, and trendy can be applied by modifying the layers. So, the comparison of these scenarios can be examined.**

- **For further studies, the incomes and social dimension can be added to the model by modifying the model's source code in order to use social-economic layer of the municipalities or districts.**

- **Finally, as Sleuth Urban Growth Prediction Model, some other kinds of models can be applied to Africa or another Continent for the sustainable development of all World.**

Thank you for Listening