

POPSATER

New improvements in population estimate



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But also Alix, Mathieu, Louis, André, Anne, Enrico, Sophie...

BELSPO EO Day
6th May 2010, Chaudfontaine

ADRASS



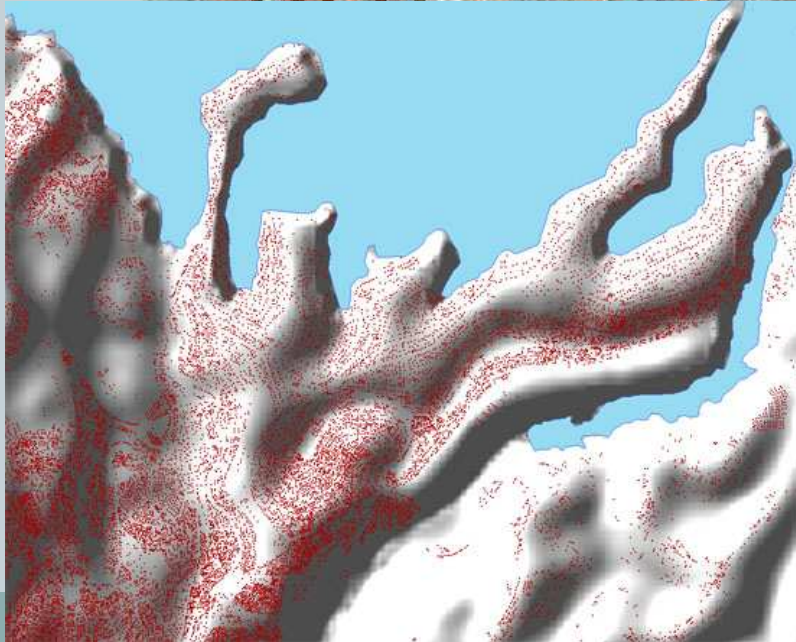
ULB
IGEAT

What do we observe in the field ?



- Population data are essential for the socio-economic development of a country, a region, etc.
- The question of population is central to adequately plan and perform the humanitarian, relief, development and engineering activities.
- Examples: IDP/refugees, major infrastructures (dams), master plans (water/sanitation/transport), energy programs, etc.

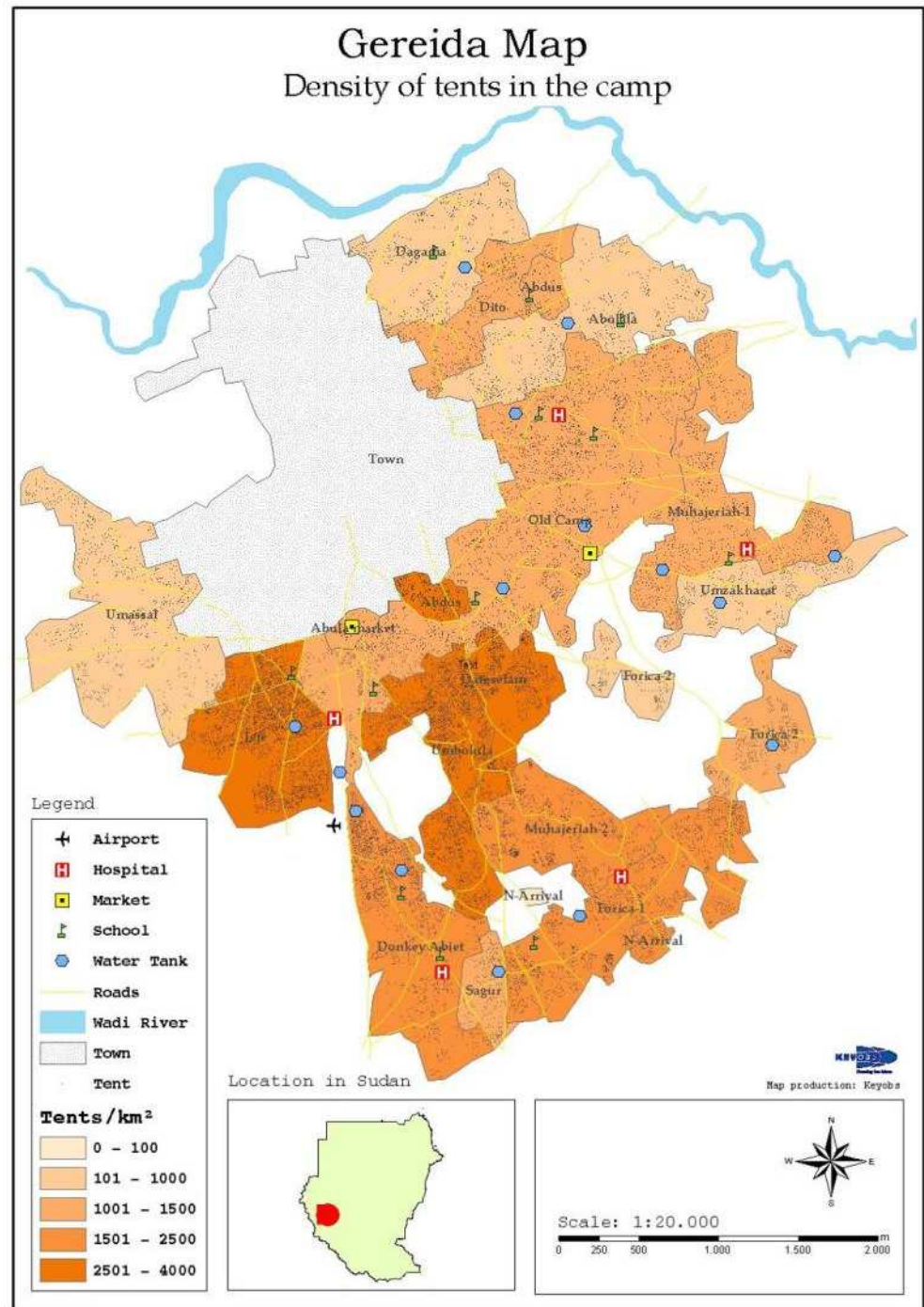
Water network DR Congo



- **Project:** Rehabilitation of infrastructures, drinking water network in the cities of Eastern DR Congo (Kalemie, Bukavu, Sake, Kibirizi, Kitshanga)
- **Information provided:** extraction of buildings, topography, estimation of population
- **Data used:** Quickbird, Ikonos, SPOT DEM

IDP/refugees in Sudan

- The local authorities state 200k people and require consequent aid
- The aid agency states 100k people
- So what ?

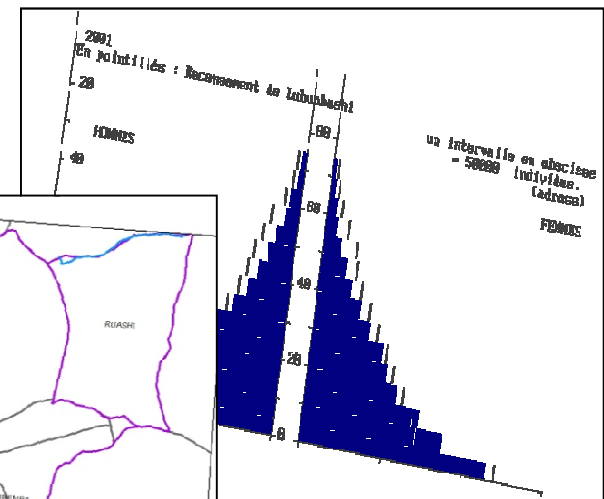
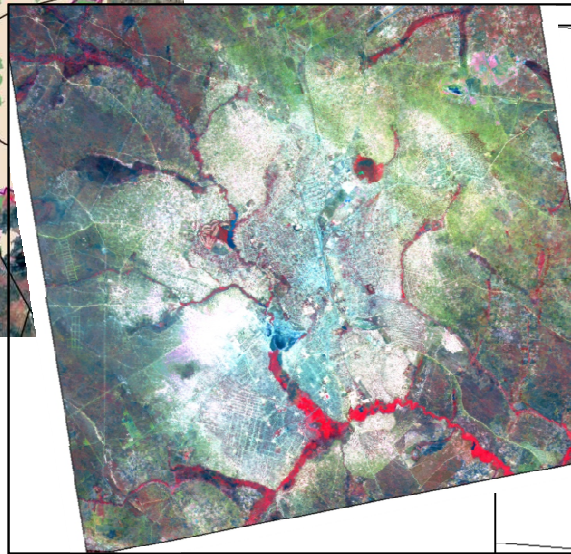
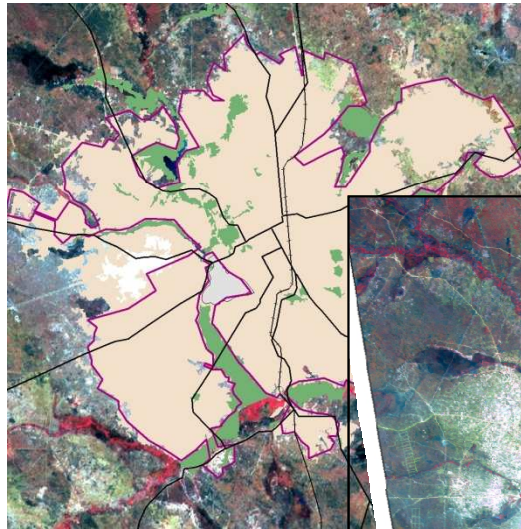


And then...POPSATER



- Strong limitation of classical demographic approaches in fast-growing and dynamic environment.
- Need for a cost-effective and fast solution.
 - ⇒ Alternative and multi-source demographic methods
 - ⇒ to identify, to test and/or to adapt methods of population estimates based on the remote sensing data

Using SPOT image with archives data

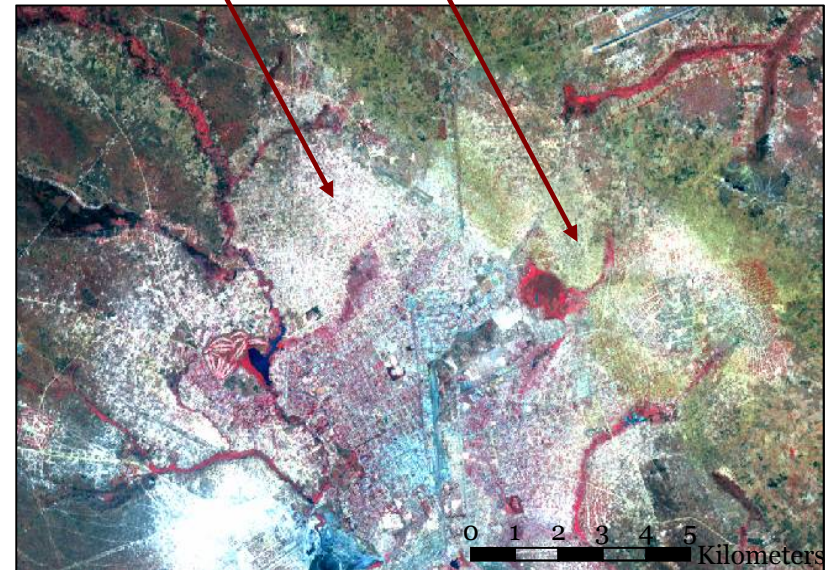


Using SPOT image with archives data

Extract the urban area: object-oriented method

- **Segmentation**
 - Green(1), red(2), near infrared(2)
 - Standard segmentation parameters chosen by trial-error according to the resolution
- **Features**
 - Spectral
 - ✦ Built-up area: means of blue and near infrared bands
 - ✦ Vegetation: NDVI
 - Textural parameters (GLMC) to remove effect of ≠ geological zones
- **Classification: nearest neighbor algorithm**
- **Validation**
 - Exhaustive comparison with manual delimitation of the built-up area

2 built-up areas on 2 geological zones



Aster 27/08/2001

Using SPOT image with archives data

Extract the urban area : thresholding method



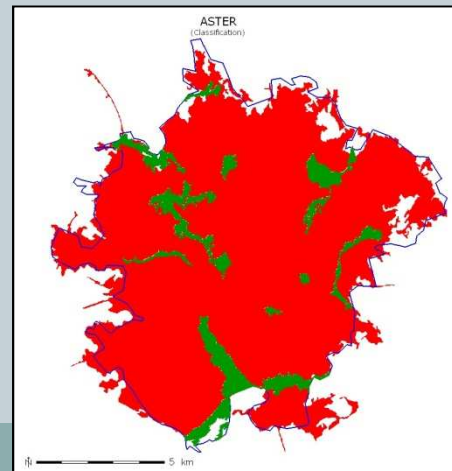
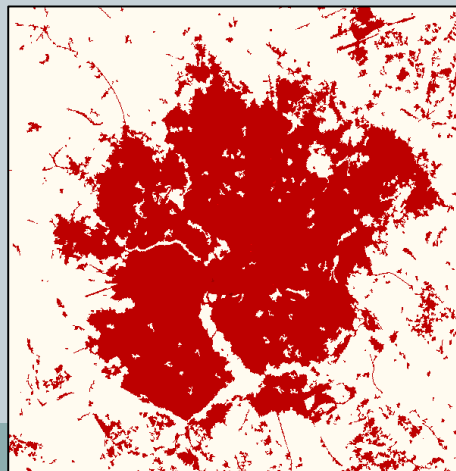
- PCA → 1st component stretched between 0 and 255
- Thresholding at each value
- Smoothed
 - Closure: dilatation + erosion windows 3 x 3
 - ✦ Reduce impact of artifact: eliminate small areas
- Urban frequency map
 - Cumulative frequency: sum of all thresholded maps
 - Analysis the discontinuities in the cumulative frequency curve (DISCOUNT algorithm)
 - 4 classes defined: certainly non urban; probably non urban; probably urban; certainly urban

Using SPOT image with archives data

Extract the urban area : Generalization for both methods



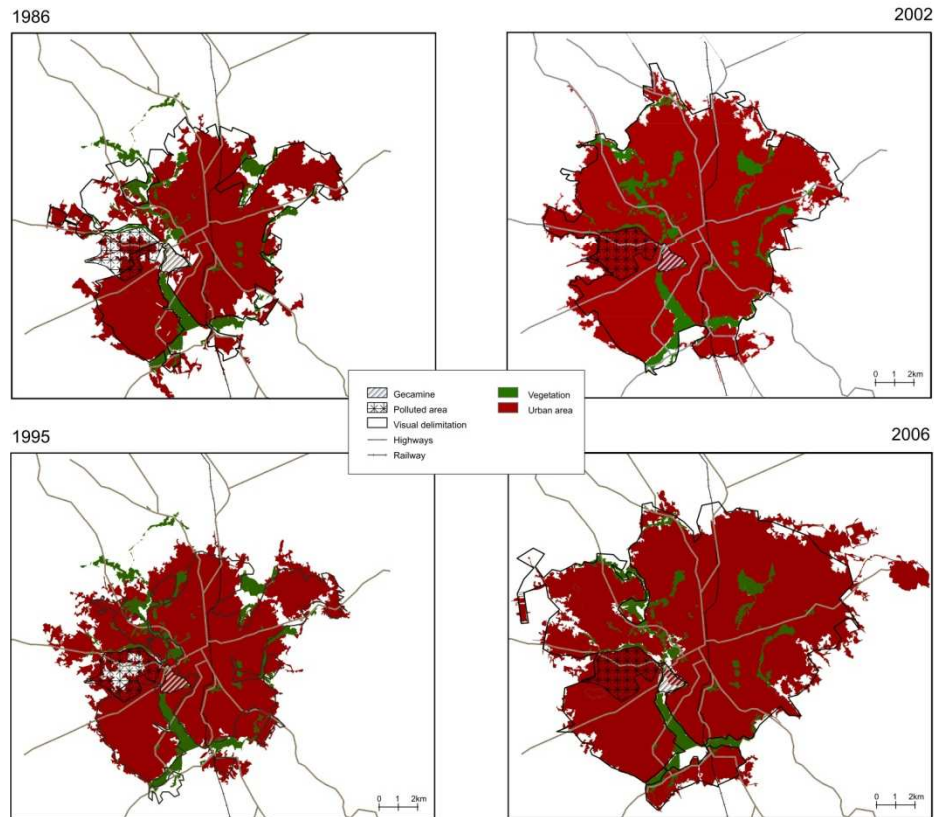
- Generalization for both methods
 - Continuous urban fabric = dwellings within 200m
 - Non built-up inclusions less than 1km² are dissolved
 - Vegetation, water, bare soil, ... are identified as no built-up



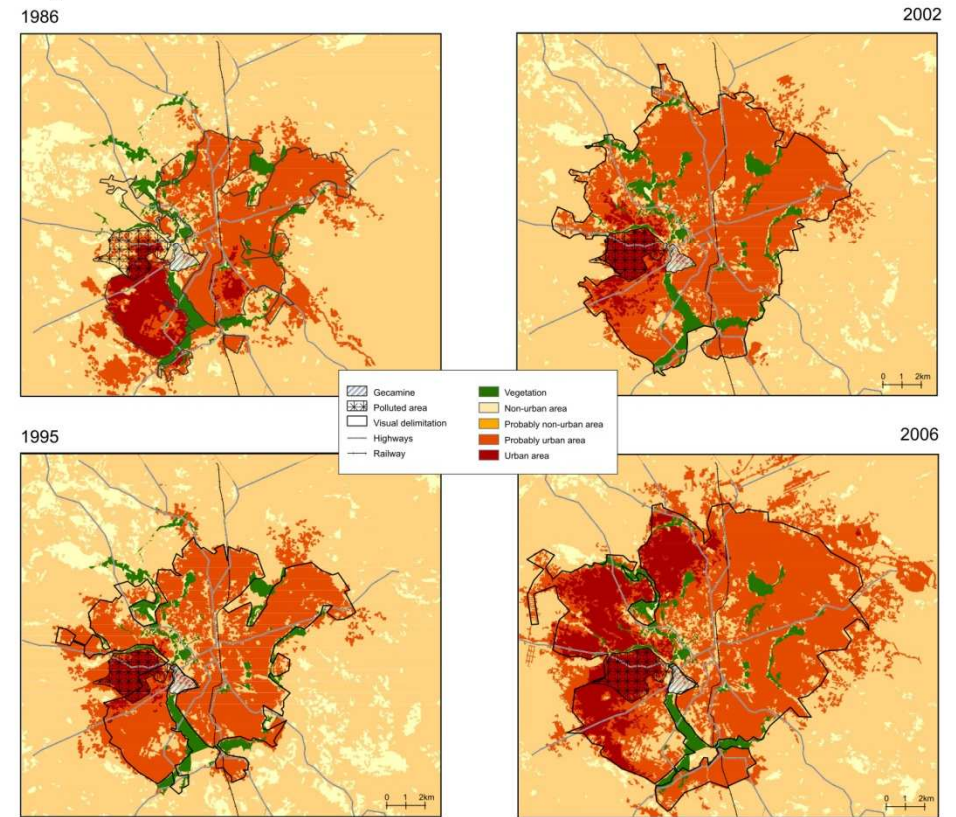
Using SPOT image with archives data

Results

Threshold method



Object-oriented method



Data sources : SPOT image (04/06/1986; 05/08/1995; 10/10/2006); ASTER image (27/08/2001)
Authors : M. De Maeyer, A. Soliaux

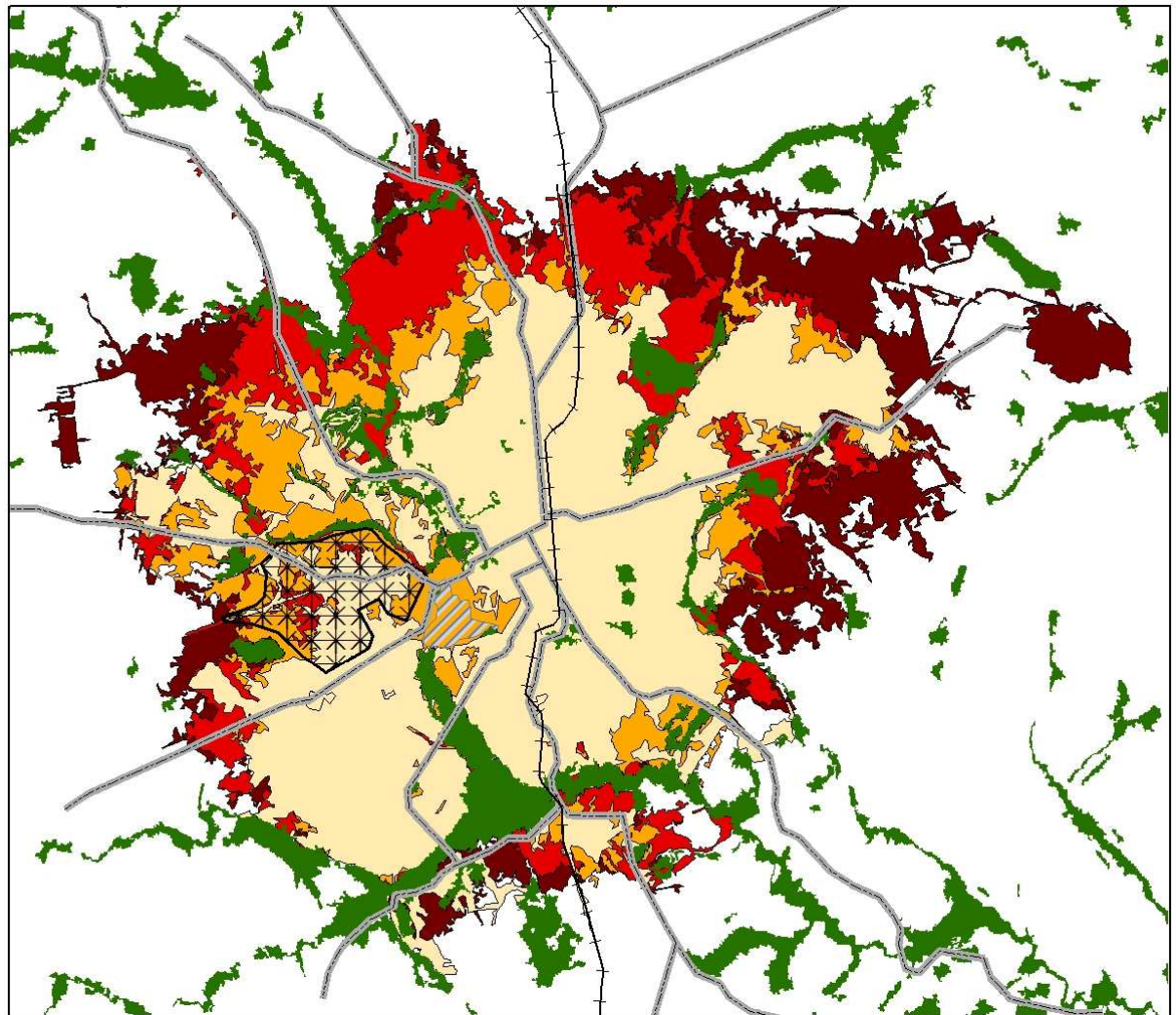
- Both method
 - Food results (+/- 3% ≠ for Surface)
 - Reproducibility : time and different sensors (SPOT; ASTER)

Using SPOT image with archives data Results and urban growth

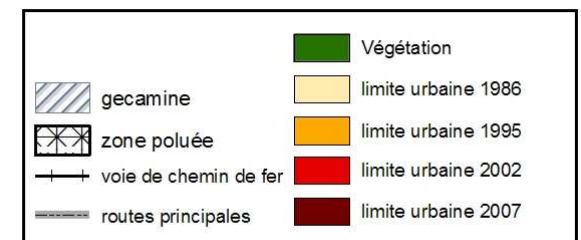
- Ho: urban growth proportional to the population growth

Years	Total area mapped (km ²)
1986	71,9
1995	88,3
2002	118
2007	144,3

- Urban areas estimation for each year



0 0.5 1 2 Km



1st method: Using SPOT image / without fieldwork

Demographic data structure :

- Population by age and sex 1984
- Idem for 2001 and 2005 but with errors
(2001 : possibility of under estimate and problems for the 0-4years
2005 : voters registration no data under 18years)



Demographic data movement:

Estimated levels of fertility and mortality

- Ho —
- To stay smooth (e.g. parameter changes are never dramatic)
 - To stay compatible with what we know about the regional/local population dynamics



Demographic Population estimation Reconstruction

Year by year
between 1984
and now

Using SPOT image with archives data



Years	Remote Sensing	Remote Sensing / Demographic estimation	Demographic estimation
1986	589 444	1,00	589 444
1995	723 450	0,85	848 819
2001	966 297	0,90	1 070 032
2007	1 182 121	0,89	1 327 320

- Reference year = 1986
- Analysis
 - Rapid decline of extremely high fertility
 - Up to 15% \neq \rightarrow very good in African context

Fieldwork



- **Sample design**
 - Sampling unit = **household**
 - Minimizing the sample size/ municipality: reference to a 95% confidence interval → **400 household/ municipality**
 - 7 municipalities = total sample of **2800 households**
 - Keeping an easy identification and minimizing field displacements clustering by "natural" identifiable units = **the blocks**
 - 40 blocks per municipality with 10 households

Fieldwork



QuickBird (12/09/2009): fine morphological and visual zoning:

- Visually segment the city into homogeneous morphological neighborhoods units
 - Following visible limits
 - ✦ natural (river, swamp...)
 - ✦ artificial (road, rail ...)
- Working rules used:
 - Constant working scale: 1:10 000
 - Minimum mapping unit: 1hectare

Fieldwork

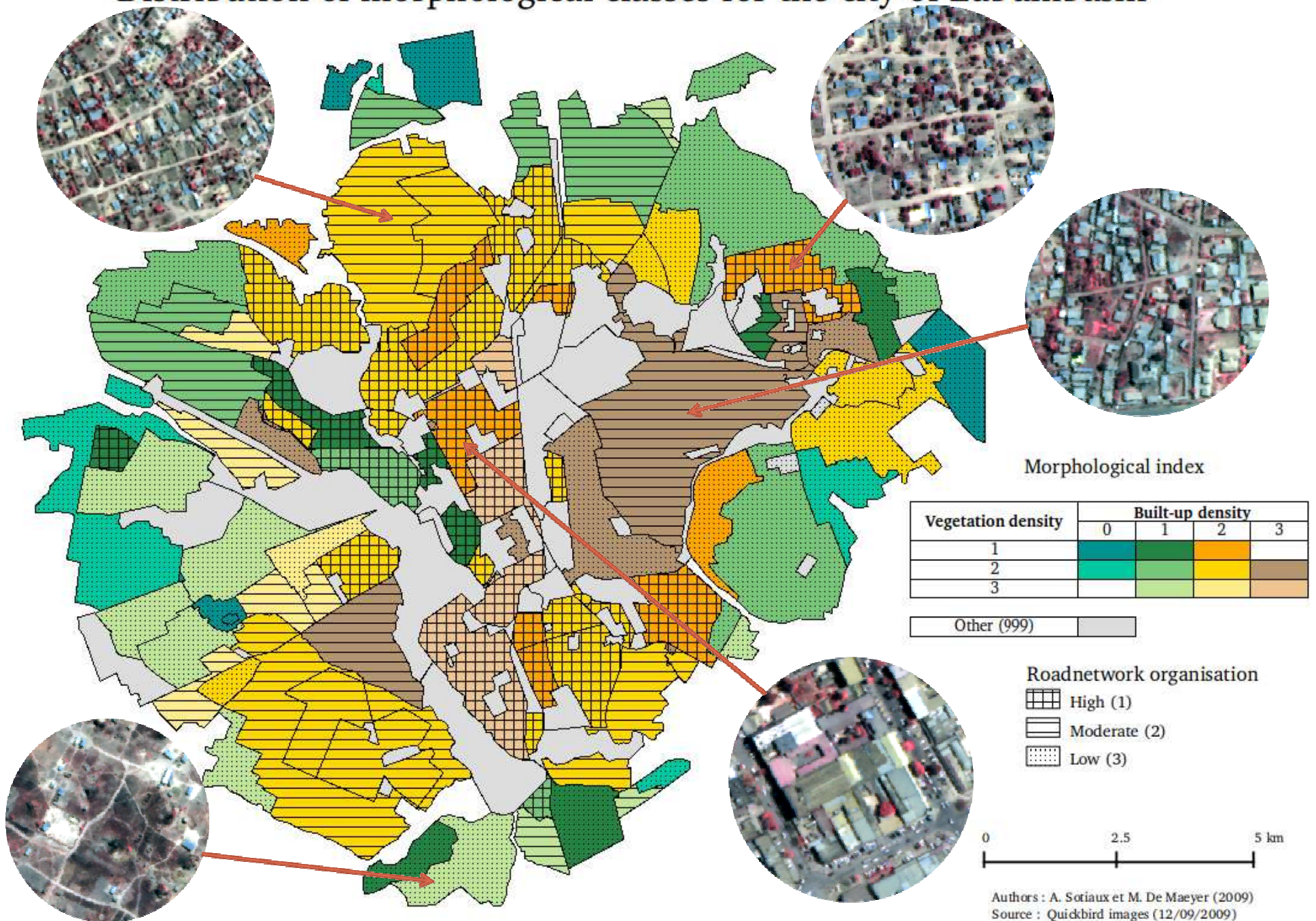


- Interpretation of each units according to a morphological typology

Code	Density of buildings	Density of vegetation	Structure of roads
0	Very low		
1	low	high	Structured and tarmac
2	medium	medium	Slightly structured
3	High	low	No apparent structure
4	/	No vegetation	

- Morphological index = 123 for low dwellings, medium vegetation and no roads structures

Distribution of morphological classes for the city of Lubumbashi

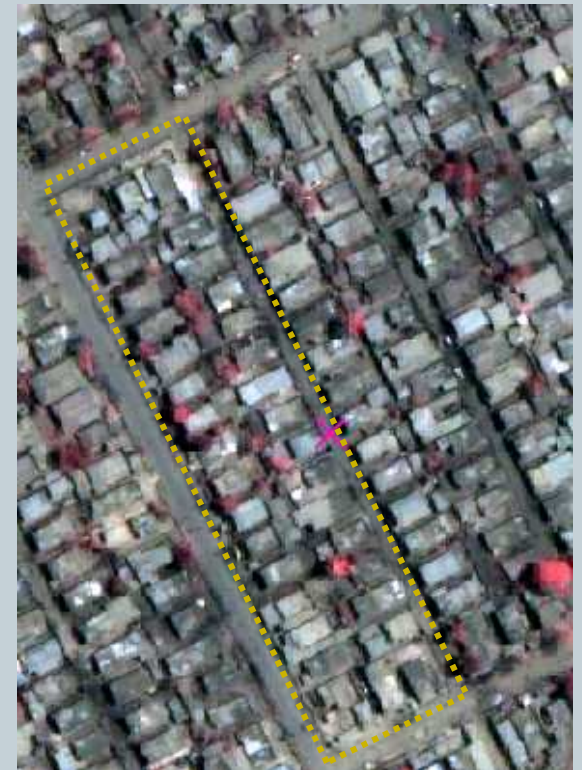


Authors : A. Sotiaux et M. De Maeyer (2009)
 Source : Quickbird images (12/09/2009)

Fieldwork



- Each selected block is surveyed by an agent
- Agents receive:
 - Questionnaire
 - 3 days training
 - User manual
 - Reference sheets (global orientation and sampling)



Fieldwork



- Examples of reference sheets used by agent (global orientation and sampling sheets)



Fieldwork



- Difficulty of drawing blocks for the municipality “Annexe”
- Impossible to define blocks in the Brondo district



Fieldwork

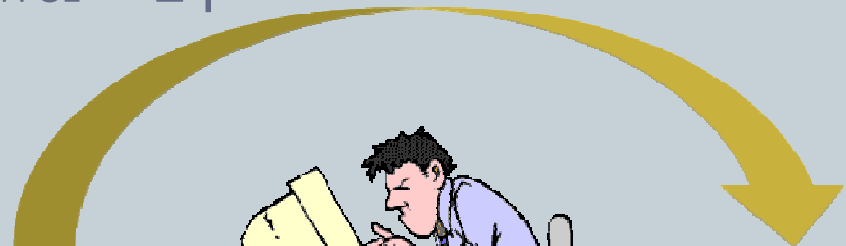
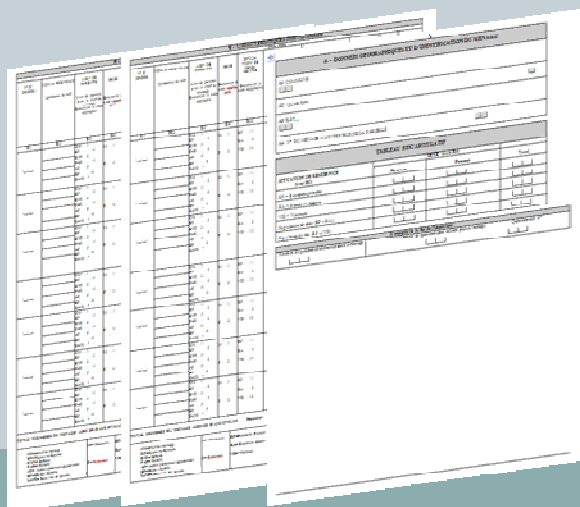


- **Approximation of block's population size**
 - Enumerate every plot, building and household
 - Note the number of dwellers/household
- **Questioning 10 households in the block (randomly selected)**
 - Demographic (full name, relationship, sex, age,...)
 - Sociologic and economic (solarisation, profession, ...)
 - Morphologic (number of habitable room, roof material, ...)

Using QuickBird image with fieldwork

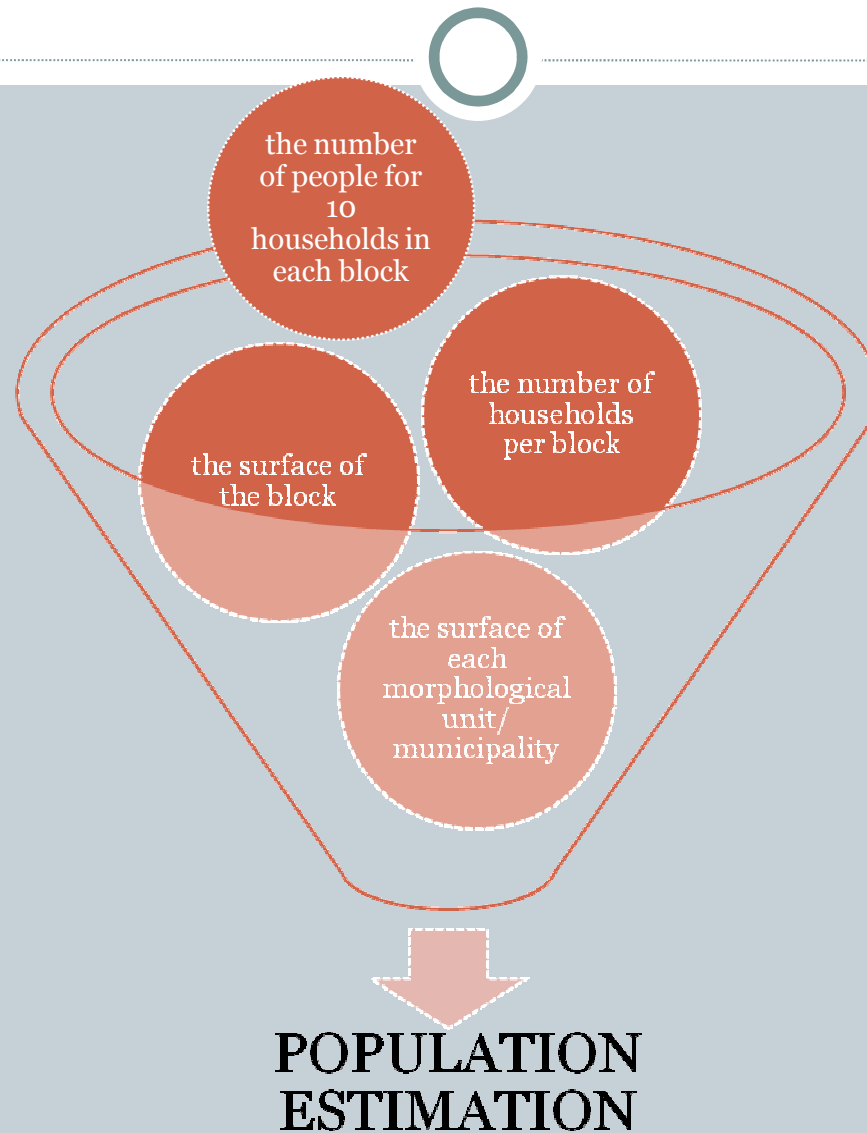


- Counting results... many problems:
 - Some questionnaires poorly completed or un completed → 1.150 missing data = 11%
 - Refusal to answer = 24



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	
1	COMMUNE	ILOT MEMBRES	DENOM	NUMER	N_ILOT	W_LOT	W_COMM	W_TOTAL	Surface en m²	NO_ILOT	CLASSE	ACLASSE	POP.	LOT	AU KM2	
2	1	96	18	15	1	1,200000	1,131052	1,131814	49387,7080960	101	111	111	115	2332,6		
3	1	2	130	30	30	2,000000	1,131052	1,131814	99719,6745940	102	111	111	130	1303,7		
4	1	3	122	28	28	3,000000	1,131052	1,131814	11336,7875140	103	111	111	122	1708,8		
5	1	4	382	87	87	4,000000	1,131052	1,131814	28332,9889630	104	132	132	382	13454,0		
6	1	5	13	13	2	8,500000	1,131052	1,131814	33047,7884930	105	201	201	85	2586,9		
7	1	6	18	6	6	6,000000	1,131052	1,131814	36620,41469710	106	311	311	18	491,5		
8	1	7	124	25	25	7,000000	1,131052	1,131814	40851,09728250	107	121	121	124	3050,3		
9	1	8	149	35	35	8,000000	1,131052	1,131814	26846,44210970	108	321	321	149	5720,8		
10	1	9	40	16	8	9,200000	1,131052	1,131814	71363,34182030	109	232	232	80	1121,0		
11	1	10	46	11	11	10,000000	1,131052	1,131814	100172,40919800	110	232	232	46	459,2		
12	1	11	103	20	20	11,000000	1,131052	1,131814	29864,01714800	111	122	122	103	3438,6		
13	1	12	64	17	17	12,000000	1,131052	1,131814	36035,90429950	112	122	122	64	1776,0		
14	1	13	18	14	3	13,466667	1,131052	1,131814	23232,31428390	113	212	212	70	1663,6		
15	1	14	113	17	17	14,000000	1,131052	1,131814	10999,80506630	114	133	133	113	10272,9		
16	1	15	136	24	23	15,043478	1,131052	1,131814	32635,56325260	115	222	222	142	4348,4		
17	1	16	70	15	15	16,000000	1,131052	1,131814	46000,06287890	116	222	222	70	1521,7		
18	1	17	35	27	9	17,300000	1,131052	1,131814	61029,36297530	117	123	123	105	1720,5		
19	1	18	254	68	68	18,117931	1,131052	1,131814	20303,57451080	118	222	222	289	14326,6		
20	1	19	814	154	153	19,086336	1,131052	1,131814	16954,57793320	119	222	222	819	48324,4		
21	1	20	140	24	24	20,000000	1,131052	1,131814	21683,38714390	120	222	222	140	6456,6		
22	1	21	278	50	50	21,000000	1,131052	1,131814	18956,22484960	121	222	222	278	14564,5		
23	1	22	277	45	45	22,000000	1,131052	1,131814	40203,78271310	122	222	222	277	6889,9		
24	1	23	47	21	8	23,250000	1,131052	1,131814	19170,07418590	123	222	222	123	6435,8		
25	1	24	314	55	55	24,000000	1,131052	1,131814	26529,76109740	124	222	222	314	11838,8		
26	1	25	63	12	12	25,000000	1,131052	1,131814	33742,49105640	125	211	211	63	1867,1		
27	1	26	78	27	19	26,142195	1,131052	1,131814	63426,07781130	126	211	211	108	2021,5		
28	1	27	51	19	19	27,055556	1,131052	1,131814	37928,38409430	127	211	211	54	1419,3		
29	1	28	588	113	112	28,088889	1,131052	1,131814	63344,99595480	128	221	221	581	6730,6		
30	1	29	125	24	24	29,000000	1,131052	1,131814	19103,77998600	129	221	221	125	5432,2		
31	1	30	86	16	14	30,142857	1,131052	1,131814	18444,07646390	130	221	221	97	5266,9		
32	1	31	268	65	67	31,140351	1,131052	1,131814	11472,44335640	131	221	221	303	7134,1		
33	1	32	122	21	21	32,000000	1,131052	1,131814	6584,26669654	132	2212	2212	122	18529,0		
34	1	33	142	23	23	33,000000	1,131052	1,131814	81293,32011660	133	2212	2212	142	1746,8		
35	1	34	151	30	30	34,000000	1,131052	1,131814	6995,44728008	134	2212	2212	151	21571,1		
36	1	35	115	21	21	35,000000	1,131052	1,131814	6748,42148190	135	2212	2212	115	17041,0		
37	1	36	#NULL!	45	0	#NULL!	1,131052	1,131814	95639,39521700	136	232	232	#NULL!	#NULL!		
38	1	37	73	28	19	37,368421	1,131052	1,131814	99959,28538440	137	232	232	100	989,4		
39	1	38	107	16	16	38,000000	1,131052	1,131814	#NULL!	138	232	232	107	#NULL!		
40	1	39	217	34	34	39,000000	1,131052	1,131814	13704,93945090	139	232	232	217	15333,6		
41	1	40	93	22	22	40,000000	1,131052	1,131814	34593,19645360	140	232	232	93	2688,4		
42	1	41	43	22	12	41,833333	1,131052	1,131814	27223,12312460	141	232	232	79	2095,8		
43	2	1	#NULL!	37	0	42	#NULL!	1,090564	1,131814	32151,64492430	201	3312	3312	#NULL!	#NULL!	
44	2	2	296	61	61	43,000000	1,090564	1,131814	9853,32864117	202	3312	3312	296	30040,6		
45	2	3	478	91	91	44,000000	1,090564	1,131814	10296,02229200	203	3312	3312	478	46425,7		

Using QuickBird image with fieldwork



Using QuickBird image with fieldwork

FIRST RAW RESULTS

	Data obtained by census	Estimation / remote sensing and fieldwork	Growth rate (%)
	2001	2009	
Kamalondo	30.427	33.556	1,2
Lubumbashi	186.279	189.340	0,2
Kenya	95.905	77.345	-2,6
Katuba	275.273	196.457	-4,1
Ruashi	149.643	94.686	-5,5
Kampemba	307.862	203.277	-5,0
Annexe	122.232	211.874	7,1
City of Lubumbashi	1.167.621	1.006.535	-1,8
Demographic reconstitution data (starting with 1984 data)	1.070.032	1.426.157	3,6

future of research needed

Conclusion

- Estimation method using SPOT archives images without fieldwork:
 - Very good results
 - Efficient
 - Now cost
- Fieldwork
 - Heavy and serious investigation
 - 11% of forms not completed after 3 days of training
 - Uncertain quality of the administrative census of 2001
 - Census of 1984 very old
- Population estimation method using QuickBird images with fieldwork
 - Further research is needed

Thanks



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