# POPSATER New improvements in population estimate

#### Herbert Hansen, Keyobs Eleonore Wolff, ANAGEO- ULB

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

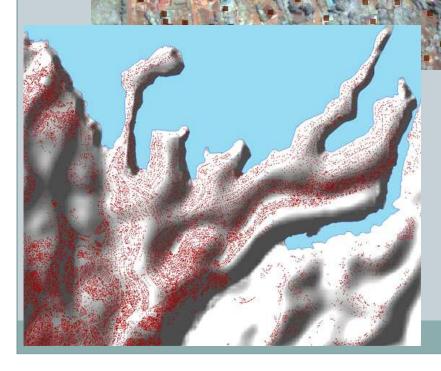
BELSPO EO Day 6th May 2010, Chaudfontaine



## 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.

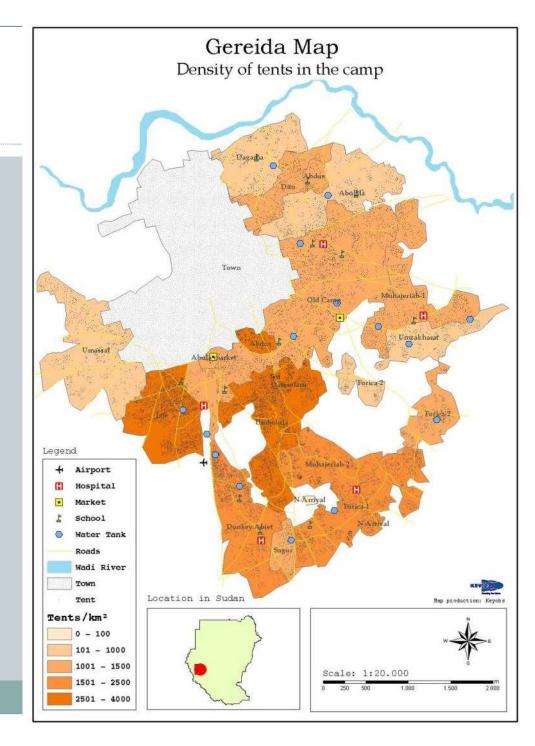
## Water network DR Congo



**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

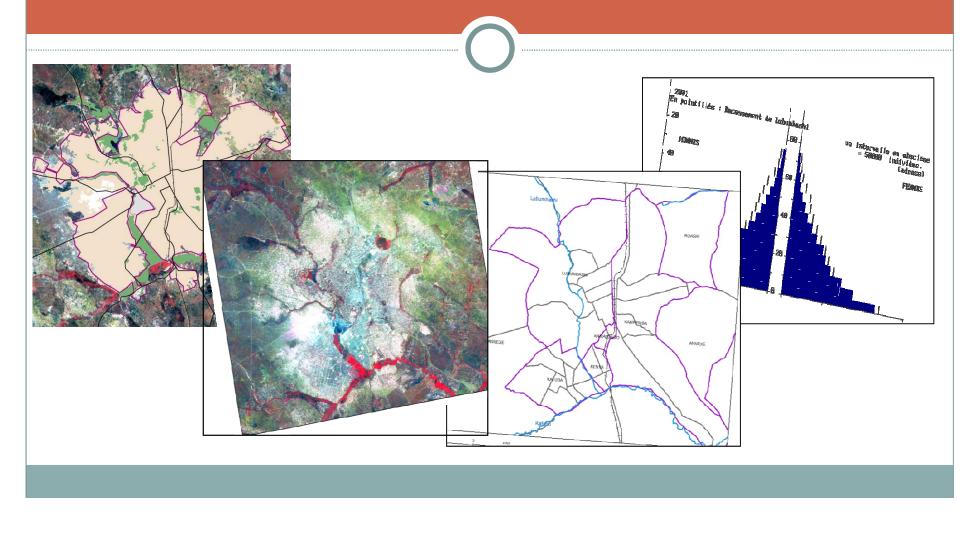
- The local authorities state 200k people and require consequent aid
- The aid agency states 100k people
- So what ?



## 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

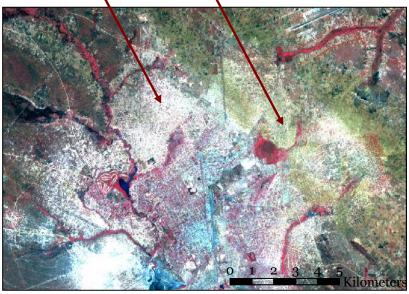
#### Segmentation

- Green(1), red(2), near infrared(2)
- Standard segmentation parameters chosen by trial-error according to the resolution

#### • Features

- o 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



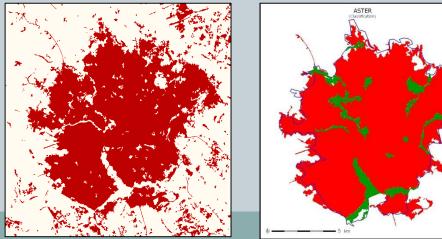
Aster 27/08/2001

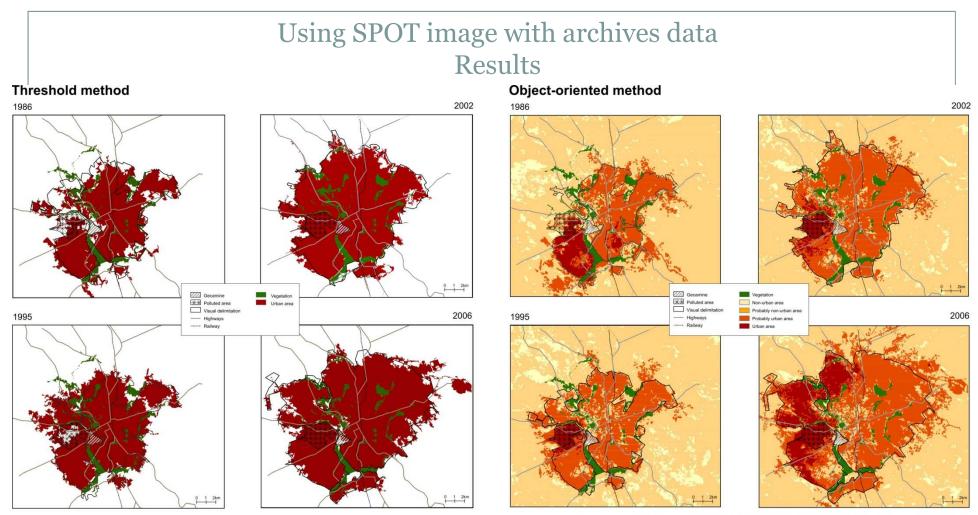
#### Using SPOT image with archives data Extract the urban area : thresholding method

- PCA  $\rightarrow$  1<sup>st</sup> 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 1km<sup>2</sup> are dissolved
  - Vegetation, water, bare soil, ... are identified as no built-up





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

#### Both method

• Food results (+/-  $3\% \neq$  for Surface)

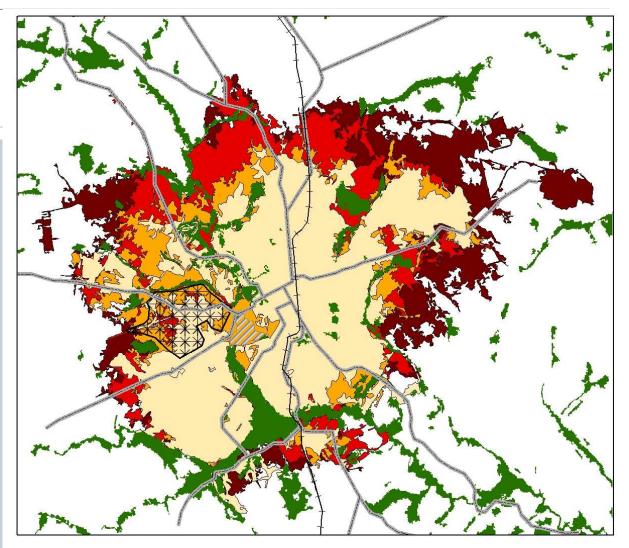
• Reproducibility : time and different sensors (SPOT; ASTER)

Using SPOT image with archives data Results and urban growth

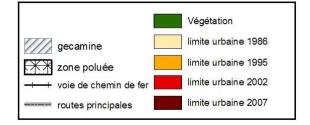
# • Ho: urban growth proportional to the population growth

Years	Total area mapped (km²)
1986	71,9
1995	88,3
2002	118
2007	144,3

• Urban areas estimation for each year



0 0,5 1 2 Km



Sotiaux Alix, d'après images satellitaires Spot fournie par le Belspo, 2010

#### 1<sup>st</sup> 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 Population estimation Reconstruction

Year by year between 1984 and now

Demographic data movement: Estimated levels of fertility and mortality

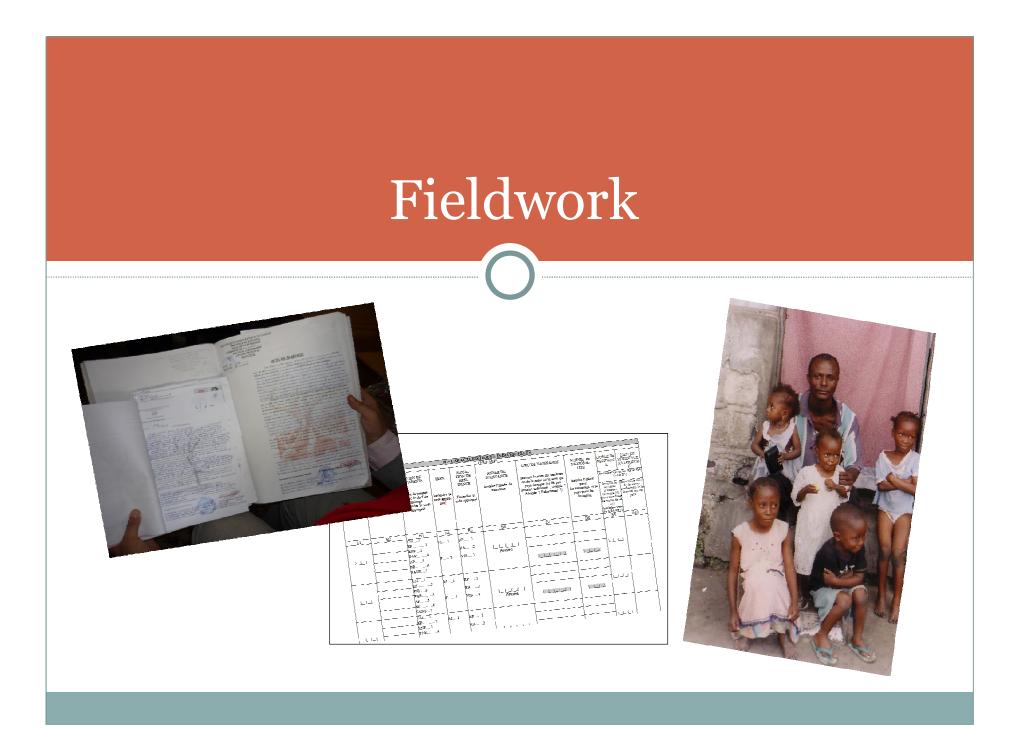
To stay smooth (e.g. parameter changes are never dramatic)

Ho-

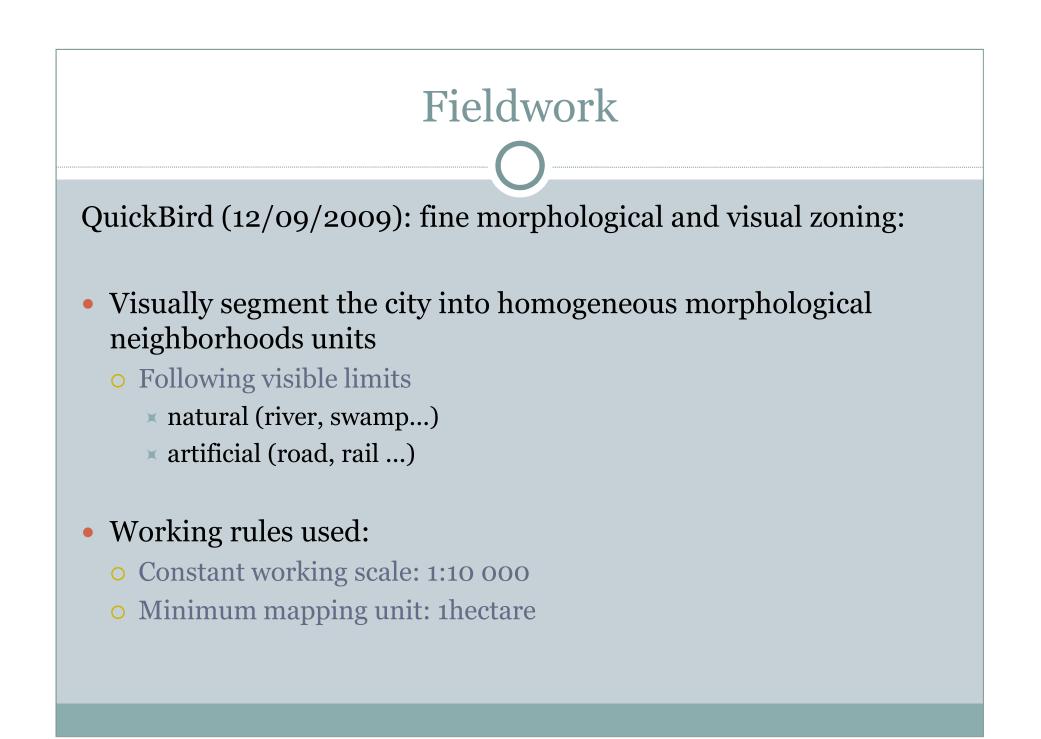
To stay compatible with what we know about the regional/local population dynamics

τ	Jsing SPOT	image with archiv	res data
Years	Remote Sensing	Remote Sensing / Demographic estimation	Demographic estimation
1986	589444	1,00	589444
1995	723 450	0,85	848 819
2001	966297	0,90	1 070 032
2007	1 182 121	0,89	1327320

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



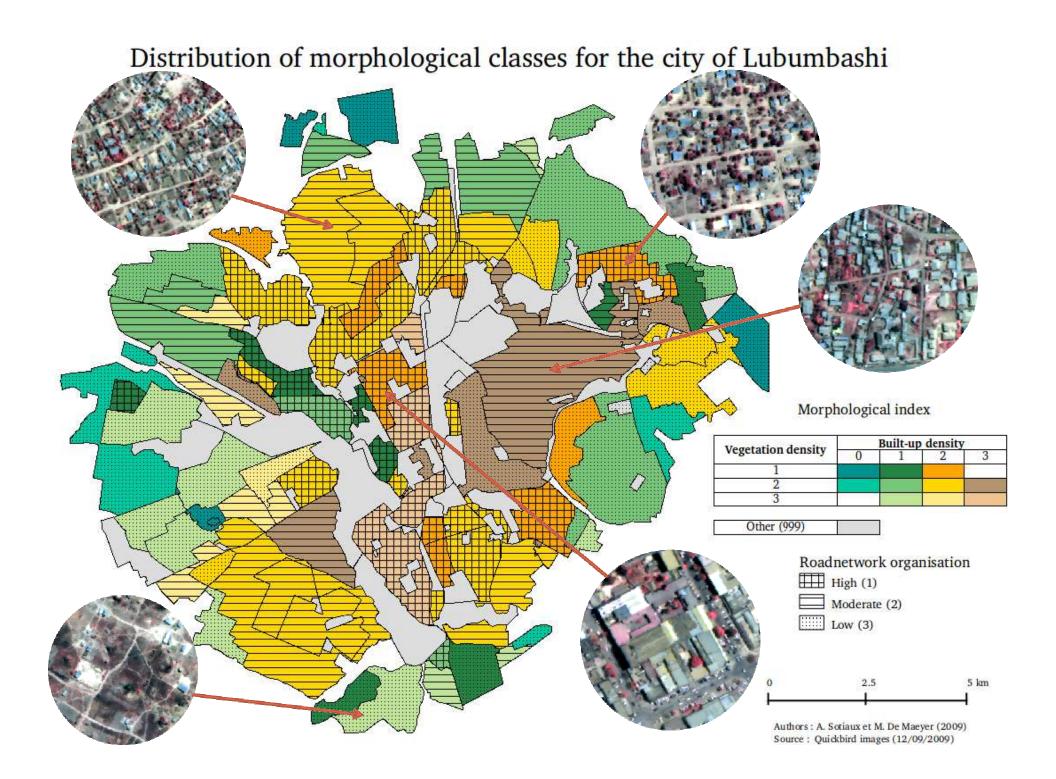
- Sample design
  - Sampling unit = **household**
  - O Minimizing the sample size/ municipality: reference to a 95% confidence interval → 400 household/ municipality
  - 7 municipalities = total sample of **2800 households**
  - Keeping an easy identification and minimizing field displacements clustering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



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

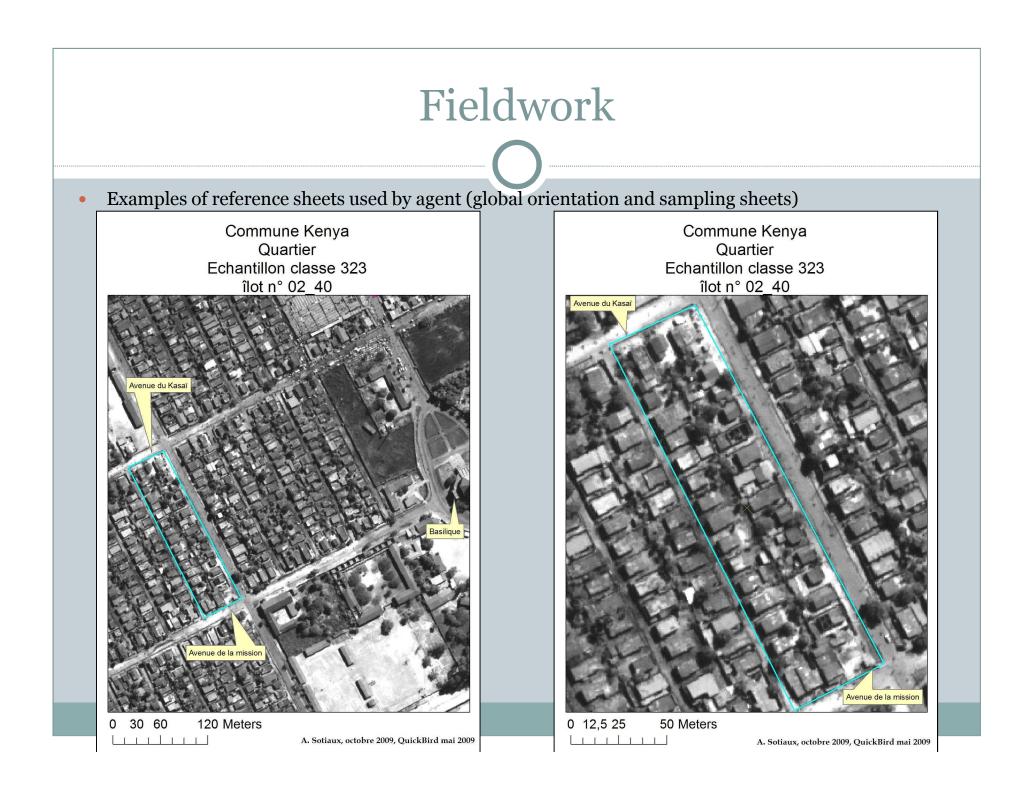


• Each selected block is surveyed by an agent

#### • Agents receive:

- Questionnaire
- 3 days training
- o User manual
- Reference sheets (global orientation and sampling)



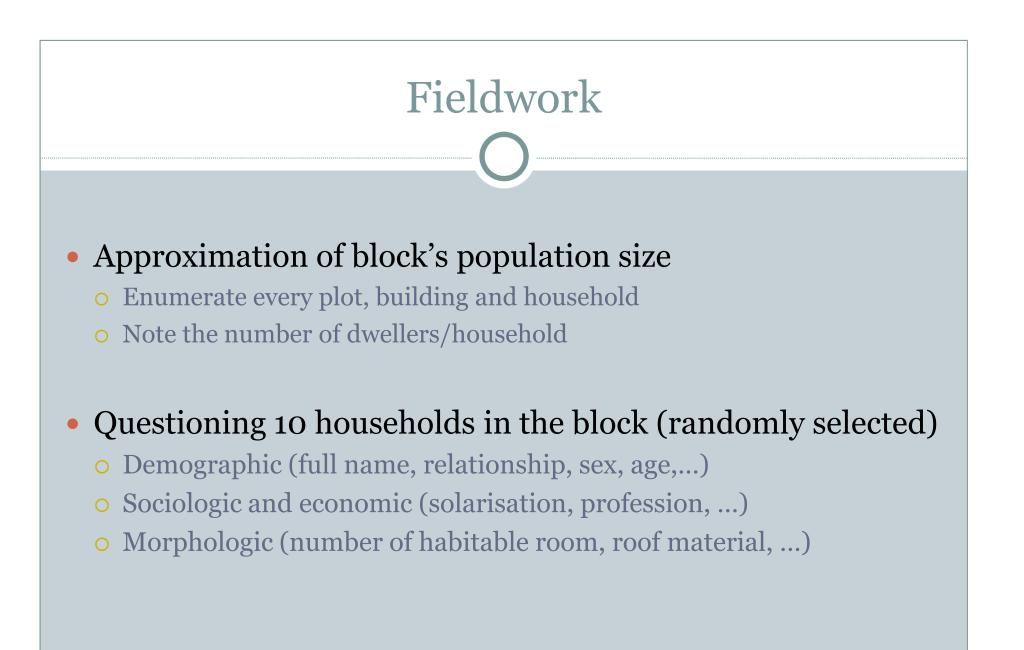


 Difficulty of drawing blocks for the municipality "Annexe"

• Impossible to define blocks in the Brondo district







# Using QuickBird image with fieldwork



			B -	CANACCTERN	ISTROUES INDIVI	DURLERS			
N" D' ORDRE	NOM et PRENDM(E) (personne de nif)	LIEN DE PARENTE Lien de parenté avec le chef de ménage. Encentier le code aggregrié	code extrem	STUA TION DE RES- DENCE Enconter le code agregné	ANNEE DE NAISSANCE Institute l'année de naissance	LIEU DE MAISSANCE Datrire le nom du territoire ou de la nome ou le nom du pays drauger (e dit pay inacrire indeterion dénote 7 Adricain 7 Pakimanais 7)	ETIENE ou NATIONA- LITE Inscripe l'ethnie pour les nationaux et le gays pour les étrangens	DURES DE RESIDENC Salamaty Int Salamaty Contents Canadas (Sanatas (Sanatas)	LIEU DE RESIDENC ANTERNE E E E E E E E E E E E E E E E E E E
81	B2	83	84	83	Bó	B7	BS	19 - 2472 1 19 - 2472 1	B10
51		CM1	24 M 1	80 88 1	50	87	55	57	810
		INT		24 2					
		742 6 47 5 87 6 5405 7	F :	15.3	Année			uu	
		CM 1							
		SP 1	M1	10 <u>1</u> 1					
ليت		ENG 3 PAR 6 AP 5		84 3 115 3					
		87 6 SAUS 7							
		CM1	м1	<b>1</b>					
		SNT		u :				1	
		742 6 47 5 87 6 5405 7	F_1	12	Année				
		CM1 87	M1	87 1 84 2					
		9.42 4 47 5 87 6		NB3	Année				
		SANS7 CM1		22 1					
		17 1 1N7 1	M1						
		7.42. 4 A7 5 B7 6		NB 3	Année				
		\$4357							
		CM1 171 13.51	M1	<b>22</b> 1					
		7.42	r :	NB_3	Année			uuu	
		SANS7 CM1	M 1	<b>1</b>					
		NT		24 2				1	
		7A2 6 A7 5 87 6		112.3	Année			uu	
	IBRES DU MENAGI	5405_7		Hommes	LL Ferme	: lotal:			
COL MEN	and be made a		- ALTER	April 1					
27-20 207-2 748-7 47-40	of do minage non eu Epocaso nfanze aronte toto personnos appazent aut. Pareone lane llion de garonte lane llion de garonte	M=Maa daa F=Edapie	R.1-	Résidant Présent Résident Absent Mitteur	Chillers is calend?	nac das informations. er historique	Ell:	tiona 20, 29 a norra di d'imgrimatic	



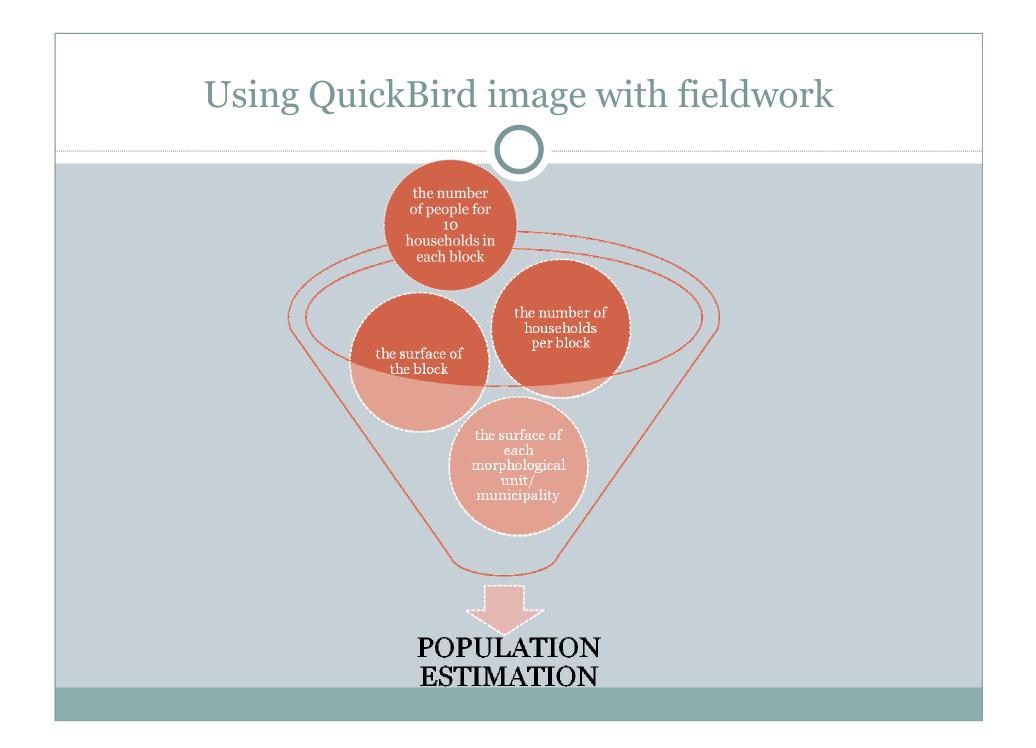
### Using QuickBird image with fieldwork

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

			and the second sec	and the second se
			And and a second s	COLUMN TO A DESCRIPTION OF
		and the second se	e beroen interestingen in bereit	STOCK PAR INC. INC.
		and the second se	TALLAND THE PARTY OF THE PARTY	and the second sec
		The second se	A DEPOSIT OF DEPOSIT	and the second se
		The second secon	A- DOWNER	
	and a second sec		and the second sec	and the second se
			and and and the second s	and the second se
		and and a second second second	at blocks if	Constant of the local division of the local
			())	
	and a second second second		Construction of the Constr	
	and a lot of the second	and a	AT INCREME	
	and the second sec			Contraction of the local division of the loc
	100		and the second s	122
			1884 ·	pair and a second
			(iii)	Contraction of the local division of the loc
				and the second se
			a 2 kontro companyini and pattor recursio	and the second
	and the second s		AND ADDRESS OF THE OWNER OWNER OF THE OWNER	And the second s
	- And		The second secon	T - 10
				terror and a state
		and the second		
		and the second s	reverse a taxa and	Judate Lake
	and the second s		FIGURE AND	
			STREET BUILDE	had a second sec
		and the second second	and a second second	Jabel
	and the second s		st-termination	halfmann Long
	E.			مستعرف المسمول المليا
			Vales	
	and the second second			September 1
	and the second sec		The state of the s	Supervision Labor
			second in the second seco	
				and a second sec
		and the second s	Company of the second se	part -
	and the second s		THE R. P. LEWIS CO., LANSING MICH.	
	- Pro-		lenteral and an and a second second	
		100		
	1 mm	Contraction in the second seco		
		Part Part		
		the second se		
		1 mil 1 m		
	E.			
		Life and the second second		
	and the second second second	and some of the second se		
	And and a set of the s	and should be related to		
	CONTRACTOR OF CONTRACT	and determined and the second se		
	and the second second second second	and the second s		
÷.	and the second s			
	and an extent			
	Junior Lange	Tarter and the second		
	21.000	And the second s		
	All and the second		the second se	
	Long the second s	and the second se	and the second division of the second divisio	
	Transferration of the second sec			



1         COMMARE LOT NEADERS ECOND NAMER NUCLEY NUCLY NUC		A	В	C	D	E	F	G	н		J	K	L	M	N	0
3         1         2         18         30         30         2         0.0000         1,1114         977.8,648489         192         111 <sup>4</sup> 11         120         1703.7           4         1         32         22         20         0.0000         1,1114         977.8,648489         102         111 <sup>4</sup> 11         120         1703.7           6         1         5         13         10         2         5         6.0000         1.1114         203.7         114         45.2         45.5           7         1         6         6         6.0000         1.1114         203.7         114         45.2         45.5           8         1         0         2.2         5.6         7         10.000         1.1114         203.7         10.000         1.1114         203.7         10.000         1.1114         203.7         10.000         1.1114         203.7         10.000         1.1114         4050.0         10.000         22.2         10.000         10.000         1.1114         4050.0         10.000         1.1114         4050.0         10.000         10.000         10.0000         1.1114         4000.0         40.000         10.0000         1.1114         4000.0 </td <td>1</td> <td>COMMUNE</td> <td>ILOT</td> <td>MEMBRES</td> <td>DÉNOM</td> <td>NUMÉR</td> <td>N_ILOT</td> <td>W_ILOT</td> <td>W_COMM</td> <td>W_TOTAL</td> <td>Surface en mª</td> <td>NO_ILOT</td> <td>CLASSE</td> <td>ACLASSE</td> <td>POP_ILOT</td> <td>AU_KM2</td>	1	COMMUNE	ILOT	MEMBRES	DÉNOM	NUMÉR	N_ILOT	W_ILOT	W_COMM	W_TOTAL	Surface en mª	NO_ILOT	CLASSE	ACLASSE	POP_ILOT	AU_KM2
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		1			18	15	1	1,200000	1,131052	1,131814	49387,70008060	101			115	2332,6
6         1         4         382         07         07         07         07         07         08         03 <td>3</td> <td>1</td> <td></td>	3	1														
6         1         6         11         12         2         6         6         1000         11114         2047.784630         106         217.211         88         884.6           7         1         6         13         6         1         100         2         5         5         11114         2047.784630         106         217.211         88         284.6         3           9         1         6         14         24         25         1         11114         2047.7153.3416230         100         227.222         48         177.03         1111         101         1	4	1	3	122	28	28	3	1,000000	1,131052	1,131814	71394,78751460	103			122	1708,8
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	5	1	- 4	382	87	87	- 4	1,000000	1,131052	1,131814	28392,98086340	104			382	13454,0
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$		1									33047,78545630	105				
9         1         0         14         0         14         0         14         0         15         15         0         100000         110100		1														
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	8	1		124	25	25	7	1,000000	1,131052	1,131814	40651,09728250	107			124	3050,3
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	9				35	35	8	1,000000	1,131052	1,131814	26045,44210870	108			149	
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$																
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$		1											232	232		459,2
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	12	1		103	20	20	11	1,000000	1,131052	1,131814	29954,01714850	111			103	3438,6
156         1         14         113         17         17         14         100         100         11016         11018         1000         11016         11018         1000         11016         11018         1000         11016         11018         1000         11016         11018         1000         11016         11018	13	1														
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		1														
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	15	1		113	17	17	14	1,000000			10999,80506630	114			113	10272,9
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	16	1				23					32635,56325630					
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $																
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	18	1	17	35	27	9	17	3,000000	1,131052	1,131814	61029,36297530	117			105	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		1		254	66	58	18	1,137931	1,131052	1,131814	20303,57451890	118			289	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	20	1	19	814	154	153	19	1,006536	1,131052	1,131814	16954,57793320	119			819	48324,4
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	21	1		140	24	24	20	1,000000			21683,38714390	120	222	222	140	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		1			50	50	21	1,000000			18950,22464960	121			276	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	23	1	22	277	45	45	22	1,000000	1,131052	1,131814	40203,78271310	122			277	6889,9
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		1	23	47	21	8	23	2,625000	1,131052	1,131814	19170,07241850	123			123	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	25	1	24	314	55	55	24	1,000000	1,131052	1,131814	26529,76106740	124			314	11835,8
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	26	1	25	63	12	12	25	1,000000	1,131052	1,131814	33742,48105640	125			63	1867,1
28         1         28         556         113         112         28         0.00229         1.0114         2034         0.00234         0.00129 <td>27</td> <td>1</td> <td></td> <td>76</td> <td>27</td> <td>19</td> <td>26</td> <td>1,421053</td> <td>1,131052</td> <td></td> <td></td> <td>126</td> <td></td> <td></td> <td>108</td> <td>2021,5</td>	27	1		76	27	19	26	1,421053	1,131052			126			108	2021,5
	28	1	27	51	19	18	27	1,055556	1,131052	1,131814	37928,39409430	127			54	1419,3
11         15         16         14         10         1,100	29	1	28	556	113	112	28	1,008929	1,131052	1,131814	83344,99595480	128			561	6730,6
22         1         31         266         65         57         31         1,52         211         2010         724.4           33         1         212         212         21         21         021	30	1	29	125	24	24	29	1,000000	1,131052	1,131814	19103,77998600	129			125	6543,2
		1		85	16		30	1,142857	1,131052	1,131814	18444,07646390	130			97	5266,9
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	32	1	31	266	65	57	31	1,140351	1,131052	1,131814	41472,44335540	131			303	7314,1
35         1         34         151         30         30         34         100000         1116         211814         4994 4282000         134         22122212         1151         2115         1151         211         2115         1150         211814         4994 4282000         134         22122212         11511         115111         11511         11511 <th< td=""><td>33</td><td>1</td><td>32</td><td>122</td><td>21</td><td>21</td><td>32</td><td>1,000000</td><td>1,131052</td><td>1,131814</td><td>6584,26669554</td><td>132</td><td></td><td></td><td>122</td><td>18529,0</td></th<>	33	1	32	122	21	21	32	1,000000	1,131052	1,131814	6584,26669554	132			122	18529,0
36         1         35         115         21         21         35         100000         110160         110140         6744,244190         135         2212/2212         115         1704.10           71         55         FMLJL         46         0         55         411,111500         110140         6743,2441910         135         2212/2212         FMLJL         460,111         1101         1101         150         2212/2212         FMLJL         460,111         1101         5222/222         FMLJL         460,111         1101         100         1011		1		142	23	23						133			142	
J7         J         56         #ULL         46         0         35         #ULL         1,515         1,511         355,352700         156         222,222         #ULL         #UL	35	1	34	151	30	30	34	1,000000	1,131052	1,131814	6999,44738008	134			151	21573,1
38         1         37         73         26         19         37         138/21         1318/22         1318/41         49962         1318/41         1318/22         122/22         100         994.4         994.4         994.4         138         222/22         100         994.4         138         222/22         100         700         1318/22         1318/44         1418         138         222/22         100         700         1318/22         1318/44         1418         138         222/22         200         700	36	1	35	115	21	21	35	1,000000	1,131052	1,131814	6748,42148190	135			115	17041,0
39         1         38         107         16         16         18         0.00000         1.11562         1.11514         MRLU         138         222         222         107         MRLU           40         1         39         217         34         39         0.00000         1.11562         1.11514		1	36	#NUL!	46	0	36	#NUL!	1,131052	1,131814	39639,39521700	136	232	232	#NUL!	
40         1         39         2217         34         34         39         1000000         113102         113104         13704.99345001         1390         222 222         2217         14581.53           41         1         40         53         22         224         10100000         1131042         1131143         4593.19545501         140         222 222         229         2884.4           42         1         41         43         22         12         41         133333         1131614         2453.19545501         140         222 222         79         28864.4           43         2         1         410.11         105062         1131614         2453.14542493         211         312.51312         #FILLUL         #WUL         WUL         WUL </td <td>38</td> <td>1</td> <td>37</td> <td>73</td> <td>26</td> <td>19</td> <td>37</td> <td>1,368421</td> <td>1,131052</td> <td>1,131814</td> <td>99958,28538440</td> <td>137</td> <td></td> <td></td> <td>100</td> <td>999,4</td>	38	1	37	73	26	19	37	1,368421	1,131052	1,131814	99958,28538440	137			100	999,4
41         1         40         93         22         22         40         1,00000         1,131052         1,131814         34593,19645380         140         232/232         93         2688,4           42         1         41         43         22         12         41         1,83333         1,131614         2722,1222440         141         232/232         79         2896,4           43         2         1         411         4000664         1,31814         2725,1222440         141         232/232         79         2896,4           43         2         1         411         423         21615,6442340         201         3312         49100000         1,31814         2716,3423400         201         3312         3312         49100000         1,31814         21615,64423400         201         3312         3312         49100000         1,31814         2315,64423400         201         3312         3312         491000000         1,31814         2315,64423400         201         3312         312         491000000         1,31814         2315,64423400         231         2312         491000000         1,31814         2315,644234000         2315         2315         2315         2315         2315	39	1	38	107	16	16	38	1,000000	1,131052	1,131814	#NUL!	138			107	#NUL!
42 1 41 43 22 12 41 1,833333 1,131052 1,131814 27223,12321240 141 232 <sup>1</sup> 232 79 2895,8 43 2 1 MINULI 37 0 42 MINULI 1,090564 1,131814 32151,64492430 201 3312 <sup>1</sup> 3312 MINULI MINULI	40	1	39	217	34	34				1,131814	13704,99345090	139	232	232	217	15833,6
42         1         41         43         22         12         41         1,833333         1,131052         1,131014         27223,12321240         141         232         232         79         2895,8           43         2         1         MNULI         37         0         42         MNULI         1,090564         1,131614         32151,64492430         201         3312         MNULI         MNULI         MNULI	41	1	40	93	22	22	40	1,000000	1,131052	1,131814	34593,19645360	140			93	2688.4
	42	1	41	43	22	12				1,131814	27223, 12321240	141			79	2895,8
44 2 2 296 61 61 43 1,00000 1,090564 1,131814 9853,32864117 202 3312 3312 296 30040.6	43	2	1	#NUL!	37	0	42	#NUL!	1,090564	1,131814	32151,64492430	201			#NUL!	#NUL!
	44	2	2	296	61	61	43	1,000000	1.090564	1,131814	9853.32864117	202	3312	3312	296	30040.6



Using QuickBird image with fieldwork FIRST RAY 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 <b>futu</b>	<b>re of</b> -4,1						
Ruashi	149.643	94.686 <b>rese</b>	<b>arch</b> -5,5						
Kampemba	307.862	203.277 <b>nee</b>	<b>eded</b> -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						

# Conclusion Estimation method using SPOT archives images without fieldwork: • Very good results o 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



Rue d'Abhooz, 31 4040 Herstal Belgique Bruxelles IGEAT Boulevard du Triomphe 1050 Bruxelles Belgique ADRASS a.s.b.l. rue des Fusillés, 7 1340 Ottignies Belgique

☎+32 04 384 63 15
금+32 04 384 62 15
⊟info@keyobs.com

**\***+32 02 650 54 86

**\***+32 010 41 73 01