### Fourth meeting of the Expert Group on Disaster-related Statistics

Organized by UNESCAP in collaboration with the Philippines National Statistics Authority 3 – 6 October, 2016, Mandaluyong, Philippines

GIS for compilation and production of new statistics on disaster risk reduction by national governments

# Example of assessment of human settlements (buildings and population) at risk of flood

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# Assessing settlements and population spatial distribution

- Knowing (including mapping) settlements and spatial distribution is needed to assess exposure to risks
- Settlements and population distribution can be known from cadastre and detailed population statistics (e.g. by primary sampling units, PSU) duly georeferenced
- When such data is not easily accessible, a solution can be found using remote sensing combined with statistics (modelling distribution)
- Several products exist at the global scale; however, they are not enough precise (WorldPop at 1ha) or accurate (Landscan at 1 km2, GWP at 16 km2)
- The Global Urban Footprint (GUF) produced by the German Aerospace Agency (DLR) from radar imagery in 2012 provide a map of houses and other buildings with an accuracy of 12m x12 m. For the research, aggregated data at ~ 77m x 77m have been kindly provided by DLR of all the DRSF test countries.
- The test has been carried out on Bangladesh with the purpose of assessing the reliability of population density produced from statistics at various scales (municipal or regional).

### Human settlements in flood prone areas (around Faridpur, Bangladesh)



Sources: WFPGeonode (World Food Programme/ Dartmouth Flood Observatory) and DLR GUF (Global Urban Footprint) 2012

# Population of municipalities and actual settlements



Sources: BBS Population Census 2011 and DLR GUF (Global Urban Footprint) 2012

# Some correlation between <u>population density by municipalities</u> and settlements size mapped with GUF (smoothed)



Sources: BBS Population Census 2011, and DLR GUF 2012 (smoothed)

# GUF data provide a fair assessment of built-up areas but are poorly correlated to population density

800	000	1.00	000	000		000	000	000	000		000	000	000	1.00	1.00
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	000	0.00	000	000	800	000	1.00	1.00	000	1.00	000	000	1.00	000	000
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## Smoothing GUF data → <u>Probability to find a human settlement in a</u> <u>neighbourhood of ~ 400m</u>

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000	003	0)00	0,00	000	000	0,00	0)00	000	000	0)00	000	(1)(1)	022	0.49	0.63
000	000	000	000	000	011	000	000	0.00	000	000	000	000	0.33	0.53	0.54
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000	000	000	000	000	000	021	0.37	0.34	024	025	0.27	0.52	0.44	0.35	000
000	000	000	000	000	0.00	025	025	000	000	027	0.35	0.34	0.33	000	000
000	000	000	000	000	0.36	033	000	8.00	000	000	029	023	000		000
000	000	000	000	000	0.33	025	000	800	000	000	000		000	000	000
000	000	000	000	021	021	000	000	000	000	000	000		000	000	000
000	000	000	026	033	000	000	000	000	000	000	000	000	000	000	000
000	000	000	0.32	0.35	000	000	000	000	000	000	000	000	000	000	000
000	800	000	000	000	000	000	000	000	000	0.23	0.23	000	000	000	000

# Gaussian smoothing and truncating 0-1 GUF data

- → Agglomerate pixels
- → Truncate out low values (e.g. < 20%): eliminate isolated pixels
- Overweight large agglomerations (cities), underweight small ones (villages)
- → Can be tuned up: smoothing parameters (radius, intensity std), truncating threshold
- → Can be used to estimate density of population by GUF pixels

# Estimation of population density by GUF pixels, using statistics by municipalities (Unions and Paurashavas), Faridpur ZILA, Bangladesh



# Estimation of population density by GUF pixels using statistics by municipalities (Unions and Paurashavas)

	89.664	89.0	365	89.666	89.667	89.68	8 8	9.669	89.670	89.671	89.	872	89.673	89.674	
23.44	4.00	4.00	4.00	4.00	4.00	26.43	34.43	37.46	25.13	4.00	4.00	4.00	4.00	4.00	0.0
23.4400	4.00	4.00	4.00	4.00	4.00	22.61	42.51	48.99	35.02	4.00	4.00	4.00	4.00	4.00	0.0072
23.4392	33.89	35.84	22.32	4.00	4.00	24.92	38.05	41.40	34.01	21.81	4.00	4.00	4.00	4.00	0.0064
23.4384	64.57	62,43	45.98	38.44	37.20	31.64	35.60	44.03	47.00	38.69	25.29	4.00	4.00	4.00	0.0056
23.4376	85.05	80.55	70.12	64.12	55.12	40.75	44.29	56.60	65.50	50.08	26.76	4.00	4.00	4.00	0.0048
23.4368	85.47	76.81	68,23	62.21	54.53	45.30	46.75	53.95	55.04	42.09	19.35	4.00	4.00	4.00	0.0040
23.4360	711.68	59.44	53.52	52,39	54.88	56.74	50.39	36.98	28.07	20.71	4.00	4.00	4.00	4.00	0.0032
23.4352	47.40	36.54	43.40	55.52	68,96	63.777	46.94	23.08	4.00	4.00	4.00	4.00	18.61	19.54	0.0)24
23.4344	30.98	22.49	30.00	45.97	54.11	47.89	28.94	4.00	4.00	20.98	24.38	25.34	25.75	18.33	0.0016
23.4336	26.79	21.59	4.00	20.84	24.01	19.73	4.00	4.00	4.00	19.11	28.98	29.21	20.23	4.00	0.0008
_	20.32	21 15 0.001	4.00 0.002	4.00	4.00	0.004	0.005	4.00	4000	ALOD 0.007	4.00	4.00	4.00	/100	8

# Population in flood prone areas



### Extraction of raster data to polygons (administrative boundaries)



#### Settlements (GUF) and Population in Flood Prone Areas, Faridpur Zila (District), Bangladesh

	GUF2012 (hectares)	GUF in flood prone areas (hectares)	% GUF in flood prone areas	Population 2011 (BBS Census)	Population in flood prone areas (GUF and dispersed)	% population in flood prone areas
Alfadanga	602	149	24.7	108302	45827	42.3
Bhanga	2752	1908	69.3	249343	184518	74.0
Boalmari	1022	160	15.7	256658	65811	25.6
Char Bhadrasan	528	414	78.5	63477	57445	90.5
Faridpur	3091	1111	35.9	469410	183383	39.1
Madhukhali	790	142	18 0	204492	58120	28 4
Nagarkandi	2430	1741	71.7	349905	269390	77.0
Sadarpur	1770	1120	63.3	186254	139814	75.1
Grand Total	12986	6745	51.9	1887841	1013415	53.7

	Settlements from GUF2012 (hectares)	Settlements (GUF) in flood prone areas (hectares)	% GUF in flood prone areas	Population 2011 (BBS Census)	Population in flood prone areas (GUF and dispersed)	% population in flood prone areas (GUF and dispersed)
Nagarkandi	2430	1741	71.7	349905	269390	77.0
Atghar	77	53	69.2	23102	17716	76.7
Ballabhdi	116	46	40.0	18739	10099	53.9
Bhawal	103	82	79.3	20356	17135	84.2
Char Jasordi	208	124	59.7	30898	24013	77.7
Dangi	263	208	79.2	22799	19718	86.5
Gatti	165	127	76.7	32456	27265	84.0
Jadunandi	97	4	3.7	17058	3377	19.8
Kaichail	157	152	96.6	16951	16661	98.3
Laskardia	253	216	85.2	23694	21246	89.7
Majhardia	90	75	84.1	17563	15506	88.3
Nagarkanda	224	186	82.8	11872	11192	94.3
Phulsuti	57	49	85.4	9168	8983	98.0
Pura Para	77	72	93.8	15839	15088	95.3
Ramkantapur	50	33	65.5	17156	13179	76.8
Ramnagar	139	90	64.3	20745	13546	65.3
Sonapur	82	21	25.2	21016	8533	40.6
Talma	272	205	75.4	30493	26133	85.7





### Statistics and maps









# Gaussian smoothing and truncating 0-1 GUF data

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- → Can be used to estimate density of population by GUF pixels

## → Issues:

- → GUF is good for urban areas, but more fragile in the countryside (isolated pixels...)
- ➔ Research carried out with generalized GUF data (77m x 77m); probably better results with native GUF (12m x 12 m)

**Calibration of the model with regional data :** requires estimation of non agglomerated population

A try of the methodology for the Philippines

# GUF and municipality boundaries (ADM2)



# GUF and ADM2 boundaries + Flood risk exposure



### GUF and ADM2 boundaries + Flood risk and landslide exposure



## Estimation of population density per smoothed GUF pixels



## Estimation of population exposed to flood risk



## Estimation of population exposed to flood and landslide risks



# Thank you!

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