ANNEX

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

Introduction

Exposure to natural hazards is essential information for assessing vulnerability and related disaster reduction policies. National assessments as well as international comparisons have to take into accounts the exposure to risk factor and DRSF includes items for that.

In the context of the DRSF tests, a research has been carried out to see how could be assessed exposure to natural hazards of people, built-up assets and ecosystems using the GIS.

Risks result altogether from disaster probability AND from the presence of population, buildings and other manmade or natural infrastructures. As long as both disaster prone areas on the one hand and human settlements and other valuable infrastructures on the other hand are not evenly distributed over space, assessing exposure to risks requires detailed and well geo-referenced data.

1. Present situation regarding information on exposure to risks

On the risk side, disaster management agencies compile maps by types of hazards for the purpose of their own missions. On the impacts side, data can be extracted from administrative registers such as cadastre, urban plans or population censuses and civil registration. In principle, such information should be sufficient for risks assessment, and is commonly used at the local level for civil security purposes. This is not that much straightforward for statistical purposes as long as detailed location of the data is either lost in the aggregation process or not accessible for country wide assessments. Modern population censuses record population by primary sampling units (PSU) which would provide an excellent level of information. However, population censuses data are disseminated by a majority of statistical offices as aggregations of PSUs by municipalities, and in many cases at a higher regional administrative breakdown. As a consequence, when a risk area intersects the boundaries of an administrative unit, it is not clear to know which proportion of buildings and population are prone at being impacted: all, part or none.

The issue of localisation of assets and population can be tackled using geographical information systems and imagery obtained by remote sensing. Since more than a decade, attempts to assess population’s spatial distribution in reference to land cover data have lead to the production of several datasets. Can be mentioned:

- LandScan Global Population from 1998 to now. Database developed by the Oak Ridge National Laboratory (ORNL), Ministry of Energy of the US and UT-Battelle. Grid resolution of circa 1 km^2. http://web.ornl.gov/sci/landscan/ (for payment out of the USA)
- Distribution of European population by CORINE Land Cover units (EEA, 2009). Resolution as of Corine (minimum mapping unit of 25 ha), rasterised at 100m. http://www.eea.europa.eu/data-and-maps/data/population-density-disaggregated-with-corine-land-cover-2000-2 (Europe only)
- Gridded Population of the World (GPW v4) by the NASA's Socioeconomic Data and Applications Center (SEDAC), hosted by CIESIN, Columbia University. Grid resolution of circa 1 km^2 http://sedac.ciesin.columbia.edu/data/set/gpw-v4-population-count-adjusted-to-2015-unwpp-country-totals/data-download
- Global Human Settlement Layer (GHSL) by the European Commission Joint Research Centre. The layer of settlements is used to downscale the GWP v4 population to a grid resolution of 250 m. http://ghslsys.jrc.ec.europa.eu/
- WorldPop, GeoData Institute, University of Southampton. Grid resolution of 100m. http://www.worldpop.org.uk/

All these layers result from more or less complex modelling which rely on various types of land cover mapping of human settlements (generally from Landsat or MODIS), or from night-time lights) and include assumptions to assess distribution of population against land cover.

These datasets have been assessed during the DRSF pilot tests. As it can be easily understood, Grid with a resolution of circa 1 km^2 are a bit coarse for the purpose of assessing populations at risk. More, fragile mapping of built-up areas in global land cover programmes using visible radiometry or night-light observation result in local uncertainties. For example, confusion between constructions and rocky areas, both with similar spectral signature, are frequent. Night-light is spectacular vision of the world human settlements but is biased due to uneven use of electricity or by specific issues such as oil pits flares or forest fires at the time when the picture is taken. Things are slowly improving due to efforts by space agencies and research centers for more reliable classifications. At the same time, complex models are developed and used to improve observations, integrating various maps, including roads (as potential attractors), elevation and slopes (which restrict possibilities of settling).

Such models (sometimes called dasymetric) improve human settlement statistical assessments without, however providing at present fully satisfactory outcomes when considering the location of population in risk areas.

For this reason, the BNPB of Indonesia has produced its own map of human settlements and population, using national data and statistics.

When the issue was discussed in the DRSF Test WG, the existence of a new global map of urban settlements produced by DLR, the German Aerospace Agency, using high resolution radar satellite imagery: GUF 2012, the Global Urban Footprint[1] . GUF is the worldwide mapping of settlements with unprecedented spatial resolution of 0.4 arcsec (~12 m). A total of 180 000 TerraSAR-X and TanDEM-X scenes (with ~3m of resolution) have been processed to create the GUF. The DLR provides for free slightly aggregated maps with a resolution of ~75 m. It was decided to test the possibility of using GUF data for mapping human settlements and population for the purpose of risk exposure assessment.

Another domain of exposure to risk relates to impacts to the environment. A second test has been done using the Net Landscape Ecosystem Potential (NLEP) proposed in the manual published in 2014 by the Convention on Biological Diversity[2] in support to the implementation of the SEEA volume 2 on Ecosystem Experimental Accounting. The NLEP indicator has been produced for the first time by the European Environment Agency in 2008. It is a way to measure and assess ecosystem integrity at a macro scale in Europe on the basis of land cover. The signal of land cover greenness is enhanced by the presence of areas representing high species/ habitats diversity and adjusted to take into account the negative impacts of landscape fragmentation by transportation networks.

Part A - Assessment of human settlements (buildings and population) at risk of flood using the GUF data and population census statistics

Tests have been carried out for Bangladesh and the chosen methodology tested in turn for the Philippines.

2. Assessment of human settlements at risk of flood in Bangladesh

a. Buildings

Human settlements (buildings) have been mapped with the GUF layers kindly provided by DLR. Their resolution is of ~75m. Statistics of buildings in flood prone areas have simply been extracted by overlaying GUF with the map of Bangladesh Flood Prone Areas[3] downloaded from the WFP GeoNode of the UN World Food Programme and then with administrative boundaries level 2 (Zilas or Districts), level 3 (Upzilas or Subdistricts) and level 4 (Mauzas and Unions, corresponding to municipalities). These geo-data have been produced in 2010 by the Department of Local Government and Engineering of Bangladesh and have also downloaded from the WFP Geonode.

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[1] http://www.dlr.de/eoc/en/desktopdefault.aspx/tabid-9628/16557_read-40454/

[2] *CBD Technical Series No. 77, "ECOSYSTEM NATURAL CAPITAL ACCOUNTS: A QUICK START PACKAGE"* for implementing Aichi Biodiversity Target 2 on Integration of Biodiversity Values in National Accounting Systems in the context of the SEEA Experimental Ecosystem Accounts (prepared by Jean-Louis Weber, independent consultant, 2014) www.cbd.int/doc/publications/cbd-ts-77-en.pdf

[3] http://geonode.wfp.org/search/?title__icontains=Bangladesh%20Flood%20Prone%20Areas&limit=10&offset=0 Map of 2013 produced by the Dartmouth Flood Observatory.

There are limitations in the test carried out, due to minor issues with GUF data. First of all, it has to be reminded that GUF focus is urban areas for which it seems well calibrated. GUF gives as well unique and very valuable information on villages and isolated houses or farms. In this case, significantly better statistical results could be obtained with information on the density of primary pixels of 12m by provided pixels of 75m. In the present 75m layer with 0 or 1 pixel values, the generalisation of isolated 12m pixels to 75m has little inconvenience for statistics in the urban area by induces an overestimation in rural areas. Regarding urban areas, would radar imagery permit assessing buildings height, it would be important information to estimate the size of building and the quantity of dwellings. Out of cities, difficulties seem to occur in identifying dispersed habitat, especially in wooded areas (plantations or forests). The issue is common to all methodologies and GUF provides a very important improvement in that respect. The issue has to be examined however and solutions provided (see discussion of possible improvements below).

b. Distribution of population by GUF pixels

The methodology used for assessing population distribution by GUF pixels is based on a few considerations and assumptions:

- Large agglomerations are better known than smaller ones. It includes statistics and maps.
- Distributing population statistics by regions and even municipalities by GUF pixels doesn't make sense as it would imply an even population density per pixels.
- Population density is higher in large agglomerations than in smaller cities and in villages.
- Modelling is still based on assumptions and a limited number of observable variables. In that respect, complex modelling is worth only when it guarantees higher quality outcomes. When uncertainties are many, simple modelling has the advantage of more transparency and allows modifying assumptions in an easier way.

The tests of distributing population density to GUF pixels have firstly consisted in applying a Gaussian filter to GUF.

The principle of such filtering (or smoothing, blurring, convolution...) is to assign a coefficient to GUF 0-1 cells according to their neighbourhood. In the example on the left, a cell with a value of 1 (e.g. a GUF cell) is the center of a kernel of 5 x 5 cells; all neighbouring cells have a value of 0 in the example. In the example Applying a Gaussian filter would give a result where the central values is reduced to 0.15, the remaining being spread around as an inverse function of the square of the distance to the center. Results of Gaussian filtering depend on the size of the pixels, the size of the kernel chosen and of σ, the standard deviation of the distribution. The size of the kernel is a radius measured as a number of cells around the middle one (for the 5x5 kernel, the radius is 2). Commonly used values are 5 or 10. The other variable to consider is the standard deviation of the distribution: larger values of σ produce a wider peak (greater blurring)[4]

[4] See https://www.cs.auckland.ac.nz/courses/compsci373s1c/PatricesLectures/Gaussian%20Filtering_1up.pdf

Figure 1 : Illustration of Gaussian smoothing (filtering) and of effect of σ on final result

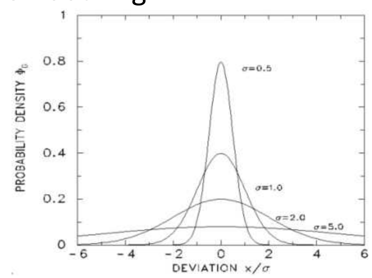
Original data

0	*0*	*0*	*0*	*0*
0	*0*	*0*	*0*	*0*
0	*0*	**1.00**	*0*	*0*
0	*0*	*0*	*0*	*0*
0	*0*	*0*	*0*	*0*

Smoothed data, σ =1

0.00	*0.01*	*0.03*	*0.01*	*0.00*
0.01	*0.06*	*0.10*	*0.06*	*0.01*
0.03	*0.10*	**0.15**	*0.10*	*0.03*
0.01	*0.06*	0.10	*0.06*	*0.01*
0.00	*0.01*	*0.03*	*0.01*	*0.00*

Effect of σ value on smoothing



Source: http://www.asp.ucar.edu/colloquium/1992/notes/part1/node15.html

Note that the total of the middle and 8 adjacent cells is here 0.77, which is the probability to find a urban area while travelling through the whole group of 9 cells. This fuzzy representation makes sense as the 1 cell in the left matrix is probably an approximation of the real world, with too crisp geometric borders. Note that if all cells in the original kernel had a value of 1, the middle cell would have kept a value of 1. Therefore, when repeating the smoothing for all cells in a map (mobile window), agglomerations of identical cells keep their values (except in their periphery) while isolated cells are diluted in their neighbourhood. As the sum totals of smoothed and non smoothed cells of a region are equal, it is therefore possible to establish a range of densities between large and small cities; it requires eliminating low smoothed values, in the example let's say below 0.1, 0.15. In the last case, the isolated cell is simply considered as non relevant. When distributing population data by smoothed GUF pixels, the agglomerated ones will be over-weighted in comparison to isolated ones which are down-weighted. An additional effect of smoothing is that it provides some agglomeration of isolated pixels which allows mapping in a fuzzy way agglomerations from discrete (crisp) data on buildings, a useful information.

It is therefore possible to parameterize the simple Gaussian model and several variants have been extensively tested for Bangladesh with the purpose of assessing the reliability of population density produced from statistics at various scales (municipal or regional).

For smoothing GUF, the Gaussian filter of the SAGA Gis[5] tool box integrated to QGIS[6] has been used.

Population statistics have been downloaded from the Population and Housing Census 2011 of BBS, the Bangladesh Bureau of Statistics[7]. The REDATAM webpage provided easy access to statistics by Zilas and Upzilas in spreadsheet format. For data by municipalities (Unions and

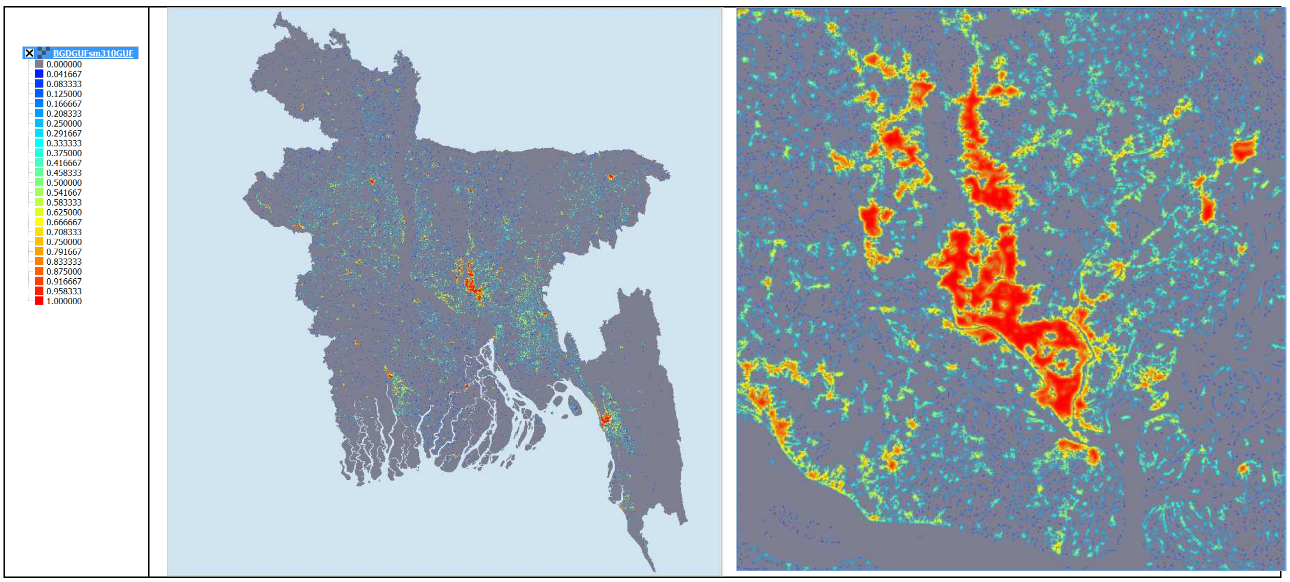
[5] http://saga-gis.sourceforge.net/en/index.html
[6] http://qgis.org/en/site/
[7] http://203.112.218.69/binbgd/RpWebEngine.exe/Portal?BASE=HPC2011_short&lang=ENG

Paurashavas), detailed statistics were available in pdf format only, which limited the test to one district (Zilas) due the amount of work needed to convert them to spreadsheet format.

The variants tested for Bangladesh combined statistics by districts, subdistricts and municipalities, a variety of processing of the GUF image and assumptions:

- Radius = 10, σ = 5
- Radius = 10, σ = 3
- Radius = 5, σ = 3
- Radius = 5, σ = 2
- Radius = 5, σ = 1

Figure 2: Example of GUF map smoothed with the SAGA Gaussian filter tool, Radius = 10, σ = 3



Dispersed settlements are mapped in blue to green colors, agglomerations in red and orange.

Integration with population statistics was done in various ways:

- Directly with smoothed data;
- With smoothed data filtered by original GUF pixels;
- In two steps, cities first:
    - extraction of a layer of cities defined as smoothed value > 80%; estimation of the population in cities,
    - then the remaining distributed other over pixels
- In two steps, countryside first:
    - Elimination of smoothed pixels < 20%;
    - Allocation of a default value to population density in the countryside: 3 and 4 persons per GUF pixel (equivalent to resp. 500 hab./km^2 and 710 hab./km^2)

Visual checks have lead to identify issues, in particular due to MAUP, the Mapping Area Unit

Problem of geographers where density of population is arbitrarily determined by the size of administrative units for which statistics are reported. Despite the improvement provided by the use of the Gaussian filter model, adjustments with formulas established at the national level are insufficient in many cases, in particular for large cities. The issue is very difficult to fix as there is in general little correspondence between the administrative boundaries of a city for which statistics are reported and the physical agglomeration of buildings and population.

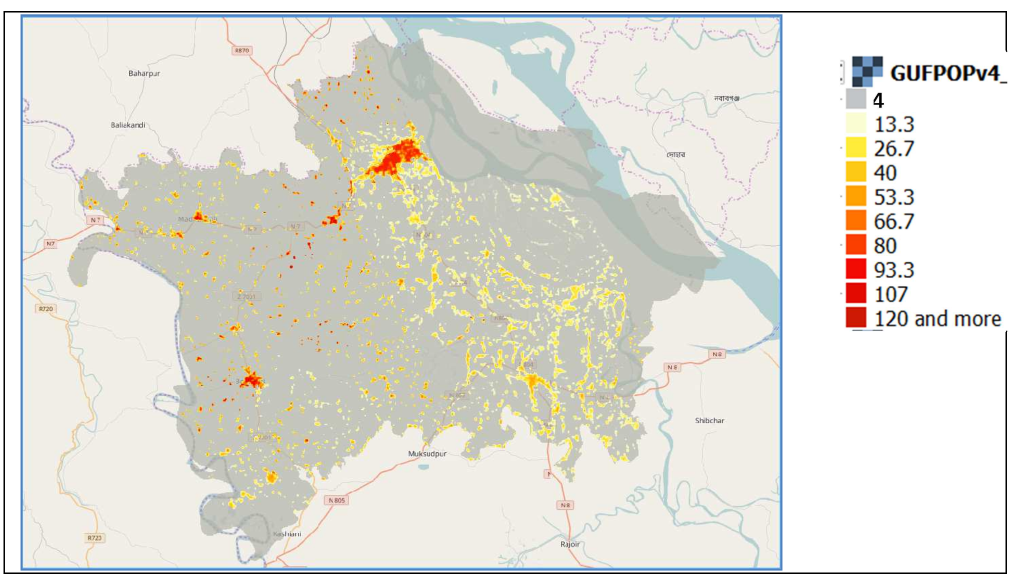
Later on, control of Zila and Upzila data have been done in reference to municipal data.

The municipal level tests were carried out after the first tests at a regional scale. As data by municipalities (Unions and Paurashavas), were available in pdf format only, a full test was carried out for the district of Faridpur only. The full use of the detailed statistics available at BBS by wards in cities and villages has not been carried out as well for two reasons. The first one is the constraint of extracting and reformatting pdf data; the second one is the absence of shapefiles (digital boundaries to use in GIS) for these units. This points shows that it should be possible to have a more precise assessment of the performance of the methodology.

The first conclusion of the Faridpur study is that the simplest methodology gives the best result at this stage. It consisted in:

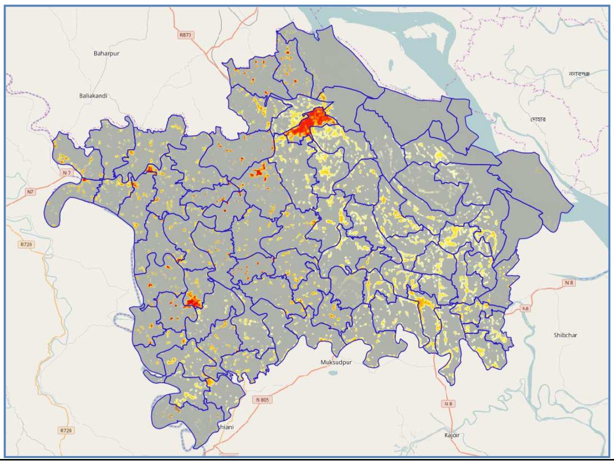
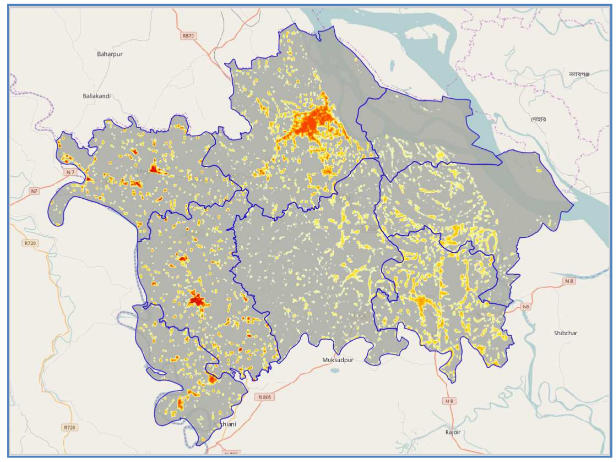
- GUF smoothing at Radius = 5, σ = 1
- Elimination (truncating) of pixels below 20%
- Assignment of a default value of 4 persons by pixel to the non-GUF pixels
- Proportional distribution of remaining population (at the municipality level) to smoothed GUF pixels.

Figure 3: Estimation of population density by GUF pixels, using statistics by municipalities (Unions and Paurashavas), Faridpur ZILA, Bangladesh 2011/2012



A try has been carried out with the same smoothed GUF data and statistics at the sub-district level (BGD ADM3, Upzila).

Figure 4: Comparison between population density by smoothed GUF pixels and population statistics by municipalities (left) and sub-district (right)

With municipalities/ unions population statistics	With sub-districts/upzilas population statistics
	

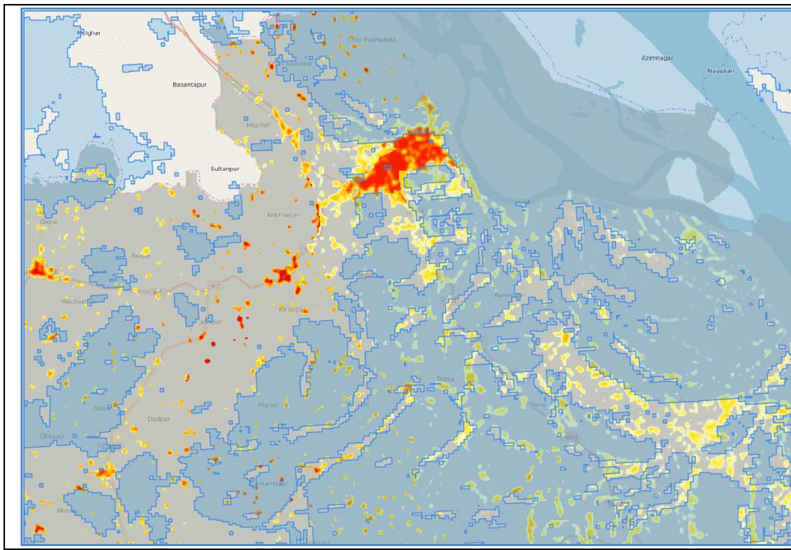
The two maps/datasets look a bit the same but there are differences. Comparisons by municipalities show that:

- 50% of unions have fairly similar results
- 40% unions have gaps of around 30%
- 10% of unions are assessed more serious issues...

With further improvements, for example using more precise GUF data and having acceptable estimations of dispersed population, the methodology would allow producing the same map globally, using data on population downloadable from the internet.

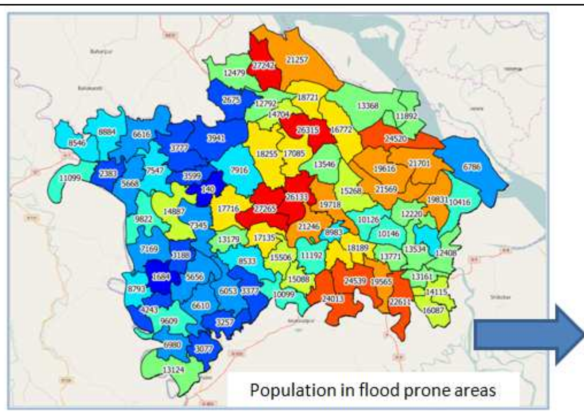
The application to assessment of population living in flood prone areas combined the population density map and the maps of flood prone areas available on the WFP Geonode.

Figure 5: Population in flood prone areas



Statistics were extracted according to usual GIS procedures.

Figure 6: Extraction of raster data to polygons (administrative boundaries)



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

	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

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

Results show that the sub-districts of Nagarkandi and Bhanga are the most exposed to flood risks with more than 70 % of total population living in flood prone areas. The population of the upzila of Faridpur, the Zila capital, is less exposed although at a rate of 39%.

Figure 7: Relative exposure of upzilas to flood risk

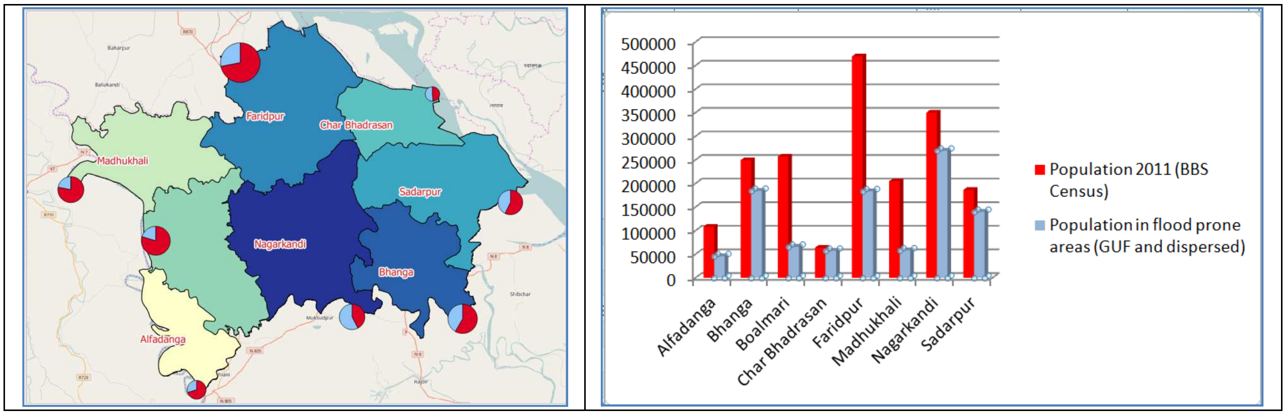
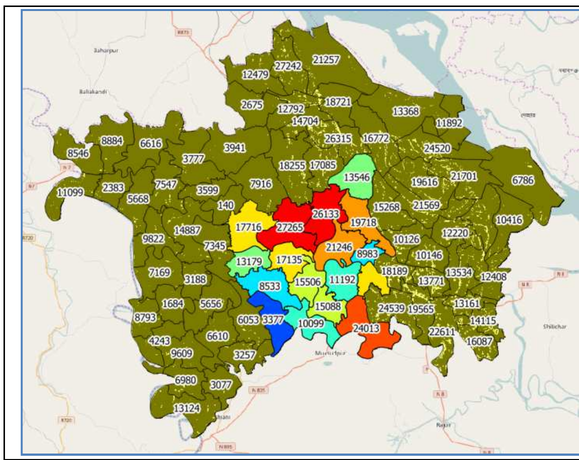
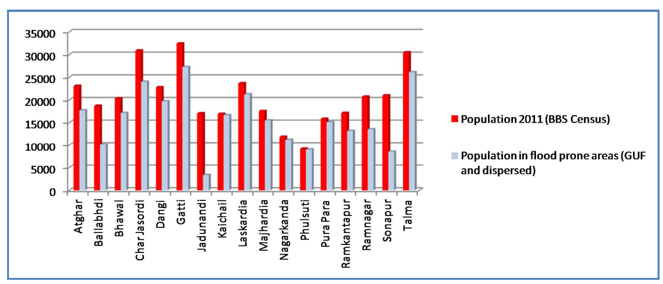


Figure 8: Exposure to flood risk in the Nagarkandi sub-district (upzila)





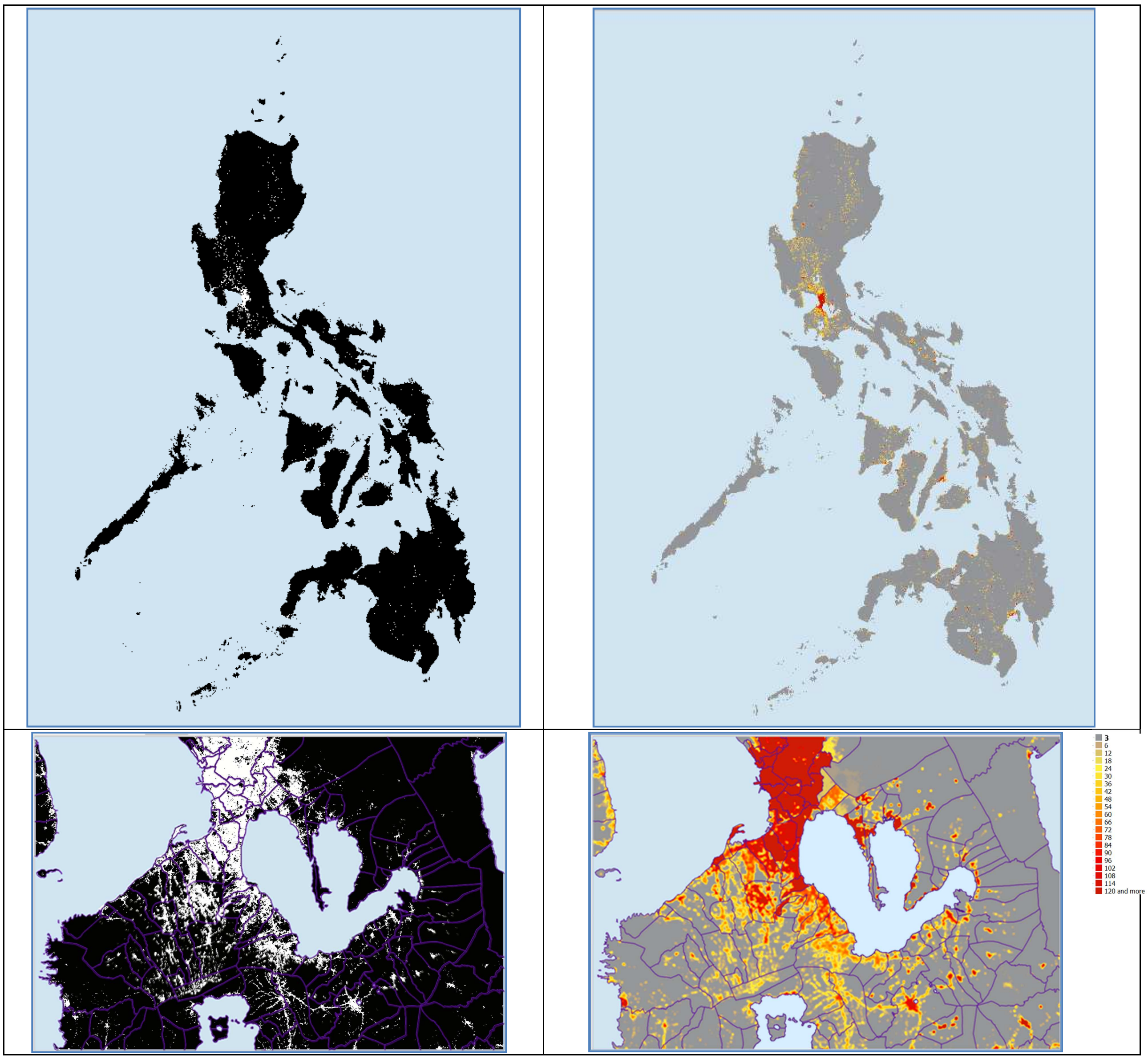
There are no major cities in Nagarkandi and it seems that small cities and dispersed population are settled in areas of high vulnerability to floods, with the exception of Jadunandi and Sonapur.

This quick assessment is for illustration mostly as it doesn't take into account floods severity, an information not available for this study.

3. *Assessment of human settlements at risk of flood and landslide in the Philippines*

The test carried out in the Philippines made use on statistics and maps at the municipal level provided by the Philippines Statistical Authority. It included population census data and several maps of vulnerability to risks. For population assessment with GUF, only the final methodology used in Bangladesh was tested.

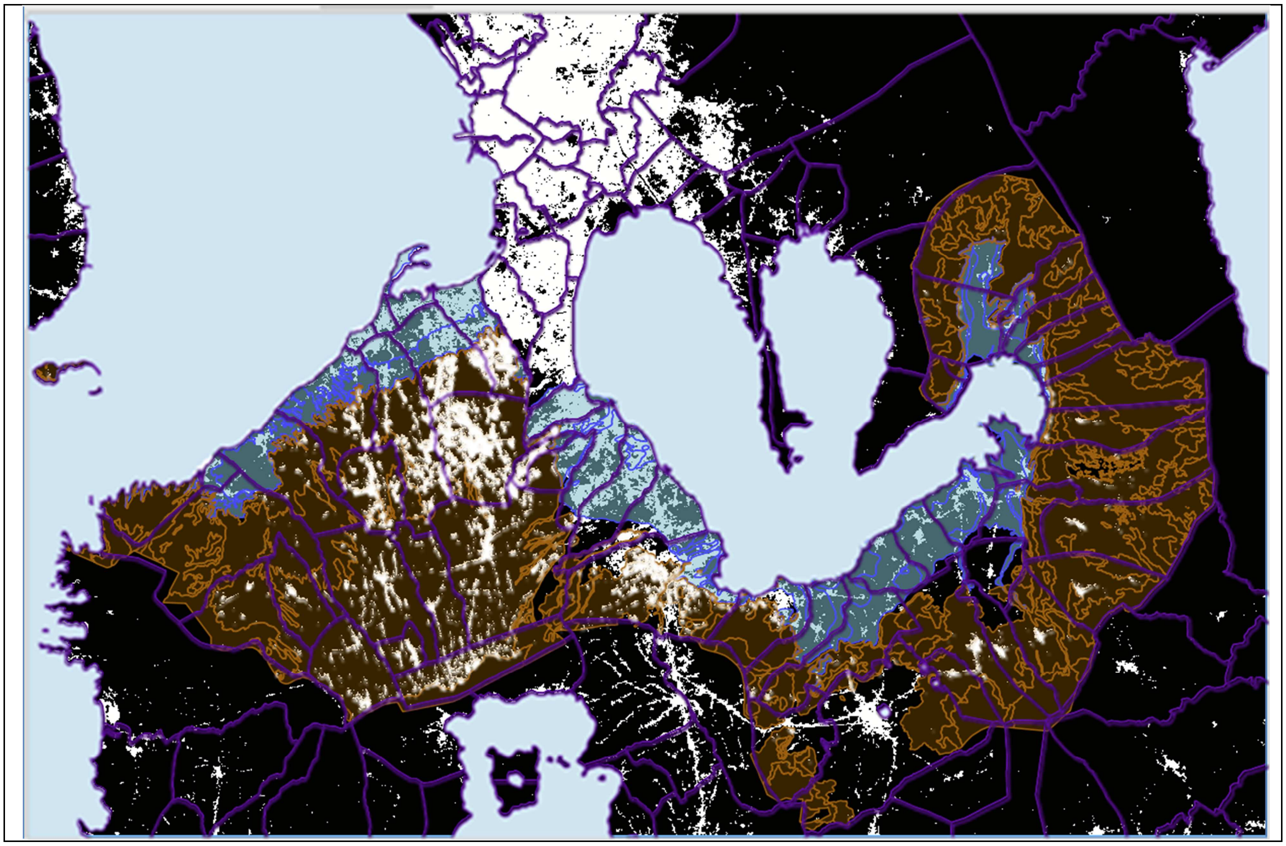
Figure 9: GUF and population distributed to GUF in the Philippines



Tests of exposure of human settlements to risks of natural disasters have been carried out using two maps, exposure to floods and exposure to landslides induced by rain.

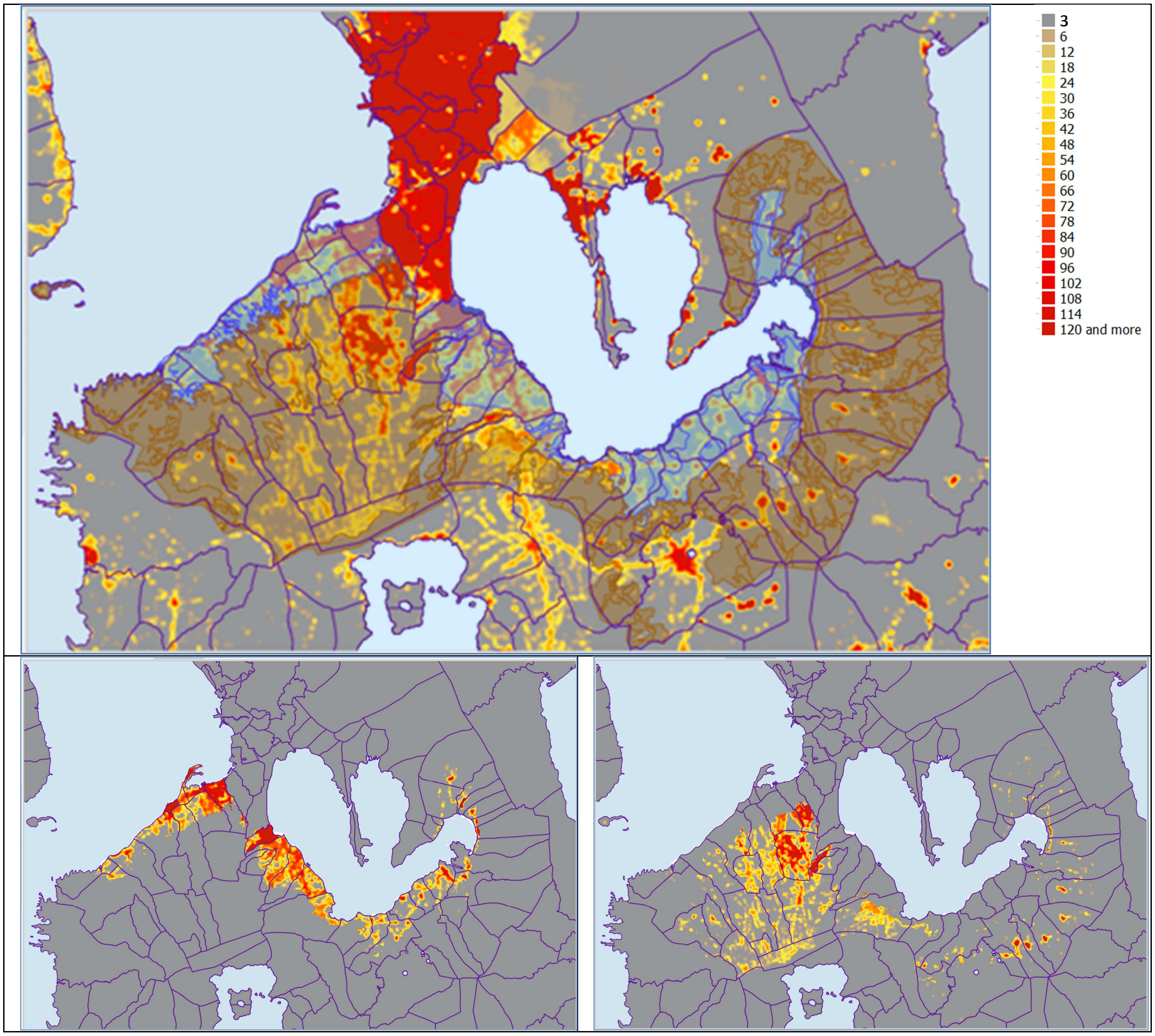
Exposure of built-up areas (GUF pixels) to risks of flood and to rain induced landslides has been overlaid to GUF data (pixels of 75m) and statistics extracted with QGIS/SAGA tools.

Figure 10: Exposure of built-up areas (GUF pixels) to risks of flood (blue) and rain induced landslides (brown)



Similar application has been done for population density.

Figure 11: Exposure of population to risks of flood (blue) and rain induced landslides (brown) (density per GUF pixel)



In the case of the Philippines, the test has been carried out with national data. It includes the production of statistics for which only an illustration can be given.

Figure 12: Illustration of a statistical table of exposure of human settlements to risks of flood and rain induced landslides, by municipalities

Exposure of settlements and population to risks of flood and rain induced landslide, Philippines

Sources: Population Census 2010: Philippines Statistics Authority; GUF (Global Urban Footprint) 2012: DLR (the German Aerospace Agency)

	Population 2010	Total area in 77m x 77m pixels	Built-up area in GUF pixels (77m x 77m)	Flood risk / GUF pixels (77m x 77m)	*Flood risk % of GUF pixels*	Rain-landslide risk / GUF pixels (77m x 77m)	*Rain-landslide risk % of GUF pixels*	Flood risk - Population 2010	*Flood risk % Population 2010*	Rain-landslide risk / Population 2010	*Rain-landslide risk % Population 2010*
Abra	**234733**	**558801**	**1516**	**892**	***58.8***	**565**	***37.3***	**128975**	***54.9***	**101668**	***43.3***
Bangued	43936	17402	480	370	*77.1*	84	*17.5*	33514	*76.3*	8153	*18.6*
Boliney	4063	25677	22	5	*22.7*	16	*72.7*	743	*18.3*	3130	*77.0*
Bucay	17126	14700	82	58	*70.7*	28	*34.1*	12057	*70.4*	5171	*30.2*
Bucloc	2176	7203	10	5	*50.0*	5	*50.0*	678	*31.2*	1375	*63.2*
Daguioman	1715	13681	13	5	*38.5*	2	*15.4*	699	*40.8*	861	*50.2*
Danglas	4734	24745	9	2	*22.2*	4	*44.4*	1457	*30.8*	2986	*63.1*
Dolores	11499	6322	60	3	*5.0*	58	*96.7*	1431	*12.4*	9382	*81.6*
La Paz	14882	7770	102	98	*96.1*	6	*5.9*	13987	*94.0*	1158	*7.8*
Lacub	2977	36456	10	1	*10.0*	8	*80.0*	667	*22.4*	2299	*77.2*
Lagangilang	13824	12882	56	44	*78.6*	9	*16.1*	10859	*78.6*	2649	*19.2*
Lagayan	4477	20288	24	6	*25.0*	23	*95.8*	1207	*27.0*	3746	*83.7*
Langiden	3170	13882	11	5	*45.5*	10	*90.9*	2092	*66.0*	1461	*46.1*
Licuan-Baay	4864	42989	14	3	*21.4*	6	*42.9*	1797	*36.9*	2968	*61.0*
Luba	6391	17772	2	0	*0.0*	2	*100.0*	1471	*23.0*	3353	*52.5*
Malibcong	3807	34022	6	0	*0.0*	6	*100.0*	0	*0.0*	3807	*100.0*
Manabo	10756	11699	116	107	*92.2*	7	*6.0*	10050	*93.4*	534	*5.0*
Penarrubia	6544	5171	18	0	*0.0*	18	*100.0*	89	*1.4*	6852	*104.7*
Pidigan	11528	8158	56	40	*71.4*	14	*25.0*	8014	*69.5*	3286	*28.5*
Pilar	9908	12934	98	7	*7.1*	93	*94.9*	537	*5.4*	9550	*96.4*
Sallapadan	5985	15632	47	7	*14.9*	35	*74.5*	1363	*22.8*	4226	*70.6*
San Isidro	4888	5853	100	17	*17.0*	73	*73.0*	721	*14.8*	3647	*74.6*
San Juan	10546	9081	64	34	*53.1*	32	*50.0*	6013	*57.0*	4433	*42.0*
San Quintin	5233	8760	28	10	*35.7*	7	*25.0*	2568	*49.1*	1682	*32.1*
Tayum	13940	6475	63	61	*96.8*	3	*4.8*	13273	*95.2*	1382	*9.9*
Tineg	4668	106250	7	4	*57.1*	0	*0.0*	2950	*63.2*	1691	*36.2*
Tubo	5719	61542	7	0	*0.0*	5	*71.4*	427	*7.5*	5234	*91.5*
Villaviciosa	5377	11455	11	0	*0.0*	11	*100.0*	310	*5.8*	6651	*123.7*
Agusan del Norte	**642196**	**397265**	**3744**	**0**	***0.0***	**0**	***0.0***	**0**	***0.0***	**44**	***0.0***
Buenavista	56139	50011	246	0	*0.0*	0	*0.0*	0	*0.0*	0	*0.0*
Butuan City	309709	91025	2225	0	*0.0*	0	*0.0*	0	*0.0*	0	*0.0*
Cabadbaran City	69241	46719	469	0	*0.0*	0	*0.0*	0	*0.0*	0	*0.0*
Carmen	19781	16652	72	0	*0.0*	0	*0.0*	0	*0.0*	0	*0.0*
Jabonga	23833	36658	64	0	*0.0*	0	*0.0*	0	*0.0*	0	*0.0*
Kitcharao	17377	16642	54	0	*0.0*	0	*0.0*	0	*0.0*	44	*0.3*
Las Nieves	26856	63675	49	0	*0.0*	0	*0.0*	0	*0.0*	0	*0.0*

4. *Discussion*

The tests of assessment of population and buildings exposure to risks using the GUF dataset show interesting outcomes and demonstrate that statistics can be compiled. The quality of GUF data is of great importance in that respect. To note is the easy detection of roads from GUF and GUF smoothed data. Roads are an attractor to human settlements and several models of population distribution include roads in their assessment, with the risk of exaggerating their importance. No need for that when using GUF where the detection of buildings gives a hint of the presence of roads.

The presentation of the research at the Fourth meeting of the Expert Group on Disaster-related Statistics organized by UNESCAP in collaboration with the Philippines National Statistics Authority in Mandaluyong, Philippines, on 3 – 6 October, 2016 confirmed the interest for this approach. Because of its promising character, further improvements have to be undertaken in order to come quickly to the production of human settlements exposure to risks maps and statistics for the whole ESCAP region.

First comparison with the map produced by the Indonesian National Disaster Management Authority (BNPB) for the same purpose reveals striking similarities and suggests the possibility of cross improvements of the two products. It shows as well points to clarify.

One point relates to dispersed habitats and the fact that their detection might be difficult, in particular in forested environment.
Inversely the generalization of the GUF data to 75m provided by DLR for the tests trends to overestimate pixels with isolated houses. A weighting factor attached to these pixels would improve the assessment.

Part B - Assessment of ecosystems at risk of landslides

The DRSF includes tables on assessment of exposure to risks and impacts of disasters on the environment. It includes in particular nature conservation areas, water and ecosystems. A test has been carried out to explore the possibility to produce a first indicator of ecosystem degradation by natural hazards using the methodology proposed in CBD Technical Series No. 77 on "Ecosystem Natural Capital Accounts: A Quick Start Package For implementing Aichi Biodiversity Target 2 on Integration of Biodiversity Values in National Accounting Systems in the context of the SEEA Experimental Ecosystem Accounts" [8]. This operational manual has been prepared to support countries willing to progress in the implementation of ecosystem accounting, following recent developments of the UN System of Environmental and Economic Accounts which includes a second volume on Experimental Ecosystem Accounting.

In the chapter on ecosystem infrastructure functional services accounts, biodiversity is recorded in two steps, systems (landscapes, rivers…) diversity and species diversity. While species diversity accounting is complex issue, landscapes ecological diversity can be monitored using GIS information: land cover and change, high nature value areas, landscape fragmentation. The European Environment Agency has developed and implemented a methodology for measuring a net landscape ecological potential or NLEP. "*Net Landcsape Ecological Potential of Europe' is a way to measure and assess ecosystem integrity at a macro scale in Europe on the basis of land cover changes. The signal of land cover changes is enhanced by the probability of presence of areas representing high species/ habitats diversity and by the weighting of presence of areas with high density of transportation networks*."[9]

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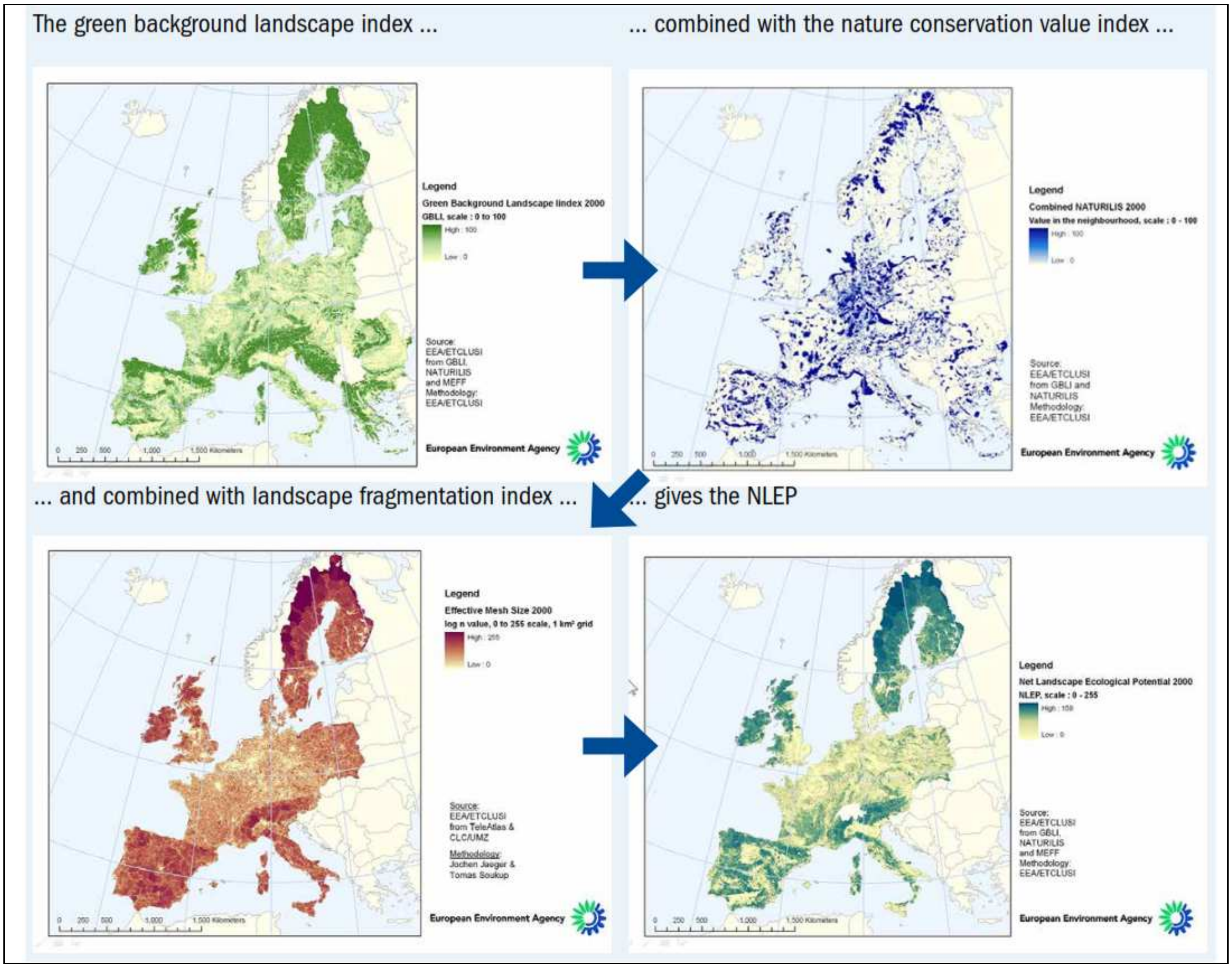
[8] http://www.cbd.int/doc/publications/cbd-ts-77-en.pdf

[9] http://discomap.eea.europa.eu/arcgis/rest/services/Land/NetLandscapeEcologicalPotential_Dyna_WM/MapServer/1 . See also "Net Landscape Ecological Potential of Europe and change 1990-2000", Jean-Louis Weber, Rania Spyropoulou, EEA and Tomas Soukup, Ferran Páramo, ETCLUSI, 2008
http://unstats.un.org/unsd/envaccounting/seeaLES/egm/EEA_bk2.pdf

Figure 13 NLEP, a composite index to measure ecosystem potential



The CBD "Quick Start Package" builds on the EEA methodology while proposing options for using simplified methodologies in a starting phase. Key elements are:

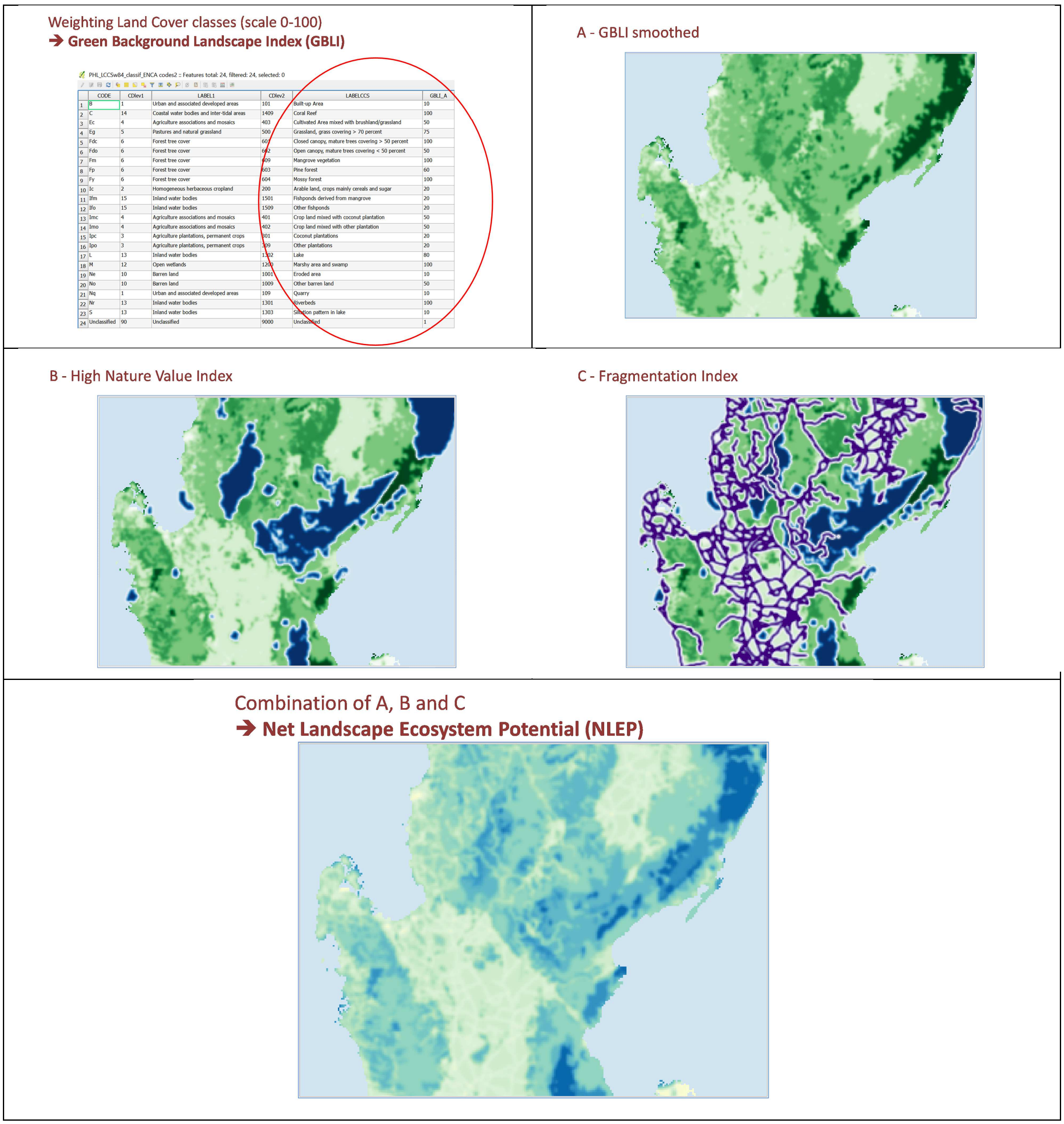
- The land cover map from which is extracted the Green Background Landscape Index (GBLI); for that, each land cover class is given a note from 10 (urban areas) to 100 (mangroves, wetlands, forests, rivers), with intermediate values for intensive broad pattern agriculture (20), mixed agriculture/nature landscapes (50), grassland, shrubs… The notes depend on natural conditions but once agreed, need to be stable for change detection.
- Protected areas are taken as an indication of a particular nature value given by scientists and environmental authorities.
- GBLI and nature value maps are smoothed in order to allow a smart combination of the two geographical layer by avoiding artifacts and outliers due to crisp and somehow arbitrary boundaries.
- Then, landscape fragmentation is integrated to reflect the fact that the reduction of ecosystems size compromises their functioning, in particular because it reduces the vital

space of many species.

For more explanation, the Chapter 7 of the CBD TS77 report can be usefully consulted.

A (quick) test has been carried out for the Philippines using land cover, protected areas and road GIS data provided by the NSA. It should be considered as an illustration at this stage as data have not been fully used.

Figure 14: Calculating NLEP for the Philippines

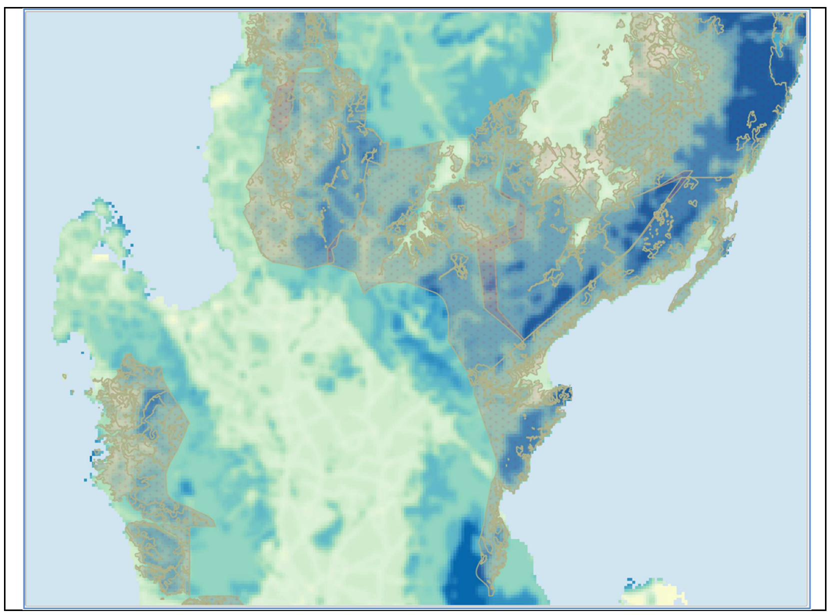


	CODE	CDlev1	LABEL1	CDlev2	LABELCCS	GBLI_A
1	B	1	Urban and associated developed areas	101	Built-up Area	10
2	C	14	Coastal water bodies and inter-tidal areas	1409	Coral Reef	100
3	Ec	4	Agriculture associations and mosaics	403	Cultivated Area mixed with brushland/grassland	50
4	Eg	5	Pastures and natural grassland	500	Grassland, grass covering > 70 percent	75
5	Fdc	6	Forest tree cover	601	Closed canopy, mature trees covering > 50 percent	100
6	Fdo	6	Forest tree cover	602	Open canopy, mature trees covering < 50 percent	50
7	Fm	6	Forest tree cover	609	Mangrove vegetation	100
8	Fp	6	Forest tree cover	603	Pine forest	60
9	Fy	6	Forest tree cover	604	Mossy forest	100
10	Ic	2	Homogeneous herbaceous cropland	200	Arable land, crops mainly cereals and sugar	20
11	Ifm	15	Inland water bodies	1501	Fishponds derived from mangrove	20
12	Ifo	15	Inland water bodies	1509	Other fishponds	20
13	Imc	4	Agriculture associations and mosaics	401	Crop land mixed with coconut plantation	50
14	Imo	4	Agriculture associations and mosaics	402	Crop land mixed with other plantation	50
15	Ipc	3	Agriculture plantations, permanent crops	301	Coconut plantations	20
16	Ipo	3	Agriculture plantations, permanent crops	309	Other plantations	20
17	L	13	Inland water bodies	1302	Lake	80
18	M	12	Open wetlands	1200	Marshy area and swamp	100
19	Ne	10	Barren land	1001	Eroded area	10
20	No	10	Barren land	1009	Other barren land	50
21	Nq	1	Urban and associated developed areas	109	Quarry	10
22	Nr	13	Inland water bodies	1301	Riverbeds	100
23	S	13	Inland water bodies	1303	Siltation pattern in lake	10
24	Unclassified	90	Unclassified	9000	Unclassified	1

Regarding impacts to ecosystems, all hazards are not equivalent. Floods as such are not a disaster for many ecosystems as long as they are part of a natural cycle and contribute to their renewal. It may be different if the occurrence and magnitude of floods increase due to climate change. In this case they impair ecosystem renewal. Such questions have to be discussed with scientists when assessing natural hazards impacts to the ecosystems.

Therefore, the test for ecosystems has been carried out with landslides, which cannot be considered as part of a cycle. This choice again is not straightforward as long as the sliding soil may accrue positively to another piece of land. In this case again, the GIS assessment has to be validated by scientists.

Figure 15: Overlay of Rain Induced Landslide Risk Areas to NLEP



As long as this information is geo-referenced, it is easy using the GIS to extract statistics for relevant breakdowns: regions, municipalities, protected areas, river catchments, coastal zones etc…

Important point to note here is that the NLEP metric allows not only to assess the ecosystem potential exposed to risks but also to measure impacts when they take place, in reference in particular to the change in land cover.