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GLOBAL PEATLAND DATABASE @ GREIFSWALD MIRE CENTRE - INTEGRATION, EVALUATION AND GENERATION OF GEOSPATIAL DATA

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SUMMARY

The importance of the huge amounts of greenhouse gases emitted by drained peatlands has recently been recognised by e.g. UNFCCC, IPCC, FAO and the European Union. Also ecosystem services delivered by undrained natural and restored peatlands, like biodiversity, conservation, water retention and -regulation, nutrient retention or provision of facilities for tourism gain increasing interest. However, the development of adequate restoration strategies requires the availability of comprehensive and exact geospatial data on the drainage status of peatlands and organic soils worldwide.

The Global Peatland Database (GPD) hosted at the Greifswald Mire Centre (http://tiny.cc/globalpeat) holds estimates on the location, extent and drainage status of peatlands and organic soils for 268 countries and regions of the World. Because of the large diversity of definitions and terms, the GPD follows a broad definition and includes all soils with a minimum soil organic carbon threshold of 12% and any depth of the organic layer larger than 10 cm (cf. Hiraishi *et al*., 2014).

The GPD collects available GIS datasets, analyses the terms and concepts used, and evaluates their completeness and accuracy. Currently, the GPD contains geospatial data on peatlands and organic soils for all countries of Europe, for other important areas of the northern hemisphere (e.g. Canada and Siberia), as well as for SE Asia and Tierra del Fuego. For countries without adequate geospatial data, new organic soil maps are generated. The recent focus of GIS mapping is on East Africa with organic soil maps at scale 1:25,000 completed for Burundi, Kenya, Rwanda, Tanzania, Uganda and Zambia. The GPD aims at completing the global inventory of distribution and status of peatland and organic soil until 2020.

Keywords: *Global Peatland Database (GPD), peatland, location, distribution, drainage status, GIS*

INTRODUCTION

Peatlands cover only 3% of the global land surface. Some 15% of these peatlands have been drained for agriculture, forestry and grazing, and peat extraction. Drained peatlands are - even when emissions from peat fires are excluded - responsible for 5% of the global anthropogenic greenhouse gas emissions, which is almost double the amount of CO_2 emissions from aviation (Wetlands International 2015). Rewetting drained peatlands has therefore a large mitigation potential. Undrained, intact peatlands provide many important ecosystem services, including water regulation, nutrient retention, as well as provision of habitats for nationally and internationally threatened wildlife (Joosten & Clarke, 2002; Parish *et al.*, 2008; Bonn *et al.*, 2016). Overall, an urgent need exists to identify the location of peatlands and organic soils, to protect them against any drainage, and to rewet already drained areas in order to decrease greenhouse gas emissions and to prevent hazardous peat fires. Comprehensive and exact geospatial data are needed to evaluate the drainage status of peatlands and organic soils and to develop effective restoration strategies.

Unfortunately, adequate geospatial data on location, extent and land use of peatlands and organic soils are rare, even in northern Europe (Barthelmes *et al.*, 2015). Moreover, the concepts, definitions and terms used differ strongly, whereas data are often spread across national authorities and scientific institutions and difficultly accessible. Also the rapidly developing remote sensing technologies do not manage to fill this gap, because the large diversity of peatlands worldwide and the multitude of land use types prevent the extrapolation of local results to the global scale. Therefore, global peatland mapping continues to depend on the aggregation of local and national data (Montanarella, 2014).

For more than 20 years, information has been collated in the Global Peatland Database (GPD), which is hosted at the Greifswald Mire Centre (http://tiny.cc/globalpeat). Currently, the GPD provides estimates on location, extent and drainage status of peatlands and organic soils for 268 countries and regions of the World. The database predominantly contains digital data, but also printed information stored in the 'Peatland and Nature Conservation International Library'(PeNCIL), also hosted at the Greifswald Mire Centre. Furthermore, thousands of digital photos from peatlands across the globe are connected with the GPD. Since 2012 the peatland/organic soil information of countries without spatially explicit data is being transferred into vector geographic information systems (GIS; scale 1:25,000) and raster GIS (0.01 x 0.01 degree grid). Additionally, GIS data on peatlands, organic soils and useful proxies are continuously collated, evaluated and integrated in the Global Peatland Database.

METHODS

To accommodate for the large diversity of definitions and terms for peatlands and organic soils, the GPD includes all soils with a minimum soil organic carbon threshold of 12% and a depth of the organic layer larger than 10 cm (cf. Hiraishi 2014).

A - Bundling and evaluation of available GIS data

A prime focus of the Global Peatland Database is the identification and collation of geospatial data on peatlands, organic soils and useful proxies (e.g. hydromorphic soils, wetlands, wetland vegetation, Holocene sediments). The analysis of these datasets includes the comprehension of underlying concepts, definitions and terms, the evaluation of their completeness and accuracy, and the detection of inherent weaknesses or failures. These assessments result in the estimation of the completeness, accuracy, and information content of the collated GIS datasets (Table 1).

Table 1: Criteria for the evaluation of completeness, accuracy, and information content of GIS datasets.

cate	**completeness**				**accuracy**			
crite rion 1	*obvious/known gaps in GIS data* [1]				*type of data*			
	yes		no		point		polygon	
crite rion 2	*accordance with best available non-GIS-data*				*accuracy of location*		*accuracy of borders*	
	l	hig	lo	h	l	high	low	h
pred	**l**	**me**	**me**	**h**	**l**	**medi**	**medi**	**h**

category	**information content**			
criterion 1	*type of data*			
	point		polygon	
criterion 2	*additional information* [2]			
	no	yes	no	yes
predicate	**low**	**medium**	**medium**	**high**

1) Expert knowledge and judgement; comparison with satellite and aerial imagery.

2) Additional information of e.g. peatland type, drainage status, applied land use types.

B - High resolution mapping of peatlands and organic soils

We developed a mapping approach that links various science networks, methodologies and databases, including those of peatland/landscape ecology for understanding where and how peatlands may occur, those of remote sensing (RS) for identifying possible locations and those of pedology (legacy soil maps) and (palaeo-)ecology for ground truthing. Such integration of field data, specialized knowledge and modern RS and GIS techniques enables acquiring a comprehensive, detailed and rather reliable overview. A crucial element in this mapping process is the weighting of conflicting information (Figure 1).

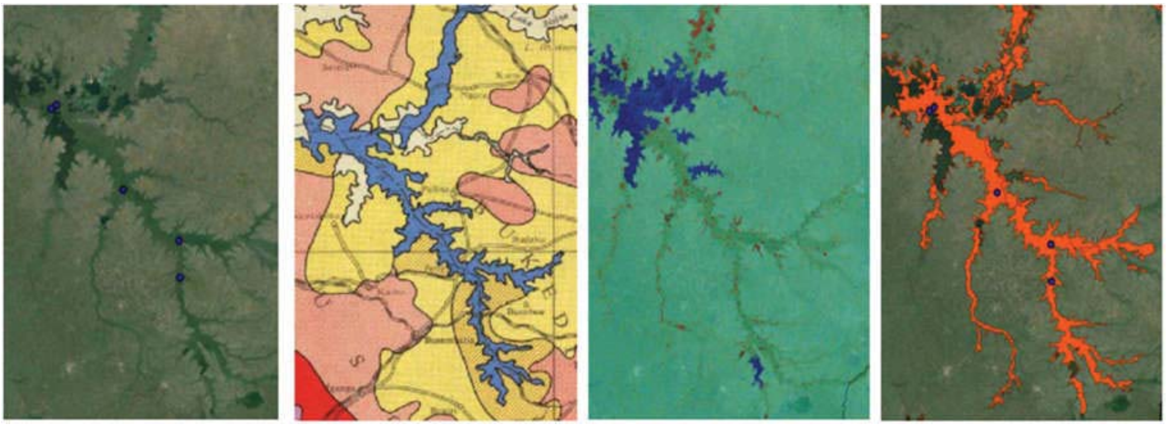

Figure 1: Example of data integration for a wetland southeast of Lake Kyoga (Uganda; satellite images from Google Maps). A: blue = peat point data (National Survey for Energy Peat 2004); B: blue = Fluvisols and Gleysols on available legacy soil maps; C: Topographical Wetness Index (TWI from AfSIS): high TWI in red, darker green and darker blue (in depressions and valleys); D: orange = deduced probable peatland area in final GPD map.

Main sources of spatially explicit information on (organic) soil and proxy data (e.g. digital maps of bedrock, relief, landforms, wetlands, vegetation, land use) have been open access online archives including those of ISRIC (World Soil Information), JRC (Joint Research Centre), FAO Corporated Document Repository, SPHAERA (Base de données Sphaera du service Cartographie), WOSSAC (World Soil Survey Archive and Catalogue) and the Perry Castanea Library of Austin University.

Soil degradation intensity (using the classes 'no, 'slight' and 'heavy degradation', Barthelmes et al. in prep.) is determined for each mapped polygon using satellite and aerial imagery by assessing the density of the drainage channel network, its connection to main outlets and soil surface disturbance by trampling and peat cutting.

RESULTS

A - Bundling and evaluation of available GIS data

An assessment of the available datasets of all European countries shows that satisfactory datasets on the location of peatlands and organic soils are only available for Estonia, Germany, Greece, Lithuania, Sweden, Switzerland, The Netherlands and Cyprus. All other countries possess datasets with different shortcomings, e.g. an incomplete coverage of peatlands and organic soils, or inaccuracies regarding the location and borders of polygons. Beside Austria and France, several countries of southern and eastern Europe have solely or predominantly point data for the location of peatlands and organic soils in place, e.g. Bulgaria, Croatia, Georgia, Italy, Portugal, Slovakia, Spain, and Turkey.

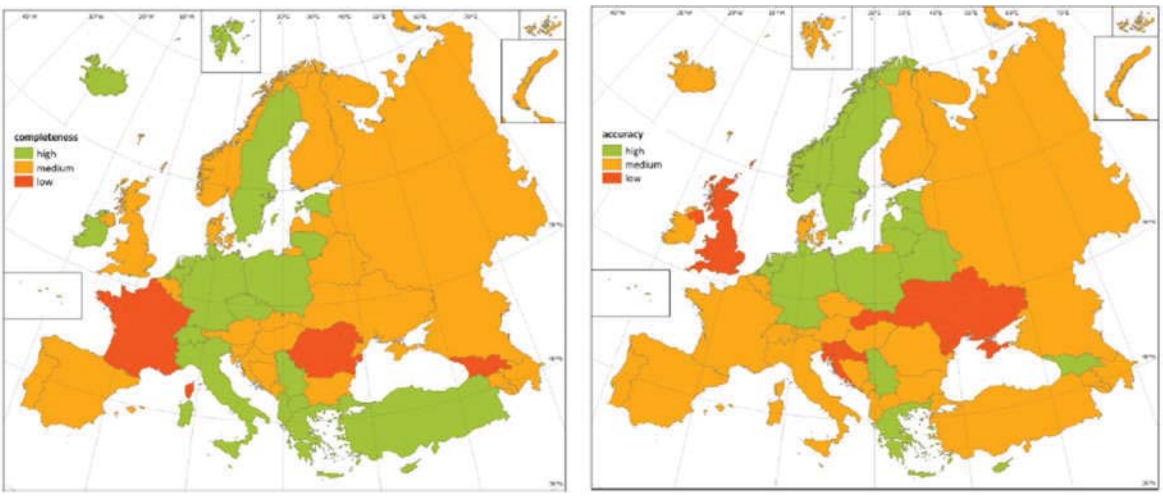

Figure 2: Assessment of the completeness (left) and accuracy (right) of available GIS datasets of European countries.

B - High resolution mapping of peatlands and organic soils

Organic soil maps (incl. peatlands) at a scale of 1:25,000 have been prepared for Burundi, Kenya, Rwanda, Tanzania, Uganda and Zambia. The mapping revealed a total organic soil area for Zambia of 16,663.5 km², of which about 1,500 km² are slightly drained for subsistence agriculture. In contrast, 900 km² of the 960 km² of organic soils in Burundi are intensively drained and heavily degrading. For Rwanda 1,201 km² of organic soils have been mapped, of which 649 km² are still undisturbed ('no degradation'), 115 km² slightly drained ('slight degradation') and 437 km² heavily drained ('heavy degradation'). Figure 3 shows the derived raster maps illustrating the degradation of organic soils in Rwanda (1 km² grid cells).

DISCUSSION

Drained peatlands and organic soils are hotspots of greenhouse gas emissions (incl. hazardous peat fires), whereas in natural condition they provide manifold ecosystem services. The effective prevention of new drainage of peatlands and organic soils, especially in developing and emerging economies, requires that their location is known. Detailed geospatial data showing the location, extent and degradation (drainage) status of peatlands and organic soils are, however, rare, and available datasets are highly variable in concepts, definitions and terms, but also in completeness and accuracy. Shortcomings, failures and gaps need to be urgently assessed by peatland experts.

For more than 20 years the Global Peatland Database has been collating peatland related information and since 2012 these data are transferred into GIS datasets. The GPD approach enables a rather fast, comprehensive, detailed and reliable mapping. Background data and key references, as well as ground truthing results, are kept for each mapped polygon. The country data in the GPD are continuously updated, refined and filled with additional information such as peat depth, carbon content, vegetation or peatland type.

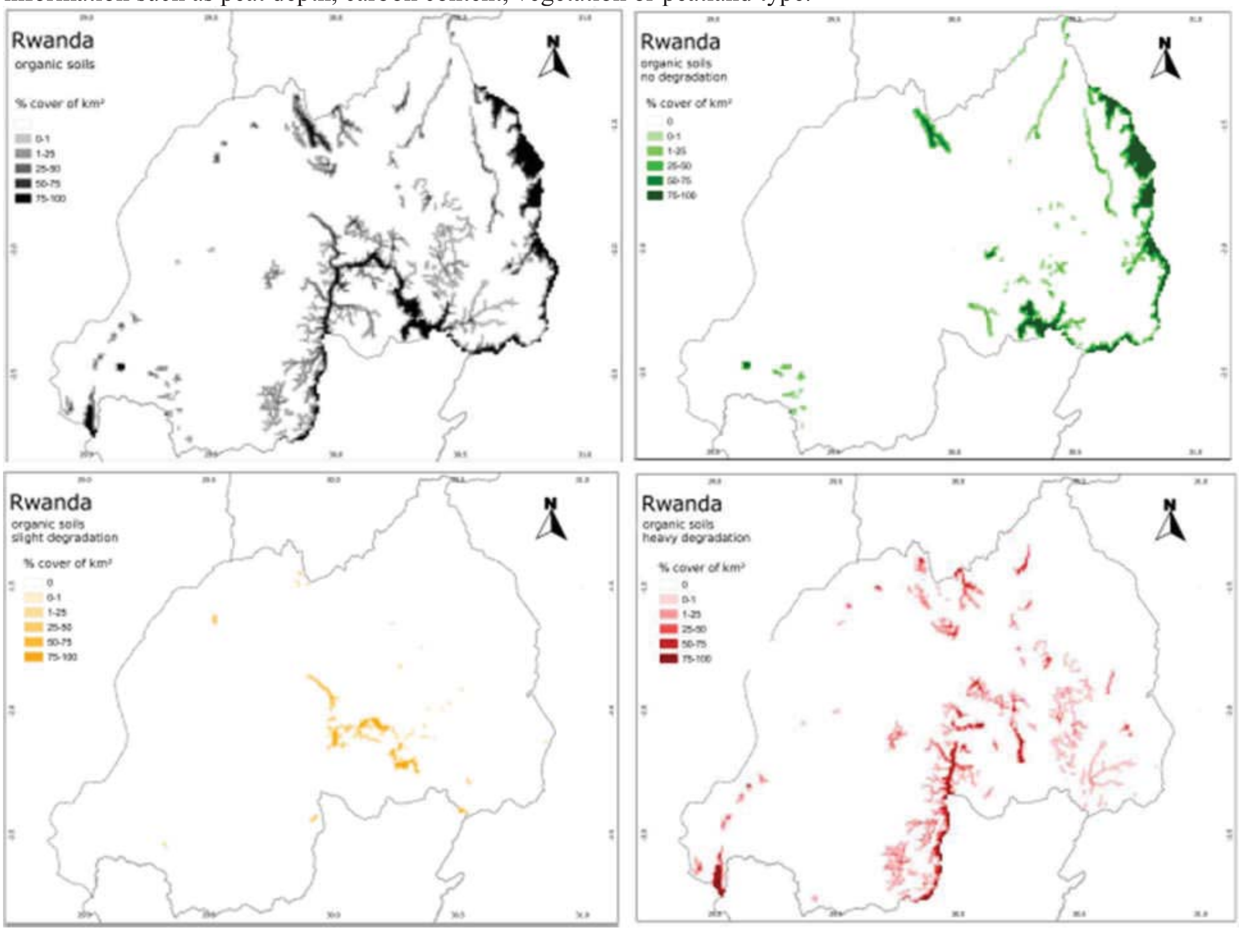

Figure 3: Raster maps of drainage induced degradation of organic soils in Rwanda (% degrading organic soils per 1 km²).

Currently, the GPD contains geospatial data on peatlands and organic soils for all European countries and other important areas of the northern hemisphere (e.g. Canada and Siberia), as well as for SE Asia, East Africa, and Patagonia. The GPD aims at completing collection and mapping of the location, extent and drainage status of peatlands and organic soils for 268 countries and regions of the World until 2020.

CONCLUSION

Greenhouse gas emissions from drained peatlands and organic soils have a disproportionally large impact on the climate. To develop effective strategies for rewetting drained and protecting wet peatlands, it is urgently necessary to know their location. Remote sensing is still no adequate option because the diversity of peatlands and land use types prevents the extrapolation of local studies to the global scale.

Several existing, national vector GIS data for location and extent of peatlands and organic soils for European countries are incomplete in coverage or inaccurate regarding the location and borders of polygons. Furthermore, several European countries solely or predominantly possess point data indicating the location of peatlands and organic soils. The profound evaluation of existing national GIS data is necessary and done in the framework of the GPD by peatland experts of the Greifswald Mire Centre in cooperation with foreign partners.

The Global Peatland Database has developed a rather simple, fast, but spatially highly resolved method to map peatlands and organic soils by linking methodologies of landscape and peatland ecology, remote sensing, pedology and (palaeo-)ecology.

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