Deltas in transboundary river basins: identification, selection and delineation

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Introduction

The GEF (Global Environmental Facility) Transboundary Water Assessment Programme (TWAP) seeks to develop methodologies for conducting a global assessment of transboundary water systems and to catalyse a partnership and arrangements for conducting such a global assessment. River basins constitute one of the water systems analysed in this programme, and may include deltas, occurring where a river flows into a lake or into the sea. The physical geography of deltas often strongly differs from the neighbouring parts of the river basin, in terms of relief, subsurface characteristics and hydrology. Deltas often host important population numbers, agricultural production areas and economic activities. For these reasons, it is felt that deltas need special attention in the TWAP river basin assessment.

An evaluation of the delta component in river basins to be analysed in the TWAP requires:

1. definition of deltas
2. identification of the deltas;
3. selection of the most relevant deltas;
4. development of suitable vulnerability indicators;
5. development of an overall delta vulnerability index.

In this document the results of the first three steps are described. Following identification and selection, the deltas have been delineated, according to geomorphological criteria. At a later stage, steps 4 and 5 will be completed and reported.

Definition of deltas

A sound definition of deltas is needed for identifying and delineating deltas in the TWAP assessment. Various delta definitions exist in the scientific literature taking into account subsurface and submarine characteristics, genesis, and geomorphological characteristics. For practical reasons we utilise a delta definition based on geomorphological criteria that can be applied to remote sensing images. Thereby we exclude offshore submarine and subsurface characteristics. A geomorphological

definition of deltas can be based on the existence of multiple active and abandoned distributary river channels on the delta plain. On a natural delta plain the river is not confined by valley slopes and will change its course from time to time, with new distributaries creating new delta lobes on the coastline. In the process of switching, which is called avulsion, multiple active distributaries may coexist for some time, although often delta river discharge is captured by one dominant channel, leaving the earlier channel as a remnant on the delta plain. Because of this typical deltaic process of channel switching, deltas can be defined geomorphologically to include *the radial complex of active and abandoned distributary channels with associated fluvial landforms and the enclosed portions of the coastal plain, which forms where a river meets the sea or a lake.* Defined as such, neighbouring parts of the coastal plain without landforms created by the delta river are excluded from the delta, as well as offshore areas and uplands that are above present river flood levels.

Identification and selection of deltas

Working from the delta definition given above, we have screened all TWAP river basins for significant deltas. In this process we used the following data sources: (1) Google Earth, (2) the TWAP database of transboundary river basins, (3) the World Delta Database (WDD, Louisiana State University: www.geol.lsu.edu/WDD, (4) the delta overviews of Syvitsky et al. (2009), Ericson et al. (2006) and Bucx et al. (2010).

After our initial survey, we followed a step-wise procedure, described below, to select the deltas that should be included in the TWAP study. In this procedure we used the following criteria:

- area of upstream river basin;
- delta area;
- delta population;
- ecological or agricultural importance;
- data availability.

Step 1
Combining the World Delta Database with the overviews of Syvitsky et al. (2009), Ericson et al. (2006) and Bucx et al. (2010) leads to a worldwide dataset of 84 important deltas.

Step 2
Screening the worldwide dataset of 84 deltas with the TWAP database results in a subset of 40 deltas that are all part of a transboundary river basin.

Step 3
Using data on upstream basin area (TWAP), delta surface area (Ericson et al., 2006; for two deltas information from the internet was used to assess delta surface area), delta population (Ericson et al., 2006; for one delta information from the internet was used to assess delta population), and an assessment of data availability, the subset of 40 deltas has been subdivided into six classes:

***** basin area >100000 km^2 and delta area >1000 km^2 and delta population >1000000 and large data availability;
**** basin area >100000 km^2 and delta area >1000 km^2 and delta population >1000000;
*** basin area >100000 km^2 and delta area >1000 km^2;
** basin area <100000 km^2 or delta area <1000 km^2;
* basin area <100000 km^2 and delta area <1000 km^2;
0 basin area >100000 km^2, but no other data.

All deltas rating *** and higher, 23 in number, have been selected. From the deltas with a large upstream river basin, but limited data availability (class 0), three out of seven have been selected, primarily based on conjectured human population and relative data availability. Inland deltas, like the Okavango Delta, have been excluded. All selected deltas meet the criterion of ecological and/or agricultural importance. Table 1 gives an overview of the selected deltas with some basic data. Note that the delta area and population given in Table 1 are from the literature (almost all data are from Ericson et al., 2006) and only serve the purpose of delta selection. In the following stages of the project these data will be updated based on our own spatial data and analyses.

Table 1 Overview of selected deltas.

	Classification	Basin area (km^2)	Delta area (km^2)	Delta population
America				
Amazon	****	5883400	106000	2930000
Colorado	***	655000	6340	336000
Grijalva	****	126800	10400	1040000
Mississippi	*****	3176500	28800	1790000
Orinoco	***	927400	25600	99200
Parana (La Plata)	***	2954500	12900	444000
Rio Grande	****	656100	13900	2030000
Yukon	***	829700	5020	1040
Europe				
Danube	***	790100	4010	156000
Rhine-Meuse	*****	172900	3810	1940000
Rhone	***	100200	1220	92100
Volga	***/****	1554900	27224	
Wisla	***	194000	1700	250000
Asia				
Ganges-Brahmaputra	*****	1634900	87300	111000000
Hong (Red)	****	157100	4590	5710000
Indus	***	1138800	6780	391000
Irrawaddy	****	404200	30400	9720000
Mekong	*****	787800	49100	20200000
Shatt-al-Arab	***	789000	3850	419000
Africa				
Congo	0	3674850		
Limpopo	0	413560		
Niger	****	2105190	17700	3730000
Nile	*****	3020100	24900	47800000
Senegal	***	434520	3240	260000
Volta	***	411200	2430	385000
Zambezi	0	1353200		

Delineation of deltas

Based on a geomorphological analysis using available remote sensing images (Google Earth and others), and working from our delta definition given above, we have delineated the selected deltas in a GIS (shape file TWAP_deltas) as accurately as possible. To assist in geomorphological interpretation of remote sensing images, we have generated worldwide contour lines (2.5, 5.0, 7.5 and 10 m altitude) based on SRTM data with GIS software. We have also consulted shape files of deltas created for the Syvitsky et al. (2009) paper. However, no delta delineations in our delta shape file have been copied from other files; all boundaries have been manually drawn based on our own geomorphological judgements. In this process we have also used a large number of geological, geomorphological and paleogeographical maps from published journal articles. In Figure 1 the global distribution of the selected and delineated deltas is shown, as well as the relative surface area of the deltas.

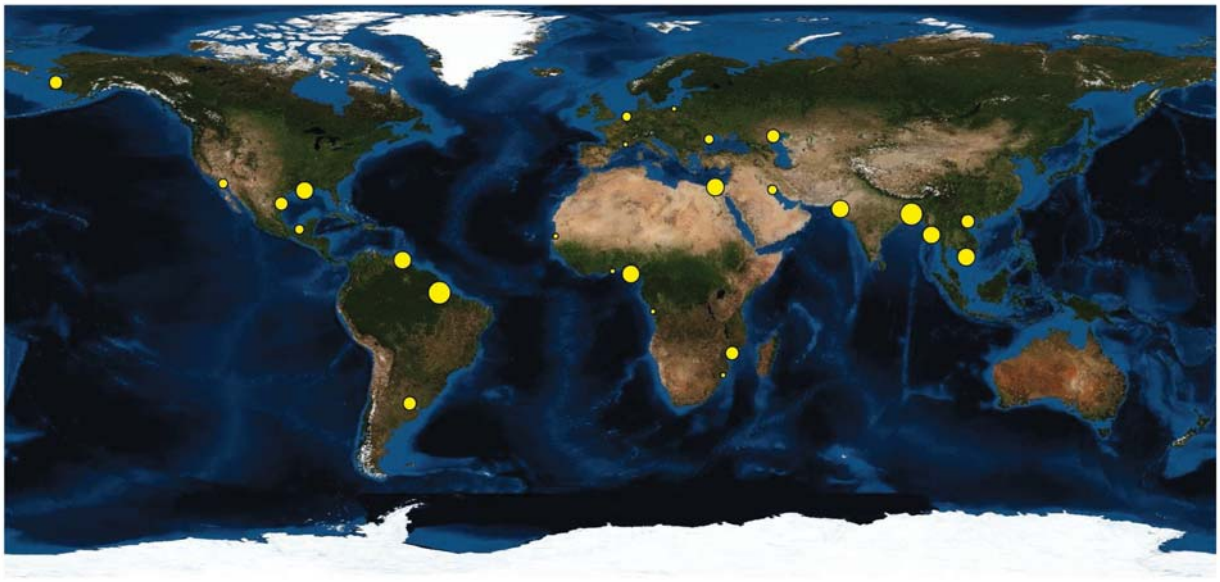

Figure 1 Global distribution of the selected deltas. The size of the yellow dots indicates the relative surface area of the delineated deltas.

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