

SUPPLEMENTARY MATERIAL

“Hydrological threats for riparian wetlands of international importance – a global quantitative and qualitative analysis”

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This supplementary material contains the following information:

A – A detailed list of all wetlands analyzed in the study

B – Detailed results for each analyzed wetland

Supplementary material (A)

In the paper, hydrological threats for a selected sample of riparian wetlands are evaluated. The wetland selection was based on two criteria: (i) wetlands must be of international importance (i.e. listed under the Ramsar Convention) and (ii) the main source of hydrological recharge is lateral overspill of adjacent rivers (i.e. fluviogenic wetlands). Altogether, 93 sites were selected ranging from 5 to 55374 km² in size. They are located in 48 different countries and 47 different river basins. A detailed list of all analyzed wetlands is provided in Table 1.

Table 1. Detailed list of riparian wetlands considered in the study

| ID | Wetland name | Country | Ramsar Ref | Area [ha] |
|-----------|--|----------------|-------------------|------------------|
| 1 | Peace-Athabasca Delta | Canada | 4CA007 | 321,300 |
| 2 | Lac Saint Pierre | Canada | 4CA036 | 11,952 |
| 3 | The Emiquon Complex | USA | 4US033 | 5,729 |
| 4 | Cache-Lower White Rivers | USA | 4US008 | 99,166 |
| 5 | La Segua | Ecuador | 6EC005 | 1,836 |
| 6 | Mamiraua | Brazil | 6BR003 | 1,124,000 |
| 7 | Ilha do Bananal | Brazil | 6BR004 | 562,312 |
| 8 | Rio Yata | Bolivia | 6BO011 | 2,813,229 |
| 9 | Rio Blanco | Bolivia | 6BO009 | 2,404,916 |
| 10 | Rio Matos | Bolivia | 6BO010 | 1,729,788 |
| 11 | Pantanal Matogrossense | Brazil | 6BR001 | 135,000 |
| 12 | Humedales Chaco | Argentina | 6AR013 | 508,000 |
| 13 | Jaaukanigas | Argentina | 6AR009 | 492,000 |
| 14 | River Luiro Mires | Finland | 3FI039 | 12,345 |
| 15 | Matsalu Nature Reserve | Estonia | 3EE001 | 48,610 |
| 16 | River Spey - Insh Marshes | United Kingdom | 3UK106 | 1,159 |
| 17 | Firth of Tay and Eden Estuary | United Kingdom | 3UK144 | 6,918 |
| 18 | Helgean | Sweden | 3SE003 | 8,050 |
| 19 | Lower Derwent Valley | United Kingdom | 3UK023 | 915 |
| 20 | Elbauen, Schnackenburg-Lauenburg | Germany | 3DE005 | 7,560 |
| 21 | Unteres Odertal, Schwedt | Germany | 3DE022 | 5,400 |
| 22 | Niederung der unteren Havel | Germany | 3DE021 | 8,920 |
| 23 | Nene Washes | United Kingdom | 3UK059 | 1,517 |
| 24 | Desna River Floodplains | Ukraine | 3UA028 | 4,270 |
| 25 | Mid-Prpyat State Landscape Zakaznik | Belarus | 3BY002 | 90,447 |
| 26 | Prypiat River Floodplains | Ukraine | 3UA021 | 12,000 |
| 27 | Unterer Niederrhein | Germany | 3DE028 | 25,000 |
| 28 | Stokhid River Floodplains | Ukraine | 3UA022 | 10,000 |
| 29 | Rheinauen zwischen Eltville und Bingen | Germany | 3DE009 | 566 |
| 30 | Litovelske Pomoravi | Czech Republic | 3CZ008 | 5,122 |
| 31 | Donauauen & Donaumoos | Germany | 3DE011 | 8,000 |
| 32 | Felső-Tisza (Upper Tisza) | Hungary | 3HU023 | 22,311 |

| ID | Wetland name | Country | Ramsar Ref | Area [ha] |
|-----------|--|----------------|-------------------|------------------|
| 33 | Moravske luhy (Morava floodplains) | Slovakia | 3SK005 | 5,380 |
| 34 | Tisa River | Slovakia | 3SK014 | 735 |
| 35 | Donau-March-Thaya-Auen | Austria | 3AT002 | 36,090 |
| 36 | Ipoly Valley | Hungary | 3HU021 | 2,227 |
| 37 | Dunajske luhy (Danube floodplains) | Slovakia | 3SK006 | 14,488 |
| 38 | Grande Briere | France | 3FR013 | 19,000 |
| 39 | Raba valley (Raba-völgy) | Hungary | 3HU025 | 10,961 |
| 40 | Upper Drava River | Austria | 3AT023 | 1,029 |
| 41 | Dnipro River Delta | Ukraine | 3UA009 | 26,000 |
| 42 | Lower Dniester (Nistru de Jos) | Moldova | 3MD002 | 60,000 |
| 43 | Dniester-Turunchuk Crossrivers Area | Ukraine | 3UA006 | 76,000 |
| 44 | Gemenc | Hungary | 3HU015 | 16,873 |
| 45 | Mures Floodplain | Romania | 3RO004 | 17,166 |
| 46 | Nature Park Kopacki rit | Croatia | 3HR002 | 23,894 |
| 47 | Lonjsko polje and Mokro polje | Croatia | 3HR003 | 51,218 |
| 48 | Danube Delta | Romania | 3RO001 | 647,000 |
| 49 | Obedska Bara | Serbia | 3RS001 | 17,501 |
| 50 | Canaralele de la Horsova | Romania | 3RO016 | 7,406 |
| 51 | Danube Islands-Bugeac-Iortmac | Romania | 3RO017 | 82,832 |
| 52 | Belene Islands Complex | Bulgaria | 3BG006 | 18,330 |
| 53 | Camargue | France | 3FR001 | 85,000 |
| 54 | Neretva River Delta | Croatia | 3HR004 | 12,742 |
| 55 | Paul de Boquilobo | Portugal | 3PT005 | 529 |
| 56 | Donana | Spain | 3ES001 | 111,646 |
| 57 | Sebkhet Kelbia | Tunisia | 1TN016 | 8,732 |
| 58 | Embouchure de la Moulouya | Morocco | 1MA015 | 3,000 |
| 59 | Delta Interieur du Niger | Mali | 1ML001 | 4,119,500 |
| 60 | Lake Chad Wetlands in Nigeria | Nigeria | 1NG002 | 607,354 |
| 61 | Baturiya Wetland | Nigeria | 1NG004 | 101,095 |
| 62 | Zone humide du moyen Niger II | Niger | 1NE007 | 65,850 |
| 63 | Plaines d'inondation des Bahr Aouk et Salamat | Chad | 1TD005 | 4,922,000 |
| 64 | Lower Kaduna-Middle Niger Floodplain | Nigeria | 1NG007 | 229,054 |
| 65 | Tana River Delta | Kenya | 1KE006 | 163,600 |
| 66 | Kilombero Valley Floodplain | Tanzania | 1TZ003 | 796,735 |
| 67 | Luangwa Flood Plains | Zambia | 1ZM005 | 250,000 |
| 68 | Zambezi Floodplains | Zambia | 1ZM007 | 900,000 |
| 69 | Marromeu Complex (Zambezi Delta) | Mozambique | 1MZ001 | 688,000 |
| 70 | Okavango Delta System | Botswana | 1BW001 | 5,537,400 |
| 71 | Ndumo Game Reserve | South Africa | 1ZA014 | 10,117 |
| 72 | Lower Dvuoobje | Russia | 2RU013 | 540,000 |
| 73 | Oka & Pra River Floodplains | Russia | 3RU007 | 161,542 |
| 74 | Volga Delta | Russia | 3RU002 | 800,000 |
| 75 | Shandong Yellow River Delta Wetland | China | 2CN045 | 95,950 |
| 76 | Lower part of Pyandj River | Tajikistan | 2TJ003 | - |
| 77 | Hawizeh Marsh (Haur Al-Hawizeh) | Iraq | 2IQ001 | 137,700 |
| 78 | Shadegan Marshes & mudflats of Khor-al Amaya & Khor Musa | Iran | 2IR006 | 400,000 |
| 79 | Dong dongting hu | China | 2CN004 | 190,000 |
| 80 | Sundarbans Reserved Forest | Bangladesh | 2BD001 | 601,700 |
| 81 | Middle Stretches of the Mekong River | Cambodia | 2KH003 | 14,600 |
| 82 | Boeng Chhmar | Cambodia | 2KH001 | 28,000 |
| 83 | Bau Sau Wetlands and Seasonal Floodplains | Viet Nam | 2VN002 | 13,759 |
| 84 | Tram Chim National Park | Viet Nam | 2VN004 | 7,313 |
| 85 | Lower Kinabatangan-Segama Wetland | Malaysia | 2MY006 | 78,803 |
| 86 | Danau Sentarum | Indonesia | 2ID002 | 80,000 |
| 87 | Kakadu National Park | Australia | 5AU002 | 1,979,766 |
| 88 | Ord River floodplain | Australia | 5AU031 | 141,453 |
| 89 | Gwydir Wetlands | Australia | 5AU051 | 823 |
| 90 | Macquarie Marshes | Australia | 5AU027 | 19,850 |
| 91 | Riverland | Australia | 5AU029 | 30,640 |
| 92 | Banrock Station Wetland Complex | Australia | 5AU059 | 1,375 |
| 93 | Barmah Forest | Australia | 5AU014 | 28,515 |

Supplementary material (B)

Hydrological threats are assessed by five different indicators in the paper. The quantitative part of the assessment is based on the flood pulse concept (Junk et al., 1989, Tockner et al., 2000) and considers the reduction in flood volume (i.e. flows above bankfull that lead to wetland inundation) due to (i) current water management and (ii) climate change in the 2050s. In the qualitative assessment, the potential for future flow modifications is assessed by the number of new dam initiatives taking currently part in the upstream area of each wetland. Further qualitative results address the capacity to act for each site by evaluating whether upstream water resource availability and the existing institutional framework could support the implementation of conservation measures. Table 2 provides the detailed results of the multi-indicator assessment described in Chapter 3 of the paper.

Table 2. Detailed results of the multi-indicator assessment for the 93 selected riparian wetlands. Numbers provided in brackets represent the number of current major dam initiatives upstream (column 6) and the number of month with water scarcity upstream (column 7). In column 8, transboundary and non-transboundary upstream areas need to be distinguished. For wetlands with a transboundary upstream area, a score ranging from zero to six was calculated to describe formal institutional capacity. For wetlands with a non-transboundary upstream area, only presence (=yes) or absence (=no) of legal provisions or official recommendation to establish eFlows are considered.

| ID | Wetland name | Ramsar Reference | Flood volume reduction water management | Flood volume reduction climate change 2050s | Potential impact by new dam initiatives | Water availability for ecol. allocations | Formal institutional capacity |
|----|----------------------------------|------------------|---|---|---|--|-------------------------------|
| 1 | Peace-Athabasca Delta | 4CA007 | seriously | increase | none | high (0) | no |
| 2 | Lac Saint-Pierre | 4CA036 | significantly | increase | none | high (0) | high (5/6) |
| 3 | The Emiquon Complex | 4US033 | slightly | increase | none | med (2) | yes |
| 4 | Cache-Lower White Rivers | 4US008 | seriously | increase | none | med (4) | no |
| 5 | La Segua | 6EC005 | seriously | increase | none | med (4) | yes |
| 6 | Mamiraua | 6BR003 | slightly | increase | high (125) | high (0) | med (3/6) |
| 7 | Ilha do Bananal | 6BR004 | slightly | slightly | med (3) | high (0) | yes |
| 8 | Rio Yata | 6BO011 | slightly | seriously | none | high (0) | no |
| 9 | Rio Blanco | 6BO009 | slightly | seriously | none | high (0) | no |
| 10 | Rio Matos | 6BO010 | slightly | slightly | med (3) | high (0) | no |
| 11 | Pantanal Matogrossense | 6BR001 | slightly | moderately | med (9) | high (0) | yes |
| 12 | Humedales Chaco | 6AR013 | seriously | slightly | high (34) | high (0) | med (4/6) |
| 13 | Jaaukanigas | 6AR009 | seriously | slightly | high (34) | high (0) | med (4/6) |
| 14 | River Luiro Mires | 3FI039 | seriously | slightly | none | high (0) | no |
| 15 | Matsalu Nature Reserve | 3EE001 | slightly | moderately | none | high (0) | yes |
| 16 | River Spey - Insh Marshes | 3UK106 | slightly | increase | none | high (0) | yes |
| 17 | Firth of Tay and Eden Estuary | 3UK144 | slightly | increase | none | high (0) | yes |
| 18 | Helgean | 3SE003 | slightly | increase | none | high (1) | no |
| 19 | Lower Derwent Valley | 3UK023 | slightly | moderately | none | high (1) | yes |
| 20 | Elbauen, Schnackenburg-Lauenburg | 3DE005 | significantly | moderately | none | high (0) | high (5/6) |

| ID | Wetland name | Ramsar Reference | Flood volume reduction water management | Flood volume reduction climate change 2050s | Potential impact by new dam initiatives | Water availability for ecol. allocations | Formal institutional capacity |
|----|--|------------------|---|---|---|--|-------------------------------|
| 21 | Unteres Odertal, Schwedt | 3DE022 | slightly | slightly | none | high (0) | high (5/6) |
| 22 | Niederung der unteren Havel | 3DE021 | slightly | increase | none | high (0) | yes |
| 23 | Nene Washes | 3UK059 | slightly | moderately | none | med (4) | yes |
| 24 | Desna River Floodplains | 3UA028 | slightly | significantly | none | high (0) | low (2/6) |
| 25 | Mid-Pripyat State Landscape Zakaznik | 3BY002 | slightly | slightly | none | high (0) | low (2/6) |
| 26 | Prypiat River Floodplains | 3UA021 | slightly | significantly | none | high (0) | no |
| 27 | Unterer Niederrhein | 3DE028 | slightly | increase | none | high (0) | high (6/6) |
| 28 | Stokhid River Floodplains | 3UA022 | slightly | moderately | none | high (0) | no |
| 29 | Rheinauen zwischen Eltville und Bingen | 3DE009 | slightly | seriously | none | high (0) | high (6/6) |
| 30 | Litovelske Pomoravi | 3CZ008 | slightly | slightly | none | high (0) | yes |
| 31 | Donauauen & Donaumoos | 3DE011 | slightly | moderately | none | high (0) | yes |
| 32 | Felső-Tisza (Upper Tisza) | 3HU023 | slightly | seriously | none | high (0) | high (6/6) |
| 33 | Moravske Luhý (Morava floodplains) | 3SK005 | seriously | moderately | none | med (3) | high (6/6) |
| 34 | Tisa River | 3SK014 | slightly | seriously | none | high (0) | high (6/6) |
| 35 | Donau-March-Thaya-Auen | 3AT002 | significantly | increase | none | high (0) | high (6/6) |
| 36 | Ipoly Valley | 3HU021 | slightly | seriously | none | med (4) | high (6/6) |
| 37 | Dunajske luhý (Danube floodplains) | 3SK006 | significantly | increase | none | high (0) | high (6/6) |
| 38 | Grande Briere | 3FR013 | slightly | increase | none | med (4) | yes |
| 39 | Raba valley (Raba-völgy) | 3HU025 | slightly | increase | none | high (0) | high (6/6) |
| 40 | Upper Drava River | 3AT023 | slightly | increase | none | high (0) | high (6/6) |
| 41 | Dnipro River Delta | 3UA009 | seriously | slightly | none | med (3) | low (2/6) |
| 42 | Lower Dniester (Nistru de Jos) | 3MD002 | seriously | seriously | none | med (3) | med (3/6) |
| 43 | Dniester-Turunchuk Crossrivers Area | 3UA006 | seriously | seriously | none | med (4) | med (3/6) |
| 44 | Gemenc | 3HU015 | moderately | increase | none | high (0) | high (6/6) |
| 45 | Mures Floodplain | 3RO004 | slightly | seriously | none | high (0) | yes |
| 46 | Nature Park Kopacki rit | 3HR002 | significantly | increase | med (2) | high (0) | high (5/6) |
| 47 | Lonjsko polje & Mokro polje | 3HR003 | slightly | increase | high (36) | high (0) | high (5/6) |
| 48 | Danube Delta | 3RO001 | moderately | increase | high (107) | med (2) | high (6/6) |
| 49 | Obedska Bara | 3RS001 | moderately | increase | high (102) | high (0) | high (5/6) |
| 50 | Canaralele de la Harsova | 3RO016 | moderately | increase | high (107) | high (1) | high (6/6) |
| 51 | Danube Islands-Bugeac-Iortmac | 3RO017 | moderately | increase | high (107) | high (1) | high (6/6) |
| 52 | Belene Islands Complex | 3BG006 | moderately | increase | high (107) | high (0) | high (6/6) |
| 53 | Camargue | 3FR001 | moderately | increase | none | med (2) | high (6/6) |
| 54 | Neretva River Delta | 3HR004 | moderately | increase | med (4) | high (0) | high (5/6) |
| 55 | Paul de Boquilobo | 3PT005 | seriously | slightly | none | med (5) | med (4/6) |
| 56 | Donana | 3ES001 | seriously | significantly | none | med (5) | yes |
| 57 | Sebkhet Kelbia | 1TN016 | significantly | increase | none | low (7) | no |
| 58 | Embouchure de la Moulouya | 1MA015 | seriously | slightly | none | low (6) | no |

| ID | Wetland name | Ramsar Reference | Flood volume reduction water management | Flood volume reduction climate change 2050s | Potential impact by new dam initiatives | Water availability for ecol. allocations | Formal institutional capacity |
|----|--|------------------|---|---|---|--|-------------------------------|
| 59 | Delta Interieur du Niger | 1ML001 | moderately | increase | med (1) | med (4) | med (4/6) |
| 60 | Lake Chad Wetlands in Nigeria | 1NG002 | moderately | increase | none | low (11) | med (3/6) |
| 61 | Baturiya Wetland | 1NG004 | seriously | increase | none | med (4) | no |
| 62 | Zone humide du moyen Niger II | 1NE007 | slightly | increase | med (3) | high (1) | med (4/6) |
| 63 | Plaines d'inondation des Bahr Aouk et Salamat | 1TD005 | slightly | slightly | none | high (0) | med (3/6) |
| 64 | Lower Kaduna-Middle Niger Floodplain | 1NG007 | seriously | increase | med (5) | high (0) | med (4/6) |
| 65 | Tana River Delta | 1KE006 | moderately | increase | none | low (7) | yes |
| 66 | Kilombero Valley Floodplain | 1TZ003 | slightly | increase | med (2) | high (0) | yes |
| 67 | Luangwa Flood Plains | 1ZM005 | slightly | increase | none | high (0) | no |
| 68 | Zambezi Floodplains | 1ZM007 | slightly | slightly | med (1) | high (0) | med (4/6) |
| 69 | Marromeu Complex (Zambezi Delta) | 1MZ001 | seriously | slightly | med (12) | high (0) | high (5/6) |
| 70 | Okavango Delta System | 1BW001 | slightly | increase | med (1) | high (0) | med (4/6) |
| 71 | Ndumo Game Reserve | 1ZA014 | slightly | increase | none | high (0) | high (6/6) |
| 72 | Lower Dvuobje | 2RU013 | slightly | increase | med (3) | high (0) | low (2/6) |
| 73 | Oka & Pra River Floodplains | 3RU007 | slightly | seriously | none | high (0) | no |
| 74 | Volga Delta | 3RU002 | seriously | seriously | none | high (0) | no |
| 75 | Shandong Yellow River Delta Wetland | 2CN045 | seriously | increase | high (56) | low (6) | yes |
| 76 | Lower part of Pyandj River | 2TJ003 | slightly | increase | none | med (2) | med (3/6) |
| 77 | Hawizeh Marsh (Haur Al-Hawizeh) | 2IQ001 | seriously | moderately | med (1) | low (7) | med (3/6) |
| 78 | Shadegan Marshes & mudflats of Khor-al Amaya & Khor Musa | 2IR006 | seriously | increase | med (1) | low (6) | no |
| 79 | Dong dongting hu | 2CN004 | seriously | increase | high (566) | high (0) | yes |
| 80 | Sundarbans Reserved Forest | 2BD001 | moderately | increase | high (276) | med (5) | high (5/6) |
| 81 | Middle Stretches of the Mekong River | 2KH003 | significantly | increase | high (45) | high (0) | med (4/6) |
| 82 | Boeng Chhmar | 2KH001 | slightly | increase | none | med (4) | no |
| 83 | Bau Sau Wetlands and Seasonal Floodplains | 2VN002 | slightly | increase | med (7) | high (0) | yes |
| 84 | Tram Chim National Park | 2VN004 | moderately | increase | high (57) | high (0) | high (6/6) |
| 85 | Lower Kinabatangan-Segama Wetland | 2MY006 | slightly | increase | none | high (0) | no |
| 86 | Danau Sentarum | 2ID002 | slightly | increase | none | high (0) | no |
| 87 | Kakadu National Park | 5AU002 | slightly | increase | none | high (0) | yes |
| 88 | Ord River floodplain | 5AU031 | seriously | increase | none | med (3) | yes |
| 89 | Gwydir Wetlands | 5AU051 | seriously | significantly | none | low (7) | yes |
| 90 | Macquarie Marshes | 5AU027 | seriously | increase | none | low (8) | yes |
| 91 | Riverland | 5AU029 | seriously | increase | none | low (9) | yes |
| 92 | Banrock Station Wetland Complex | 5AU059 | seriously | increase | none | low (10) | yes |
| 93 | Barmah Forest | 5AU014 | seriously | increase | none | med (5) | yes |