NILE BASIN INITIATIVE
INITIATIVE DU BASSIN DU NIL

SUDD WETLANDS DIAGNOSTIC ANALYSIS STUDY - PHYSICAL BASELINE

BY **GEORG PETERSEN**

Study context

- Nile Basin wetlands of transboundary significance: Inventory, Baseline Study and Framework Management Plan with a nested case study on the Sudd
  - Wetland mapping
  - Wetland inventory
  - Modelling wetland hydraulics
  - Wetland ecosystem services assessment
  - Wetland biodiversity assessment
  - Wetland eflows assessment
  - Wetland management policies
  - Wetland framework management plan

Generation of knowledge of physical baseline conditions

Physical baseline

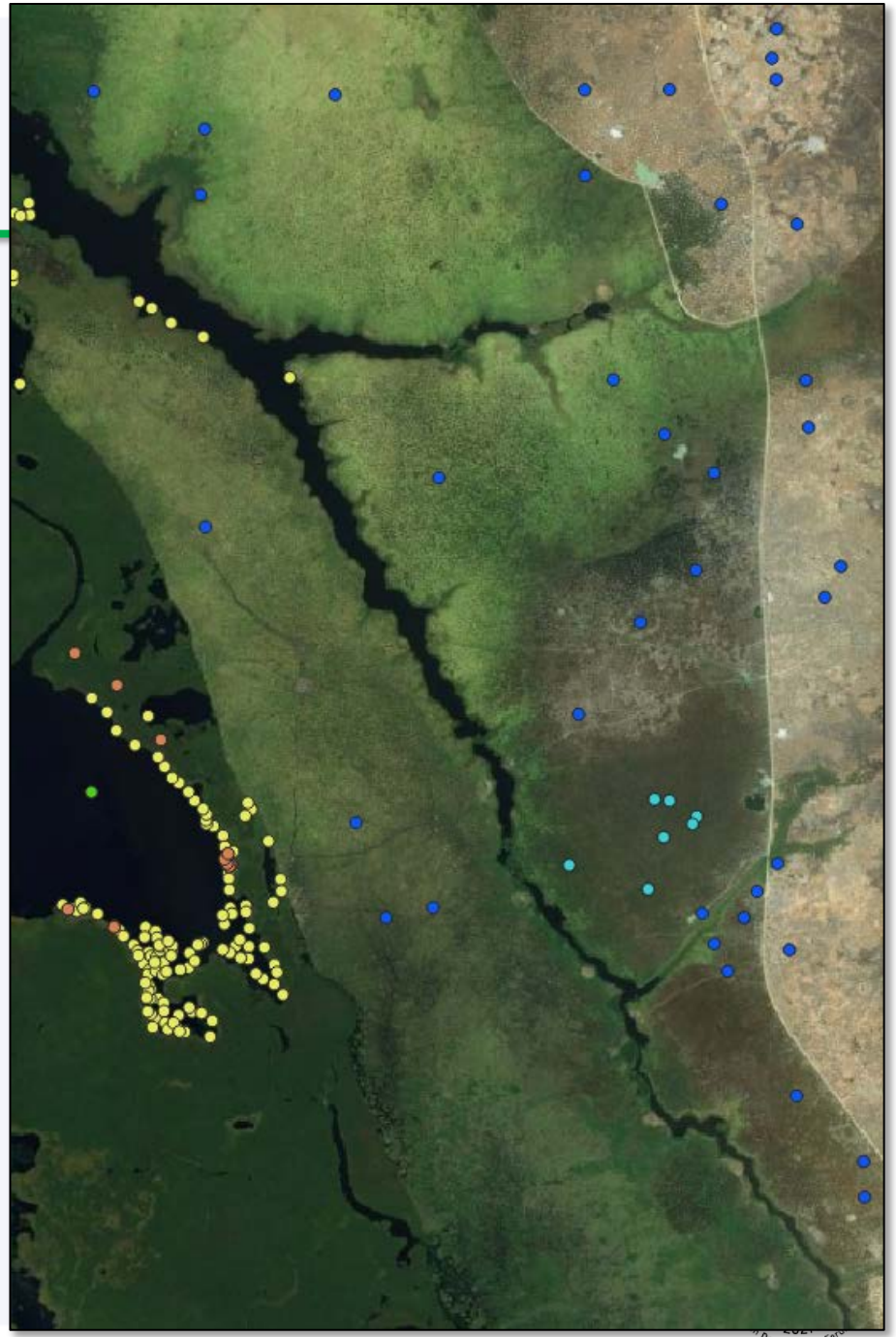
- Wetland mapping
  - Based on Remote Sensing data
  - Resulting in different landcover classes
- Wetland inventory
  - Wetland structure/overview
  - Wetland knowledge database

Wetland mapping objectives

- Provision of high-quality land cover and land use information for the Nile basin (-> improving quality of the 2009 study)
  - 10m spatial resolution (compared to 30m in 2009) to provide more spatial detail
  - Separation of reeds, papyrus and flooded grassland to provide more thematic detail
  - Map production for 3 different epocs (±3 years): 1985, 2005 and 2015 to permit change analysis
- Further requirements
  - Data ready for GIS integration
  - Rigorous validation of final products
  - Transparent and objective methodology
  - Cost-efficient and repeatable methodology

Wetland mapping methods

- Based on different satellite data: Landsat-5, Landsat-7, Sentinel-2
- Timestamps 1985, 2005, 2015
- 25,000 satellite images analyzed
- Big data: 14 billion pixels with values for each spectral band, each season and each year
- Ground control point collection for referencing/machine learning



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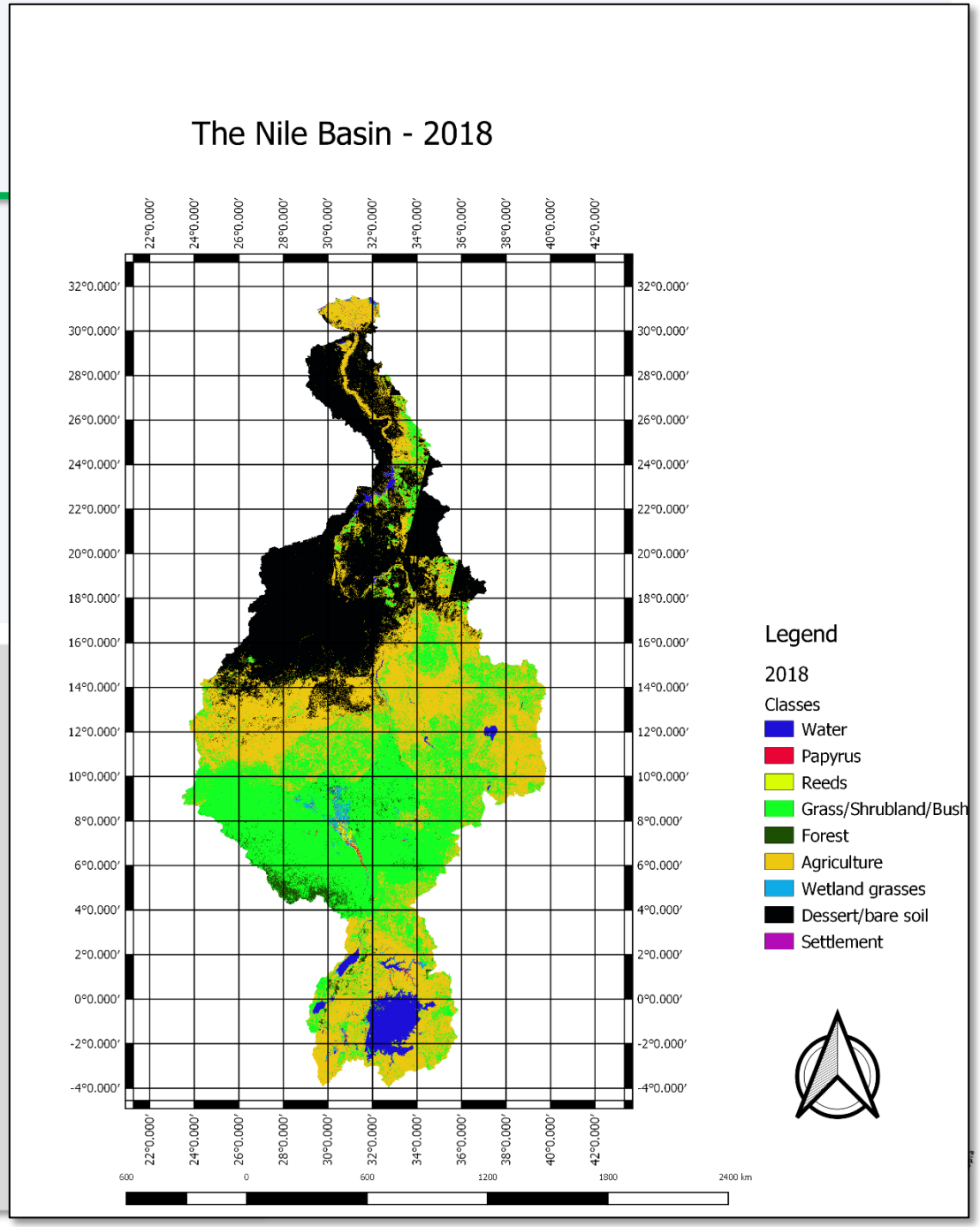
Wetland mapping results

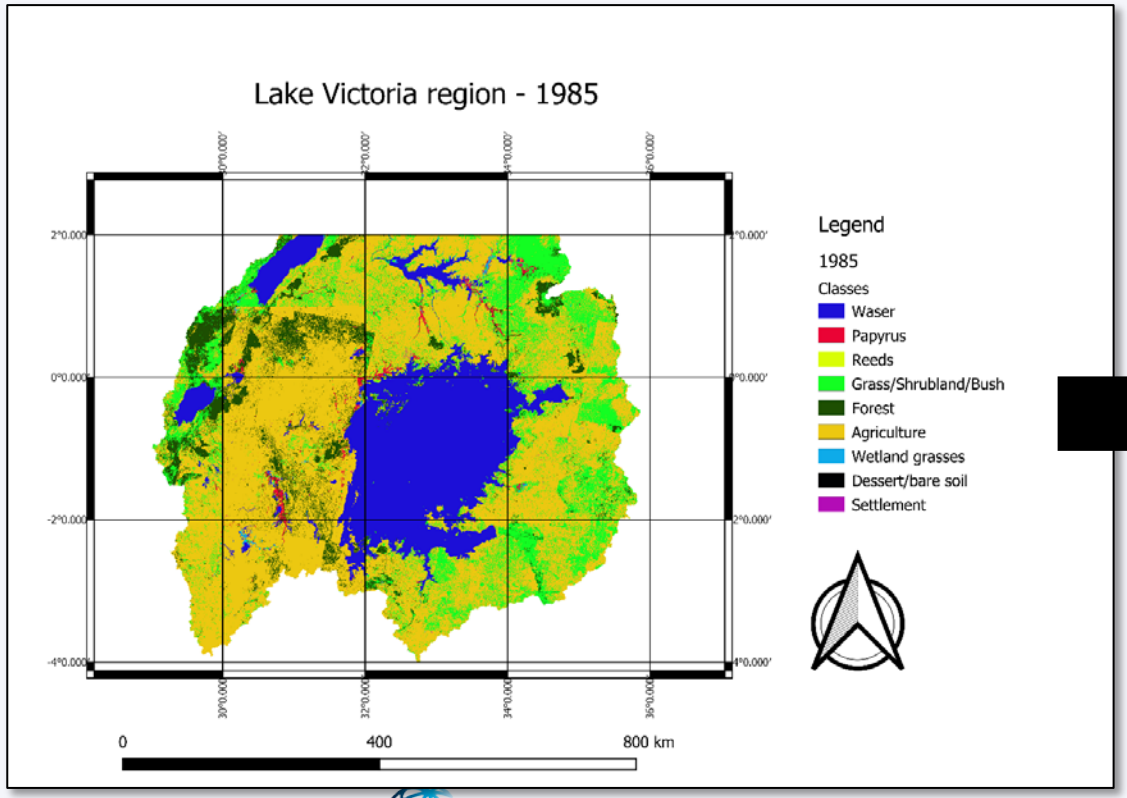
- Entire Nile basin mapped in 10m resolution
- Nine different landcover classes mapped
- Accuracy depending on class

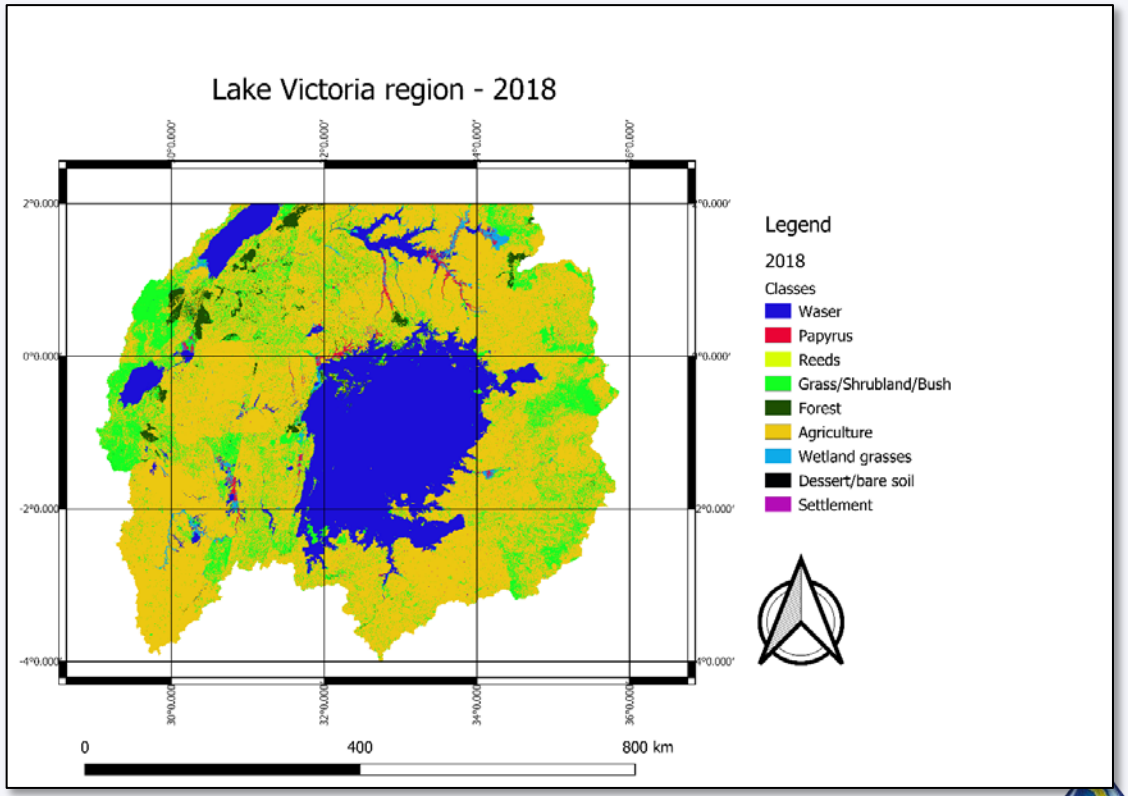
	REFERENCES (n = 3,603)						
	Papyrus	Reeds	Wetland grasses	Grass/Shrub	Forest	Agriculture	Water
Papyrus	396	43	3	5	1	13	6
Reeds	132	208	7	15	2	14	8
Wetland grasses	56	18	326	3	2	38	2
Grass/Shrub	6	4	5	345	17	26	0
Forest	7	1	4	3	275	40	2
Agriculture	0	0	18	3	7	1030	1
Water	31	11	1	0	0	1	467
PA(%)	63,1	73,0	89,6	92,2	90,5	88,6	96,1



Wetland mapping change analysis

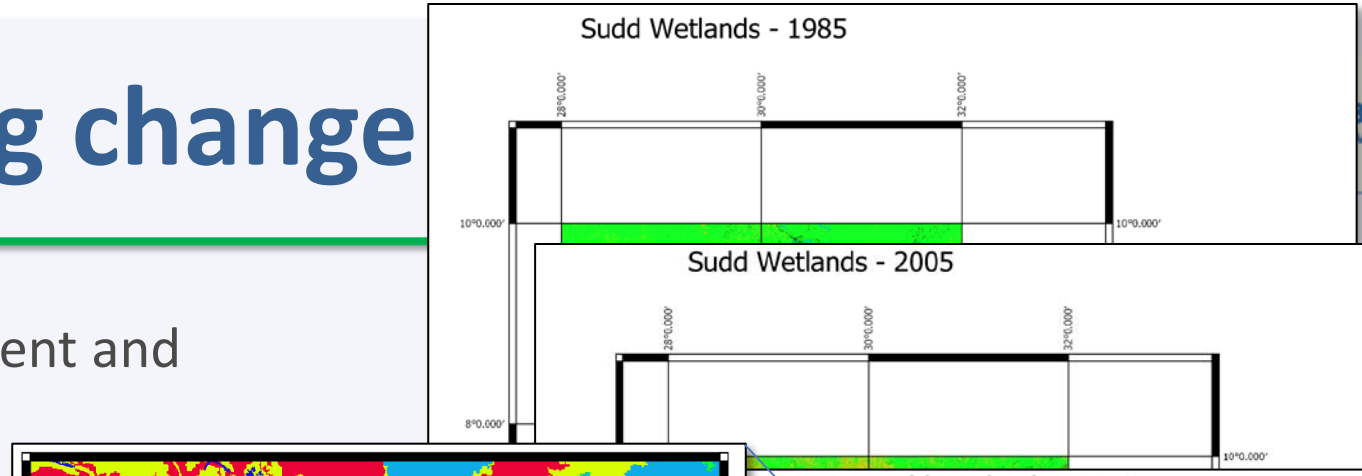
- Example for Lake Victoria, 1985 -> 2015

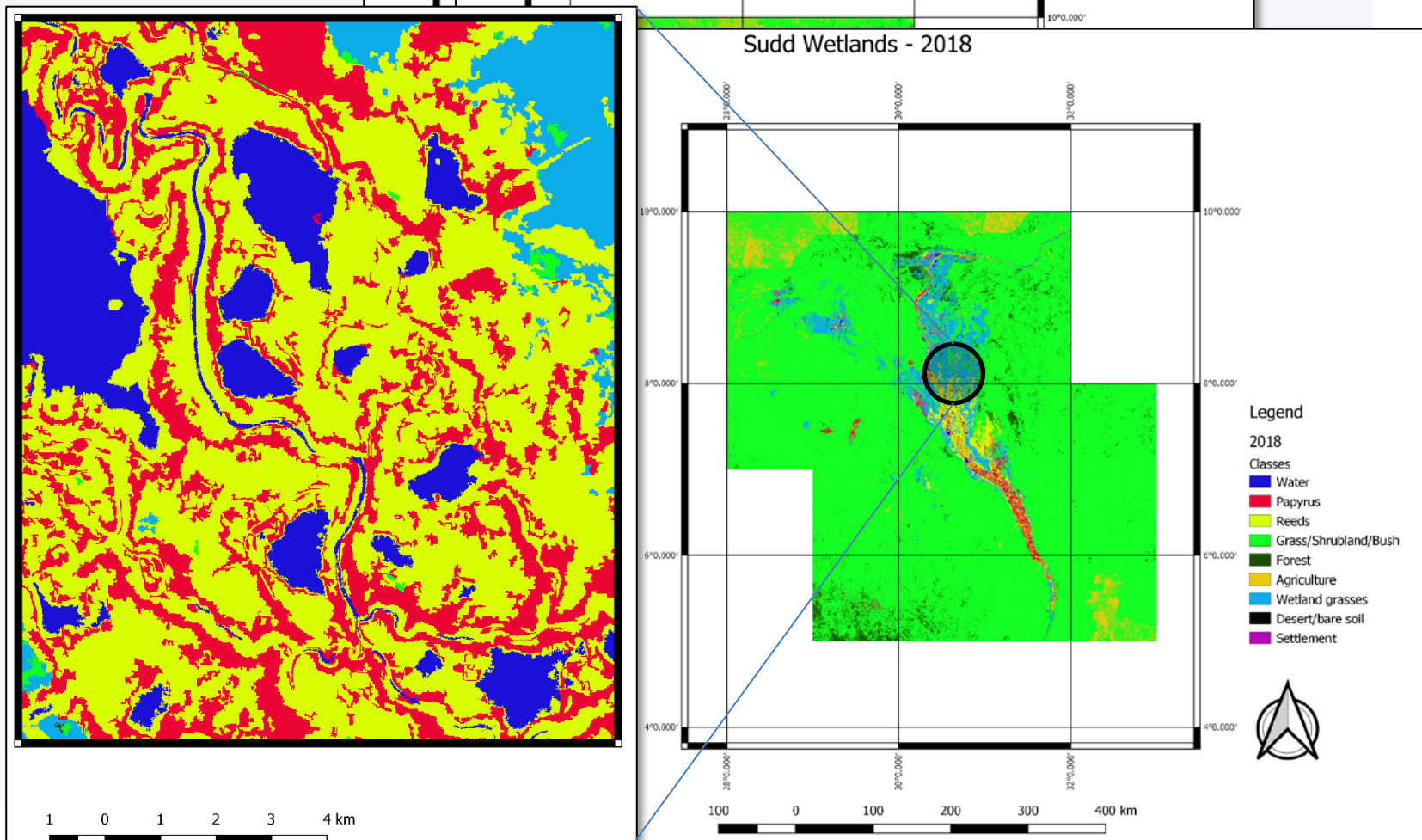




Wetland mapping change

- E.g. change analysis wetland extent and change in plant composition
- E.g. morphological studies (channel dynamics)





Wetland inventory objectives

- To provide a knowledge base for an ecosystem approach to sustainable management of wetlands of transboundary relevance in the Nile Basin.

  -> Base for educated decisionmaking

Wetland inventory methods

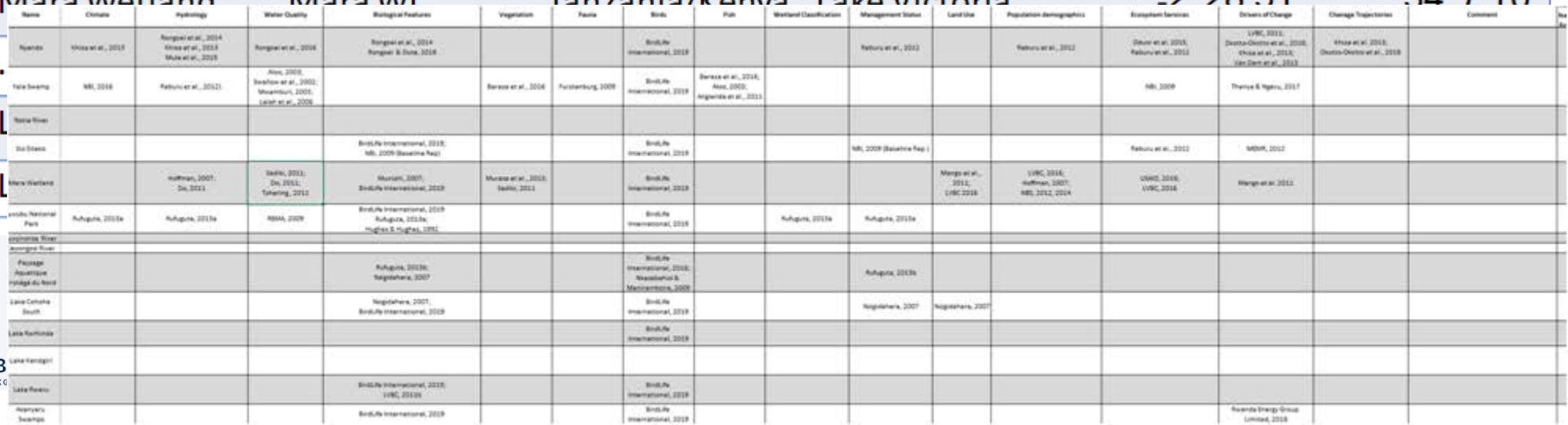
- Based on RAMSAR approach

Ramsar core wetland inventory fields	NB inventory fields
Site name: **Official name of site and catchment/other identifier(s)**	Sub-basin name Wetland group Wetland (site) name Overview (narrative)
Area, boundary and dimensions: **Site shape (cross-section and plan view), boundaries, area, area of water/wet area (seasonal max/min where relevant), length, width, depth (seasonal max/min where relevant)**	Country or countries Coordinates Area Nearest Town(s)
Location: **Projection system, map coordinates, map centroid, elevation**	Maps Altitude
Geomorphic setting: **Setting in the landscape/catchment/river basin - including altitude, upper/lower zone of catchment, distance to coast where relevant, etc.**	Physical features Wetland Classification
Biogeographical region:	Physical features Wetland Classification
Climate: **Overview of prevailing climate type, zone and precipitation, temperature, wind**	Physical features
Water regime: **Water source (surface and groundwater), inflow/outflow, evaporation, flooding frequency, seasonality and duration; magnitude of flow and/or tidal regime, links with groundwater**	Physical features

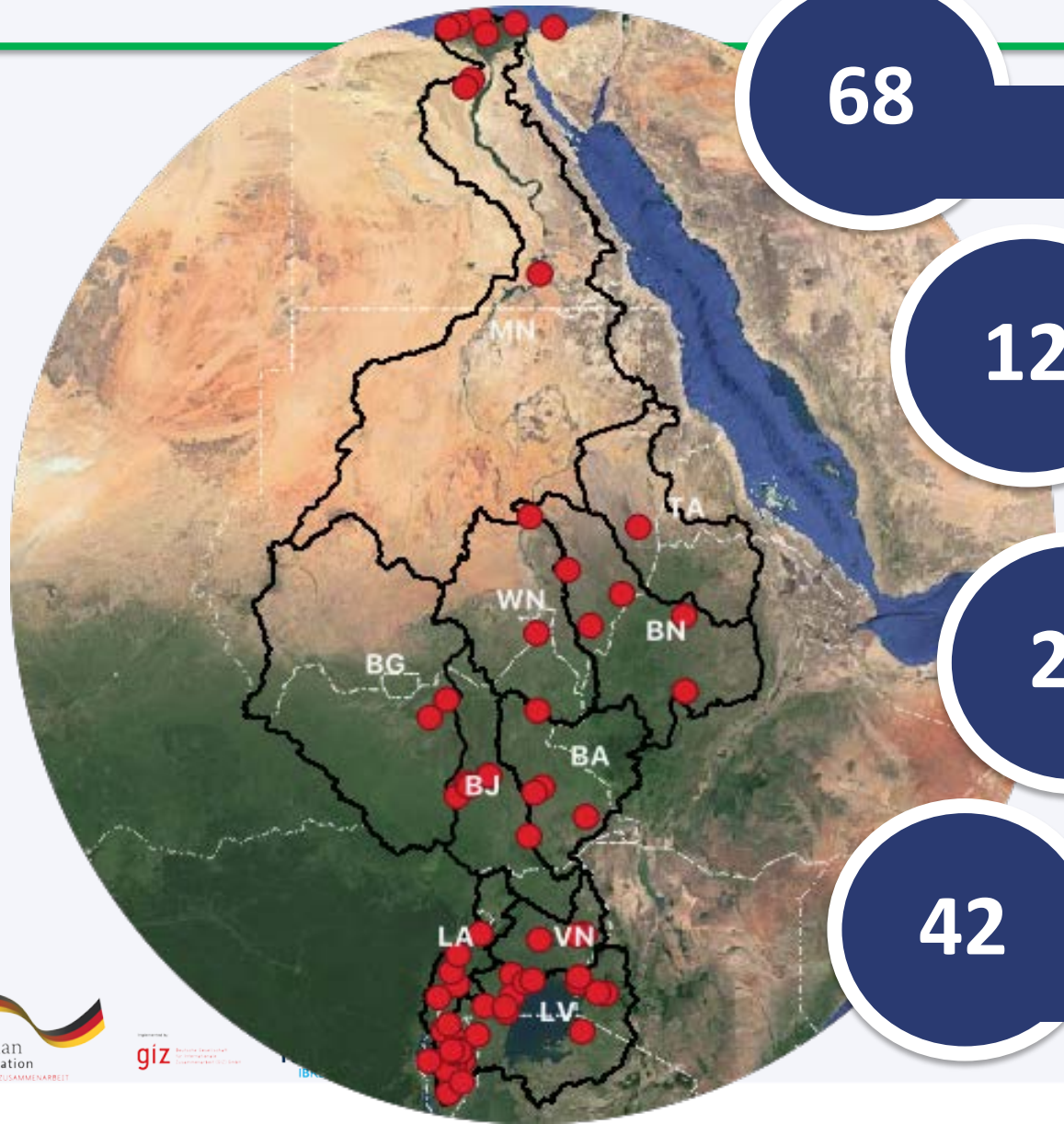
Wetland inventory results

- Database structure

Nr	Subbasin	Name	WL Group	Country	River/Lake	Lat	Long
1	LV	Nyando	SNYN WL 1	Kenya	Nyando River	-1°42'44"	34°51'57"
2	LV	Yala Swamp	SNYN WL 2	Kenya	Yala River	0°2'42"	34°2'26"
3	LV	Nzoia River	SNYN WL 3	Kenya	Nzoia River	0°4'29"	33°58'48"
4	LV	Sio Siteko	SNYN WL 4	Kenya	Sio/ Siteko River	0°14'48"	34°0'55"
5	LV	Mara Wetland	Mara WL	Tanzania/Kenya	Lake Victoria	-2°28'51"	34°7'10"
...	...	...					
67	MN	L					
68	MN	L					



Wetland inventory coverage



68 Wetlands

12 Trans-boundary Wetlands

20 Ramsar Sites

42 Important Bird Areas

Wetland inventory database

Nr	PhysFeat
Sub basin	GeomorphSoil
Wetland	Climate
WLGroup	Hydrology
Country	Water Quality
River/Lake	Biodiversity
Lat	Vegetation
Long	Fauna
Altitude	Birds
Area	Fish
Nearest Town	Class
Transboundary	PolicyFram
Ramsar	LandUse
IBA	Demography
	Ecosystem Services
	Drivers
	Changes

Wetland inventory database

- Literature database

Full Reference	Author	Year	Type of Document	Sbasin	WLGroup
Wilusz, D. C., Zaitchik, B. F., Anderson, M. C., Hain, C. R., Yilmaz, M. T., & Mladenova, I. E. (2017). Monthly flooded area classification using low resolution SAR imagery in the Sudd wetland from 2007 to 2011. Remote Sensing of Environment, 194, 205–218.	Wilusz et al.	2017	Scientific Publication	BJ	Sudd
Petersen, G., Bast, H., & Fohrer, N. (2008). Estimation of ungauged Bahr el Jebel flows based on upstream water levels and large scale spatial rainfall data. Advances in Geosciences, 18, 9–13.	Petersen et al.	2008	Scientific Publication	BJ	Sudd
Mohamed, Y., & Savenije, H. H. G. (2014). Impact of climate variability on the hydrology of the Sudd wetland: Signals derived from long term (1900-2000) water balance computations. Wetlands Ecology and Management, 22, 191–198.	Mohamed & Savenije	2014	Scientific Publication	BJ	Sudd
Mohamed, Y. A., Van Den Hurk, B. J. J. M., Savenije, H. H. G., & Bastiaanssen, W. G. M. (2005). Impact of the Sudd wetland on the Nile hydroclimatology. Water Resources Research, 41(8), 1–14.	Mohamed et al.	2005	Scientific Publication	BJ	Sudd
Petersen, G., Sutcliffe, J.V., & Fohrer, N. (2008). Morphological analysis of the Sudd region using land survey and remote sensing data. Earth Surface Processes and Landforms, 33, 1709-1720.	Petersen et al.	2008	Scientific Publication	BJ	Sudd

Wetland inventory database

- Individual wetland

41. The Sudd

Name: The Sudd
Country: South Sudan
Coordinates: 6°48'14''N / 31°11'51''E
Altitude: 448 – 394 m a.s.l.
Area: 23,633 km²
Nearest Towns: Juba, Mongalla, Malakal
International Importance: Ramsar Site, IBA

Each wetland Descriptions includes:

Physical features

Water regime

Classification

Management status

Land Use and Land Cover

Example: Physical features of the Sudd: Climate

- General description of the wetland area
- Chapter on hydrology of the Sudd
  - Wet season: May and October
  - Dry season: November and April
  - Average rainfall 700-1000 mm/year (NBI, 2016)
  - Significant year to year variation (Wilusz et al., 2017)
  - Evapotranspiration 1200 -1500 mm/year (NBI,2016)
  - Evapotranspiration deficit from August to April (Rebelo et al., 2012)

Example: Physical features of the Sudd: Hydrology

- Climate variations upstream of the Sudd and changing water levels of the Lakes Victoria, Kyoga, Edward and George are the main drivers of the wetland hydrology.
- Half of the Bahr al Jebel flow evaporates on its course through the Sudd (J. Sutcliffe & Brown, 2018)
  - Inflow: 49.2 km^3
  - Outflow: 20.8 km^3 (Data from 1961-83)

- 7% of the Bahr el Jebel flow moves though swamps and lagoons 93 % flows in a network of channels (Petersen et al., 2008)

Example: Classification of the Sudd

Inland Wetland

N Seasonal/intermittent/irregular rivers/streams/creeks

M Permanent rivers/streams/creeks

P Seasonal/intermittent freshwater lakes (over 8 ha); includes floodplain lakes

O Permanent freshwater lakes (over 8 ha)

Tp Permanent freshwater marshes/pools

Ts Seasonal/intermittent freshwater marshes/pools on inorganic soils

U Non-forested peatland

Example: Management Status of the Sudd

Management/ Protection Status of all wetlands was assessed, using the UNEP and IUCN World Database on Protected Areas

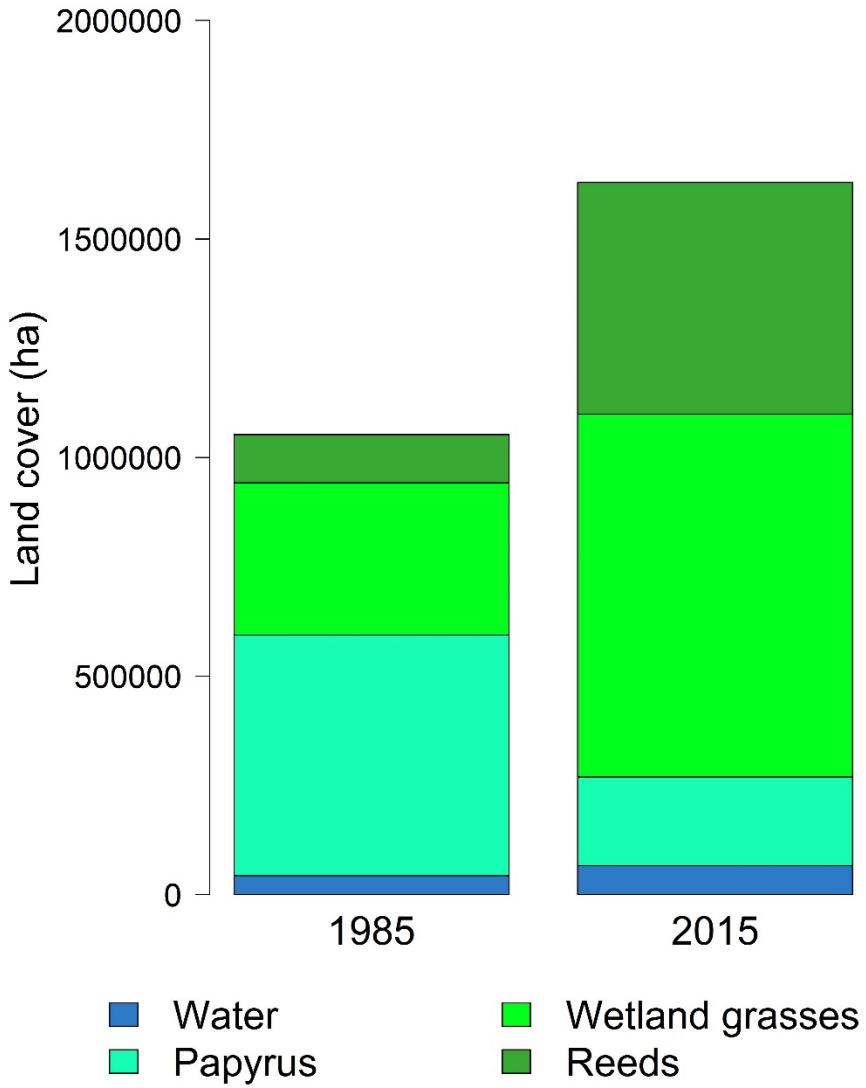
available at: https://www.protectedplanet.net/c/world-database-on-protected-areas

Table 1 Protected area fully or partly within the Sudd wetland boundaries

Name	Type*	Designation Year
Badingilo	National Park (II)	1986
Shambe	National Park (II)	1985
Ez Zeraf	Game Reserve (VI)	1939
Fanyikang	Game Reserve (VI)	1939

*Number in brackets refers to the IUCN management categories. *Strict Nature Reserve (Ib), Wilderness area (Ib), National Park (II), Natural monument or feature (III), Habitat/species management area (IV), Protected landscape (V), Protected area with sustainable use of natural resources (VI)*

Example: Land cover – The Sudd



Land Cover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	43,589	66,203	51.9
Papyrus	550,021	203,171	-63.1
Wetland grasses	348,482	829,792	138.1
Reeds	110,340	529,912	380.3
Total area	2,390,265	2,390,265	0.0

Wetlands inventory coverage

- Based on available data
- Structure allows periodic updating
- Data coverage heterogeneous, good coverage in areas of high economic interest
- Data gaps

- Future updates to be scheduled or structure to be implemented to allow for life updating including quality control

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THANK YOU!