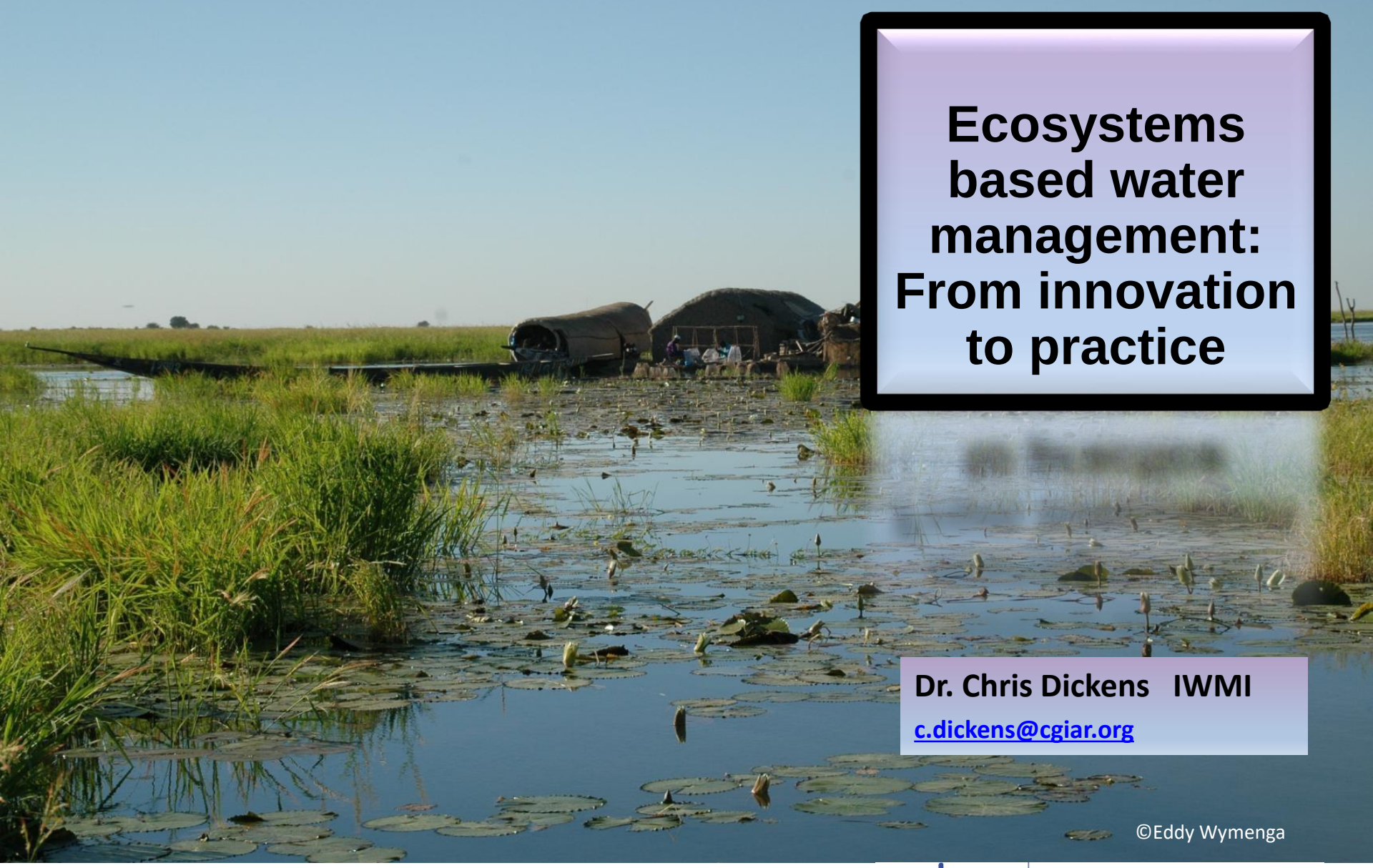

Ecosystems based water management: From innovation to practice

Dr. Chris Dickens IWMI

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IWMI International Water Management Institute

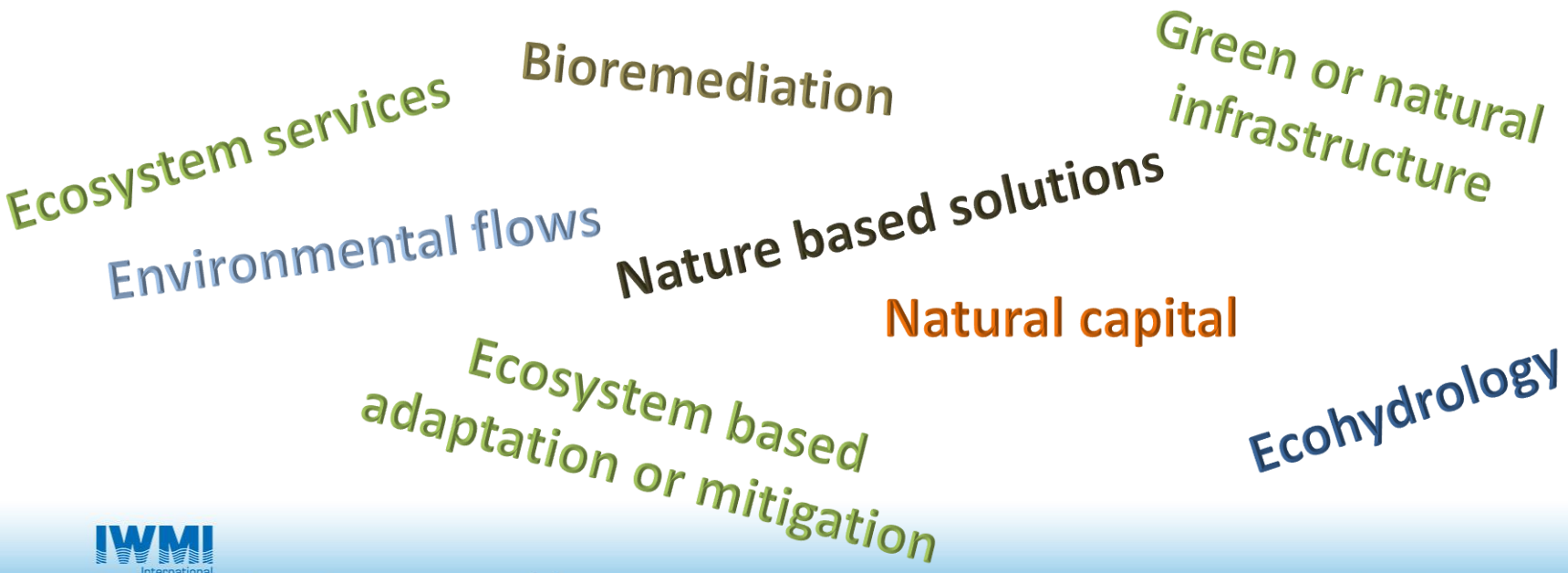
A water-secure world

CGIAR

RESEARCH PROGRAM ON Water, Land and Ecosystems

ECOSYSTEM BASED WATER MANAGEMENT

- **Definition: An approach to maintaining or restoring the composition, structure, function, and delivery of services of natural and modified ecosystems for the goal of achieving sustainability.**
  - **It is based on an adaptive, collaboratively developed vision of desired future conditions that integrates ecological, socioeconomic, and institutional perspectives, applied within a geographic framework, and defined primarily by natural ecological boundaries (MEA 2005)**



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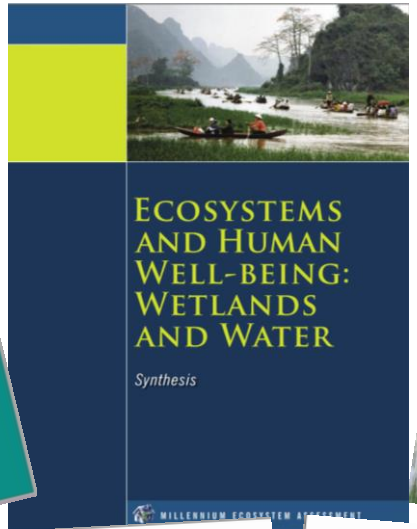

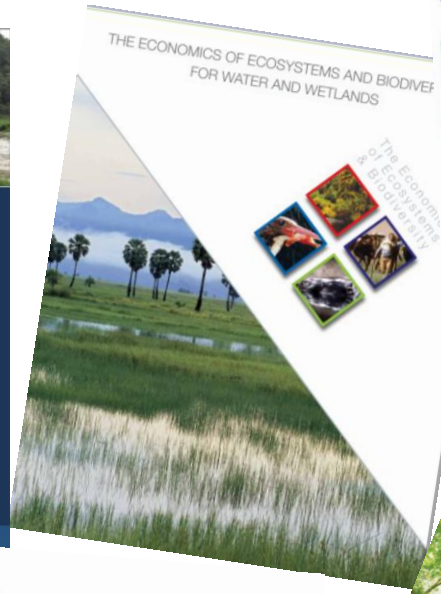

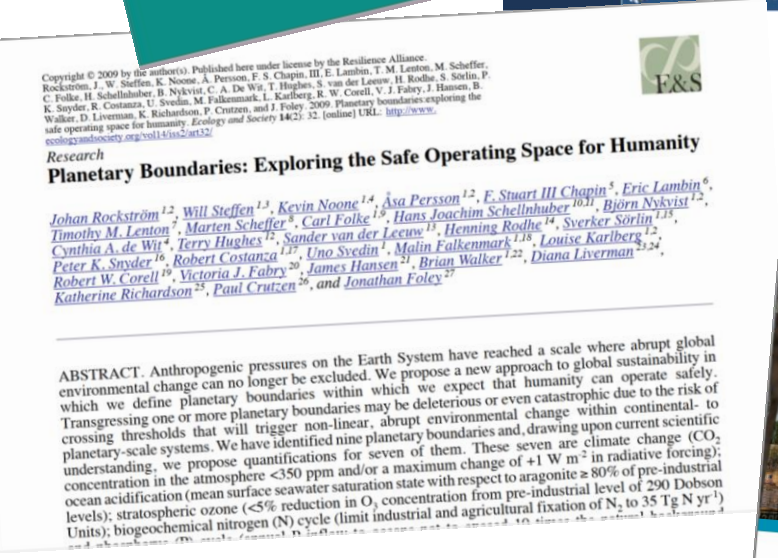
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Rockström, J. W. Steffen, K. Noone, Å. Persson, F. S. Chapin, III, E. Lambin, T. M. Lenton, M. Scheffer, C. Folke, H. Schellnhuber, B. Nykvist, C. A. De Wit, T. Hughes, S. van der Leeuw, H. Rodhe, S. Sörlin, P. K. Snyder, R. Costanza, U. Svedin, M. Falkenmark, L. Karlberg, R. W. Corell, V. J. Fabry, J. Hansen, B. Walker, D. Liverman, K. Richardson, P. Crutzen, and J. Foley. 2009. Planetary boundaries: exploring the safe operating space for humanity. *Ecology and Society* 14(2): 32. [online] URL: http://www.ecologyandsociety.org/vol14/iss2/art32/

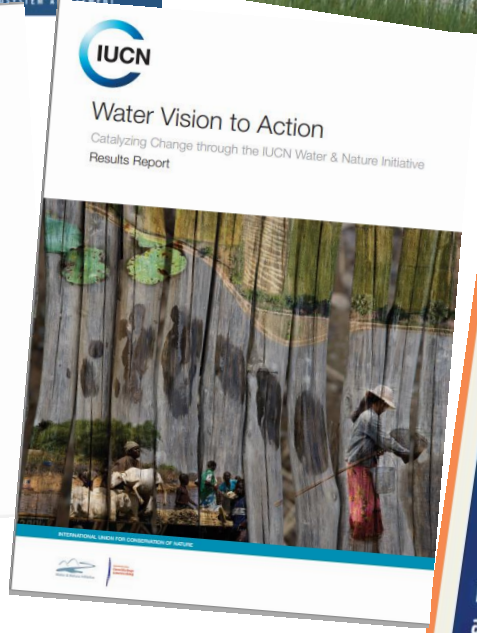
F&S

Research

Planetary Boundaries: Exploring the Safe Operating Space for Humanity

Johan Rockström[1,2], Will Steffen[1,3], Kevin Noone[1,4], Åsa Persson[1,2], F. Stuart III Chapin[5], Eric Lambin[6], Timothy M. Lenton[7], Marten Scheffer[8], Carl Folke[1,9], Hans Joachim Schellnhuber[10,11], Björn Nykvist[1,2], Cynthia A. de Wit[4], Terry Hughes[12], Sander van der Leeuw[13], Henning Rodhe[14], Sverker Sörlin[1,15], Peter K. Snyder[16], Robert Costanza[1,17], Uno Svedin[1], Malin Falkenmark[1,18], Louise Karlberg[1,2], Robert W. Corell[19], Victoria J. Fabry[20], James Hansen[21], Brian Walker[1,22], Diana Liverman[23,24], Katherine Richardson[25], Paul Crutzen[26], and Jonathan Foley[27]

ABSTRACT. Anthropogenic pressures on the Earth System have reached a scale where abrupt global environmental change can no longer be excluded. We propose a new approach to global sustainability in which we define planetary boundaries within which we expect that humanity can operate safely. Transgressing one or more planetary boundaries may be deleterious or even catastrophic due to the risk of crossing thresholds that will trigger non-linear, abrupt environmental change within continental- to planetary-scale systems. We have identified nine planetary boundaries and, drawing upon current scientific understanding, we propose quantifications for seven of them. These seven are climate change (CO_2 concentration in the atmosphere <350 ppm and/or a maximum change of +1 W m^{-2} in radiative forcing); ocean acidification (mean surface seawater saturation state with respect to aragonite ≥ 80% of pre-industrial levels); stratospheric ozone (<5% reduction in O_3 concentration from pre-industrial level of 290 Dobson Units); biogeochemical nitrogen (N) cycle (limit industrial and agricultural fixation of N_2 to 35 Tg N yr^{-1})



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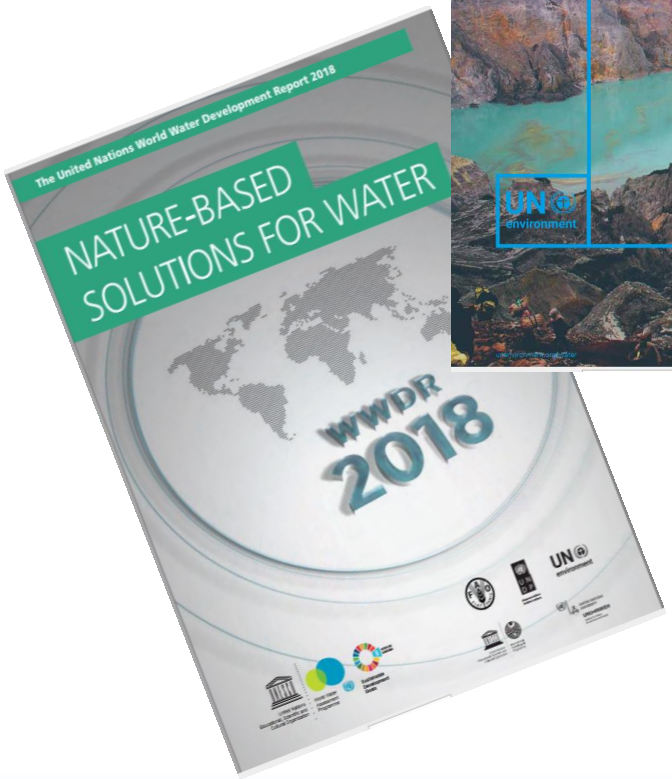
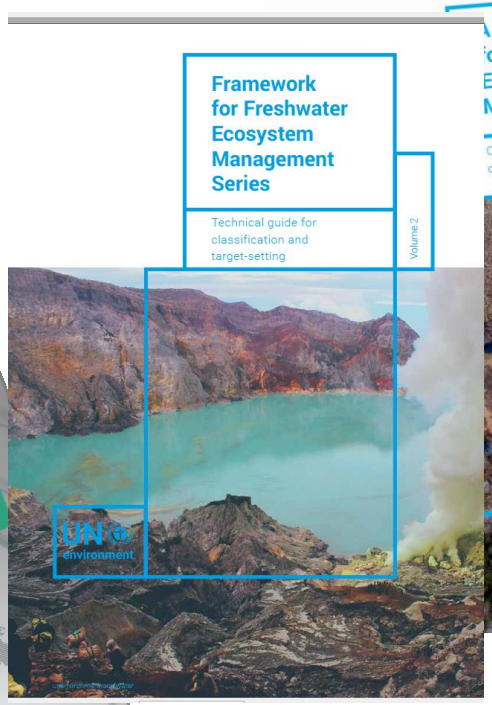
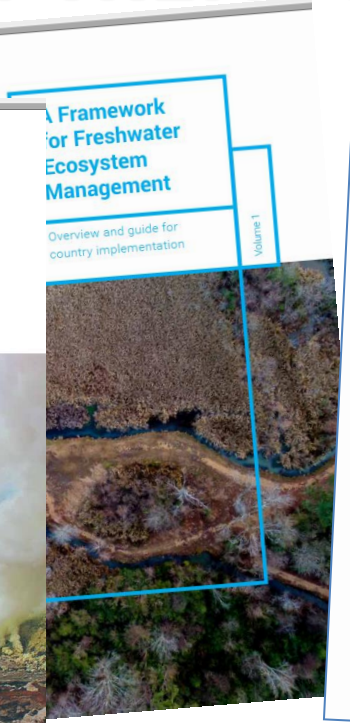
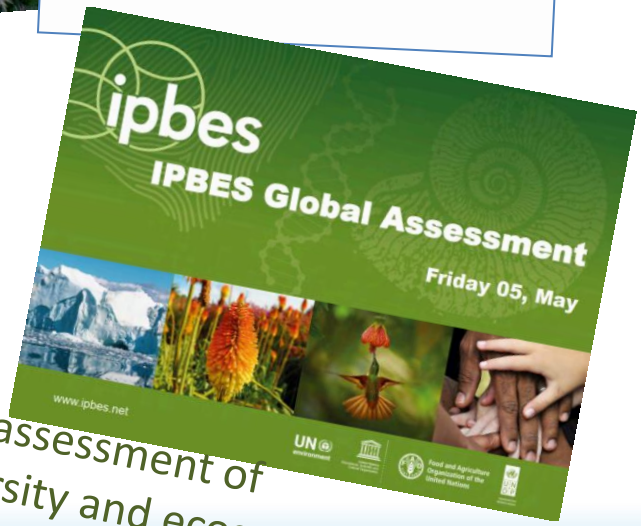




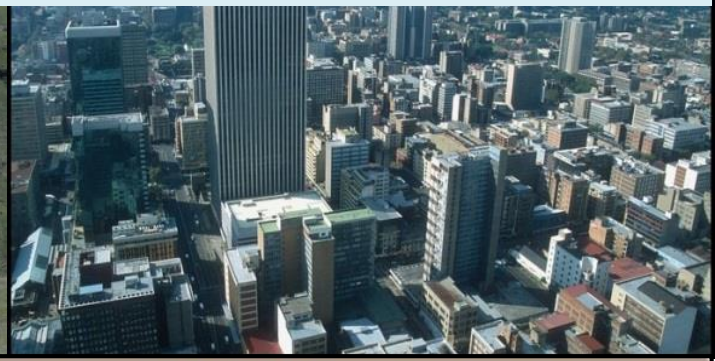




Global assessment of biodiversity and ecosystem services

Ecosystems at work – environmental flows



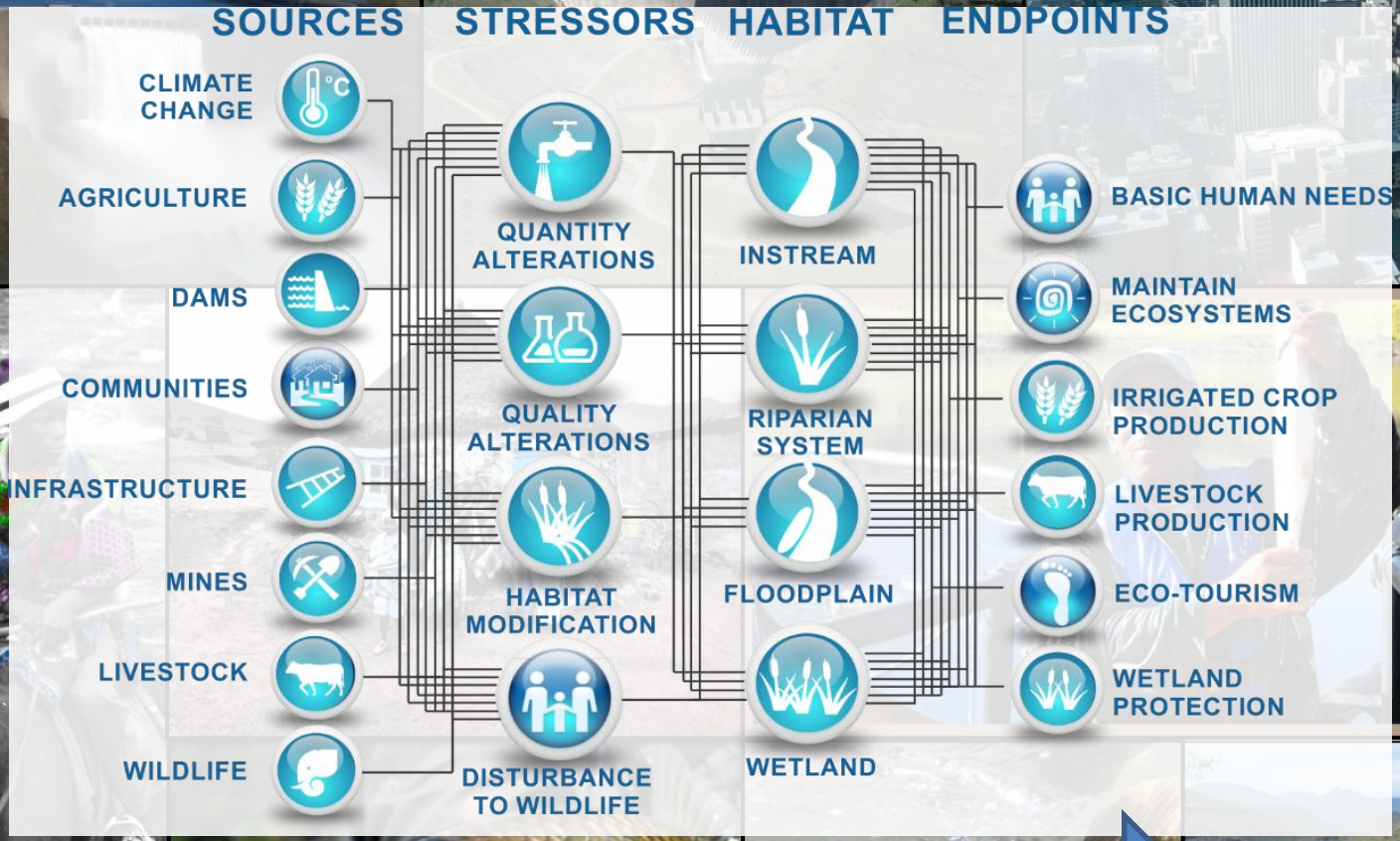




Environmental flows describe the quantity, timing, and quality of freshwater flows and levels necessary to sustain aquatic ecosystems which, in turn, support human cultures, economies, livelihoods, and well-being.

Brisbane declaration of environmental flows (2018)

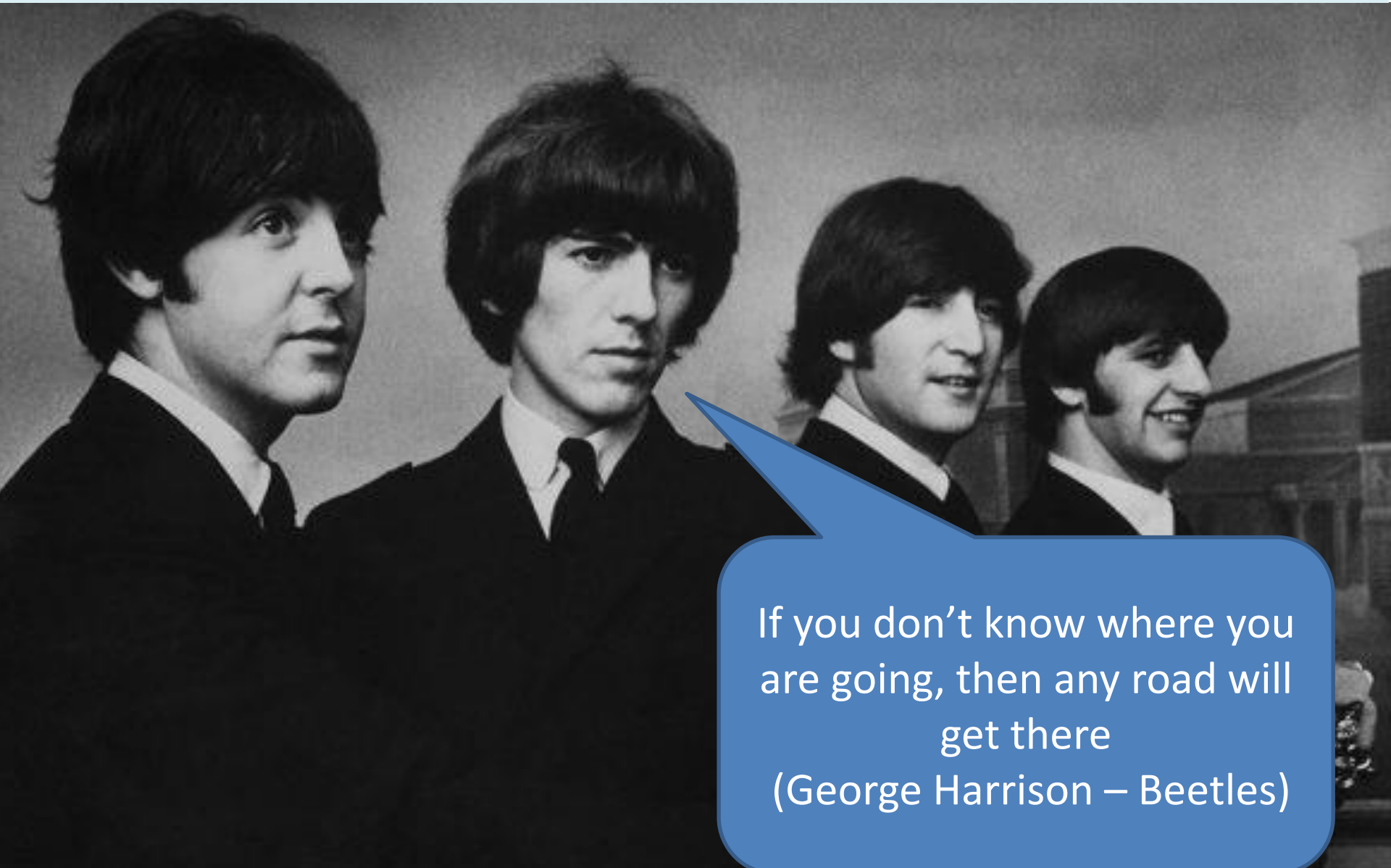
Ecosystems at work – environmental flows



River conditions required to maintain Social and Ecological Endpoints

PROBFLO
a new e-flows framework – O'Brien et al. 2018

Ecosystems at work – objectives based ecosystem management



Ecosystems at work – objectives based ecosystem management

SETTING TARGETS – ECOLOGICAL MANAGEMENT CLASSES

EMC	*Most likely ecological condition*
A (natural)	Natural rivers with minor modification of in-stream and riparian habitat
B (largely natural)	Slightly modified and/or ecologically important rivers with largely intact biodiversity and habitats
C (moderately modified or "fair" condition)	The habitats and dynamics of the biota have been disturbed, but basic ecosystem functions are still intact.
D (largely modified)	Large changes in natural habitat, biota and basic ecosystem functions have occurred.
E (seriously modified)	Modifications have reached a critical level and ecosystem has been completely modified with almost total loss of natural habitat and biota. In the worst case, the basic ecosystem functions have been destroyed .

Target values for biota, water quantity & quality

RESOURCE UNIT SCALE RIVER HABITAT AND BIOTA RESOURCE QUALITY OBJECTIVES										
IUA	Class	River	RU	Node	REC	Component	Sub Component	RQO	Indicator/ measure	Numerical Criteria
1	III	Olifants (releases from Witbank Dam) and Klipspruit (confluence with Olifants)	RU9 RU12	9 and 12	D	Habitat	In stream Habitat	The in-stream habitat should be maintained in a sustainable state to support the ecosystem.	State of in stream habitat according to Rapid Habitat Assessment Method (RHAM)	RHAM: Moderate change from reference.
12	II	Olifants (outlet of quaternary - outlet of IUA12)	RU116	116	C	Habitat	Riparian	The riparian vegetation must be improved to ensure that the biodiversity of KNP is retained and the Ecostatus category required by the WRCS is met.	State of in riparian habitat according to Vegetation Response Assessment Index (VEGRAI)	VEGRAI A/B category
8	II	Spekboom (outlet of quaternary - outlet of IUA8)	RU82	82	B	Biota	Fish	Fish communities should be improved to a good condition and should include viable populations of ecologically important species.	State of fish populations according to Fish Response Assessment Index (FRAI) Score.	FRAI Score B category
									Critical habitat of Southern dwarf minnow (*Opsaridium peringueyi*) must be maintained according to Rapid Habitat Assessment Method (RHAM).	Instream habitat requirements of species must be suitable for maintenance of local population.
2	II	Bronkhorstpruit (outlet from Nronkhorstspruit Dam) and Wilge (EWR site - EWR4, outlet of IUA2) (existing)	RU24 RU31	24 and 31	C	Biota	Aquatic invertebrates	Aquatic invertebrates must be improved to healthy levels.	State of aquatic invertebrates according to Macroinvertebrate Response Assessment Index (MIRAI) Score, using the SASS5 sampling method	MIRAI Score C category
7	III	Olifants (releases from Flag Boshielo Dam)	RU52	52	D	Biota	Birds	Riparian habitat must be mainatined to protect the local riparian and aquatic bird populations.	State of the riparian zone using VEGRAI and bird community structure based on diversity and abundance**	VEGRAI C category
										Bird community structure must not differ significantly from reference state.
10	II	Olifants (EWR11, confluence with Blyde) (existing)	RU96	96	D	Biota	Mammals	The local Hippopotamus population must remain in a viable state, as this species contributes to local ecosystem processes	Hippopotamus and other riparian mammals population structure using approved methodologies. Hippo census with a helicopter.	Hippos in this reach should not become less than 6 individuals of at least 5 cows and one bull.

*** Data obtained from bird clubs and conservation authorities and measured as per methods prescribed by Avian Demography Unit, Department of Statistical Sciences University of Cape Town or*

Target values for water quantity and quality

RESOURCE UNIT SCALE RIVER WATER QUANTITY & QUALITY RESOURCE QUALITY OBJECTIVES

IUA	Class	River	RU	Node	REC	Component	Sub Component	RQO	Indicator/ measure	Numerical Criteria
4	III	Elands (outlet of quaternary - outlet of IUA4)	RU46	46	D	Quantity	Low and High Flows	Low flows need to be improved in order to provide for the ecosystem and basic human needs.	1. EWR maintenance low and high flows and drought flows: Elands EWR6 in B31G VMAR = 60.32X10^{6}m^3 PES=D category	Maintenance low flows: Oct 1.110; Nov 1.682; Dec 2.040; Jan 2.471; Feb 3.042; Mar 2.667; Apr 2.323; May 1.842; Jun 1.473; Jul 1.233; Aug 1.009; Sep 0.876 Drought flows (m^3/s): 0.636; 0.941; 1.129; 1.357; 1.664; 1.460; 1.161; 1.023; 0.830; 0.701; 0.582; 0.514 Freshets (m^3/s): 0.063; 0.392; 0.492; 0.955; 0.197; 0.360; 0.160
								High flows (freshets) must be provided to maintain the ecosystem and replenish natural storage.		
1	III	Olifants (releases from Witbank Dam)	RU9	9	D	Quality	Nutrients	Nutrient concentrations must be maintained in the river at mesotrophic or better levels	Phosphate(PO_4)*	≤ 0.125 mg/L P
									Nitrate (NO_3) & Nitrite (NO_2)*	≤ 4.00 mg/L N
									Total Ammonia*	≤ 100 µg/L N
		Olifants (EWR site 1 - EWR1) (existing)	RU11	11	D			Nutrient concentrations should be improved to prevent nuisance conditions for	Phosphate(PO_4)*	≤ 0.125 mg/L P
									Nitrate (NO_3) & Nitrite (NO_2)*	≤ 4.00 mg/L N
									Total Ammonia*	≤ 100 µg/L N
		Klipspruit (confluence with Olifants)	RU12	12	D			The nutrient concentrations need to be improved for the ecosystem and users.	Phosphate (PO_4)*	≤ 0.125 mg/L P
		Olifants	RU13	13	B			Nutrient concentrations should be improved to maintain the	Nitrates (NO_3)*	≤ 0.70 mg/L N
									Phosphate (PO_4)*	≤ 0.015 mg/L P

Target values for water quantity and quality

RESOURCE UNIT SCALE RIVER WATER QUANTITY & QUALITY RESOURCE QUALITY OBJECTIVES

IUA	Class	River	RU	Node	REC	Component	Sub Component	RQO	Indicator/ measure	Numerical Criteria			
										Maintenance low flows		Drought flows (m^3/s)	Freshets (m^3/s)
4	III	Elands (outlet of quaternary - outlet of IUA4)	RU46	46	D	Quantity	Low and High Flows	Low flows need to be improved in order to provide for the ecosystem and basic human needs.	1. EWR maintenance low and high flows and drought flows: Elands EWR6 in B31G VMAR = 60.32X10^{6}m^3 PES=D category	Oct	1.110	0.636	0.063
										Nov	1.682	0.941	0.392
										Dec	2.040	1.129	0.492
										Jan	2.471	1.357	0.955
										Feb	3.042	1.664	0.197
										Mar	2.667	1.460	0.360
								High flows (freshets) must be provided to maintain the ecosystem and replenish natural storage.		Apr	2.123	1.161	0.160
										May	1.842	1.023	
										Jun	1.473	0.830	
										Jul	1.233	0.701	
										Aug	1.009	0.582	
										Sep	0.876	0.514	
1	III	Olifants (releases from Witbank Dam)	RU9	9	D	Quality	Nutrients	Nutrient concentrations must be maintained in the river at mesotrophic or better levels	Phosphate(PO_4)*	≤ 0.125 mg/L P			
									Nitrate (NO_3) & Nitrite (NO_2)*	≤ 4.00 mg/L N			
									Total Ammonia*	≤ 100 µg/L N			
		Olifants (EWR site 1 - EWR1) (existing)	RU11	11	D			Nutrient concentrations should be improved to prevent nuisance conditions for	Phosphate(PO_4)*	≤ 0.125 mg/L P			
									Nitrate (NO_3) & Nitrite (NO_2)*	≤ 4.00 mg/L N			
									Total Ammonia*	≤ 100 µg/L N			
		Klipspruit (confluence with Olifants)	RU12	12	D			The nutrient concentrations need to be improved for the ecosystem and users.	Phosphate (PO_4)*	≤ 0.125 mg/L P			
		Olifants	RU13	13	B			Nutrient concentrations should be improved to maintain the	Nitrates (NO_3)*	≤ 0.70 mg/L N			
									Phosphate (PO_4)*	≤ 0.015 mg/L P			

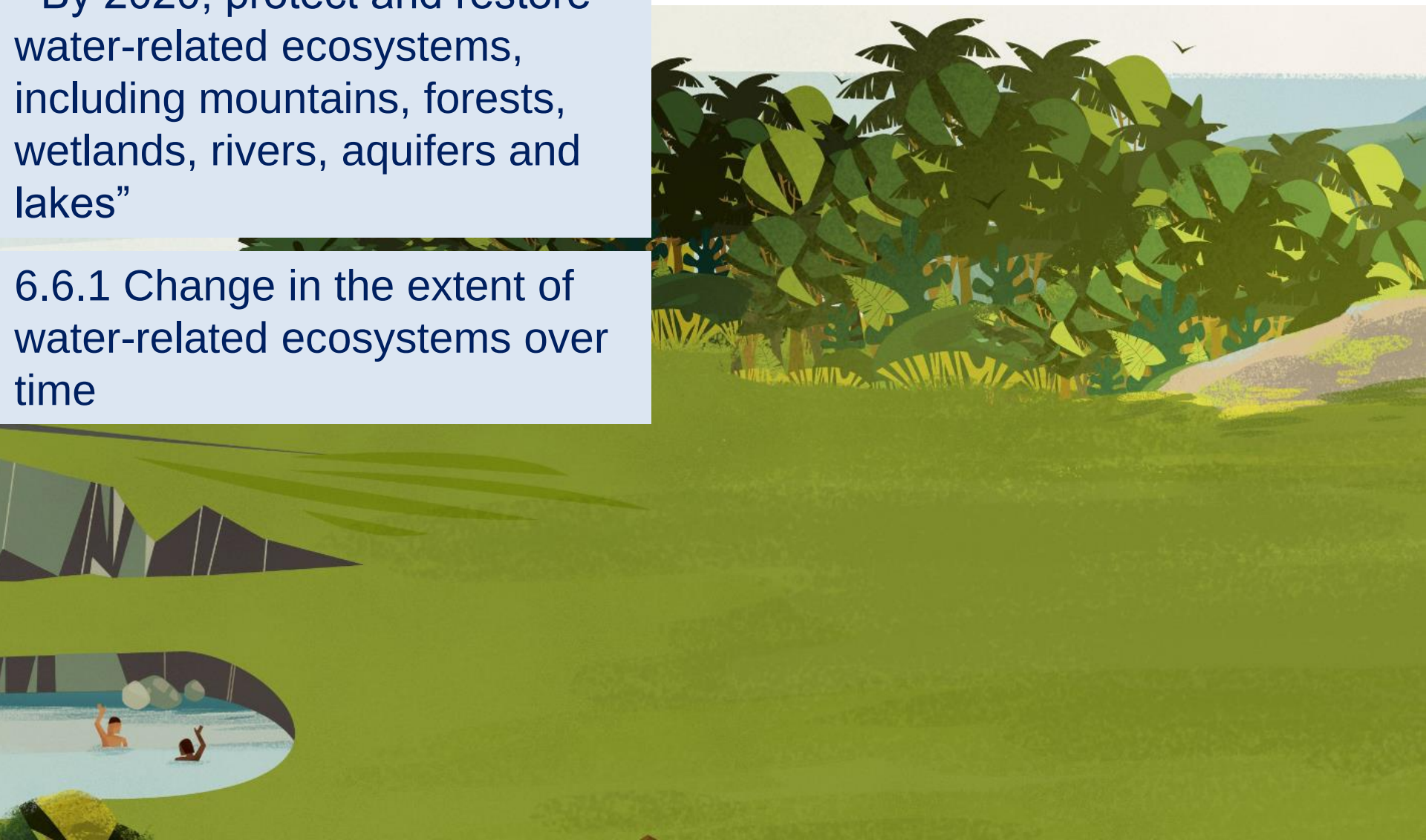
2030 Agenda for Sustainable Development

17 SDGs for people-planet-prosperity-peace-partnership

TARGET 6.6 WATER-RELATED ECOSYSTEMS

"By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes"

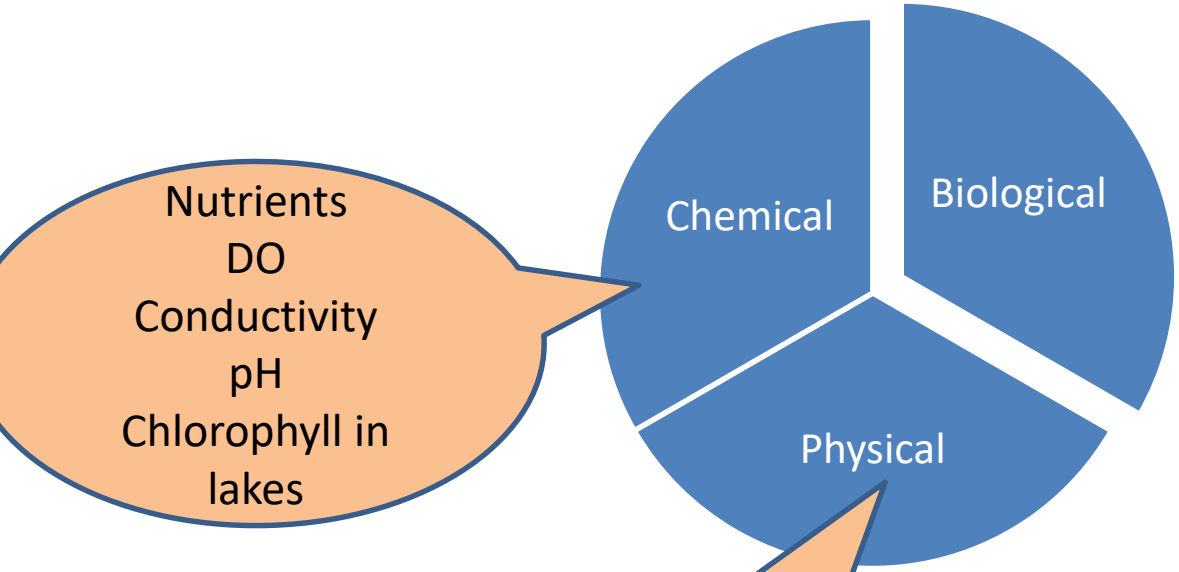
6.6.1 Change in the extent of water-related ecosystems over time



SDG 6.6.1 PROGRESSIVE MONITORING

Level 1	1. spatial extent of water-related ecosystems 2. water quality of lakes and artificial water bodies
Level 2	3. quantity of water (discharge) in rivers and estuaries 4. water quality of rivers and lakes imported from SDG Indicator 6.3.2 5. quantity of groundwater within aquifers *6. Ecosystem health recommended but not required*
Indicator methods are available at www.sdg6monitoring.org	

WATER-RELATED ECOSYSTEM COMPONENTS MONITORED BY THE SDGS



WATER-RELATED ECOSYSTEM COMPONENTS MONITORED BY THE SDGS

Optional - Important local variables

Nutrients
DO
Conductivity
pH
Chlorophyll in lakes

Chemical

Biological

Physical

Missing – Ecosystem health & biodiversity (planned but not yet implemented)

Spatial extent
Water quantity

Missing – Habitat structure
Sediments

GAPS & CHALLENGES

- Ecosystems in the SDGs – protection of resources
  - Only 13% of the SDG Targets about resource security (Wackernagel et al 2017)
- Setting targets – global and country
  - Reference conditions and % change over time
- Methods for monitoring ecosystems health for the SDGs


THANK YOU!