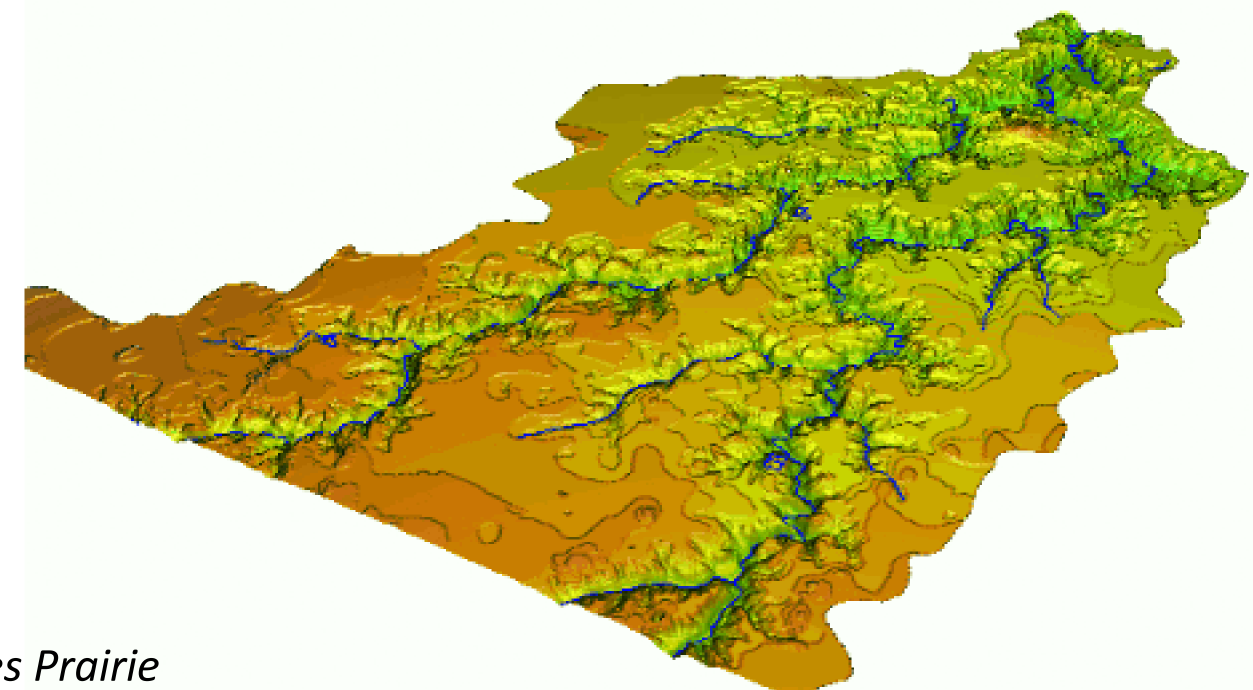
Målinger, analyser, verktøy og forskning
Klimagassutslippp fra magasin

2012-06-25

Hvor står vi og hvor går vi?

Reservoirs as landscape transformation

Ecological footprint of freshwater reservoirs, in particular in term of their greenhouse gas (GHG) status



from Yves Prairie

How the Project was created

- 2006 – First International Workshop (Paris, December 2006)
- 2007 – Second International Workshop (Iguassu, November 2007)
- 2008 – Scoping Paper completed by UNESCO Working Group (April 2008)
- 2008 – UNESCO/IHA Project for an initial two-year programme (April 2008)

UNESCO Workshop on Greenhouse-Gas Emissions from Freshwater Reservoirs

United Nations Educational, Scientific and Cultural Organization, Paris, France
6-8 December 2006

Statement by Workshop Participants

Rationale

The proposed methodology from the Intergovernmental Panel on Climate Change (IPCC) for estimating a national inventory of anthropogenic greenhouse-gas (GHG) emissions from freshwater reservoirs has met with differing views. The debate associated with GHG emissions from freshwater reservoirs is not focussed on the fact that emissions occur; the debate is on the incremental proportion, if any, that is related to human activity (both as a result of the impoundment, and as a result of human activities in the upstream watershed).

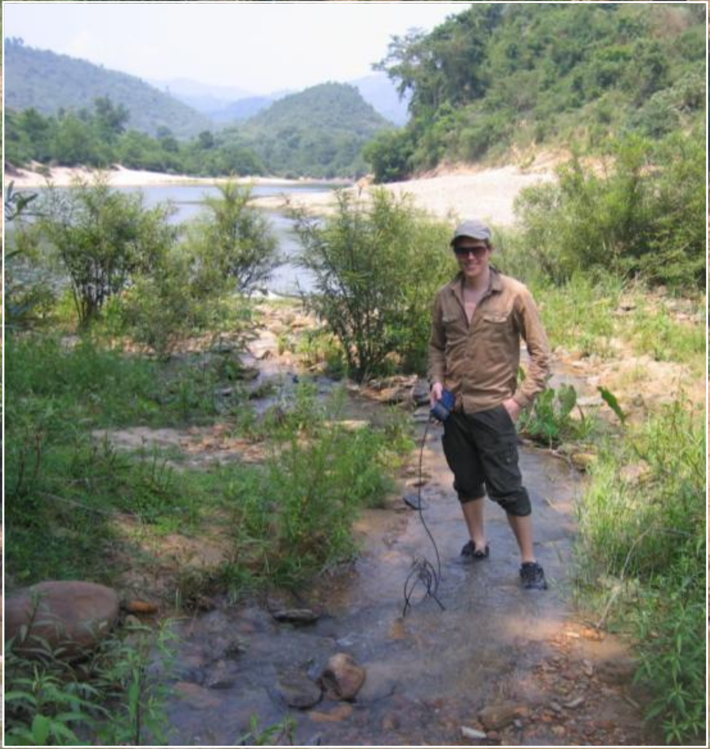
In January 2006, the Executive Board of the UN Framework on the Convention on Climate Change (UNFCCC) Clean Development Mechanism introduced criteria that exclude hydropower schemes with significant water storage from this mechanism. The decision was taken as a precautionary measure, pending further clarification of reports in the scientific literature on GHG emissions associated with freshwater reservoirs.

Note: The UNESCO Workshop on GHG Emissions from Freshwater Reservoirs was organized as part of UNESCO IHP-VI (2002-2007), which includes a theme dealing with Global Changes and Water Resources. In this context, UNESCO provided a forum for the debate of the scientific aspects of GHG emissions from freshwater reservoirs. Please note that presentations and statements by participants are the responsibility of participants and UNESCO does not necessarily endorse the views of any individual participant, nor the collective conclusions of the workshop.

from Joel Goldenfum

Field campaigns were performed in wet and dry seasons and during day and night time

Water sampling

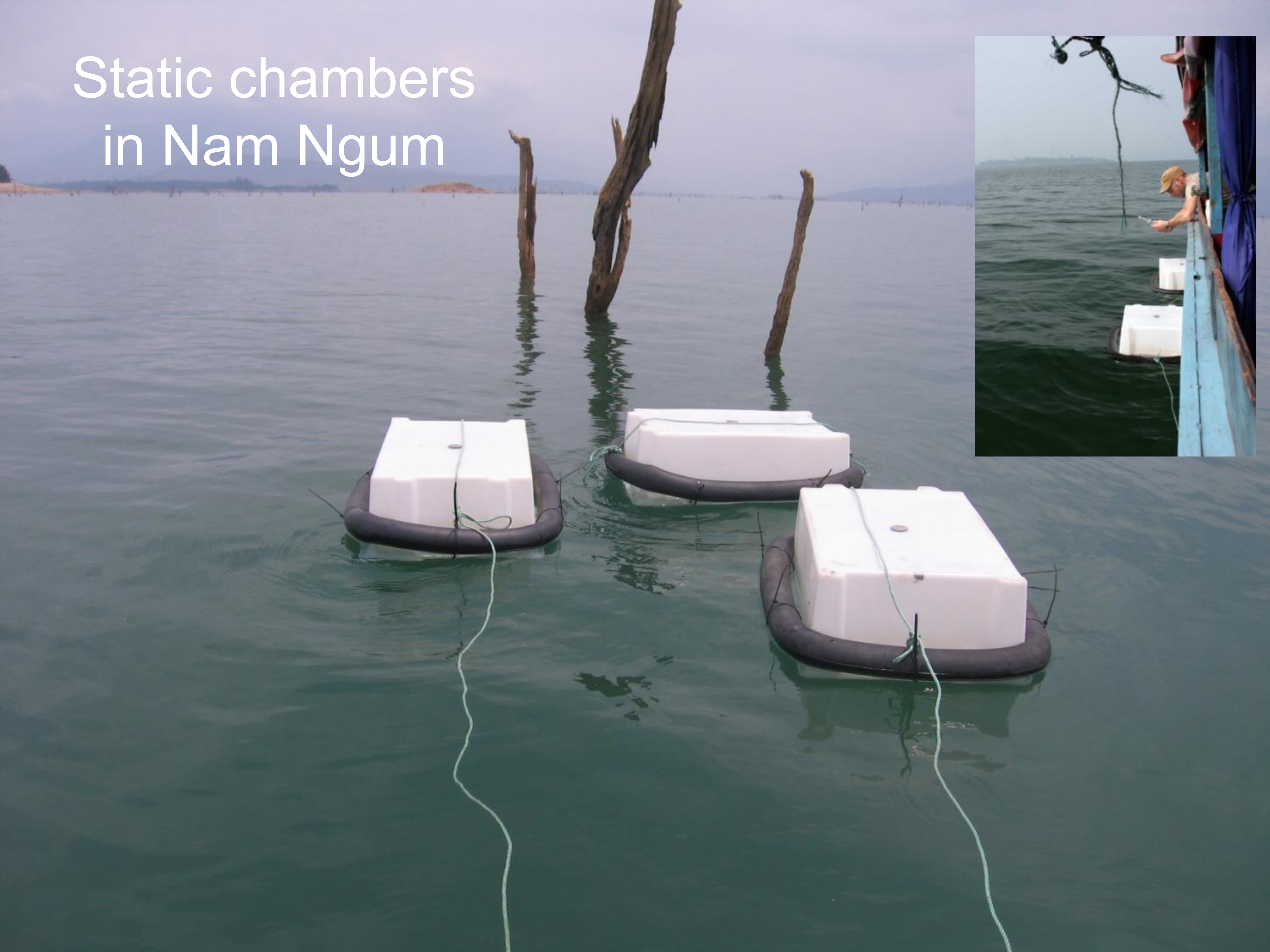


Measurements of physical and chemical parameters


Flow measurements

Static chambers

Static chambers in Nam Ngum



Samples of water and gas

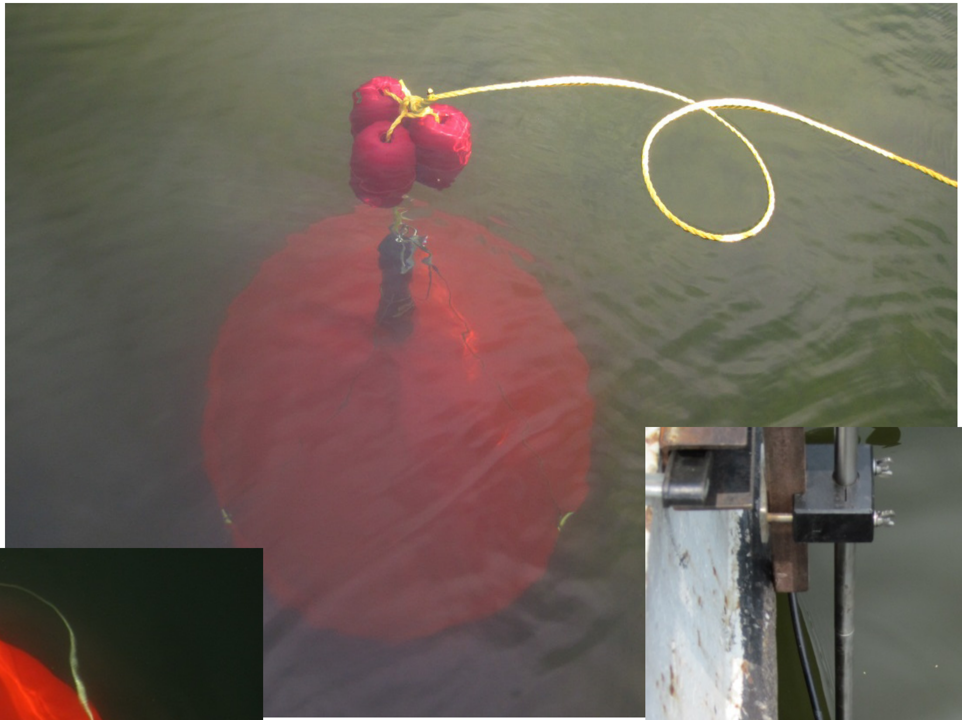
Gas chromatography for analysing CO_2 and CH_4

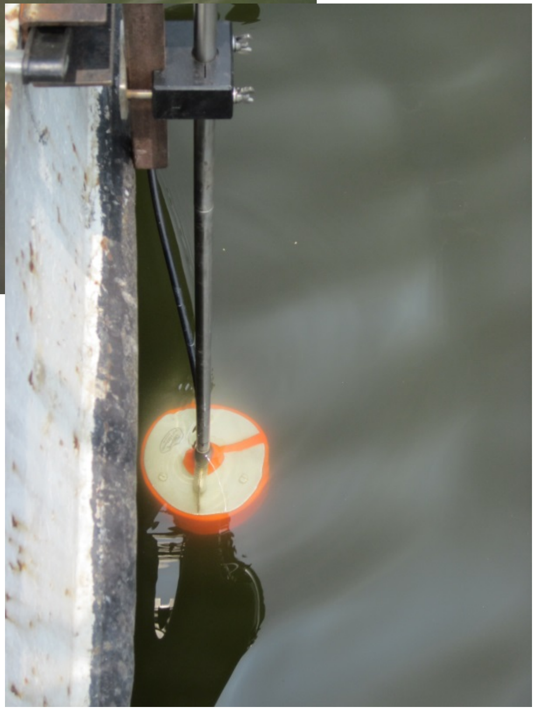
Kontinuerlige målinger

Karbontilførsel

from Brad Sherman

Trakter for å fange bobling

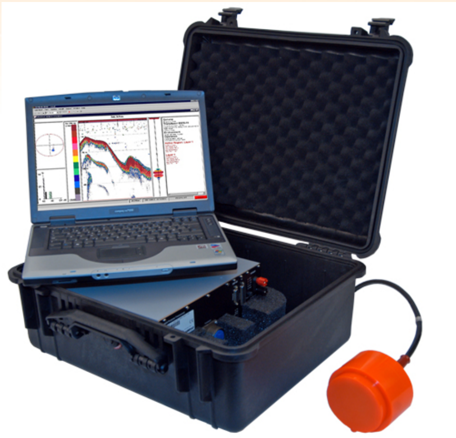


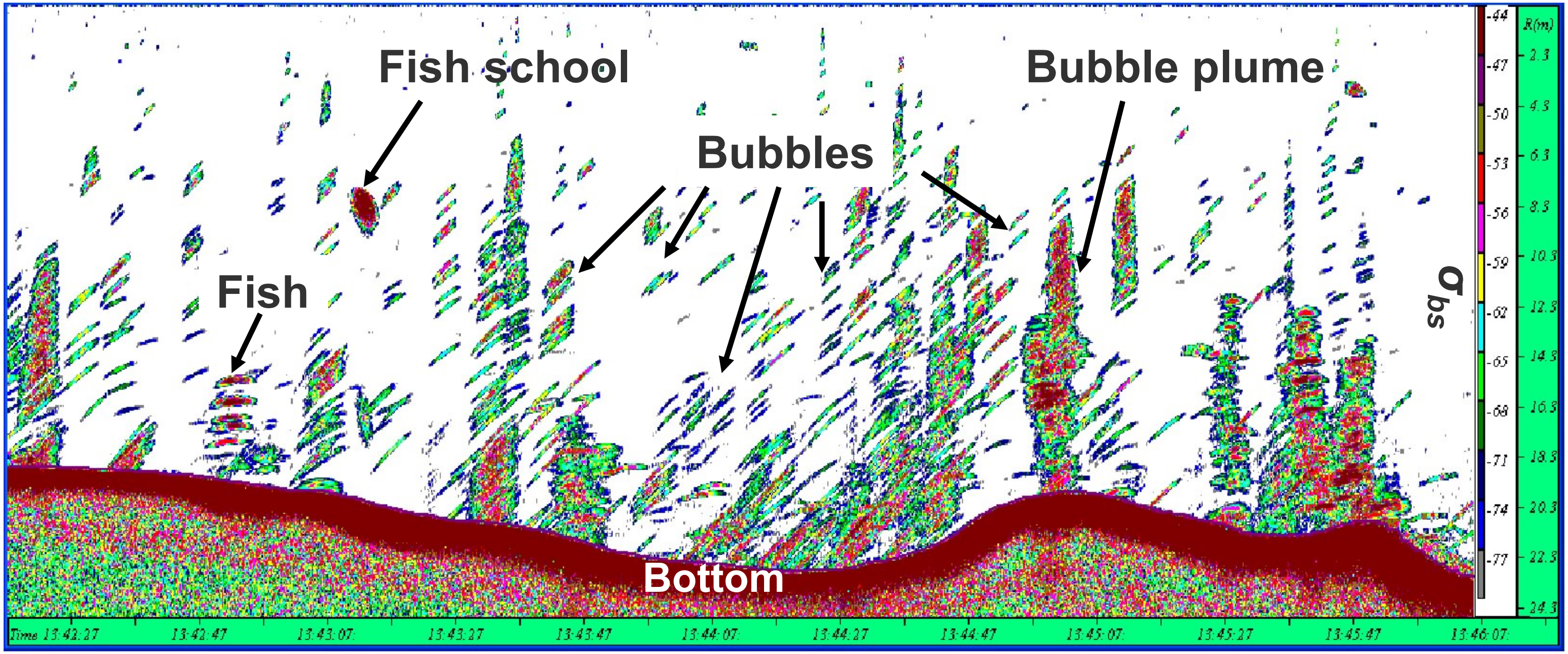


Measuring Bubbles

Kongsberg Simrad EK60 Split-beam echosounder with 120 kHz transducer

- Similar to sonar
- Use sonar signal to estimate bubble size/volume
- Methods same as measuring fish biomass

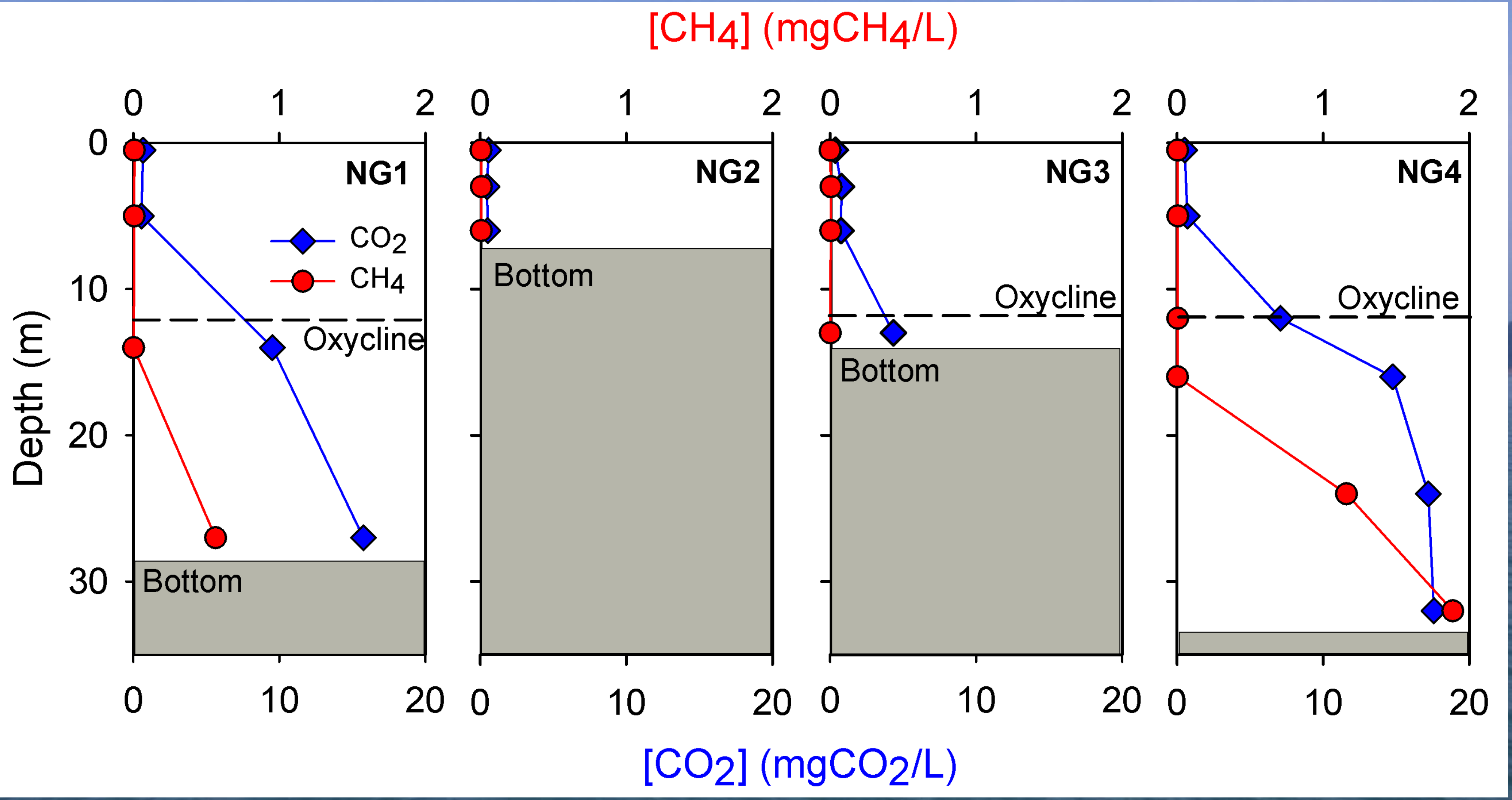


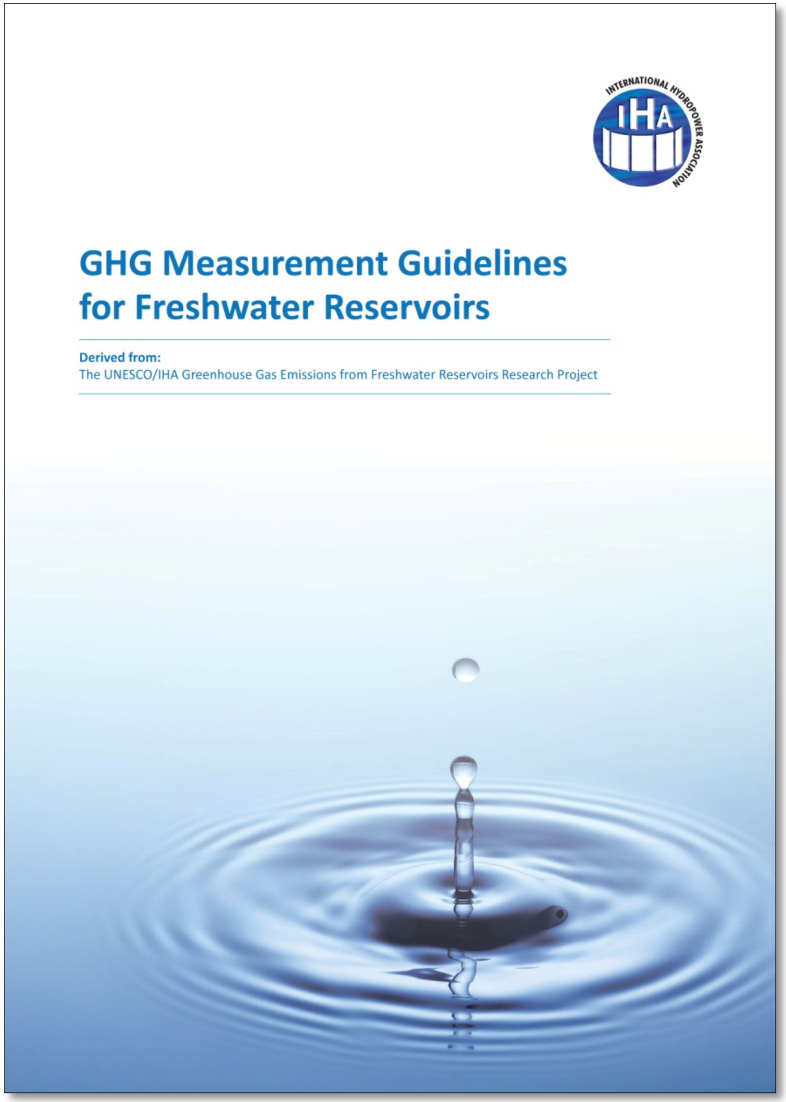


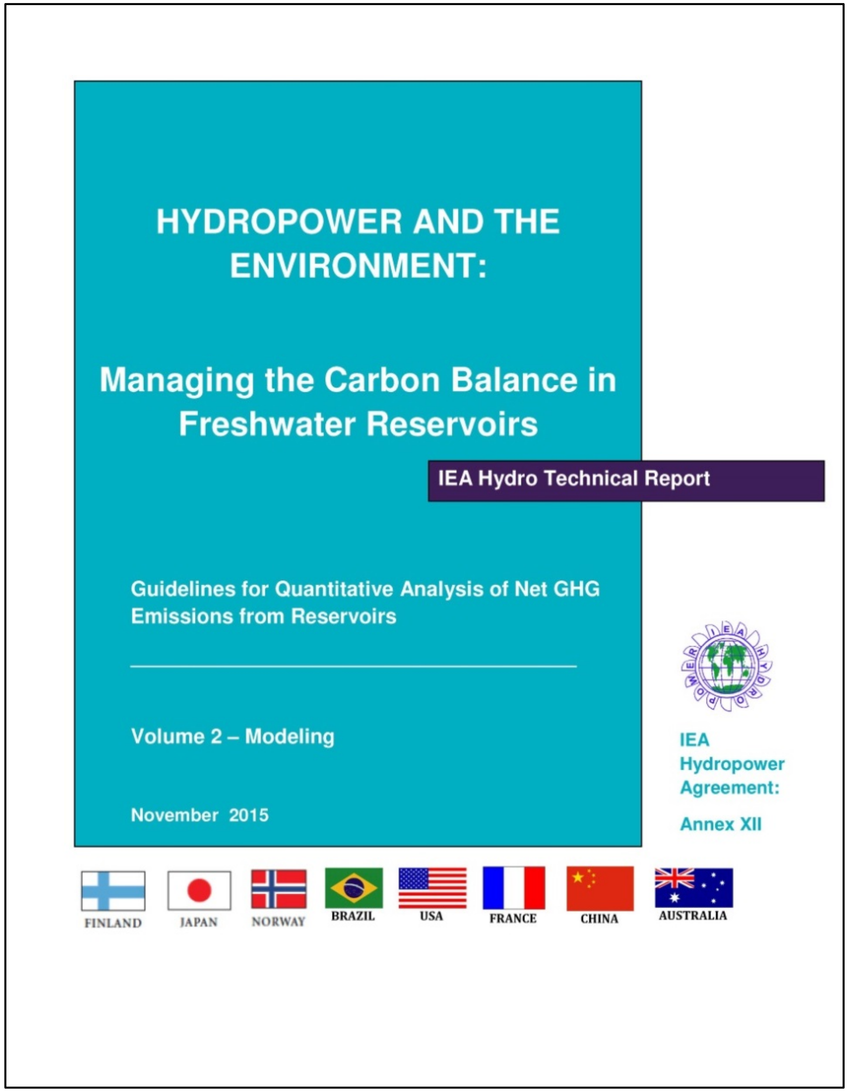
Time

from Tonya del Sontro

Nam Ngum Results
Dissolved gases



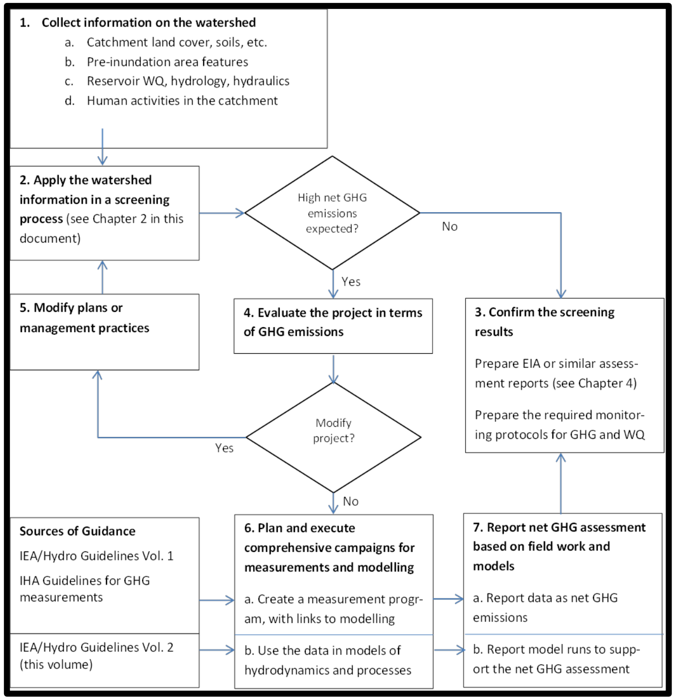

INTERNATIONAL HYDROPOWER ASSOCIATION
IHA
GHG Measurement Guidelines for Freshwater Reservoirs
Derived from:
The UNESCO/IHA Greenhouse Gas Emissions from Freshwater Reservoirs Research Project


HYDROPOWER AND THE ENVIRONMENT:
Managing the Carbon Balance in Freshwater Reservoirs
IEA Hydro Technical Report
Guidelines for Quantitative Analysis of Net GHG Emissions from Reservoirs
Volume 2 – Modeling
November 2015
IEA Hydropower Agreement:
Annex XII
FINLAND
JAPAN
NORWAY
BRAZIL
USA
FRANCE
CHINA
AUSTRALIA

Study methods and analysis

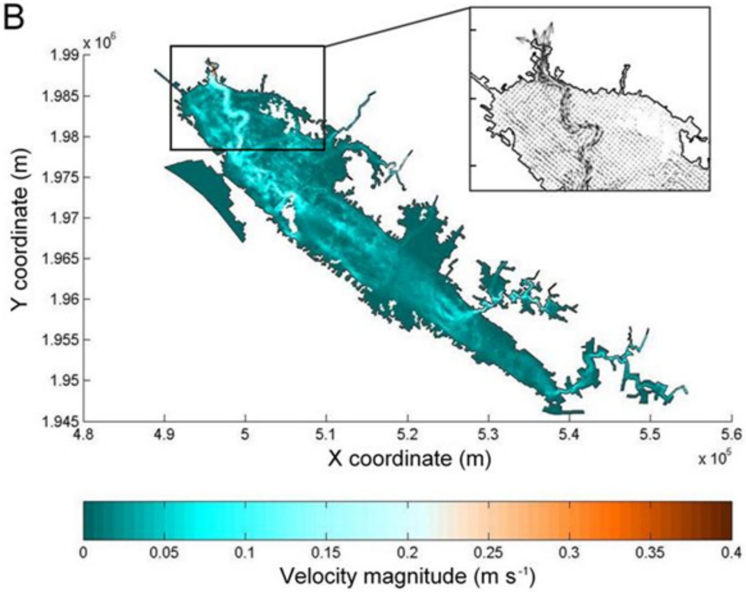
Screening tool

- Evaluate the risk of net GHG emissions



Process-based modelling

- Evaluate the expected value of net emissions



G-res tool Development

- Building on previous work undertaken by the UNESCO/IHA research project
- Collaboration between a number of international research institutes and organisations working together since December 2014
- Leading the development of the *G-res tool* and responsible for one of each of the key modules are:

Yves Prairie — Université du Québec à Montréal (UQÀM)

Jukka Alm — Luke, Natural Resources Institute Finland

Atle Harby — SINTEF

from Vanessa Warnock

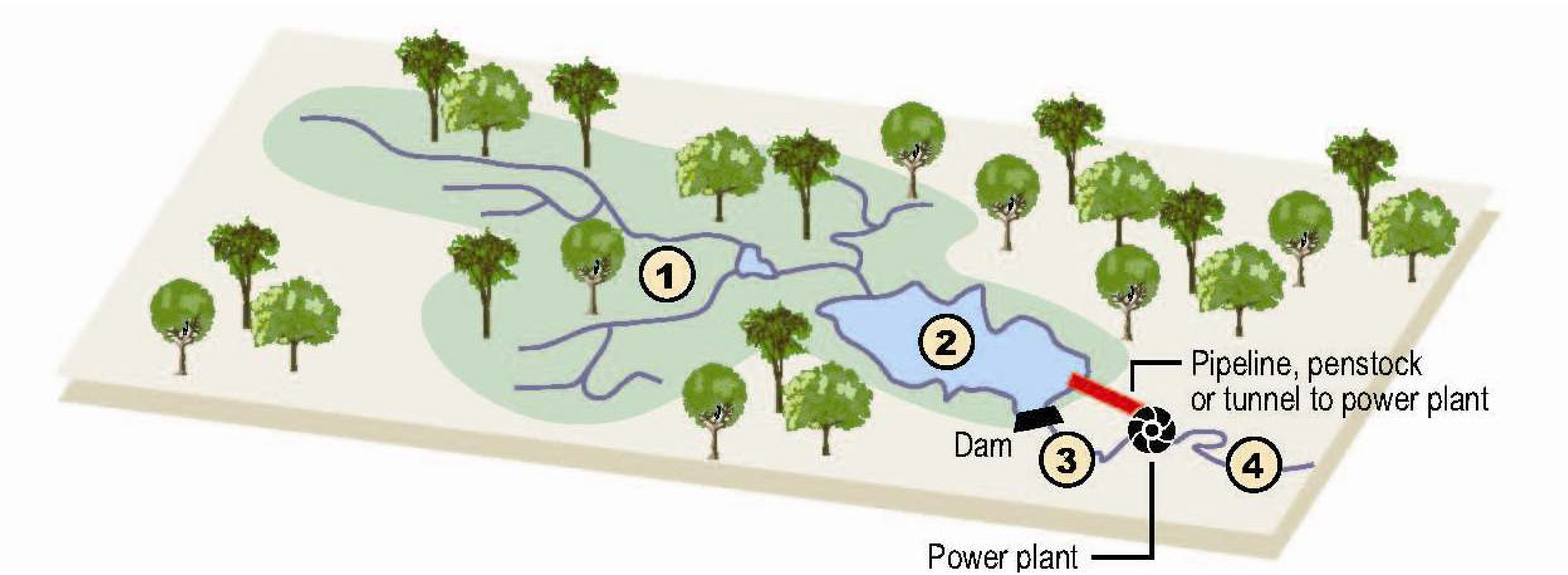
What does the Tool do?

- Calculates **Pre-impoundment GHG** e of the reservoir
- Calculates the Net GHG balance after flooding, how it evolves th **Post-impoundment GHG** sions over its lifetime (100 years)
- It estimates, in terms of **UAS** ow much of this Net GHG impact is influenced by ctivities in the reservoir and its catchment.
- If the reservoir has m **Allocation** ttempts to apportion the GHG y among these purposes

from Vanessa Warnock

Step 1: Identify areas

- Upstream of the reservoir 1
- The area to be inundated 2
- The area downstream affected by the reservoir 3 4



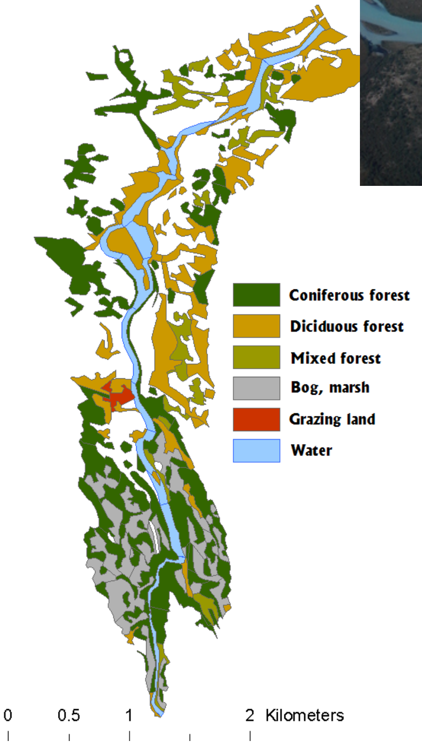
Step 2: Identify land cover

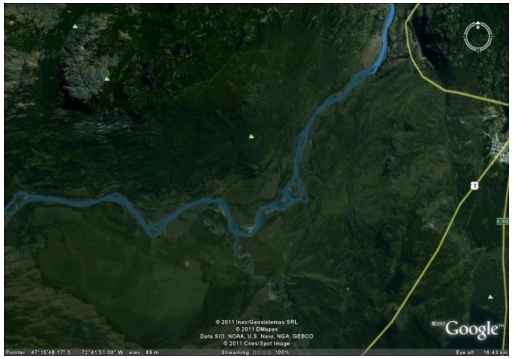
<u>Known land cover</u>

- from global maps derived from satellite images or aerial photographs
- from local maps
- from field survey

<u>Unknown land cover</u>

- modelling
- estimating





Land cover types

- Agriculture
- Bare areas
- Terrestrial wetlands
- Forest
- Grassland/Shrubland
- Peatland
- Snow and ice
- Urban areas
- Water bodies
- No data

Step 3: Determine the net balance of emissions and removals of GHG in terrestrial and aquatic systems of the area to be inundated

Locally adapted emission factors
- from national surveys
- from field survey

Default emission factors
- based on IPCC emission factors

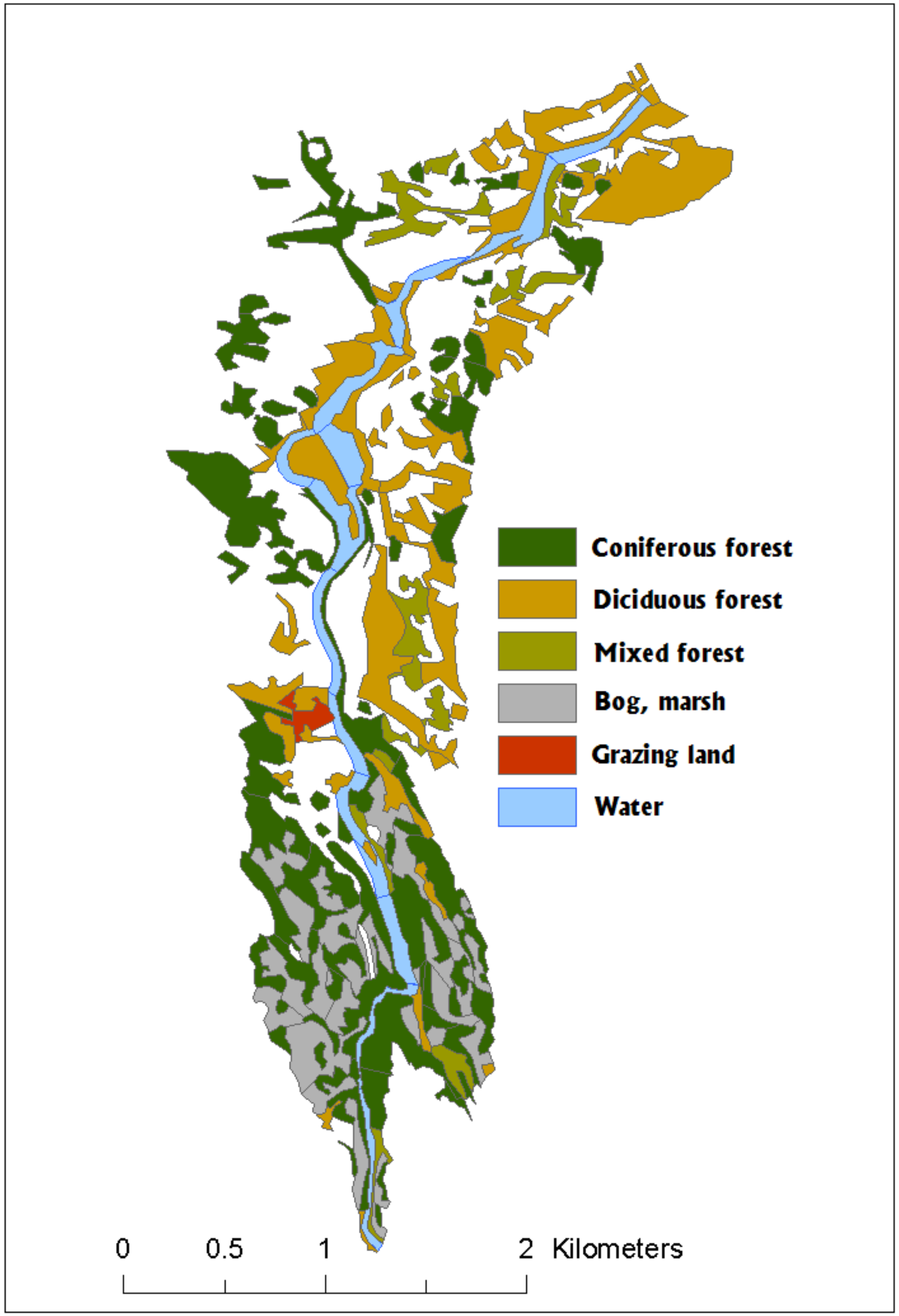
→ adapted to fit model purpose

….or a mixture of both!

Follsjø reservoir, Norway

- Land-use before dam
- Emission values for marsh, bog, running water and grazing land found in literature
- CO_2 uptake from different types of forest also found in the literature

  \- 0.14 Gg CO_2 pr year
  \+ 0.02 Gg CH_4 pr year



Step 4: Evaluate loading of carbon and nutrients, released naturally or by human activities from upstream and entering area to be inundated

from Brad Sherman

Locally adapted loading data

- From national surveys
- From field survey and measurements

Default loading data

- Based on land cover and land use

→ Global, national or local data

Challenge

- Divide loading between natural and human impacts

Pre-impoundment, flooded croplands. Gramsh, Albania

from Jukka Alm


Non-flooded croplands in the catchment. Gramsh, Albania
from Jukka Alm

Community carbage and sewage, Gramsh, Albania

Step 5: Establish baseline GHG balance in the downstream watercourse

<u>Locally adapted baseline data</u>

- from national surveys
- from field survey

<u>Default baseline data</u>

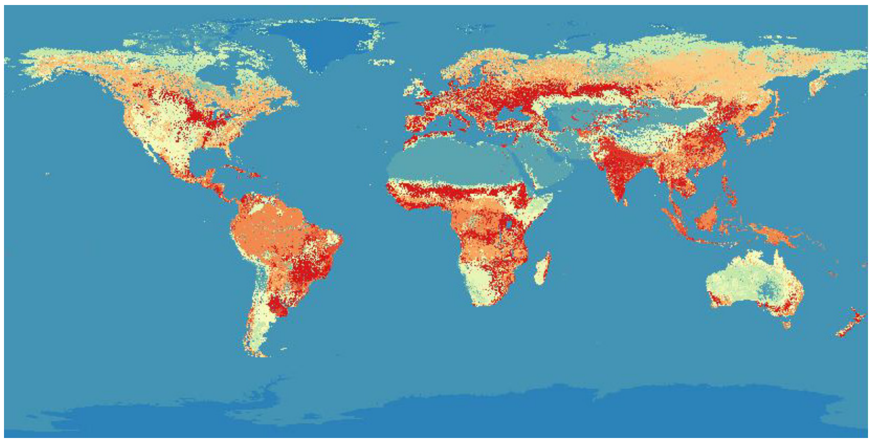
- based on default values or literature

→ adapted to fit model purpose

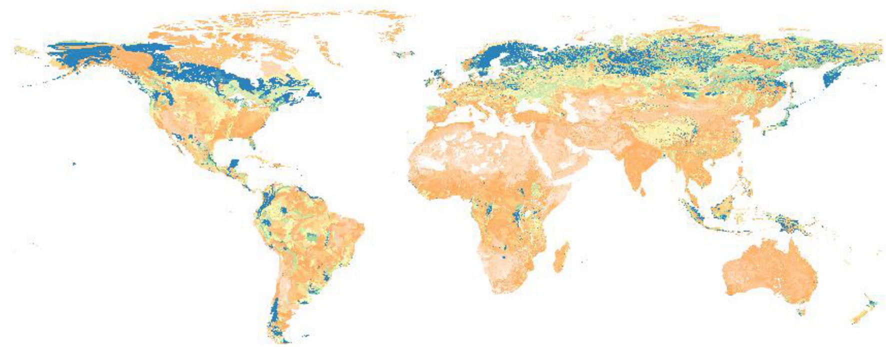
….or a mixture of both!

Post-impoundment GHG Balance

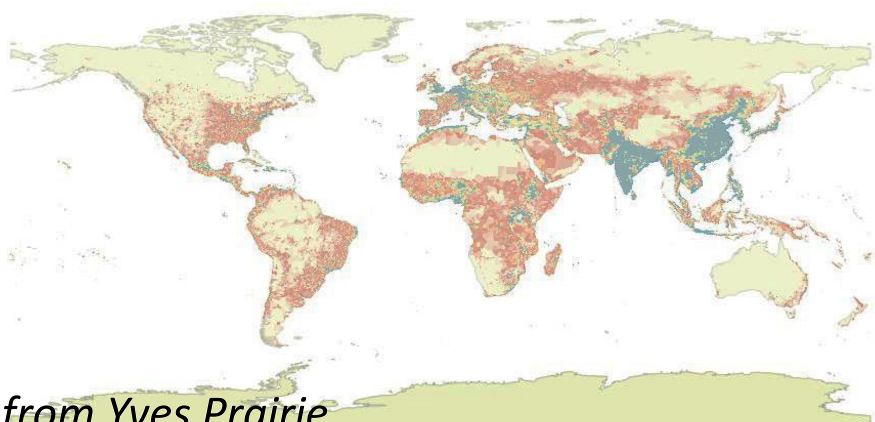
Land Cover (2010)



Soil Carbon Density



Population Density



from Yves Prairie

- Monthly temperature
- Monthly wind
- Precipitation
- Runoff
- Topography
- Soil drainage
- Trophic status
- Etc…

Post-Flooding GHG Balance

The spread of observational data

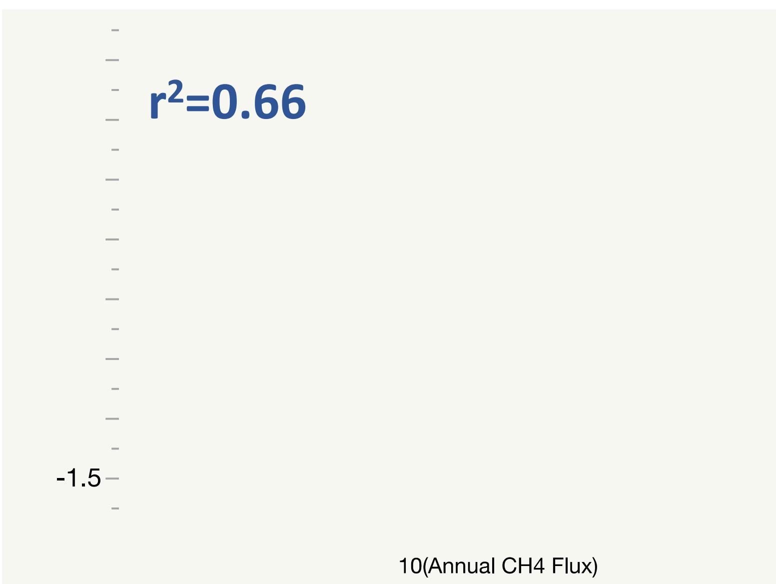
from Yves Prairie

Post-impoundment GHG Balance

Model development

Statistical approach

- Multiple regression with elastic net selection
- Validation using Bayesian Information Criterion



Variables retained

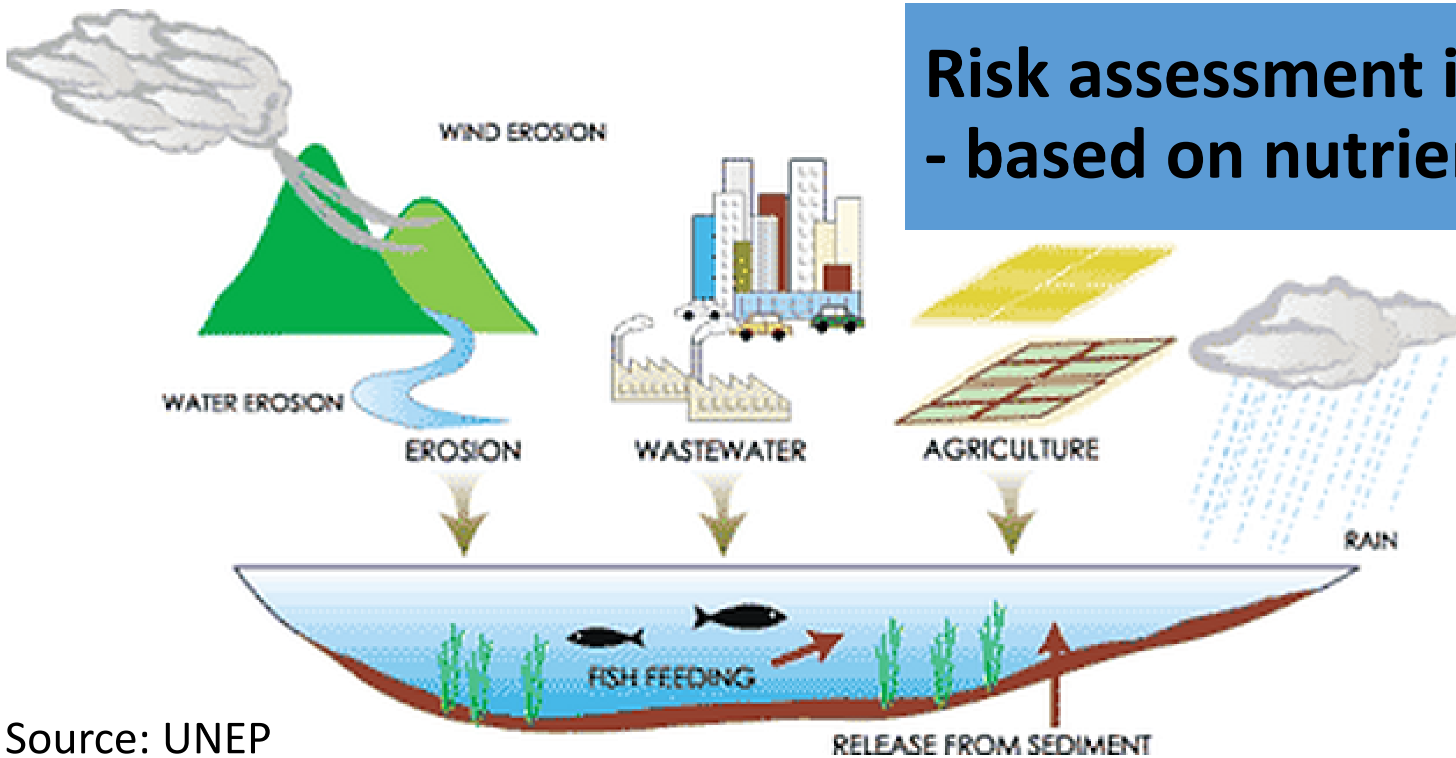
- Mean Slope of Catchment (°)
- % Reservoir Surface area <3m
- Soil C content (kg C m^{-2})
- Temperature
- Age

from Yves Prairie

UAS GHG Balance

Where do the nutrients come from?

Risk assessment in the Tool - based on nutrient loading



Source: UNEP

from Jukka Alm

What the G-res tool ultimately needs

CO_2

- Annual temperature cycle
- Reservoir Nutrients
- Thermocline depth
- Reservoir perimeter
- Precipitation
- Soil carbon

CH_4

- Annual temperature cycle
- Catchment slope
- Littoral zone extent

CLIMATE

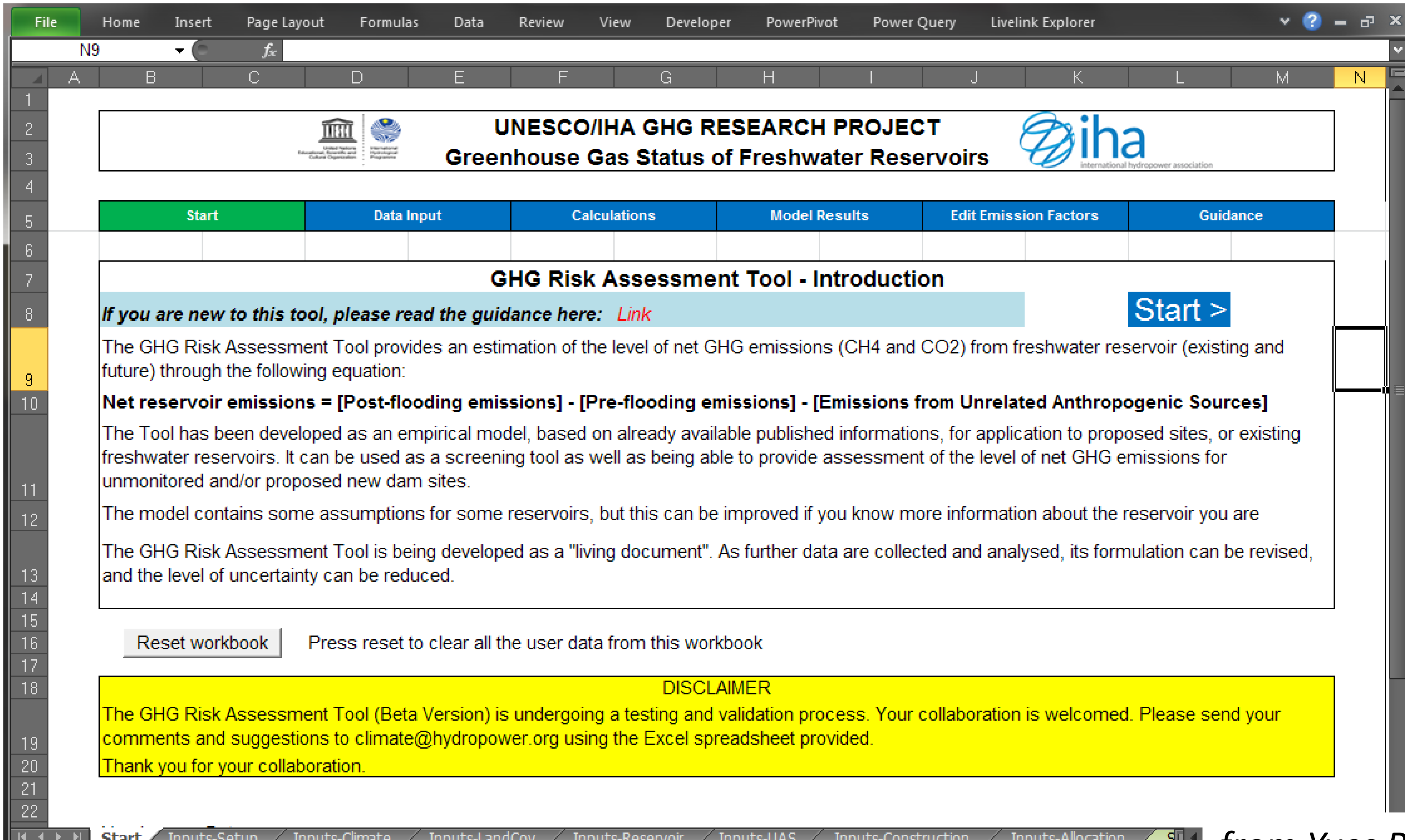
CATCHMENT

RESERVOIR

from Yves Prairie

Development of the Tool

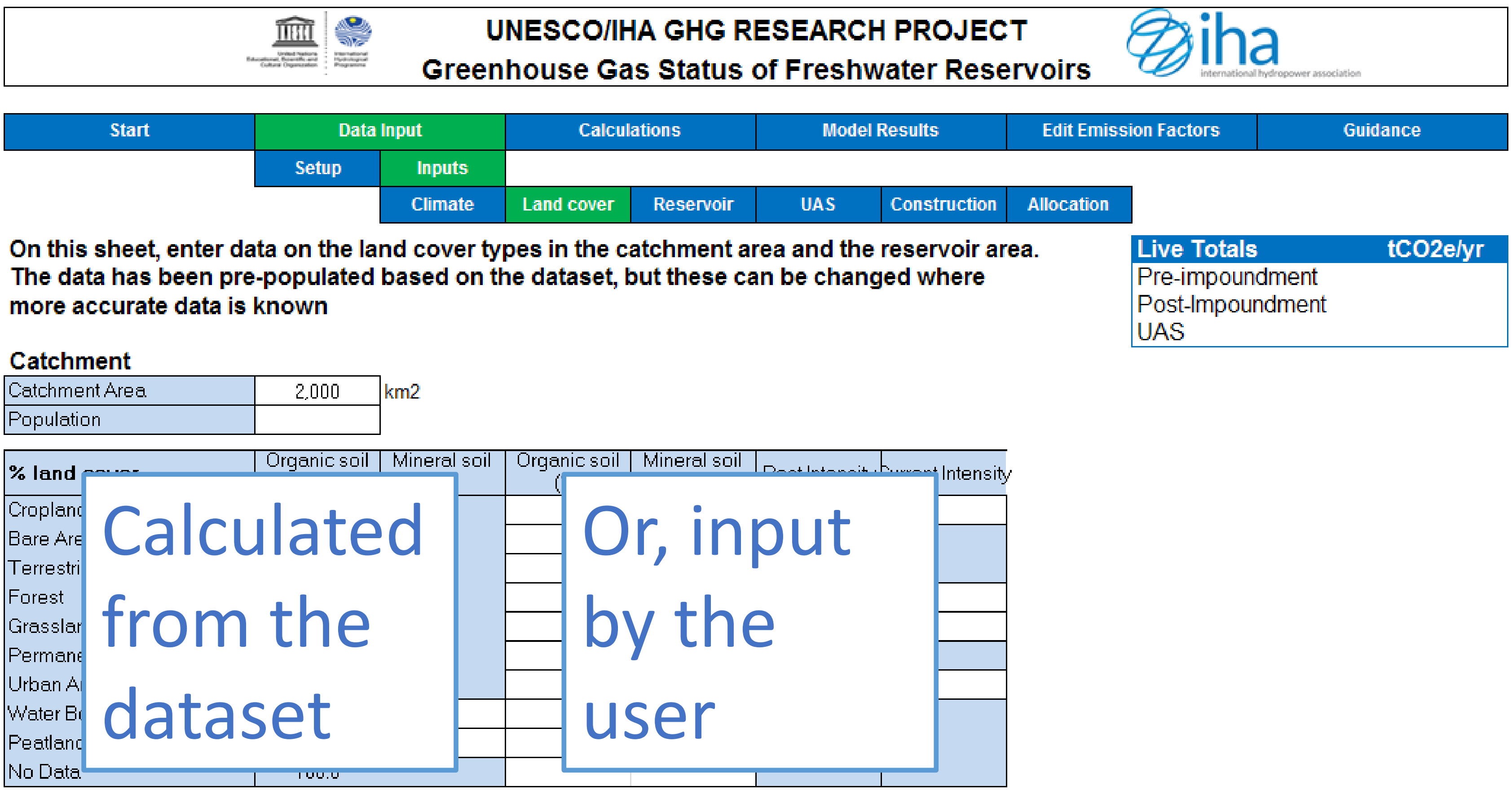
Inputs of the Screening Tool



from Yves Prairie

Development of the Tool

Inputs of the Screening Tool



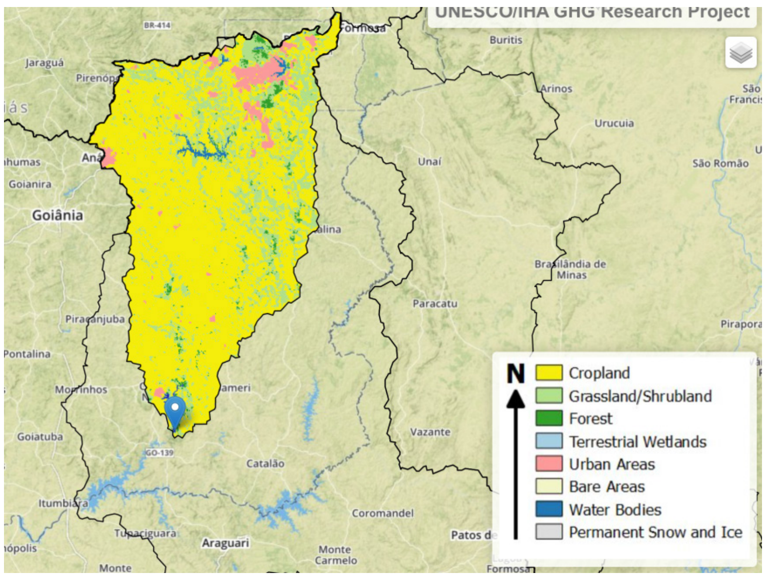
Calculated from the dataset

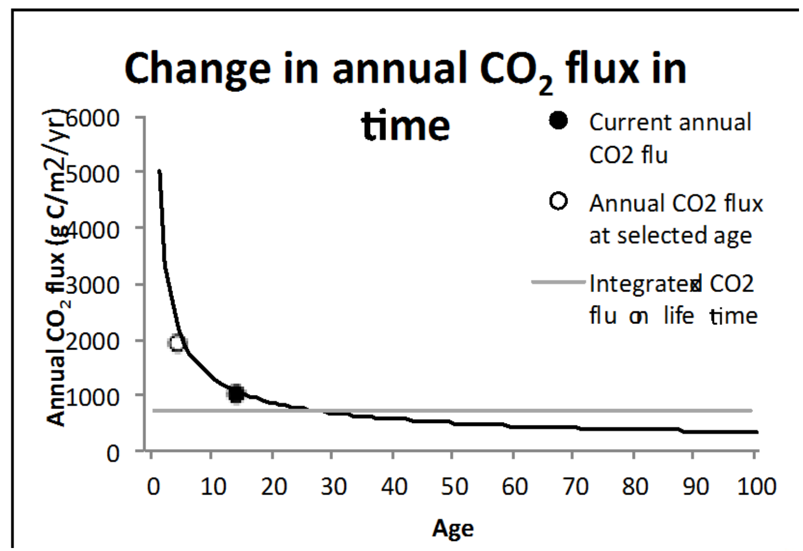
Or, input by the user

from Yves Prairie

Development of the Tool

Visual information





from Yves Prairie

Development of the Tool

Summary Reports

UNESCO/IHA GHG RESEARCH PROJECT
Greenhouse Gas Status of Freshwater Reservoirs

Start	Data Input	Calculations	Model Results	Edit Emission Factors	Guidance
			Print		

Predicted emissions associated with the reservoir

Net predicted annual CO_2e emission As CH_4

Net post-impoundment	13,000 tCO2e/y
Net pre-impoundment	4,000 tCO2e/y
Net unrelated anthropogenic sources	0 tCO2e/y
Total net change in emissions	9,000 tCO2e/y

Net predicted 100-year total CO_2e emission As CO_2

Net post-impoundment	1,300,000 tCO2e/100y
Net pre-impoundment	400,000 tCO2e/100y
Net unrelated anthropogenic sources	0 tCO2e/100y
Total net change in emissions	900,000 tCO2e/100y

Identified risk factors

Risk factors	Risk Profile
Intake is below thermocline - risk of CH4 release	Medium risk
High proportion of organic soils	Low risk
Risk of UAS in catchment	High risk

Warnings and notes

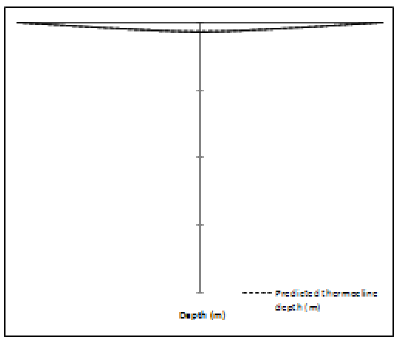
User has input own land use emission factors
User has not entered existing water area in pre-flooding case

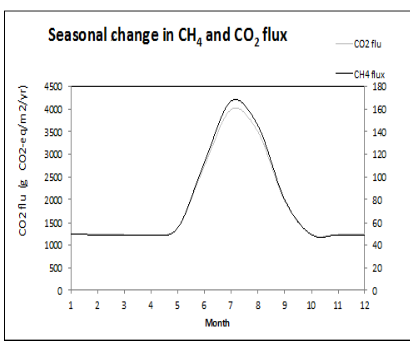
from Yves Prairie

Development of the Tool

Detailed information on calculation parameters and model results

Idealized bathymetry
(vertical exageration X50)





Basic reservoir informations		
Country	Canada	
Latitude	52.18	DD
Longitude	-76.05	DD
Elevation	275	m asl
Climate	Boreal	
Hydroelectric power type	Reservoir	
Reservoir Area	648.8	km^2
Reservoir volume	6.9	km^3
Reservoir perimeter	529.8	km
Mean depth	11.1	m
Maximum depth	28.0	m
Impoundment Year	2005	

Derived reservoir informations		
Littoral area	637.43	km^2
% Littoral area	16	%
q-Bathymetric shape	1.53	
SDI-Shoreline development index	5.9	
Mixing pattern	Dimictic	
Thermocline	26.3	m
Dynamic ratio	2.23236894	
Annual mean temperature	-2.3	°C
Annual mean wind	4.2	m/s
Mean annual precipitation	838	mm
WRT-Water residence time	0.3	year
Eutrophication level	Mesotrophic	
Phosphorus concentration	28.7	mg/L
Wastewater treatement - Please sel	None	
Soil carbon content under impounde	20.4	kg C/m^2

Hydropower informations		
Turbine intake under thermocline ? (YES/NO)		
Energy production	8600	GWhr/yr
Current emissions in GWP (CH4 + CC	1927956	Mg CO_2eq/yr

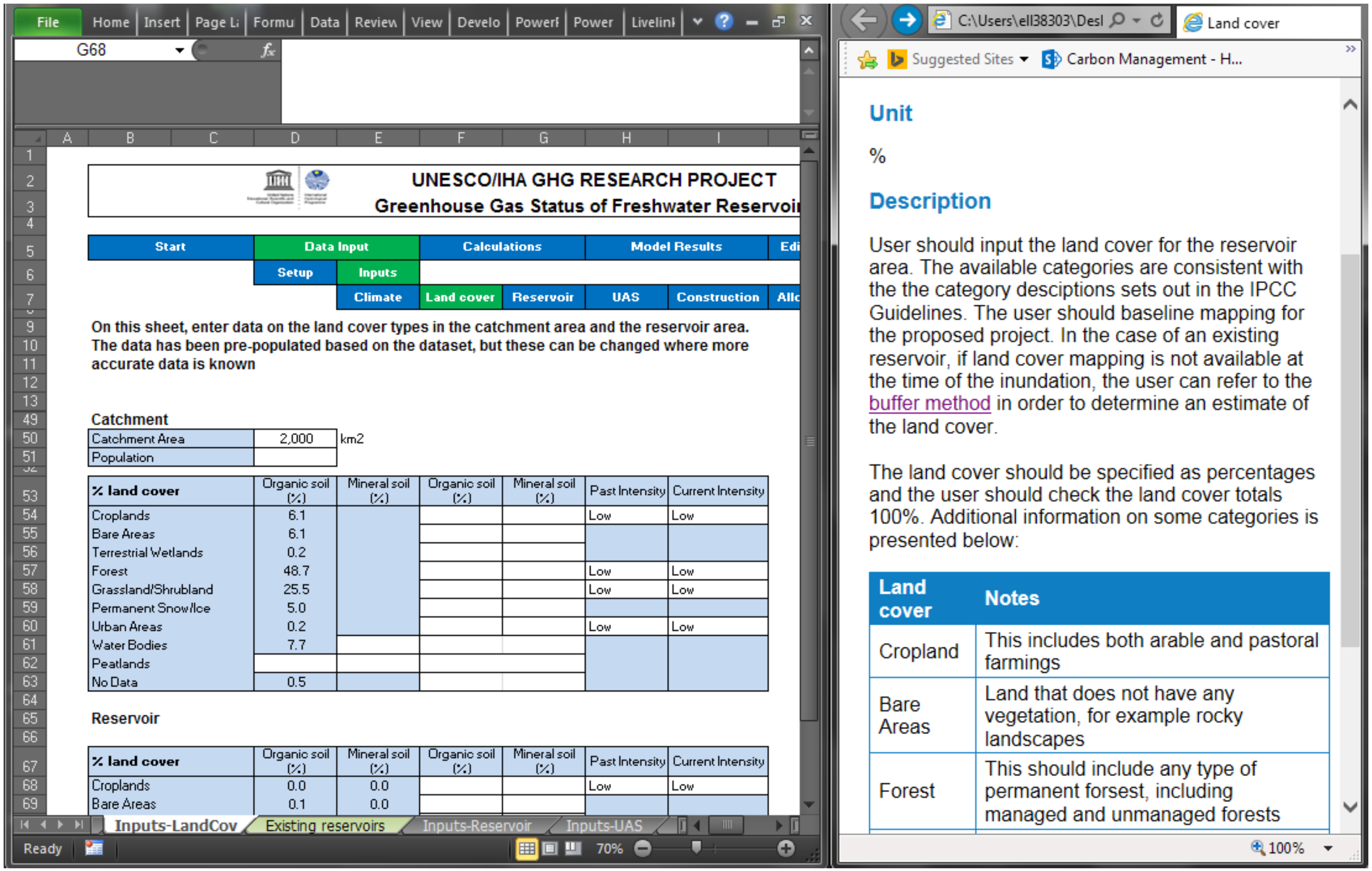
Catchment caracteristics		
Catchment Area	28455.5	km^2
Catchment perimeter	1789.6	km
Mean annual runoff	709	mm
Catchment slope	0.33	°
Population density	0.0	p/km^2
Soil C content (Surface)	12.4	kg C/m^2
Soil C content (Bottom)	10.0	kg C/m^2
NPP (Net primary production)	0.36	kg/m^2/yr
Catchment phosphorus loading to the r	1402.61	kg/m^2/yr
Population phosphorus loading to the r	0.00	kg/m^2/yr
Catchment organic carbon loading	52.6	kg/m^2/yr
Land cover % in 2010		
Croplands	6.1	%
Bare Areas	6.1	%
Terrestrial Wetlands	0.2	%
Forest	48.7	%
Grassland/Shrubland	25.5	%
Permanent Snow and Ice	5.0	%
Urban Areas	0.2	%
Water Bodies	7.7	%
Peatland	NA	%

Data From Literature	Tremblay et al 2008	
Age when sampled	2	yr
Mean Temperature when sampled	-0.52	°C
Average wind when sampled	4.17	m/s
Total average precipitation when samp	785.8	mm
Annual diffusive CH_4 flux	100.3	g CO_2eq/m^2/yr
Bubbling CH_4 flux	28.1	g CO_2eq/m^2/yr
Total CH_4 flux	142.3	g CO_2eq/m^2/yr
Annual CO_2 flux	1838.4	g CO_2eq/m^2/yr

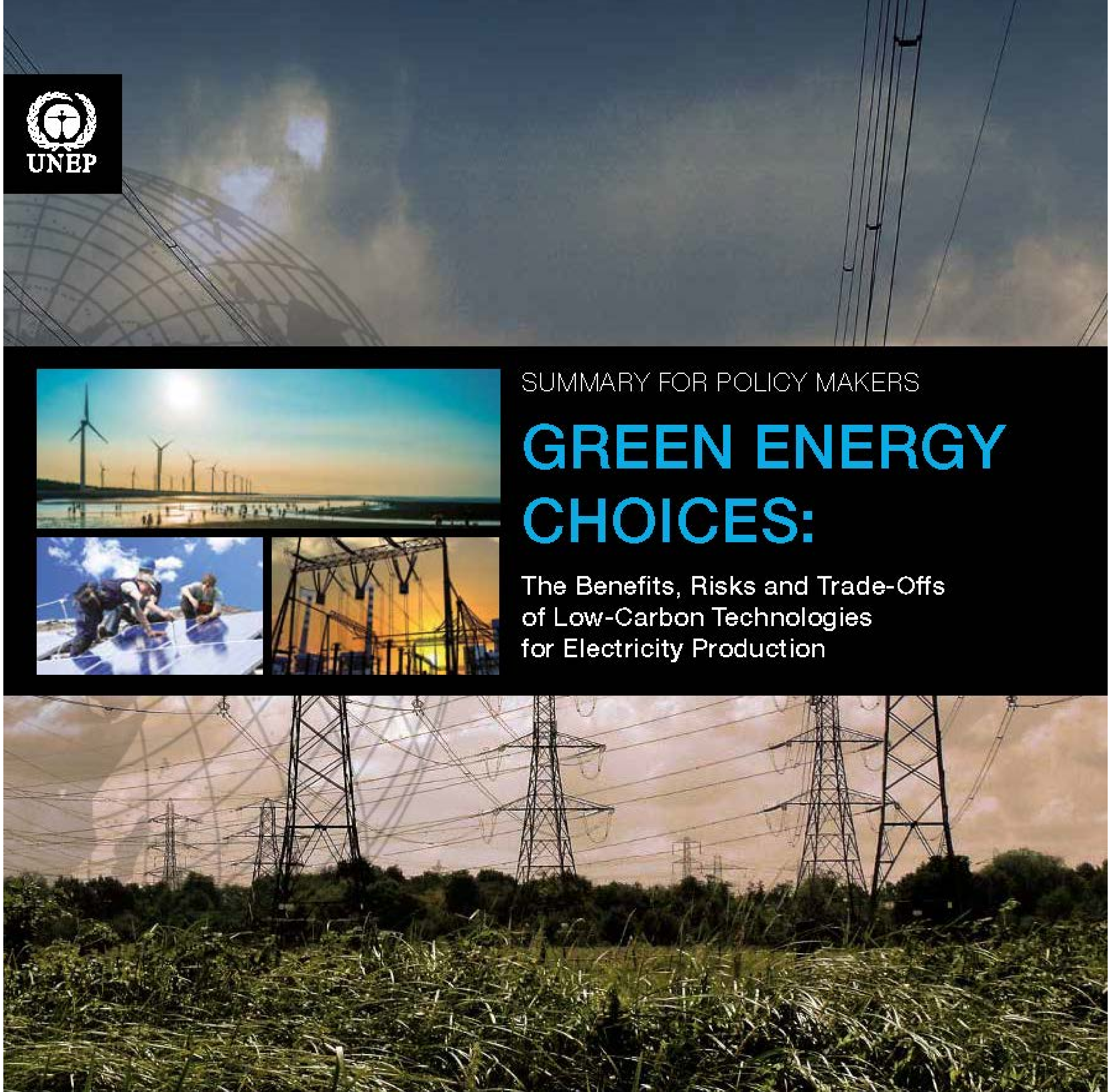
from Yves Prairie

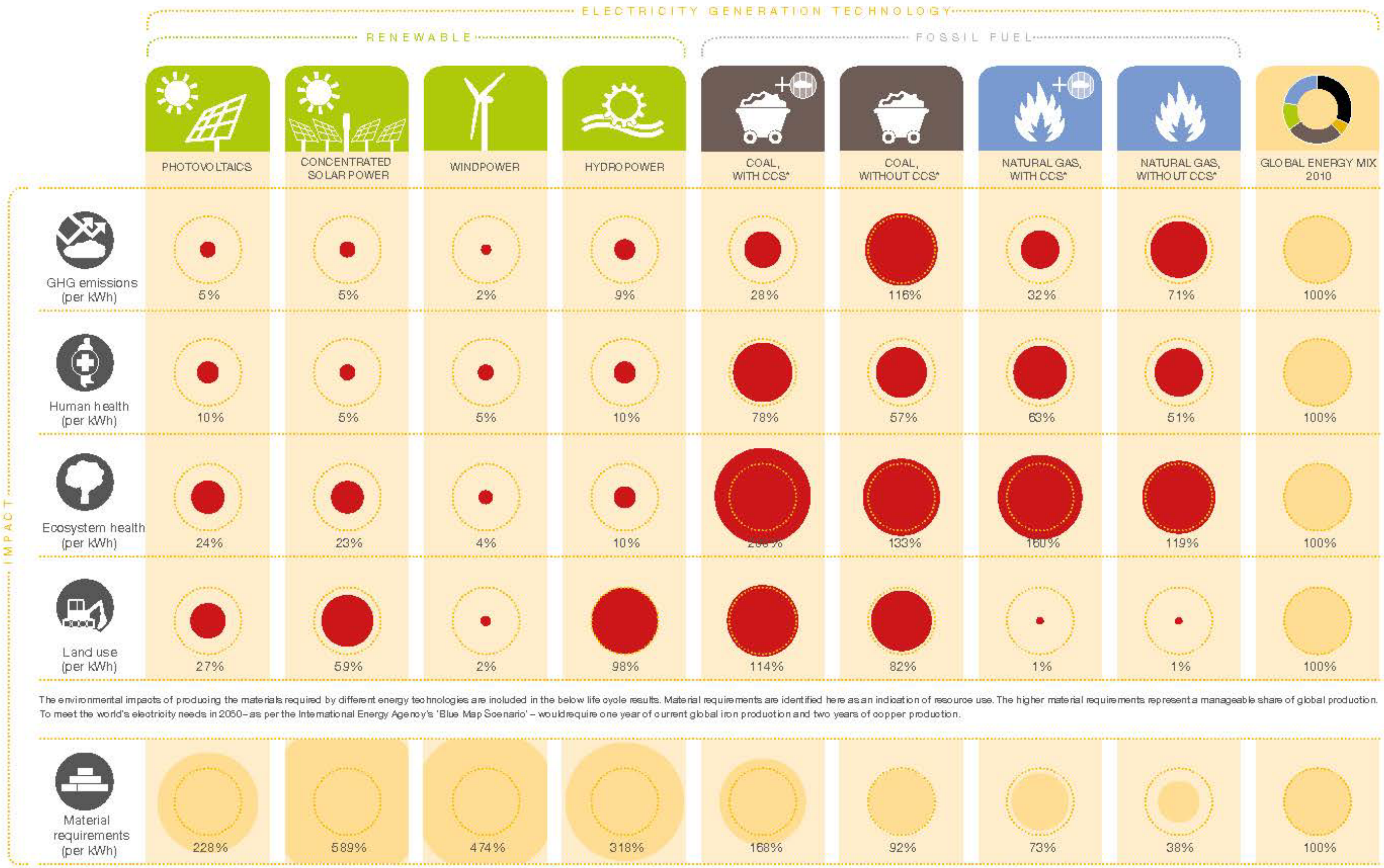
Development of the Tool

Integrated User Guidance and Help



from Yves Prairie


UNEP
SUMMARY FOR POLICY MAKERS
GREEN ENERGY CHOICES:
The Benefits, Risks and Trade-Offs of Low-Carbon Technologies for Electricity Production



*Carbon capture storage (CCS) technology entails the capture of CO2 from large anthropogenic sources, transport of the CO2 to an underground storage reservoir and long-term isolation from the atmosphere.

25 SE4All is an initiative launched by the UN Secretary General gathering support by a wide range of partners to reach three complementary objectives by 2030: universal access to modern energy services, doubling the share of renewables in the global energy mix, and doubling the global rate of improvement of energy efficiency. www.sustainableenergyforall.org

Hydropower: 70 g CO2/kWh (Hertwich et al 2014)

	World total	In Hertwich 2013	% of world tot
Number of reservoirs	10 0000 for hydro	110	1,1 %
Reservoir area	330 000 km^2	60 031 km^2	18,2 %
Average reservoir area		536 km^2	
Hydropower capacity	949 GW	82,96 GW	8,7 %
Hydropower generation	3 551 TWh/y	364,7 TWh/year	10,3 %

Videre arbeid

- IEA, IHA arbeidsgrupper
- IPCC, banker og finansiering
- Utbyggere og konsulenter

- Teste og verifisere G-RES Tool
- Publisere

- Vitenskapelig publisering
- Mer data