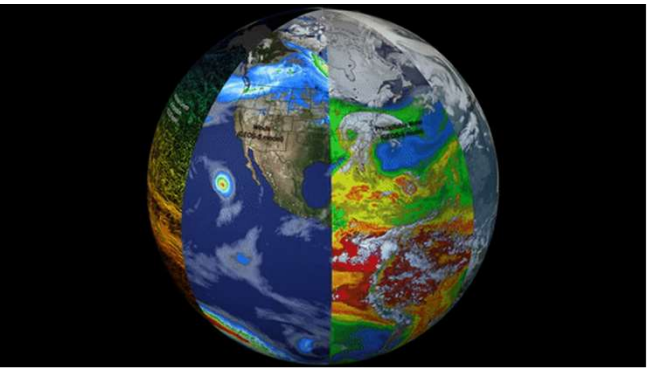


Technological Disruption of Transboundary Water Data & Information

Nagaraja Rao Harshadeep
Global Lead (Disruptive Technology)

WORLD BANK GROUP

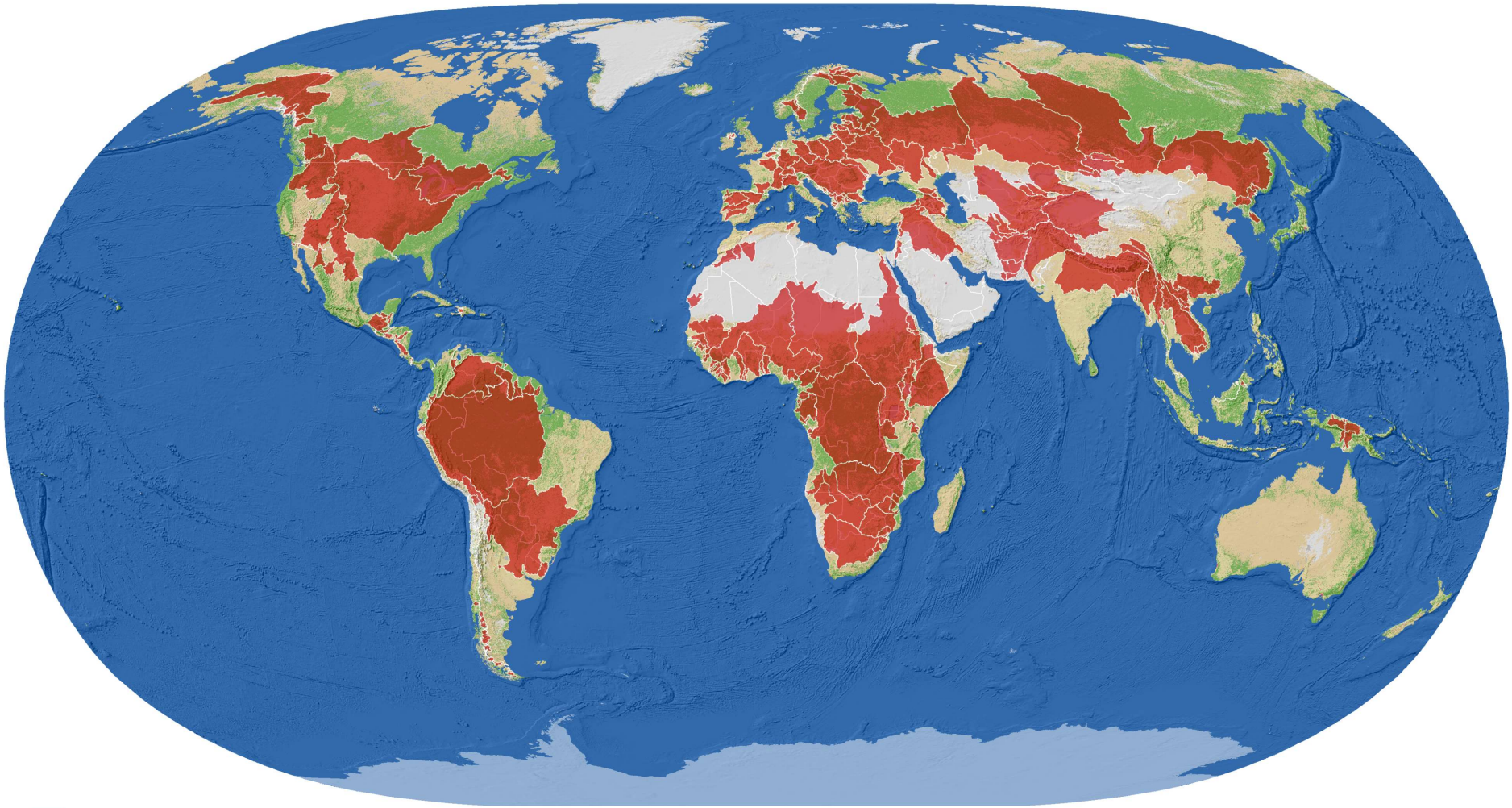
Session III Improving Transboundary Data Availability, Access & Exchange

Workshop on Strengthening Legal and Institutional Arrangements for Transboundary Water Cooperation and Data and Information Exchange

Beirut, Lebanon

30-31 May, 2023

GLOBAL TRANSOUNDARY BASINS

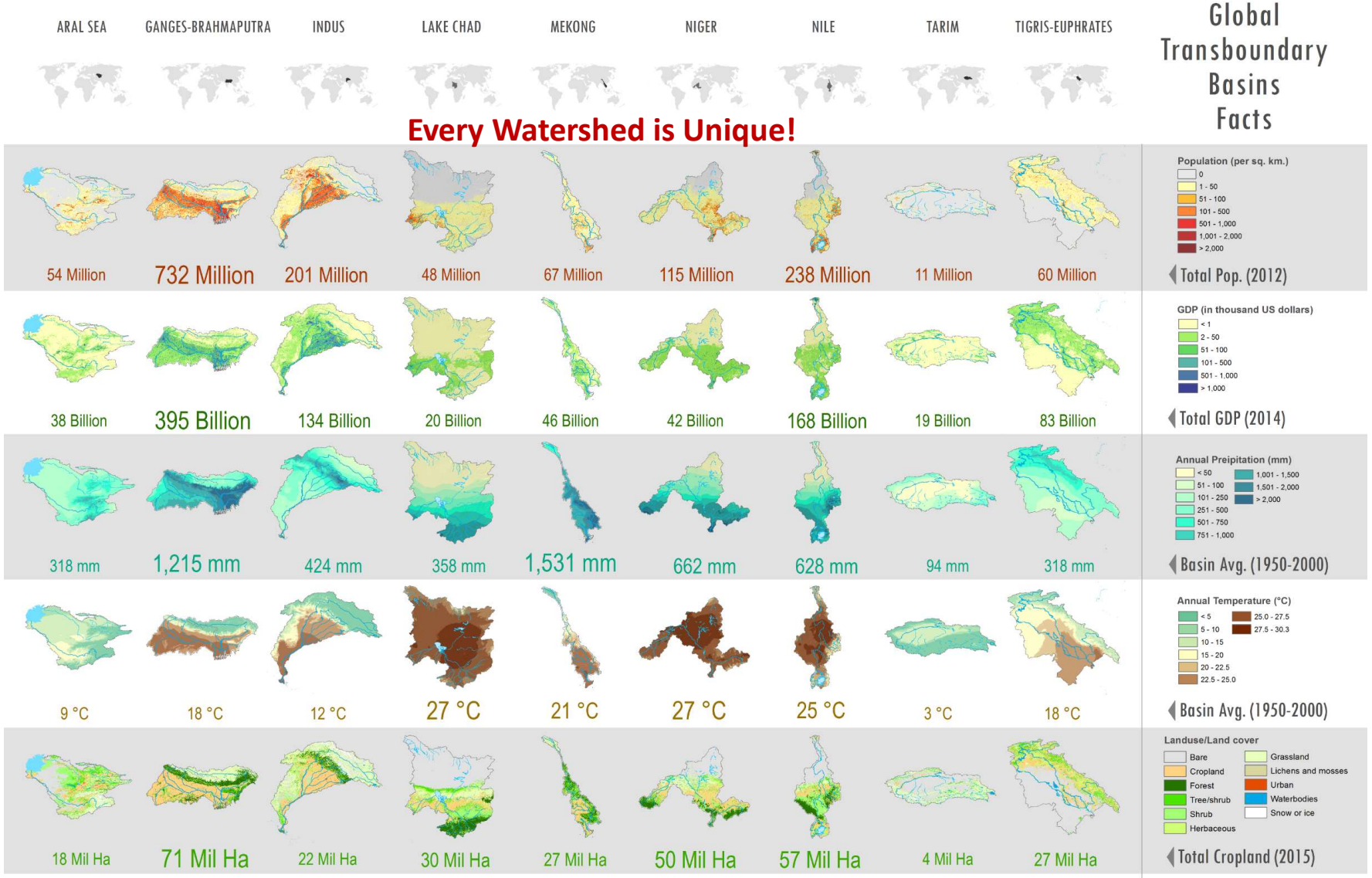


TRANSBOUNDARY BASINS

Data Source: Transboundary Water Assessment Program (TWAP)

Global Transboundary Basins Facts

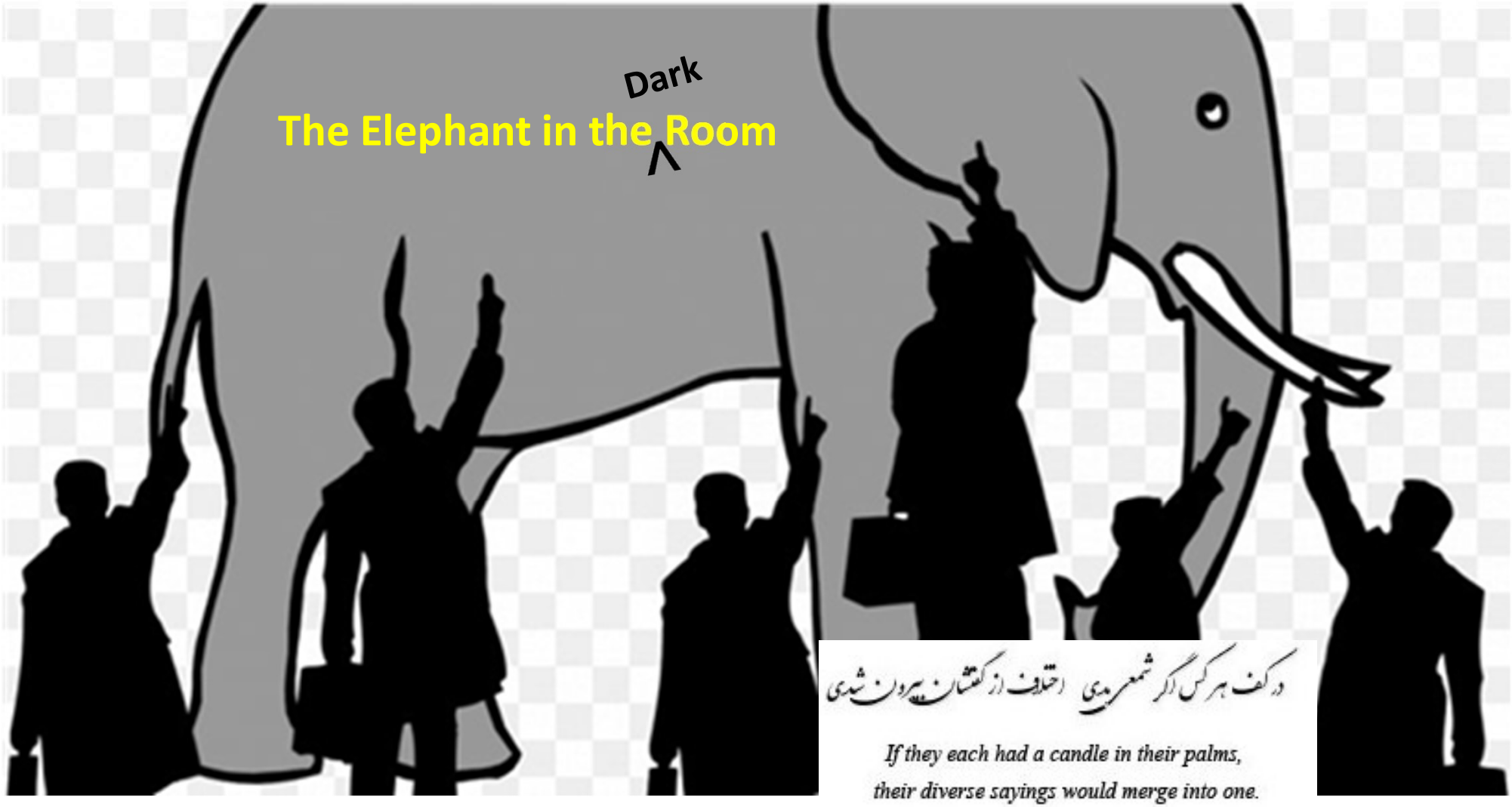
Every Watershed is Unique!

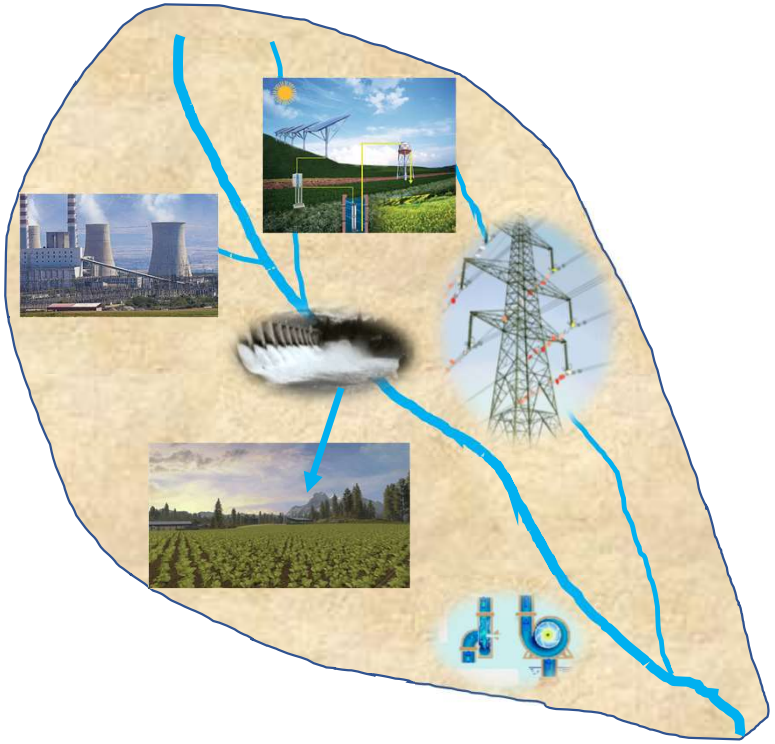


Population: Oak Ridge National Laboratory (ORNL); GDP: DECRG, The World Bank; Landcover: ESA; Climate Data: World Clim

Note: Total and average figures are derived using GIS processing.

Transcending narrow sectoral perspectives…

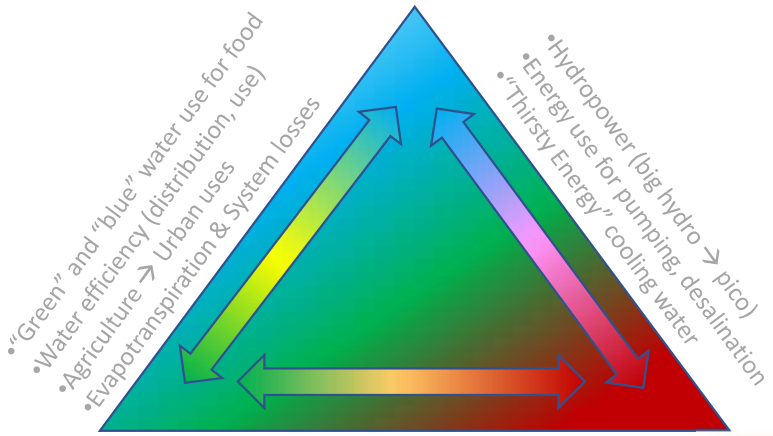




The Water-Energy-Food Nexus

- Basin planning
- Monitoring
- Water infrastructure (storage, distribution) system operations

Water Security



- Agricultural energy use (e.g. pumping)
- Solar Pumps
- Biofuels
- Energy use for Inputs, Processing

Food Security

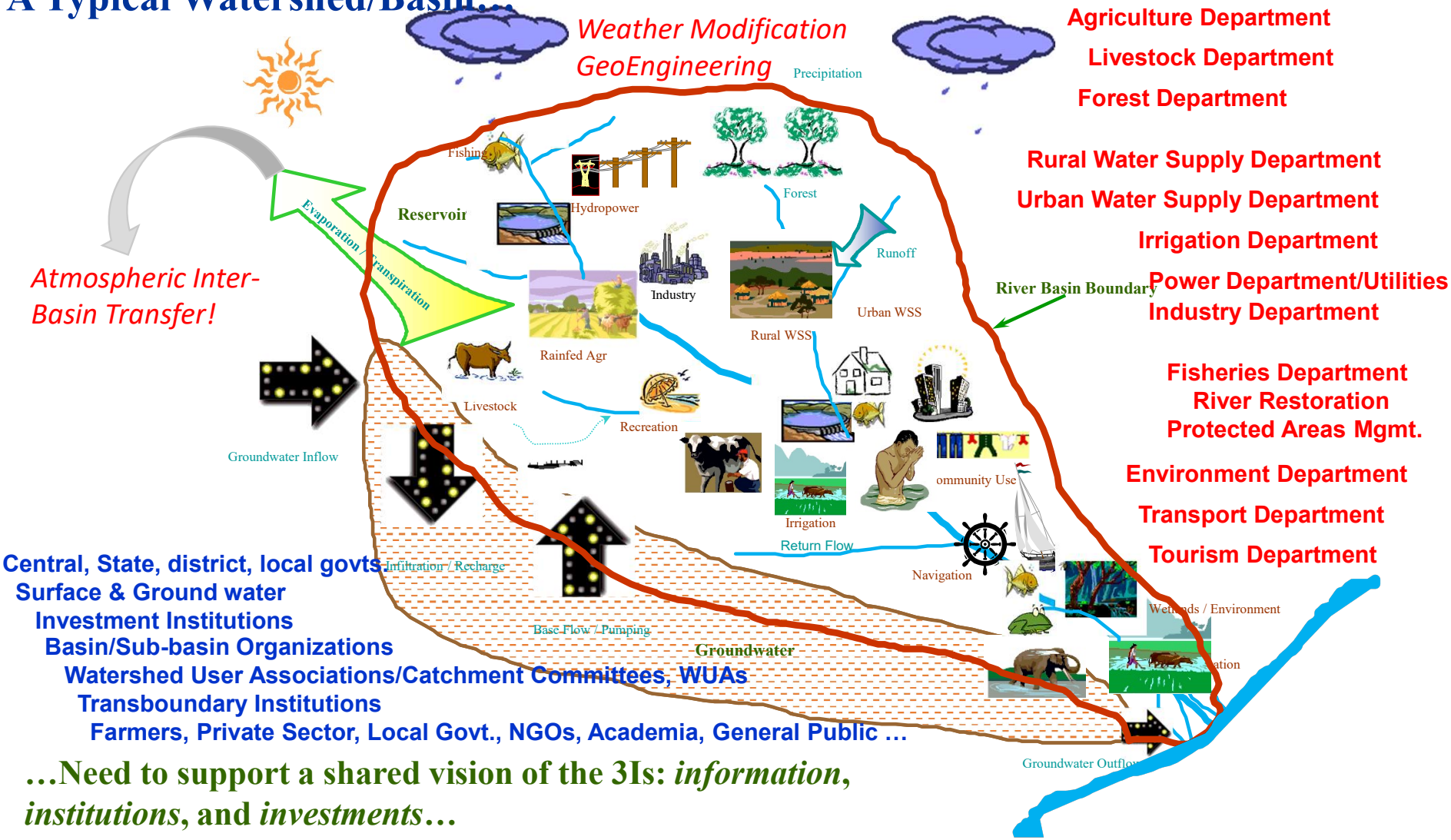
- Sustainable production
- Value chain mgmt. from inputs to consumption (e.g. agriculture, livestock, fisheries)

Energy Security

- Energy systems optimization - planning & operation
- Energy access
- Energy efficiency

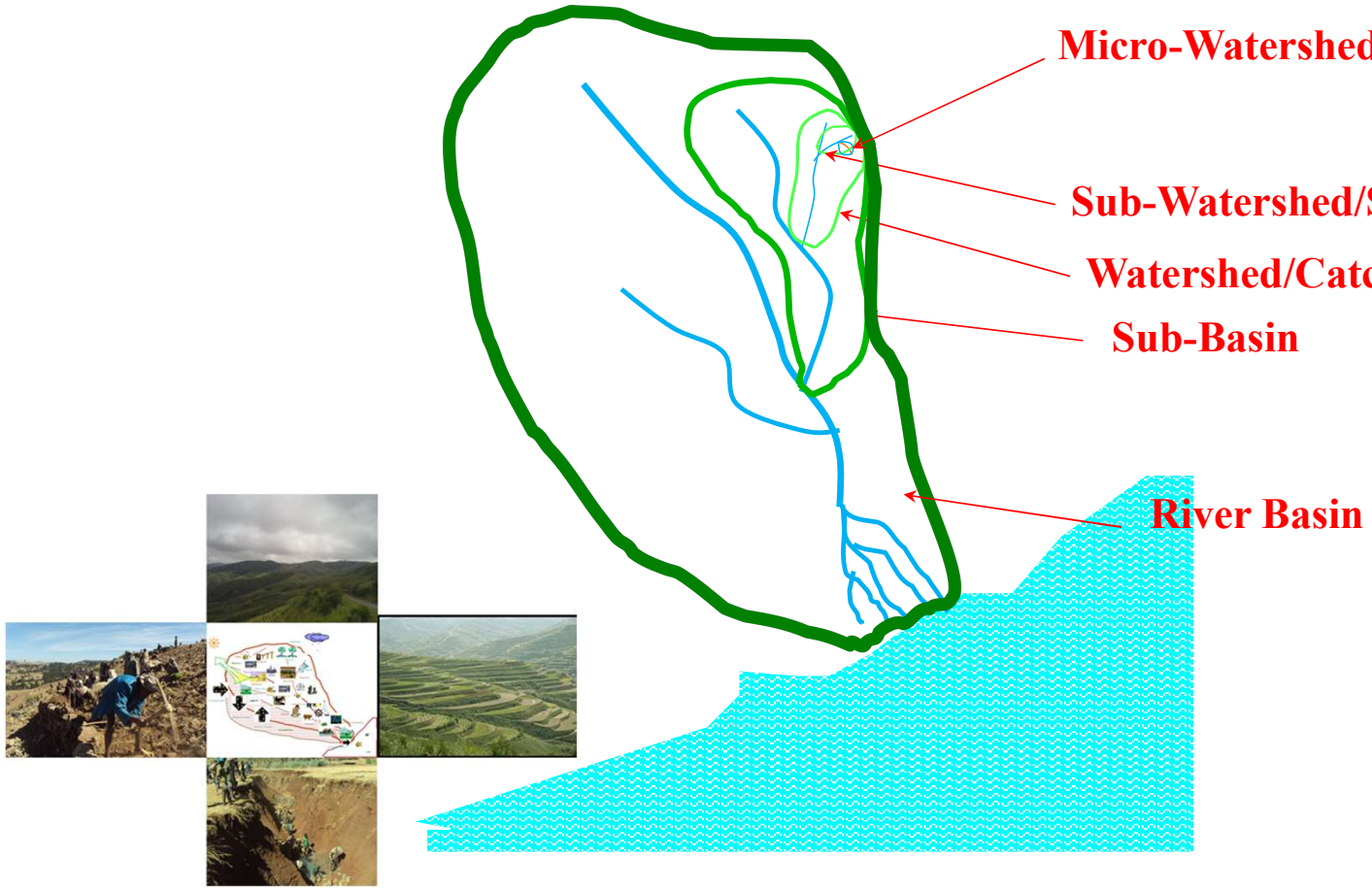
Multiple sectors, multiple institutions, linked by water and natural resources…

A Typical Watershed/Basin…



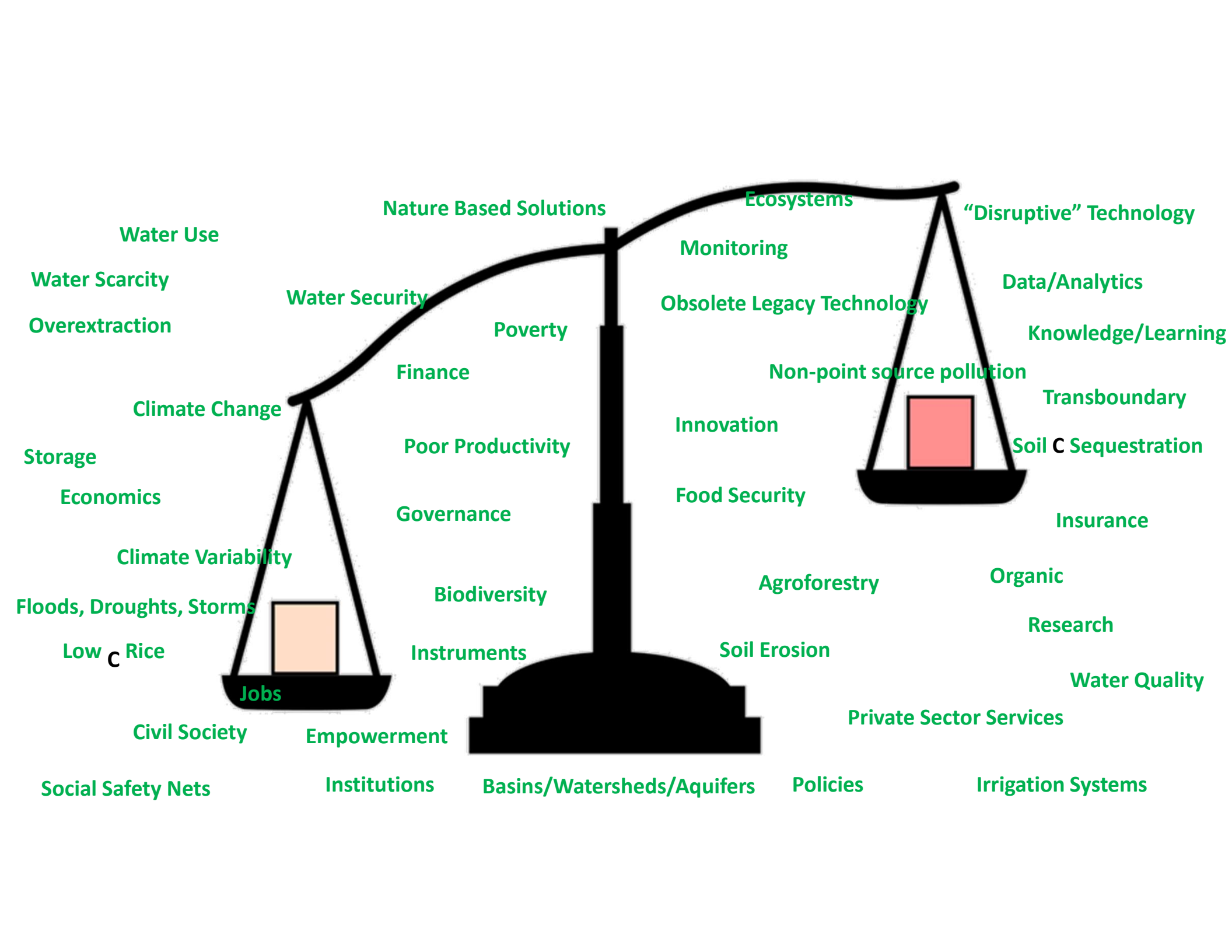
…Need to support a shared vision of the 3Is: *information*, *institutions*, and *investments*…

Scales



Transboundary Water Contexts:

- River Basins
- Lake/Inland Sea Basins
- Groundwater Aquifers
- Marine Areas


Nature Based Solutions
Ecosystems
"Disruptive" Technology
Water Use
Monitoring
Water Scarcity
Data/Analytics
Water Security
Obsolete Legacy Technology
Overextraction
Poverty
Knowledge/Learning
Finance
Non-point source pollution
Transboundary
Climate Change
Innovation
Poor Productivity
Soil C Sequestration
Storage
Economics
Food Security
Governance
Insurance
Climate Variability
Agroforestry
Organic
Biodiversity
Floods, Droughts, Storms
Research
Low C Rice
Instruments
Soil Erosion
Water Quality
Jobs
Private Sector Services
Civil Society
Empowerment
Social Safety Nets
Institutions
Basins/Watersheds/Aquifers
Policies
Irrigation Systems

Major Transboundary Waters Challenges

Information

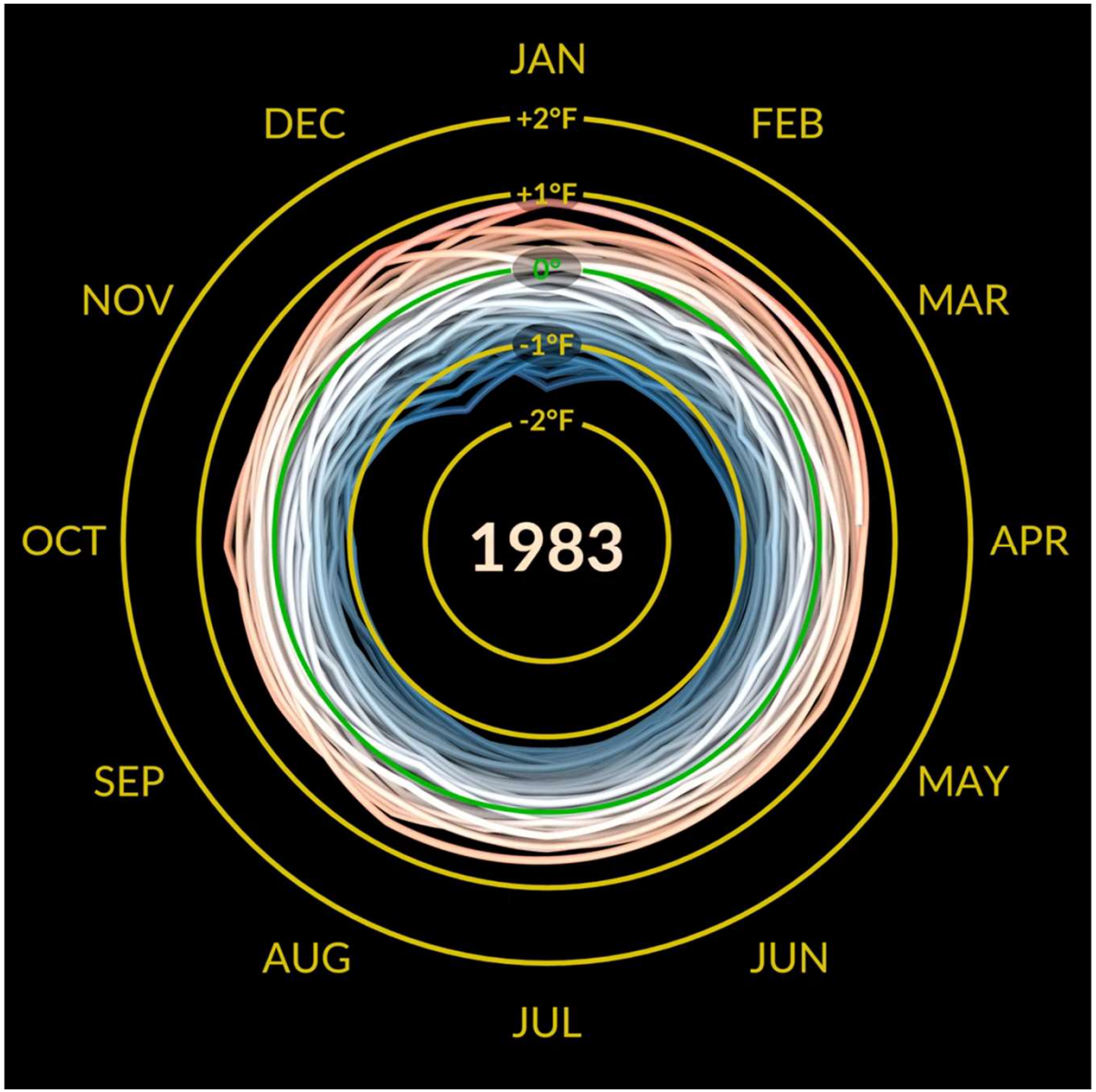
- Inadequate monitoring (e.g. real-time, coverage) – weather, snow, glaciers, levels, flows, groundwater, water quality, biodiversity, etc.
- Poor data access (especially in the public domain)
- Poor knowledge base (e.g. elevation in flood-prone areas, groundwater, water quality)
- Poor mainstreaming of climate risks (e.g. historical variability, climate change)
- Poor tools for planning (investment, resource) and management (e.g. forecasting, system operations within and across boundaries)

Institutions

- Inadequate institutional arrangements (e.g. transboundary water institutions/coordination)
- Poor institutional capacity and country commitment to regional organizations
- Poor access to global good practice
- Poor contribution to global good practice
- Poor use of ICT/modern tech
- Poor links with potential partners (e.g. academia, CSOs, private sector, etc.) at various levels (global, regional, national, local)

Investments

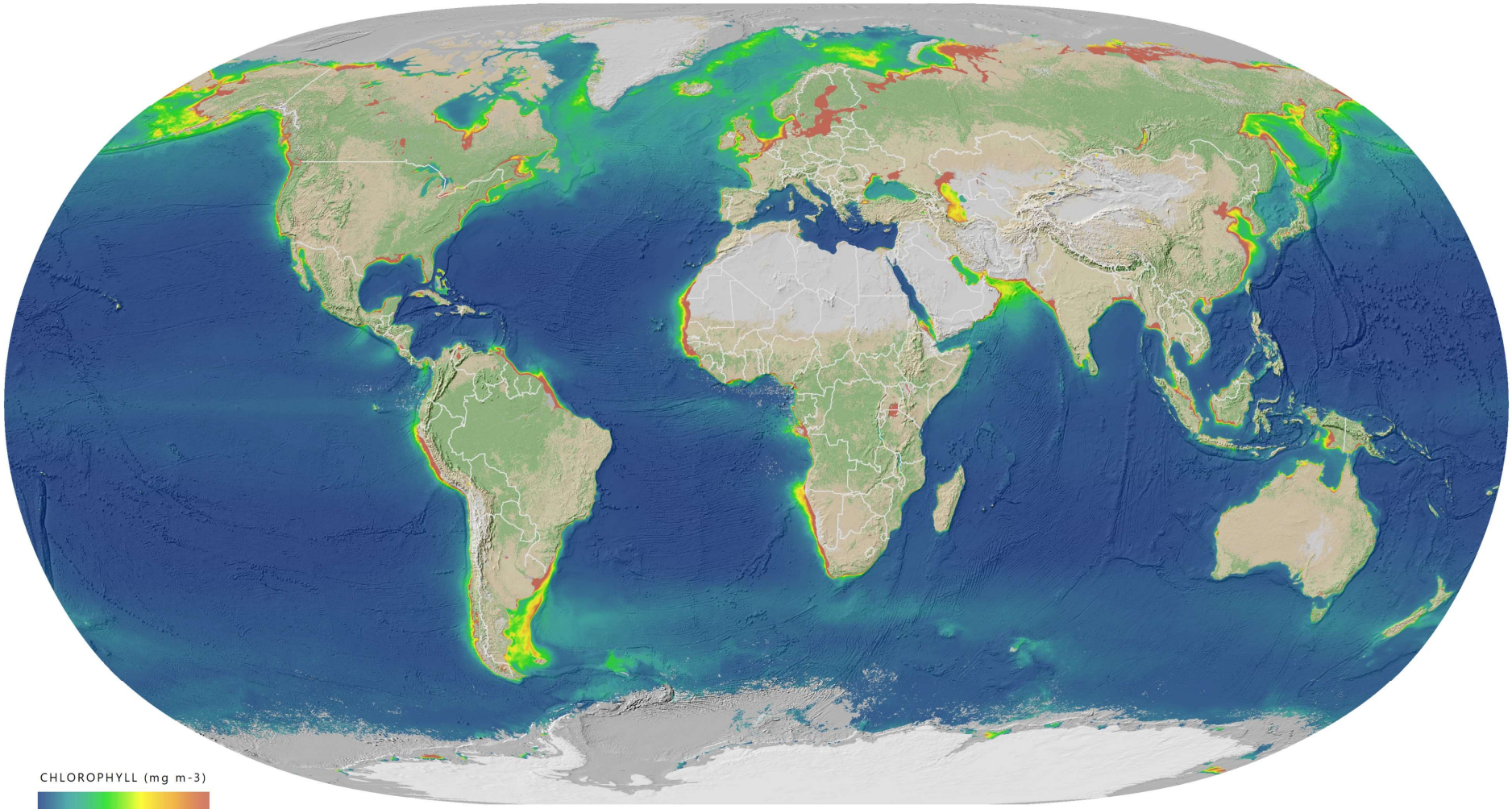
- Poor monitoring infrastructure
- Poor institutional infrastructure (operational centers/control rooms, computer training rooms, VCs, etc.)
- Inadequate investments (e.g. water infrastructure, watersheds, complementary and enabled infrastructure) contributing to, enabled by, or requiring regional cooperation
- Disputes during infrastructure creation/operation



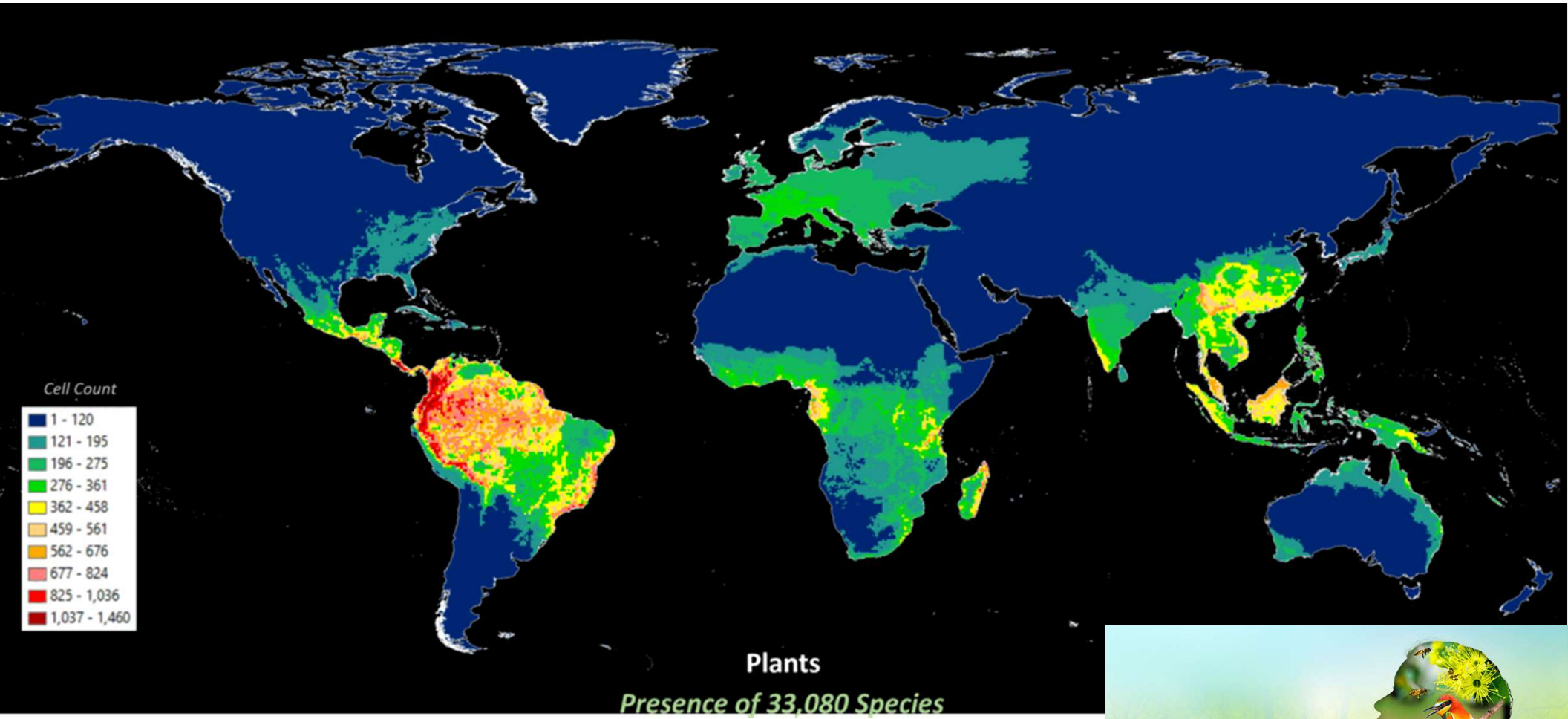
Source: NASA

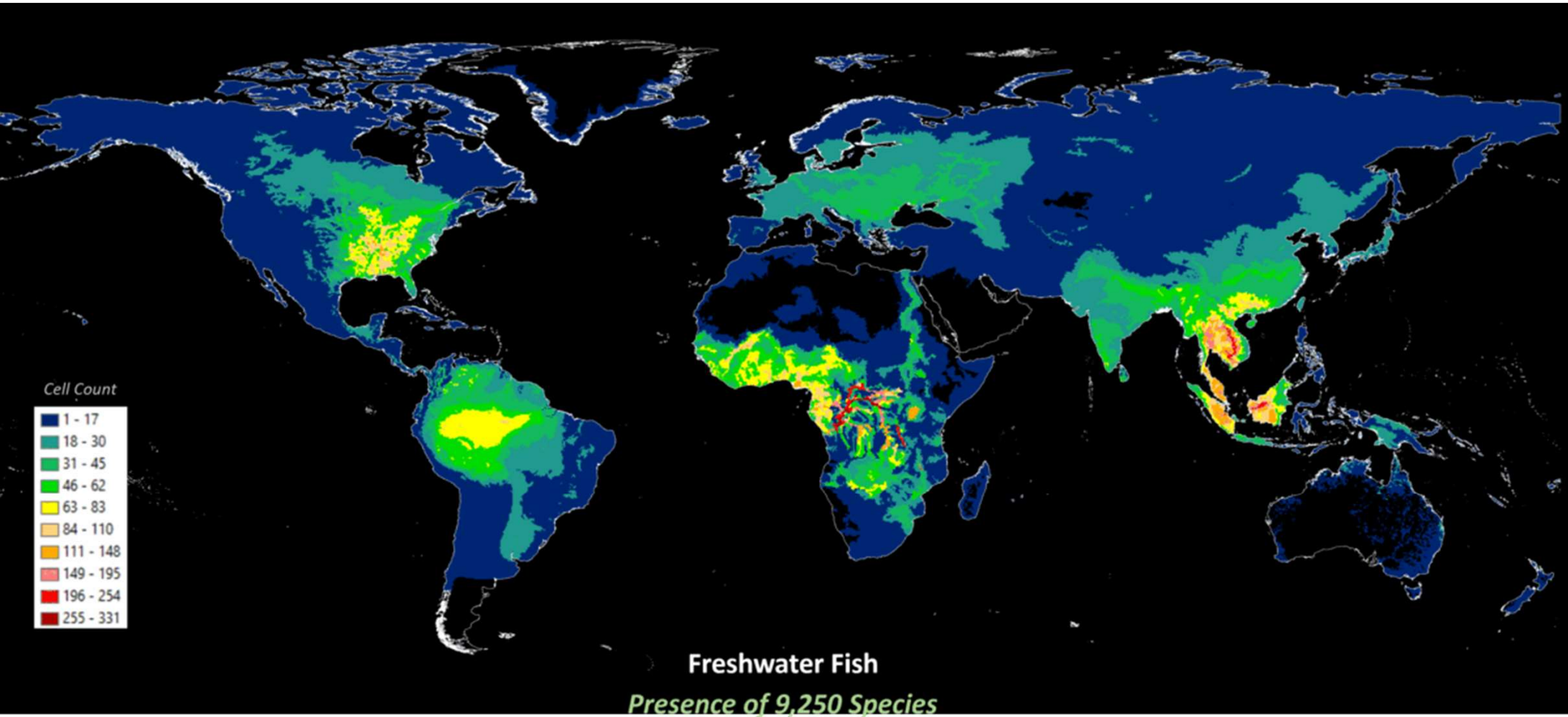
WATER CHLOROPHYLL

(2002-2021 AVERAGE)



Data Source: MODIS-Aqua, NASA

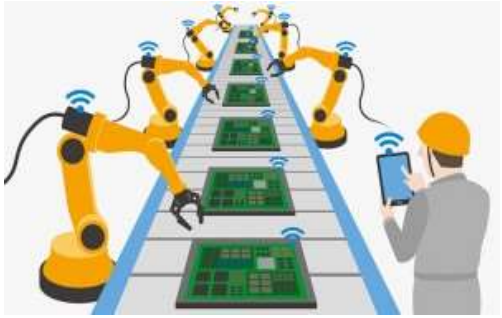

Cell Count
1 - 120
121 - 195
196 - 275
276 - 361
362 - 458
459 - 561
562 - 676
677 - 824
825 - 1,036
1,037 - 1,460
Plants
Presence of 33,080 Species


Cell Count
1 - 17
18 - 30
31 - 45
46 - 62
63 - 83
84 - 110
111 - 148
149 - 195
196 - 254
255 - 331
Freshwater Fish
Presence of 9,250 Species

A new world of “Disruptive Technology”

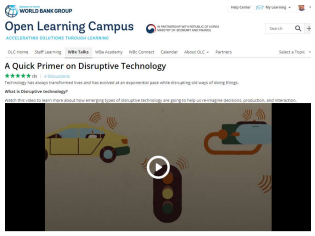
“Disrupt” data value chains

- ***Data Collection***: Monitoring/Surveys (in-situ sensors/IoT/Biometrics, earth observation (satellite, aerial, UAVs), crowdsourcing, digitization…
- ***Data Management:*** Telemetry, 5G, cloud services, open data, Blockchain, …
- ***Data Analysis:*** Big data, Geospatial/ AI/Machine Learning, modeling/ scenario analysis, script repositories, Cloud/Edge/Quantum computing…
- ***Data Access:*** Open data APIs, data visualization, gamification, mixed reality-AR/VR, …
- ***Outreach:*** Platforms/Social Media/Portals/ Apps/e-books/Competitions…



“Disrupt” production value chains

- 3D/4D printing/additive manufacturing…
- “Digital Twins”
- Automation/SCADA…
- Robotics/ Autonomous transport…
- Advanced materials/nanotech/ biotech/genomics/energy tech/ green tech, ag tech…



http://www.appsolutelydigital.com/dt/

“Disrupt” stakeholder value chains

- Virtual social networks/ Digital Platforms…
- Sharing economy…
- Crowdsourcing, gamification, competitions (e.g. *hackathons*, *appathons…*)
- Mobile money, fintech, cryptocurrency…
- Blockchain enabled value chains
- Maker movement/DIY/Tech Incubators…
- Virtual learning/re-skilling…

Disruptive tech could help us reimagine global development

Making "smart development" wrt climate, water and natural resources, energy, food, waste, mobility, knowledge, services, networks

Online Services

Green Energy

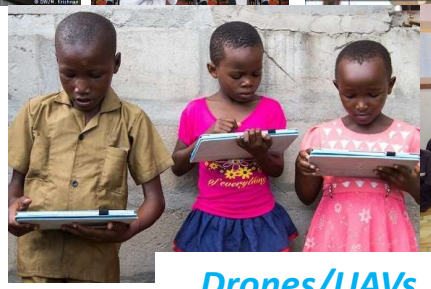
SmartClass in Rural Govt. Schools

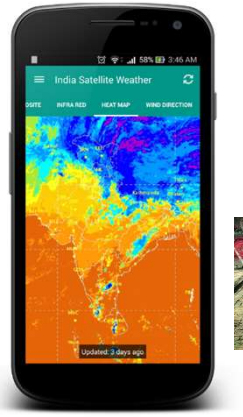
Broadband & Smartphone Access

WiFi in villages

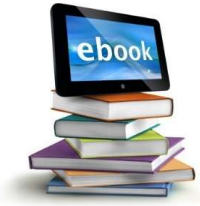
Apps, e-services & e-learning

Planning





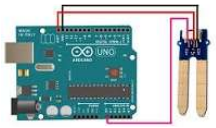
Access to a new world of Data, Information, Knowledge and Services



3D Printed Infrastructure

Sensors/IoT

(e.g. for soil moisture)



Drones/UAVs

(e.g. for monitoring, seeding, delivery)

Looking Ahead in the Transboundary Water World…

Tech-facilitated Transboundary Waters Solutions

Information

- Comprehensive Knowledge base (hydrology, environmental/climate, socio-economic, infrastructure, …)
- Online data services & cloud services
- Real-time monitoring/analysis (e.g. nowcasting, forecasting – weather, flows/levels, flood, drought)
- Climate risk management (variability, change)
- E-packaging (dashboards, interactive documentation, eBulletins,…)
- Investment and Resource Planning and operational coordination decision support systems (DSS)

Institutions

- Innovative capacity development (e.g. tech awareness/skills, e-learning)
- Basin/sub-basin organization collaboration platforms
- Partnerships/ outreach (internships, diaspora, hackathons, private sector services)
- Access and contribution to global good practice

Investments

- In-situ monitoring
- Modern Institutional Infrastructure (e.g. for basin/sub-basin coordination)
- Shared innovative water systems infrastructure design, planning, financing, implementation
- Coordinated water infrastructure filling/ operating

Information & Analysis Trends

What's Out?

Are we part of the problem?

Paper Records/Publication

Inadequate and Inaccessible Data

"Retail" info systems & modeling

Reliance on Websites and Pdfs

"Have you registered first?"

"Tell me why you need the data"

What's In?

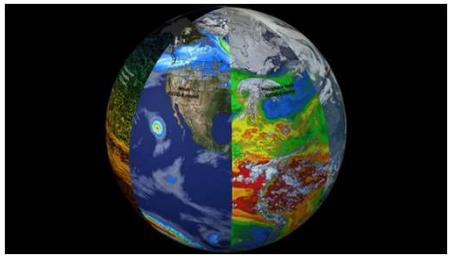
Can we be part of the solution?

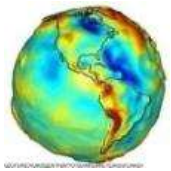
Online interoperable OGC data service formats/ Open APIs

Free and subscription services

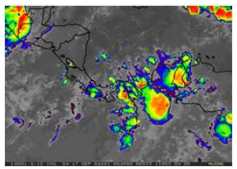
"Wholesale" Cloud Analytics

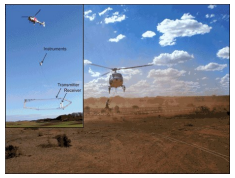
Separate data services and consumption platforms (e.g. dashboards, Interactive documentation)



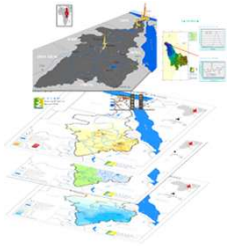


"Top-Down" Data Acquisition System

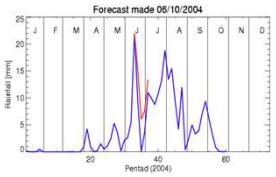




Satellite & Aerial Earth Observation



Data Rescue
GIS and other datasets



Data Management

Analytics/Models

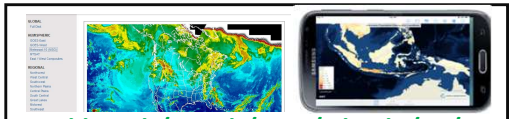
Big Data
Data Science

Platforms
APIs

Cloud Services

Machine Learning
& other AI

ChatBots
Crowdsourcing



Dashboards/Portals/Apps/e-books/AR/VR

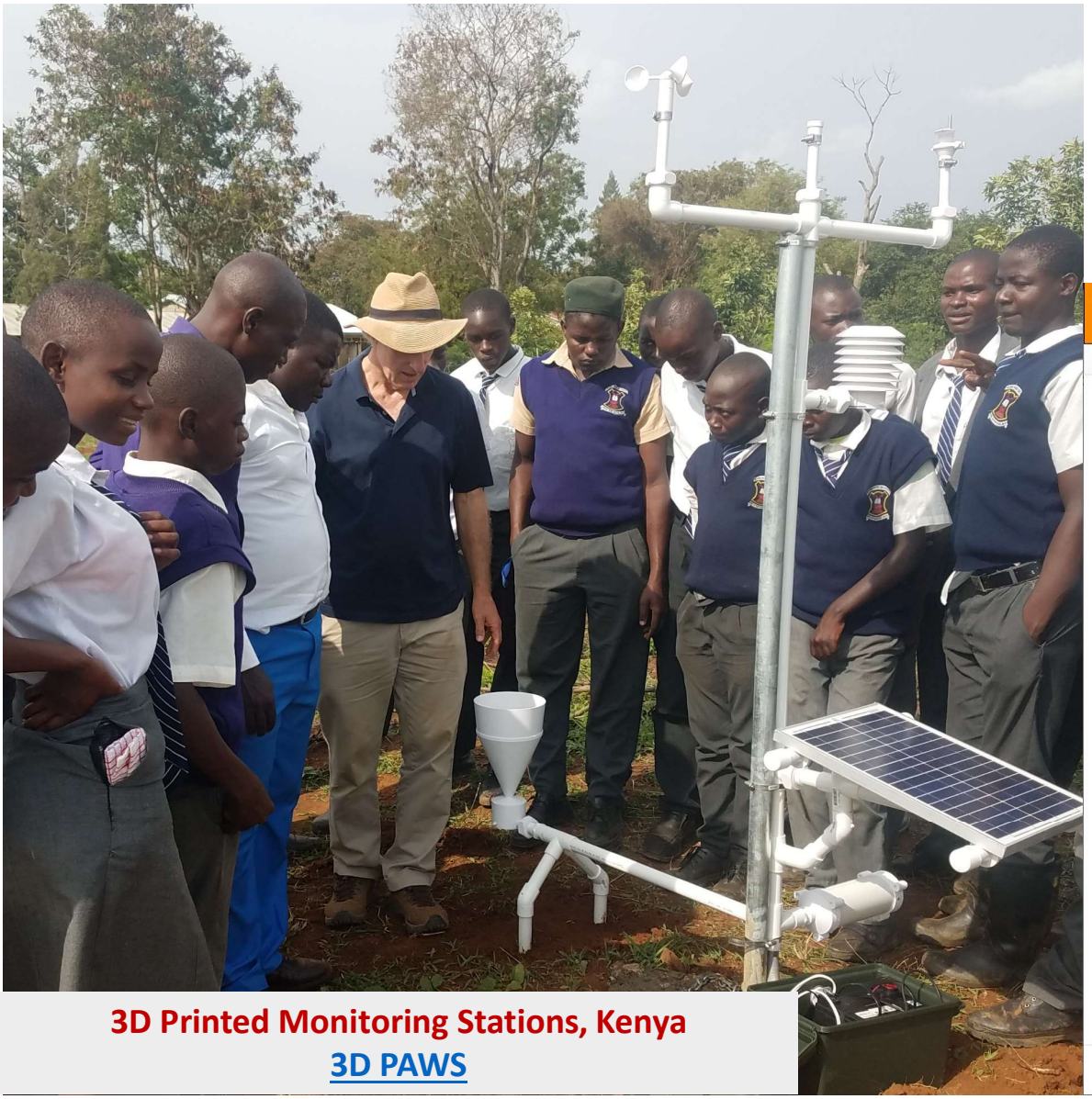
Stakeholder Alerts

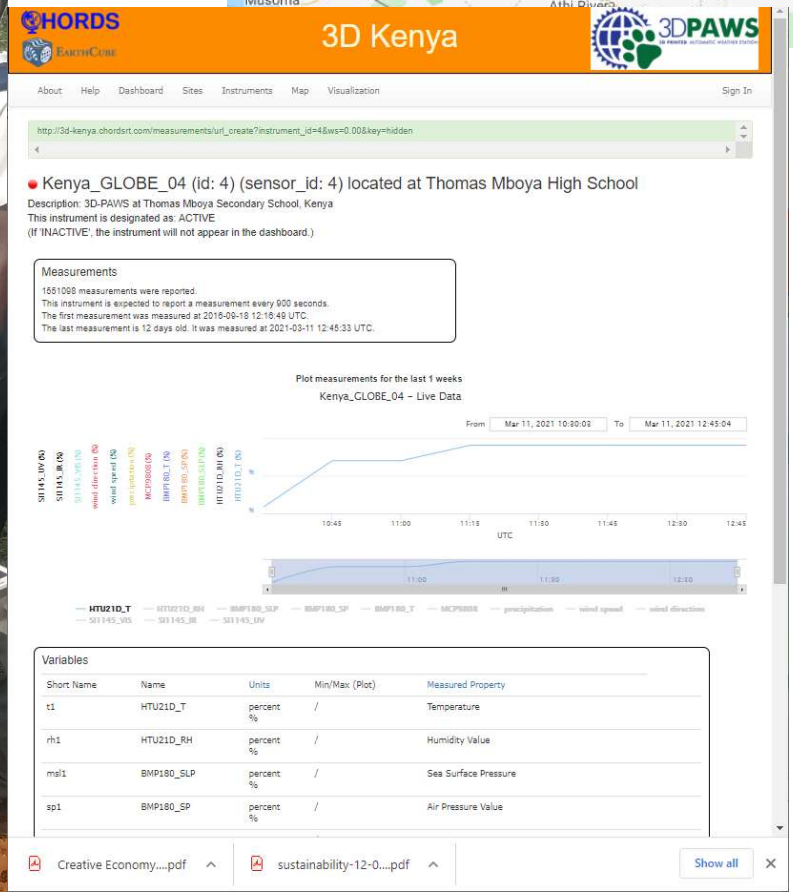
Operational Control Rooms

Manual Monitoring
Crowdsourcing

Automated Monitoring

"Bottom-up" Data Acquisition System → IoT

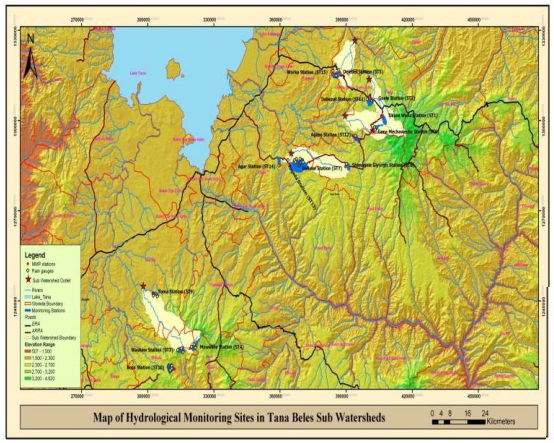




3D Printed Monitoring Stations, Kenya

3D PAWS

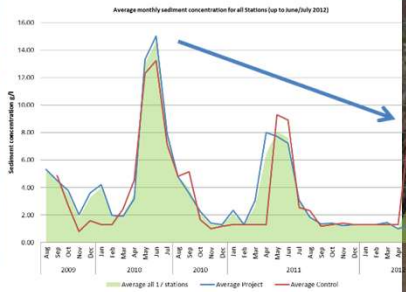
Community Monitoring

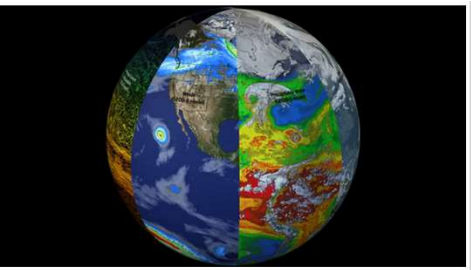


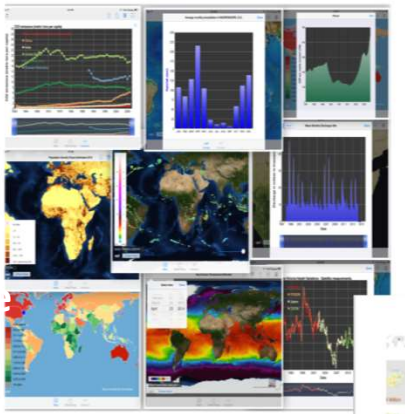
	2009	2010	2011	2012	Total
Staff	3132	11812	12409	6522	33875
Turbidity	3131	12069	12469	6624	34293
Rain	3116	>12777	>15000	>15000	>47000
Flow					>500
Sed samples	1425	4176	3139	1216	9956

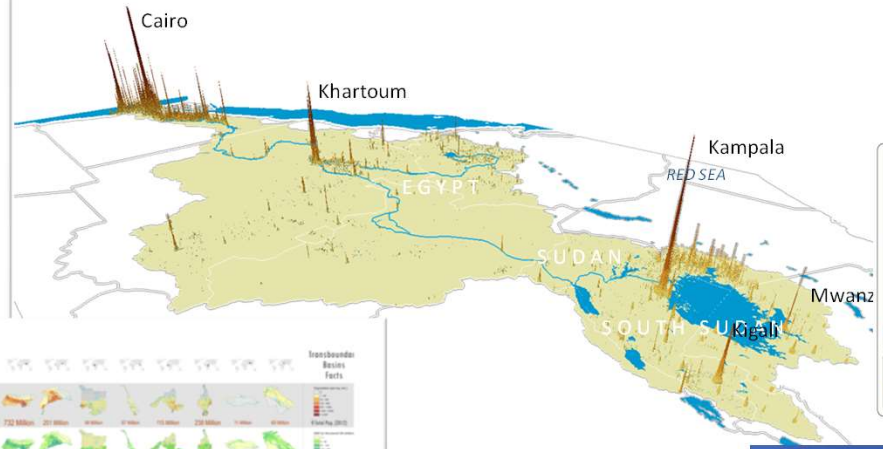
Secchi Jug for turbidity

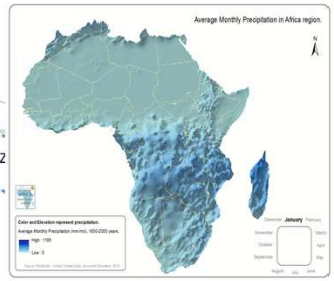
Sediment Concentration Analyses

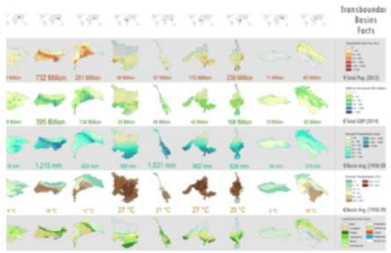










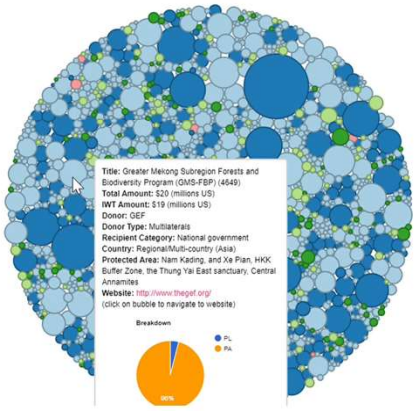


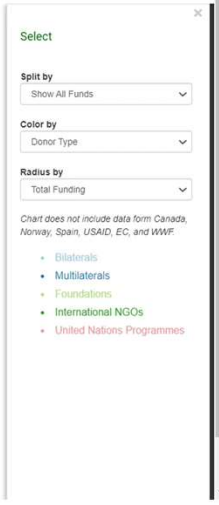
Illegal Wildlife Trade Charts

Not secure | appsolutelydigital.com/WildLife/charts.html

ANALYSIS OF INTERNATIONAL FUNDING TO TACKLE ILLEGAL WILDLIFE TRADE

Chord Chart | Geographical Distribution | Charts | Bubble Chart | Search | Map Search





HydroInformatics eBook
https://spatialagent.org/HydroInformaticsEbook/

HydroInformatics eBook

spatialagent.org/HydroInformaticsEbook/

"Disrupting" HydroInformatics

An Interactive E-book

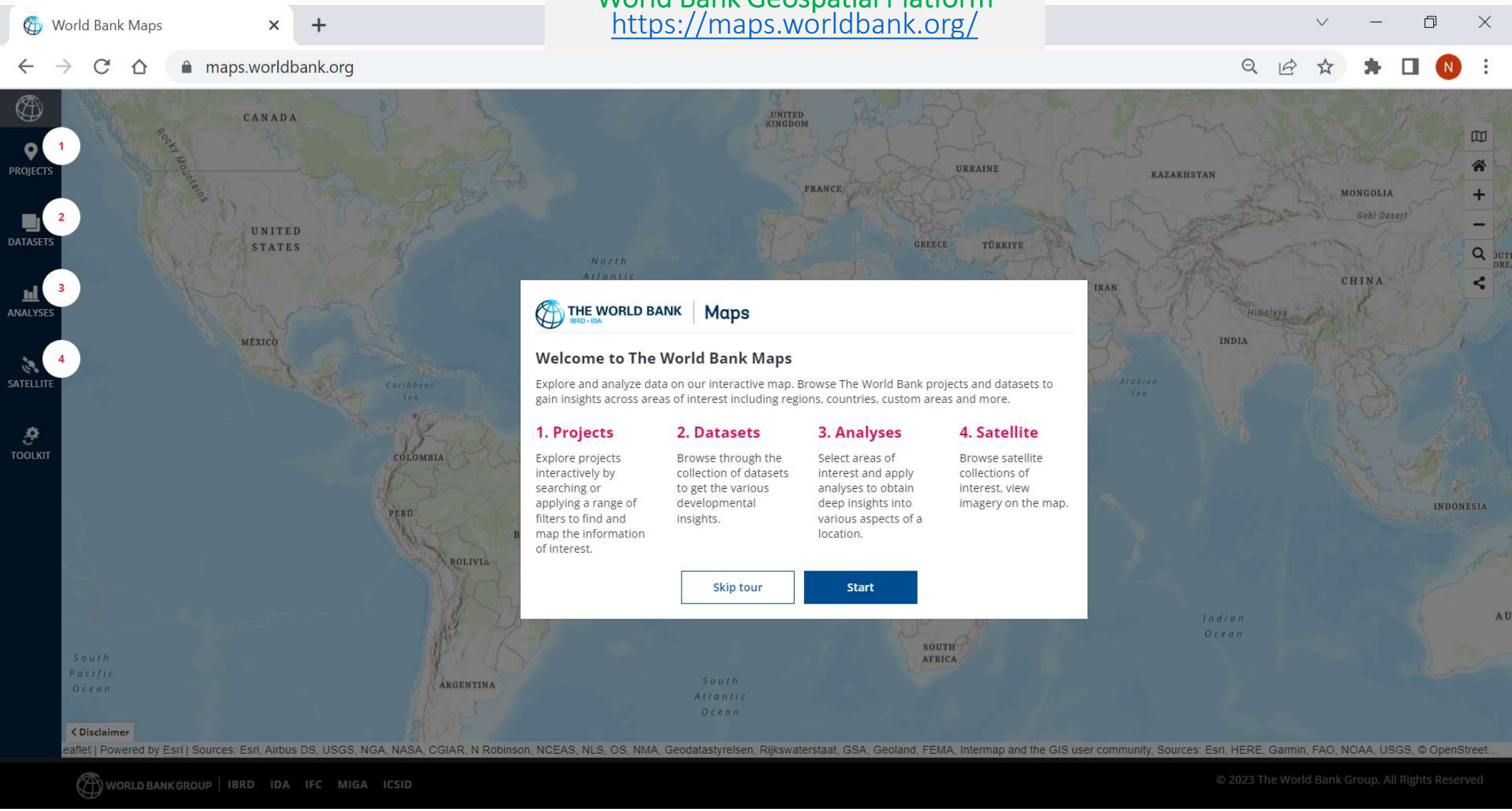
Table of Contents

Brought to you by:

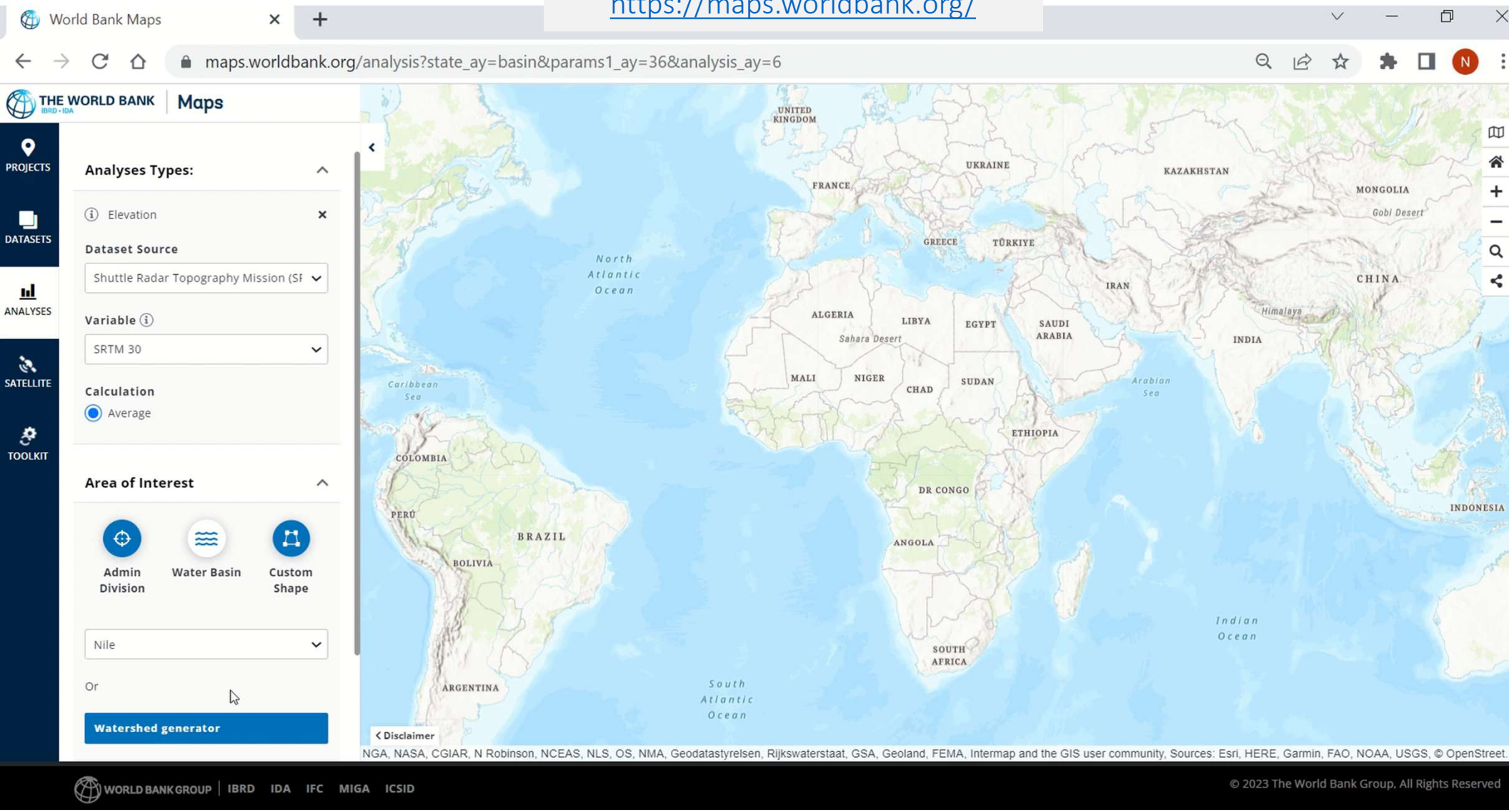
WORLD BANK GROUP
Environment, Natural Resources & Blue Economy

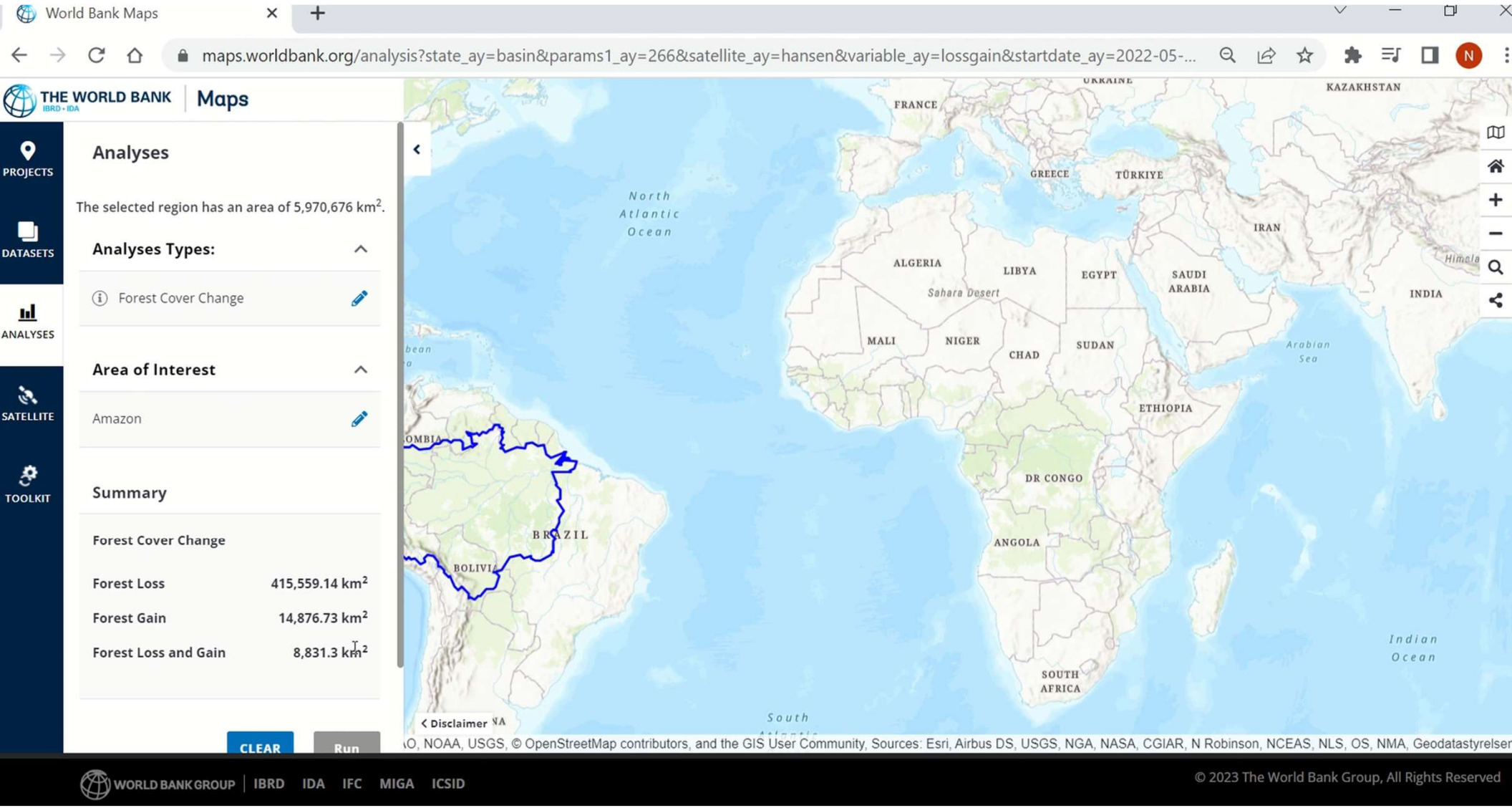
OLC

World Bank Geospatial Platform
https://maps.worldbank.org/



World Bank Geospatial Platform
https://maps.worldbank.org/




World Bank Maps
maps.worldbank.org/analysis?state_ay=basin&params1_ay=266&satellite_ay=hansen&variable_ay=lossgain&startdate_ay=2022-05-...
THE WORLD BANK
IBRD • IDA
Maps
PROJECTS
DATASETS
ANALYSES
SATELLITE
TOOLKIT
Analyses
The selected region has an area of 5,970,676 km².
Analyses Types:
Forest Cover Change
Area of Interest
Amazon
Summary
Forest Cover Change
Forest Loss 415,559.14 km²
Forest Gain 14,876.73 km²
Forest Loss and Gain 8,831.3 km²
CLEAR
Run
North Atlantic Ocean
FRANCE
GREECE
TÜRKIYE
KAZAKHSTAN
IRAN
ALGERIA
LIBYA
EGYPT
SAUDI ARABIA
Sahara Desert
INDIA
MALI
NIGER
CHAD
SUDAN
Arabian Sea
ETHIOPIA
DR CONGO
BRAZIL
BOLIVIA
ANGOLA
SOUTH AFRICA
Indian Ocean
South Atlantic
Disclaimer
O, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelser
WORLD BANK GROUP | IBRD IDA IFC MIGA ICSID
© 2023 The World Bank Group, All Rights Reserved

Hydro Informatics Data Portal | Water Monitor Lakes and Reserv | Hydroweb

spatialagent.org/HydroInformatics/

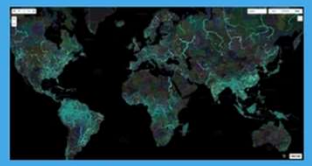
Select Language

All | Water | Disasters | Climate | Environment | Social | Economic

Lake Levels


Standardized Precpitation Index


GEOGloWS Streamflow Explorer


Earth Engine Water Watch


Hydromet Catalog


Water In Agriculture Portal


CHRS iRain


City Water Intakes


Glacier Inventory


Soil Erosion Watch

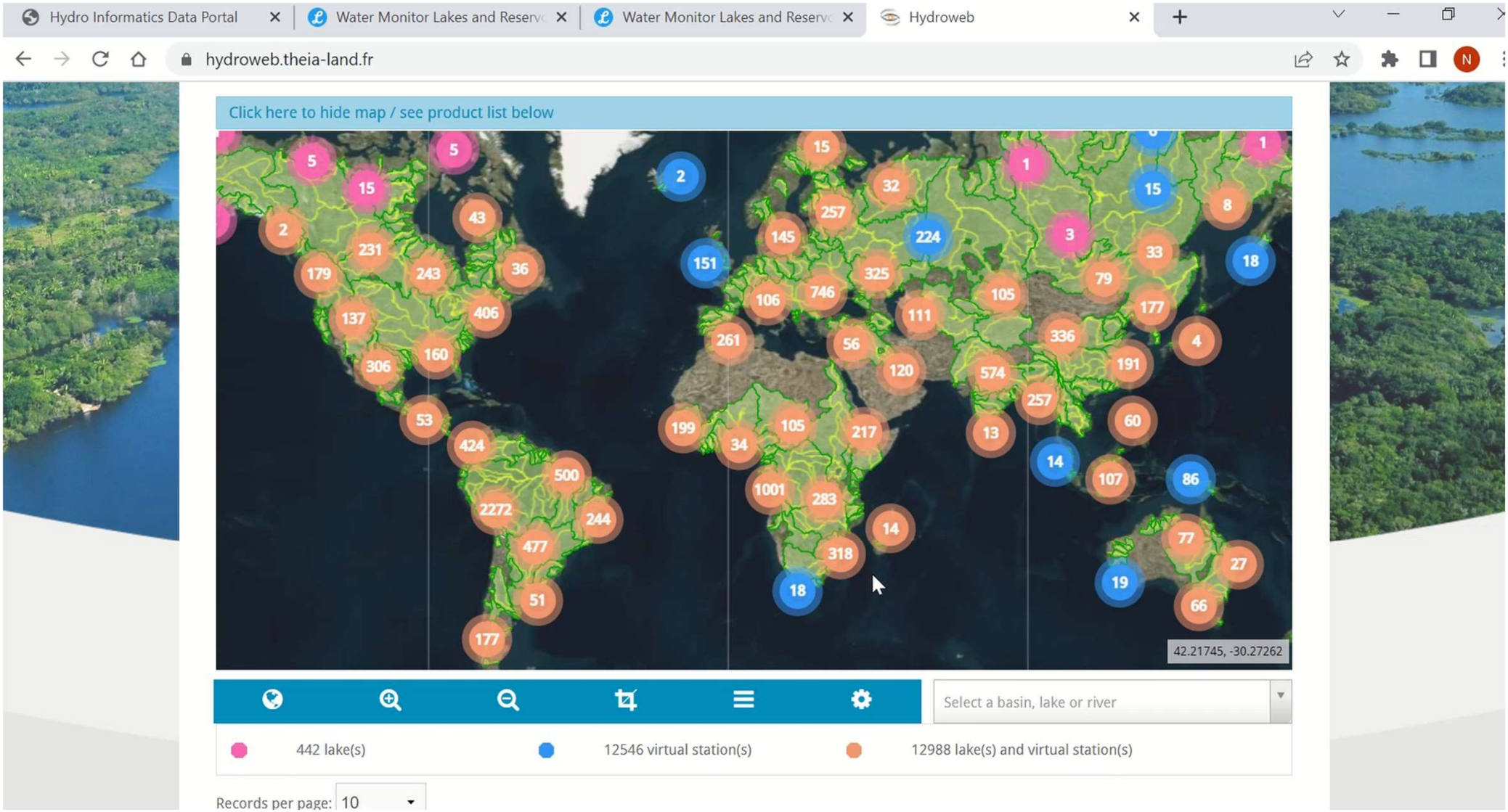

Surface Water Explorer


Cropping Extent


Water Conflicts

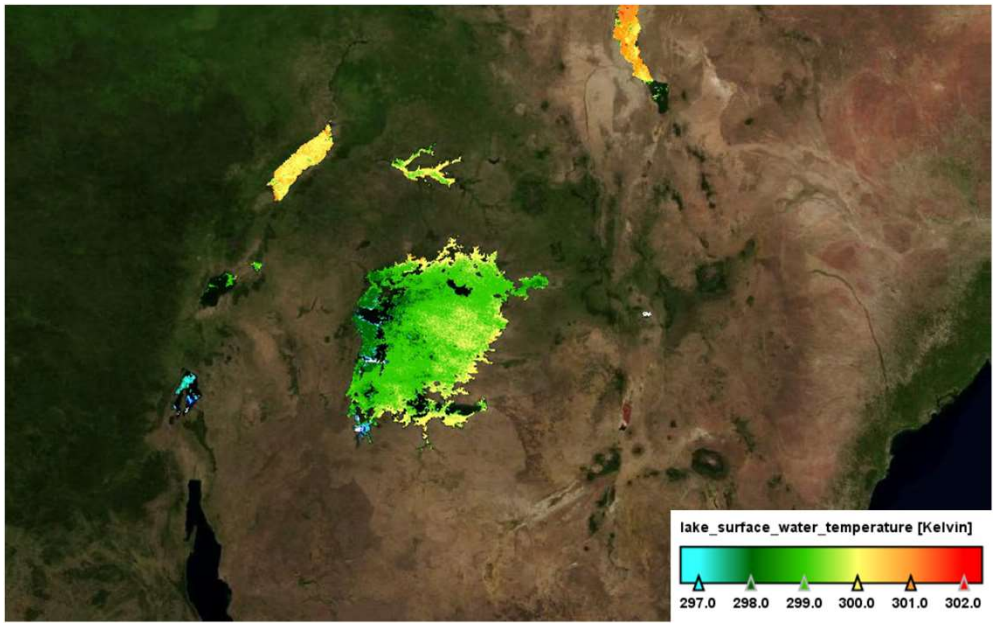

Population Density

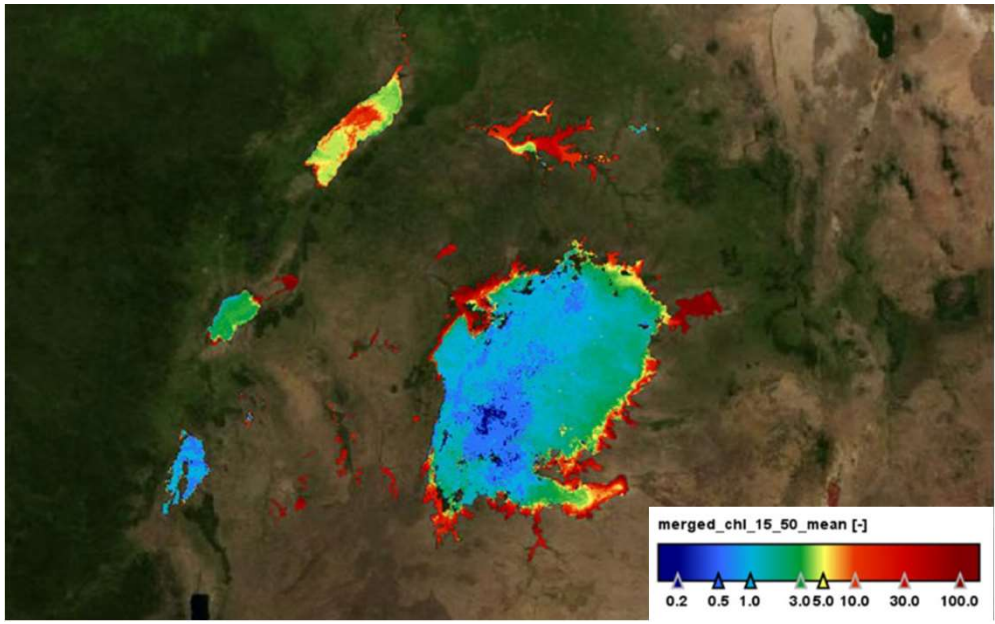

Land Cover Comparison

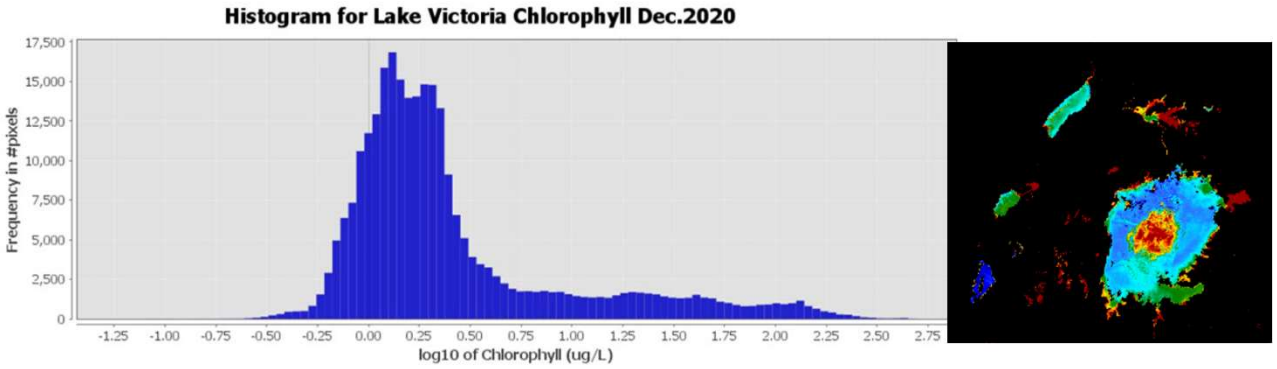

Hydro Informatics Data Portal
Water Monitor Lakes and Reserv
Water Monitor Lakes and Reserv
Hydroweb
hydroweb.theia-land.fr
Click here to hide map / see product list below
42.21745, -30.27262
Select a basin, lake or river
442 lake(s)
12546 virtual station(s)
12988 lake(s) and virtual station(s)
Records per page: 10

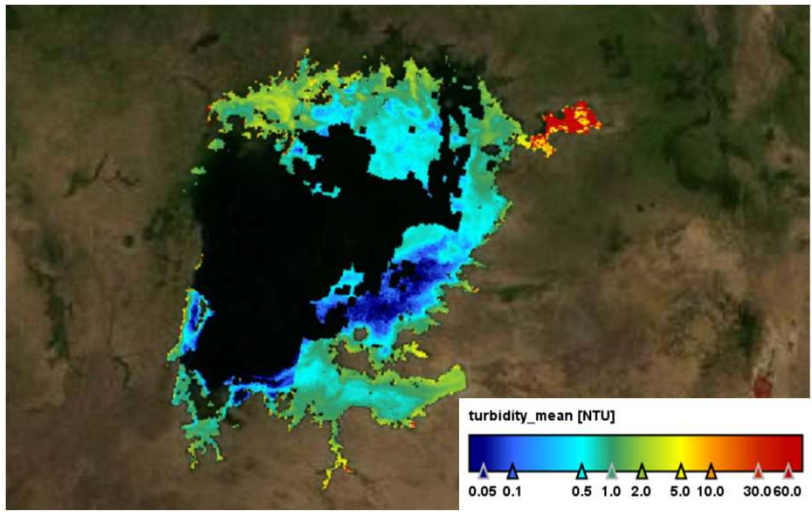
Remotely Sensed Lake Products

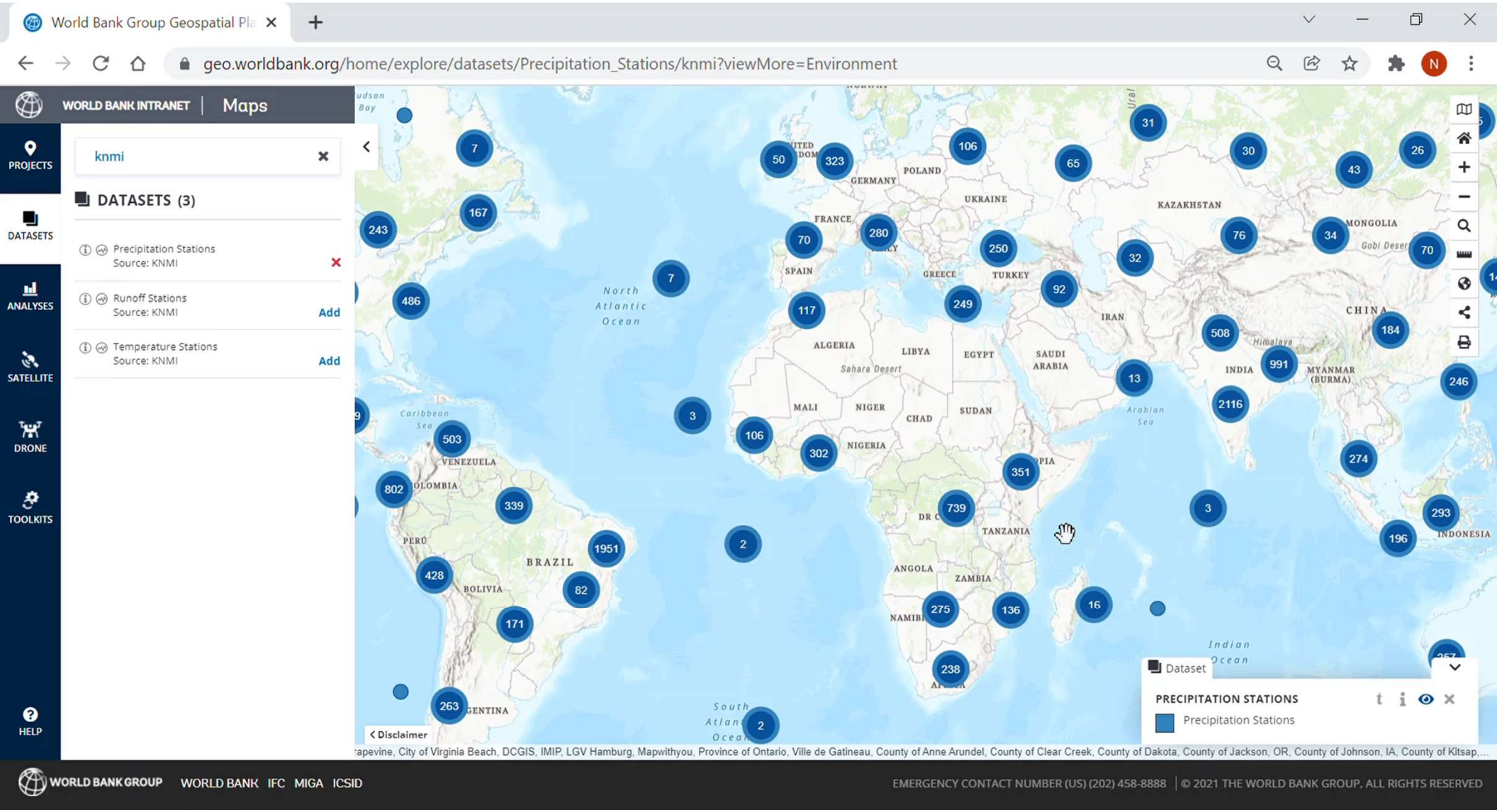
Source: GEO Aquawatch/WB





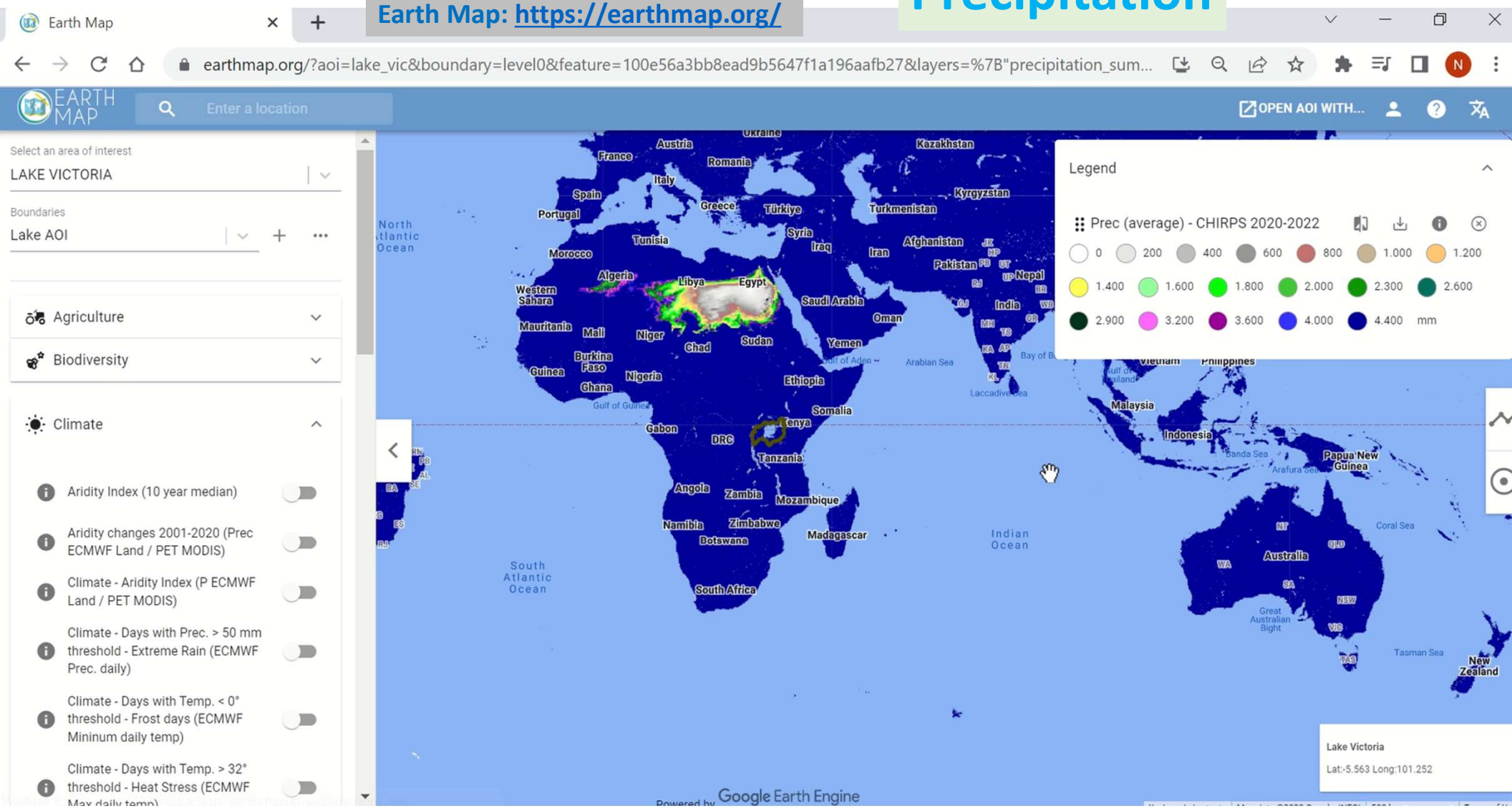





World Bank Group Geospatial Pla
geo.worldbank.org/home/explore/datasets/Precipitation_Stations/knmi?viewMore=Environment
WORLD BANK INTRANET | Maps
PROJECTS
DATASETS
ANALYSES
SATELLITE
DRONE
TOOLKITS
HELP
knmi
DATASETS (3)
Precipitation Stations
Source: KNMI
Runoff Stations
Source: KNMI
Add
Temperature Stations
Source: KNMI
Add
North Atlantic Ocean
Caribbean Sea
Sahara Desert
Arabian Sea
Indian Ocean
South Atlantic Ocean
Himalaya
Gobi Desert
Dataset
PRECIPITATION STATIONS
Precipitation Stations
Disclaimer
WORLD BANK GROUP
WORLD BANK IFC MIGA ICSID
EMERGENCY CONTACT NUMBER (US) (202) 458-8888
© 2021 THE WORLD BANK GROUP, ALL RIGHTS RESERVED

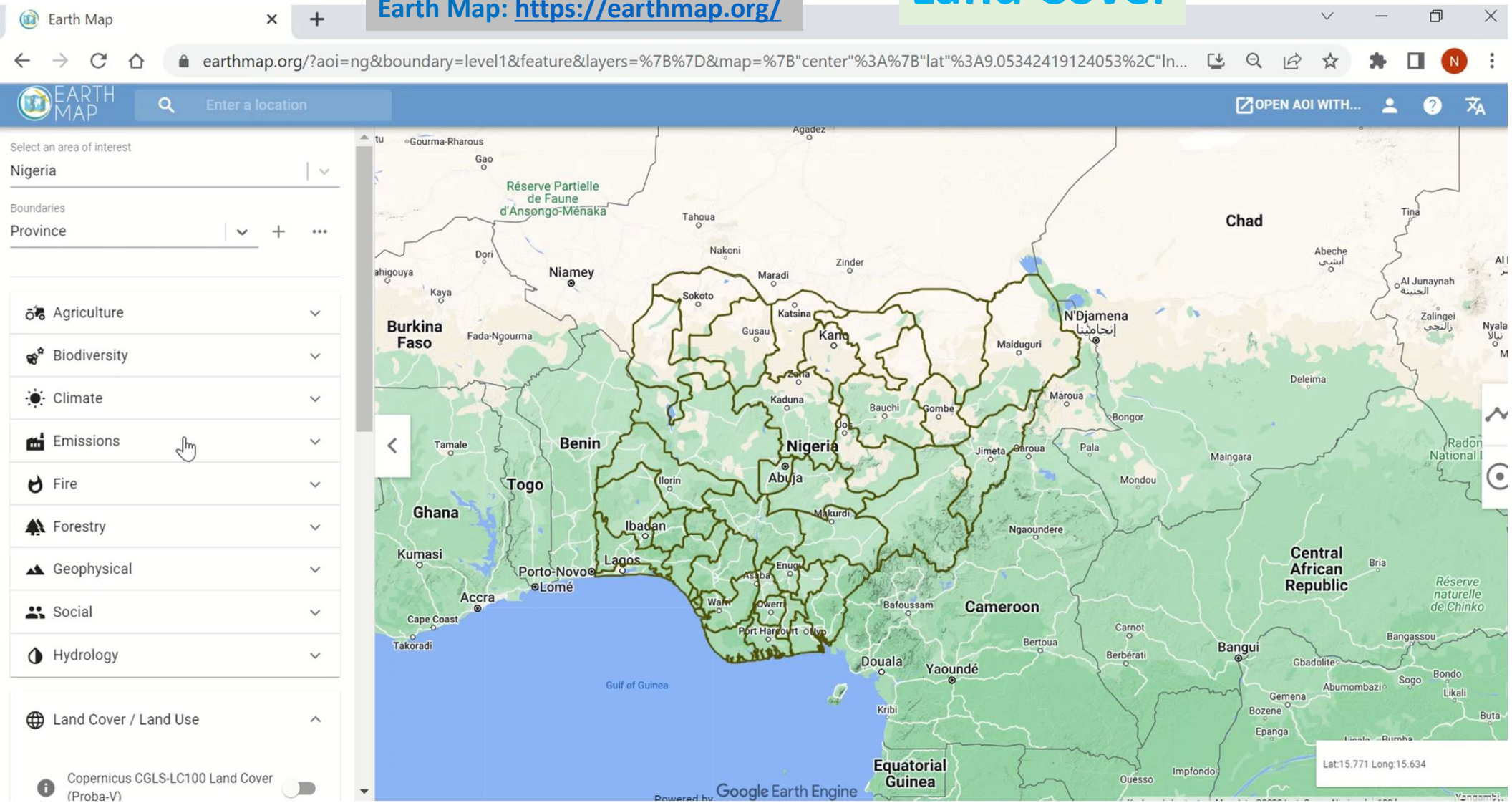
Precipitation

Earth Map: https://earthmap.org/



Land Cover

Earth Map: https://earthmap.org/



Article | Open Access | Published: 01 March 2023

Sub-continental-scale carbon stocks of individual trees in African drylands

Compton Tucker, Martin Brandt, Pierre Hiernaux, Ankit Kariryaa, Kjeld Rasmussen, Jennifer Small, Christian Igel, Florian Reiner, Katherine Melocik, Jesse Meyer, Scott Sinno, Eric Romero, Erin Glennie, Yasmin Fitts, August Morin, Jorge Pinzon, Devin McClain, Paul Morin, Claire Porter, Shane Loeffler, Laurent Kergoat, Bil-Assanou Issoufou, Patrice Savadogo, Jean-Pierre Wigneron, ... Rasmus Fensholt

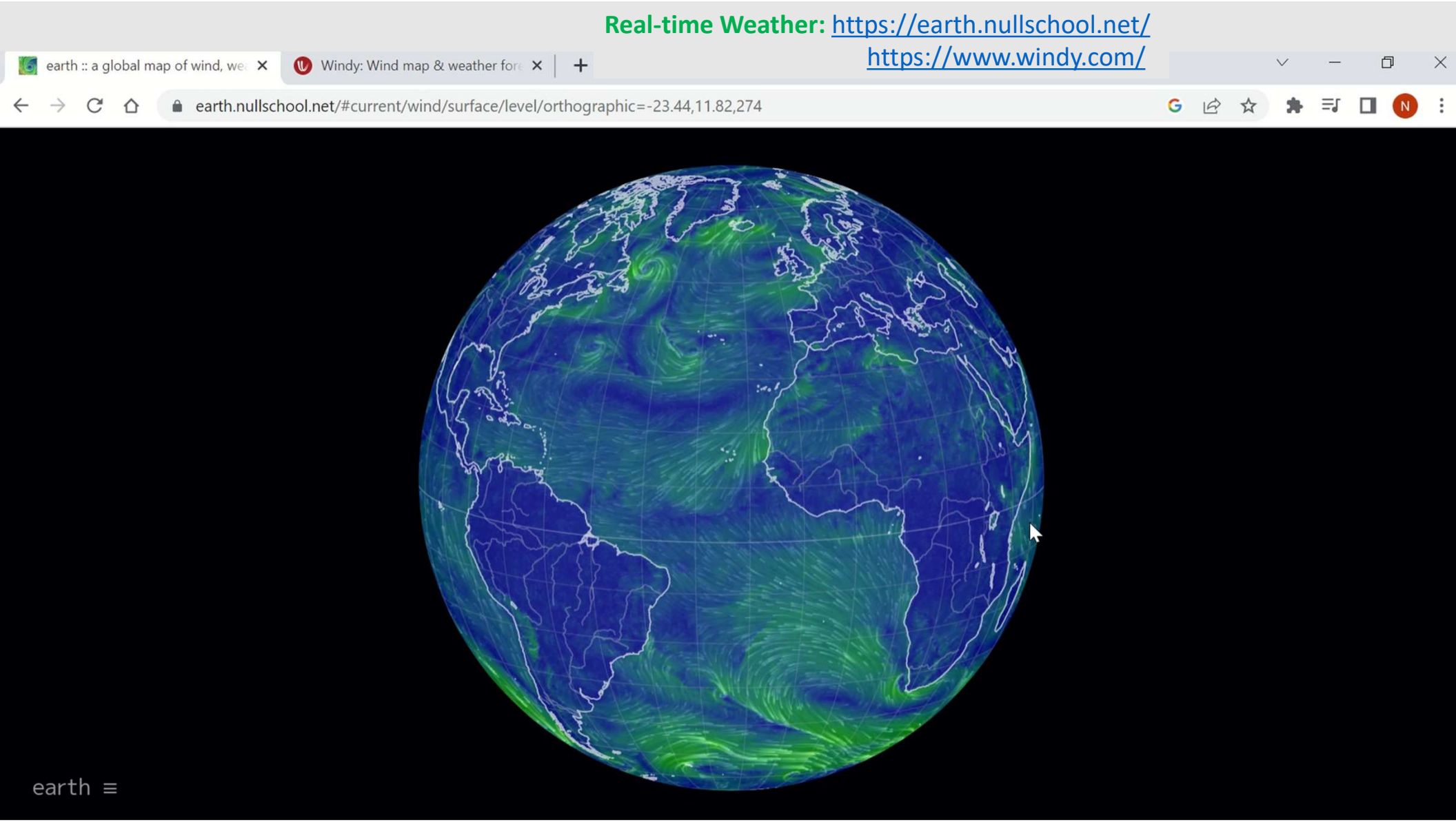
+ Show authors

Nature **615**, 80–86 (2023) | Cite this article

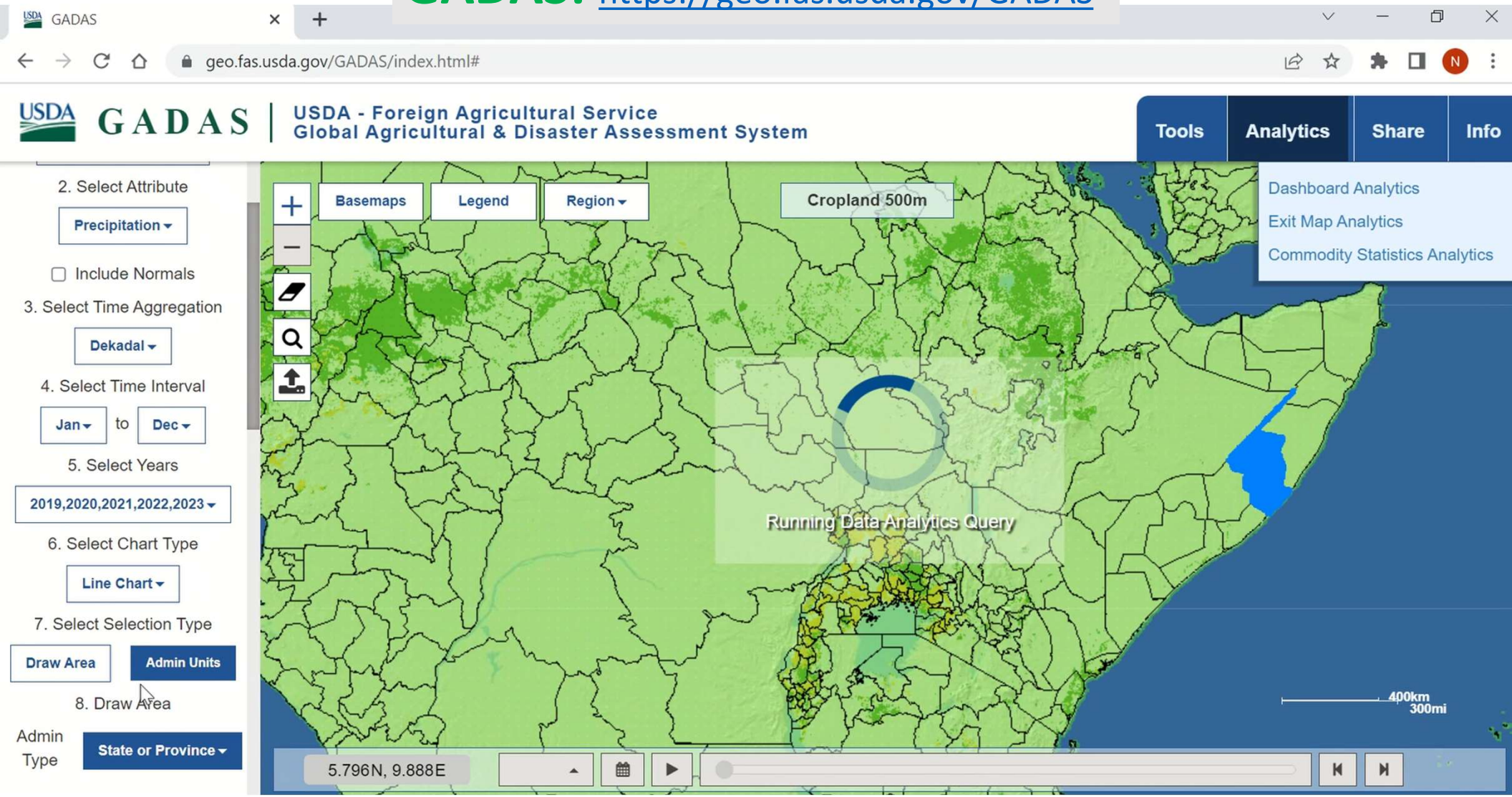
Abstract

The distribution of dryland trees and their density, cover, size, mass and carbon content are not well known at sub-continental to continental scales[1,2,3,4,5,6,7,8,9,10,11,12,13,14]. This information is important for ecological protection, carbon accounting, climate mitigation and restoration efforts of dryland ecosystems[15,16,17,18]. We assessed more than 9.9 billion trees derived from more than 300,000 satellite images, covering semi-arid sub-Saharan Africa

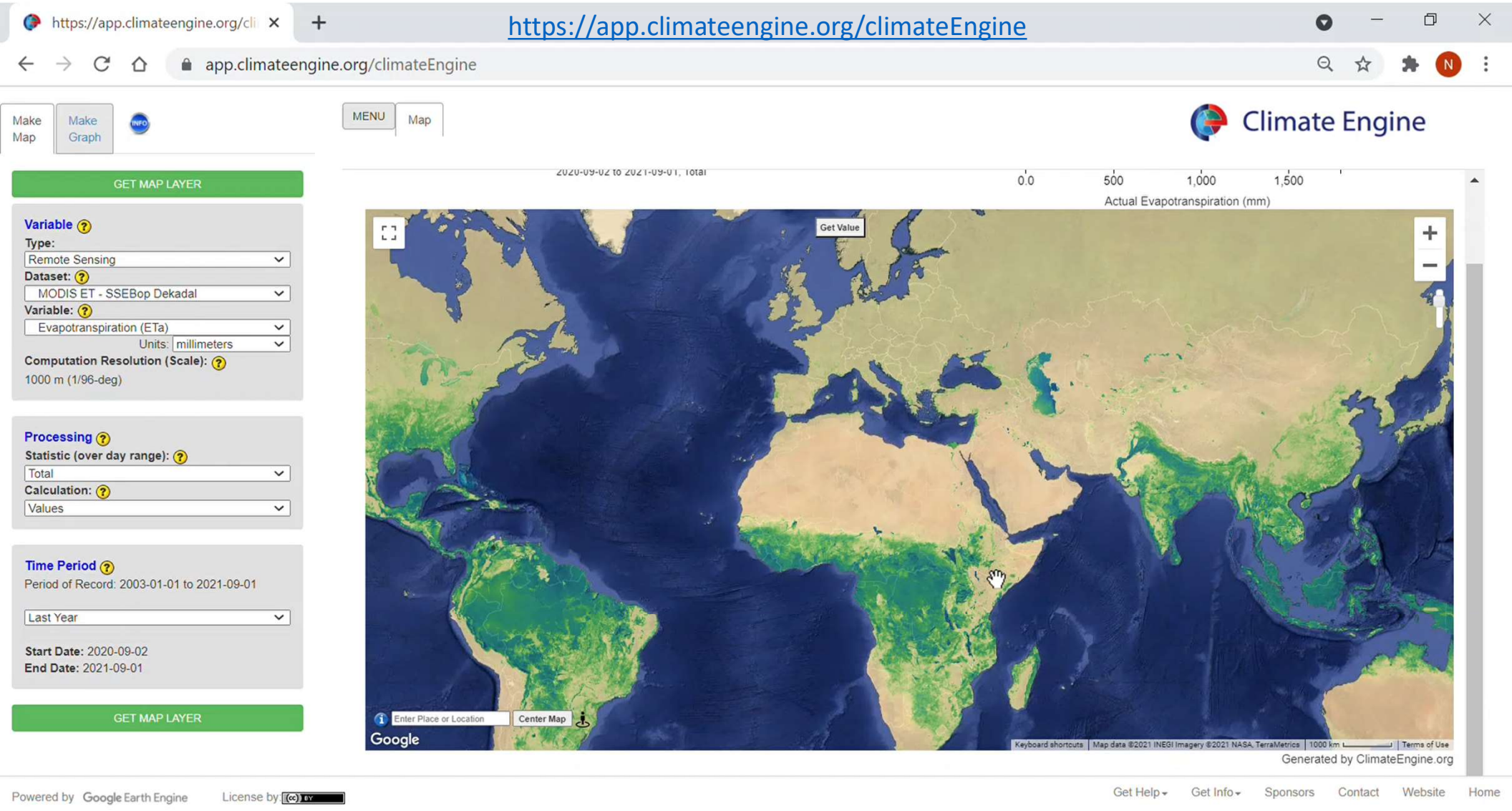
Real-time Weather: https://earth.nullschool.net/
https://www.windy.com/



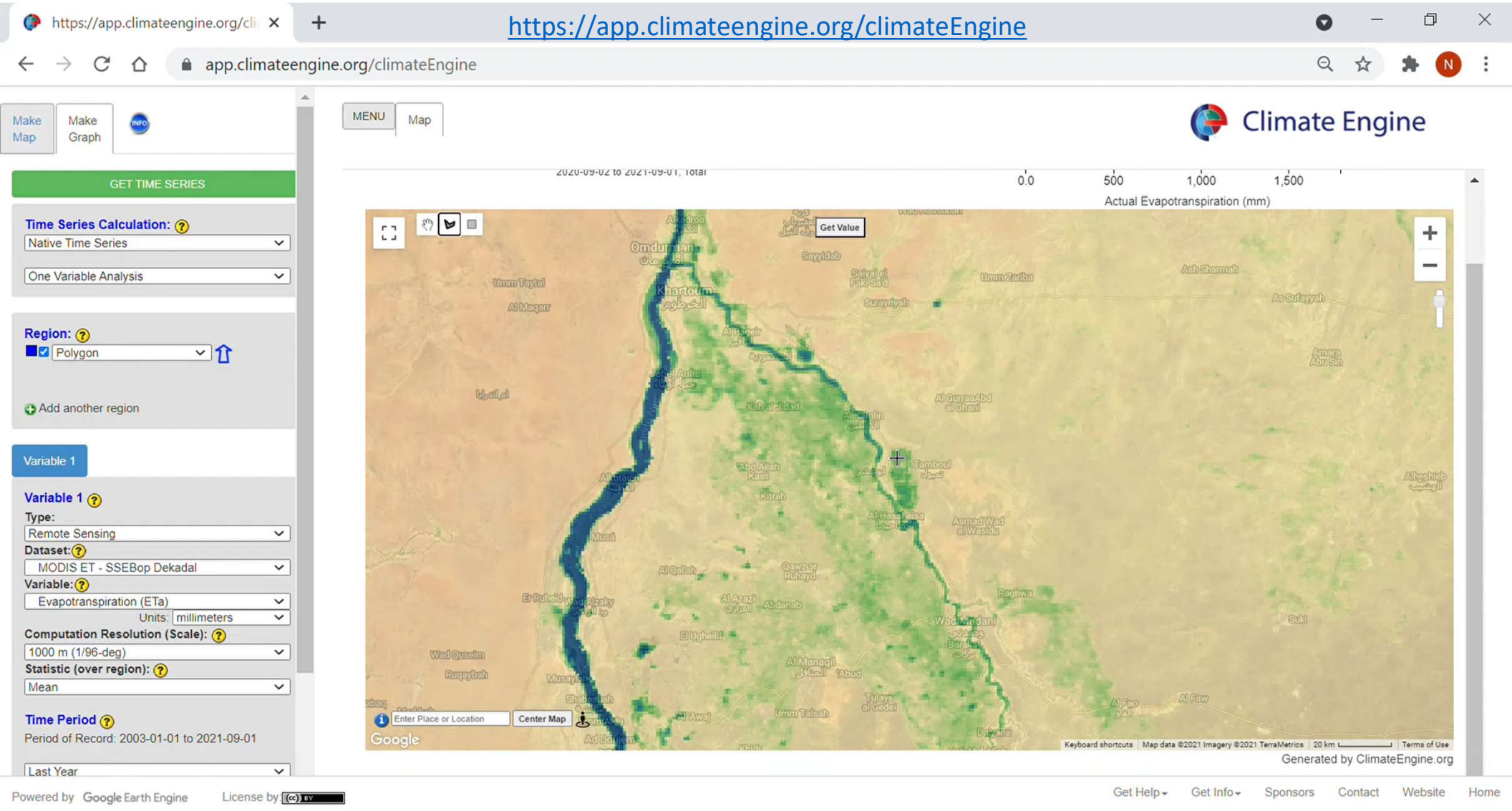
GADAS: https://geo.fas.usda.gov/GADAS



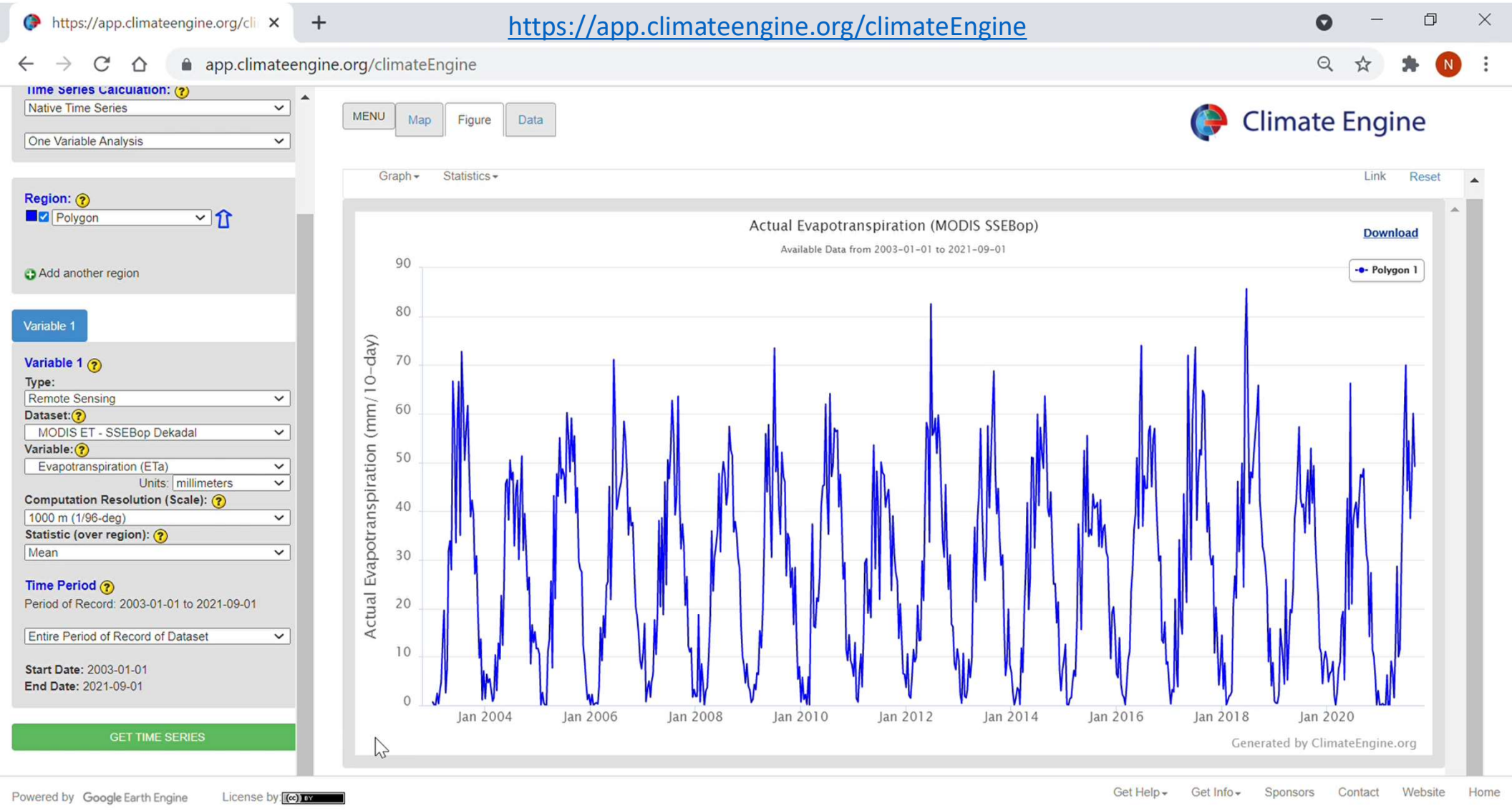
https://app.climateengine.org/climateEngine

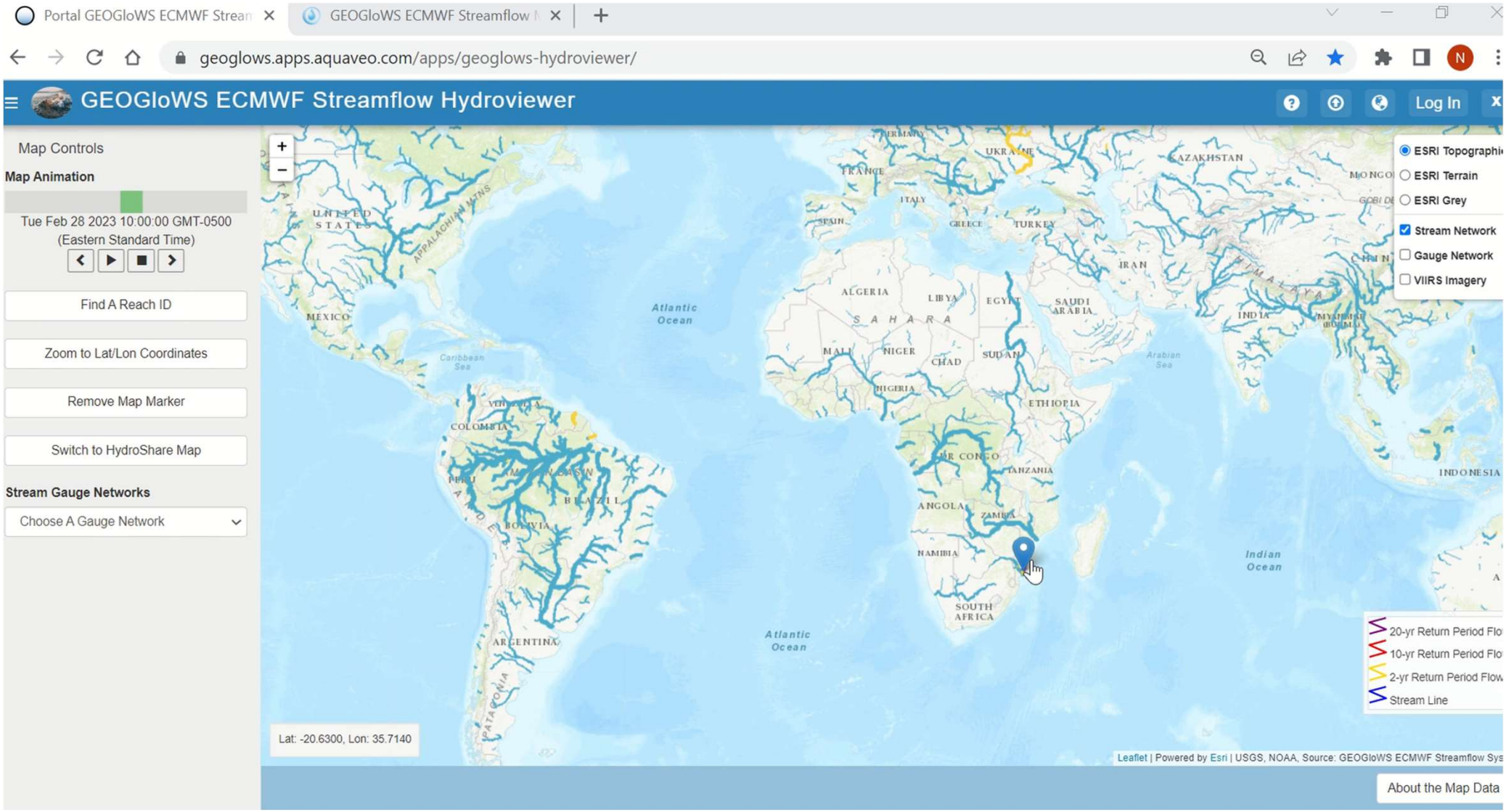


https://app.climateengine.org/climateEngine



https://app.climateengine.org/climateEngine




Portal GEOGloWS ECMWF Strean
GEOGloWS ECMWF Streamflow M
geoglows.apps.aquaveo.com/apps/geoglows-hydroviewer/
GEOGloWS ECMWF Streamflow Hydroviewer
Log In
Map Controls
Map Animation
Tue Feb 28 2023 10:00:00 GMT-0500
(Eastern Standard Time)
Find A Reach ID
Zoom to Lat/Lon Coordinates
Remove Map Marker
Switch to HydroShare Map
Stream Gauge Networks
Choose A Gauge Network
ESRI Topographi
ESRI Terrain
ESRI Grey
Stream Network
Gauge Network
VIIRS Imagery
20-yr Return Period Flo
10-yr Return Period Flo
2-yr Return Period Flow
Stream Line
Lat: -20.6300, Lon: 35.7140
Leaflet | Powered by Esri | USGS, NOAA, Source: GEOGloWS ECMWF Streamflow Sys
About the Map Data
Atlantic Ocean
Indian Ocean
Arabian Sea
Caribbean Sea
UNITED STATES
MEXICO
COLOMBIA
BRAZIL
BOLIVIA
ARGENTINA
PATAGONIA
APPALACHIAN MTNS
FRANCE
SPAIN
ITALY
GREECE
TURKEY
UKRAINE
KAZAKHSTAN
IRAN
HIMALAYA
INDIA
ALGERIA
LIBYA
EGYPT
SAHARA
SAUDI ARABIA
MALI
NIGER
CHAD
SUDAN
NIGERIA
ETHIOPIA
DR CONGO
TANZANIA
ANGOLA
ZAMBIA
NAMIBIA
SOUTH AFRICA
INDONESIA

Complex Water Systems Models
Scenario Analysis (e.g. climate, investments)

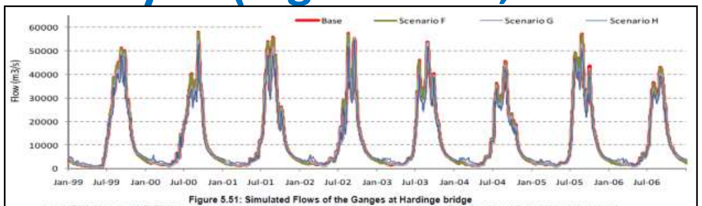
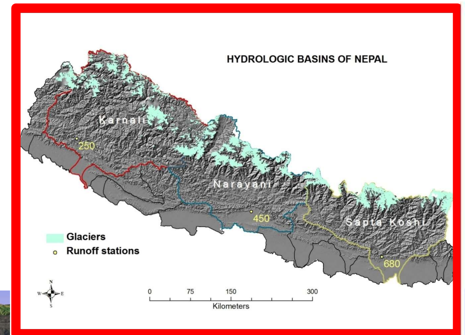
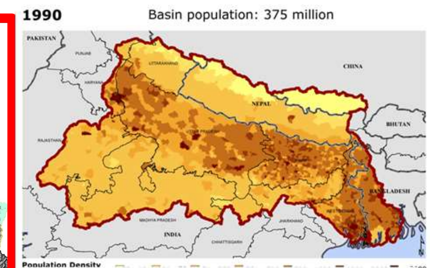
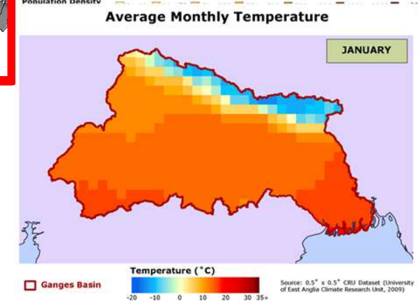
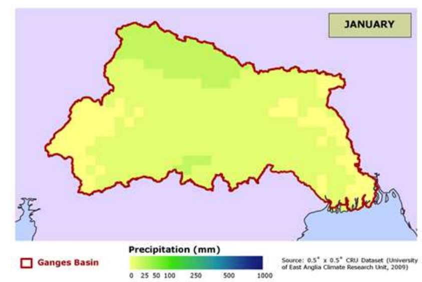


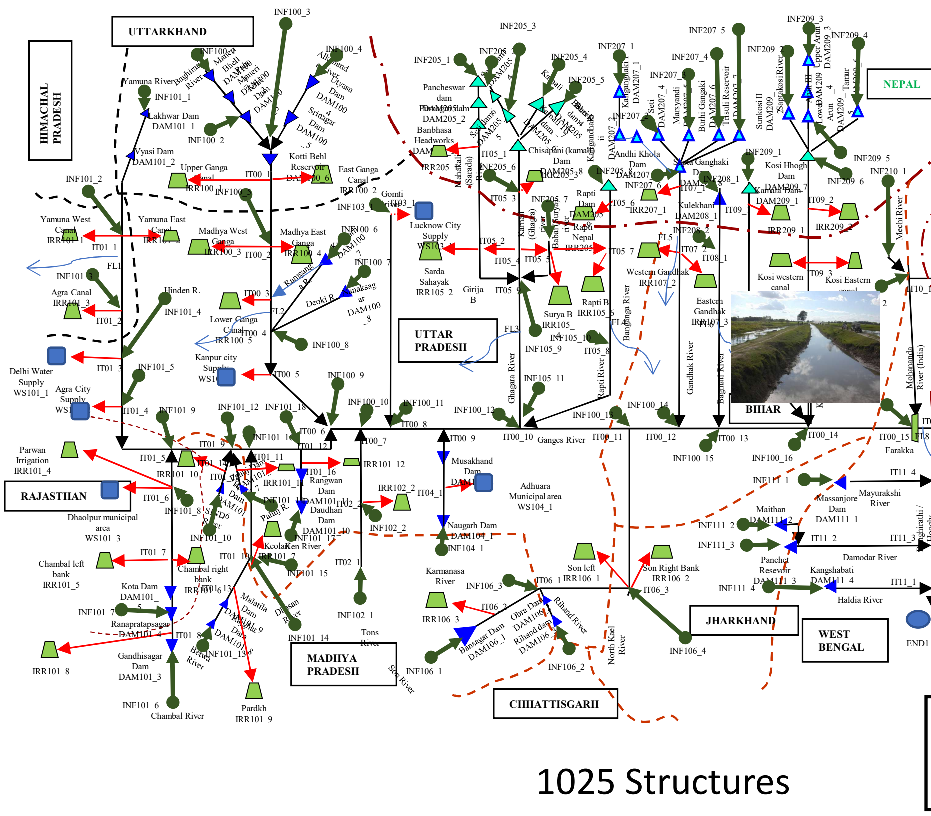
Figure 5.51: Simulated Flows of the Ganges at Hardinge bridge
Scenario E= Kosi dam, scenario F= Pancheswar dam on the Sarda, scenario G= large dams (Kosi, Pancheswar and Chisapani on Ghaghara) and scenario H= all planned dams in Nepal



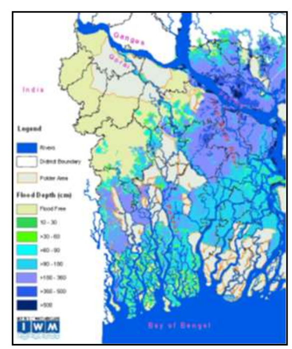


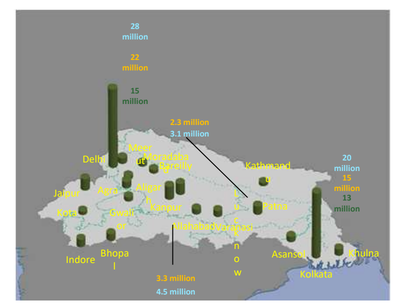




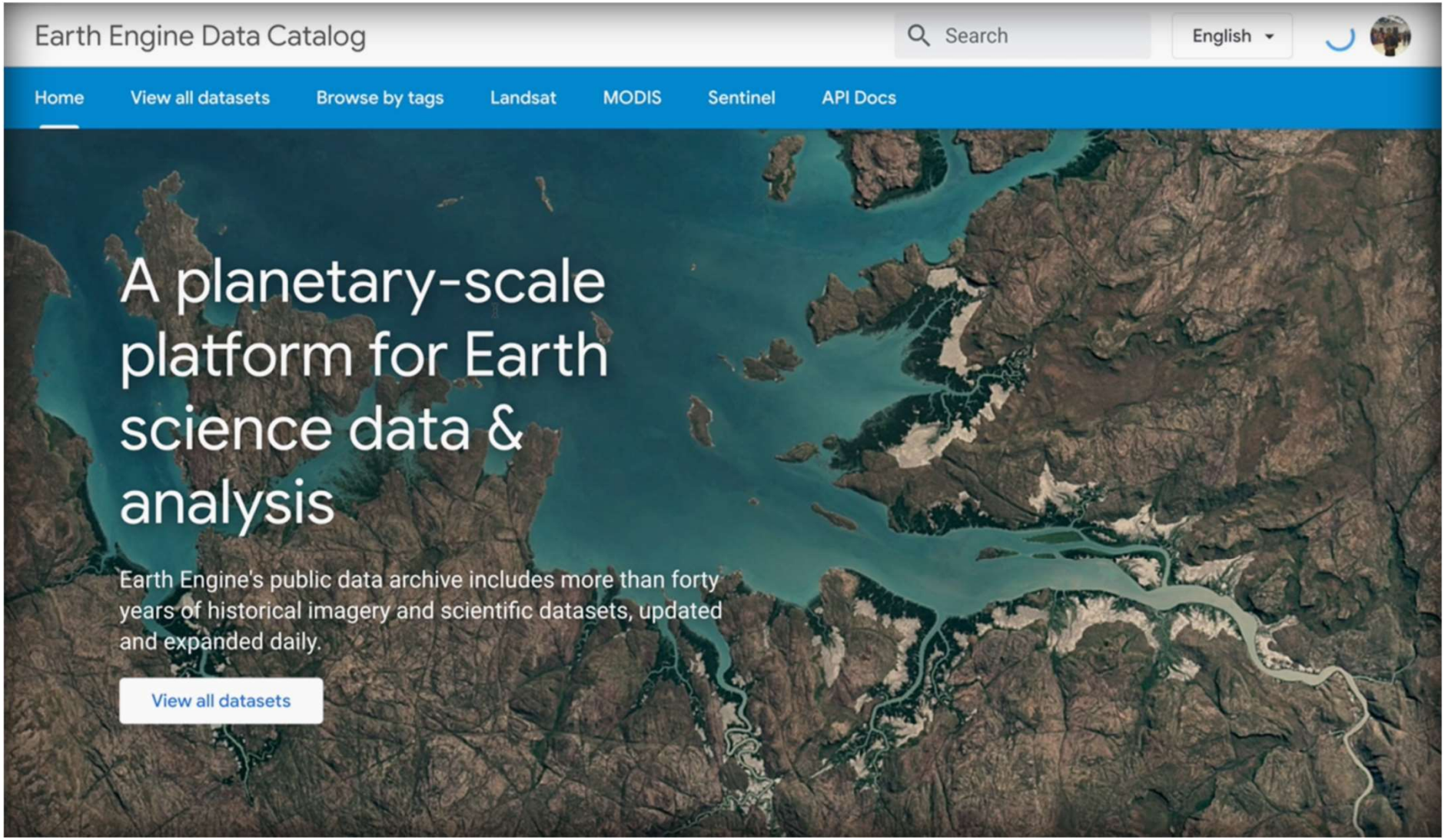


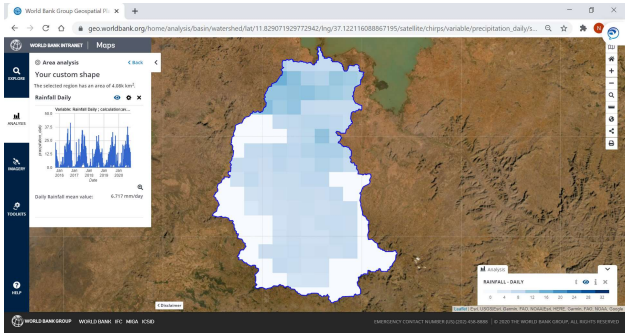
1025 Structures





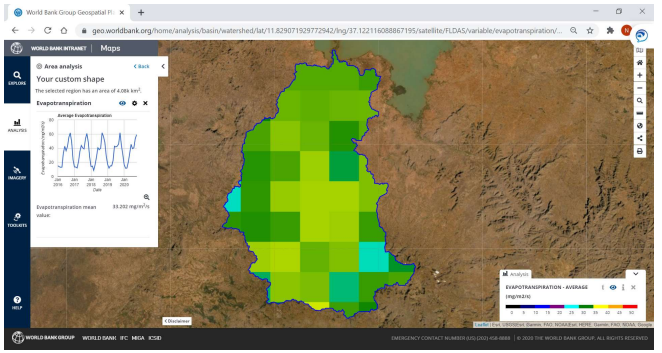
Google Earth Engine Data Catalog

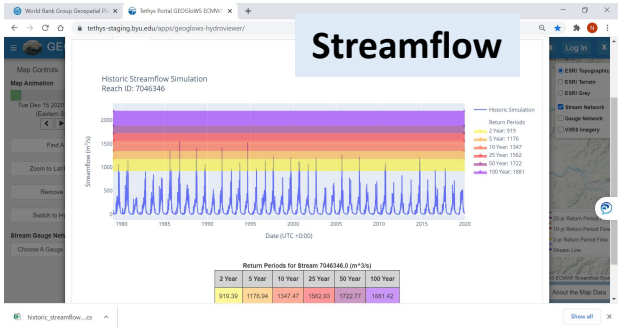




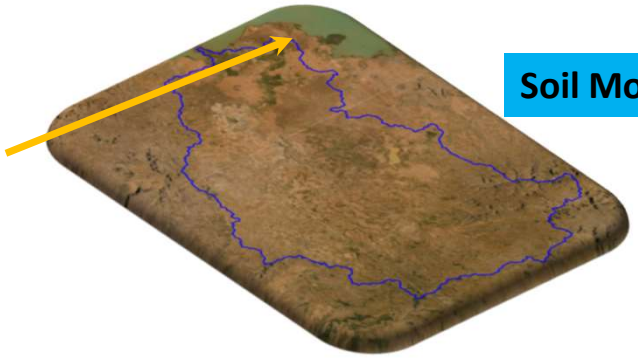
Precipitation

Evapotranspiration

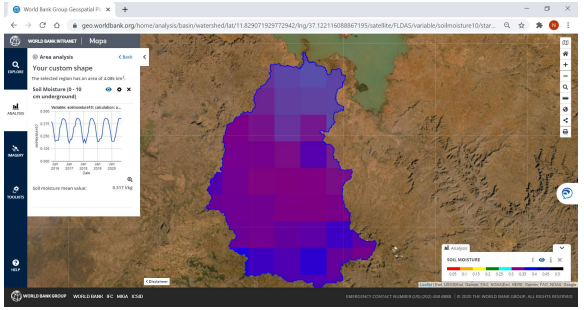


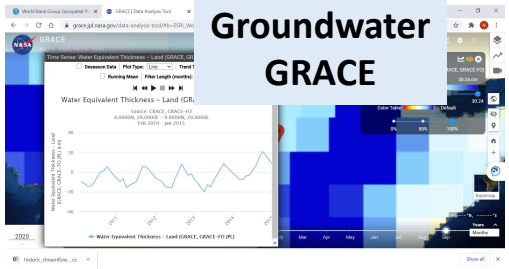


Streamflow

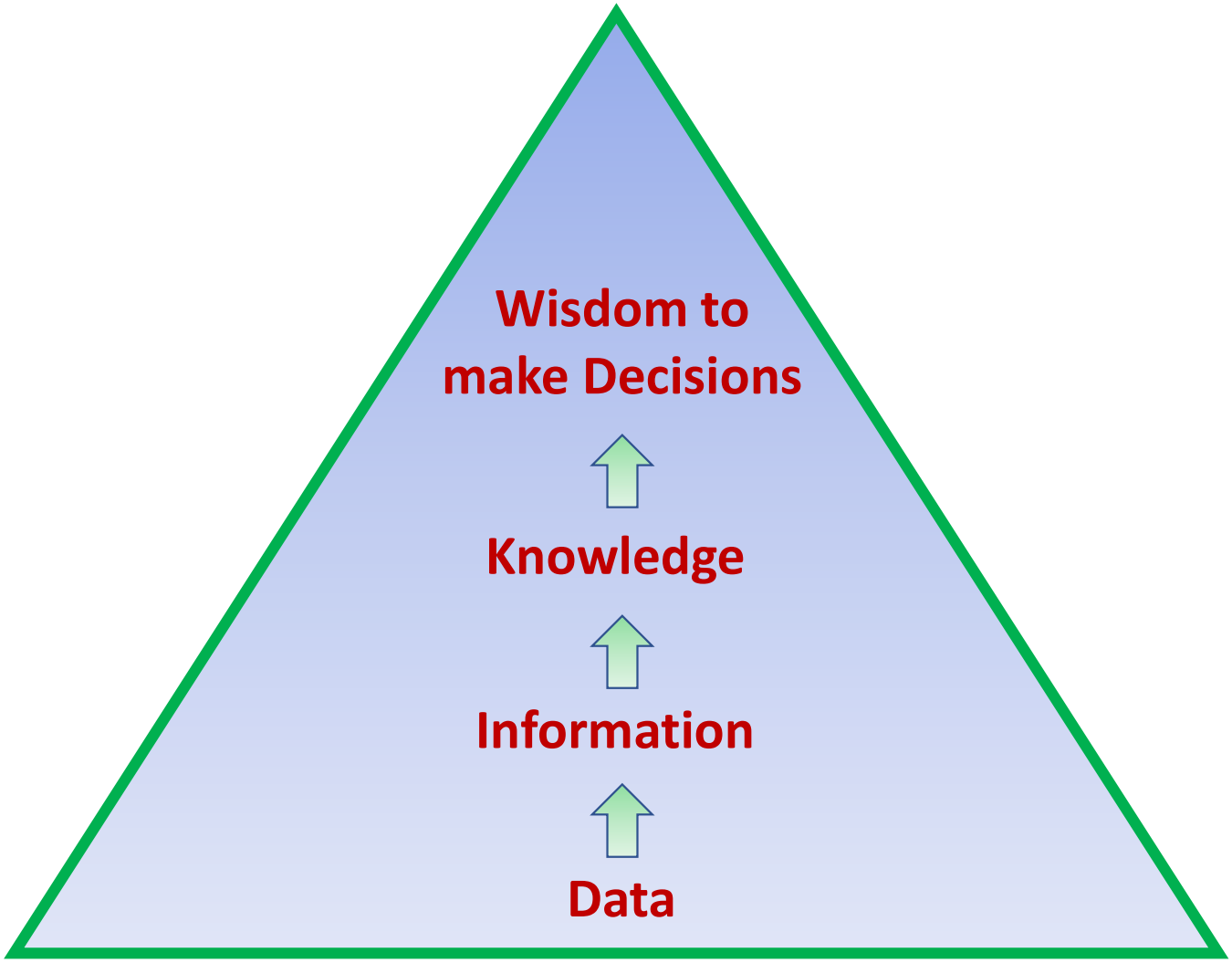


Soil Moisture



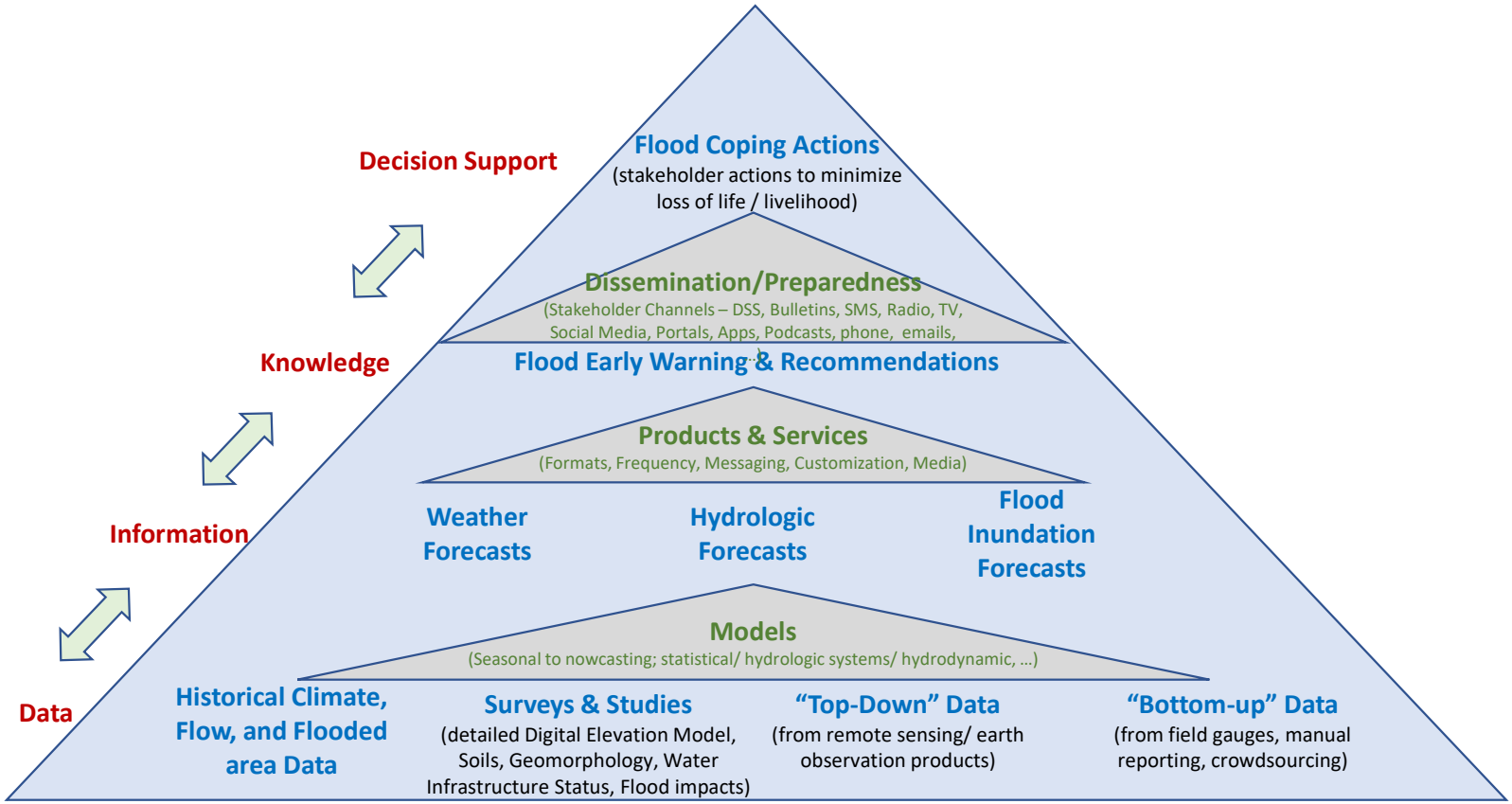


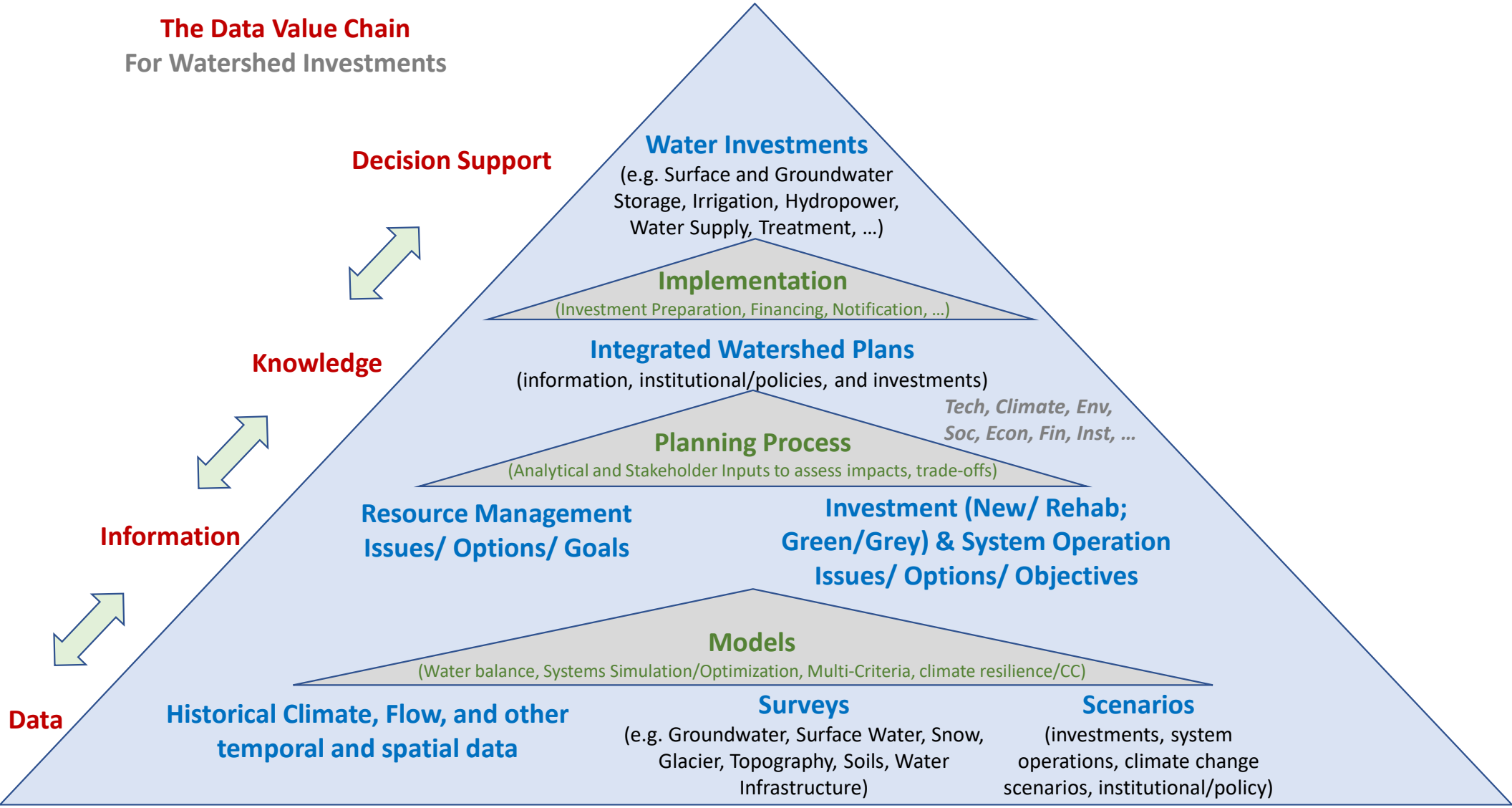
Groundwater GRACE


Wisdom to
make Decisions
Knowledge
Information
Data

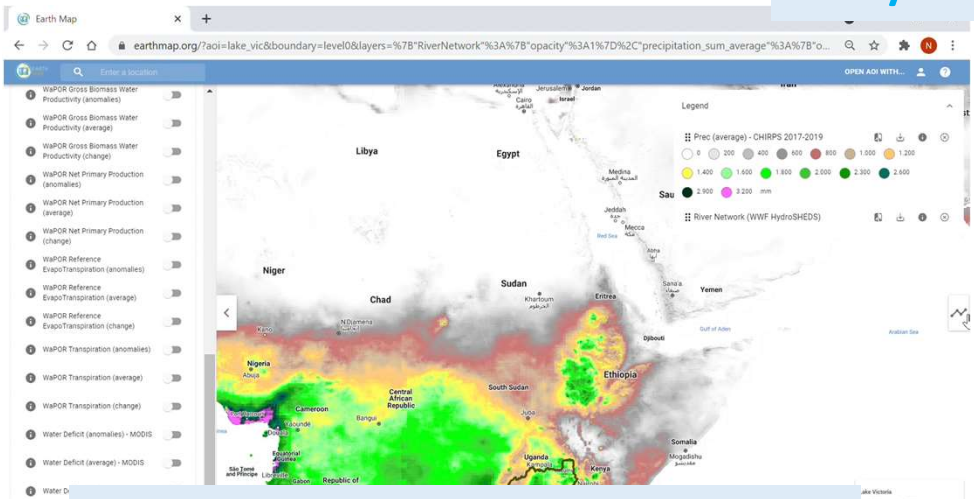
The Data Value Chain

Example: Deciding on Coping with Floods



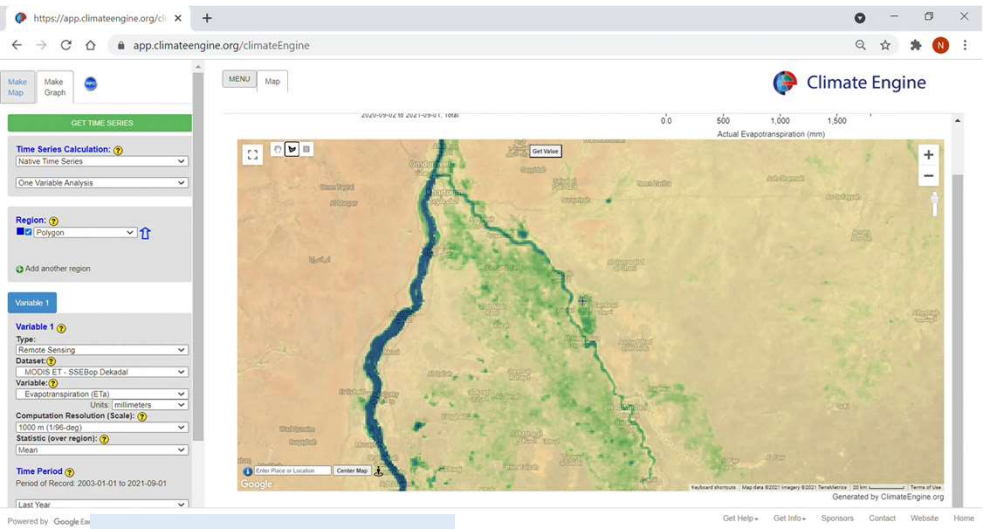

The Data Value Chain
For Watershed Investments
Decision Support
Knowledge
Information
Data
Water Investments
(e.g. Surface and Groundwater Storage, Irrigation, Hydropower, Water Supply, Treatment, …)
Implementation
(Investment Preparation, Financing, Notification, …)
Integrated Watershed Plans
(information, institutional/policies, and investments)
Tech, Climate, Env, Soc, Econ, Fin, Inst, …
Planning Process
(Analytical and Stakeholder Inputs to assess impacts, trade-offs)
Resource Management Issues/ Options/ Goals
Investment (New/ Rehab; Green/Grey) & System Operation Issues/ Options/ Objectives
Models
(Water balance, Systems Simulation/Optimization, Multi-Criteria, climate resilience/CC)
Historical Climate, Flow, and other temporal and spatial data
Surveys
(e.g. Groundwater, Surface Water, Snow, Glacier, Topography, Soils, Water Infrastructure)
Scenarios
(investments, system operations, climate change scenarios, institutional/policy)

Data/Analytics Platforms

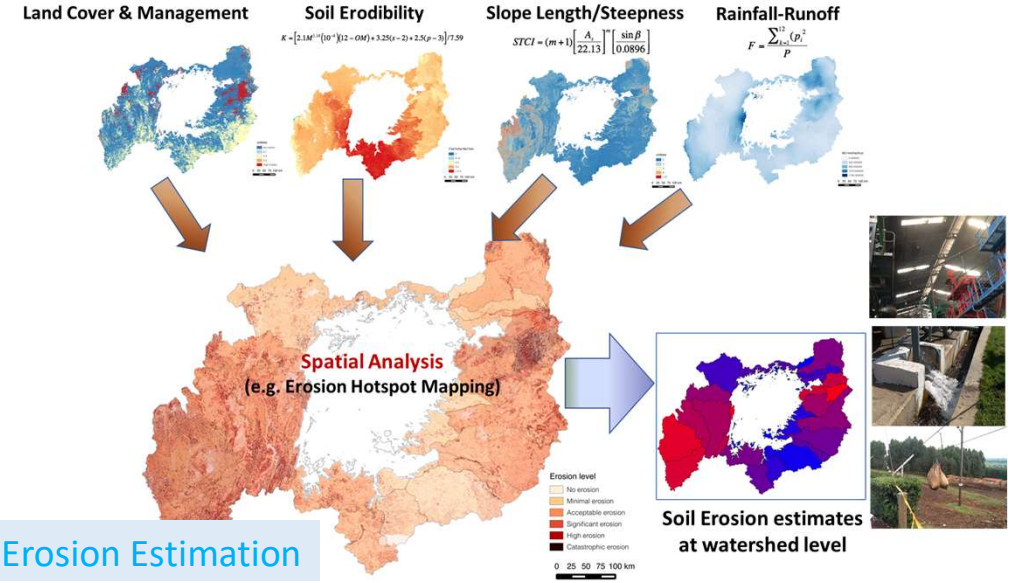


Cloud Analytics (e.g. FAO's Earthmap, UNEP, …)

World Bank Geospatial Platform
Internal: https://geo.worldbank.org/
External: https://maps.worldbank.org/



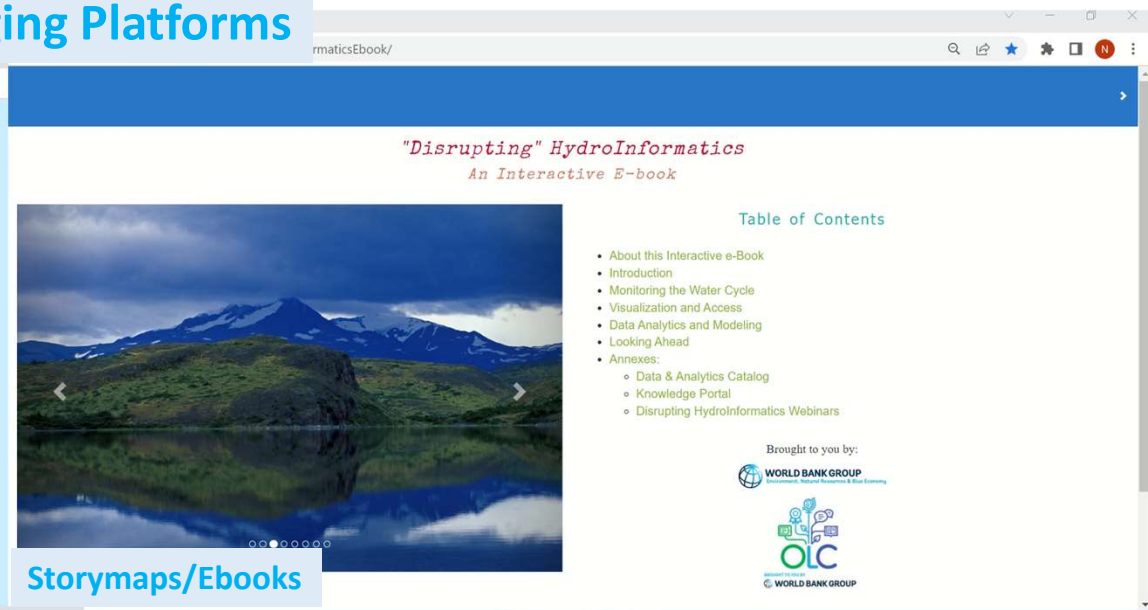
Climate/ET Analytics



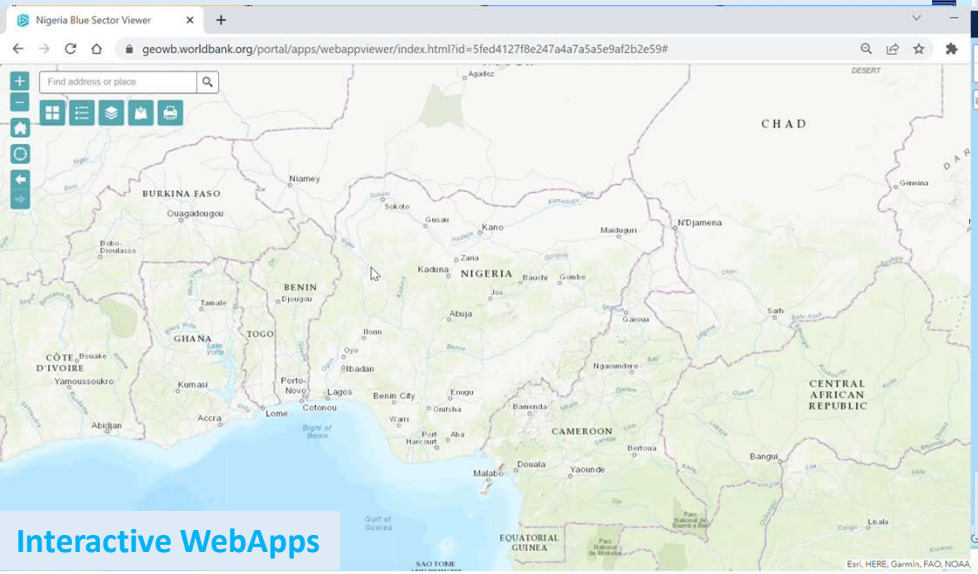
Erosion Estimation

E-Packaging Platforms

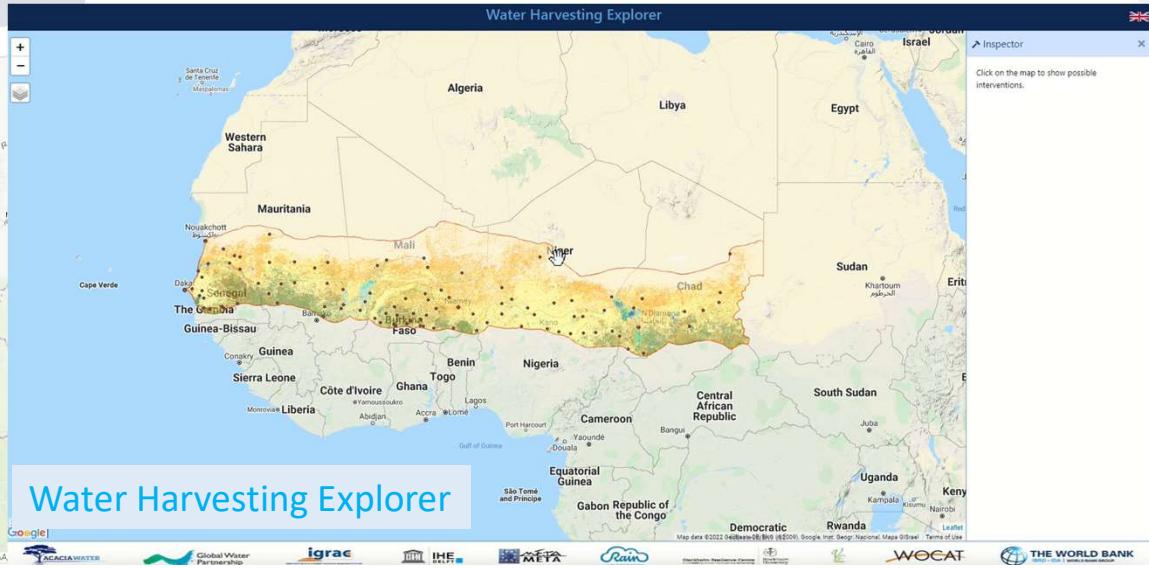
Dashboards e.g. https://spatialagent.org/HydroInformatics/



Storymaps/Ebooks

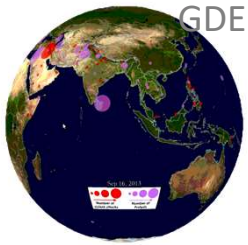


Interactive WebApps



Water Harvesting Explorer

AI/Machine Learning

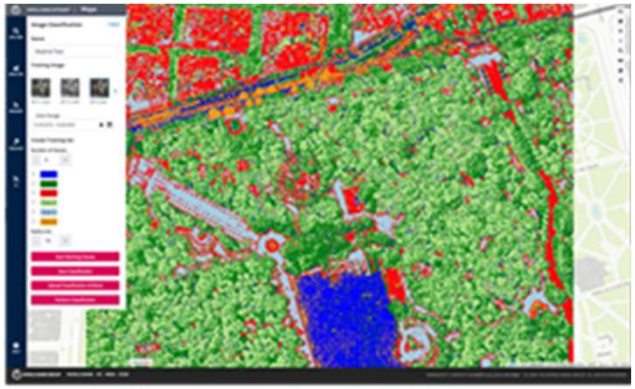


GDELT

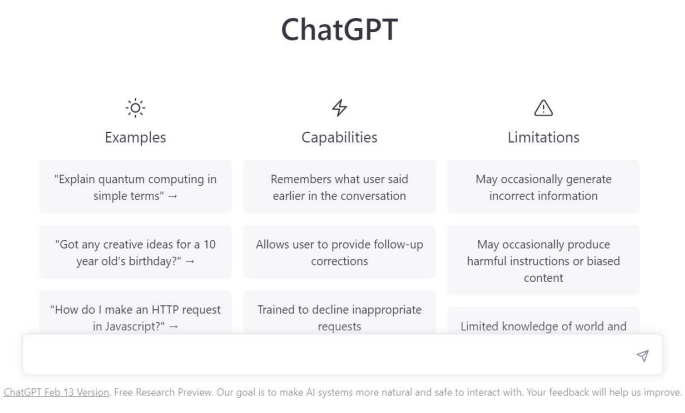
AI-Enabled Text and Data Mining of documents, news & social media

AI-Enabled Chatbots
Natural Language Processing

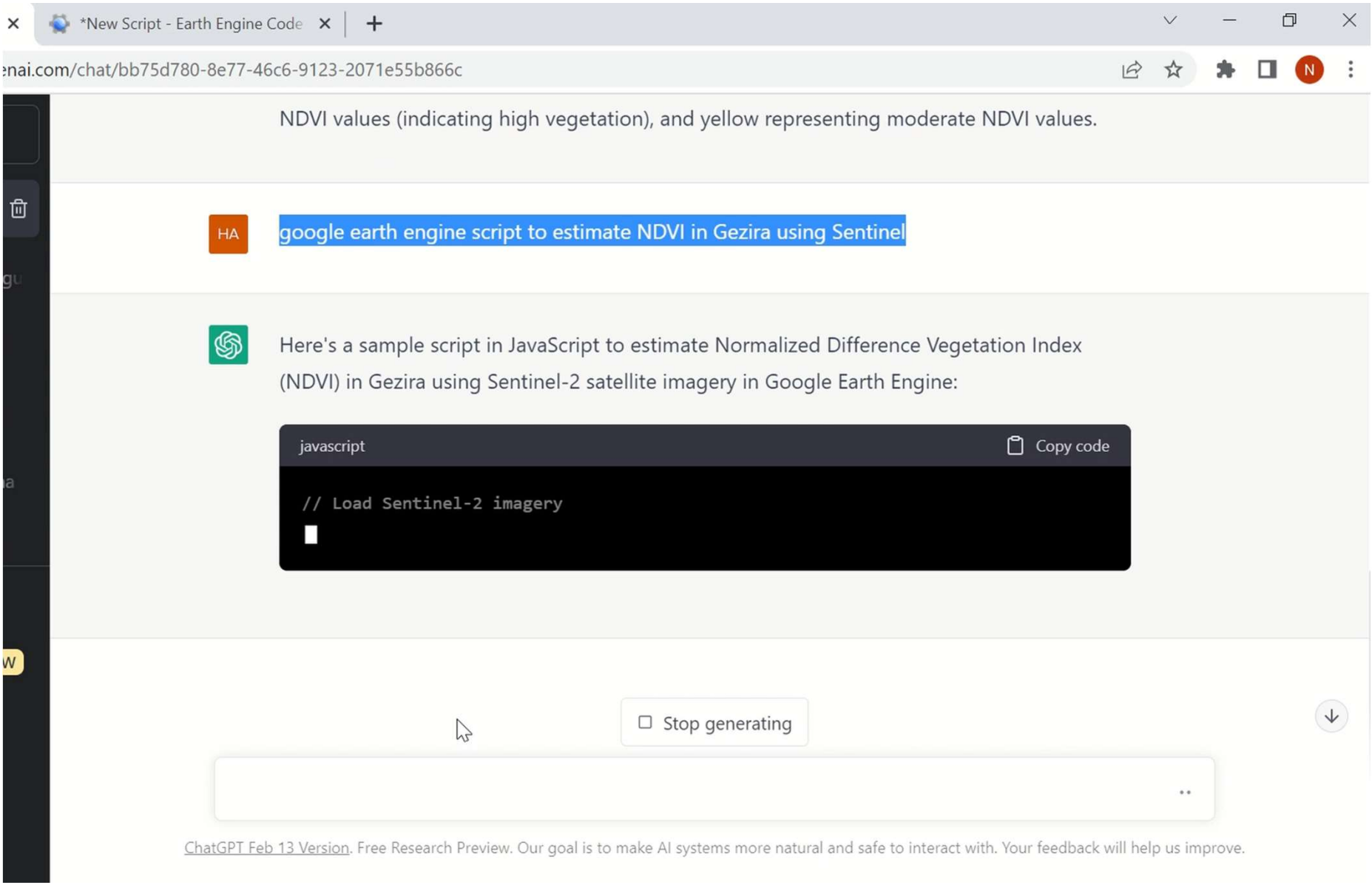
Training Data for Machine Learning Classification



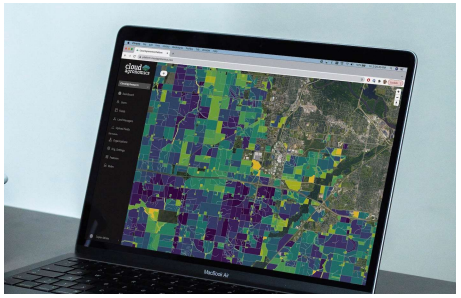
Land Cover Classification using Training Data



Machine-Learning Image Classification – e.g. from Earth Observation, Photos, …
CNN, ANN, Deep Learning…

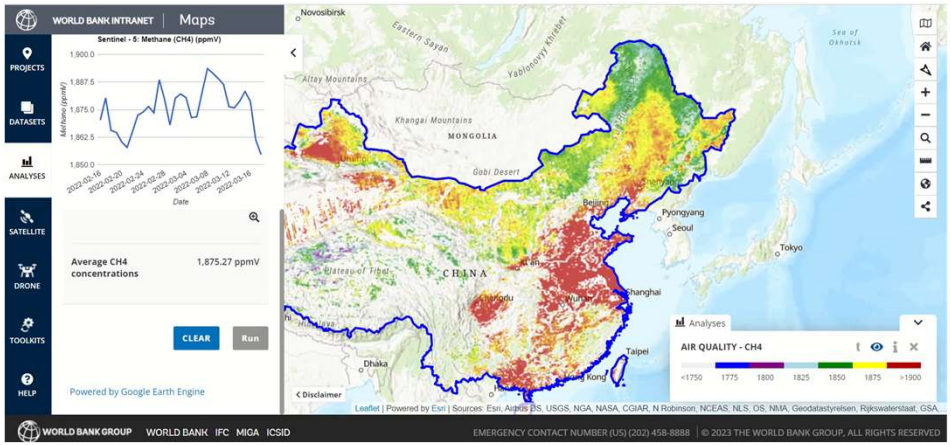

*New Script - Earth Engine Code
enai.com/chat/bb75d780-8e77-46c6-9123-2071e55b866c
NDVI values (indicating high vegetation), and yellow representing moderate NDVI values.
HA
google earth engine script to estimate NDVI in Gezira using Sentinel
Here's a sample script in JavaScript to estimate Normalized Difference Vegetation Index (NDVI) in Gezira using Sentinel-2 satellite imagery in Google Earth Engine:
javascript
Copy code
// Load Sentinel-2 imagery
Stop generating
ChatGPT Feb 13 Version. Free Research Preview. Our goal is to make AI systems more natural and safe to interact with. Your feedback will help us improve.

Scalable Platforms to Incentivize Services for a Healthier Planet



New ***Global*** Investment Platforms (e.g. Apps with automated/simplified MRV and flexible financing sources and digital payments) to incentivize ***Local*** action on:

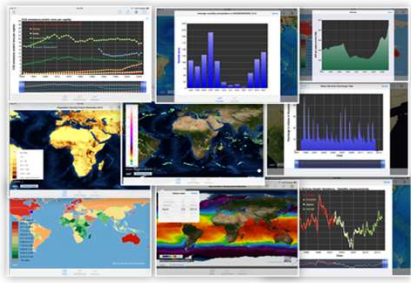
- **Climate** (e.g. for Mitigation and Adaptation) – e.g. for Low C Rice, Soil C Sequestration, agroforestry, Blue Carbon, Insurance
- **Ecosystems** (e.g. PES for biodiversity protection, sustainable soil and water management)
- …

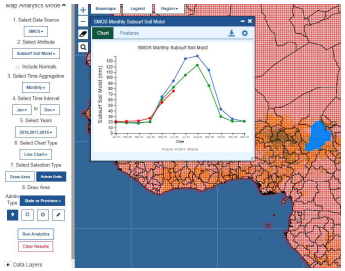


Customized Interactive Dashboards

Example for Check Dam Operation

Decisions to be Supported: When to release? How much to release?





Climate

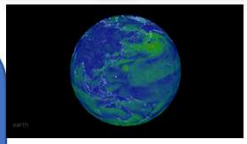
- Rainfall in upstream watershed (GPM, in-situ gauges/radar, CHIRPS, …) – current & historical
- Weather forecasts (short-term, seasonal); Storm tracks
- Snowmelt estimates (if relevant)…

Flows

- Current and historical flows (from in-situ observations, satellite estimates where possible)
- Dam inflow forecasts (e.g. from GEOGLOWS Global Streamflow Forecasting, local forecasts)…

System Levels

- Current and historical levels of this dam's reservoir as well as other storages in system (e.g. from satellite, in-situ gauges)…



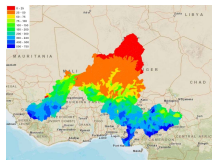
Downstream

- Irrigation status (crops, crop stage from earth observation and in-situ)
- Soil and sub-surface soil moisture, groundwater (from earth observation and in-situ)…

Other Data & Analytics

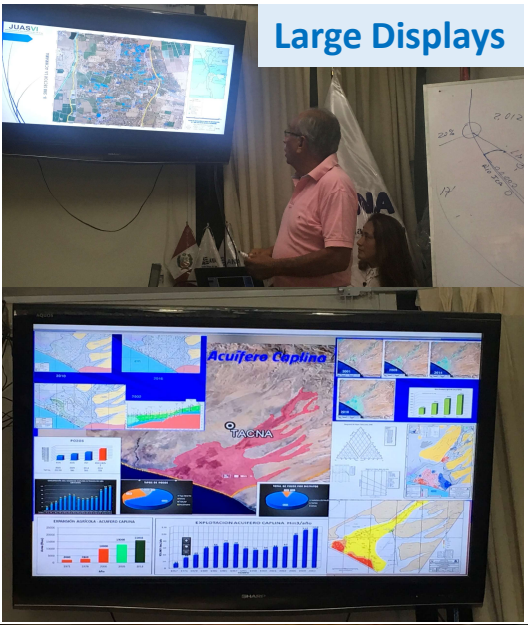
- Inundation forecasts
- Systems water infrastructure needs
- Systems model to explore implications of alternative dam operations
- Hi-resolution Satellite data
- Crowdsourced data

…



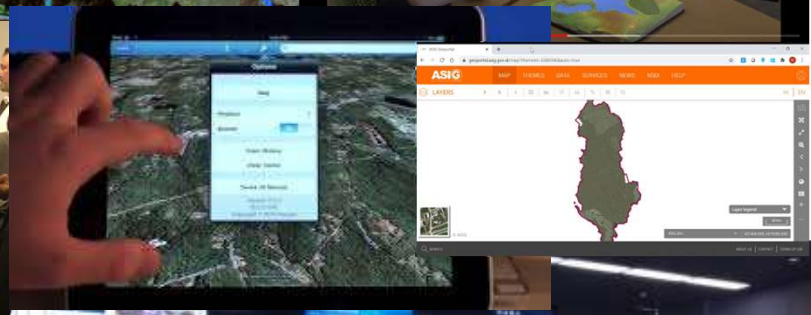
Critical to draw upon thousands of data and analytic services to develop customizable dashboards to provide the right information in the right formats to empower everyone to make their decisions more data-driven!

Large Displays



TouchScreens

Physical Interactive Models



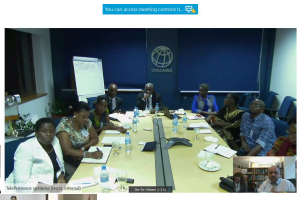
Touch Tables

VR

Touch Projectors

Modernizing Institutions

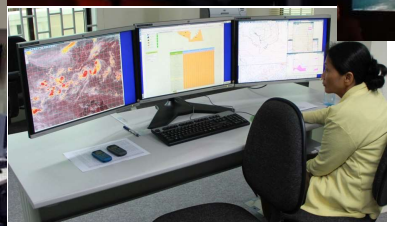
Collaborative Workspaces/Internships



Audio/Video-Conferencing/ Distance Learning/ Helpdesk

Computer Training Room

Document, Map & Digital Library



Situation/ Decision Rooms

Innovation Marketplace

Competitions (e.g. Hackathons)

Collation ⟷ **Analysis** ⟷ **Use**

Knowledge Repository

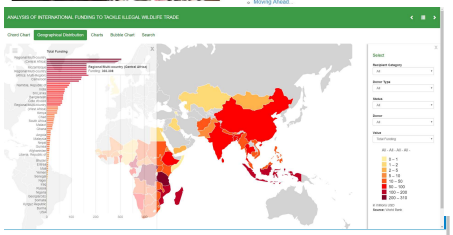
Monitoring Hub

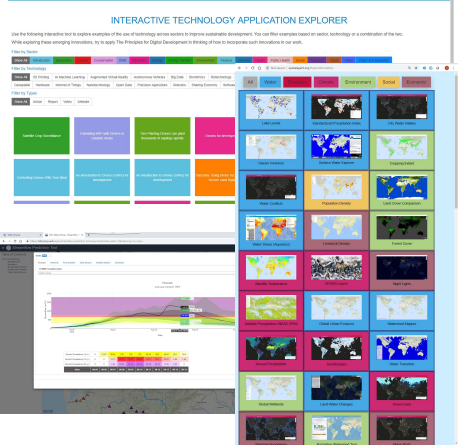
Knowledge Tools/Products

Targeted Research

Outreach & Capacity-Building

Institutional Support



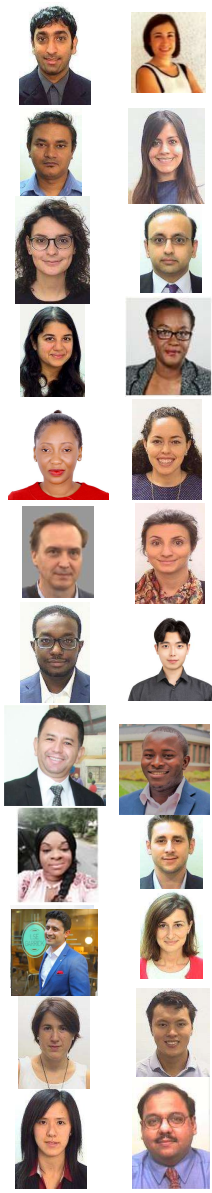


Disruptive Technology

WORLD BANK GROUP

Disruptive KIDS (Knowledge, Information & Data Services) Helpdesk

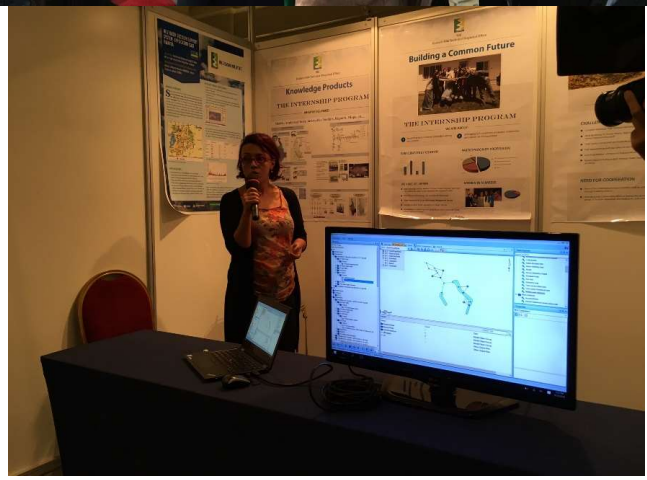
http://spatialagent.org/KIDS/



Professional Interactions

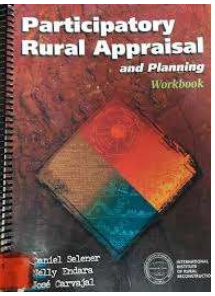
Learning from national and global good practices; Building Capacity

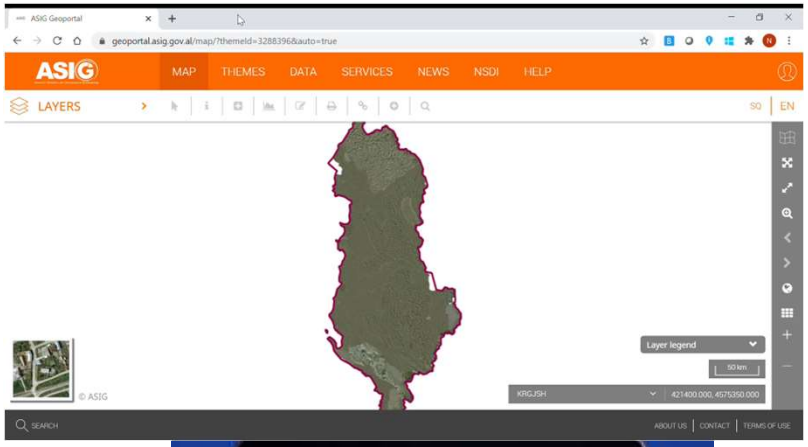
Forum, Expos, Training



Internships, Competitions

Improving Community Interactions





In Summary…

- There is **a new world of emerging technologies** that can "disrupt" the way transboundary waters are planned, developed, and managed
  - ***Information:*** More relevant hydroinformatics information and insights at everyone's fingertips (but can be made much better with more open in-situ data access in harmonized formats)
  - ***Institutions:*** Learn quickly from global good practices (enhanced collaboration, cross-learning, engaging with global expertise, and tapping into their own young talent can be transformational) – everyone can facilitate with open data services, open science, enabling policies/regulations/laws
  - ***Investments:*** Many opportunities to tap into innovative designs - e.g. NBS, climate-smart investments, finance, and partnerships (but require open-minded leadership and meaningful collaboration)

- **Keep learning and disrupting!**

Disrupt or Be Disrupted!

Thanks!

harsh@worldbank.org

https://spatialagent.org/KIDS/
https://spatialagent.org/HydroInformaticsEbook/

Disruptive Technology
WORLD BANK GROUP
Disruptive KIDS (Knowledge, Information & Data Services) Helpdesk