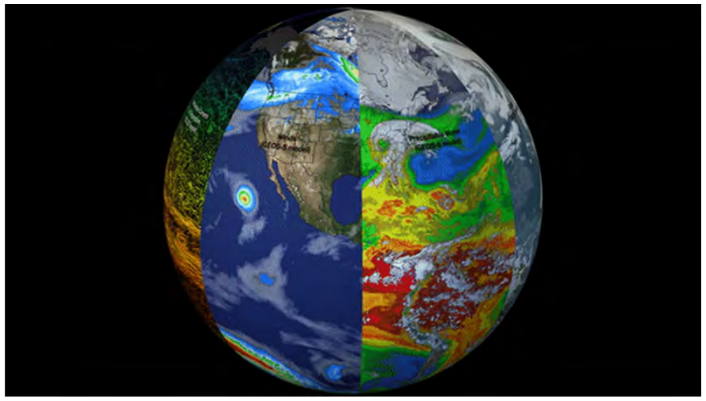


"Disrupting" Water Resources Management

A New World of Disruptive Technologies for Water Resources Planning and Management

Dr. Nagaraja Rao Harshadeep (Harsh)

Global Lead (Disruptive Technology)

Disruptive Technology

WORLD BANK GROUP

Environment, Natural Resources & Blue Economy

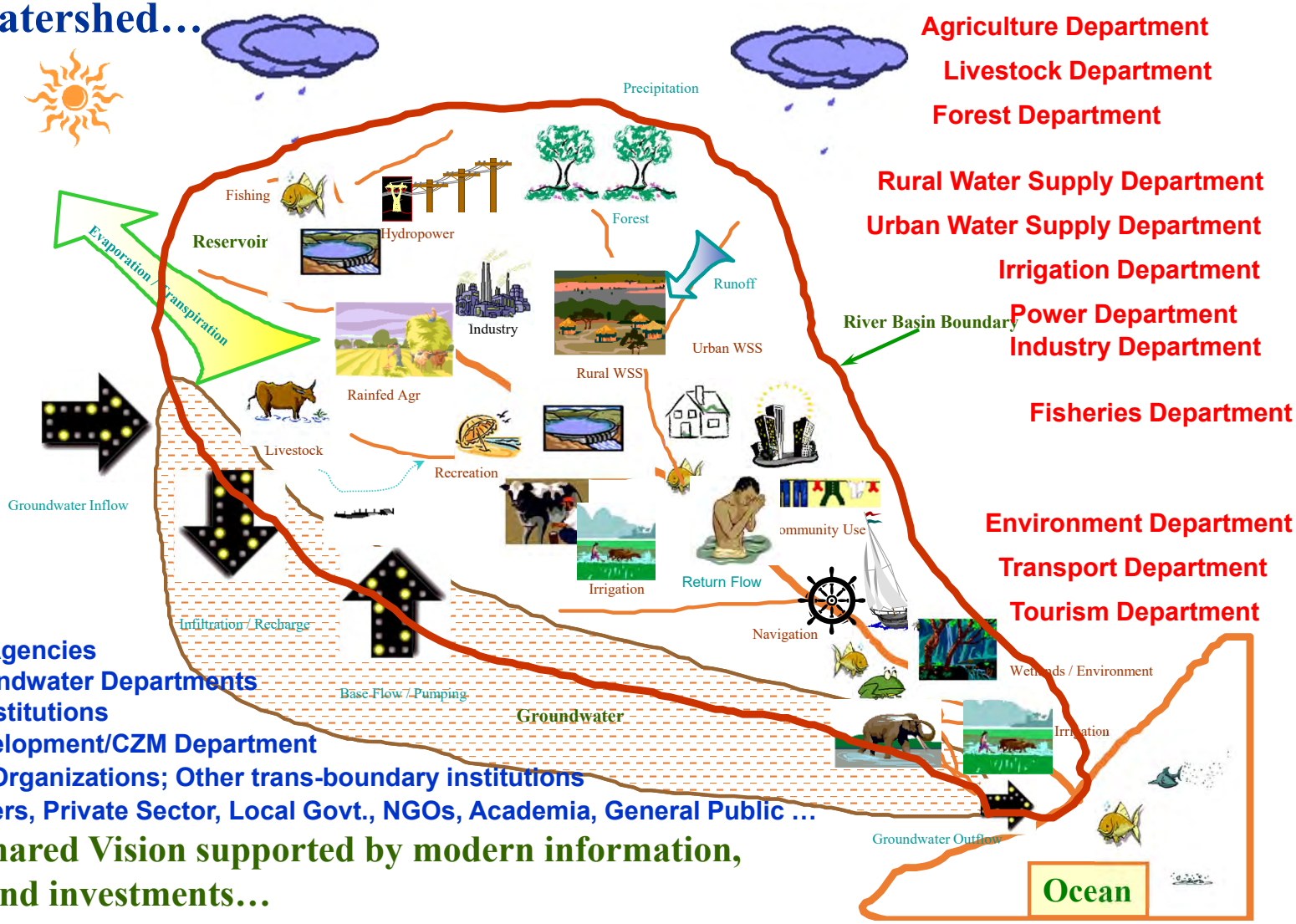
Economic and Social Commission for Western Asia (ESCWA)

Building Capacity for Accessing Disruptive Technologies for Improved Water Resources Management under Climate Change

14-15 January 2020, Beirut, Lebanon

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

A Typical Watershed…



Agriculture Department
Livestock Department
Forest Department

Rural Water Supply Department
Urban Water Supply Department
Irrigation Department
Power Department
Industry Department

River Basin Boundary

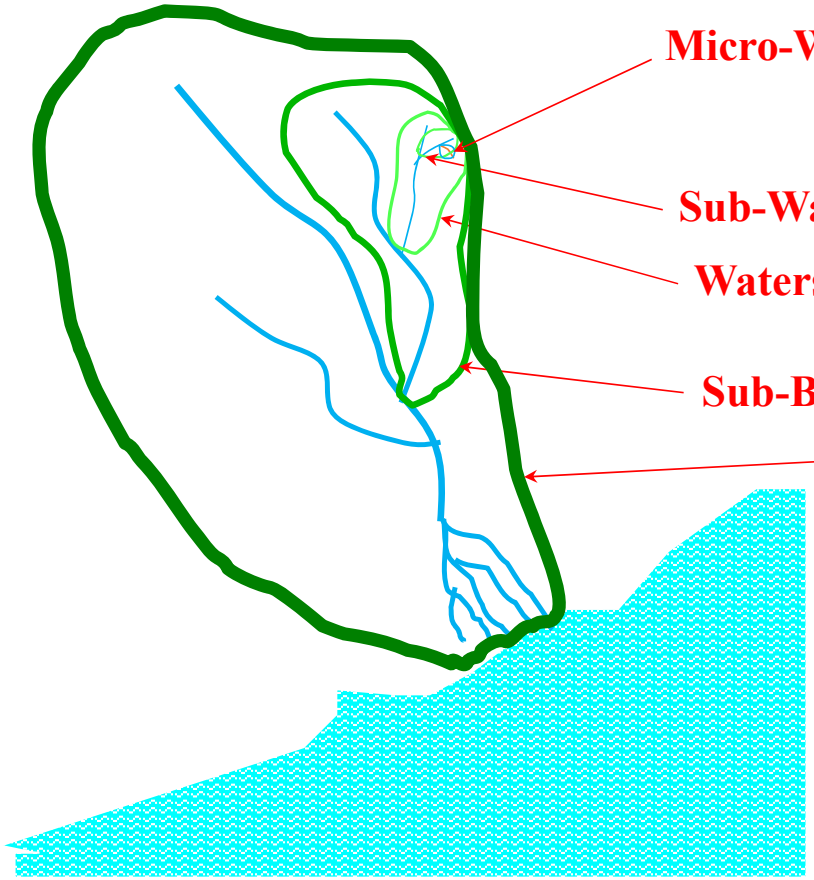
Fisheries Department

Environment Department
Transport Department
Tourism Department

Central & State Agencies
Surface & Groundwater Departments
Investment Institutions
Ocean Development/CZM Department
Basin Organizations; Other trans-boundary institutions
Farmers, Private Sector, Local Govt., NGOs, Academia, General Public …

…Need for Shared Vision supported by modern information, institutions, and investments…

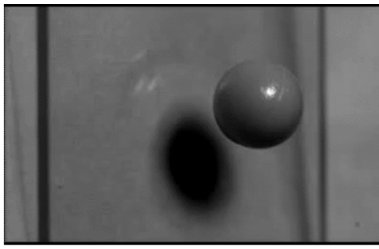
Scales



Transboundary Water Contexts:

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

What's Broken?



Information

- Data coverage and quality
- Widespread use of modern analytical tools
- Public access to data, tools, and knowledge products

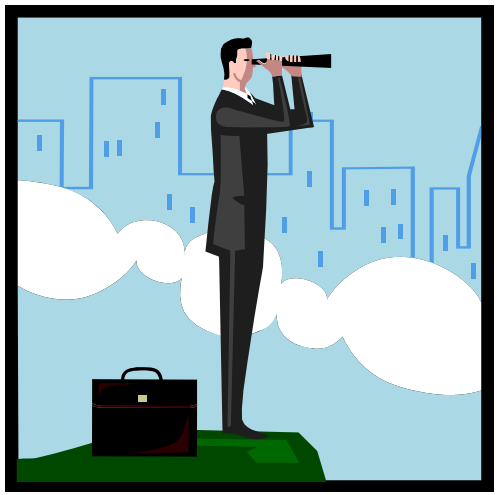
Institutions

- Technical capacity
- Meaningful stakeholder involvement
- Decision making
- Collaboration/ Partnerships

Investments

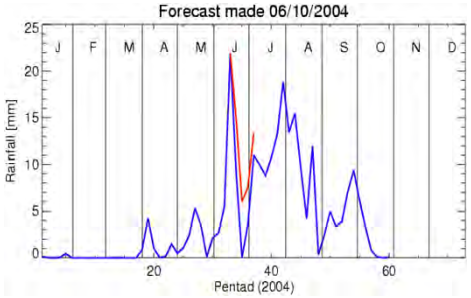
- Infrastructure deficit (storage, power, transport, agriculture, sustainable land management, …)
- Inadequate monitoring and forecasting systems
- Poor office infrastructure and equipment
- Investment coordination

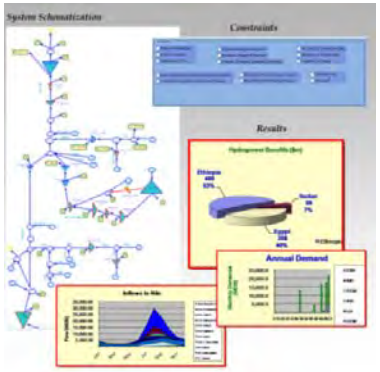
Modernizing Approaches to Address these Challenges…
The 3 Is…

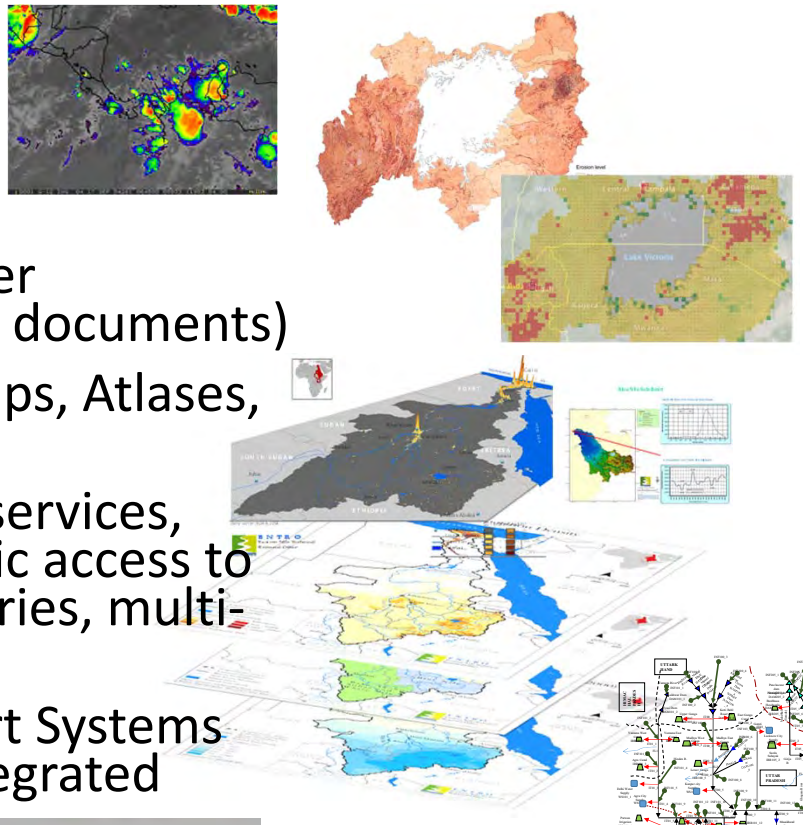


Information & Analysis

- **Resource Information Base** (standards; harmonization; data rescue; monitoring; comprehensive spatial, temporal and other databases; improved use of satellite data; documents)
- **Knowledge Products/Special Studies** (maps, Atlases, interactive toolkits, surveys)
- **Access and Outreach mechanisms** (data services, publications, web portals, Apps with public access to open data services, technical/ success stories, multi-media documentation)
- **Analytical Tools** (models/Decision Support Systems for planning/operations support in an integrated systems context)

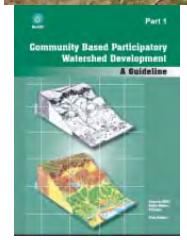


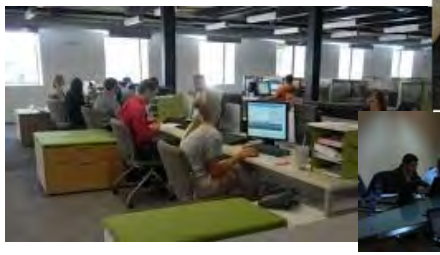




Institutions & Policy

- **Strengthening Institutions** (office modernization, stakeholder participation, capacity development and training incl. distance learning, improved links with academia, internships, visiting experts, professional networks/ communities of practice; forums, competitions)
- **Strengthening Policies** (streamlining institutional design/policy/mandates, improving synergy, economic instruments, decentralization)
- **Innovative Instruments** (e.g. knowledge-driven facilitated diplomacy, policy instruments, incentive frameworks)





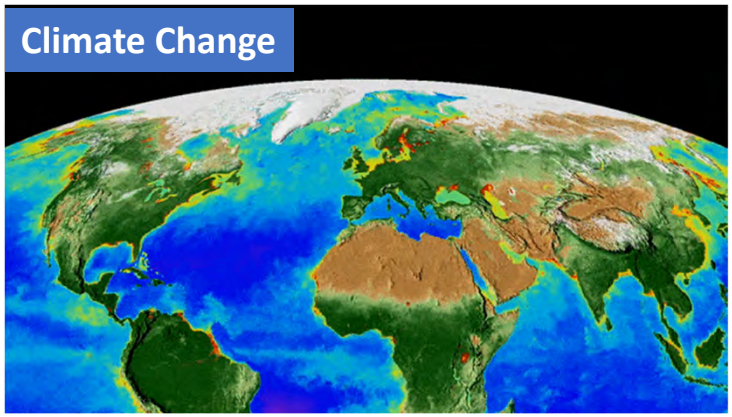
Investments & Operations

- **Preparation of a new generation of modern investments** (with adequate attention to technical, environmental/climate, social, economic, and institutional aspects) – upgrading existing infrastructure and building new infrastructure analyzed in a systems context and reflecting innovation and climate-smart development
- **Implementation facilitation, monitoring, and lessons** (adequate technical assistance, ownership, services, M&E)
- **Infrastructure planning and operational coordination**

There are many ongoing changes…

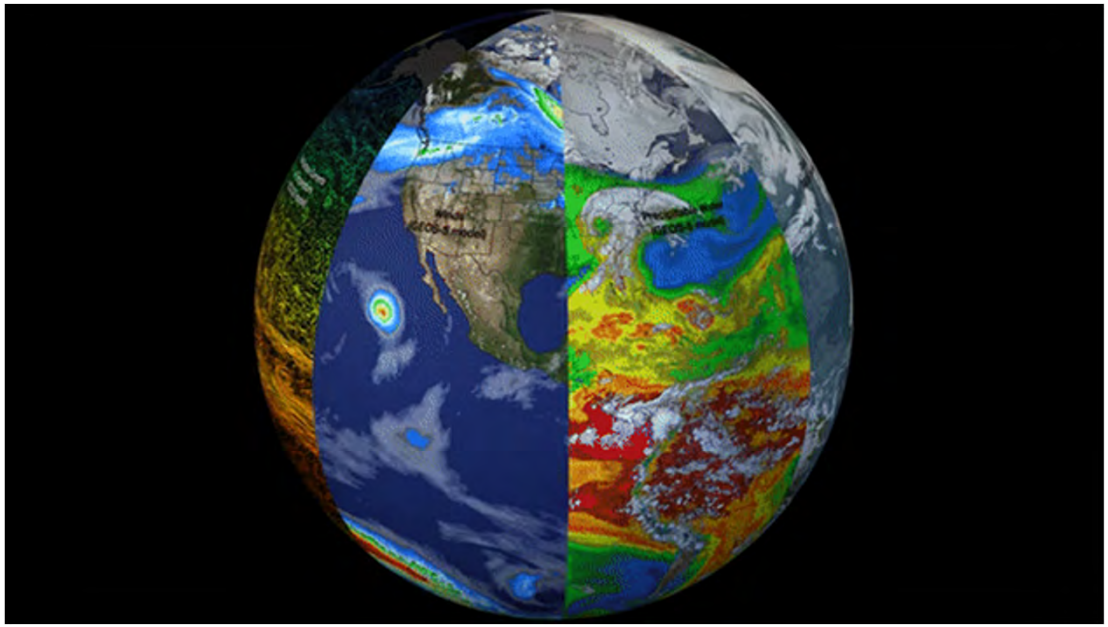
Urbanization

Climate Change

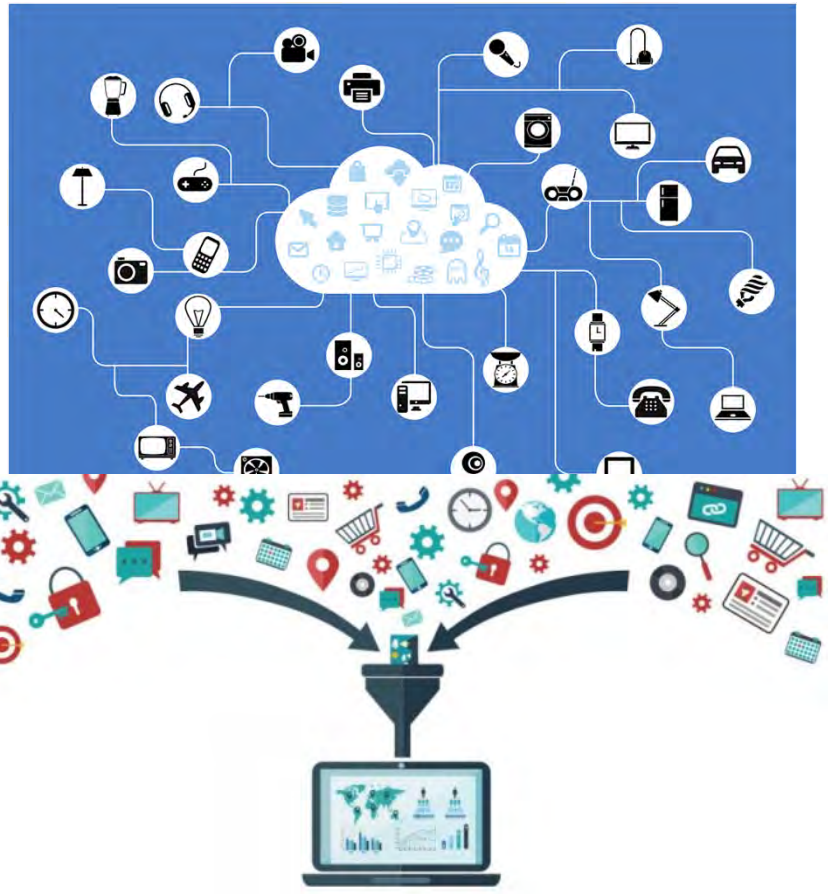


Rising Expectations

Disruptive Tech

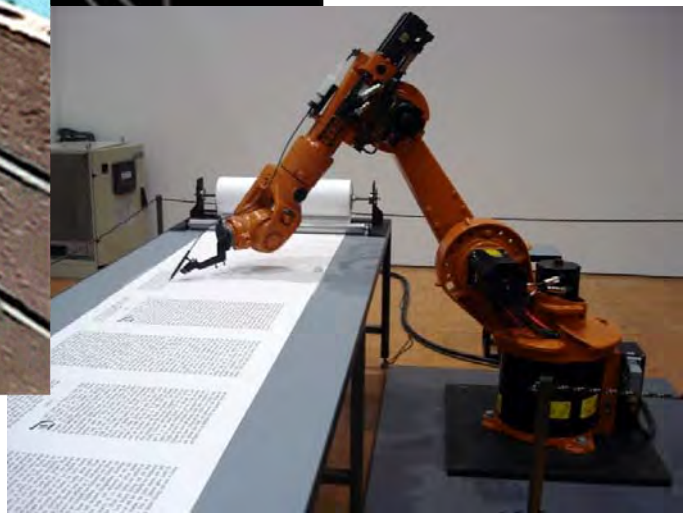


"DISRUPT" DECISION SUPPORT



- ***Data Collection***: Monitoring/Surveys (in-situ sensors/IoT, Earth Observation, UAVs, crowdsourcing…); Digitization
- ***Data Management*** (telemetry, cloud services, open data services, Blockchain, …)
- ***Data Analysis*** (Big data, Geospatial/AI/Machine Learning, modeling, script repositories …)
- ***Data Access*** (open data APIs, data visualization, gamification, mixed reality-AR/VR, …)
- ***Outreach:*** Platforms/Portals/Apps/e-books/Competitions

“DISRUPT” PRODUCTION



- 3D printing/additive manufacturing
- Automation/Robotics/automated transport
- Advanced materials/nanotech/biotech/clean tech/ smart energy/ smart farms…

“DISRUPT” INTERACTION

- Social Media
- Knowledge/Learning Platforms
- Crowdsourcing, gamification, competitions
- Mobile money, Fintech
- Maker movement/DIY/Tech Incubators
- Sharing economy

All Companies will be Data Companies…

90% of the World's data has been produced in the last 2 years…

Two-thirds of the jobs todays kids will pursue haven't even been invented yet…

- **IoT can add US$2.7-6.2 trillion annually by 2025…**
- **Autonomous transportation could have a US$7 trillion annual revenue stream…**
- **Blockchain will deliver US$3.1 trillion in value by 2030…**
- **AI will add US$15 trillion to the global economy by 2030…**
- **AR/VR will disrupt a US$30 trillion industry…**
- **3D printing will disrupt the US$30 trillion manufacturing sector…**
- **Robots could disrupt the US$15.5 trillion construction industry…**
- **Clean energy tech could be a US$50 trillion industry…**
- **The sharing economy could be $335 billion by 2025…**
- **Nanotechnology is already a US$1trillion industry…**
- **Fintech eyes US$124 trillion of transfer payments…**

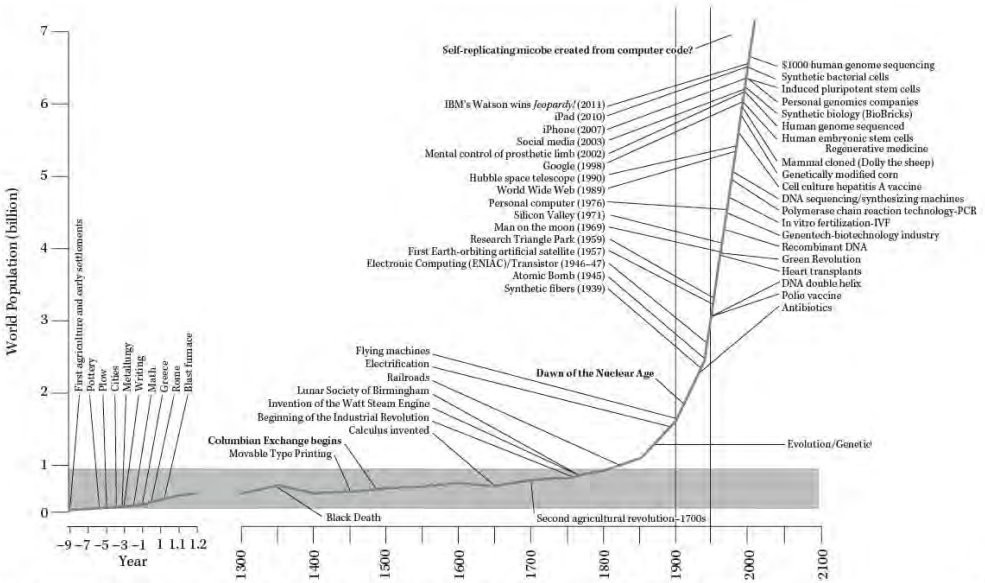
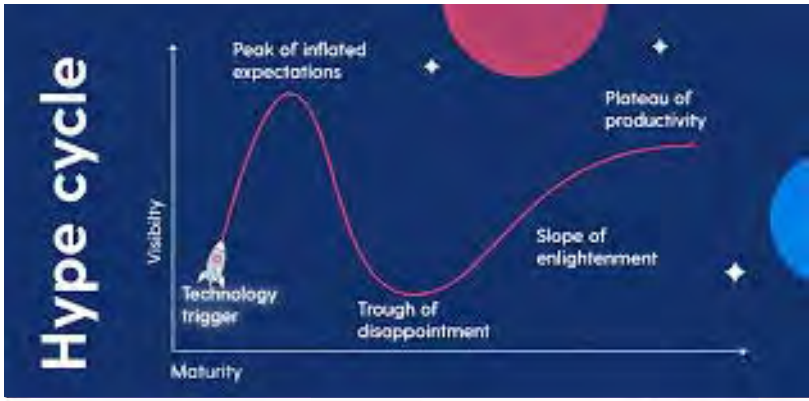
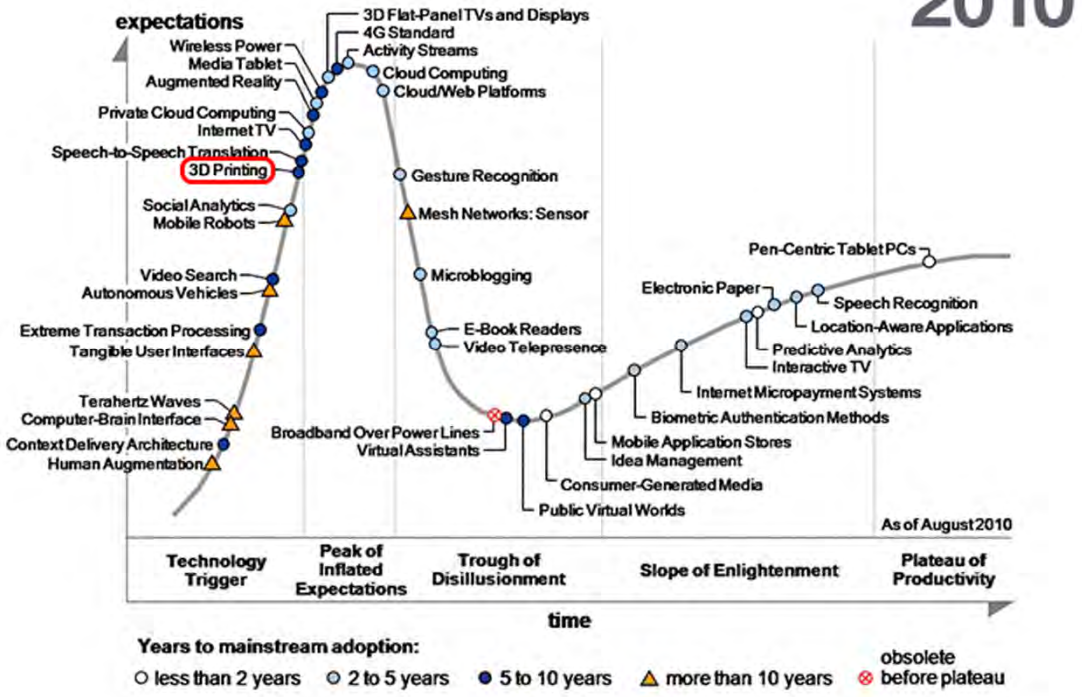


FIGURE C.1 Journey of *Homo innovaticus* since the dawn of agriculture highlighting recent advances in technology and bioscience.

Source: The authors with the assistance of James Hudak. Modified from Figure 1 of Robert W. Fogel, "Catching Up With the Economy," *American Economic Review* 89/1 (





>$900,000 worth of applications in a smart phone today

	Application	$ (2011)	Original Device Name	Year*	MSRP	2011's $
1	Video conferencing	*free*	Compression Labs VC	1982	$250,000	$586,904
2	GPS	*free*	TI NAVSTAR	1982	$119,900	$279,366
3	Digital voice recorder	*free*	SONY PCM	1978	$2,500	$8,687
4	Digital watch	*free*	Seiko 35SQ Astron	1969	$1,250	$7,716
5	5 Mpixel camera	*free*	Canon RC-701	1986	$3,000	$6,201
6	Medical library	*free*	e.g. CONSULTANT	1987	Up to $2,000	$3,988
7	Video player	*free*	Toshiba V-8000	1981	$1,245	$3,103
8	Video camera	*free*	RCA CC010	1981	$1,050	$2,617
9	Music player	*free*	Sony CDP-101 CD player	1982	$900	$2,113
10	Encyclopedia	*free*	Compton's CD Encyclopedia	1989	$750	$1,370
11	Videogame console	*free*	Atari 2600	1977	$199	$744
	Total	**free**				**$902,065**

*Year of Launch

A new world of “Disruptive Technology”

“Disrupt” decision making

- ***Data Collection***: Monitoring/Surveys (in-situ sensors/IoT, Earth Observation, UAVs, crowdsourcing…); Digitization
- ***Data Management*** (telemetry, cloud services, open data, Blockchain, …)
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“Disrupt” production

- 3D printing/additive manufacturing
- Automation/Robotics /automated transport
- Advanced materials/nanotech/ biotech/distributed energy/green tech…

“Disrupt” interaction

- Crowdsourcing, gamification, competitions (e.g. *hackathons*, *appathons*)
- Mobile money, Fintech
- Maker movement/DIY/Tech Incubators/OLC
- Sharing economy, Mobile learning

"Disrupting" Development

An Interactive Primer on Disruptive Technology in Development

World Bank e-book on Disruptive Tech (draft)
http://www.appsolutelydigital.com/dt/

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- Introduction
- Acknowledgements
- Key Development Challenges
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  - Economic
  - Social
- Emerging Disruptive Technologies
  - Types of Disruptive Technology
  - Examples of Disruptive Technology
- Disruptive Tech in Development
  - Rethinking Development
  - Disrupting our Challenges
  - Explore Global Resources at your Fingertips
    - Interactive Tech Application Explorer
    - Casestudies
- Looking Ahead
  - Regulatory Environment
  - Moving Ahead...

Benefits of using emerging technology

- Cheaper, faster, better, …
- More participatory, information-based decisions
- Do things not possible before, smaller world…

Risks of using emerging technology

- Traditional jobs becoming obsolete
- Changes in decision making
- Privacy, Cybersecurity, Accelerated pace of change…

Disruptive tech could change Development

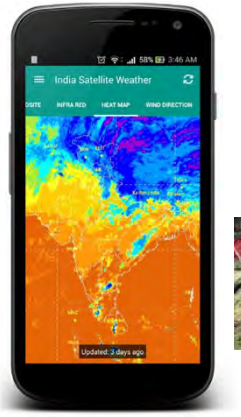
Making "smart development" wrt climate, water and natural resources, energy, food, waste, mobility, knowledge, services, networks

Online Services

Broadband & Smartphone Access

Apps, e-services & e-learning

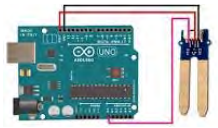
Planning



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

3D Printed Infrastructure

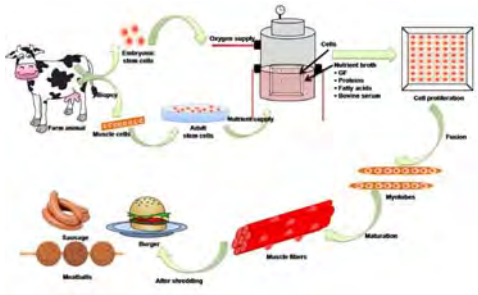
Sensors/IoT
(e.g. for soil moisture)



Drones/UAVs
(e.g. for monitoring, seeding, delivery)

Fundamental Project Design Implications

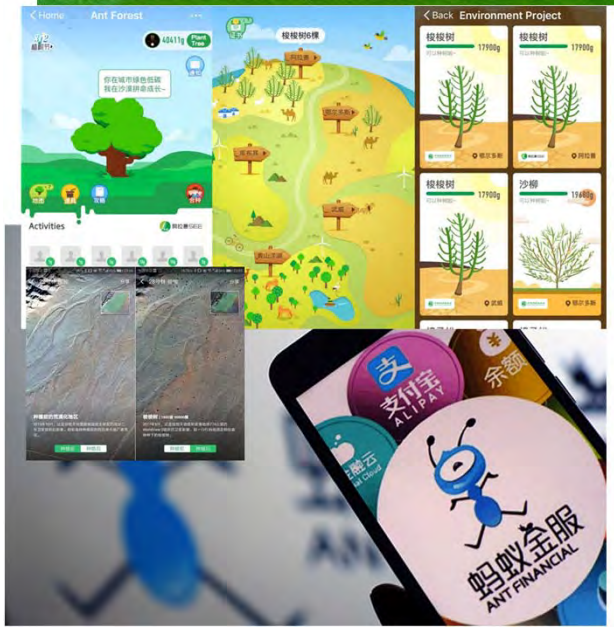
The $325,000 Lab-Grown Hamburger Now Costs Less Than $12



27 September 2018

Official launch of the Ultra-sonic algae control devices and algae monitoring stations in Lake Qaraoun

Wed. 19 September 2018 - by Lidi Remmelzwaal

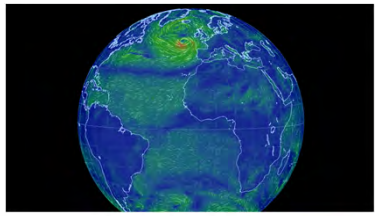


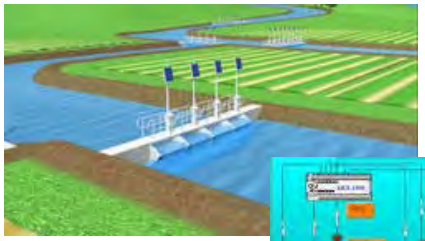
Solar-covered Canals

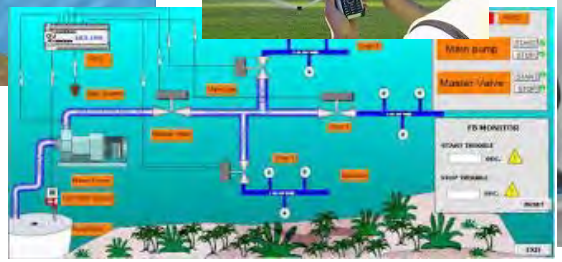
“Floto-voltaics”

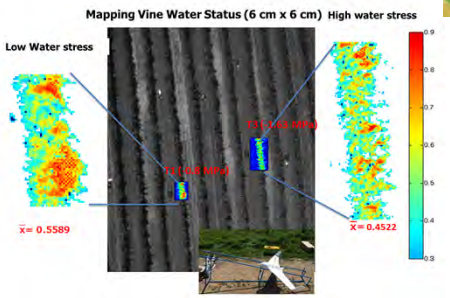
Disruptive Tech can change individual “sectors”

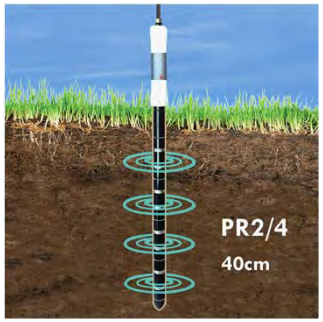
Doing things differently…

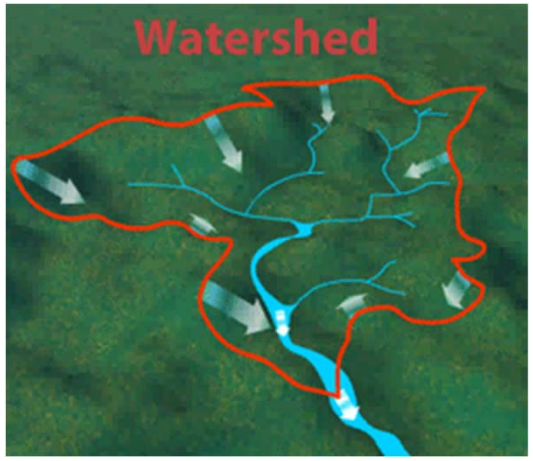












Disruptive Tech can change individual “sectors”

e.g. Agriculture

Doing different things…

Platforms

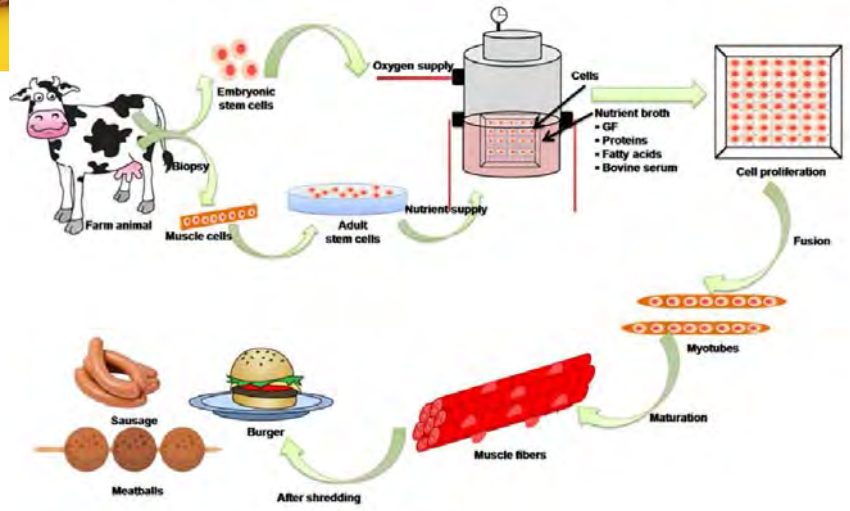
Watch This Space!

04.01.15

The $325,000 Lab-Grown Hamburger Now Costs Less Than $12

A real burger made without the cruelty and pollution is now within reach.

[TOP PHOTO: NEVODKA VIA SHUTTERSTOCK]

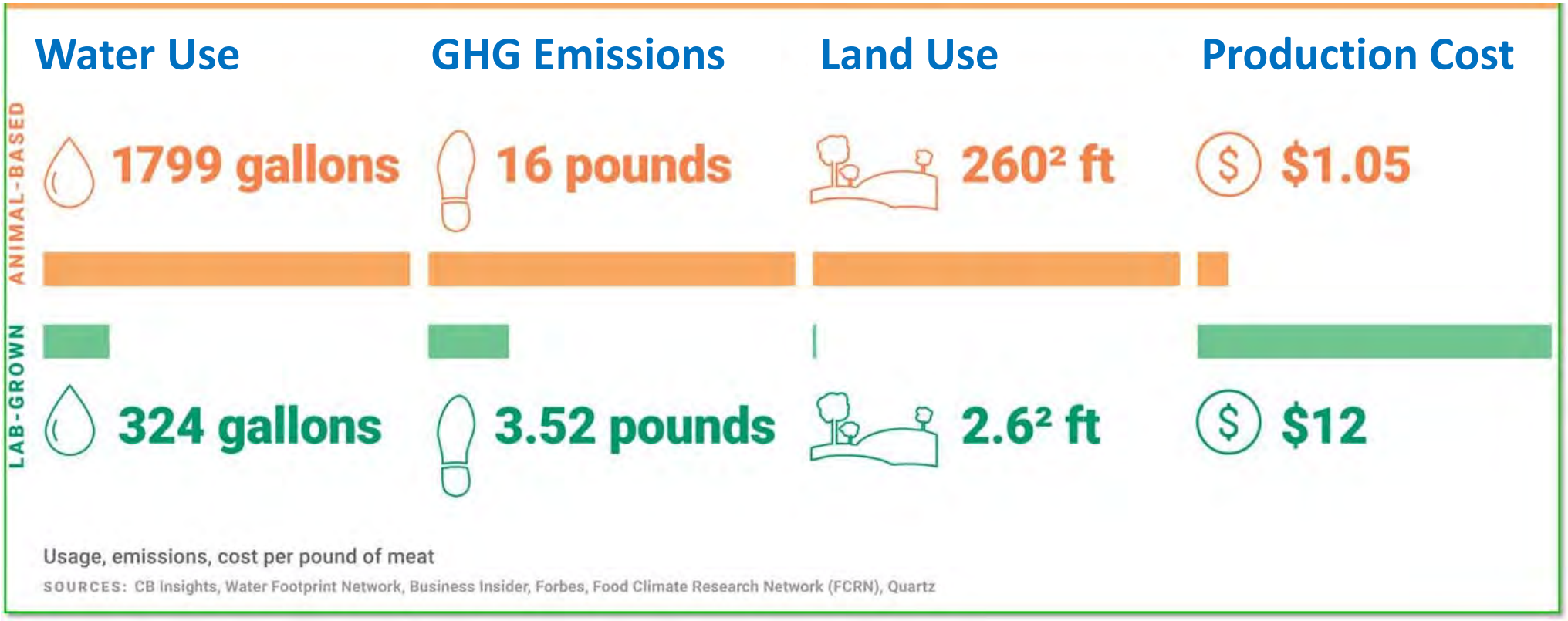


Many multi-sectoral implications (incl. for the Amazon!)

A third of global agricultural water use is for fodder!

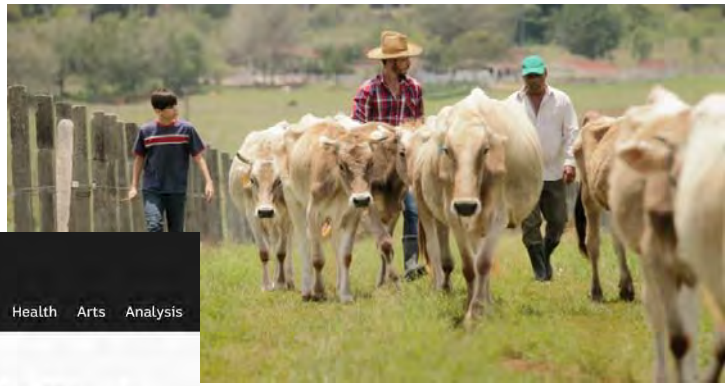
~

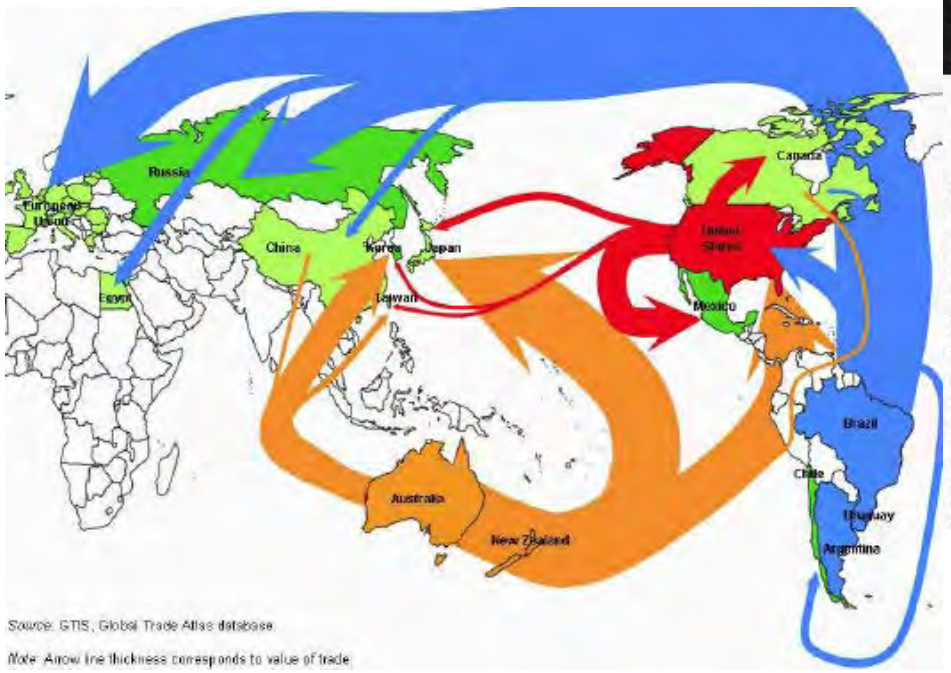
70% of agricultural land is used for pasture (~28m km^2)!



Livestock:

- Supports 1.3 billion people
- 40% of global value of agricultural output





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'Cultured meat' could spell end of traditional cattle farming within decades, scientist behind lab-grown beef burger says

AM By the National Reporting Team's Dominique Schwartz

Posted 27 Mar 2015, 1:08am

The Dutch scientist who served up the world's first laboratory-grown beef burger says "cultured meat" could spell the end of traditional cattle farming within decades.

That is the confronting message Maastricht University Professor Mark Post has for the Northern Territory Cattlemen's Association, which is holding its annual conference in Darwin.

"I do think in 20, 30 years from now we will have a viable industry producing alternative beef and there will be a growing market for it and eventually a really large market," he said.

PHOTO: Professor produced for $80 a

USDA and FDA Announce a Formal Agreement to Regulate Cell-Cultured Food Products from Cell Lines of Livestock and Poultry

WASHINGTON, March 7, 2019 — The U.S. Department of Agriculture's (USDA) Food Safety and Inspection Service (FSIS) and the U.S. Department of Health and Human Services' (HHS) Food and Drug Administration (FDA) today announced a formal agreement to jointly oversee the production of human food products derived from the cells of livestock and poultry.

FSIS and FDA released a formal agreement to

Press Release
Release No. 0027.19

USDA Media and Consumer Inquiries:
USDA FSIS Office of Congressional and Public Affairs, Press (202) 720-9113

FDA Media Inquiries:
Megan McSeveney, 240-402-4514, megan.mcseveney@fda.hhs.gov

pandaily

- **Ant Financial is the most valuable fintech company globally**
- **>300m users of Ant Forest app**
- **Planted >13m trees planted ~ 1.5m tons CO_2**

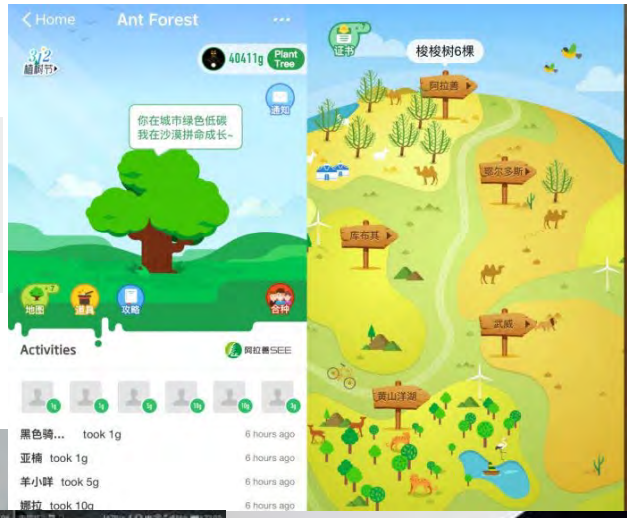
Ant Forest to invest $79M over next 5 years to plant 500M trees

ENTERPRISE SOUHU MARCH 13, 2018

3 min read

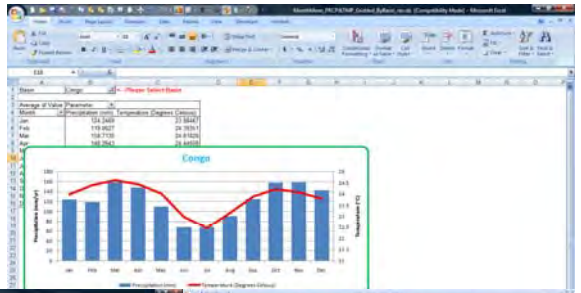
How many netizens will reduce their carbon footprint with Ant Forest to plant real trees? Alipay is serious about this ecological undertaking.

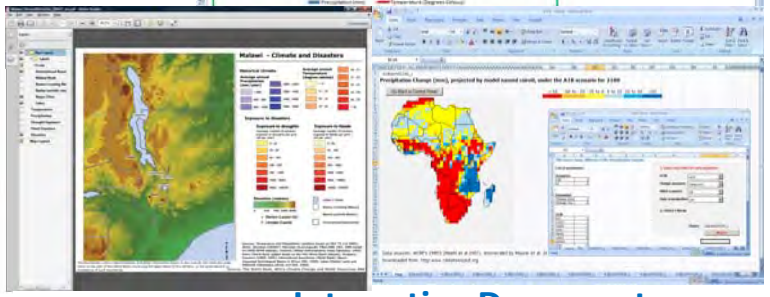
SEE ALSO: Ant Financial to Raise $5B, May Go Public in Two Places



Many new Innovations

Software/Analytical & Visualizaton Tools

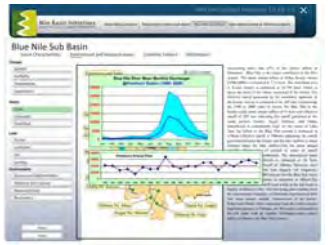




Interactive Documents

Innovative Hardware
(e.g. Tablets)

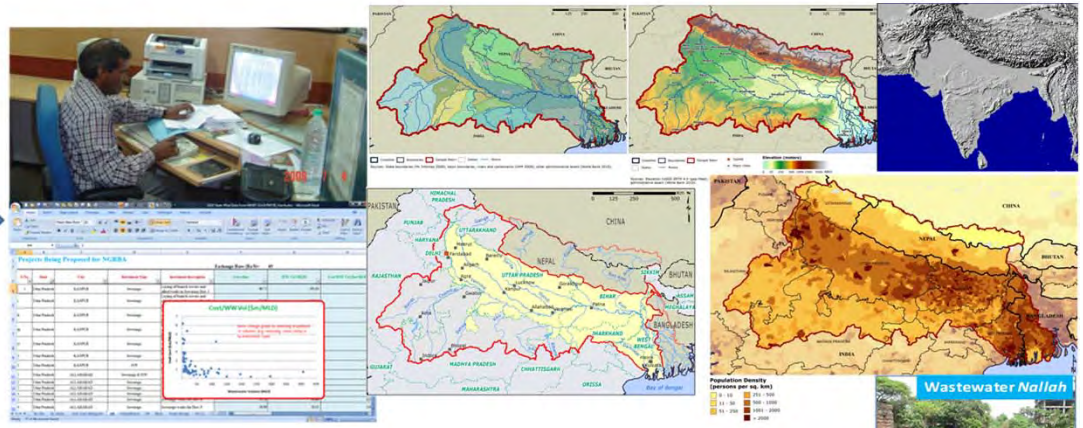
Online Portals



Data Rescue

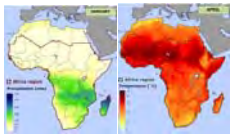
Digitizer

Scanner

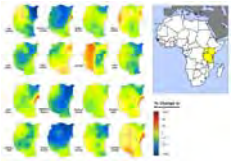


Building on curated public-domain datasets…

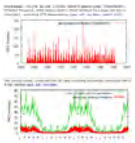
Irrigated, Rainfed Areas (IWMI, FAO)



Historical Climate (CRU/UEA)



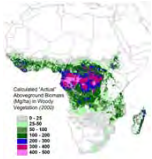
Climate Change (IPCC, TNC/WB)



Climate/Flow data (KNMI, GRDC, …)

Gridded GDP (Yale, NOAA)

DEM (SRTM, ASTER)



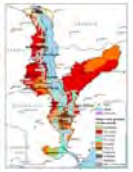
CO2 emissions (EDGAR-JRC-PBL, …)
C Biomass (Winrock)

Biodiversity (CI, WWF, IUCN…)

Flood/Drought (DFO, GDACS, UNEP…)

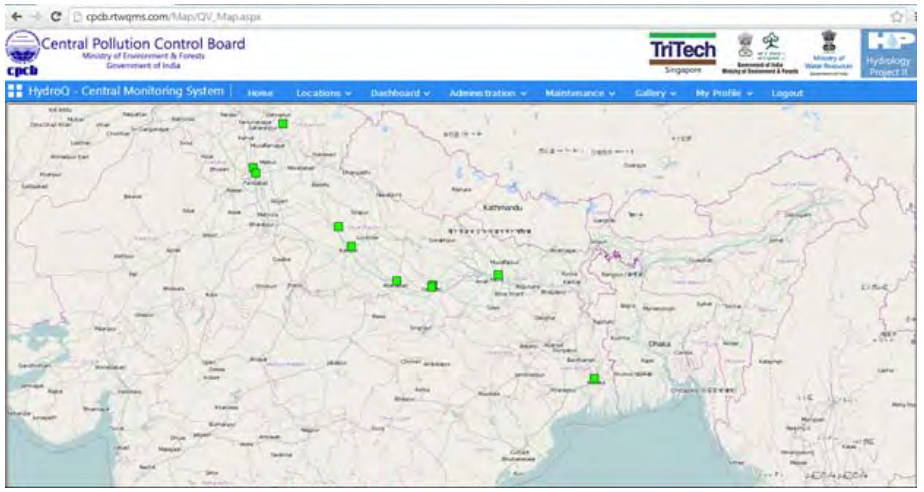
Landcover (ESA, USGS, …)

Population (CIESIN, Landscan, …)



Soils (UNESCO, FAO, …)

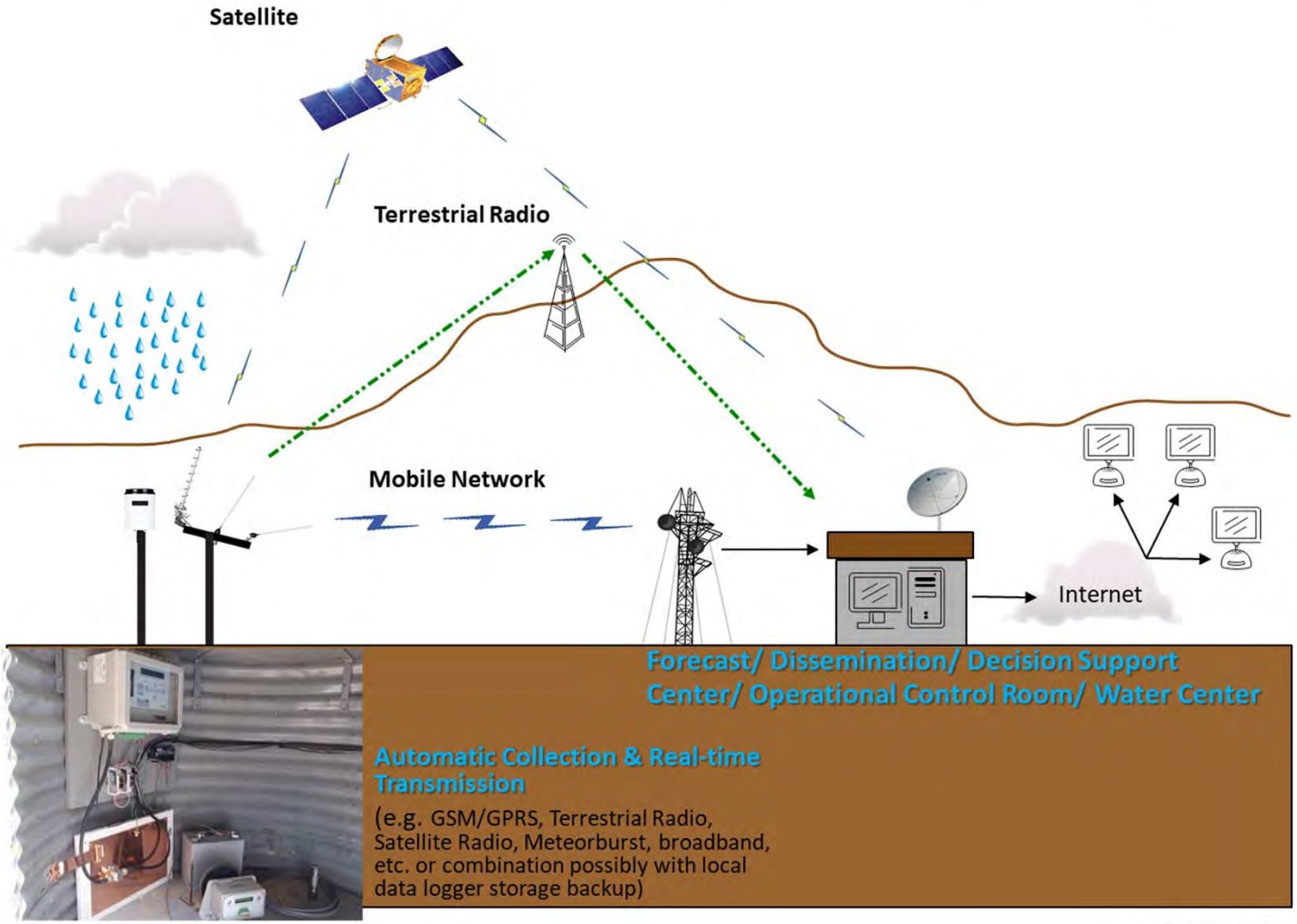
“Bottom-up” Monitoring Systems



Explore e-book we have created:
http://appsolutelydigital.com/MonitoringSystems/hydrology.html

Crowdsourcing Monitoring

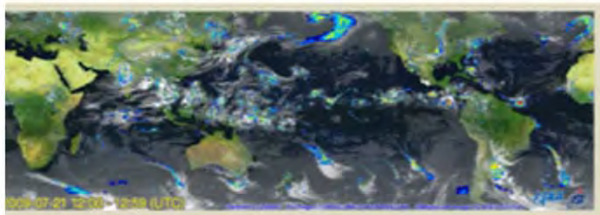
Illustrative Options for Real-time Telemetry



Source: Innovative Hydrology

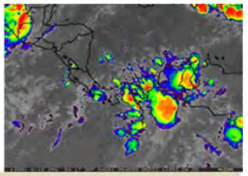
"Top-down" Measurements from Space

"Space-based Rain Gauge" e.g. TRMM



igure 10 An example satellite image from the Global Rainfall Map Source: http://sharaku.eorc.jaxa.jp/GSMaP/

Weather Products



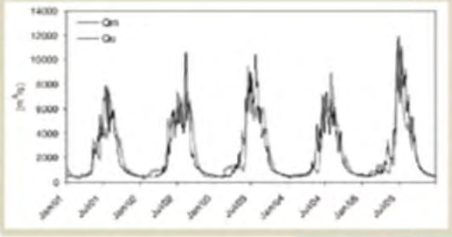
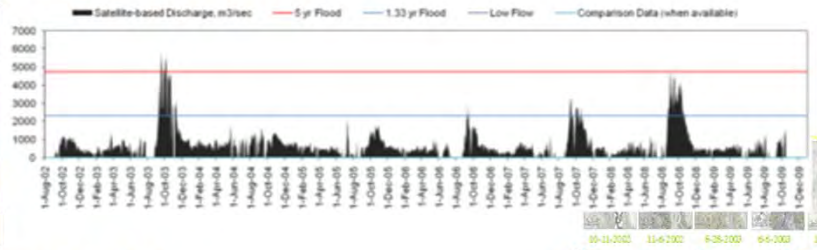
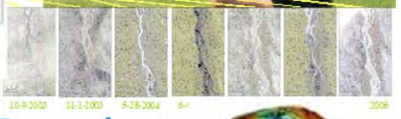


Figure 11 Observed (Qo) and modelled (Qm) runoff at Besham Qila, Upper Indus based on remotely sensed (TRMM) snow cover and precipitation data.

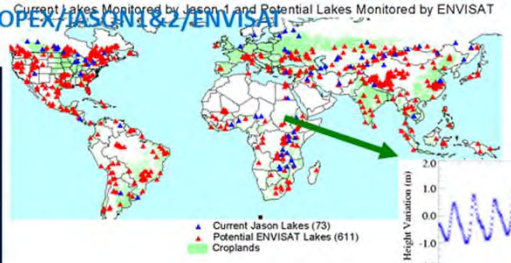
Source: Immerzeel et al. (2009)

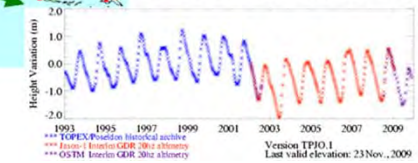
"Space-based Stream Gauge" e.g. AMSR





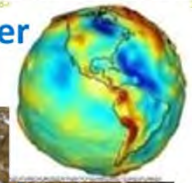
"Space-based Reservoir Levels" e.g. TOPEX/JASON1&2/ENVISAT

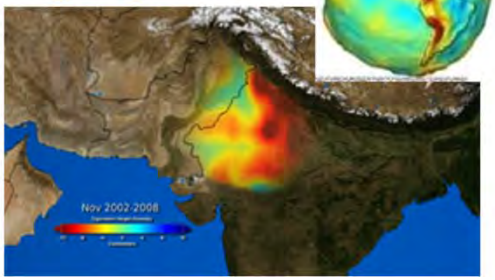




+ Snowcover, Glaciers, Soil Moisture, Temperature, Evapo-transporation, Landcover, and much more…

"Space-based Groundwater monitoring" e.g. GRACE





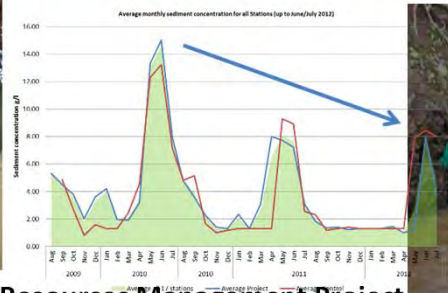
Detailed Monitoring Information

(incl. Community Monitoring in Tana-Beles Project, Ethiopia)

	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

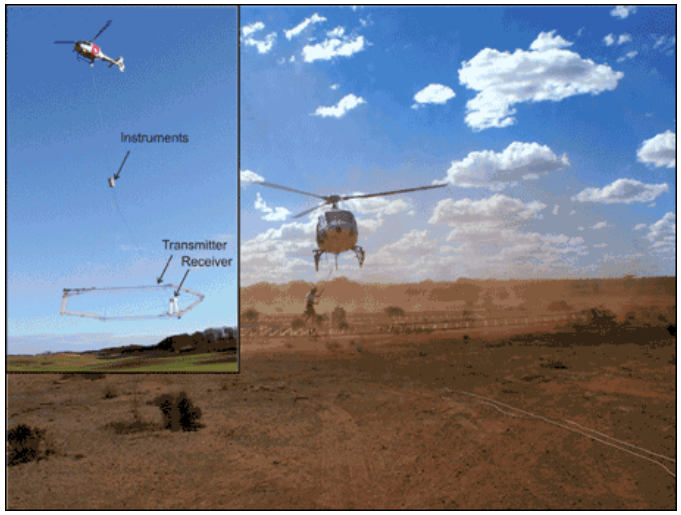
Sediment Concentration Analyses



Ethiopia: Tana and Beles Integrated Water Resources Management Project

Thanks JB for some of the photos!

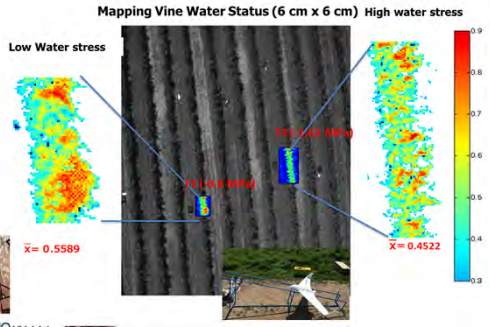
Potential to use Modern Technology

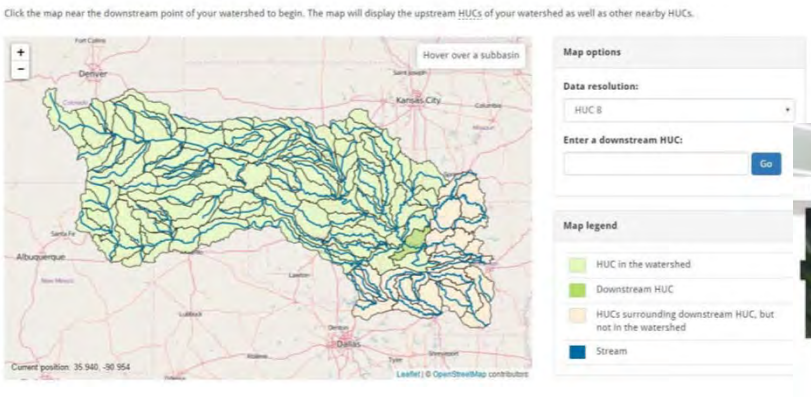


Heliborne Geophysical Surveys

Free Satellite Data & Cloud Computing

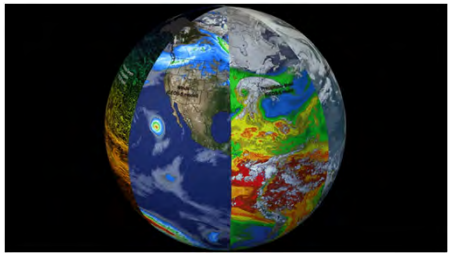
Global Services (e.g. hydrologic forecasts)



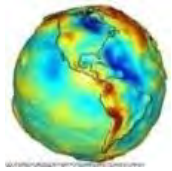


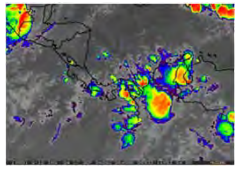
Online Modeling Platforms

High-resolution Subscription Services (based on Satellite, UAV, IOT, Analysis…)

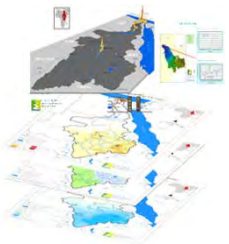


"Top-Down" Data Acquisition System

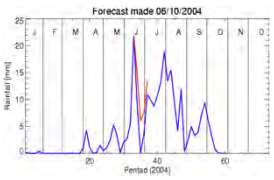




Satellite & UAV Earth Observation



GIS and other datasets
Data Rescue



Data Management

Analytics/Models

Big Data

Platforms

Cloud Services

Machine Learning/AI

Crowdsourcing

Web Portals/Apps/e-books

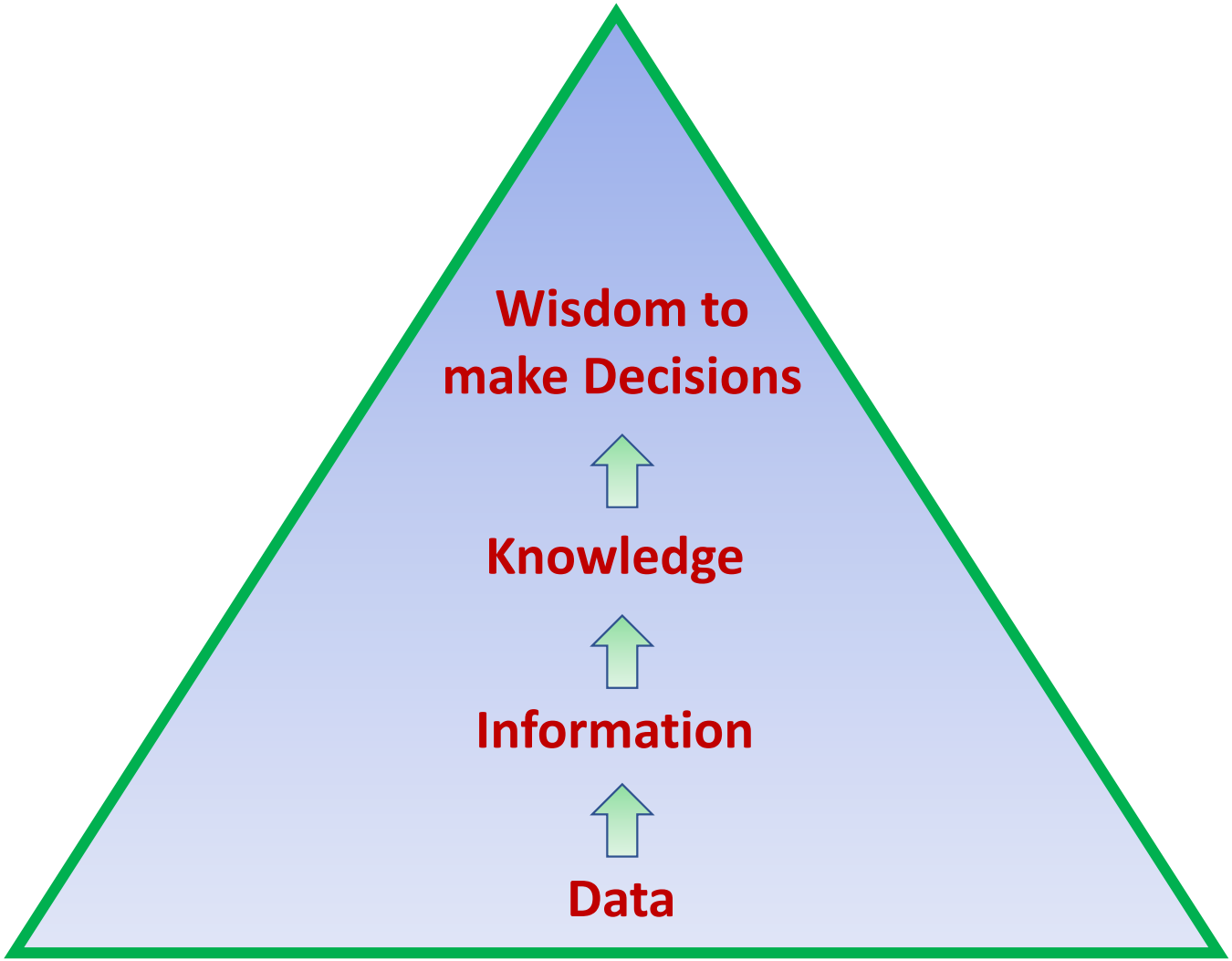
Stakeholder Alerts

Operational Control Rooms

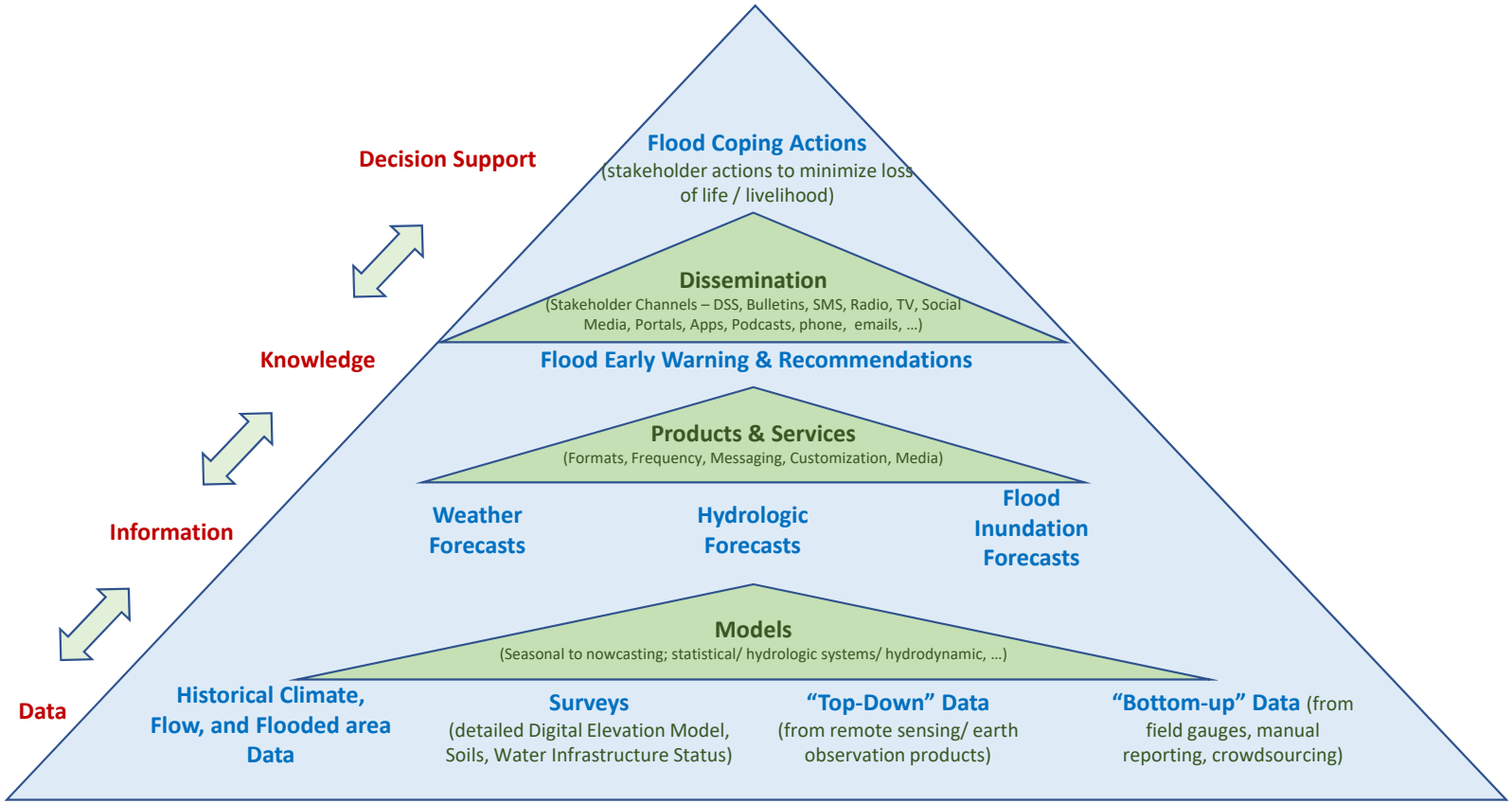
Manual Monitoring

Automated Monitoring

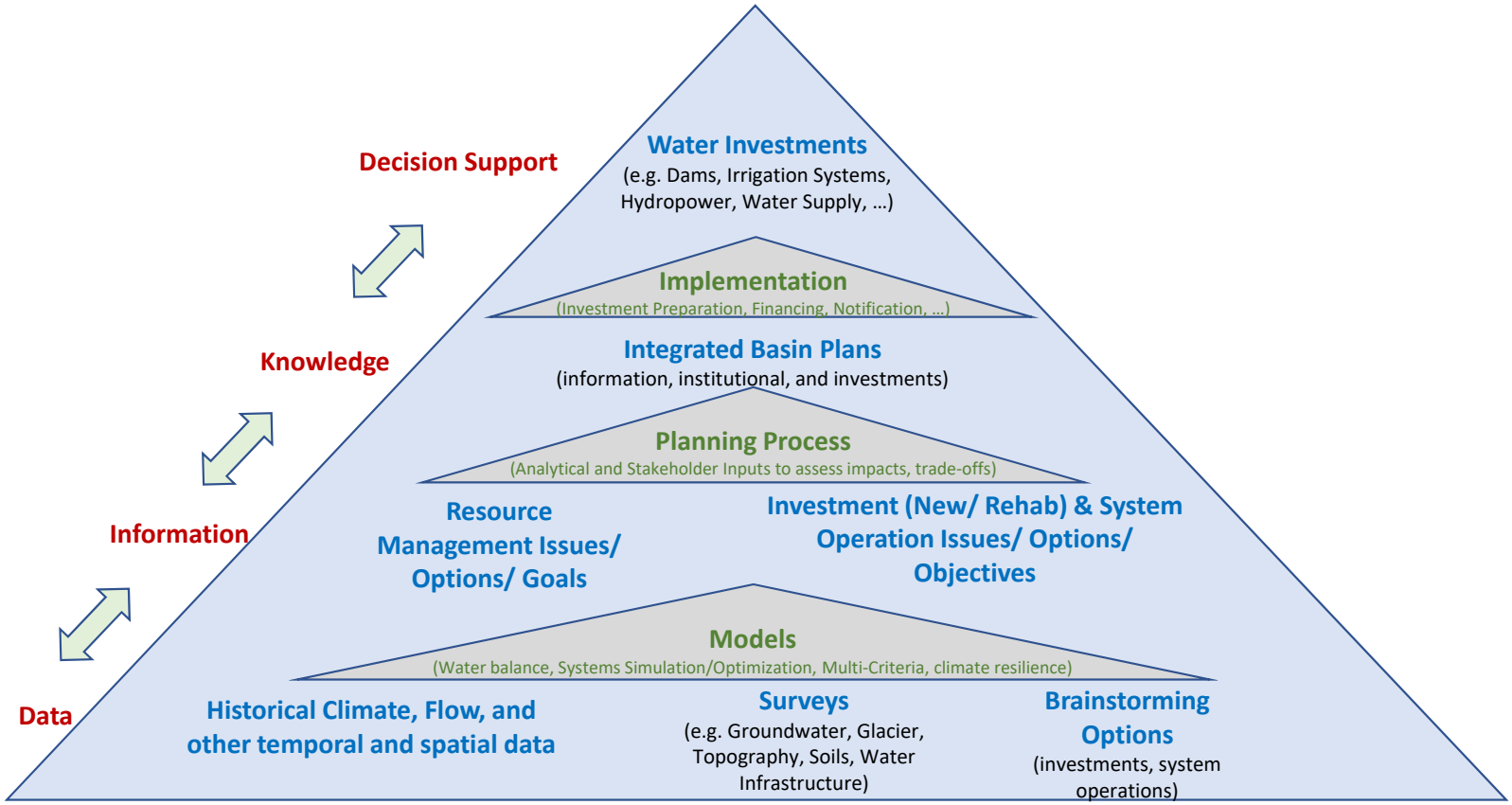
"Bottom-up" Data Acquisition System → IoT


Wisdom to
make Decisions
Knowledge
Information
Data

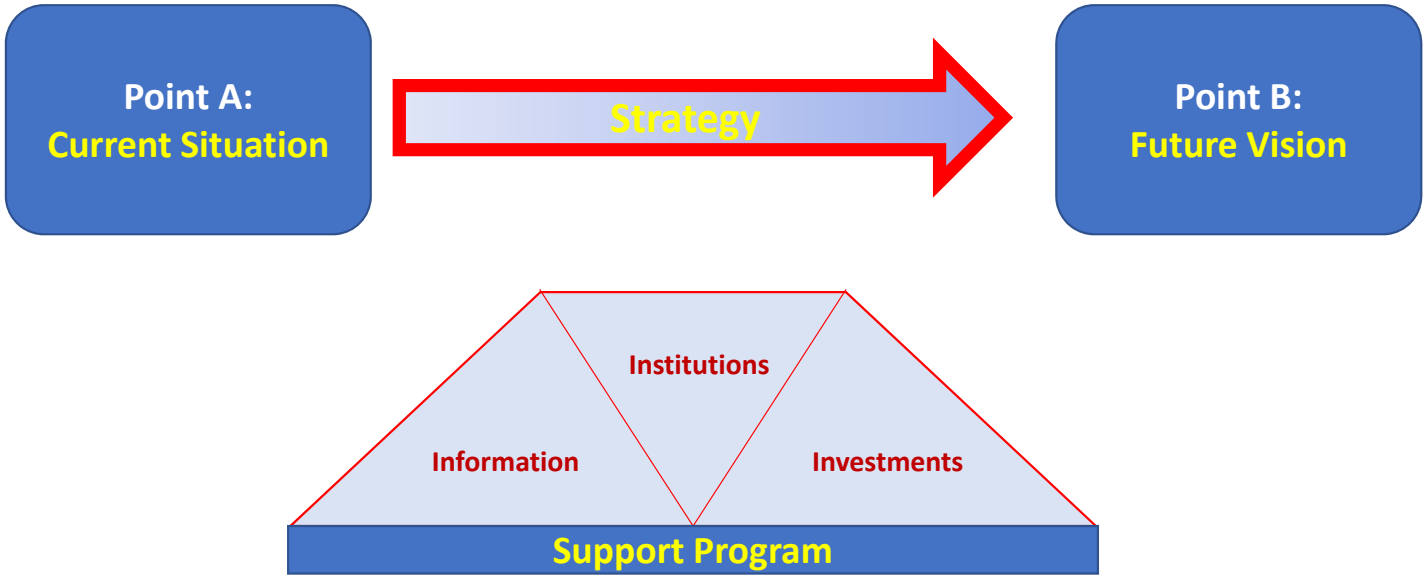
Data Value Chain: Coping with Floods



Example: Deciding on Water Infrastructure Investments (New, Rehabilitation)



Basin Planning
Envisioning the Future



Analytical & Stakeholder Tracks to Multi-sectoral Spatial Planning…

Decisions→

Stakeholder Identification

Understanding Basin Issues/Problems (Pt. A – where now?)

Shared vision for future potential (Pt. Bs – where could the Basin be?)

Selection of development options (getting from A to B)

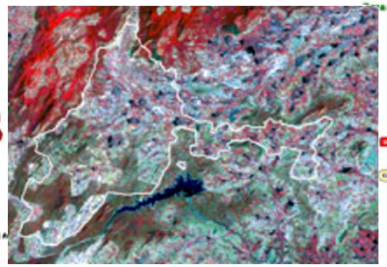
Agreement on Basin Development Plan

Investment Facilitation/Implementation/Supervision

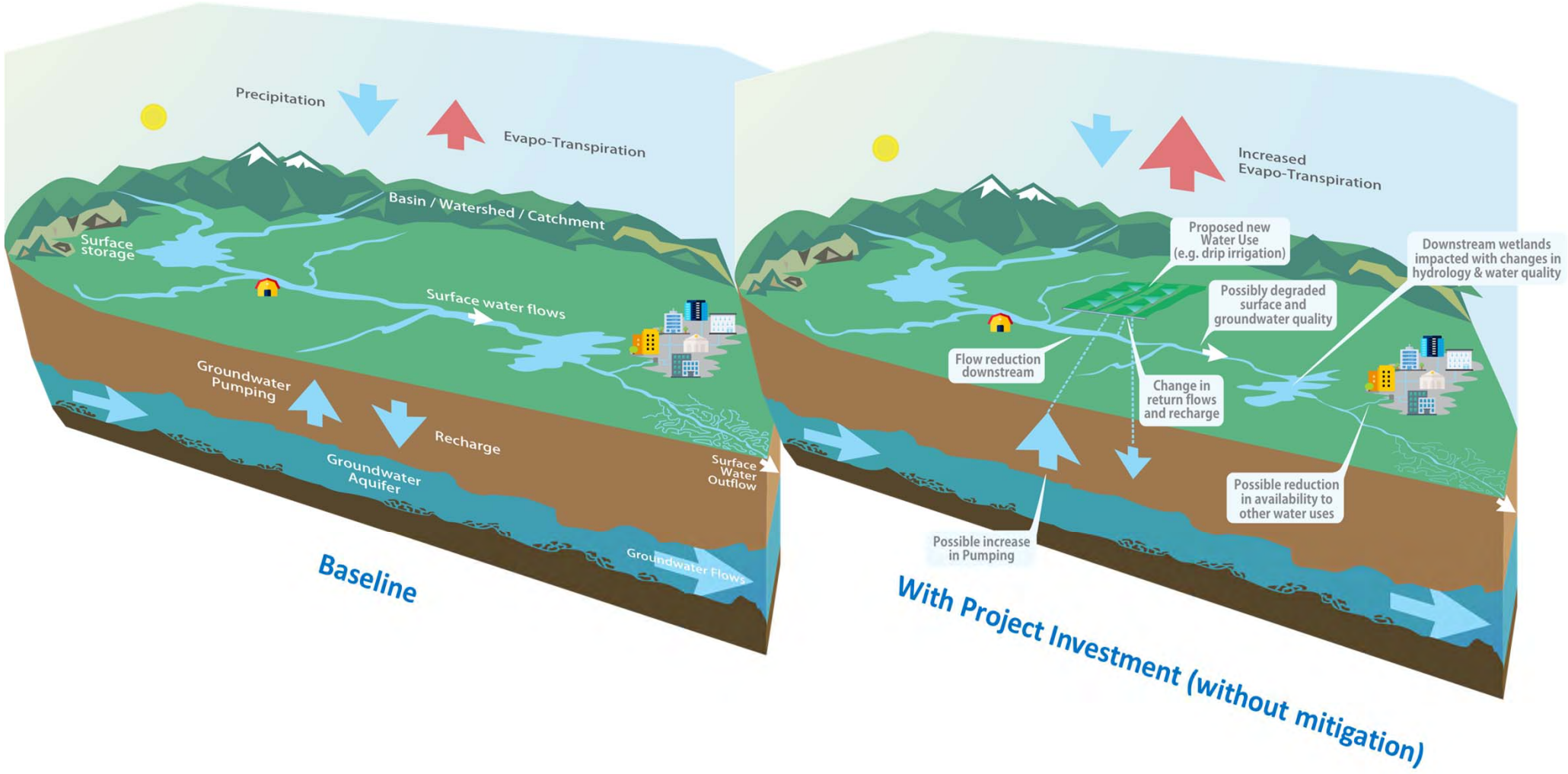
Consensus on Additional Needs

Stakeholder Involvement →

Analytical →



Water Use

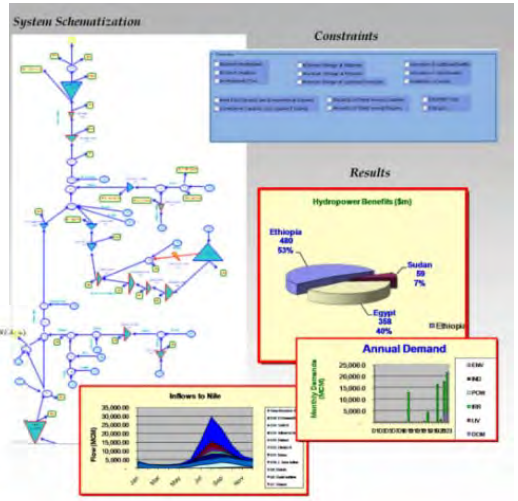


Source: *Good Practice Note on Water Use (ESS3) - forthcoming*

Planning Modeling Tools

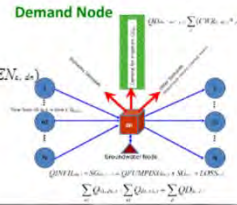
e.g. Eastern Nile Planning Model Project

Simulation

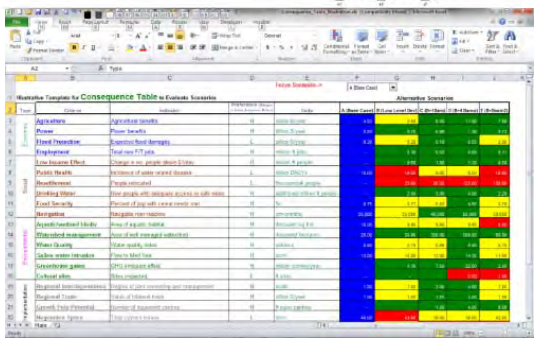


Optimization

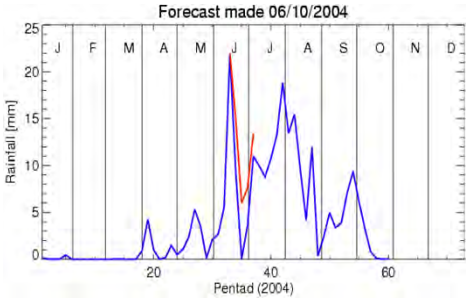
$$\text{Maximize}$$
$$\text{Net\_Benefits}, Z = \text{Irrigation\_Benefits} \sum_{c} \sum_{dv} (AREA_{c,dv} * YIELD_{c,dv} * NETBEN_{c,dv})$$
$$- \text{Power\_Benefits} \sum_{ys} MWH_{ys,s} * NETPRICE_{ys,s}$$
$$- \text{Costs}(\text{storage}, \text{pumping}, \text{conveyance}, \text{treatment})$$

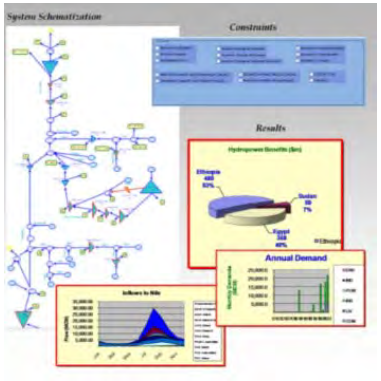


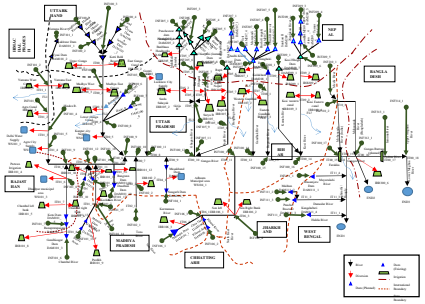
Multi-Criteria Analysis



Many free systems modeling tools available today: Some Examples…







InVEST
integrated valuation of ecosystem services and tradeoffs

RIOS

Watershed Conservation Screening Tool

SWAT Soil & Water Assessment Tool

eWater

KING'S College LONDON
WaterWorld
supported by:
CGIAR
Water, Land and Ecosystems
espa
CONSERVATION INTERNATIONAL

Variable Infiltration Capacity (VIC) Macroscale Hydrologic Model

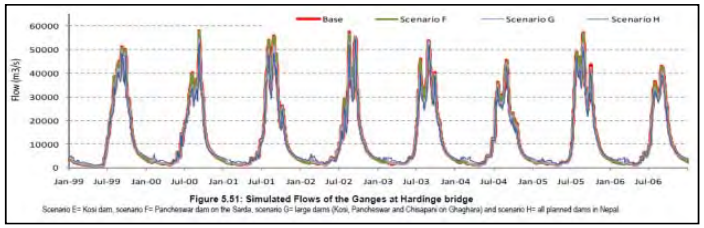
US Army Corps of Engineers
Hydrologic Engineering Center (HEC)

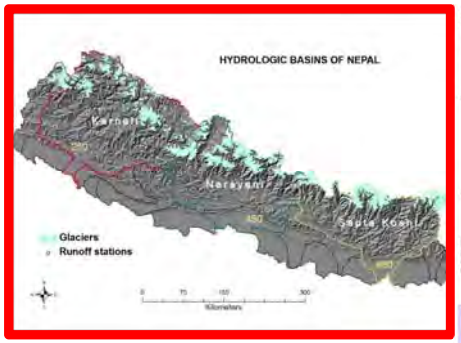
GAMS

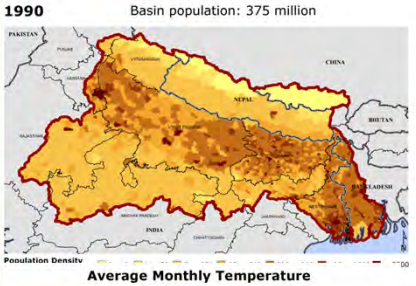
Water Evaluation And Planning
WEAP

Early Draft Model Primer e-book (World Bank)
http://www.appsolutelydigital.com/ModelPrimer/cover.html

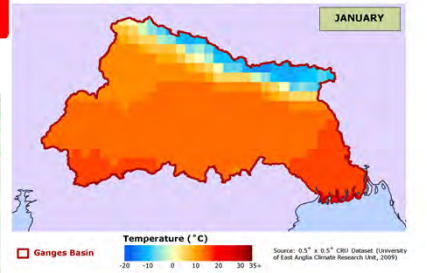
Complex Water Systems Models

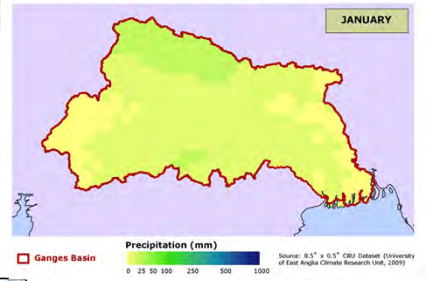


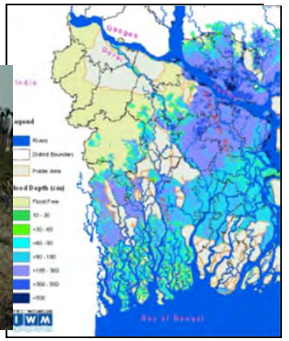


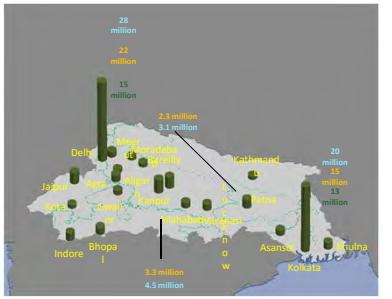


Average Monthly Temperature







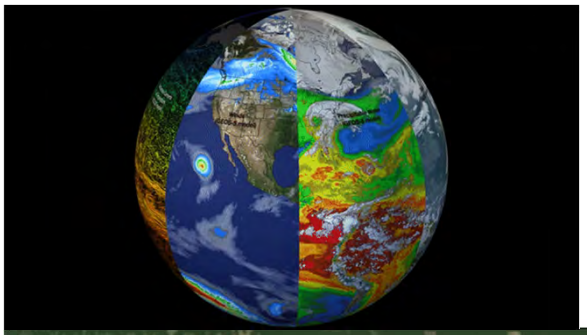


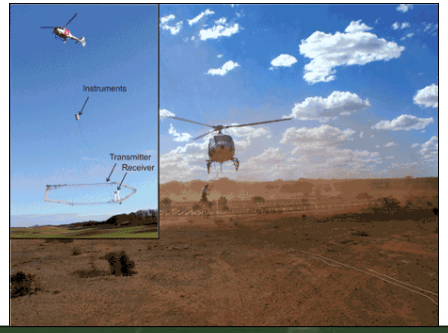
1025 Structures

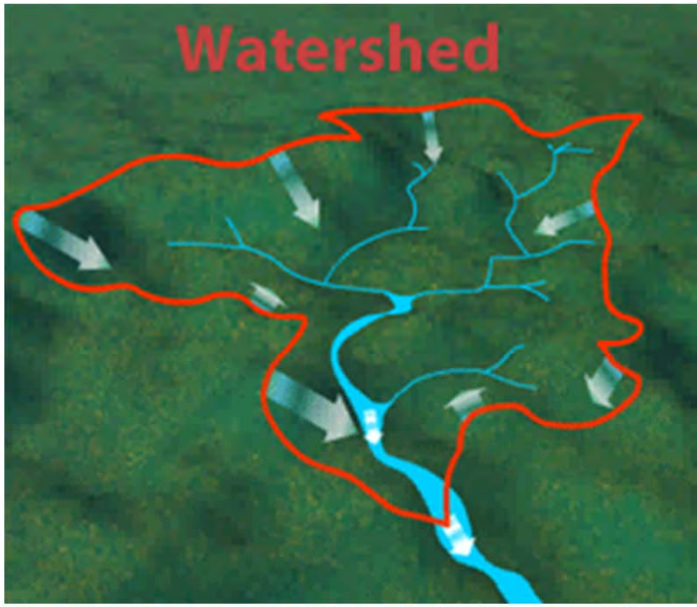
Depth
Area

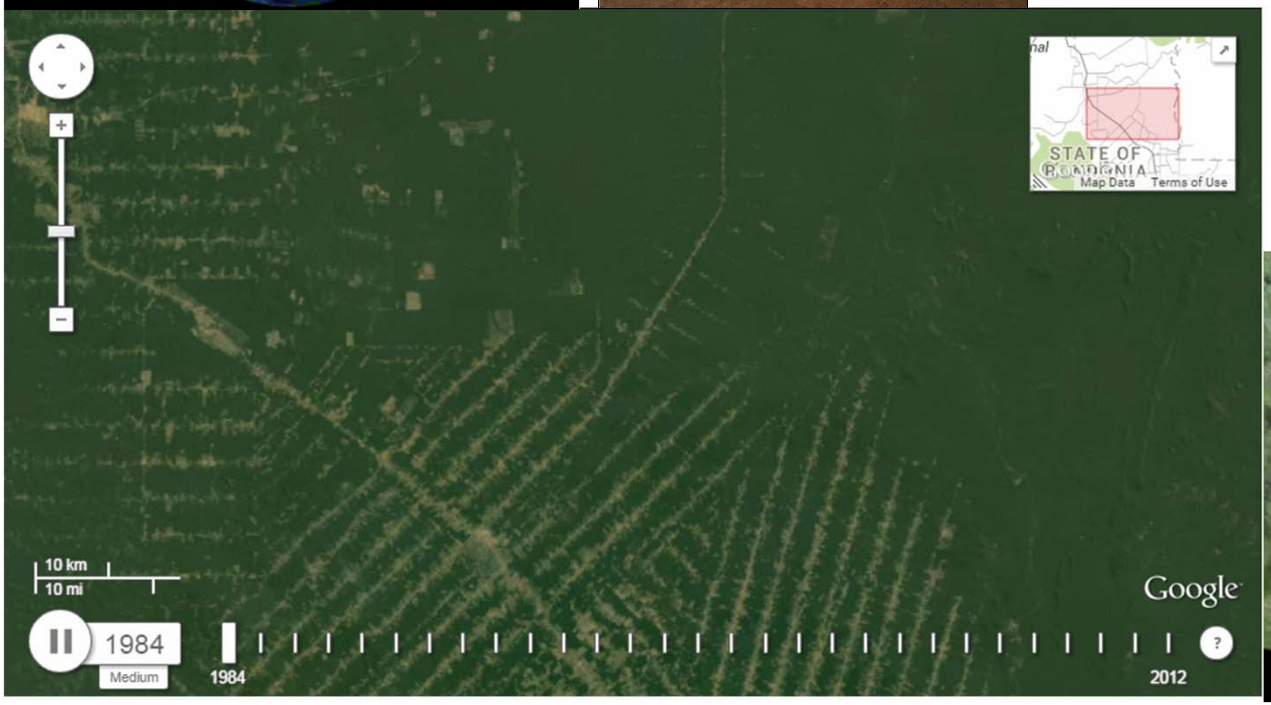
Tangible Landscape + Immersive Virtual Reality
Watch later
Share
0:48
0:57 / 2:30
YouTube

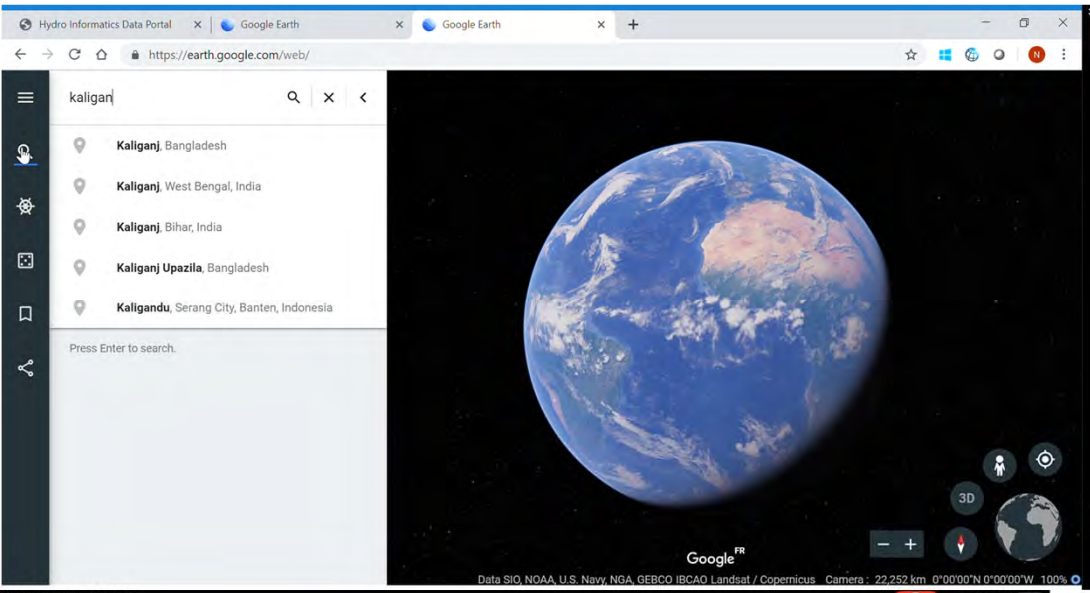
Big Data – In the Sky










Hydro Informatics Data Portal
Google Earth
Google Earth
https://earth.google.com/web/
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Kaliganj, Bangladesh
Kaliganj, West Bengal, India
Kaliganj, Bihar, India
Kaliganj Upazila, Bangladesh
Kaligandu, Serang City, Banten, Indonesia
Press Enter to search.
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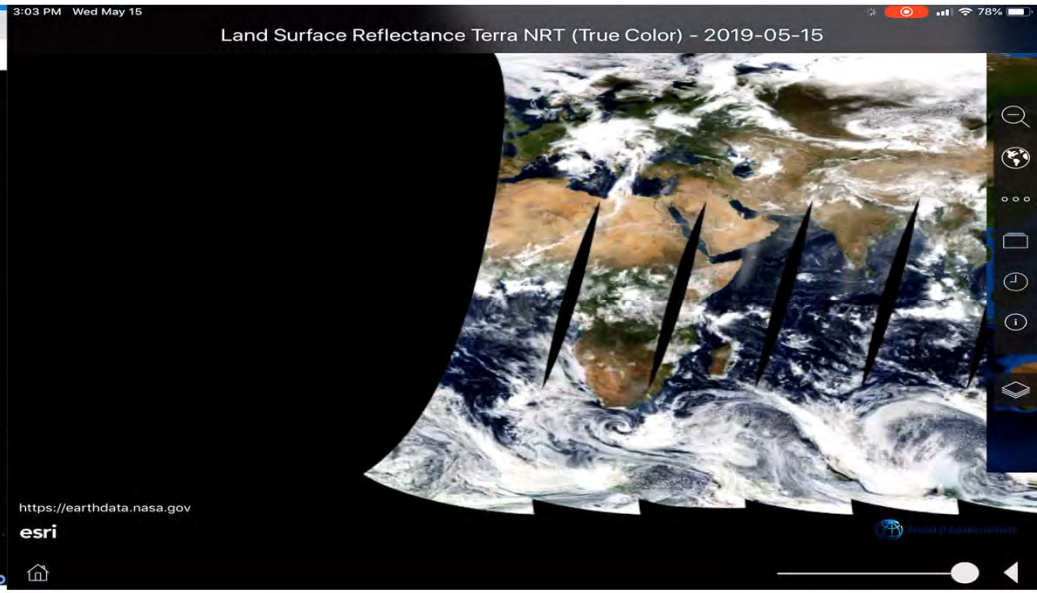
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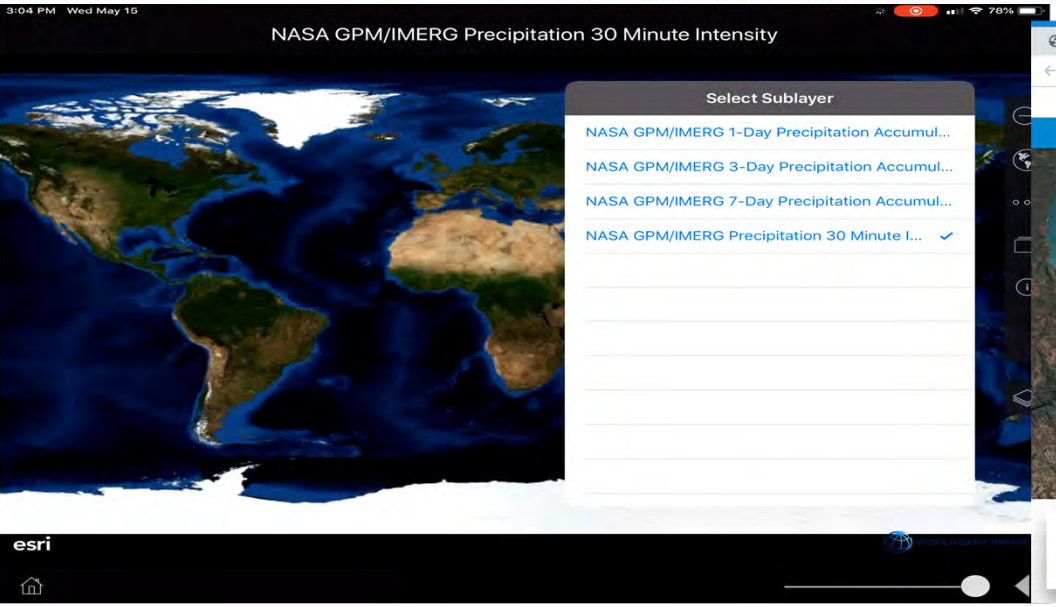
Land Surface Reflectance Terra NRT (True Color) - 2019-05-15
https://earthdata.nasa.gov
esri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NASA GPM/IMERG Precipitation 30 Minute Intensity
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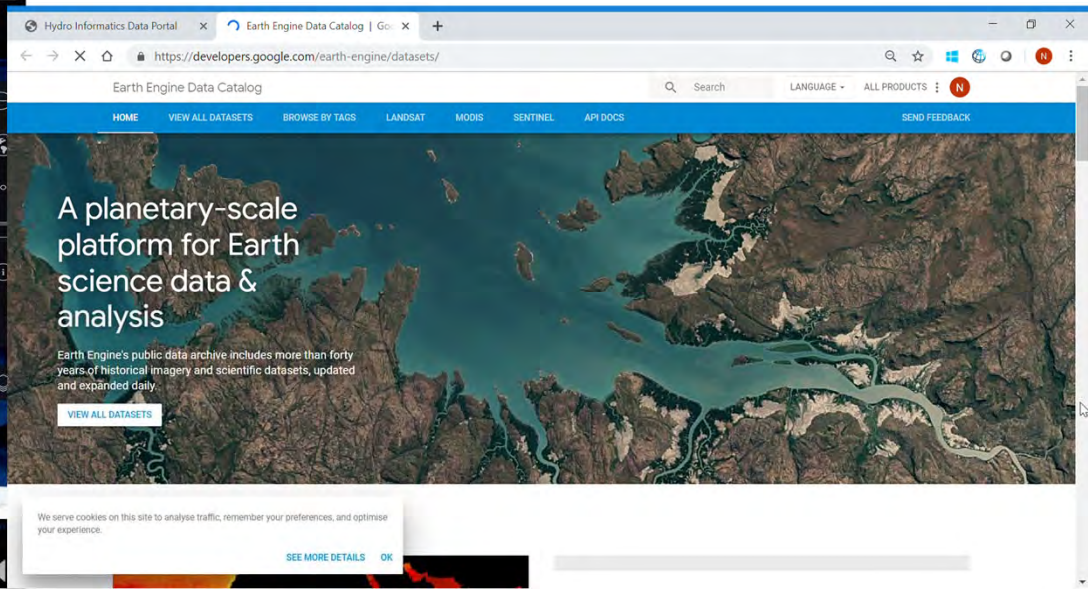
Hydro Informatics Data Portal
Earth Engine Data Catalog | Go
https://developers.google.com/earth-engine/datasets/
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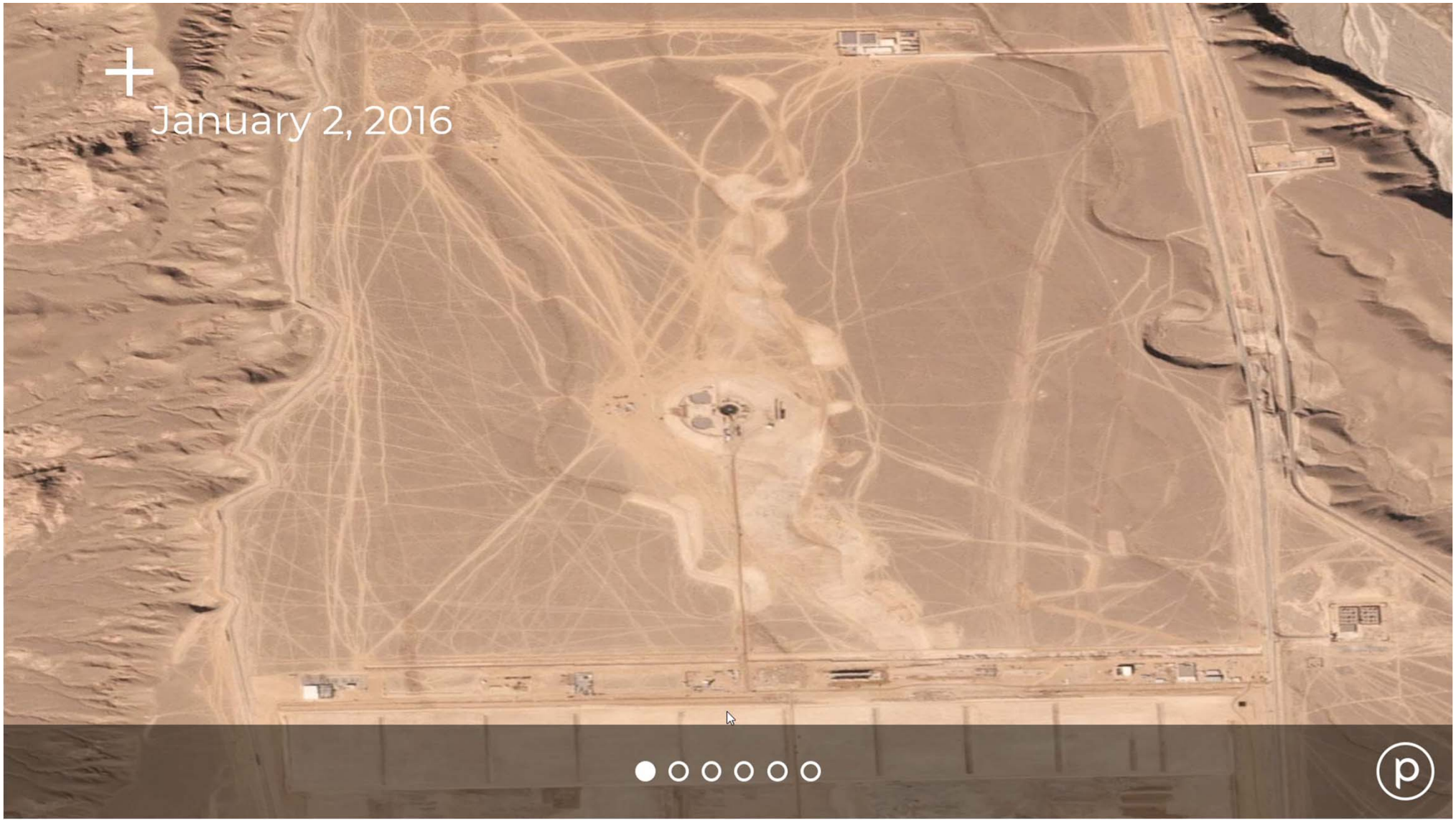
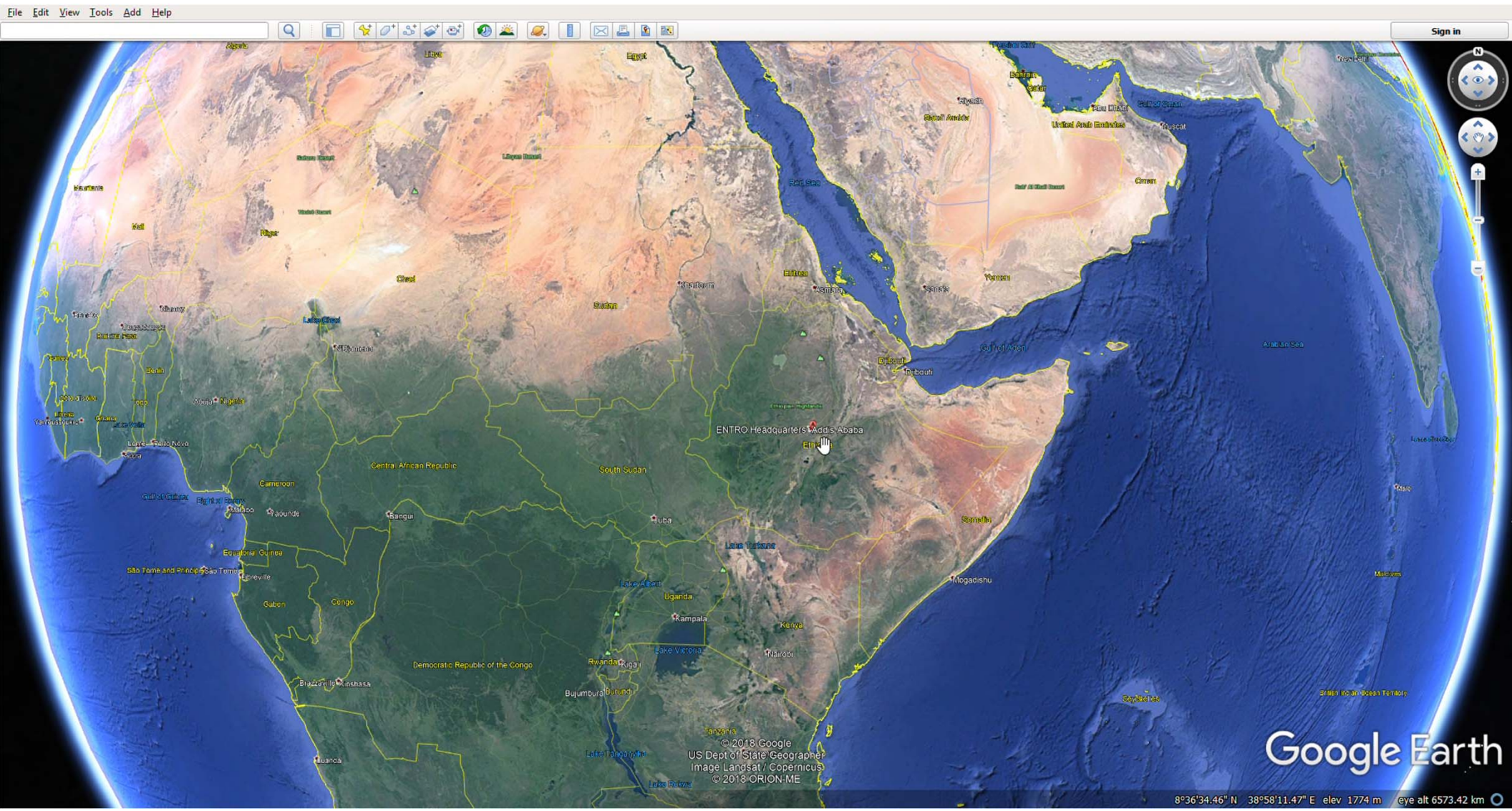


Source: Zara Khan, **Planet**, Presentation at World Bank Disruptive Tech in Agriculture & Watersheds Workshop, May 2019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Bangui
Cameroon
Yaoundé
Malabo
Equatorial Guinea
São Tomé and Príncipe
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Libreville
Gabon
Congo
Brazzaville
Kinshasa
Democratic Republic of the Congo
Luanda
Uganda
Kampala
Kenya
Nairobi
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Burundi
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Tanzania
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Lake Rukwa
Lake Turkana
Lake Chad
Niamey
Niger
Mali
Chad
Libya
Egypt
Red Sea
Gulf of Aden
Arabian Sea
Yemen
Sanaa
Oman
Muscat
United Arab Emirates
Abu Dhabi
Riyadh
Saudi Arabia
Qatar
Persian Gulf
Seychelles
Maldives
Mauritania
Algeria
Nigeria
Abuja
Benin
Togo
Ghana
Accra
Lome
Cotonou
Porto Novo
Gulf of Guinea
Bight of Bonny
Yamoussoukro
Ouagadougou
Burkina Faso
Guinea
Lake Volta
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US Dept of State Geographer
Image Landsat / Copernicus
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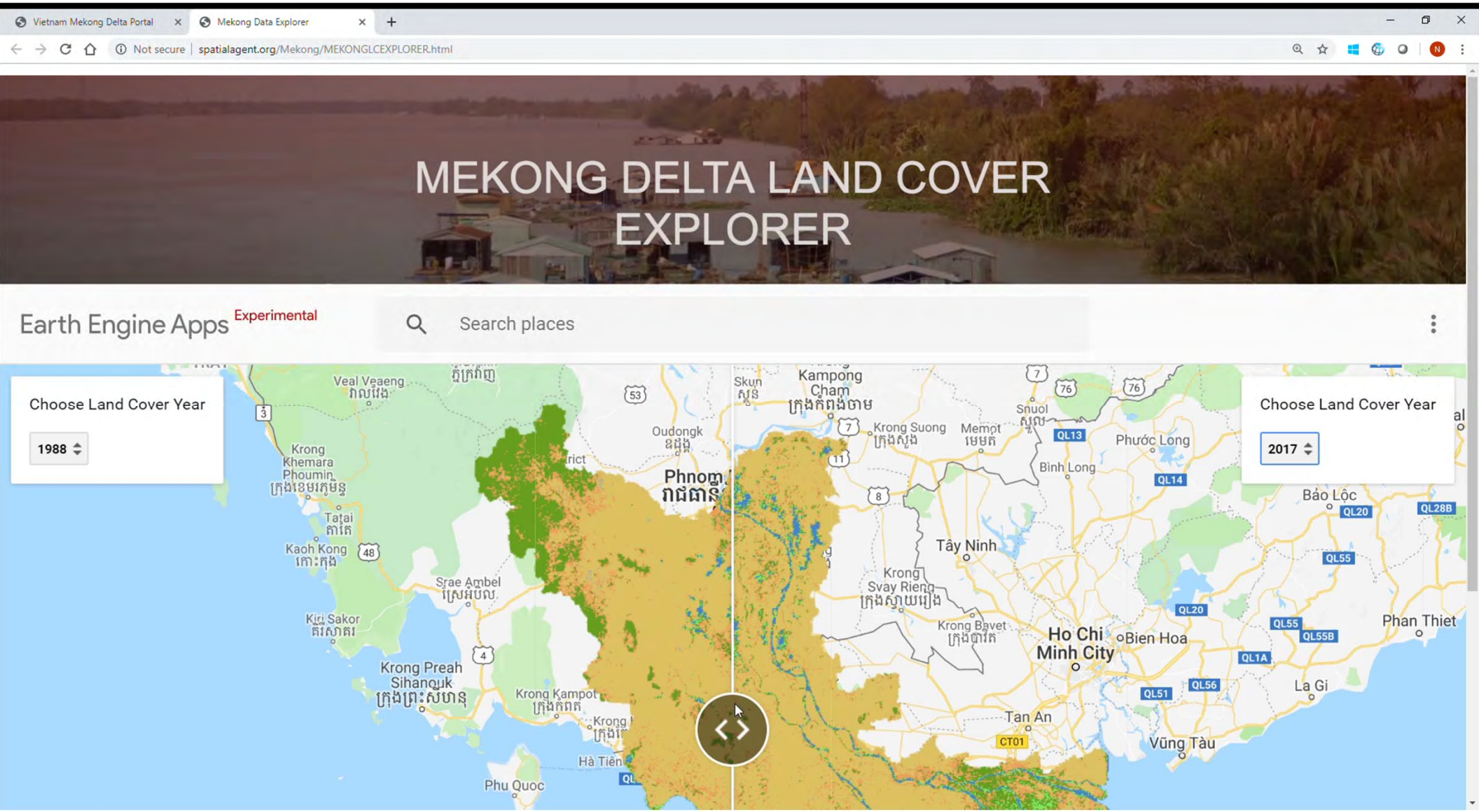
Google Earth
8°36'34.46" N 38°58'11.47" E elev 1774 m eye alt 6573.42 km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Kampong Cham
Krong Suong
Memot
Snuol
Phước Long
Bình Long
Bảo Lộc
Tây Ninh
Krong Svay Rieng
Krong Bavet
Ho Chi Minh City
Bien Hoa
Phan Thiet
La Gi
Tan An
Vũng Tàu
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Hà Tiên
Phu Quoc

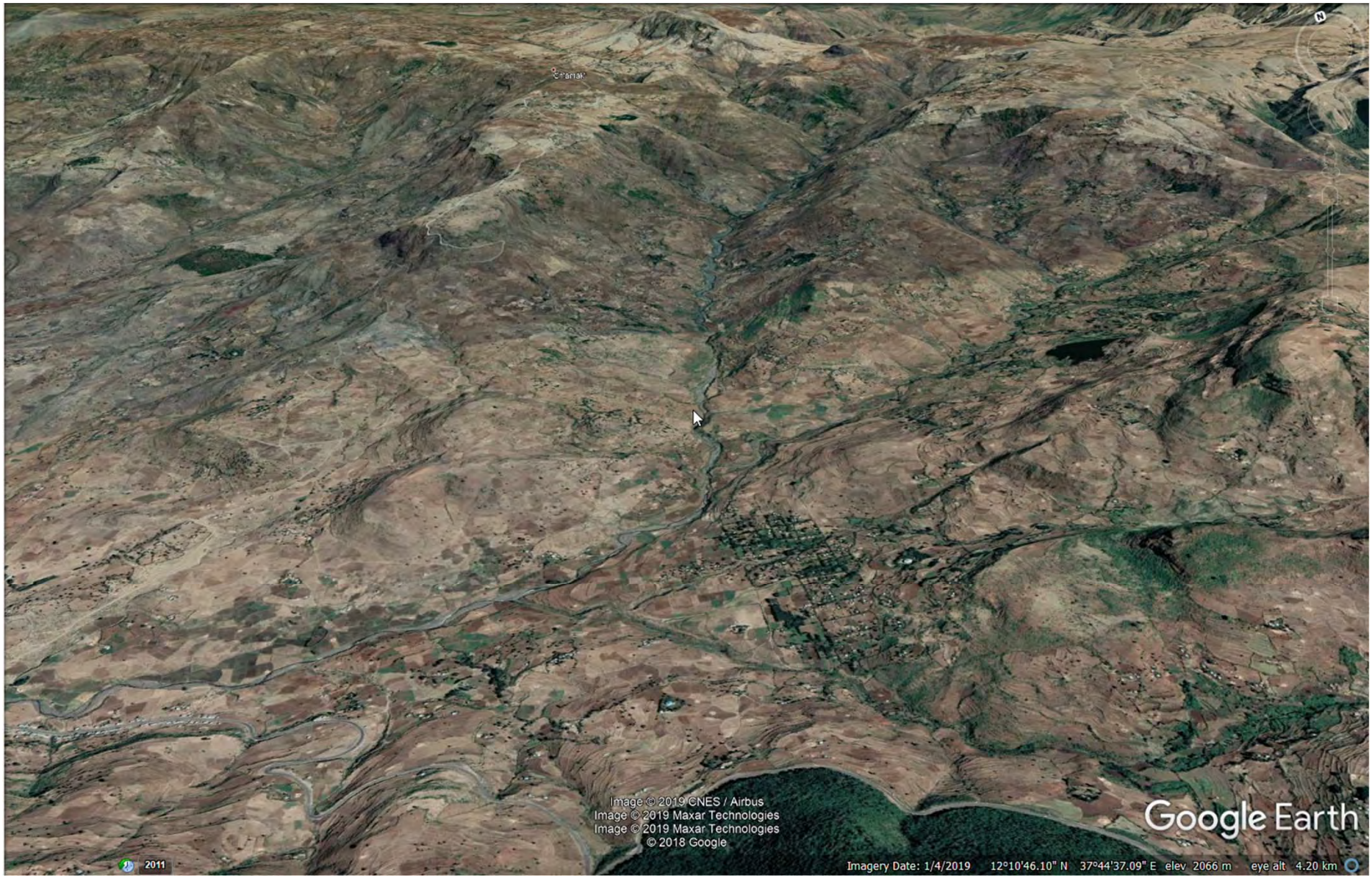
Image © 2019 CNES / Airbus
Image © 2019 Maxar Technologies
Image © 2019 Maxar Technologies
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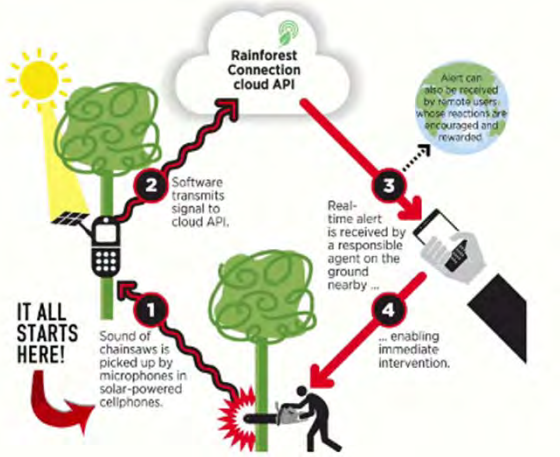
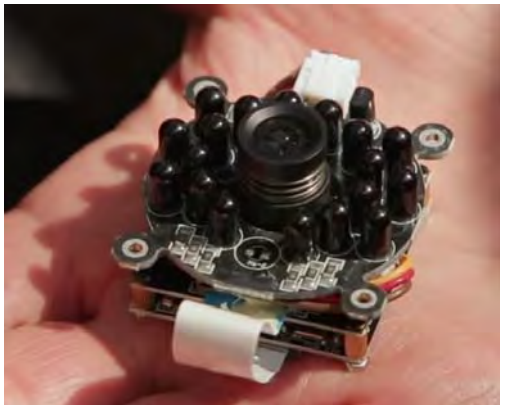
Google Earth
2011
Imagery Date: 1/4/2019 12°10'46.10" N 37°44'37.09" E elev 2066 m eye alt 4.20 km

Big Data – on the ground…

Wisdom of the Crowd

In-Situ Sensors: Now when a tree falls in a forest, you can actually hear it!





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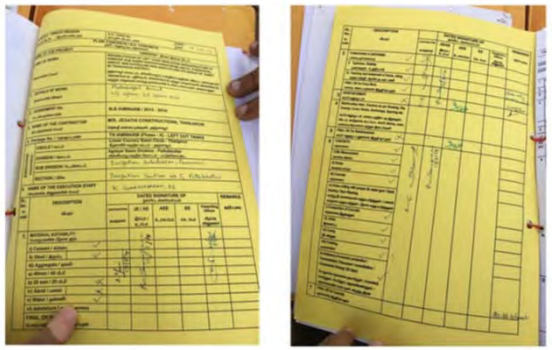
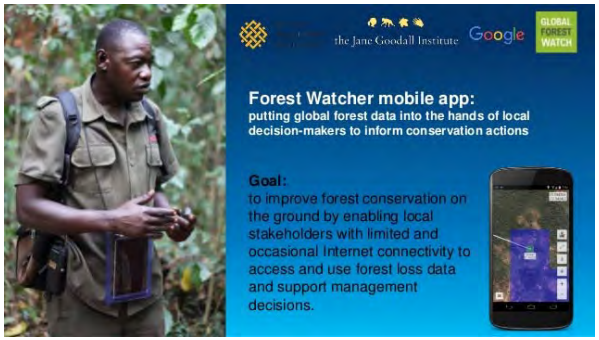
Figures 5 and 6. Illustration of "OK Card" for Pudirivayal Anicut, Thanjavur District

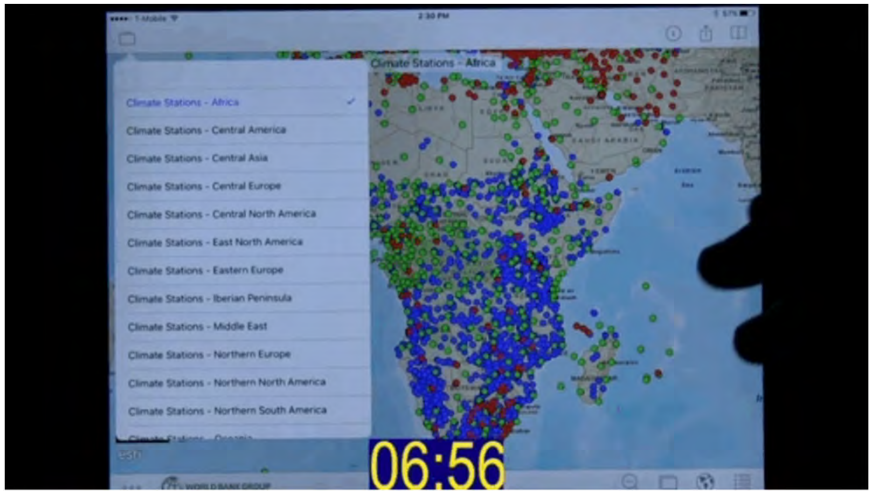


Citizen Science
Citizen Engagement
E-Surveys/Service Ratings
"OK Cards"

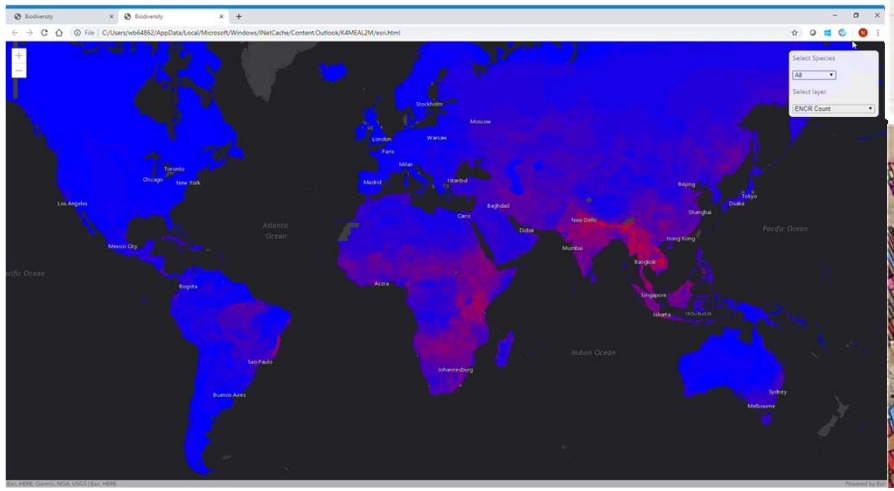
Representative Image: Flickr/ Climate



Big Data & Analytics



WBG DEC Open-Source Global Geospatial Biodiversity Database



IUCN Red List of Threatened Species

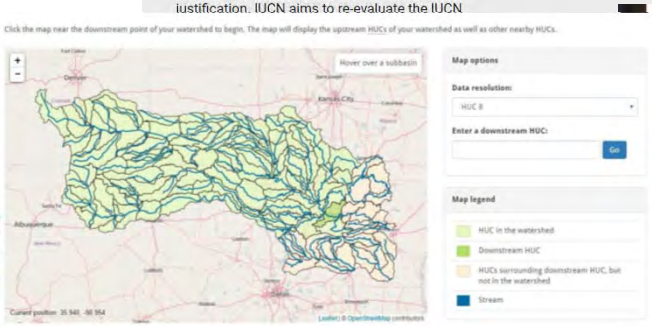
The IUCN Red List of Threatened Species (also known as the IUCN Red List) is a rich compendium of information on threats, ecological requirements, and habitats of over 90,000 species; and on conservation actions that can be taken to reduce or prevent extinctions. It is based on an objective system for assessing the risk of extinction of a species based on past, present, and projected threats. Species assessments are conducted following a standardized process using the rigorous IUCN Red List Categories and Criteria, ensuring the highest standards of scientific documentation, information management, expert review, and justification. IUCN aims to re-evaluate the IUCN

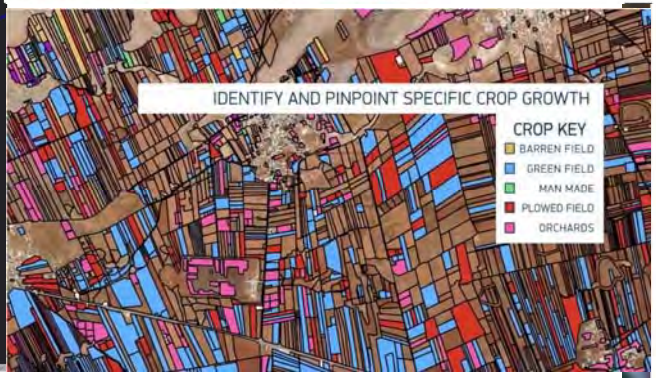
World Database on Protected Areas

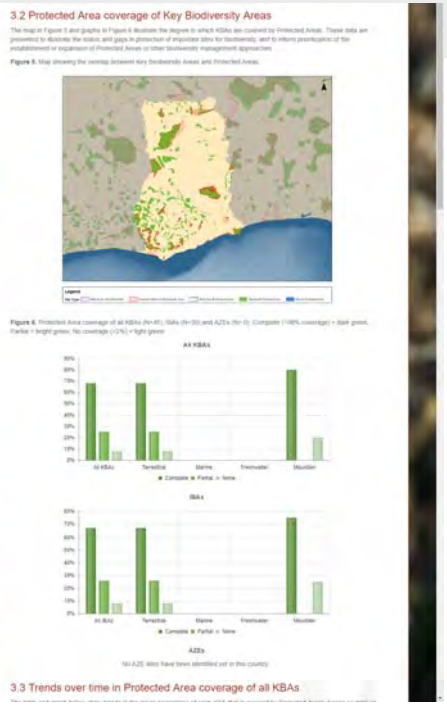
The World Database on Protected Areas (WDPA) is a joint project between UN Environment and the International Union for Conservation of Nature (IUCN), managed by UN Environment World Conservation Monitoring Centre. Data for the WDPA is collected from international convention secretariats, governments, and collaborating NGOs. The WDPA uses the IUCN definition of a protected area as the main criteria for entries included in the database.

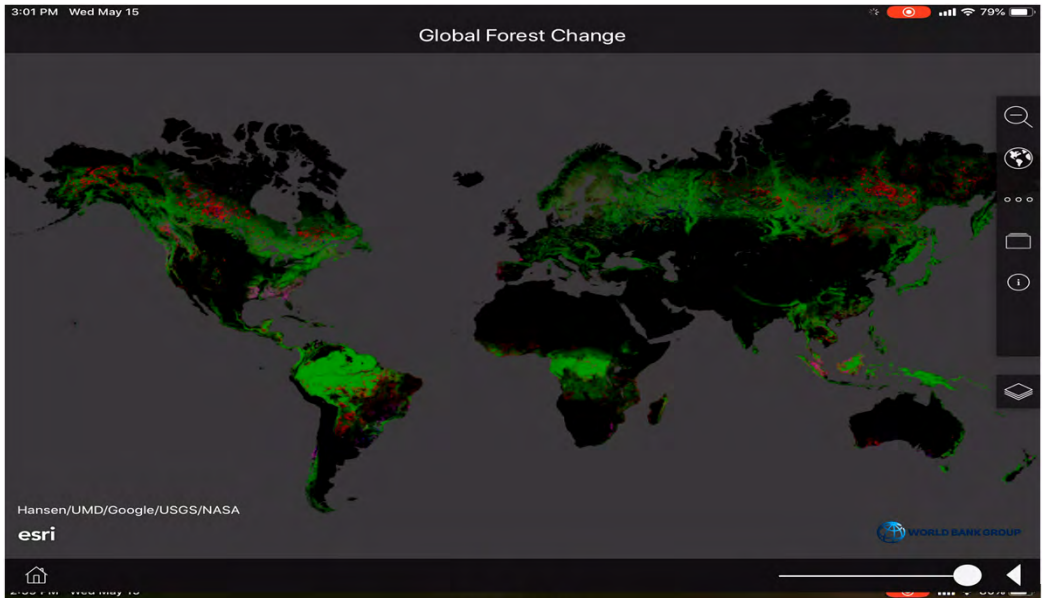
World Database of Key Biodiversity Areas

Key Biodiversity Areas (KBA) are 'sites contributing significantly to the global persistence of biodiversity', in terrestrial, freshwater and marine ecosystems. Sites qualify as global KBAs if they meet one or more of 11 criteria, clustered into five categories: threatened biodiversity; geographically restricted biodiversity; ecological integrity; biological processes; and, irreplaceability. The World Database of Key Biodiversity Areas is managed by BirdLife International on behalf of the KBA Partnership.








3:01 PM Wed May 15
79%
Global Forest Change
Hansen/UMD/Google/USGS/NASA
esri
WORLD BANK GROUP

3:00 PM Wed May 15
80%
CHIRPS (Rainfall) - Precipitation
EUROPE
ASIA
Atlantic Ocean
Pacific Ocean
SOUTH AMERICA
Indian Ocean
AUSTRALIA
https://earthengine.google.com
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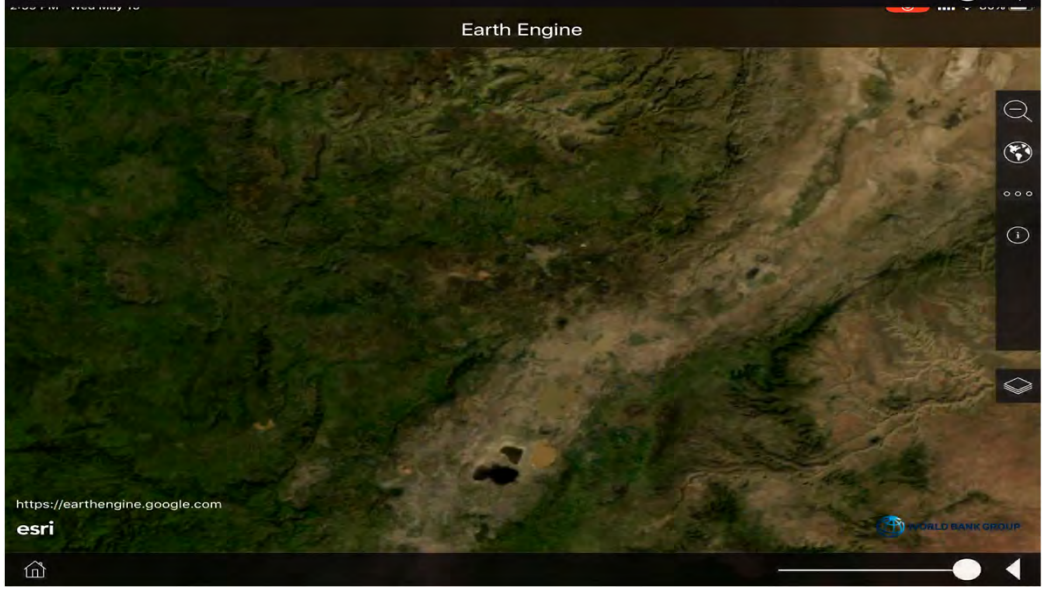
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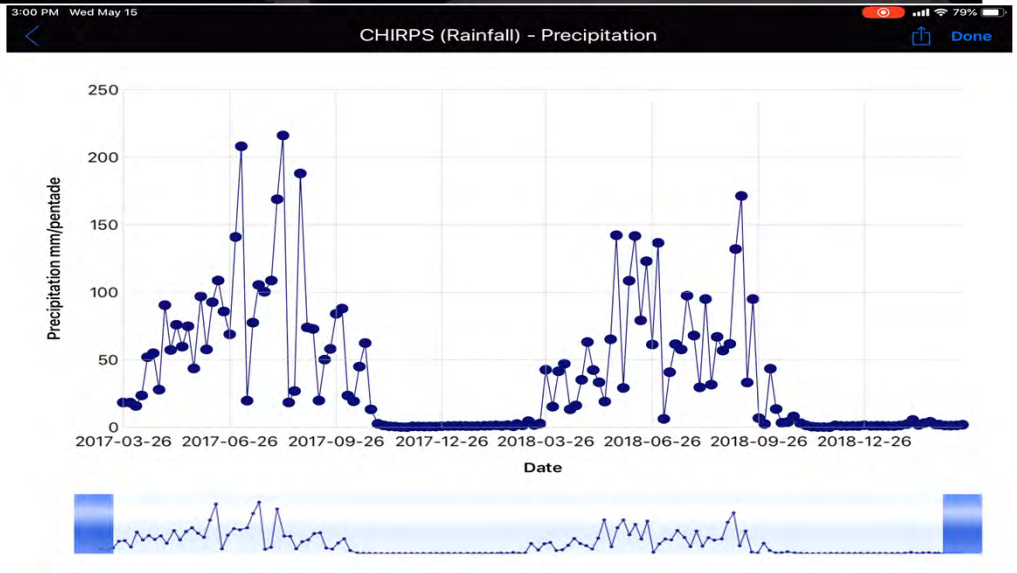
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CHIRPS (Rainfall) - Precipitation
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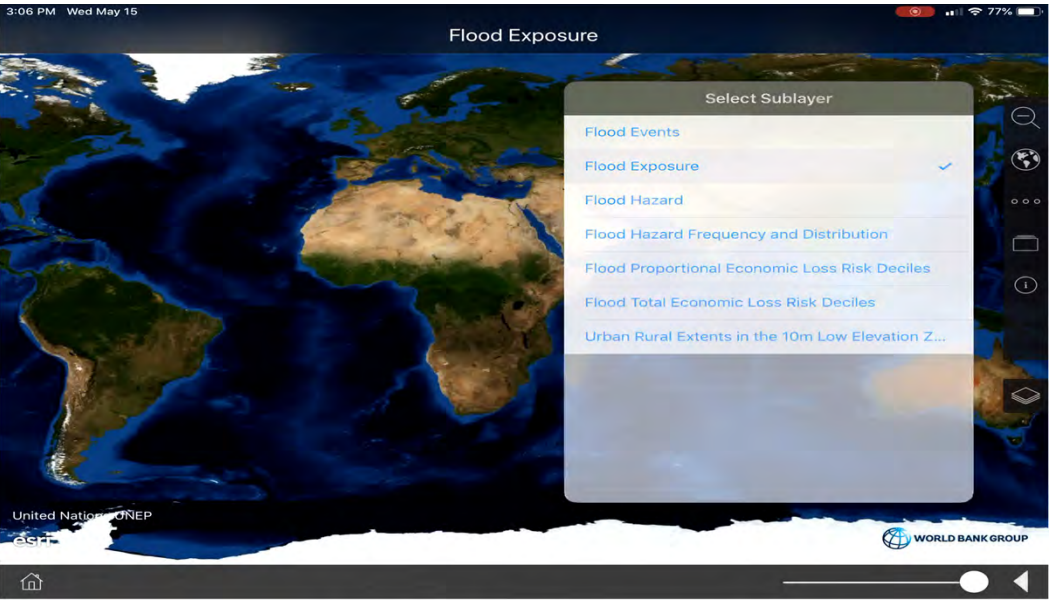
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Urban Rural Extents in the 10m Low Elevation Z...
United Nations UNEP
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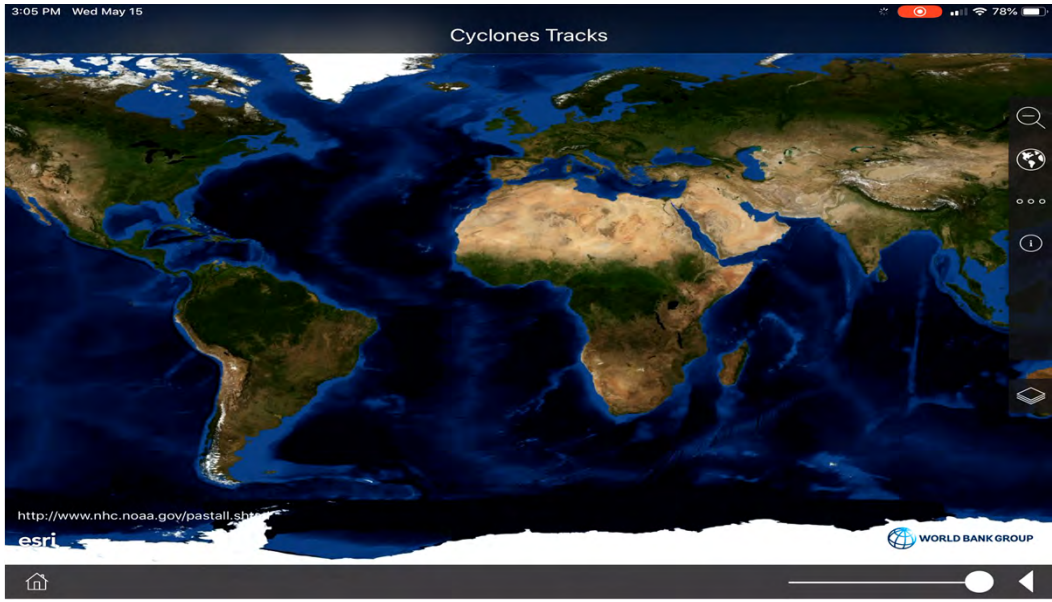
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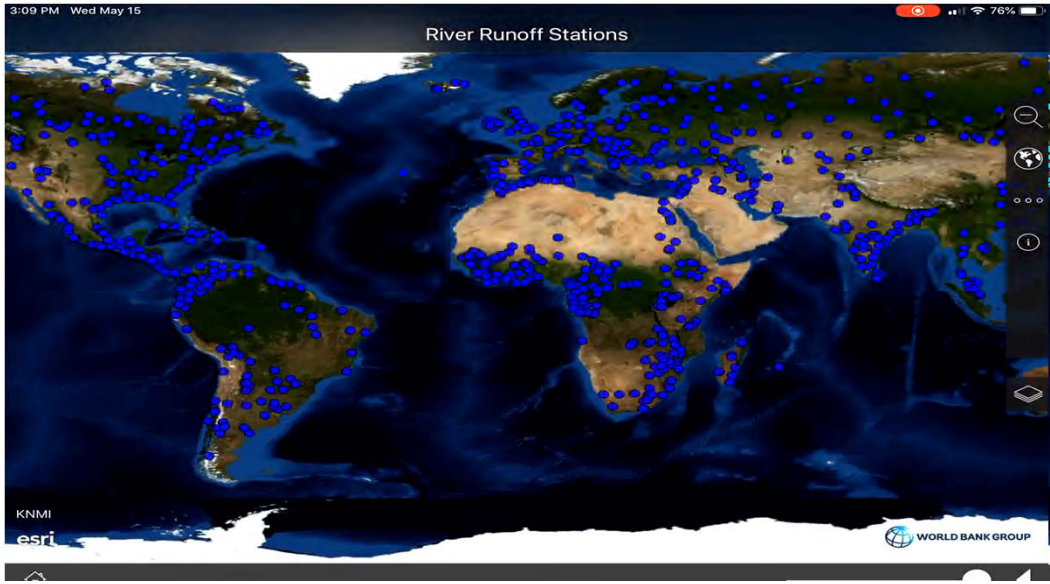
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River Runoff Stations
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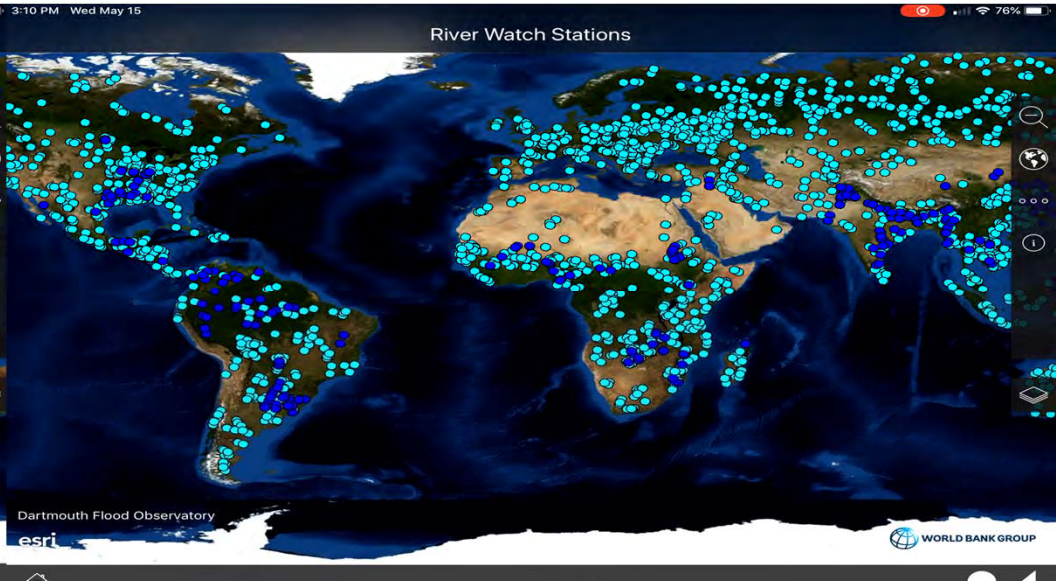
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River Watch Stations
Dartmouth Flood Observatory
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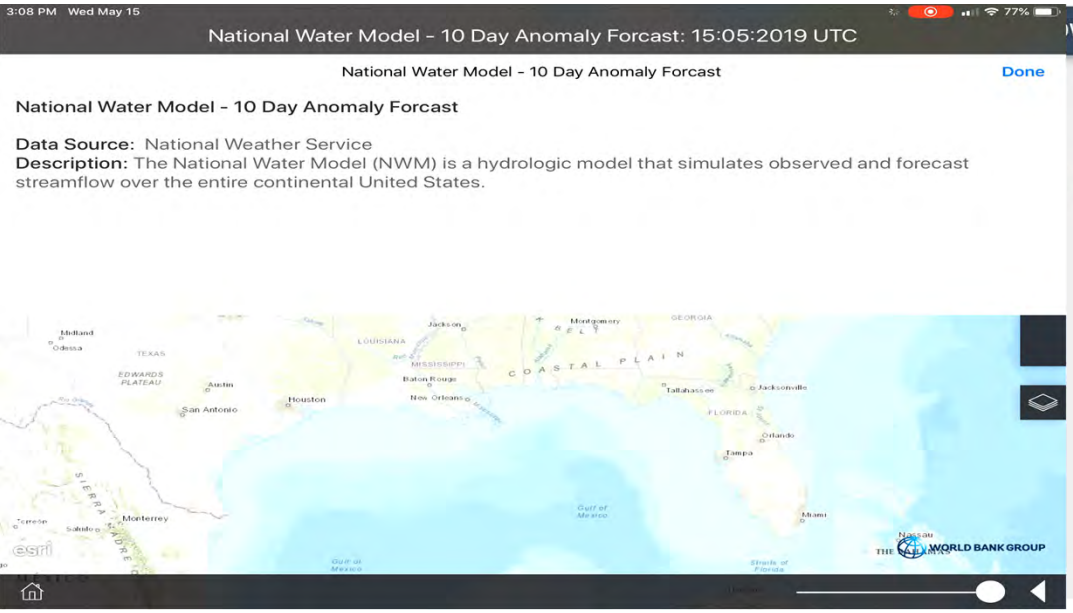
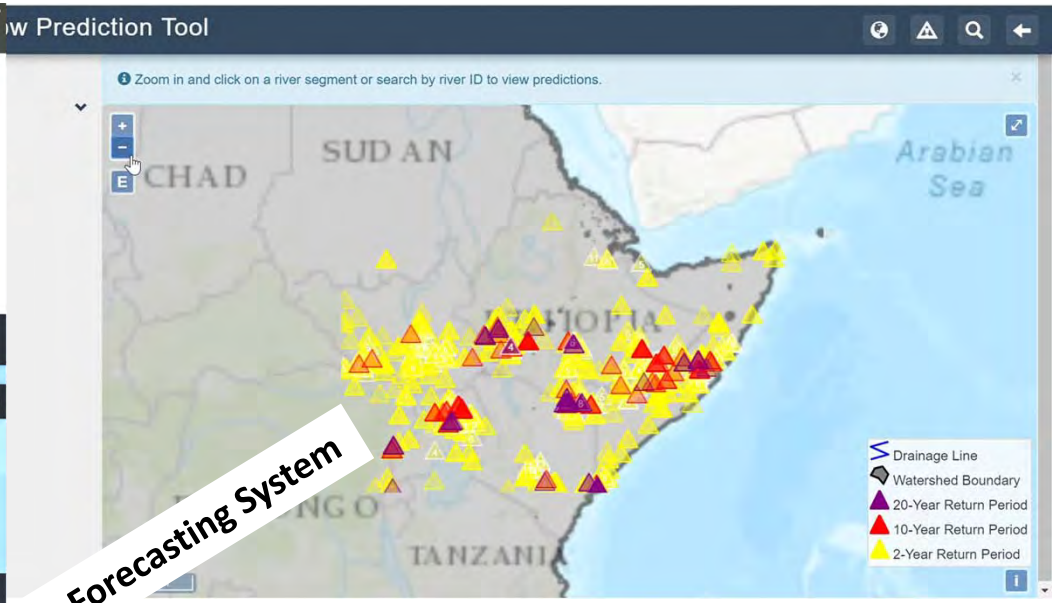
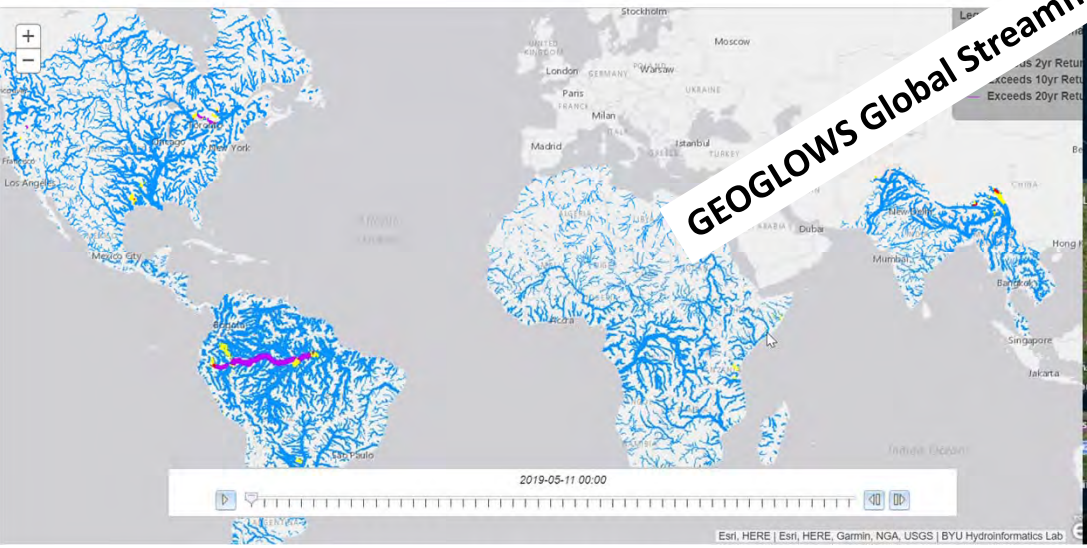
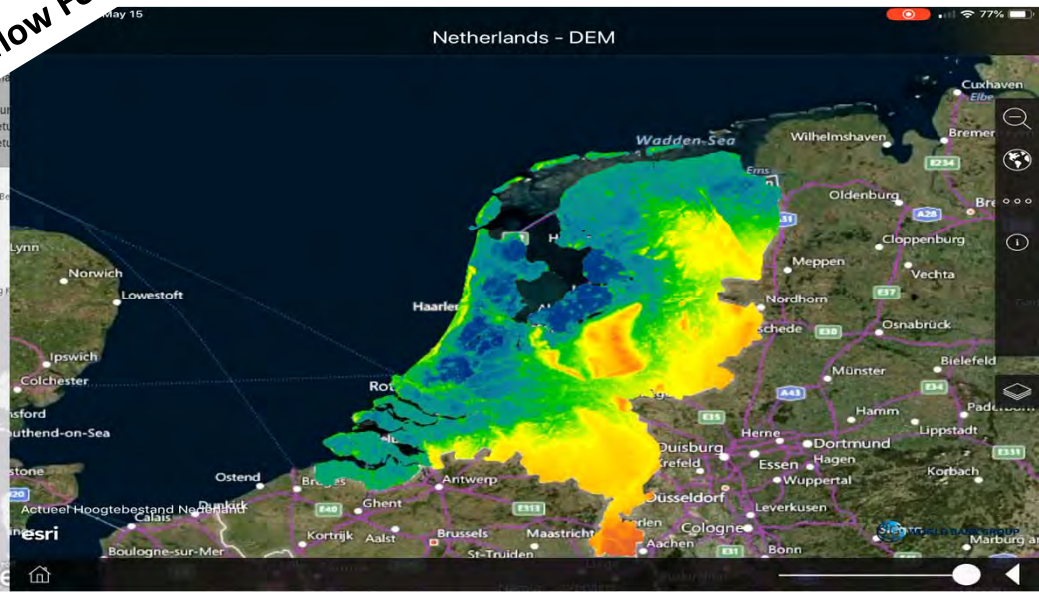


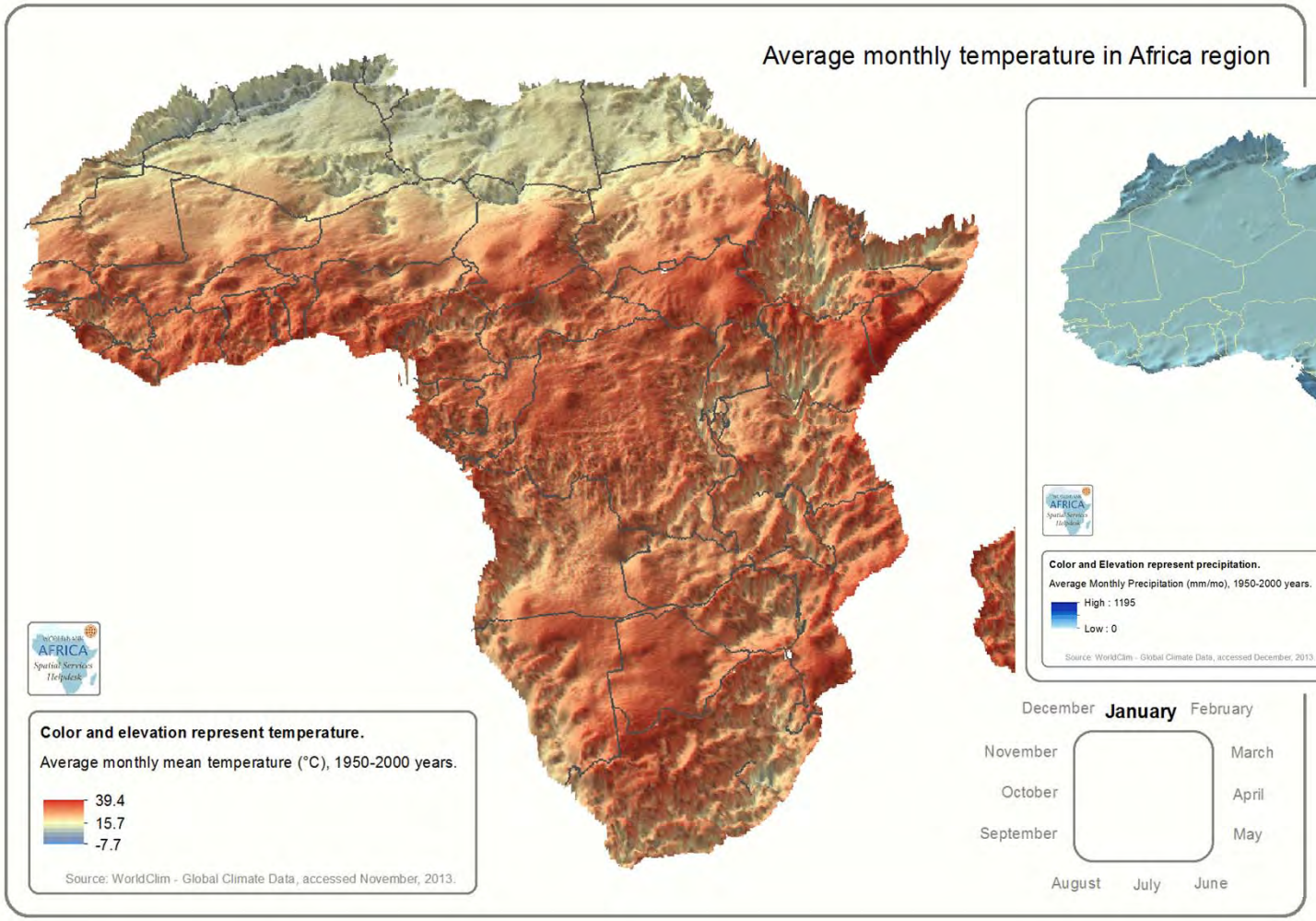


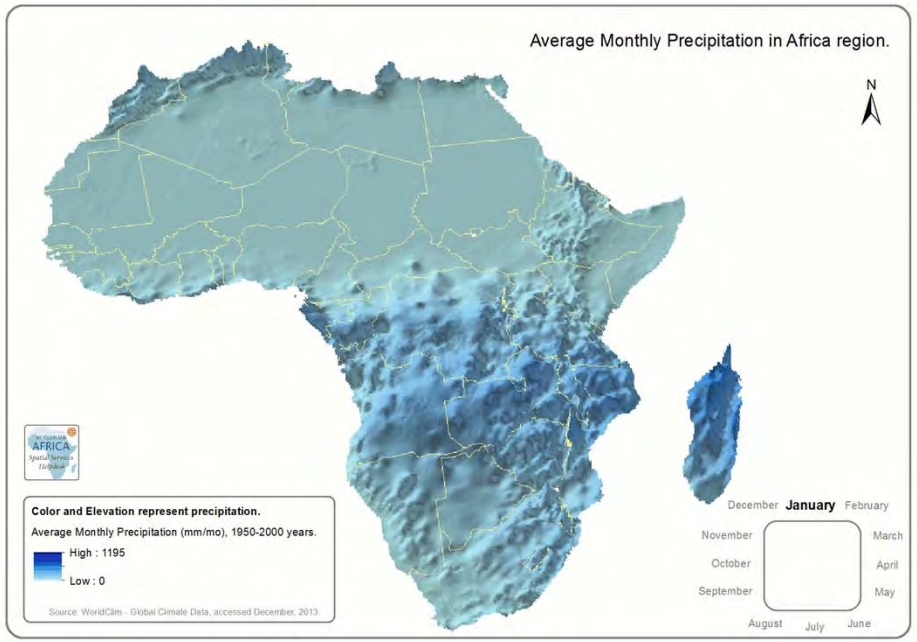




GEOGLOWS Global Streamflow Forecasting System

Climate Variability (within a year)





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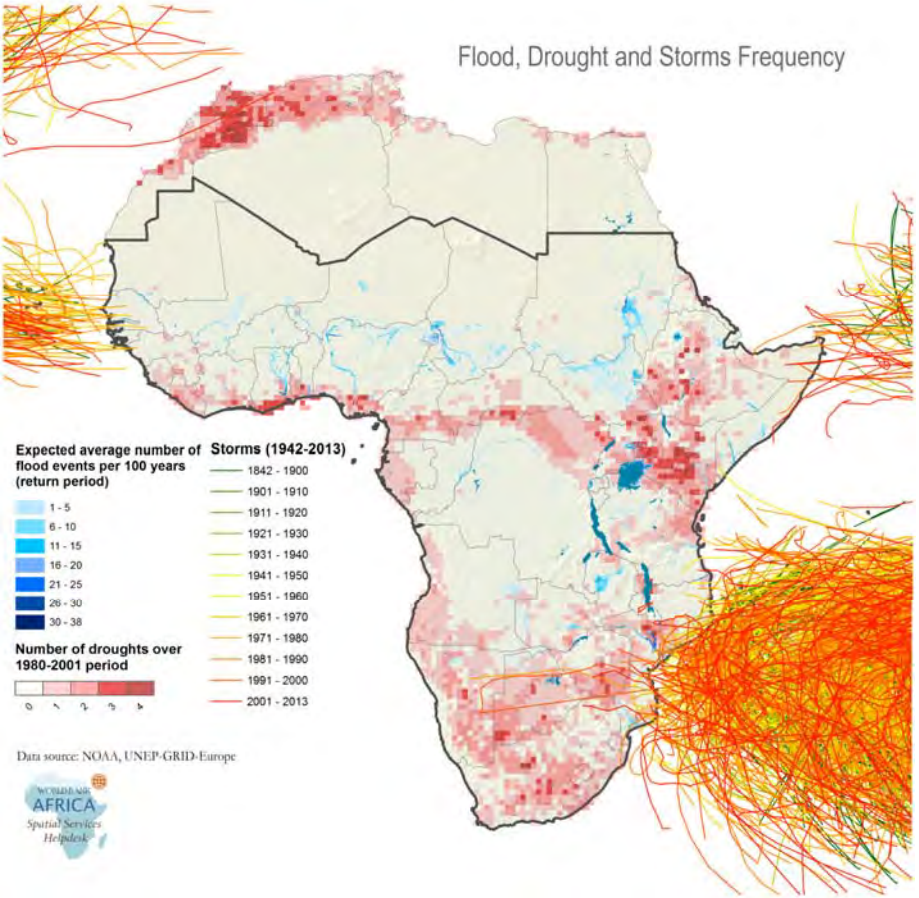
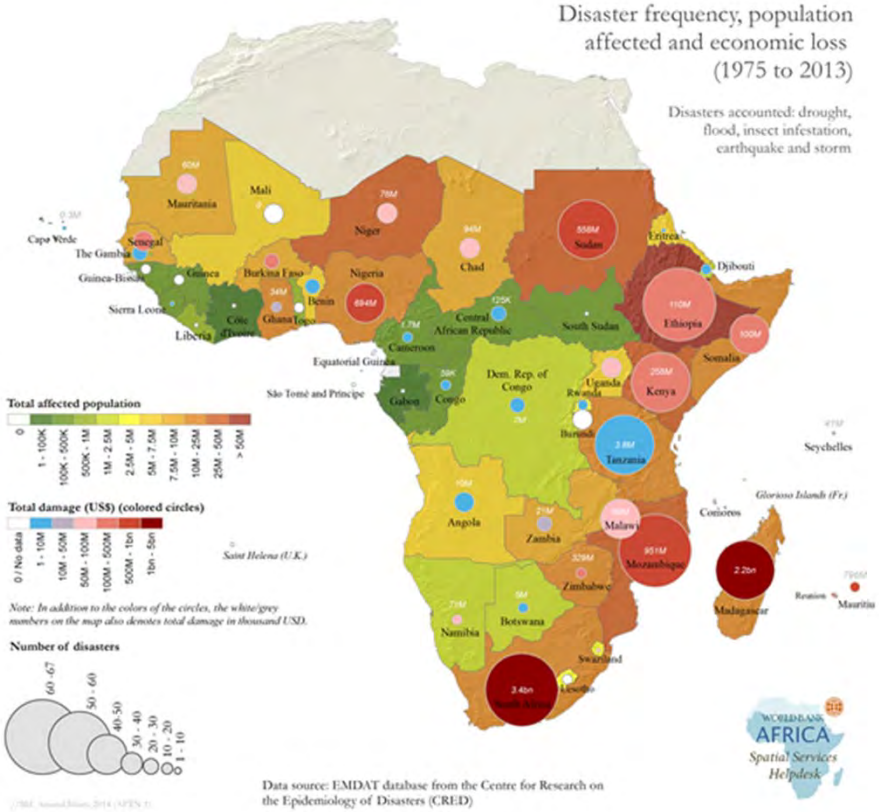
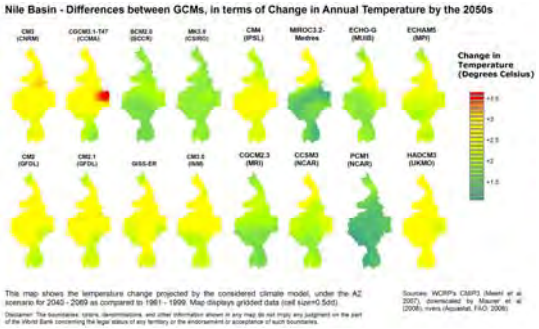
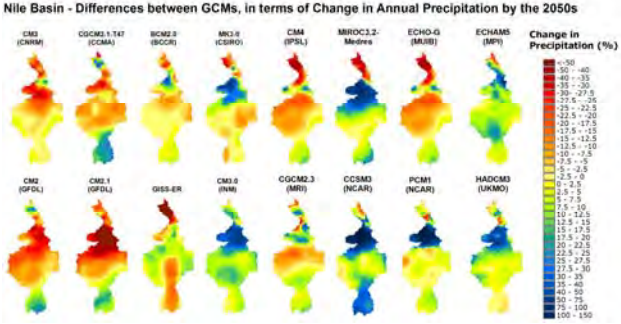


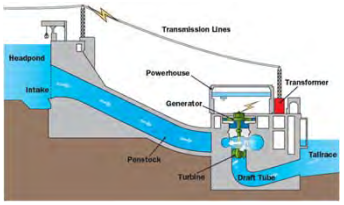


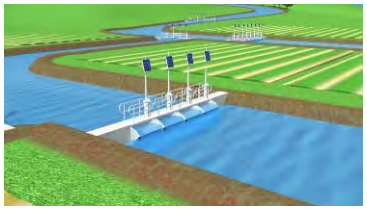
& Climate Change…

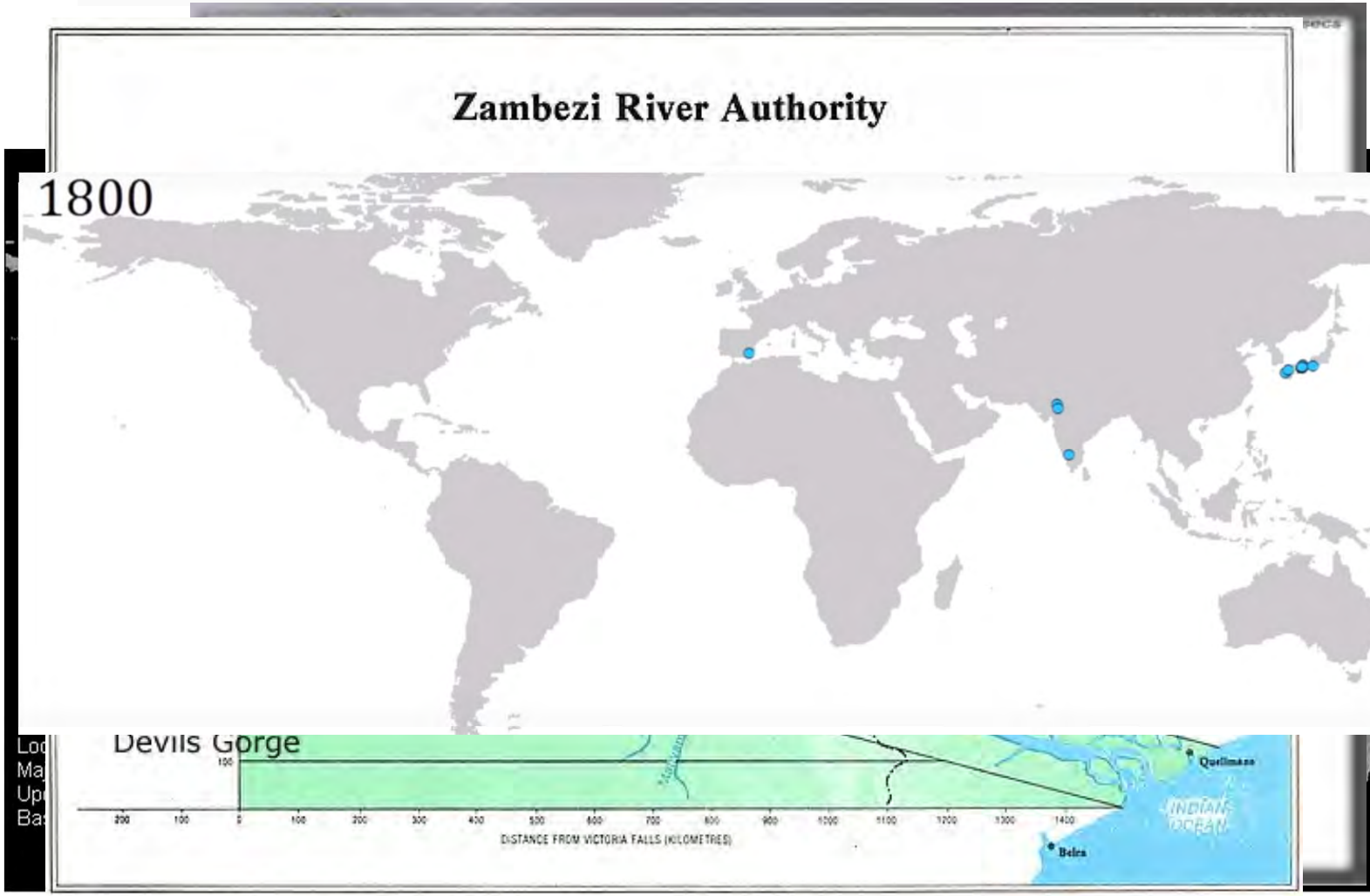




Illustrative Decisions to be Supported



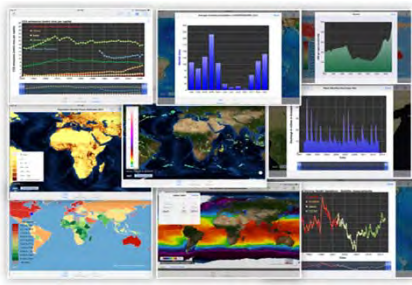




Illustrative Interactive Dashboards

Example for 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

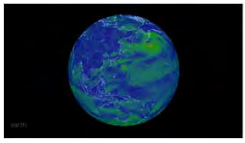
- Irrigation status (crops, crop stage from earth observation and in-situ)
- Soil and sub-surface soil moisture, groundwater (from earth observation and in-situ)…

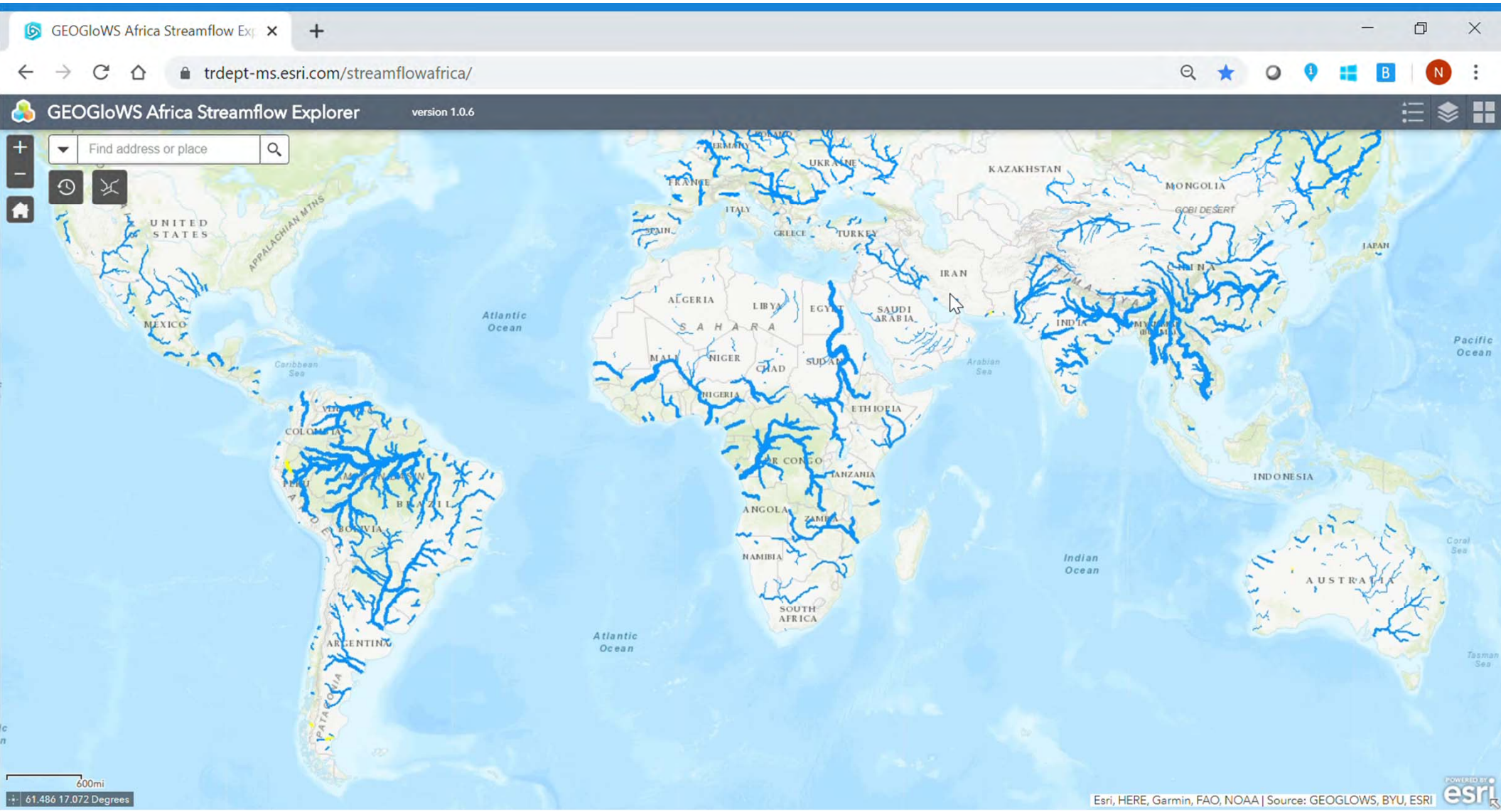
Other Data & Analytics

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

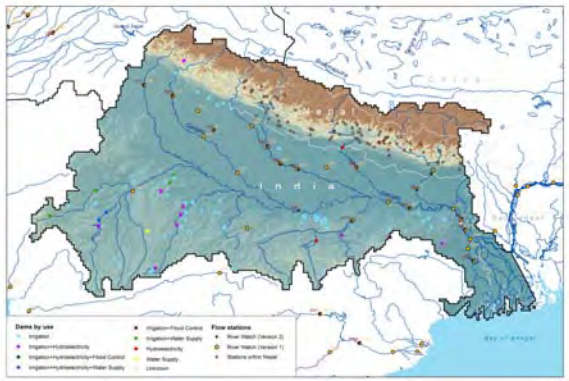
…

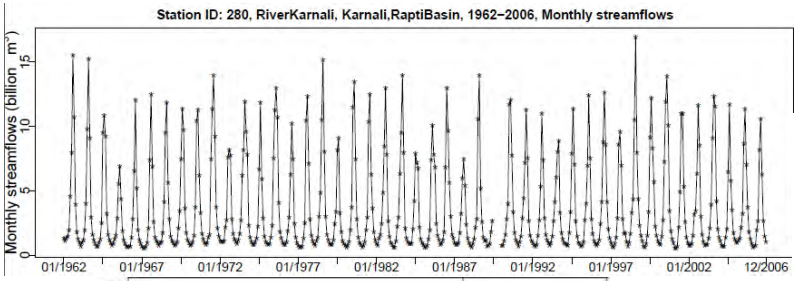
Need to draw upon global and other accessible data and analytic services to make interactive maps, graphs, and analytics for such decision support dashboards that are accessible on portals, apps, e-books, touchscreens, etc.

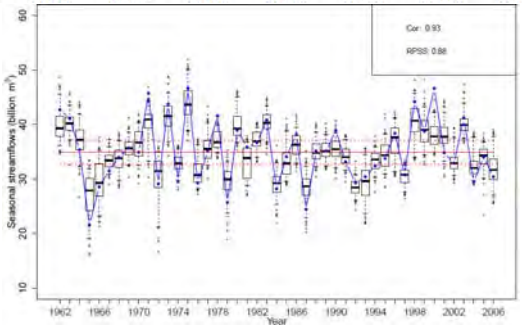



GEOGloWS Africa Streamflow Ex
trdept-ms.esri.com/streamflowafrica/
GEOGloWS Africa Streamflow Explorer
version 1.0.6
Find address or place
UNITED STATES
MEXICO
Caribbean Sea
COLOMBIA
PERU
BRAZIL
BOLIVIA
ARGENTINA
PATAGONIA
Atlantic Ocean
FRANCE
SPAIN
ITALY
GREECE
TURKEY
UKRAINE
KAZAKHSTAN
MONGOLIA
GOBI DESERT
IRAN
ALGERIA
LIBYA
EGYPT
SAUDI ARABIA
SAHARA
MALI
NIGER
CHAD
SUDAN
NIGERIA
ETHIOPIA
DR CONGO
TANZANIA
ANGOLA
ZAMBIA
NAMIBIA
SOUTH AFRICA
Arabian Sea
INDIA
JAPAN
CHINA
Pacific Ocean
INDONESIA
Indian Ocean
AUSTRALIA
Coral Sea
Tasman Sea
600mi
61.486 17.072 Degrees
Esri, HERE, Garmin, FAO, NOAA | Source: GEOGLOWS, BYU, ESRI

Improving Seasonal Hydrologic Forecasts







Illustrative Predictors

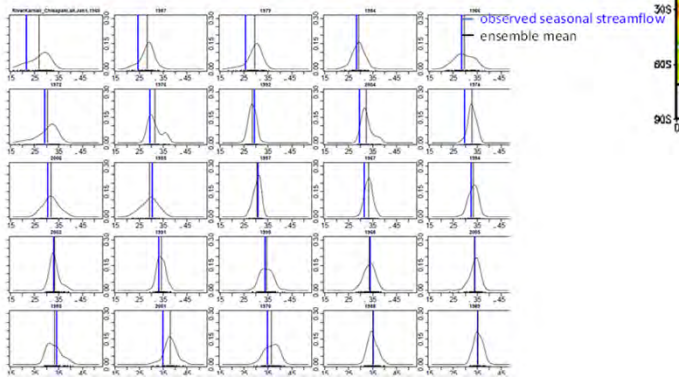
Large scale climate variables:

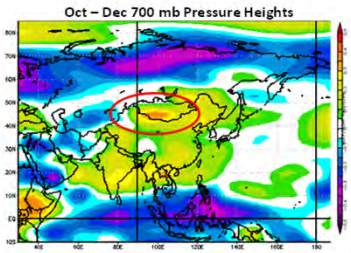
700 mb Geopotential Height [GPH]; Surface Air Temperature [SAT]; 700mb Zonal Winds [ZW]; 700mb Meridional Winds [MW]; Sea Surface Temperatures [SST];

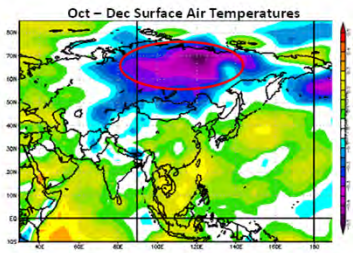
Teleconnection indices:

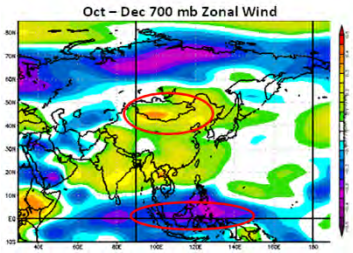
Antarctic Oscillation [AAO]; Atlantic Multidecadal Oscillation [AMON]; Arctic Oscillation [AO]; Atlantic Tripole SST EOF [ATL TRI] ; Caribbean Index [CAR] ; Indian Ocean Dipole, i.e., Dipole Mode Index [DOI]; Eastern Asia/Western Russia [EA]; Tropical Pacific SST EOF [EOFPAC] ; East Pacific/N.Pacific Osci. [EP-NP/EPO] ; North Atlantic Oscillation [NAO] ; Extreme Eastern Tropical Pacific SST [NINA1] ; Eastern Tropical Pacific SST [NINA3] ; East Central Tropical Pacific SST [NINA 34] ; Central Tropical Pacific SST [NINA4] ; Northern Oscillation Index [NOI] ; North Tropical Atlantic Index [NTA] ; Pacific Warmpool [PACWARM] ; Pacific Decadal Oscillation [PDO] ; Pacific North American Index [PNA] ; Southern Oscillation Index [SOI] ; Tropical Northern Atlantic Index [TNA] ; Tropical Southern Atlantic Index [TSA]

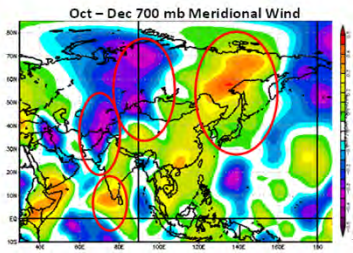
PDF plots, Jan. 1st issued forecasts

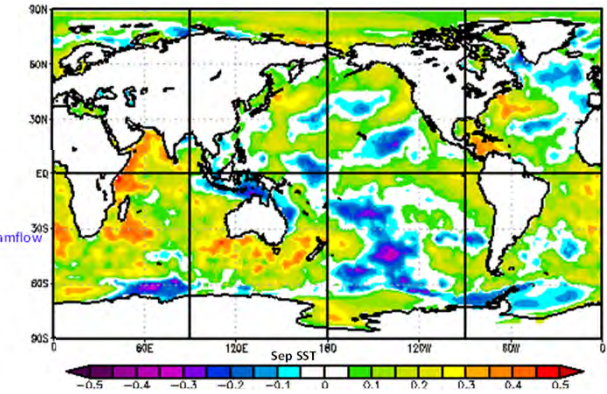












Value-Added Services: ET Applications for Irrigation Management

Sonia Salas, Western Growers

Use of ET

Challenges

- ET data gaps due to lack of local/ representative weather stations in certain locations
- Lack of local commodity specific irrigation scheduling calculators (Real-time crop, regional/site specific conditions should be considered when using ET)

Opportunities

- ET data enhancement. For example, CIMIS * is utilizing remotely sensed satellite data to generate ETo maps and address data gaps.
- Support/continue successful efforts that consider crop, regional/site specific conditions (irrigation calculators for avocados, lettuce, almonds, wine grapes)

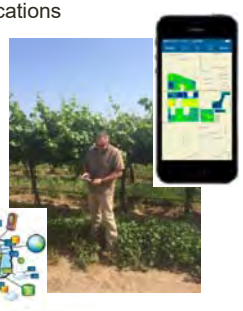
Forrest Melton, NASA ARC-CREST

Satellite Irrigation Management Support (SIMS) Web Services

Martin Mendez-Costabel, E & J Gallo

PRESENT Model for deployment of Satellite-Based applications

- Desktop and mobile based – information delivered to growers real time via mobile applications
- Use of 'Landsat web services' and cloud computing systems via:
  - Amazon S3
  - Google Earth Engine
- Custom mobile applications for:
  - Viewing
  - Editing
  - Collection
- *24-HOUR DELIVERY*

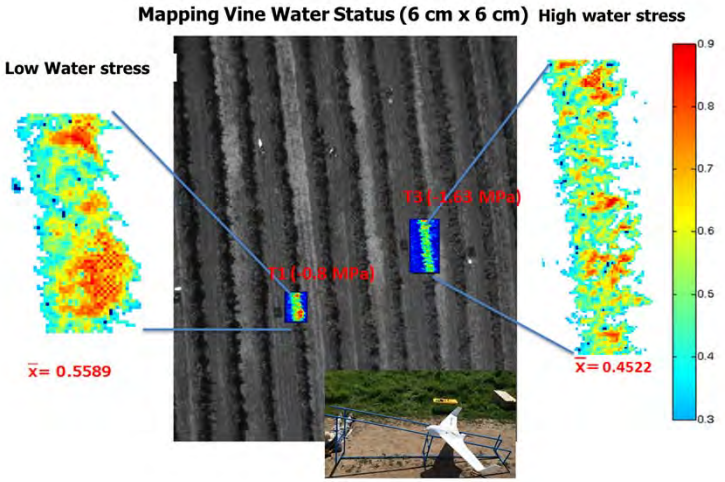


Custom Irrigation Schedules

- Growers get access to authoritative content (Maps/Apps – real time information)
- Mobile-based
- Farming to tier & specific stress index

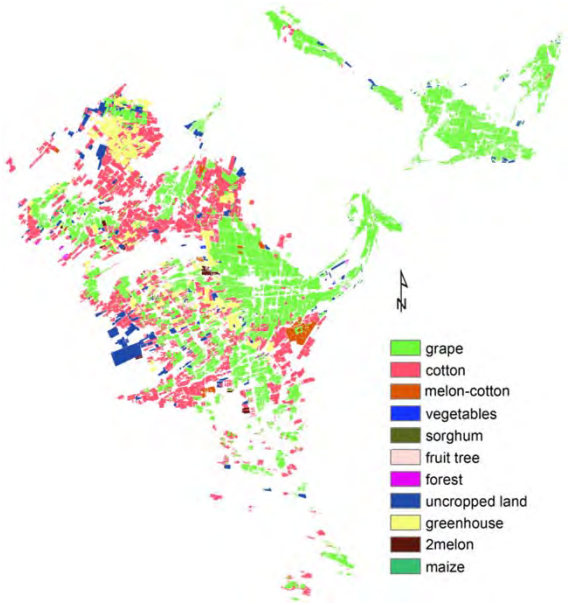
Using UAV (Drones) to monitor ET

Prof. Ortega-Farias

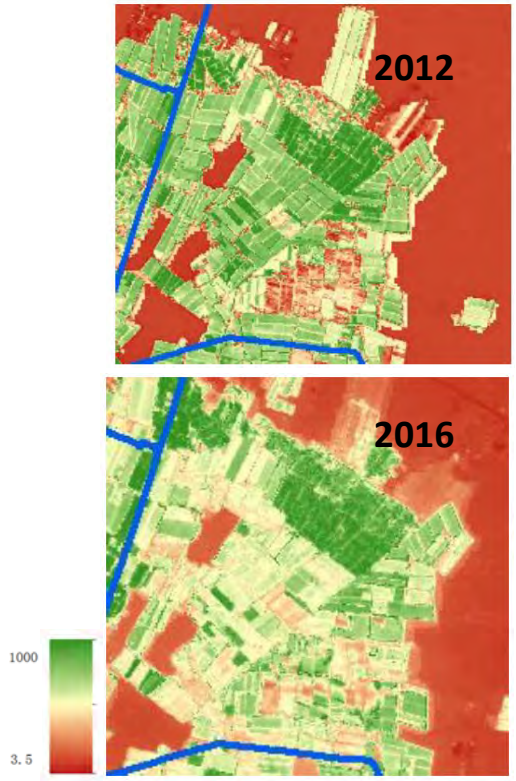


Source: International Workshop on Evapotranspiration Mapping for Water Security (organized by NASA and World Bank, 2015)

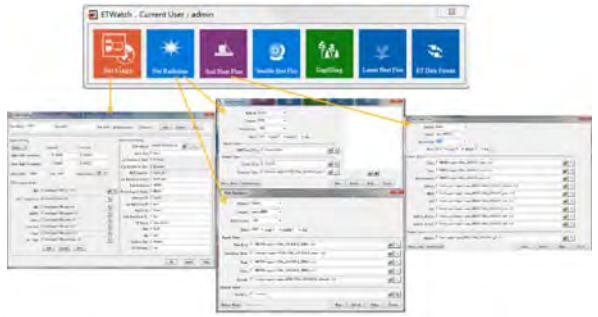
Estimating Evapotranspiration

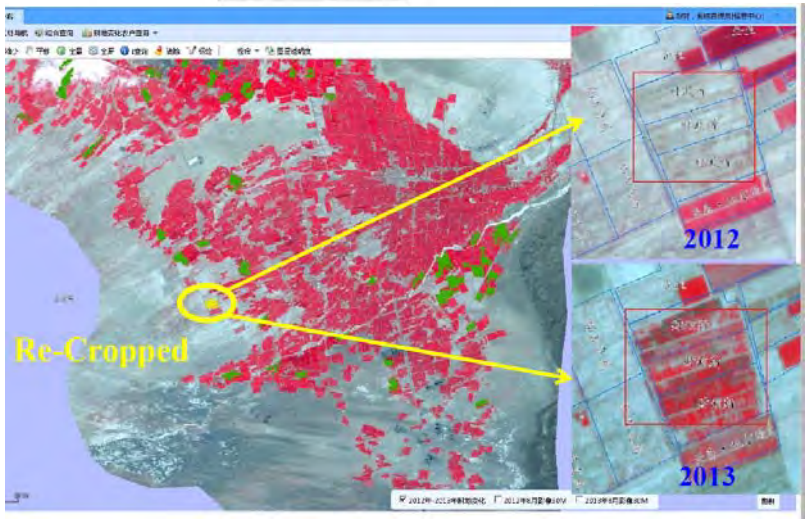


Changes of Crop Pattern



Changes of ET





Reduction of Irrigated Land

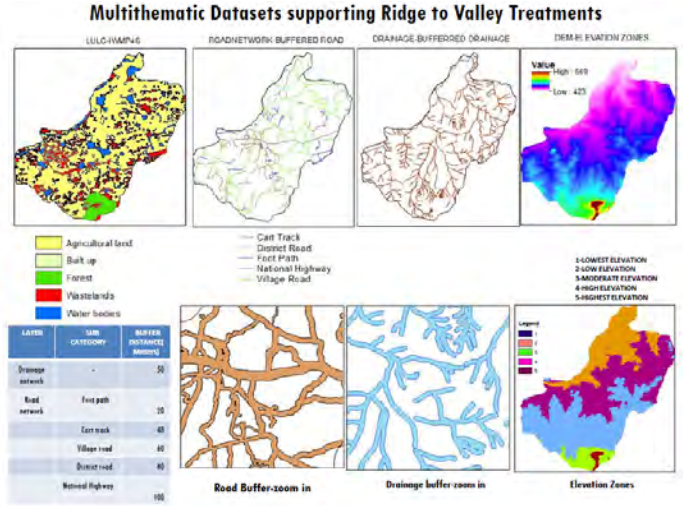
Source: Si Gou, The World Bank & Prof. Bingfang Wu, Chinese Academy of Sciences

WORLD BANK GROUP
Water

India

National Remote Sensing Center
Information Support (e.g. geospatial analysis, Apps)
for 500 m ha of watershed improvement

http://bhuvan.nrsc.gov.in/projects/iwmp/



Other Popular Farmer Apps: http://claroenergy.in/top-10-apps-revolutionizing-indian-agriculture/

Monitoring and Evaluation of IWMP Watersheds using Geospatial Technologies

Study Area
• IWMP watersheds in entire country

Total projects covered : 8200
Projects in Special IWMP(50) Districts: 1598

Srishti : Web GIS using IRS High Resolution image base for monitoring and evaluation

Drishti : Android Application for Real time Field inventory and uploading to server using Geo-tagged Photo

User: Dept of Land Resources, Min of Rural Development

Srishti

Drishti

❖Satellite Data Ordered : 10400 Scenes (4 years)
❖ Satellite data Hosted : 6700 Scenes
❖ Drishti Ver 2.3 released and App hosted on Bhuvan

7.10 Lakh Drishti Points uploaded as on date

Duration : 2015-16 to 2020

MORE THAN 1000 OFFICIALS OF DIFFERENT STATES TRAINED IN 17 WORKSHOPS

Details:
Agroclimatic zone: Godavari zone
District: West Godavari
IWMP-1
Micro watershed: 4D8A6c1a

T0: 2009-10

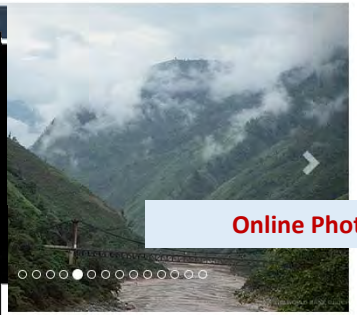
T1: 8th Jan 2015

Karnataka Watersheds

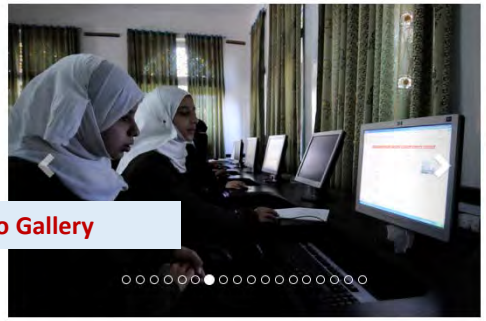
Illustrative Elements of an E-book

Responsive Design

[NASA-WB e-book on EO for WRM](#) (on OLC)



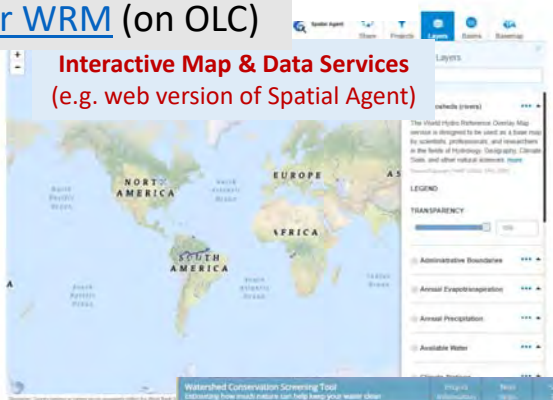
Online Photo Gallery



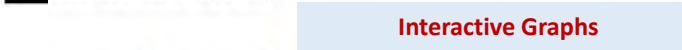
Text/Hypertext

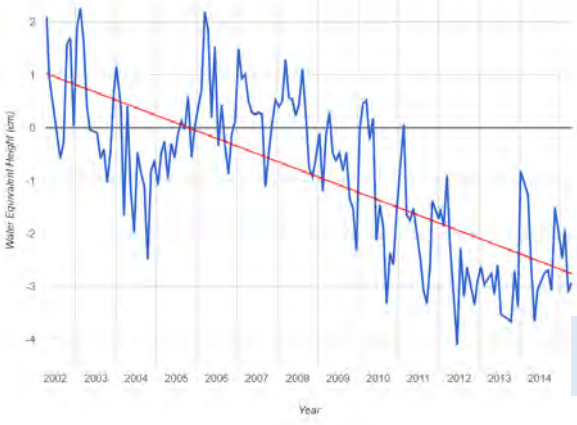
Interactive Presentation Slides

Online Video Gallery

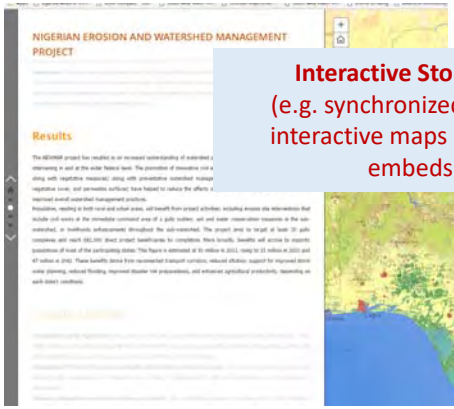


Interactive Map & Data Services
(e.g. web version of Spatial Agent)

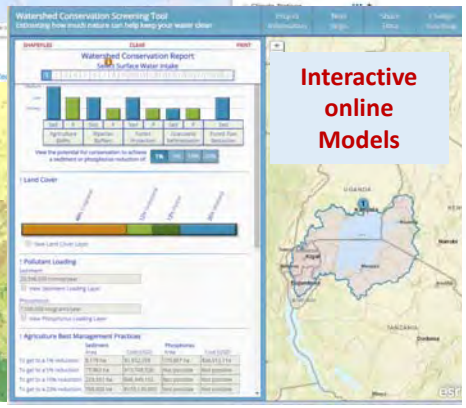




Interactive Graphs



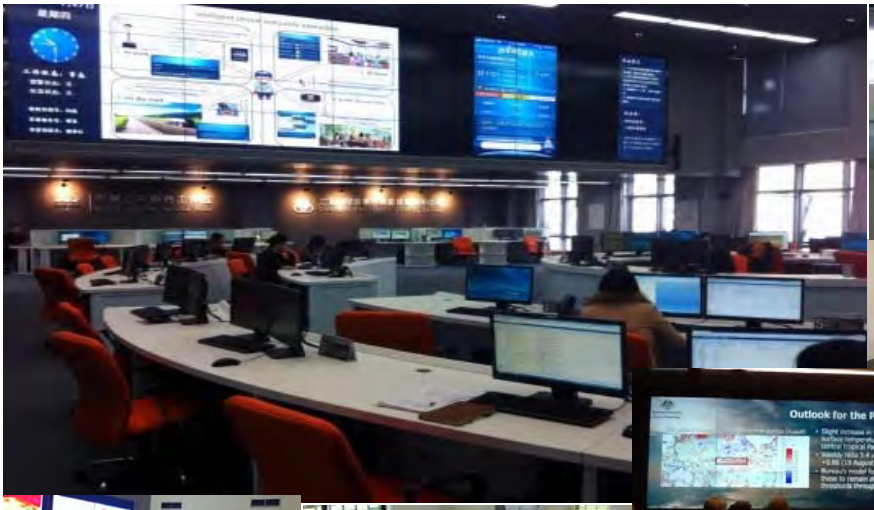
Interactive Storymaps
(e.g. synchronized text and interactive maps and other embeds)

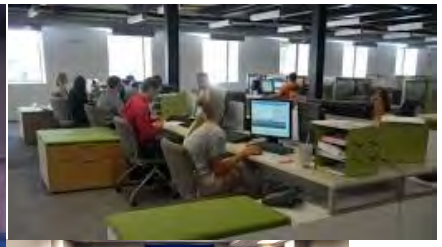


Interactive online Models

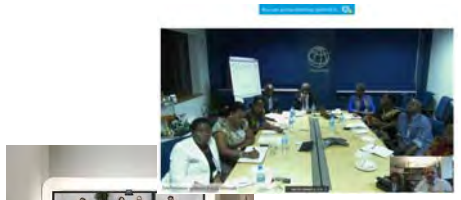
Interactive Spatial Gateways
(e.g. World Bank financed Projects)

Modernizing Institutions



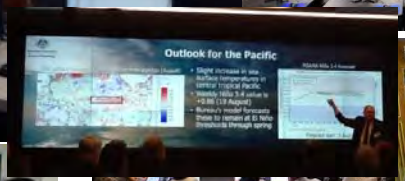


Collaborative Workspaces/Internships

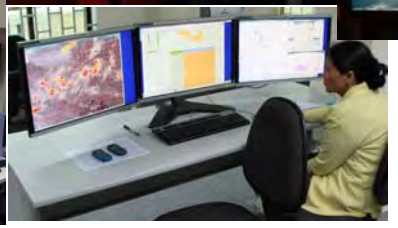


Audio/Video-Conferencing/ Distance Learning/ Helpdesk

Computer Training Room



Document, Map & Digital Library



Situation/ Decision Rooms

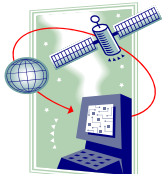
Innovation Marketplace

Competitions (e.g. Hackathons)

Collation ⟷ **Analysis** ⟷ **Use**

Knowledge Repository

Monitoring Hub



Knowledge Tools/Products

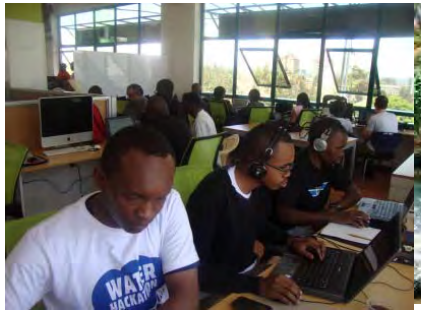
Targeted Research

Outreach & Capacity-Building

Institutional Support

Competitions

Water Appathon
Water Hackathon
Data Jams
X-Prize
Internships
E-books, Designs, Products, Processes…



Water Events/Expos

Forum, Expos, Training – e.g.
http://centralasiawaterfuture.org

Learning from national and global good practices

Biodiversity & Protected Areas

Data Standards, Access & Visualization

Monitoring Equipment

Policies & Institutions

ESIA Analytics

Groundwater Management

Drought Preparedness

Earth Observation

Leverage WBG Infrastructure & Convening

Pollution Management

Nature-based Infrastructure

Corporate Sustainability

Disaster Management

Watershed Management

Citizen Engagement

Climate Adaptation

Operational Basics & Recent Advances

Evolving Global Good Practices

Lessons Learned

Government Implementation Experiences

Private Sector Perspectives

Online courses, e-books

Professional Networking

Videoconference/Collaborative Digital Networks

Virtual Seminars on Key Topics from Global Experts

Virtual Desktop Participation; e-learning

Disrupt or Be Disrupted!

harsh@worldbank.org