Next Frontier Technologies: How to Scale SDG Monitoring

Dean Angelides
Corporate Director, Esri

Vision

GIS

Is Enabling a
Sustainable World

Our World Needs a Nervous System

An Intelligent and Responsive Platform

Creating More Understanding

. . . Collaboration and

. . . Action

. . . Geography Is Essential

Your Work

Is Already Creating Geospatial Infrastructure

Intelligent and Responsive . . .

Integrating All Sources of Data . . .

. . . Creating Digital Nervous Systems for Your Organizations and Countries

Connecting Everything . . . And Everyone

Applying The Science of Where . . .

Your Work

Is Also Contributing to Global Geospatial Infrastructure

Connecting & Integrating

Sharing Data, Apps
. . . and Geographic Knowledge

. . . At Scale

Creating a Global Nervous System

A System for Understanding . . . And Collaborative Action

Geospatial Infrastructure

Supports Individuals . . .

. . . And Organizations of All Sizes

Communities

Engaging Everyone

Organizations

Departments

Teams

Individuals

GIS at Scale

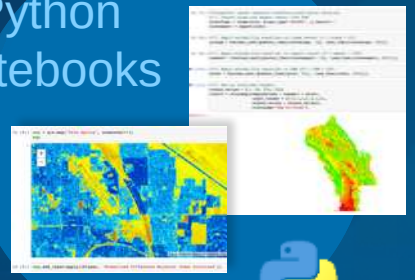
Distributed . . . And Interconnected

Sharing and Collaboration

Integrating Open Science, AI and Machine Learning

Revolutionizing Spatial Analysis and Data Science

Python Notebooks



Analytic Services

Python API

Integration

AI & Machine Learning

Open Science Tools

Open Science

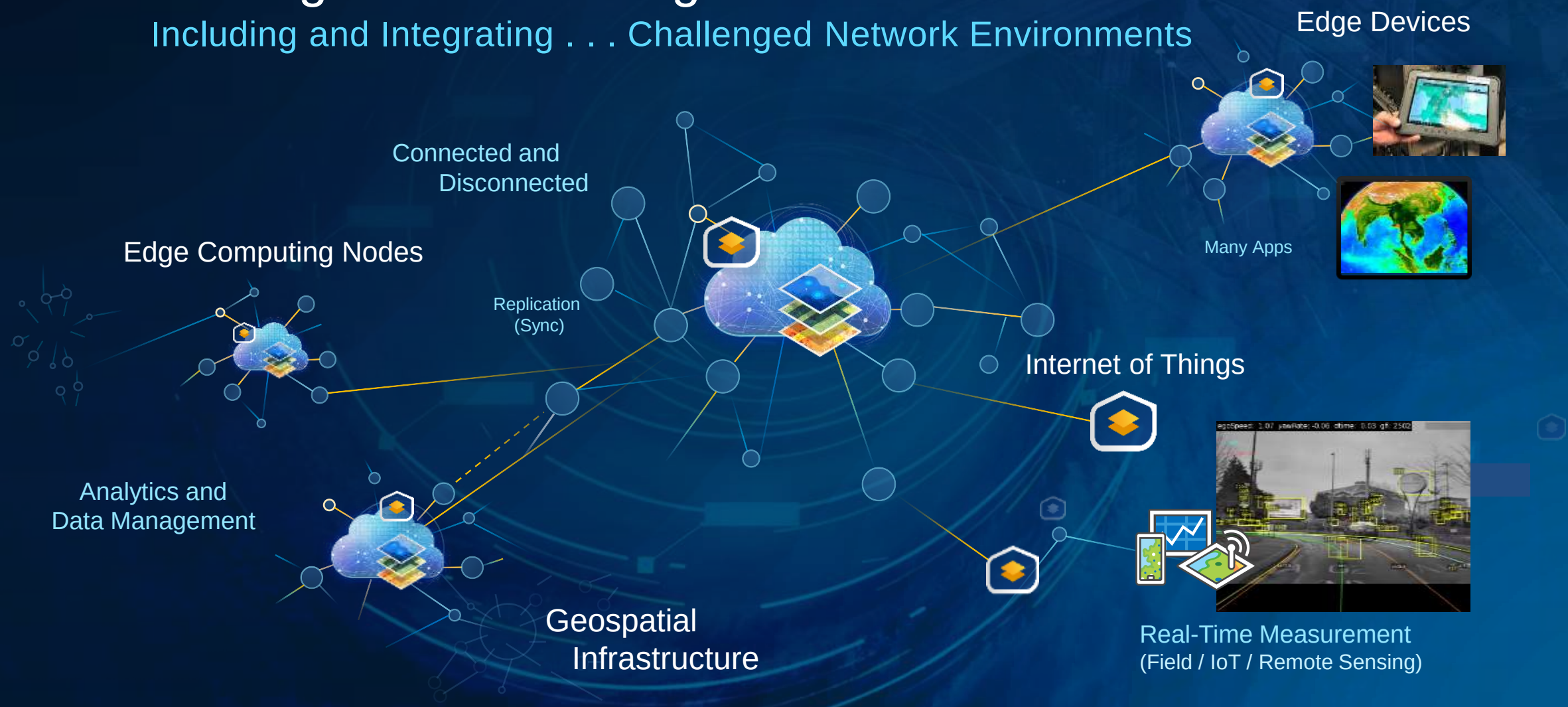
Big Data GeoAnalytics

Spatial Analysis & Geoprocessing

Geospatial Infrastructure

Extending GIS to the Edge

Including and Integrating . . . Challenged Network Environments



Supporting GIS Workflows in All Environments

Supporting and Integrating Advanced Technologies

Accessing and Leveraging Distributed Resources

Open Data

GeoEnrichment

StoryMaps

Distributed Services

AI & ML

Data Science

Tracking

Big Data

Geocoding

Content Management

Remote Sensing

Search & Discover

Publishing Services

Shared Apps

Analytic Services

Field Operations

Extensive Content

Real-Time Measurement

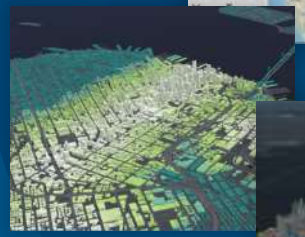
Geospatial Infrastructure

3D Visualization

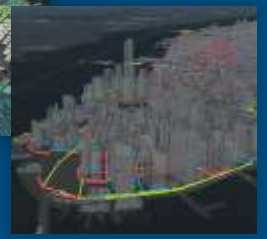
New and Improved

- 3D Smart Mapping
- Mobile
- Point Clouds
- BIM Support
- Symbology

Smart Mapping



Data Visualization



Symbology

3D Symbols

Effects

Power Lines

City Modeling

BIM Integration

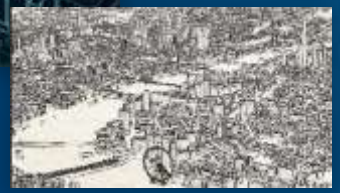
Lidar

Underground

Extrusion

BIM as Scene Layers

Edge Rendering



Mobile Scene Packages

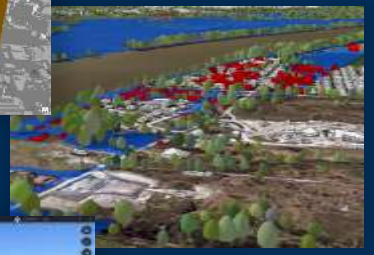
Augmented Reality / VR

Mobile

3D Analysis

Analytics

Shadow Analysis



Flood Impact

3D Measurement

Lidar to Buildings

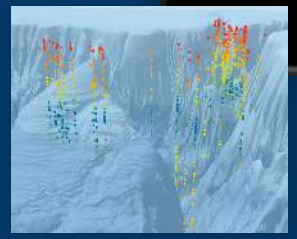
Elevation Profile

Line of Sight & Viewshed

Volumetrics

Volumetric Slicing

Interactive Slice



3D Interpolation (EBK)

Apps

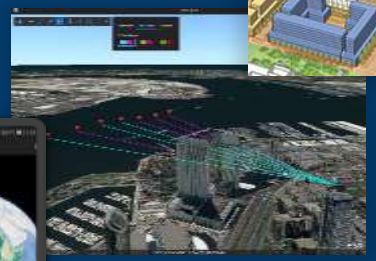
Pro

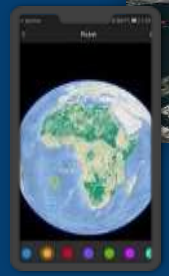
3D GIS

CityEngine

Procedural Modeling

Earth





3D Visualization and Analytics

Mobile

Scene Viewer

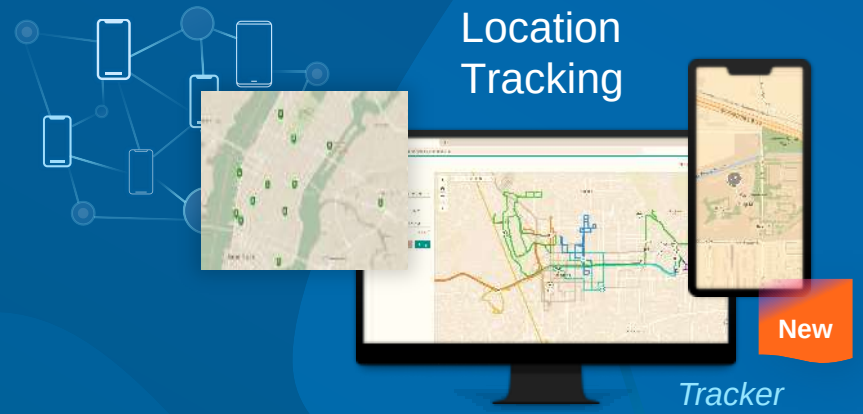
Visualization

Field Operations

Location-Enabling All Aspects of Field Work

New Capabilities

- Tracking
- Offline Workflows
- Preplanned Routes



Location Tracking

New

Tracker

Navigation

Navigator

Data Capture

New

Collector

Survey123

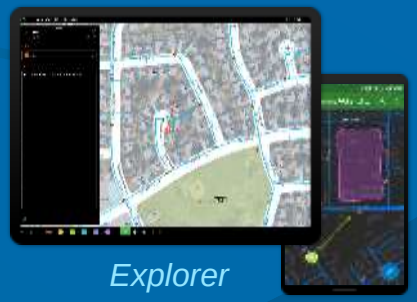
QuickCapture

Planning and Management

Workforce

Dashboard

Maps & Mark Up



Explorer

Spatial Analysis and Data Science

Many Improvements

- Functionality
- Scalability
- Accessibility

Spatial Statistics

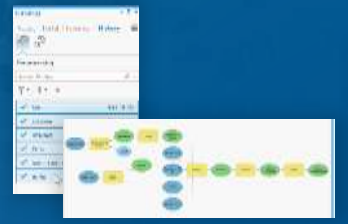
Balanced Zones

Logistical Regression

3D Interpolation (EBK)

Forest-based Classification and Regression

Improved Processing



Tool History to Models

Models to Python

Hosted Python Notebooks

Enterprise

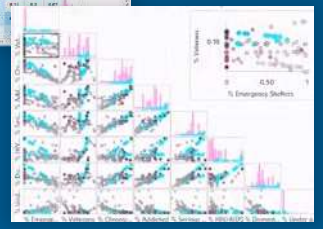
Pro

Scalable GeoAnalytics

Deep Learning

Charting

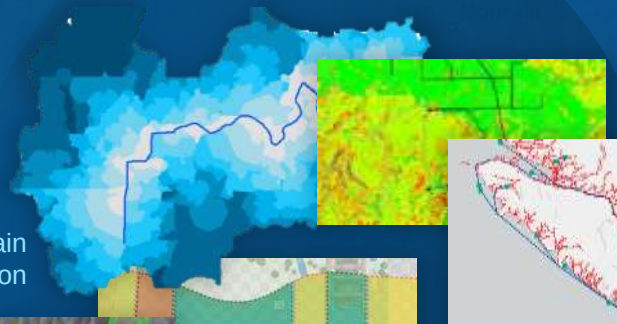
Calendar Heat Map



Scatter Plot Matrix

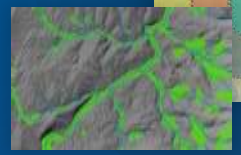
Data Clock

Raster Functions



Floodplain Delineation

Cost Distance



DEM Error

River Classification

Hosted Python Notebooks For Integration, Modeling and Automation

Integrating Distributed Services and Data . . .

. . . The World of Open Science & Big Data

Interactive Computing

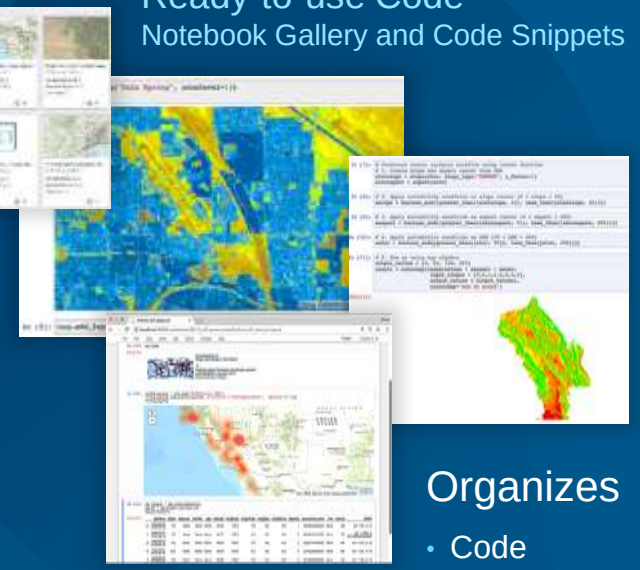
ArcGIS

Notebook Server

Enterprise (Now) and Online (soon)

Ready-to-use Code

Notebook Gallery and Code Snippets



Organizes

- Code
- Data
- Visualization
- Documentation

Data Stores / Lakes

ArcGIS Analytic Servers

(Image, GeoAnalytics, Spatial)

Open Science Libraries

Providing Notebooks as Items . . .

. . . and ArcPy Geoprocessing as a Service

AI, ML and Deep Learning Integrating Open Science

New and Improved

- Clustering
- Prediction
  - Classification
  - Regression
  - Interpolation
- Object Identification

Coming

- Feature Extraction
- Site Selection
- Event Prediction

Desktop GIS

Pro

Python Notebooks

Spatial Machine Learning

Empirical Bayesian Kriging Regression Prediction

Density-Based Clustering

Training Data Preparation

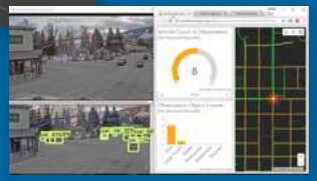
AI, ML and Deep Learning

Feature Extraction

PACI, Kuwait

Accident Prediction

Object Detection



OpenCV

Keras

TensorFlow

scikit learn

PYTORCH

Multiple Frameworks & Platforms

Imagery A Comprehensive System for Imagery and Remote Sensing

New

- Image Cube Support
- Deep Learning Tools

Image Management

Image Mosaics
Dynamic

Image Cube
Pre-Processed

Imagery

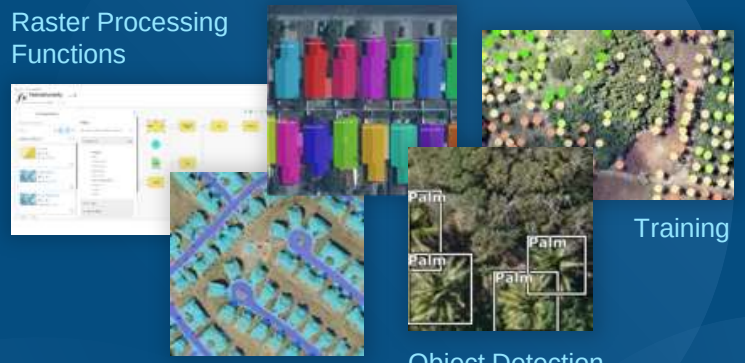
Rich Content
All Types & Formats

Analysis

Raster Processing Functions

Segmentation

Deep Learning Tools

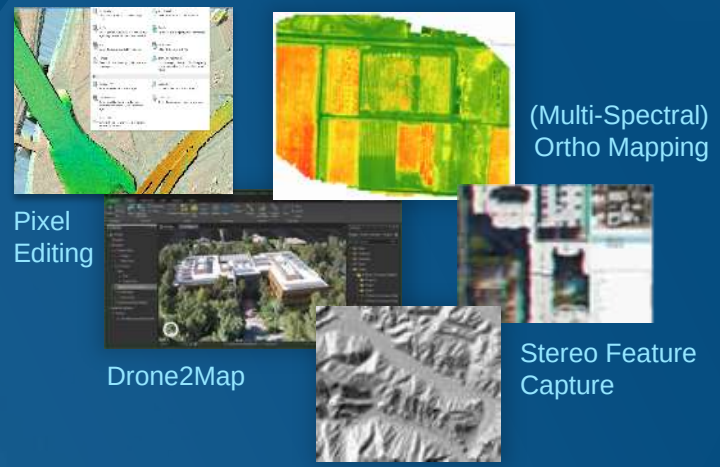


Training

Pixel Classification

Object Detection

Map Production



Pixel Editing

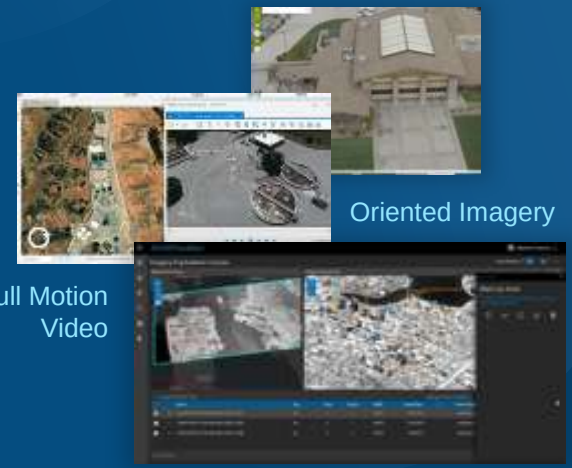
(Multi-Spectral) Ortho Mapping

Drone2Map

Stereo Feature Capture

DTM Generation

Visualization & Exploitation



Oriented Imagery

Full Motion Video

Structured Observations

Real-Time Analytics Integrating Sensor Networks and IoT

Supporting High-Velocity Data Streams

Tracking, Monitoring and Alerting

Improved

- Performance
- Scalability
- Resiliency
- Cloud Connectors
- Actuation

Enterprise Now . . .
. . . SaaS Coming

Collapsing the Time from Measurement to Decision Making

Engaging and Interconnecting Communities

Bringing Together People, Organizations and Stakeholders

Creating New Opportunities to Participate

. . . Collaborating Around Common Interests and Initiatives

A Network for Monitoring SDGs Is Emerging

Connecting Statistics Agencies and Communities

http://data-irelandsdg.opendata.arcgis.com

Ireland

UAE

http://sdgsuae-fcsa.opendata.arcgis.com

https://senegals-ansdsdg.opendata.arcgis.com

Senegal

UNSD

http://sdg-pcbs.opendata.arcgis.com

Palestine

http://www.sdg.org

Tanzania

https://mapstat-psa.opendata.arcgis.com

Mexico

Colombia

Philippines

http://odsprueba-ambiente-esri-co.hub.arcgis.com

A Global Network of Collaboration

Geospatial Infrastructure provides SDG monitoring at scale

Enabling federated data management, and sharing best practices and advanced analytics

UN Big Data Global Working Group

Scanner Data

Mobile Phone Data

Big Data GWG

Analytic Services

Python API

Integration

Open Science Tools

Python Notebooks

Big Data

Spatial Analysis & Geoprocessing

Social Media Data

Create … Publish … Share

UNSD Federated Information System for the SDGs

Palestine

Palestine Central Bureau of Statistics

Philippines

Philippine Statistics Authority

Mexico

Instituto Nacional de Estadística y Geografía (INEGI)

UN SDG Hub Network

Partner

Ireland

Central Statistics Office & Ordnance Survey Ireland

UAE

Federal Competitiveness & Statistics Authority

Partner

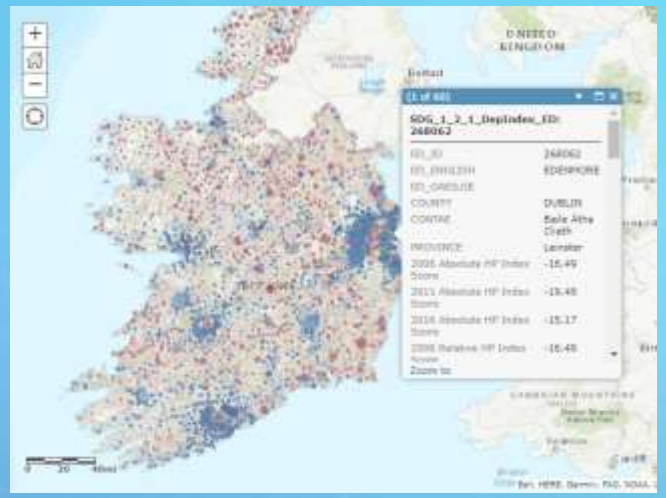
A Global Network of Collaboration

Target Contribute to progress on the Target, not necessarily the Indicator									Goal	Indicator Direct measure or indirect support to the Indicator					
							1.4	1.5	1 No poverty	1.4.2					
						2.3	2.4	2.c	2 Zero hunger	2.4.1					
					3.3	3.4	3.9	3.d	3 Good health and well-being	3.9.1					
									4 Quality education						
								5.a	5 Gender equality	5.a.1					
		6.1	6.3	6.4	6.5	6.6	6.a	6.b	6 Clean water and sanitation	6.3.1	6.3.2	6.4.2	6.5.1	6.6.1	
					7.2	7.3	7.a	7.b	7 Affordable and clean energy	7.1.1					
								8.4	8 Decent work and economic growth						
					9.1	9.4	9.5	9.a	9 Industry, innovation and infrastructure	9.1.1	9.4.1				
						10.6	10.7	10.a	10 Reduced inequalities						
	11.1	11.3	11.4	11.5	11.6	11.7	11.b	11.c	11 Sustainable cities and communities	11.1.1	11.2.1	11.3.1	11.6.2	11.7.1	
				12.2	12.4	12.8	12.a	12.b	12 Responsible consumption and production	12.a.1					
					13.1	13.2	13.3	13.b	13 Climate action	13.1.1					
		14.1	14.2	14.3	14.4	14.6	14.7	14.a	14 Life below water	14.3.1	14.4.1	14.5.1			
	15.1	15.2	15.3	15.4	15.5	15.7	15.8	15.9	15 Life on land	15.1.1	15.2.1	15.3.1	15.4.1	15.4.2	
								16.8	16 Peace, justice and strong institutions						
17.2	17.3	17.6	17.7	17.8	17.9	17.16	17.17	17.18	17 Partnerships for the goals	17.6.1	17.18.1				

EARTH OBSERVATION AND GEOSPATIAL INFORMATION
LINKAGES TO SDG GOALS, TARGETS AND INDICATORS

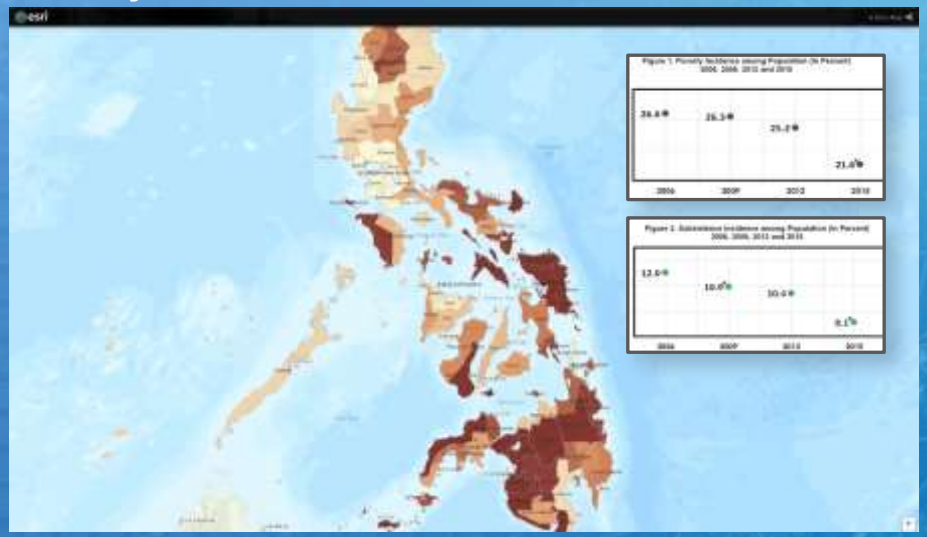
1 NO POVERTY

Population Below Poverty Line



Ireland

Poverty Incidence



Philippines

2 ZERO HUNGER

Food Supply

UN-Yemen

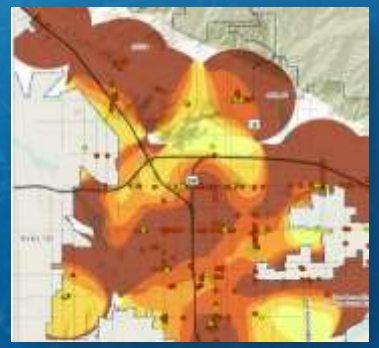
Crop Rotation

USA

Malnutrition

World

Healthy Food Access



California

Precision Agriculture

New Zealand

2 ZERO HUNGER

Machine Learning using Drone Data

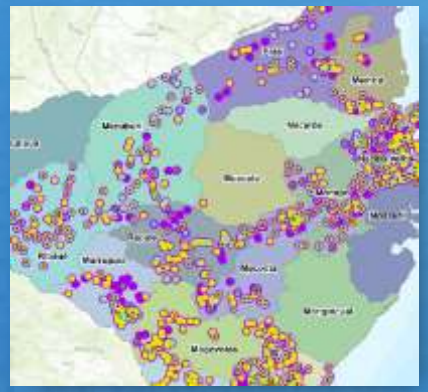
- **Captured images for two study areas**
  - Animal Farms
  - Crop Farms
- **Use Esri Artificial Intelligence tools**
  - Multi-spectral image analysis
  - Auto-detect features
- **Focus on-site inspections to farms that have regulatory issues**

Animal Farms

3 cm resolution

6 CLEAN WATER AND SANITATION

Water and Sanitation Projects



Mozambique

Sanitation Cleanout Locations

California

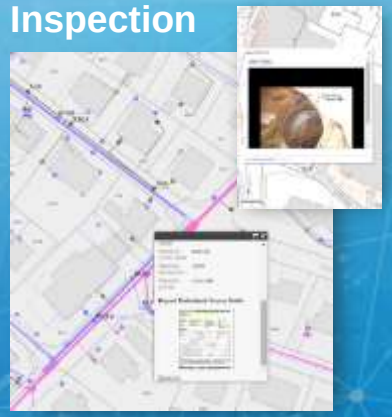
Water Monitoring

Los Angeles

Drainage Network Modeling

Washington

Sewer Inspection



Switzerland

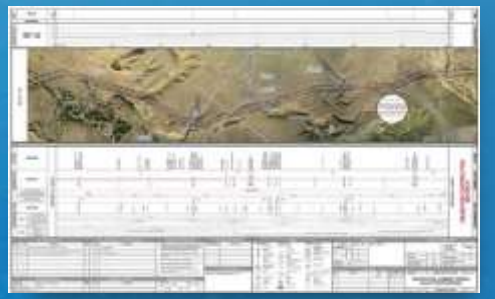
Work Order Management

New Jersey

Water Quality Monitoring

China

Pipeline Alignment



Montana

7 AFFORDABLE AND CLEAN ENERGY

Rooftop Solar Potential

Massachusetts

Solar Potential

Singapore

Wind Farm Design

Bavaria, Germany

Renewable Energy Monitoring

China

Solar and Wind Energy

Philippines

Renewable Energy Connection Network

Southern California

Wind Resources

England

7 AFFORDABLE AND CLEAN ENERGY

Electricity Consumption per Capita:

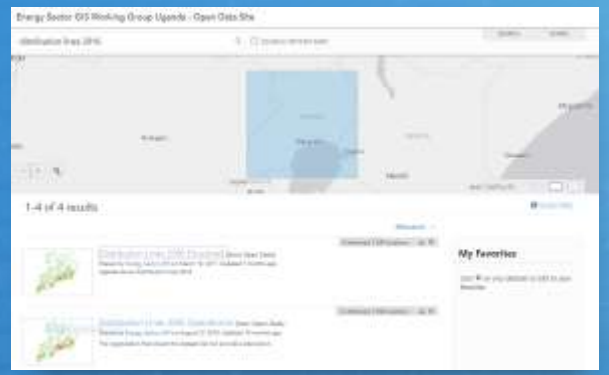
- Uganda (2016): 71 kWh/Capita
- Germany (2014): 7,035 kWh/Capita
- EU (2014): 5,909 kWh/Capita
- World (2014): 3,128 kWh/Capita

Solar Containers for rural communities

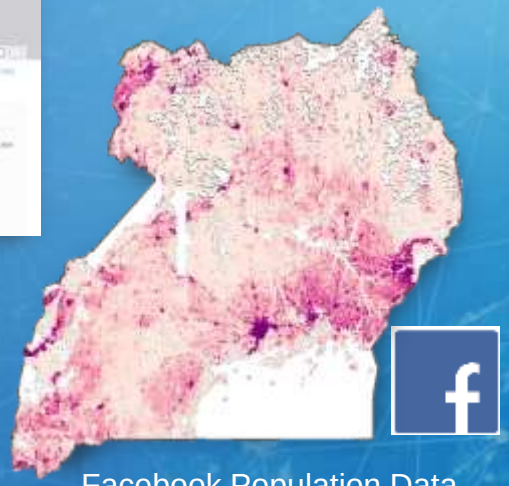
Goal:

Developing a GIS based decision support Model to decide whether it is more economical to electrify a village using Solar Home Systems, Mini-Grid or On-Grid Solutions

Data:



Energy Sector GIS Working Group Uganda Open Data Site



Facebook Population Data

https://ciesin.columbia.edu/data/hrsl/

Building Extraction from Satellite Images

↓

Cluster Buildings to Settlements

↓

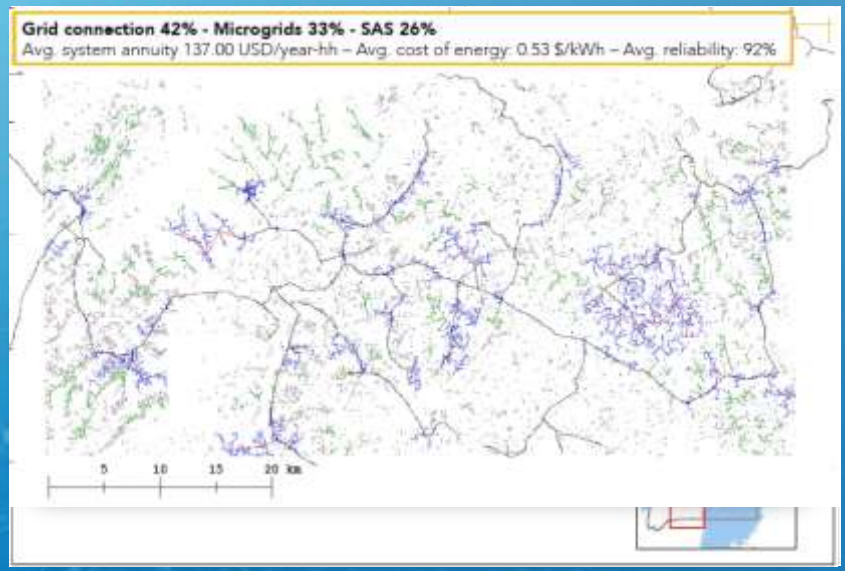
Load Transformer and Distribution Line Data as well as Electrification Status Estimates

↓

Creating buffer around distribution lines and transformers according to economic data

→ Create a Ranking of Villages/Trading Centres to be electrified first

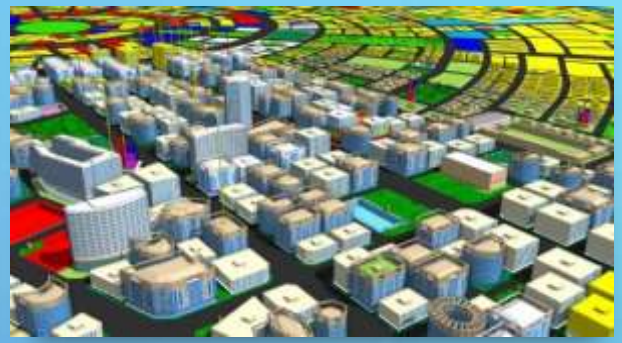
→ Sharing this information with investors



Electrification Planning in Uganda using Satellite Data

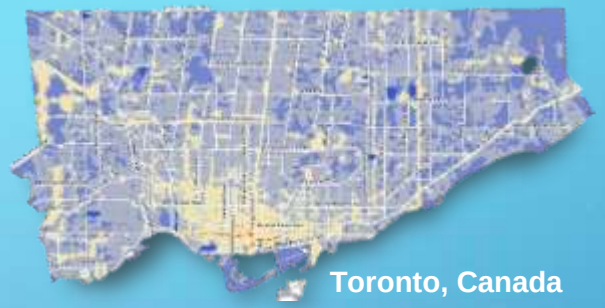
11 SUSTAINABLE CITIES AND COMMUNITIES

Urban Planning



Abu Dhabi, UAE

Vertical Intensification



Toronto, Canada

Urban Design

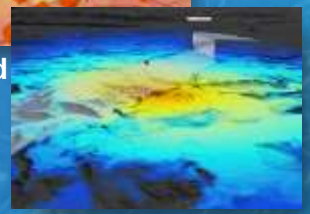
California

Urban Heat Islands

Minneapolis

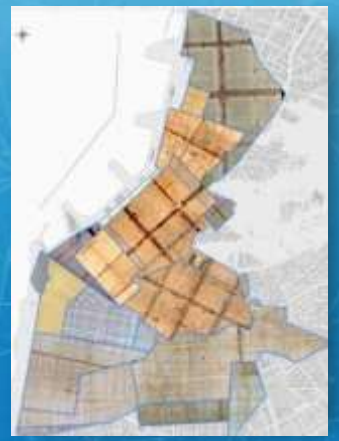
Noise Pollution

Switzerland



Switzerland

Neighborhood



Greece

Zoning

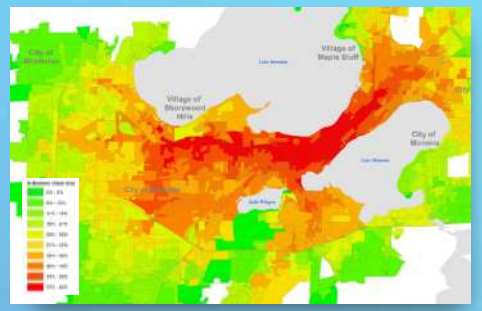
Honolulu

Land Use

Miami-Dade

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

Walking and Transit Model



Wisconsin

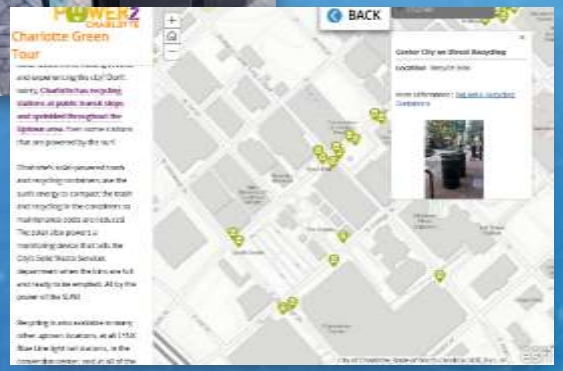
Traffic Management

Germany

Public Transit

Washington

Recycling Communications



Charlotte

Rail Status Monitoring

USA

Smart Routing (UPS)

Pennsylvania

Postal Delivery

Los Angeles

13 CLIMATE ACTION

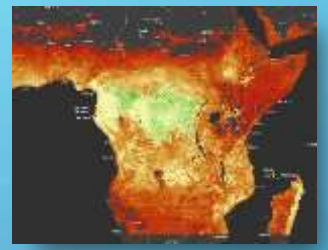
Glacial Melt

Bhutan (ICIMOD)

Desertification Survey

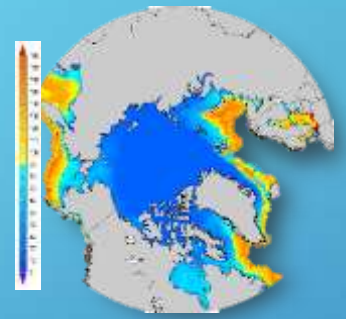
Turkey

Biomass Assessment



Africa

Calculating First Ice Freeze



Monitoring Drought

NOAA

Sea Level Rise

South Carolina

San Francisco

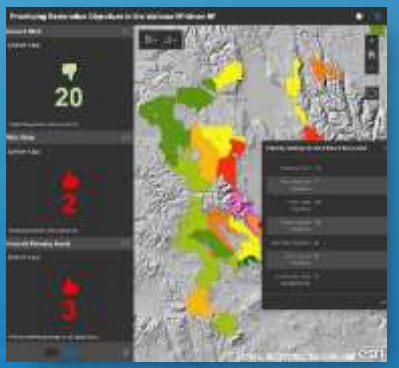
Forest Carbon Reserves

South America

Groundwater Change

California

Forest Restoration



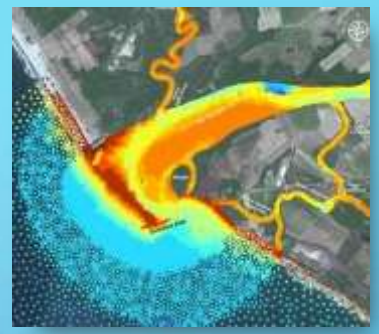
Wallowa-Whitman NF

14 LIFE BELOW WATER

Ecologically Significant Areas

NOAA—Monterey Bay

Sediment Change



Mexico

Marine Sanctuary

California

Reef Health

Cook Islands

Coral Communities

Martinique

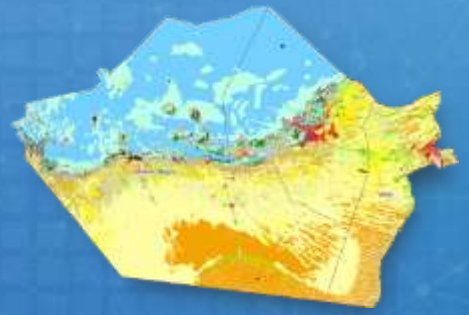
Ocean Modeling

NOAA

Biodiversity

Philippines

Marine and Terrestrial Habitat



Abu Dhabi, UAE

Marine Protection Planning

Australia

14 LIFE BELOW WATER

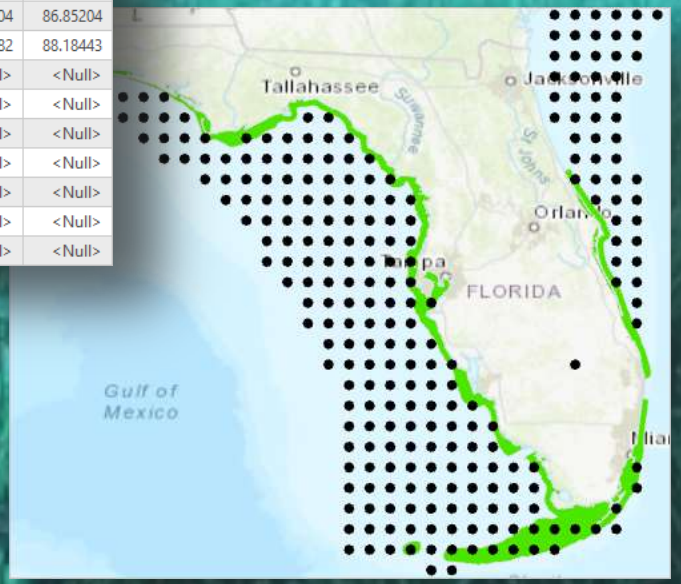
Predicting Environmental Phenomena

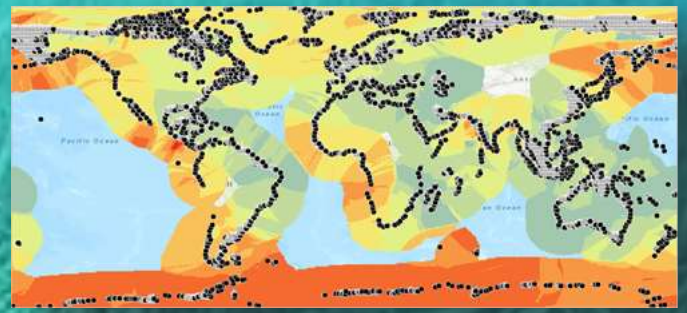
Where Seagrasses Grows, Empirical Bayesian Kriging (EBK), Random Forest classifier

EMU_Global_90m

Field: Add Delete Calculate Selection: Zoom To Switch Clear Del

OBJECTID	SHAPE	pointid	temp	salinity	appO2ut	dissO2	nitrate	percO2sat
11	Point Z	24	-1.433144	34.18222	<Null>	<Null>	<Null>	<Null>
13	Point Z	26	-1.439945	34.17537	<Null>	<Null>	<Null>	<Null>
118	Point Z	307	-1.387401	34.32391	<Null>	<Null>	<Null>	<Null>
753	Point Z	1739	-1.600642	34.03786	1.110779	7.211782	22.96304	86.85204
754	Point Z	1740	-1.56238	34.02853	0.997919	7.310482	21.98382	88.18443
871	Point Z	2184	-1.619098	33.9525	<Null>	<Null>	<Null>	<Null>
872	Point Z	2185	-1.678768	33.97821	<Null>	<Null>	<Null>	<Null>
882	Point Z	2211	-1.616092	33.94105	<Null>	<Null>	<Null>	<Null>
884	Point Z	2219	-1.697907	33.92028	<Null>	<Null>	<Null>	<Null>
885	Point Z	2220	-1.68471	33.92426	<Null>	<Null>	<Null>	<Null>
886	Point Z	2221	-1.69101	33.94196	<Null>	<Null>	<Null>	<Null>
887	Point Z	2222	-1.69061	33.93676	<Null>	<Null>	<Null>	<Null>





Empirical Bayesian Kriging

```
from sklearn.ensemble import RandomForestClassifier
import numpy as NUM
import arcpy as ARCPY
import arcpy.da as DA
import pandas as PD
import seaborn as SEA
import matplotlib.pyplot as PLOT
import arcgisscripting as ARC
import SSUtilities as UTILS import os as OS
```

15 LIFE ON LAND

Wildlife Conservation

South Africa

Wilderness Tour

Steens Mountain Wilderness, Oregon

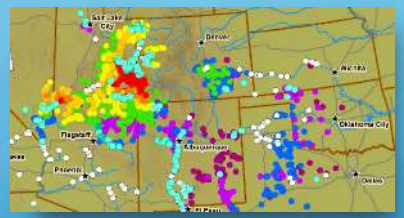
Green Infrastructure

New Jersey

Habitat Corridors

Atlanta

Invasive Species



Southwest, USA

Ecosystem Sensitivity

Bolivia

Watershed

Alaska

Wildlife Imagery

California

Habitat Monitoring

USA

15 LIFE ON LAND

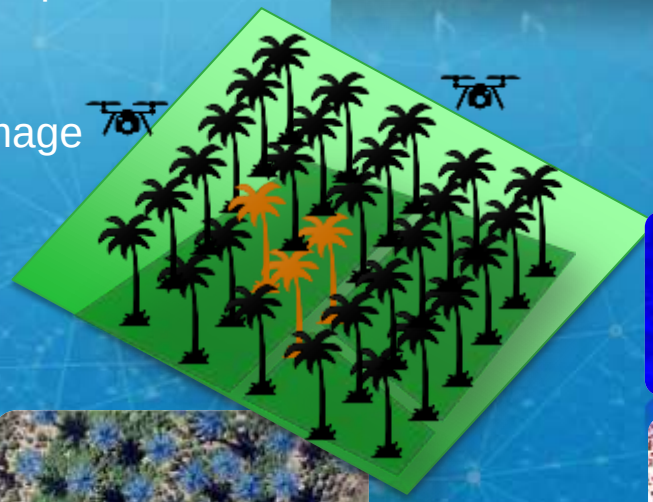
Using Deep Learning to Assess Palm Tree Health

Leaf Spots and Leaf Blights of Palm

Bud Rot of Palm

Graphiola Leaf Spot (False Smut) of Palm

- Harnessing drone real-time capabilities of **monitoring** of crops and plants (e.g. Palm Trees)
- Inferring presence of **fungal** & **bacterial** diseases using image classification enabling an immediate response to identify containment zones & to contain contaminations
- **Benefits:**
  - Supervised Classification for autonomous systems
  - Real-Time Detection & Accelerated Response



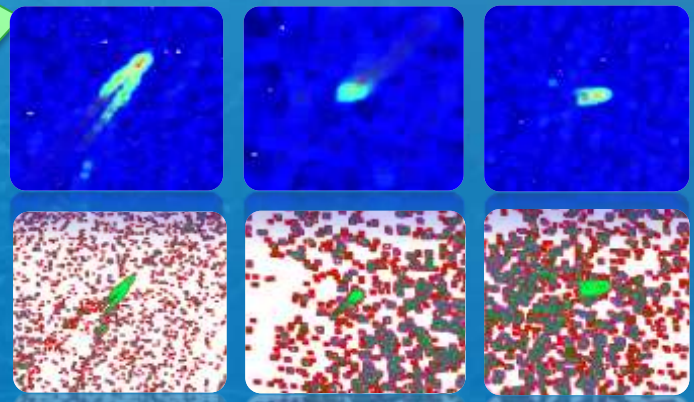
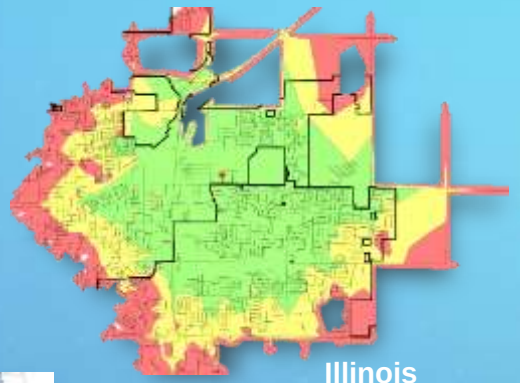


Image Classification to help Infer presence of contamination

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

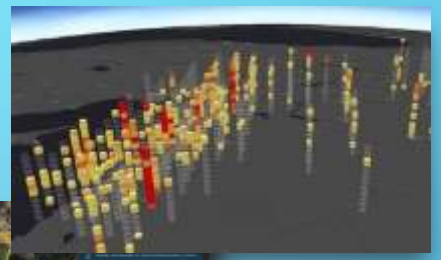
16 PEACE AND JUSTICE STRONG INSTITUTIONS

Fire Response Times

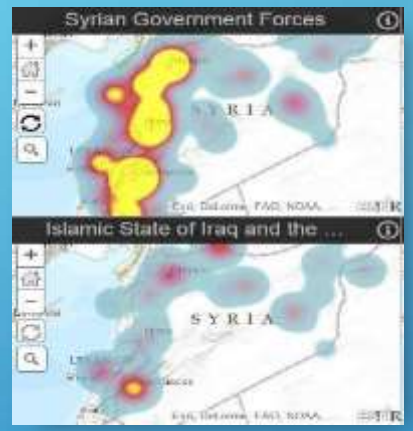


Illinois

Acts of Terrorism



Violence Hot Spots



Syria

Infrastructure Protection

DHS

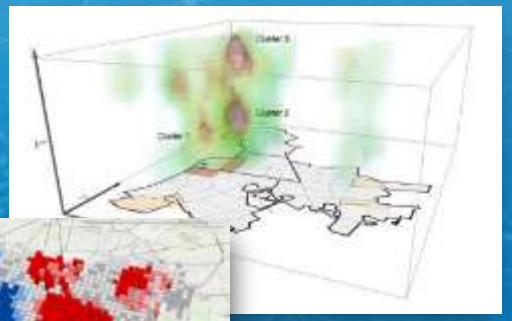
Fire Station Location/Allocation

Texas

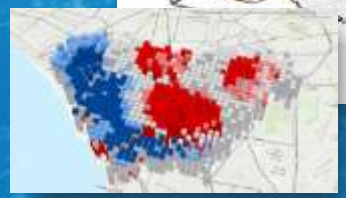
Marathon Viewshed

London, England

Spatiotemporal Crime Patterns



Louisiana



Peru

Officer Involved Shootings

Texas

EMS Resources

Tel Aviv, Israel

16 PEACE AND JUSTICE STRONG INSTITUTIONS

City in Motion

Geography-Wide Monitoring

CRM
Demographics,
Visitor Lines

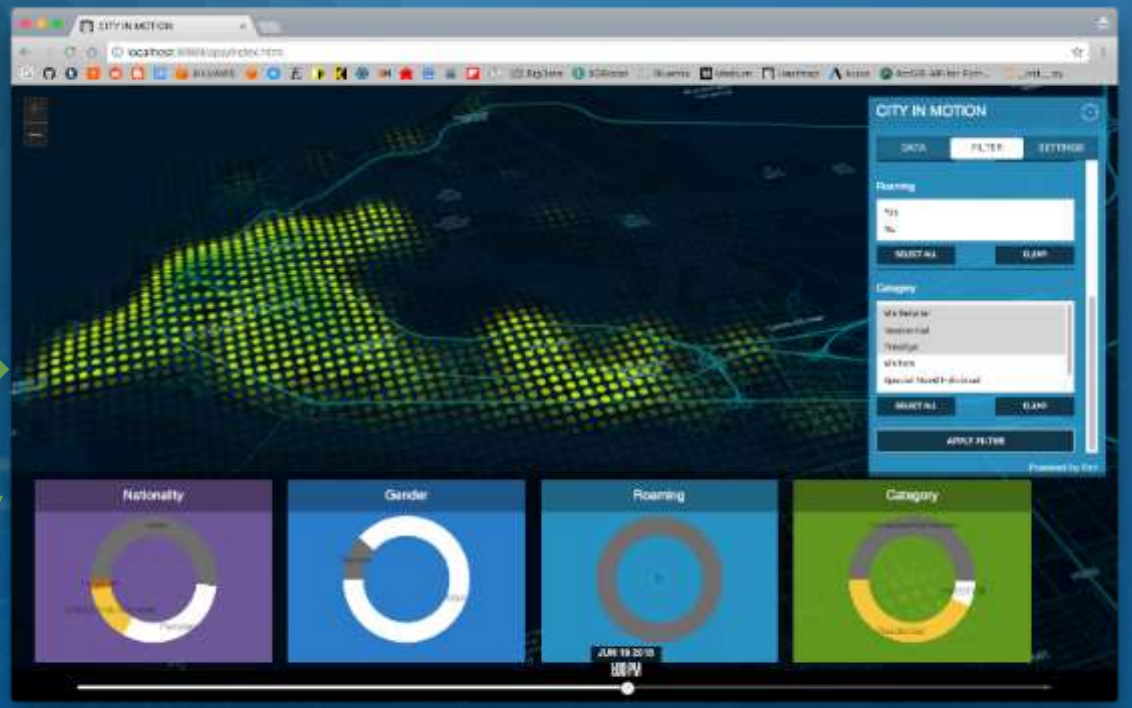
Signaling Network
Movement, Roaming

Analytics
Home/Work
Locations

Data Packet Inspection DPI
Web Activity

1 Billion Records Daily

200 GB Daily

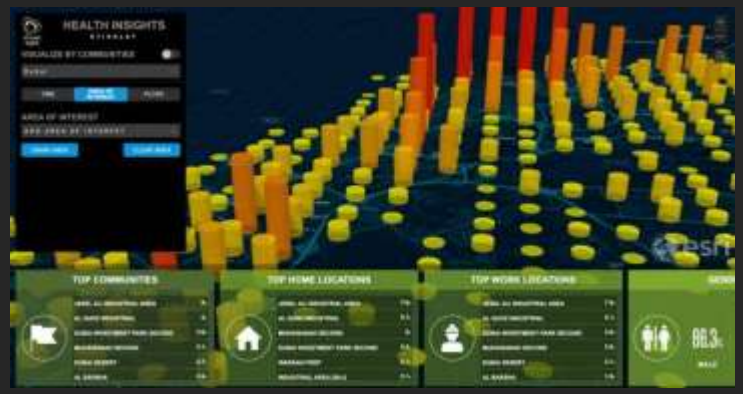



esri
Etisalat's City
BACK


esri
Etisalat's City
Insights
esri


esri
Etisalat's City
UAE Eye - Accident Analysis
BACK


UAE EYE
PROCESSING
esri
TOP COMMUNITIES
GENDER
AGE


HEALTH INSIGHTS
esri
TOP COMMUNITIES
TOP HOME LOCATIONS
TOP WORK LOCATIONS


MOBILITY INSIGHT
esri
TOP COMMUNITIES
GENDER
AGE

AI4SDG – roadmap to a Global Data Commons to achieve the Sustainable Development Goals (1/2)

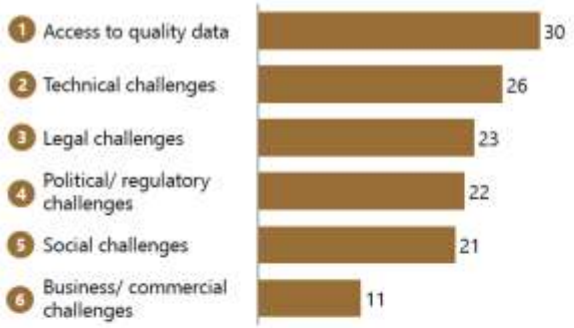
Strategic support by: McKinsey&Company

We invited global technology leaders to submit their views on what it would take to make Global Data Commons a reality

The Global Data Commons aims to deploy AI to help achieve the SDGs

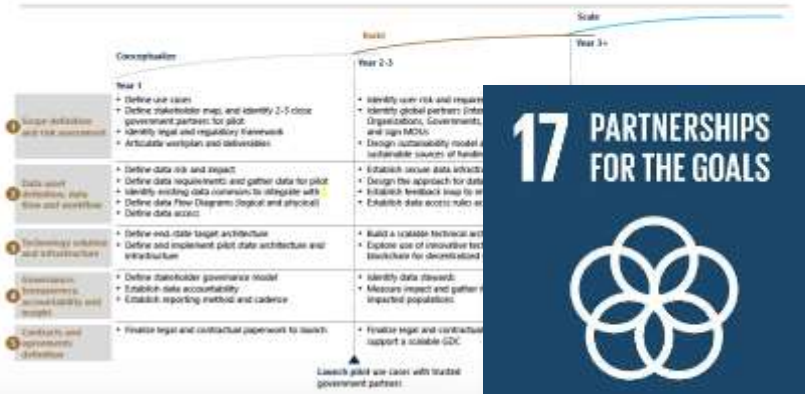
- Capitalizing on the immense volume of data available and use AI to tackle the world's greatest challenges
- Detect, present and help scale-up use cases for AI enabling the 17 SDGs
- The use of AI for Sustainable Development Goals will allow us to:
  - Monitor progress towards the achievement of SDG
  - Simulate implications
  - Predict outcomes of measures taken
  - Provide recommendations for policy makers

The position papers discuss several challenges that prevent the implementation of a GDC



Example quotes from position papers

Our review of the position papers indicates that we can follow an iterative and systematic approach to creating the Global Data Commons



17 PARTNERSHIPS FOR THE GOALS

القمة العالمية للحكومات
WORLD GOVERNMENT SUMMIT


esri
THE
SCIENCE
OF
WHERE