Building Capacity to Use Earth Observations in Addressing Food Security Challenges in Bhutan

Aparna Phalke (Thematic Lead and Scientist for Agriculture and Food Security Area, SERVIR),
Sarah Cox (Scientist for Agriculture and Food Security Area, SERVIR)

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Trainers

Aparna R. Phalke, PhD

Thematic lead and Scientist

NASA SERVIR Agriculture and Food Security theme

Sarah Cox

Research Scientist

NASA SERVIR Agriculture and Food Security theme

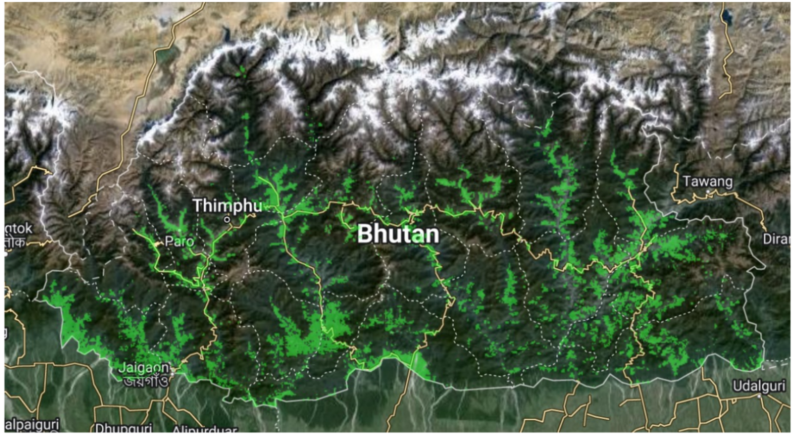
Prerequisites

- Fundamentals of Remote Sensing

Training Learning Objectives

By the end of this training, participants will be able to identify:

- Which satellite and sensors can be used for Agriculture and Food Security (AFS) applications
- Characteristics of satellite data used for AFS
- Data products applicable for AFS
- Overview of SERVIR services applying satellite data for decision making
- Case study of Bhutan cropland extent mapping using Landsat data and machine learning (ML) model
- Remote Sensing (RS) for mountainous regions vs flat regions
- Differences between different ML models
- SERVIR-Bhutan Cropland Monitoring tool overview

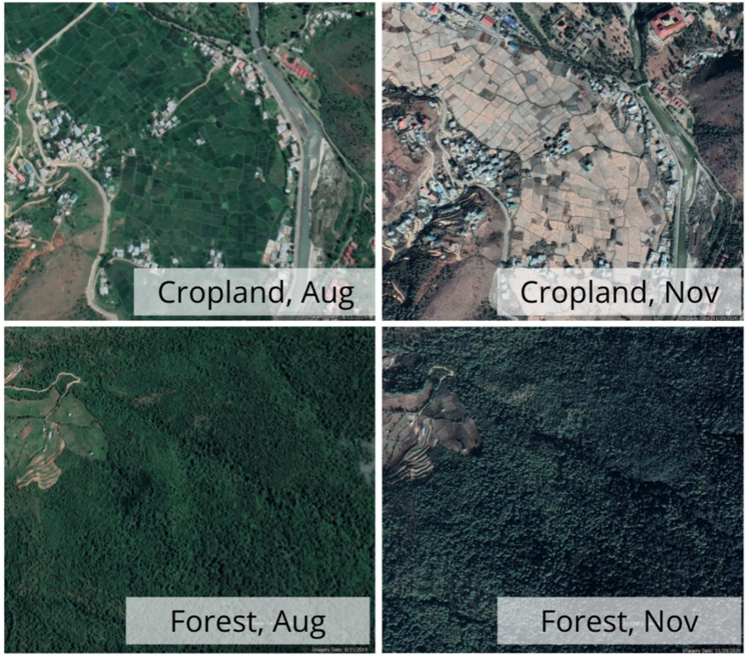


Cropland area map in Bhutan, SERVIR

Outline

- Overview of satellite data applications for AFS
  - History of Earth observations in agriculture
  - Satellites and sensors for agricultural applications
  - Caveats of remote sensing
- Overview of SERVIR services applying satellite data for decision making
  - About SERVIR
  - Introduction to SERVIR AFS service

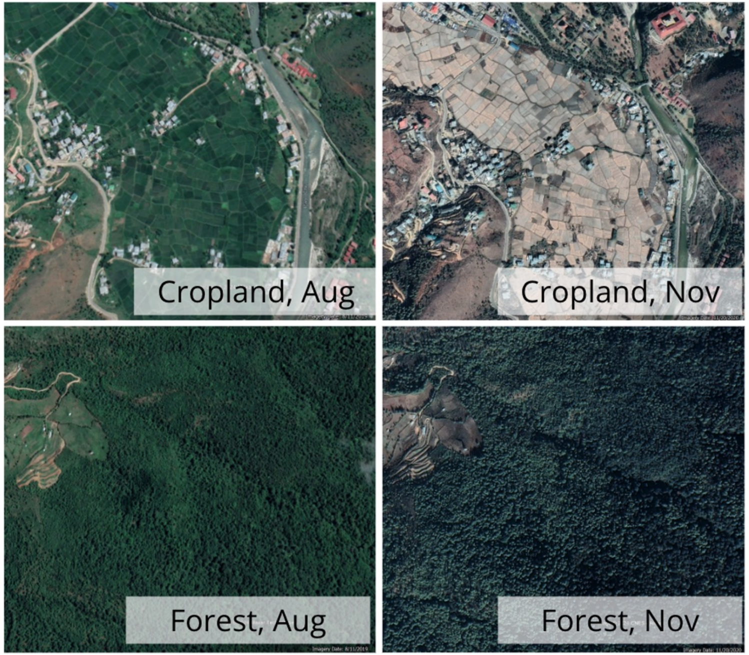
Scenes in Paro, Bhutan observed Pre- & Post Harvest Time



Outline

- Case study of Bhutan cropland extent mapping using Landsat data and machine learning (ML) models
  - Overview of satellite data application for AFS in Bhutan
  - Overview of ML modeling using satellite data
  - Best practices to collect field-data for training ML model
  - Method and framework to map cropland extent in Bhutan using Landsat data and ML
- Demonstration of methods and algorithms to classify cropland areas using Google Earth Engine and ML in Bhutan

Scenes in Paro, Bhutan observed Pre- & Post Harvest Time



Overview of Satellite Data Applications for Agriculture and Food Security (AFS)

Long-lasting Role of Landsat Satellites in Agriculture

- Landsat-1 launch in July 23, 1972 (0.5-1.1µm spectral range with green, red and only two infrared bands with Multispectral Scanner MSS)
- Landsat has provided a longest record of earth surface since its first launch to recent Landsat-9 launch
- The Landsat-1 sensor design was motivated by USDA-ARS and NASA agreement in mid to late 1960s.
- After Landsat-1 launch, consistent global agricultural monitoring application
- Large Area Crop Inventory Experiment (LACIE) (1974-77)
- Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing (AgRISTARS) (1980)

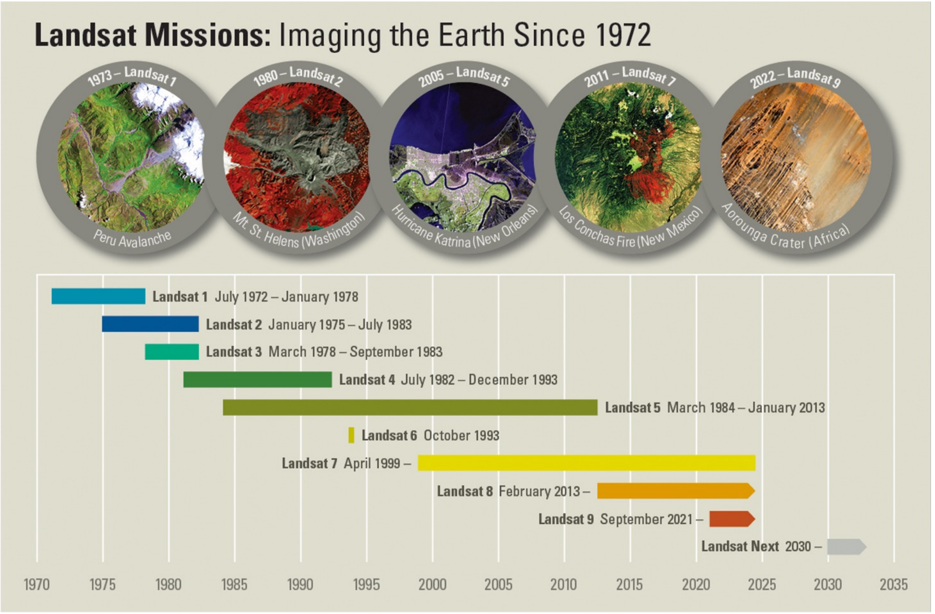


Image credit: United States Geological Survey

Satellite and Sensors for Earth Science Applications

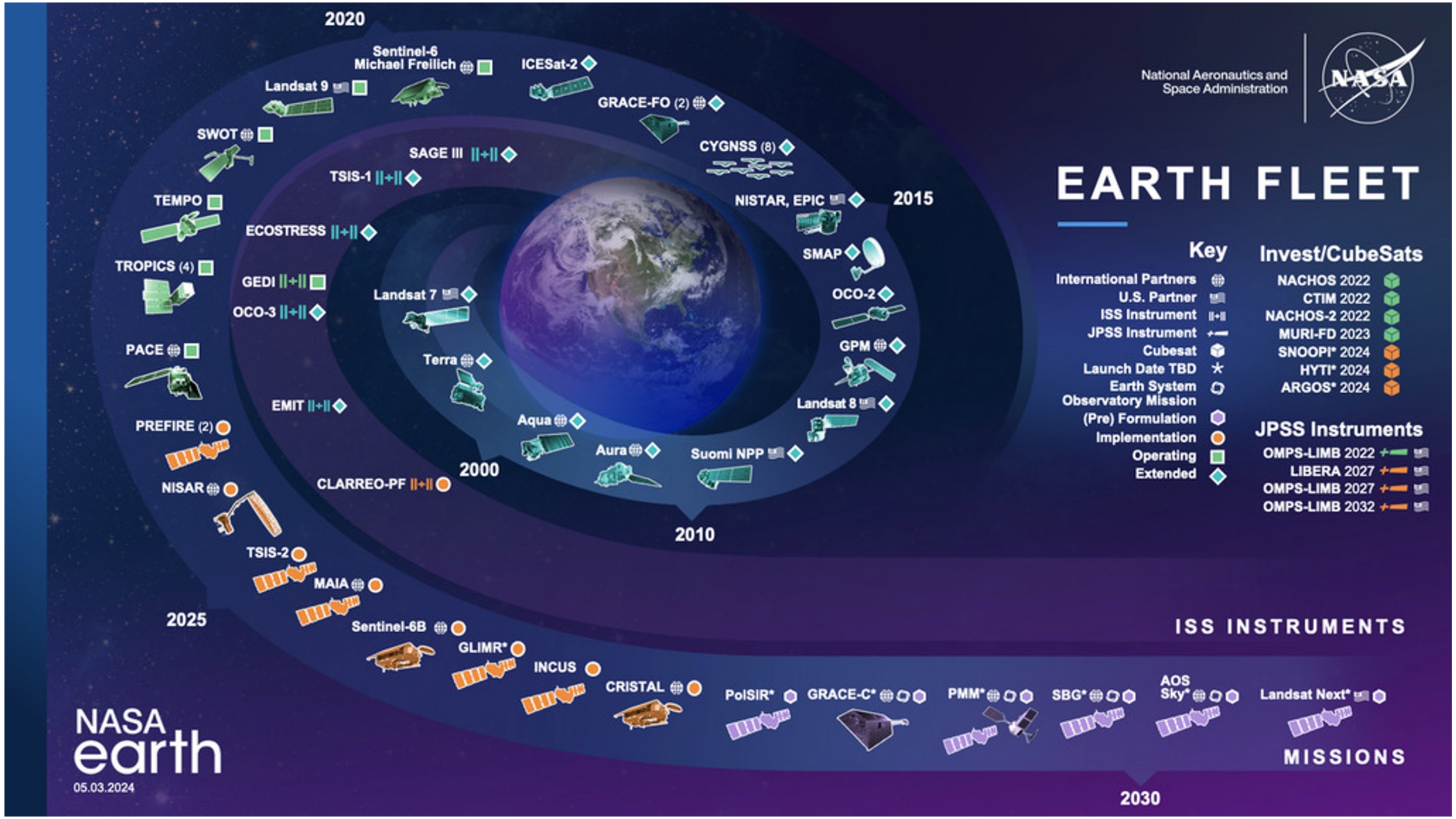


Image credit: NASA

Satellite and Sensors for AFS Applications

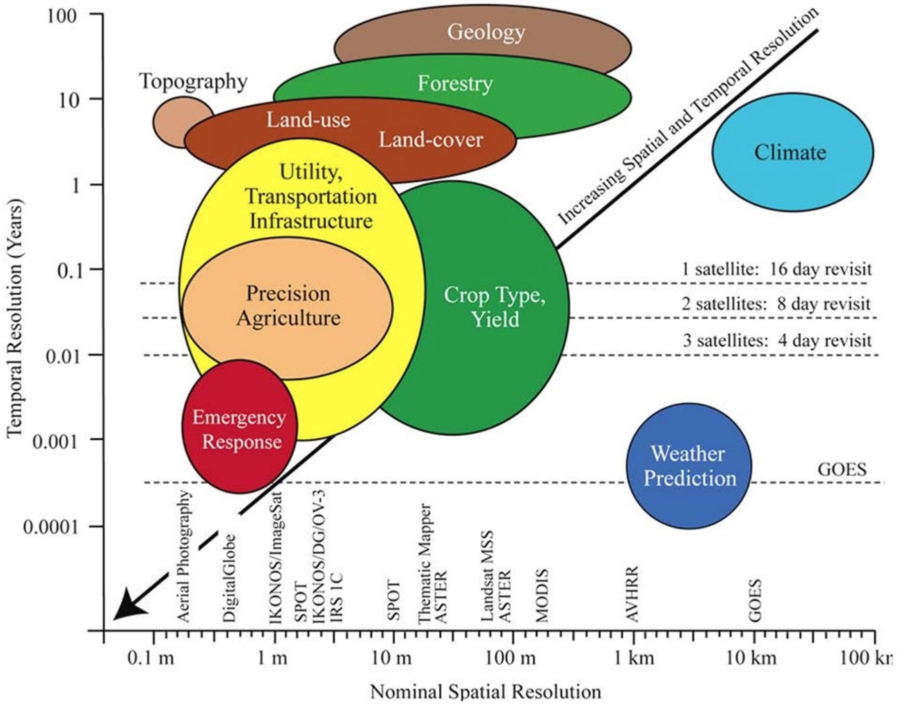


Image credit: Jensen, 2007

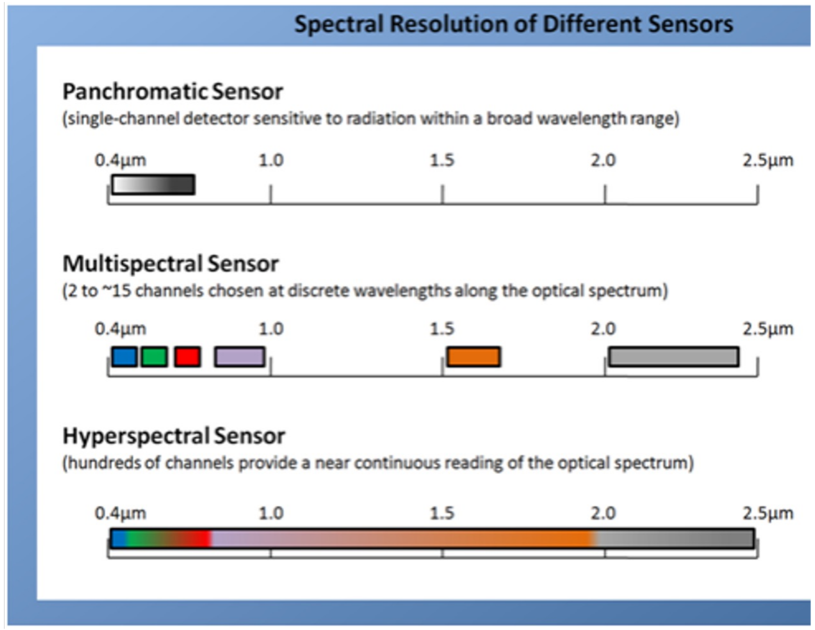


Image credit: ENVI

Satellite and Sensors Products for AFS Applications

Satellite-derived proxies give us an idea of crop biophysical characteristics

- Chlorophyll Content
- Above ground biomass
- Leaf Area Index (LAI)
- Primary Productivity

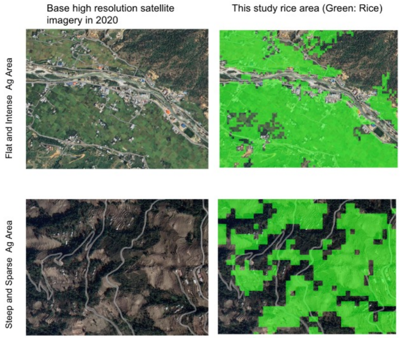
and environmental variables

- Soil moisture
- Temperature

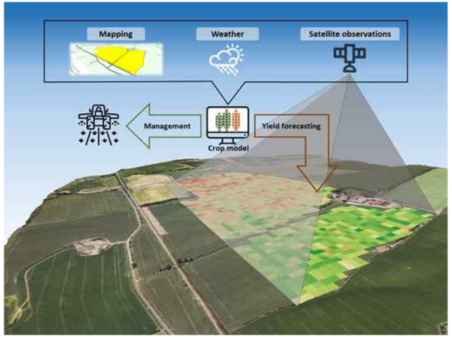
		Scientific Products						
Satellite	**Sensor**	**Land Surface Reflectance**	**Evapotranspiration**	**Land Surface Temperature**	**Precipitation**	**Soil Moisture**	**Vegetation Greenness**	**Structure**
Terra	MODIS	X	X	X			X	
Aqua	MODIS	X	X	X			X	
Suomi-NPP	VIIRS	X		X			X	
NOAA-20	VIIRS	X		X			X	
Landsat 8	OLI	X					X	
Sentinel 2	MSI	X					X	
Landsat 8 & Sentinel 2	HLS	X					X	
International Space Station	ECOSTRESS		X					
Land Data Assimilation System	Modeled output		X			X		
Global Precipitation Measurement	GMI, DPR				X			
CHIRPS	Multiple				X			
Soil Moisture Active Passive	L-band radar					X		
Sentinel 1	C-band radar							X

Source: ARSET

Satellite Data Applications for Agriculture and Food Security



Cropland Monitoring



Cropland Forecasting

Supply-chain/Market Analysis

Humanitarian Aid

Policy Assessment

Climate Resilient Farming

Image credit: SERVIR

Characteristics of Vegetation through Satellites

- Vegetation greenness
  - Satellite sensors detect absorption and reflection of certain wavelength of lights and can detect vegetation greenness
  - Indices such as normalized difference vegetation index (NDVI), enhanced vegetation index (EVI), Green NDVI (GNDVI), Soil Adjusted VI (SAVI)
- Vegetation density
  - Vegetation density index (VDI)
- Above ground biomass
- Leaf Area Index
  - It is defined as the one-sided green leaf area per unit ground surface area in broadleaf canopies.

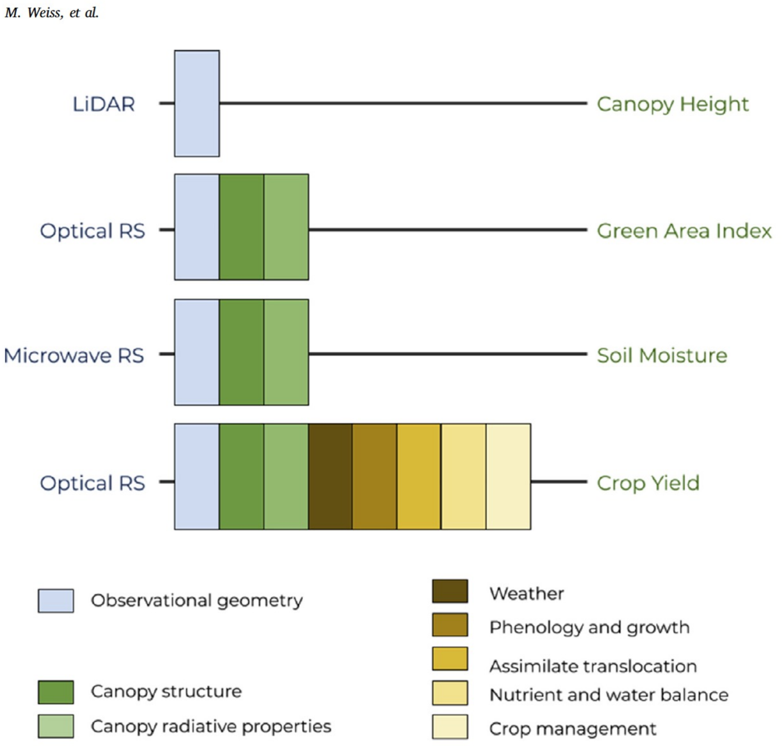


Image credit: M. weiss et al., 2020

Characteristics of Vegetation through Satellites

- Photosynthetic Primary Production (PPP)
  - Carbon dioxide intake during photosynthesis minus carbon dioxide release during respiration
- Fraction of Absorbed Photosynthetically Active Radiation (FAPAR)
  - Solar radiation absorbed by vegetation during photosynthesis
- Light Use Efficiency
- Canopy Nitrogen
- Leaf pigment
- Canopy water content

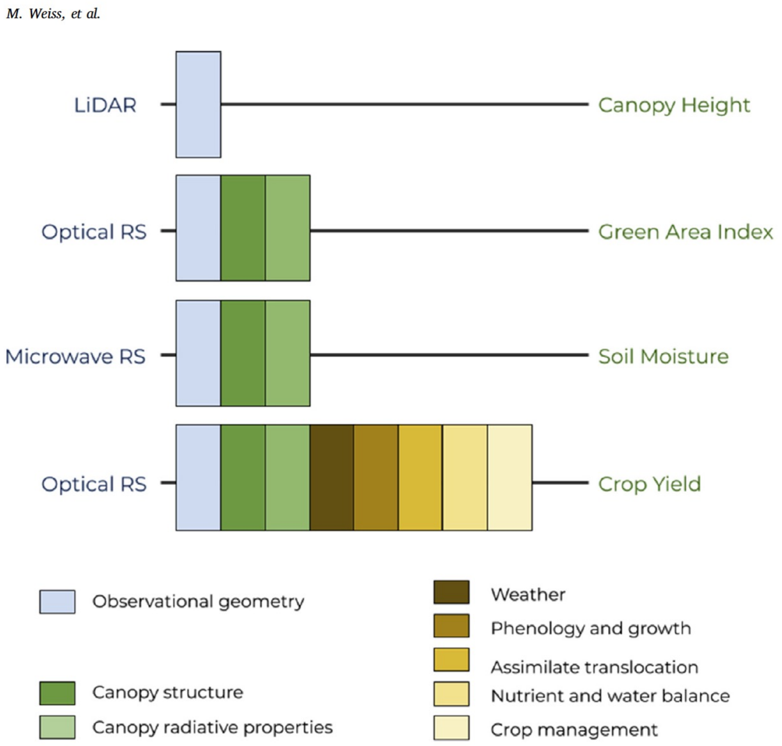
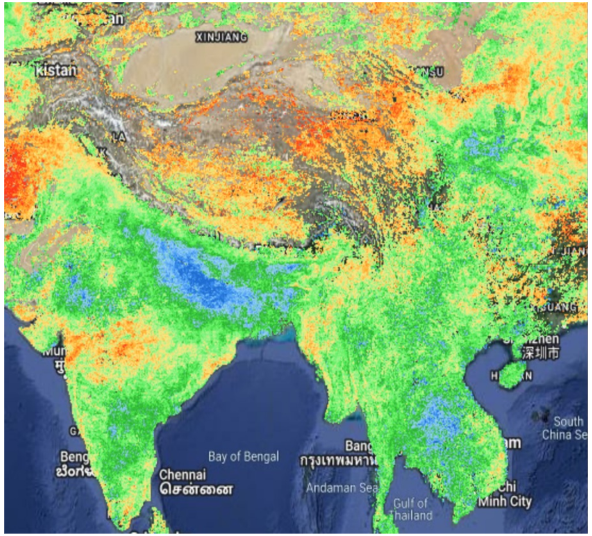
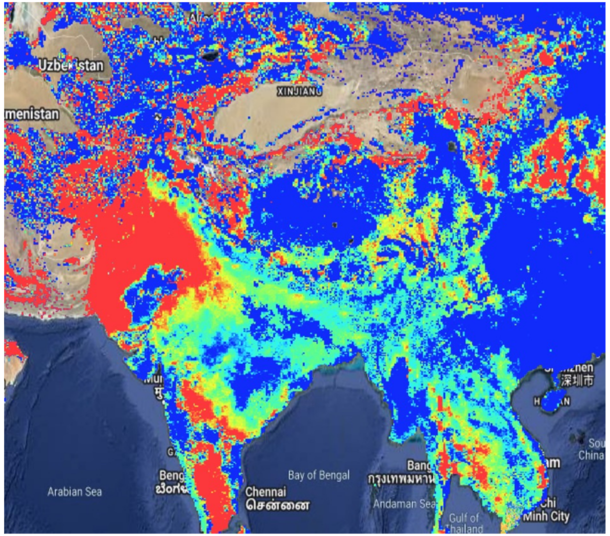


Image credit: M. weiss et al., 2020

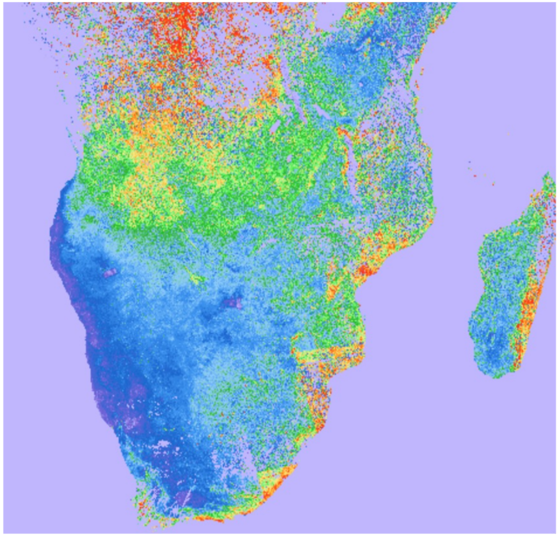
Satellite Data Products Supporting Agriculture Applications



SpoRT Evaporative Stress Index



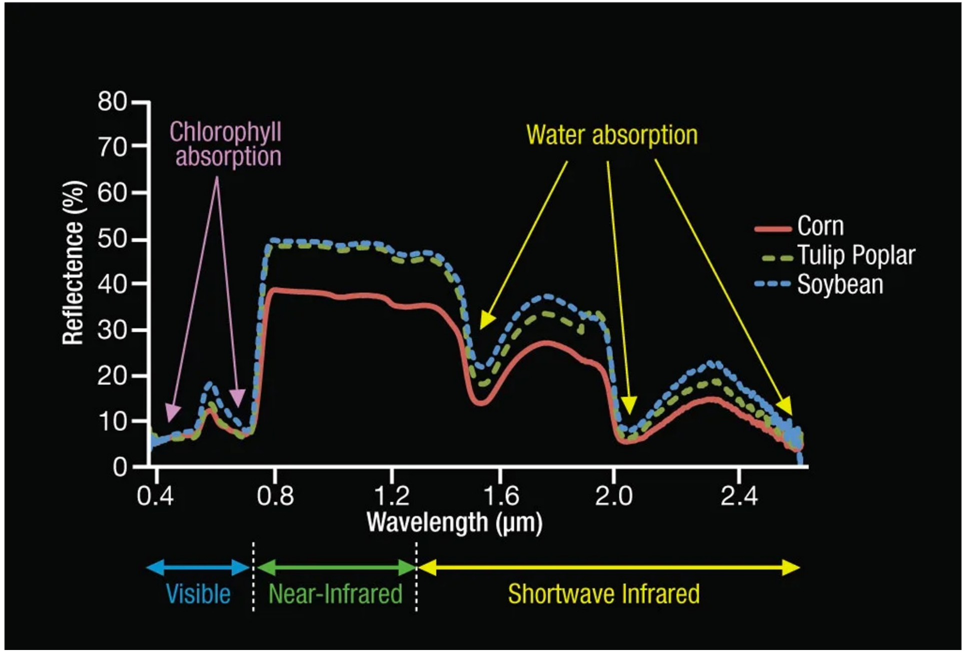
Subsurface soil moisture USDA-SMAP



USGS eMODIS NDVI

Source: https://climateserv.servirglobal.net/map

Satellite Data Based Vegetation Greenness



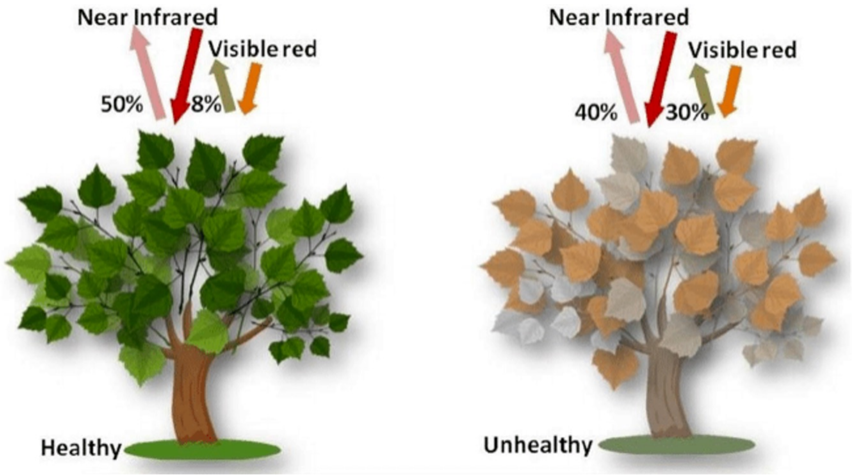


Image credit: NASA

Image credit: Wu et al., 2014

Satellite Data Based Vegetation Greenness Indices

Commonly used indices:

NDVI: (NIR-RED)/(NIR+RED)

NDWI: (Green-NIR)/ (Green+NIR)

Others:

EVI = G *((NIR-R)/(NIR+C1*R-C2*B+L))

NDSI = (Green-SWIR)/(Green+SWIR)

NBRI = (NIR-SWIR)/(NIR+SWIR)

BSI = ((Red+SWIR)-(NIR+Blue))/((Red+SWIR)
+(NIR+Blue))

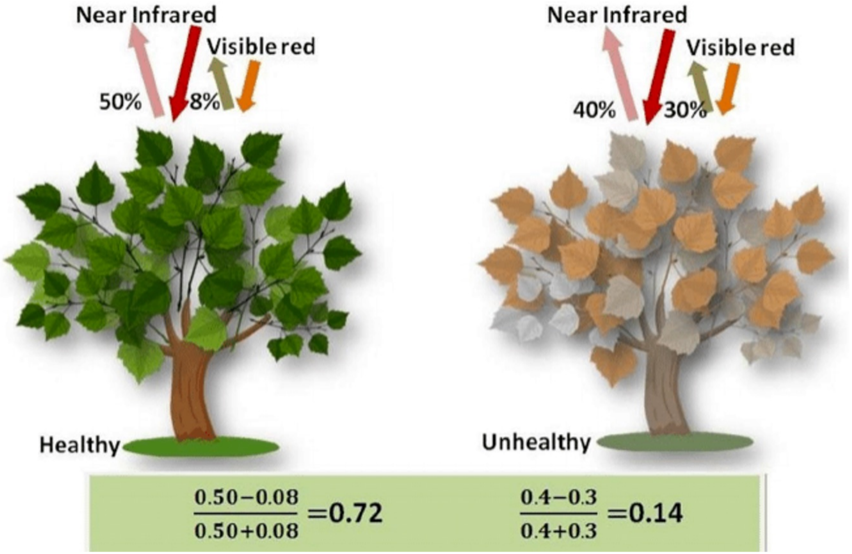
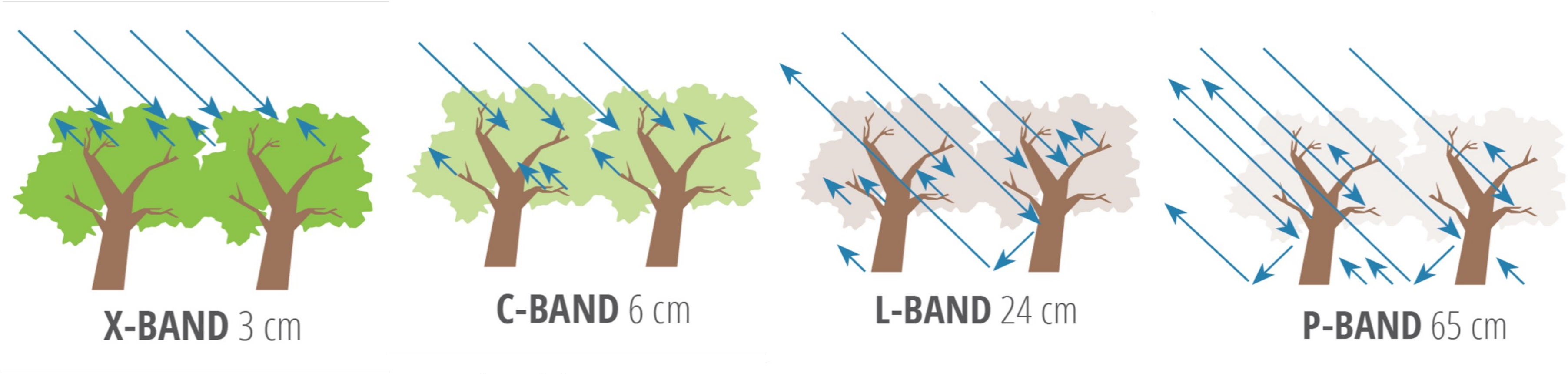


Image credit: Wu et al., 2014

SAR Data Products for Vegetation Monitoring



COSMO-SkyMed
PAZ SAR

Radarsat-2
Sentinel-1
RCM

ALOS-2 PALSAR-2
SAOCOM
NISAR*
TANDEM-L

BIOMASS*

Image credit: SAR Handbook

SAR Data Advantages and Disadvantages

Advantages

- Certain bands penetrate clouds
- Minimal atmospheric effect
- Senses information on surface roughness, dielectric properties and moisture content

Disadvantages

- Topography (foreshortening, layover, shadow)
- Requires pre-processing
- Speckle filter
- Resulting data are complex and can be difficult to interpret

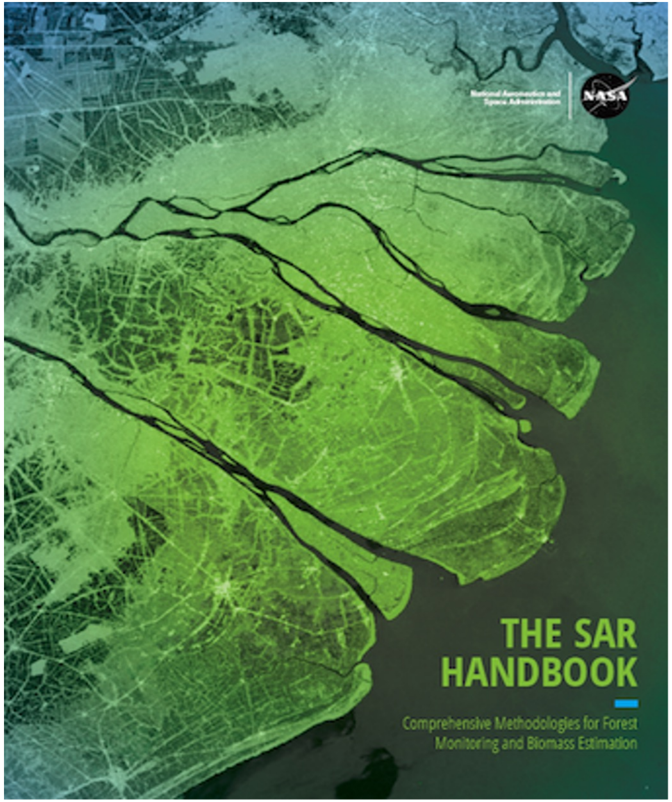
SAR Handbook: Comprehensive Methodologies for Vegetation Monitoring

SERVIR and **SilvaCarbon**, published an open-source book that covers topics:

SAR basics, forest change detection, forest high estimation, biomass estimation, etc.

This open source book contains:

- Tutorials,
- Data
- Supplementary materials
- All available for you!



Satellite Data Application to Agriculture vs Other Vegetation

What's **different** about natural vegetation (forest) vs managed vegetation (croplands, rangelands)?

Human managed vegetation have:

- Peculiar growth stages according to cultivar type and related crop growth calendar
- Distinct growth cycle according to the inputs applications like fertilizers and irrigation
- Distinct boundary characteristics with patterns and edges
- Distinct cultivating practices for example transplanted rice and seeded rice

Image credit: SERVIR-Bhutan

Benefits of Use of Satellite Data in Agriculture

- Consistent and unbiased information on agriculture
- Timely, consistent and precise information
- Field scale to global scale perspectives
- Plant growth monitoring
- Benefits to small-holder to large-holder farmers
- Early detection of crop conditions and related variables such as soil, water and weather conditions
- Realistic and timely estimate on crop production
- Early advisory in managing farm inputs or farm management practices such as time of planting, time of harvesting, fertilizer inputs, irrigation/water inputs.
- With new advancements in computational field such as AI and advanced satellite data, the information flow is fast and robust between farmers and markets

Image credit: SERVIR-Bhutan

Limitations of Use Satellite Data for Agriculture

- The satellite sensor with high overall resolution including temporal, spatial with same instrument is yet to be launched
- Data do not have standard format, size, type and thus, processing needs special attention.
- Capacity building needs to convert the data into products used for decision making

Image credit: SERVIR-Bhutan

Limitations of Use Satellite Data for Agriculture

- Active remote sensing data such as Sentinel-1 and passive remote sensing data such as optical datasets like Landsat and Sentinel-2 have different advantages and disadvantages.
  - Optical data is sensitive to cloud, cirrus and other atmospheric conditions while Radar data is not.
  - Optical data has measurements through energy reflected due to leaf structure, pigmentation or soil moisture while Radar data has measurement through scattered energy and dependent on vegetation structure (size, density, orientation) and dielectric properties.
  - Optical sensor only measures surface energy whereas Radar has sub-surface measurement capability.
  - Optical data has range of bands from visible to infrared but Radar has single wavelength.

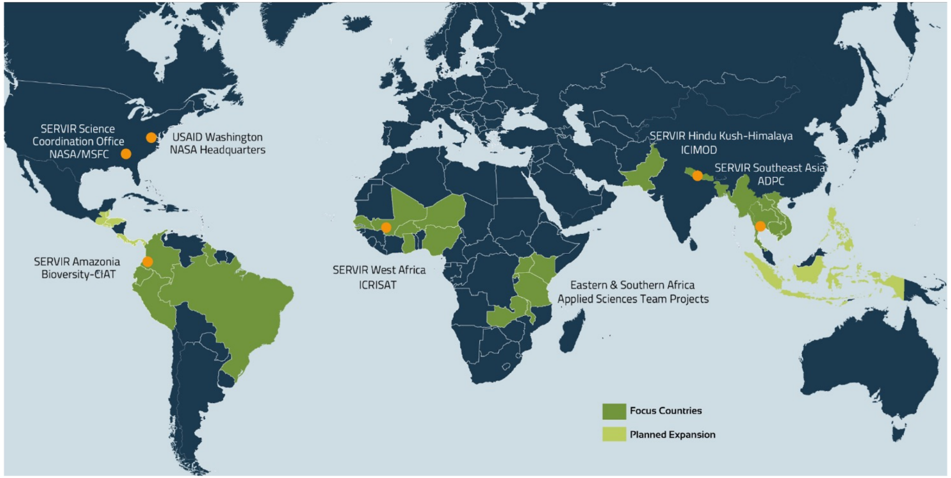
Image credit: SERVIR-Bhutan

Overview of SERVIR Services Applying Satellite Data for Decision Making

About SERVIR

- **SERVIR is a joint initiative of NASA, USAID,and leading geospatial organizations in Asia, Africa, and Latin America that partners with countries and organizations to address challenges in climate change, food security, water and related disasters, land use, and air quality.**

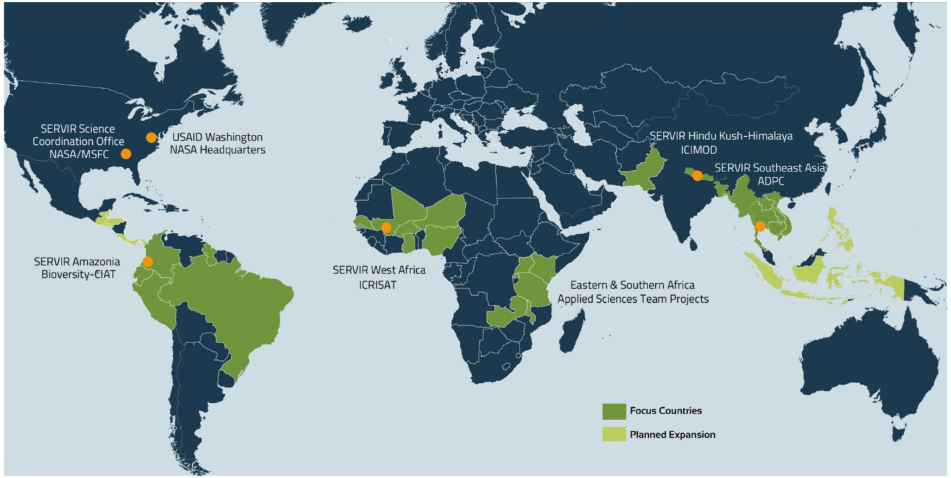
- SERVIR's goal is to build capacity of developing countries through supporting the user-centered services with its implementing partners in order to address environmental challenges through Earth Observation data based tool.



servirglobal.net

About SERVIR

- SERVIR is co-developing a service to **Bhutan** implementing partners from government and non-government agencies to help monitor cropland area and production in order to help The Kingdom of Bhutan in their food self-sufficiency goals and early warning response to natural disasters.



servirglobal.net

Capacity & Services: Gender Integration and Action

41% of people trained in 2019 identify as female

SERVIR-Mekong Vietnam Gender Inequality Index (GEII) **serves gender differentiated data**, giving insight into service design and delivery.

SERVIR-HKH has an ongoing country level training series

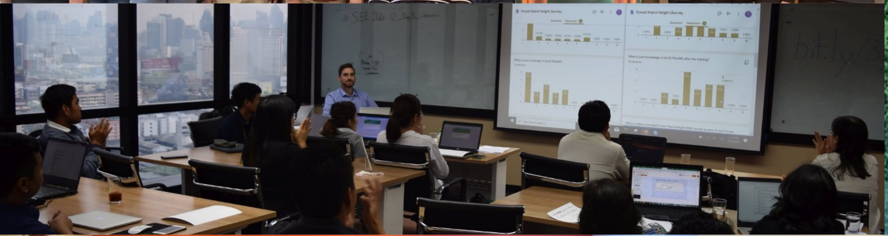
Building women leaders and gender champions in SERVIR

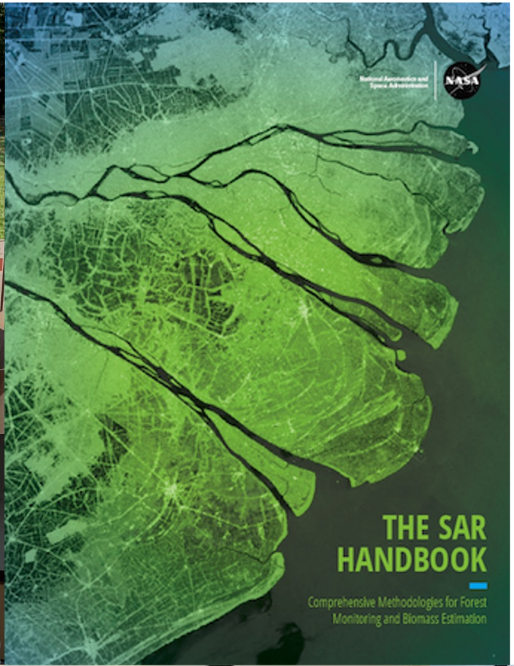
Empowering women and girls to explore STEM fields

Integrating gender considerations in service planning

Using remote sensing and GIS to address development issues that are inclusive of underrepresented groups

Capacity Building and Trainings

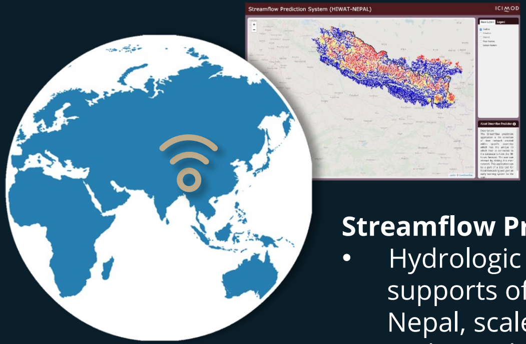




NASA Capacity Building program

Collaboration with universities, civil society, governments, and other institutions

Services: Scaling, Replicating, and Exchanging across the SERVIR Global Network

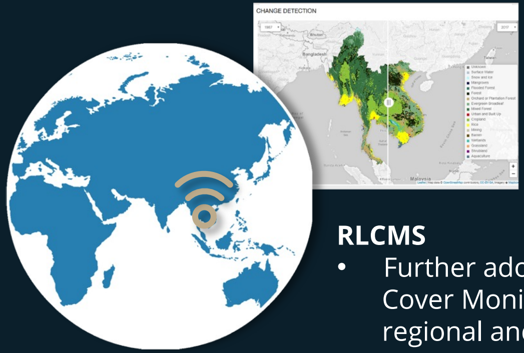


Streamflow Prediction Tool

- Hydrologic forecast system supports official flood bulletins in Nepal, scaled to Americas, Africa, and Asia through GEOGLOWS

Collect Earth Online (CEO)

- Used in Forest Resource Assessments worldwide and to collect reference data across thematic areas

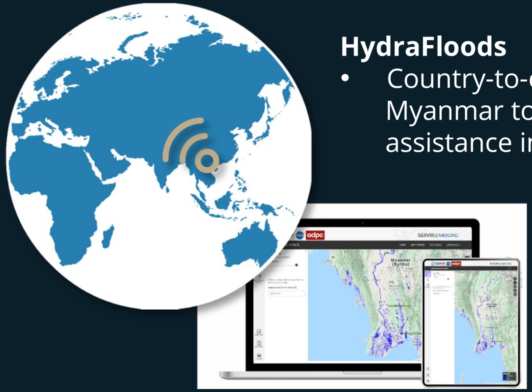


RLCMS

- Further adoption of Regional Land Cover Monitoring System (RLCMS) at regional and national levels

HydraFloods

- Country-to-country replication from Myanmar to Cambodia to prioritize food assistance in the face of floods via WFP

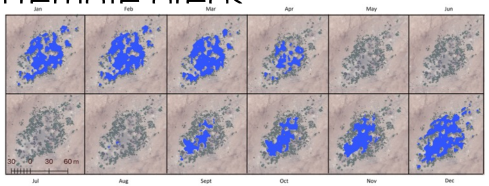


SERVIR Small Water Body Detection Guides Pastoralists To Water in SERVIR East Africa

SERVIR monitors thousands of small seasonal ponds across the Senegal to determine water availability *(PHOTO CREDIT: Rebekke Muench/NASA SERVIR)*

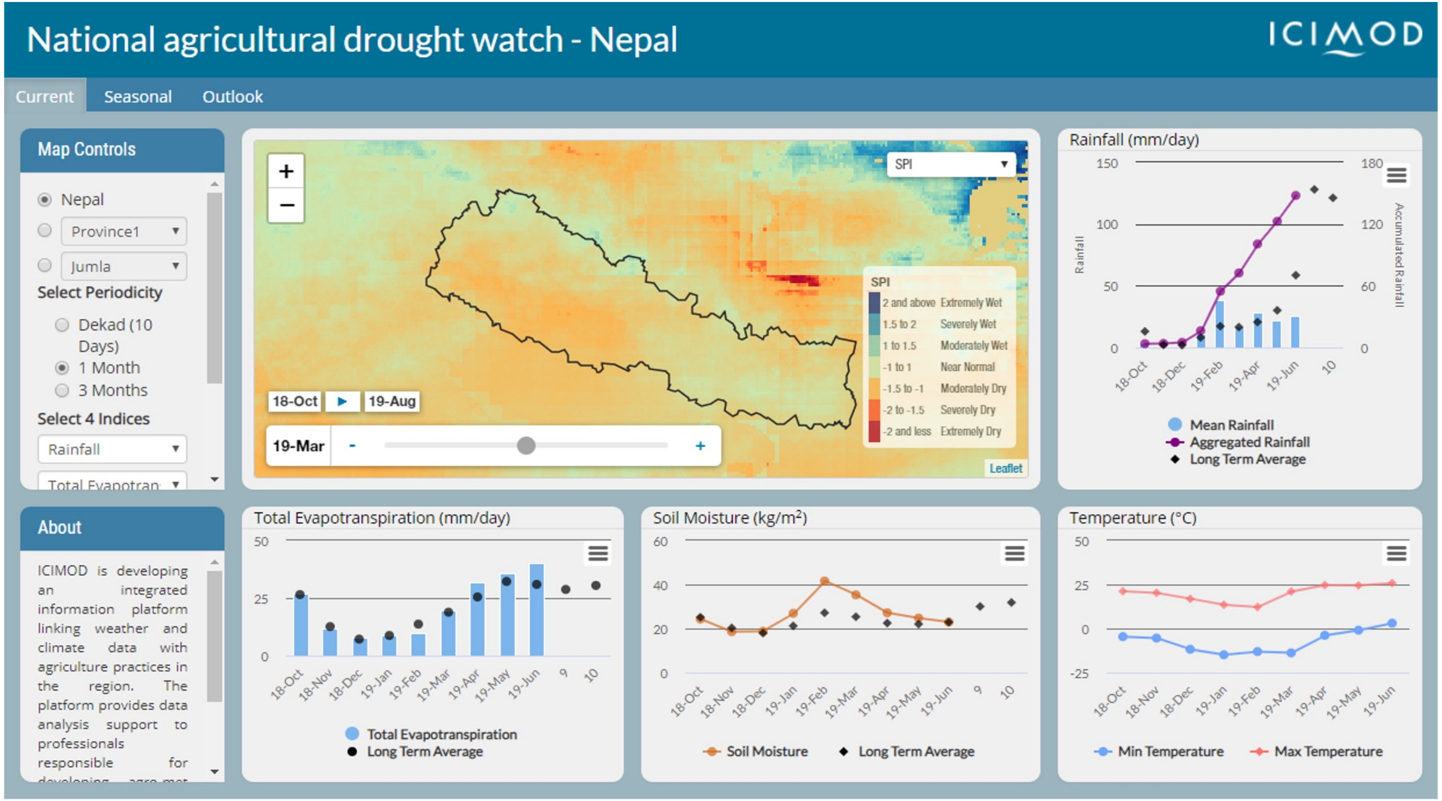
Pastoralists in parched West African rangelands rely on small ponds for their livestock. SERVIR has developed a tool to monitor and map where water is available.

- These small water bodies hold water for part of the year, providing for the region's nearly 60,000 herders
- Current imagery provide actionable information to direct herds during the dry season (Oct-June)
- Information is relayed by a web-based platform and community radio broadcasts in remote areas



Monthly water content composites (PHOTO CREDIT: SERVIR-West Africa)

Regional Drought Monitoring Service at SERVIR-HKH



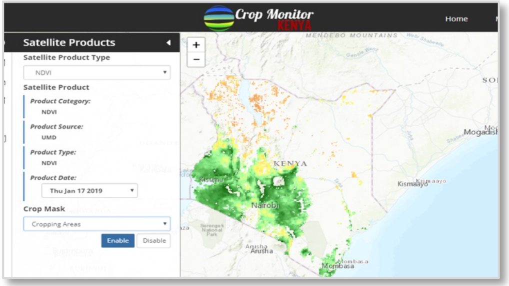
SERVIR Crop Maps Help Protect 425,000 Kenyan Farmers

Farmers in East Africa regularly face droughts, but are seldom covered by traditional insurance

Kenya’s State Department of Agriculture used SERVIR-Eastern & Southern Africa’s crop maps to design an Agricultural Insurance System

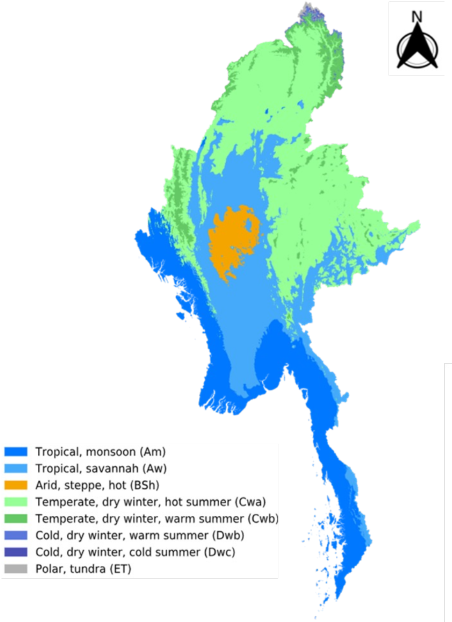
The new system has led to 70% cost savings compared to previous mapping methods

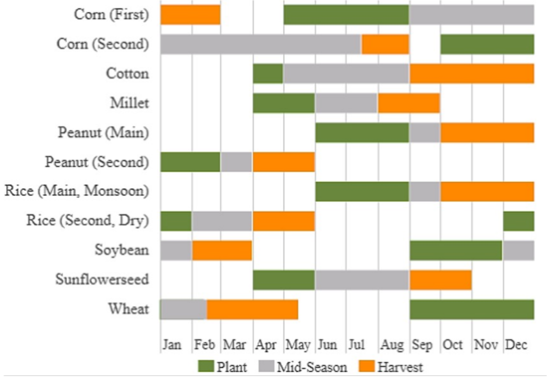
Between 2015 and today, the insurance program has grown from 900 to 425,000+ individuals protected from crop loss

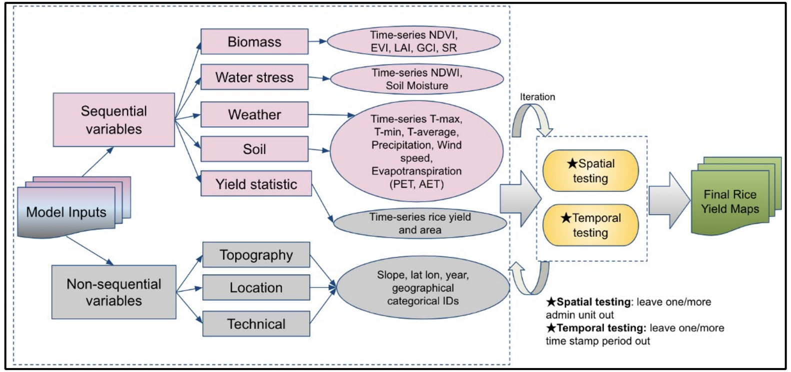


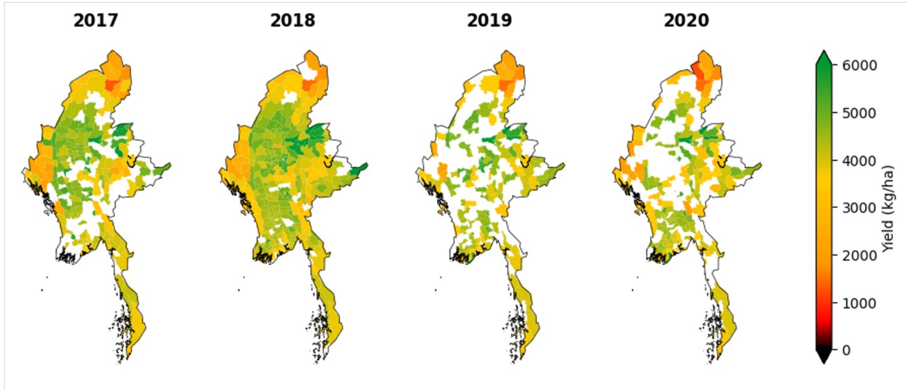
Farmers in Makueni County, Kenya, have been some of the hardest hit by drought in all east Africa. In 2019, more than 12,000 farmers were compensated for crop losses through agriculture insurance programs.. (CREDIT: USAID)

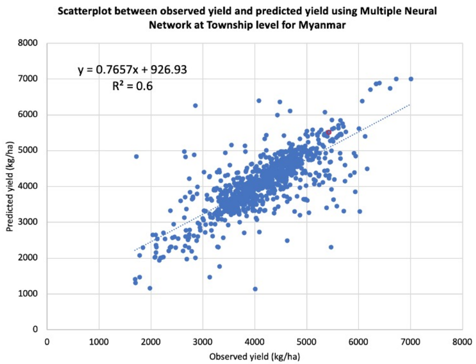
Myanmar Food Security Service aims to help Stakeholders in Food Crisis due to Political Conflict in SERVIR-SEA











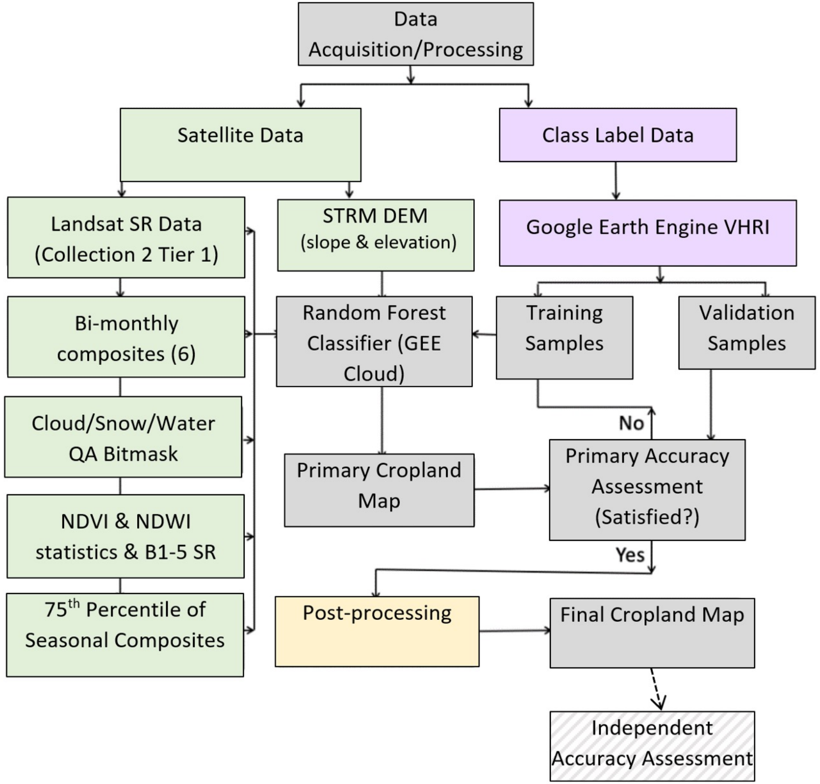
Case Study of Bhutan Cropland Extent Mapping Using Landsat Data and Machine Learning (ML) Models

Methods Overview

This study uses **random forest modeling to classify binary cropland/non-cropland maps from 2002–2023 at the field-scale**

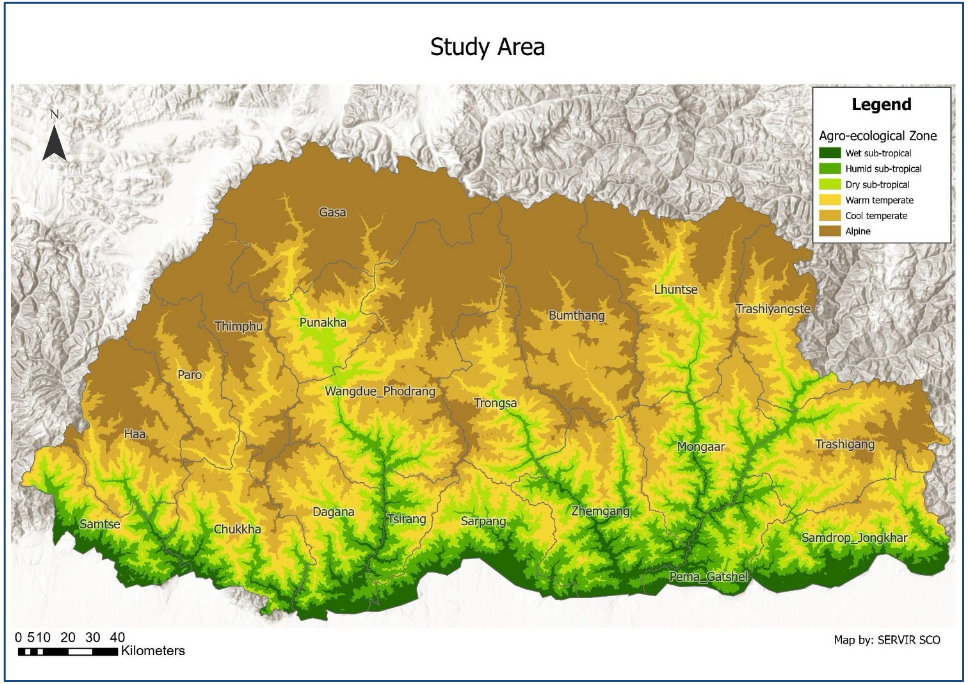
Steps:

1. Select study area
2. Collect/prepare training and testing samples
3. Collect Landsat data, preprocess it, prepare composites
4. Run the model
5. Apply the model and classify the entire study area
6. Validate the map/outcome
7. Export the map
8. Post-process the map



Primary Goal and Geographic Coverage

Primary goal of this study is - to map cropland extent of study area for year 2023 using Landsat data and statistical models.



Cropland Extent Mapping Overview

Why is it important to know where crops are?

Mapping crop type
Estimating crop productivity
Aligning farmer support policies
Assessing food security
Modeling water use

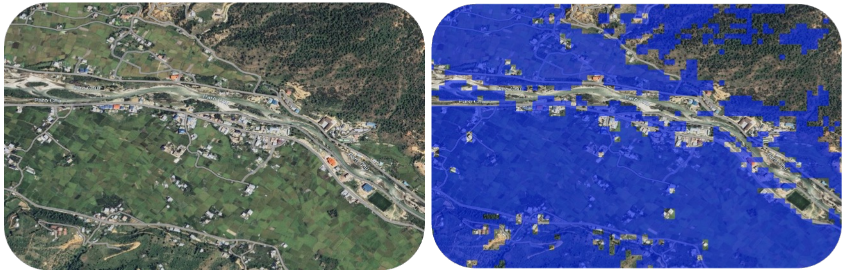
Few regional crop maps exist for Bhutan

No historical maps

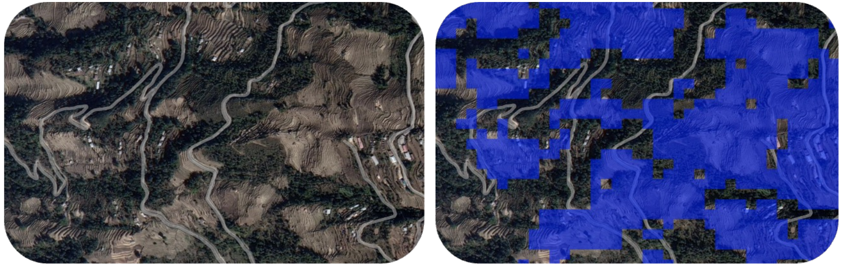
- GFSAD30 (see 2020 cropland extents below)

Image Source: NPR

Flat and Intense Ag Area



Steep and Sparse Ag Area



Overview of Satellite Data Availability in Bhutan

Satellite Data availability for Bhutan

Landsat Tier 1

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	10	6	8	10	10	6	0	2	8	6	6	4
1999	8	10	12	10	8	4	4	6	18	14	8	16
2000	11	14	8	8	8	6	6	10	14	20	14	18
2001	14	12	10	20	12	12	10	12	8	8	4	10
2002	4	8	12	8	10	8	2	4	10	8	4	4
2003	10	8	10	8	8	0	4	8	2	2	16	20
2004	12	18	14	16	18	12	4	18	16	22	22	20
2005	14	18	22	20	10	14	6	8	16	14	14	8
2006	12	22	10	14	14	4	14	16	10	20	16	20
2007	20	12	16	20	14	8	4	12	10	12	10	8
2008	10	18	18	20	18	10	4	6	18	22	16	22
2009	20	22	16	16	16	14	12	14	12	22	20	18
2010	20	18	12	20	12	8	8	6	6	18	22	18
2011	18	16	14	16	12	6	6	12	22	16	14	12
2012	12	12	10	10	9	2	0	6	8	12	10	12
2013	12	6	10	16	18	10	12	12	18	18	24	22
2014	22	20	24	22	20	20	24	16	18	20	20	24
2015	24	21	22	18	24	18	18	14	18	24	24	24
2016	24	18	24	24	21	13	10	20	22	24	24	22
2017	22	20	22	20	20	18	12	14	20	22	20	24
2018	24	22	22	22	22	20	16	14	18	24	24	24
2019	24	16	24	24	20	18	10	20	14	22	22	22
2020	22	22	24	18	18	12	6	20	14	22	18	24
2021	24	22	22	22	16	16	12	14	15	22	32	34
2022	36	28	33	26	30	18	26	29	30	30	30	34
2023	30	32	32	29	30	26	12	20	25	10	0	0

Sentinel 2 (2a & 1C, 100%

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015	0	0	0	0	0	0	0	0	0	0	0	36
2016	100	36	36	64	64	92	92	100	100	136	148	86
2017	50	66	52	50	50	50	102	58	102	116	104	136
2018	156	180	226	186	178	202	220	204	204	214	214	322
2019	408	370	454	400	404	404	432	420	424	408	376	448
2020	408	408	408	406	438	398	384	424	400	420	370	376
2021	444	372	408	408	460	420	406	422	442	438	404	404
2022	412	372	408	408	484	406	406	406	408	460	408	408
Grand Tota	1978	1804	1992	1922	2078	1972	2042	2034	2080	2192	2024	2216

Sentinel 1 (all)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2014	0	0	5	0	4	4	0	4	5	0	0	0
2015	6	3	5	3	5	5	6	5	5	3	6	6
2016	5	4	4	4	7	7	5	7	4	4	5	5
2017	23	25	27	25	25	25	23	25	27	25	23	23
2018	22	28	24	28	28	28	22	28	24	28	22	22
2019	26	25	29	25	29	29	26	29	29	25	26	26
2020	29	30	28	30	30	30	29	30	28	30	29	29
2021	26	27	29	27	26	26	26	26	29	27	26	26
2022	25	27	28	27	28	28	25	28	28	27	25	25
Total	162	169	179	169	182	182	162	182	179	169	162	162

Overview of Availability of Reference Data in Study Area

- **Bhutan reference data is limited** in quantity and quality
  - Limited or no remote sensing based evaluated national scale cropland extent data
  - Government statistical data is collected by non-consistent methods and present discrepancies
  - Missing years
  - Changing district names/boundaries
  - Inconsistent units
  - Erroneous values
- **Solution:**
  - Use of high resolution satellite data to label cropland vs non-cropland class
  - Carefully designed sampling strategy
  - Integrate understanding of agronomy and climatological knowledge in the model tuning and building

Overview of Machine Learning Model

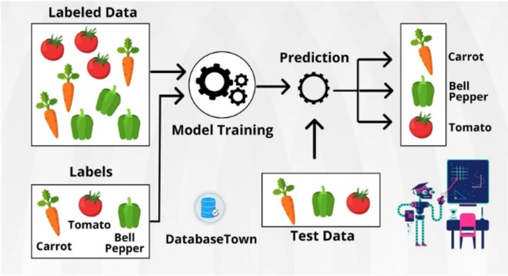
What is machine learning:

"Machine learning enables a machine to **automatically learn from data**, **improve performance from experiences**, and **predict things without being explicitly programmed.**"

- Arthur Samuel, 1959

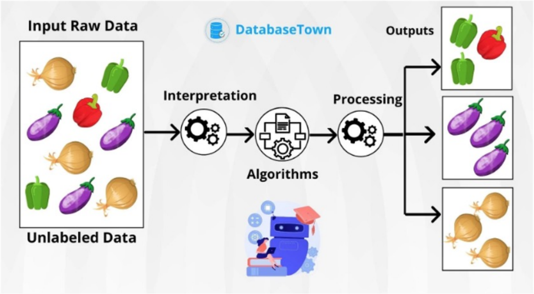
Supervised

- **Requires labeled training data**
- **How it works:**
  - Algorithm uses a sample dataset to train itself to make predictions
  - Then adjusts to minimize error
  - Labeled data provides the "correct" answer
- **Purpose:**
  - Defining relationships between input and output data
- **Applications:**
  - Classification & regression
    - Weather forecast, spam detection



Unsupervised

- **Does NOT use labeled training data**
- **How it works:**
  - Algorithms work independently learn data structure and identify natural patterns in data
- **Purpose:**
  - Exploration / new patterns
- **Applications:**
  - Exploratory data analysis & clustering
    - Big data visualization

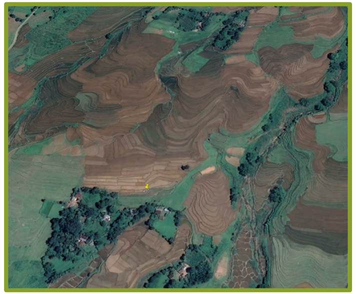


Cropland Extent Definition

Cropland Definition:

"lands cultivated with plants harvested for food, feed, and fiber, including both annual crops as well as continuous plantations (e.g., coffee, tea, rubber, cocoa, oil palms). Cropland **fallows,** defined as areas equipped for cultivation (including plantations) but are **not cultivated for a season or two are included** in the cropland category" (Teluguntla et al., 2015; Thenkabail et al.,2020).

- Important notes:
  - Plantation/Agroforestry operations = **crop**
  - Gardens/small-scale horticulture = **crop**
  - Fields left fallow <3 years = **crop**
  - Pasture/grazing-land/rangeland **= non-crop**



Best Practices to Collect Field Training Data for ML Modeling

- In-person or on-road visit to fields to collect ground reference data using,
  - Traditional GPS based data collection
  - GeoFairy Application by SERVIR
  - Go-pro camera mounted on Helmet or Car

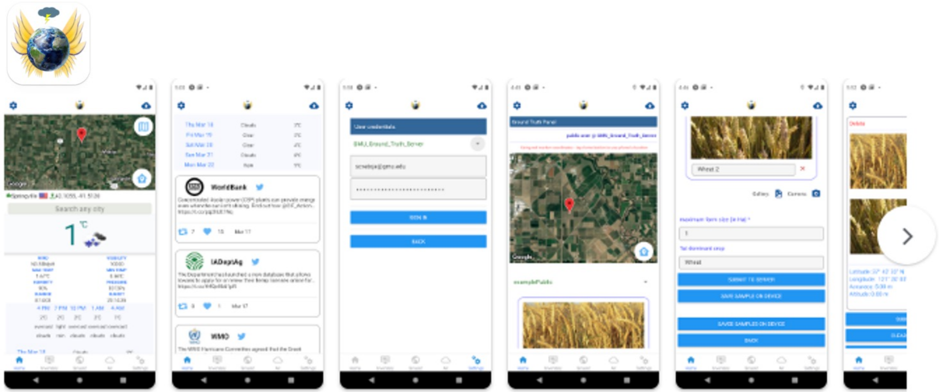


Image credit: SERVIR Applied science team -3 Dr. Liping Di, [Download App]

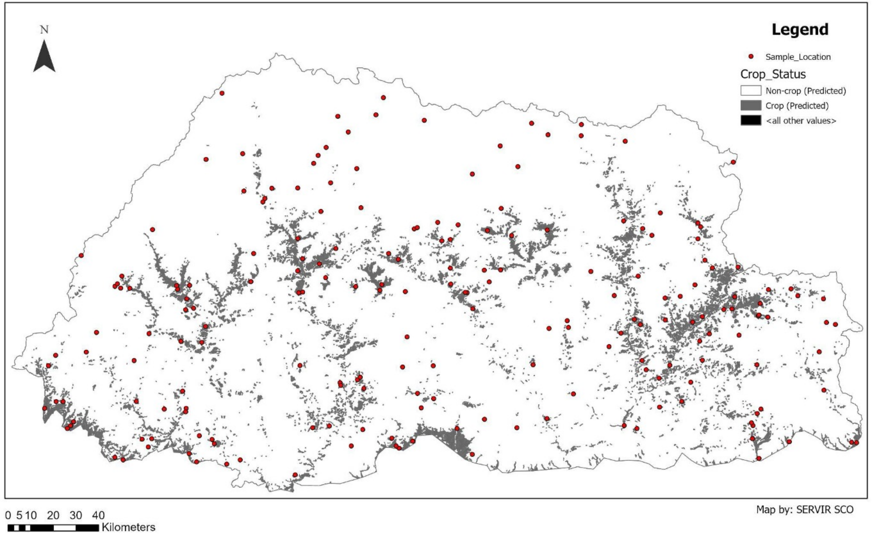
Image credit: SERVIR Applied science team AFS lead Dr. Catherine Nakalembe

Data Labeling Method & Independent Validation

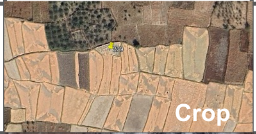
1. Create Sample Points (200)

- Stratified Random Sampling
  - Crop (100)
  - Non-crop (100)

2020 Cropland Area Map of Bhutan from Phase II Modeling



2. Label Points

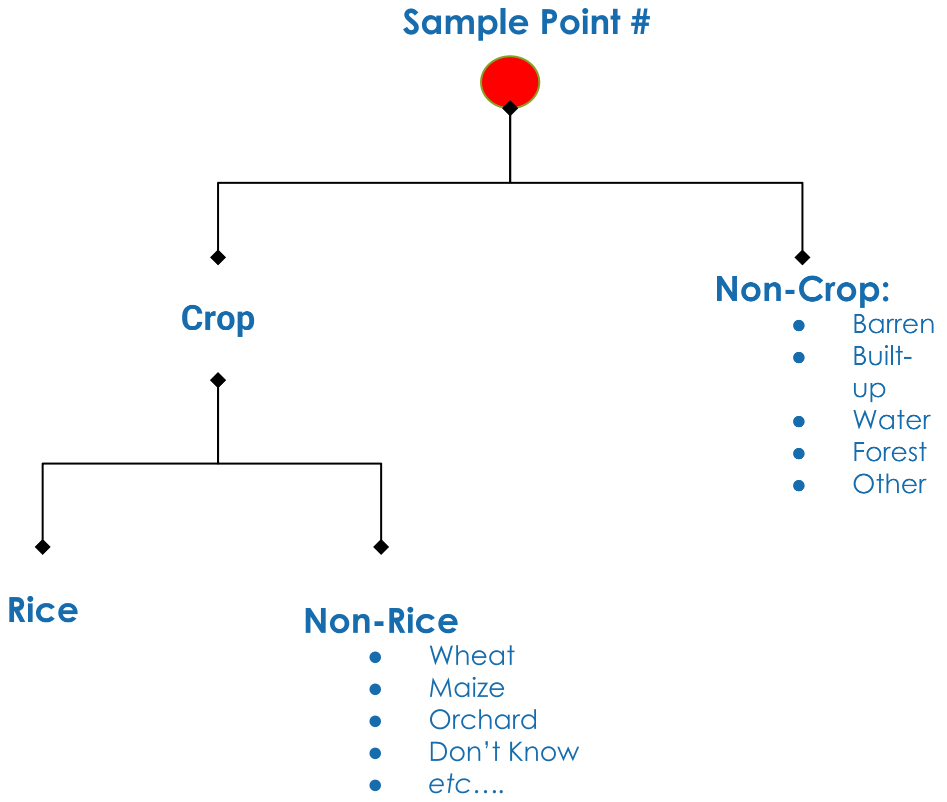
Point	Actual Label *(Majority vote from high-res imagery)*	2020 Model Prediction *(Crop/Non-Crop)*	Error
1	 Crop	Crop	Correct!
2	 Non-crop	Non-Crop	Correct!
3	 Crop	Non-Crop	**False-Negative** *(Omission error)*
4	 Non-crop	Crop	**False-Positive** *(Commision error)*

3. Generate Accuracy Statistics *(eg. confusion matrix)*

Interpreting Imagery: Purpose

1. **Land class?**

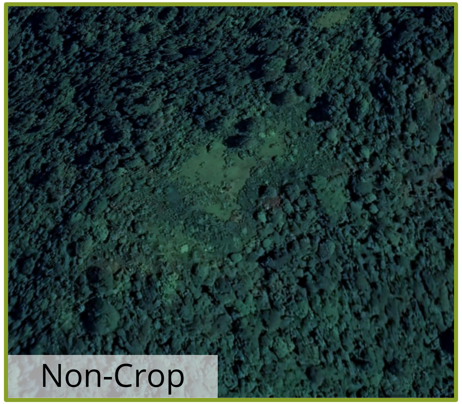
2. **Dominant Crop Type?**



Recognizing Cropland in Imagery

Consider 6 Tips:

1. Shape & Size
- Field boundaries
- Fencing
- Shadows can show size



2. Texture *(fine/coarse)*
- Maybe uniform, lacking variation
- Unlike natural forest

Recognizing Cropland in Imagery

Consider 6 Tips:

3. Pattern

- Clear pattern
- Distinct from surroundings

4. Proximity

- Other agricultural land
- Housing
- Roads

5. Color *(over time)*

- Color/texture changing between seasons
  - Growing/Harvest
  - Wet & Dry

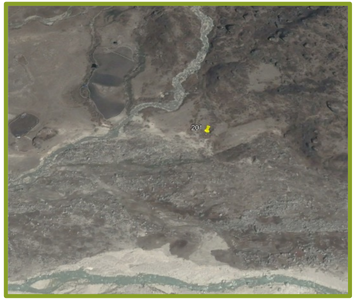
6. Logic & Experience

Recognizing Non-Cropland in Imagery

Built-up

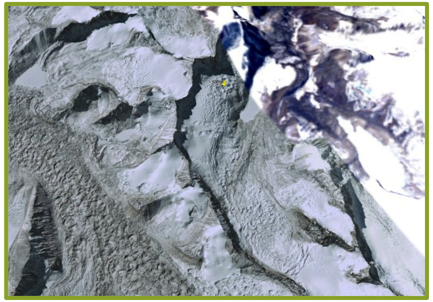
Water

Barren



Forest

Other



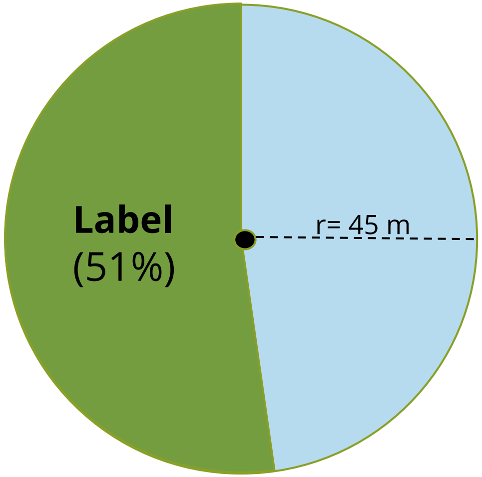
Identifying: Non-cropland

Class	Definition	Examples
Barren	Limited capacity to support life and having < 5% vegetative cover. Vegetation, if present, is widely spaced. Typically, the surface of barren land is sand, rock, exposed subsoil, or salt-affected soils	*Ex. rocky mountain tallace, bare soil, rocky river bank*
Built-up	Residential, industrial, commercial, and institutional land.	*Ex. buildings, parking lots, and roadways*
Forest	At least 10% stocked by single-stemmed woody species of any size that will be at least 4 meters (13 feet) tall at maturity. ***In aerial imagery, this equates to to a canopy cover of leaves and branches 25% or greater.***	
Water	Comprises water bodies and streams that are permanent water.	
Other	***Catch-all for anything non-crop***	***Ex. wetland, shrubland, glacier, unsure***

Assigning a Label

- **Minimum Mapping Unit (MMU) =** circle with 45m radius
    - Area of the smallest feature that is being reliably mapped
        - Covers 3x3 pixel grid (Landsat)
- **Class Label Threshold =** >50%
- **Confidence Level (CL)**
        - 1 = Very low
        - 2 = Low
        - 3 = Moderate
        - 4 = High

Minimum Mapping Unit



Example Labels:

Forest
CL: 4

Forest
CL: 4

Cropland
CL: 2

Final Reference Data Labels

Platforms for Reference Data Collection

PRO

COLLECT EARTH
ONLINE

Challenges in Mapping Croplands Using Satellite Data in Bhutan

- Optical data - Landsat 5,7,8,9 pixel have only average 2–4 observations across the country.
- SAR data is not useful on the steep slope areas where high rice producing district like Paro is situated.
- Reference data is limited, less accessible, and less reliable with historical timeline
- Small-holder practices
- Distinct cropping calendars for each cultivars of crop type
- Terraces vs flat area satellite data has shadow and cloud issues

Demonstration of Methods and Algorithms to Classify Cropland Areas Using Google Earth Engine and ML

Get the repository

https://bitly.cx/6IZn

SERVIR-Bhutan Farm Action Toolkit overview

SERVIR-Bhutan Farm Action Toolkit Theory of Change

Problem → **Input** → **Output** → **Outcomes** → **Impact**

Problem

1.Livelihoods of people of Bhutan are affected by less availability and accessibility of food due to dependency on imported food from India. The Kingdom of Bhutan planned to be self-sufficient for rice and other crops 2. Crop losses due to Natural disasters

Input

- Capacity Building
- Data (Earth Observations, in-situ)
- Model and algorithms (Crop area and yield mapping)

Output

- Crop area and yield loss/change information and improved stakeholder capacity
- Bulletins providing hotspots of change areas and dissemination mechanisms

Outcomes

Service enables agencies in Bhutan to manage severe area and yield loss conditions

Implementing partners

Impact

1.Self-sufficiency on rice related country plans are supported by timely, historical consistent and accurate data at field-scale. 2. Improved farming practices and low crop losses while considering crop suitability data.

Farming communities

Co-development, User engagement, Consultation and Gender consideration

Farm Action Toolkit Service Goals

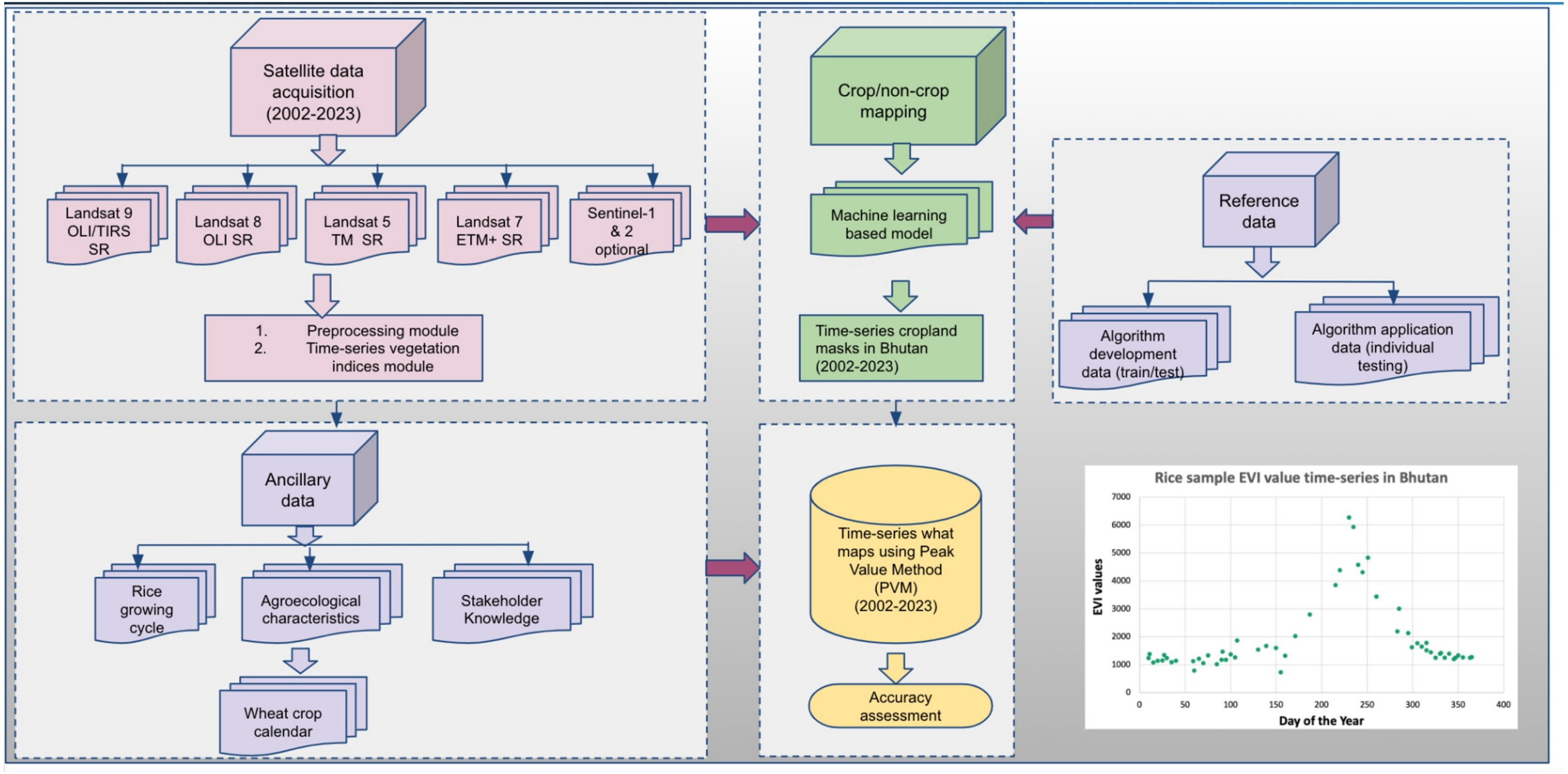
Overarching goals and objectives:

To support Kingdom of Bhutan in its goal to be food self-sufficiency and resilience against climate related disasters

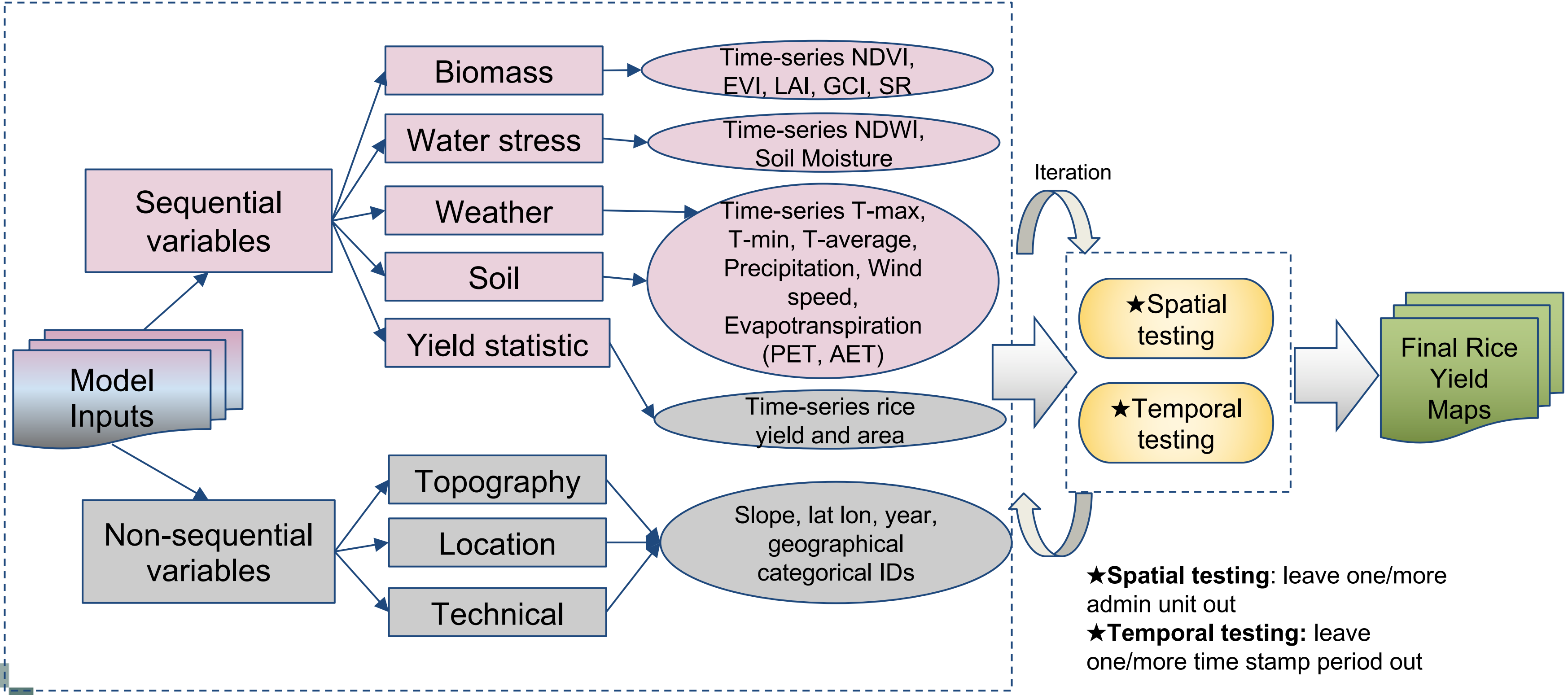
Main objectives of this service area:

1. Co-develop earth-observation data based service for making decisions related to food security by mapping crop type area and yield;
   a. To map 30-m cropland extent 2002-2023
   b. To map 30-m paddy area extent 2002-2023
   c. To predict rice yield at field-scale
2. Build capacity of the region by providing trainings on advanced geospatial models and science advising

Bhutan crop-non crop and rice area mapping



Rice Yield Monitoring Service Framework

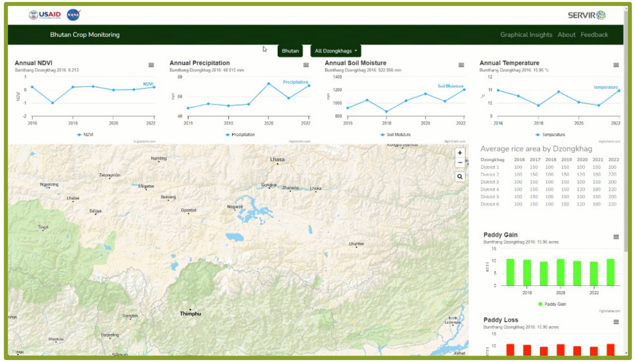


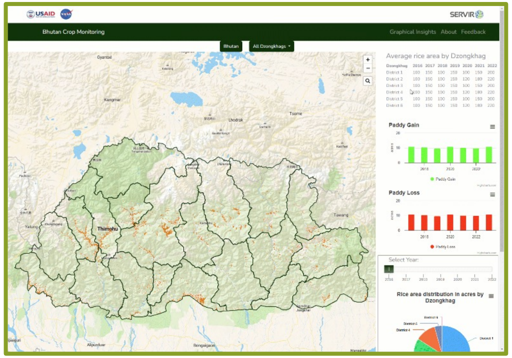
★Spatial testing: leave one/more admin unit out
★Temporal testing: leave one/more time stamp period out

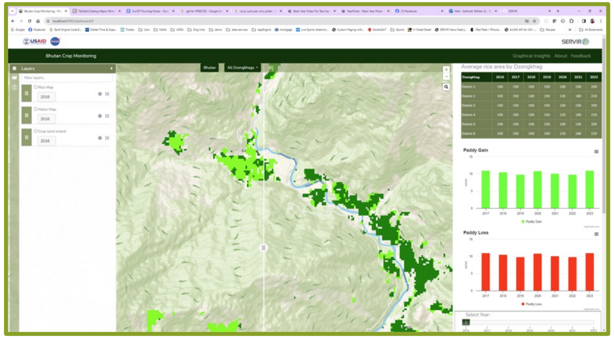
Farm Action Toolkit service UI

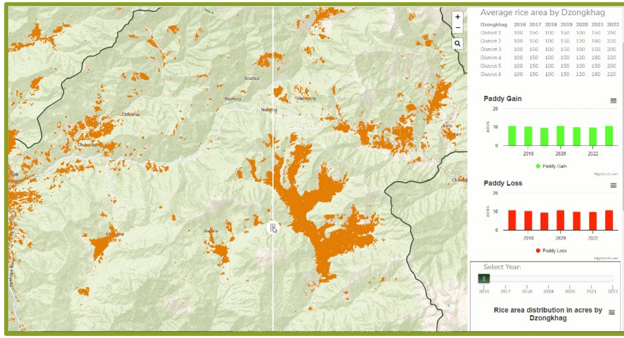
Let's walkthrough the UI Dashboard!

- https://crops.servirglobal.net/dashboard/
  - Work in-progress
  - Web-app development credit to SERVIR-SCO GIT team









Time to win NASA prizes for quiz competition

Contact Information

Trainers:

- Aparna Phalke
  - aparna.r.phalke@nasa.gov
  - aparna.phalke@uah.edu
- Sarah Cox
  - sec1825@uah.edu

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Resources

- SERVIR service catalogue : https://servirglobal.net/what-we-do/agriculture-food-security
- Jensen, J.R. (2007) Remote Sensing of the Environment: An Earth Resource Perspective. 2nd Edition, Pearson Prentice Hall, Upper Saddle River.
- https://ntrs.nasa.gov/api/citations/19780010554/downloads/19780010554.pdf

Thank You!