

Operational Annual wheat area mapping for Afghanistan using Sentinel data and Google Earth Engine

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International Center for Integrated Mountain Development (ICIMOD)



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- 3. Methodology**
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- 5. Operationalization**
- 6. Status**
- 7. Way forward**

Team Members



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Noorullah Stanikzai & Team

MAIL, GIROA

- **Afghanistan is a land locked country with population of 35 million among which 30% are food insecure**
- **Wheat is a major crop and staple food with 80% of total cereal planted area**
- **Climatic conditions such as drought hampers the production of the wheat.**
- **Country is not food sufficient, depended on import.**



- **From 2008, MAIL, FEWSNet, WFP conducting pre-harvest survey for area estimation.**
- **Current estimation is qualitative. More accurate and timely estimation is required for better planning**



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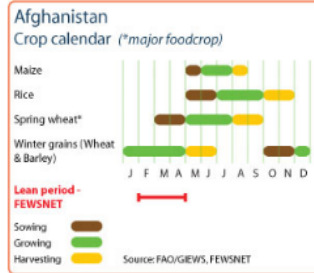


Afghanistan

Reference Date: 06-February-2017

FOOD SECURITY SNAPSHOT

- Mixed prospects for 2017 winter grains following dry weather conditions in autumn
- Slightly below-average cereal crop harvested in 2016
- Cereal import requirements in 2016/17 forecast at levels similar to 2015/16
- Wheat prices stable, inflation easing
- Food insecurity on the rise



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Mixed prospects for 2017 winter grains

Planting of winter barley and wheat for harvesting from May 2017 was completed by the end of November. Dry weather conditions and resulting limited soil moisture delayed plantings in some areas, while some farmers postponed wheat planting until spring. Official estimates for planted area are not yet available.

Current weather conditions remain relatively favourable for cereal crop development after the rains and high elevation snow resumed in January and ended an early season dryness across most of the country. However, as of the end of January, abnormal dryness persisted in western parts of the country, from Jawzjan Province in the north to Hilmand Province in the south. In the northern and eastern part of the country, the snow water equivalent – an important source of irrigation water – remains on par with average values for the season.

The bulk of farmers rely on their own farm-saved seeds. Households

Afghanistan Cereal production

	2011-2015 average		2015	2016 estimate	change 2016/2015
	000 tonnes				percent
Wheat	4 730	4 673	4 554	4 554	-3
Rice (paddy)	711	612	620	620	1
Barley	402	403	400	400	-1
Others	324	335	320	320	-4
Total	6 167	6 023	5 894	5 894	-2

Note: percentage change calculated from unrounded data.
Source: FAO/GIEWS Country Cereal Balance Sheets

Afghanistan

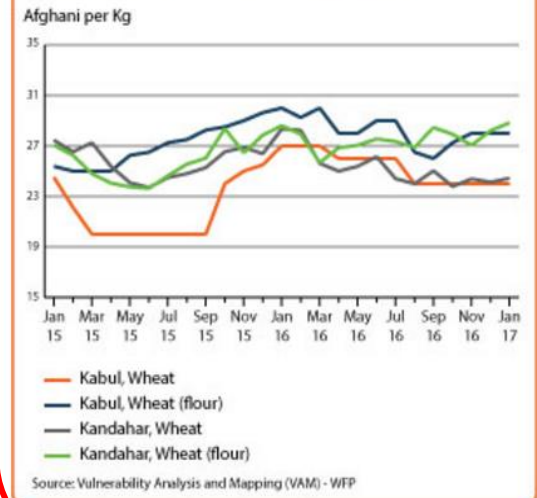
Total cereal production and imports



Notes: Total cereal includes rice in milled terms. Split year refers to individual crop marketing years.
Source: FAO/GIEWS Country Cereal Balance Sheets

Afghanistan

Retail prices of wheat and wheat flour



Timely and accurate estimation of wheat cropped area is essential for food security management.



Crop yield forecasting



**Distribution- Export/
Import etc.**



Pricing



**Formulation and
implementations of policy
related to food procurement**



Transportation and Storage



Advance planning

- **Main objective**

- To develop an operational system for quantitative assessment of wheat sown area to support food security management.

- **Specific objective**

- Develop methodology for wheat area mapping at high spatial resolution using Sentinel data
- Automation of the process and installation at Ministry of Agriculture, Irrigation and Livestock (MAIL), GIRoA
- Capacity building of MAIL for operation and maintenance of the system.

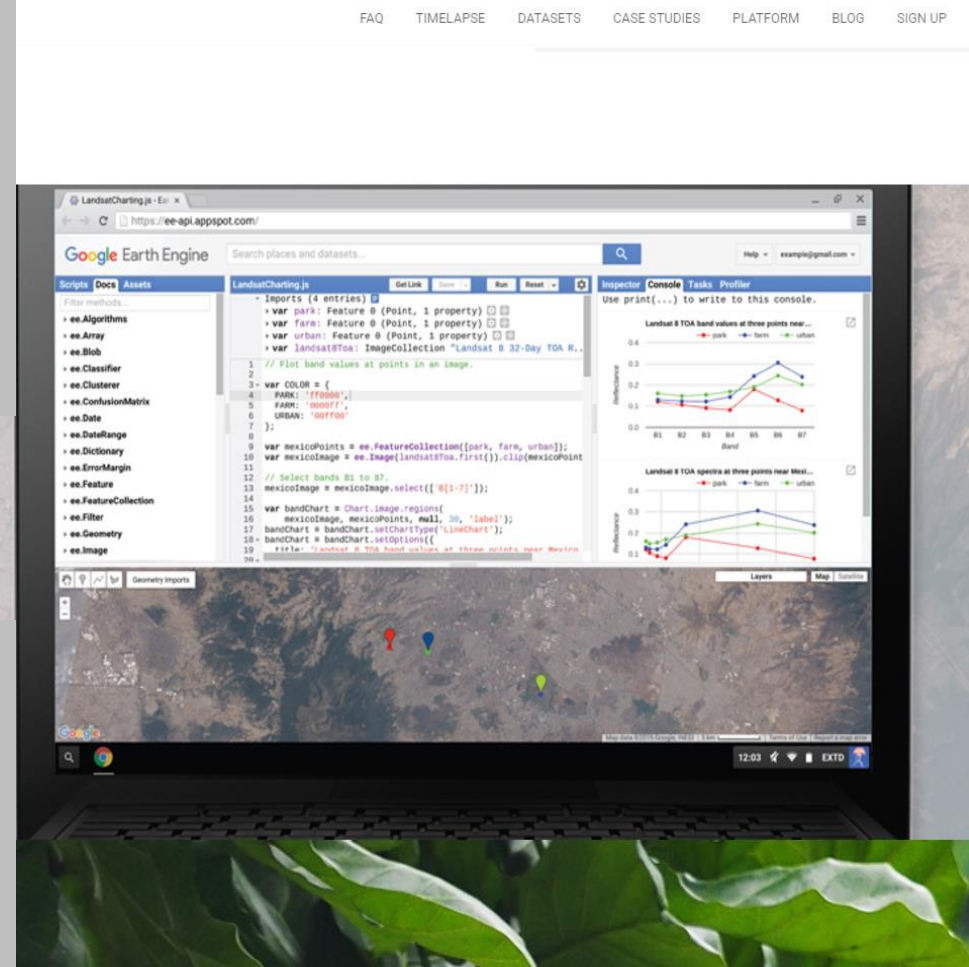
- Availability of high resolution satellite datasets.
- Cloud coverage around Afghanistan.
- Smaller field size.
- Limitation of the internet speed for downloading in Afghanistan.
- Requirement of high end work stations/
Processors/ Computers.
- Atmospheric correction of datasets.

Operationalization – use of Google Earth Engine

Google Earth Engine combines a multi-petabyte catalog of satellite imagery and geospatial datasets with planetary-scale analysis capabilities and makes it available for scientists, researchers, and developers to detect changes, map trends, and quantify differences on the Earth's surface

Use our web-based code editor for fast, interactive algorithm development with instant access to petabytes of data.

[LEARN ABOUT THE CODE EDITOR](#)



• Advantage

- Increased speed
- Data availability
- Transparency and security
- Automation



- Sentinel 2A

- Sentinel 1A

Sentinel 2 A (Optical Products)

Name	High Level Description	Product & Distribution	Data Volume
Level-1 B	Top-of-Atmosphere radiance in sensor geometry	Systematic generation and online distribution	27 MB (each 25 X23 km ²)
Level-1C	Top-of- atmosphere reflectance in cartographic geometry	Systematic generation and on-line distribution	500MB (1 Tile) (100x100 km ²) / 7 GB (11 Tiles) (290 km)
Level-2A	Bottom- of- reflectance in cartographic geometry (prototype product)	Generation of user side (using sentinel 2 Toolbox)	600 MB (100x100 km ²)

Data Specification

Characteristics	SENTINEL-2 A
Data Availability	2014- present <i>*(For Indian Sub continent)</i>
Mission Instrument Principle	Push-broom
Repeat cycle (days)	5
Swath width (km)	290
Spectral Bands	13
Spatial Resolution (m)	10,20,60
Thermal Band	Absent
Operational lifespan	7.25 years (consumables for 12)

Sentinel-2 Bands	Central Wavelength (µm)	Resolution (m)
Band 1 - Coastal aerosol	0.443	60
Band 2 - Blue	0.490	10
Band 3 - Green	0.560	10
Band 4 - Red	0.665	10
Band 5 - Vegetation Red Edge	0.705	20
Band 6 - Vegetation Red Edge	0.740	20
Band 7 - Vegetation Red Edge	0.783	20
Band 8 - NIR	0.842	10
Band 8A - Vegetation Red Edge	0.865	20
Band 9 - Water vapour	0.945	60
Band 10 - SWIR - Cirrus	1.375	60
Band 11 - SWIR	1.610	20
Band 12 - SWIR	2.190	20

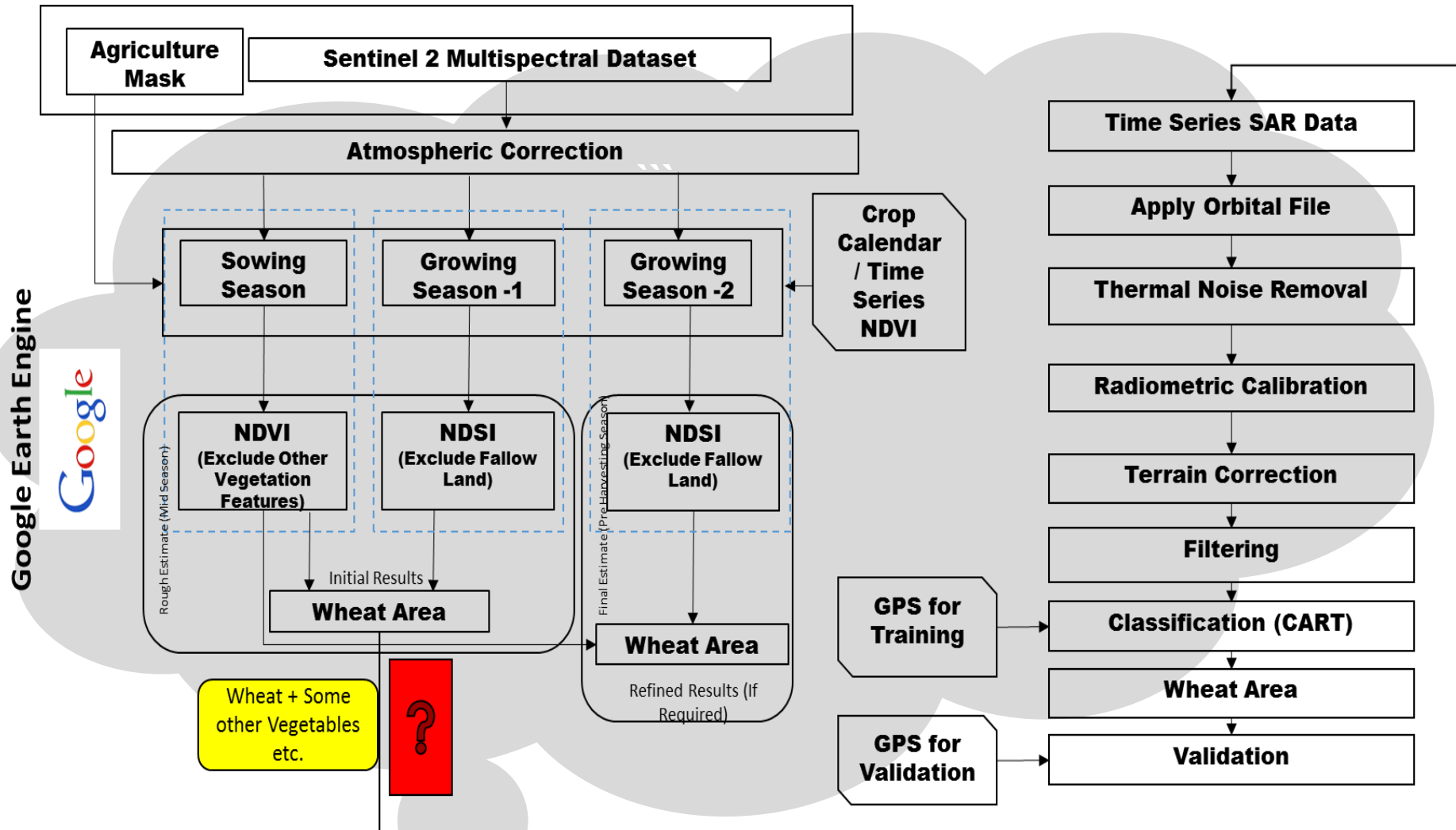
Microwave (SAR)

Sentinel-1A	ESA	Launch: C-band April 3, 2014 Design life: 7 years	12 days (per orbit) 6 days (for constellation with future 1B per orbit)	5 x 20 m	Dual-pol	29.1-46.0° at target: 40.2 at target: 39.2
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Data set used in this study:

- S1- VV Polarization (for Afghanistan on VV polarization is available)
- GRD Product.

Methodology - Overview



Results and Discussion

Atmospheric correction of Sentinel 2A data

Remote sensing images are contaminated by various radiative process.

Absorption
by gases

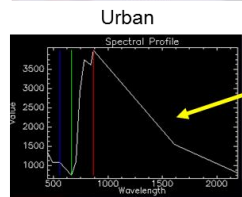
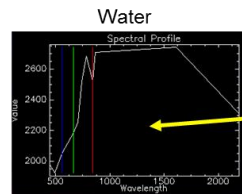
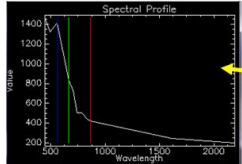
Scattering
by Aerosols

Water Vapours,
etc.

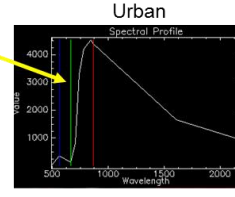
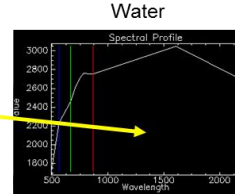
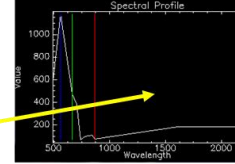
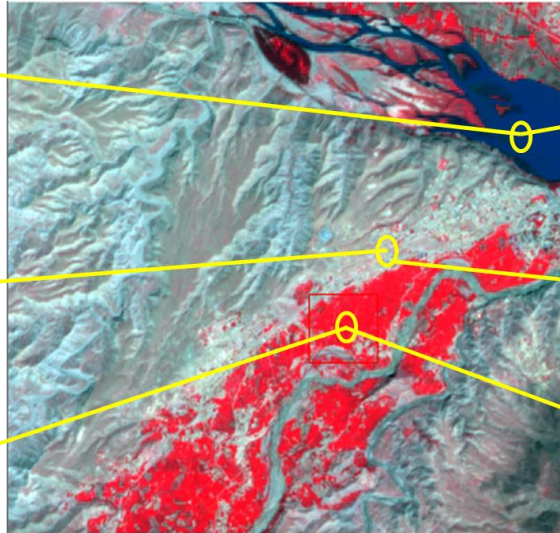
Before
Correction

Atmospheric Correction

After Correction

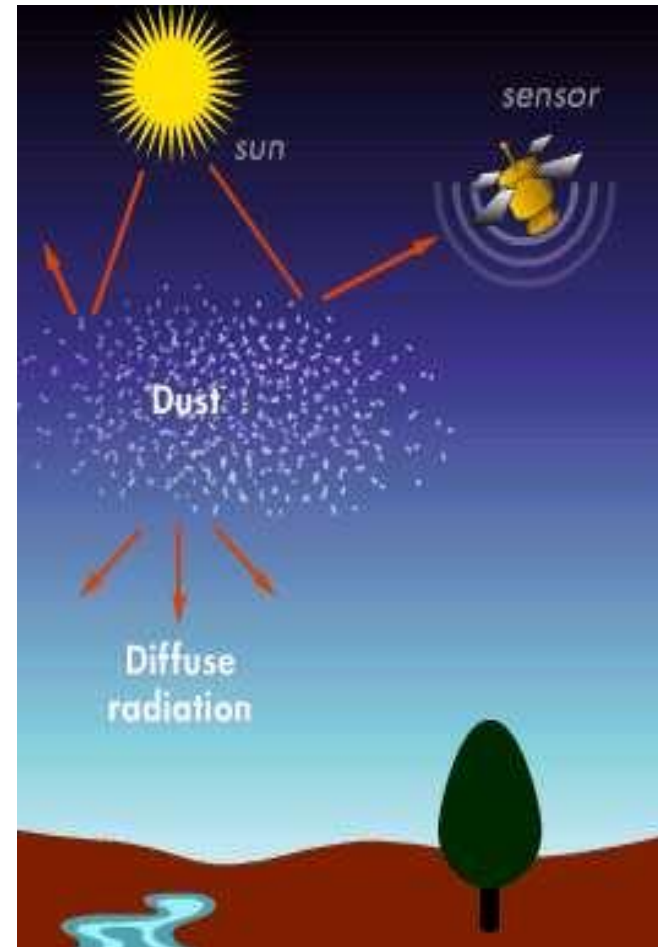


Vegetation



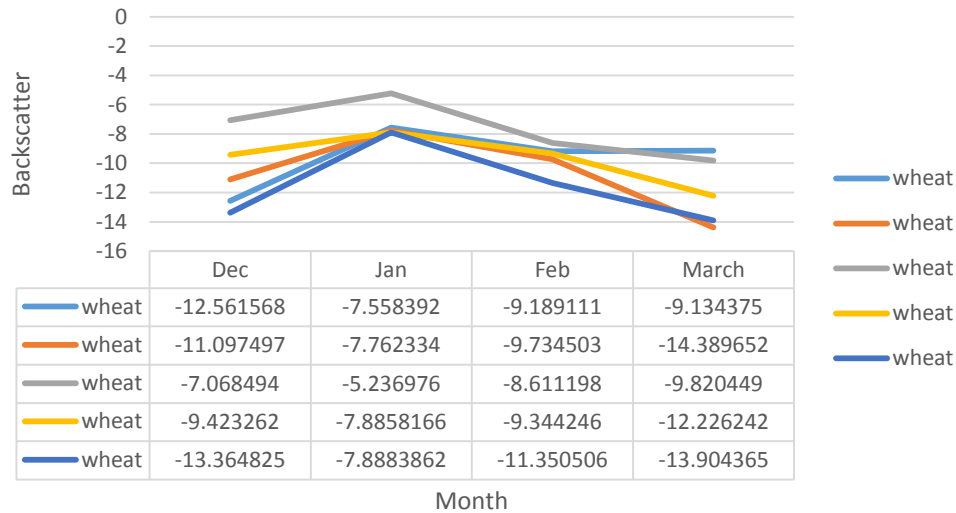
Vegetation

Atmospheric correction using sen2cor

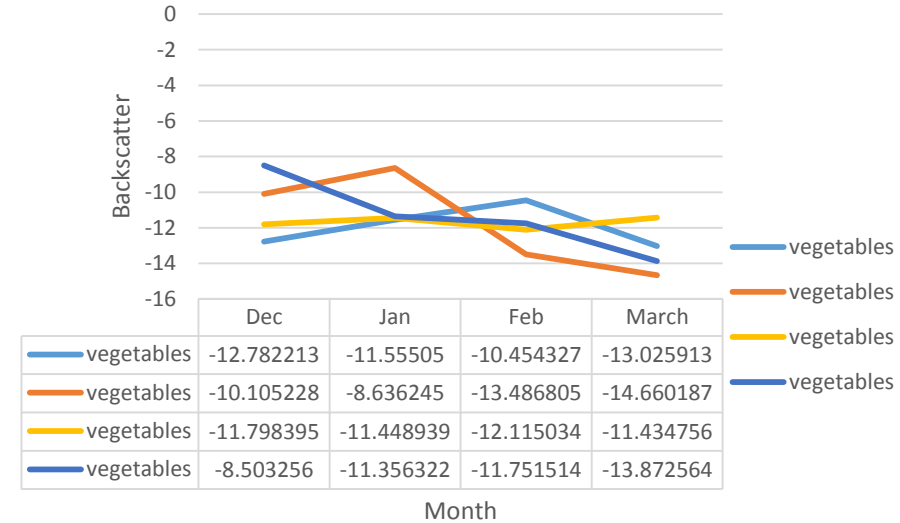


Time Series SAR Backscatter

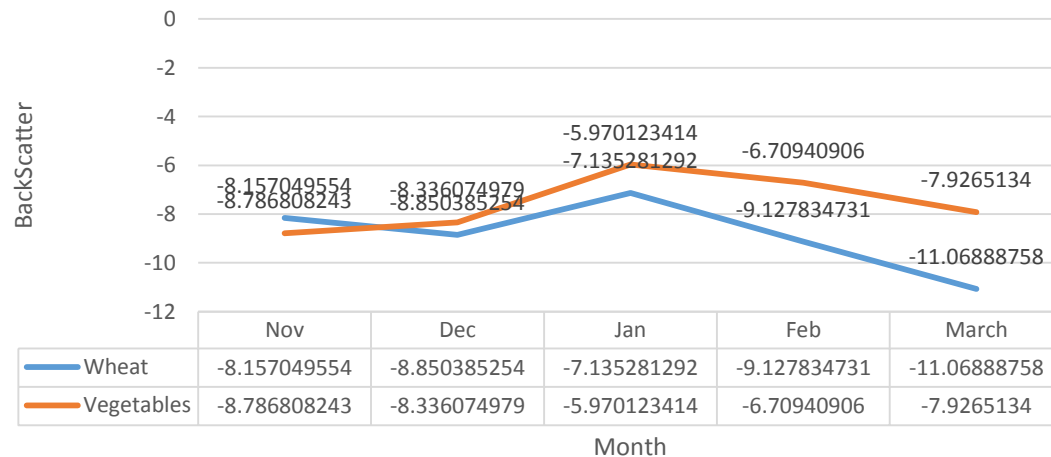
Laghman Wheat 2016-2017



Laghman Vegetables 2016-2017



Laghman- Average Time Series SAR -2016-2017



Outcomes:

Crop Calendar

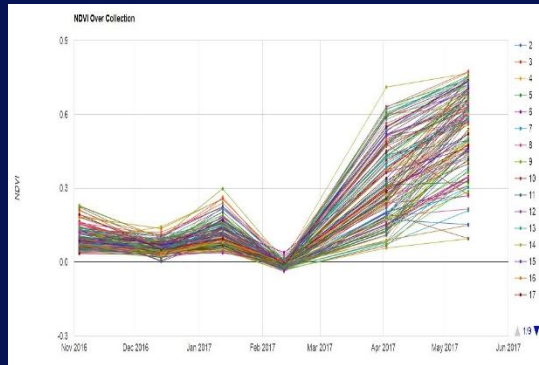
Cropping Calendar: Dates of Planting and Harvest major crops
Region: EAST (north of the Spingar Mountains) Kunar, Laghman, Nangarhar

Crop	Season	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wheat	Autumn												
Barley	Autumn												
Rice	Spring												
Maize	Summer												
Pulses	Summer												
Potato	Autumn												
Onion	Autumn												
Onion	Autumn												
Onion	Autumn												
Alfalfa	Autumn												
Cotton	Summer												
Melons	Summer												
Opium	Autumn												
Sugarcane	Autumn												

Planting: Green squares, Harvest: Orange squares

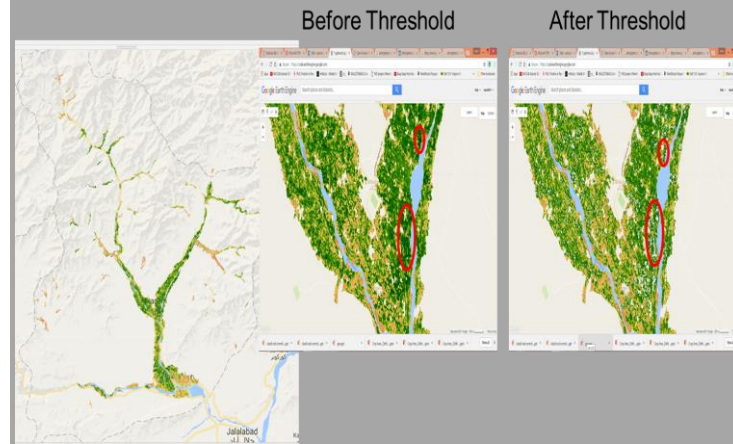
Crop	Season	Harvest notes
Wheat	Autumn	All Autumn sown
Barley	Autumn	Very little
Rice	Spring	Mainly Kunar
Maize	Summer	Grain and forage
Pulses	Summer	Mainly Mung
Potato	Autumn	Upper Nangarhar
Onion	Autumn	
Onion	Autumn	Mustard, Flax and Sesame
Onion	Autumn	
Alfalfa	Autumn	Harvest perennial, Commercial in Lower Surkhud
Cotton	Summer	Domestic production
Melons	Summer	
Opium	Autumn	Most important in Nangarhar
Sugarcane	Autumn	Biennial: Lower elevations

Time Series NDVI

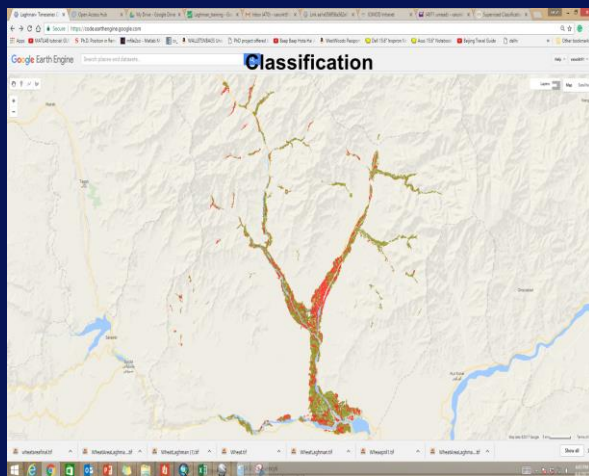


Identification of sowing dates

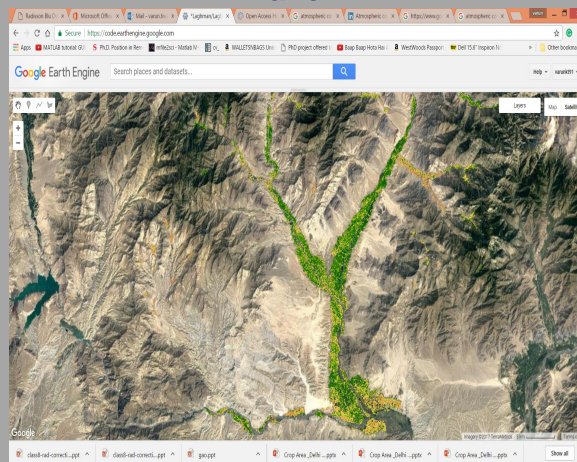
Stage 1: Exclusion of other vegetation features



Final Wheat Map

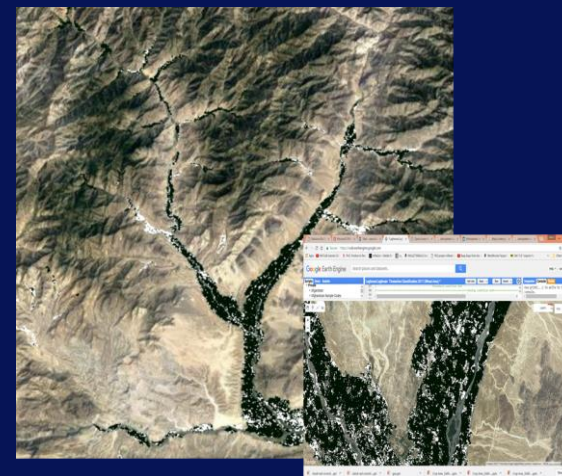


Excluding Fallow from Wheat + Fallow



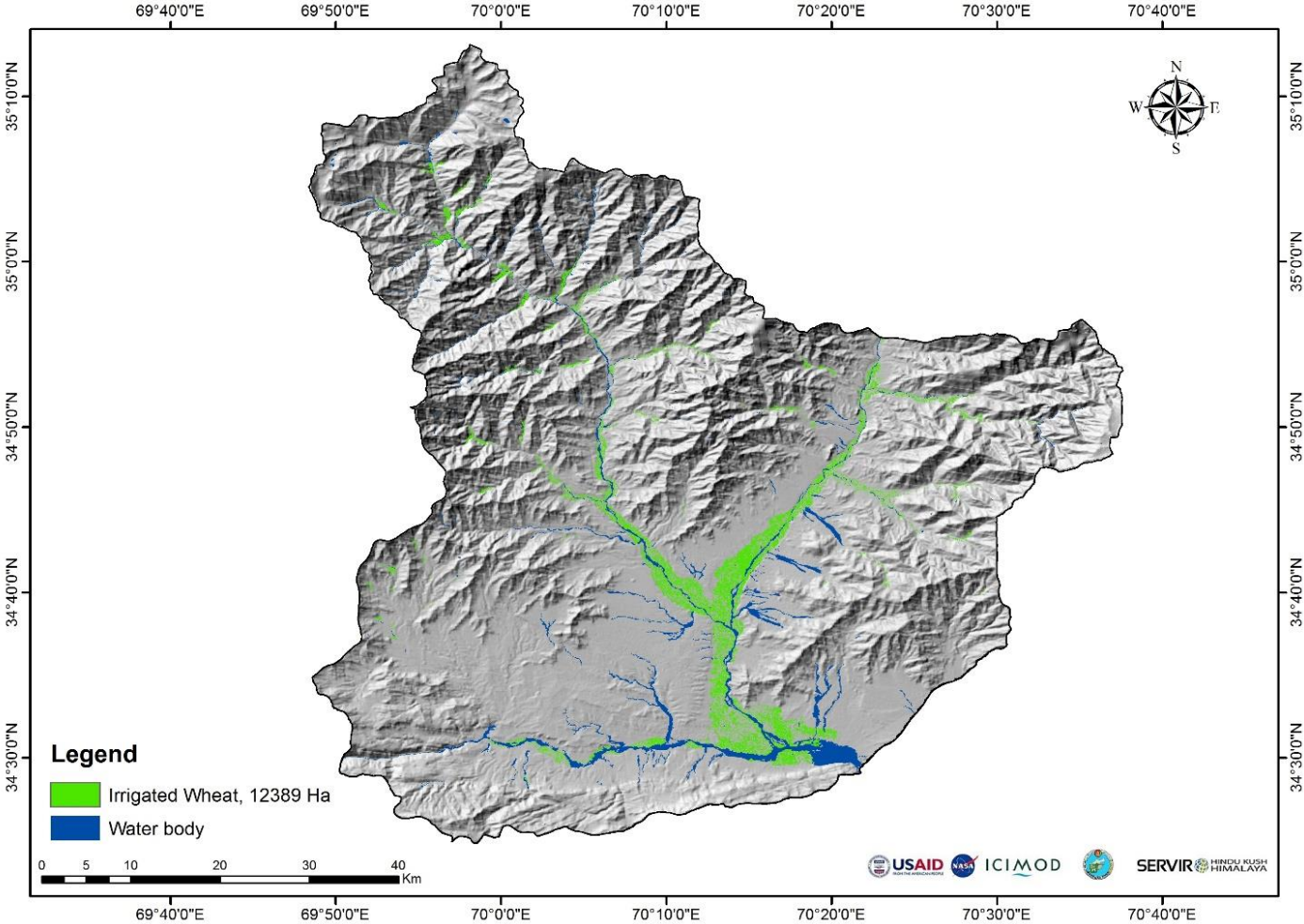
It may include some crops

Identification of fallow land



NDSI > 0 (for Fallow)

Classification



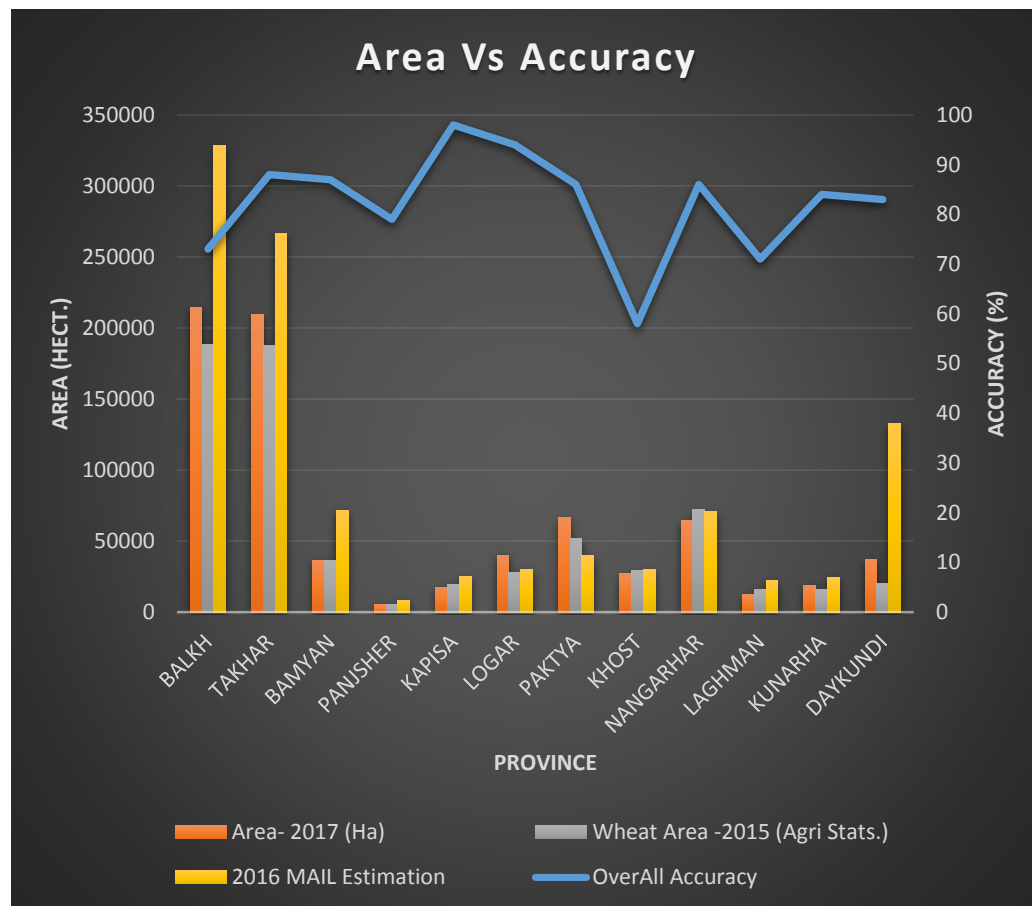
Mid Season Accuracy Assessment

Laghman

Row Labels	Vegetation	Wheat	Grand Total	User Accuracy
Vegetation	24	10	34	70.59%
Wheat	14	36	50	72.00%
Grand Total	38	46	84	
Producer Accuracy	63.16%	78.26%		

Overall Accuracy 71.42857143

Sentinel (2017)	Agriculture Stats. (2015)
12389 Ha	12830 Ha



The screenshot displays the Google Earth Engine (GEE) interface. The top panel shows a search bar and navigation tools. The main panel contains a JavaScript script titled "Laghman- TimeSeries Classification 2017 (Wheat Area)". The script defines a geometry for the Laghman region, sets a center point, and adds a layer. It then defines a region and a date range for the time series. The script uses the `ee.ImageCollection` to filter Sentinel-2 images from 2016-12-1 to 2016-12-31, filters them by the defined region, and applies a wheat mapping algorithm. The bottom panel shows a map of the region with a yellow boundary indicating the wheat area. A sidebar on the right shows a list of projects and folders, including "AFG-Wheat" and "Afghan_Sen2", with sub-folders for the months of April, February, January, March, March 2, and November.

```
1 //=====DEFINE Agriculture Mask=====
2 var geometry1 = ee.FeatureCollection("ft:la000/wgs84/S15/S15Area/Nov15/FB/Nov15Area/B1_D14", "geometry");//oneClassLaghman
3 //Map.setCenter(70.2177, 34.657, 10);
4 //Map.addLayer(geometry1, {"color": "FF0000"});
5 //=====test=====
6 //-----test-----
7 var region1 = ee.Geometry.Polygon
8   ([
9     [69.6979, 35.1833],
10    [70.6596, 35.2147],
11    [70.6596, 34.4035],
12    [69.7742, 34.4111]]);
13 //=====Methodology Part I=====
14 //-----sowing-----
15 var sowing00 = ee.ImageCollection('projects/servir-hkh/ICIMOD/Afghanistan').filterDate('2016-12-1', '2016-12-31');
16 //Filter date range
17
18 //filterBounds(geometry1)
19 .select(['b1', 'b2', 'b3', 'b4', 'b5']).mosaic();
20 print(sowing00);
21 var vis = {min: 0, max: 1, palette: [
22   'FFFFFF', 'CE7E45', 'FD0E14', '666666', '207481',
23   ]};
```

Downloading Sentinel 2 Images

Atmospheric correction

Uploading Images To GEE Assert

Apply Wheat Mapping Algorithm in GEE

Sentinel 1 A Time Series

Validation

- Status
 - Initial results verified for 18 provinces.
 - Order is placed for the acquisition of High resolution DG images.
- Way forward
 - More datasets can be used (from April, May, June) to improve the accuracy.
 - Automation of the process and application development
 - Capacity building of MAIL.

A man wearing a white traditional long-sleeved tunic and a dark, patterned scarf stands in the center of a lush green field. The field is filled with tall, vibrant green grass. In the background, there are several bare trees and a range of rugged, grey mountains under a clear sky. The overall scene is bright and natural.

**Thank you for your kind
Attention...**

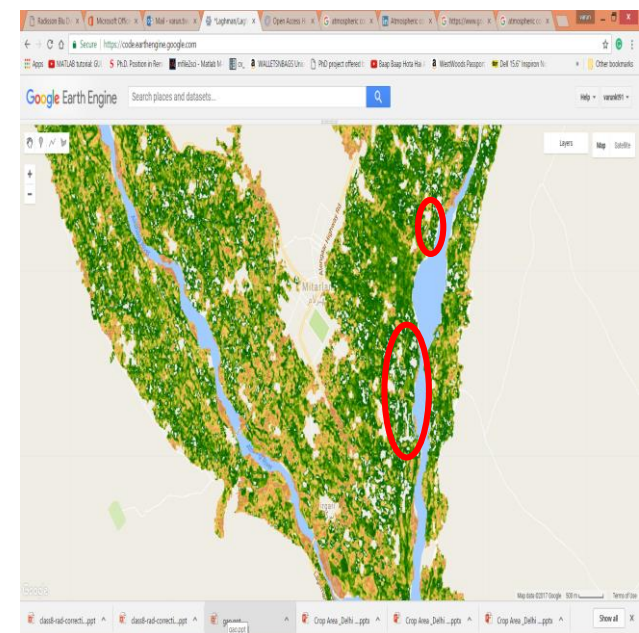
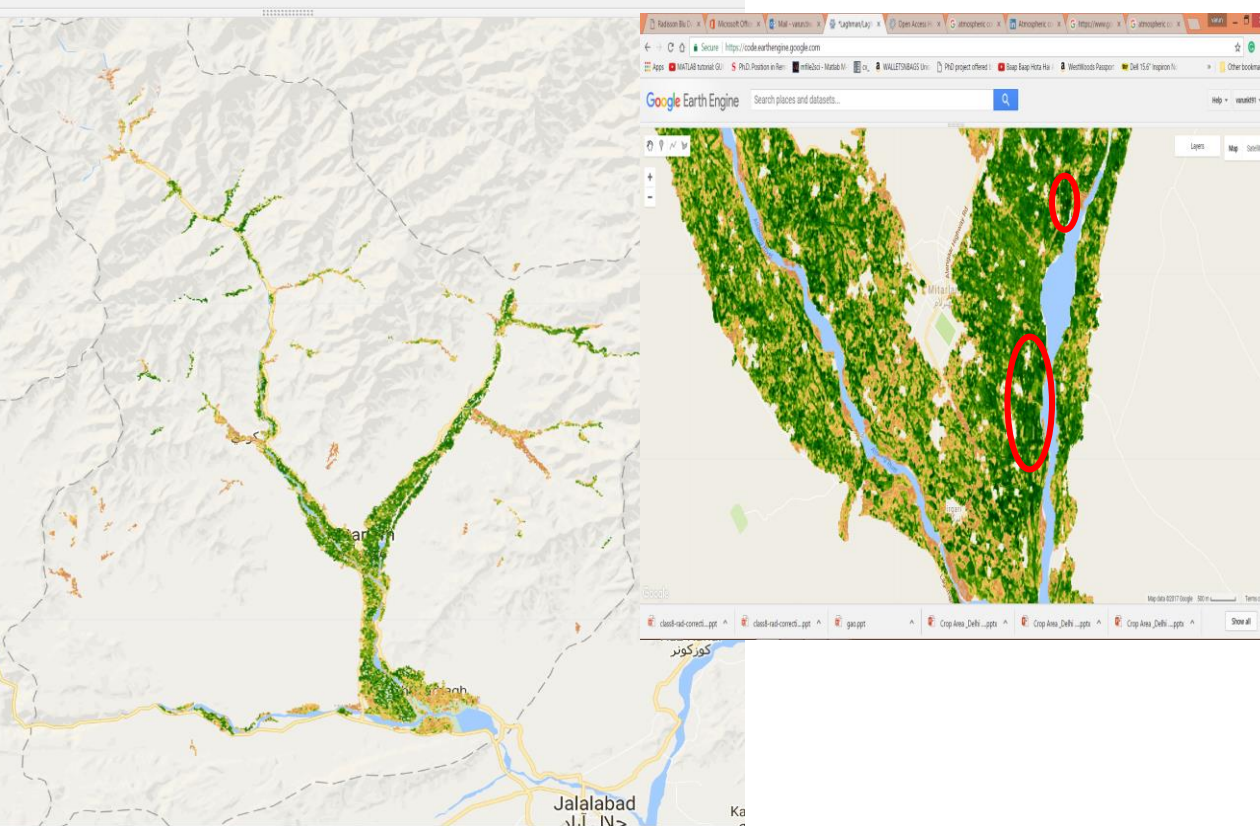
EXTRA SLIDES

- **Afghanistan is a land locked country with arid and semi-arid climate. 11% of the arable land mostly lies in temperate ecological zones.**
- **Wheat is a major crop and staple food covering 80% of the total cereal planted area in Afghanistan.**
- **Climatic conditions such as droughts, increased incidences of pests and crop diseases, lack of irrigation, changing farming practices – increased use of pesticides and insecticides, land preparation etc. are some of the factors that have further hampered wheat productivity. Despite being a significant producer, Afghanistan still imports wheat from other countries.**
- **The timely forecast/estimation of wheat production is highly important for planning and ensuring food security in case any shortage is predicted.**

Phase 1 Conti...

Before Threshold

After Threshold

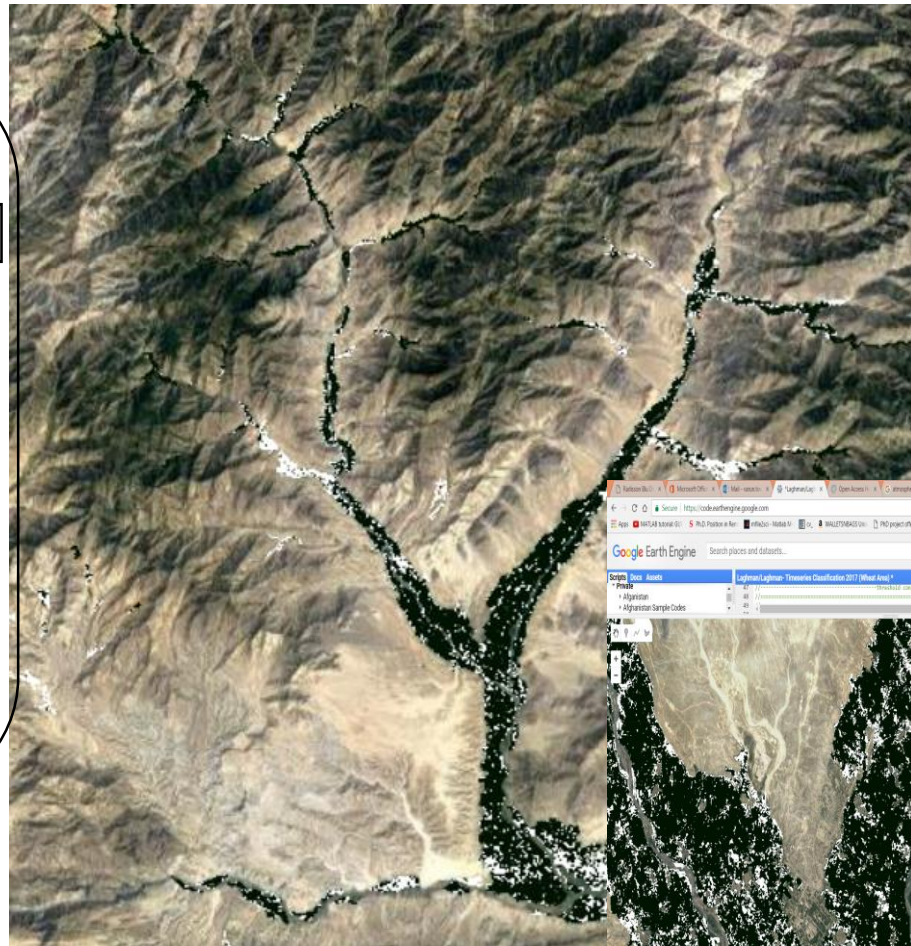
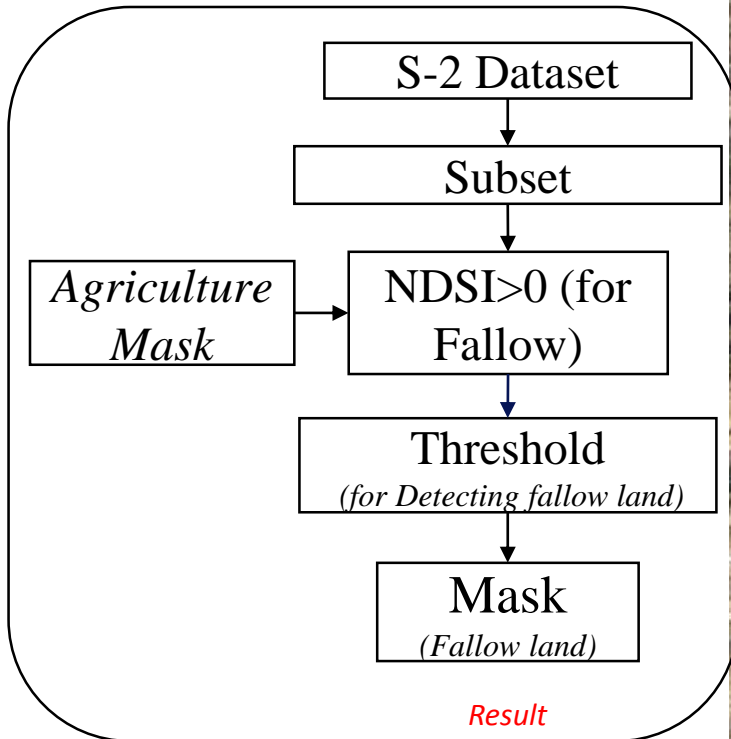


Methodology Conti...

Phase 2

ICIMOD

FOR MOUNTAINS AND PEOPLE



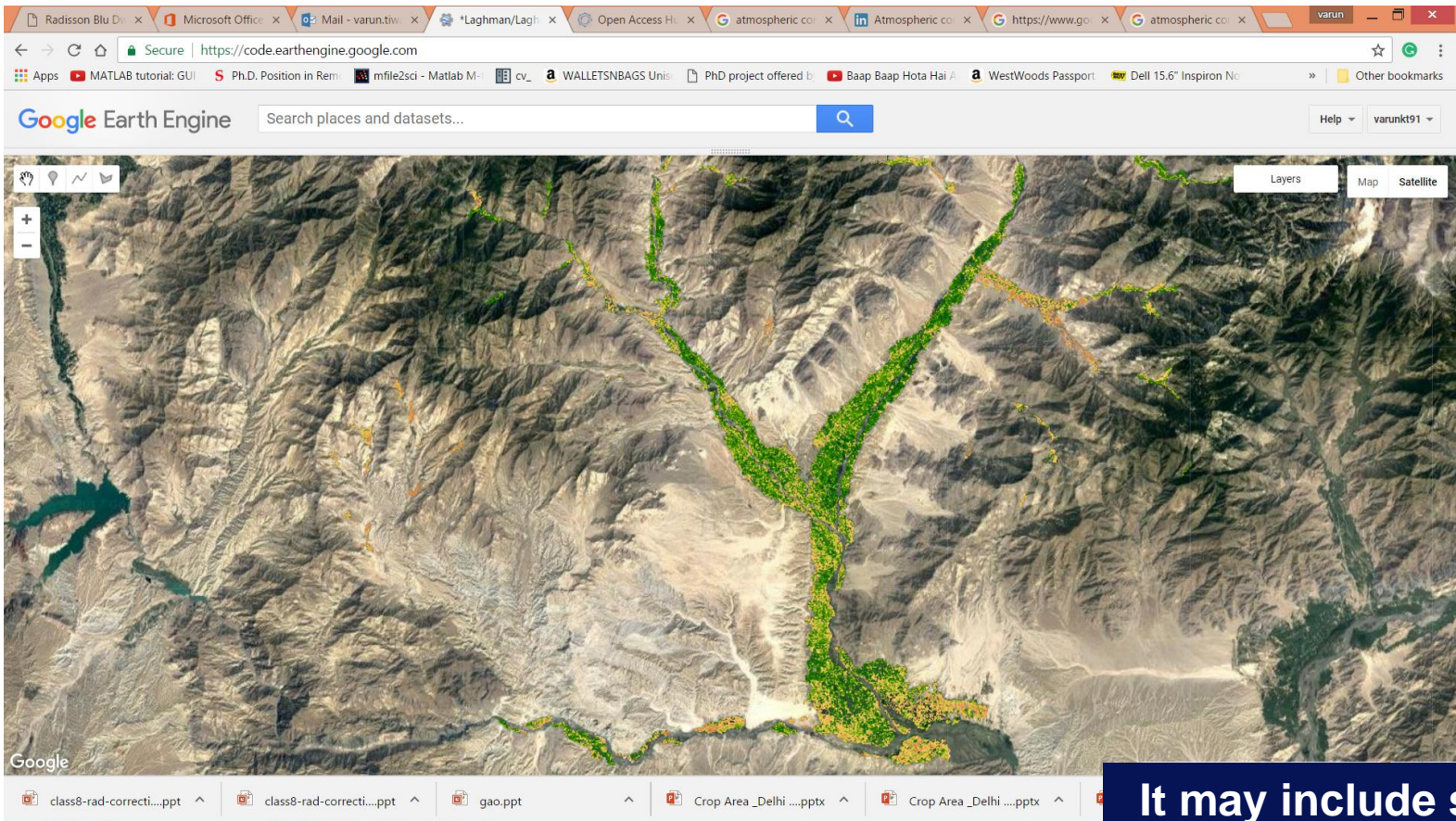
USAID
FROM THE AMERICAN PEOPLE



ICIMOD

SERVIR HINDU KUSH HIMALAYA

Excluding Fallow from Wheat + Fallow



It may include some crops

Initial Results

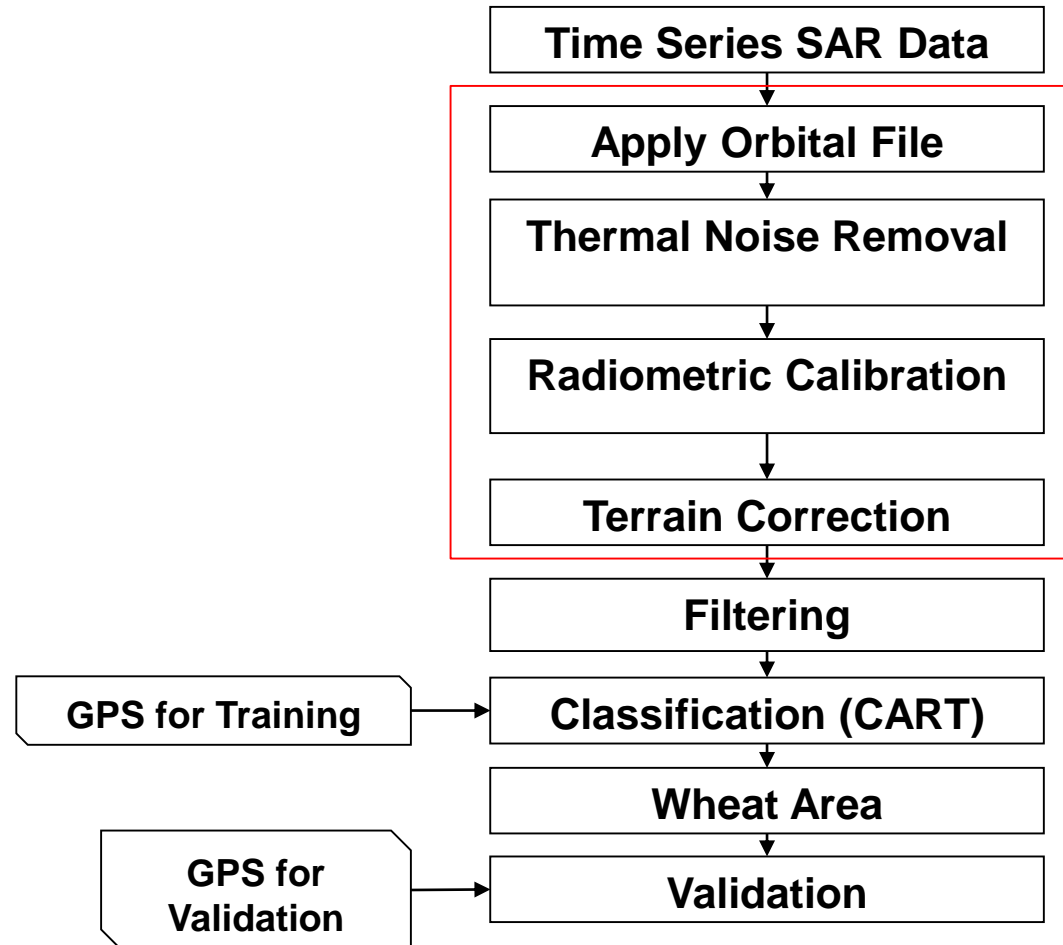


Methodology Conti..

Phase 3

ICIMOD

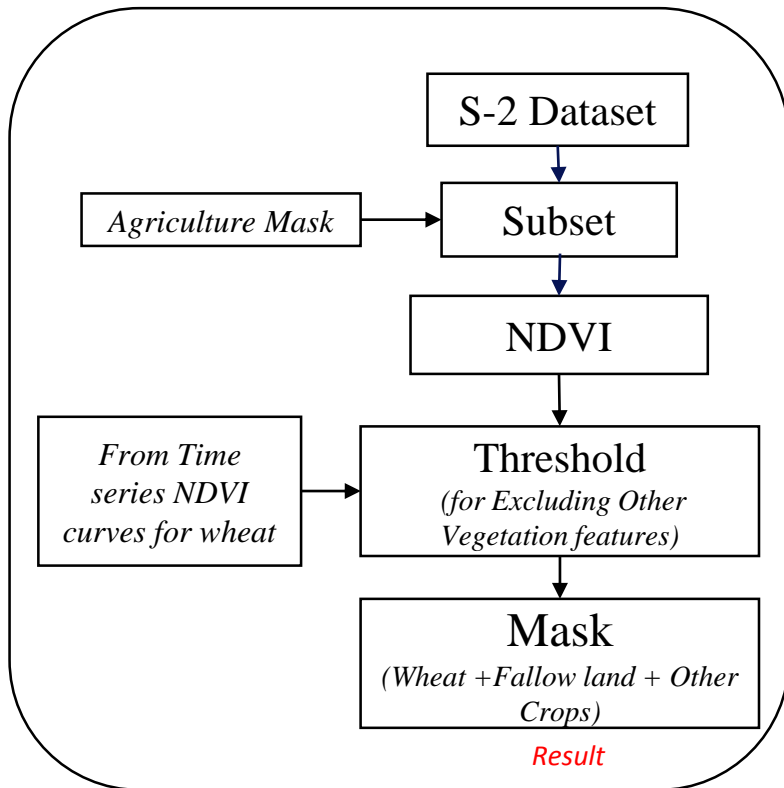
FOR MOUNTAINS AND PEOPLE



In GEE

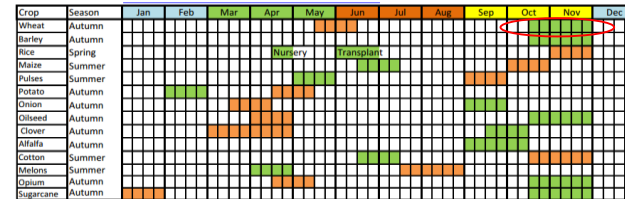


Methodology



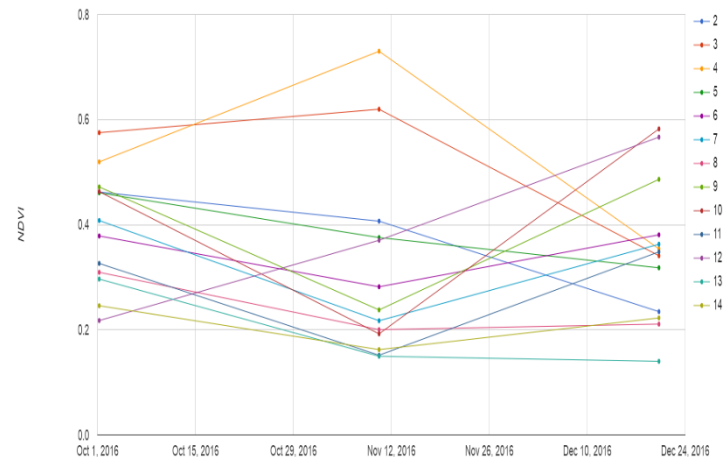
Cropping Calendar: Dates of Planting and Harvest major crops

Region EAST: (north of the Spingar Mountains) Kunar, Laghman, Nangarhar

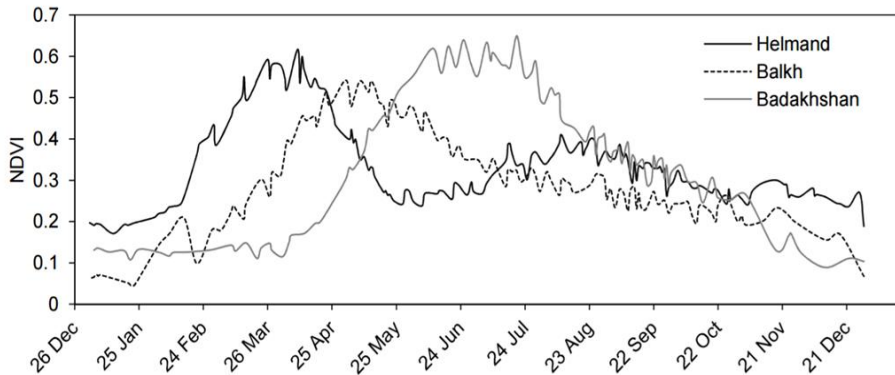


Crop	Season	Harvest notes
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Barley	Autumn	Very little
Rice	Spring	Mainly Kunar
Maize	Summer	Grain and forage
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Onion	Autumn	
Oilseed	Autumn	Mustard, Flax and Sesame
Clover	Autumn	
Millets	Autumn	Harvest perennial, Commercial in Lower Surkhrud
Cotton	Summer	Domestic production
Melons	Summer	
Opium	Autumn	Most important in Nangarhar
Sugarcane	Autumn	Biennial: Lower elevations

NDVI Over Collection

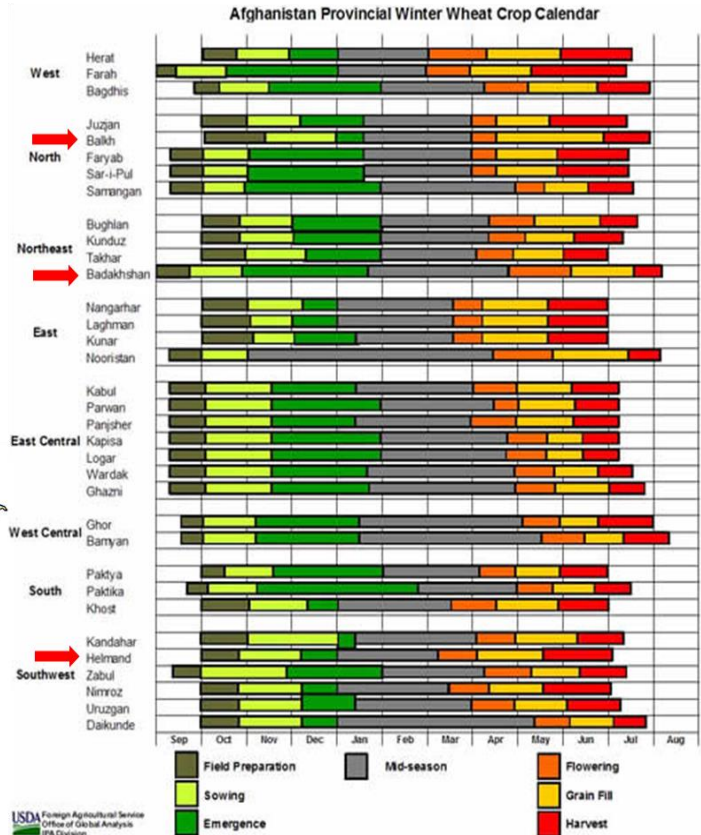


Methodology – Crop calendar



Representative MODIS NDVI temporal profile along distinct elevations in Afghanistan

In December – January crop emergence is limited thus remote sensing data can only be effectively used from March mid-February to end-August



Foreign Agriculture service office of global analysis IFA Division**

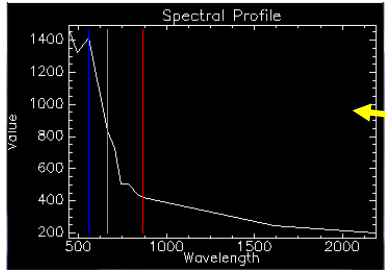




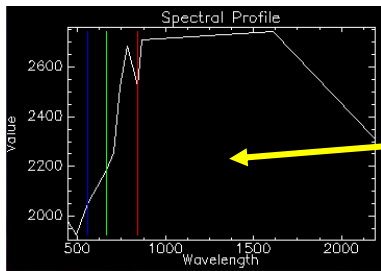
Before Correction

Atmospheric Correction

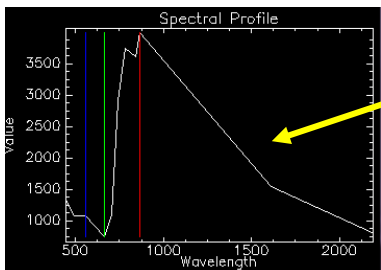
After Correction



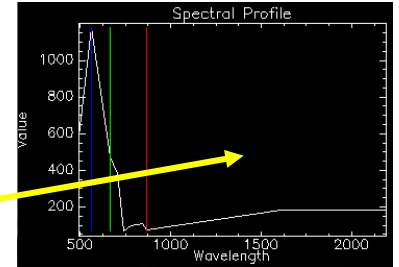
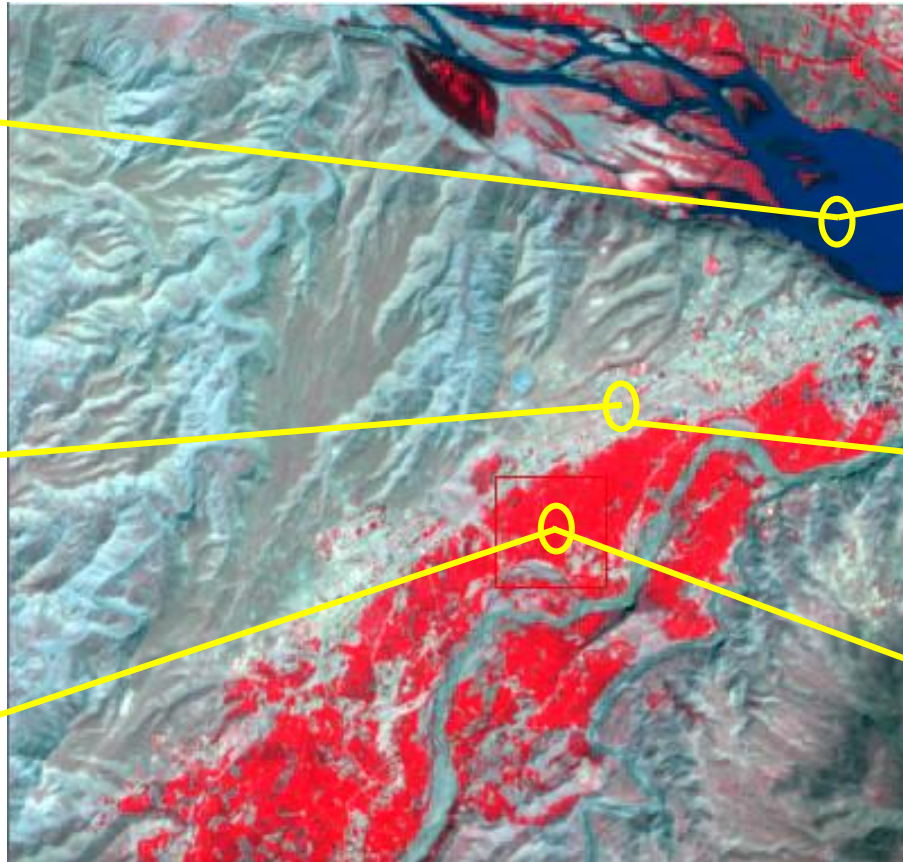
Water



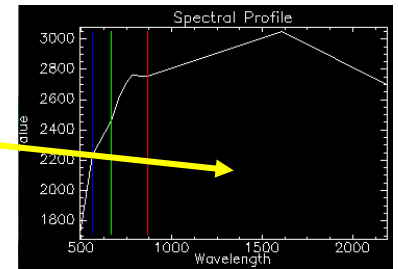
Urban



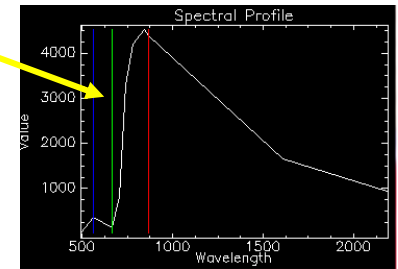
Vegetation



Water



Urban



Vegetation

Atmospheric correction using sen2cor

Time Requirement (Download & Processing)

Google Earth Engine

Open Source Google Platform
Data can be fetched in few
Processing can be done
Data can be processed
and results can be exported
in Dual core
as RASTER
(even in table
formats in few

Traditional Approach

Proprietary (ESRI, ArcGIS etc.)
Size 6 GB = $6 \times 1024 = 6144$ MB
(It has cost) It requires number of
High end Work Stations are
days for processing
ed (15,17 processors)

SOFTWARE