Introduction to
GIS & Remote Sensing Applications

November, 2020

Doktar

Agenda

- **About Me & Doktar**
- GIS & Remote Sensing
- The Industry & Community
- Types of GIS & Remote Sensing Data
- Data Science in GIS & Remote Sensing
- Implications for Decision Making & Opportunities

Who I am?

Batuhan Kavlak

Management
2013

Referee
2015

Service
2015

Intern
2018

Analyst
2019

Source: Doktar

Who we are?

Established	• January 2012
Purpose	• Improve agriculture via informed decisions.
Capabilities	• Agronomic know-how, software and hardware development, big data
Offices	• 3 offices (Istanbul & Izmir) in Technology Development Zones • Total team: 49
Highligts	• More than 500k registered farmers • Growth protocols for 117 different crops • Robust methodology to develop growth protocol for a new crop, in a new region • Algorithms for fungal diseases, irrigation and fertilization programs • Crop identification via remote sensing for highvalue crops besides all grains and industrial crops

Source: Doktar

Since 2012, Doktar has been growing both in number of offered services and clients.

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Products

2012 — Mobile Agronomist Service (Turkcell)

2013 — Agricultural Weather Service (Turkcell)

2014 — First Mobile App (Adama)

2015 — Farmers' Pulse Research (Doktar)

2016 — Sensor Station

2017 — Digital Trap

2012 — Crop Growth Modelling Engine (Doktar)

2013 — Agricultural Technical Hotline

2015 — Crop Health Service

2016 — Digital Soil Analysis

2017 — Farm Management System

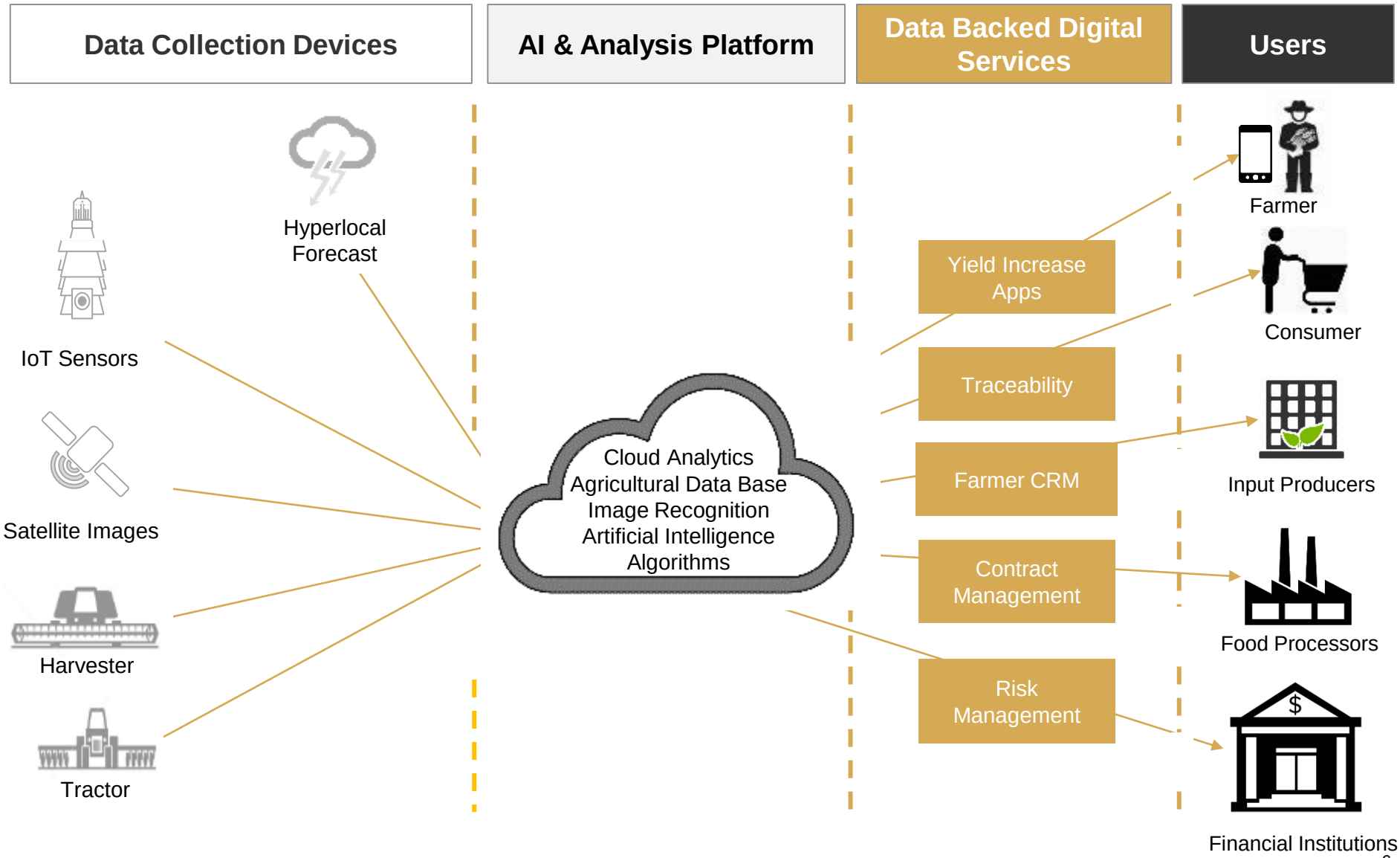
Clients

DenizBank, Dekalb, Sumitomo, Seminis grow forward, DenizBank, New Holland Agriculture, MAY, Timac Agro, Cargill, Corteva agriscience, Sumi Agro, Toros, WWF, tat, syngenta, Turkcell, Eurodrip, Adama, Enza Zaden, nunhems, Bayer, Fibabanka, Frito Lay

Source: Doktar

Digital Agriculture Services of Doktar

High Level Service Architecture

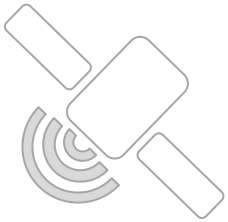


Doktar Products & Services

Dijital Products

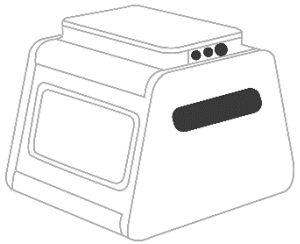
Fungus and Irrigation Management

Crop & Health Monitoring



Digital Soil Analysis

Digital Pest Trap



Smart Phone Applications

Farm Management System

Source: Doktar

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GIS is set of tools and methods to organize, communicate, and understand the data of our world.

Geographical Information Systems

System Diagram

Source: Doktar

GIS are helpful systems for tracking the situation of our world and for taking action.

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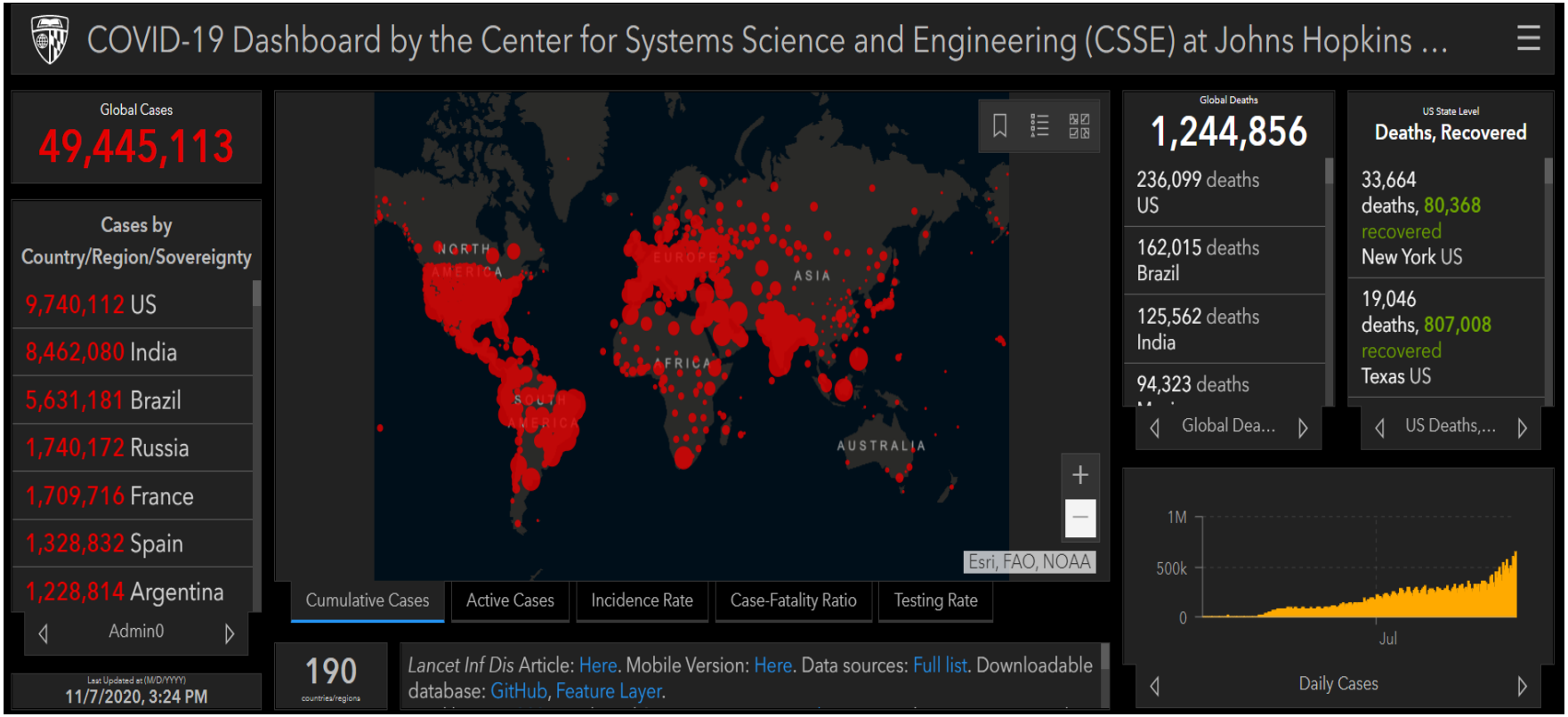
Geographical Information Systems

Coronavirus Map



Source: CSSE at John Hopkins: https://coronavirus.jhu.edu/map.html

GIS is necessary for us to mobilize all over the world easily and safely.

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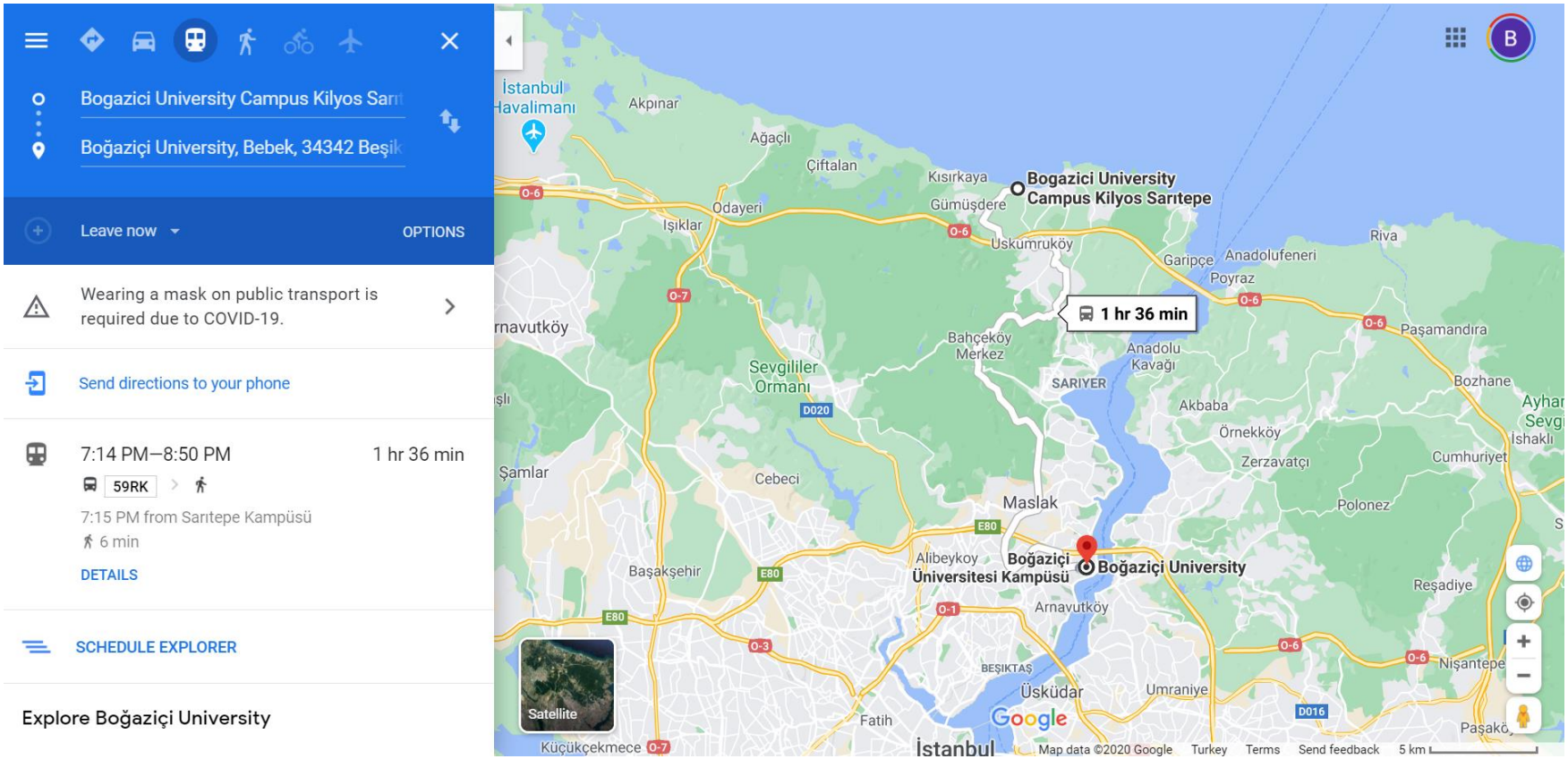
Geographical Information Systems
Google Maps

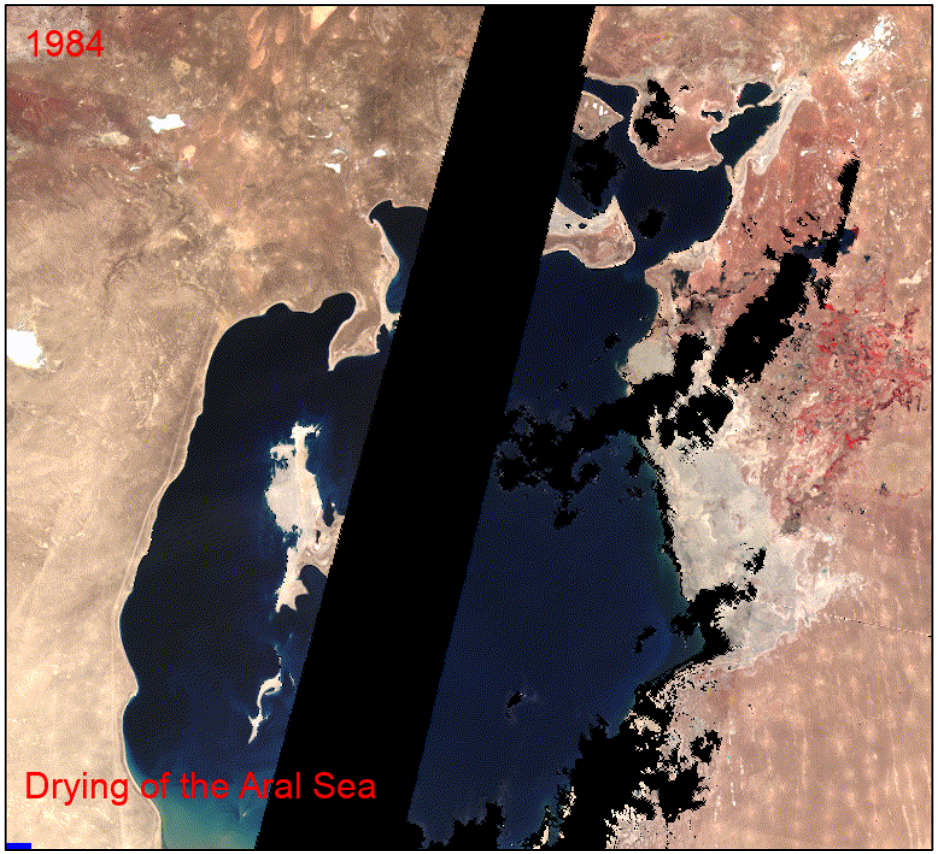


Source: Google Maps

GIS are advanced systems to monitor the Earth and analyze our environment.

Geographical Information Systems

Timelapse of Aral Sea



Timelapse by Qiusheng Wu :
Source: https://www.linkedin.com/posts/qiushengwu_landsat-earthengine-geemap-activity-6715046788841254912-pLTh

Remote sensing technologies use electromagnetic spectrum to extract desired information from a target.

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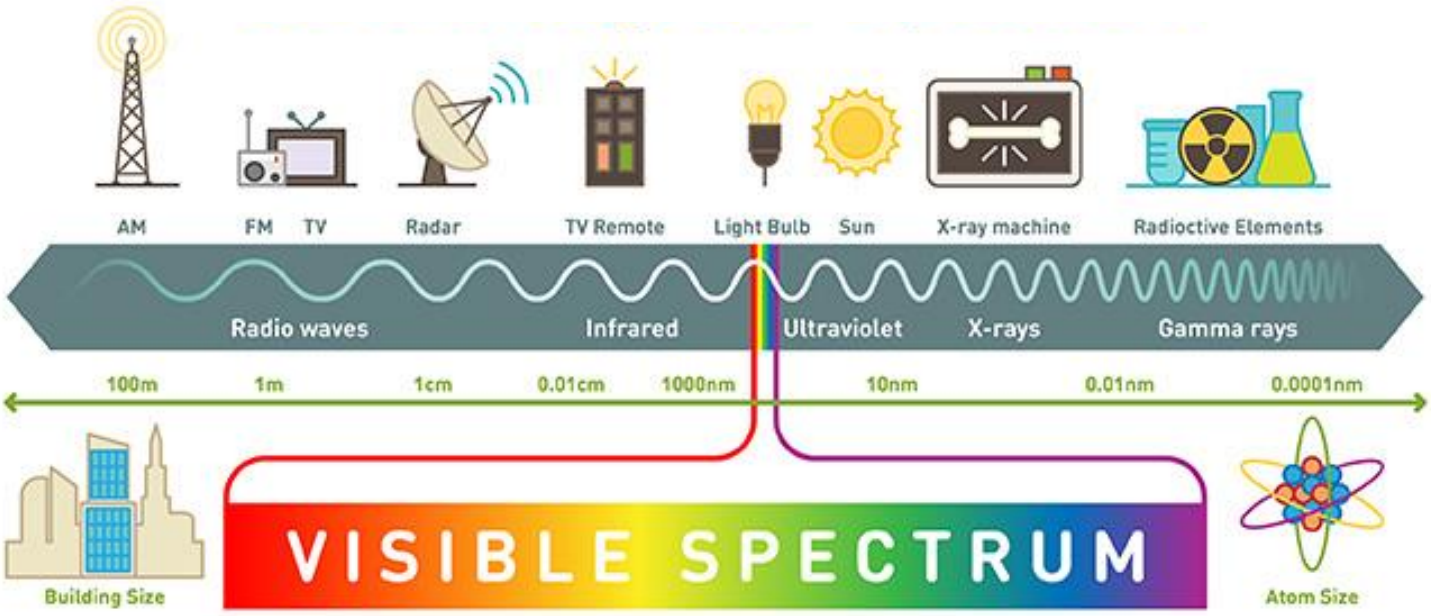
Remote Sensing Technologies

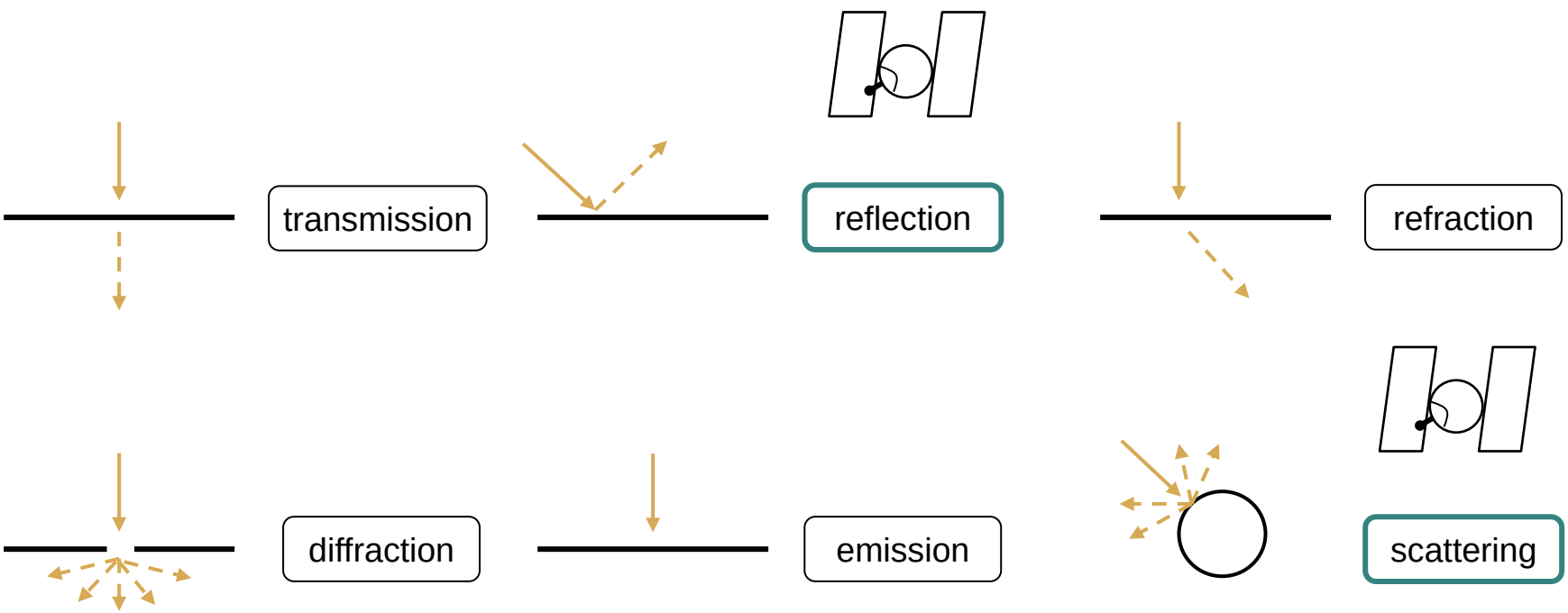
Electromagnetic Spectrum



Source: https://www.computerhope.com/jargon/e/elecspec.htm

The reaction of the objects to electromagnetic spectrum changes, and their reactions determine the measurements.

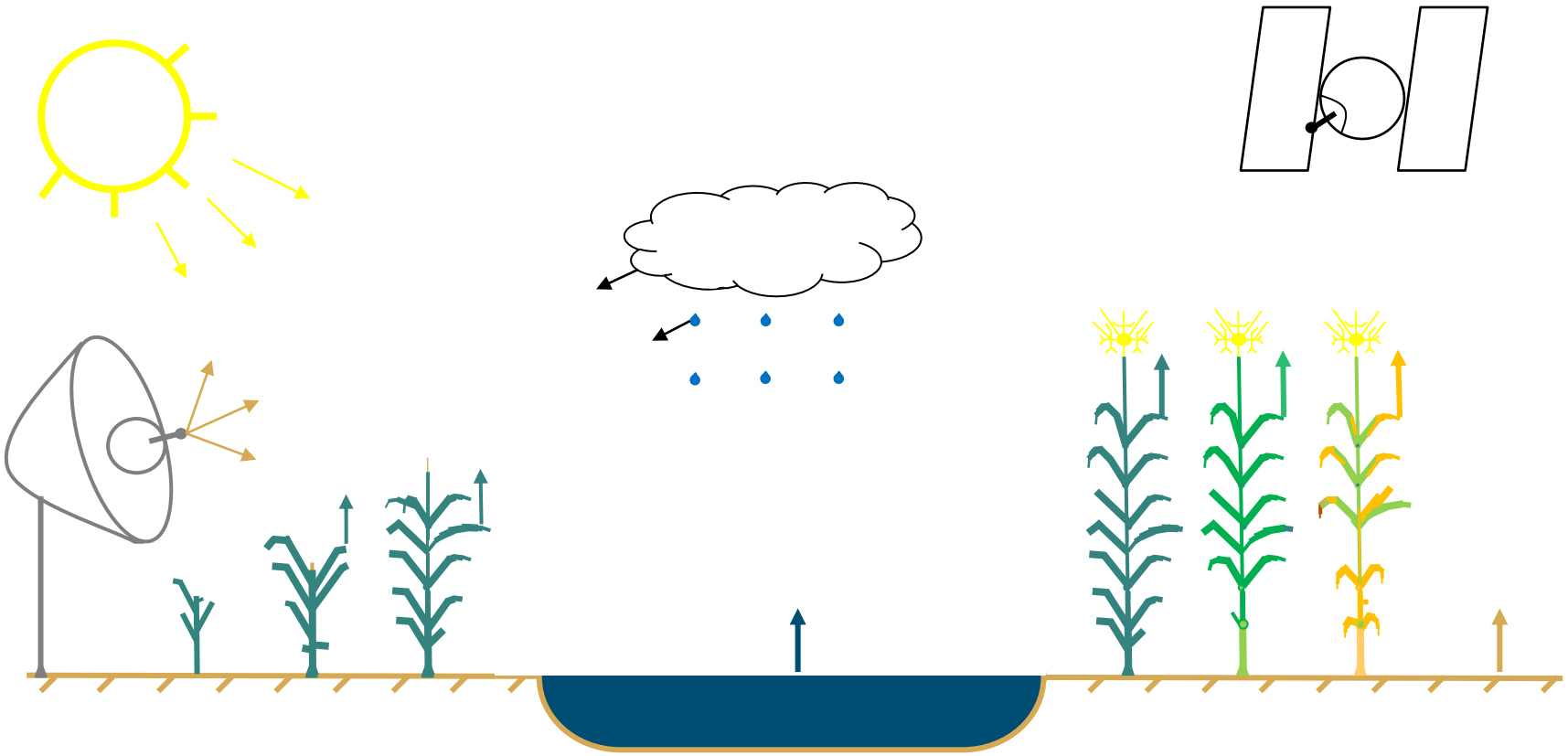
Remote Sensing Technologies
Optic Sensor Measurements



Source: Doktar

The Sun is a significant source of light, and Sun's interaction with the Earth helps us see and monitor.

Remote Sensing Technologies
Earth & Atmosphere Observation



Source: Doktar

Interpreting the reflection from sun, the satellite technologies can render images to analyze and process further.

Remote Sensing Technologies
Satellite Imagery

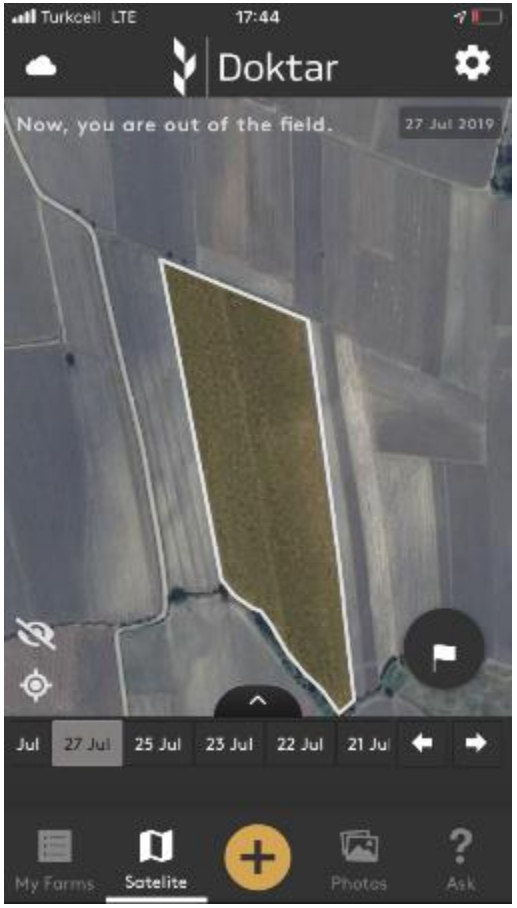
RGB

False Color

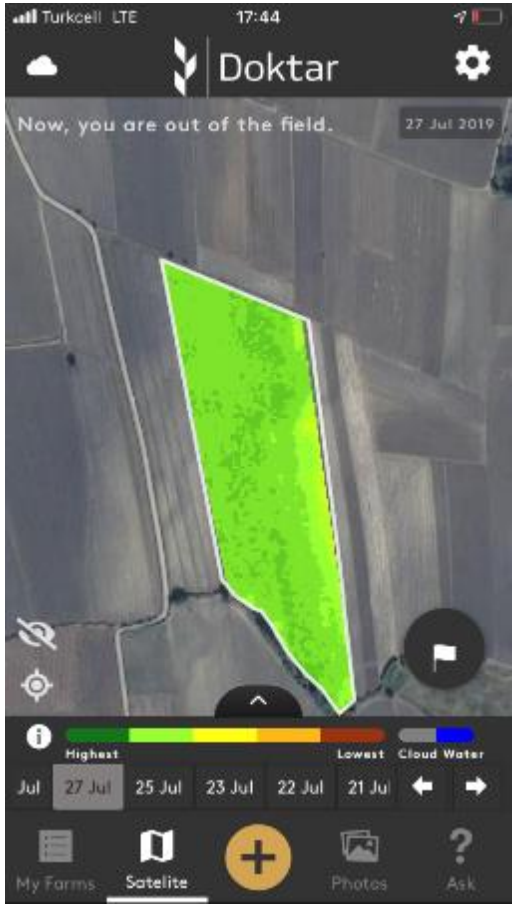
Source: Doktar

Doktar's Product
Crop Health Monitoring via Satellite (1/2)

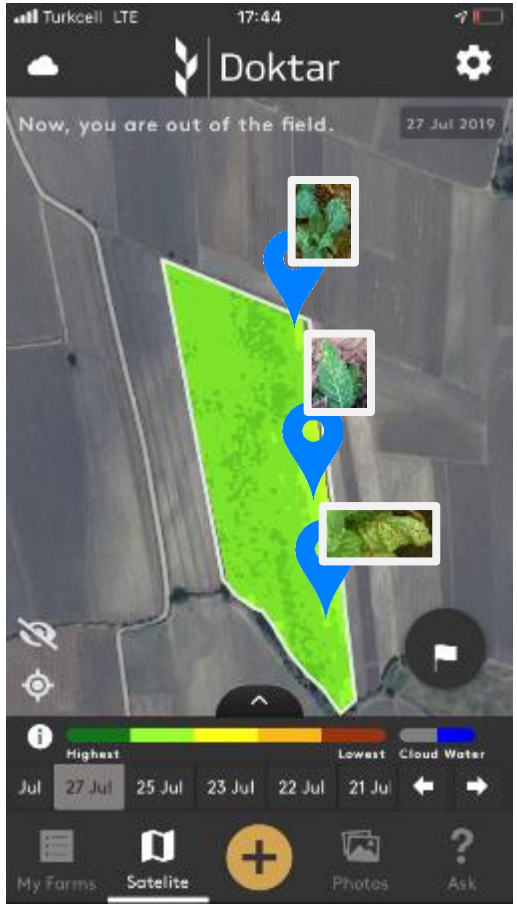
Set field boundaries from Orbit App,...



... satellite data then proces-sed to create health map,...



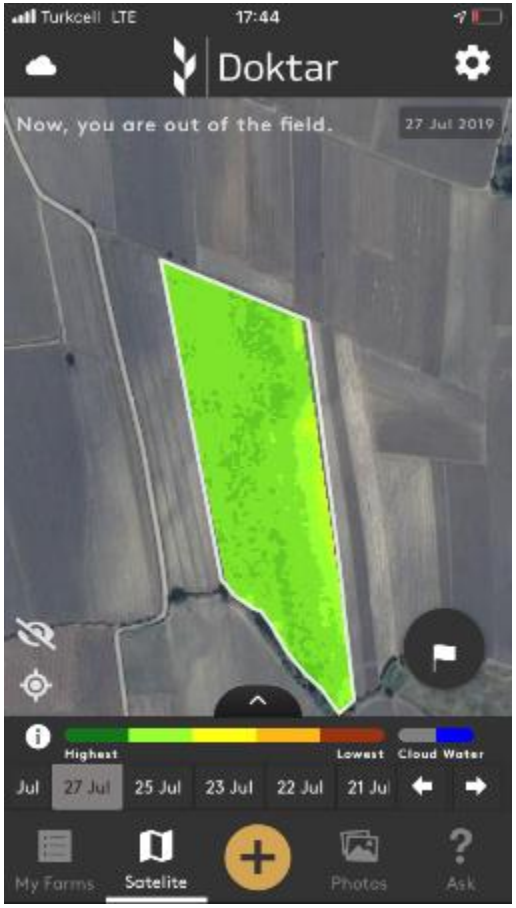
...low progressing areas identifed for inspection



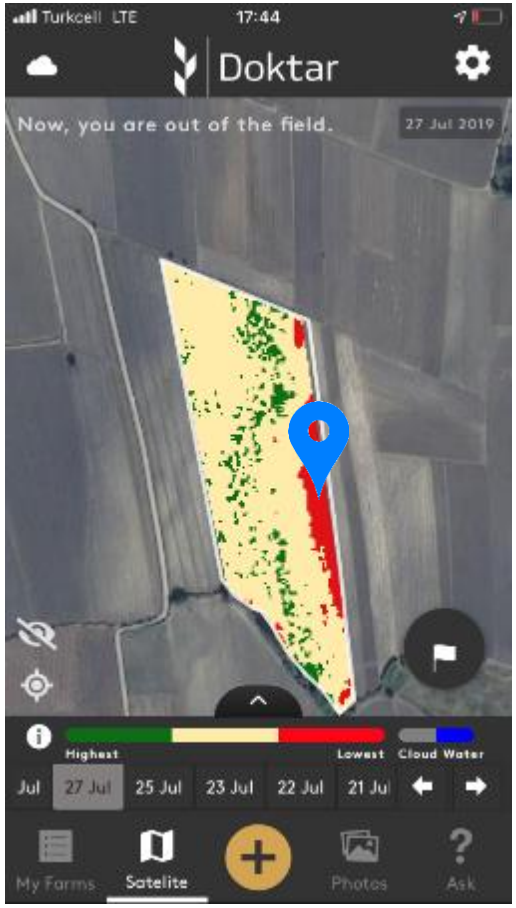
Source: Doktar

Doktar's Product
Crop Health Monitoring via Satellite (2/2)

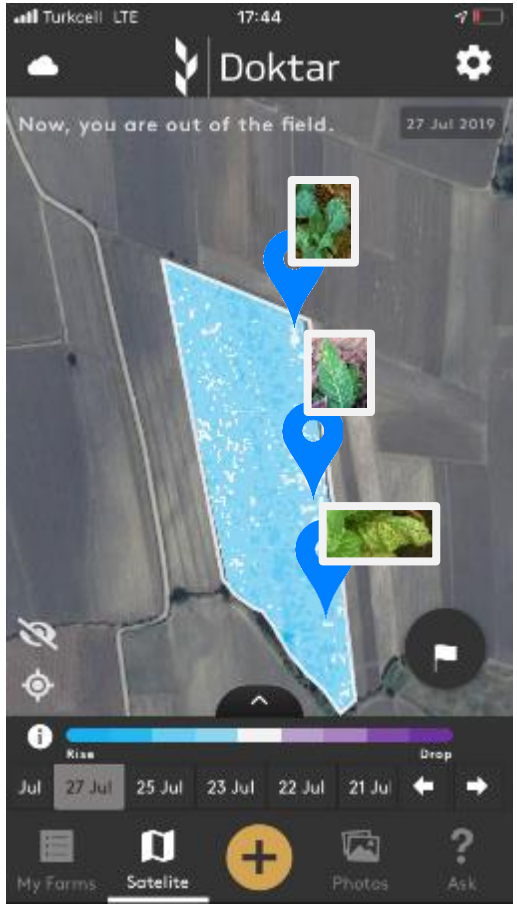
Health Map
Phenological Progress



Inspection Map
Inspection Priotization



Difference Map
Field Follow-up



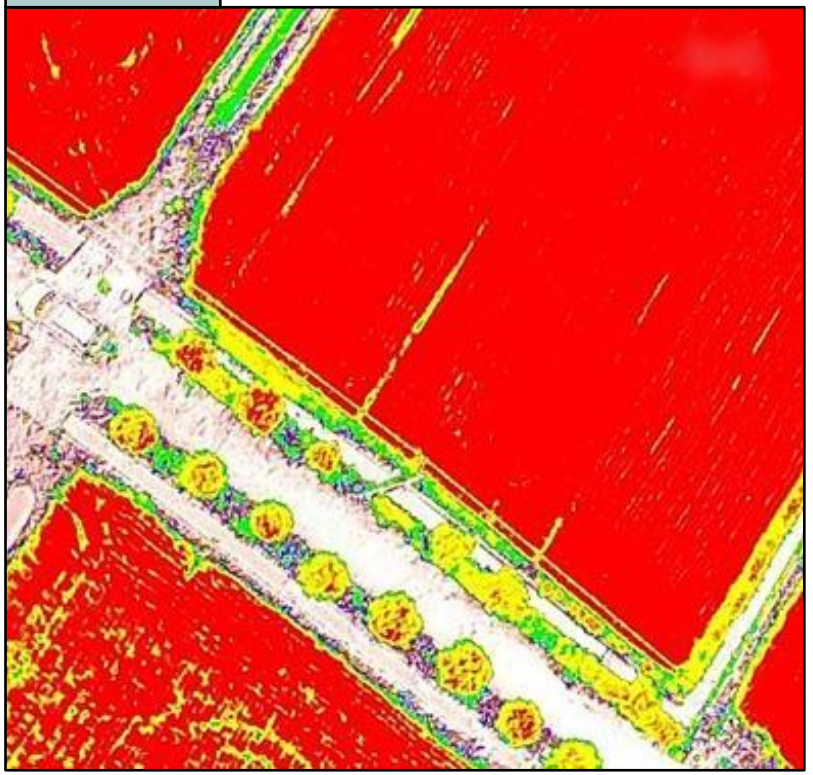
Source: Doktar

Drones can be equipped with multispectral sensors to increase the amount of information taken from the area.

Remote Sensing Technologies
Drone Imagery

RGB

False Color



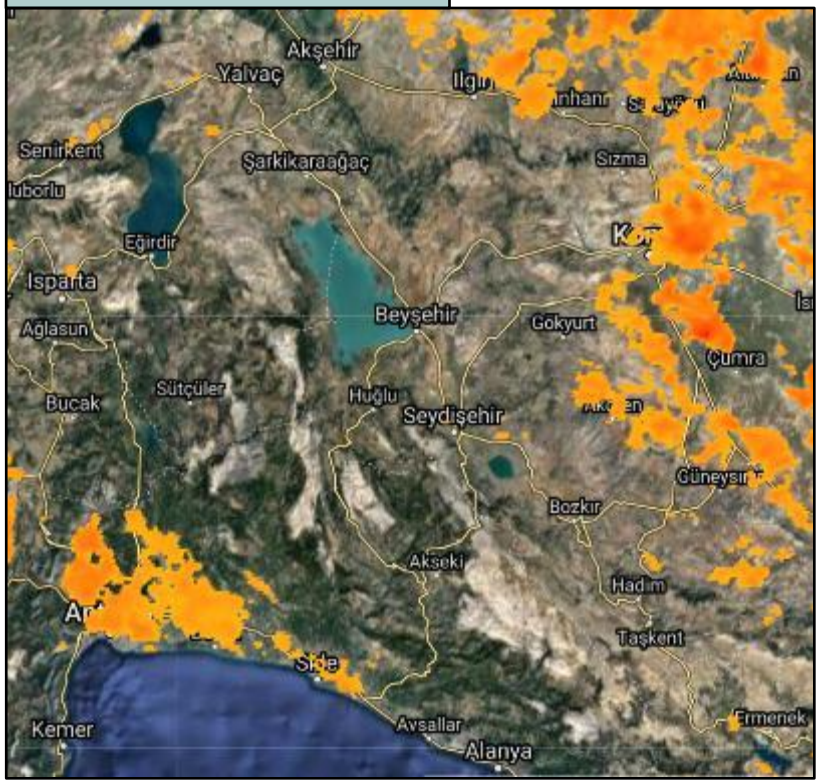
Source: Doktar

Meteorological stations and satellites are also using remote sensing technologies to measure variables such as precipitation and land-surface temperature.

Remote Sensing Technologies
Weather Data

Precipitation

Land-surface Temperature

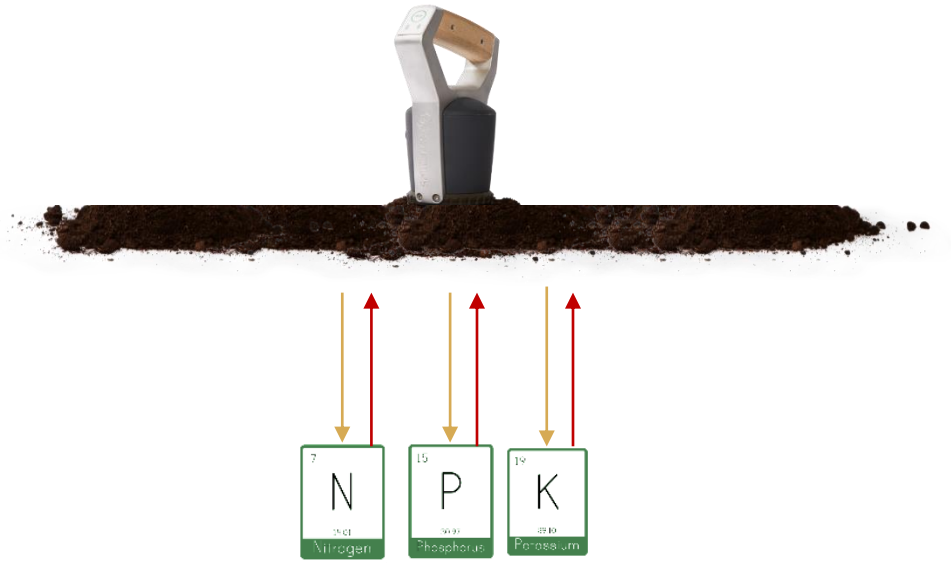


Source: Doktar

Remote sensing technologies are also used for more precise calculations on the ground.

Remote Sensing Technologies

Soil Analysis Device



Source: Doktar

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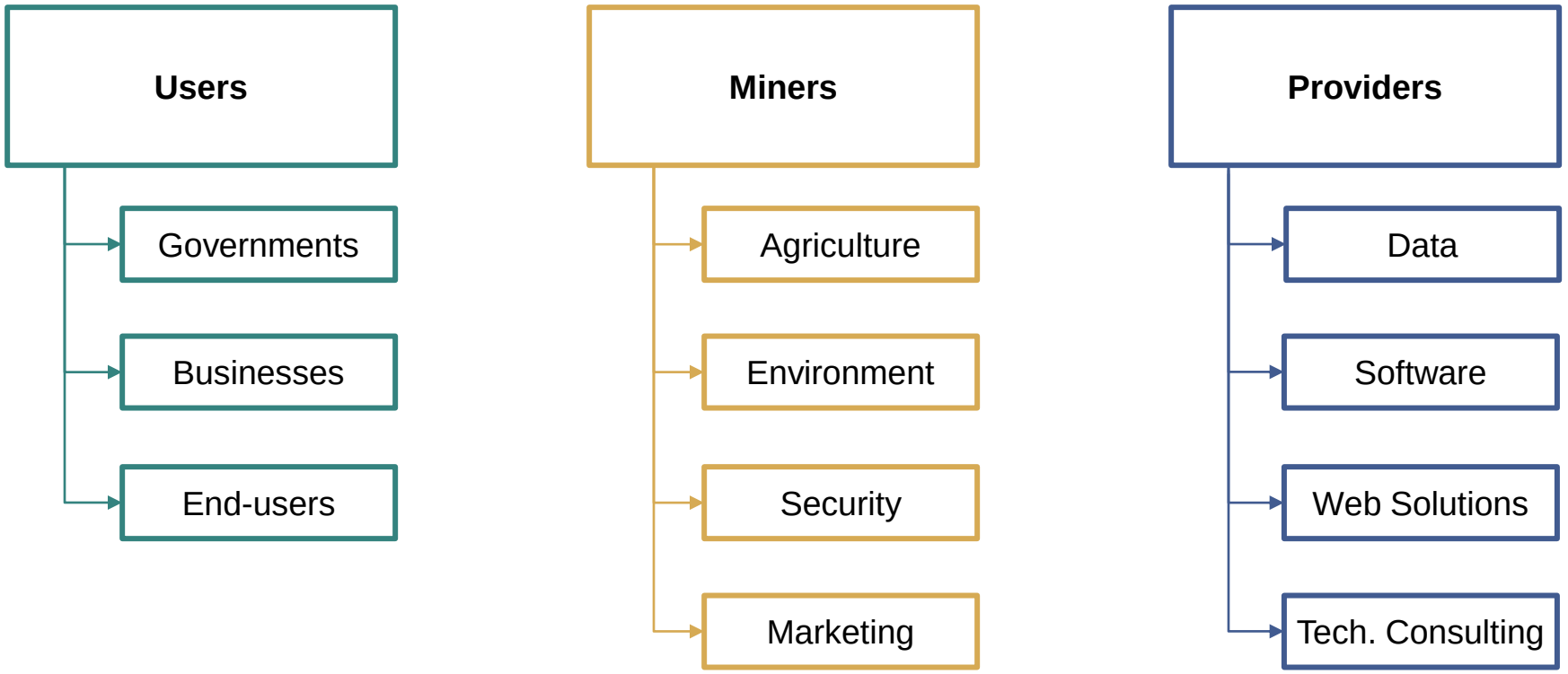
GIS and Remote Sensing industry can be categorized into three: the users, the miners, and the providers.

GIS & Remote Sensing Industry
The Value Chain



Source: Doktar

Governments use such system for decision making in many topics such as agriculture, economical planning, environment, security & emergency.

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GIS & Remote Sensing Industry
The Governments

Users

Source: Doktar

Businesses are integrating GIS & Remote Sensing to their operation flows. There are also companies built on the geographical information systems.

GIS & Remote Sensing Industry
The Businesses

Users

Source: Doktar

The use of GIS & Remote Sensing in Agriculture is becoming widespread across continents.

GIS & Remote Sensing Industry
Agriculture

Miners

OneSoil

Descartes Labs

AUGMENTA
PRECISION AGRICULTURE · REDEFINED

Source: Doktar

Because of the Climate Change, the need for analyzing environmental variables is increasing.

GIS & Remote Sensing Industry
Environment

Miners

CLIMATE AI

Algopoly

overstory

Source: Doktar

GIS & Remote Sensing are widespread in the arms industry. In addition, thanks to recent advancements, we are able to use RS efficiently in the state of emergency.

GIS & Remote Sensing Industry
Security & Emergency

Miners

BAYKAR

CYSTELLAR

Source: Doktar

Companies are now using GIS analyses to optimize their operations and their marketing purposes.

GIS & Remote Sensing Industry
Marketing & Supply Chain

Miners

Pointr

GeoInsight
ENVIRONMENTAL STRATEGY & ENGINEERING

FIREFLY

Source: Doktar

There are many imagery providers from both private sectors and government institutions.

GIS & Remote Sensing Industry
Data

Providers

planet.

AIRBUS

esa

NASA

QUADRANT

GroundTruth

Source: Doktar

Especially in remote sensing, software capabilities are barriers for analysts. Different solutions are becoming popular.

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GIS & Remote Sensing Industry
Software

Providers

esri
THE SCIENCE OF WHERE™

eCognition®

PCI GEOMATICS

Google Earth Engine

Source: Doktar

Companies mainly provide solutions at the back-end for map integrations to the applications. There are now new platforms for analyzing RS data with cloud integration, as well.

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GIS & Remote Sensing Industry
Web Solutions

Providers

mapbox

Dark Sky

UP 42

SINERGISE

Google Maps

Source: Doktar

Mostly research institutions consult to governments and some privately holding companies, especially in construction industry.

GIS & Remote Sensing Industry
Technique Consulting

Providers

UHUZAM

MAPit
Bilgi Teknolojileri A.Ş.

Manaaki Whenua Landcare Research

Source: Doktar

You can find full of benevolent people in GIS & Remote Sensing communities where everything is shared freely.

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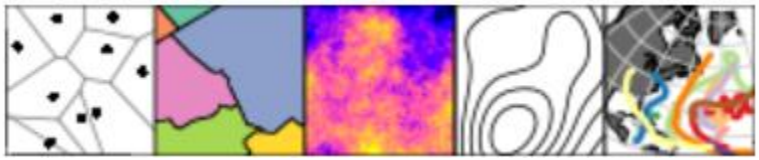
GIS & Remote Sensing Community
Open Source Platforms

OSGeo

OpenGeoHUB

r-spatial



SPATIAL ECOLOGY

Source: Doktar

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While vector data are defined geometrically with their attributes in the data set, raster data stored as pixel values on time and space dimension associated with their locations.

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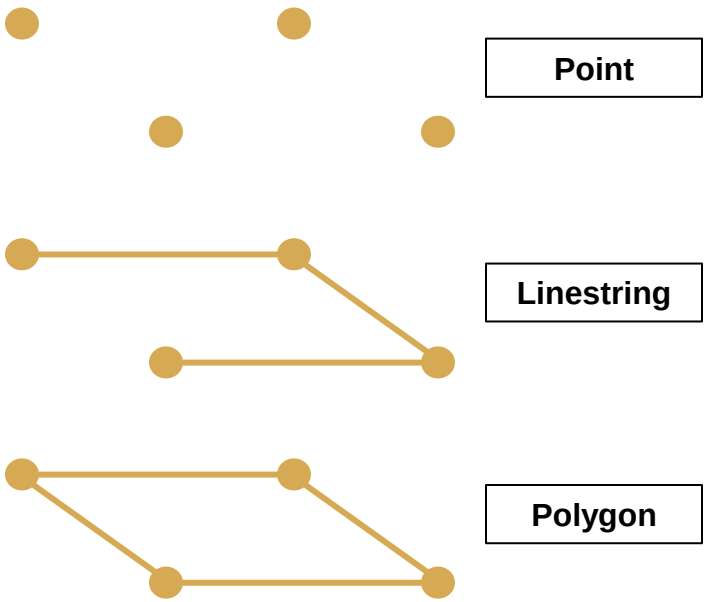
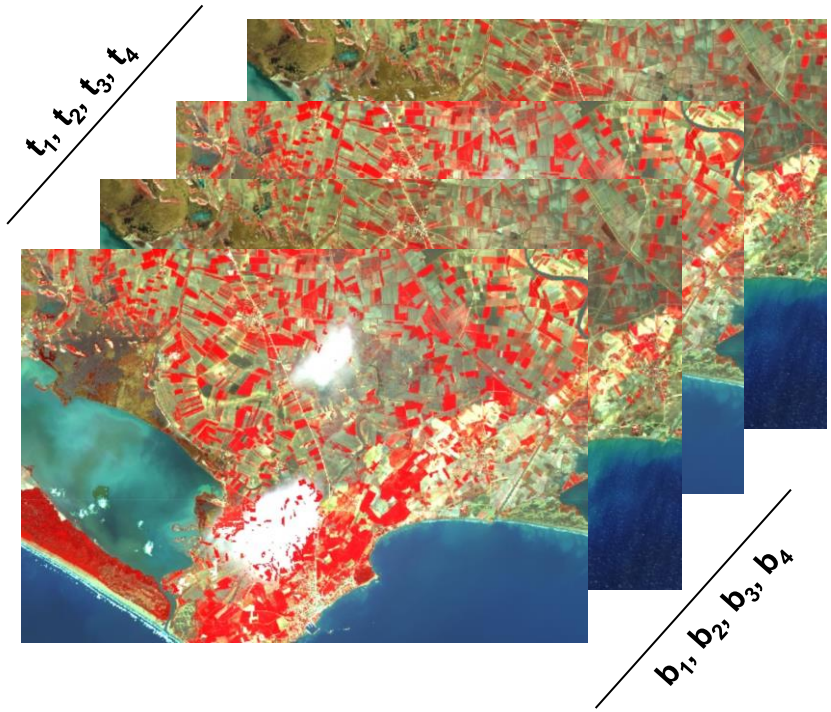
Vector Data

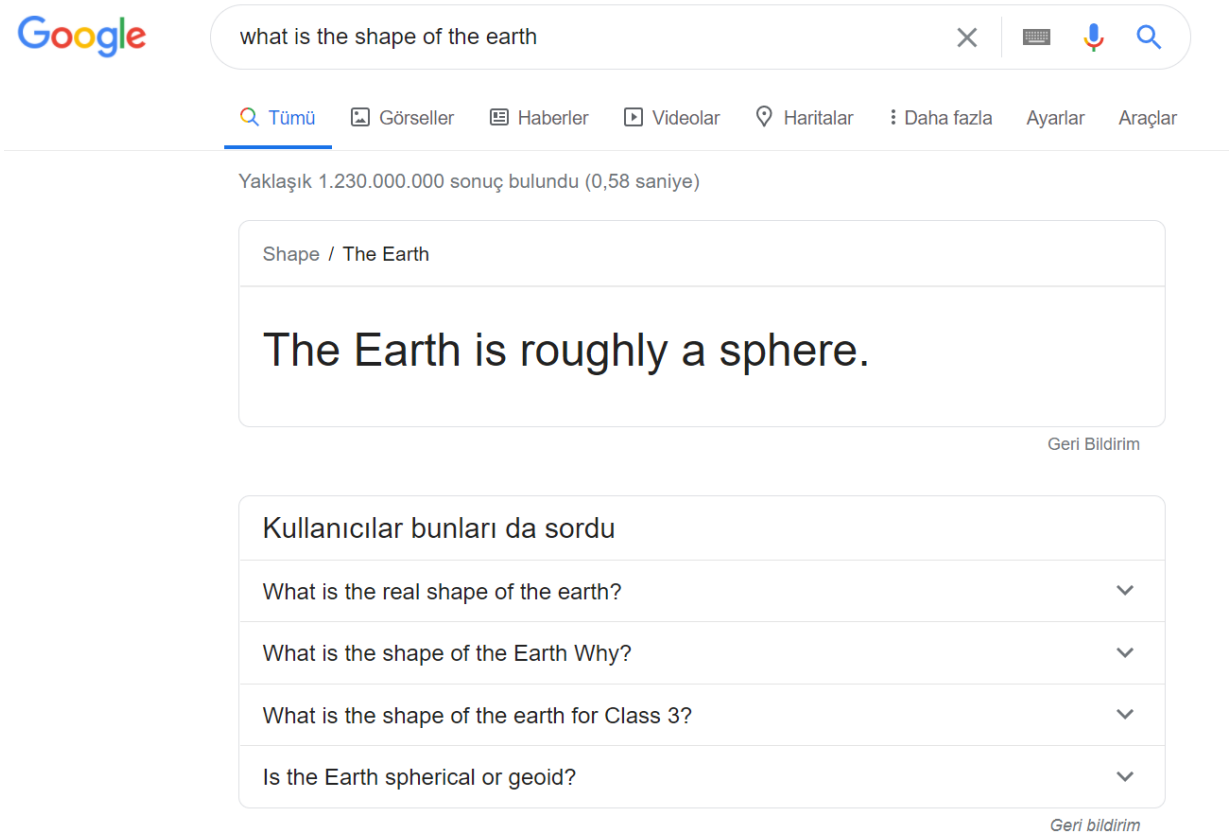


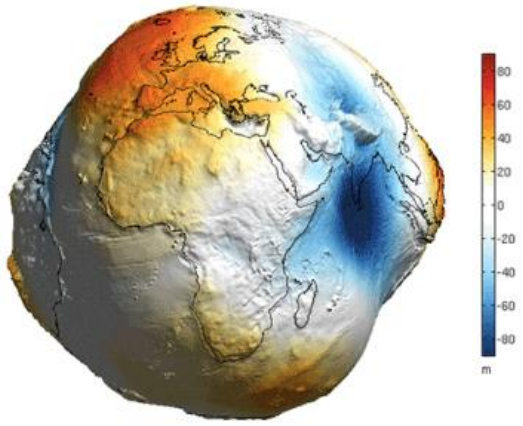
Raster Data



Source: Doktar

There is not an exact model of the Earth.

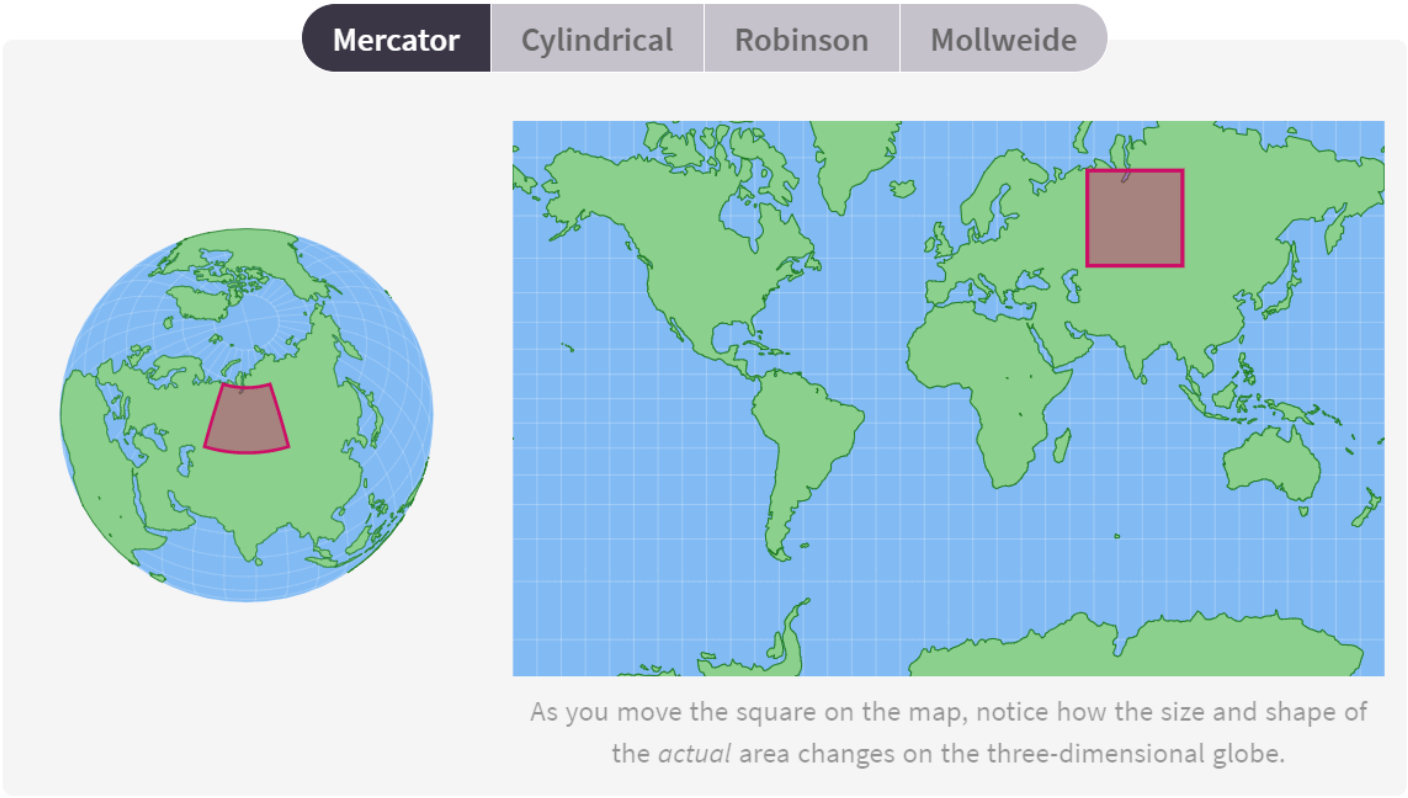




Geoid:
https://en.wikipedia.org/wiki/Geoid

Source: Doktar

We need to project the Earth (3D object) into maps (2D surface), and there isn't any perfect projection.



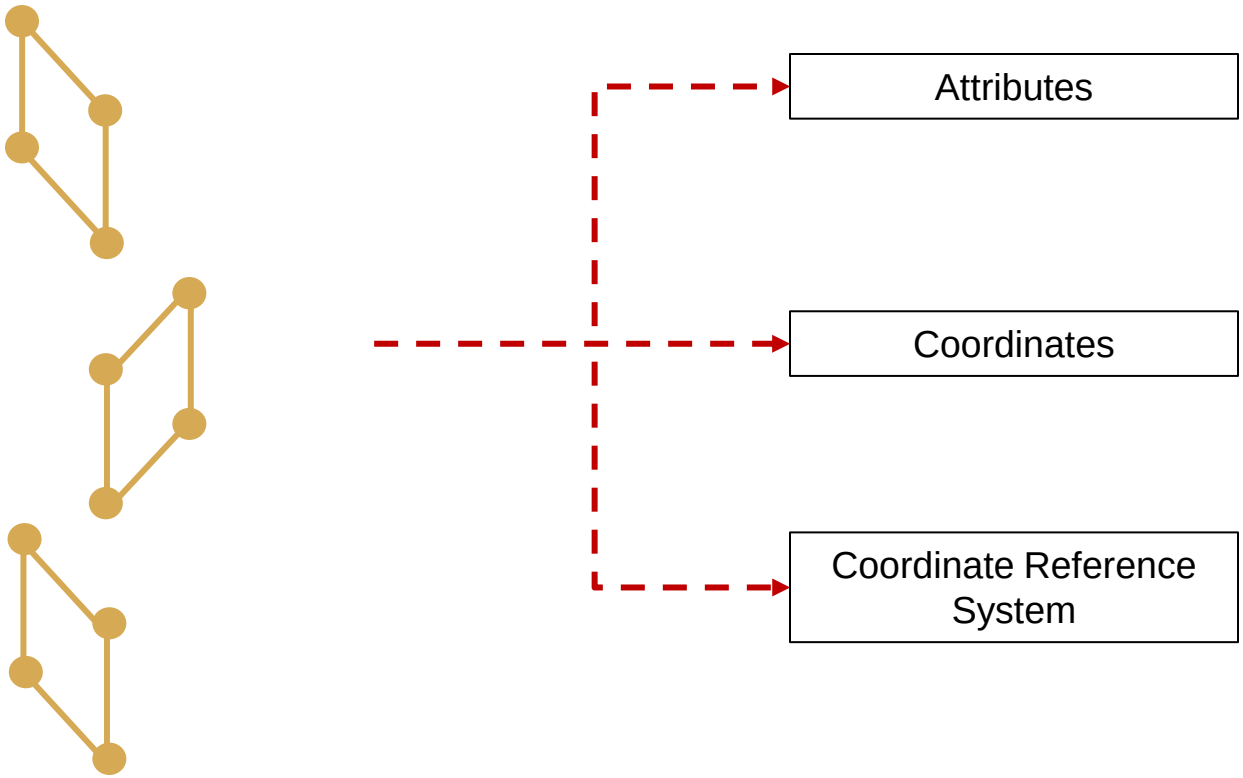
See here for example:
https://mathigon.org/course/circles/spheres-cones-cylinders#sphere-maps

Mathematical Explanation:
https://www.youtube.com/watch?v=D3tdW9l1690&ab_channel=Numberphile

Source: Doktar

Vectoral data store attributes, coordinates and coordinate reference systems. If we know those variables, we can convert and process the data.

Vector Data
Geographical Format



Kaynak: Doktar

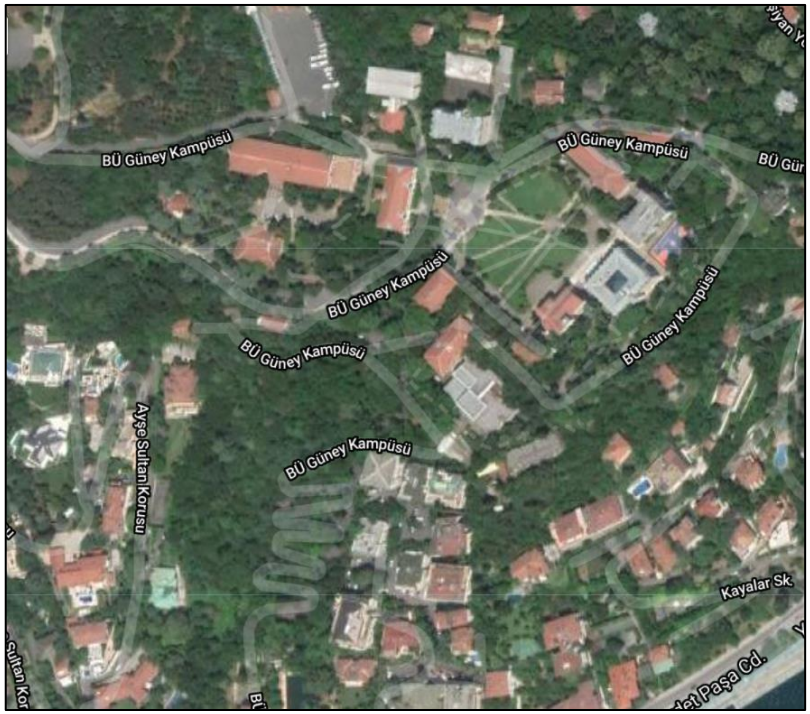
This is not different than a usual tabular data; however, we have an extra columns here to define the geometry.

PolygonID	Class	Region	City	District	Geom
1	Building	MARMARA	ISTANBUL	EYUP	POLYGON (21.
2	Building	MARMARA	ISTANBUL	EYUP	POLYGON (21.
3	Building	MARMARA	ISTANBUL	EYUP	POLYGON (21.
4	Building	MARMARA	ISTANBUL	ATASEHIR	POLYGON (21.
5	Building	MARMARA	ISTANBUL	ATASEHIR	POLYGON (21.
6	Forest	MARMARA	ISTANBUL	BEYKOZ	POLYGON (21.
7	Forest	MARMARA	ISTANBUL	BEYKOZ	POLYGON (21.
8	Forest	MARMARA	ISTANBUL	BEYKOZ	POLYGON (21.
9	Forest	MARMARA	ISTANBUL	SARIYER	POLYGON (21.
10	Forest	MARMARA	ISTANBUL	SARIYER	POLYGON (21.
11	Water	MARMARA	ISTANBUL		POLYGON (21.
12	Water	MARMARA	ISTANBUL		POLYGON (21.
13	Water	MARMARA	ISTANBUL		POLYGON (21.

Source: Doktar

The information from raster data can change according to different parameters such as resolution, band number, and projection.

Worldview – 30cm
RGB Image



Sentinel-2 – 10m
RGB Image

Source: Doktar

Raster data store extent, resolution, coordinate reference system, band attributes, and pixel values. If we know those variables, we can convert and process the data.

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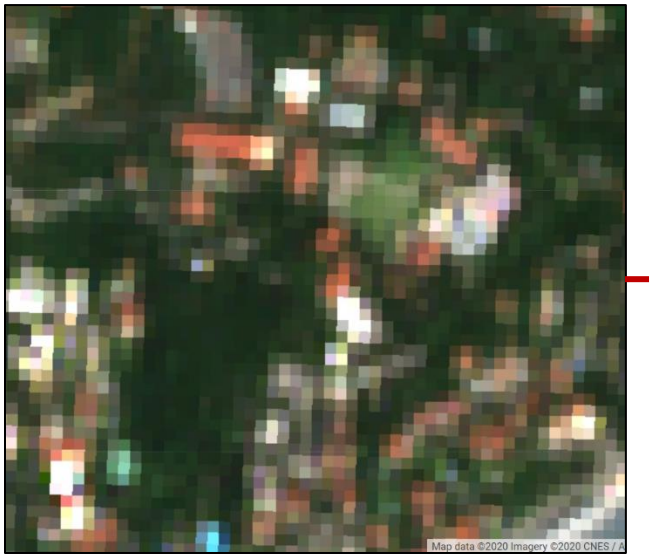
Raster Data
Geographical Format



- Extent
- Resolution
- Coordinate Reference System
- Band Attributes
- Pixel Values

Kaynak: Doktar

Raster data can also be converted to tabular data format if we can extract the pixel values and organize them properly.

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	Coordinates		t_1 Satellite Bands				$t_{2, \dots, t_n}$ Satellite Bands	
PixelID	X	Y	Red1	Green1	Blue1	NIR1	Red2	...
1	27.7834	40.1535	660	500	369	1049	630	...
2	27.7835	40.1536	615	572	379	1136	580	...
3	27.7836	40.1537	681	546	389	1066	652	....
4	27.7837	40.1538	660	553	434	1168	620	...
5	27.7838	40.1539	651	538	385	1183	630	...
6	27.7804	40.1525	608	503	429	1032	573	...
7	27.7805	40.1526	656	489	356	1008	643	...
8	27.7806	40.1527	646	549	392	1069	618	...
9	27.7807	40.1528	671	519	351	1181	661	....
10	27.7808	40.1529	660	529	359	1168	503	...
11	27.7734	40.1435	672	559	366	1017	648	...
12	27.7735	40.1436	634	539	358	1137	601	...
13	27.7736	40.1437	669	510	361	1074	623	...

Source: Doktar

Vectoral data store attributes, coordinates and coordinate reference systems. If we know those variables, we can convert and process data.

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Computing Environment

Open Source Computing Environment

Dependencies

GDAL

GEOS Geometry Engine Open Source

PROJ

Softwares

PK tools

SAGA System for Automated Geoscientific Analyses

Google Earth Engine

QGIS

Back-End

GeoServer

PostGIS

GRASS GIS

MapServer open source web mapping

Languages

R

python

C++

BASH THE BOURNE-AGAIN SHELL

Kaynak: Doktar

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We can work with many models in GIS & Remote Sensing; however, geographical considerations are needed to be taken when analyzing the cases.

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Geostatistics

Tobler's First Law of Geography

"everything is related to everything else, but near things are more related than distant things."

Kaynak: Doktar

Spatial and temporal autocorrelation are some painful bias on the datasets. You need be aware of such biases when testing your accuracy.

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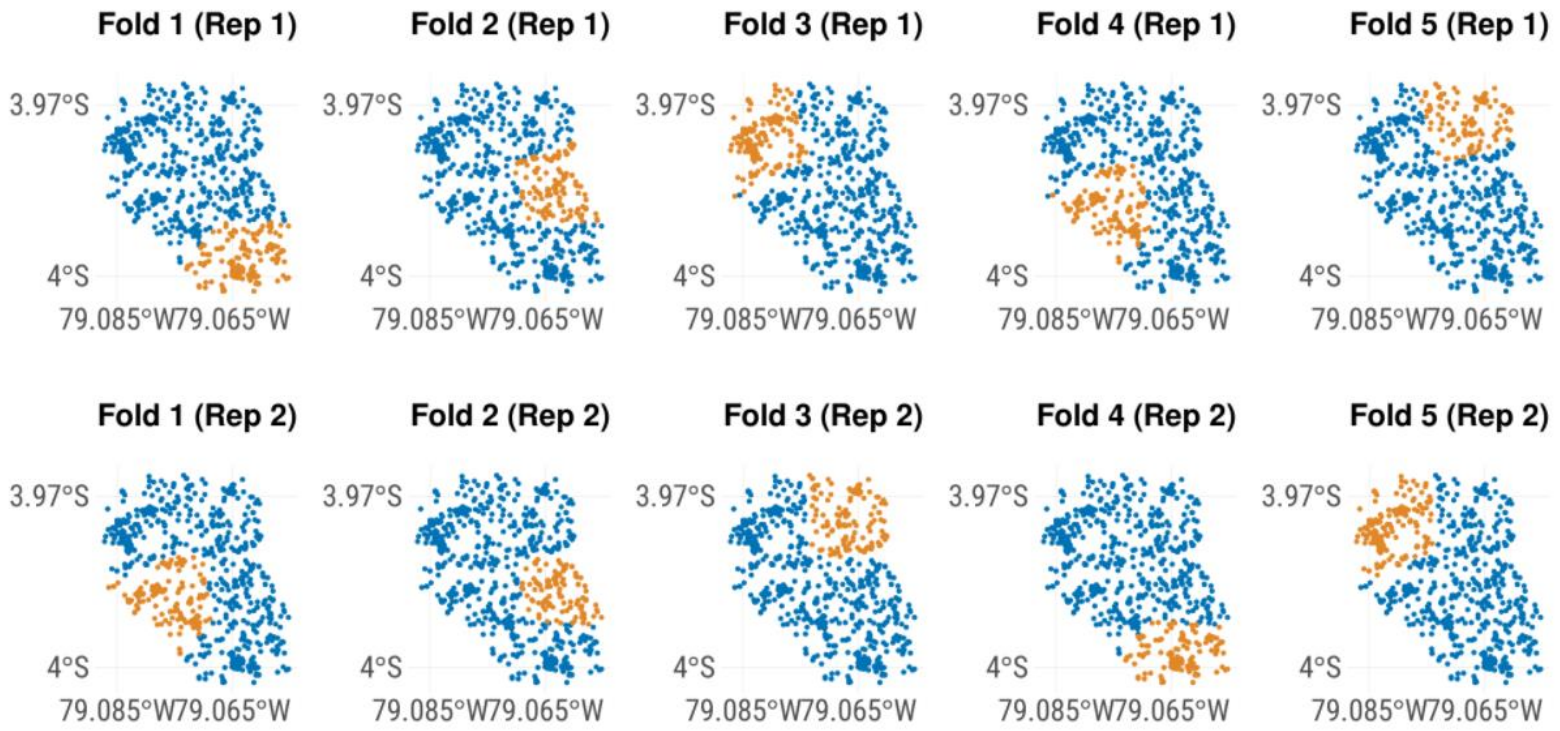
Geostatistics

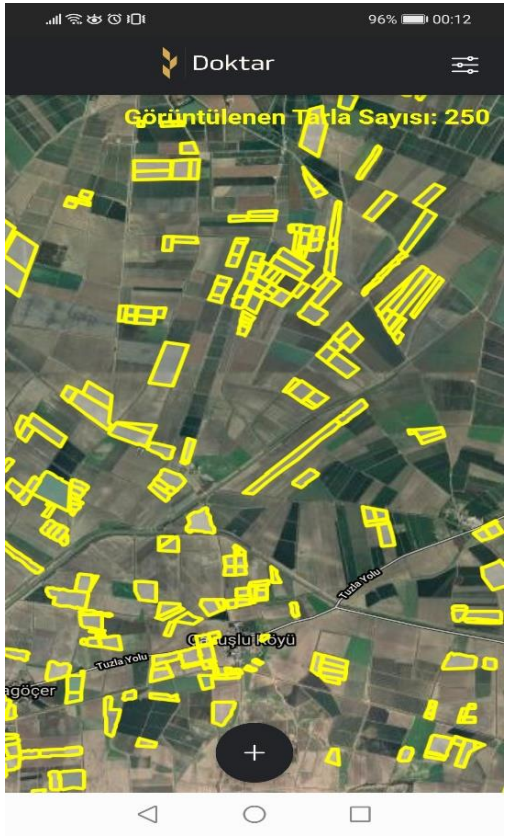
Spatial Cross-Validation



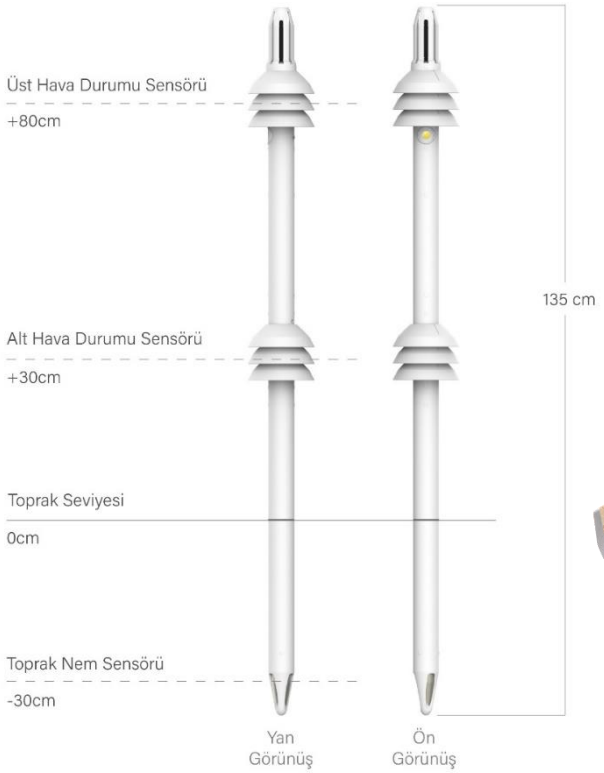
Kaynak: Doktar

Ground truth data collection on large areas is the most challenging issue against the development of statistical models in GIS.

FieldWork
Field Location, Crop Type



Electronic Devices
Soil and Temperature Information



Source: Doktar

Almost in all geographical decision-making, data science techniques are necessary for extracting relevant information.

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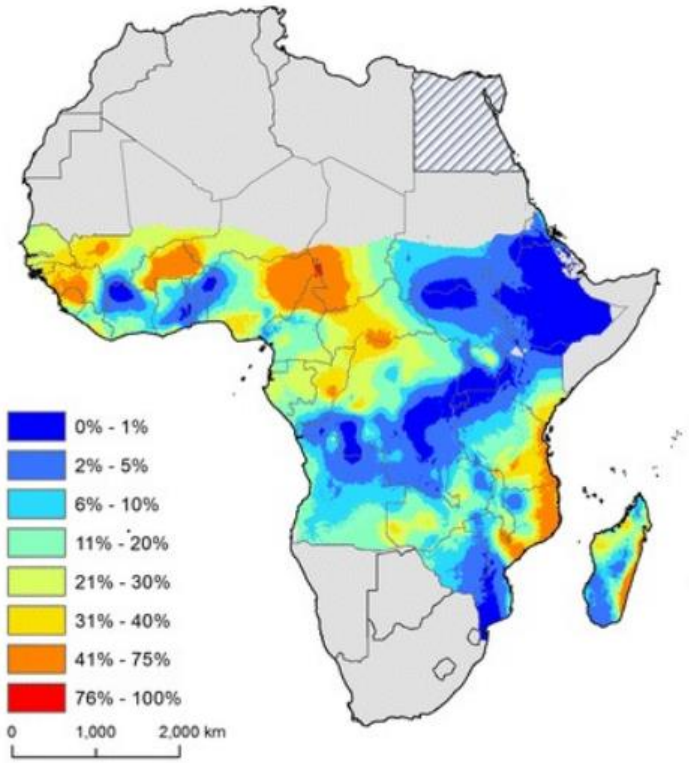
Data Science in GIS & RS
Epidemiology



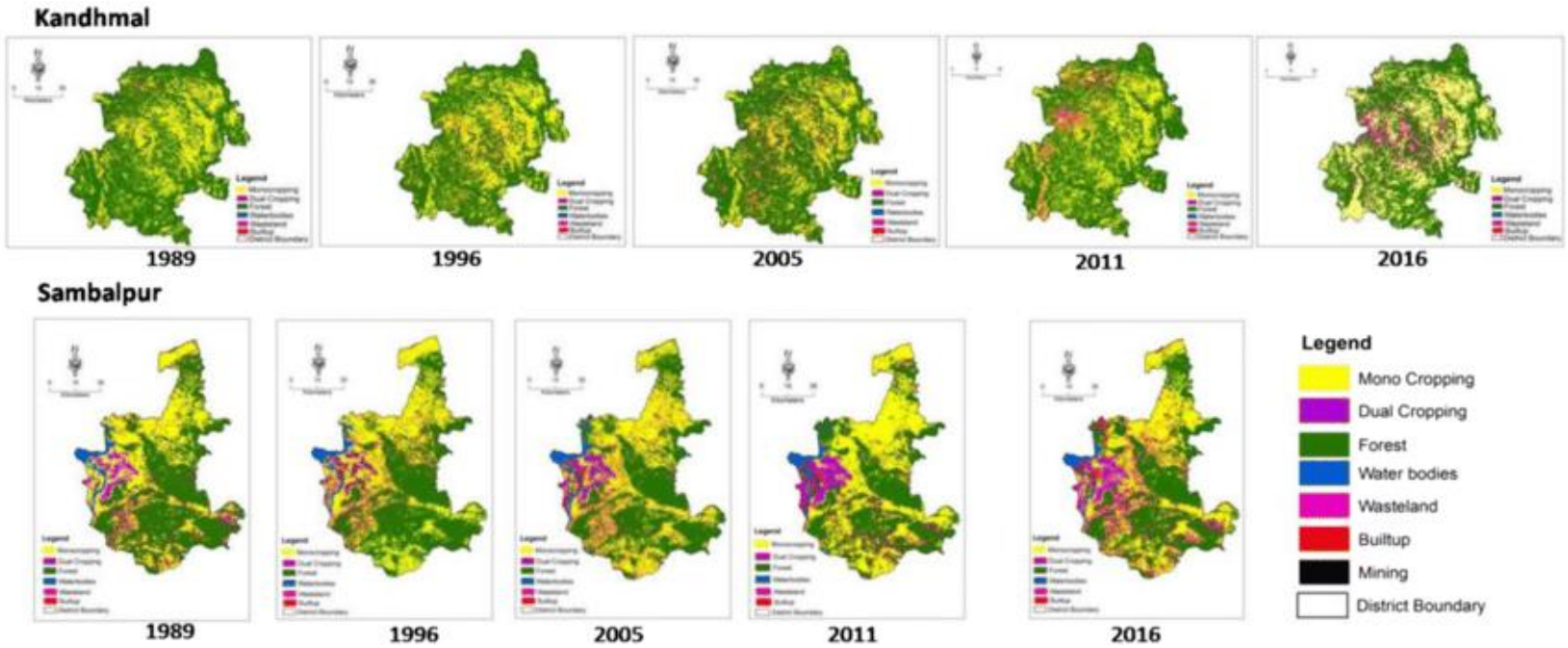
Lymphatic filariasis in sub-Saharan Africa

See here for nice examples: https://www.paulamoraga.com/research/

Source: Doktar

The demand and need for environmental solutions are increasing; thus, the data are being collected more.

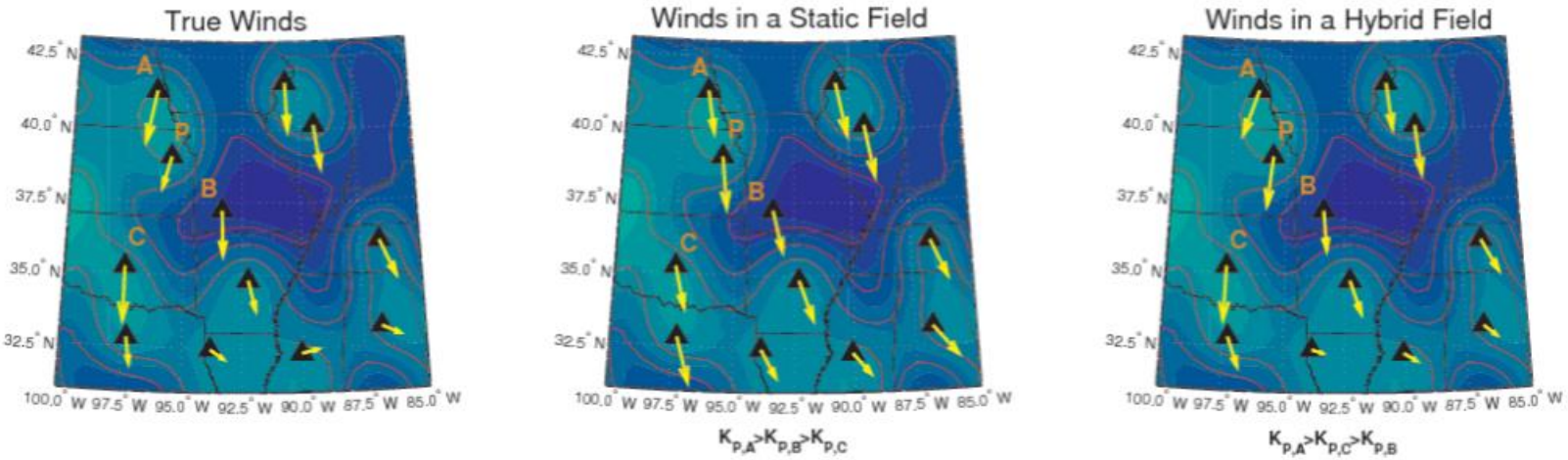
Machine Learning in GIS & RS
Environment



Source: https://www.researchgate.net/publication/330609547_Ecosystem_services_in_different_agro-climatic_zones_in_eastern_India_impact_of_land_use_and_land_cover_change/figures?lo=1

Especially in meteorology, physical models are being powered with deep learning models for weather forecasts.

Machine Learning in GIS & RS
Weather Forecast



Source: https://aditya-grover.github.io/files/publications/kdd15.pdf

Deep Learning algorithms are perfect fit with the civil engineering and urban planning since there is a large amount of capital to collect and process data.

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Machine Learning in GIS & RS

Civil Engineering & Urban Planning

RGB channels

Rasterized Aerial LiDAR

Manually digitized Hip (purple) and Gable (orange) segments

3D reconstruction of building using manually digitized segments

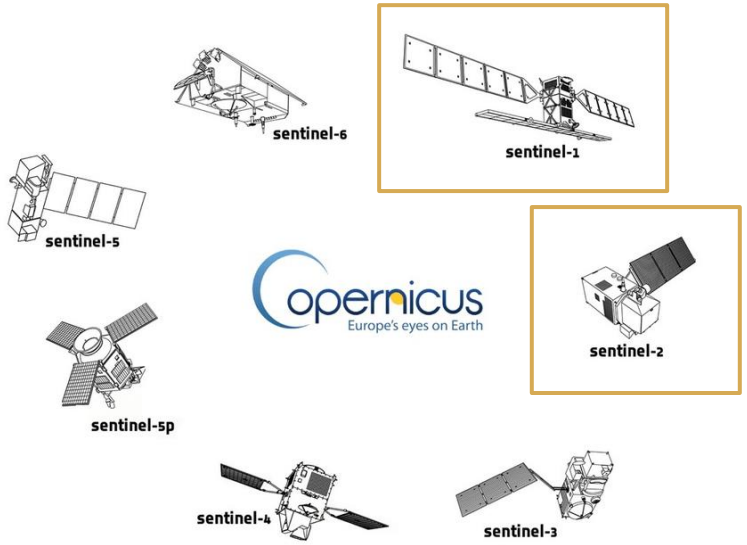
Source: Esri Examples

Agenda

- About Me & Doktar
- GIS & Remote Sensing
- The Industry & Community
- Types of GIS & Remote Sensing Data
- Data Science in GIS & Remote Sensing
- **Implications for Decision Making & Opportunities**

Governments increased their support on Earth Observation data data collection, and now, there are many free data providers.

Satellite Data Sources



Land Monitoring Service

Atmosphere Data Sources

NASA POWER
Prediction of worldwide energy resources

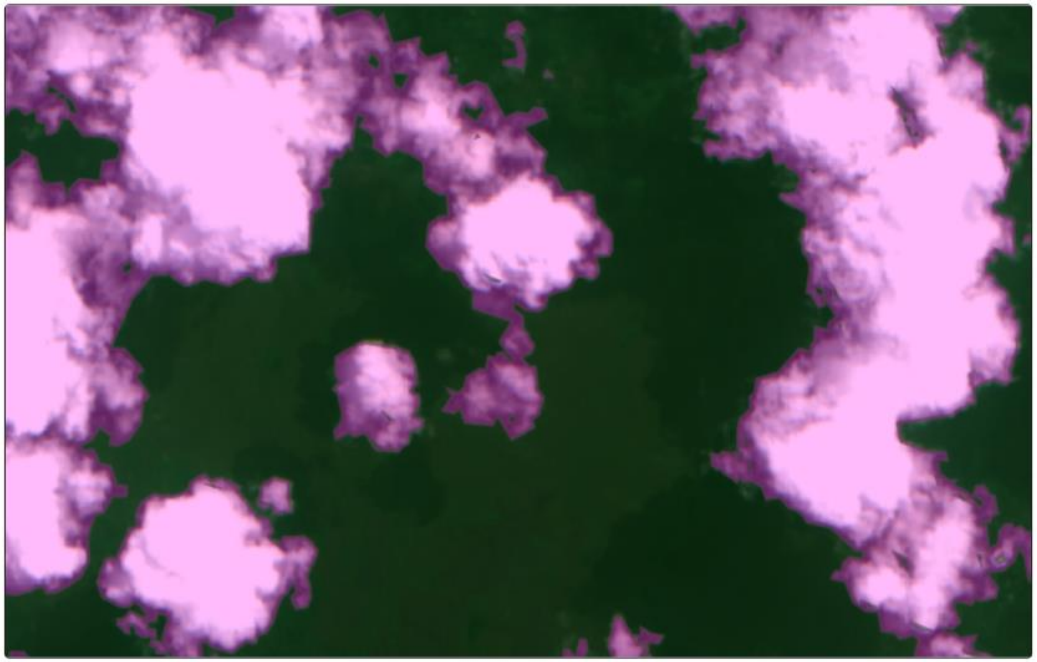
Atmosphere Monitoring Service

Sources: Doktar

Challenges in Remote Sensing are trying to be solved with crowdsource solutions.

Announcing the Winners of the Data Labeling Contest

Radiant Earth Foundation Following
Sep 25 · 3 min read



Representative hand-labeled task for the prize category, Best Quality Labeler.

Sources: Doktar

Heavy computations are now being solved with different solutions.

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Sources: Doktar

In the near future, the cost of operating with satellite will decrease as the services become more widespread. The increases in frequency will solve many problems.

Service	Spectral Resolution	Spatial Resolution	Temporal Resolution	Access
MODIS	36 Bands	250m	1 day	Free
Landsat-8	11 Bands	15m	16 days	Free
Sentinel-2	13 Bands	10m	5 days	Free
PlanetScope	4 Bands (5 ve 8 Bands)	3m	1 day	On-demand
Pleiades	4 Bands	50cm	On-demand	On-demand
Worldview	8 Bands	30cm	On-demand	On-demand

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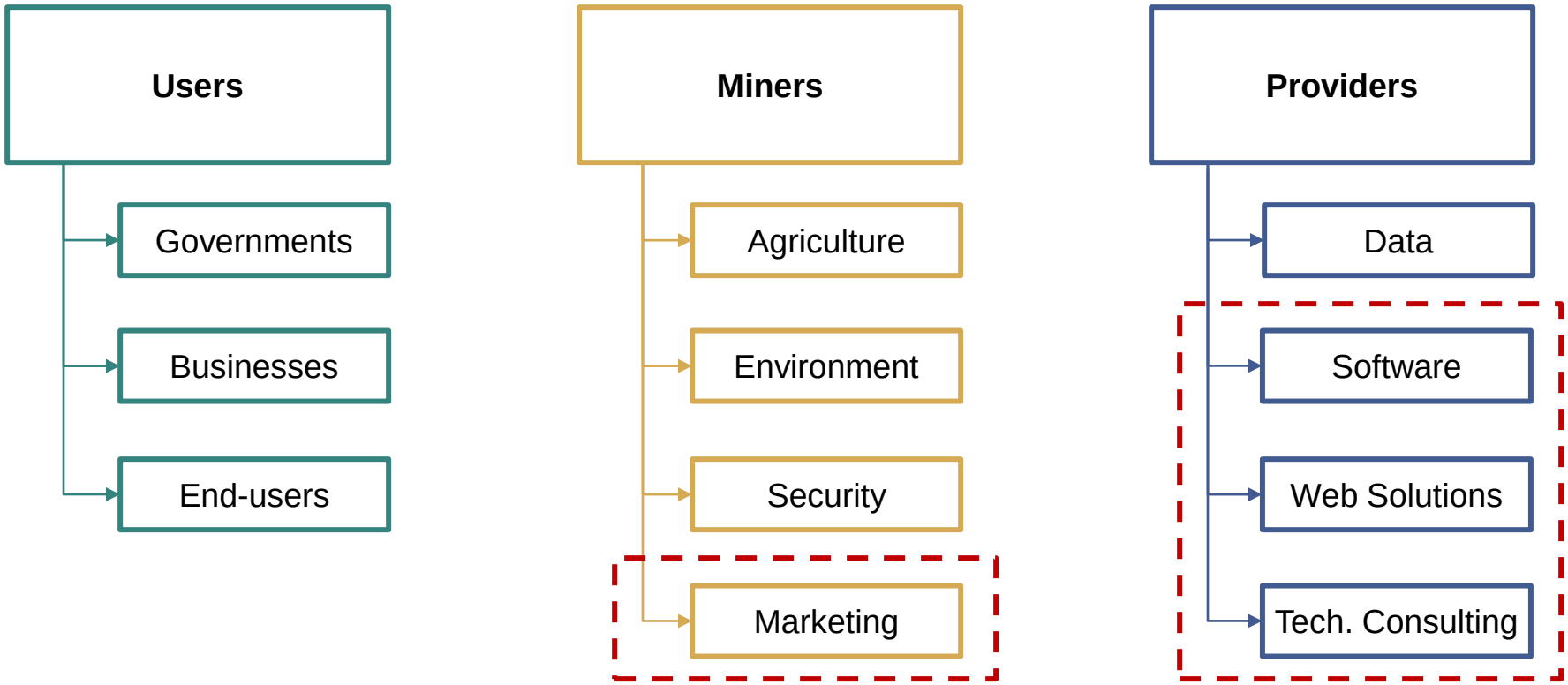
Sources: Doktar

Software and Web Solutions segments are growing as the need for data processing is increasing. You can also create solutions in marketing with the locational data especially in retail.

GIS & Remote Sensing Industry

The Value Chain



Source: Doktar

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