# United Nations Global Working Group on Big Data for Official Statistics

## Task Team:
## Earth Observation for Agricultural Production Statistics

## Design of Training Program

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# Task Team – Terms of Reference (extract)

"Support member countries by helping develop new methods for the collection, analysis and use of new data sources, such as Earth Observation (EO) data, for evidence-based decision making in support of national policies and international agreements."

Focus on SGD Goal 2, Target 2.4:

"By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality."

Indicator 2.4.1:

"Proportion of agricultural area under productive and sustainable agriculture."

# Task Team – Objectives (extract)

## *Trusted Methods*

- Analysis of Analysis Ready Data (ARD) and Production Ready Data (PRD) satellite-based Earth Observation (EO) Data for estimation of crop types, areas and yields, and land-use change

## *Trusted Training*

- Training material on the use of methods and algorithms to estimate crop types and crop yields

# Task Team – Training Approach

*Phase 1*

- Define User Profiles and Knowledge Areas
- Collate existing online training courses from trusted sources
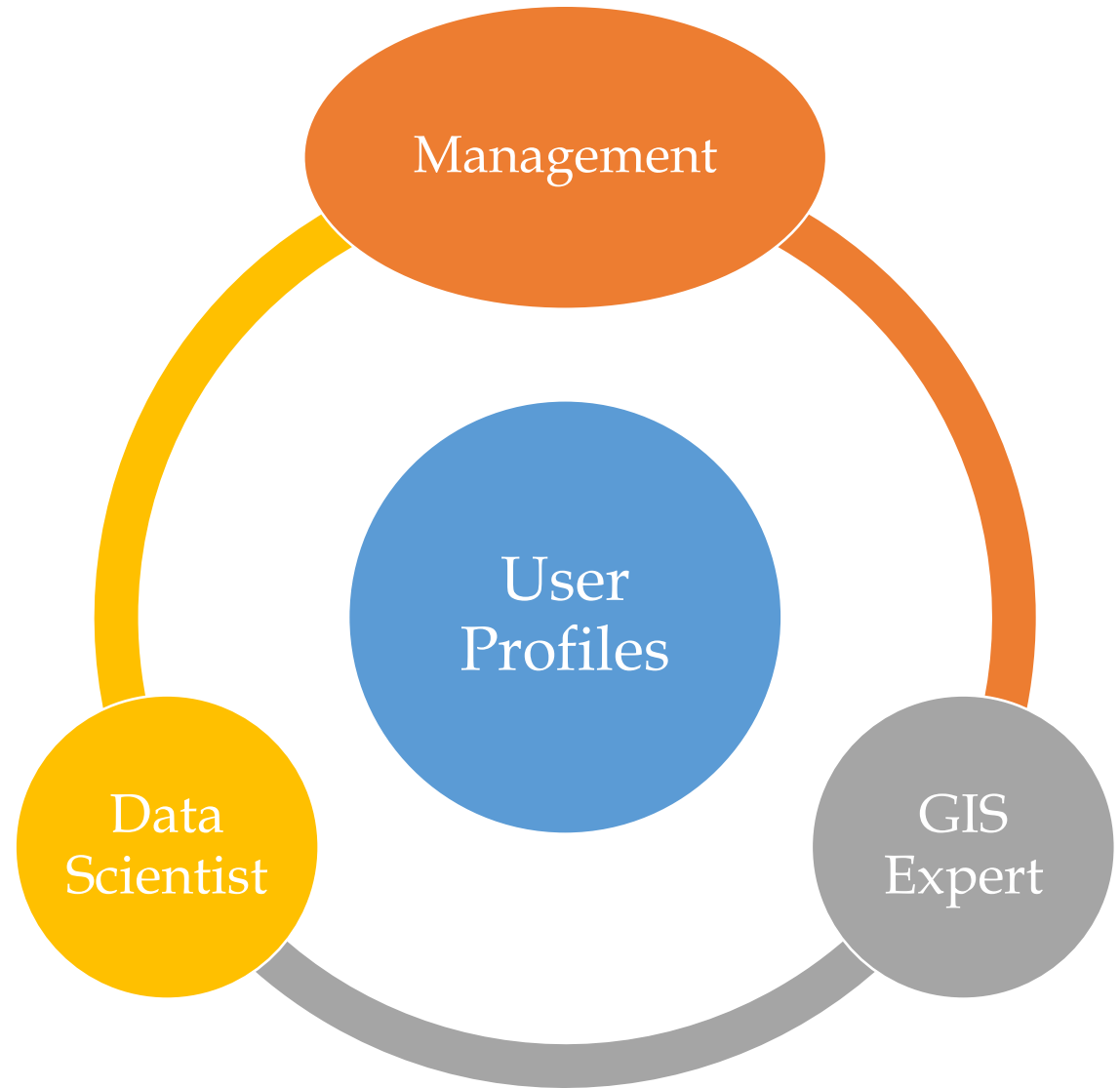- Create a Personalized Training Program based on existing courses

*Phase 2*

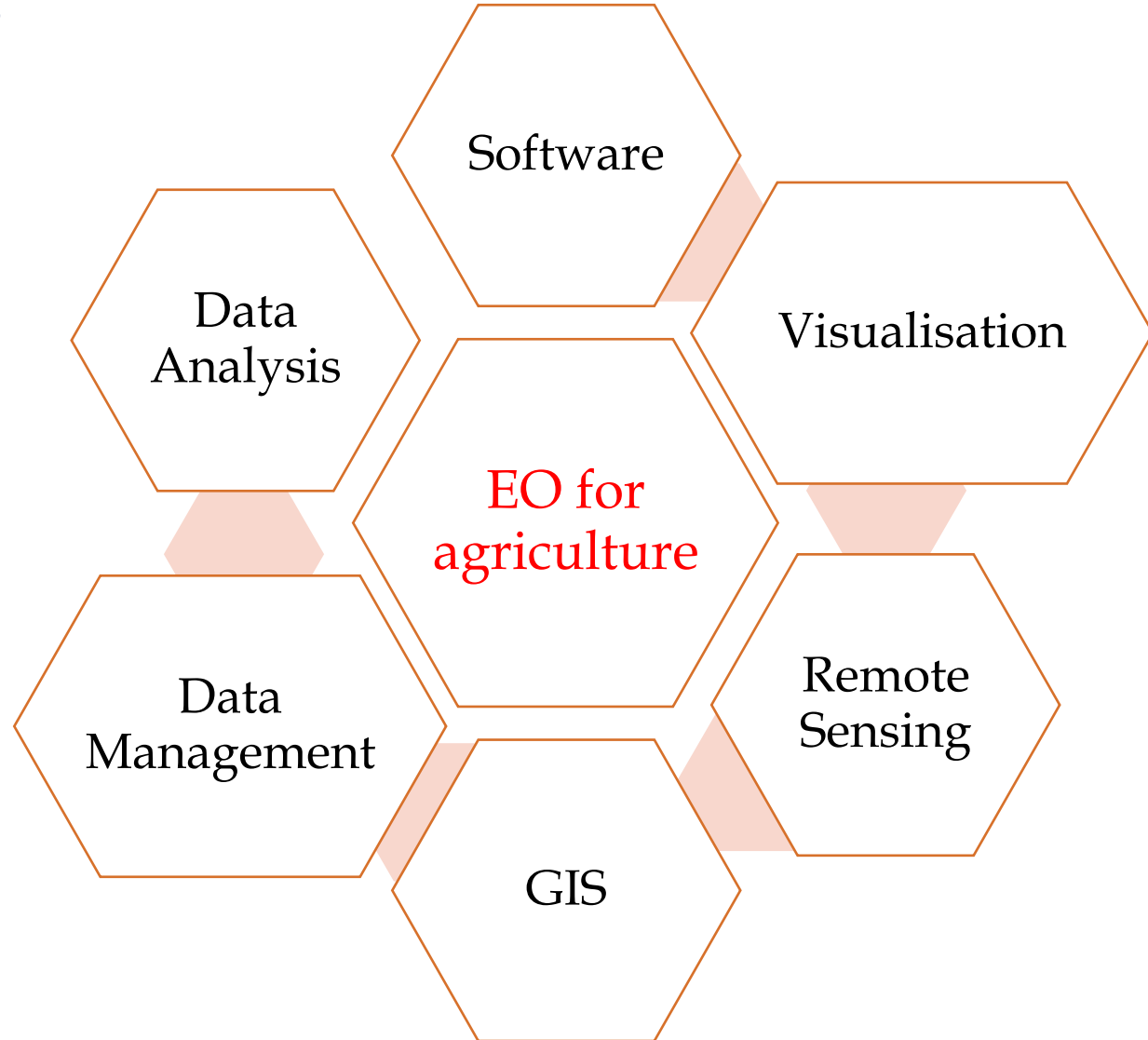- Add a *spine* of UN short courses to introduce training modules

*Phase 3*

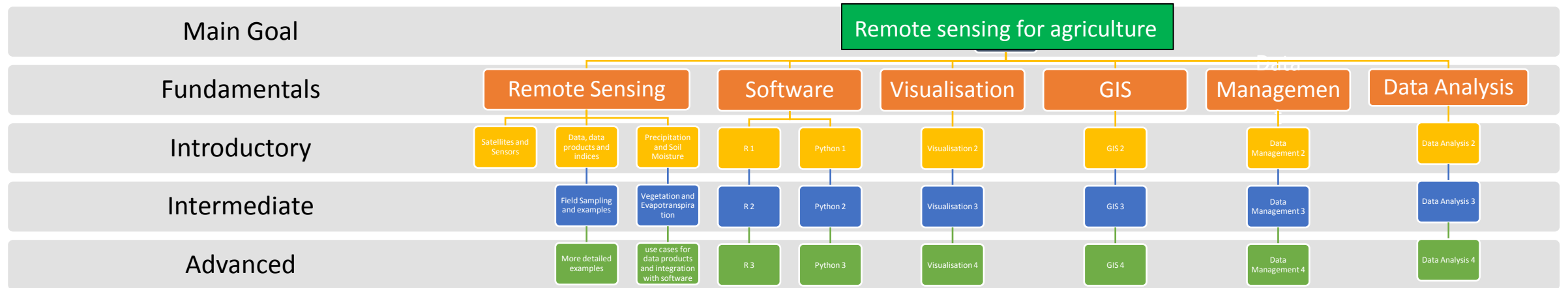- Create a full suite of tailored UN short courses

# User Profiles

# Knowledge Areas

# User profiles

| Role | Professional Background | ID | Use Case | Software | Programming language |
|------|------------------------|----|----------|----------|---------------------|
| M | All | E1 | EO and GIS for agricultural statistics: high level introduction to the new technology and paradigm shift provided by Big Data, Cloud Computing and Machine learning | NA | NA |
| M/G | | E2 | Basics of GIS: raster and vector mode data                              Georeferencing statistical data and production of maps       WebGis Dashboards and Web Gis apps (e.g. Story maps) | NA | NA |
| G | | E3 | Land cover mapping Supervised methods desktop users | FD/CD | NA/Python |
| G | | E4 | Crop mapping  Supervised methods desktop users | FD/CD | NA/Python |
| G | | E5 | Development of webgis apps and dashboards | CD/CO | NA/Python |
| G | | E6 | Extracting land cover and land use statistics from available GIS sources (e.g Forest and Crop cover from ESA maps) | CD/CO | NA/Python |
| G/D | | E7 | Field data collection - Best practices, GPS,  field spectrometer | | |
| G/D | All | M1 | Land cover mapping using optical data in Google Earth Engine/R/Python | FO | Python/R/Jjavascript |
| G/D | | M2 | Crop type mapping using   optical data in Google Earth Engine/R/Python | FO | Python/R/Jjavascript |
| G/D | | M3 | Crope type mapping using unsupervised method in Google Earth Engine/R/Python | FO | Python/R/Jjavascript |
| G/D | | M4 | Crope type mapping using unsupervised method in Google Earth Engine/R/Python | CD | Python/R/Jjavascript |
| G/D | | M5 | Field data collection with drones | CD | N/A |
| G/D | All | A1 | Classification using Optical and SAR supervised | any | Python/R/Jjavascript |
| G/D | | A2 | Classification using Optical and SAR unsupervised | any | Python/R/Jjavascript |
| G/D | | A3 | Fourier transform and Principal Component analysis | any | Python/R/Jjavascript |
| G/D | | A4 | Crop type mappign using Optical and SAR | any | Python/R/Jjavascript |
| G/D | | A5 | Convolutional networlk and Deep Learning - Land cover and Crop mapping | any | Python/R/Jjavascript |
| G/D | | A6 | Working with hyperspectral data | any | Python/R/Jjavascript |

# Knowledge Areas - Larger picture



| | | | | | | |
|---|---|---|---|---|---|---|
| **Main Goal** | | | Remote sensing for agriculture | | | |
| **Fundamentals** | Remote Sensing | Software | Visualisation | GIS | Data Managemen | Data Analysis |
| **Introductory** | Satellites and Sensors / Data, data products and indices / Precipitation and Soil Moisture | R 1 / Python 1 | Visualisation 2 | GIS 2 | Data Management 2 | Data Analysis 2 |
| **Intermediate** | Field Sampling and examples / Vegetation and Evapotranspiration | R 2 / Python 2 | Visualisation 3 | GIS 3 | Data Management 3 | Data Analysis 3 |
| **Advanced** | More detailed examples / use cases for data products and integration with software | R 3 / Python 3 | Visualisation 4 | GIS 4 | Data Management 4 | Data Analysis 4 |

# Remote Sensing Module

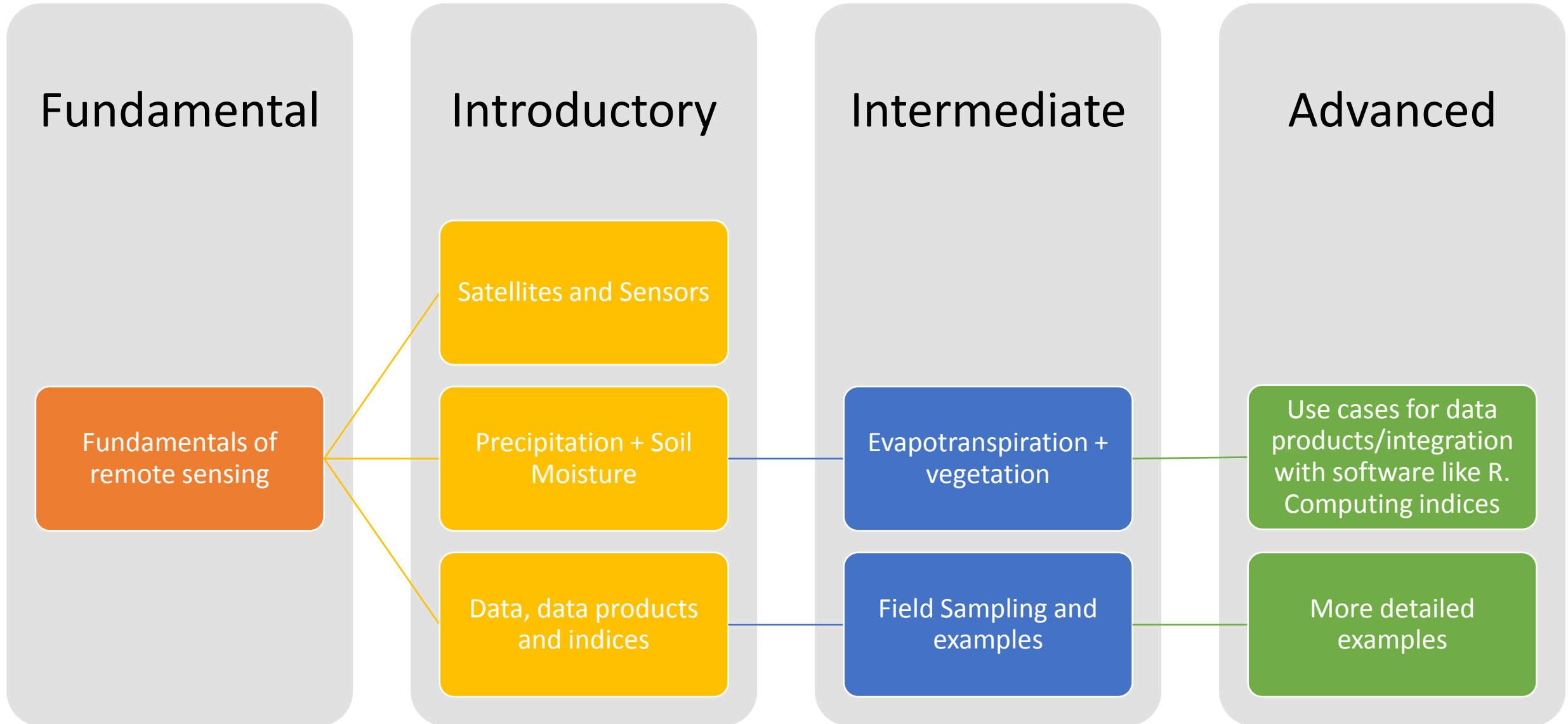| Fundamental | Introductory | Intermediate | Advanced |
|---|---|---|---|
| Fundamentals of remote sensing | Satellites and Sensors | | |
| | Precipitation + Soil Moisture | Evapotranspiration + vegetation | Use cases for data products/integration with software like R. Computing indices |
| | Data, data products and indices | Field Sampling and examples | More detailed examples |

# Example – Remote Sensing Module



- Teach people how to handle satellite imagery

**Overall Goal**

**Fundamental**

- What is remote sensing?
- What are some of the agricultural applications?
- What data do we have access to?

- What is this data product and why do we measure it?
- Where can I find this data?
- How might I use this data?
- How do I calculate indices?

**Introductory**

**Intermediate**

- What are some examples of remote sensing in Agriculture? E.g. water resources management
- How do I do field sampling?

- More detailed examples Bringing all the knowledge gained so far together
- How can we use software to handle this data?

**Advanced**

# Summary of courses

| key | | | | | | | |
|---|---|---|---|---|---|---|---|
| not yet investigated | | | | | | | |
| investigated and summarised | | | | | | | |
| Content downloaded and saved | | | | | | | |
| Provider | Mode | Course name | Level | Role | ID | Software | Pre-requisites |
| NASA | Free and Online | Satellites, Sensors, Data and Tools for Land Management and Wildfire Applications | Entry level | M/G/D | E1-E7 | | |
| NASA | Free and Online | Fundamentals of Aquatic Remote Sensing | Entry level | M/G/D | E1-E7 | | |

# Agricultural Courses

| Provider | Mode | Course name | Level | Role | ID | Software | Pre-requisites | L |
|---|---|---|---|---|---|---|---|---|
| NASA | Free and Online | Satellites, Sensors, Data and Tools for Land Management and Wildfire Applications | Entry level | M/G/D | E1-E7 | | | h |
| NASA | Free and Online | Fundamentals of Aquatic Remote Sensing | Entry level | M/G/D | E1-E7 | | | |
| NASA | Free and Online | Satellite Remote Sensing for Agricultural Applications | Entry level | M/G/D | E1-E7 | | | h |
| NASA | Free and Online | Fundamentals of Remote Sensing | Entry level | M/G/D | E1-E7 | | | |
| NASA | Free and Online | Using Earth Observations to Monitor Water Budgets for River Basin Management | Entry level | M/G/D | E1-E2 | | | h |
| NASA | Free and Online | Introductory Webinar: Overview and Applications of Integrated Multi-Satellite Retrievals for GPM (IMI | Entry level | | | | | h |
| NASA | Free and Online | Groundwater Monitoring using Observations from NASA's Gravity Recovery and Climate Experiment (GRACE) Missions | Entry level | M/G/D | E1-E2 | | | h |
| NASA | Free and Online | Introduction to Synthetic Aperture Radar | Entry level | M/G/D | E1-E7 | | | h |
| NASA | Free and Online | Remote Sensing of Coastal Ecosystems | Entry level | M/G/D | Not sure | | | h |
| NASA | Free and Online | Investigating Time Series of Satellite Imagery | Medium | G/D | M1-M4 | | | h |
| NASA | Free and Online | Forest Mapping and Monitoring with SAR Data | Advanced | G/D | A1-A2 | | | h |
| NASA | Free and Online | SAR for Landcover Applications | Advanced | G/D | A1, A2, A4 | | | h |
| NASA | Free and Online | Applications of GPM IMERG Reanalysis for Assessing Extreme Dry and Wet Periods | Advanced | D | A6 | | | h |
| NASA | Free and Online | Using Earth Observations to Monitor Water Budgets for River Basin Management II | Advanced | G/D | A6 | | | h |
| NASA | Free and Online | Accuracy Assessment of a Land Cover Classification | Medium | D | M3-M4 | Google Earth Engine | | h |
| NASA | Free and Online | Change Detection for Land Cover Mapping | Advanced | D | A1-A2 | QGIS, R | | h |
| NASA | Free and Online | Remote Sensing of Drought | Advanced | D | A6 | QGIS | | h |
| NASA | Free and Online | Land Cover Classification with Satellite Imagery | Advanced | D | A6 | QGIS | | h |
| NASA | Free and Online | Creating and Using Normalized Difference Vegetation Index (NDVI) from Satellite Imagery | Advanced | D | A7 | QGIS | | h |
| ESA | Free and Online | Echoes in space: Introduction to Radar remote sensing | MOOC | M/G/D | E1-E7 | | | h |
| ESA | Free and Online | Earth Observation from Space: the Optical View | MOOC | M/G/D | E1-E7 | | | t |
| ESA | Free and Online | Monitoring Climate from Space | MOOC | M/G/D | E1-E8 | | | t |
| | | | | | | | | |
| Penn State University | Online | Master of Geographic Information Systems | A range of courses from entry to advanced level | M/G/D | | | | t |
| University of Missouri | on campus | **Certificate in Precision Agriculture Technology** | Precision Agriculture | M/D | M5 | | | |
| | | *Precision Agriculture Science and Technology* | | | | | | |
| | | *Machinery Management Using Precision Agriculture Technology* | | | | | | |
| | | *Data Management and Analysis Using Precision Agriculture Technology* | | | | | | |
| | | *Profit Strategies Using Precision Agriculture Technology* | | | | | | |
| | | | | | | | | |
| IHE Delft Institute for Water Education | Online | Remote Sensing for Agricultural Water Management | | D | | | | |
| | | *Introduction to Earth observation and remote sensing techniques* | | | | | | |
| | | *Remote Sensing data analysis* | | | | | | |
| | | *Land cover classification* | | | | QGIS, Google Earth Engine | | |
| | | *Remote sensing for Evapotransipration, biomass production and water productivity assessment* | | | | python | | |
| | | *Remote sensing for enhancing performance of irrigation systems* | | | | | | |

# Spatial Statistics Courses

| | | | | | | |
|---|---|---|---|---|---|---|
| Atlan | Free online | Introduction to GIS: Manipulating and Mapping Geospatial Data in R | Entry level | | R | https://atlan.com/courses/intro |
| ESRI | Free online MOOC | Spatial Data Science: The new frontier in analytics | Entry level | | | https://www.esri.com/training/ |
| ESRI | Free online MOOC | Going places with spatial analysis | Entry level | | not currerntly running | https://www.esri.com/training/ |
| MIT open courseware | Free and Online | Spatial statistics | Entry level | | | https://ocw.mit.edu/resources/ |
| University of Toronto | Free online through cousera | GIS, Mapping, and Spatial Analysis Specialization | Entry level | | | https://www.coursera.org/spec |
| ANU | Internal | GIS and spatial analysis | Entry level | | | https://programsandcourses.an |
| datacamp | free and online to a point | Spatial Statistics in R | Entry level | | | https://www.datacamp.com/c |
| University of Helsinki | free and online | Geo-python 2019 | Entry level | | | https://geo-python.github.io/si |
| University of Helsinki | free and online | Automating GIS-processes | Follow on | | | https://automating-gis-process |
| Yonsia university | free to audit via coursera | Spatial Data science and applications | Intermediate level | | | https://www.coursera.org/learn |

# Personalised Self Learning System

Say we have a selection of user profiles, and a selection of knowledge areas.
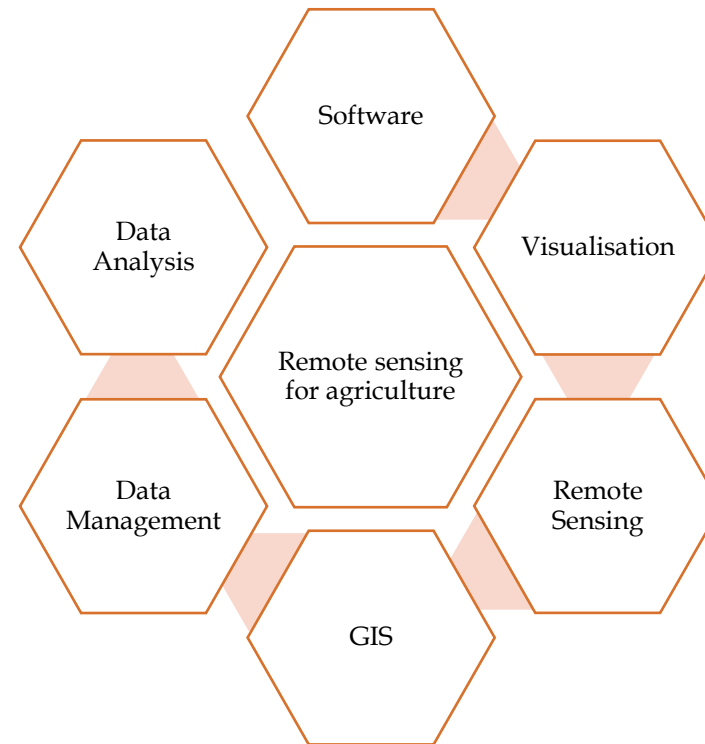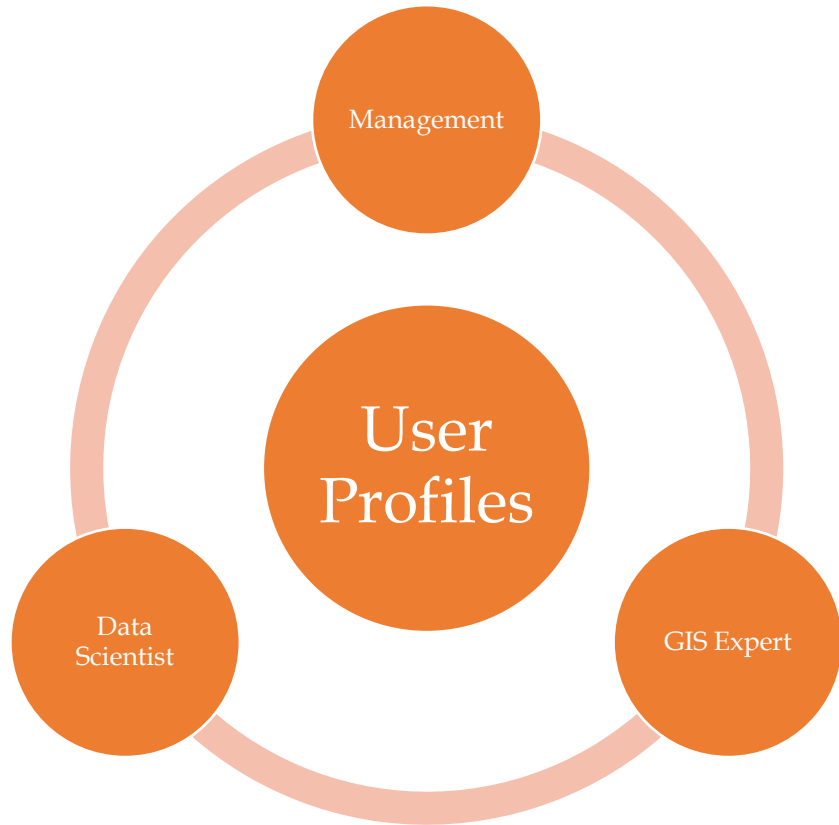
# Personalised Self Learning System

## What is your role?

| Data Scientist |
|---|

## Where are you now?

| 3 | In python? | 3 | In R? | 5 | In Data Acquisition? | 3 | In Data Processing? | 1 | In Data Analysis? | 1 | In GIS? |
|---|---|---|---|---|---|---|---|---|---|---|---|

## Where do you want to be?

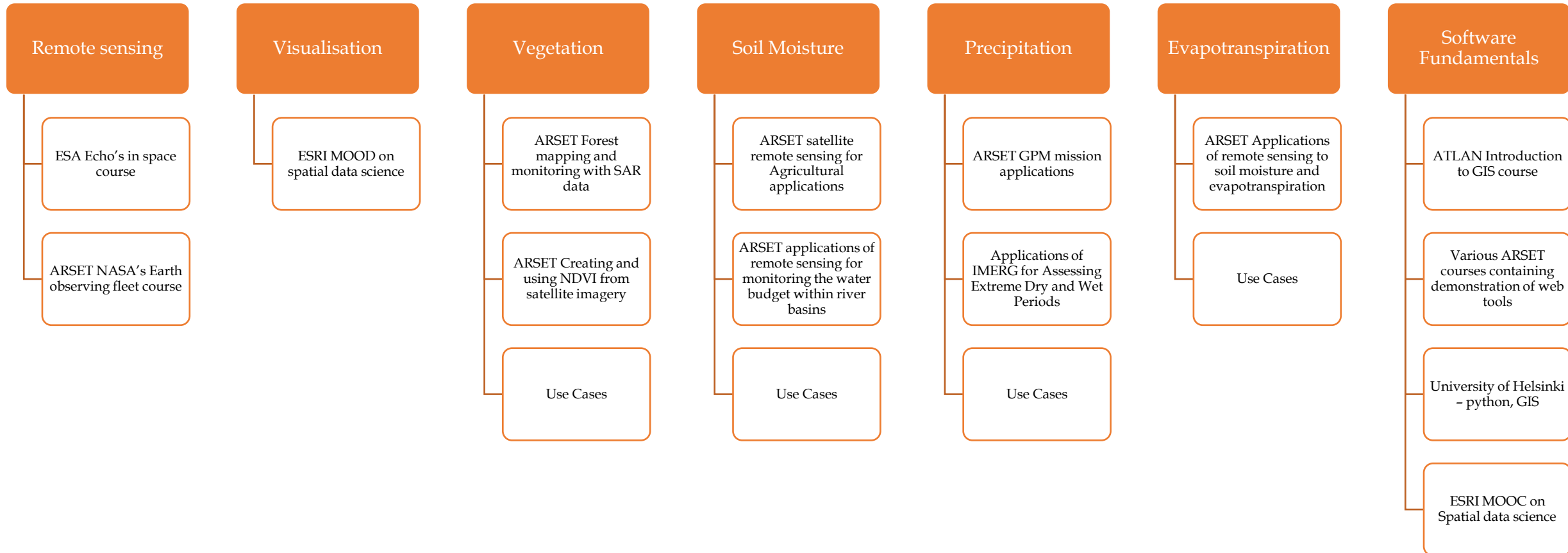| 5 | In python? | 3 | In R? | 5 | In Data Acquisition? | 4 | In Data Processing? | 3 | In Data Analysis? | 3 | In GIS? |
|---|---|---|---|---|---|---|---|---|---|---|---|

## Recommended Courses

The university of Helsinki's Auto-GIS courses will improve both your python and GIS skills

Esri's MOOC on spatial data science will help boost your data processing and analysis skills

# Phase 2: Training Course "Spine"

Orange coloured in boxes form the spine and some recommendations for further reading on each topic follows below (not an exhaustive list).

| Remote sensing | Visualisation | Vegetation | Soil Moisture | Precipitation | Evapotranspiration | Software Fundamentals |
|---|---|---|---|---|---|---|
| ESA Echo's in space course | ESRI MOOD on spatial data science | ARSET Forest mapping and monitoring with SAR data | ARSET satellite remote sensing for Agricultural applications | ARSET GPM mission applications | ARSET Applications of remote sensing to soil moisture and evapotranspiration | ATLAN Introduction to GIS course |
| ARSET NASA's Earth observing fleet course | | ARSET Creating and using NDVI from satellite imagery | ARSET applications of remote sensing for monitoring the water budget within river basins | Applications of IMERG for Assessing Extreme Dry and Wet Periods | Use Cases | Various ARSET courses containing demonstration of web tools |
| | | Use Cases | Use Cases | Use Cases | | University of Helsinki – python, GIS |
| | | | | | | ESRI MOOC on Spatial data science |

# Example Spine Course

| Course | No. of Sessions | Description | User Profile | Keywords | Recommendations |
|---|---|---|---|---|---|
| **Fundamentals of remote sensing** | 1 | Session 1:<br>- The EM Spectrum<br>- Spectral Signatures<br>- Satellites vs sensors<br>- Radar vs optical<br>- Types of orbit<br>- Passive vs active<br>- Resolution<br>- Data processing levels<br>- Advantages and disadvantages<br>- Vague applications<br>- The radar bands<br>- Scattering mechanisms | M/D/G | Fundamental; remote sensing; manager; data scientist; GIS expert; | ARSET NASA's Earth observing fleet; ESA Echo's in space; |

# Next Steps

1. Complete Audit of Trusted Online Training Courses
   - Integrate UN affiliated courses from other regions

2. Create a prototype of the Personalised Self Learning System
   - Add features, e.g. "number of hours" to gain a level of competency to user

3. Design Training Course Spine and networked courses

# Example Use Case (Lorenzo DeSimone) OVERALL GOAL

## *Crop Mapping using Sen2Agri tool box*
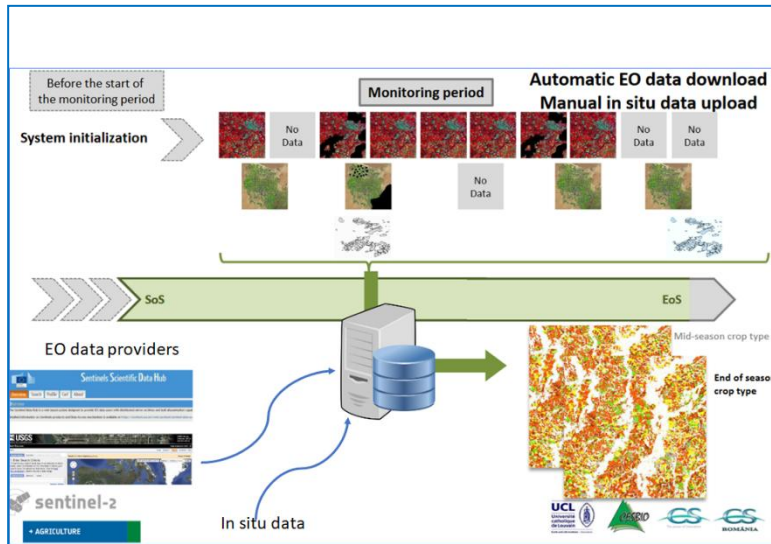
**Abstract**: **Sen2Agri,** is a user friendly software that allows for automatic acquisition and **preprocessing of EO data**, manual **upload of in-siti data**, and production of crop maps using a **Random Forest classifier**. It can run both local or on **Cloud**

**Learning goals**
- How to install the software
  - Cloud deployment
  - Local machine deployment
- How to select EO data, How to ingest in-situ data
- How to generate seasonal crop masks and crop maps

**Fundamentals**
- Remote sensing: Principles
- Agronomy: Crop calendars
- Statistics: Classification methods

**Introductory**
- Phenology and Vegetation indexes from EO data
- Pixel based VS Object based classification approaches
- Map accuracy evaluation methods

**Intermediate**
- Random Forest classifier in R or in Python
- Field sampling design
- Best practices in georeferencing crop data in the field

**Advanced**
- Cloud masking algorithms
- Cloud Services: how to use AWS cloud services for Sen2Agri