

Online training :Addressing the Water-Energy-Food-Ecosystems (WEFE) Nexus in the context of Climate change in the Mediterranean region (6-8 Dec.,2021).

Session 4 - Operationalization of WEFE Nexus in agri-food systems in Egypt

Impact of Nexus practices on the sustainability of Corn and Summer Legumes Production

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PRIMA PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA

Statement of the Problem

- **The decreasing acreage of cultivated land and summer legumes in Egypt necessitates adopting untraditional solutions for upgrading the efficiency of utilizing the agricultural resources.**
- **Excessive applied irrigation water and nitrogen (N) mineral fertilization are common agricultural practices that often negatively influence soil and environmental quality in crop production systems.**
- **Intercropping various crops in the same field upgrading the agricultural production particularly under limited agricultural resources.**
- **The intensification of cropping systems may be greatly compensate the shortages of production and consequently the food and commodities insufficient in Egypt.**

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SIGMA Nexus

Advantages of Intercropping

- **1-Higher Land Equivalent Ratio (LER) of intercropped production of unit area than solid cropping systems.**

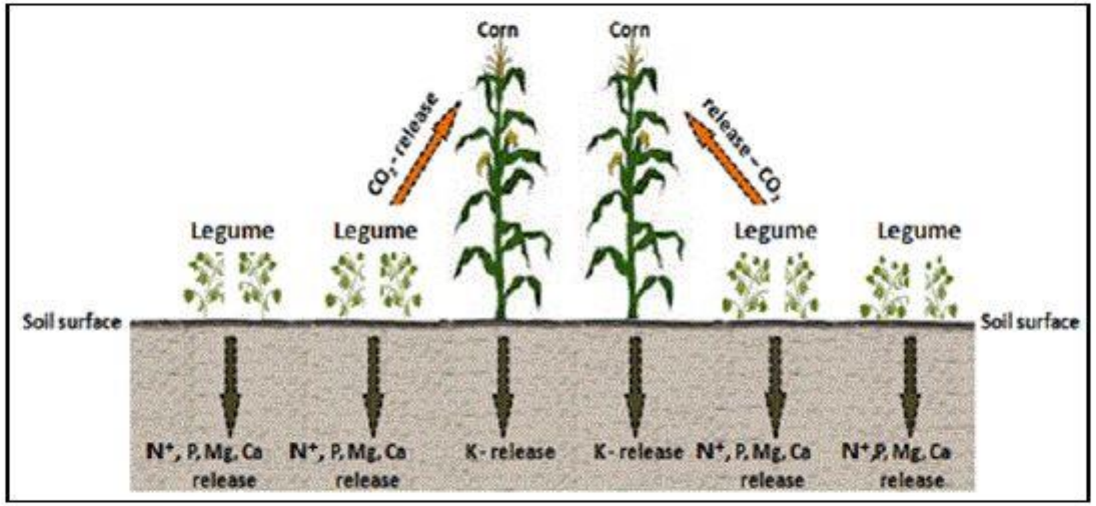
- 2-**Intercropping reduces applied irrigation water.**

- **3-Intercropping reduces required mineral N fertilization.**

4-Strenghten the advantages of multiple cropping pattern than mono-crop systems .

5-Intercropped enhances soil productivity.

C.F Metwally *et al* (2019)



The results show that legume as C3-crop has 33% of light saturation that loses large amounts of carbon dioxide and consequently enhances total soil phosphor (P^-), nitrogen (N^+), magnesium (Mg^{++}) and calcium (Ca^{++}). Corn as C4-crop has 100% of light saturation that benefited largely from legume photorespiration in photosynthesis process and consequently enhances total soil potassium (K^+). These results confirmed that intercropping legumes with corn enhanced soil productivity especially under marginal and new lands.

General Objectives

Elucidating the proper cropping **pattern/s** and cultural practices that will **maximize** the productivity, land equivalent ratio (**LER**), irrigation water use efficiency (**IWUE**) of intercropping corn with some summer food legumes **versus** traditional practices in Al-Minia governorate.

Specific Objectives

Exploring the effects of corn/legumes intercropping patterns and cultural practices that upgrading the LER and IWUE as follows:

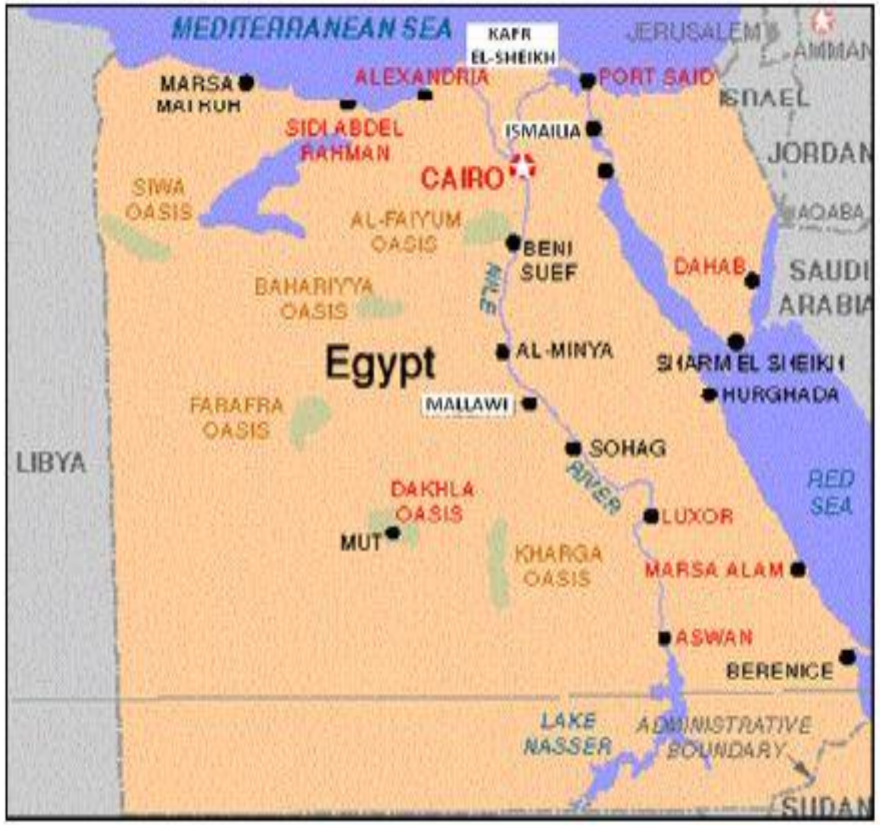
1-Saving 25% of adopting irrigation water (S) *vs.* Normal (N) watering regimes, by each 12 and 15 days, respectively.

2-Using 2x 2 intercropping system (with 100% corn and legume plants) *vs.* solid planting of both crops.

3-Intercropping both soybean and mungbean with corn with different varieties and hybrids.

4-Using traditional ridges (distanced 70 cm) vs. 140 cm growing beds.

5- Try to replacing some nitrogenous fertilizer with symbiotic N / natural Bio foliar application.


MEDITERRANEAN SEA
KAFR EL-SHEIKH
JERUSALEM
AMMAN
MARSA MATRUH
ALEXANDRIA
PORT SAID
ISRAEL
SIDI ABDEL RAHMAN
ISMAILIA
JORDAN
CAIRO
SIWA OASIS
AL-FAIYUM OASIS
AQABA
BENI SUEF
DAHAB
SAUDI ARABIA
BAHARIYYA OASIS
NILE
AL-MINYA
Egypt
SHARM EL SHEIKH
HURGHADA
FARAFRA OASIS
MALLAWI
SOHAG
LIBYA
RIVER
RED SEA
DAKHLA OASIS
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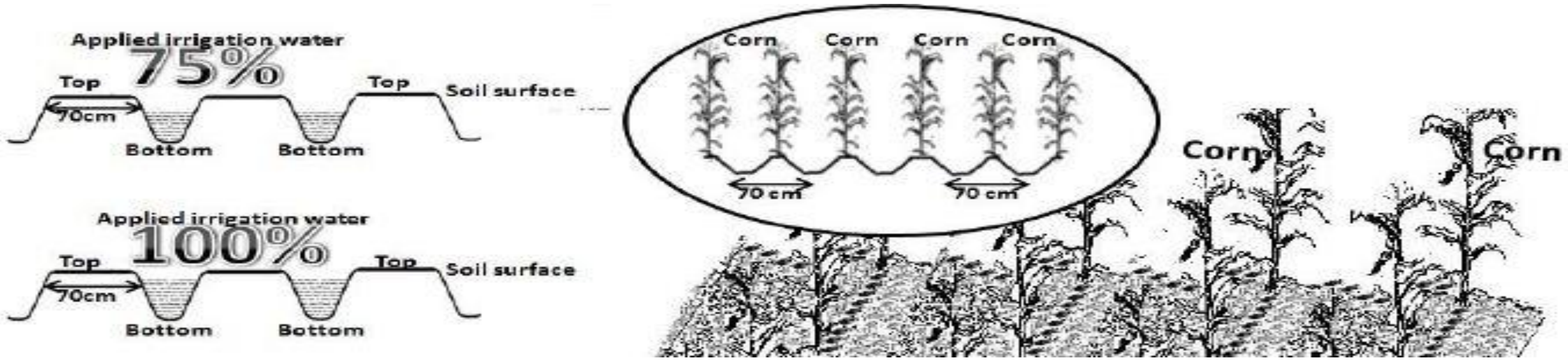
KHARGA OASIS
MARSA ALAM
ASWAN
BERENICE
LAKE NASSER
ADMINISTRATIVE BOUNDARY
SUDAN


Applied irrigation water
75%
Top
Top
Soil surface
70cm
Bottom
Bottom
Applied irrigation water
100%
Top
Top
Soil surface
70cm
Bottom
Bottom
Corn
Corn
Corn
Corn
70 cm
70 cm
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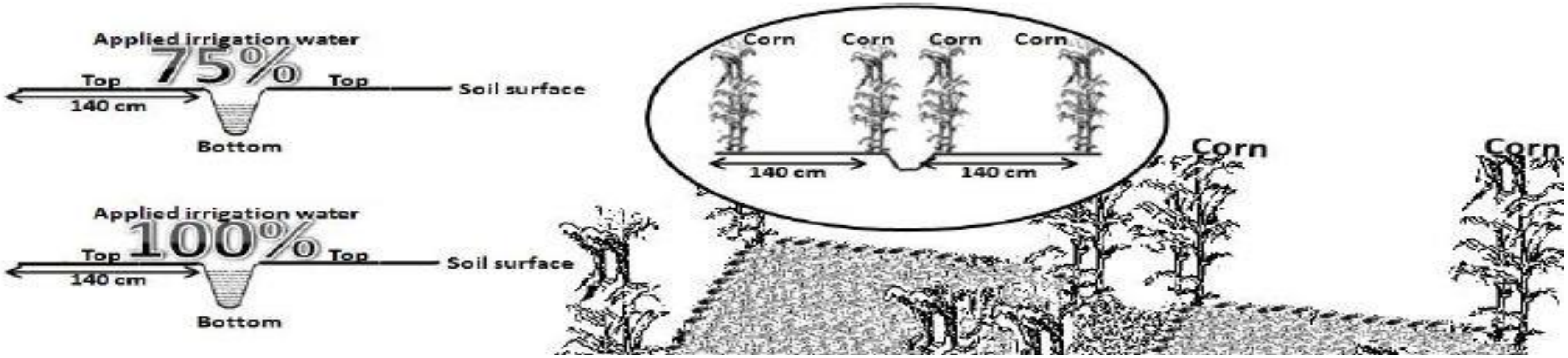
Corn


Applied irrigation water
75%
Top
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Soil surface
140 cm
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Applied irrigation water
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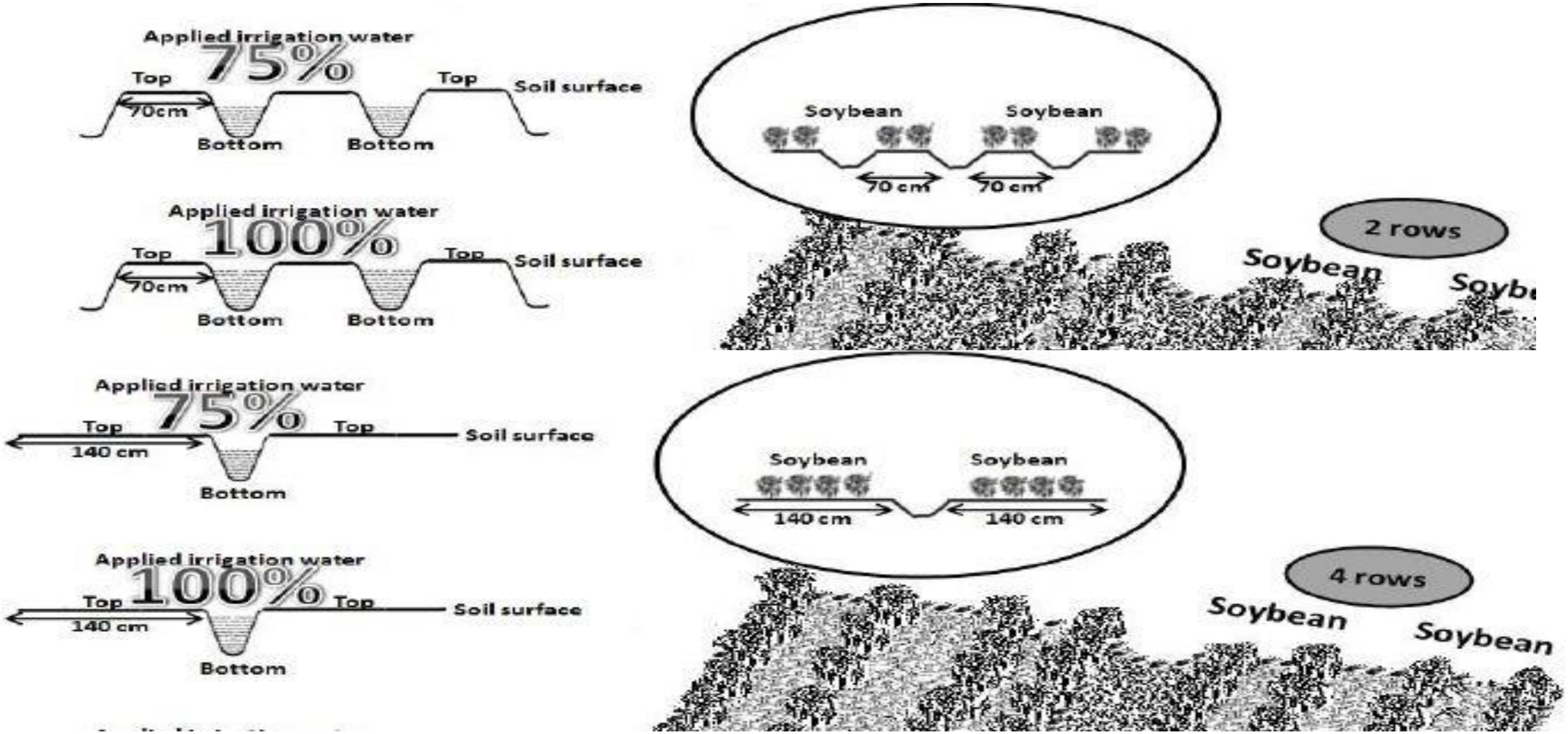
Corn


Applied irrigation water
75%
Top
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Soil surface
70cm
Bottom
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Applied irrigation water
100%
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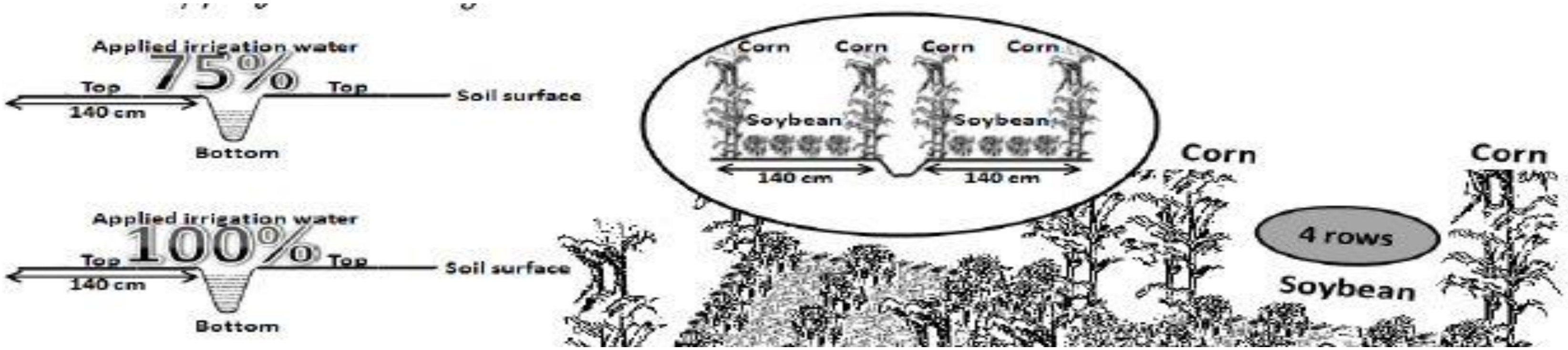
Applied irrigation water
75%
Top
Top
Soil surface
140 cm
Bottom
Applied irrigation water
100%
Top
Top
Soil surface
140 cm
Bottom
Soybean
Soybean
70 cm
70 cm
2 rows
Soybean
Soybean
Soybean
140 cm
140 cm
4 rows
Soybean
Soybean


Applied irrigation water
75%
Top
Top
140 cm
Soil surface
Bottom
Applied irrigation water
100%
Top
Top
140 cm
Soil surface
Bottom
Corn
Corn
Corn
Corn
Soybean
Soybean
140 cm
140 cm
Corn
Corn
4 rows
Soybean

Materials and Methods

Three corn hybrids (EG 90, SC 10 and 30K 8), two of soybeans (G.111 and G. 22) and Qawmy 1 mungbean were evaluated under field condition of Al-Minya Governorate of Middle Egypt.

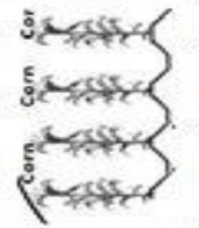
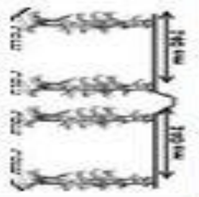
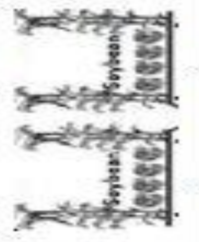
Experimental Design and Factorial Analysis:

- **Split-split plot design with 2 replications field demonstration trial was conducted at Al-Minya district of Middle Egypt.**

1-**Main plots** assigned to irrigation with recommended normal watering regimes(**NWR**) (≈ 8100 m3 per ha) ***vs.*** saving watering regime **SWR** (75% of recommended WR ≈ 6070 m3/ha): by irrigation in 12 and 15 days intervals, respectively.

- Traditional **ridges** distanced 70 cm ***vs.*** **bed** ridges were adopted which may save additional irrigation water.

2- First split plots were occupied the intercropping (of 30 k 8 corn hybrid ***vs.*** soybeans/ mungbean) ***vs.*** solid cropping pattern under bed ridges.

Cropping Systems	Fig. #	R1 (NWRSF)[1]	R1 (NWRFA)[2]	R2 (NWRSF)[1]	R2 (NWRFA)[2]	R1 (SWRSF)[1]	R1 (SWRFA)[2]	R2 (SWRSF)[1]	R2 (SWRFA)[2]
3 Corn Hybrids solid, each 4 ridges distanced 70 cm, one row / ridge in single-plant hills spaced 25cm.		EG.90							
		SC.10							
		30 k 8							
3 Legumes solid each in 4 ridges distanced 70 cm, two rows on each ridge….		Q 1							
		G.111							
		G.22							
3 Corn Hybrids solid each in 2 beds ridges distanced 140cm, two rows on each bed in one plant hills spaced 25cm.		SC.10							
		30 k 8							
		EG.90							
3 Legumes solid each in 2 bed ridges distanced 140 cm, four rows on each bed ridge….		Q 1							
		G.22							
		G.111							
3 Legumes intercropping with 30 k 8 each in 2bed ridges distanced 140 cm, four rows of legume alternated with 2 rows of corn on each bed ridge….		30 K 8 × Q 1							
		30 K 8 × G.22							
		30 K 8 × G.111							

1) NWRSF= Normal watering regime, each 12 days intervals, with soil application of N fertilizer, but SWRSF is stress w regime.
2) NWRFA= Normal watering regime, each 12 days intervals, with foliar application of…, but SWRSF is stress w regime.

Land equivalent ratio (LER)

Land equivalent ratio (LER): It defines as the ratio of area needed under sole cropping to one of intercropping at the same management level to produce an equivalent yield **(Mead and Willey, 1980)**. It is calculated as follows: LER = $(Y_{ab} / Y_{aa}) + (Y_{ba}/ Y_{bb})$; where Y_{aa} = Pure stand yield of crop a (corn), Y_{bb} = Pure stand yield of crop b (soybean), Y_{ab} = Intercrop yield of crop a (corn) and Y_{ba} = Intercrop yield of crop b (soybean).

Water relations

Irrigation water use efficiency (IWUE) values were calculated according to **Bhattarai *et al.* (2006)** as follow: IWUE = (Ey/ Ir). Where IWUE is irrigation water use efficiency (kg/m^3), Ey is the economical yield (kg/ha) and Ir is the amount of applied irrigation water (m^3).

-LER defines as the sum ratios of intercropped yields to those of solid counterparts.

- The IWUE is the ratio of economic yield (Kg/plot) to the amount of applied water (m^3).

Analysis of Variances

Significance of variances due different sources of variation of factorial statistical analysis for yield /plot (10.2 m2) and estimates of land equivalent ratio (LER) and irrigation water use efficiency (IWUE).

Sources of variation	df	Corn yield/plot kg	Legume yield/plot kg	LER	IWUE
Cultural P.(CP)	3	1.643 ns	1.696*	1.072ns	0.288*
Varieties (V)	2	14.922**	0.083ns	0.176ns	0.625**
CP x V	6	7.796*	0.148	0.135ns	0.280*

Ns, * and ** indicate insignificance, significance at 5% and 1%, respectively.

Effects of Cropping Patterns, WR and Varieties on IWUE

Significance of variances due different sources of variation of split-split experimental design for irrigation water use efficiency (IWUE).

Sources of variation	df	IWUE
Cropping patterns (CP)	4	57.654 **
Watering regimes & fert. (WR)	3	0.307 *
CP x WR	12	0.271 *
Varieties (V)	2	0.217 ns
CP x V	8	0.290 **
WR x V	6	0.068 ns
CP x WR x V	24	0.094 ns

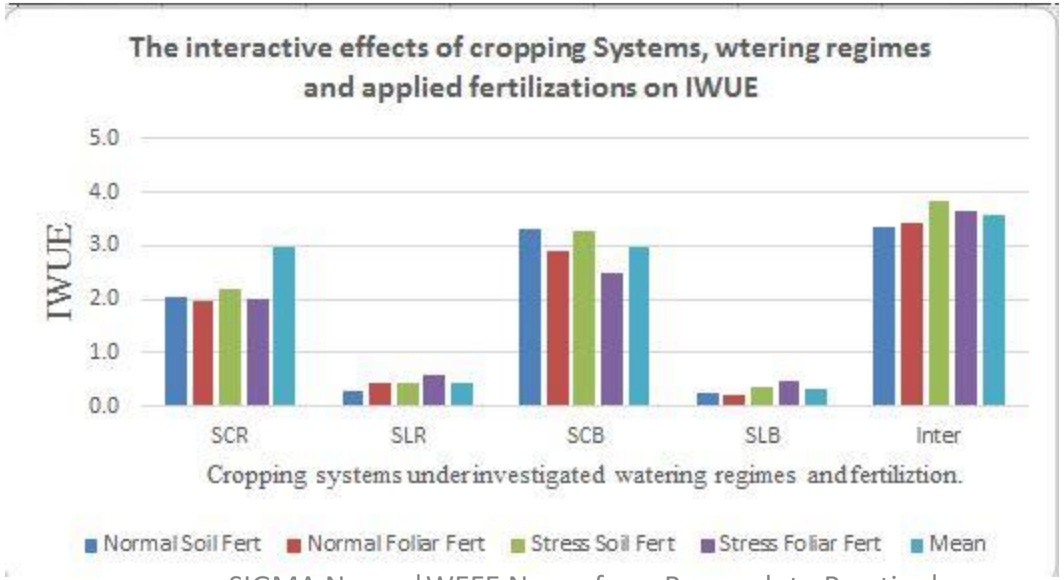
Ns, * and ** indicate insignificance, significance at 5% and 1%, respectively.

Cultural Practices & cropping systems and IWUE

Effects of cropping systems, watering regimes (WR) and fertilizer application on IWUE of growing crops during 2021 summer season.

WR	Fert. App.	SCR	SLR	SCB	SLB	Inter
Normal	Soil	2.043	0.302	3.302	0.235	3.338
	Foliar	1.976	0.455	2.902	0.198	3.420
Stress	Soil	2.208	0.448	3.272	0.375	3.818
	Foliar	2.019	0.593	2.498	0.462	3.653
Mean		**2.990**	**0.450**	**2.993**	**0.318**	**3.558**

SCR= Solid corn ridges. SLR= Solid legumes ridges. SCB=Solid corn beds. SLB=Solid legumes beds. Inter=intercropping 30k6 corn hybrid with each of three legumes.



Cultural Practices and intercropping effects on LER

Effects of watering regimes (WR) and fertilizer application on LER of intercropped legumes crops under 30k8 corn hybrid in soil beds during 2021 summer season.

WR	Fert App	Mungbean	G.111	G.22	Mean
Normal	Soil	1.365	1.210	1.385	**1.32**
	Foliar	1.735	2.610	2.515	**2.287**
Stress	Soil	1.245	1.645	1.555	**1.482**
	Foliar	1.760	1.610	1.725	**1.698**
Mean		**1.526**	**1.769**	**1.795**	


OPPO F11 · @Ahmed Elmahdy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OPPO F11


Corn (Ridges-NWR)
EG. 90
SIGMA Nexus
Demonstration Field Elminya.
September 17, 2021
OPPO F11 · ©Ahmed Elmahdy
2021/09/17 08:15


Intercropping-NWR
Corn (30K8) vs. Soybean (G. 111)
SIGMA Nexus
Demonstration Field Elminya.
September 17, 2021


Corn (Ridges-NWR)
SC. 10
SIGMA Nexus
Demonstration Field Elminya.
September 17, 2021
2021/09/17 08:13

Conclusion

- **The Intercropping corn / summer legumes reflected in higher land equivalent ratio (LER) which indicates proper utilization of available resources.**
- **The intercropped corn yield is higher than those of solid one due to its positive response of light fertilization of corn as C 4 plants (intercropping environmet).**
- **However, legume plants affected negatively (relative solid counterpart) by adopted the intercropping pattern of 100% plant density of both crops due crowding in spite of their tolerance to light shading generated by corn.**
- **Cropping patterns in wider ridges (Bed) either solid or Intercropping greatly recommended for saving 25% of irrigation water.**
- **Encouraging genotypic variability of both crops under different patterns and practices could be observed.**

The obtained results will help to explore some approaches of WEFE nexus:

- **Water relationship** :

  Between corn and legumes productivities with cropping systems and furrow systems.
- Determining varieties that saving water.
- **Food relationship:**
- Is intercropping will increase the productivity and diverse comodities.
- **Ecosystem relationships:**
- Intercropping will save fertilizers and insecticides.
- Intercropping will fix about 48 kg/ha from atmospheric nitrogen.
- Intercropping will reduce the evapotranspiration because the corn will shade on soybeans.
- **Energy relationship:**
- Intercropping will increasing light fertilization.



Thank you

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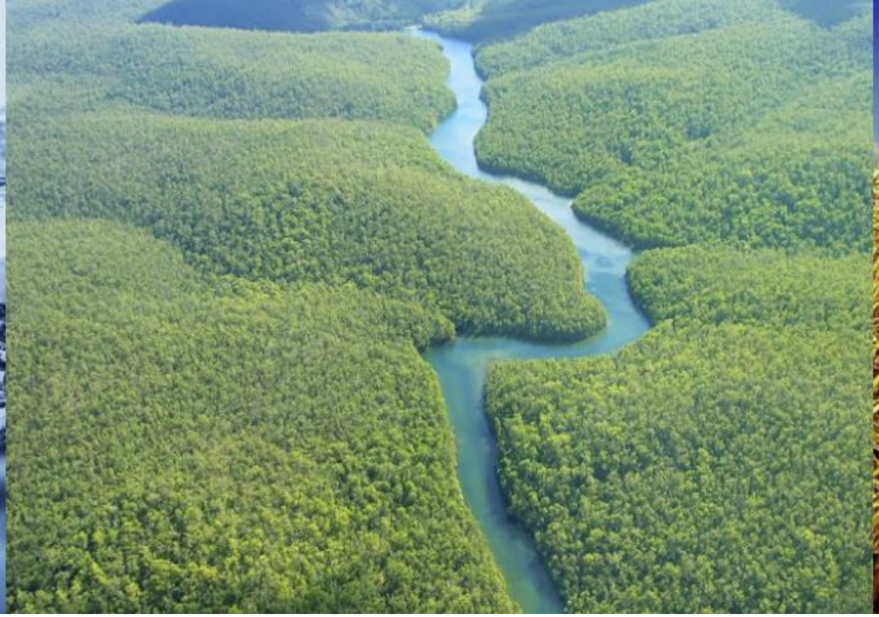


SIGMA Nexus

Hydrological Modelling for Optimizing Cropping Pattern Using WEAP Software

European Commission
Horizon 2020
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IN THE MEDITERRANEAN AREA

Hydrological Modelling for Optimizing Cropping Pattern Using WEAP Software

Presented By

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WEF Nexus Project Coordinator

Dr. Maria Vrachioli
Technical University of Munich
Agricultural Production and Resource Economics

Prepared By

Eng. Abir M Badr
PhD student

Abdelazim Negm's Short Biography

- **1-**B.Sc. Degree in "Civil Engineering - Irrigation and Environmental Engineering" with average grade "Very Good with honors, with 84.5%".
- 2-M.Sc. Degree in Civil Engineering (Irrigation and Hydraulics) from Ain Shams University, Egypt. And PhD degree in Hydraulics on 1992 from Zagazig University.
- 4-Professor of Hydraulics at Faculty of Engineering of Zagazig University since June 2004. and Vice Dean for Academic and Student Affair (12/2008-12/2011).
- 6- Professor of Water Resources at Egypt-Japan University of Science and Technology (E-JUST) Since Dec. 2012 until Sept. 2016.
- 7- Chairperson of Environmental Engineering Dept. at E-JUST since March 2013 until March 2016.
- 8- Listed in (a) Marquis Who is Who?, (b) IBC's 2000 Outstanding Intellectuals of the 21st Century , and (c) ABI directory for his achievement in the field of Hydraulics and Water Resources.
- 9- He was nominated for many other awards from both IBC and ABI.
- 10- Participated in more than 95 conferences and published about 400 papers in national and international journals and conferences. In addition to more than 40 book chapters.
- 11-Awarded the prizes of best papers three times and the top reviewer 2 times (Publons.com).

12-Member of IAHR since 1994

13- General Secretary of the committee of the Egyptian permanent promotion committee for Water Resources (51b) for promotion associate and professor positions and currently General Secretary of the committee (Cycle 2016-2019).

14- Member of the editorial board of several scientific journals and Guest editor in others.

15- Member of the Int. Advisory Board/Scientific Committee of several Int. Conferences.

16- Associate Editor of Several International and local journals.

17- Ex-Editor in Chief of EIJEST, Faculty of Engineering, Zagazig University

18- Editor of 35 books and published by Springer publishing Int. (10 of them about Egypt)

19- Reviewer for more than 50 international and national journals.

20-Keynote speakers in several Int. Conferences

21- Head of the Permanent Scientific Promotion Committee for Water Resources (51b) for promotion associate and professors positions (cycle from 2019-2022).

OUTLINES

1. INTRODUCTION

2. OBJECTIVE

3. STUDY AREA (Location, Data, Challenges)

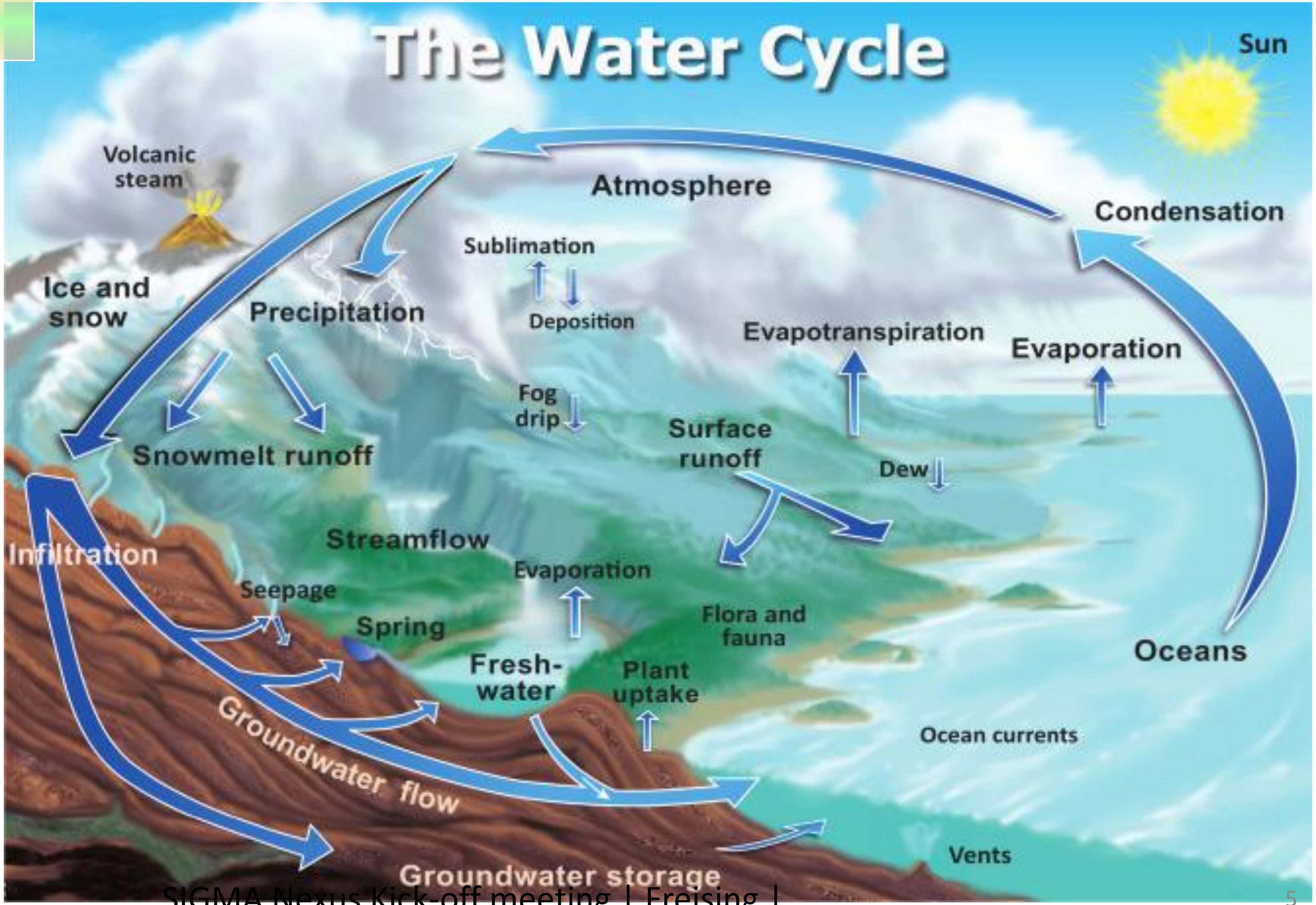
4. STUDY AREA (State of the Art Review

5. METHODOLOGY

6. EXPECTED RESULTS/OUTCOMES

7. CONCLUSIONS/RECOMMENDATIONS

1. INTRODUCTION



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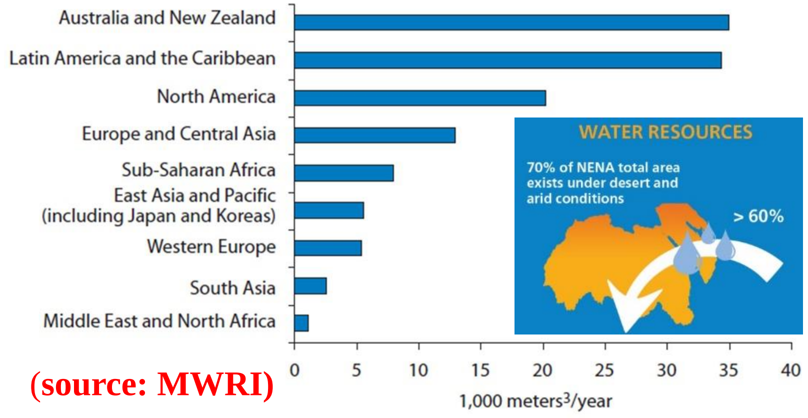
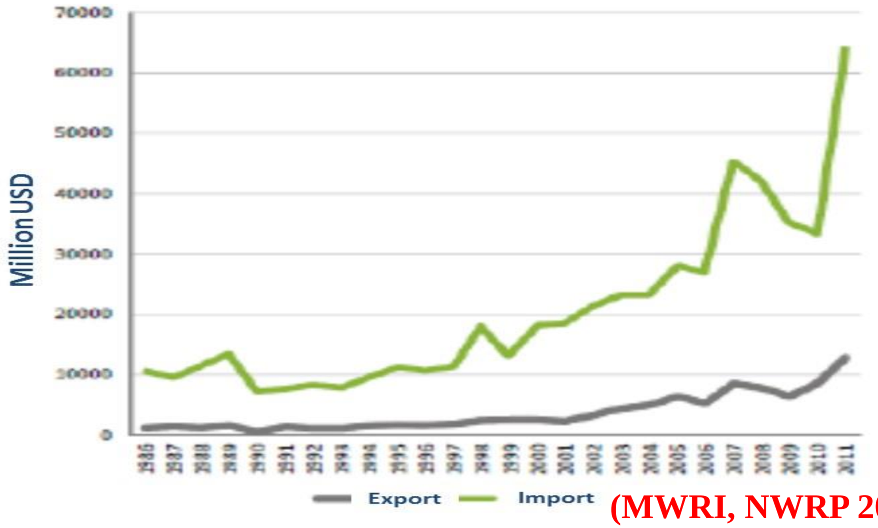
1. INTRODUCTION (Challenges)

Water Scarcity



(source: MWRI)

Food Security



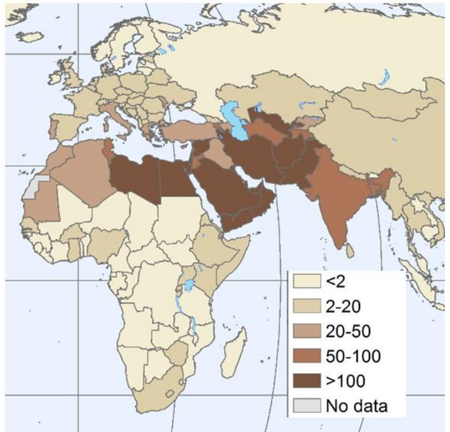
(MWRI, NWRP 2017)

Groundwater abstraction as % of annual recharge

GCC countries depending 100% on groundwater irrigation

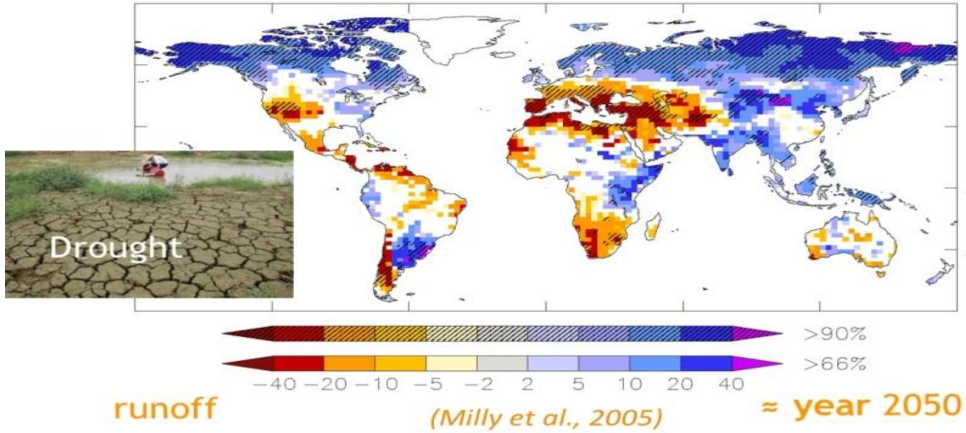
Since 1980s, Saudi Arabia have induced an estimated depletion of two thirds of the country's fossil water

In Yemen the groundwater table is falling by as much as 6 m per year



(Anthony A. Jones et al., 2011)

Increased climate variability and change

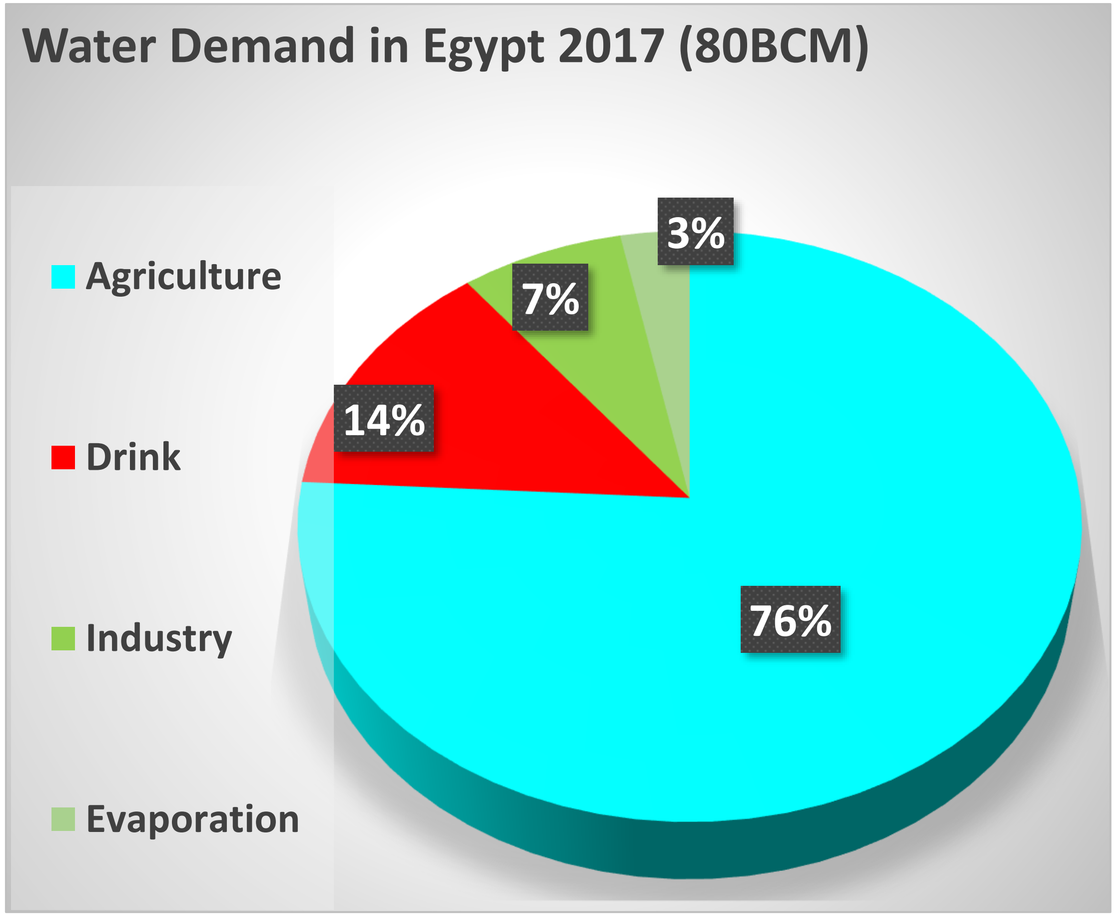


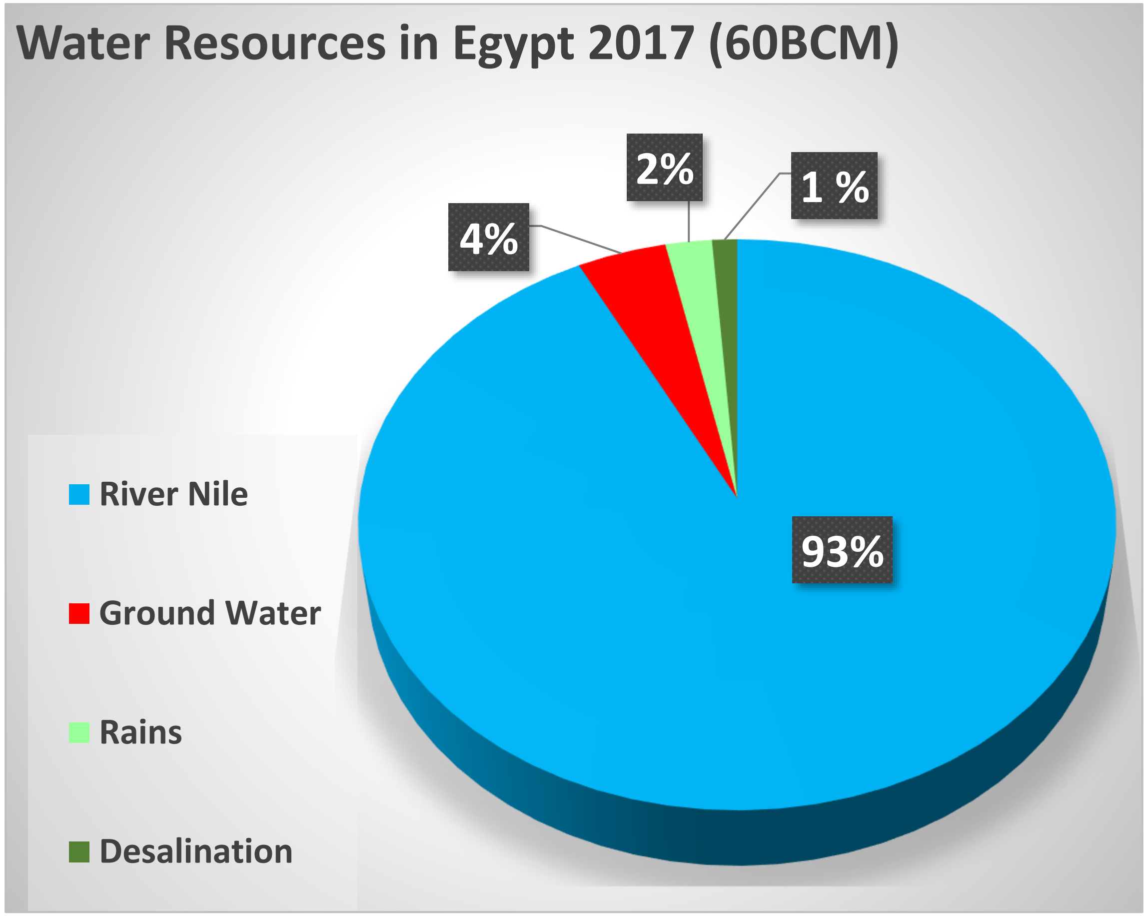
(Milly et al., 2005)

All of these problems lead to intensification of water scarcity

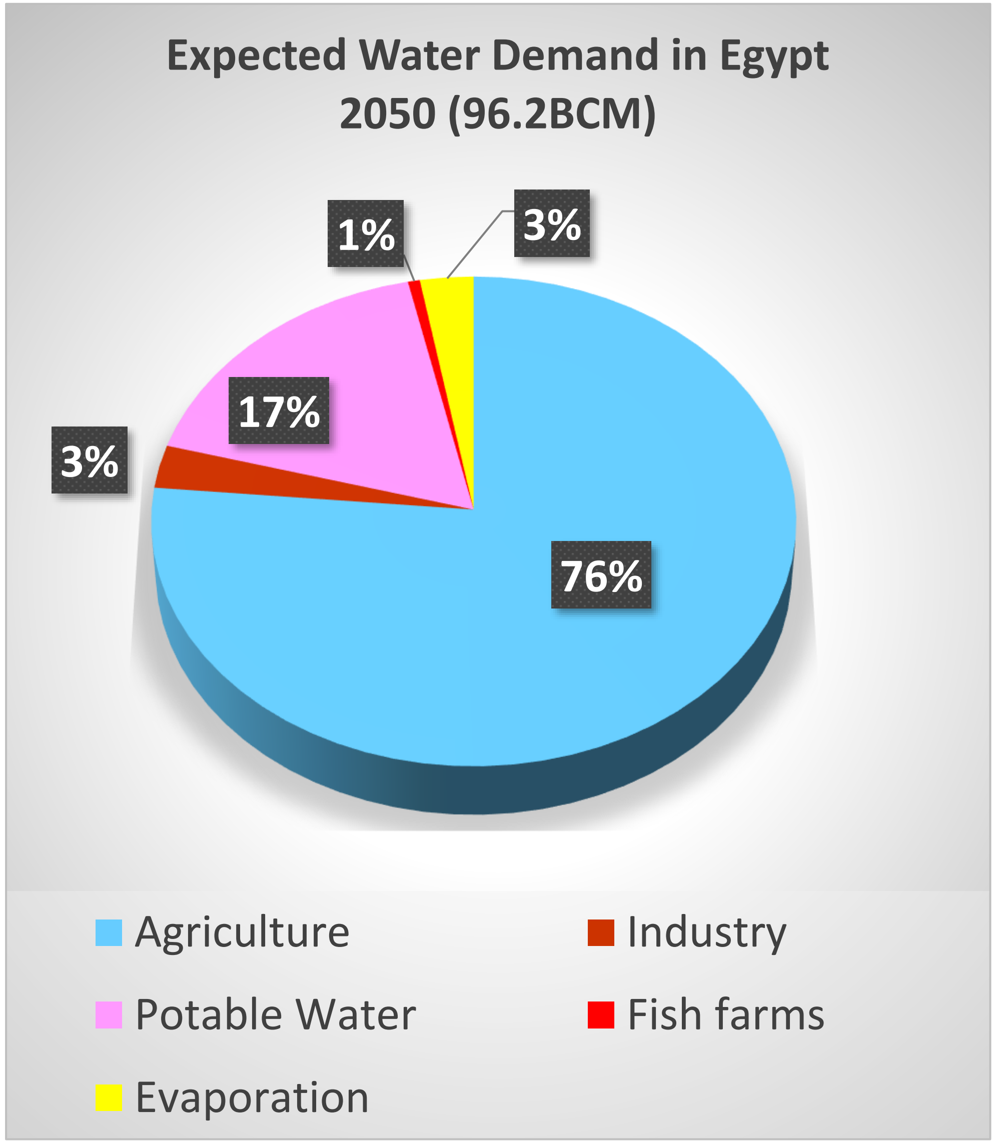
1. INTRODUCTION (Egypt's Water Resources)

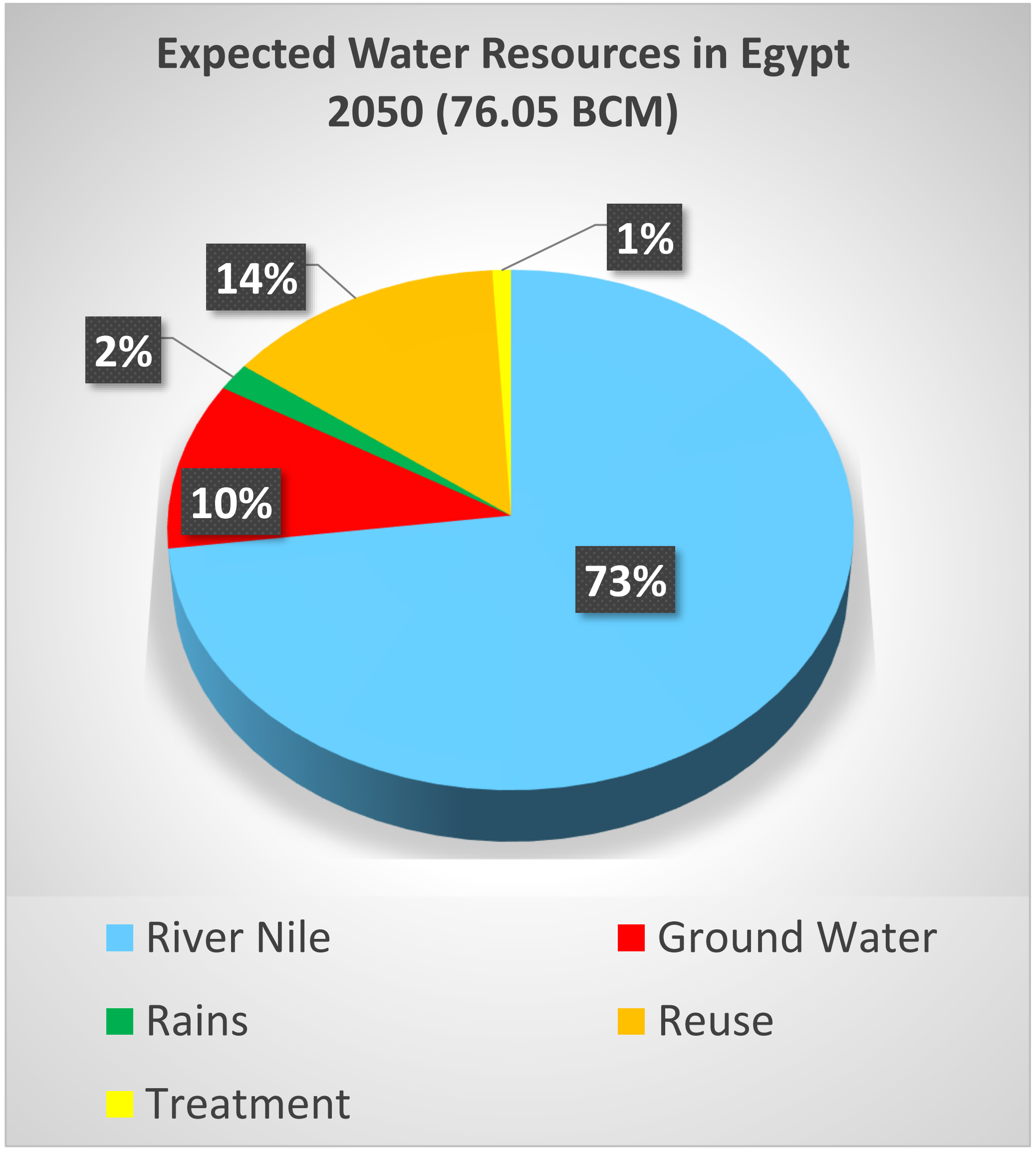
Available water resources and uses in Egypt for year 2017 (source :MWRI)



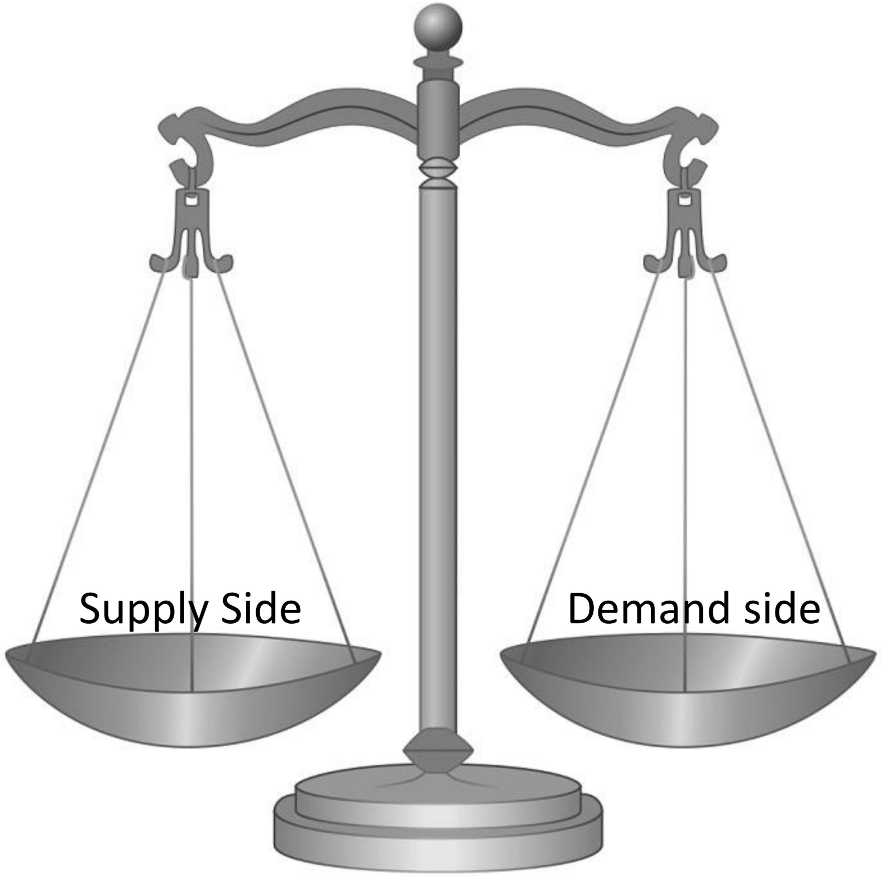


Expected water resources and uses in Egypt for year 2050 (source MWRI)





1.INTRODUCTION (Water Resources Management)



Mismanagement or water Scarcity, challenges are there

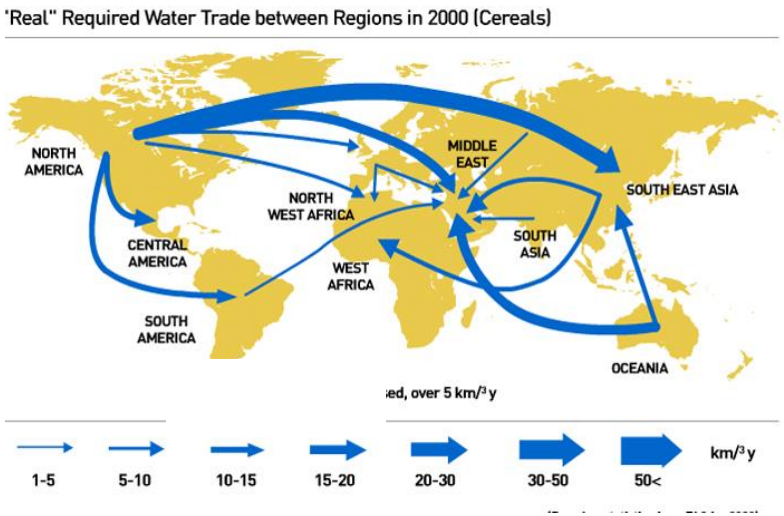
Good Management but it is difficult to maintain

1-Introduction (Gap overcome -Water supply Side

Water harvesting

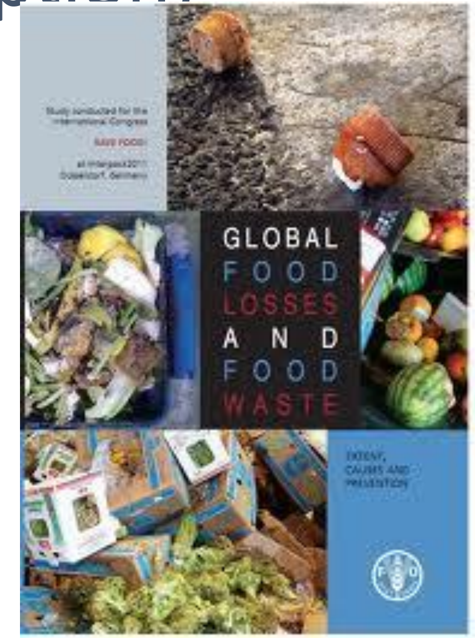
Non-conventional water
Waste water treatment plant
Desalination plant

Virtual water



1-Introduction (Wise Usage (water demand/consumption)

Reducing food losses and minimize waste



Enhanced farming systems (irrigation technology) Green houses

Drip Irrigation saves 30%

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SIGMA Nexus

1-Introduction (Improve water efficiency & productivity/return

1. Introduction (WR Gap Overcome Summary)

1. Adopting water saving strategies in all sectors to minimize water losses.

2. Canal Lining National projects similar to Irrigation Improvement Projects.

3. Developing nonconventional WR for the added agricultural lands

4. Adopting cost-effective water treatment technologies to increase the availability of non-conventional water supply.

5. Rainfall water harvesting

6. Adopting optimized crop patterns (less water consumption and high productivity).

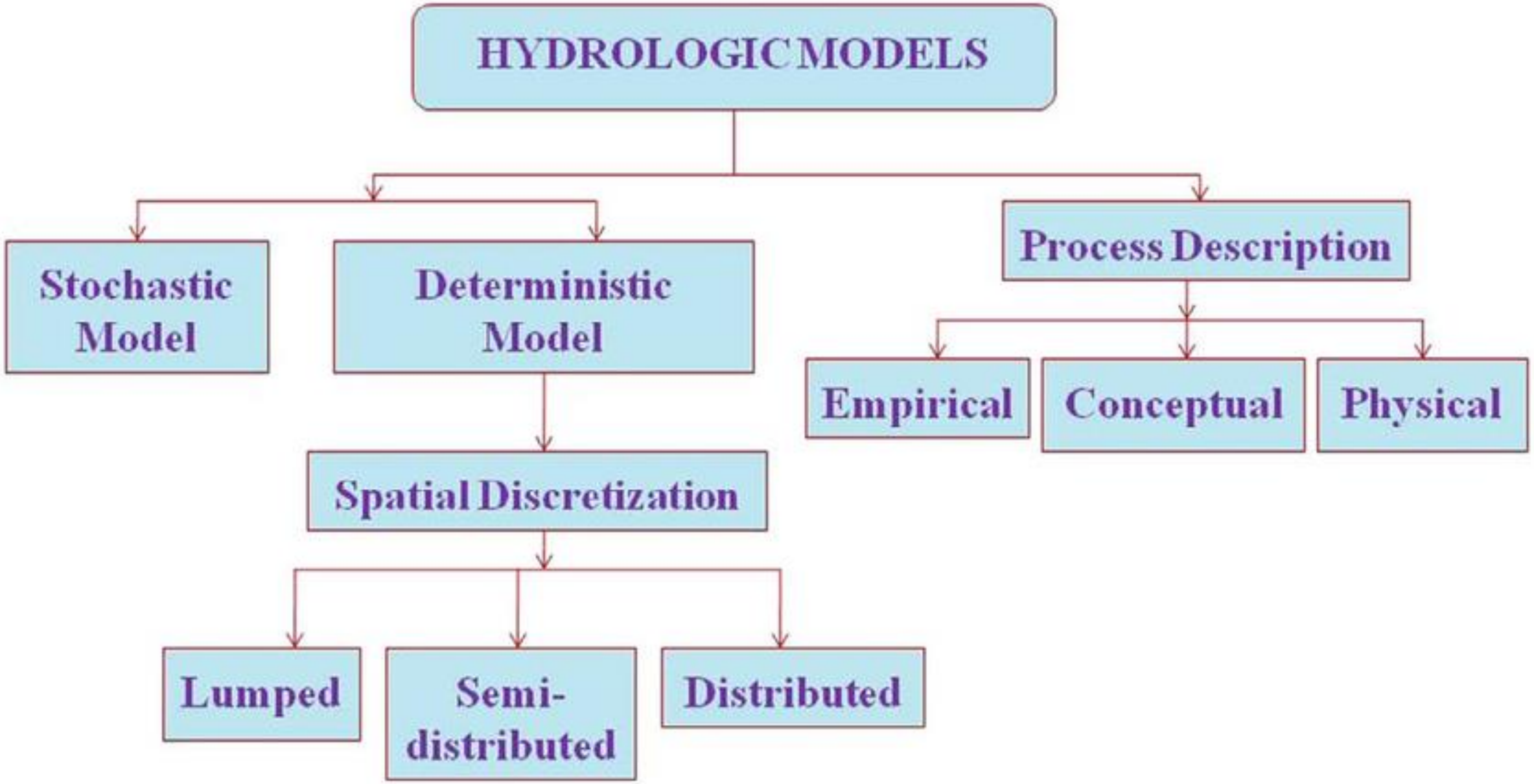
7. Rehabilitation and enhancing the potable water network to reduce losses.

7. Increasing the surface water supply by enhancing the collaboration between Nile Basin Countries and implementing water harvesting project in the upper Nile basin.

Modeling Existing Water Challenges using Hydrological modelling

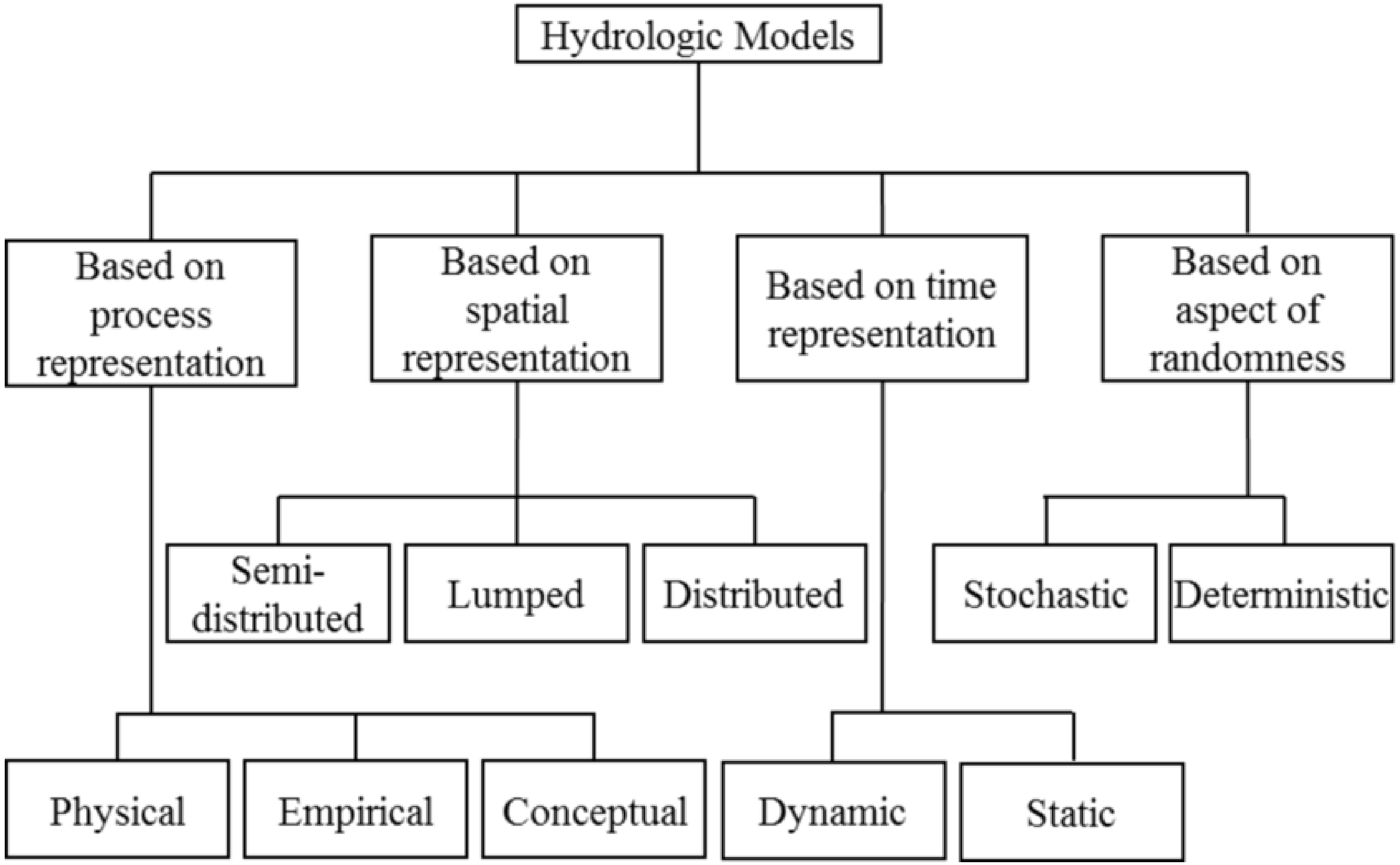
- **Modeling** is a simplification of a real-world system.
- **Hydrological Modeling**: Simulation or simplified representation (e.g., surface water, soil water, wetland, groundwater, estuary) that aids in understanding, predicting, and managing water resources to minimize **water shortage**.
- Both **flow quantity and quality** of water are commonly studied using hydrologic models.

Hydrological Models Classification 1/2



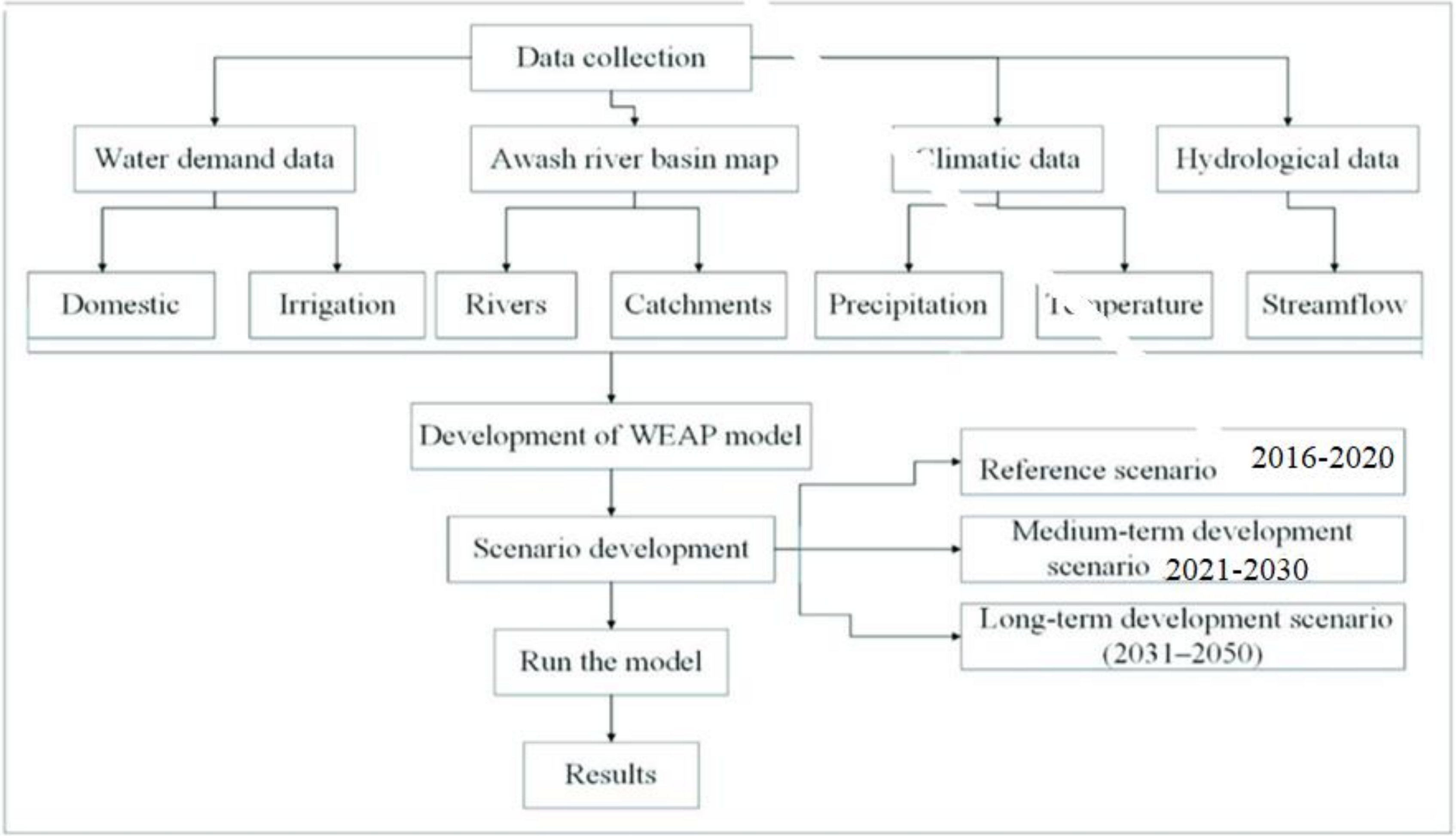
https://www.researchgate.net/publication/287374409_Impact_of_land_use_change_on_hydrological_systems_A_review_of_current_modeling_approaches/figures?lo=1

Hydrological Models Classifications 2/2



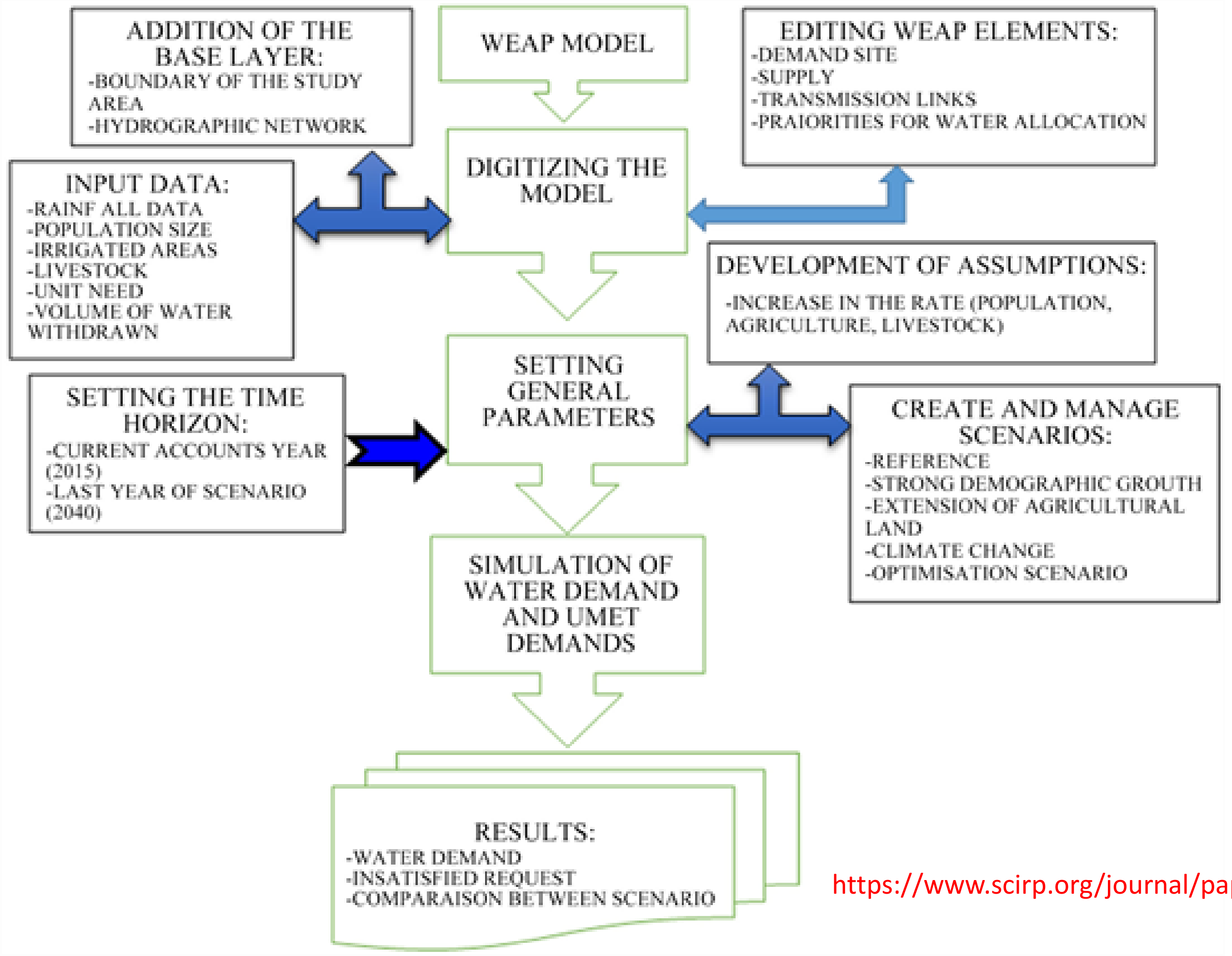
https://www.researchgate.net/publication/320760918_INVESTIGATION_INTO_THE_EFFECTS_OF_CLIMATE_VARIABILITY_AND_LAND_COVER_CHANGE_ON_THE_HYDROLOGIC_SYSTEM_OF_THE_LOWER_MEKONG_BASIN/figures?lo=1

WEAP Model Development (General)



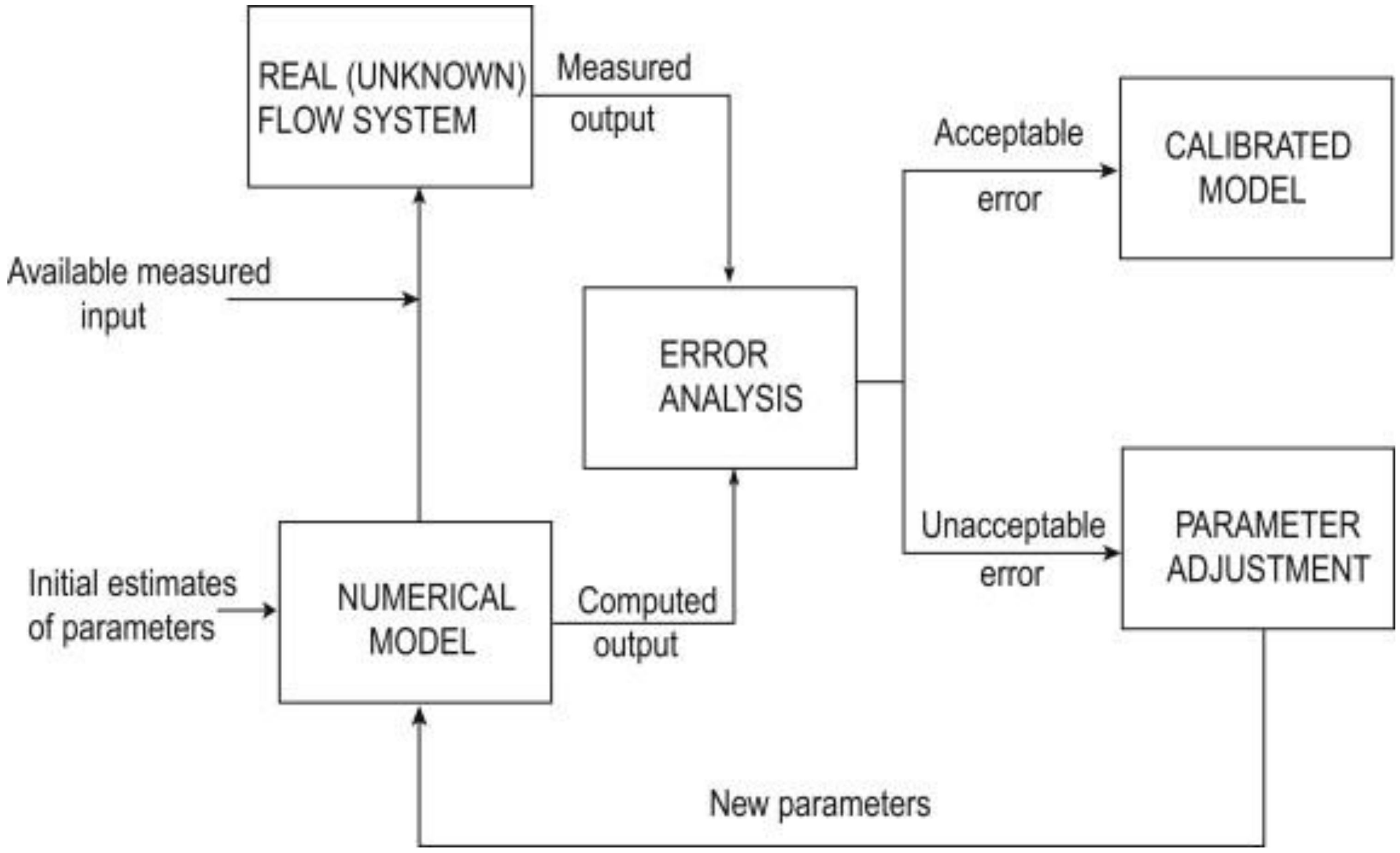
https://www.researchgate.net/publication/335980523_Water_Resources_Allocation_Systems_under_Irrigation_Expansion_and_Climate_Change_Scenario_in_Awash_River_Basin_of_Ethiopia/figures?lo=1

Detailed Modeling Processes Using WEAP



https://www.scirp.org/journal/paperinformation.aspx?paperid=107718

Model Calibration



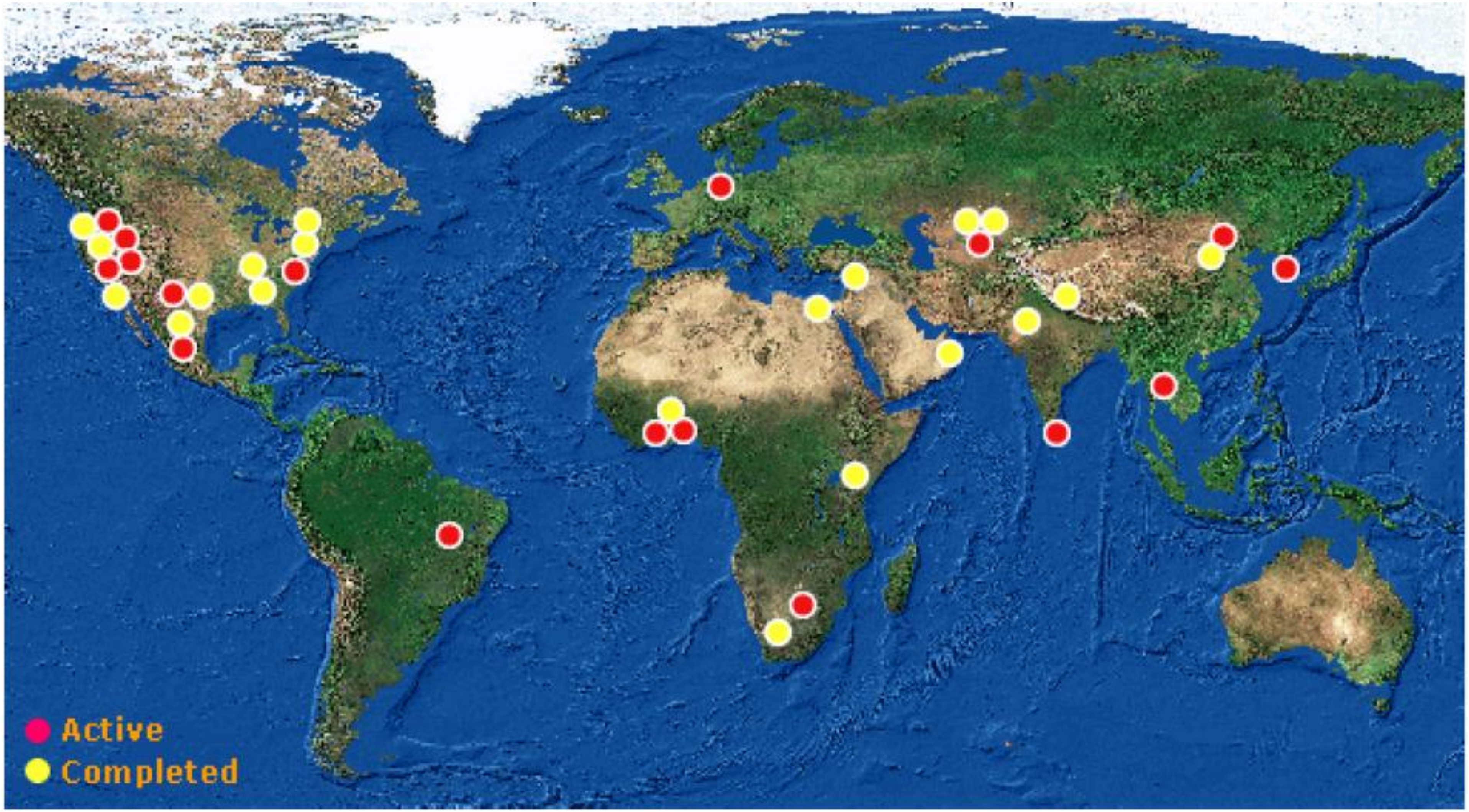
https://ars.els-cdn.com/content/image/3-s2.0-B9780123822253001729-f00172-03-9780123822253.jpg

Examples of WEAP Scenario Analysis

- Scenario analysis is central to WEAP. Scenarios are used to explore the model with an enormous range of "what if" questions, such as :
- What if population growth and economic development patterns change?
- What if reservoir operating rules are altered?
- What if groundwater is more fully exploited?, What if water conservation is introduced?
- What if ecosystem requirements are tightened?
- What if a conjunctive use program is established to store excess surface water in underground aquifers?
- What if a water recycling program is implemented?
- What if a more efficient irrigation technique is implemented?
- What if the mix of agricultural crops changes? , What if climate change alters demand and supplies?
- How does pollution upstream affect downstream water quality?, How will land use changes affect runoff?

Over 500 published applications allover the world for (WEAP)

https://www.weap21.org/index.asp?action=216



USEFUL LINKS: WEAP Information

- WEAP WEBSITE https://www.weap21.org/index.asp?action=200
- WEAP USER GUIDE https://www.weap21.org/index.asp?action=208
- WEAP TUTORIAL https://www.weap21.org/index.asp?action=213
- WEAP VIDEOS https://www.youtube.com/c/WEAP-System
- WEAP PUBLICATIONS https://www.weap21.org/index.asp?action=216

2. Objectives: Importance of Hydrological modelling

** **Developing** the hydrological model is a helpful tool to maximize the productivity of each cubic meter of water (assuming constant area) considering the country strategic plans (water/agriculture) by optimizing the crop patter to produce maximum profit with less water consumption.

** **Investigating** the impacts of any expected future scenarios on the optimized crop pattern.

** **Studying** impacts of climate changes (different scenarios) on the optimized crop pattern and investigate and test mitigation and/or adaptation strategies (changing irrigation methods, changing crop pattern (new optimized one)….etc).

2. OBJECTIVES – Phase I

- ✓Understanding water resources system schematic/balance and components and the resulting productivities
- ✓Evaluating the used hydrological tool for proposing proper solution to water shortage and low productivity in the study areas.
- ✓Building web GIS applications to facilitate communicating model data

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2. Objectives – Phase II

- ✓ Assessment of water resources (quantity and quality) and crop pattern (productivity) in El-Minia and Noubaria (Egypt) for different sources of water.

- ✓ Simulate different scenarios to predict the future situation under climate variability for both El-Minia and Noubaria for a period from 2020-to 2050-2100) to decide the optimal crop pattern(s) over the these periods.

- ✓ Suggest mitigation/adaptation measures to overcome the water scarcity and food shortage in case of using other crop patterns based on the national strategies for agricultural production.

3. STUDY AREA AND DATA USED for El-Minia GOVERNORATE

- ✓ El-Minia is one of the most important governorates of Egypt

- ✓El-Minia covers about 56587 km2 and located in central Egypt, north of Upper Egypt, on the western bank of the Nile, Egypt.

- ✓It extended between latitudes 27°35' 32.39" and 28°46' 44.04" N and longitudes 28°27' 51.90" and 32°34' 0.31" E.

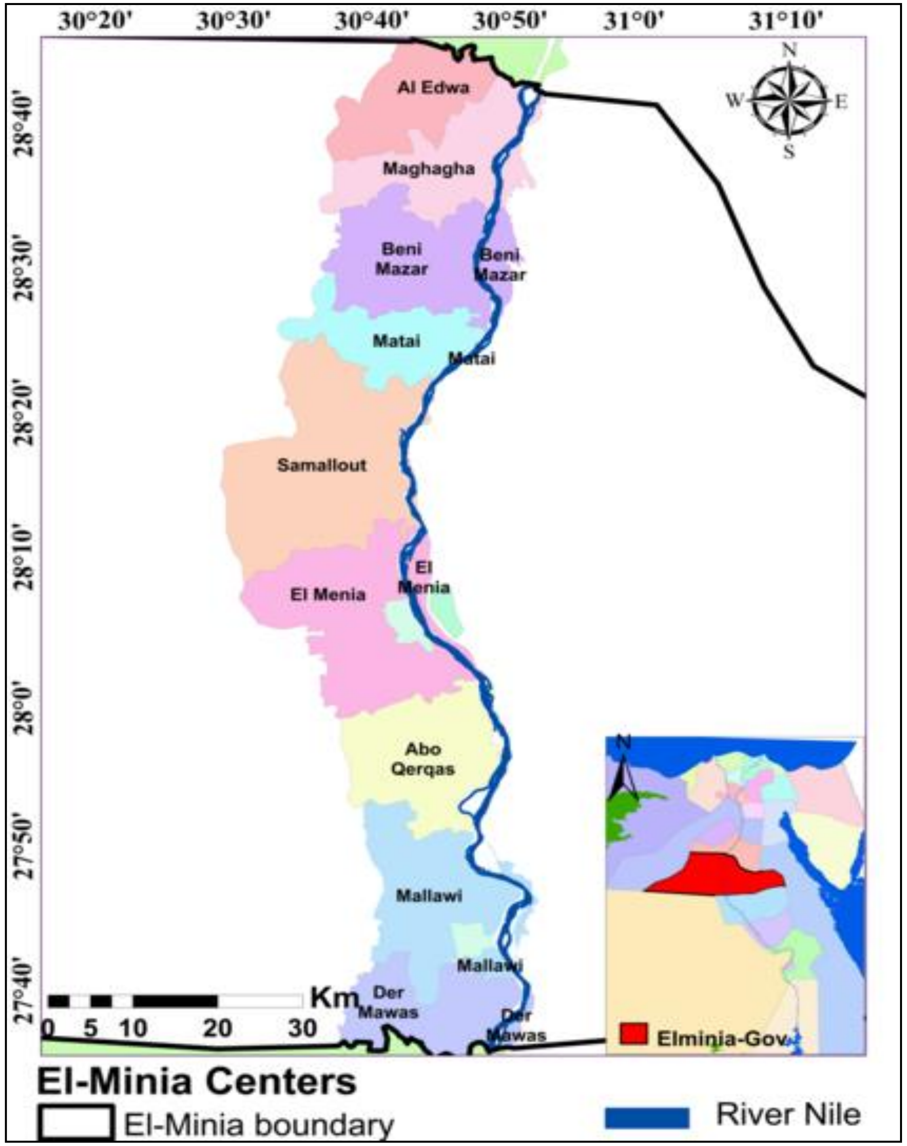
- ✓its boundaries as follows; Bani Souef Governorate in the North, Assuit and Al-Wadi Al-Gadid Governorates in South, Eastern desert in the East and Al-Giza Governorate in the West.

Available data

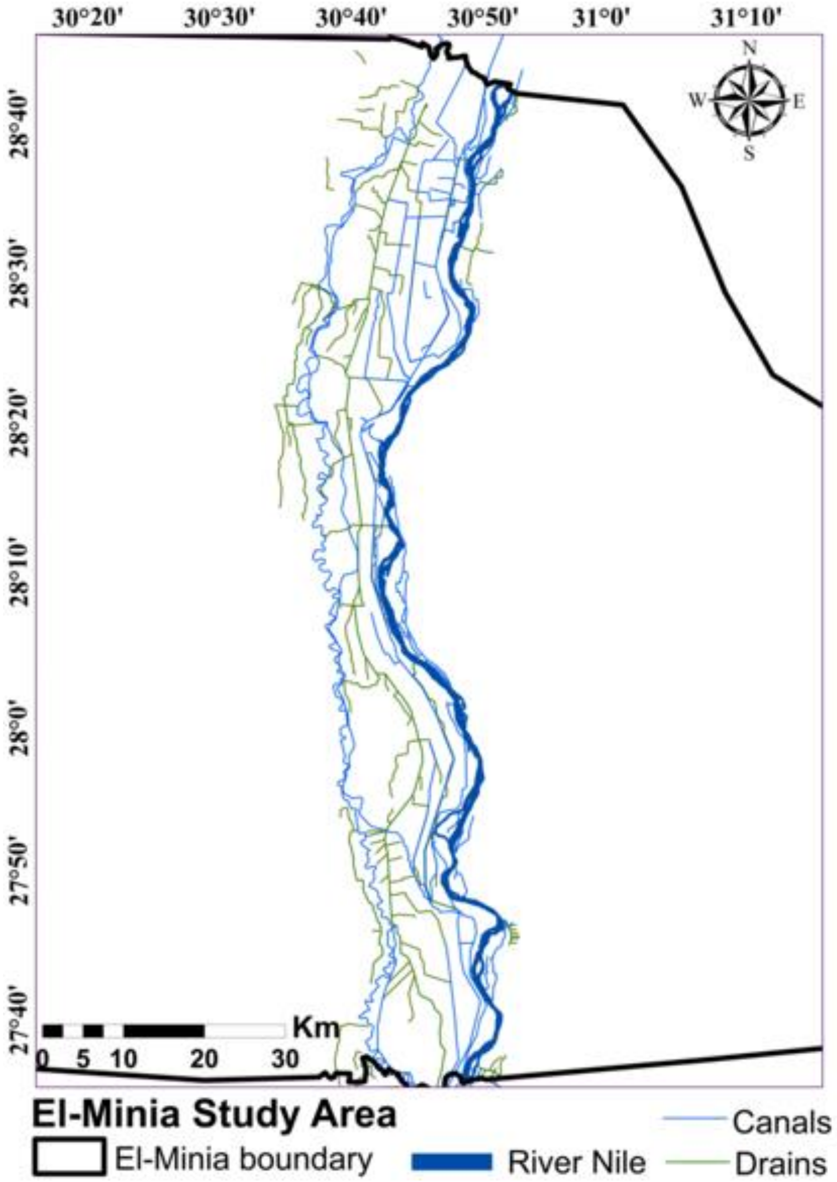
- ✓ The River Nile is considered the main surface water resource for El-Minia Governorate.
- ✓ The nature of water resources in El-Minia Governorate is characterized by the diversity of its sources, including surface, groundwater and recycling agricultural drainage water.
- ✓ The freshwater canals network in the study area are about 854 canals

Available data

✓ The governorate extends on the axis of the River Nile from Km. 612 to Km. 760 North of Assiut Barrages on the Nile are the controlling construction of the waters of El-Minia Governorate and the governorates following it that irrigated from Al-Ibrahimia canal and its branches



study area centres



Main water resources in the Study Area

4. LITERATURE REVIEW of water quality models in El-Minia GOV.

A wide range of literature reveals were presented under the following broad categories:

A. **RBF and measurement of traced elements in surface water quality (e.g.** Shamrukh and Abdel-Wahab, 2011, *Ghodeif et. al., 2016)*

B. **GIS Models, (e.g.** El-Ammawy et. al., 2020, Shehata et. al., 2019**)**

C. **Integration of DEM, Statistical Analysis and GIS, (e.g.** Sallam, et. al., 2020, Ahmed, et. al., 2019**)**

D. **Integration of Remote Sensing and GIS. (e.g.** Yousif, et. al., 2018**)**

5. Methodology

(Recalling slides 17 and 18)

WEAP Hydrological Modeling Steps

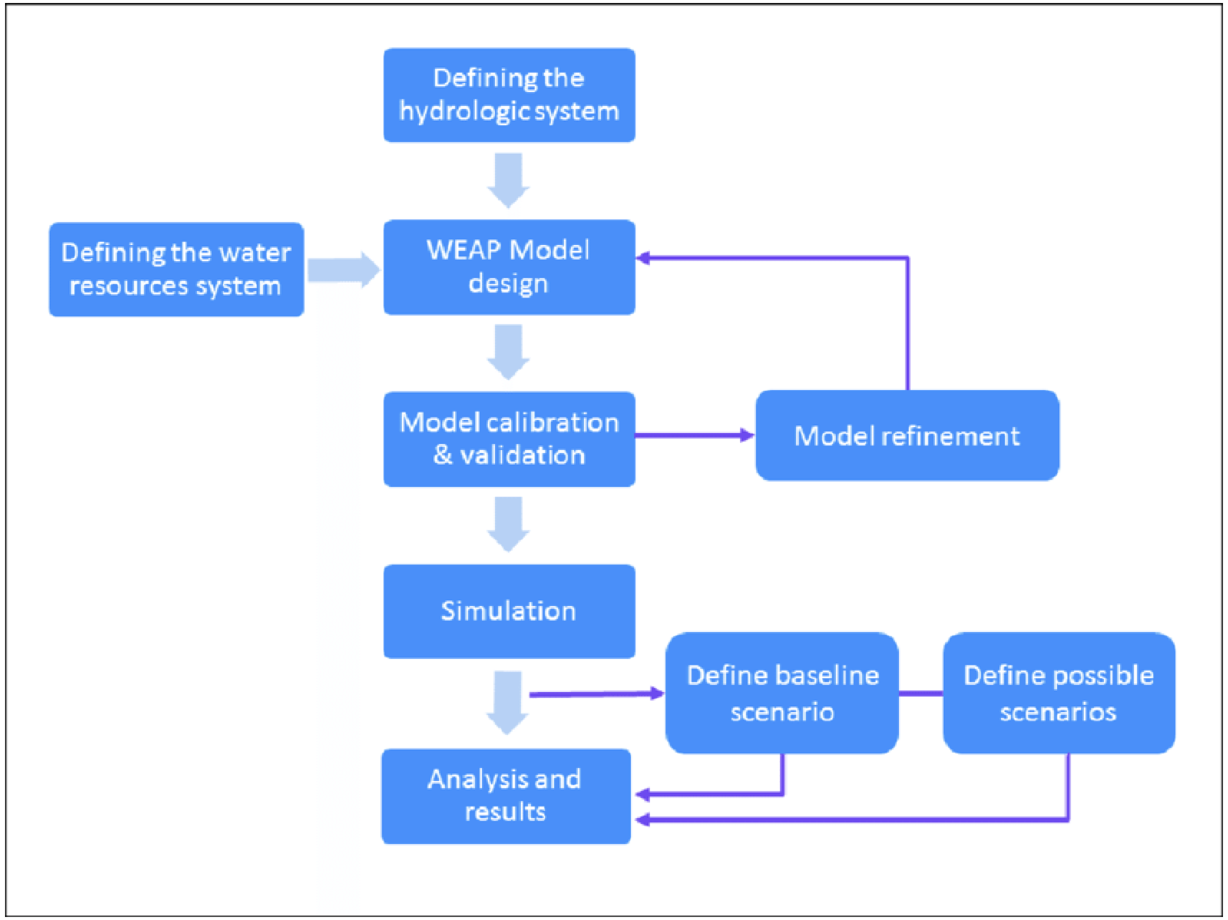
WEAP applications generally include several steps.

Study definition: The time frame, spatial boundaries, system components, and configuration of the problem are established.

Current accounts: A snapshot of actual water demand, pollution loads, resources and supplies for the system are developed. This can be viewed as a calibration step in the development of an application.

Scenarios: A set of alternative assumptions about future impacts of policies, costs, and climate, for example, on water demand, supply, hydrology, and pollution can be explored. (Possible scenario opportunities are presented in the next section.)

Evaluation: The scenarios are evaluated with regard to water sufficiency, costs and benefits, compatibility with environmental targets, and sensitivity to uncertainty in key variables.



https://www.researchgate.net/publication/317901090_Application_of_Water_Evaluation_and_Planning_Model_for_Integrated_Water_Resources_Management_Case_Study_of_Langat_River_Basin_Malaysia/figures?lo=1

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Challenges facing us in WEAP

- When importing stream's shapefile from the Arc Map on WEAP program, it wasn't read correctly, so we search and it was found that was due to the difference in the projection system, as the WEAP uses the un-projected system but GIS uses projected system.
- WEAP inputs need canals discharges, and these data could not be obtained as it is not available, so the possibility of using canal's crop pattern structures, consumptive use for each crop and the areas planted with crops was found to be able to overcome this challenge.

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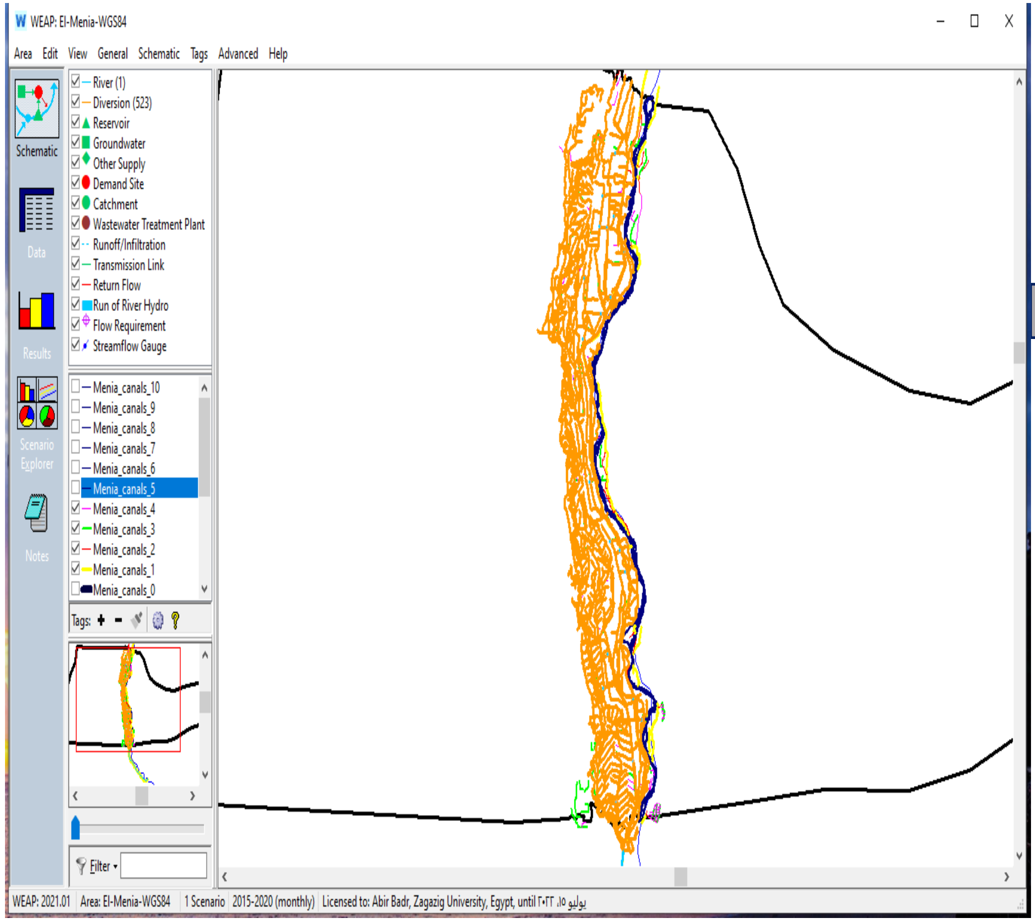
Achieved Tasks: General Workflow

Water Allocation Model

- weather,
- surface runoff,
- return flow,
- losses,
- reservoir storage
- crop growth and irrigation,
- groundwater flow
- reach routing,
- nutrient and pesticide loading,

Inputs



Outputs

Values of Decision Variables, Performance Indicators

Schedule for Operations

Water accounting data

Statistics

Reports

Post-processing:

- Statistical Analysis
- Tradeoff Analysis
- GIS Maps

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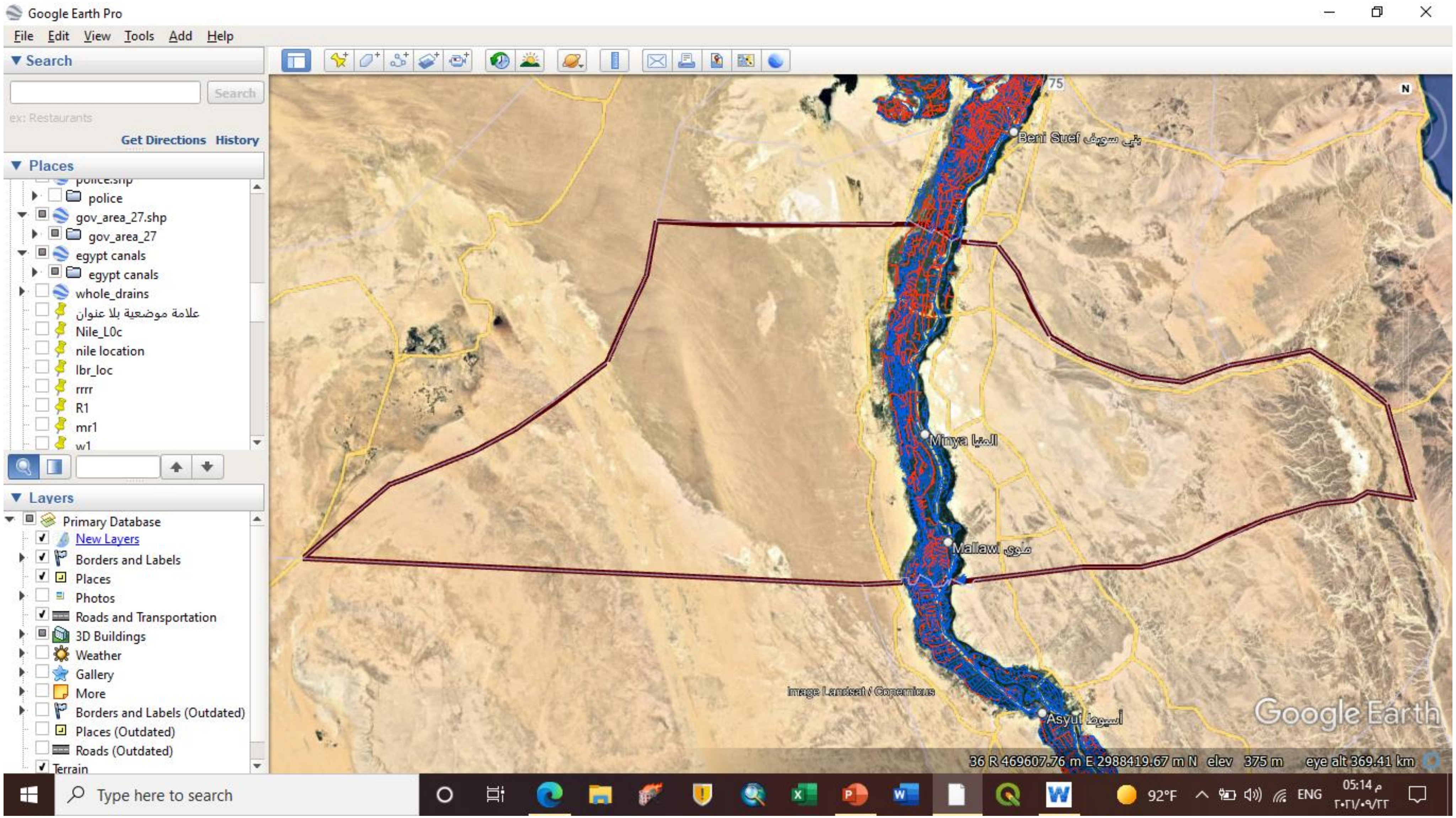
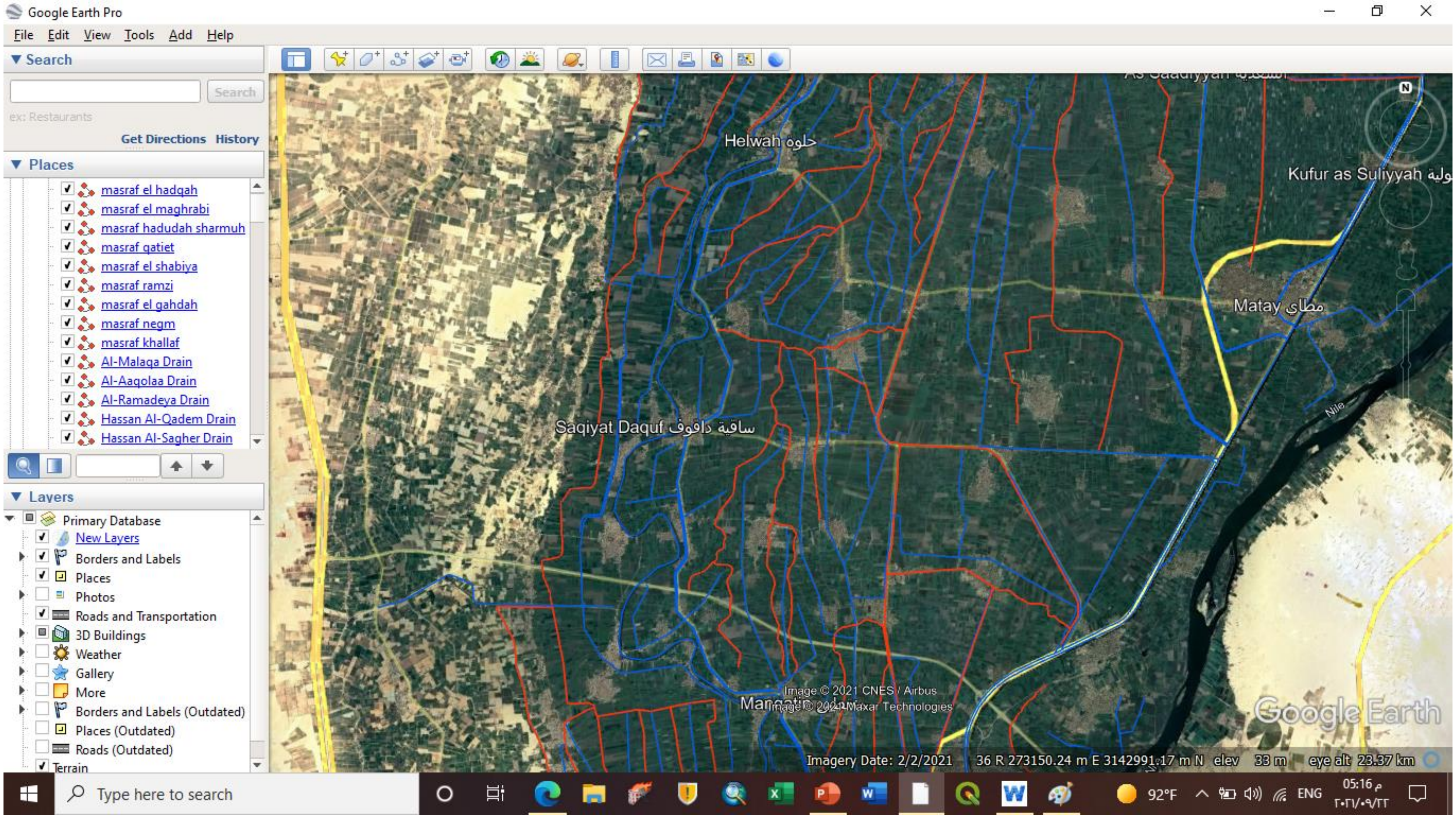
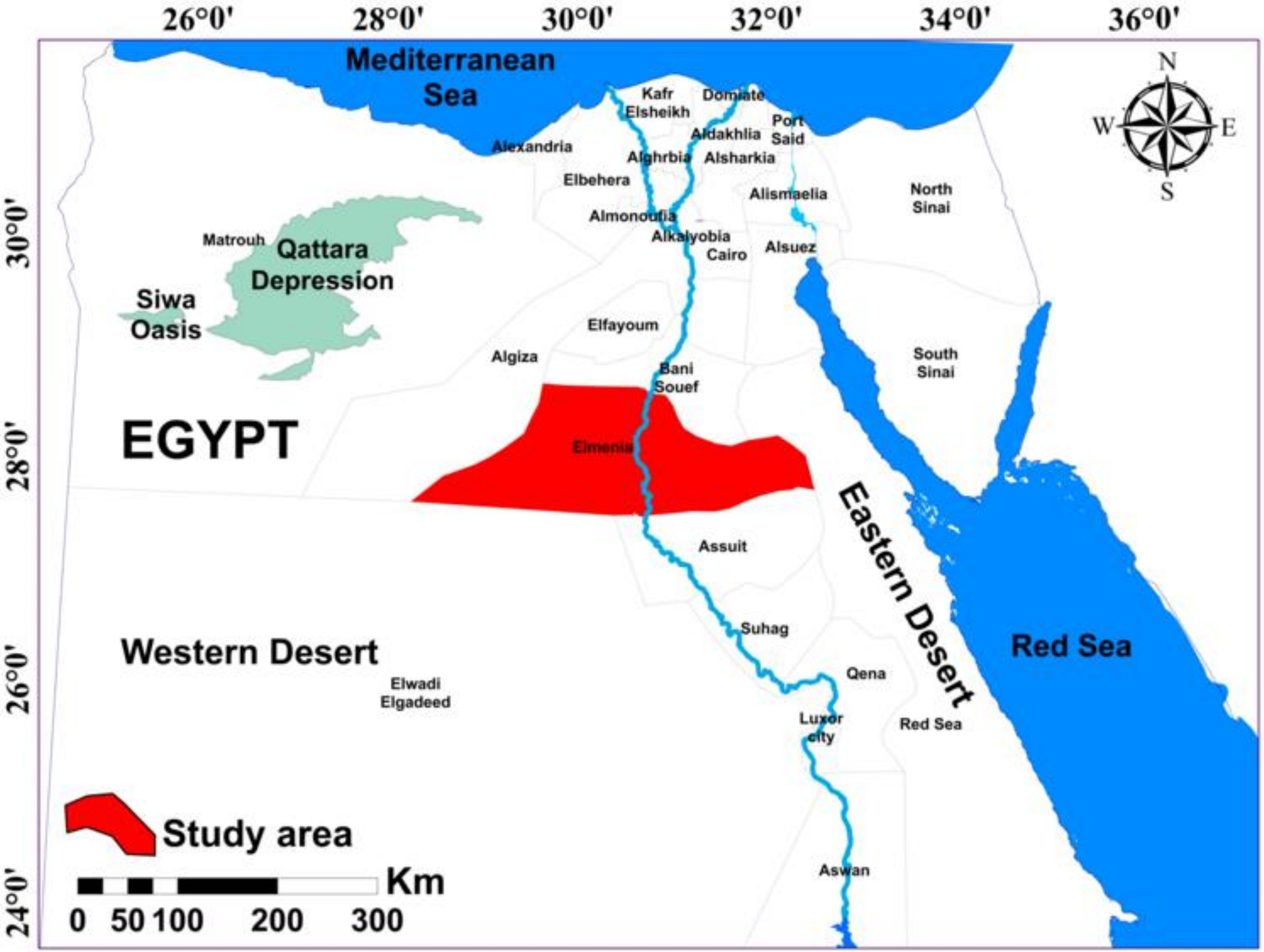
Step (1) Drawing limits of the study area on Google Earth pro



Step (2) Drawing whole canals and drains of El-Minia study area on Google Earth pro

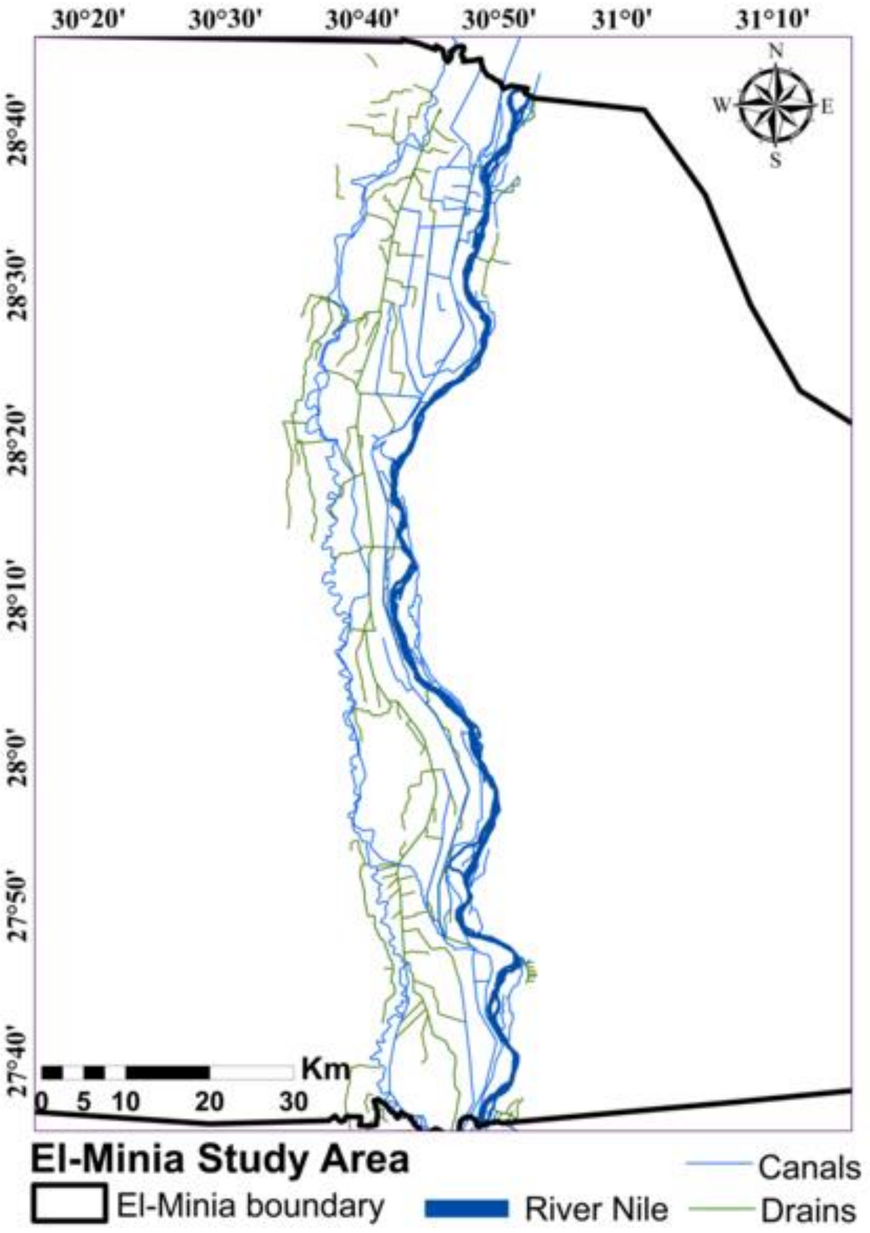


Step (3) Import the limits on ArcMap *(vol. 10.3)*



Step (4)

Import the Canals and Drains on ArcMap (vol. 10.3) and convert them to shapefile



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Step (5) Generate geodatabase for the streams including all data

Table

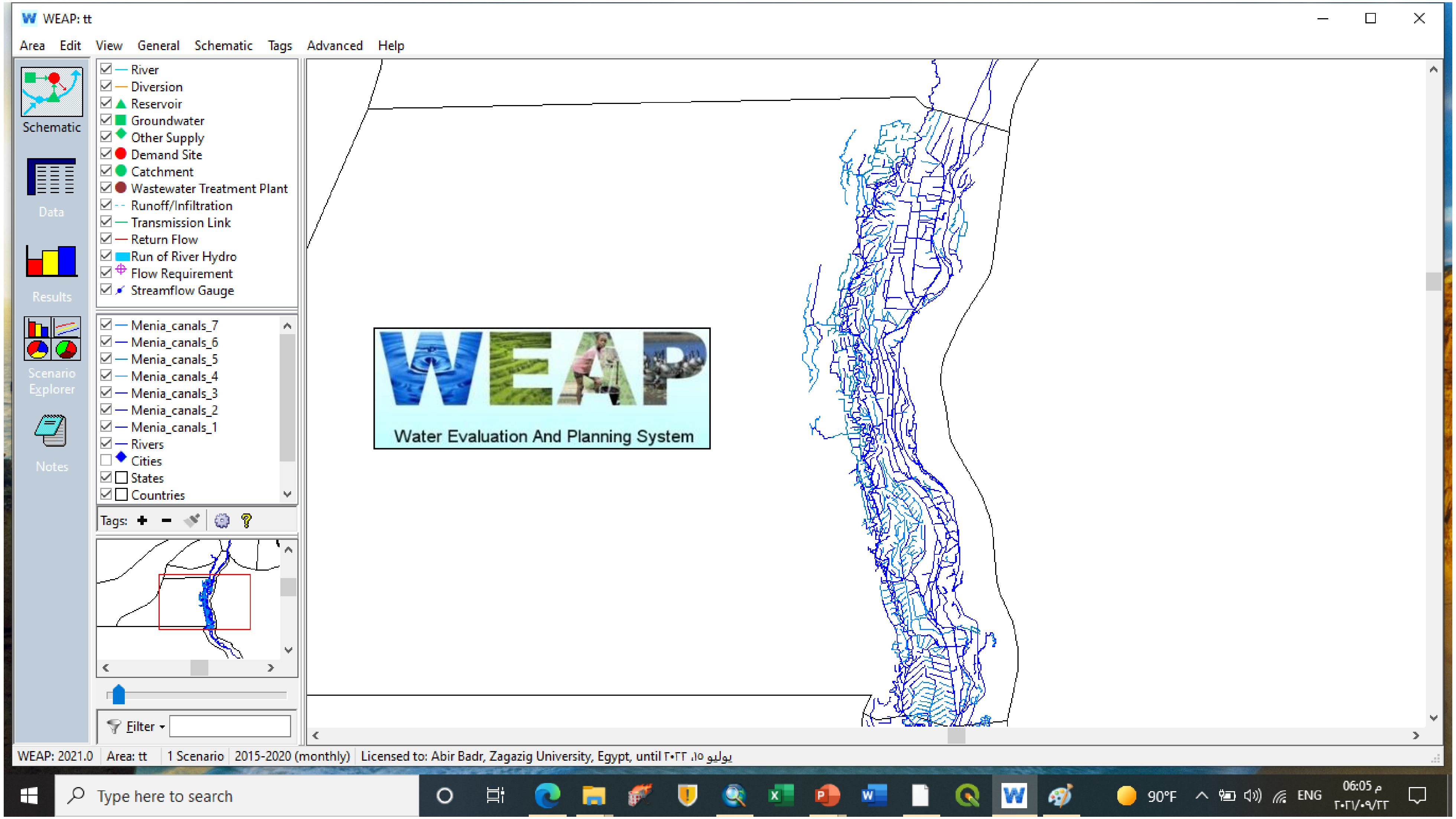
canal

FI	Shape *	OBJECTI	Name	degree	mwri	be	source	destinatio	km_on_s	handc	dir	m	zone	can	SHAPE_L	Cen	mwri_le	cove	E_Name
5	Polyline	10358	فرع ٢ شريف	4	100	0	ج شريف العليا	مصرف كبكب ال	3.43	شرق ديرو	شرق	0	مصر ا		801.09839	المنيا	0.8	0	Fara 2 shereif
6	Polyline	10476	التغذية	2	100	0	الطراد	حوض المص لمح	0.625	ملوي	شرق	0	مصر ا		1084.3779	المنيا	1.055	0	Altaghzia
7	Polyline	10587	فرع طهنشا الشرقي	5	100	0	فرع طهنشا الغر	نهاية مغلقة	1.7	شرق سما	شرق	0	مصر ا		851.90176	المنيا	0.82	0	Fara tahnasha alsharky
7	Polyline	10606	فرع ١ زويلة	4	100	0	دفش	نهاية مغلقة	3.9	شرق سما	شرق	0	مصر ا		1340.7289	المنيا	1.93	0	Fara 1 zewela
7	Polyline	10608	فرع ٢ زويلة	5	100	0	فرع ١ زويلة	نهاية مغلقة	0	شرق سما	شرق	0	مصر ا		893.16128	المنيا	0.42	0	Fara 2 zewela
7	Polyline	10634	تغذية أبو الليل	3	100	0	بشير	ترعة مسقى أبو ا	0.8	بني مزار	شرق	0	مصر ا		2382.4709	المنيا	1.7	0	Taghzeat abo allel
5	Polyline	10349	فرع حنا	4	115	0	ج دير مواس ال	نهاية مغلقة بموا	3.22	شرق ديرو	شرق	0	مصر ا		926.36205	المنيا	0.95	0	Fara hanna
5	Polyline	10396	فرع ١ من فرع الصا	4	120	0	فرع الصافية الب	مصرف ملوي	1.18	ملوي	شرق	0	مصر ا		2075.4218	المنيا	2	0	Fara 1 men fara alsafia a
6	Polyline	10451	فرع محمد اسماعيل	4	120	0	الأشمونين	نهاية مغلقة	15.76	ملوي	شرق	0	مصر ا		1254.0776	المنيا	1.25	0	Fara mohamed esmaeil
5	Polyline	10351	فرع شناوي	4	130	0	ج البدرمان	نهاية مغلقة بموا	0.835	شرق ديرو	شرق	0	مصر ا		613.69946	المنيا	0.7	0	Fara shennawy
5	Polyline	10412	نفرتيتي	3	130	0	أخناتون	مصرف أتون البح	3	شرق ديرو	شرق	0	مصر ا		3340.8765	المنيا	3.525	0	Nefertety
6	Polyline	10477	الجبل	3	138	0	التغذية	مخر سيل درب ع	1.055	ملوي	شرق	0	مصر ا		3939.9451	المنيا	4	0	Algabal
6	Polyline	10504	فرع ١ عروس	4	150	0	ج العروس	مسقى خاصة	1.45	ديرمواس	شرق	0	مصر ا		1371.2280	المنيا	1.37	0	Fara 1 aros
9	Polyline	10507	فرع شكري	3	150	0	البدرمان	نهاية مغلقة	7.17	ديرمواس	شرق	0	مصر ا		1267.6807	المنيا	1.27	0	Fara shokry
6	Polyline	10550	فرع ابوقرقاص الشر	3	150	0	ج حافظ الشرقيه	نهاية مغلقة	14.175	شرق أبو	شرق	0	مصر ا		1628.3317	المنيا	1.65	0	Fara abo qerqas alshark
9	Polyline	10553	فرع السحاله (مغذي	4	150	0	السحاله	نهاية مغلقة	1.23	شرق أبو	شرق	0	مصر ا		771.34197	المنيا	0.82	0	Fara alsahala
3	Polyline	10571	فرع بني احمد	6	150	0	جزيره بني أحمد	نهاية مغلقة	0.92	شرق أبو	شرق	0	مصر ا		1496.2191	المنيا	1.56	0	Fara bani ahmed
4	Polyline	10196	امتداد أبوحلفاية	6	150	0	أبوحلفاية الرئيس		0	منشأة الده	غرب	0	مصر ا		1057.4013	المنيا	0	0	Emtdad abo helfaia
4	Polyline	10220	أيسر راحيل	6	150	0	ترعة راحيل		0.07	منشأة الده	غرب	0	مصر ا		981.77384	المنيا	0	0	Ayser rahel
4	Polyline	10225	فرع عمار	6	150	0	ج ٣ منشأة الده	فرع سرير	0	منشأة الده	غرب	0	مصر ا		1386.3921	المنيا	0	0	Fara ammar
4	Polyline	10227	فرع منصور عبد القاد	6	150	0	أبوحلفاية الرئيس		0	منشأة الده	غرب	0	مصر ا		1286.1234	المنيا	0	0	Fara mansor abdelkade
5	Polyline	10243	تفريعة أيسرراحيل	7	150	0	أيسر راحيل		0	منشأة الده	غرب	0	مصر ا		874.07457	المنيا	0	0	Tafreeaat ayser raheel
5	Polyline	10244	فرع ابو اليزيد	6	150	0	ترعة راحيل		0	منشأة الده	غرب	0	مصر ا		1120.8549	المنيا	0	0	Fara aboelyazed
5	Polyline	10245	فرع البكل	5	150	0	ج طوخ الشرقية		0	منشأة الده	غرب	0	مصر ا		1004.2020	المنيا	0	0	Fara albokl
6	Polyline	10425	أتون	3	150	0	اخناتون		2.35	شرق ديرو	شرق	0	مصر ا		3051.6094	المنيا	3.265	0	Aton
7	Polyline	10689	فرع محجوب	4	150	0	أبو عسير البحر	يصب بماسورة	1.04	بني مزار	شرق	0	مصر ا		2203.0993	المنيا	2.2	0	Fara mahgob
8	Polyline	10738	أتون	3	150	0	اخناتون		2.35	شرق ديرو	شرق	0	مصر ا		214.11900	المنيا	3.265	0	Aton

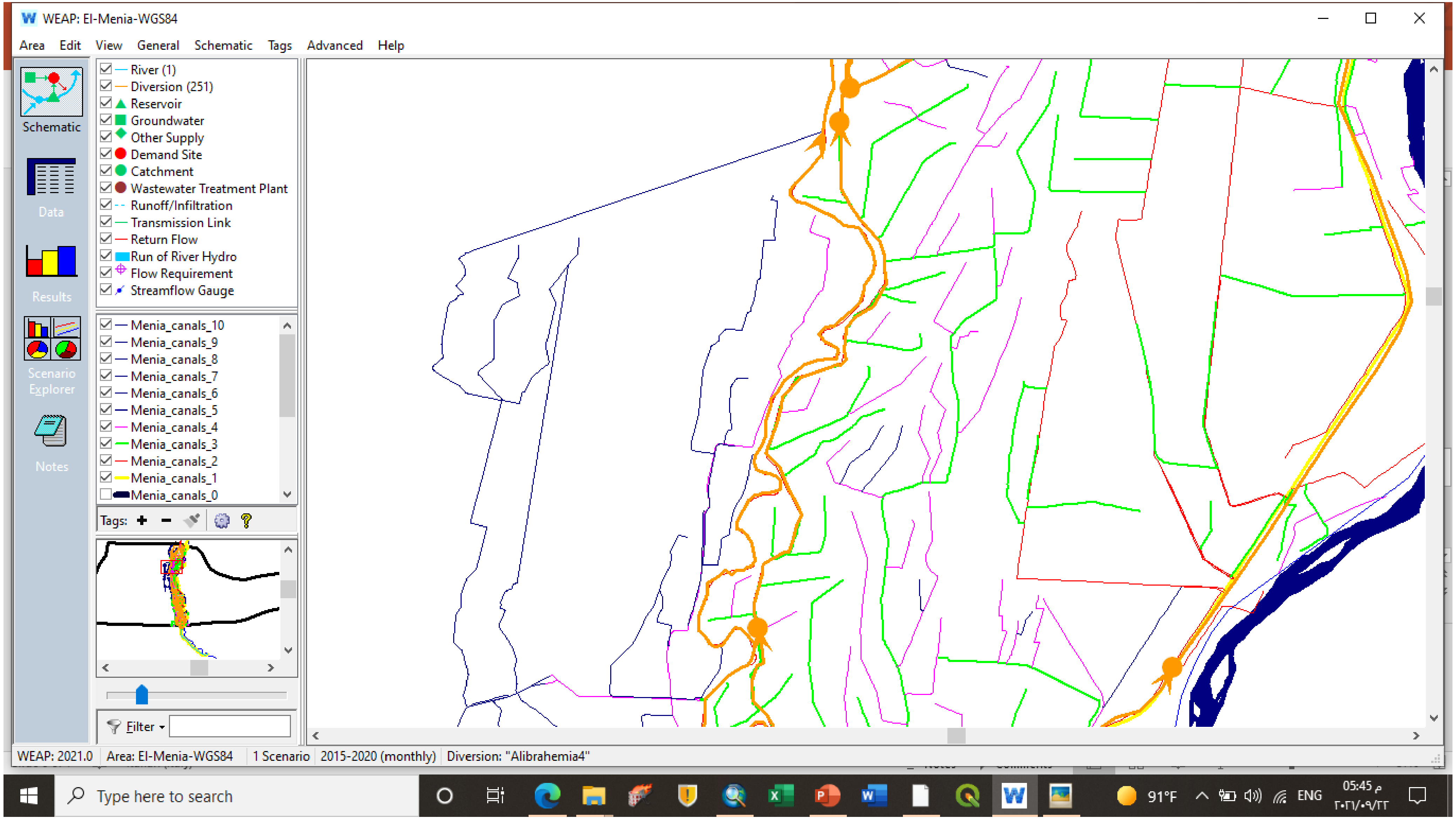
0 (0 out of 854 Selected)

canal

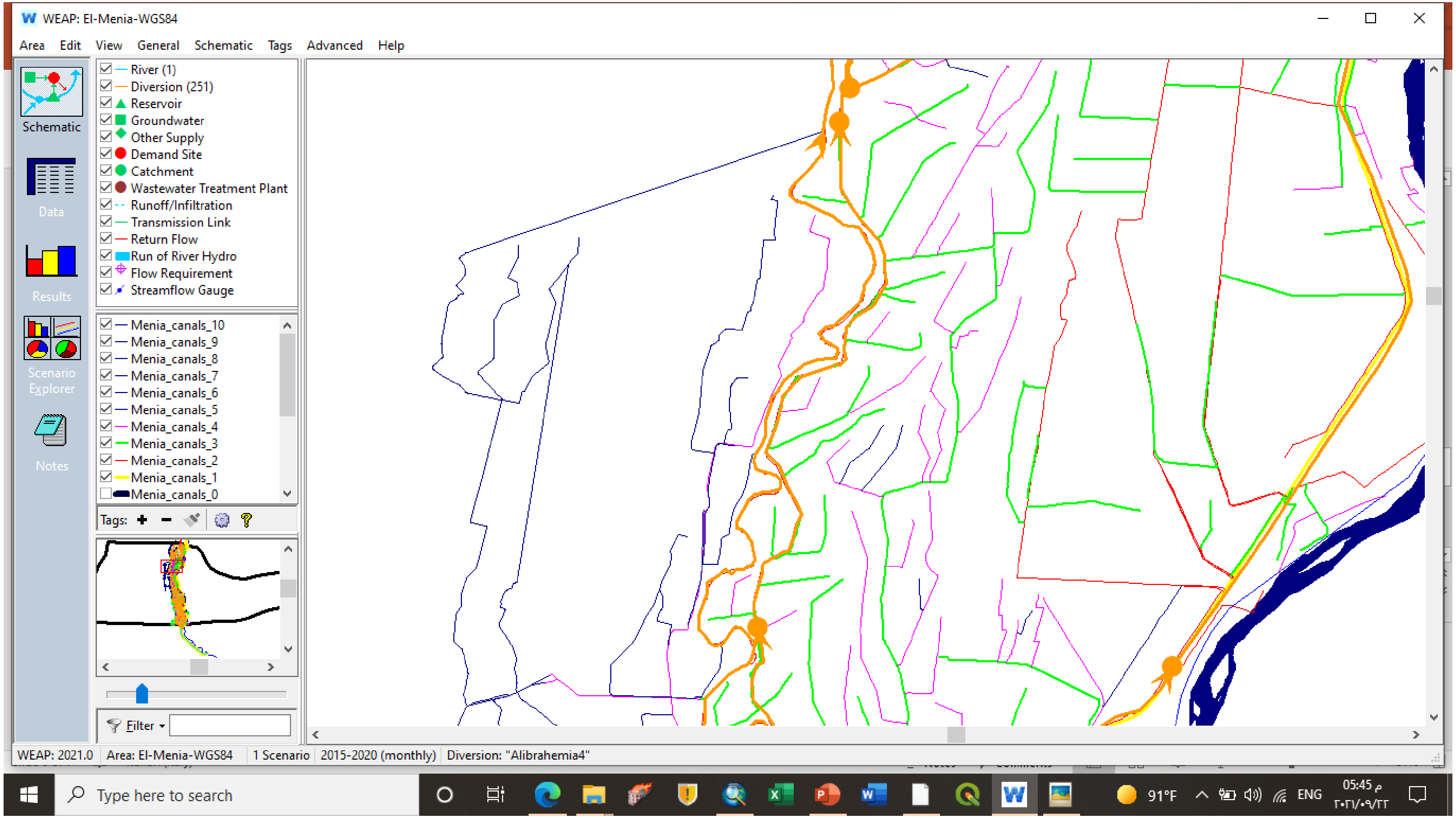
Step (6) Import the Shapefiles on WEAP



Step (7) Classification of canals to categories according to their degree on WEAP



Step (8) Drawing the streams on WEAP



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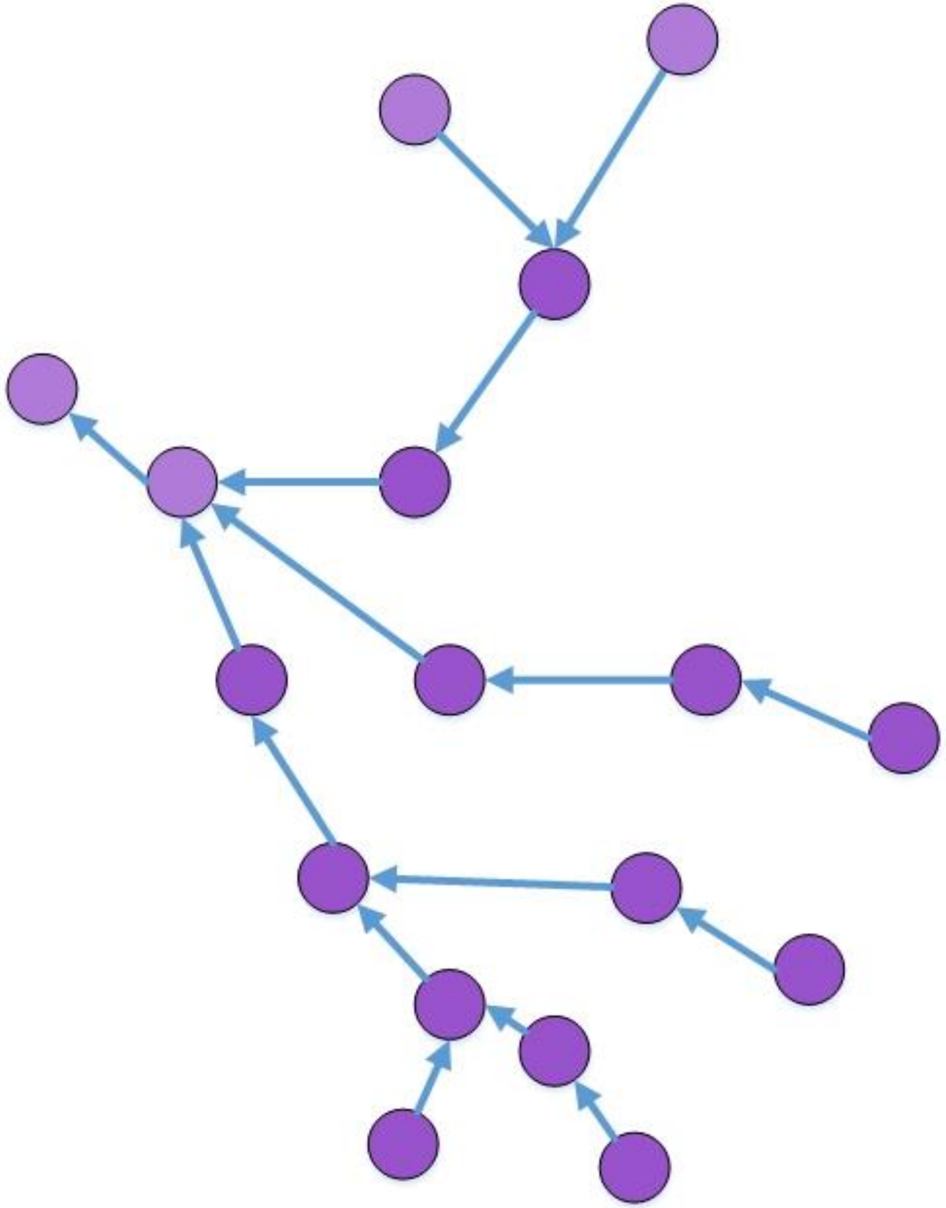
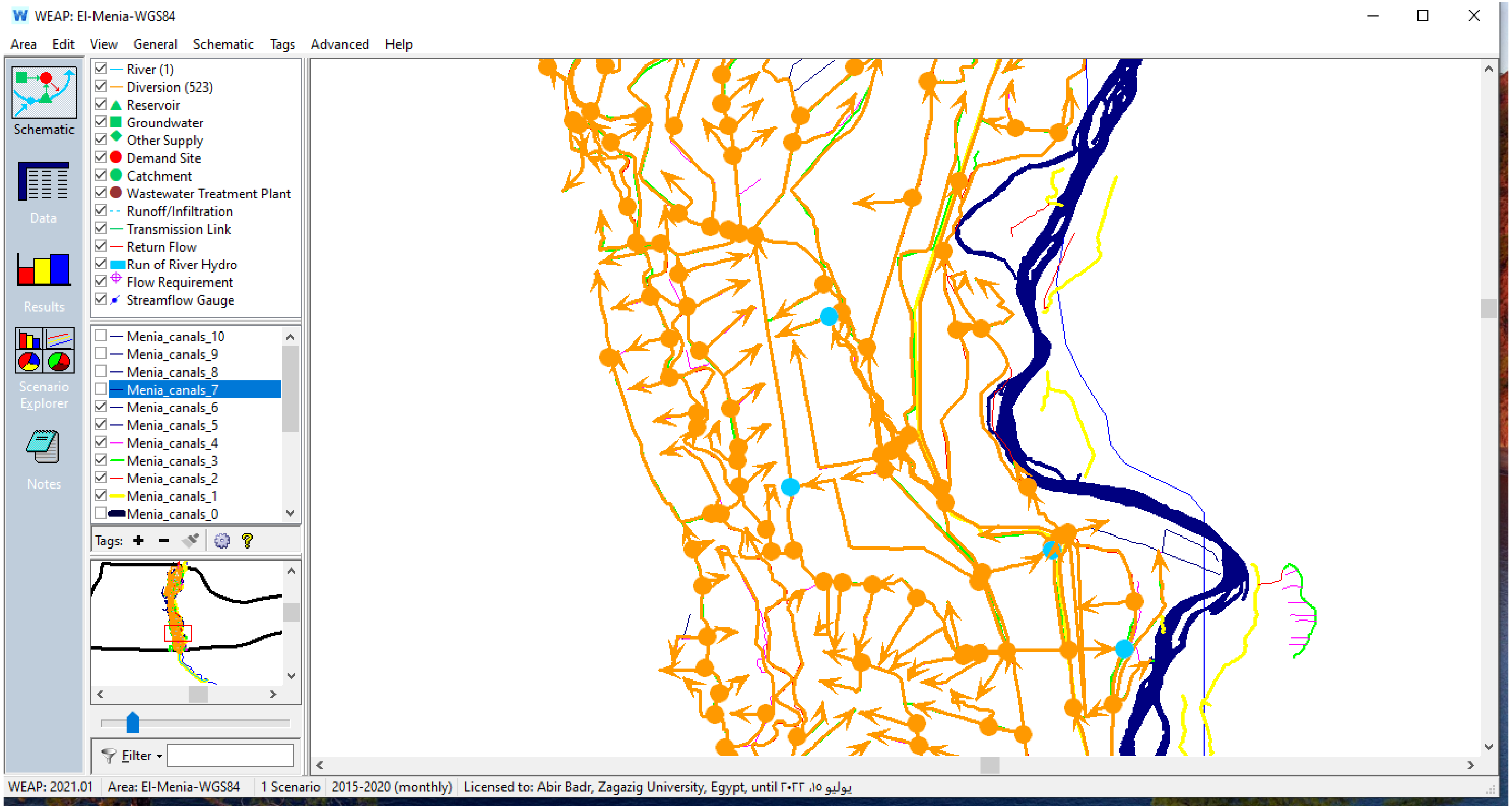
Step (9)

Node and link network schema conceptually represent spatial distribution of stream components showing its source and its destination



Step (10) Sample of the obtained canals stream maps in El-Minia Region



Coming Next

Once we have finished building the model and entered the inputs, the following task will be achieved:

- Model Calibration (Slid 19).
- Evaluation of the existing crop pattern.
- Evaluation of the proposed scenarios.
- Evaluation of the climate change impacts on the proposed scenarios.
- Recommending the set of optimized crop pattern(s) over time and space.

Expected Modeling schedule to Produce Optimized Crop Pattern(s)

- Land use
- Water quantity contribution
- Water resources
- Demand & supply

6 months (3 for each case study)

- Development of the conceptual WEAP Model

8 months (4 for each case study)

- Run the Model and evaluate the present situation

8 months (4 for each case study)

Build scenarios, make the scenarios analysis and conclusion

6 months (3 for each case study)

Expected Results

- Through the WEAP model, it is possible to simulate the hydrological changes for the study areas for the period 2016-2050 and for different climate scenarios (favorable, intermediate, extreme).

- The analysis of the results aims to investigate trends in variables and the required amount of water for irrigation under all tested conditions.

- The results are expected to obtain different scenarios for crop pattern to give the highest productivity on water resources availability as well as the country strategic plans.

7. CONCLUSIONS

- WEAP with its capabilities is suitable for the study area according to the available hydrological data.

- Testing the climate change different scenarios will be useful for the future of the study area to meet the farmers expectations and to achieve Egypt’s agenda 2030 for the area.

- Coupling other models with WEAP could enable us to investigate other aspects as water quality and ecosystems.

SIGMA Nexus

Thanks for your Attention

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PRIMA PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA

This project has received funding from the PRIMA and European Union's H2020 research and innovation programme under Grant Agreement No. 1943

The detection of Agricultural Land Changes using Remote Sensing Techniques. A case study in the South of Egypt

7 December 2021

WP3:

Eman Hussein Mohammed

European Commission
Horizon 2020
European Union funding
for Research & Innovation

This project has received funding from the PRIMA and European Union's H2020 research and innovation programme under Grant Agreement No. 1943

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IN THE MEDITERRANEAN AREA

Agenda

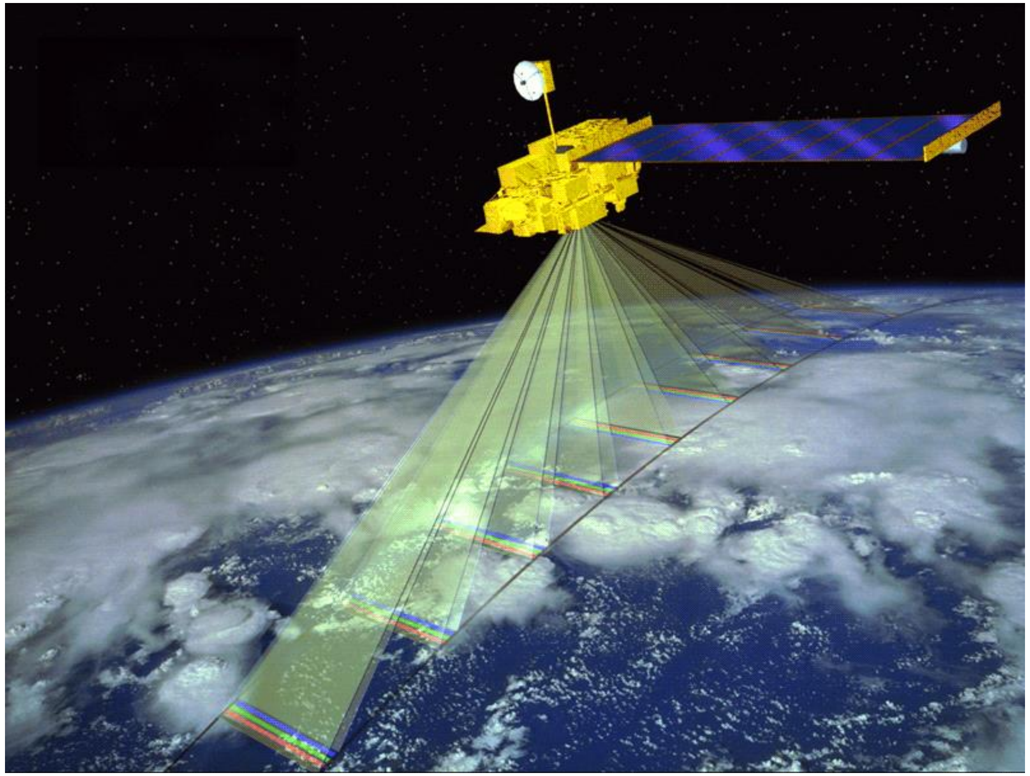
- Introduction about Remote Sensing
- Remote Sensing in NEXUS
- A case study in the South of Egypt – El Minya Governate
- Conclusion - Advantages and Challenges -

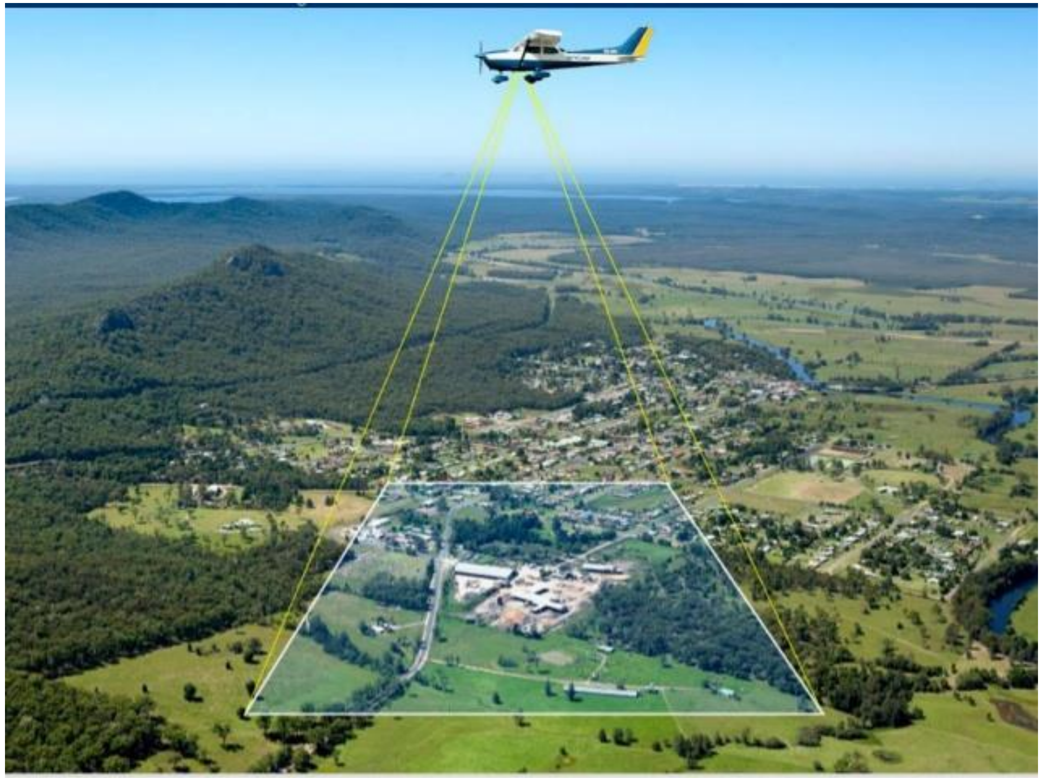
Agenda

- **Introduction about Remote Sensing**

Geomatics, Remote Sensing, GIS, GPS ?

How?



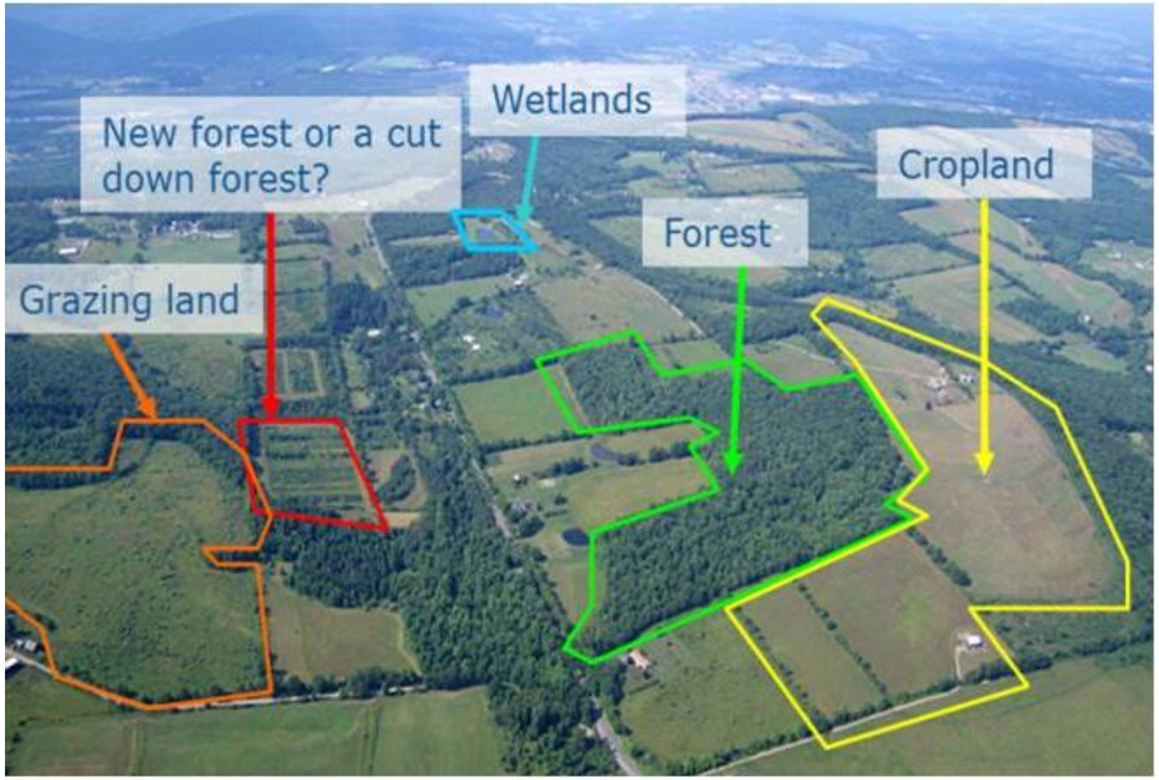


Geomatics, Remote Sensing, GIS, GPS ? Where?

Geomatics, Remote Sensing, GIS, GPS ?

Location itself has no meaning?

What?

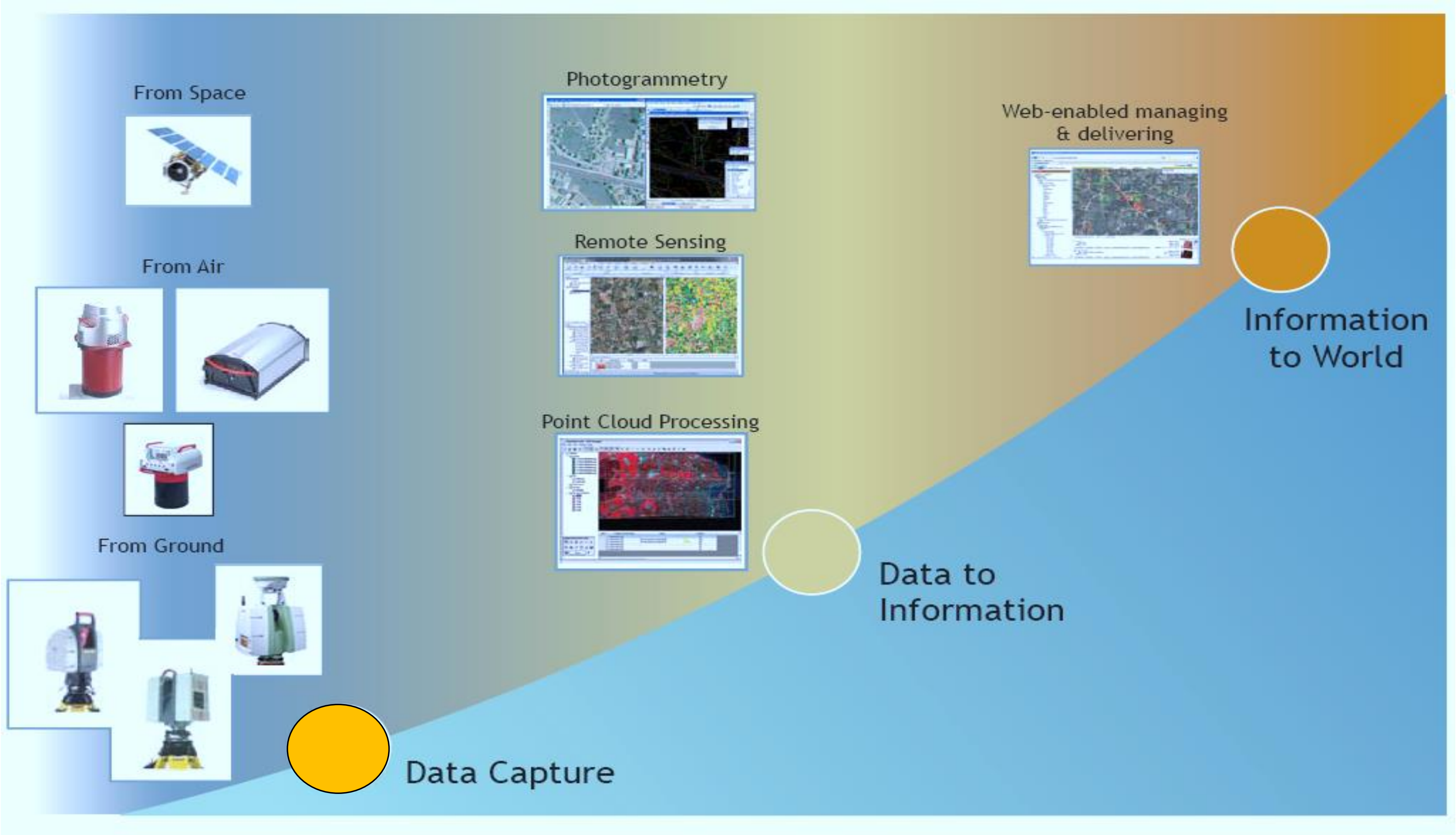


Geomatics, Remote Sensing, GIS, GPS ?

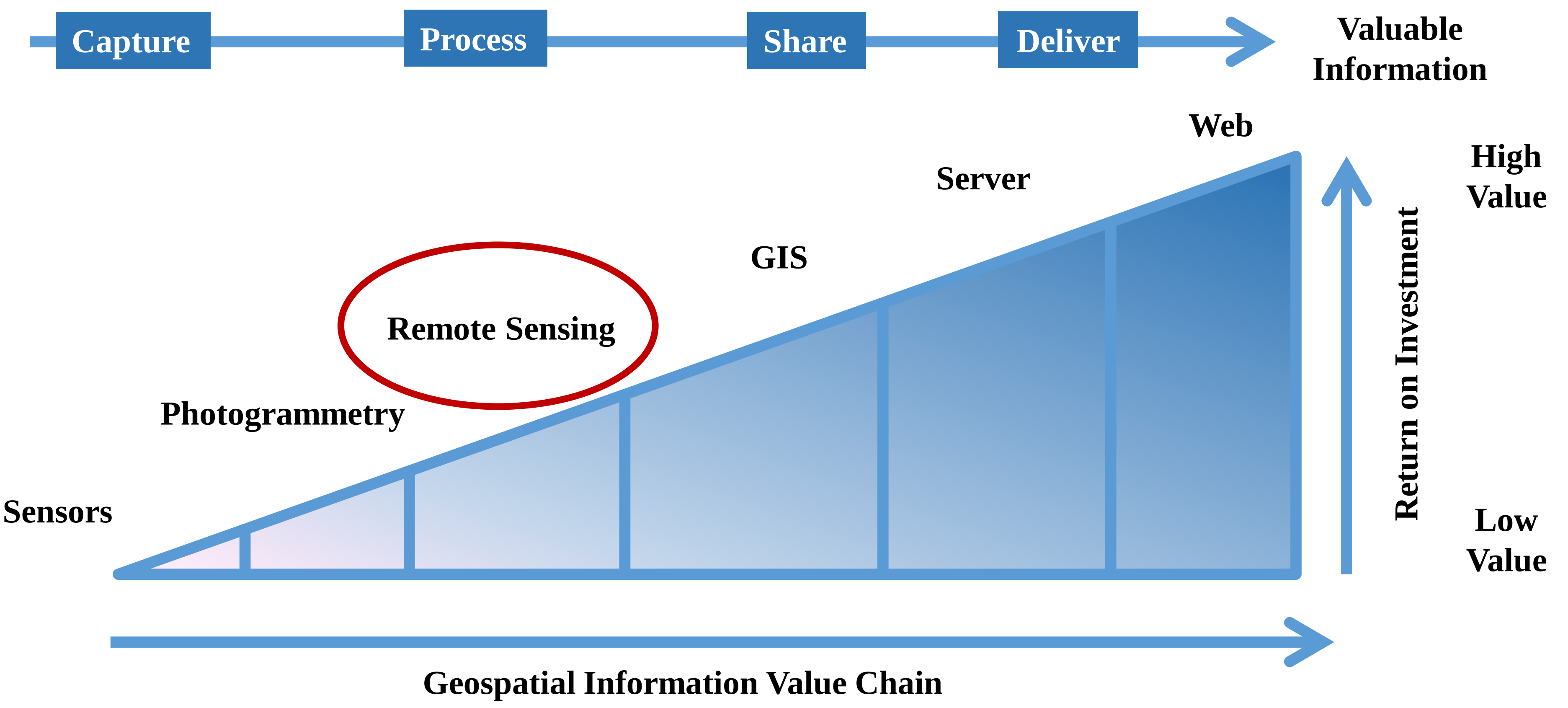
Geomatics enabled information – communication Device

GIS, RS, GPS

Geospatial Information Cycle



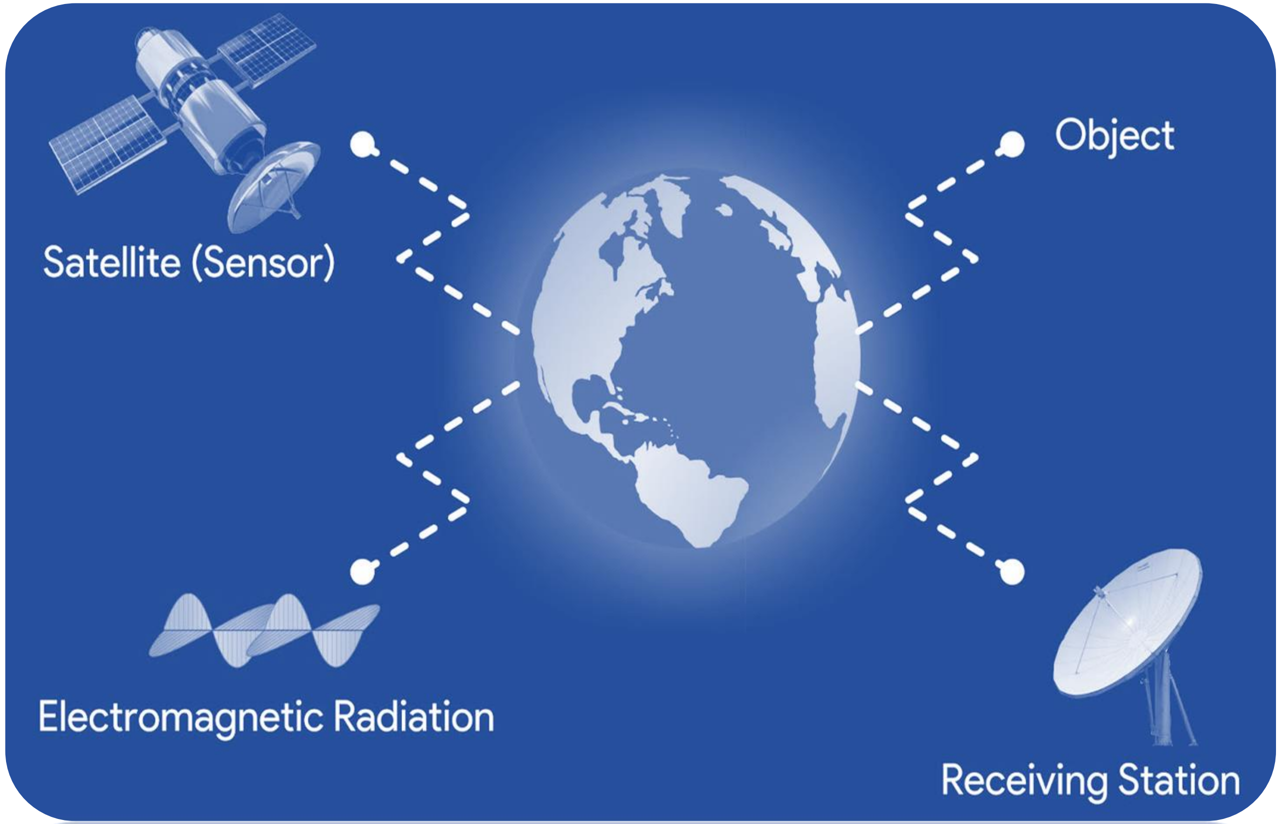
Geospatial Information Cycle



What is Remote Sensing?

Look-Look, NO Touch

- REMOTE SENSING includes all methods and techniques used to gain qualitative and quantitative information about distant objects without coming into direct contact with these objects.



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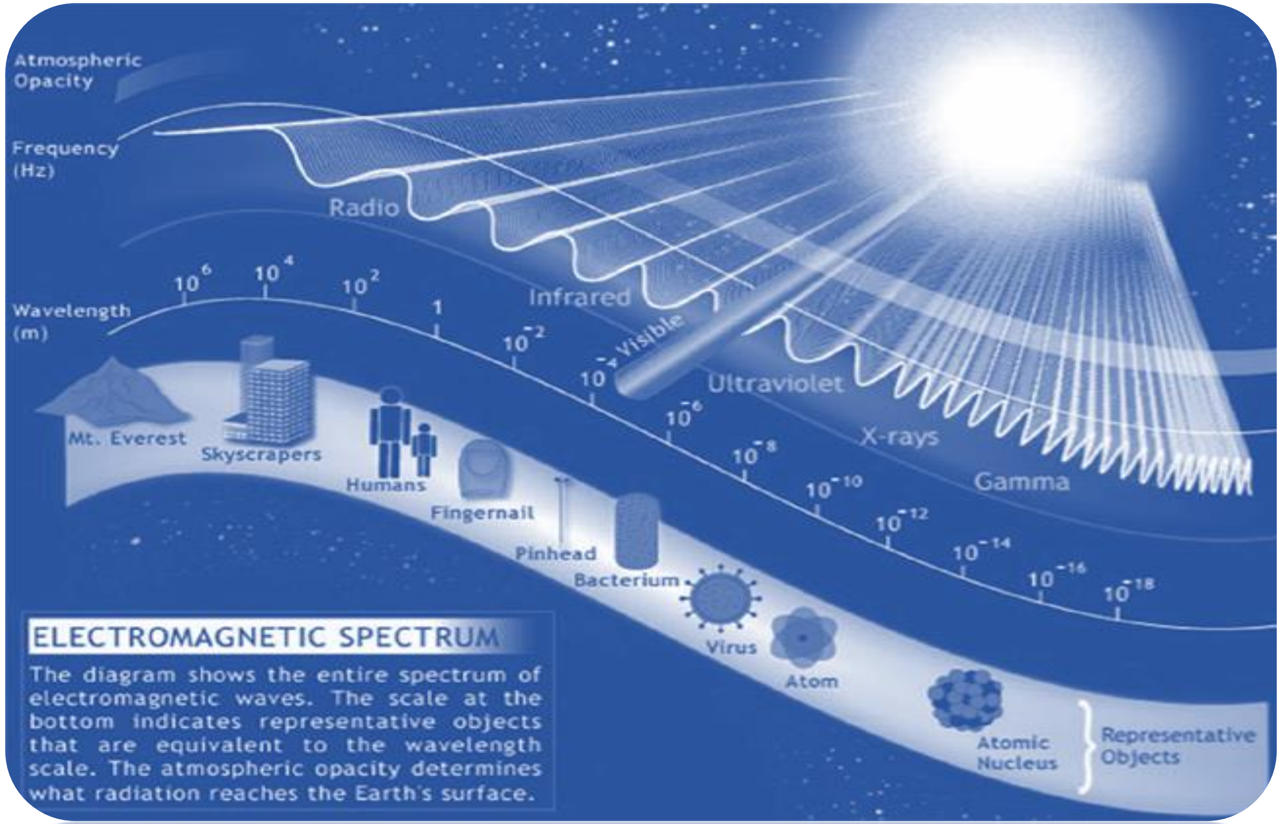
What is Remote Sensing?

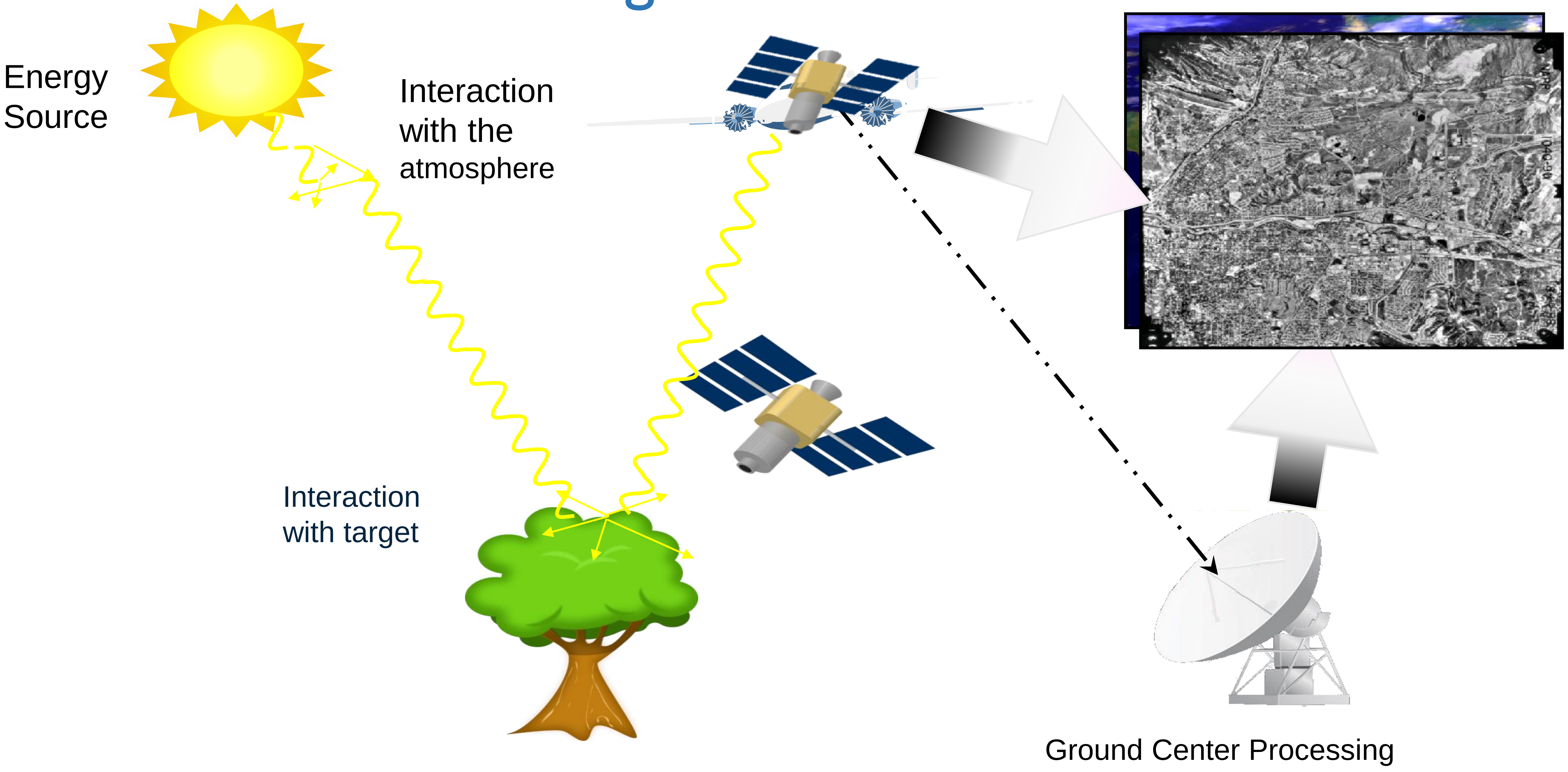
- The information needs a physical carrier to travel from the object/events to sensors through an intervening medium.

- The **Electromagnetic radiation** is normally used as an information carrier in remote sensing.

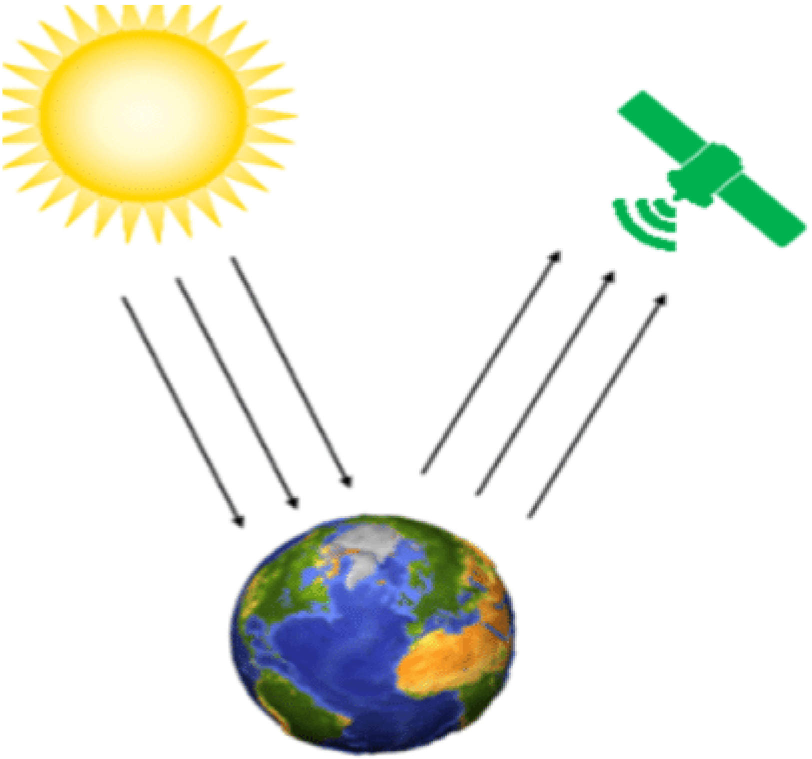
- The output of a remote seining system is usually an image representing the scene being observed.



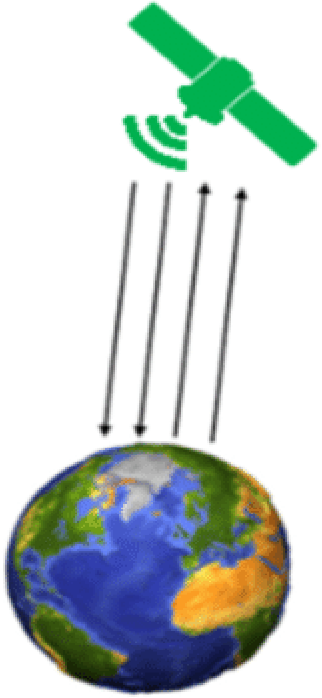
What is Remote Sensing?



Passive and Active Sensors



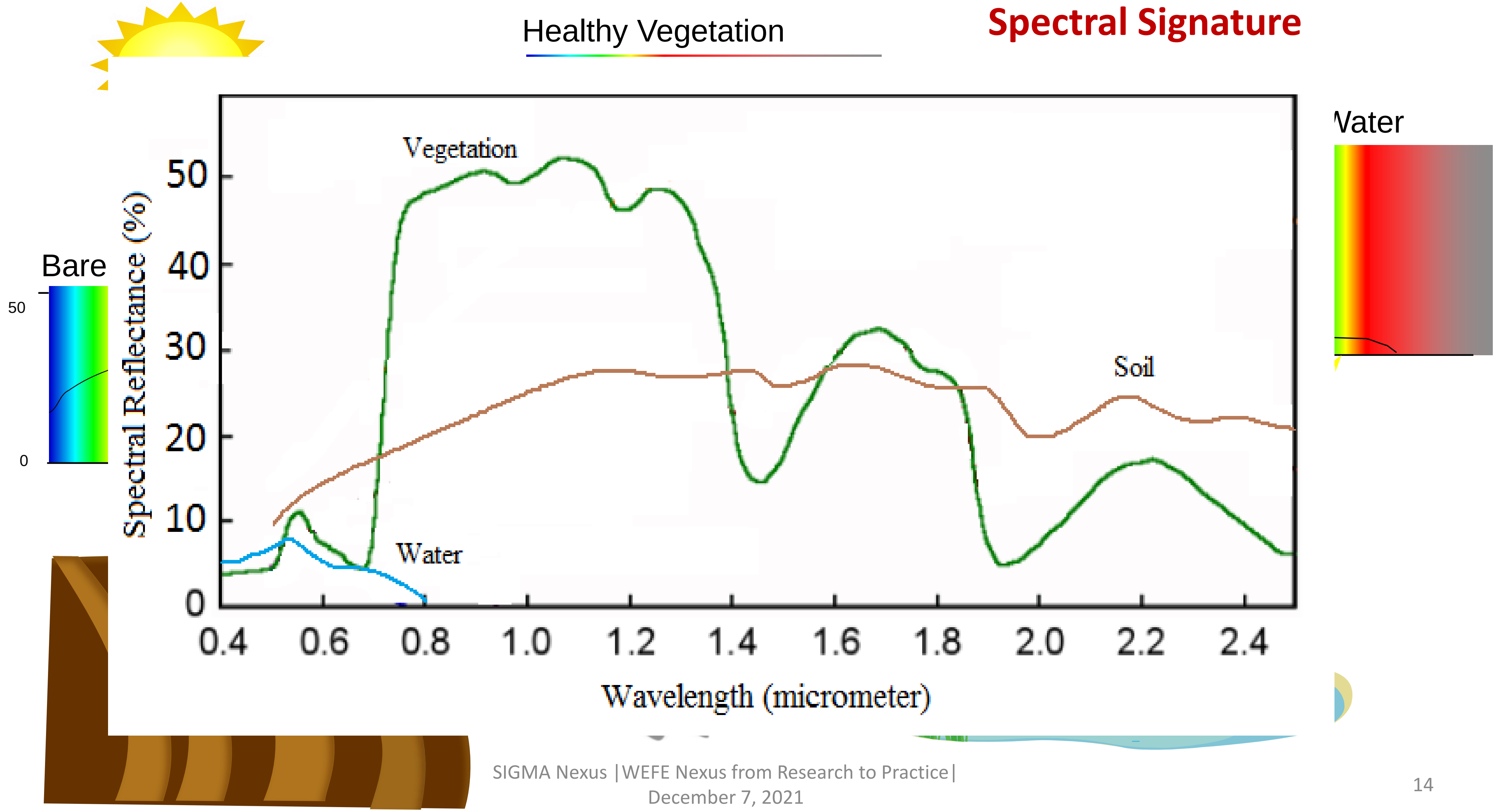
Passive Sensors



Active Sensors

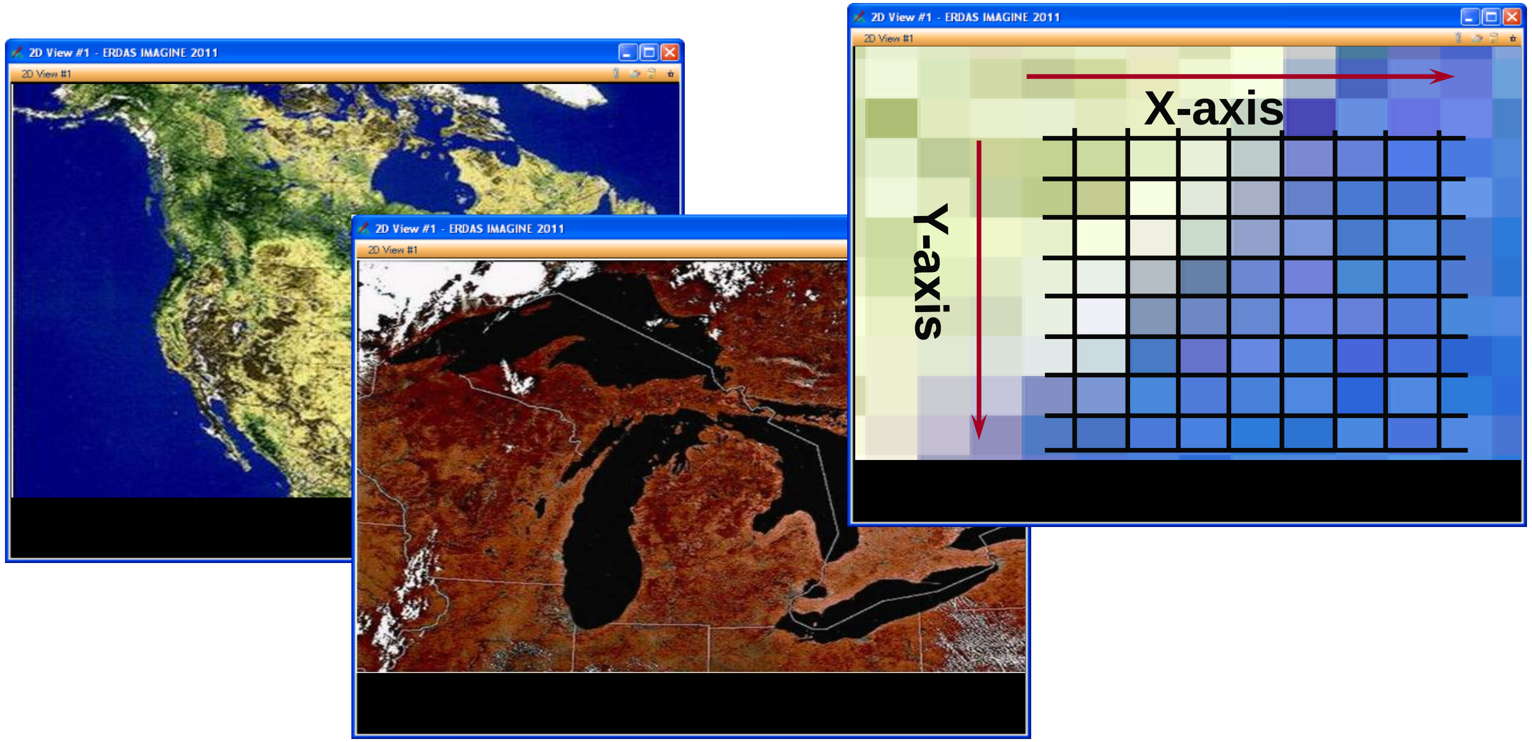
Reflectance

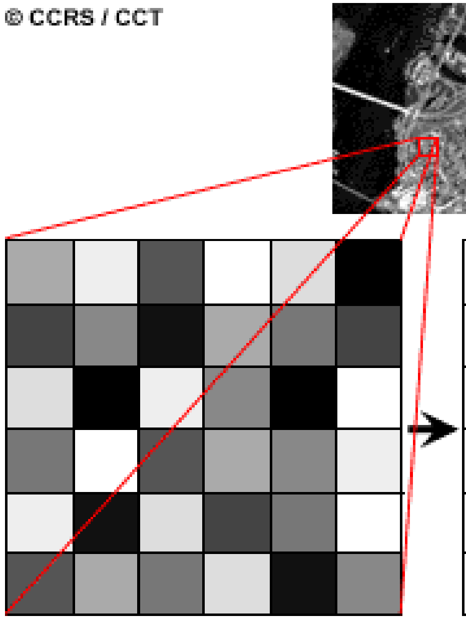
Spectral Signature



What is an image

- Data that are organized in a grid of columns and rows (a grid of pixels).
- Each pixel stores a digital number (DN) measured by the sensor.

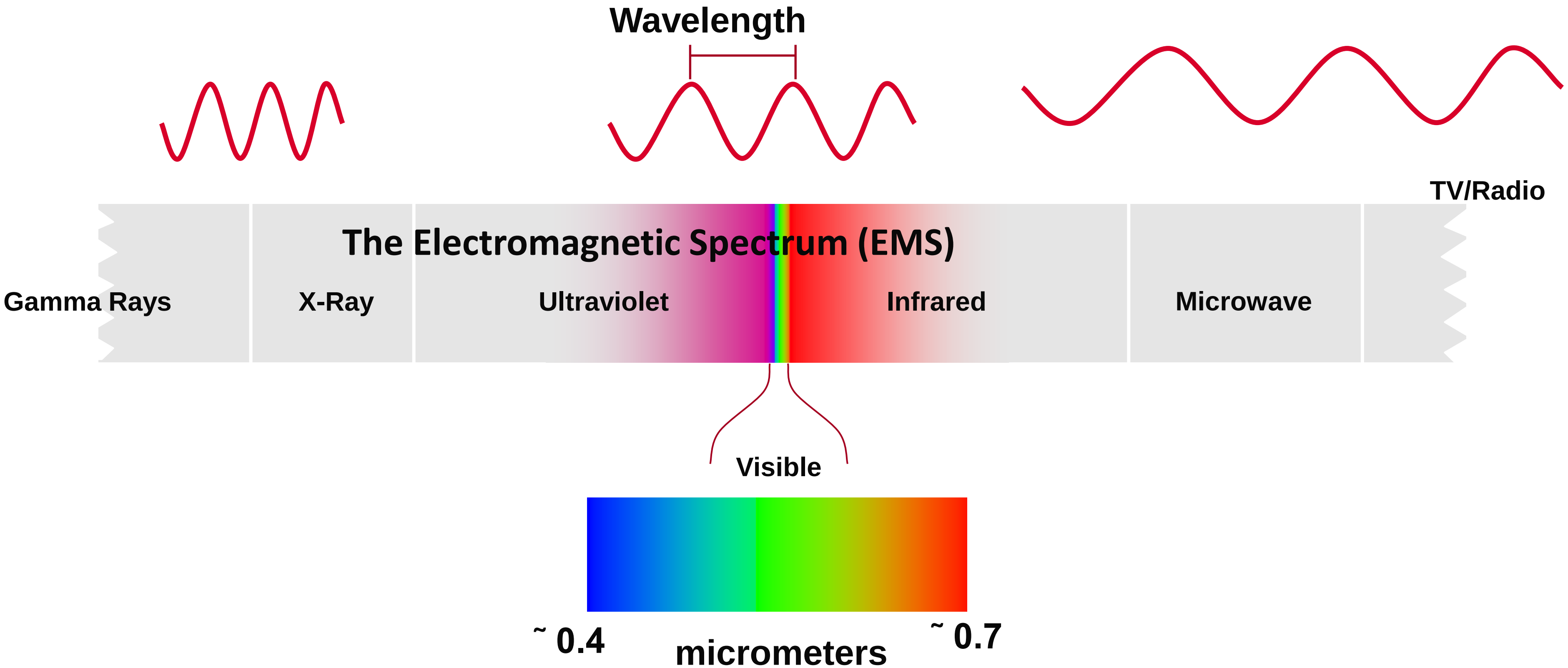




170	238	85	255	221	0
68	136	17	170	119	68
221	0	238	136	0	255
119	255	85	170	136	238
238	17	221	68	119	255
85	170	119	221	17	136

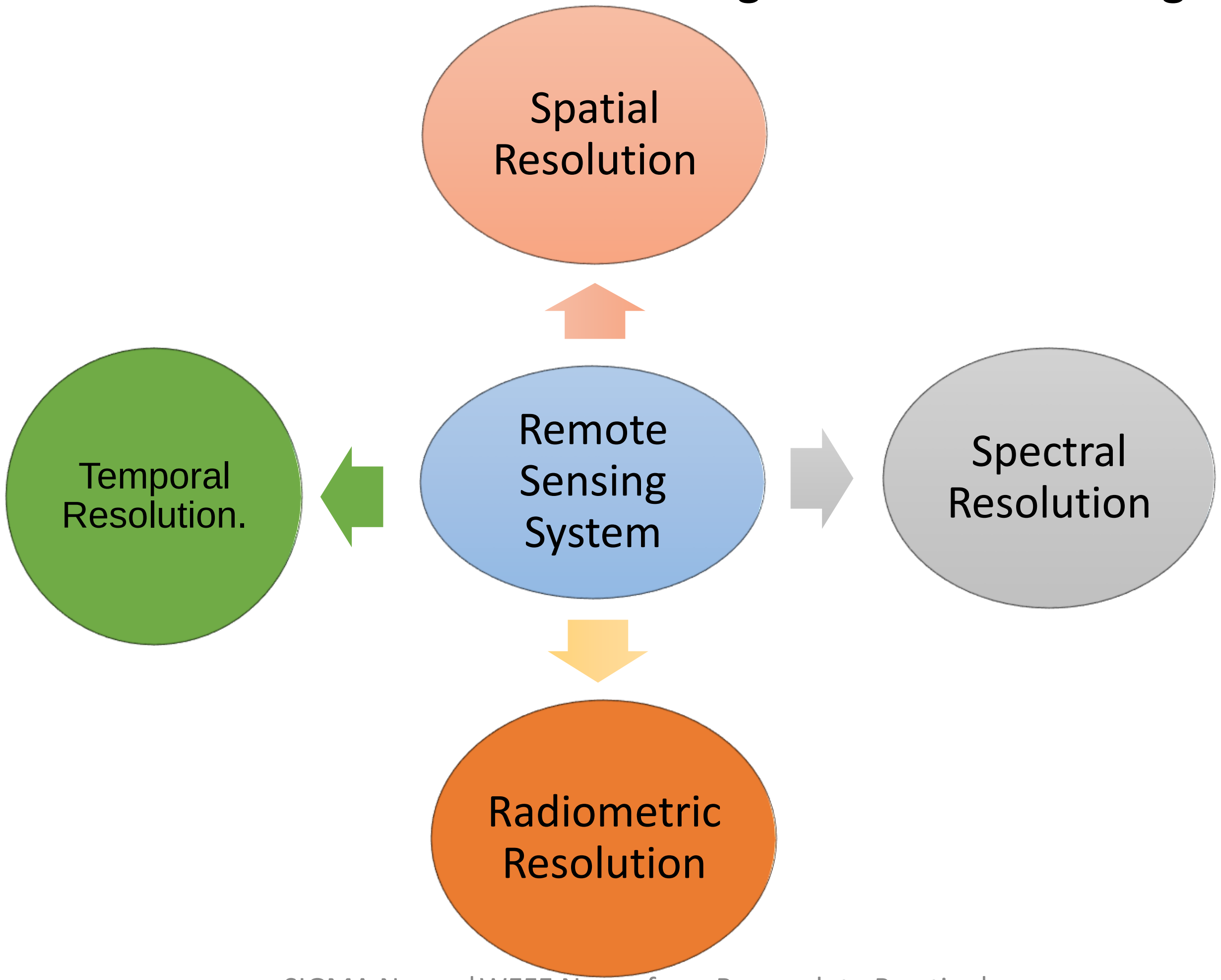
What is an image

- The information inside the pixel is the result of measuring the light reflected from the target. It start from a narrow wavelength range is gathered and stored in a channel, also sometimes referred to as **a band**



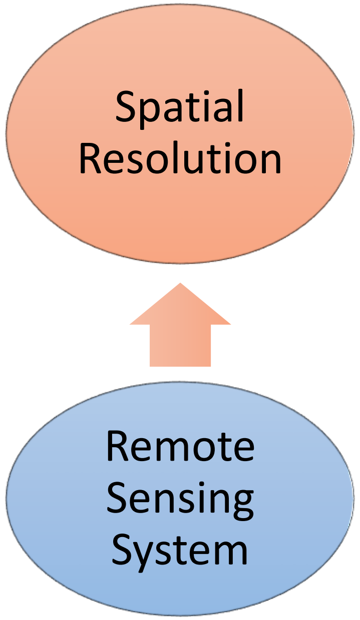
Satellite Characteristics

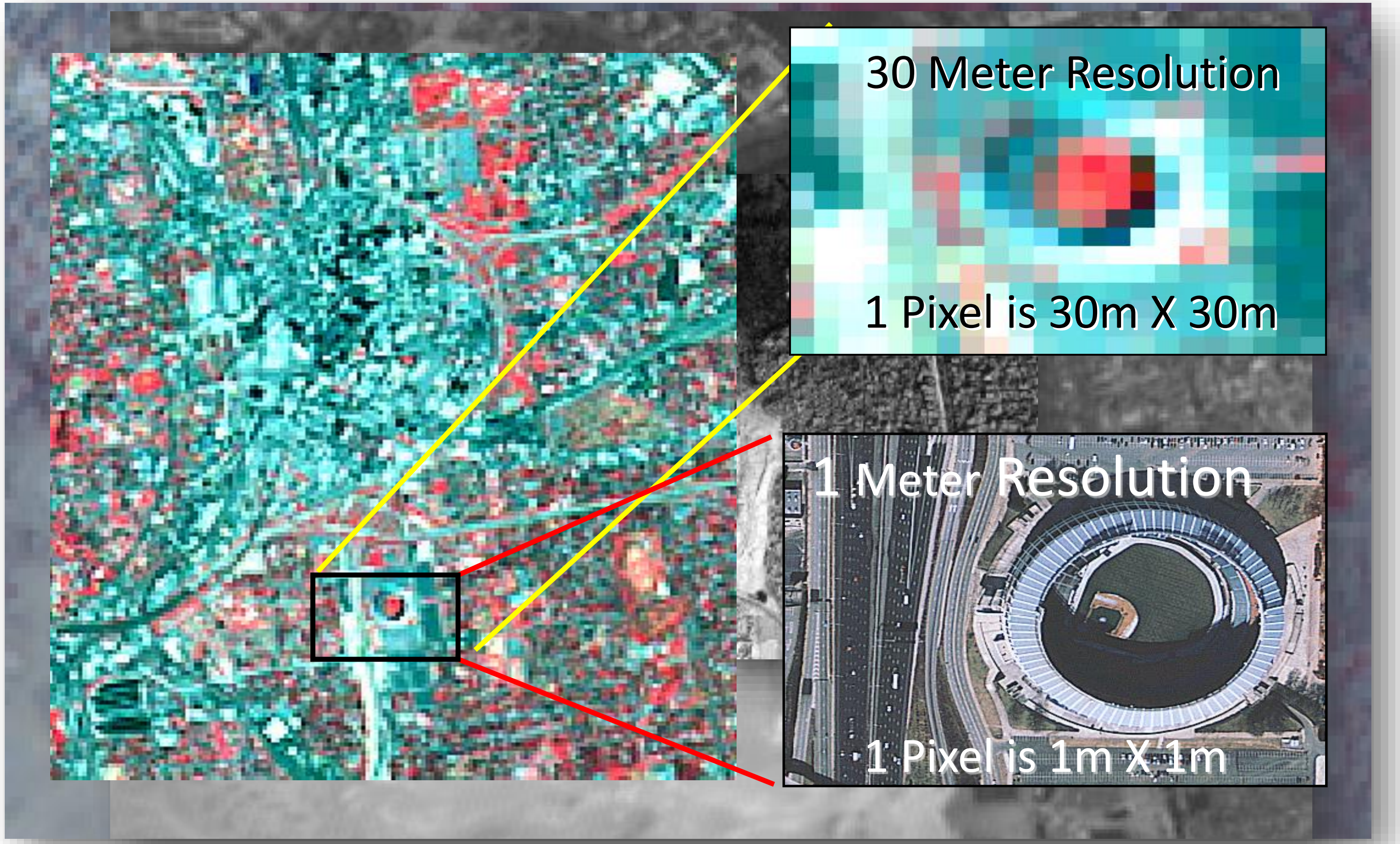
- There are several factors to consider when choosing a remote sensing system for a particular application.



Satellite Characteristics

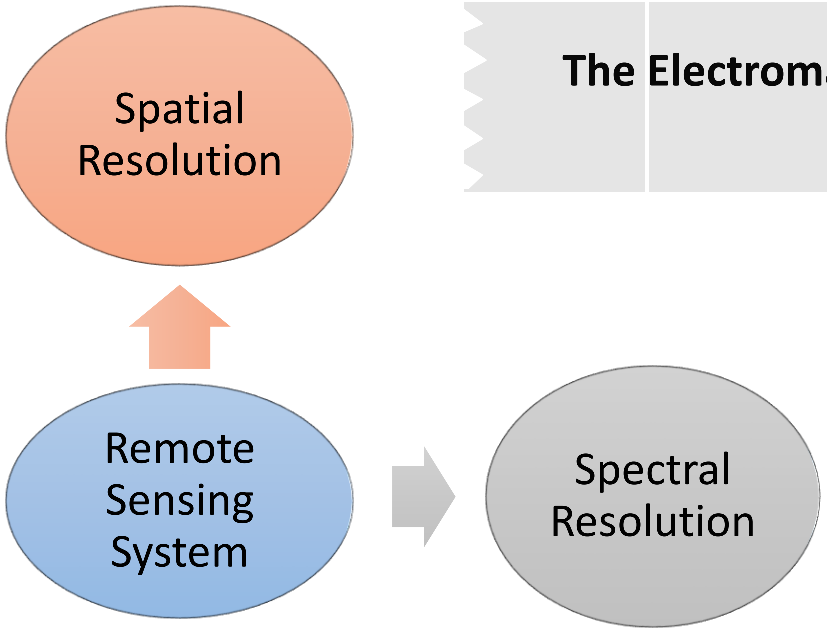
- **Spatial Resolution:** the area on the ground represented by each pixel. Expressed as the smallest object that can be detected by the sensor

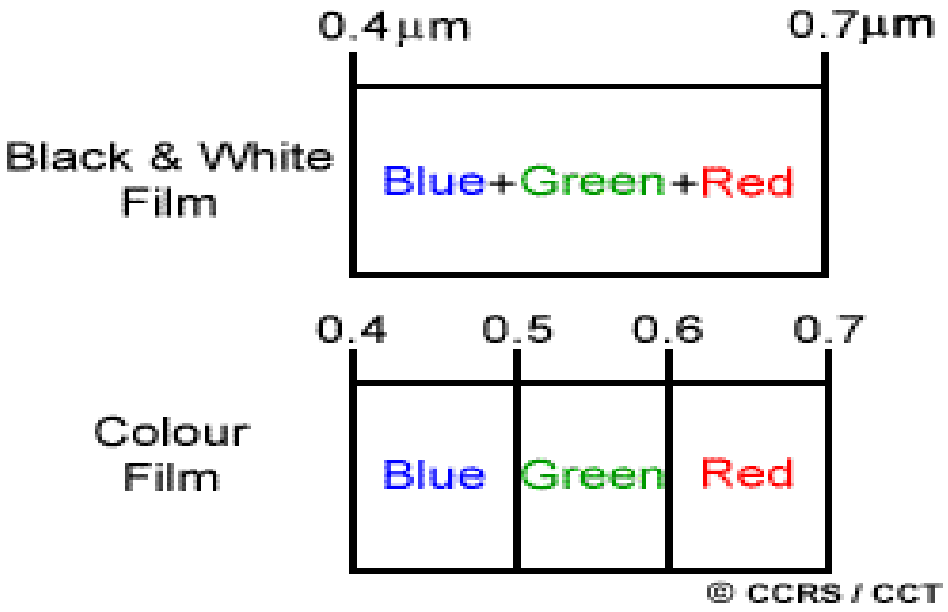




Satellite Characteristics

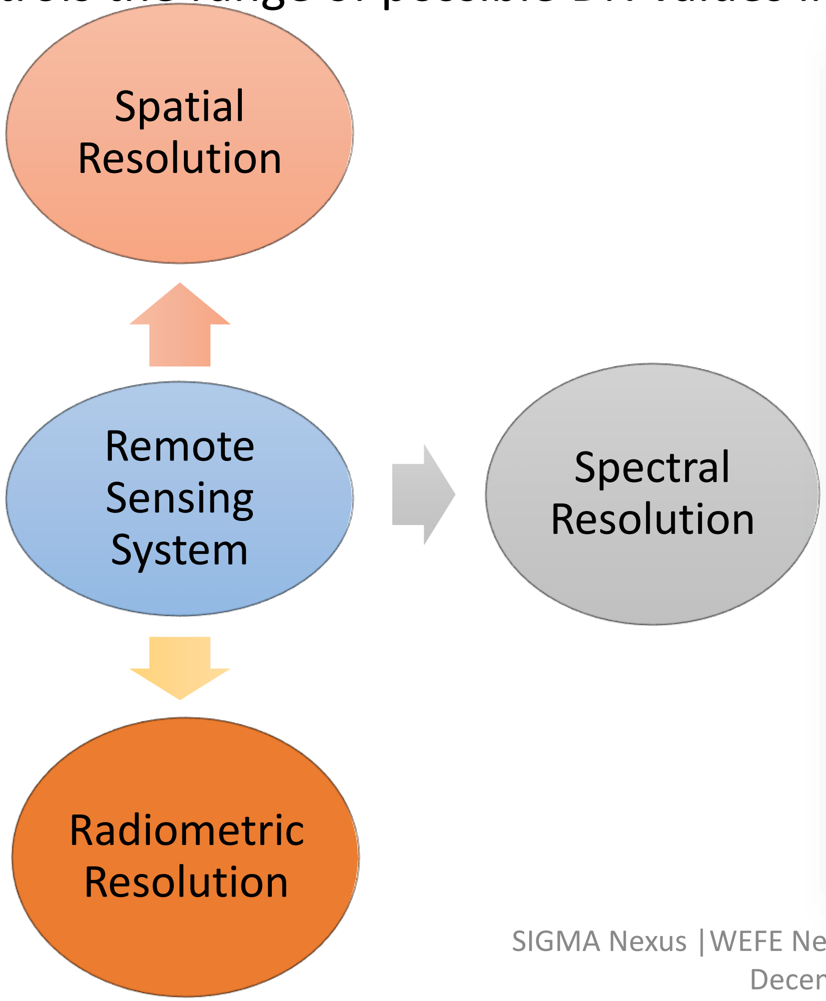
- **<u>Spectral Resolution:</u>** the specific wavelength intervals that a sensor can record.

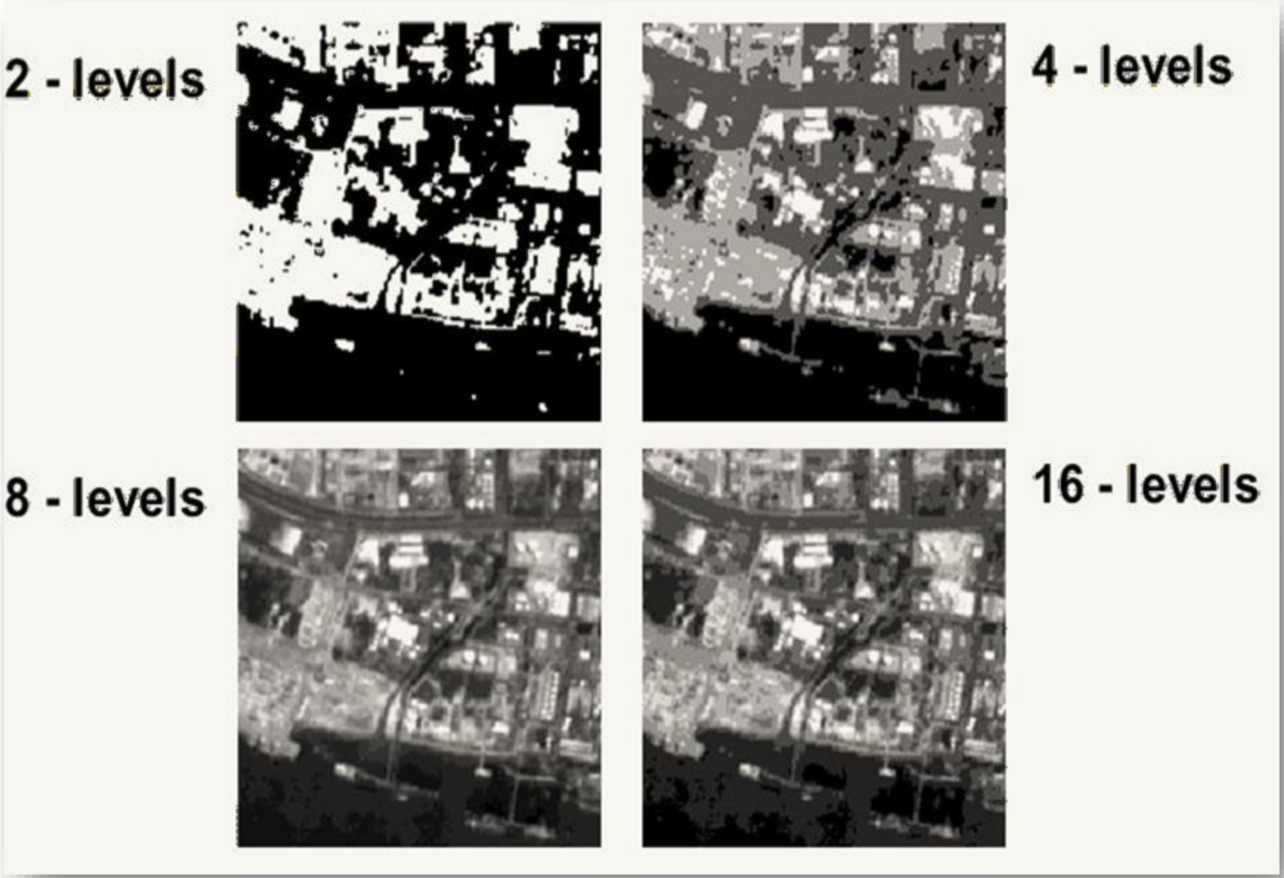




Satellite Characteristics

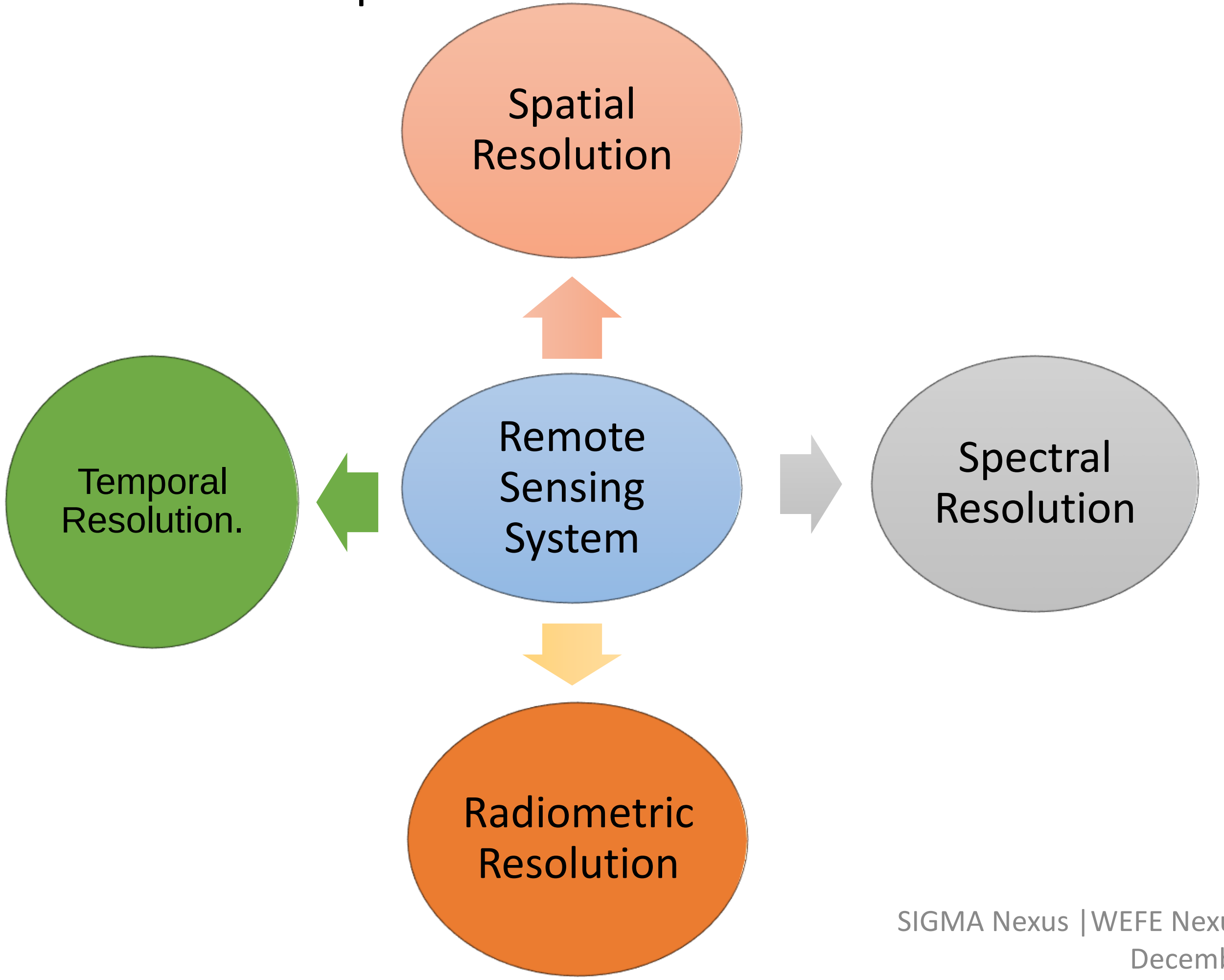
- **<u>Radiometric Resolution:</u>** describes its ability to discriminate very slight differences in energy. Number of bits controls the range of possible DN values in a band

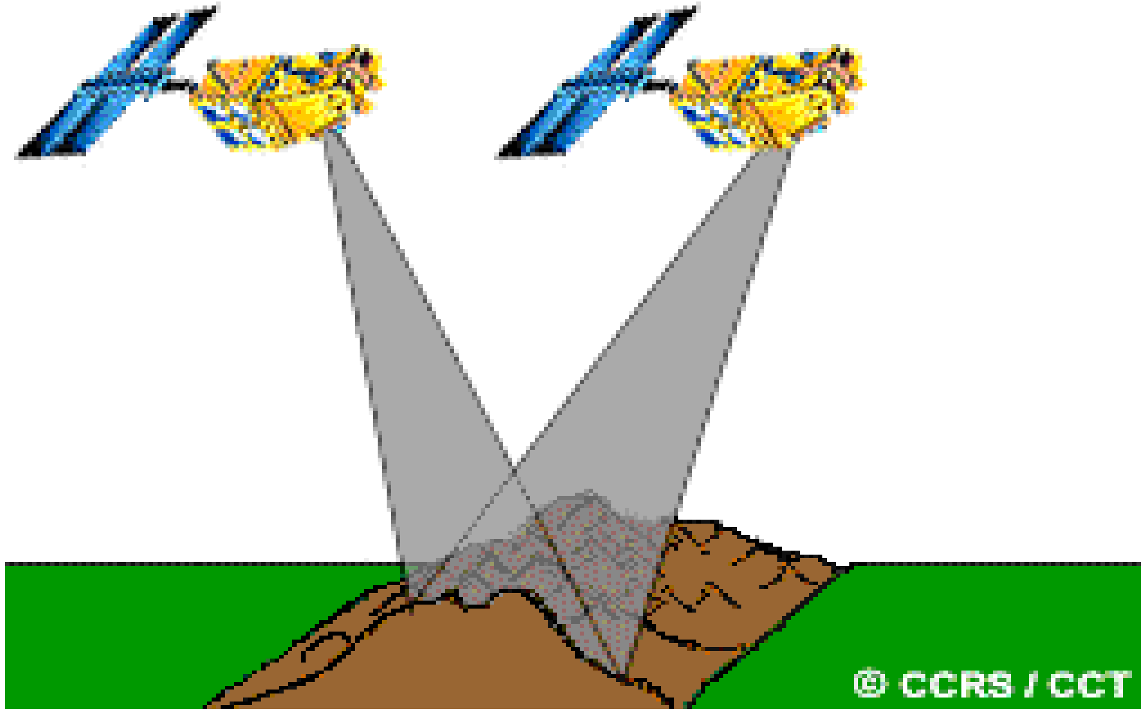




Satellite Characteristics

- **<u>Temporal Resolution:</u>** how often a sensor obtains imagery of a particular area. Each collection method has a unique revisit time**.**





Common Satellites

WorldView 3

Origin: USA
Date: 2014
Spatial Resolution:
1.5x1.5 m (multispectral)
0.3x0.3 m (panchromatic)
Spectral Resolution:
8 bands
Temporal Resolution:
Less than one day

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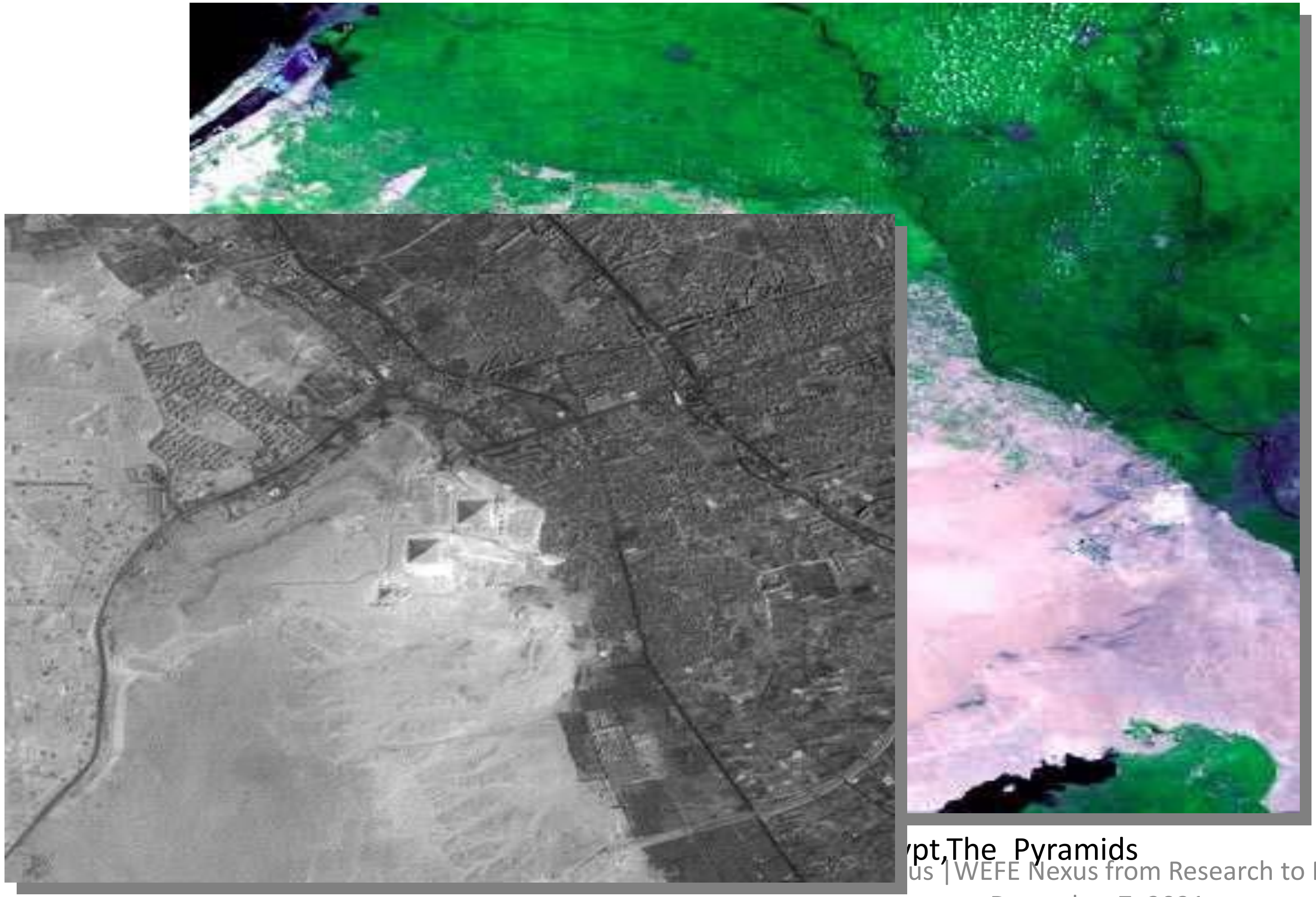
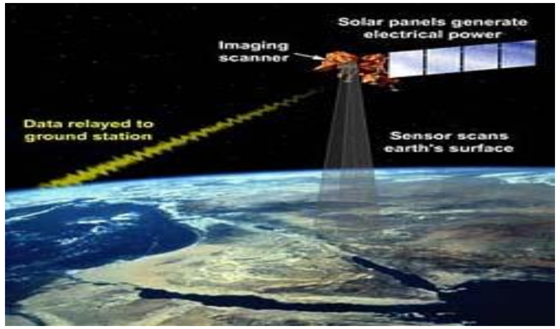
Common Satellites

Landsat 8



ypt,The Pyramids



Origin: USA

Date: 2013

Spatial Resolution:

30x30 m (multispectral)

15x15 m (panchromatic)

Spectral Resolution:

11 bands

Temporal Resolution:

Every 16 days

Common Satellites

Sentinel 2

Origin: France Airbus
Date: 2015
Spatial Resolution:
10,20 to 60 m (multispectral)
Spectral Resolution:
13 bands
Temporal Resolution:
6 days

Agenda

- Introduction about Remote Sensing
- **Remote Sensing in NEXUS**

Remote Sensing in NEXUS

- To **support the NEXUS approach** we need evidence based **monitoring tools** that can provide **policy makers**, conservation **managers, entrepreneurs**, **scientists** and the **general public** with information on the state, pressures and associated changes in the environment.

- **Satellite imagery can provide information at appropriate spatial and temporal resolution that can support evidence based monitoring** .

Remote Sensing in NEXUS

- Remotely sensed information can help to provide information on e.g. **land cover** and associated dynamics such as **urban sprawl**, surveying terrain conditions such as **soil moisture conditions** and erosion hazards associated within catchments, **sea level rise** and **changing coastlines**, and on many aspects of the vegetation **(natural and agriculture), such as plant traits, phenology and plant growth**.

- Remotely sensed information can in general make **field surveys and monitoring more effective, and can thoroughly support decision making**.

Remote Sensing in NEXUS

- Talking About Agriculture, there are many vegetation indices, which can subsidize crop management decision-making such as:

1. **Normalized differential vegetation index (NDVI):**

NDVI is commonly used to assess **the impacts of drought** in agricultural areas and to understand the **crop response to water availability**. It has a positive correlation with **biomass**. Studies have shown that such index is more sensitive **to early plant growth stages**.

2. **Soil Adjusted Vegetation Index (SAVI)**

SAVI is an index designed to consider **soil effects** on analyzed images if the land surface is not fully covered by vegetation. On other word, SAVI is used to correct Normalized Difference Vegetation Index (NDVI) for the influence of **soil brightness in areas where vegetative cover is low**.

3. **Moisture stress index (MSI)**

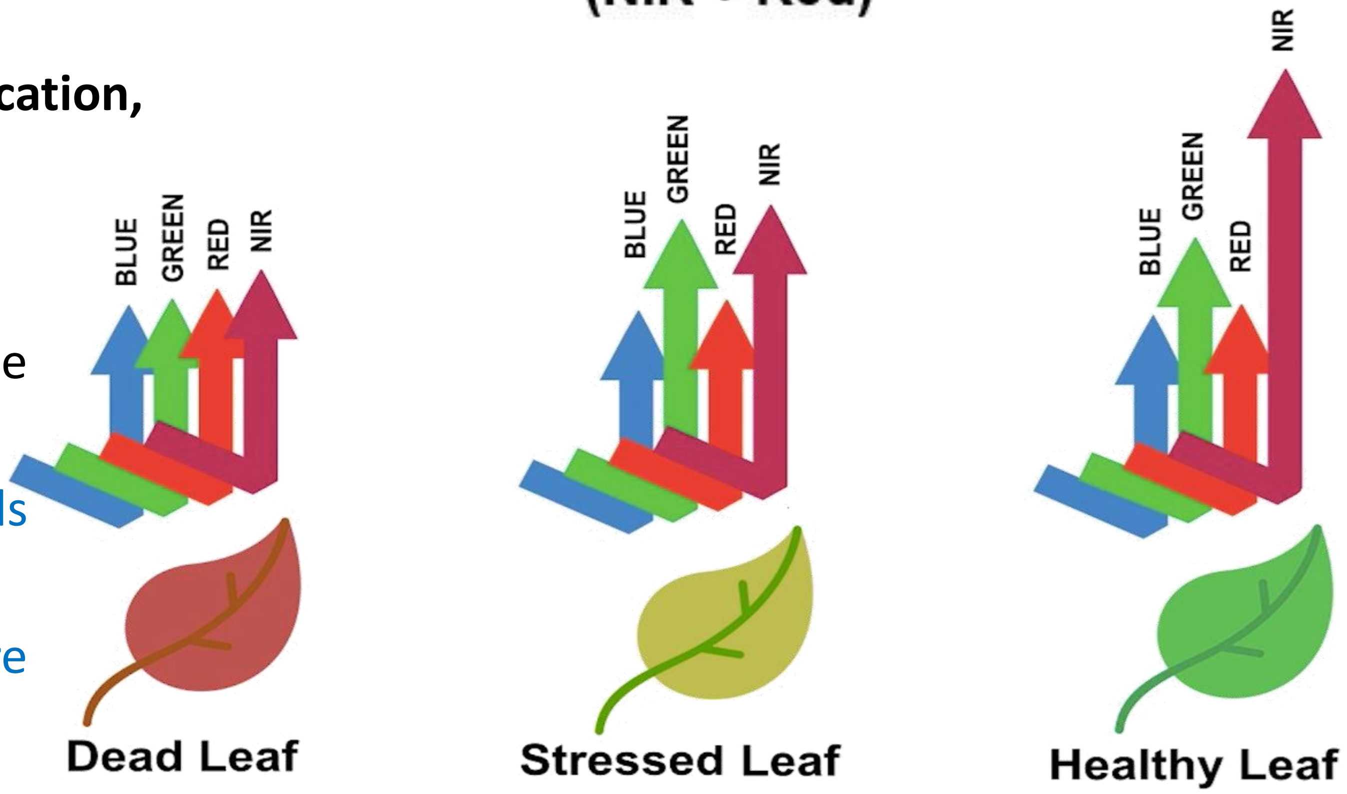
MSI index quantify plant physiological **stress due to water loss**, detecting changes in relative **water content in leaves**. MIS is A good predictors of **water potential in vegetation canopy**.

4. **Red-edge Normalized Difference Vegetation Index(RENDVI)**
5. **Normalized Difference Infrared Index (NDII)**

❑ Normalized differential vegetation index (NDVI)

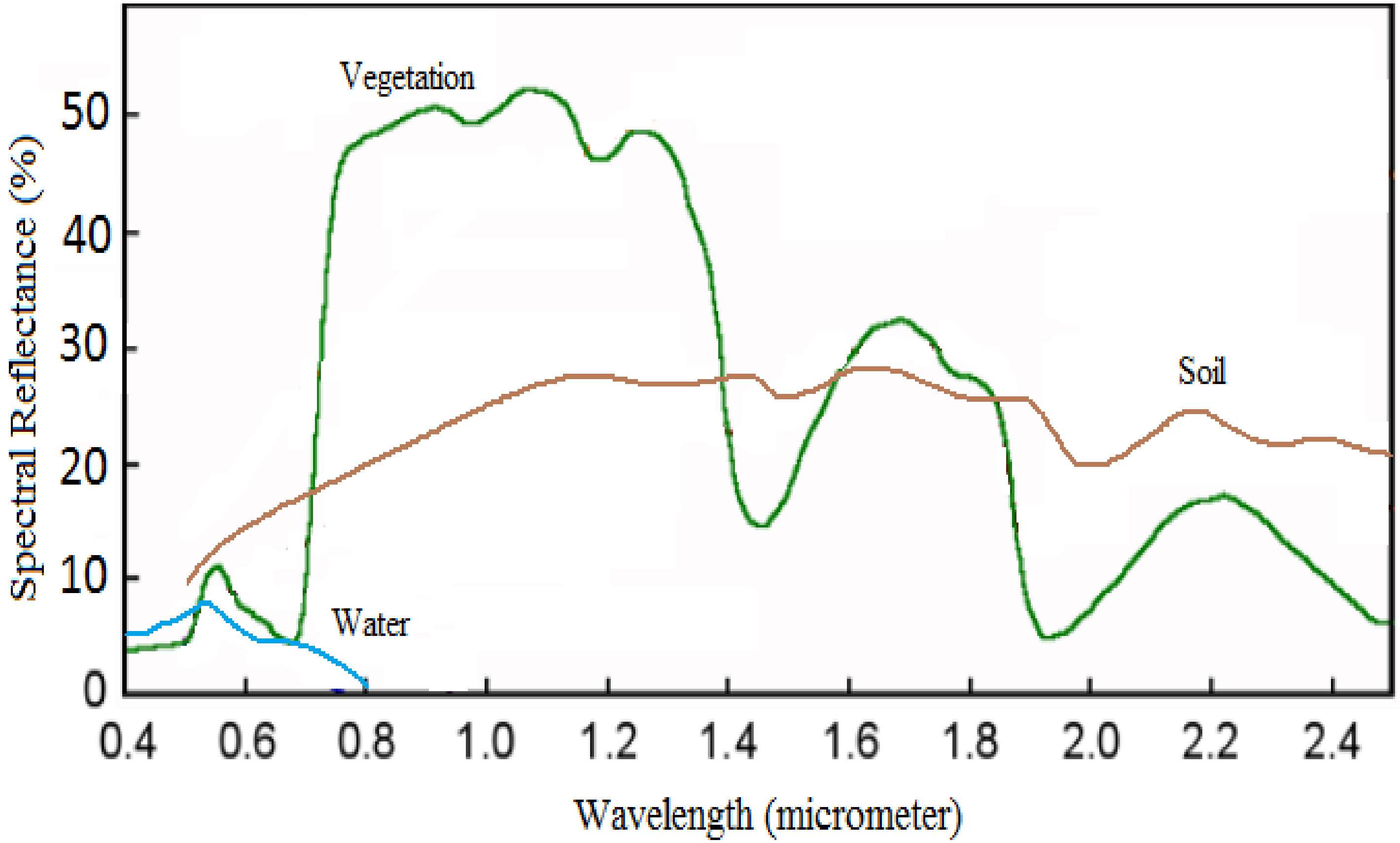
$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

- ✓ NDVI is used for mapping **vegetation cover** and **land Cover change detection**.
- ✓ Good indicator for **Climate Change**, **Desertification, Fire Prediction**.
- ✓ It's good indicator for **vegetation health**.
- ✓ The threshold varied between −1 to 1 (Stancalie et al. 2014)
  - ❖ Negative values below 0 indicate clouds and water
  - ❖ Positive Values close to zero indicate bare soil
  - ❖ 0.1 to 0.5 indicate sparse vegetation
  - ❖ ≥ 0.6 indicate dense vegetation



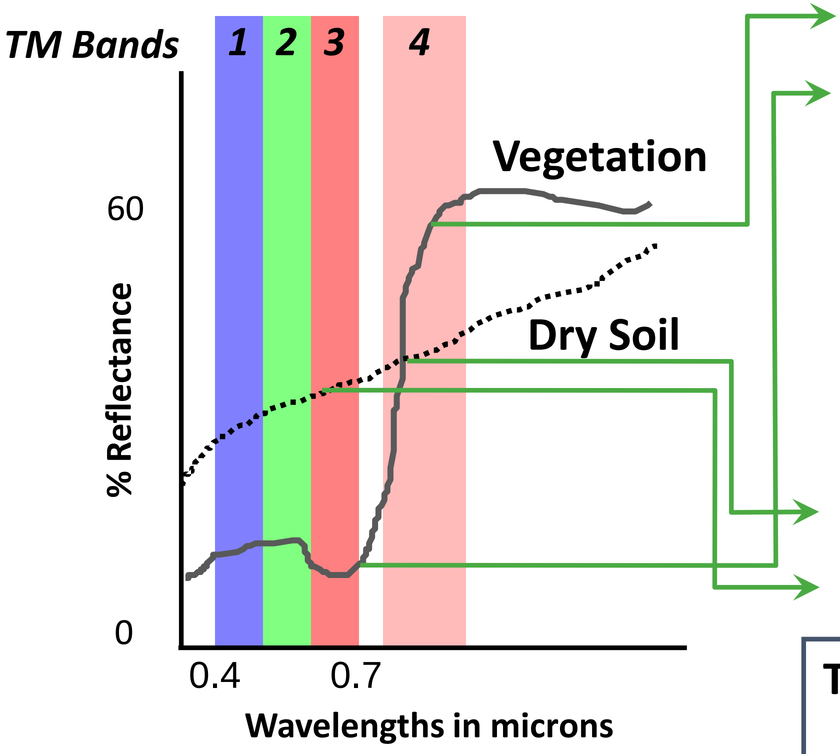
Remote Sensing in NEXUS

Bands Algebra



Remote Sensing in NEXUS

Bands Algebra



HEALTHY VEGETATION

TM Band 4: HIGH Value

TM Band 3: LOW Value

TM Band 4 ÷ TM Band 3

= HIGH VALUE

DRY SOIL

TM Band 4: MODERATE Value

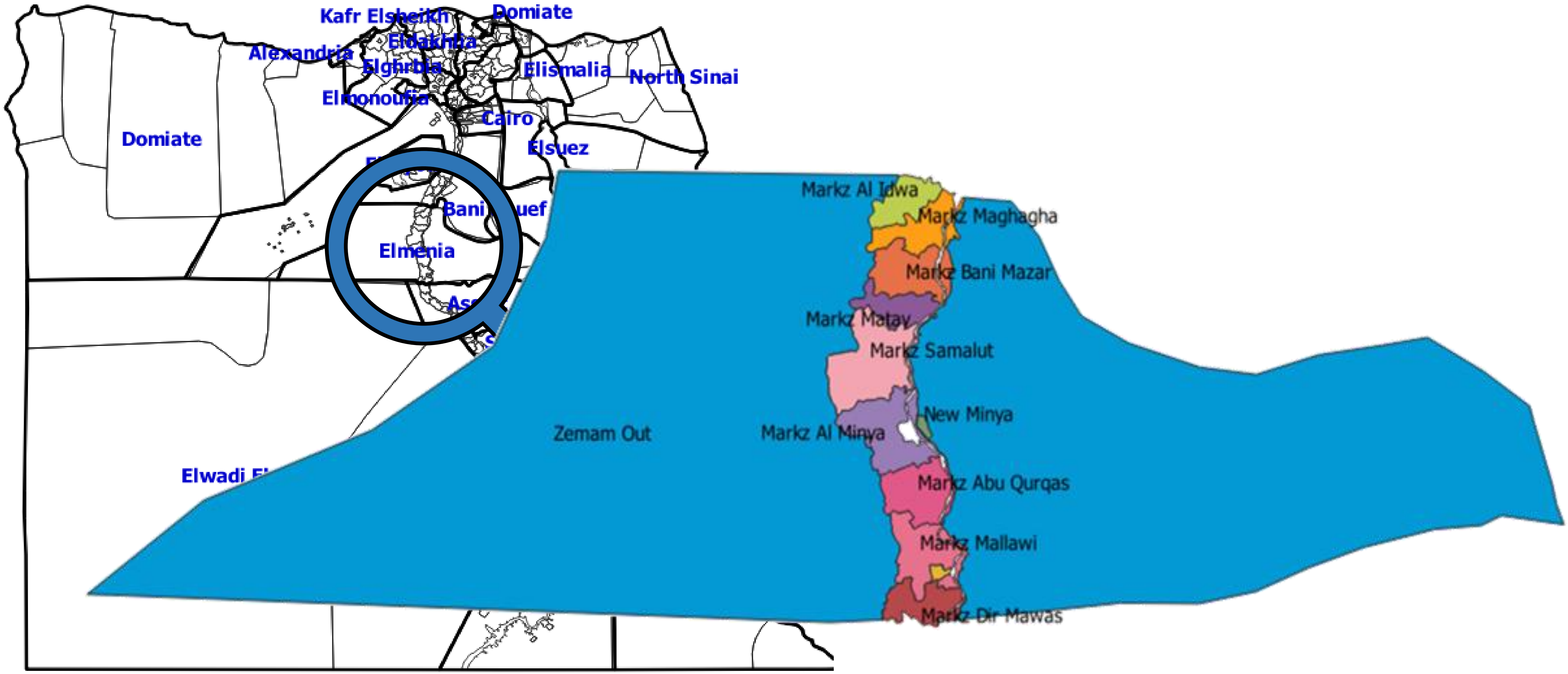
TM Band 3: MODERATE Value

TM Band 4 ÷ TM Band 3

= LOW VALUE

Agenda

- Introduction about Remote Sensing
- Remote Sensing in NEXUS
- **A case study in the South of Egypt – El Minya Governate**


Kafr Elsheikh
Domiate
Eldakhlia
Alexandria
Elghrbia
Elismalia
North Sinai
Elmonoufia
Cairo
Domiate
Elsuez
Elmenia
Markz Al Idwa
Markz Maghagha
Markz Bani Mazar
Markz Matay
Markz Samalut
New Minya
Zemam Out
Markz Al Minya
Markz Abu Qurqas
Markz Mallawi
Markz Dir Mawas

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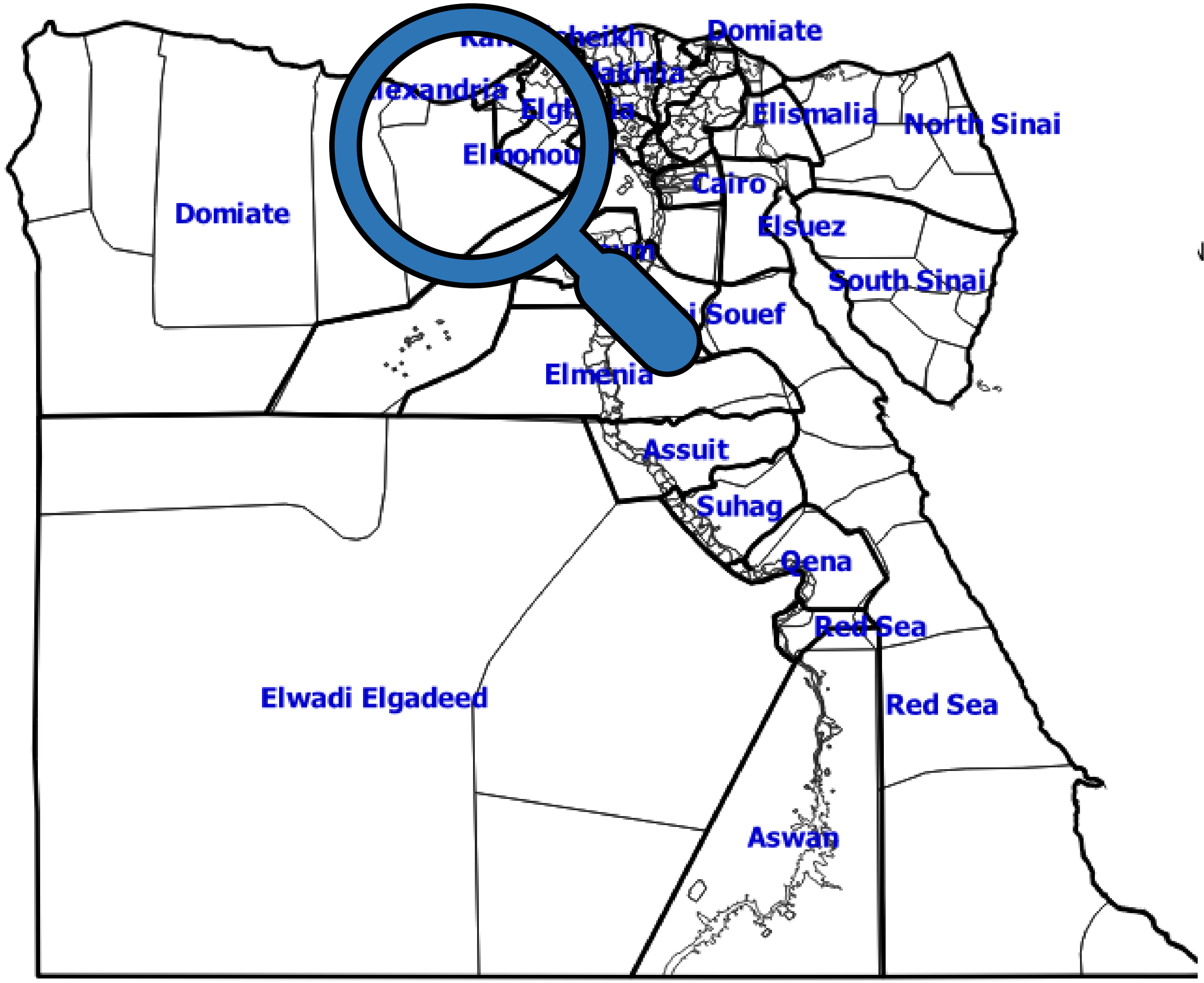
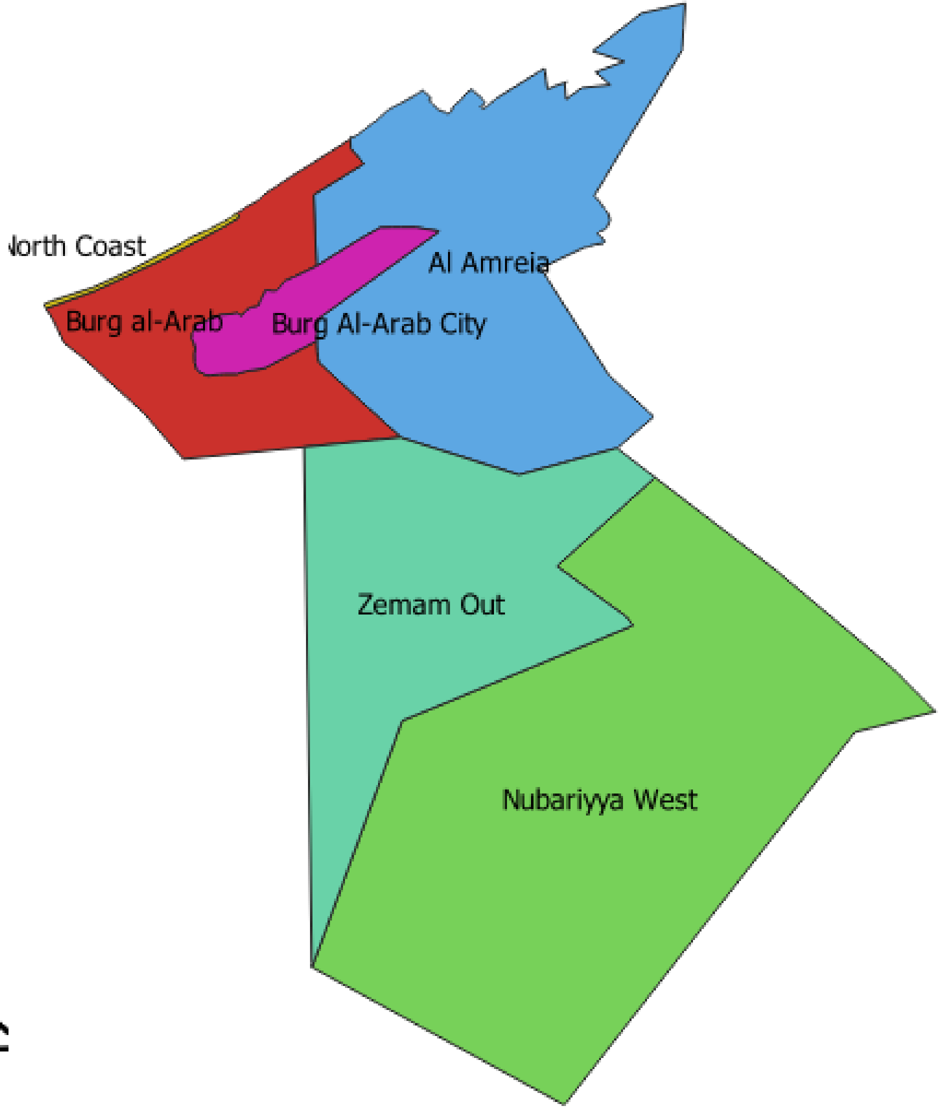




Remote Sensing in NEXUS

A case study in Egypt

- **Satellite:** **Sentinel 2**, The mission supports a broad range of services and applications such as agricultural monitoring, emergencies management, land cover classification or water quality.

Satellite Characteristics :

1. Spatial Resolution: 10, 20 to 60 m
2. Spectral Resolution: 13 bands
3. Temporal Resolution: 6 days

Spectral Bands	Wavelength (nm)	Spatial Resolution (m)
Band 1 (Aerosol)	443	60
Band 2 (Blue)	490	10
Band 3 (Green)	560	10
Band 4 (Red)	665	10
Band 5 (Vegetation Red-Age)	705	20
Band 6 (Vegetation Red-Age)	740	20
Band 7 (Vegetation Red-Age)	783	20
Band 8 (NIR)	842	10
Band 8A (Vegetation Red-Age)	865	20
Band 9 (NIR)	945	60
Band 10 (MIR)	1375	60
Band 11 (MIR)	1610	20
Band 12 (MIR)	2190	20

Remote Sensing in NEXUS

A case study in Egypt

- **Changing Detection period:** From 2017 until 2021

Desired Months:

January	Winter Season	Growing
April	Winter Season	Harvest
July	Summer Season	Growing
September	Summer Season	Harvest
October	Late Summer Season	Growing

Remote Sensing in NEXUS

A case study in Egypt - Methodology

Sentinel 2 Satellite Images

- Jan 2017
- Jan 2018
- Jan 2019

Pre Processing → **Cloud Effect**

- Close to Zero

Pre Processing → **Layer Stacking**

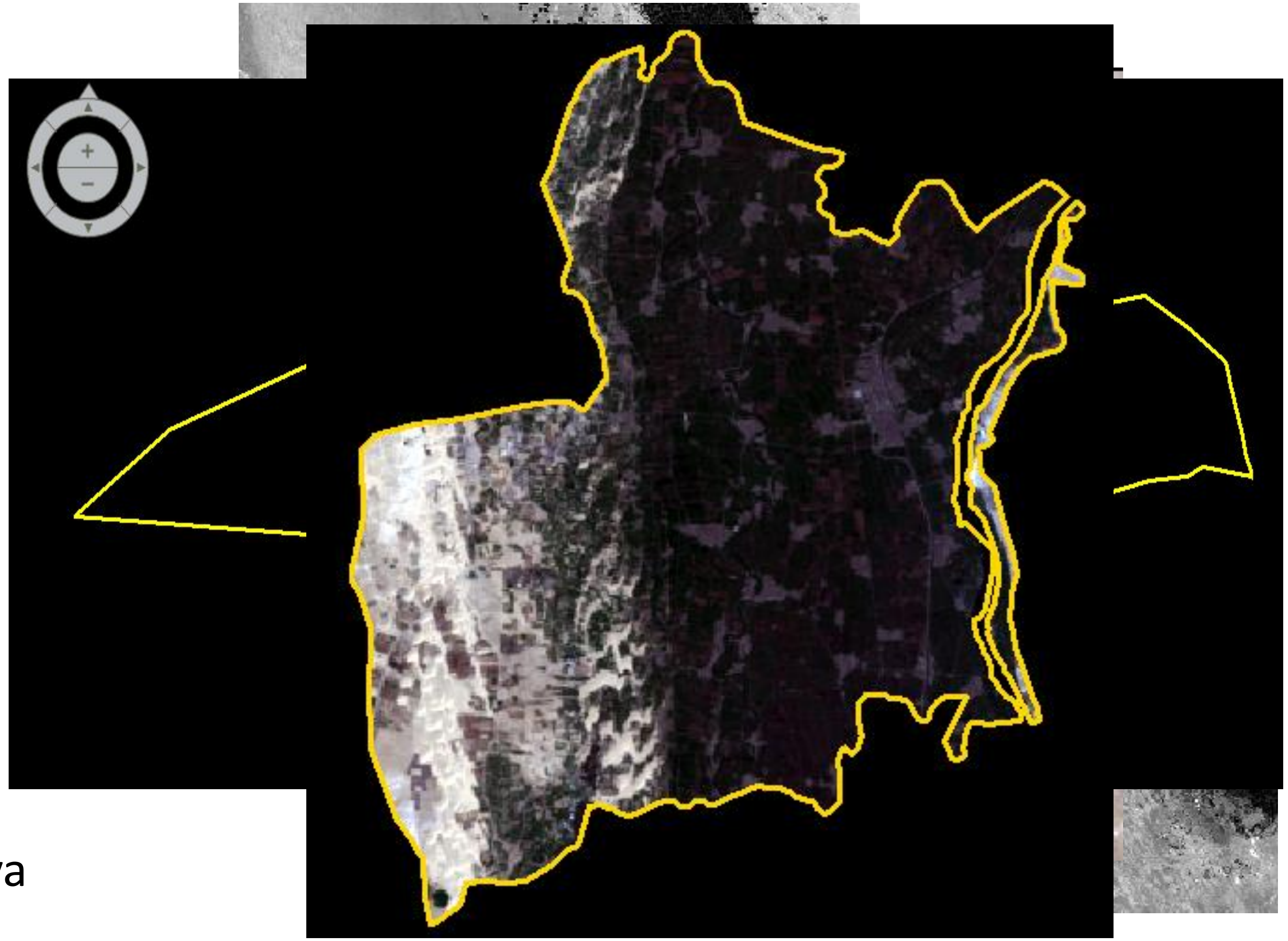
- Band 1
- Band 2
- Band 3 ….
- Band 13

Pre Processing → **Mosaicking**

- El-Minya Governate

Pre Processing → **Subset**

- El-Minya Sectors



Remote Sensing in NEXUS

A case study in Egypt - Methodology

Subset
- El- Minya Sector

Processing → Visual Interpretation
- NIR G B

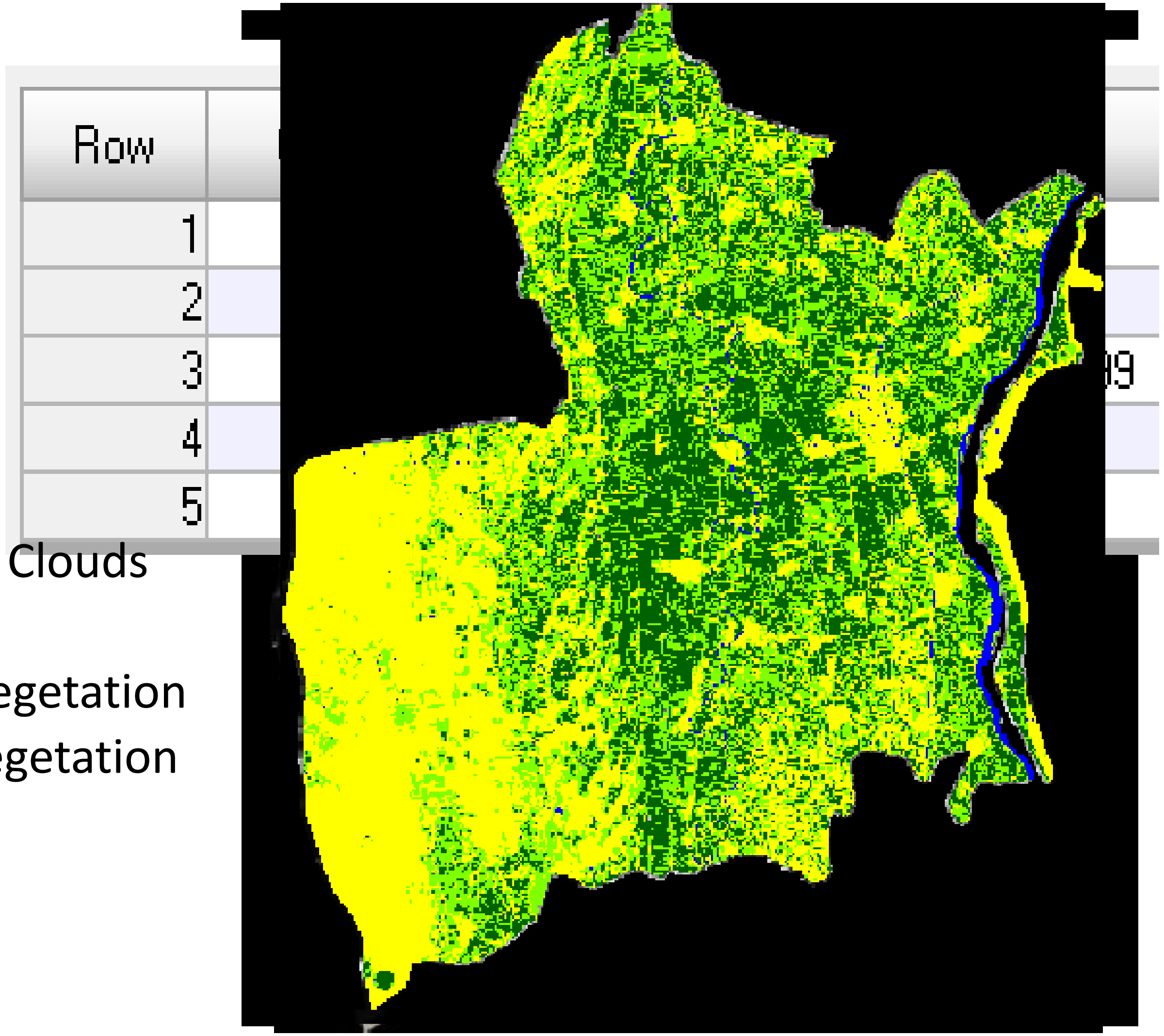
Processing → NDVI

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

Processing → NDVI Classification
- **Class 1:** Water or Clouds
- **Class 2:** Bare Soil
- **Class 3:** Sparse Vegetation
- **Class 4:** Dense Vegetation

Processing → Compute Classes Area

Processing → Change Detection



Remote Sensing in NEXUS

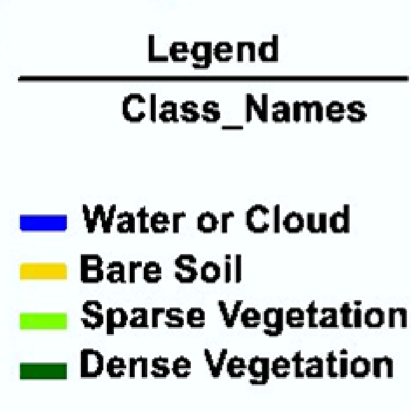
A case study in Egypt - Results

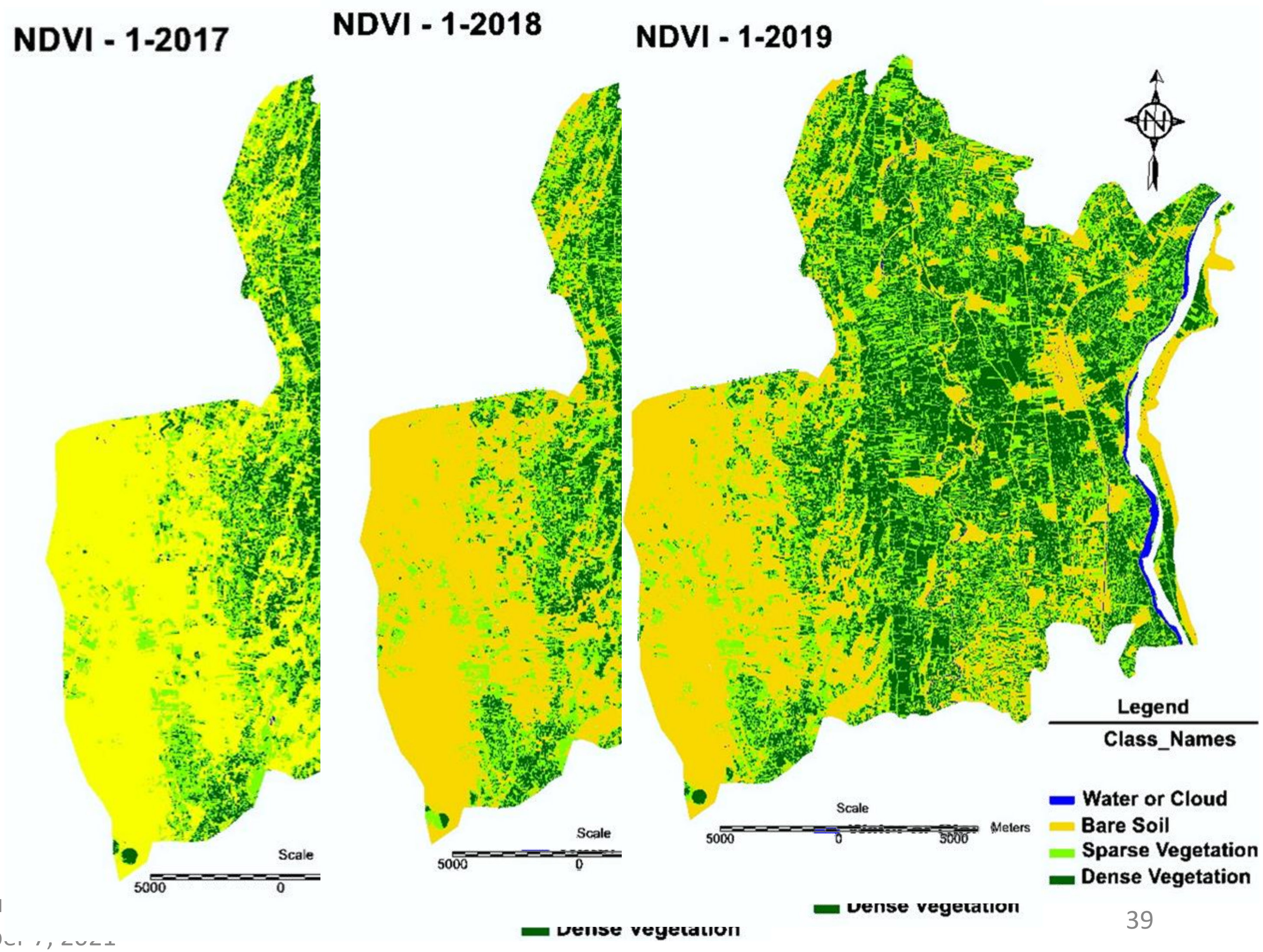
Normalized differential vegetation index (NDVI)

El Minya Governate – Samalut Sector
Jan 2017, Jan 2018, Jan 2019

Processing → NDVI Classification

Processing → Compute Classes Area





Remote Sensing in NEXUS

A case study in Egypt - Results

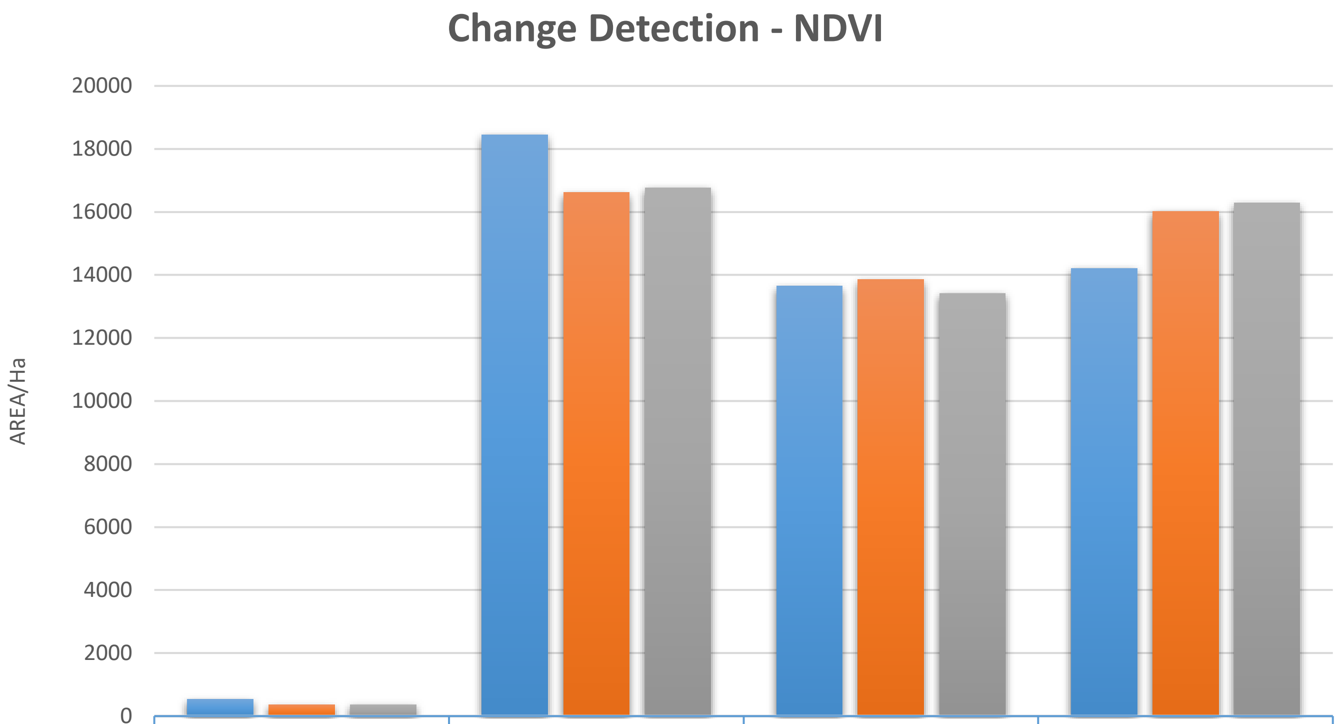
Normalized differential vegetation index (NDVI)

El Minya Governate – Samalut Sector
Jan 2017, Jan 2018, Jan 2019

Processing → Change Detection

- **Class 1:** Water or Clouds
- **Class 2:** Bare Soil
- **Class 3:** Sparse Vegetation
- **Class 4:** Dense Vegetation

- The Vegetation increased in 2018 and 2019 compared with 2017.



	Class 1	Class 2	Class 3	Class 4
1_2017/ha	531.12	18451.5	13651.9	14208.8
1_2018/ha	351.84	16620.2	13847.2	16020.1
1_2019/ha	371.06	16773.3	13412.1	16284.9

Remote Sensing in NEXUS

A case study in Egypt - Results

Normalized differential vegetation index (NDVI)

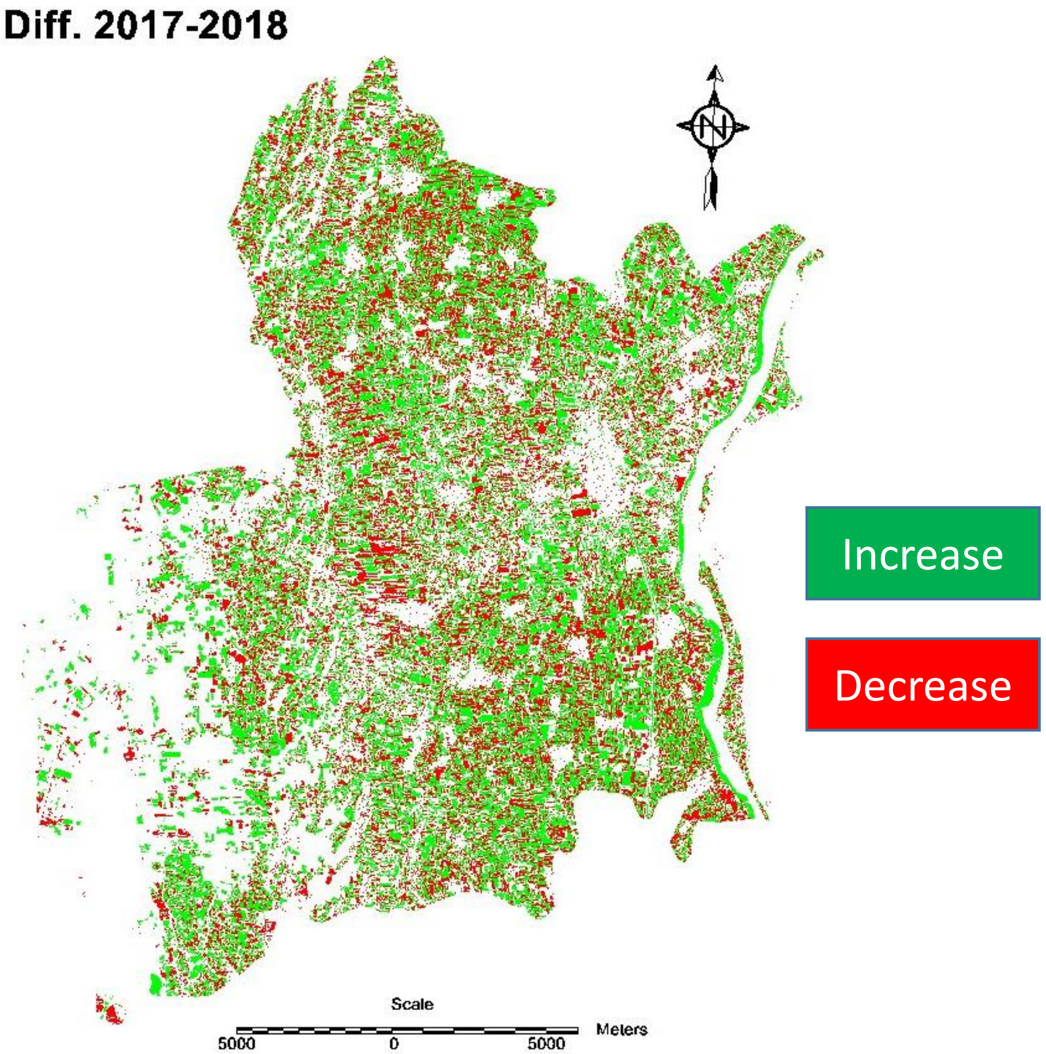
El Minya Governate – Samalut Sector

Jan 2017, Jan 2018, Jan 2019

Processing → Change Detection

- **NDVI**

▪ About 19 % decreased in NDVI threshold. On the other hand, there was 25% increased



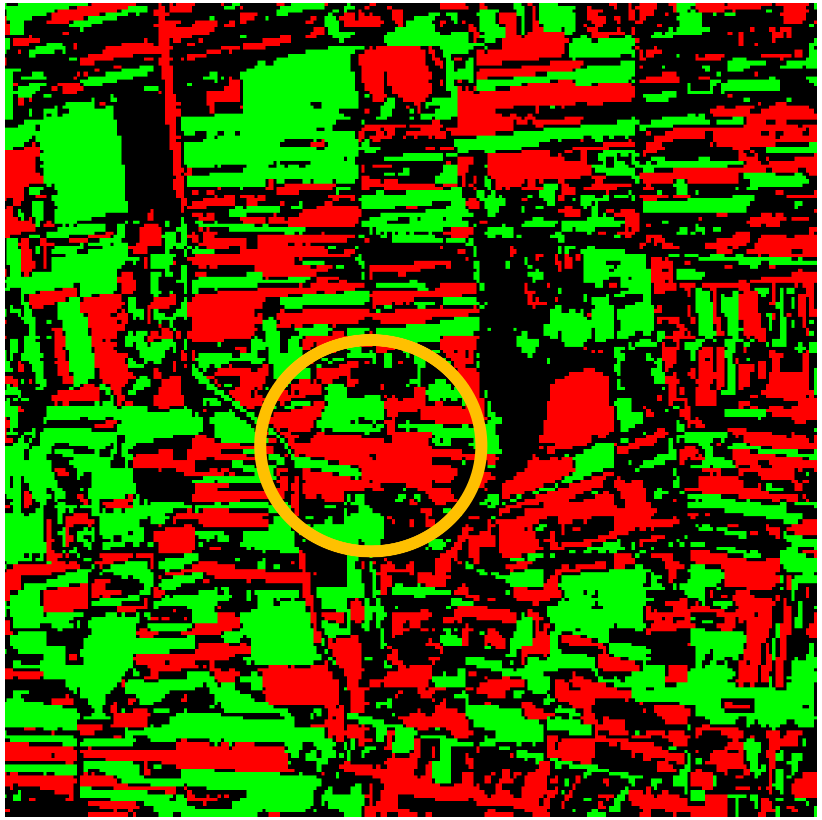
Remote Sensing in NEXUS

A case study in Egypt - Results

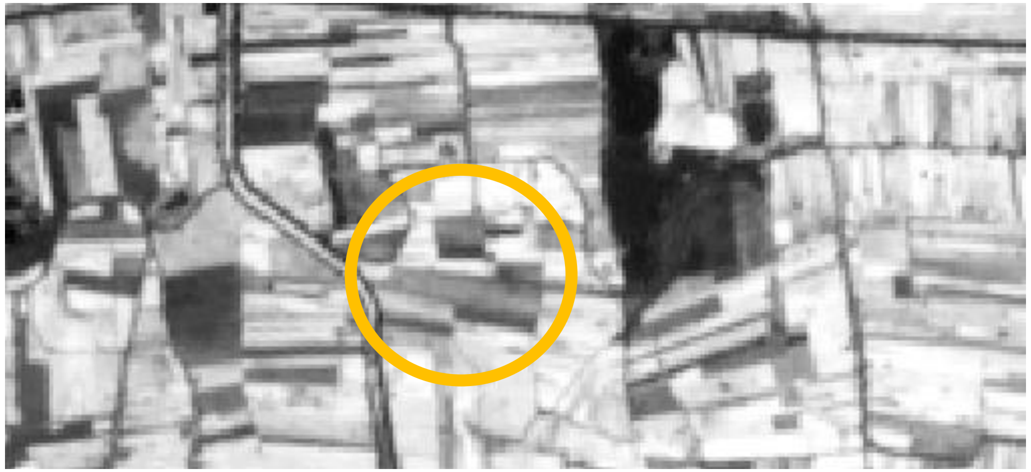
Normalized differential vegetation index (NDVI)

El Minya Governate – Samalut Sector

Jan 2017, Jan 2018, Jan 2019



Jan 2017



Jan 2018

Remote Sensing in NEXUS

A case study in Egypt - Results

Normalized differential vegetation index (NDVI)

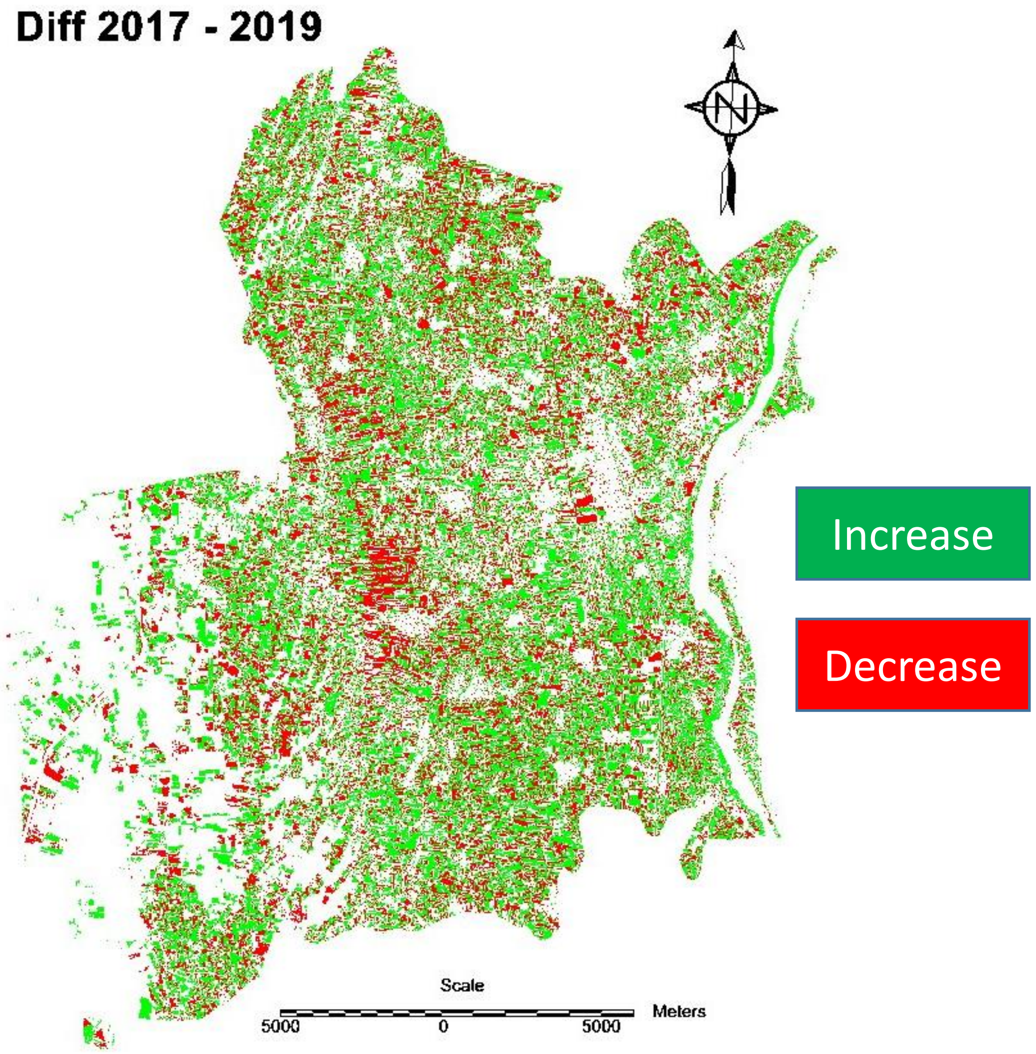
El Minya Governate – Samalut Sector

Jan 2017, Jan 2018, Jan 2019

Processing → Change Detection

- **NDVI**

- About 18 % decreased in NDVI threshold. On the other hand, there was 27% increased

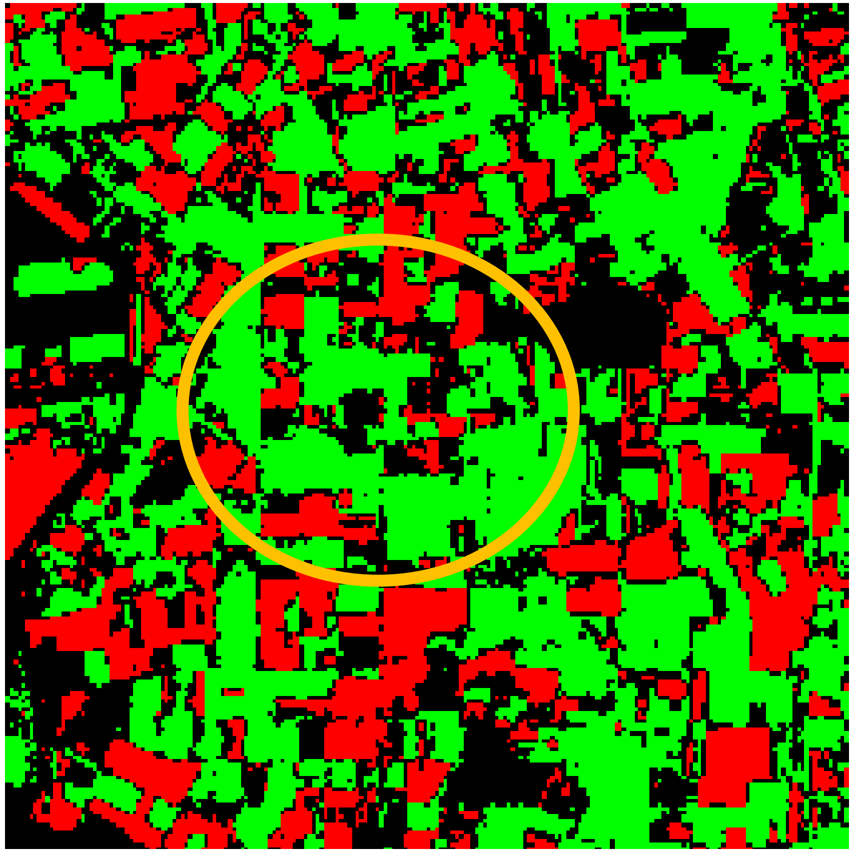


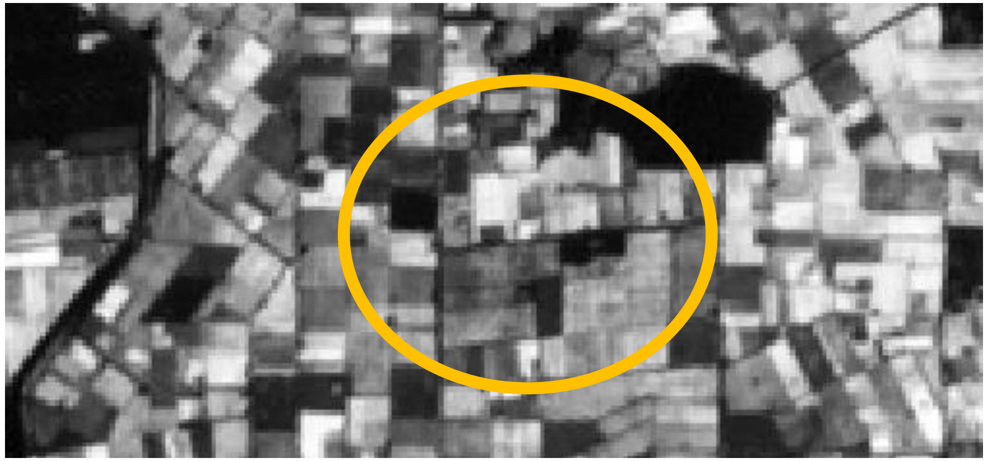
Remote Sensing in NEXUS

A case study in Egypt - Results

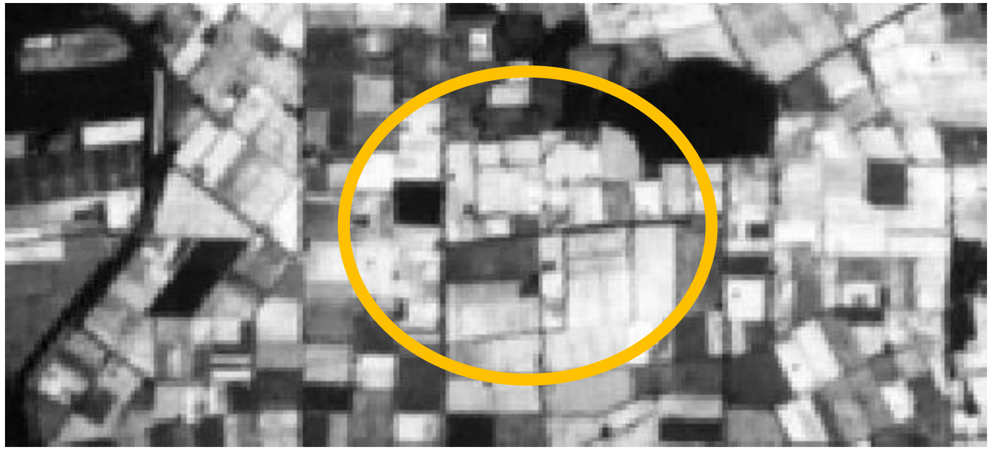
Normalized differential vegetation index (NDVI)

El Minya Governate – Samalut Sector
Jan 2017, Jan 2018, Jan 2019





Jan 2017



Jan 2019

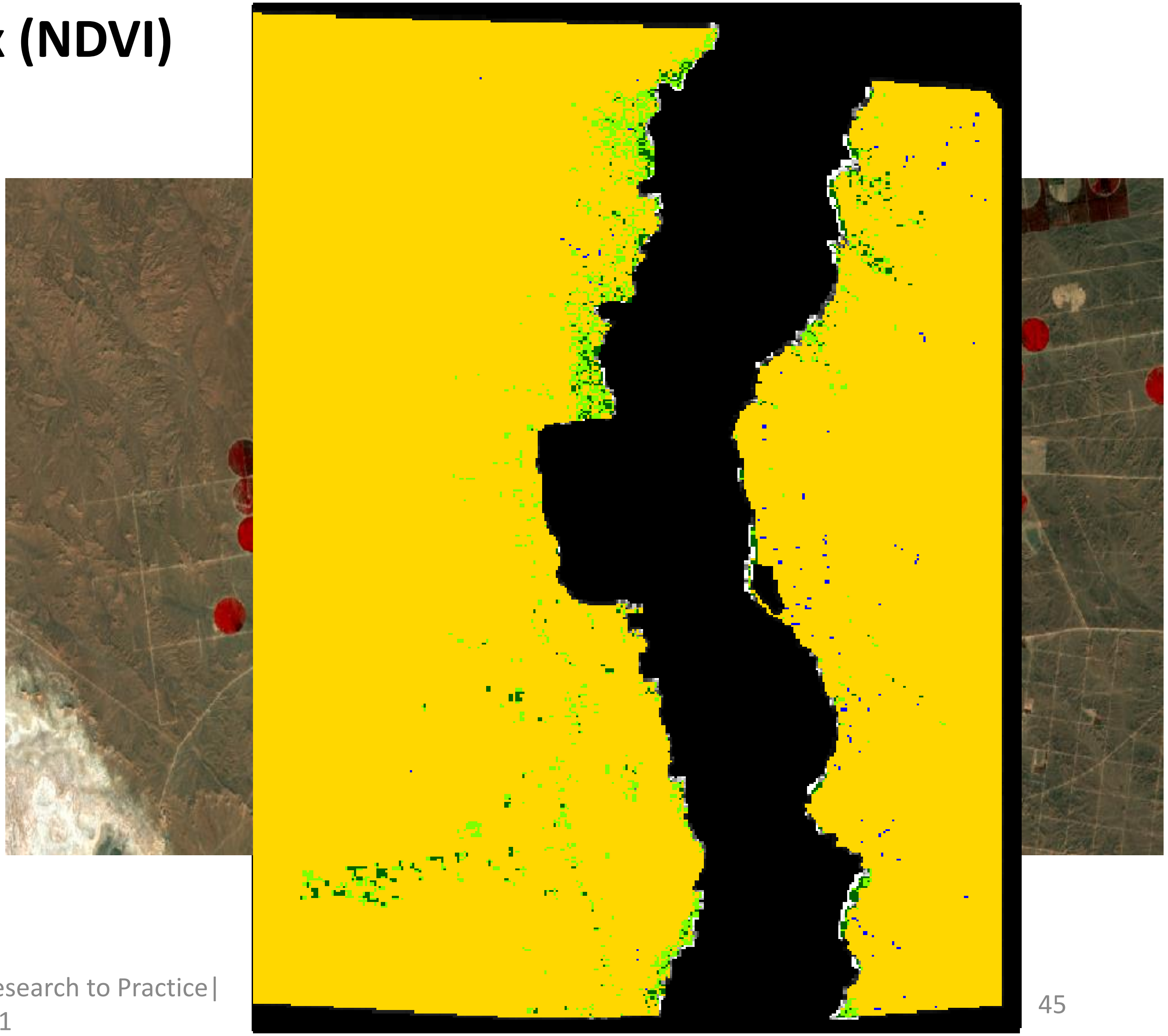
Remote Sensing in NEXUS

A case study in Egypt - Results

Normalized differential vegetation index (NDVI)

El Minya Governate – Zemam Sector

Jan 2017, Jan 2018, Jan 2019



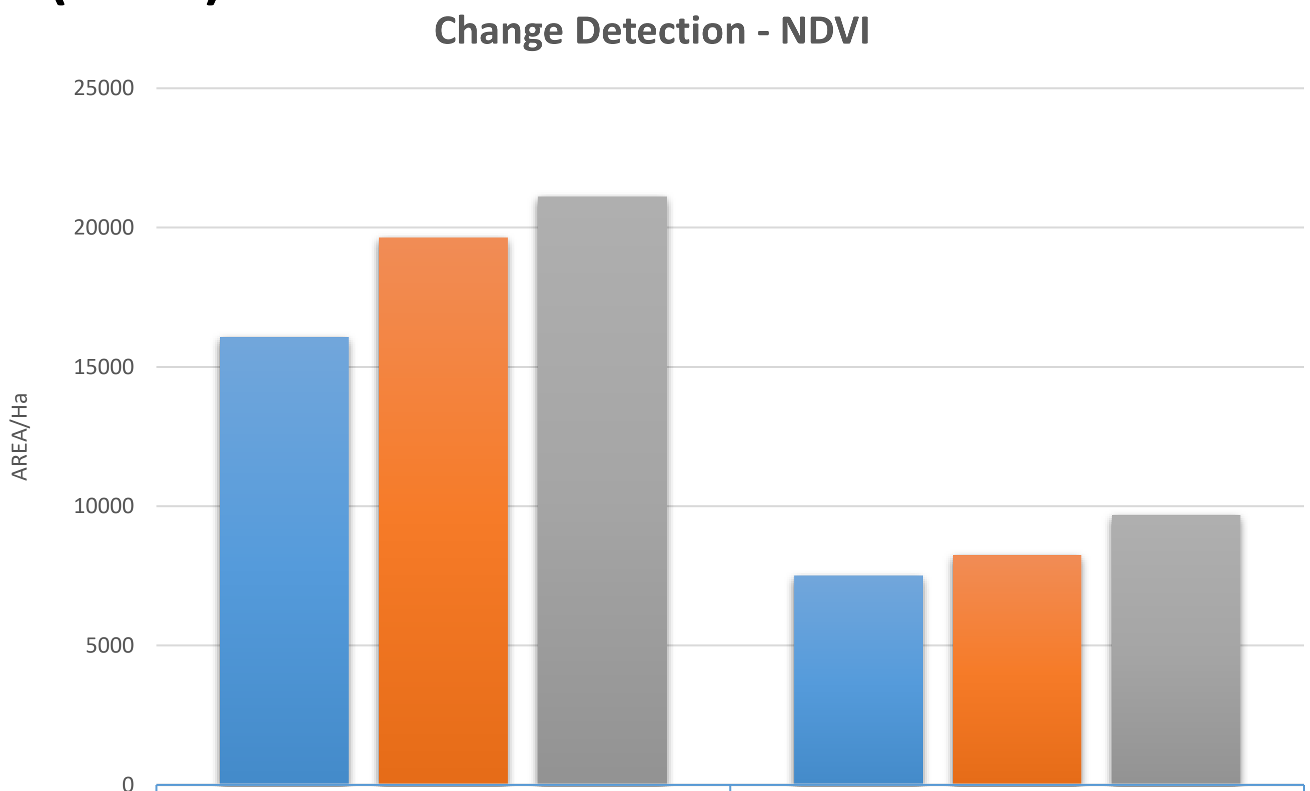
Remote Sensing in NEXUS

A case study in Egypt - Results

Normalized differential vegetation index (NDVI)

El Minya Governate – Zemam Sector
Jan 2017, Jan 2018, Jan 2019

- The Vegetation increased in 2018 and 2019 compared with 2017.
  - **Class 3:** Sparse Vegetation
  - **Class 4:** Dense Vegetation



	Class 3	Class 4
1_2017/ha	16060	7494.29
1_2018/ha	19636.8	8242.3
1_2019/ha	21108	9675.66

Remote Sensing in NEXUS

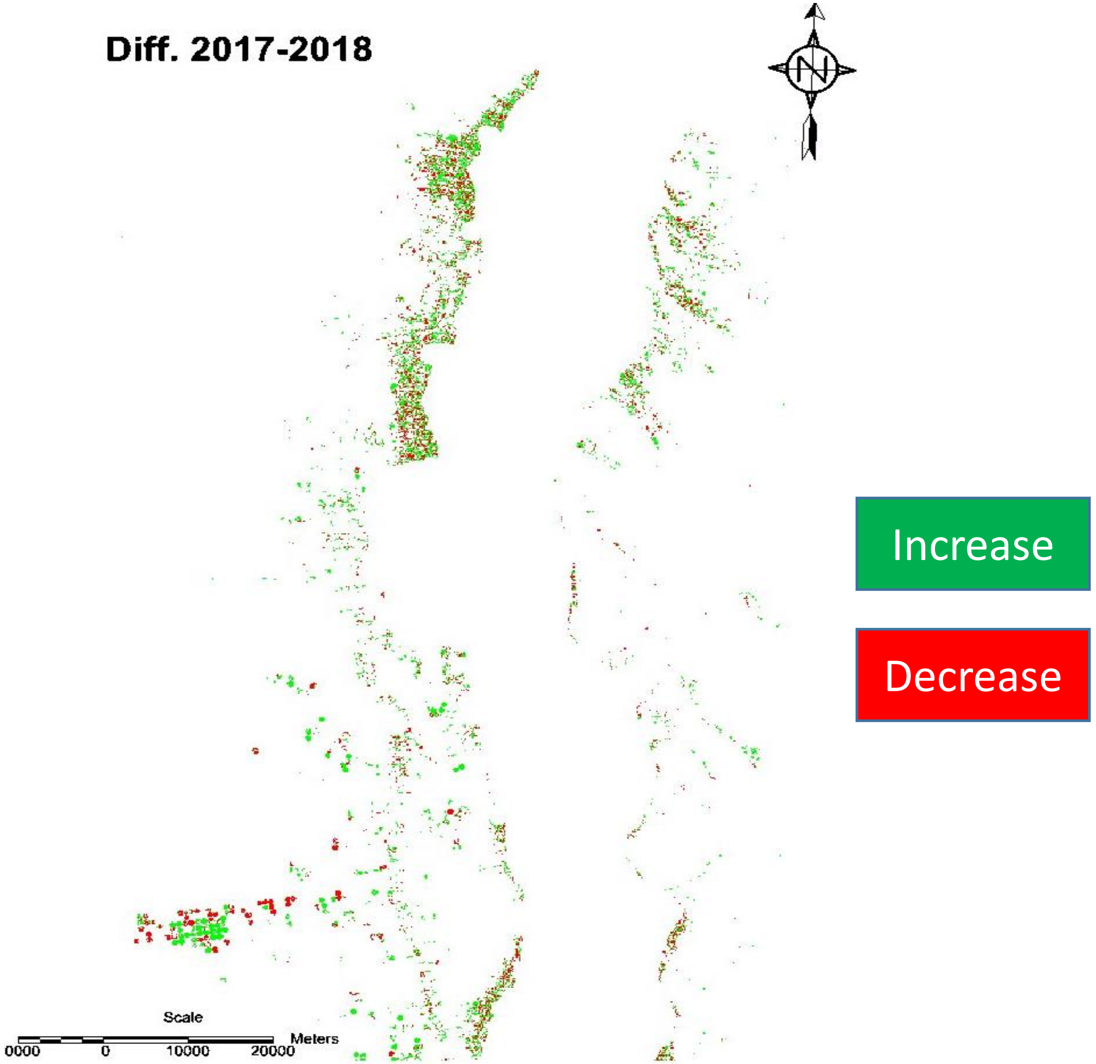
A case study in Egypt - Results

Normalized differential vegetation index (NDVI)

El Minya Governate – Zemam Sector

Jan 2017, Jan 2018, Jan 2019

- About 0.34 % decreased in NDVI threshold. On the other hand, there was 0.5% increased
- Moreover, it increased more in the comparison about 5 % between 2017 and 2019

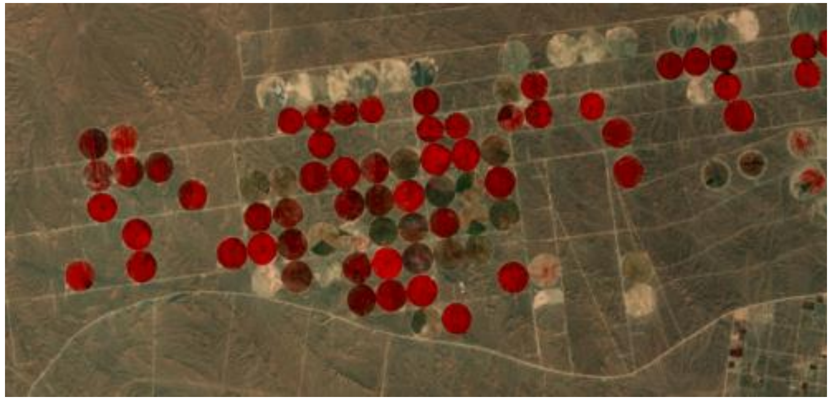


Remote Sensing in NEXUS

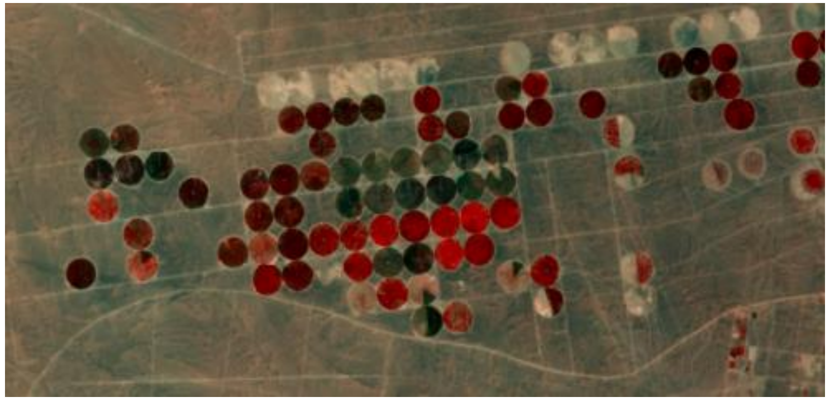
A case study in Egypt - Results

Normalized differential vegetation index (NDVI)

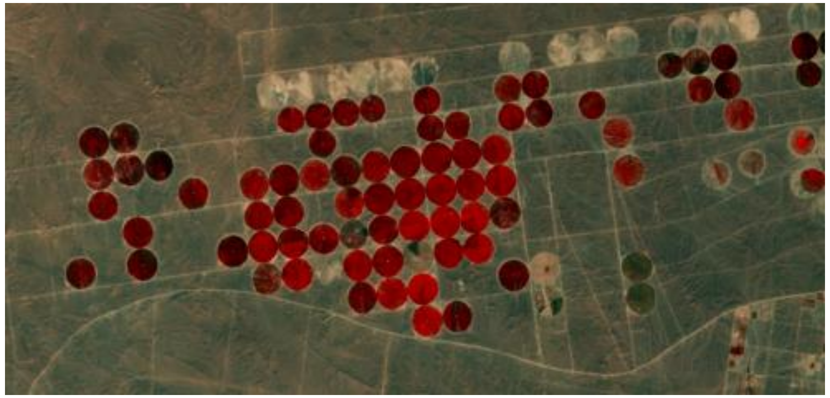
Jan 2017

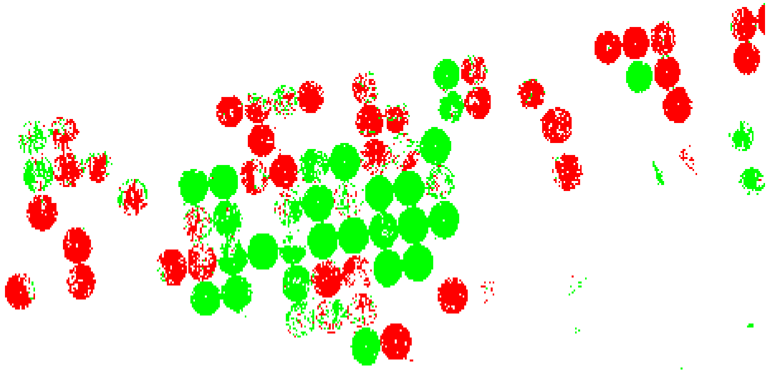


Jan 2018

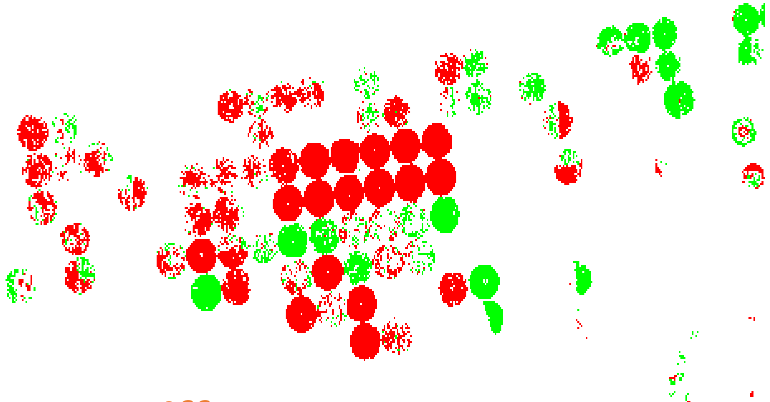


Jan 2019





Diff 2017 - 2018



Diff 2018 - 2019

Diff 2017 - 2019

Agenda

- Introduction about Remote Sensing
- Remote Sensing in NEXUS
- A case study in the South of Egypt – El Minya Governate
- **Conclusion - Advantages and Challenges -**

Remote Sensing in NEXUS

Conclusion - Advantages

- Remote Sensing is a fast information processing technology which can survey large and inaccessible areas saving more time and resources.
- Remote Sensing works as a monitoring and evaluation tool to track and maintain the plans of countries and organizations.
- Integrating between Remote Sensing and WEFE Nexus allows policy makers to tackle worldwide challenges like Food Hunger, shortage in Water and Energy …etc.

Remote Sensing in NEXUS

Conclusion - Challenges

- The captured satellite images requires huge storage capacity.
- To process this amount of huge data, massive processing power is required.
- In order to get more information regards the types of crops that have been cultivated, advanced tools are required to collect the spectral signature for each crop to produce the classified maps.



Thank you

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