Sneak Peak

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1 RS Learning Diary

This is a Quarto book to document my learning journey in **Remote Sensing Cities and Environments** course during my time at CASA UCL 24/25, offering insights learned, its applications, and my own reflections. The module is based on Dr Andrew Maclachlan github page [here].

*For those of you who also want to learn Geographic Information Scicene beyond 'typical GIS' Software, as in use R-Studio, you could also visit his other github page [here].

1.1 Introduction

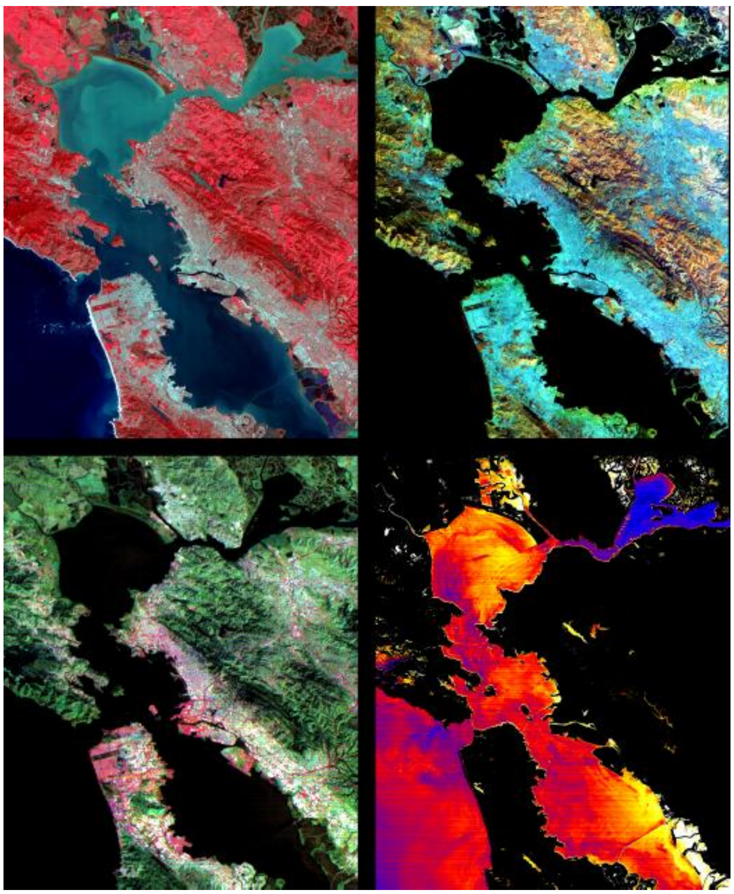
Hi, I'm Nooriza, a student currently pursuing a Master's degree in Urban Spatial Science at UCL. I have an academic background in Geography with a specialization in Regional Development Studies and have several substantial work experience in government consultancies in Indonesia.

1.2 Why do I choose this module?

The reason I choose remote sensing is because I want to use its vast open resources to analysis various topics. I had learned the foundations during my undergraduate degree but I haven't delved further into it and haven't got any experience to use GEE yet. Thus, I hope at the end of this class, I will get knowledge on to get alternative of spatial data using remote sensing plus analyse various topic across different scale using GEE.

Remote sensing is also an interesting field as it could produce wealth of information without direct contact. Don't you think learning remote sensing makes us have the eye of the bird even beyond? I mean we agree that remote sensing offers perspectives far beyond what our human eyes can naturally perceive : *allowing* to *see things from above and to see the unseen of the naked eye.*

Figure 1 : ASTER images of San Fransisco. source : NASA/JPL



For example, see the ASTER images of San Fransisco Bay above it highlights different object such as vegetation (upper left); soil & rocks in mountainous area (upper right); urban materials (lower left) ; and water temperature (lower right).

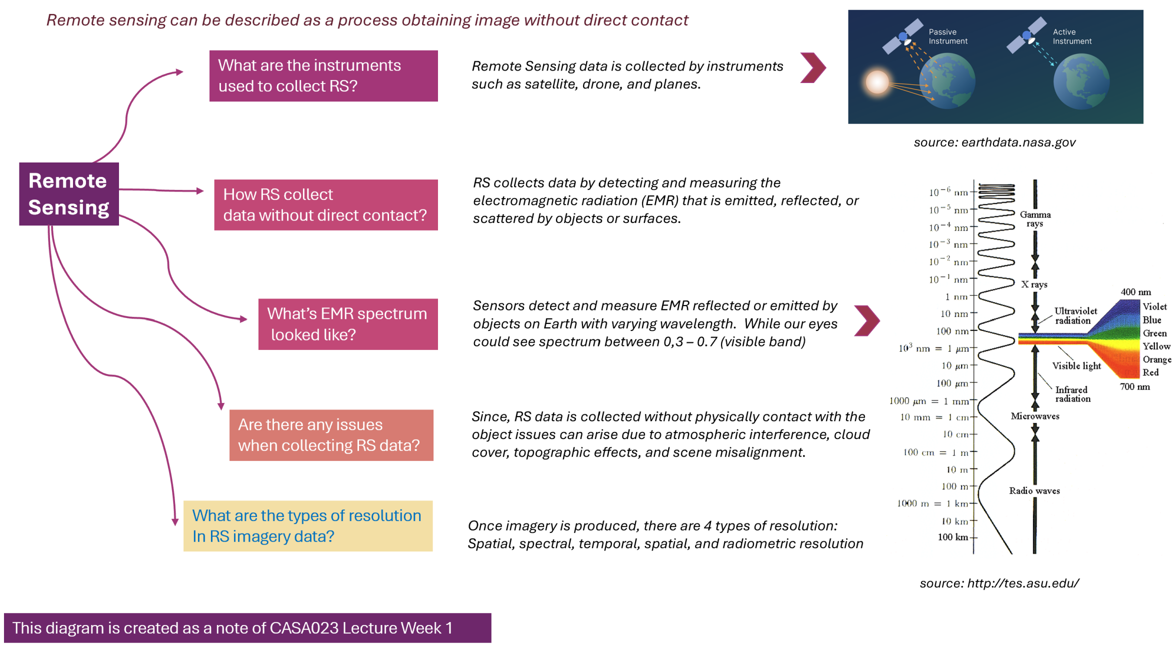
Practically, learning this course will, hopefully, help me address the challenges I faced during my previous work in Indonesia. For example, while working on a project focused on healthcare accessibility across hundreds of small islands, we struggled to obtain real-time data to identify which islands were inhabited and which were not. Additionally, we faced challenges in determining which islands had ports suitable for docking ships. I believe that applying remote sensing data is both cost- and time-efficient in helping the government maintain more precise and up-to-date data, which is particularly important in world's largest archipelago country like Indonesia.

Feel free to explore my site to learn more about my learning experience. Hope it helps!

2 Getting to Know Remote Sensing

2.1 Summary

This week the lecture covers an introduction of remote sensing is, such as its vast application, instruments, collection method, and things we have to consider when we deal with remote sensing data. I tried to make the summary using visualization below to make it easier to understand.



During the practical, we explore several tools to deal with remote sensing data such as SNAP (Sentinel Application Platform) and R-studio to plot spectral signature. We are also introduced with 2 imagery : Sentinel-2A and Landsat-8. It is interesting how this two imagery has a global coverage and for FREE. Both of them has spectral bands that could be useful for vegetation monitoring, land cover classification, and agricultural applications. We could benefit from Sentinel-2 frequent observations to monitor rapid changes. Meanwhile, Landsat data allows us to do large areas and long-term vegetation monitoring as it has extensive historical archive and consistent global coverage. Below I discussed the application of both Landsat and Sentinel in a vegetation analysis.

2.2 Application

Landsat for monitoring accross vast region : Detecting of vegetation evolution across China Urban Development

- When I mentioned Landsat have a vast amount of historical data, @han2025 explores this historical archive of 30 years Landsat data (spanning of landsat 5 to 8) on 2.125 city to monitor the vegetation evolution, using reflective bands such as Blue, green, red, NIR and SWIR (1 and 2) and highlighting vegetation characteristics using NDVI, EVI, and OSAVI. The NDVI and RGB bands were further processed to derive texture variables, including variance, contrast, entropy, angular second moment, and correlation. These texture metrics capture spatial patterns and fine-scale structural details of urban vegetation that may not be visible through spectral bands alone. The findings will classify vegetation in urban area, whether it is decreasing or increasing over time. I genuinely believe this finding has the potential to serve as a framework for evaluating the effectiveness of the government's long-term plan on urban greening. For instance in my country, Indonesia we have long-term regional planning that spanning for 20 years (reviewed every 5 years), the analysis will help the policy maker to formulate more measured-target.

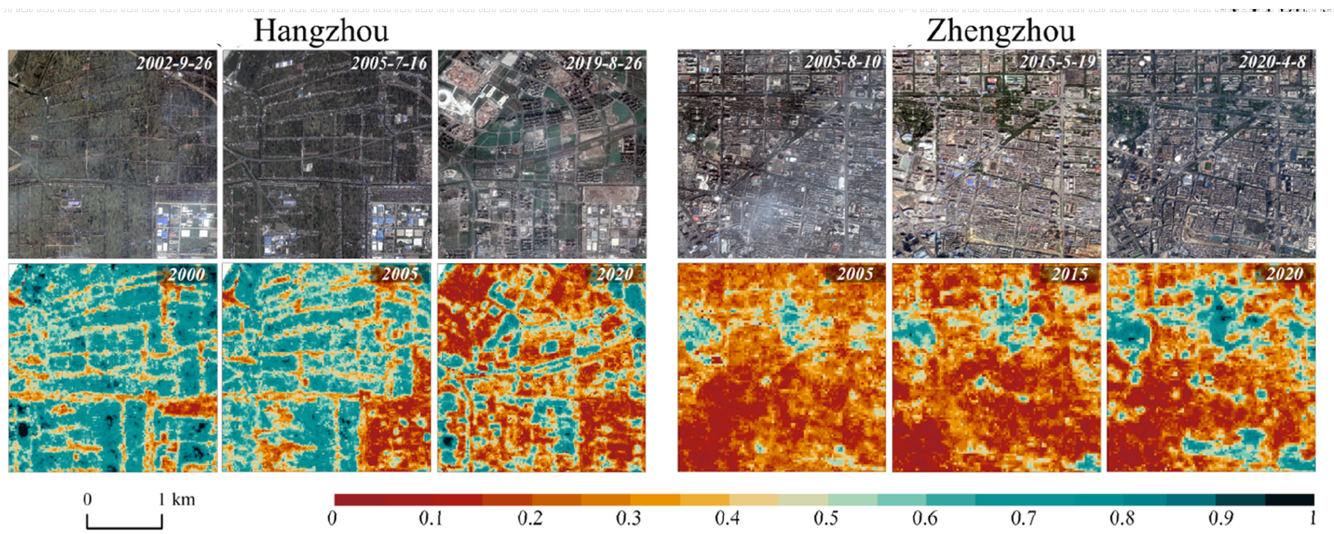


Figure 1: A sample result shows urban vegetation degradation in Hangzhou and an increase in vegetation in Zhengzhou. source : (Han et al. 2025).

However, Landsat is an optical imaging system that is often susceptible to cloud cover and has limitations in distinguishing different vegetation types based solely on spectral characteristics. Imagine studying a mountainous region where cloud cover is persistent—using optical images like Landsat for vegetation monitoring and identification would be challenging.

To address this issue, Li et al. (2023) utilized Sentinel-1, which operates with C-band Synthetic Aperture Radar (SAR), enabling vegetation mapping under all weather conditions. The SAR data from Sentinel-1, when combined with the optical imagery of Sentinel-2, allows for the production of high-resolution maps that effectively differentiate bamboo forests from other vegetation types. This integration helps overcome the limitations of optical data in vegetation monitoring, where mixed spectral characteristics often lead to uncertainty in distinguishing bamboo from other forest types.

2.3 Reflection

After exploring the application of the two selected satellites, I have concluded that remote sensing data is particularly effective for analyzing large-scale and long-term variations. It can also help mitigate the high costs of manual data collection across vast regions. This insight made me reflect on a similar challenge in my country, Indonesia. We often have challenges to find dataset for spatial analysis as we rely much on vector data, if any it would be outdated. Using remote sensing data not only allows us to have more updated data but also allows us to explore various potential variables derived from satellite imagery.

2.4 References

3 Xaringan and Quarto Book

Lecture this week reminded me of one of powerful figure in Uchiha Clan, the one who can manipulate reality once he activates this-so-called Xaringan. Well, but this Xaringan is not related to figures in Konoha's world but related to a certain library in R Studio that enable us to create neat HTML slides in R.

3.1 Summary

```
xaringanExtra::embed_xaringan(url = "https://nooriza16.github.io/Xaringan/Xaringan.html",
```

3.2 Reflections

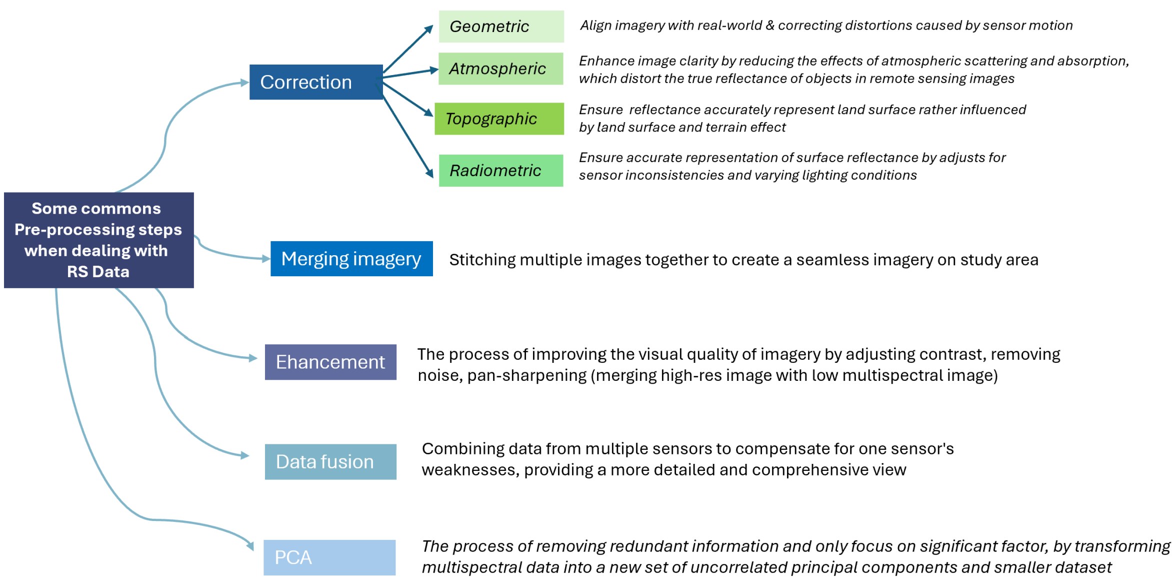
For someone who is not familiar with html, learning Xaringan is definitely challenging compared to powerpoint, as we just usually click tabs on power point. Honestly, I still consider power point provides more themes and more visualization effects that is easily to access compared to Xaringan. However, as I delved further I realize that using Xaringan is providing us with flexibility even such as positioned our picture.

So far, I feel like Xaringan is best at incorporating snippet code on presentation or interactive features that usually too heavy to load in power point. Besides, it helps me to give a sense of what html look like.

4 Image Correction

4.1 Summary

Here is my note based on this week's lecture that explores steps people usually do in image correction. Although sometimes we get a "ready-to-use data" without the need to going through all of these process, having the basic understandings of these steps would help us understand the quality our data.



This diagram is created as a note of CASA023 Lecture Week 3

I also add several new terminologies, based on my own note during the lecture, related to image processing during this week's summary

Reflectance and radiance	Reflectance is basically the amount of light when a surface reflect the light, while radiance is the amount of light captured by sensor after interacting with Earth's surface

Digital Number	A raw value for a given pixel that represents the intensity of radiation received in a specific spectral band. Digital number is important because it serves as a basis for image classification, for example digital number close to 0 represents object that absorbs much incoming light (low reflectance) such as water bodies or shadows.
Digital Object Substraction (DOS)	DOS is an atmospheric correction method that subtracts pixel values based on the amount of difference between digital values of dark objects (usually water bodies) with their corresponding reflectance
Collection, level, and tier	I will use the Landsat case to explain this terminology. In Landsat the collection would be named as Collection 1 and 2, it represents the sequence of launching time and their mission : Landsat 2 is the latest. Level 1 is a scaled digital number, while level 2 is further processed data. Meanwhile, tier 1 is the highest quality data from landsat and suitable for time series analysis. source: https://www.usgs.gov/landsat-missions/landsat-collection-2-level-1-data

4.2 Application

In this week application, I would like to explore the application of remote sensing on my favorite topic : data unavailability. In developing countries like Indonesia, maintaining updated and comprehensive data is challenging due to time and cost constraints. A study in Pakistan also mentioned similar challenges, particularly data related to socioeconomic condition that often limited and sporadic Arshad et al. (2023). Honestly, this topic piques my interest because Bill Gates came across an article in The Washington Post and seems fascinated with the idea of using remote sensing to identify wealth, as he shared on X

Figure 1 : Tweet about satellite imagery on detecting poor region. Source : https://x.com/yohaniddawela/status/1857398431146299437

Arshad et al. (2023) addressed this issue using imagery that automatically could derive insights about poverty. They use publicly accessible high-resolution satellite imagery (Google Maps API with 16 zoom) and Landsat 7 (low resolution data). Google Maps API provides high-resolution imagery to identify man-made features like buildings and highway which are indicators of development levels meanwhile Landsat 7 is used to train Convolutional Neural Networks (a method of feature extraction from imagery in Machine Learning) in identifying nightlight bin (low to high). Areas with higher levels of economic activity and development tend to have more lights at night. This method will produce a map that indicates a poverty and development level compared to poverty line. The results are then validated using actual socioeconomic data from surveys. Below is a map where each point represents a poverty clusters (10x10 km area), comparing predicted and actual data. Green points indicate clusters above the poverty line, while red points indicates the opposite.

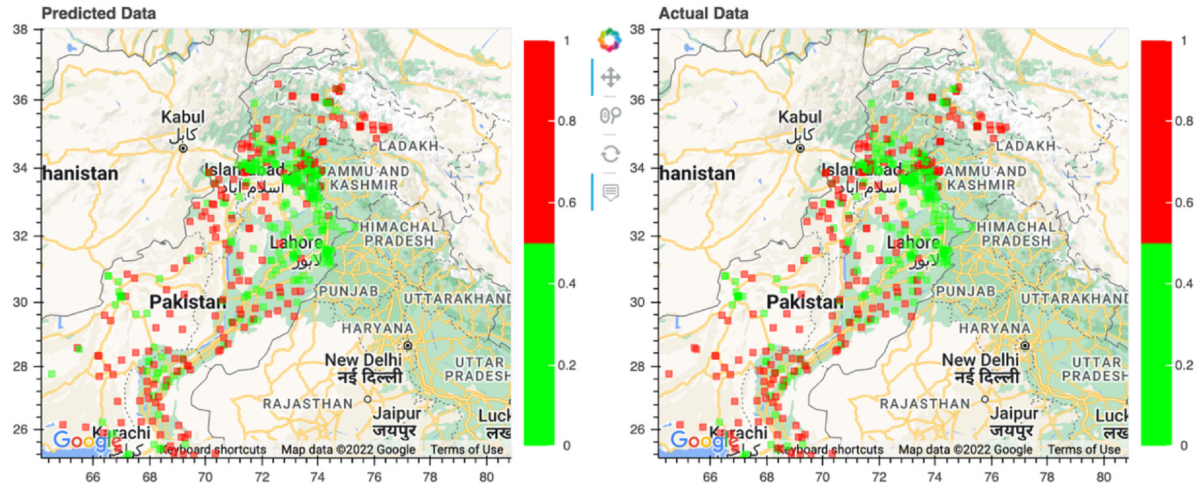


Figure 2 : Socioeconomic conditions compared to poverty line in Pakistan. Source : (Arshad et al. 2023).

When reflecting on the map above, I would prefer to visualize the classification results as polygon rather than points, as they were more intuitive. Additionally, it would be nice to map the difference across the years, Ben Abbes et al. (2024) just do this ! They use multispectral images (Landsat 5, 7,8) and Nightlight images (from Defense Meteorological Satellite Program (DMSP) and the Visible Infrared Imaging Radiometer Suite (VIIRS)) in Southeast Brazil. The classification result is represented using estimated wealth index and they could even map the socioeconomic transformation across 10 years in a single map!

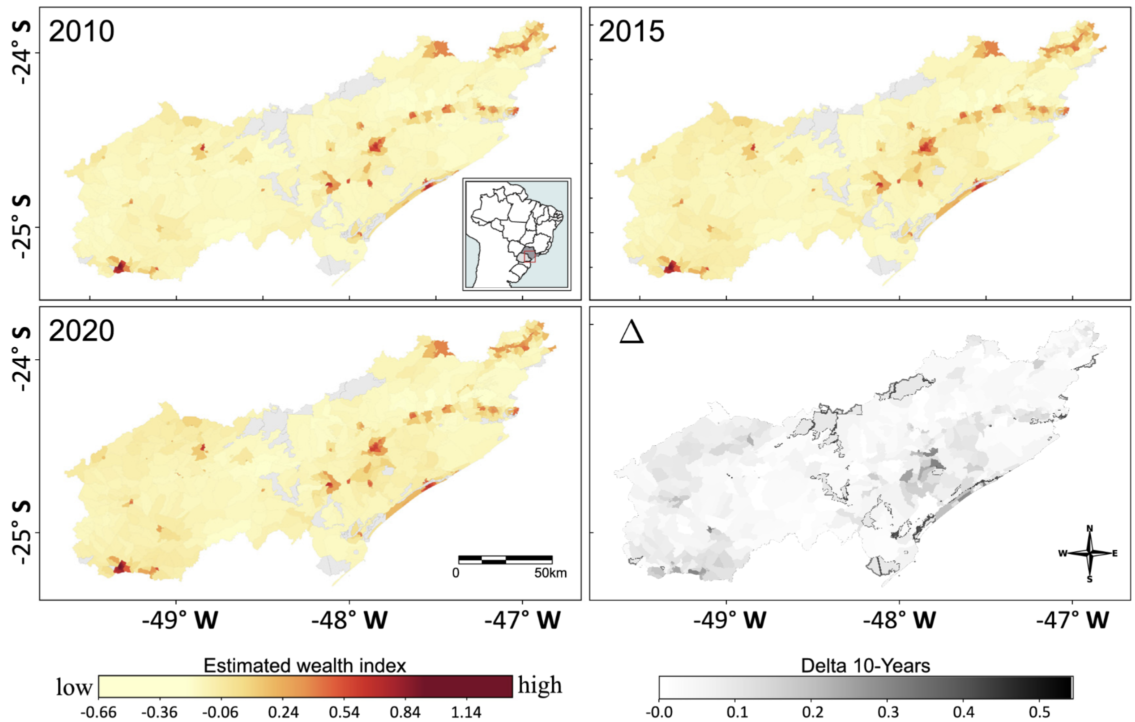


Figure 3 : Spatio-temporal mapping of wealth index estimations in Southeast Brazil. Source : Ben Abbes et al. (2024).

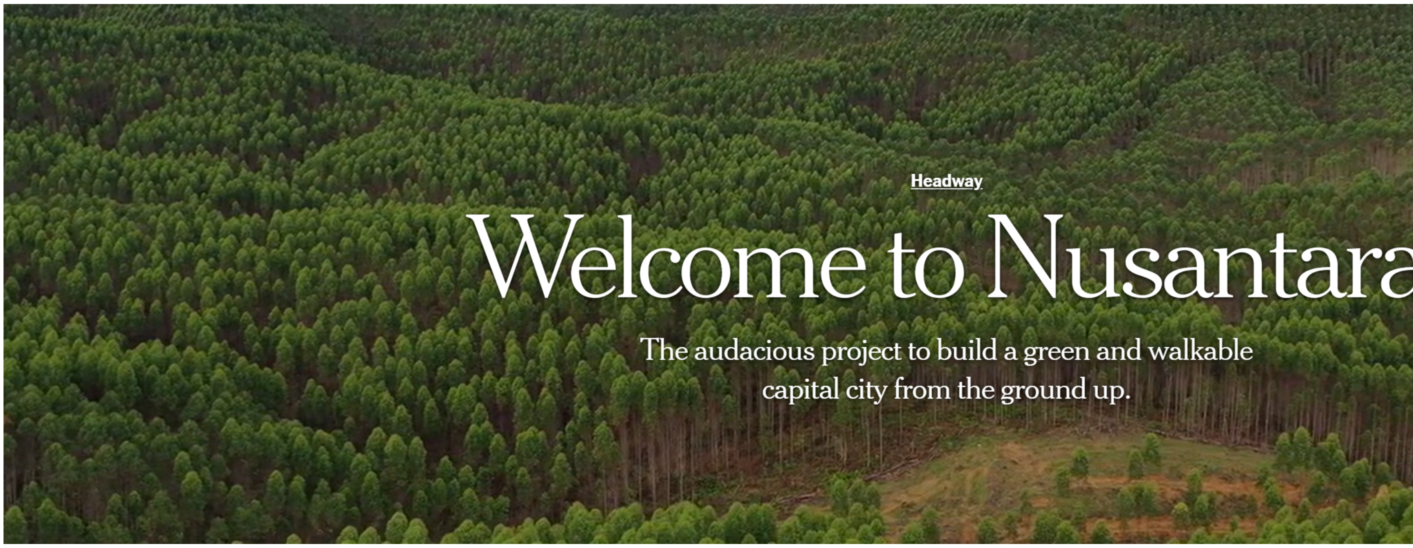
4.3 Reflection

I think performing Remote Sensing correction on R Studio is quite challenging, as I become more used to using 'button' in Remote Sensing application such as ENVI or SNAP. After this week's lecture, I genuinely think that Remote Sensing is quite complex as it is not only an image but beyond the imagery each pixel is composed by digital number and it could be linked and better interpreted using regression too.

Understanding the image classification using machine learning is also quite challenging for me, as they use new terminologies that I haven't heard before such as convolutional neural network, epoch, data training.

5 Policy

Project Case : A New Relocated Capital City of Indonesia ; From Jakarta to Nusantara



Source : www.nytimes.com

5.1 Summary

Recently Indonesia planned to move its capital city from Jakarta (in Java islands) into Penajam Paser Utara City (Borneo Islands), as the current capital city, Jakarta, faced an issue of sinking, land subsidence, overcrowding, low air and water quality (Bappenas 2021). The term Nusantara is used to name this new capital city, symbolizing the varied geographic settings and cultural diversities of Indonesia.

As for the time this published, Nusantara Development is on the phase 2 (2025-2029) that involved strengthening core area (housing, office, commercial zone). Thus, in the time being, Jakarta will still remain the capital of Indonesia until the Presidential Decree on the transfer of the capital to Nusantara is issued. The issuance of this decree will depend on the readiness of the new capital city, including the preparation of all supporting systems such as infrastructure, human resources, and governance systems.

Figure 1: The Relocation Settings and Vision. source: (Capital Authority 2024)

As the development is still in the initial stage, the detailed planning documents haven't been launched yet. Thus, I use available published documents regarding the detail of Nusantara's Development which all of them are publicly available, such as Nusantara Sustainable Development Goals (SDGs) Voluntary Local Review Baseline [2024] and Nusantara Biodiversity Management Master Plan [2024]

Policy

The new capital city, Nusantara, is designed as a **forest city**, with 75% of its designated area being green space. This design aims to create a harmonious blend of urban development and biodiversity hotspots (Borneo Island, where Nusantara is located, is famous for its tropical rainforests). However, the design of being a forest city, its proximity to the rainforest, and its drive on landscape change would present significant **challenges**. One of the major concerns is the increasing likelihood of mosquito-borne diseases (such as **malaria**) spreading in the new capital, which are prevalent in tropical regions Surendra et al. (2024). Since malaria is both a global and local challenge, certain goals should be considered to support Nusantara's sustainability, such as:

A. Global Goals : Sustainable Development Goals (SDGs) 3.3 : Fight Communicable Diseases

The SDGs propose achievable global in combating malaria with target that in include reducing incident, mortality rates, eliminate malaria in 35 countries by 2030 and prevent resurgence of the disease in a malaria-free country. Meanwhile, Indonesia's estimated malaria incidence per 1000 population at risk is still on range between 1-50 incidents per 1000 population in 2023. To achieve target of Global Goals, (WHO 2021) have launched global technical strategy for malaria with framework such as:

Figure 2 : SDGs Goal and WHO Technical Strategy

B. Local Goals (National Level): Eliminate malaria case by 2030 and maintain malaria free status

Translating the global goals on malaria elimination, Indonesia's Ministry of Health (Ministry of Health and Control 2023) had proposed recommendations, including the new capital city such as:

- Malaria elimination policies and implementation need basic research, operational support, and efficient technology development.
- Provide input to the IKN special authority regarding malaria risk to ensure the design of the IKN area drainage system is free from malaria mosquito larvae habitat
- Mapping legal and illegal forest encroachers to develop an activity plan and budget

5.2 Application

Remote Sensing as Baseline for detecting malaria hotspot

In malaria elimination projects, remote sensing can serve as a crucial baseline data source for mapping malaria hotspots by integrating climatic and land-use factors. @wimberly2021 proposed a framework that leverages Earth observation products to identify mosquito habitats based on climate conditions, human activities, and specific land-use patterns.

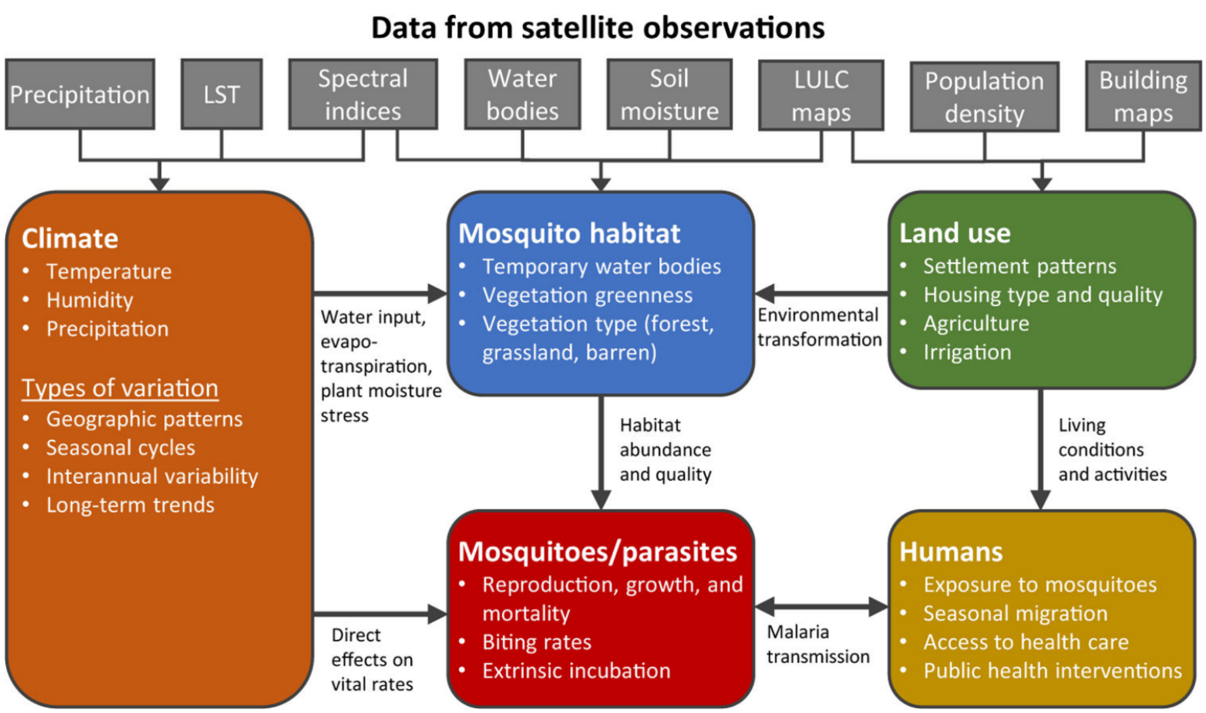


Figure 2: Framework in which Remote Sensing used in Malaria studies. source : Wimberly et al. (2021).

To address policy mentioned in section 2, I underlined some dataset that could be used to the analysis:

Data	Purpose
• **Sentinel-2 (rainy season)**	• *Highlight water bodies and wetlands* – These serve as proxies for mosquito breeding sites. • *Vegetation and land cover* – Provides insight into potential mosquito habitats. • *Surface temperature* – Acts as a proxy for mosquito activity.
• **Digital Elevation Model (DEM) Data/Topography**	• Helps to provide topografy to identify potential inundation areas, which could influence mosquito breeding patterns.
• **Microsoft Open Buildings**	• Useful as a proxy for human settlements and potential exposure risk.
• **Rainfall Data**	• The rainfall season can be considered as a timeframe for analysis. However, if locally recorded rainfall data from the Indonesian Climatic Institution is available, it could help refine the identification of rainfall patterns, allowing for a more informed selection of the time series.

5.3 Reflections

During this week, I got a lot of reflections as I finally found lecture that explicitly bridging the gap of 'academics' to real-world policy. My reflections would be:

1. Combining remote sensing with GIS

   Since Nusantara is still uninhabited, we could model nearby settlements to investigate the remote sensing framework. By combining the results with malaria incident data, we can validate our classification—analyzing what percentage of high-risk areas have recorded incidents and which have not. While global and local malaria elimination frameworks mention aggregating incident data and risk levels, they do not explicitly emphasize mapping. Using maps, we can overlay malaria hotspots with incident data, land use, and socio-economic factors. As (Naserrudin, Yong, et al. 2023) notes, people are exposed to malaria due to professions that require them to venture deeper into the forest.

2. Remote Sensing and GIS is good, but enriching the analysis with **affected communities** make it better

   Beyond remote sensing data, incorporating local knowledge can improve the analysis. Understanding how affected communities respond to malaria provides insight into the effectiveness of mitigation efforts (Naserrudin, Lin, et al. 2023). These communities have lived near rainforests for generations and are directly affected, making their experiences valuable for practical prevention strategies.

3. Implementation challenges, the need for collaboration

   One the most important key-takeaway from the lecture is that "some academics papers are too technical, without clearly addressed policy; some policy don't include academic findings they could benefit for." This condition lead to a gap between academics and urban governance. However, in my observation during my work with the government the potential cause is human resources (make the adoption of academics finding hard to implement), annual budget cycles (governments prioritize immediate results and may be reluctant to invest in the long-term experimental processes typical of academia). Bridging the gap on malaria prevention requires collaboration and commitment not only between epidemiologists, healthcare, and geospatial analysts but with the governments to ensure research translates into actionable policies.

5.4 References

6 Introduction to GEE

6.1 Summary

This week's material is all about GEE (Google Earth Engine). In a simple definition, GEE is a cloud platform that allows us to access satellite imagery for the whole world and spatial-computation on Google for free. GEE hosts massive amounts of satellite imagery and we as a user request their imagery data and analyse it on the cloud-platform without have to worry about the capability of our local machine.

Basically, GEE has an architecture that collects user input (client side) and then process this input (server side). In GEE we could manage both raster and feature (vector) data. We input command on GEE mostly using Java Script programming lanaguange. As someone enthusiastic with GEE, the need to learn 'a new' programming language almost discourages me, as I worry that I might mix up all the programming languages I have learnt before.

However, when I looked at the way GEE articulates data structures, I found it quite similar to Python, with just a few additional keywords, such as 'var' to denote variable. Below are some basic pieces of information about the GEE language that we need to know from my lecture. Check out this introduction from Google if you're still unconvinced [here].

```
// All the javascript you need to know (almost)

var number = 1

var string = 'Hello, World!'

var list = [1.23, 8, -3]
print(list[2])

var dictionary = {
  a: 'Hello',
  b: 10,
  c: 0.1343,
  d: list
}

print(dictionary.b)
print(number, string, list, dictionary)
```

Figure 1 : Basic javascript in GEE. source : https://andrewmaclachlan.github.io/CASA0023/5_GEE_I.html

When I was first introduced to the idea that GEE is efficient in managing raster data, I was curious about how this efficiency works. For example, if I want to use Landsat 8 (30 m resolution) to analyze the whole UK, it would require processing every 30 m pixel across the whole region, which I assumed would take longer time. However, what makes GEE faster dealing with those data actually because there is a pyramid of reduced resolution in GEE, which able to optimizes performance using lower-resolution versions of the data when full detail is not necessary and also resampling method to adapt the analysis requirement. Thus when performing analysis, GEE does not just take the original image resolution, but GEE adjusts image resolution based on our output needs. In summary, when you are zooming out and zooming in, GEE retrieves different resolution of imagery. Below is the picture of GEE interface, comprising the code editor where we write our code.

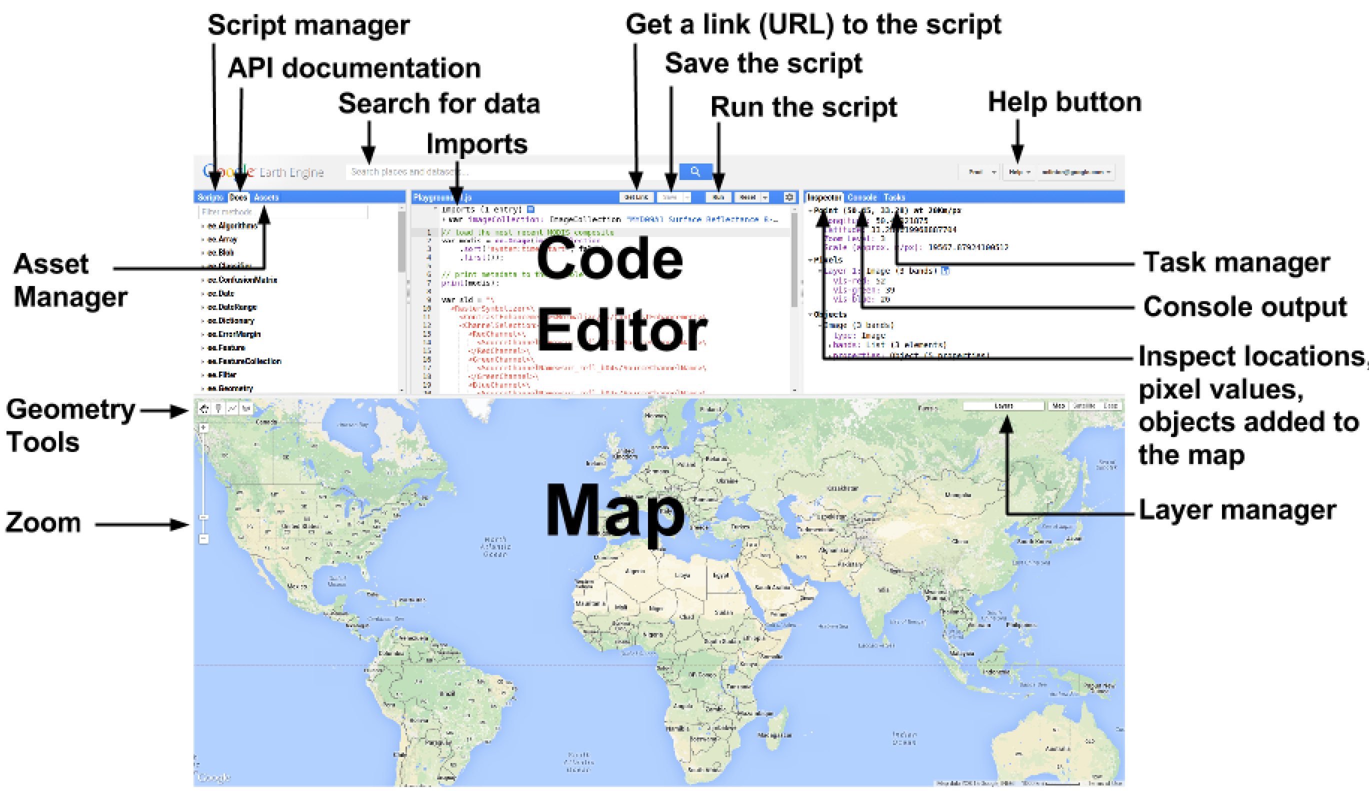


Figure 2 : GEE Interface. source : GEE Beginer cookbook

6.2 Application

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