L'INITIATIVE
sida, tuberculose, paludisme

IMPLEMENDED BY EXPERTISE FRANCE GROUPE AFD

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Fraternité

AS PART OF THE FRENCH CONTRIBUTION TO THE GLOBAL FUND

INTEGRATING ENVIRONMENTAL INDICATORS WITH EPIDEMIOLOGICAL SURVEILLANCE SYSTEMS: AN OPERATIONAL AND ITERATIVE APPROACH

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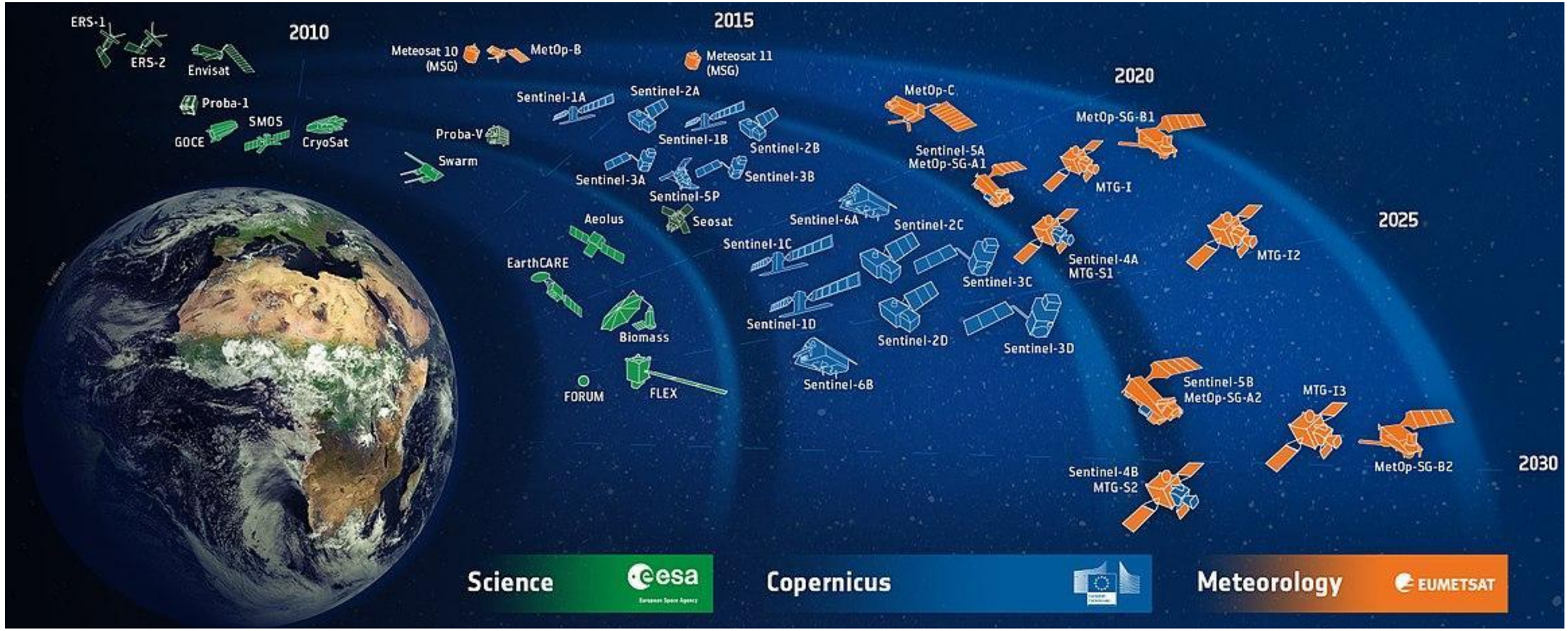
EARTH OBSERVATION SATELLITES

- Increasing number of Earth Observation satellites
- Information availability (processing and price)
- Increasing computing capacities

→ Potential to provide environmental & meteorological information in real-time to inform disease surveillance



EARTH OBSERVATION SATELLITES

- Increasing number of Earth Observation satellites
- Information availability (processing and price)
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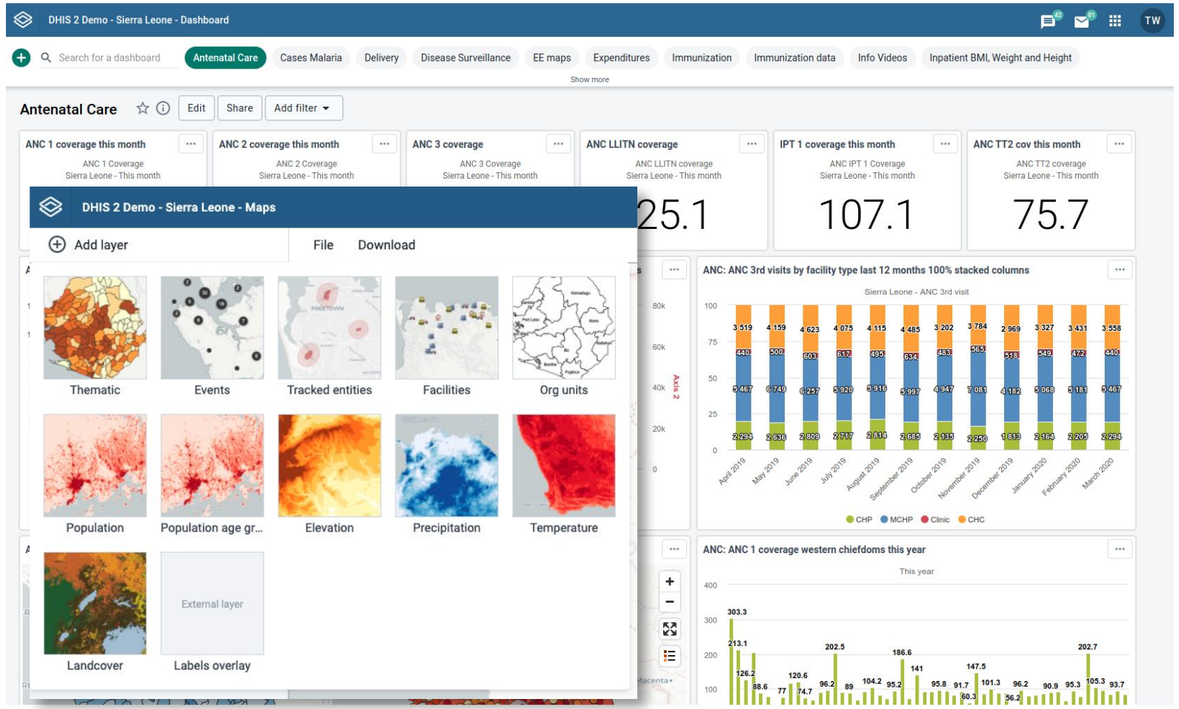
→ Potential to provide environmental & meteorological information in real-time to inform disease surveillance

 But still no such data populating in near real time health information systems



DHIS2 (Digital Health Information System, dhis2.org)

Recent possibility to integrate weather and climate data into DHIS2 data elements:

-> Limited number of variables

-> Based on Google Earth Engine

Table 1
Main characteristics and references of the P-datasets. In the data source column, S, R, and G stands for satellite, reanalysis, and gauge information. Spatial coverage refers to the absolute maximum and minimum latitude with precipitation information, and latency refers to the time delay for data availability. The P-datasets including gauge-based information are represented in blue, and italic font is used for P-datasets available in NRT latency of one to three days.

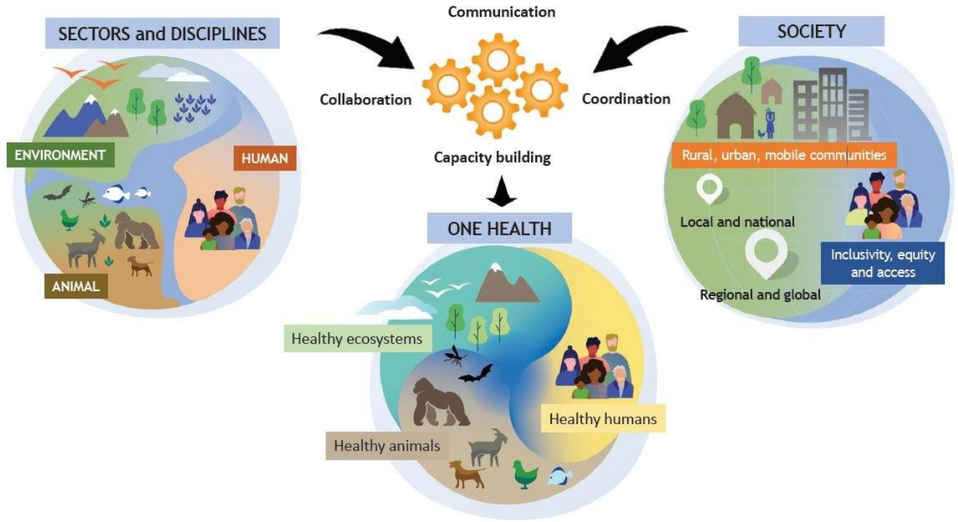
Acronym	Full Name	Data	Temporal Coverage	Temporal Resolution	Spatial Coverage	Spatial Resolution	Latency	Link	References
ARC-2	Africa Rainfall Climatology v.2	S, G	1983–present	Daily	Africa	0.1°	2 days	ftp://ftp.cpc.ncep.noaa.gov/fews/fewsdata/africa/arc2/	Novella and Thiaw (2012)
CHIRP v.2	Climate Hazards Group InfraRed v.2	S, R	1981–present	Daily	50°	0.05°	2 days	ftp://ftp.chg.ucsb.edu/pub/org/chg/products/	Funk et al. (2015)
CHIRPS v.2	CHIRP with Station v.2	S, R, G	1981–present	Daily	50°	0.05°	1 month	ftp://ftp.chg.ucsb.edu/pub/org/chg/products/	Funk et al. (2015)
CMORPH-Raw v.1	Climate Prediction Center MORPHing raw v.1	S	1998–present	3 h	60°	0.25°	2 days	ftp://ftp.cpc.ncep.noaa.gov/precip/CMORPH_V1.0/	Joyce et al. (2004)
CMORPH-CRT v.1	CMORPH bias corrected v.1	S, G	1998–present	3 h	60°	0.25°	6 months	ftp://ftp.cpc.ncep.noaa.gov/precip/CMORPH_V1.0/	Xie et al. (2017)
CMORPH-BLD v.1	CMORPH satellite-gauge merged v.1	S, G	1998–present	Daily	60°	0.25°	10 months	ftp://ftp.cpc.ncep.noaa.gov/precip/CMORPH_V1.0/	Xie et al. (2017)
CPC v.1	Climate Prediction Center unified v.1	G	1979–present	Daily	Global	0,5°	1 days	ftp://ftp.cpc.ncep.noaa.gov/precip/CPC_UNI_PRCP/GAUGE_GLB/	Xie et al. (2007) Chen et al. (2008)
ERA-Interim	European Centre for Medium-range Weather Forecast Re Analysis Interim	R	1979–present	3 h	60°	0.75°	3 months	https://www.ecmwf.int/en/forecasts/datasets/reanalysis-datasets/era-interim-land	Dee et al. (2011)
GSMaP-RT v.6	Global Satellite Mapping of Precipitation standard v.6	S	2000–present	Hourly	60°	0.1°	3 days	ftp://hokusai.eorc.jaxa.jp/standard/v6/	Ushio et al. (2009) Yamamoto and Shige (2014)
GSMaP-Adj v.6	GSMaP adjusted v.6	S, G	2000-–resent	Hourly	60°	0.1°	3 days	ftp://hokusai.eorc.jaxa.jp/standard/v6/	Ushio et al. (2009) Yamamoto and Shige (2014)
GPCC v.7	Global Precipitation Climatology Center	G	1901–2013	Monthly	Global	1°	Irregular	https://rda.ucar.edu/datasets/ds496.0/	Becker et al. (2013); Schneider et al. (2014)
JRA-55	Japanese 55-year Re Analysis	R	1959–present	3 h	Global	0,56°	1 Month	https://rda.ucar.edu/datasets/ds628.0/	Kobayashi et al. (2015)
JRA-55 Adj	JRA-55 Adjusted	R,G	1959–2013	3 h	Global	0,56°	Stopped	http://search.diasjp.net/en/dataset/S14FD	Izumi et al. (2017)
MERRA-2	Modern-Era Retrospective Analysis for Research and Applications 2	S, R, G	1980–present	Hourly	Global	0,5°	2 Months	https://disc.gsfc.nasa.gov/	Gelaro et al. (2017) Reichle et al. (2017)
MSWEP v.2.2	Multi-Source Weighted Ensemble Precipitation v.2.2	S, R, G	1979–present	3 h	Global	0.1°	Few months	http://www.gloh2o.org/ (Personal communication)	Beck et al. (2018) Beck et al. (2019)
PERSIANN-CDR	Precipitation Estimates from Remotely Sensed Information using Artificial Neural Network and Climate Data Record	S, G	1983–2016	Daily	60°	0.25°	6 months	https://chrsdata.eng.uci.edu/	Ashouri et al. (2015)
PERSIANN-RT	PERSIANN real time	S	2000–present	6 h	60°	0.25°	2 days	https://chrsdata.eng.uci.edu/	Hsu et al. (1997) Sorooshian et al. (2000)
PERSIANN-Adj	PERSIANN Adjusted	S, G	2000–2010	3 h	60°	0.25°	Stopped	http://fire.eng.uci.edu/PERSIANN/	Hsu et al. (1997) Sorooshian et al. (2000)
SM2Rain-CCI v.2	Soil Moisture to Rain applied on ESA Climate Change Initiative v.2	S	1998–2015	Daily	Global	0.25°	Stopped	https://zenodo.org/record/846260#.XQEZtYgzZaQ	Ciabatta et al. (2018)
TAMSAT v.3	Tropical Applications of Meteorology using	S, G	1983–present	Daily	Africa	0.0375°	3 days	https://www.tamsat.org.uk/about	Maidment et al. (2017)

CLIMATE-INFORMED HEALTH PROGRAMMING

- Combining evidence from **multiple sources** presents significant data integration and **interoperability** challenges.
- Accessing and processing environmental and weather satellite data for **operational** use remain a limiting factor
    - Most of the time, it leads to strictly **retrospective** analysis.

The necessary workflow can be complex, requiring :

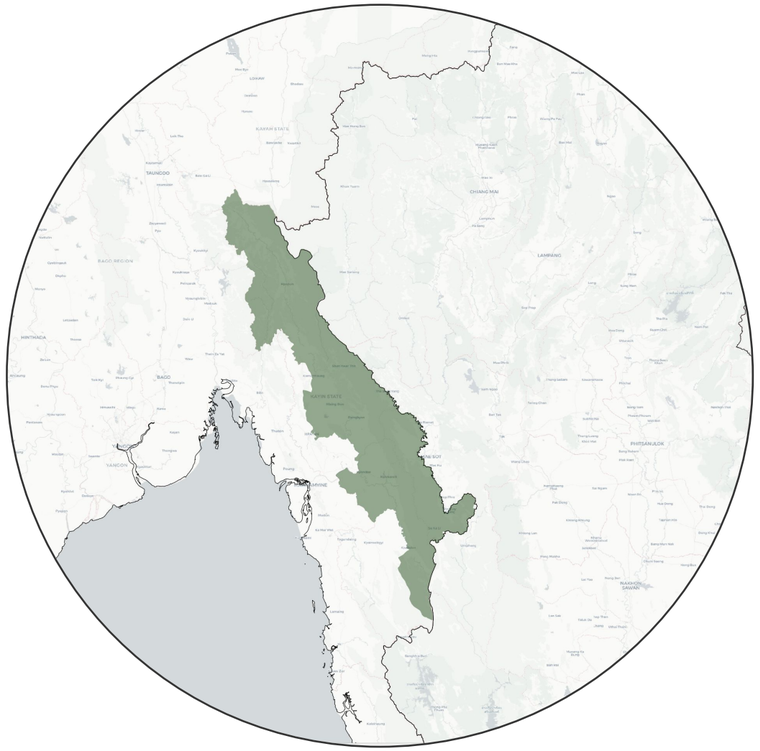
- (i) **automatic** acquisition and processing of large volumes of remote sensing data from online archives,
- (ii) processing of environmental data from disparate sources into a unified database format, and
- (iii) **automatic** updating of the environmental database for rapid availability.



https://www.who.int/news/item/01-12-2021-tripartite-and-unep-support-ohhlep-s-definition-of-one-health

Environment Analysis and Surveillance to Improve Malaria Elimination Strategies

EASIMES



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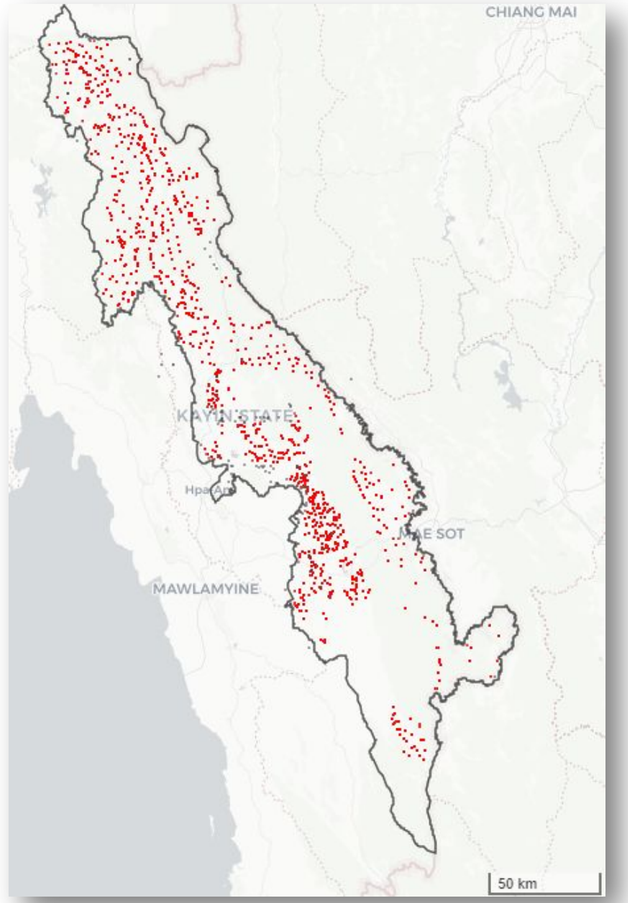
Shoklo Malaria Research Unit

EASIMES Project aimed to improve the understanding of **environmental conditions which influence malaria transmission** in the forested environments of Eastern Myanmar

- support micro stratification and active surveillance tools used by the control and/or elimination programs.

Malaria Elimination Task Force

Community-based access to early diagnosis (RDTs) and treatment (ACTs) of over 1250 malaria posts since 2014



4 main activities:

- Accurate mapping of land-use/land cover and monitoring of fluctuations in environmental conditions
- Defining the malaria epidemiological landscape: Spatio-temporal analysis
- Defining vector-suitable high-risk environments
- Development of a Malaria environmental surveillance system

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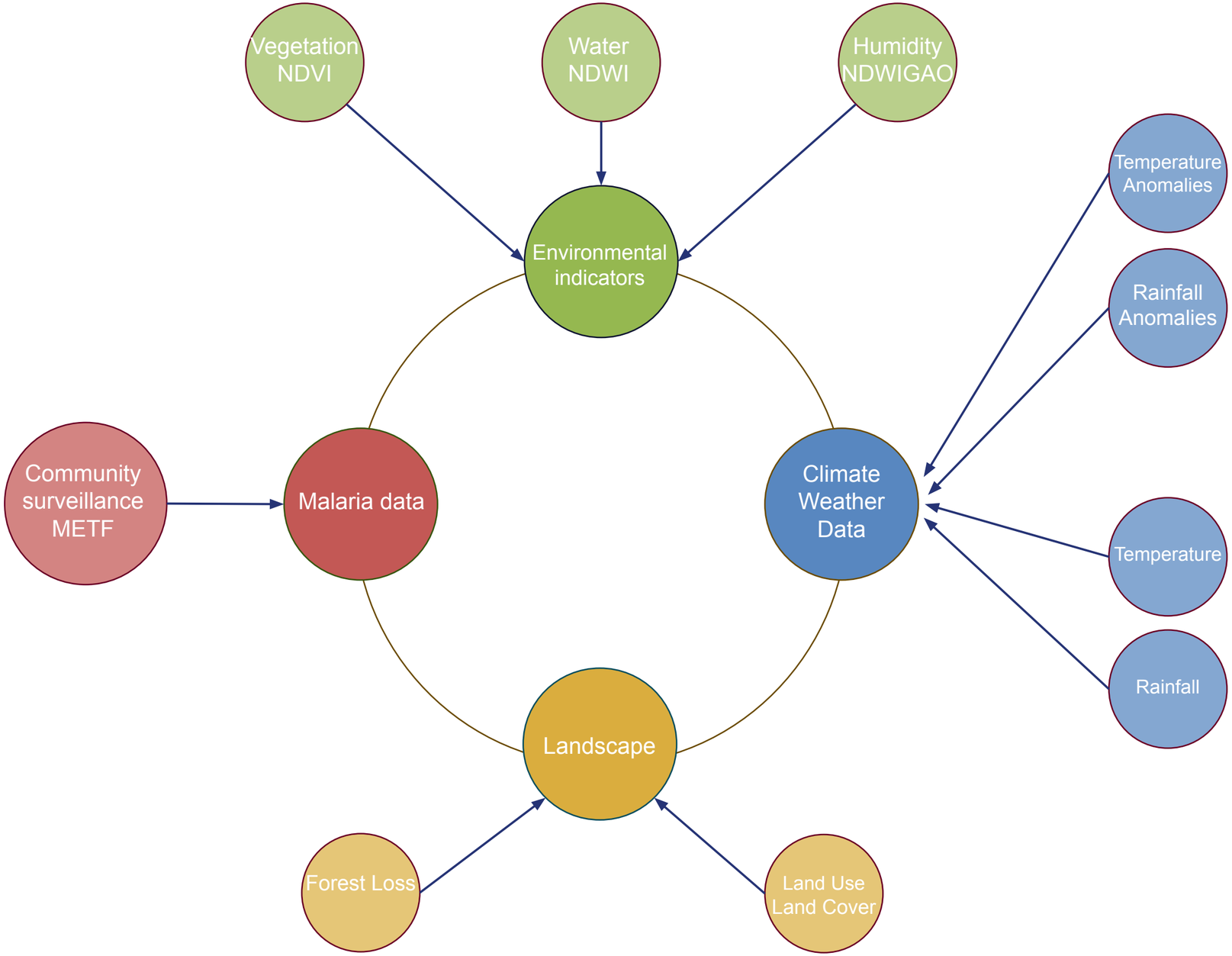
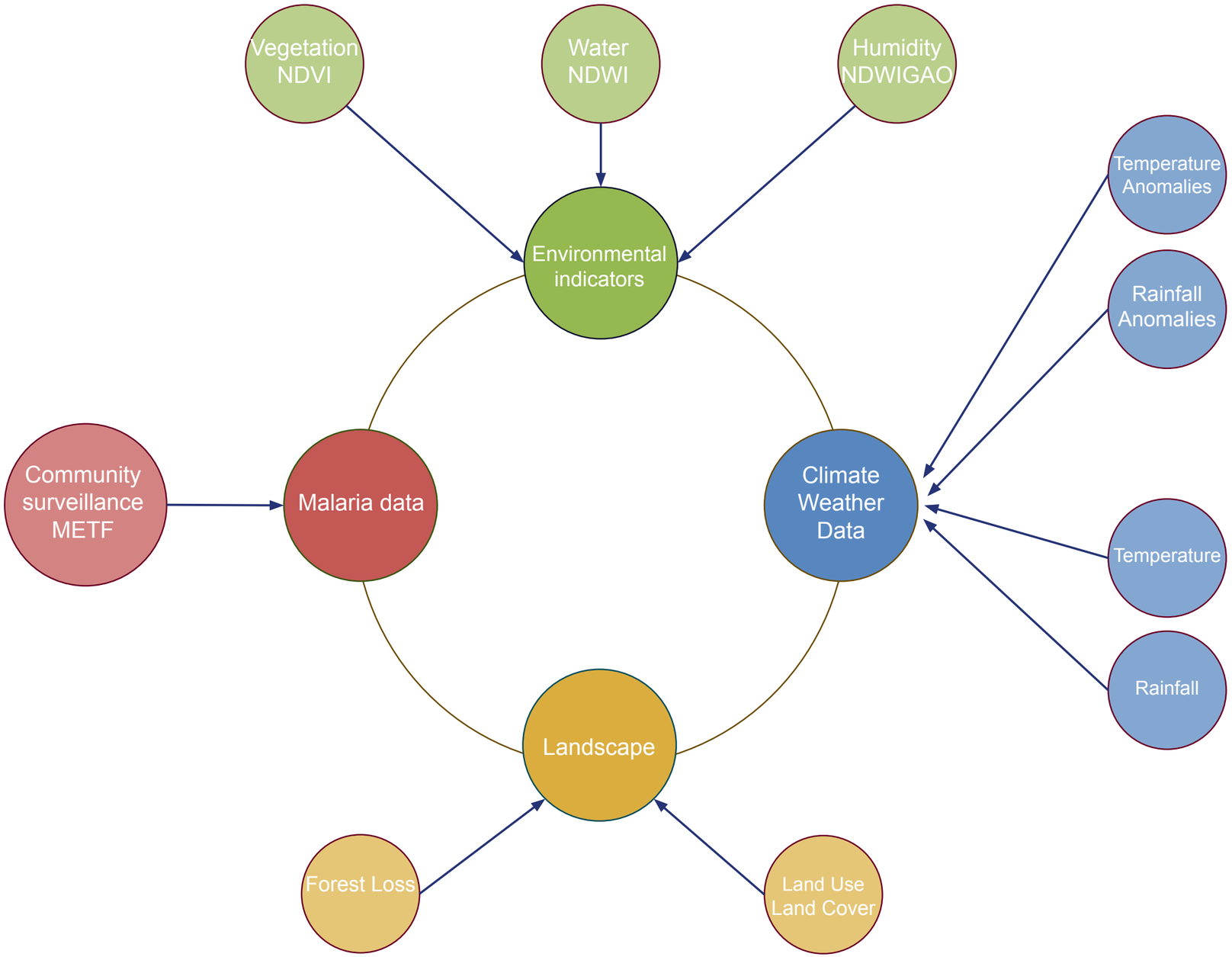
Malaria Environmental Surveillance System



Malaria Environmental Surveillance System

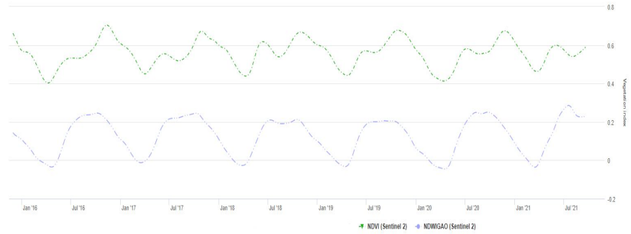


Environmental indicators

sentinel-2

opernicus
Europe's eyes on Earth

5 days at 10m of spatial resolution



Automated processing chain to obtain :

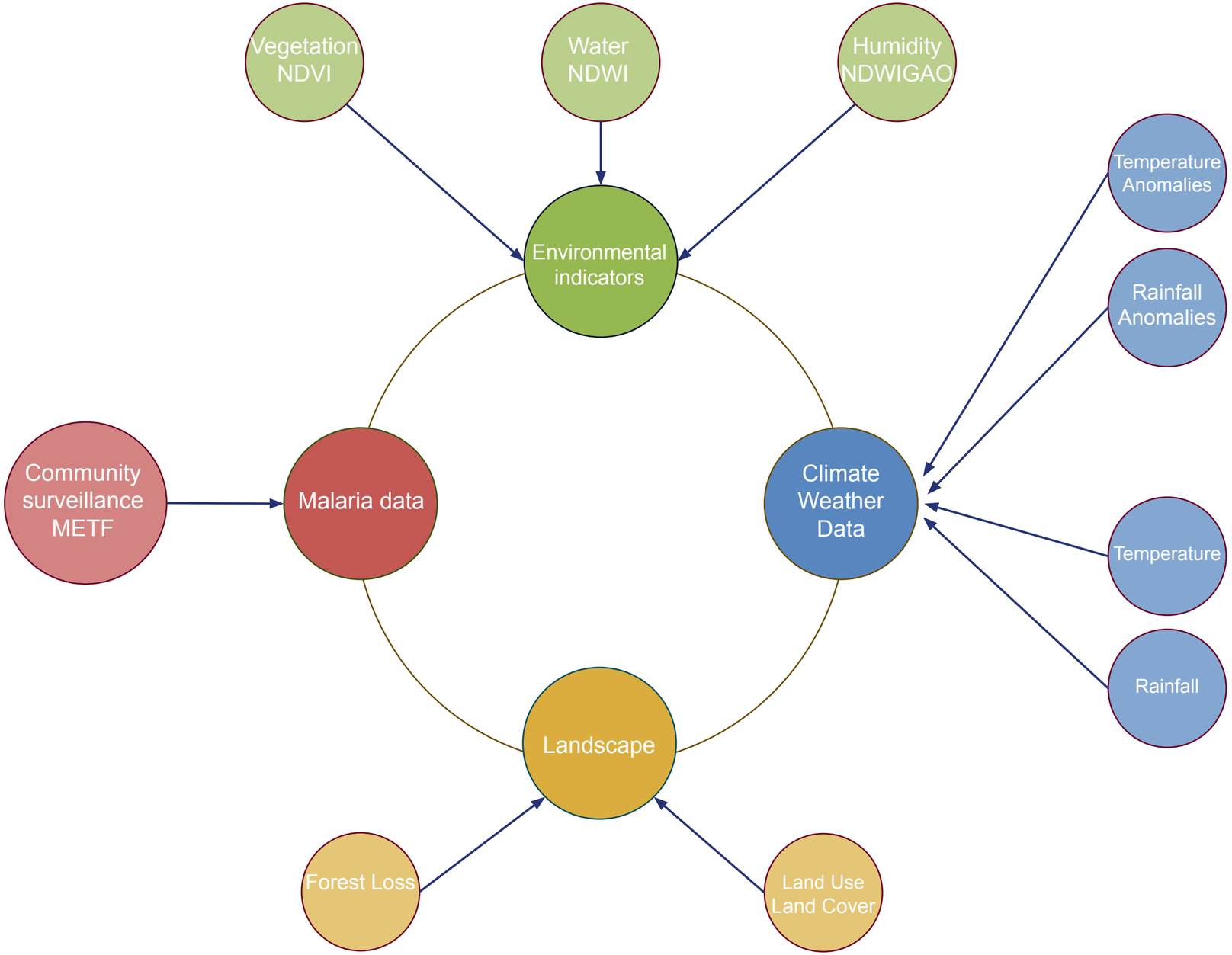
SEN2COR algorithm : Make atmospheric conditions correction automatically and routinely

Sen2Chain : Process Sentinel2 from L1C to L2A level

Sen2liss : Provide index production and time series computation

Time series of weekly S2 indicators over a buffer of 2000m around each Malaria post

Malaria Environmental Surveillance System

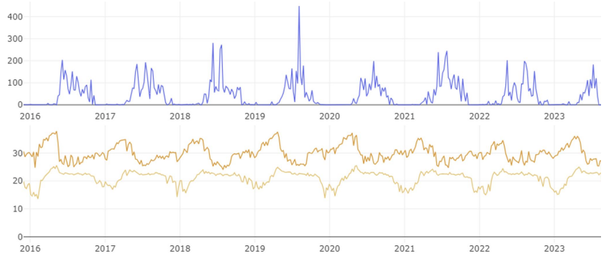


Climate and Weather data

era5

opernicus
Europe's eyes on Earth

Daily data

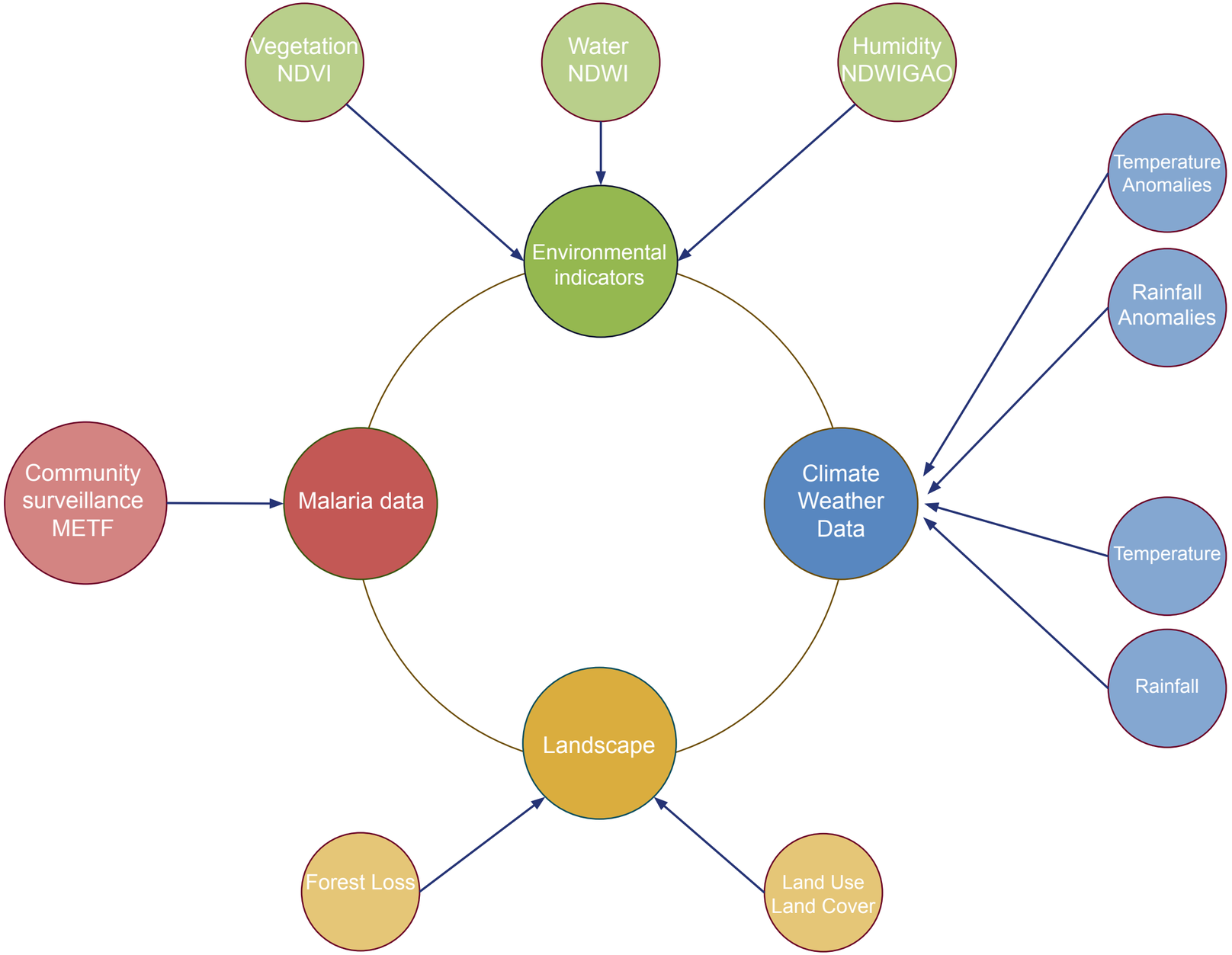


R and Google Earth Engine combination

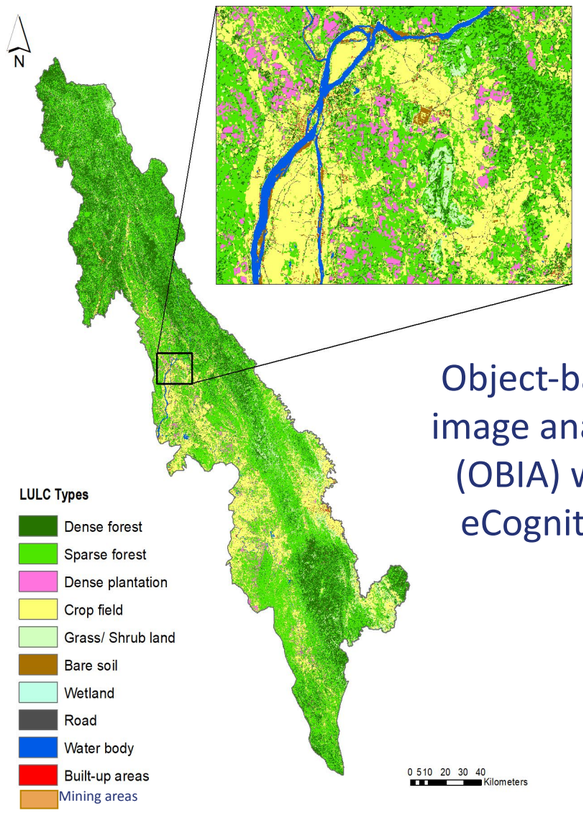
rgee

Time series of weekly rainfall, min temp and max temp information over a buffer of 2000m around each Malaria post

Malaria Environmental Surveillance System

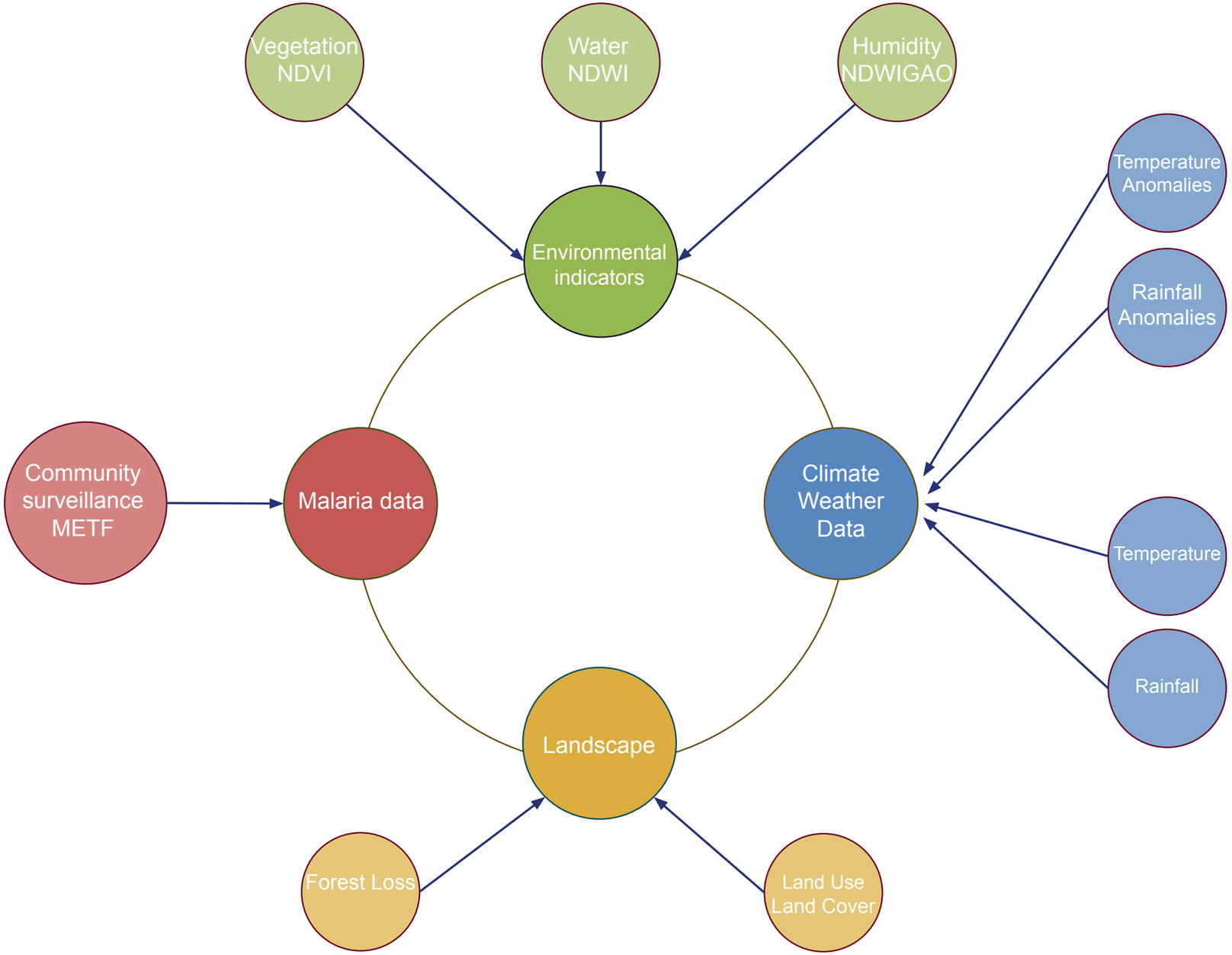


Land Use Land Cover



Object-based image analysis (OBIA) with eCognition

Malaria Environmental Surveillance System



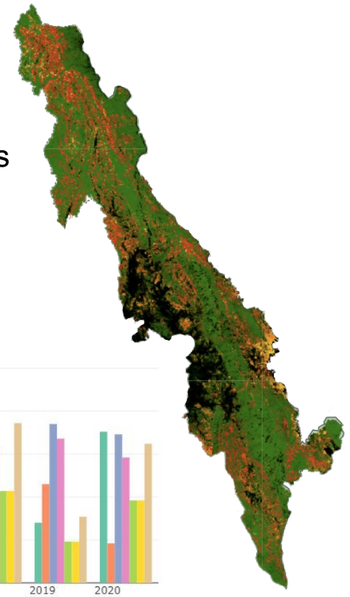
Forest Loss

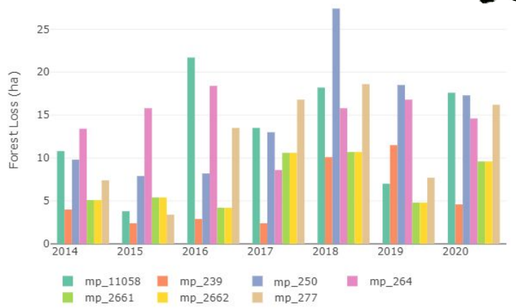
Global Forest Change

Published by Hansen, Potapov, Moore, Hancher et al.

University of Maryland

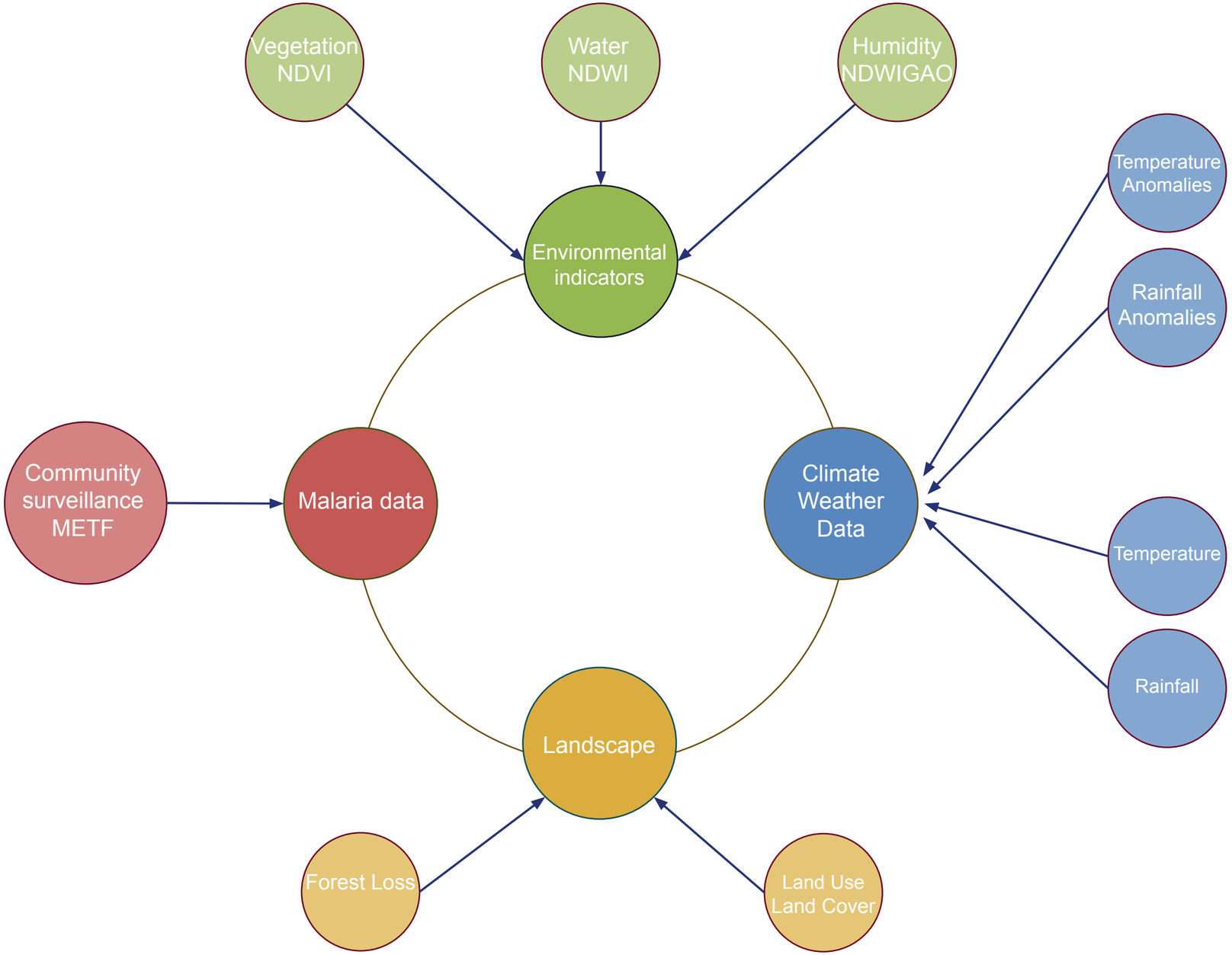
Results from time-series analysis of Landsat images characterising forest extent and change.





Yearly time series of Forest loss by ha over within a 2000m buffer around each malaria post

Malaria Environmental Surveillance System



Malaria data

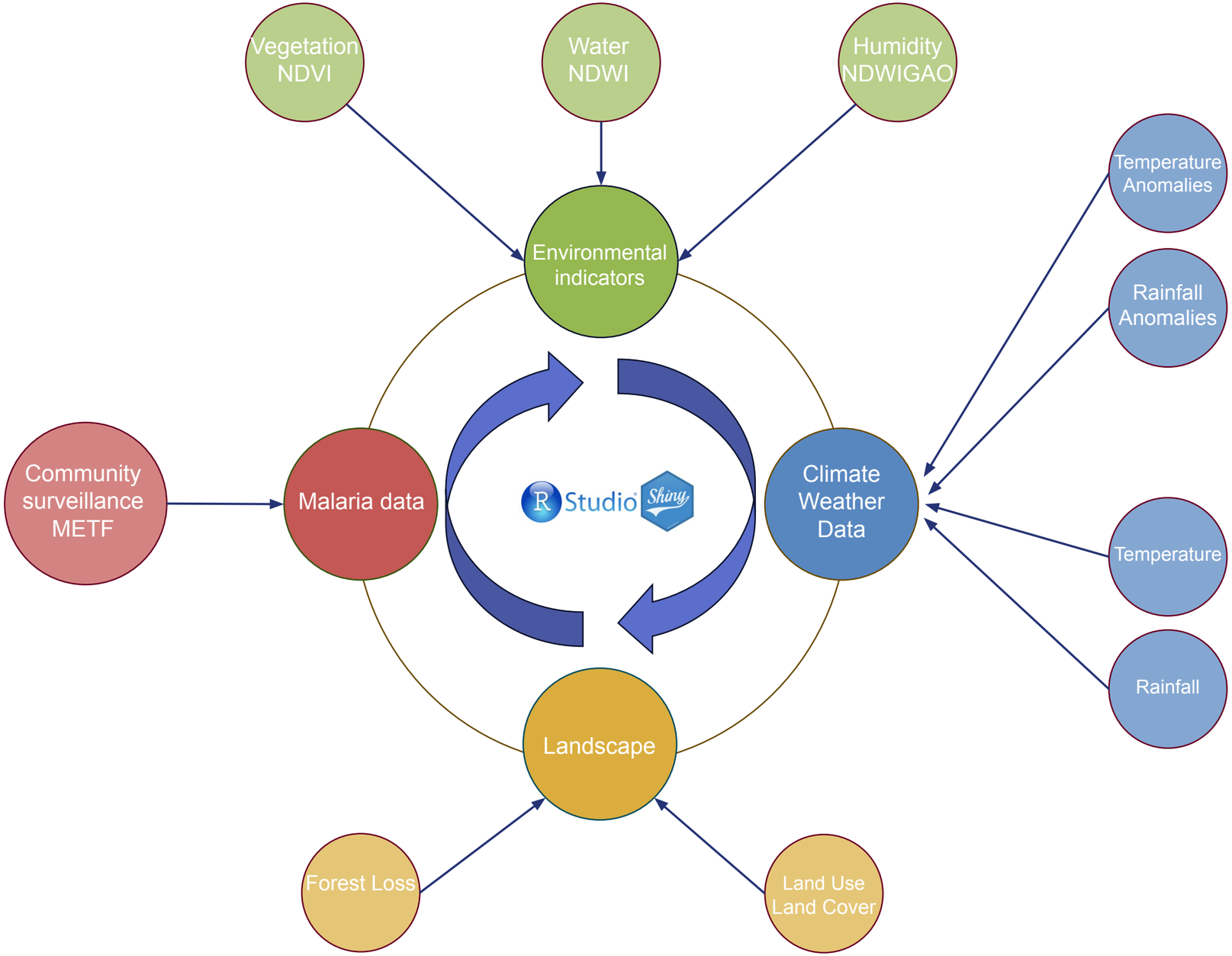
Community-based access to early diagnosis (RDTs) and treatment (ACTSs) of over 1250 malaria posts.

Paper-based or digital reporting (email or SMS)

Data are checked and cleaned each week, and any errors in data entry are corrected after communication with the data entry team

Number of fever cases and the number of RDT-confirmed P. falciparum and P. vivax infections by age and gender, etc.

Malaria Environmental Surveillance System



Malaria Environmental Surveillance System

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French National Research Institute for Sustainable Development

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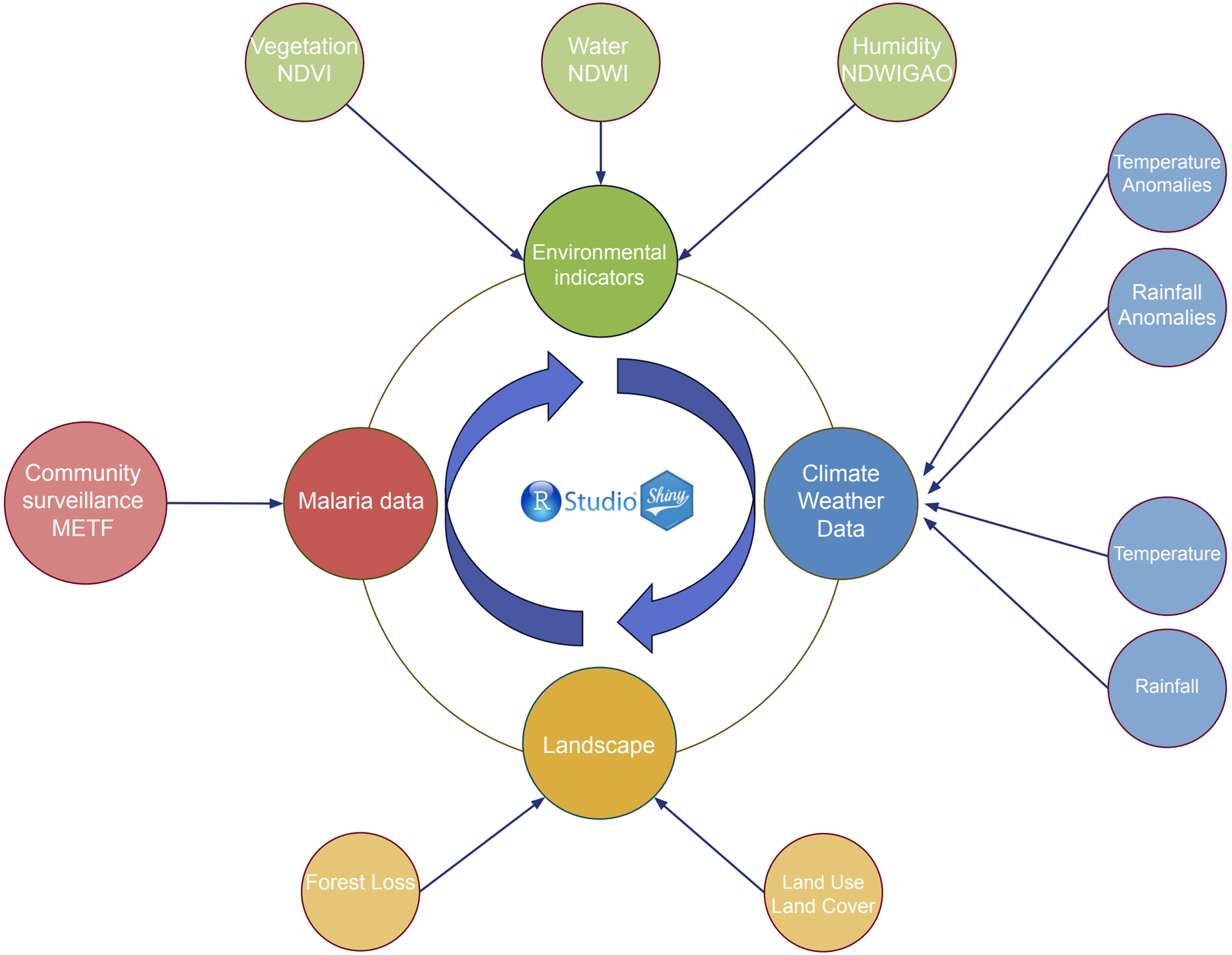
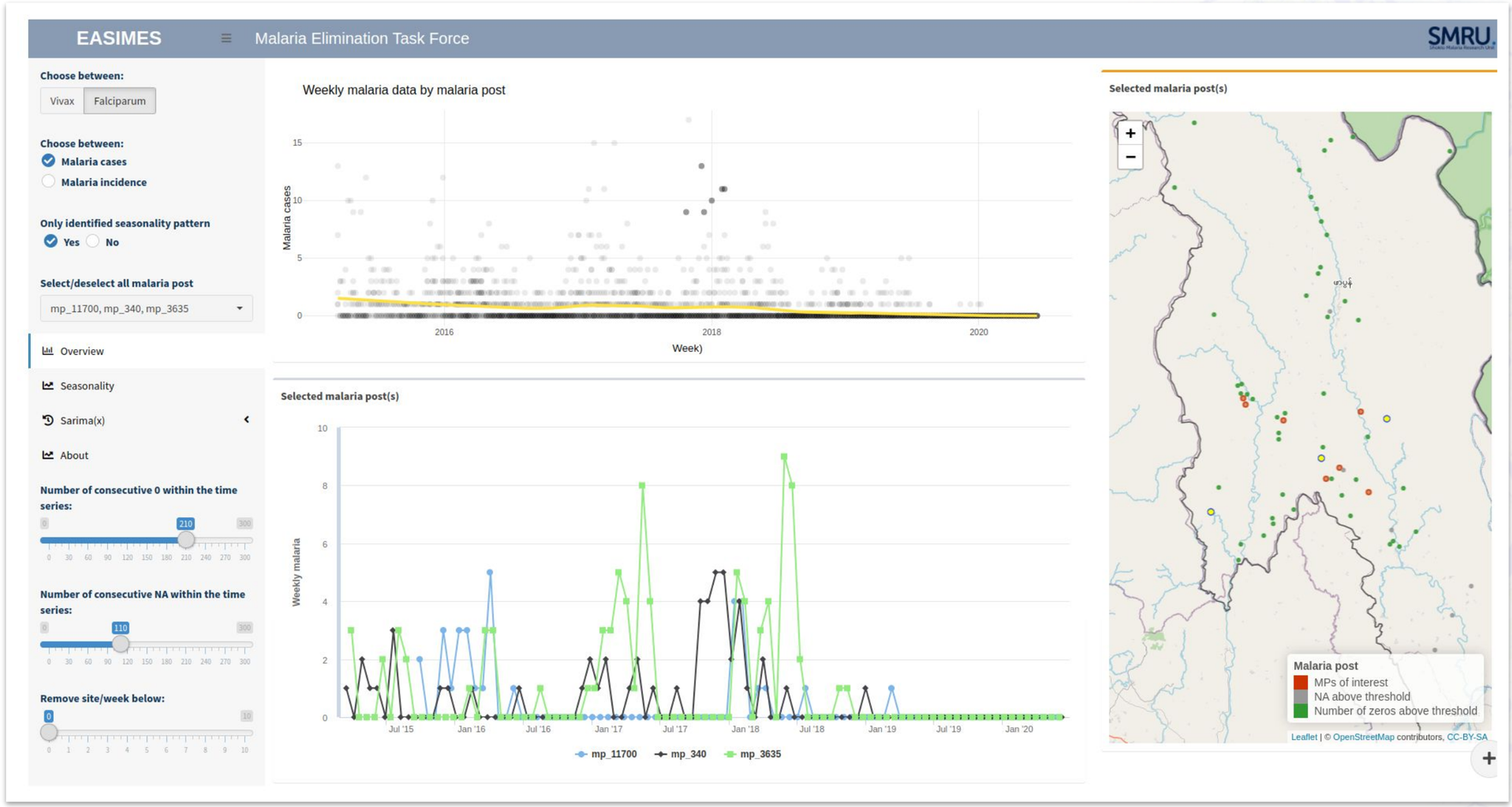
L'INITIATIVE sida, tuberculose, paludisme



Continuously Enhanced Platform



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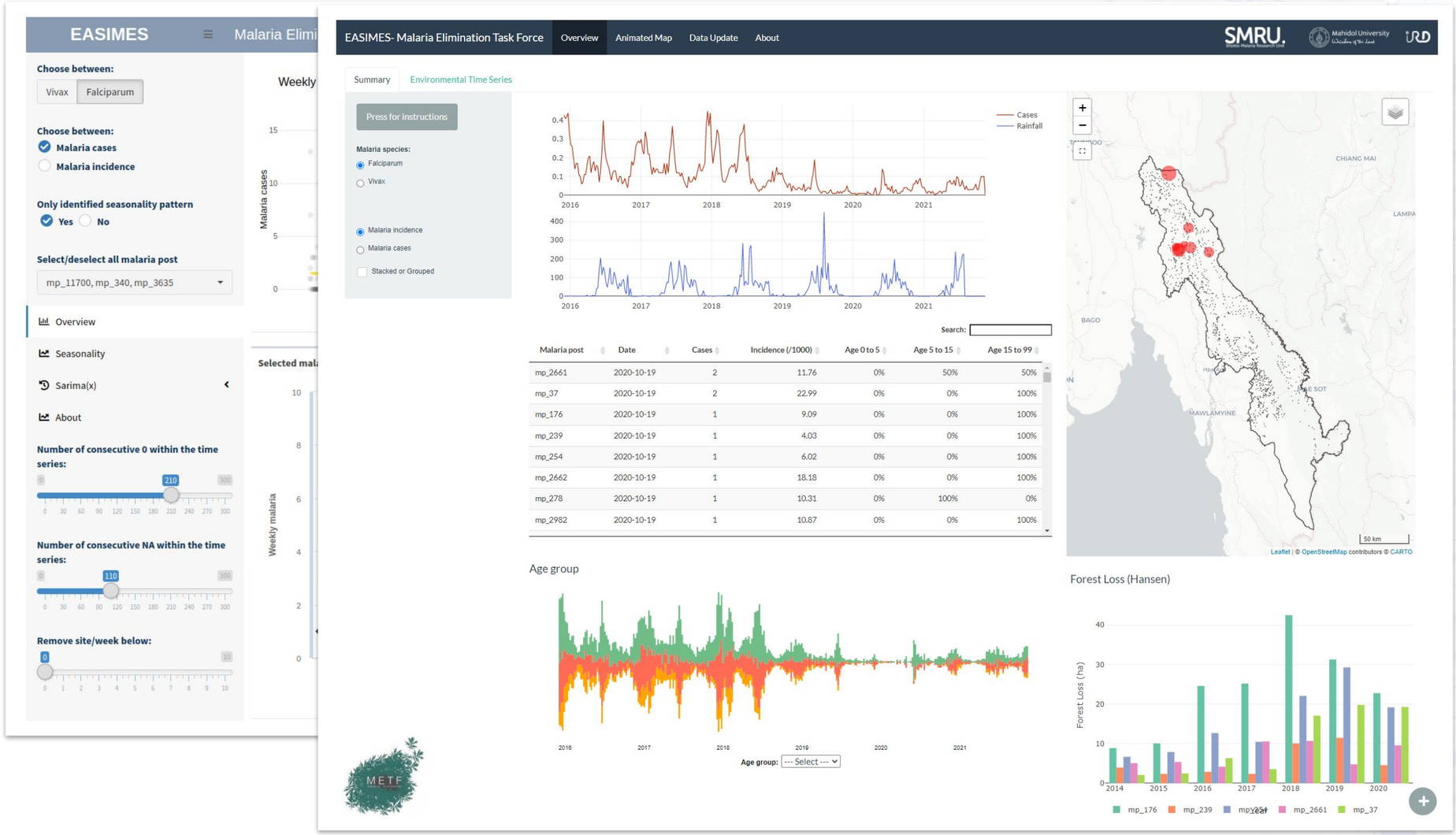
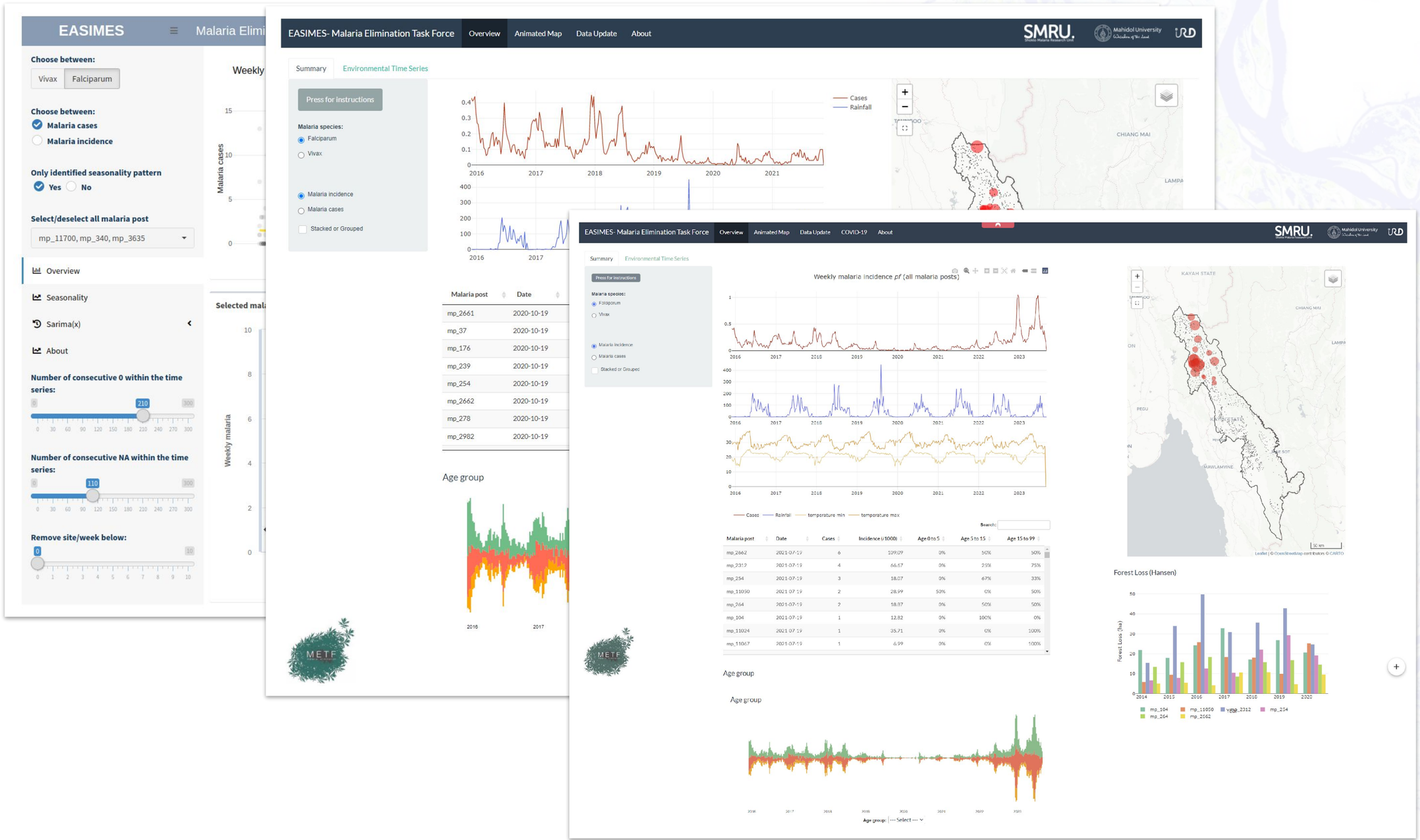


Continuously Enhanced Platform



Continuously Enhanced Platform

EASIMES- Malaria Elimination Task Force | Overview | Animated Map | Data Update | About

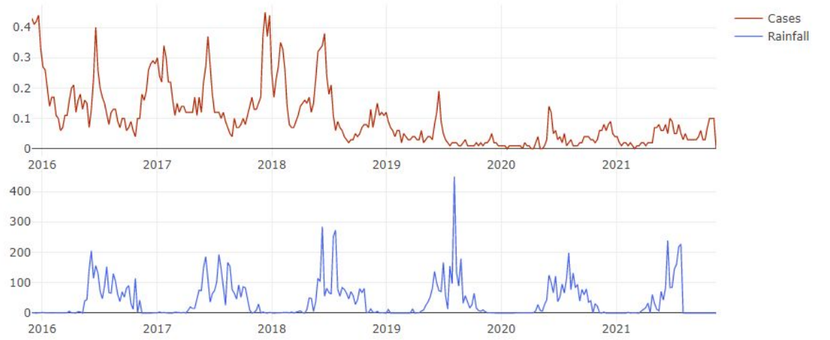
Summary | Environmental Time Series

Press for instructions

Malaria species:
- (•) Falciparum
- ( ) Vivax

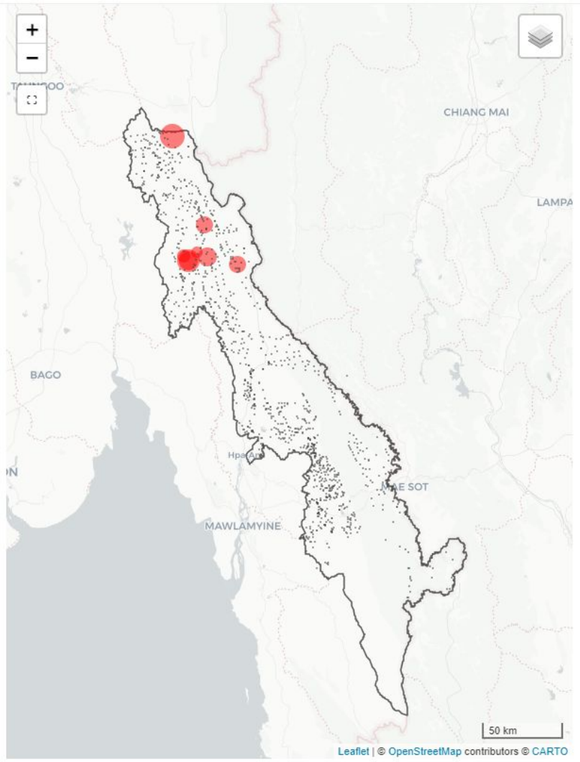
- (•) Malaria incidence
- ( ) Malaria cases

☐ Stacked or Grouped



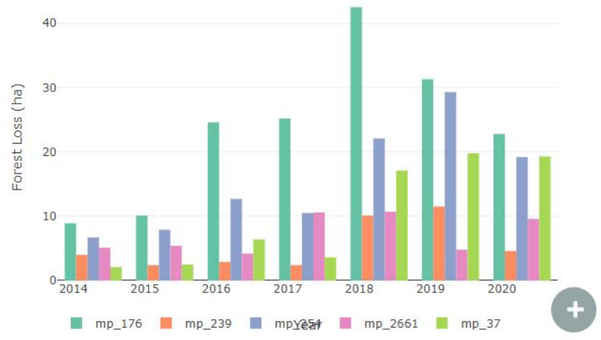
Search:

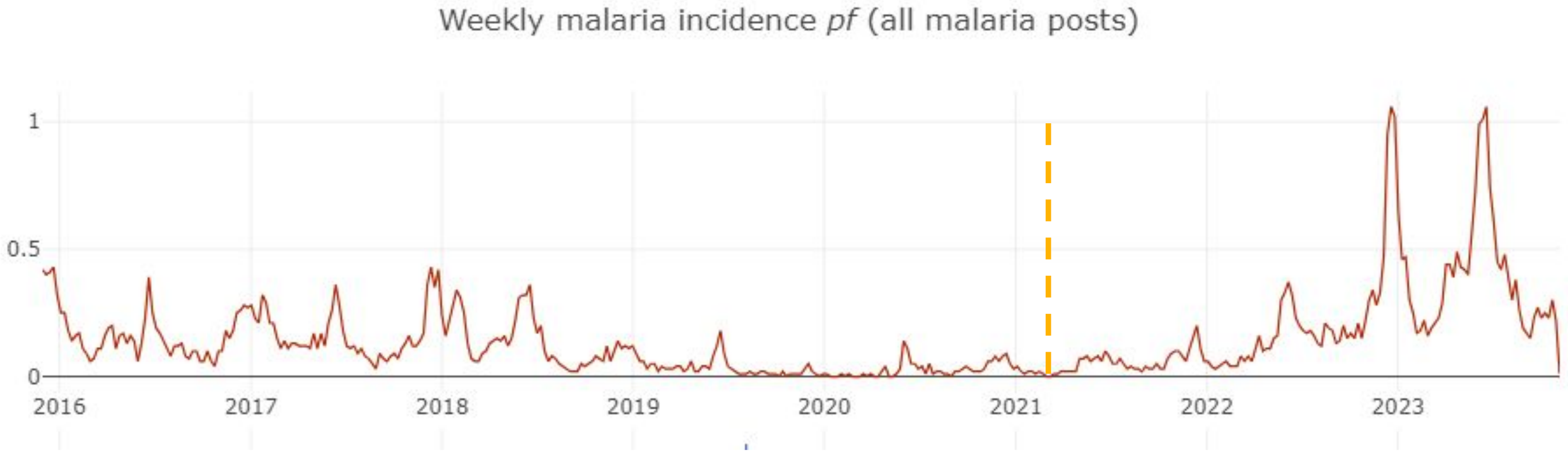
Malaria post	Date	Cases	Incidence (/1000)	Age 0 to 5	Age 5 to 15	Age 15 to 99
mp_2661	2020-10-19	2	11.76	0%	50%	50%
mp_37	2020-10-19	2	22.99	0%	0%	100%
mp_176	2020-10-19	1	9.09	0%	0%	100%
mp_239	2020-10-19	1	4.03	0%	0%	100%
mp_254	2020-10-19	1	6.02	0%	0%	100%
mp_2662	2020-10-19	1	18.18	0%	0%	100%
mp_278	2020-10-19	1	10.31	0%	100%	0%
mp_2982	2020-10-19	1	10.87	0%	0%	100%



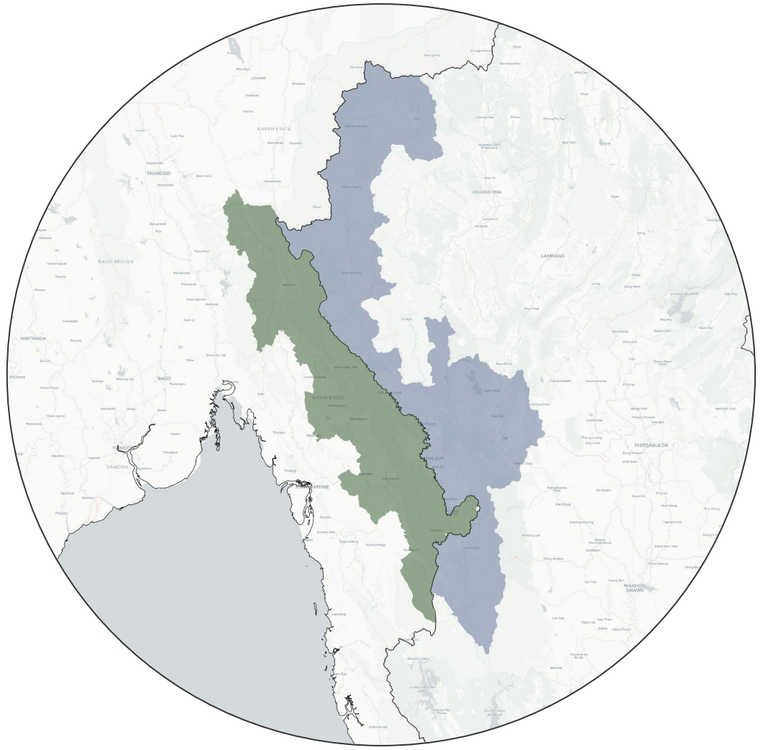
Age group

Forest Loss (Hansen)




Weekly malaria incidence *pf* (all malaria posts)
1
0.5
0
2016
2017
2018
2019
2020
2021
2022
2023

Cross Border Malaria Surveillance



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กรมควบคุมโรค
DEPARTMENT OF DISEASE CONTROL

Transborder Malaria Surveillance

Overview About

SMRU. IRD

Plasmodium

- [x] falciparum
- [ ] knowlesi
- [ ] malariae
- [ ] mix
- [ ] ovale
- [ ] vivax

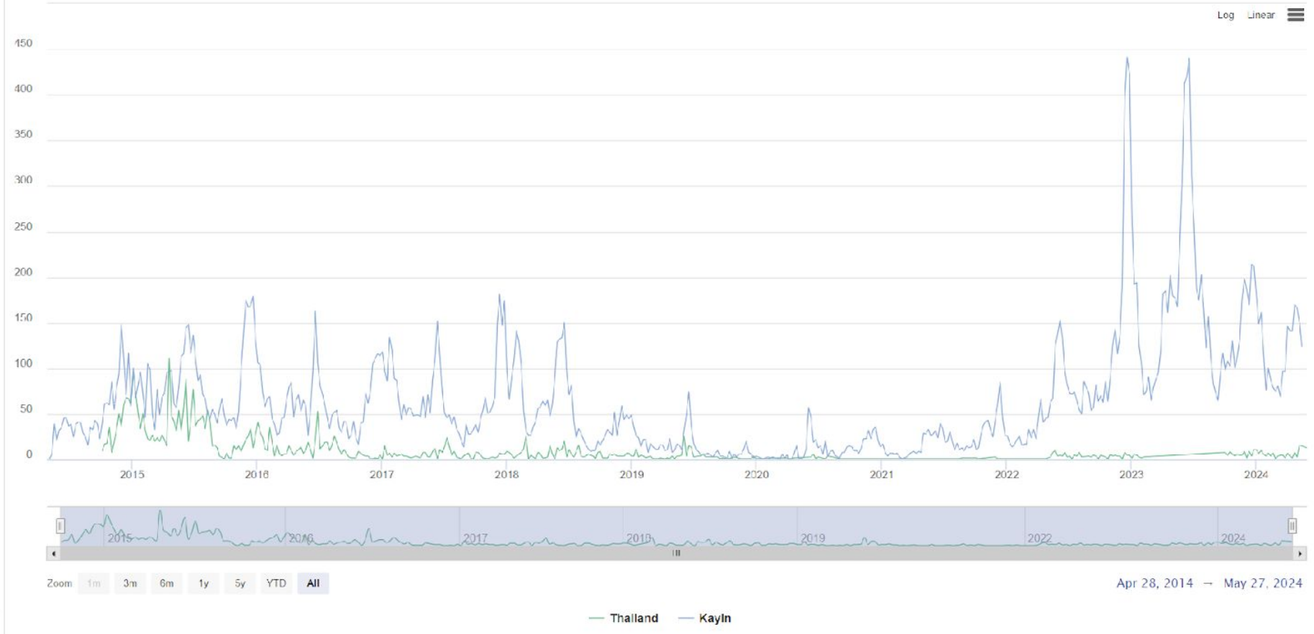
Date:

2014-04-28 — 2021-07-12

Cases 7/30 days before 2021-07-12

Plasmodium	falciparum		vivax		mix		ovale		knowlesi		malariae	
Since	7d	30d	7d	30d	7d	30d	7d	30d	7d	30d	7d	30d
Thai border	0	0	66	249	0	0	0	0	0	0	0	0
Kayin	20	113	325	1688	0	0	-	-	-	-	-	-

Graph | Gender Group | Age Group



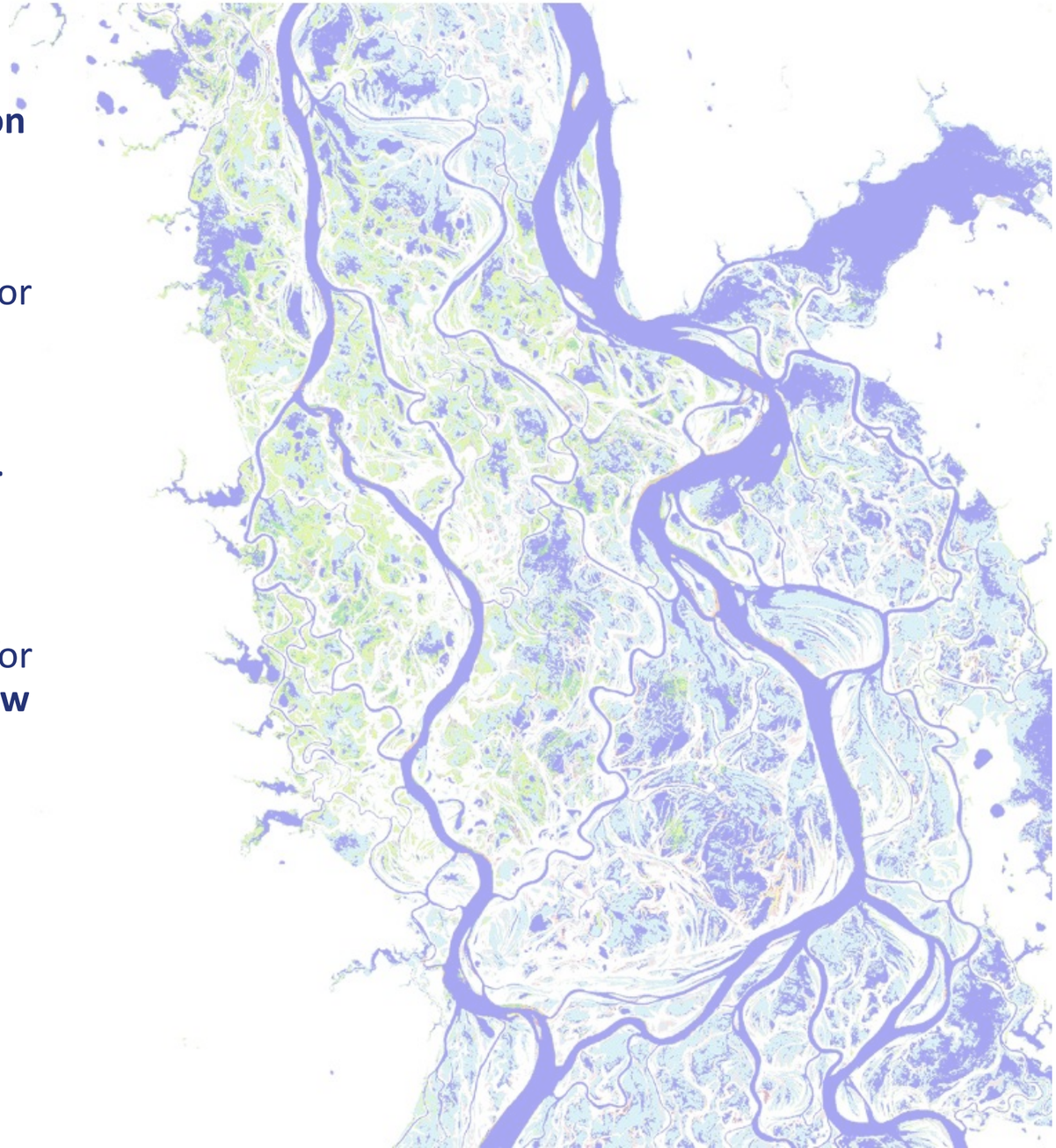
- These platforms enable a dynamic **exchange** and **collaboration** facilitating mutual **understanding** and **knowledge** sharing.

- Interactive One Health surveillance platforms are **meeting places** for experts from different disciplines.

- Environmental surveillance must be implemented **across all sectors**.
  - KHEOBS Laboratory

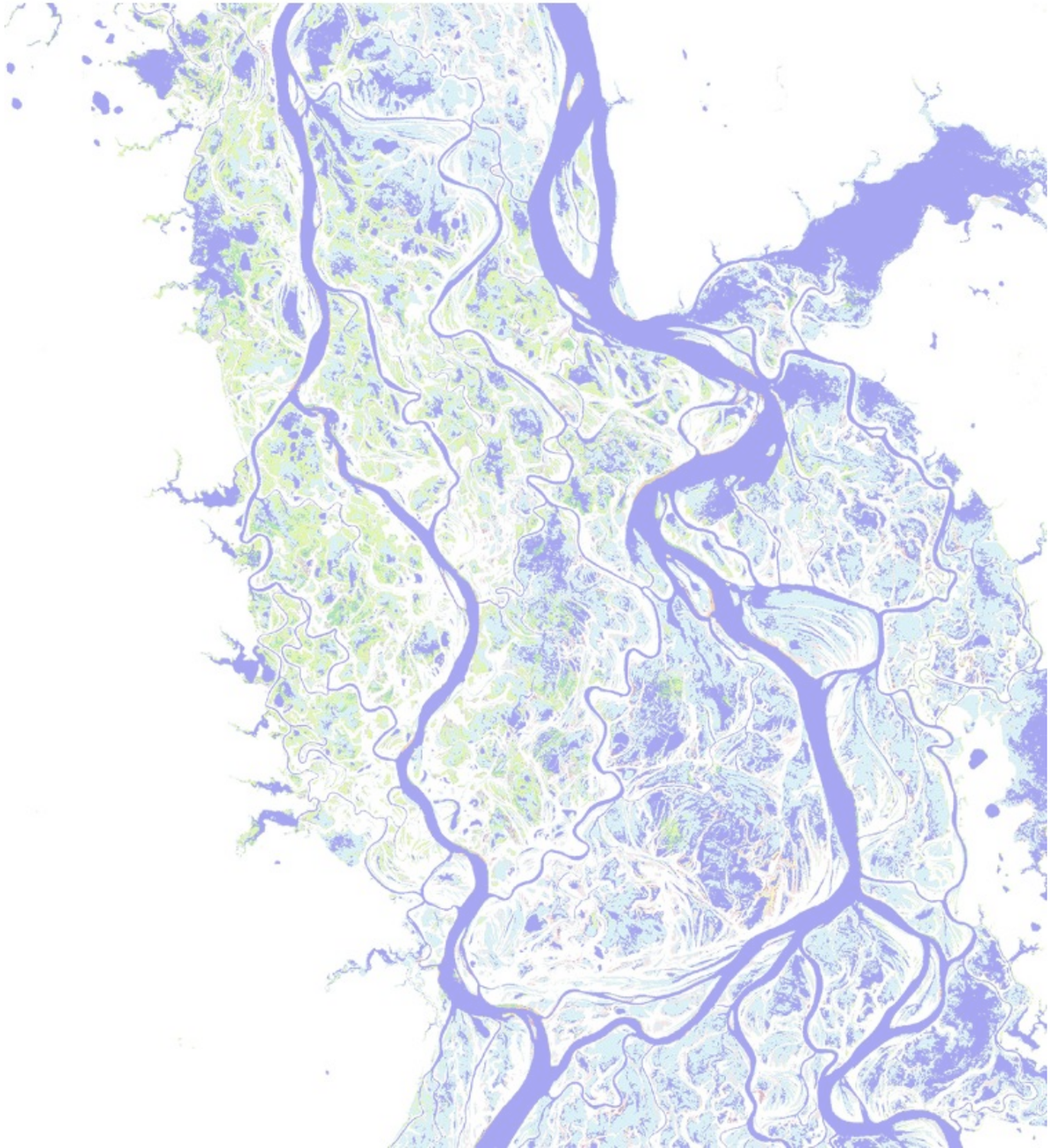
- Data visualisation and exploratory analysis techniques for **contextualisation** and eventually provide **evidence** to generate **new hypotheses** to test.

- The importance of **open-source environment**.



Acknowledgments

- Shoklo Malaria Research Unit (SMRU) & METF
- Department of Disease Control, MoPH – Thailand
- Communicable Disease Control Department - Cambodia
- IRD, UMR ESPACE-DEV
- IRD, UMR SESSTIM
- KHEOBS laboratory
- National Institute of Technology - Cambodia
- Université de la Réunion (France)
- Institut Pasteur du Cambodge



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Thank you

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