

Myanmar Malaria Early Warning System (MMEWS):
Multi-sensor satellite data fusion system for monitoring
environmental predictors of malaria in the region of
emerging artemisinin resistance

Tatiana Loboda (UMD)

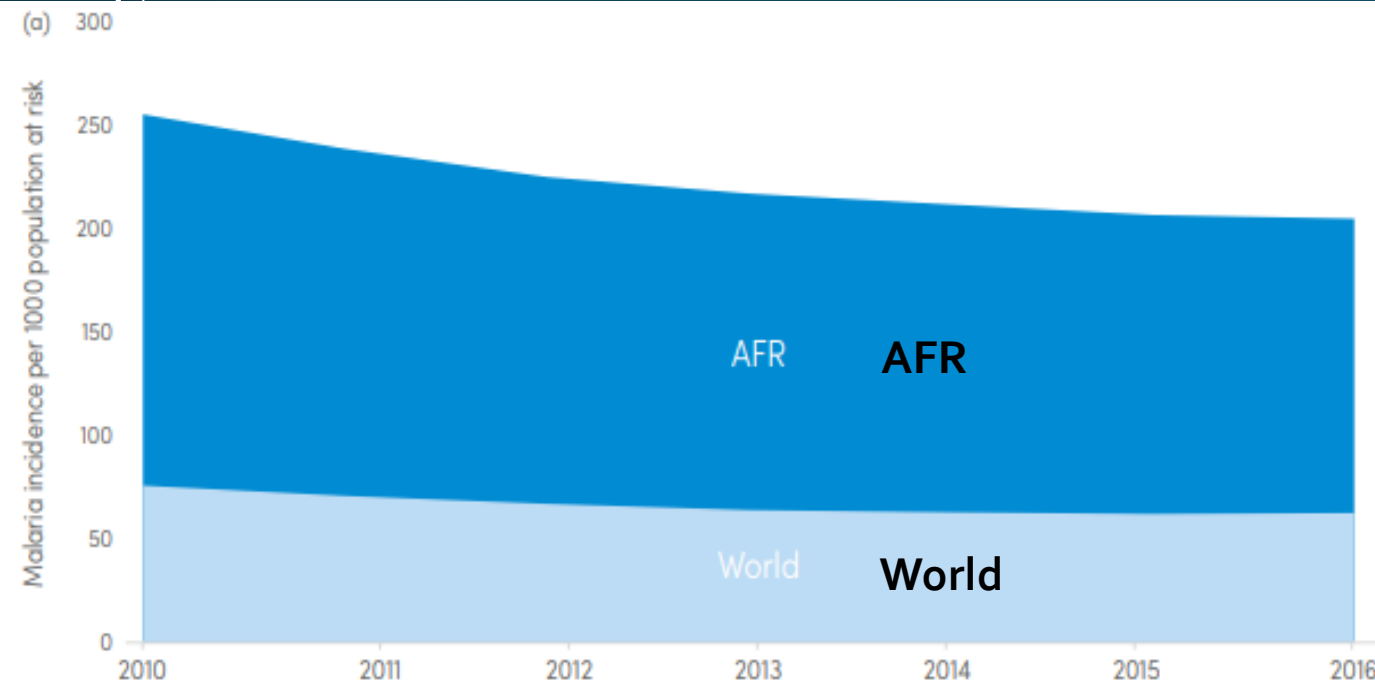
Mark Carroll (SSAI/GSFC)

Myaing Nyunt, Chris Plowe (DGHI)

Good news about malaria

- Clinical cases of malaria have declined globally

Trends in malaria case incidence globally and by WHO region 2010-2016 (World Malaria Report 2017)



WHO Regions:

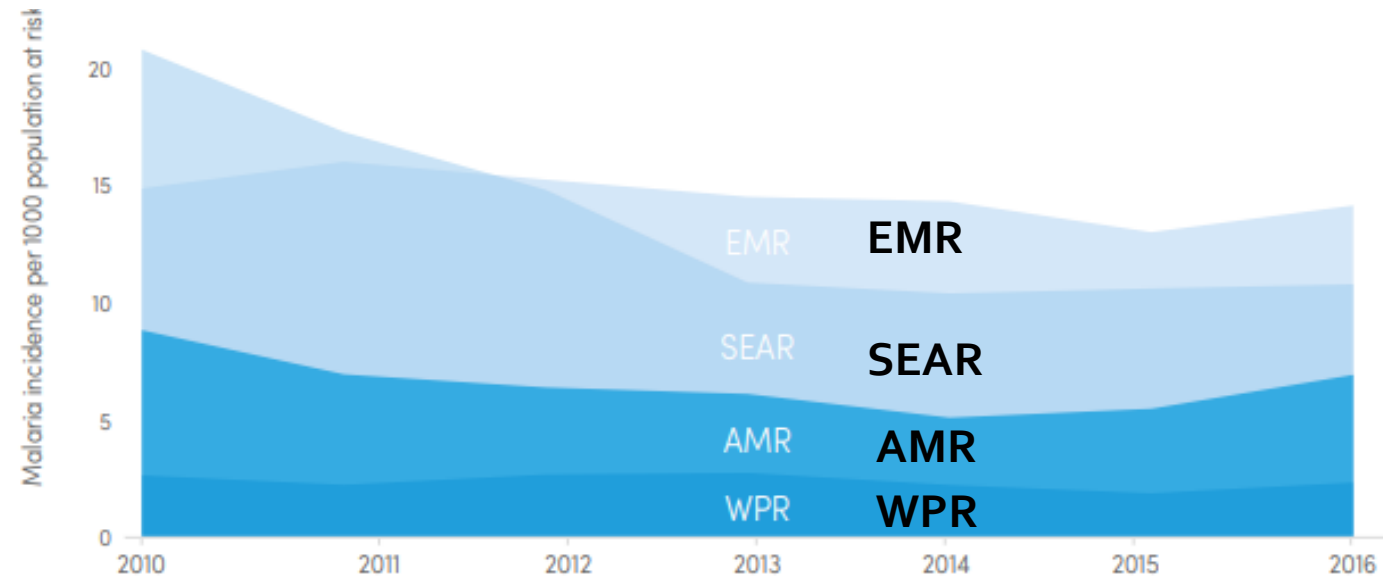
AFR – Africa

AMR – Americas

EMR – Eastern Mediterranean

SEAR – South-East Asia

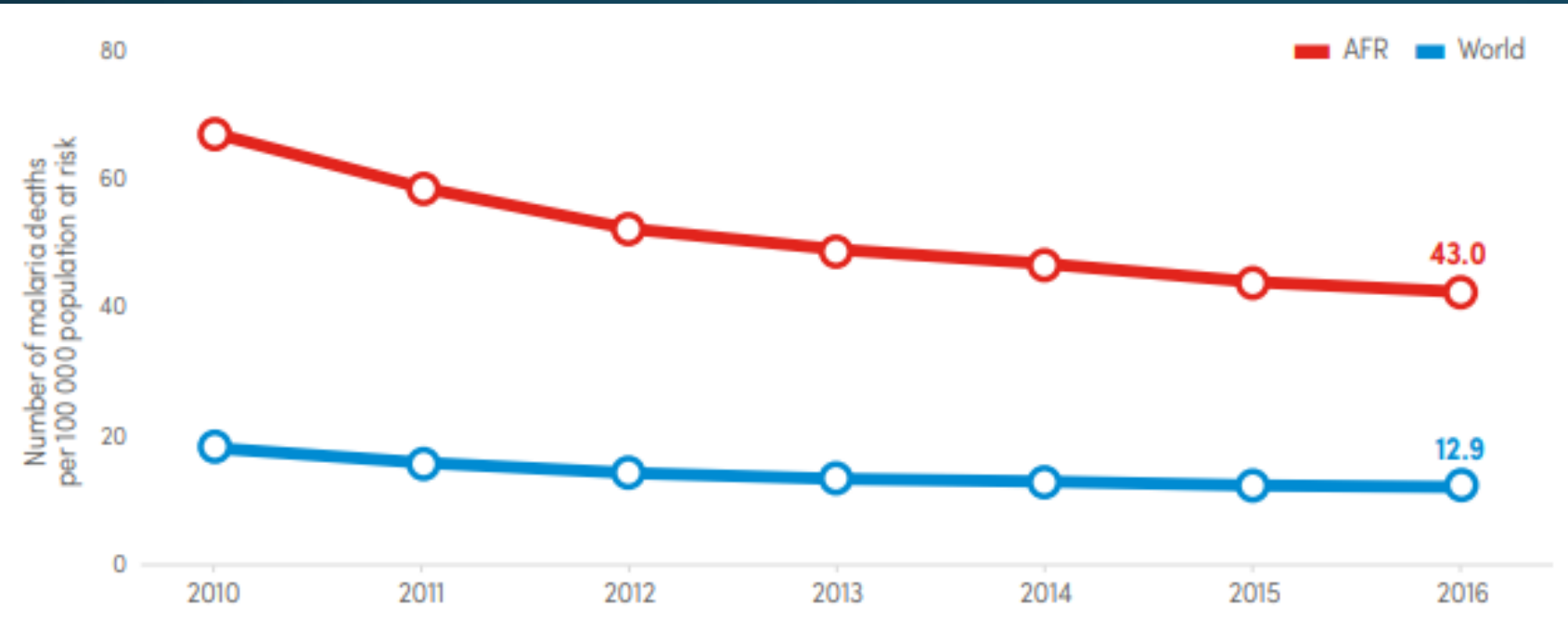
WPR – Western Pacific



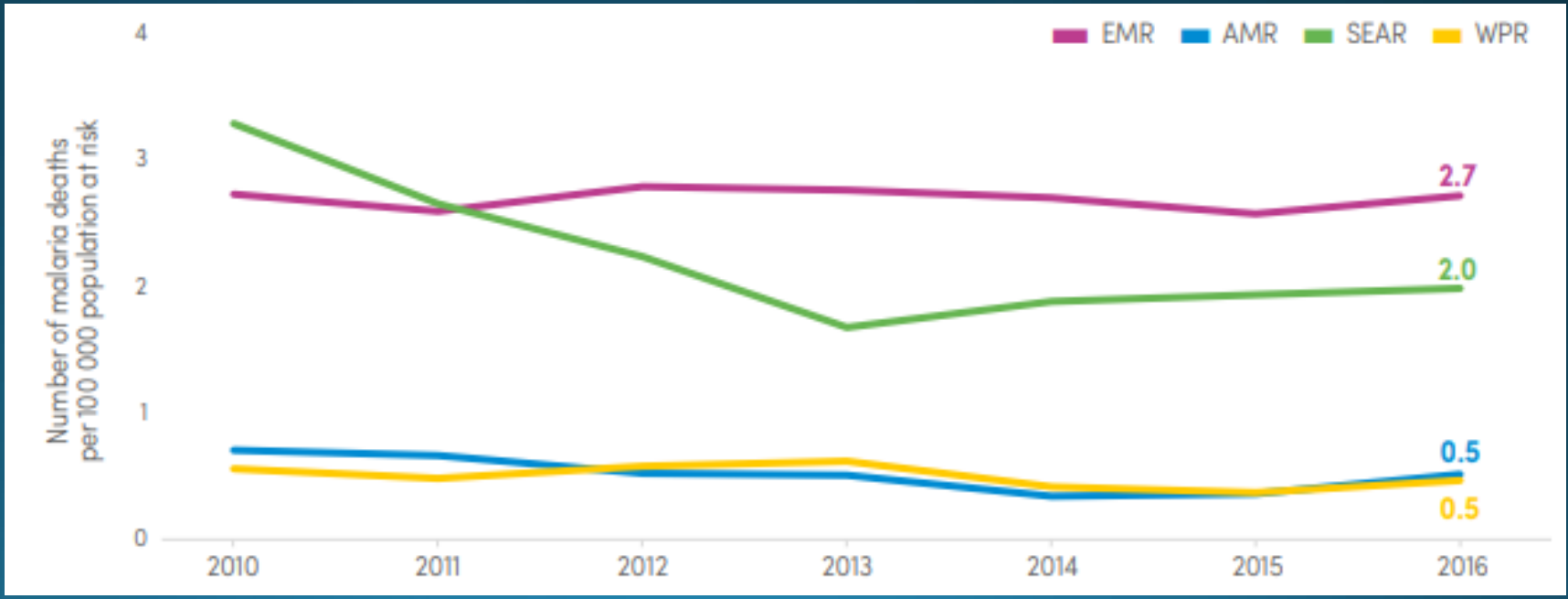
Good news about malaria

- Clinical cases of malaria have declined globally
- Malaria-caused death rate has dropped by nearly 30% (since 2010)

Trends in malaria death rate globally and by WHO region 2010-2016 (World Malaria Report 2017)



WHO Regions:
AFR – Africa
AMR – Americas
EMR – Eastern Mediterranean
SEAR – South-East Asia
WPR – Western Pacific

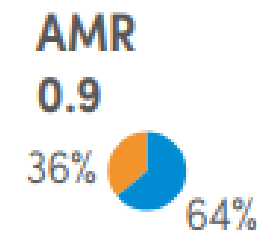
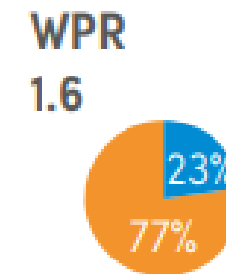
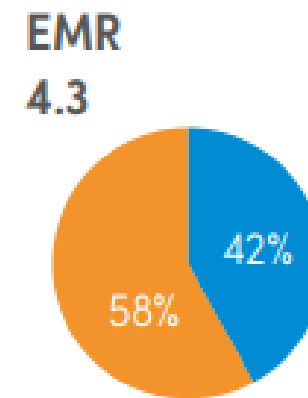
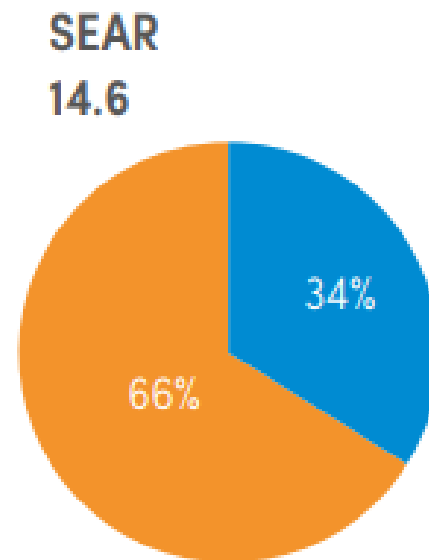
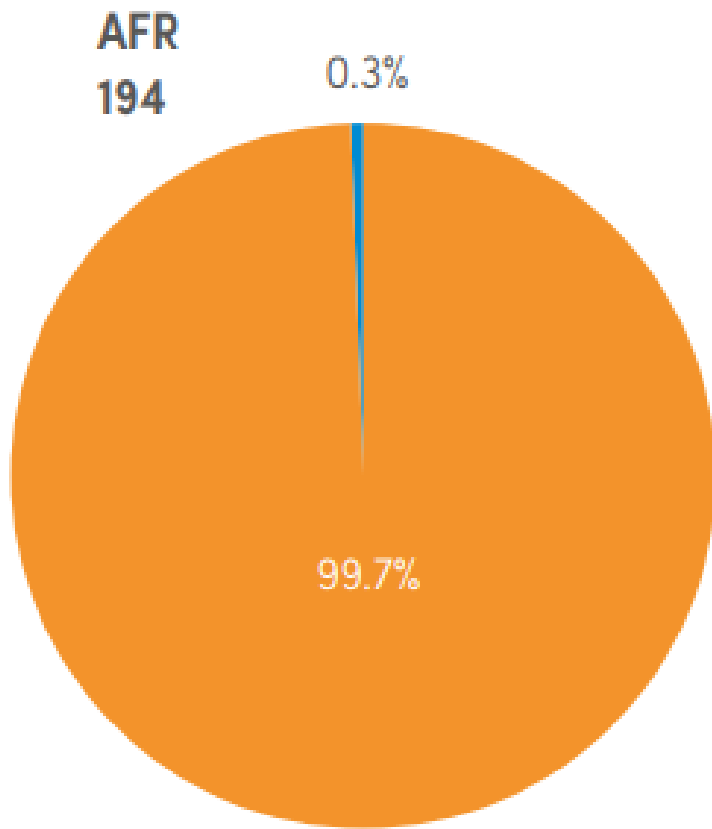


BUT

- In 2015
 - 212 million malaria cases
 - 429 000 malaria deaths

Estimated malaria cases (millions) by WHO region, 2016 (World Malaria Report 2017)

■ *P. falciparum* ■ *P. vivax*



As Malaria Resists Treatment, Experts Warn of Global Crisis



War on malaria: on the brink of a breakthrough?



Health

Malaria experts fear disease's resurgence

By Michelle Roberts
Health editor, BBC News online

© 18 April 2018

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HEALTH

Spread of insecticide resistance could derail malaria prevention

Study comes as the World Health Organisation warns efforts to eradicate malaria have "stalled"



MALARIA
WHO: Venezuela malaria cases jump by 69 percent



MALARIA
▶ Nearly half a million people killed by malaria in 2016



SCIENCE PHOTO LIBRARY

For the first time in 10 years, global malaria cases are no longer falling, sparking concerns about a resurgence of the too often deadly disease.

Number of countries where a reduction (green) or increase (red) of more than 20% in malaria cases has occurred between 2015 and 2016, by WHO region (World Malaria Report 2017)



WHO Regions:

AFR – Africa

AMR – Americas

EMR – Eastern Mediterranean

SEAR – South-East Asia

WPR – Western Pacific

OP-ED CONTRIBUTOR

Taking the Battle Against Malaria to the Mekong

By Christopher Plowe

Sept. 26, 2017

Malaria infected more than 200 million people in 2015, and killed more than 400,000, most of them children in Africa. As devastating as those numbers are, they were a major improvement: Deaths fell by 48 percent since 2000. This impressive drop was the result of billions in funding and decades of effort by thousands of people across the globe.

"...We must ramp up quickly; drug resistance is spreading; if it spins out of control, we run the risk of a huge resurgence of malaria in other parts of Asia and especially in Africa."

Malaria Atlas Country Profile: Myanmar



THE MALARIA ATLAS PROJECT



MYANMAR

Myanmar has the highest rate of malaria-related mortality in south-east Asia. The primary parasite is *Plasmodium falciparum* and there is also *P. vivax* present. Vectors include *Anopheles dirus*, *A. minimus* and *A. epiroticus*.

FEEDBACK

Data enquiries, corrections, or other comments? Contact us.

SEND FEEDBACK

[RETURN TO COUNTRY LIST](#)

ENDEMICITY		
Parasite	Endemic	Year Eliminated
<i>Plasmodium falciparum</i>	Yes	Not applicable
<i>Plasmodium vivax</i>	Yes	Not applicable

DATA SOURCES

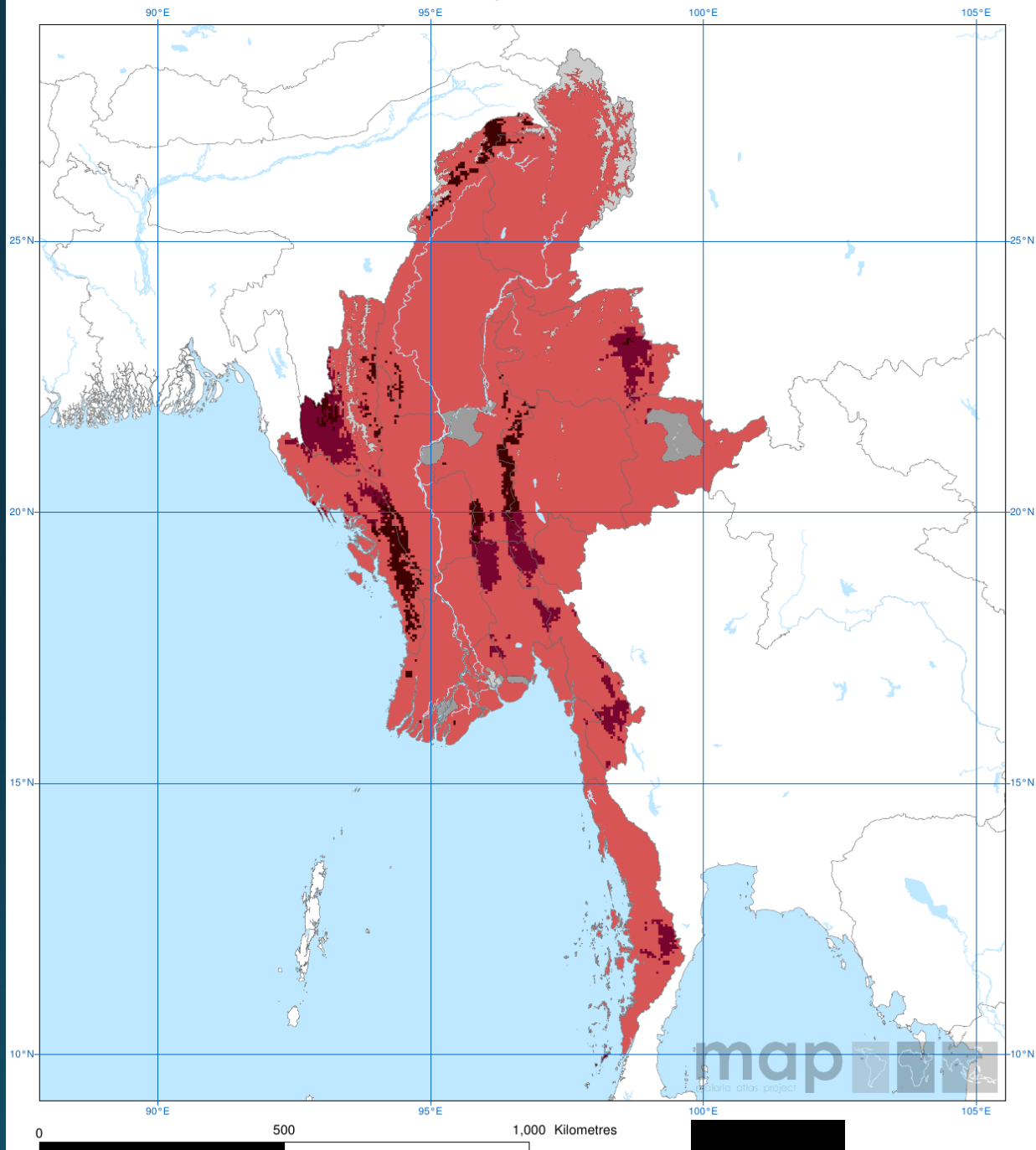
- T.T. Oo, V. Storch, N. Becker (2003) *Anopheles dirus and its role in malaria transmission in Myanmar*.
- W. Tun-Lin, A.A. Sebastian, Myo-Paing (1989)

Premise

As the “malaria lake” is drained, malaria transmission separates into “pools” and then shrinks into “puddles”, understanding malaria risk as it varies over time and space becomes essential for effective targeting of interventions.



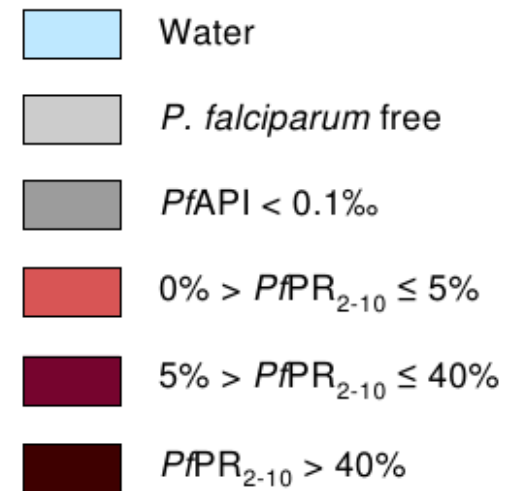
The spatial distribution of *Plasmodium falciparum* malaria in 2010 stratified by endemicity class
Myanmar



Gething et al. 2011 – Available
via Malaria Atlas Project

Fig 3 shows predictions
categorized as:

- low risk - light red;
- intermediate risk - medium red;
- high risk - dark red.



Scope and objectives of MMEWS

- Support malaria eradication planning and implementation activities
 - Enable spatially-explicit monitoring of current conditions
 - Enable forecasting of potential surges in malaria burden
 - Inform stakeholders through the on-line visualization platform and tabular reports

Malaria Burden Potential

Population vulnerability

Population presence/density:

- urban centers
- rural sites

Occupation-related exposure:

- rice cultivation
- plantation work
- forest harvesting

Access to care:

- distance to roads and medical facilities
- political stability

Subclinical parasitemia:

- *Plasmodium* prevalence
- drug resistance

Vector abundance

Standing water

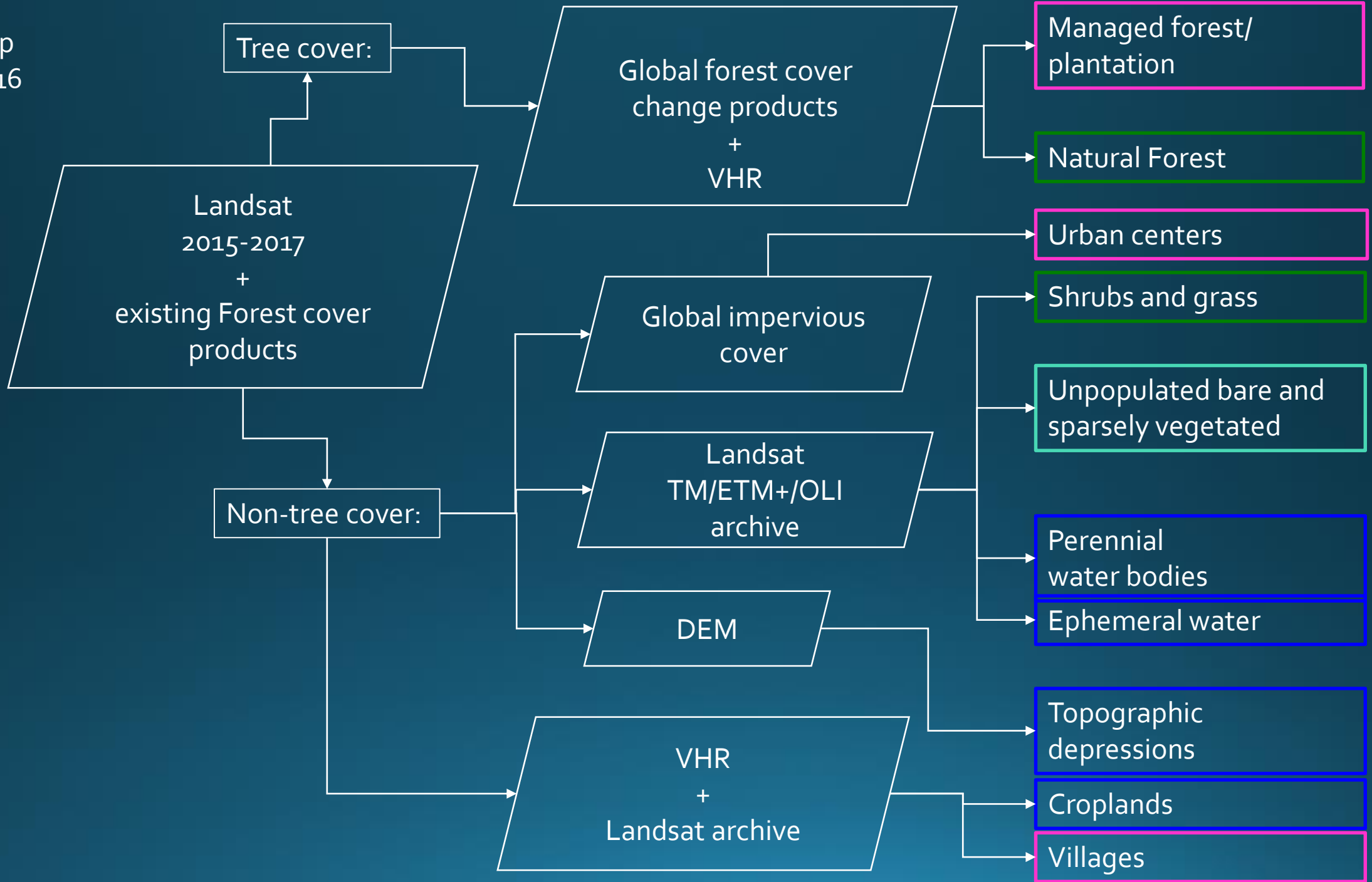
Vegetative stress

Land surface temperature

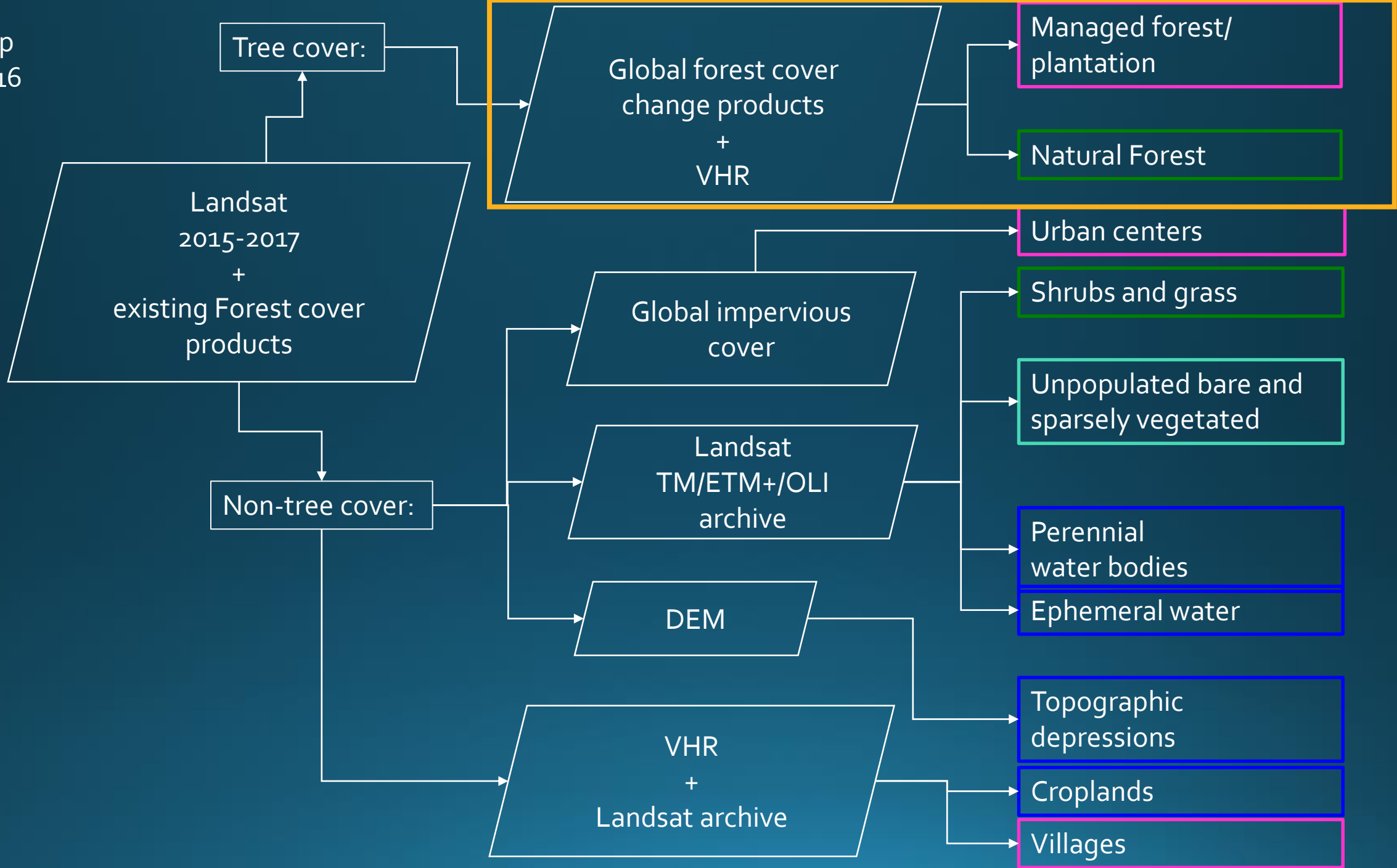
Task 1

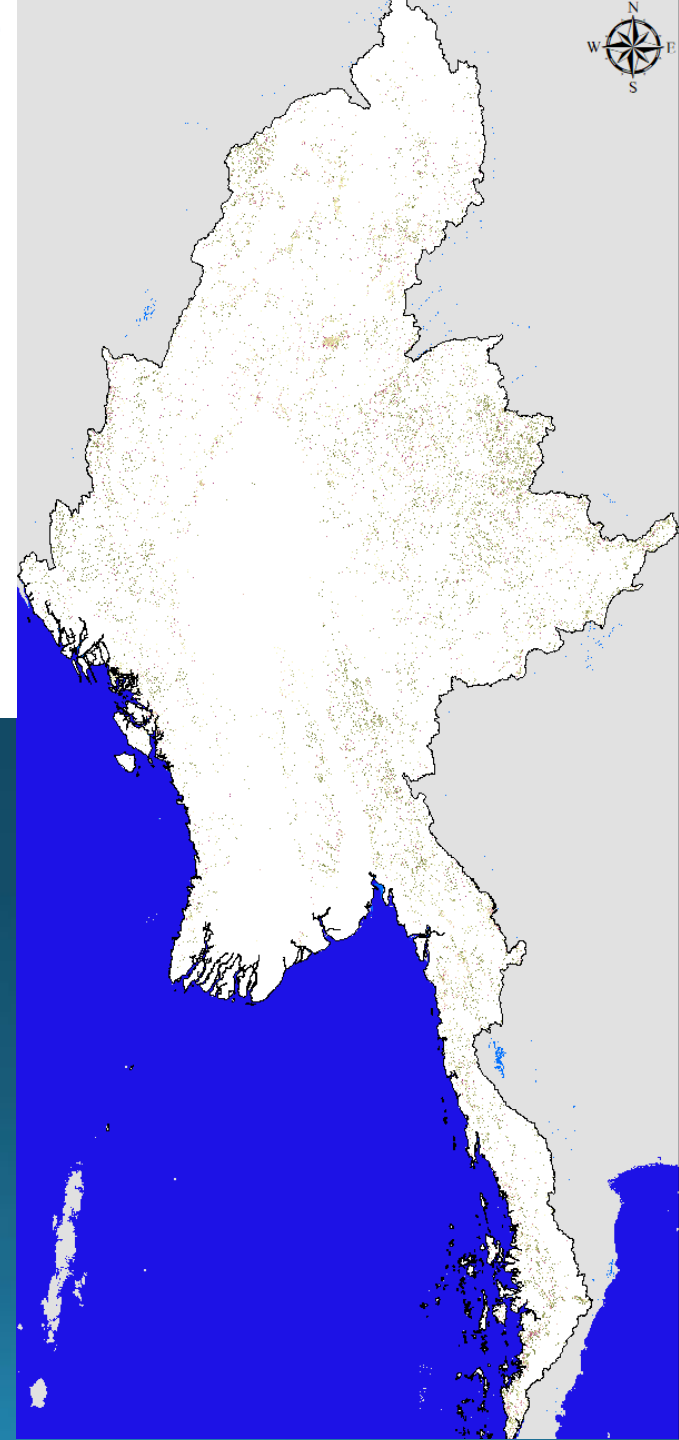
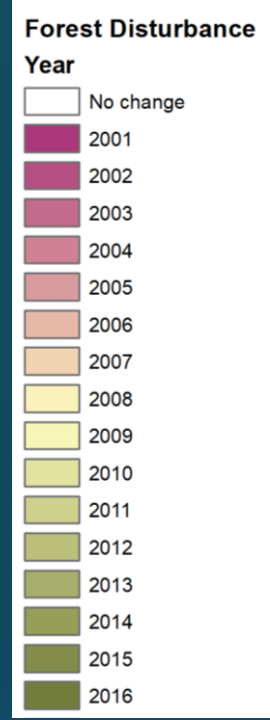
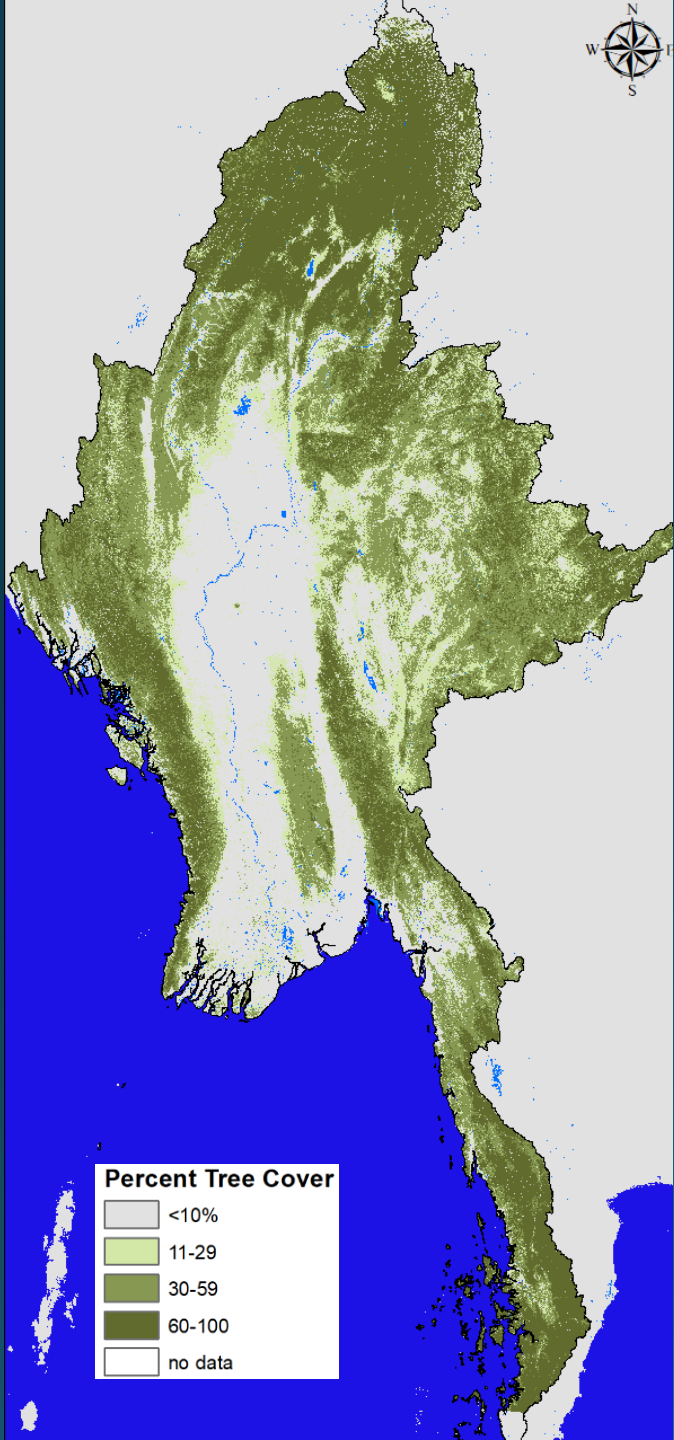
Base map development

Basemap
circa 2016

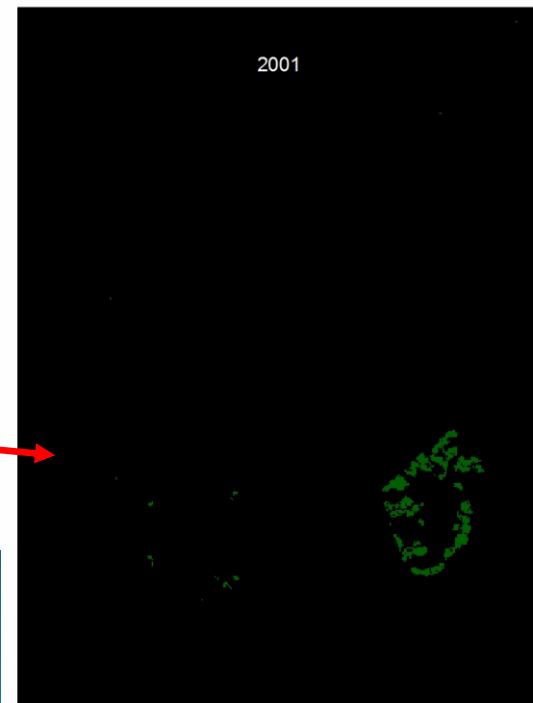
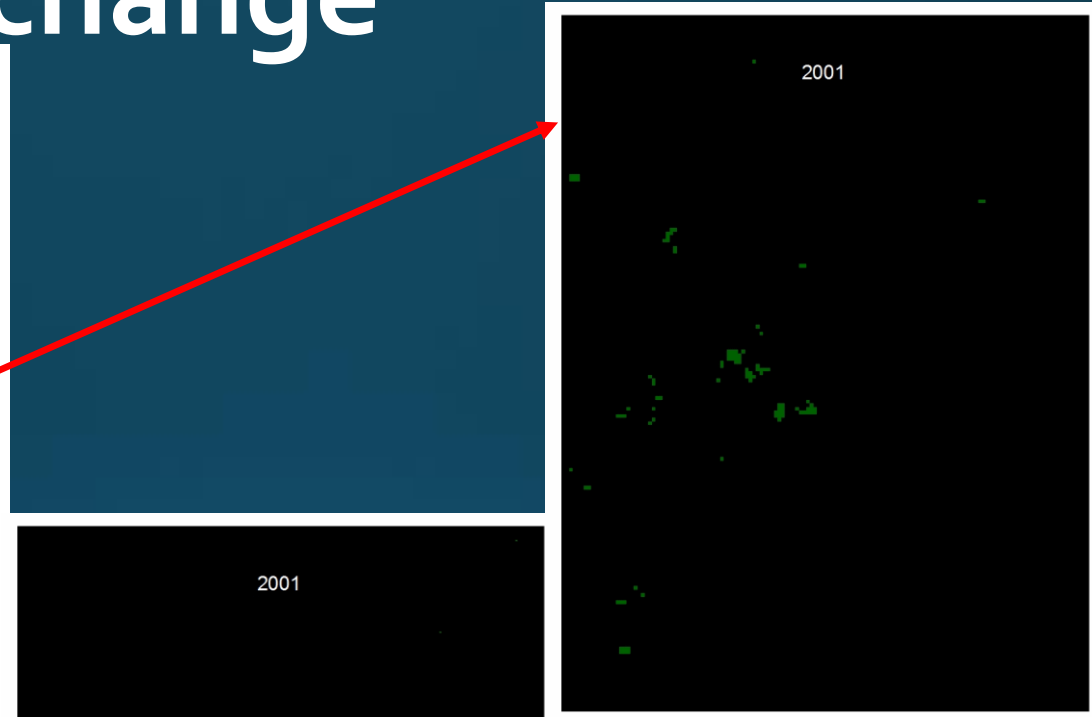
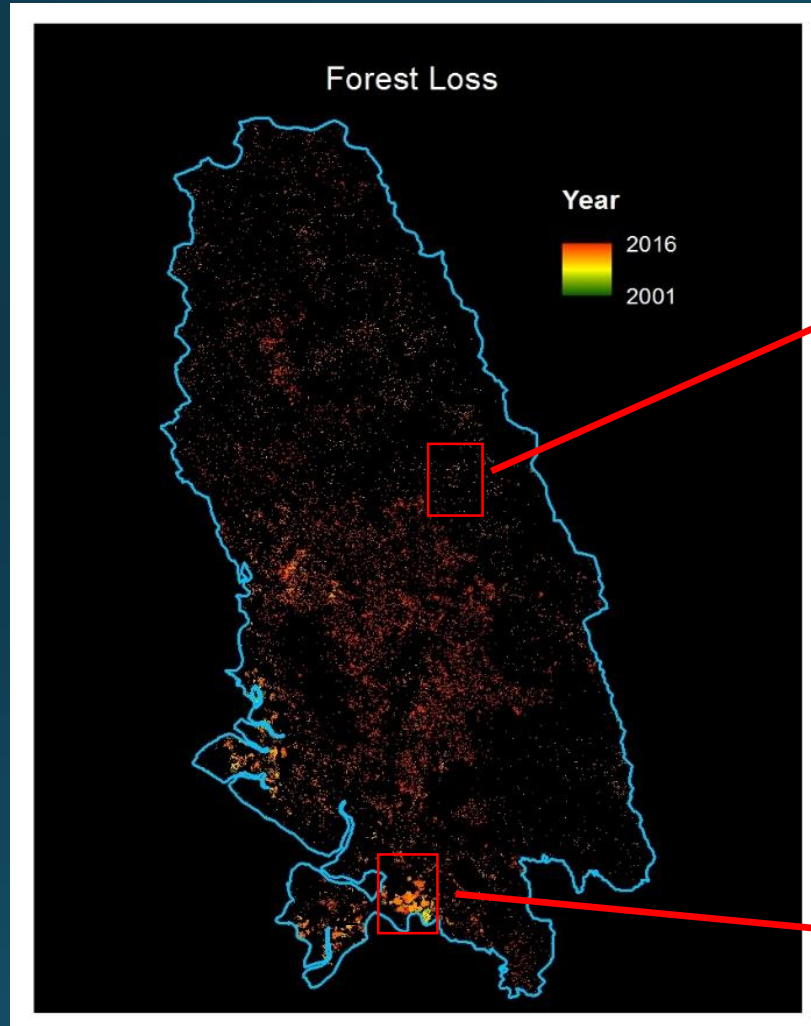


Basemap
circa 2016

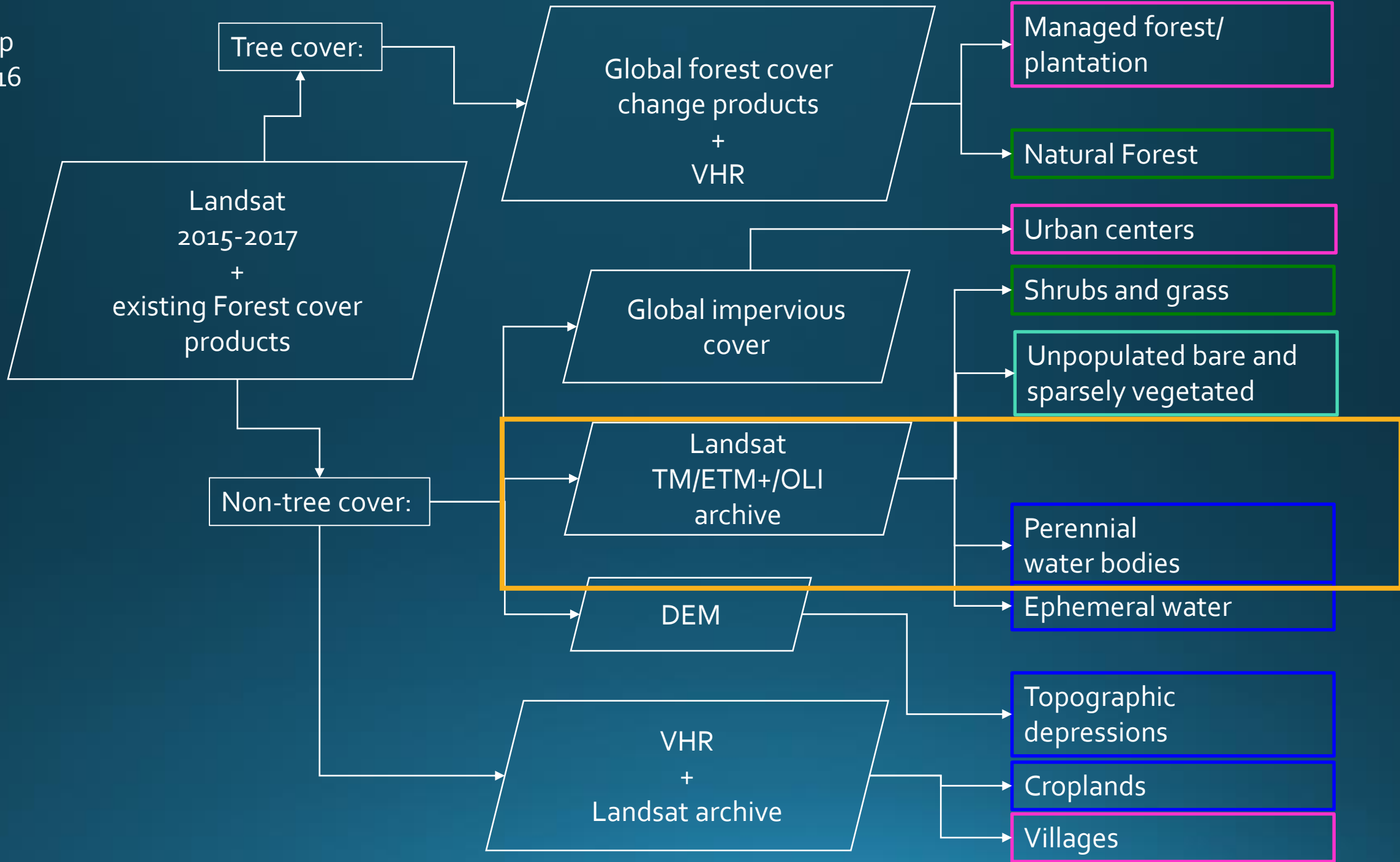


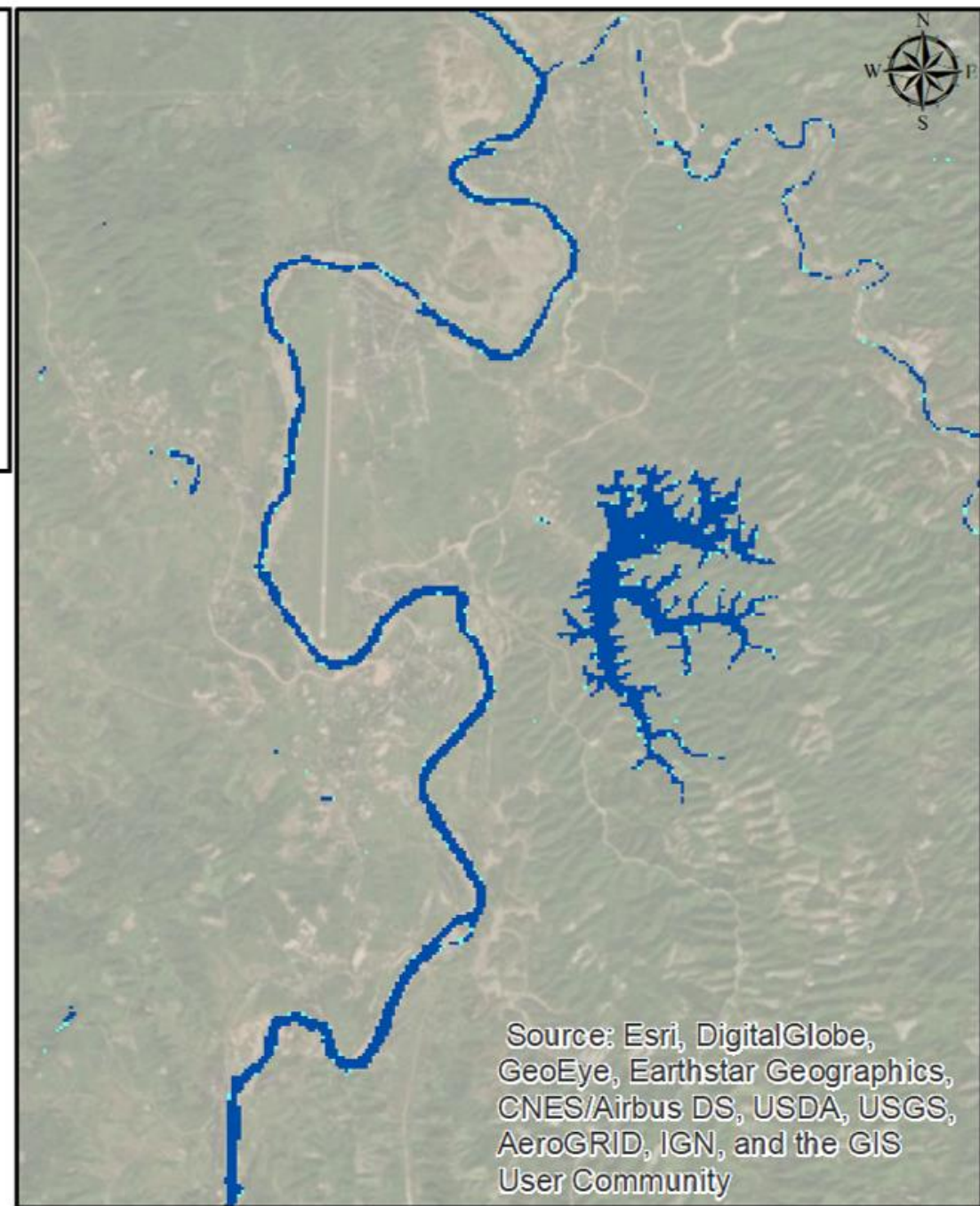
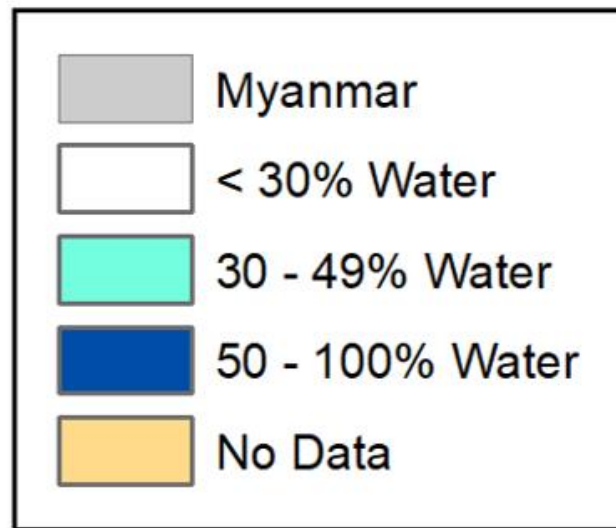
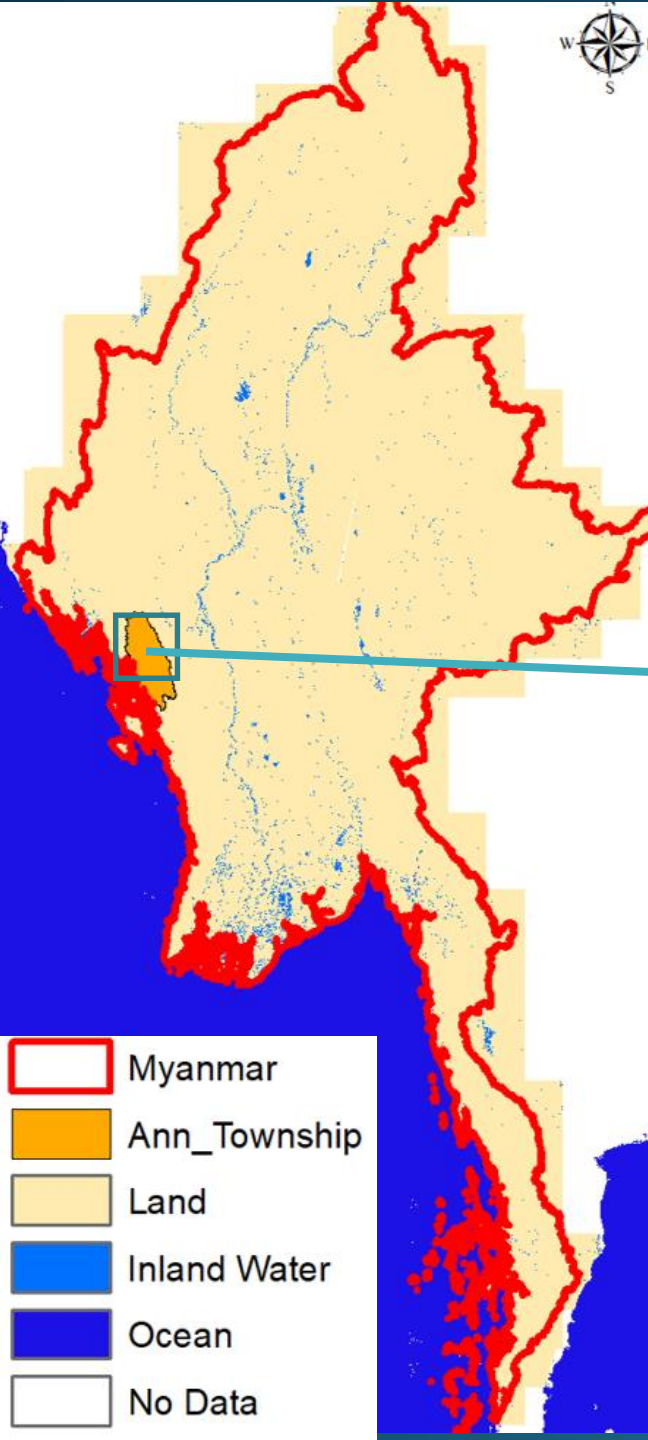


Inferring land use patterns from forest cover change



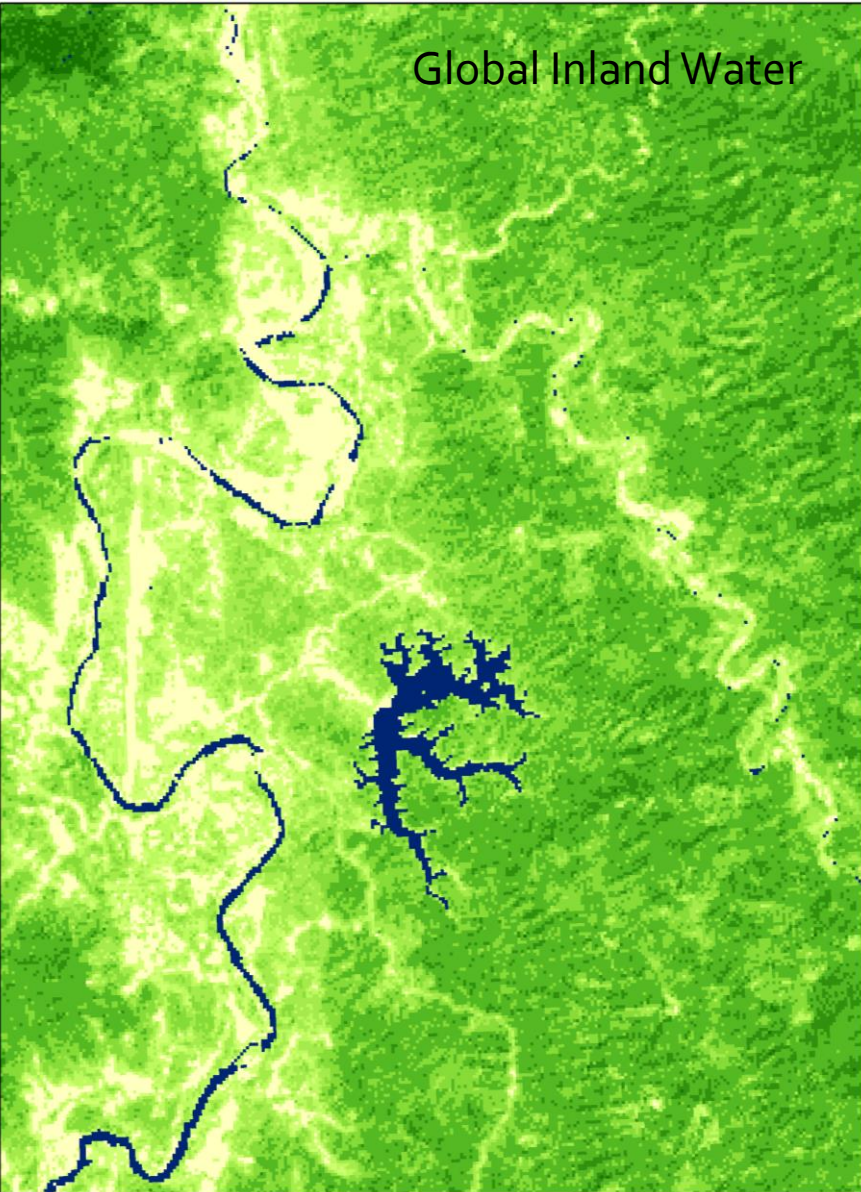
Basemap
circa 2016



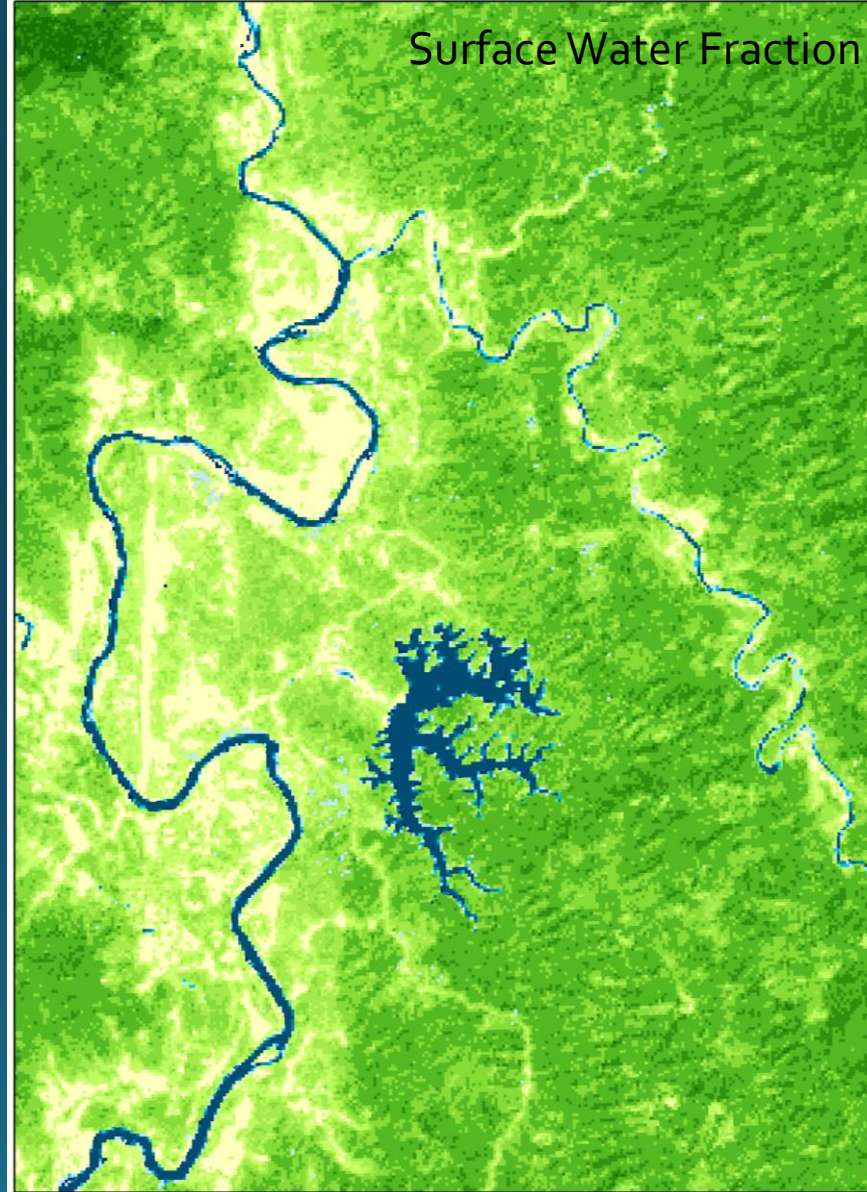


Multi-year 30m Surface Water Fraction

Global Inland Water

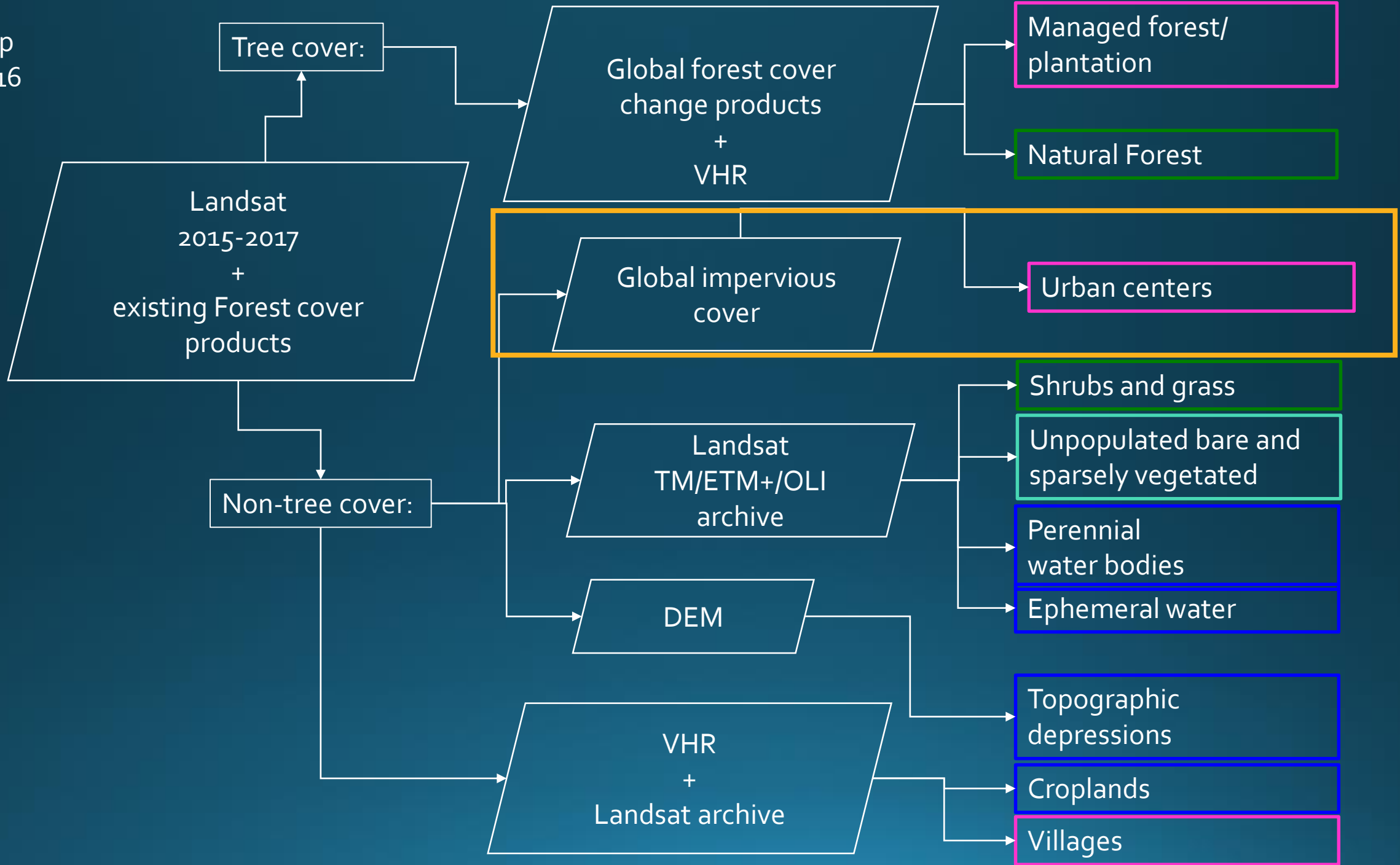


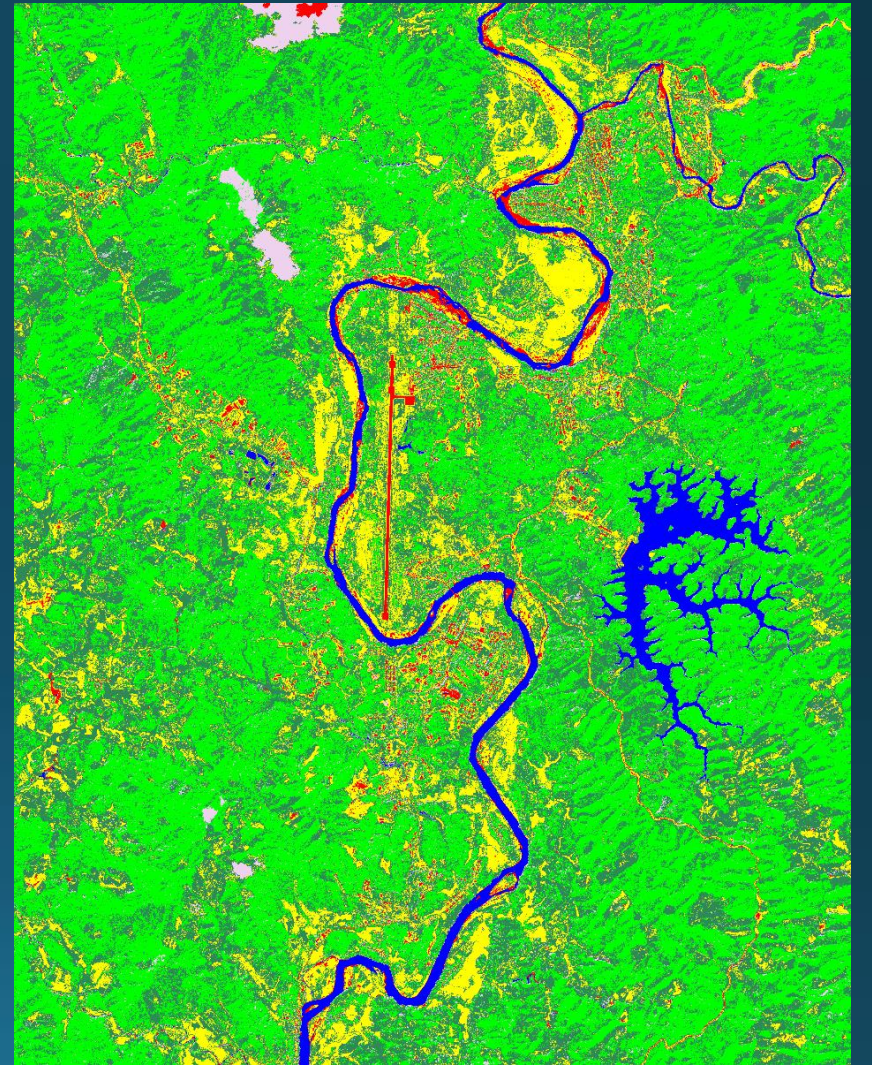
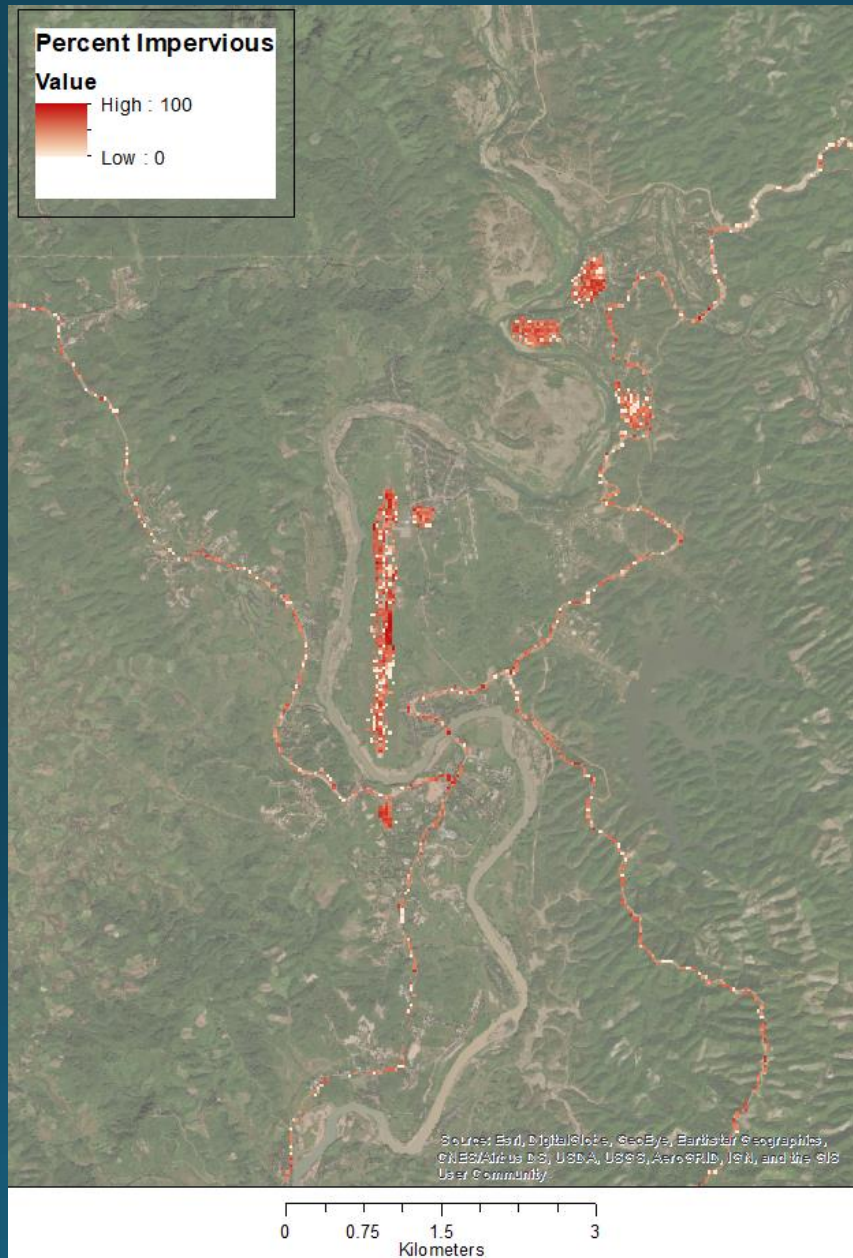
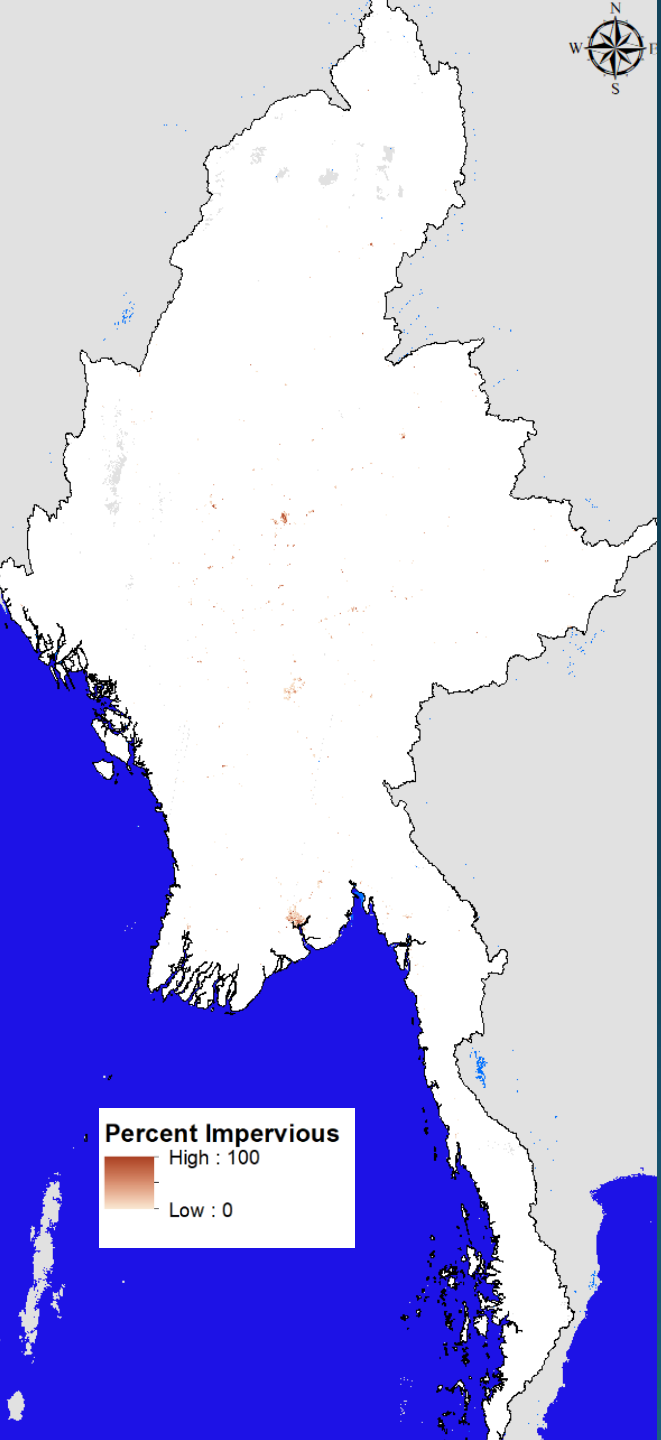
Surface Water Fraction

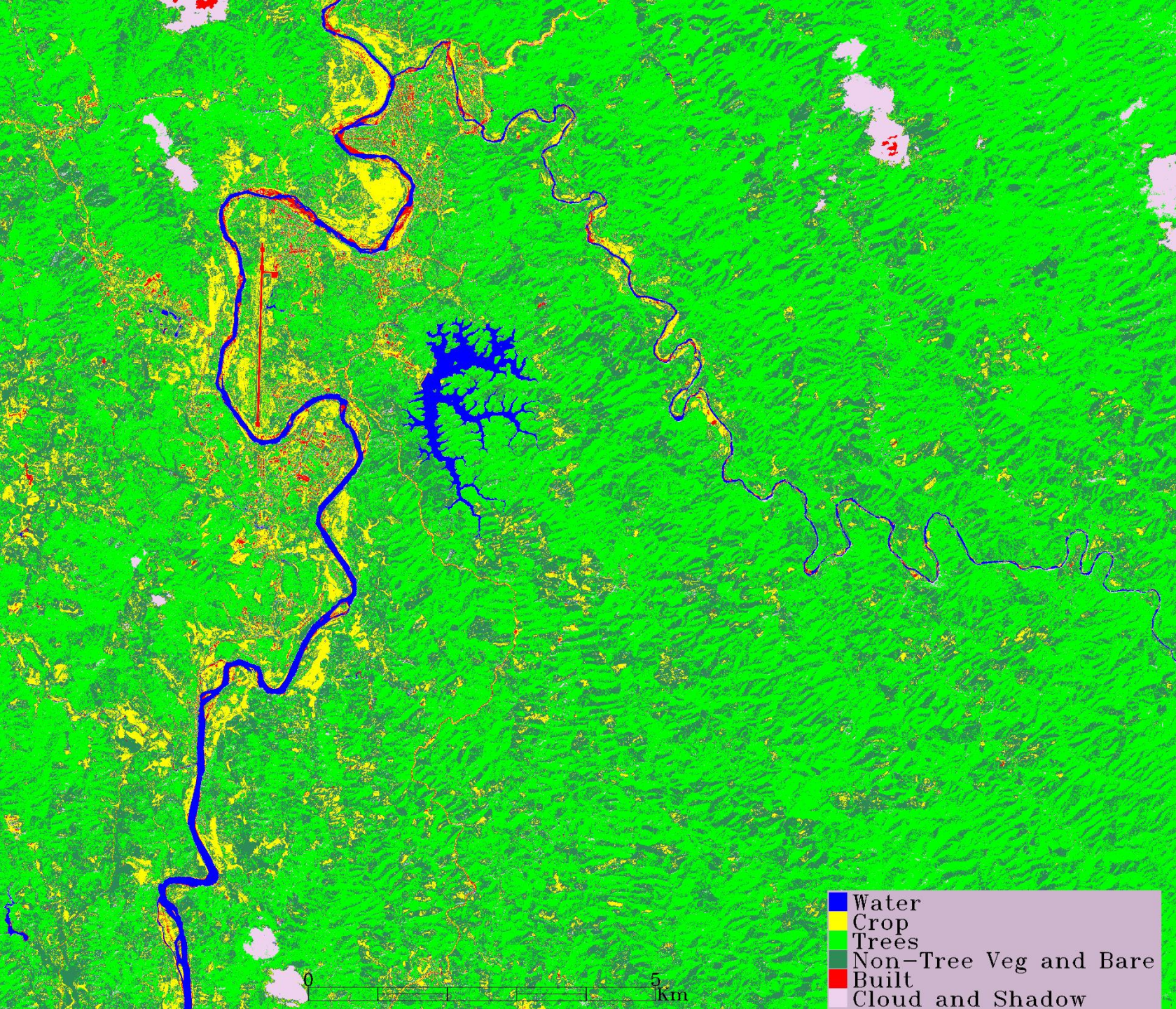


- All individual Landsat scenes for years 2013-2017

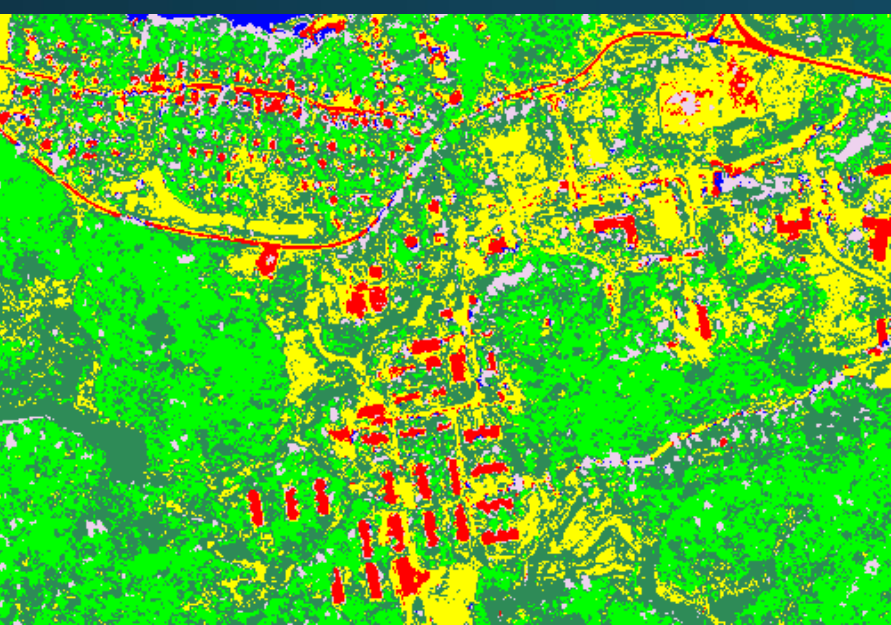
Basemap
circa 2016





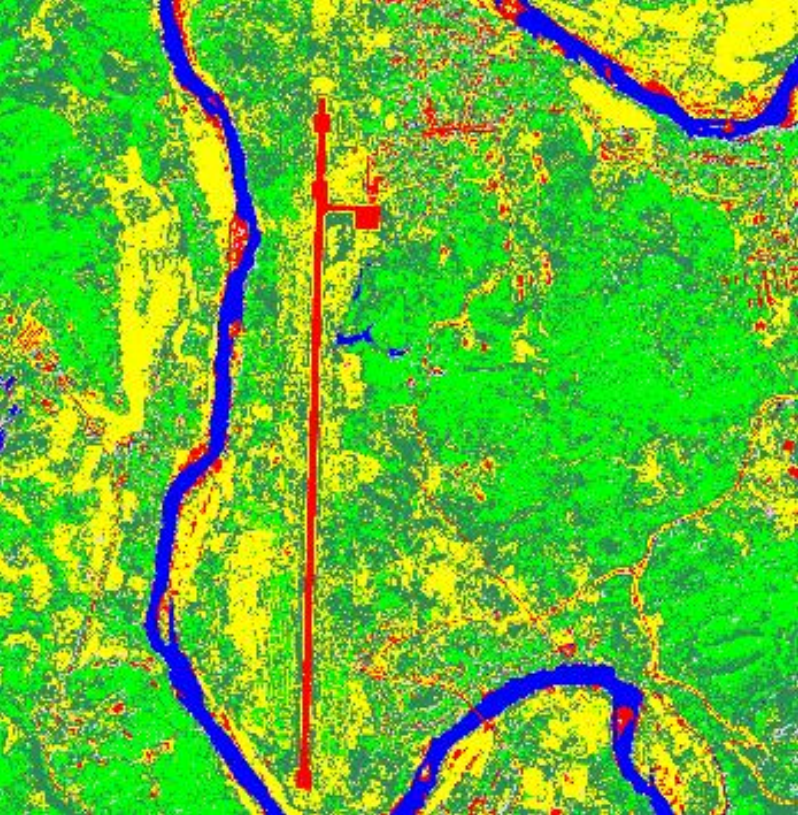


	Prod Acc%	User Acc%
Water	71.79	100
Crop	79.17	79.17
Trees	100	88.14
Non-tree&bare	63.95	98.21
Built	9.09	3.85
Cloud&shadow	100	58.62
Overall Acc = 79.7		
Kappa Coefficient = 0.73		



Water
Crop
Trees
Non-Tree Veg and Bare
Built
Cloud and Shadow





- Water
- Crop
- Trees
- Non-Tree Veg and Bare
- Built
- Cloud and Shadow





2018.05.20 22:55

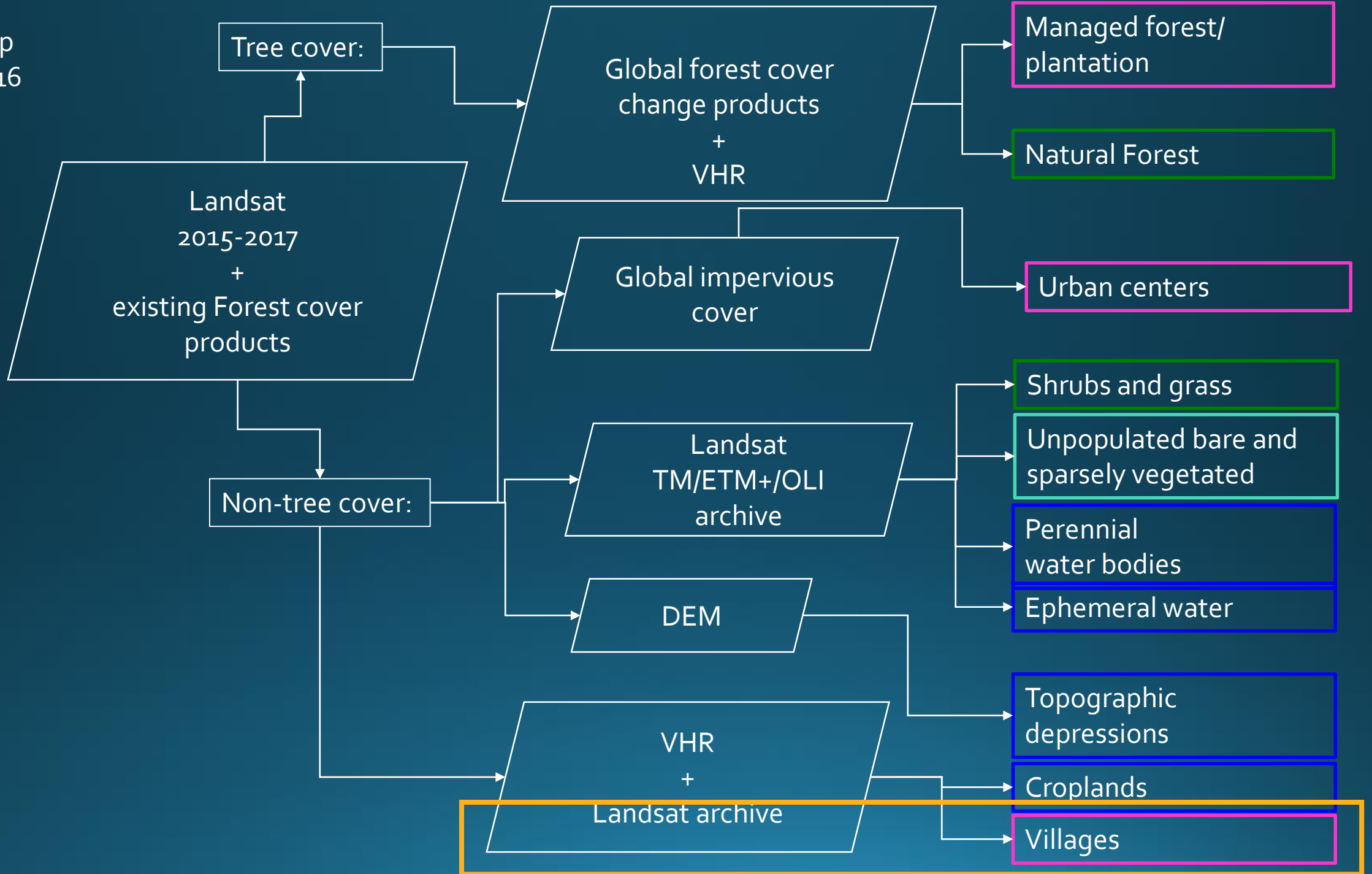


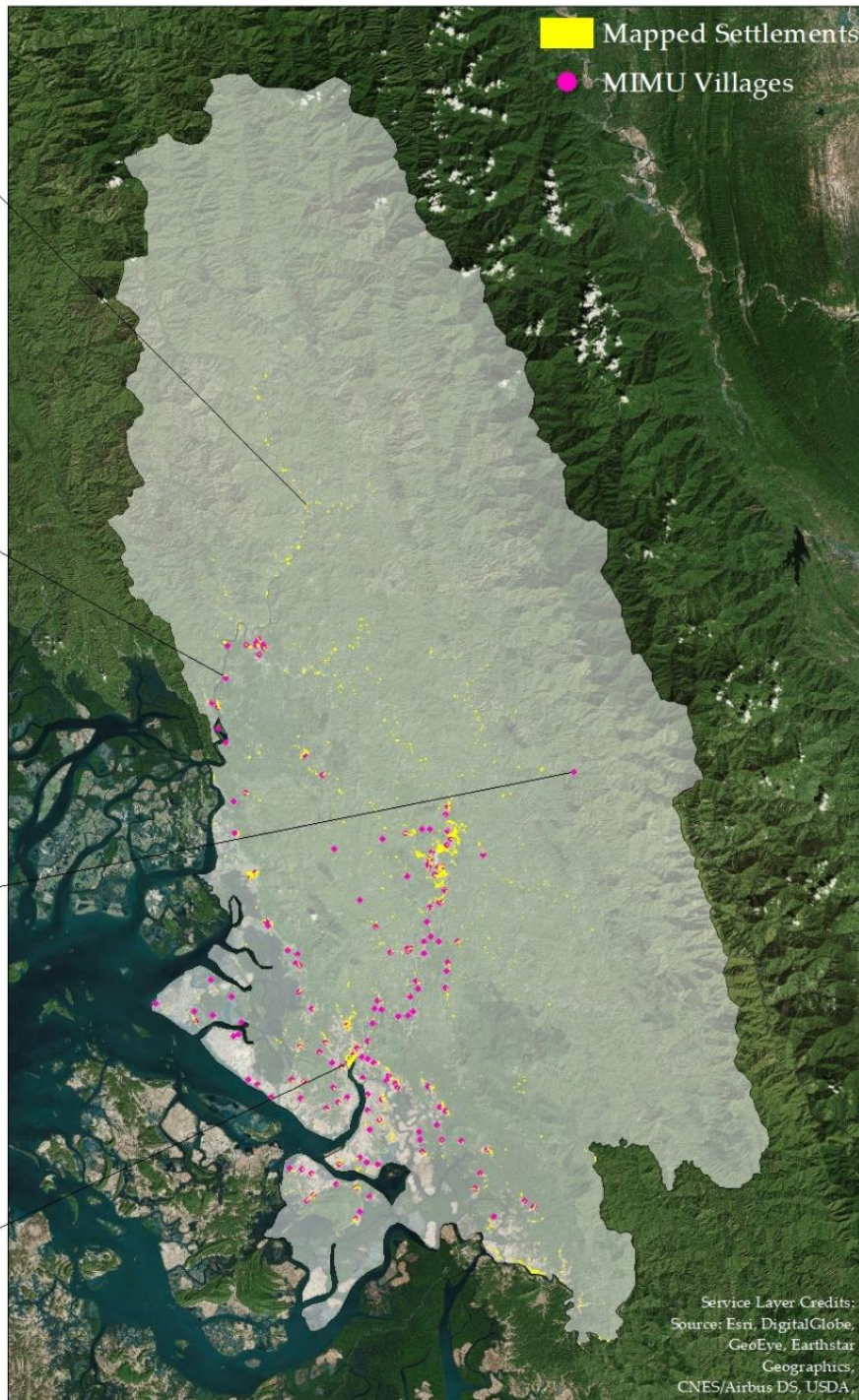
2018.05.19 22:34



2018.05.20 22:00

Basemap
circa 2016





Mapping population distribution from Landsat

Hoffman-Hall et al. (in prep). Rural Population Mapping at Moderate Spatial Resolutions Using Geospatial Data-Fusion . Remote Sensing .

Task 2

Monitoring capacity

Malaria Burden Potential

Population vulnerability

Population presence/density:

- urban centers
- rural sites

Occupation-related exposure:

- rice cultivation
- plantation work
- forest harvesting

Access to care:

- distance to roads and medical facilities
- political stability

Subclinical parasitemia:

- *Plasmodium* prevalence
- drug resistance

Vector abundance

Standing water

Vegetative stress

Land surface temperature

Update frequency and data source:

8-day update:

Landsat OLI, Sentinel 2, Sentinel 1, MODIS, VIIRS

Annual update:

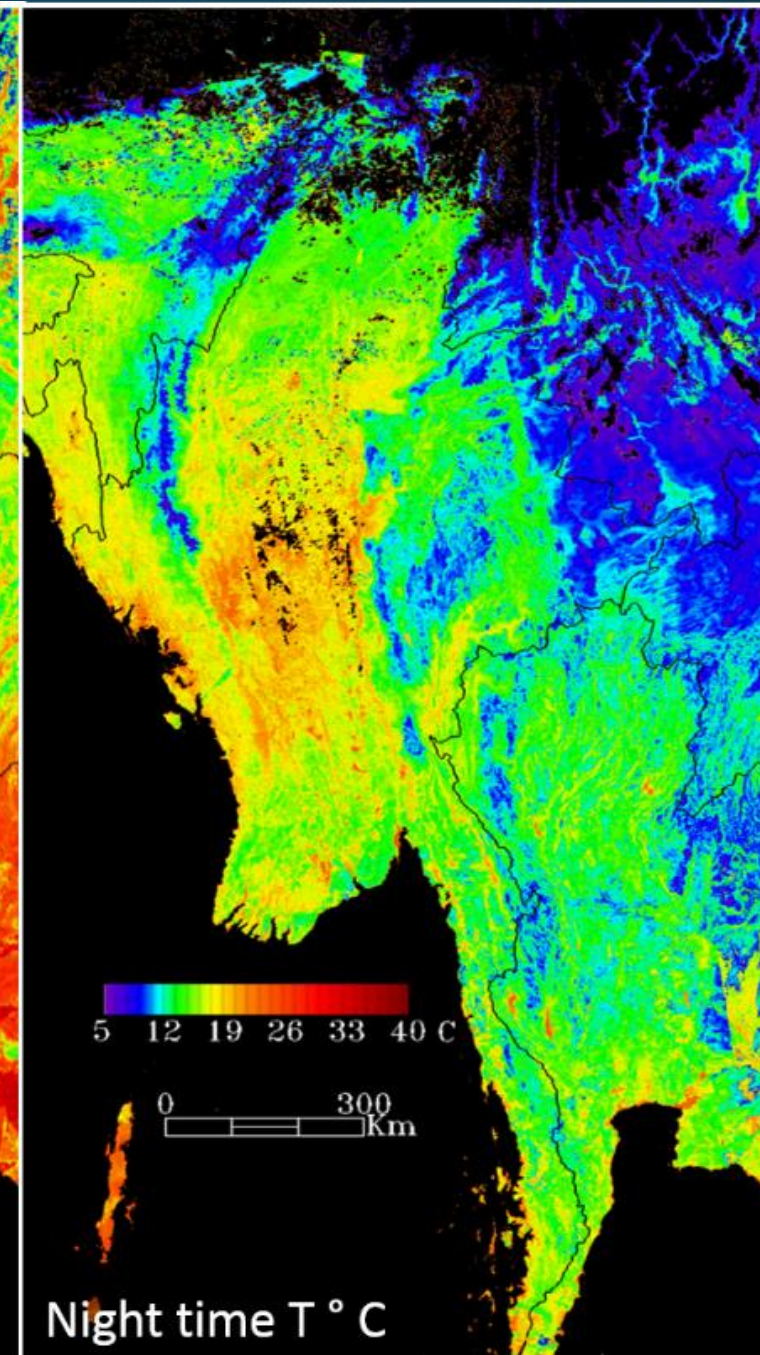
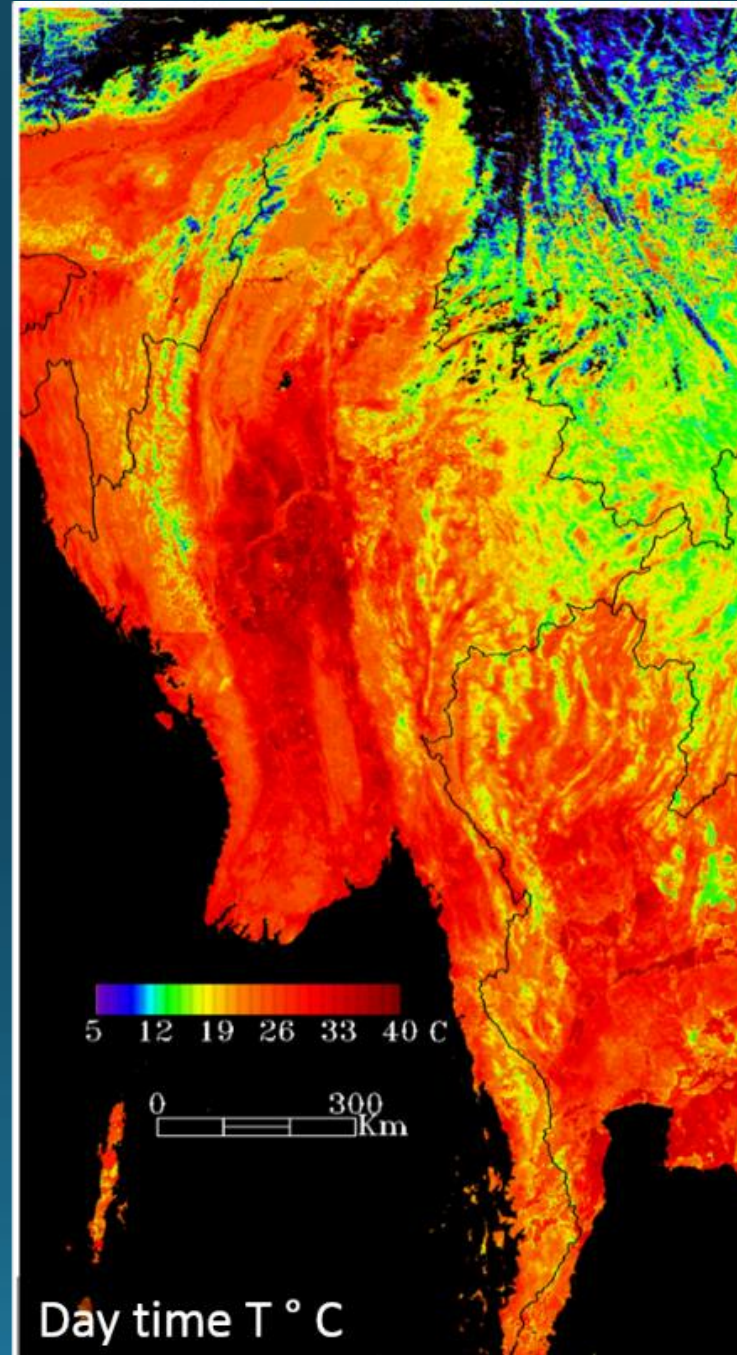
Landsat OLI, Sentinel 2, Sentinel 1, VHR

As needed:

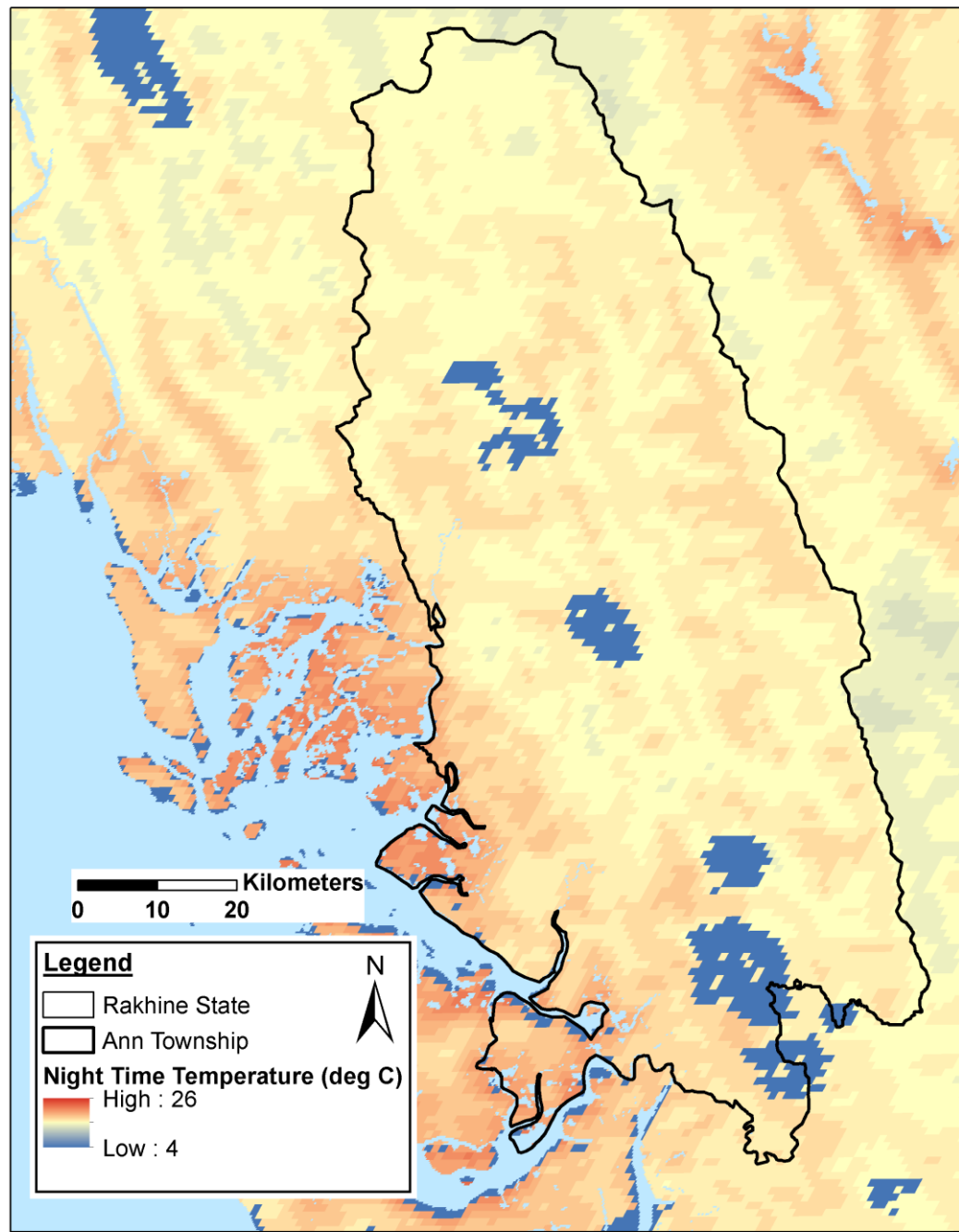
Auxiliary geospatial data, expert opinion, medical studies

Downscaling meteorological parameters

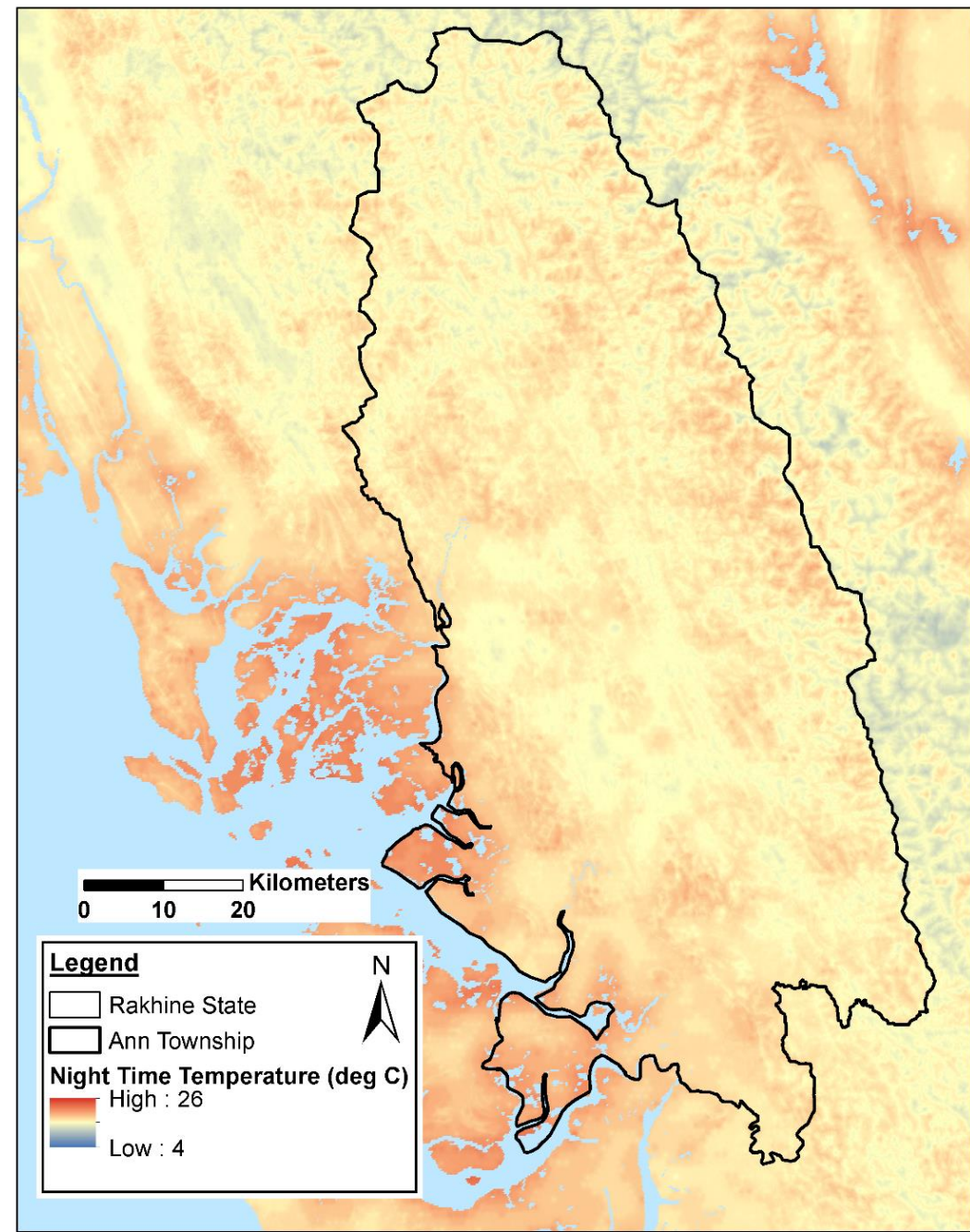
- MODIS 8-day land surface temperature (MOD/MYD11A2)
- MODIS daily precipitable water (MOD/MYD05L2)



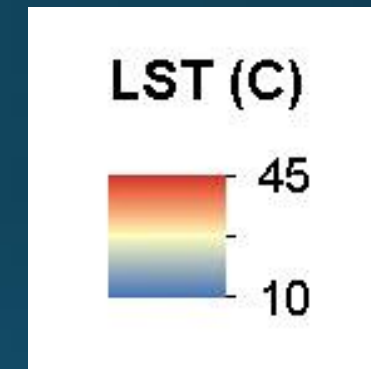
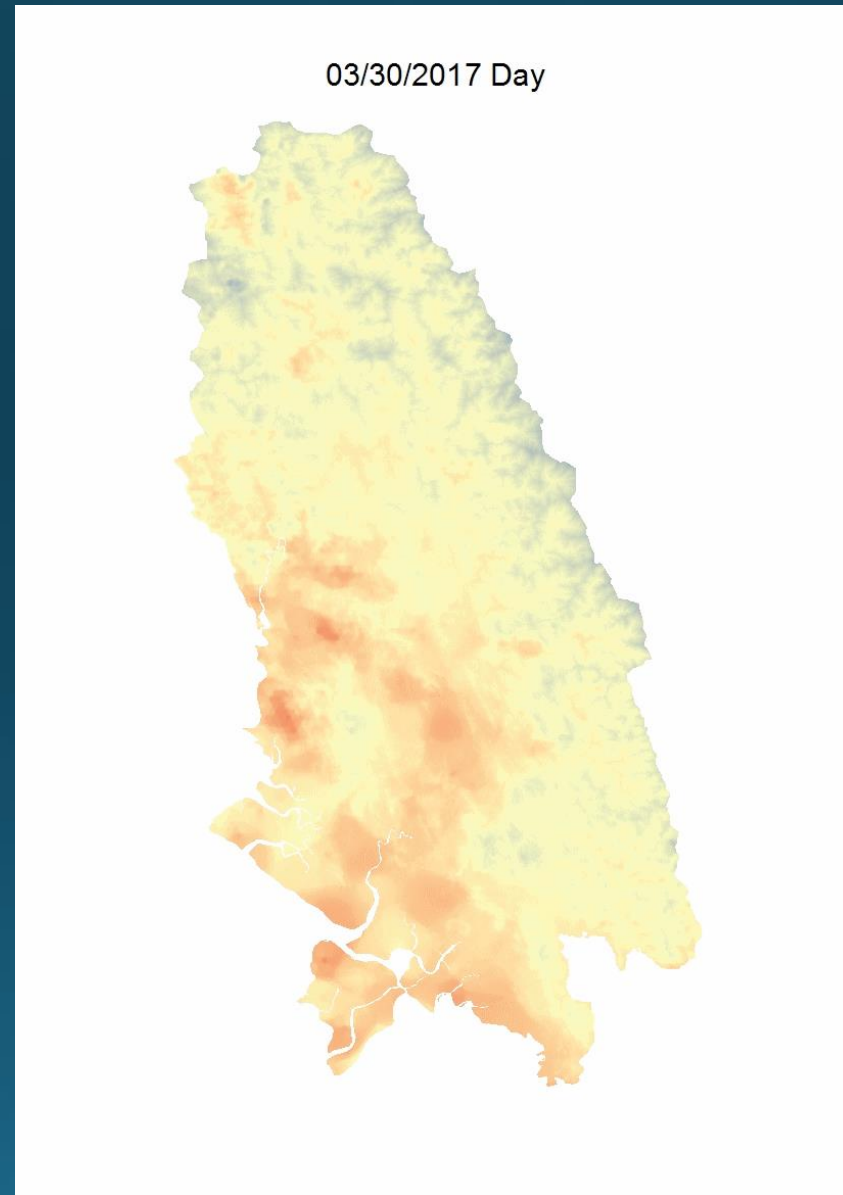
MODIS TERRA Land Surface Temperature (Night Time)
1km resolution: 1st January 2014



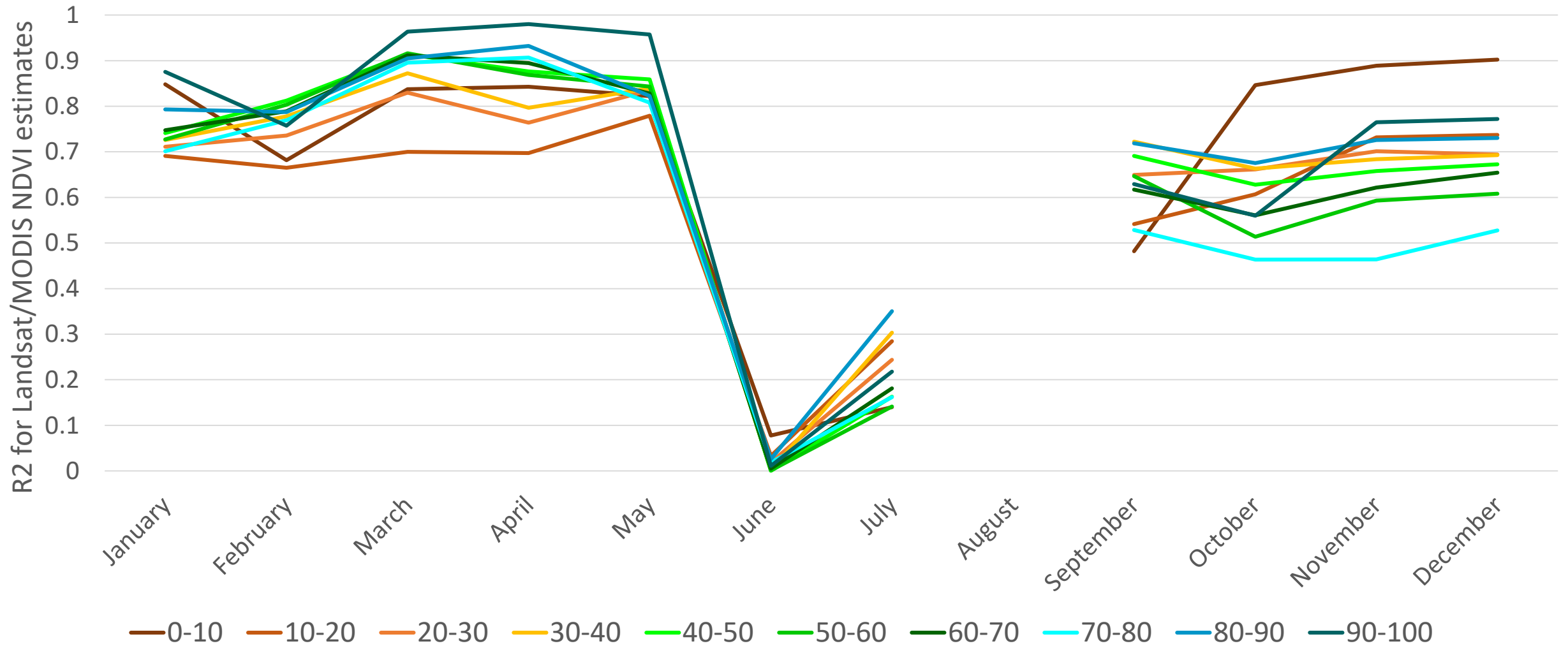
MODIS TERRA Land Surface Temperature (Night Time)
30m resolution: 1st January 2014



Downscaled Land surface Temperature change (Day and Night)



Landsat / MODIS NDVI assessment



Malaria Burden Potential

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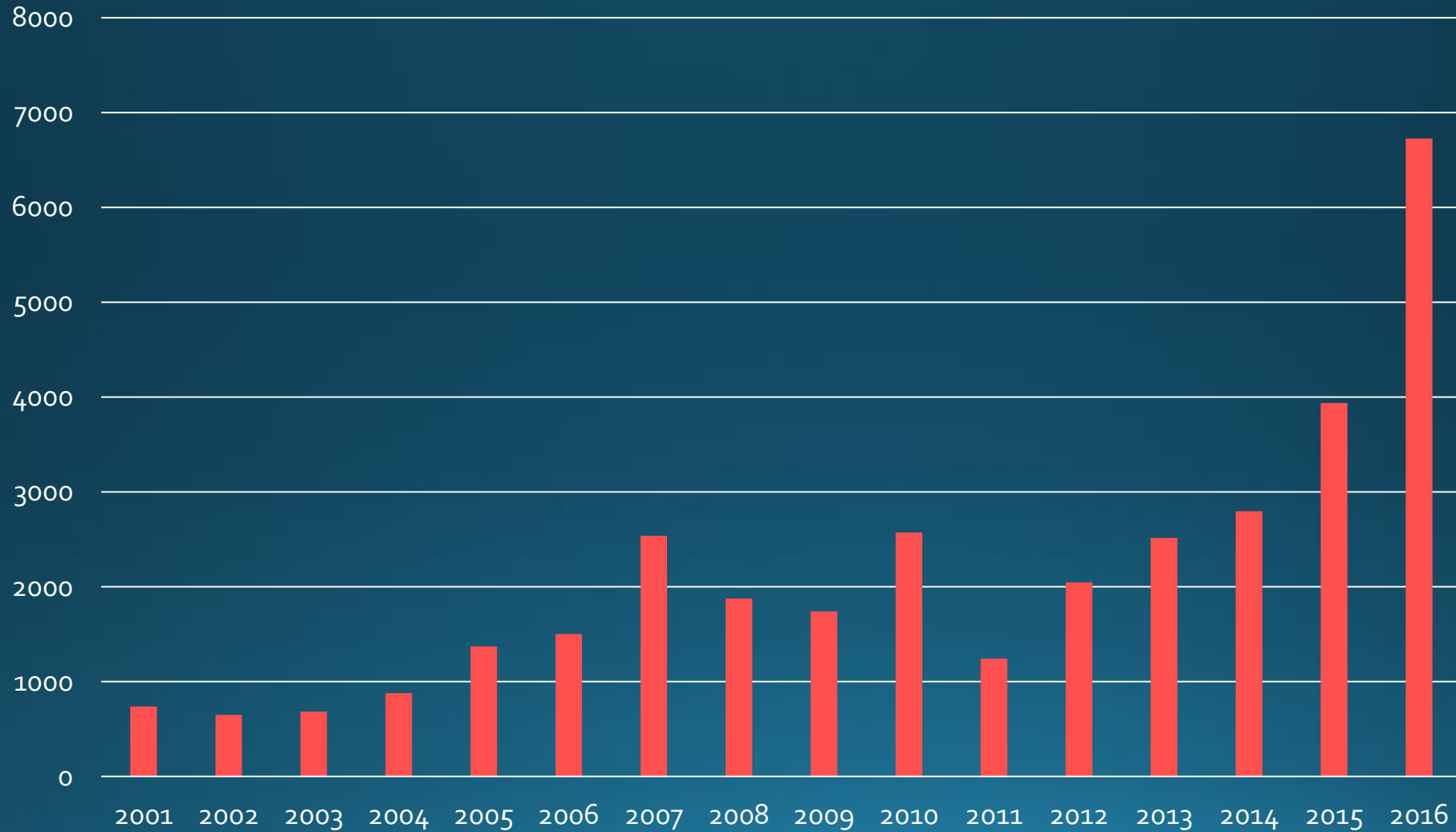
Landsat OLI, Sentinel 2, Sentinel 1, VHR

As needed:

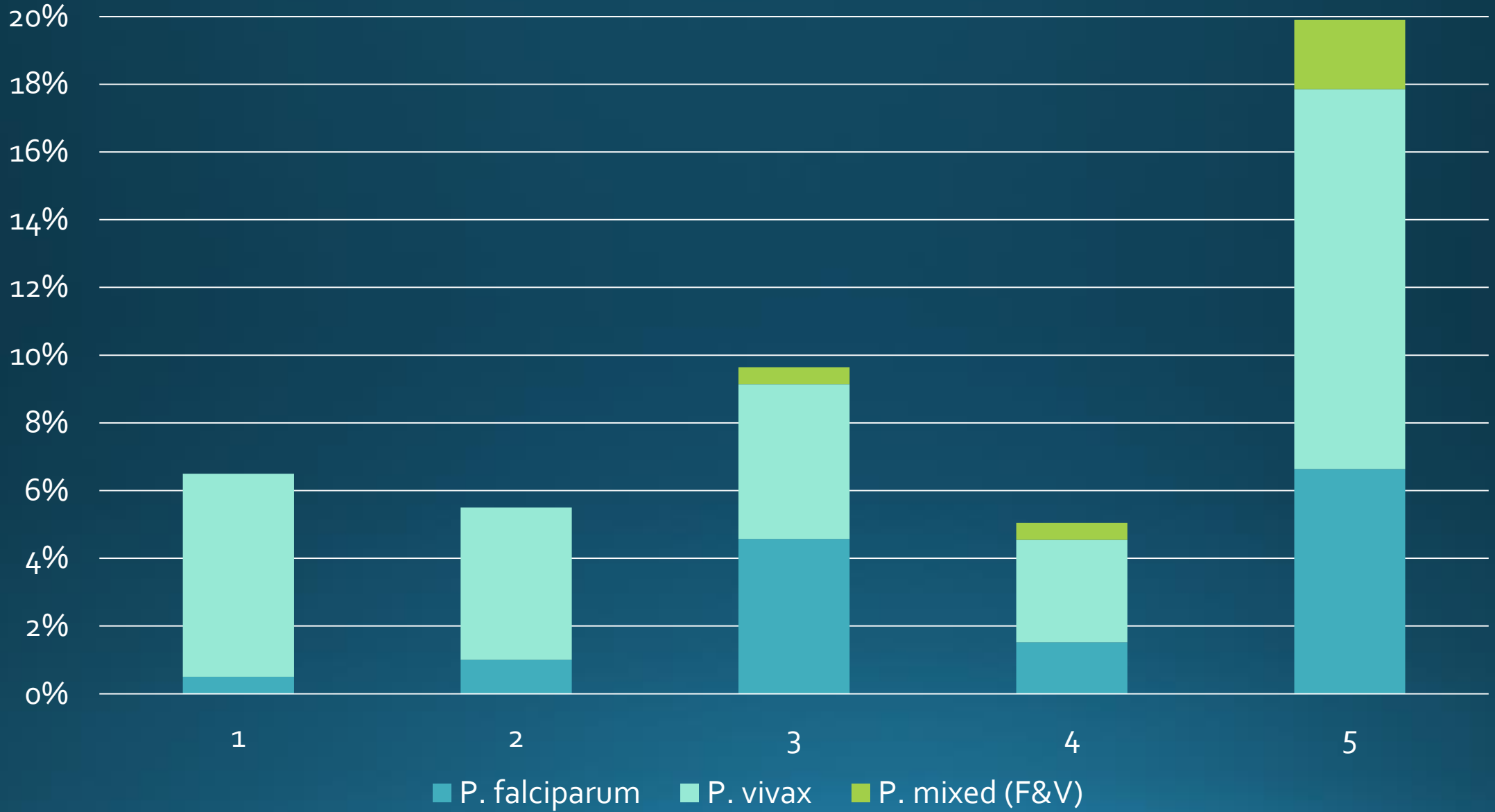
Auxiliary geospatial data, expert opinion, medical studies

MONITORING FOREST COVER CHANGE

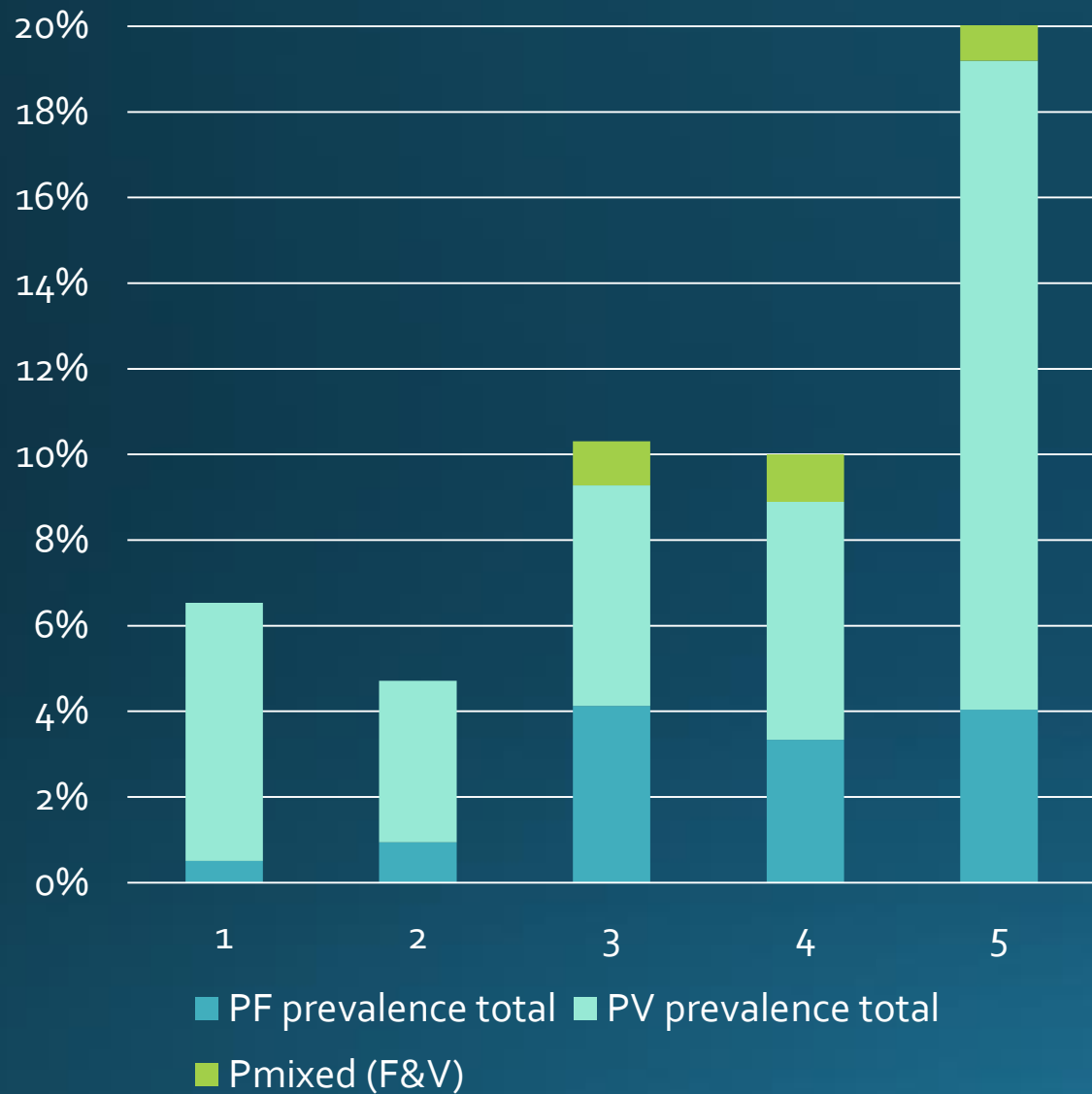
Annual Forest Loss in Ann (ha)



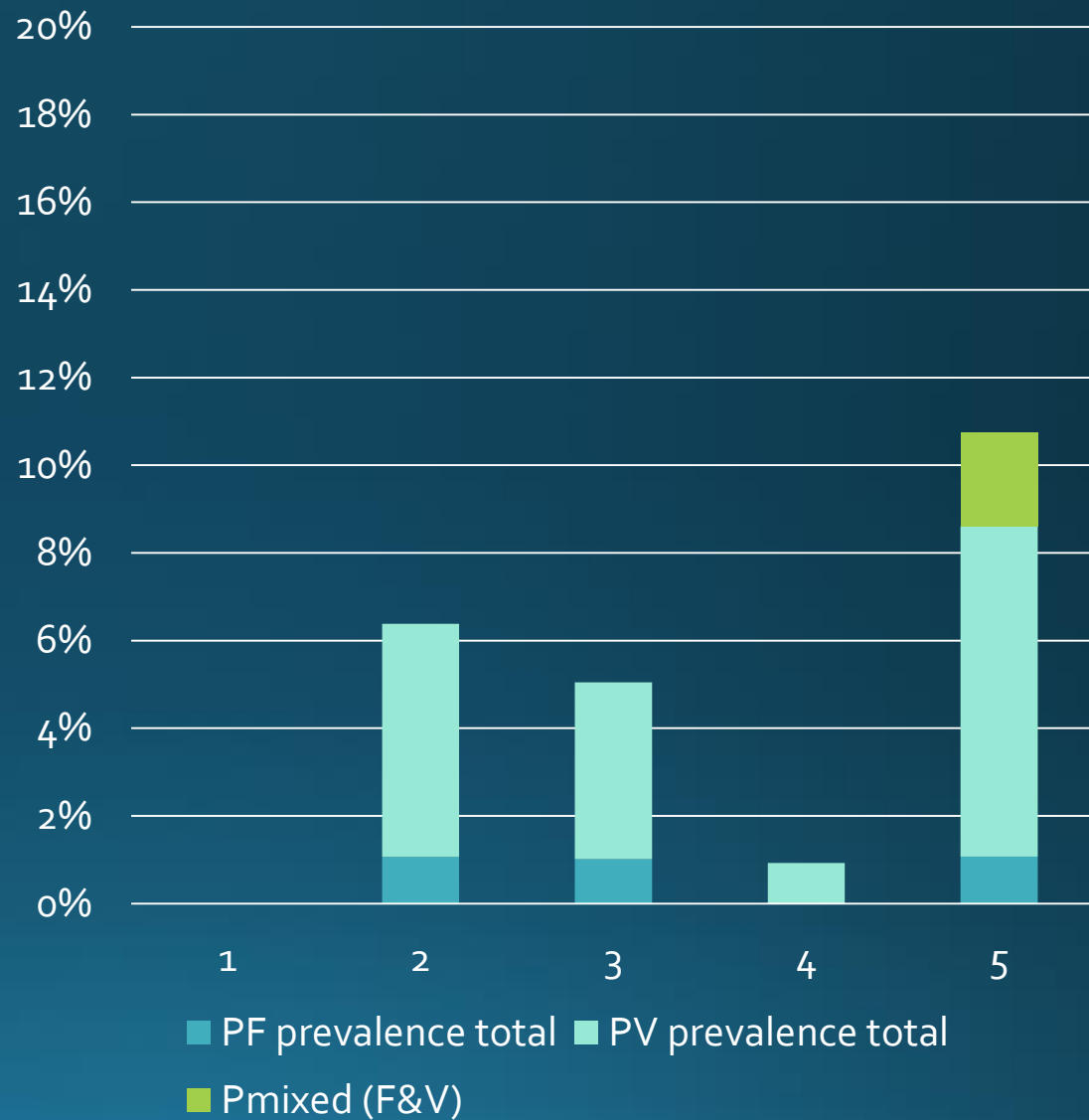
Malaria prevalence (all population)



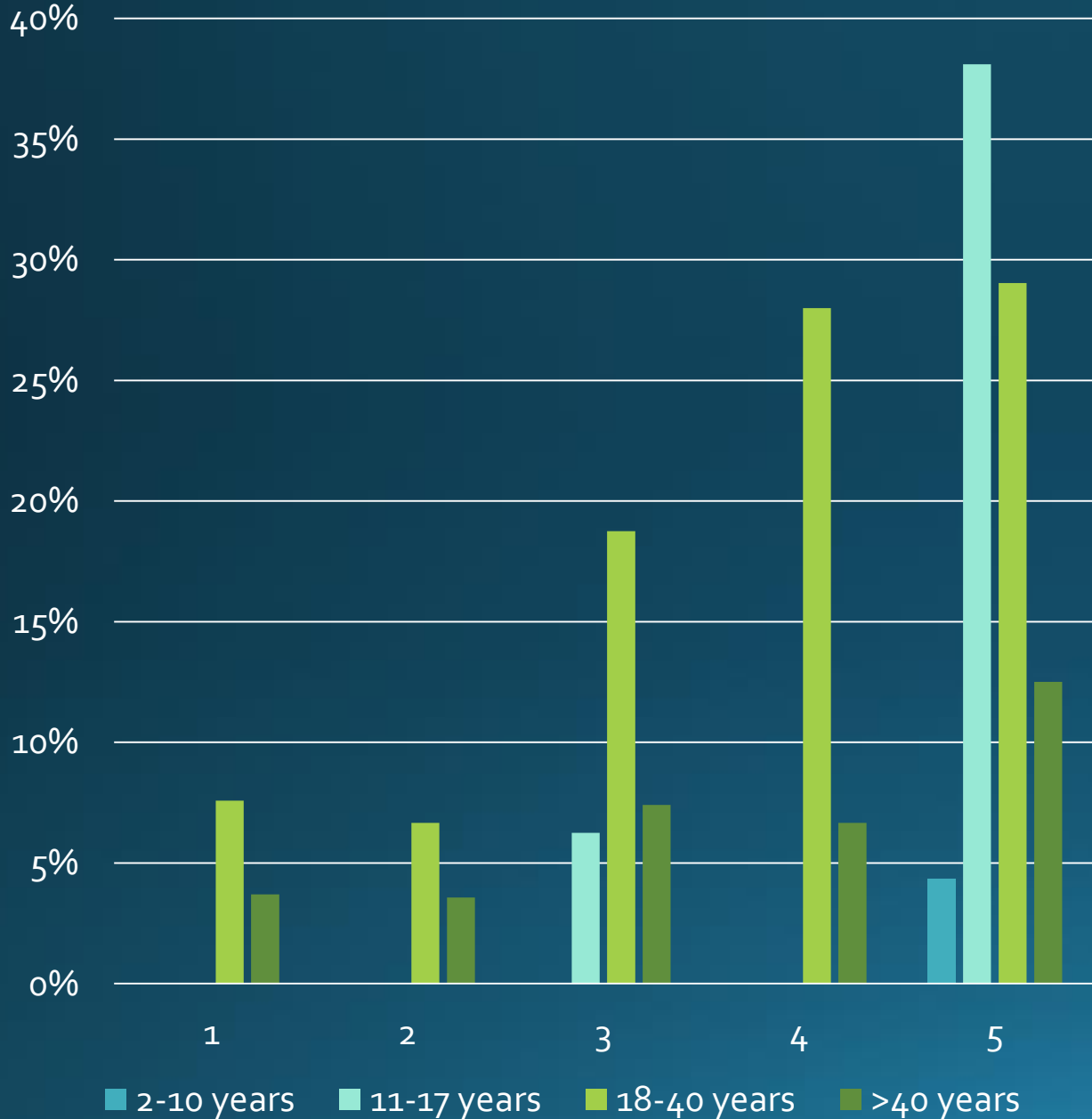
Malaria prevalence (men)



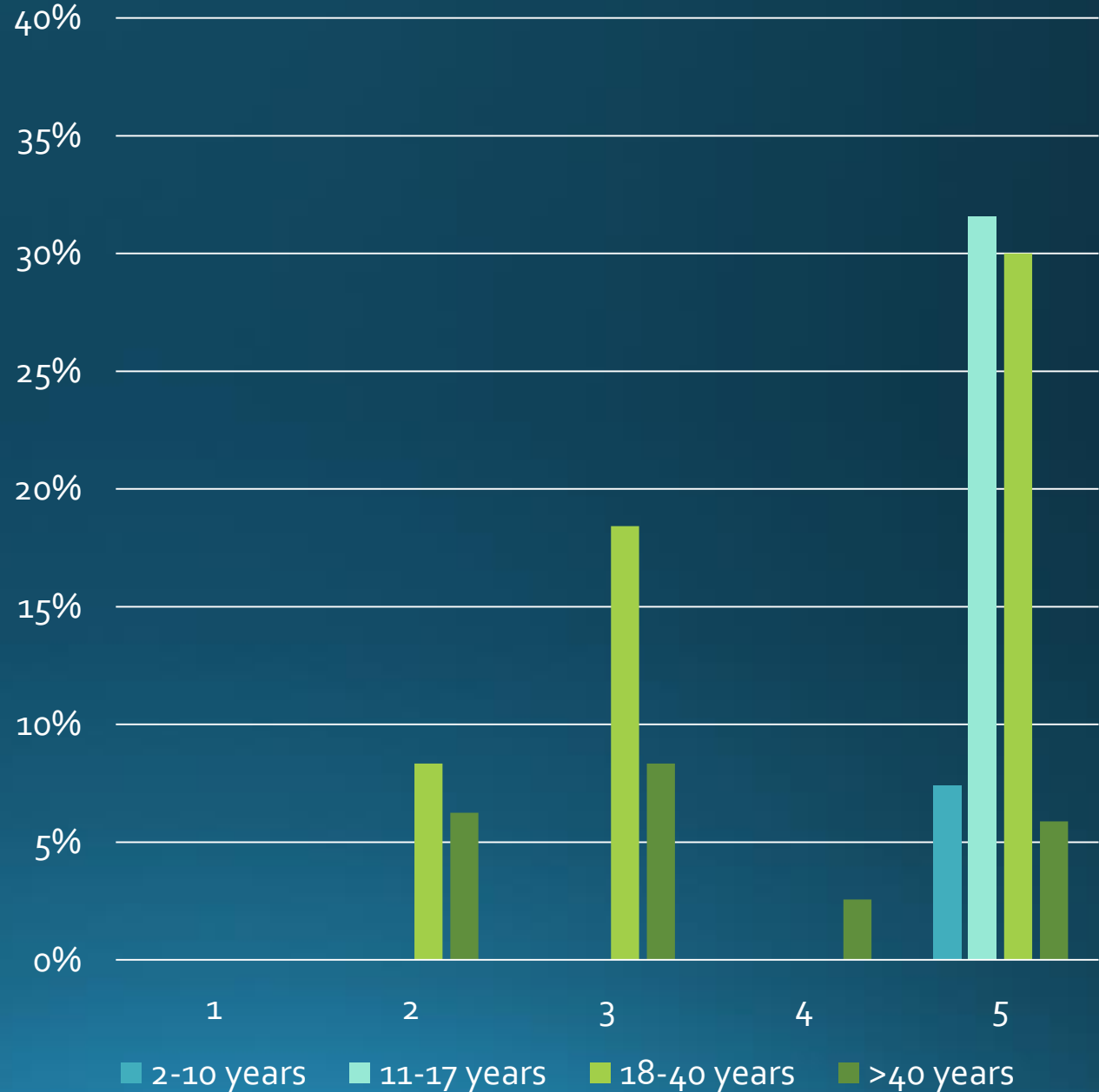
Malaria prevalence (women)



All malaria prevalence by age group (men)



All malaria prevalence by age group (women)



Task 3

Threat level reporting

Malaria Burden Potential

Population vulnerability (w = 0.5)

Population presence/density (w = 0.25)

Occupation-related exposure (w = 0.25)

Access to care (w = 0.25)

Subclinical parasitemia (w = 0.25)

Vector abundance (w = 0.5)

Standing water (w = 0.34)

Vegetative stress (w = 0.33)

Land surface temperature (w = 0.33)

Malaria Burden Potential (MBP)

MBP =

$$0.5*(0.34*SW+0.33*VS+0.33*Ts)+0.5*(0.25*PD+0.25*OE+0.25*AC+0.25*SP)$$

Parameter	Category definitions				
	Very Low (1)	Low (2)	Moderate (3)	High (4)	Very High (5)
Surface Water	no water	coastal wetlands - low numbers of Anopheles spp.	deep or running water (30m inward within perennial water bodies)	Shallow water edge (± 30 m buffer from perennial water bodies edge)	shallow stagnant water (water mapped within ephemeral water, depressions, and cropland classes)
Vegetative Stress (VS) ¹	$VS > \mu + 0.5\sigma$	$\mu - 0.5\sigma < VS < \mu + 0.5\sigma$	$\mu - 1\sigma < VS < \mu - 0.5\sigma$	$\mu - 1.5\sigma < VS < \mu - 1\sigma$	$VS < \mu - 1.5\sigma$
Land surface temperature (Ts) ²	$33^{\circ}\text{C} < Ts < 17^{\circ}\text{C}$	$17^{\circ}\text{C} \leq Ts \leq 20^{\circ}\text{C}$	$30^{\circ}\text{C} \leq Ts \leq 33^{\circ}\text{C}$	$20^{\circ}\text{C} < Ts \leq 25^{\circ}\text{C}$	$25^{\circ}\text{C} < Ts < 30^{\circ}\text{C}$
Population presence/ density (PD) ³	$PD \leq 250$ people or unknown	$250 \text{ people} < PD \leq 1000 \text{ people}$	$1000 \text{ people} < PD \leq 10,000 \text{ people}$	$10,000 \text{ people} < PD \leq 100,000 \text{ people}$	$PD > 100,000 \text{ people}$
Occupation-related exposure (OE) ⁴	urban areas	coastal fisheries – few Anopheles mosquitoes are present	forest-related subsistence activities	rice-paddy agriculture	plantation, logging, and mining ⁵
Access to care (AC) ⁶	expert opinion	expert opinion	expert opinion	expert opinion	expert opinion
Subclinical parasitemia (SP) ⁷	expert opinion	expert opinion	expert opinion	expert opinion	expert opinion
Malaria Burden Potential (MBP) ⁸	$MBP < 1.5$	$1.5 \leq MBP < 2.5$	$2.5 \leq MBP < 3.5$	$3.5 \leq MBP < 4.5$	$MBP \geq 4.5$

MMEWS reporting (8-day update)

1. Spatial:
Landscape object-level reporting - maps
2. Non-spatial:
Township –level aggregated – tables

Task 4

Testing, verification, deployment




 အကာအကွယ်ပေးထားသည့် နယ်မြေ
 (Protected Zone)



 Protected Zone

ဤဆေးရုံ/ ကျန်းမာရေးဌာနသည်
 မှေးခွယ်စောင့်ရှောက်မှုပေးသူ နှင့် ဆေးကုသမှုဆောင်ရွက်ပေးသူများ
 အတွက် အကာအကွယ်ပေးထားသည့် နယ်မြေဖြစ်ပါသည်။

This hospital health center is
 the
 for all patients
 care providers.

No one
 threat,
 terrorism

2018.01.27 04:04



2018.01.27 21:42

Questions?

