Cambodia Nesting System – Forest Reference Level Allocation Options

Training of Trainers – July 2021
Deforestation Risk Map Methodology & Tool

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Training structure

Objective:

Disclose and share with all stakeholders in deep details about general principles and technical procedures followed to develop the Deforestation Risk Map Methodology and Tool:

- **Gather technical feedback** from participants
- **Implement**, in a collaborative effort, the agreed **improvements**
- **Document the process** to enhance transparency and robustness

Agenda

The training will be held during July 2021, including three virtual meetings (zoom calls/meetings):

- **July 8th, Risk Map Methodology and Tool presentation**

The general principles and technical procedures followed to develop the methodology and tool will be described to the participants.

All supportive documents and files to install and test the Tool will be shared with stakeholder in other to create a common understanding

- **July 9th – 14th, Individual assessment.**

Participants are encouraged to analyse in detail the tool and methodology to identify potential findings and improvements.

It is suggested to participants, to share the findings and proposals with the working group using the systems prepared by the organization.

Agenda (2)

- **July 15th, Improvement Options.**

Participants will present the potential findings identified and the improvement proposals during the individual analysis.

All proposals will be discussed in a round table to reach an agreement of improvements to be implemented and to define the arrangements to run the process

- **July 16th – 28th, agreed improvements and procedures implementation.**

The improvements and procedures previously agreed will be implemented.

The upgrades will be executed following the specific arrangements established by the participants and overseed by the RTS responsible officers.

- **July 29th, Final session**

Final session will be held to describe all procedures followed, including a training for the final user´s.

Participants:

Technicians´ government officers from the MRV team:

- MoE
- FA
- FiA
- GDA

Technicians from NGO´s and Project Developers:

- FAO
- JICA
- WCS
- CI
- WA

Current Session:

Hour	Activity	Relator
14:00-14:30	**Welcome and Introduction**. • Participant's presentation • Objectives and Agenda	Chivin Leng – MoE Carlos Riaño – RTS
14:30-15:00	**Practical work presentation**: • Resources and methodology	Javier Cano – UNDP Consultant
15:00-15:50	**Cambodia FRL Allocation**: • Basic Principles • Methodology and Preliminary results	Javier Cano – UNDP Consultant
15:50-16:10	**BREAK**	
16:10-17:00	**Deforestation risk map tool installation**	Javier Cano – UNDP Consultant
17:00-17:45	**Deforestation risk map tool application**: • Include round table about preliminary findings	Javier Cano – UNDP Consultant
17:45-18:00	**Next steps and closure**	Chivin Leng – MoE Carlos Riaño – RTS

Resources and Methodology

Methodology

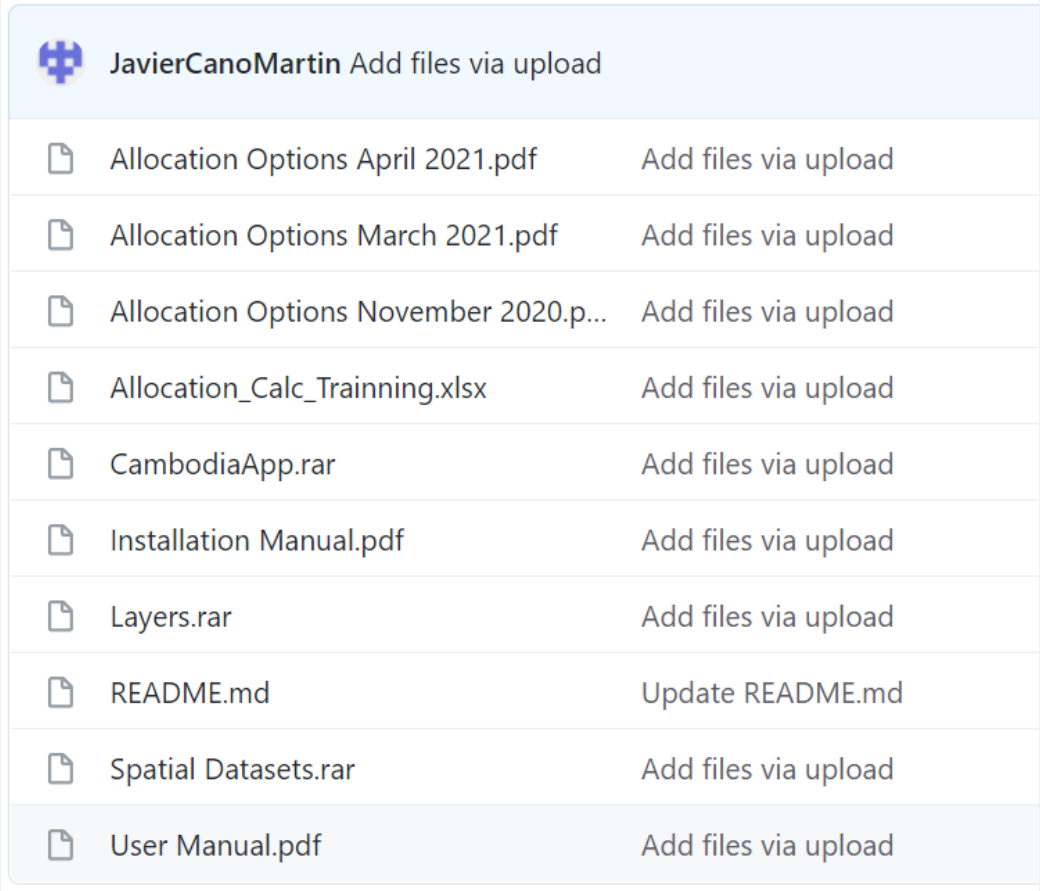
The training will follow a collaborative development method divided in three steps:

- Creation of a common understanding and rules
- Individual analysis and improvement proposals
- Consensus agreement to implement improvements

From the start of the workshop a GitHub Repository will be created to host the documentation, develop the code, and facilitate the collaborative work.

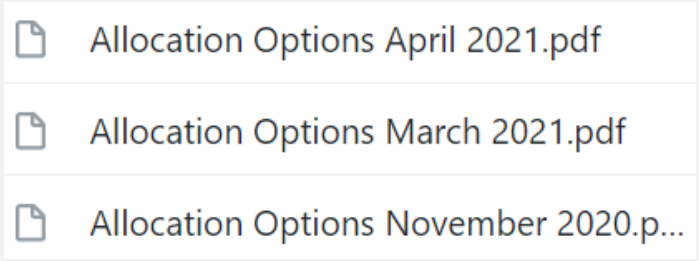
Resources

Resources are upload in the following GitHub Repository:
https://github.com/JavierCanoMartin/Allocation_Training/tree/Stakeholders

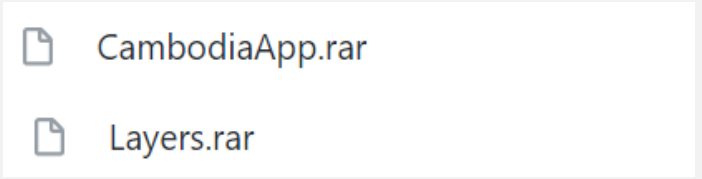


Resources

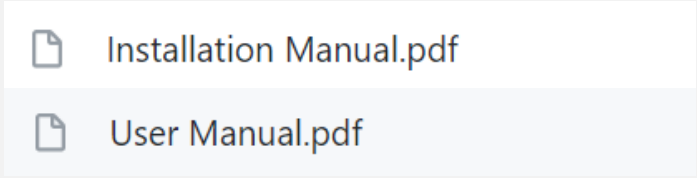
- Technical Reports



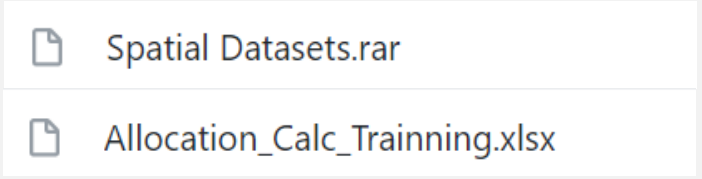
- Deforestation Risk Map Tool and Datasets



- Deforestation Risk Map Supporting Documents



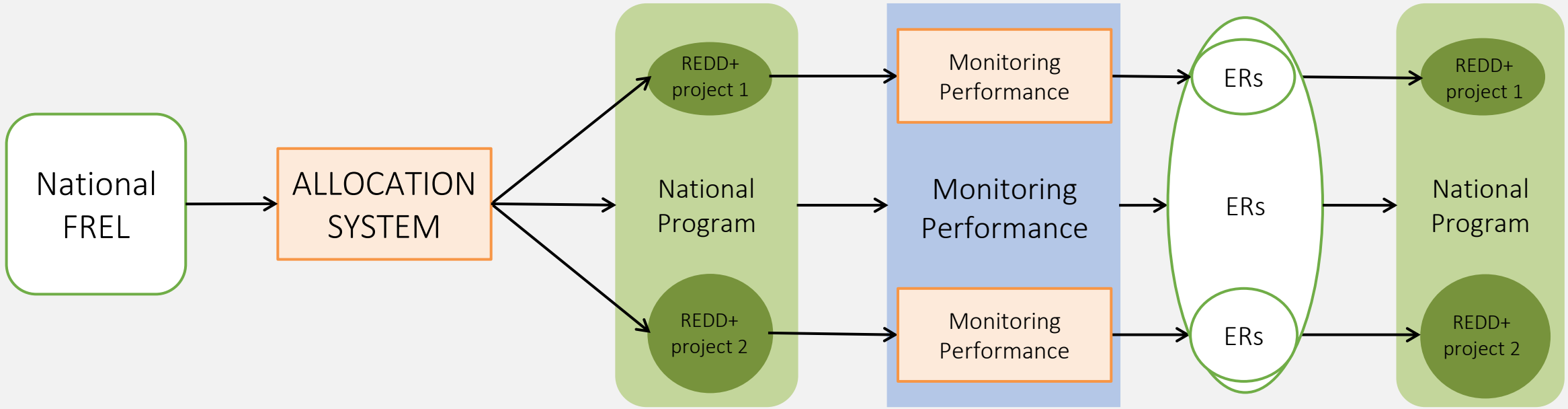
- Allocation Final Results Preliminary Option



Cambodia FRL Allocation: Basic Principles

Basic Principles

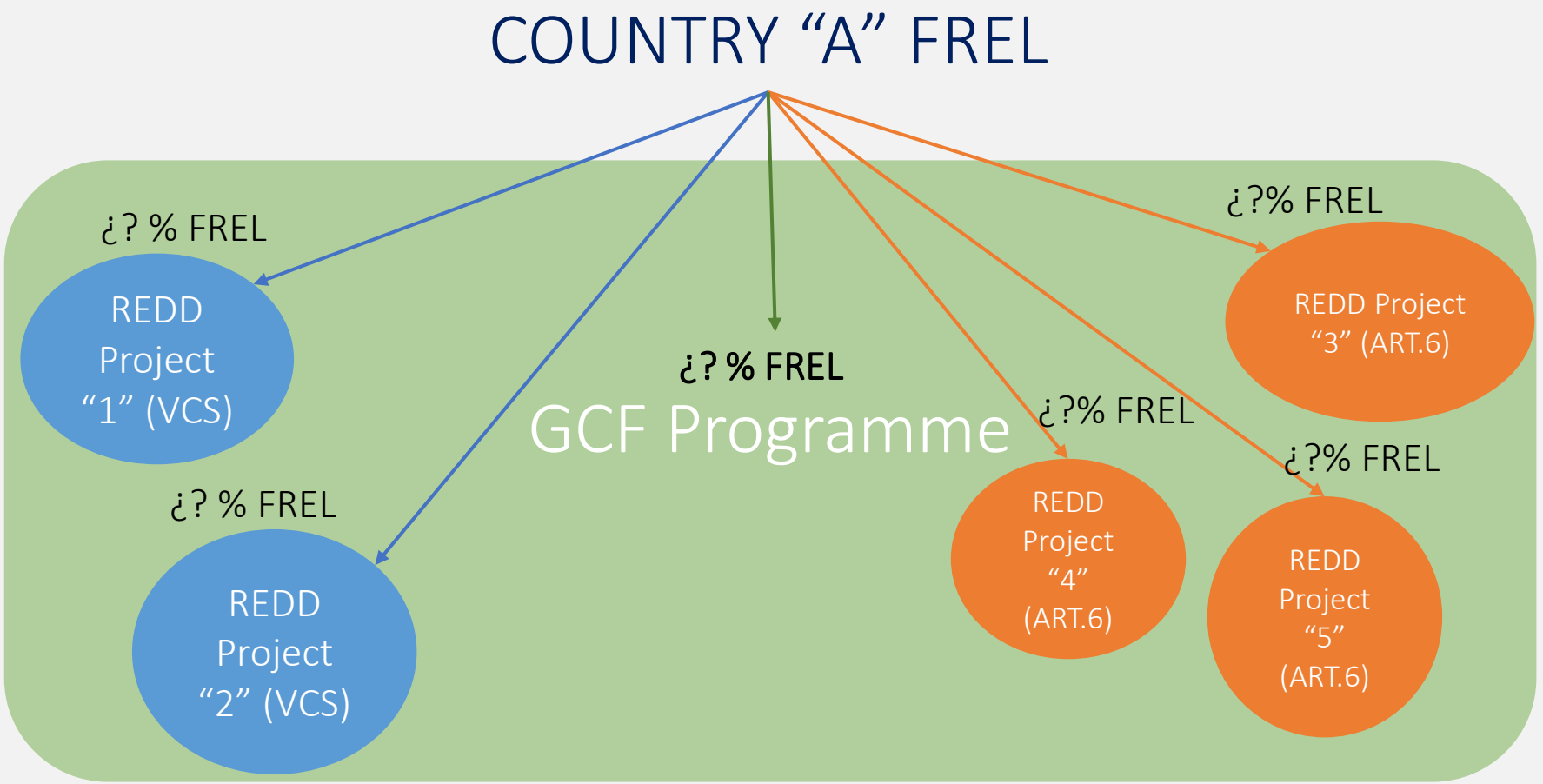
The **FRL ALLOCATION** System aims to fairly distribute the FRL to different initiatives and scales:



Basic Principles

Allocation methods try to distribute baselines/reference level to projects, avoiding overestimation and double account, and being as fair as possible

- Distributing the Jurisdictional/National Reference Level
- Identifying the effort needed to achieve the results



FRL Allocation

- ✓ Helps to align baselines and ER claims at different scales
- ✓ Reduce the mismatch between projects-level and national scale
- ✓ Promote environmental integrity of ER claims
- ✓ Allow to improve NFMS data accuracy and GHG estimates

Risk-based allocation

- ✓ The most accepted methodologies to allocate a FRL are the Risk-based methods.
- ✓ Risk-based methods distribute the FRL according to the probability of GHG emissions in each location.
- ✓ FRL allocated portion would be related to the Level-of-effort and site-specific conditions.
- ✓ Therefore, the main question is **HOW TO ESTIMATE THE RISK OF EMISSIONS?**

Basic Principles

Transparency

The willingness of build a relationship based on honesty

Robustness

The quality of being strong and in good condition

Accuracy

The quality of being correct or precise

Consistency

The conformity in the application of something for the sake of logic

Equity

The quality of being fair and impartial

Specific criteria to select data:

- ✓ Related to the drivers at the national level
- ✓ Cover the full area of interest (i.e., Cambodia national wide) at the same quality level
- ✓ Consistent with the information used in the related elements (i.e., FRL)
- ✓ Publicly available. Otherwise, available to be consulted under request
- ✓ Accurate. Use the better existing data (if previous conditions are met)
- ✓ Periodically updated (specially for dynamic variables)

Requirements related to Methodology :

- ✓ Robust: Based on appropriate principles of spatial statistics
- ✓ Reliable: Results obtained are based on most significant trends
- ✓ Appropriate: Adjusted to national specific conditions
- ✓ Flexible: Able to adopt variations and adjustments
- ✓ Aligned: Relatively close to the most used methods
- ✓ Down-to-earth: Level of complexity adjusted to final users

Cambodia FRL Allocation: Methodology and Preliminary Results

FRL Allocation scope

- ✓ Activities: Unplanned Deforestation / ~~Planned Deforestation~~
- ✓ Pools: Above and belowground biomass
- ✓ Gases: CO_2
- ✓ Coverage: Cambodia, National wide
- ✓ Reference period: 2014-2018

After several exchanges with stakeholders Planned Deforestation was excluded from the scope of the FRL Allocation

Methodology evolution

- ✓ The Cambodia FRL Allocation Methodology process started in January 2020
- ✓ Several modifications from the initial proposal were made
- ✓ Deforestation risk is estimated based on a linear regression model projection
- ✓ The methodology is based on the following main steps:
    1. Deforestation drivers and variables identification
    2. Data preparation and variable's analysis
    3. Deforestation regression model development and application
    4. Combination of projected deforestation and biomass stock (EF)
    5. Adjust emissions projected to FRL emissions.

Deforestation drivers and variables identification

Direct Drivers

Wood extraction:

Charcoal,
Woodfuel, Logging

Shifting cultivation:

Paddy fields

Rubber plantations

Underlying Drivers

Law enforcement

Forest Regulation

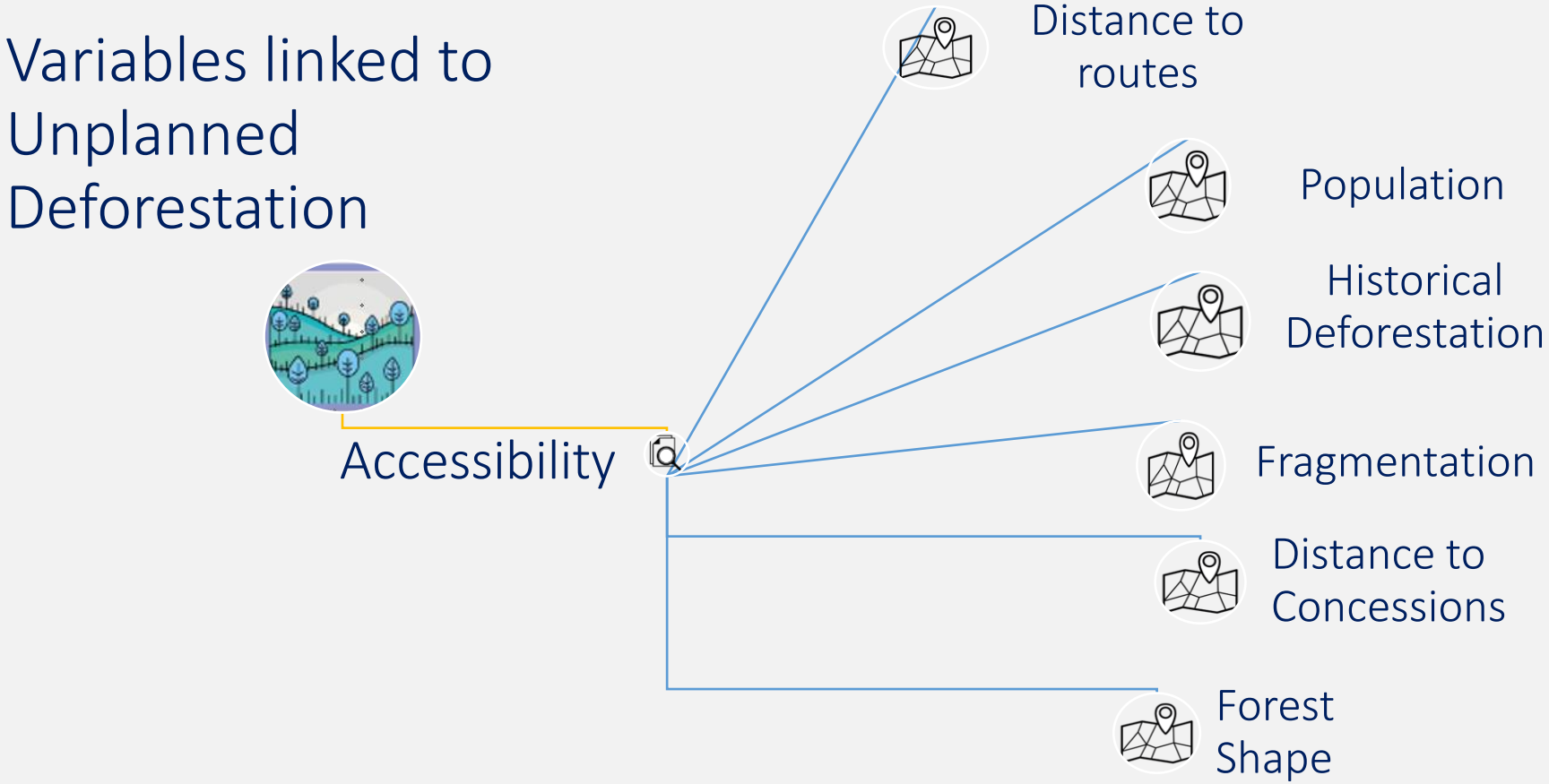
Socieconomic

Poverty
Low employment

Demography

High rural population

Deforestation drivers and variables identification

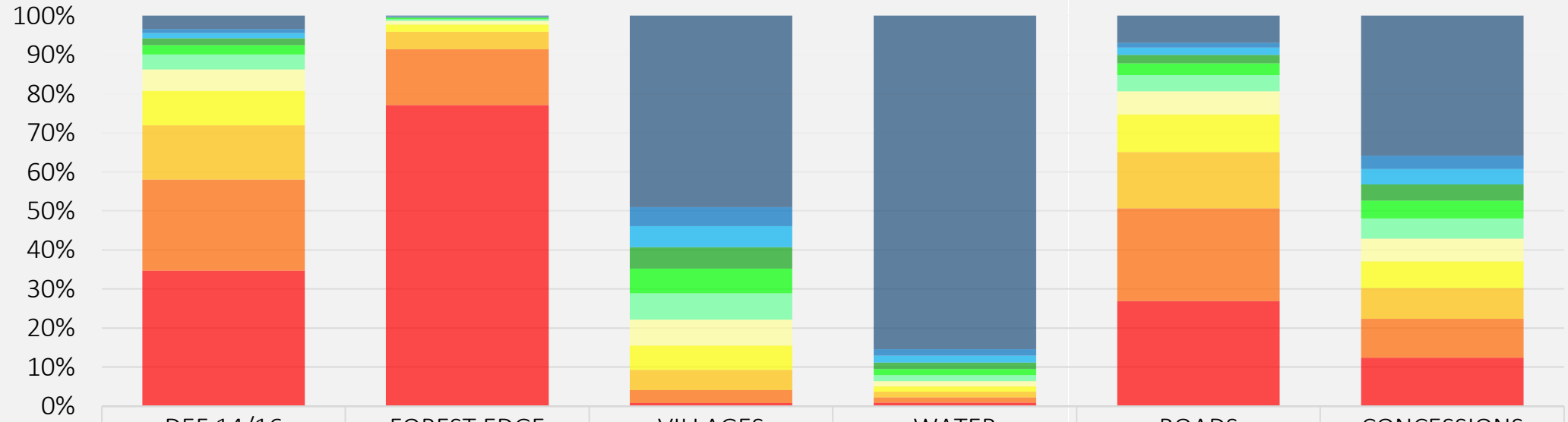


Data preparation and variable's analysis

- ✓ HYPOTESIS: recent deforestation is more likely to occur closer to the risk variables.
- ✓ Variable's selection: availability of spatial information
- ✓ TEST: relation between recent deforestation and each variable at 500-meter intervals up to 5 km

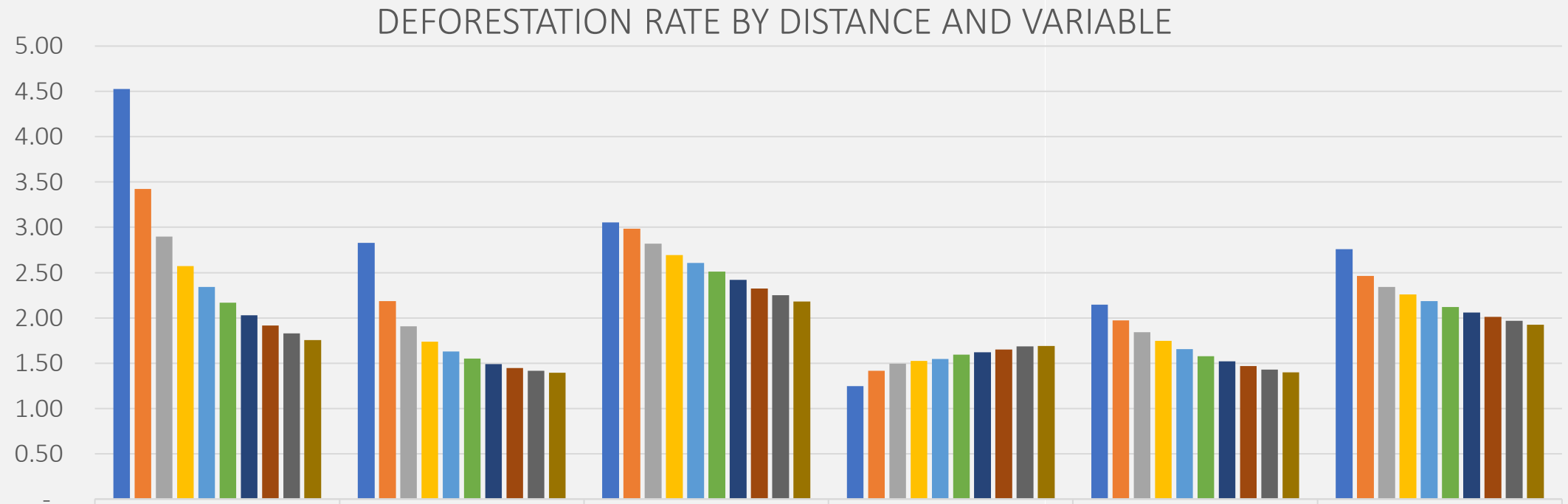
Variable	Source
DEPENDENT VARIABLE	
Deforestation 2016-2018	Land Use Change Maps – MoE – FRL
INDEPENDENT VARIABLES	
Deforestation 2014-2016	Land Use Change Maps – MoE – FRL
Forest Edge 2016	Forest Cover Maps – MoE - FRL
Roads	JICA
Villages	Open Development Cambodia
Water bodies	Open Development Cambodia
Concessions (ELC – SLC – Dir 001)	Open Development Cambodia
~~Natural Protected Areas~~	~~Open Development Cambodia~~
~~REDD+ Projects Boundaries~~	~~Projects Developers – VERRA Registry~~

Methodology & Preliminary Results



	DEF 14/16	FOREST EDGE	VILLAGES	WATER	ROADS	CONCESSIONS
>5000	3.37	0.15	49.04	85.45	6.93	35.84
5000	1.05	0.10	4.86	1.61	1.27	3.42
4500	1.38	0.19	5.39	1.80	1.80	3.92
4000	1.73	0.20	5.49	1.66	2.19	4.22
3500	2.46	0.26	6.35	1.56	3.05	4.53
3000	3.78	0.46	6.69	1.56	4.14	5.17
2500	5.53	0.85	6.67	1.34	5.88	5.80
2000	8.80	1.90	6.21	1.35	9.66	6.82
1500	13.92	4.45	5.15	1.37	14.39	7.97
1000	23.29	14.30	3.32	1.38	23.77	9.91
500	34.70	77.13	0.82	0.91	26.92	12.41

Methodology & Preliminary Results



	DEF 14/16	FOREST EDGE	VILLAGES	WATER	ROADS	CONCESSIONS
500	4.53	2.83	3.05	1.25	2.14	2.76
1000	3.42	2.18	2.98	1.42	1.97	2.46
1500	2.90	1.91	2.82	1.50	1.84	2.34
2000	2.57	1.74	2.69	1.52	1.75	2.26
2500	2.34	1.63	2.61	1.55	1.66	2.19
3000	2.17	1.55	2.51	1.59	1.58	2.12
3500	2.03	1.49	2.42	1.62	1.52	2.06
4000	1.92	1.45	2.32	1.65	1.47	2.01
4500	1.83	1.42	2.25	1.69	1.43	1.97
5000	1.76	1.39	2.18	1.69	1.40	1.93

Methodology & Preliminary Results

- ✓ The last step durign the analysis is the selection of variables to be used in the Regression Model development.
- ✓ This step is based on the user experience and supported by informatioin derived from the previous analysis.
- ✓ The Deforestation Risk Map Tool, allow the user to run or modify the process as many times as needed, checking several times the best variables to be included in the analysis

Variables	Distance range	Deforestation rate	Deforestation explained
Historical Deforestation	0-2000m	2,6%	83.5%
Forest boundaries	0-500m	2,8%	77,13%
Villages	0-3000m	2,5%	28,9%
Roads	0-3500m	2,6%	16,9%
Concession areas	0-500m	2,8%	12,4%

Deforestation regression model

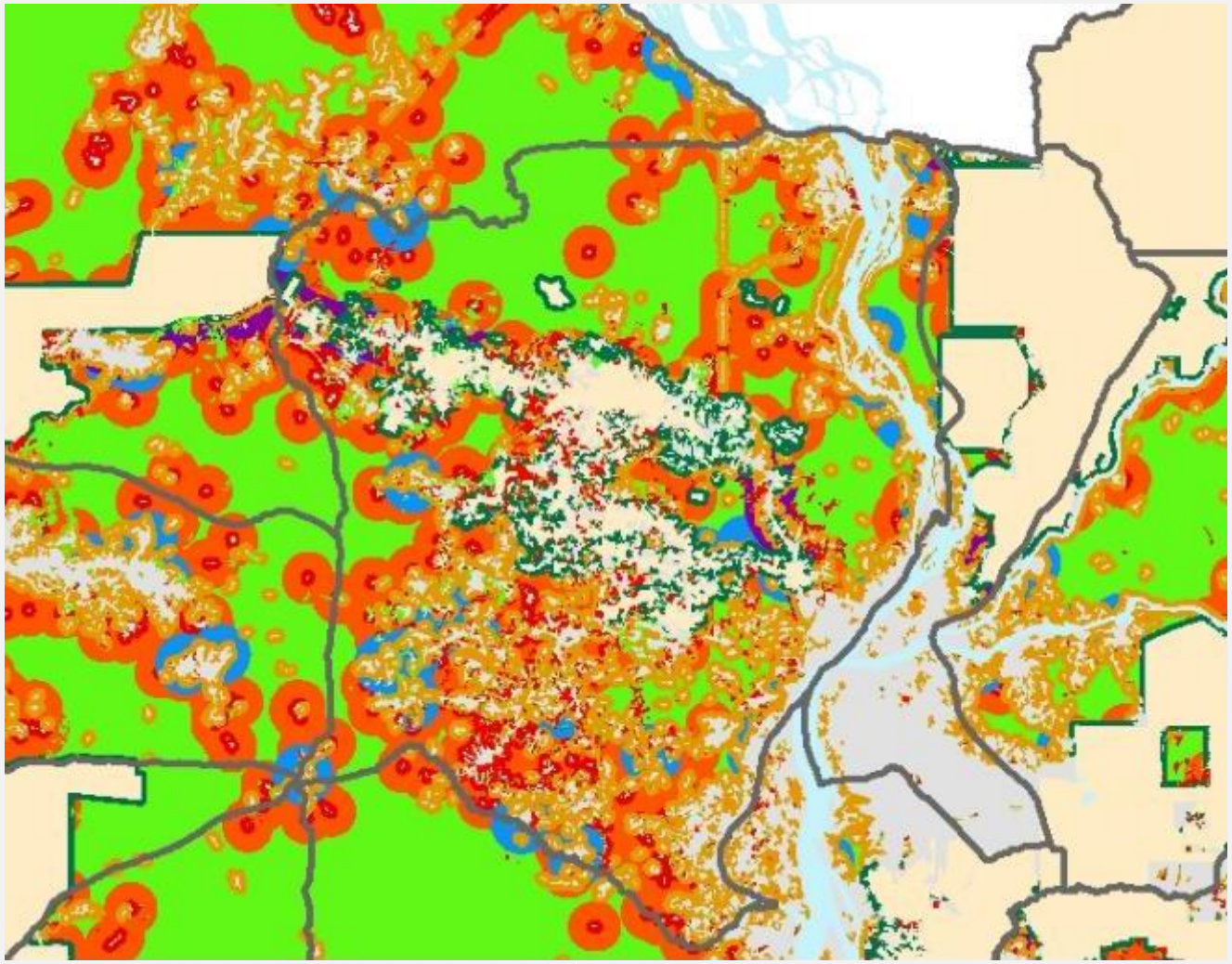
- ✓ To develop a regression model is needed to aggregate the data at a given spatial boundary division.
- ✓ We tested three different scales:
  - ✓ Province boundaries
  - ✓ Districts boundaries
  - ✓ 6x6 km regular grid based on the NFI sampling design.

- ✓ **The best fit of the models was at the District level.**

Methodology & Preliminary Results

The information is aggregated at the District level

- Districts
- Forest
- Water bodies
- Concessions
- Deforestation 16/18
- Roads (2000m)
- Villages (2500m)
- Deforestation 14/16 (500m)
- Deforestation 14/16 (2000m)
- Forest Boundaries 14/16 (500m)
- Concessions (500m)



Methodology & Preliminary Results

The information is aggregated at the District level

DISTRICT	Forest Area	Deforestation 16/18	Deforestation 14/16 2000m	Forest Boundaries 14/16 500m	Roads 3500m	Concessions 500m	Villages 3000m
A	1.494	20	972	1.093	54	1	427
B	3.788	202	2.342	1.365	1	1	99
C	4.450	50	1.449	3.478	197	161	814
D	753	3	421	697	88	414	573
E	272	5	69	266	240	1	266
F	4.064	413	1.852	1.930	1.732	1.083	526
G	1.460	174	489	1.266	131	658	370
H	4.370	263	2.192	2.912	402	89	797
I	133		6	137	73	20	93
J	3.924	136	2.236	3.547	505	26	2.226
K	9.879	53	3.091	5.361	1	1	1

Methodology & Preliminary Results

And the best combination of variables are selected using the Akaike Information Criteria (AIC).

Akaike information criterion (AIC) (Akaike, 1974) is a fined technique based on in-sample fit to estimate the likelihood of a model to predict/estimate the future values. A good model is the one that has minimum AIC among all the other models.

(Mohamemed, E.A; et al. 2015)

	1 Variable	AIC Value
1	rg_Concessions_500	1.965,65
2	rg_Def_14_16_2000	1.893,86
3	rg_No_Forest_16_500	1.909,53
4	rg_Roads_3500	2.049,42
5	rg_Villages2_3000	2.053,08
6	populationDensity	2.084,56

	2 Variables		AIC Value
1	rg_Concessions_500	_2000	1.895,68
2	rg_Concessions_500	est_16_500	1.906,14
3	rg_Concessions_500	rg_ _3500	1.967,21
4	rg_Concessions_500	rg_V ges2_3000	1.965,48
5	rg_Concessions_500		1.967,64
6	**rg_Def_14_16_2000**	**rg_No_Forest_16_500**	**1.890,48**
7	rg_Def_14_16_2000	rg_Roads_3500	1.895,72
8	rg_Def_14_16_2000	rg_Villages2_3000	1.895,86
9	rg_Def_14_16_2000	populationDensity	1.895,40
10	rg_No_Forest_16_500	rg_Roads_3500	1.909,26
11	rg_No_Forest_16_500	rg_Villages2_3000	1.905,79
12	rg_No_Forest_16_500	populationDensity	1.911,49
13	rg_Roads_3500	rg_Villages2_3000	2.041,90
14	rg_Roads_3500	populationDensity	2.051,40
15	rg_Villages2_3000	populationDensity	2.054,90

	3 Variables			AIC Value
1	rg_Concessions_500	rg_Def_14_16_2000	rg_No_Forest_16_500	1.892,41
2	rg_Concessions_500	rg_Def_14_16_2000	rg_Roads_3500	1.897,61
3	rg_Concessions_500	rg_Def_14_16_2000	rg_Villages2_3000	1.897,67
4	rg_Concessions_500	rg_Def_14_16_2000	populationDensity	1.897,21
5	rg_Concessions_500	rg_No_Forest_16_500	rg_Roads_3500	1.907,66
6	rg_Concessions_500	rg_No_Forest_16_500	rg_Villages2_3000	1.905,02
7	rg_Concessions_500	rg_No_Forest_16_500	populationDensity	1.908,02
8	rg_Concessions_500	rg_Roads_3500	rg_Villages2_3000	1.967,47
9	rg_Concessions_500	rg_Roads_3500	populationDensity	1.969,17
10	rg_Concessions_500	rg_Villages2_3000	populationDensity	1.967,23
11	rg_Def_14_16_2000	rg_No_Forest_16_500	rg_Roads_3500	1.892,27
12	rg_Def_14_16_2000	rg_No_Forest_16_500	rg_Villages2_3000	1.892,16
13	rg_Def_14_16_2000	rg_No_Forest_16_500	populationDensity	1.892,10
14	rg_Def_14_16_2000	rg_Roads_3500	rg_Villages2_3000	1.897,67
15	rg_Def_14_16_2000	rg_Roads_3500	populationDensity	1.897,17
16	rg_Def_14_16_2000	rg_Villages2_3000	populationDensity	1.897,38
17	rg_No_Forest_16_500	rg_Roads_3500	rg_Villages2_3000	1.907,58
18	rg_No_Forest_16_500	rg_Roads_3500	populationDensity	1.911,07
19	rg_No_Forest_16_500	rg_Villages2_3000	populationDensity	1.907,03
20	rg_Roads_3500	rg_Villages2_3000	populationDensity	2.043,53

Methodology & Preliminary Results

Once final variables are defined the Regression Model can be calc is run.

At this point is important to check the results deliver by the model, considering at least:

- The coefficients, are positive or negative?
- The confidence interval, do encompass negative and positive values?
- The significance of each variable

We must run the model as many times as needed, modifying the variables included and the distance ranges, until reach a statistically robust model:

Regression model obtained in the last update of the Cambodia FRL Allocation Options. March 2021

```
Call:
lm(formula = deforestationSurface ~ . + 0, data = mod3Results$regressionModel)

Residuals:
    Min      1Q  Median      3Q     Max
-494.36  -52.34  -17.45   -0.74  724.25

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
rg_def_14_16_2000    0.026393   0.006006   4.394 1.82e-05 ***
rg_non_forest_16_500 0.039399   0.012125   3.249  0.00136 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 142.5 on 195 degrees of freedom
Multiple R-squared:  0.7399,         Adjusted R-squared:  0.7373
F-statistic: 277.4 on 2 and 195 DF,  p-value: < 2.2e-16
```

Methodology & Preliminary Results

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```

Methodology & Preliminary Results

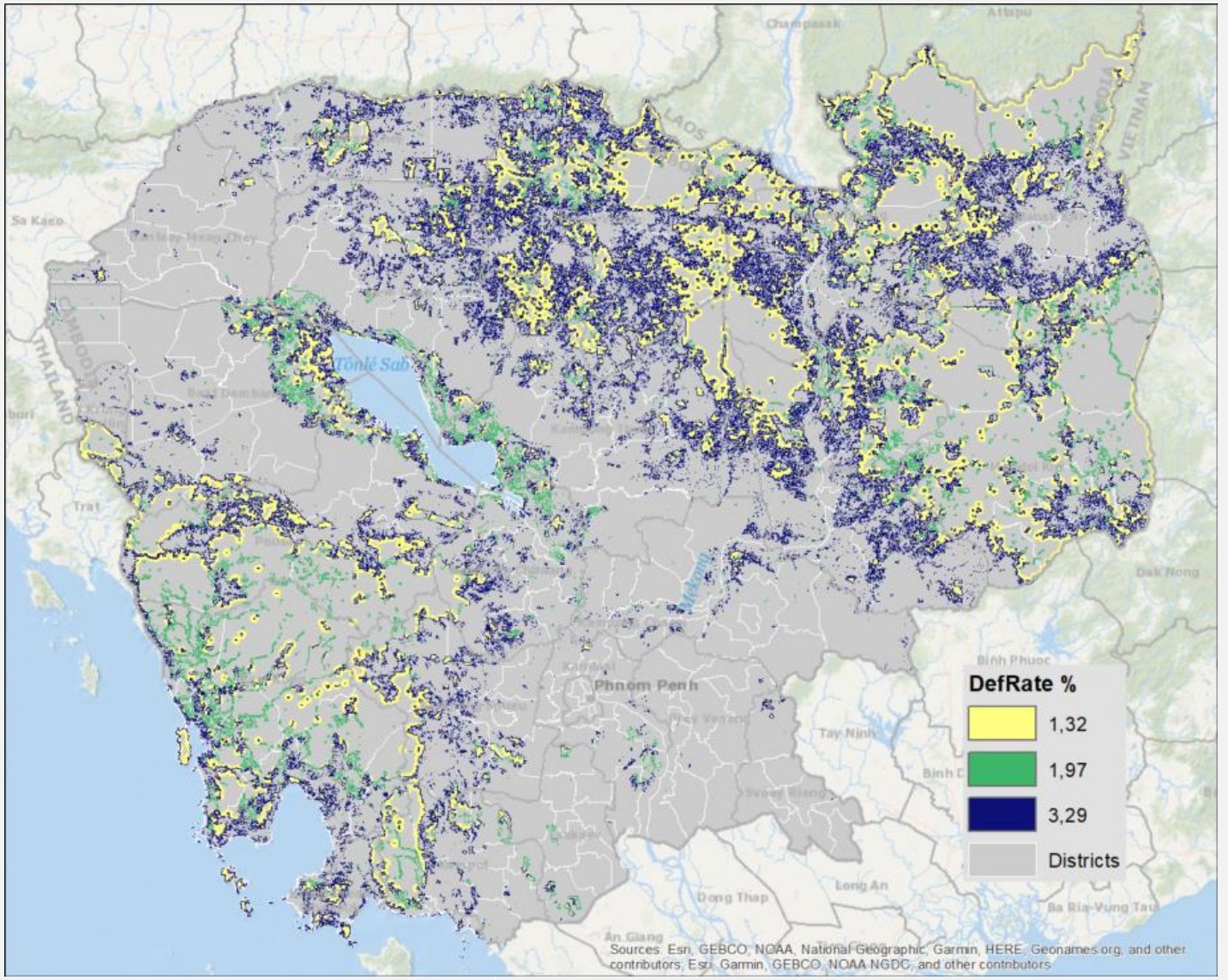
Once we get the Regression Model it must be applied, considering:

- The spatial resolution (100 m)
- The most recent data:
  - Updating the Forest Edge map (i.e., from 2016 to 2018)
  - Updating the Deforestation map (i.e., from 2014-2016 to 2014-2018)

Methodology & Preliminary Results

What is the result?

- We obtained a “Deforestation Model/Risk Map”
- Each cell value represent an estimation of:
  - Annual deforestation rate
  - Annual deforested area



Methodology & Preliminary Result

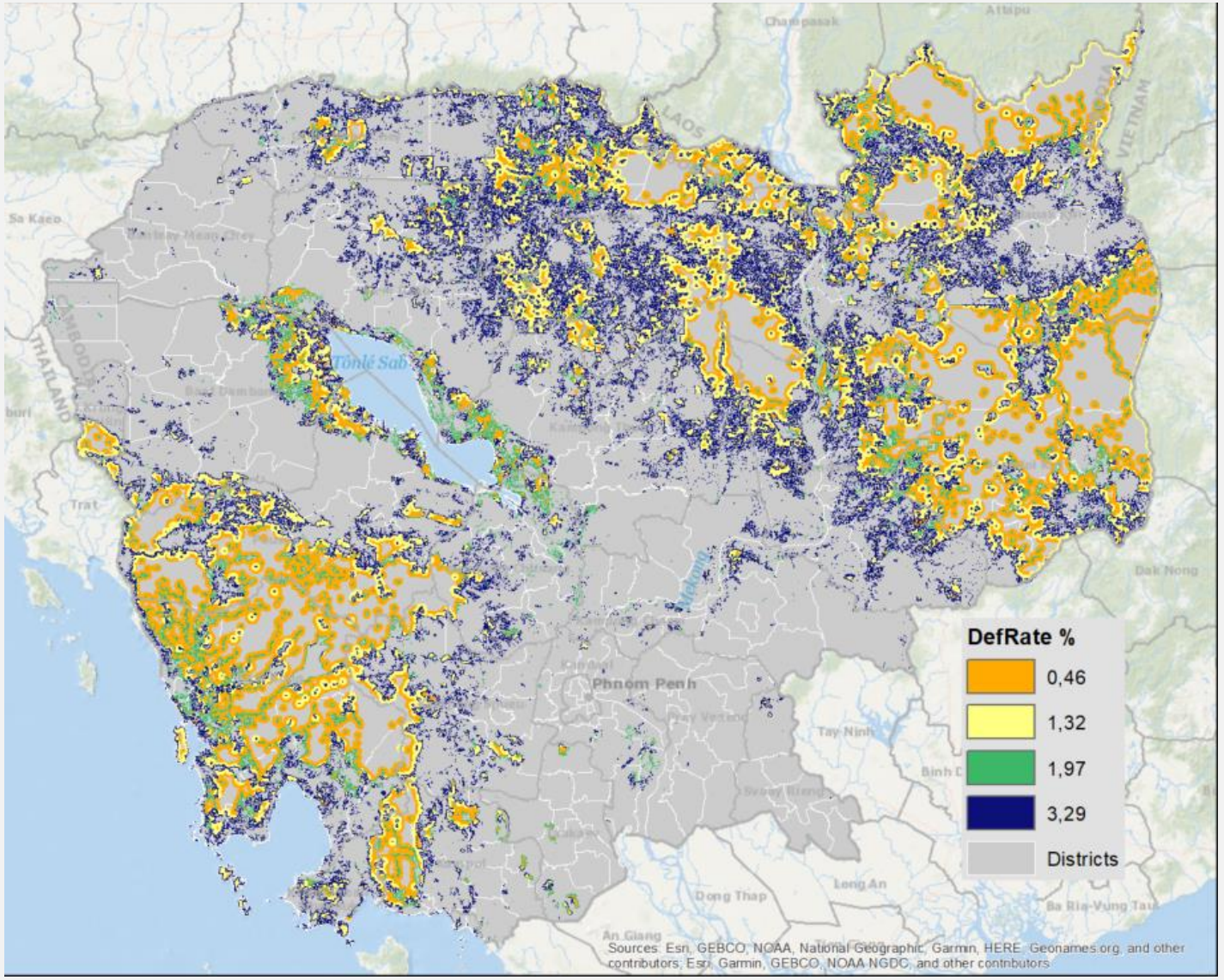
After several exchange with stakeholders and government a **Default Risk Class was created**.

- Considering the variables and distance selected and the spatial resolution of the result, 3,8 million ha of forest (47% of total forest) was located outside the model boundaries and no emissions were allocated to this forest area.
- Based on the data from 2016-2018, Deforestation within this area were 22.000 ha/year (8,6% of the total). However, VCS JNR recommendation is that the zero-risk class would represent 1% of historical deforestation.
- Therefore:
  - **The Zero-Risk Class** covering the 1% of deforestation in the 2016-2018 was identified as the area beyond 1.600m from the model boundaries. The forest area within this class was 1.688.604 ha.
  - The **Default Risk Class** was established for the forest area within a maximum distance of 1.600m from the model boundaries (2.110.020 ha), applying a 0,46% deforestation rate

Methodology & Preliminary Result

Default deforestation rate category

The result is very similar to the previous one, but with this update, there are a larger area of forest where the FRL will be allocated.



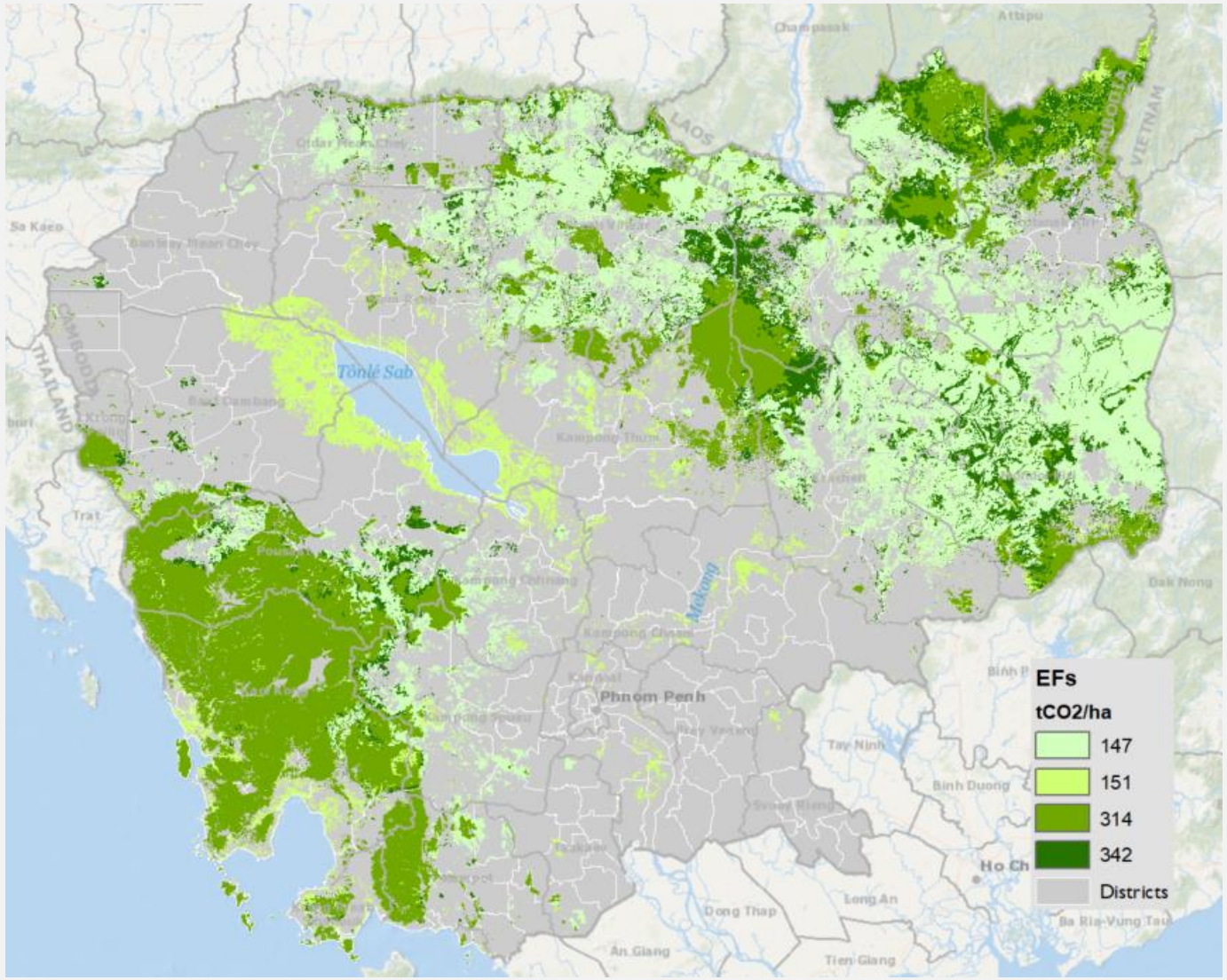
Methodology & Preliminary Result

Integrating carbon stock

In the following step the estimated deforested area is combined with the carbon stock of the corresponding forest type.

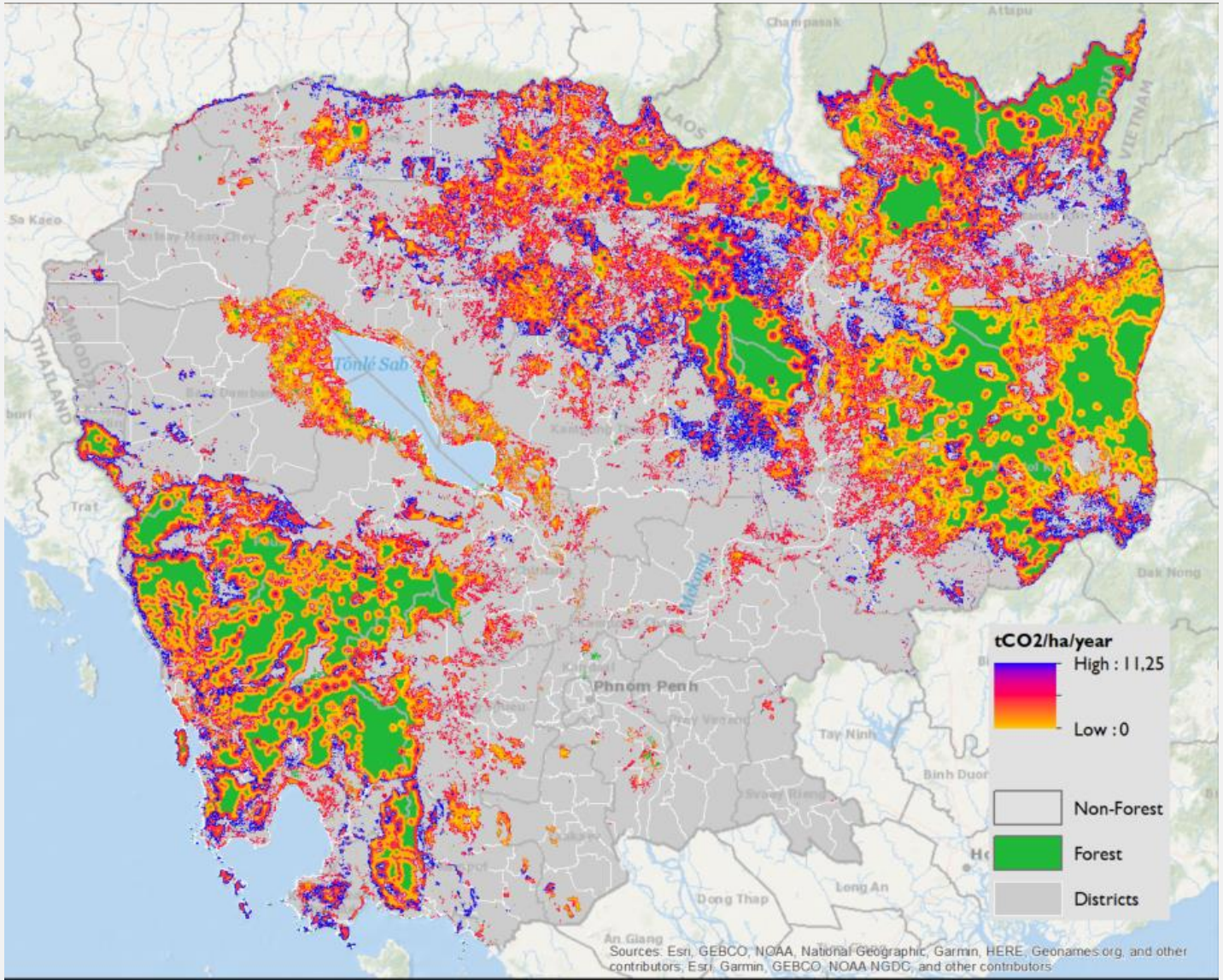
Carbon stock used in the FREL were used:

- Deciduous Forest: 147 tCO2ha
- Other Forest: 151 tCO2ha
- Evergreen Forest: 314 tCO2ha
- Semi-evergreen Forest: 342 tCO2ha



Methodology & Preliminary Result

Combining expected deforestation and carbon stock we can estimate annual expected GHG emissions at a 100m spatial resolution for the whole country



Methodology & Preliminary Result

To estimate the proportion of emissions estimated for each project the ArcGIS Zonal Statistics as a Table Tool was used.

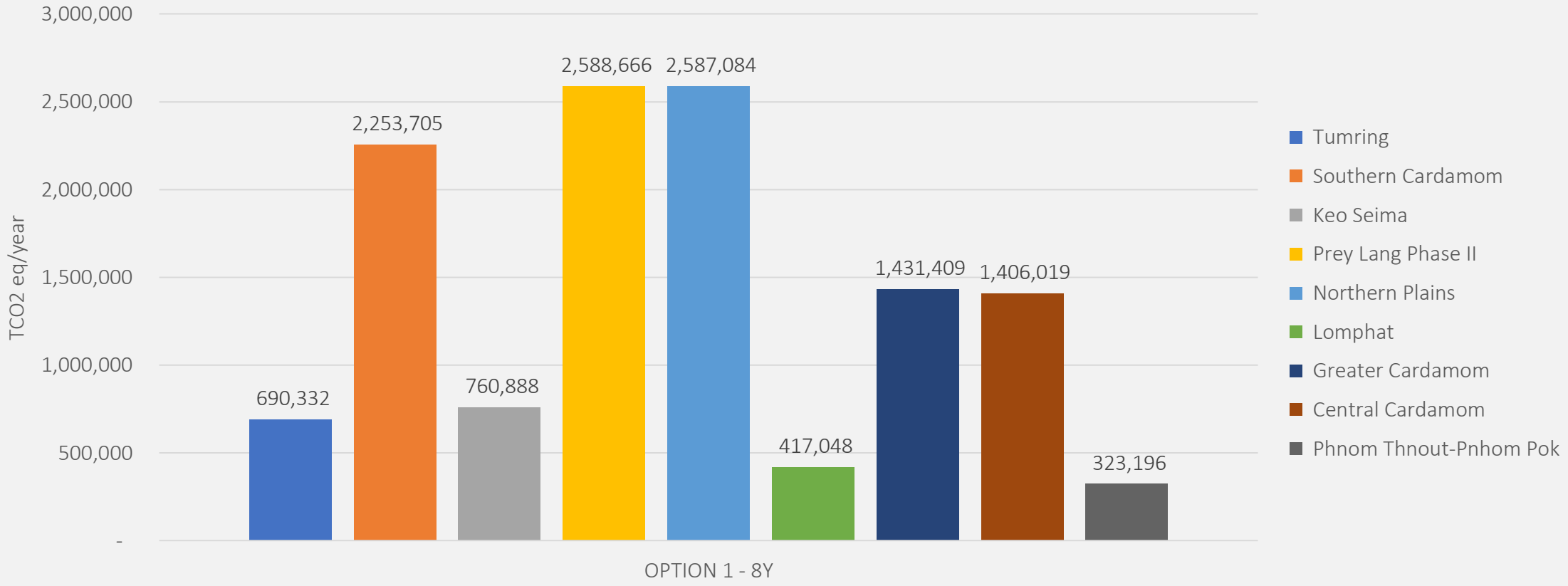
Finally, this estimation is used to weight the percentage of the total FRL Allocated to each project.

PROJECT	Total Area (ha)	Estimated Emissions (tCO2eq/year)	% of the National estimated	FRL Deforestation (t CO2eq/year)	Uncertainty (%)	Emissions to Allocate (t CO2eq/year)	Allocation results (t CO2eq/year)
Tumring	67,791.17	**322,762.00**	1.29%	60,257,501	10.98%	53,638,914	**690,332.4**
Southern Cardamom	493,548.64	**1,053,710.00**	4.20%				**2,253,704.5**
Keo Seima	166,983.40	**355,750.00**	1.42%				**760,888.1**
Prey Lang Phase II	431,607.61	**1,210,320.00**	4.83%				**2,588,666.4**
Northern Plains	477,296.07	**1,209,580.00**	4.82%				**2,587,083.7**
Lomphat	184,169.05	**194,989.00**	0.78%				**417,047.9**
Greater Cardamom	309,870.00	**669,249.00**	2.67%				**1,431,408.6**
Central Cardamom	401,065.40	**657,378.00**	2.62%				**1,406,018.5**
Phnom Thnout	42,097.10	**151,109.00**	0.60%				**323,196.2**
Rest of the Country	15,628,683.00	**19,253,800.00**	77.38%				**41,180,568.1**
Cambodia	18,203,111	**25,078,647**	100.00%				**53,638,914.5**

Methodology & Preliminary Result

To estimate the proportion of emissions estimated for each project the ArcGIS Zonal Statistics as a Table Tool was used.

Finally, this estimation is used to weight the percentage of the total FRL Allocated to each project.



Deforestation Risk Map Tool Installation

Deforestation Risk Map Tool Installation

Click the link to download the Installation Manual:
https://github.com/JavierCanoMartin/Allocation_Training/raw/main/Installation%20Manual.pdf

Deforestation Risk Map Tool Application

Deforestation Risk Map Tool Application

Click the link to download the User Manual:
https://github.com/JavierCanoMartin/Allocation_Training/raw/main/User%20Manual.pdf

Next steps

Next steps

Individual assessment – July 9th to 14th

Participants are encouraged to analyse in detail the tool and methodology to identify potential findings and improvements.

It is suggested to participants, to share the findings and proposals with the working group using the systems prepared by the organization.

Improvement Options – July 15th, 2-6PM

Stakeholders will present the potential findings identified and the improvement proposals during the individual analysis.

All proposals will be discussed in a round table to reach an agreement of improvements to be implemented and to define the arrangements to run the process.

Cambodia Nesting System – Forest Reference Level Allocation Options

Training of Trainers – Deforestation Risk Map Methodology & Tool

JavierCano

Thank you very much

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