

## ANALYSIS OF FRL ALLOCATION OPTIONS

March 2021 – Javier Cano

### INTRODUCTION

The following analysis presents 16 different options to allocate the Cambodia National Updated FRL.

In all the cases, the analysis is based on the Deforestation Risk Map Methodology described in the document: “Options to Allocate the FREL Draft Report”, delivered on October 31<sup>st</sup>, 2020.

The options analysed are based on the combination of 4 variations (

Table I):

- Stratification of deforestation typology; considering:
  - the segregation of Planned and Unplanned deforestation, or
  - the application of the Unplanned deforestation method over the total area in the country.
- Default deforestation risk rate; considering:
  - Not emissions allocated to the forest area outside the boundaries estimated by the regression model used to develop the Deforestation Risk Map.
  - The application of a default risk rate estimated considering the historical deforestation rate in the forest area outside the boundaries considered by the Deforestation Risk Map.
- Forest edge data source; considering:
  - The original Forest Cover Map developed by the Ministry of Environment (MoE)
  - A refined dataset by merging the MoE Forest Cover Map and the JICA Roads Map.
- Emission factors (EFs) used, considering:
  - National EFs used in the National Updated FRL
  - A combination of National EFs for the forest area outside REDD+ projects and Local EFs for the REDD+ projects area.<sup>1</sup>

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<sup>1</sup> Data was derived from VCS Project Description Documents and the National EFs Database. In the case of Prey Lang, the data was derived from the document “Report on the Plot survey in the Prey Long area”.

Table 1. Combination of different variations analysed.

OPTION	Deforestation Stratification	Default Def. Rate	Forest Edge data source	Emission Factors
1	Planned & Unplanned	Def rate: 0%	MoU Forest Cover Map	National EFs
2	Unplanned	Def rate: 0%	MoU Forest Cover Map	National EFs
3	Planned & Unplanned	Def rate: 0,17%	MoU Forest Cover Map	National EFs
4	Unplanned	Def rate: 0,23%	MoU Forest Cover Map	National EFs
5	Planned & Unplanned	Def rate: 0%	Refined data using JICA Roads	National EFs
6	Unplanned	Def rate: 0%	Refined data using JICA Roads	National EFs
7	Planned & Unplanned	Def rate: 0,16%	Refined data using JICA Roads	National EFs
8	Unplanned	Def rate: 0,22%	Refined data using JICA Roads	National EFs
1B	Planned & Unplanned	Def rate: 0%	MoU Forest Cover Map	Local EFs for projects area
2B	Unplanned	Def rate: 0%	MoU Forest Cover Map	Local EFs for projects area
3B	Planned & Unplanned	Def rate: 0,17%	MoU Forest Cover Map	Local EFs for projects area
4B	Unplanned	Def rate: 0,23%	MoU Forest Cover Map	Local EFs for projects area
5B	Planned & Unplanned	Def rate: 0%	Refined data using JICA Roads	Local EFs for projects area
6B	Unplanned	Def rate: 0%	Refined data using JICA Roads	Local EFs for projects area
7B	Planned & Unplanned	Def rate: 0,16%	Refined data using JICA Roads	Local EFs for projects area
8B	Unplanned	Def rate: 0,22%	Refined data using JICA Roads	Local EFs for projects area

Following, the allocation results obtained by REDD+ project using each of the options are presented.

## OPTIONS 1 and 1B:

This option follows the original allocation method proposed in the document “Options to Allocate the FREL Draft Report” from October 2020. Including the following:

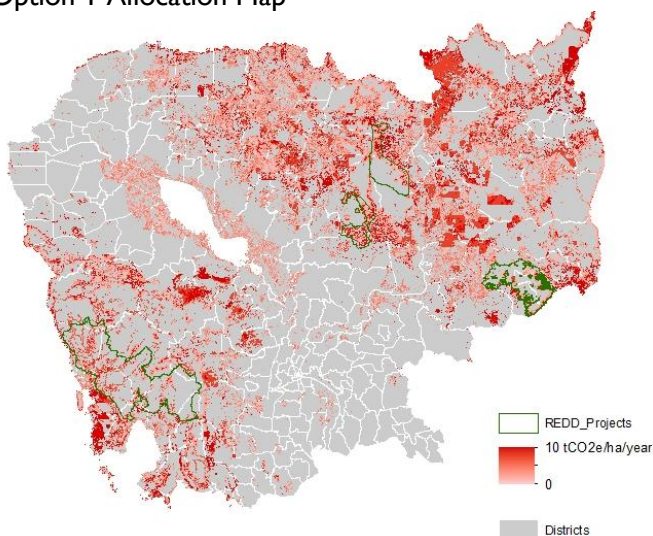
- Deforestation risk are estimated separately between Planned (inside concessions) and Unplanned.
- For Planned Deforestation, the annual deforestation rate by concession type was estimated for the period 2014-2018, and then applied for the crediting period over the forest inside concessions, by concession type, at a 1 ha scale.
- For Unplanned Deforestation, a regression model based on a spatial statistical analysis, was applied to project future potential deforested area by hectare.
  - The variables analysed were: Historical Deforestation, Forest Edge, Concessions, Roads (JICA), Villages, Rivers and Population Density.
  - The best model obtained was the combination between Historical Deforestation and Forest Edge.
- Both results were merge and multiplied by the carbon stock.
- Finally, the allocation equation included in the “Options to Allocate the FREL Draft Report” was applied.

In Option 1 the carbon stocks were derived from the national EFs.

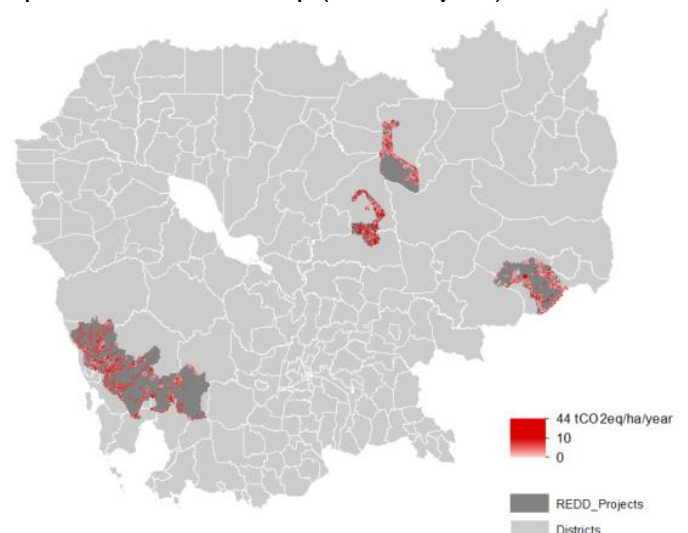
In Option 1b the carbon stocks for areas inside REDD+ projects were derived from the specific field data inventory

In the following figure the spatial distribution of allocation is shown for both options.

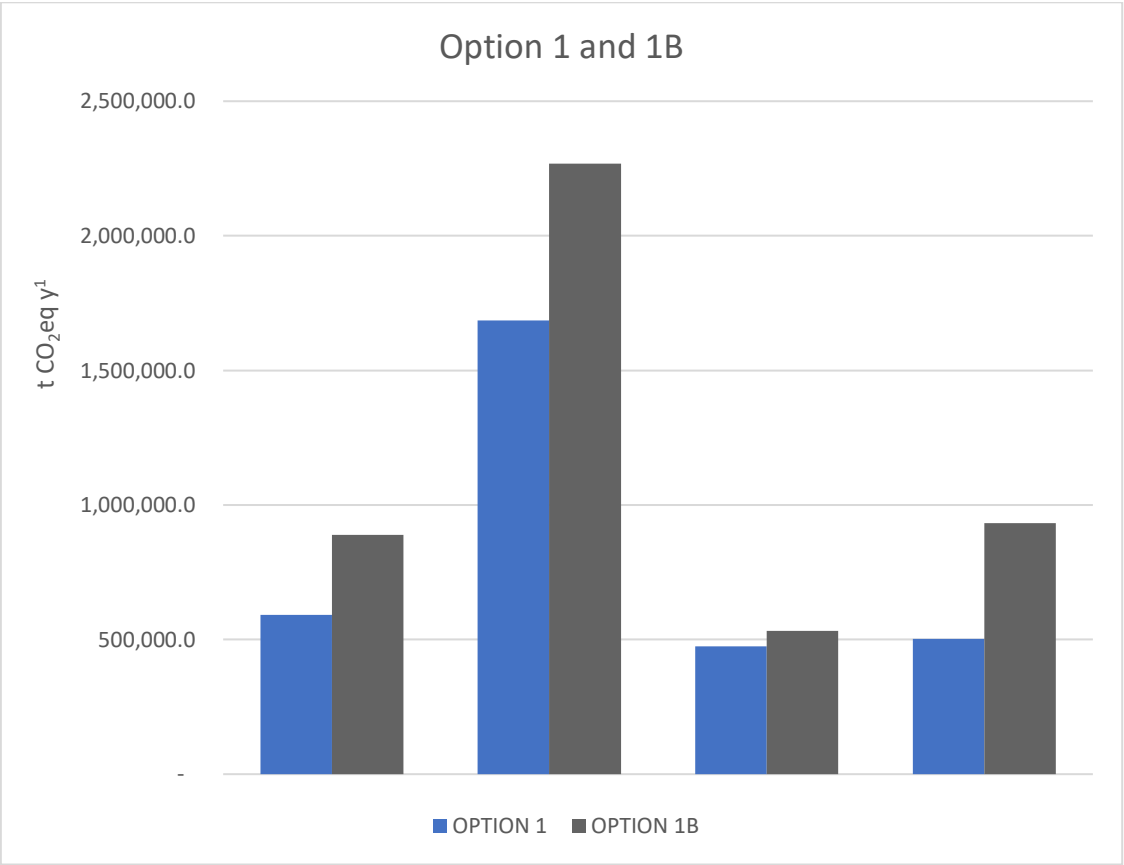
Option 1 Allocation Map



Option 1b Allocation Map (Redd Projects)



In the following chart and table, the results of the options I and Ib are detailed by project and comparing with the original baseline (in red) and the original baseline adjust to the current National FRL (in blue)



## OPTIONS 2 and 2B:

This option follows a variation from the allocation method proposed in the document “Options to Allocate the FREL Draft Report” from October 2020. Including the following:

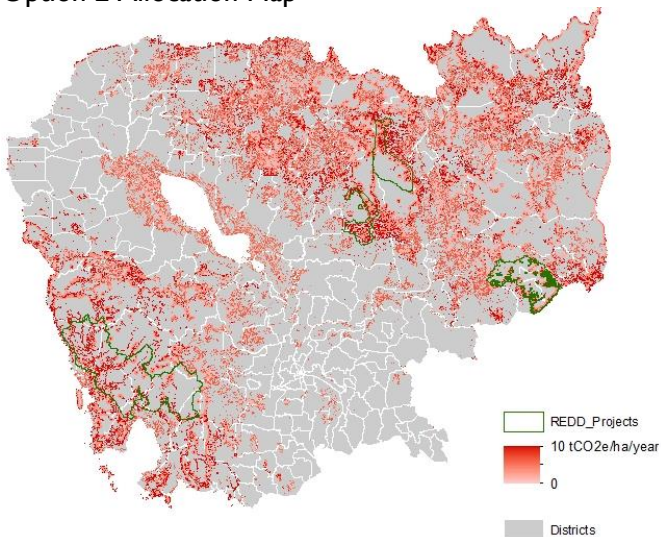
- Deforestation risk are estimated using the Unplanned Deforestation methodology for the total forest area in the country.
- A regression model based on a spatial statistical analysis, was applied to project future potential deforested area by hectare.
  - The variables analysed were: Historical Deforestation, Forest Edge, Concessions, Roads (JICA), Villages, Rivers and Population Density.
  - The best model obtained was the combination between Historical Deforestation and Forest Edge.
- Finally, the allocation equation included in the “Options to Allocate the FREL Draft Report” was applied.

In Option 2 the carbon stocks were derived from the national EFs.

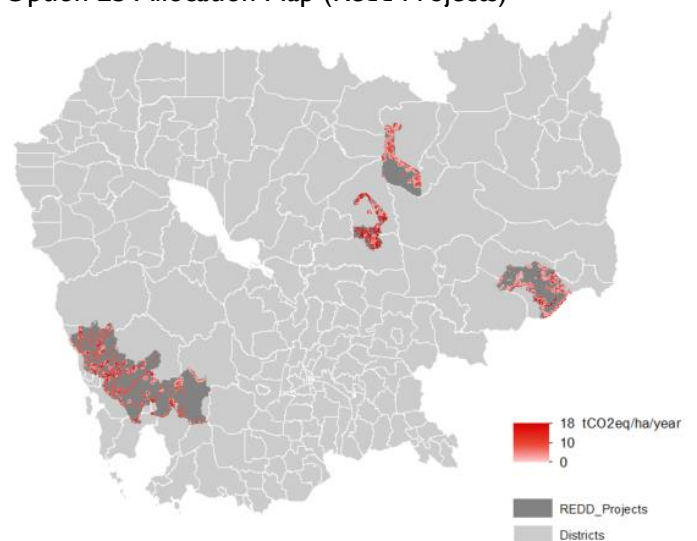
In Option 2b the carbon stocks for areas inside REDD+ projects were derived from the specific field data inventory

In the following figure the spatial distribution of allocation is shown for both options.

Option 2 Allocation Map



Option 2b Allocation Map (Redd Projects)



In the following chart and table, the results of the options 1 and 1b are detailed by project and comparing with the original baseline (in red) and the original baseline adjust to the current National FRL (in blue)



### OPTIONS 3 and 3B:

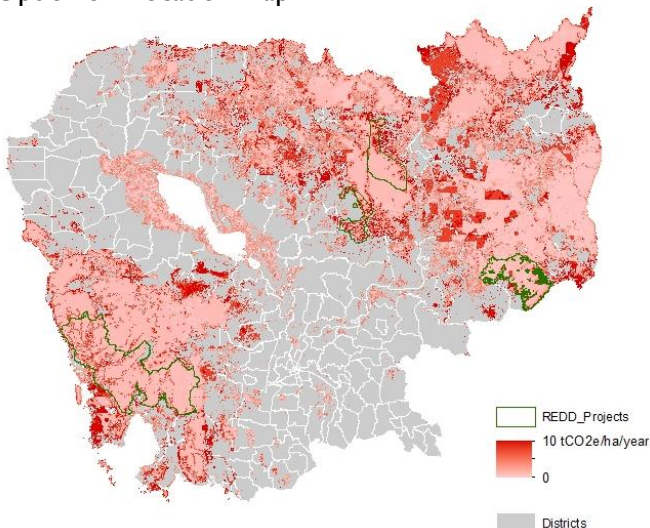
This option follows a variation from the original allocation method proposed in the document “Options to Allocate the FREL Draft Report” from October 2020. Including the following:

- Deforestation risk are estimated separately between Planned (inside concessions) and Unplanned.
- For Planned Deforestation, the annual deforestation rate by concession type was estimated for the period 2014-2018, and then applied for the crediting period over the forest inside concessions, by concession type, at a 1 ha scale.
- For Unplanned Deforestation, a regression model based on a spatial statistical analysis, was applied to project future potential deforested area by hectare.
  - The variables analysed were: Historical Deforestation, Forest Edge, Concessions, Roads (JICA), Villages, Rivers and Population Density.
  - The best model obtained was the combination between Historical Deforestation and Forest Edge.
- Both results were merge and multiplied by the carbon stock.
- A default deforestation rate ( $0.17\% \text{ year}^{-1}$ ) was estimated for the forest originally classified without risk by the regression model.
- Finally, the allocation equation included in the “Options to Allocate the FREL Draft Report” was applied.

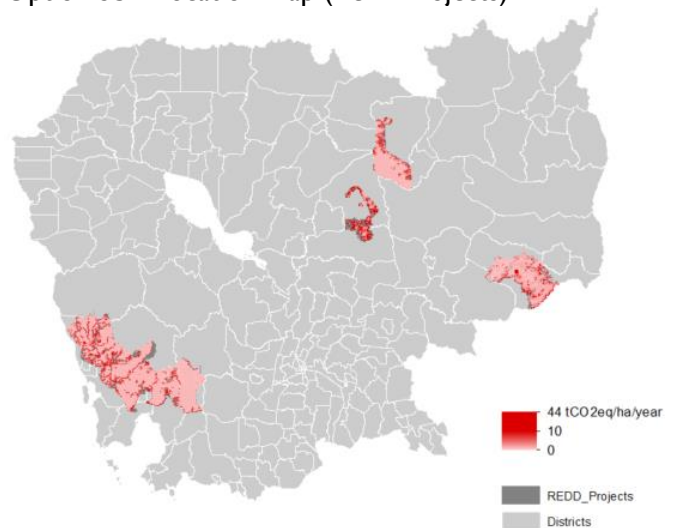
In Option 3 the carbon stocks were derived from the national EFs.

In Option 3b the carbon stocks for areas inside REDD+ projects were derived from the specific field data inventory

Option 3 Allocation Map

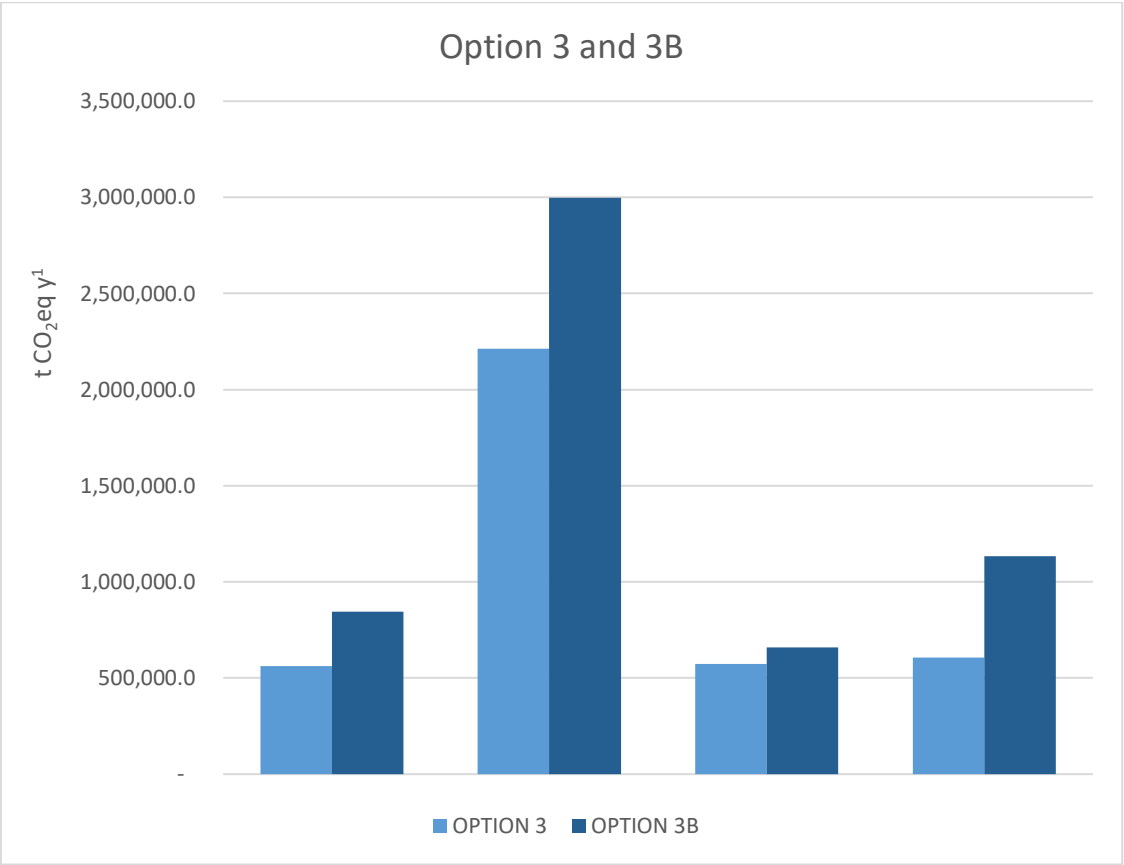


Option 3b Allocation Map (Redd Projects)





In the following chart and table, the results of the options I and Ib are detailed by project and comparing with the original baseline (in red) and the original baseline adjust to the current National FRL (in blue)



## OPTIONS 4 and 4B:

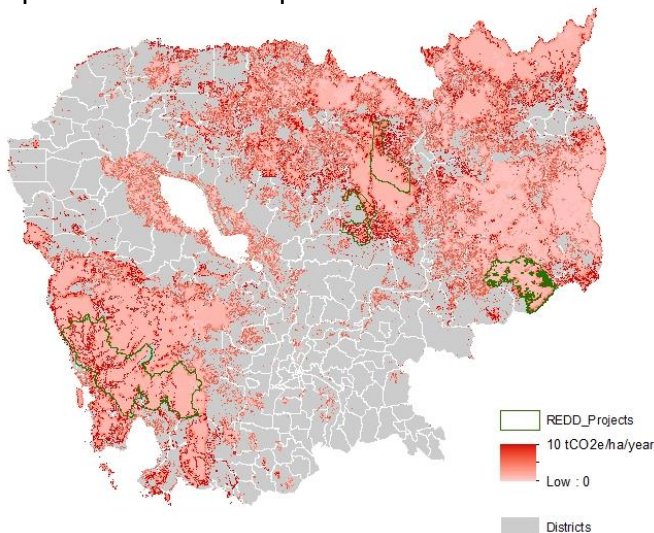
This option follows a variation from the original allocation method proposed in the document “Options to Allocate the FREL Draft Report” from October 2020. Including the following:

- Deforestation risk are estimated using the Unplanned Deforestation methodology for the total forest area in the country.
- A regression model based on a spatial statistical analysis, was applied to project future potential deforested area by hectare.
  - The variables analysed were: Historical Deforestation, Forest Edge, Concessions, Roads (JICA), Villages, Rivers and Population Density.
  - The best model obtained was the combination between Historical Deforestation and Forest Edge.
- Both results were merge and multiplied by the carbon stock.
- A default deforestation rate (0.23% year<sup>-1</sup>) was estimated for the forest originally classified without risk by the regression model.
- Finally, the allocation equation included in the “Options to Allocate the FREL Draft Report” was applied.

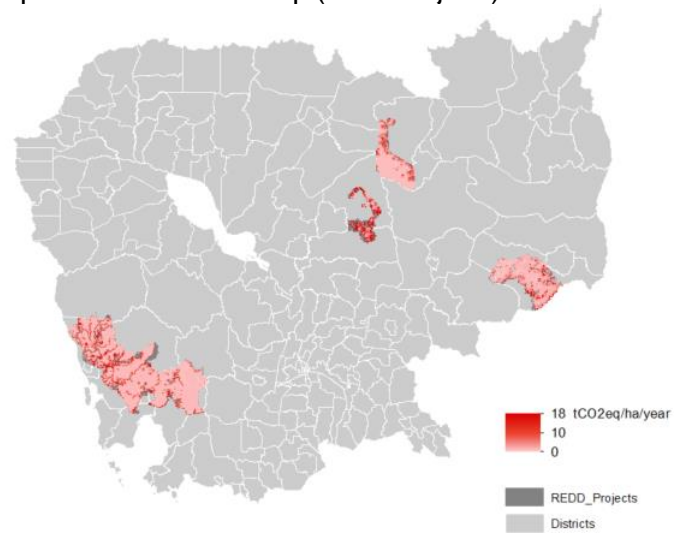
In Option 4 the carbon stocks were derived from the national EFs.

In Option 4b the carbon stocks for areas inside REDD+ projects were derived from the specific field data inventory

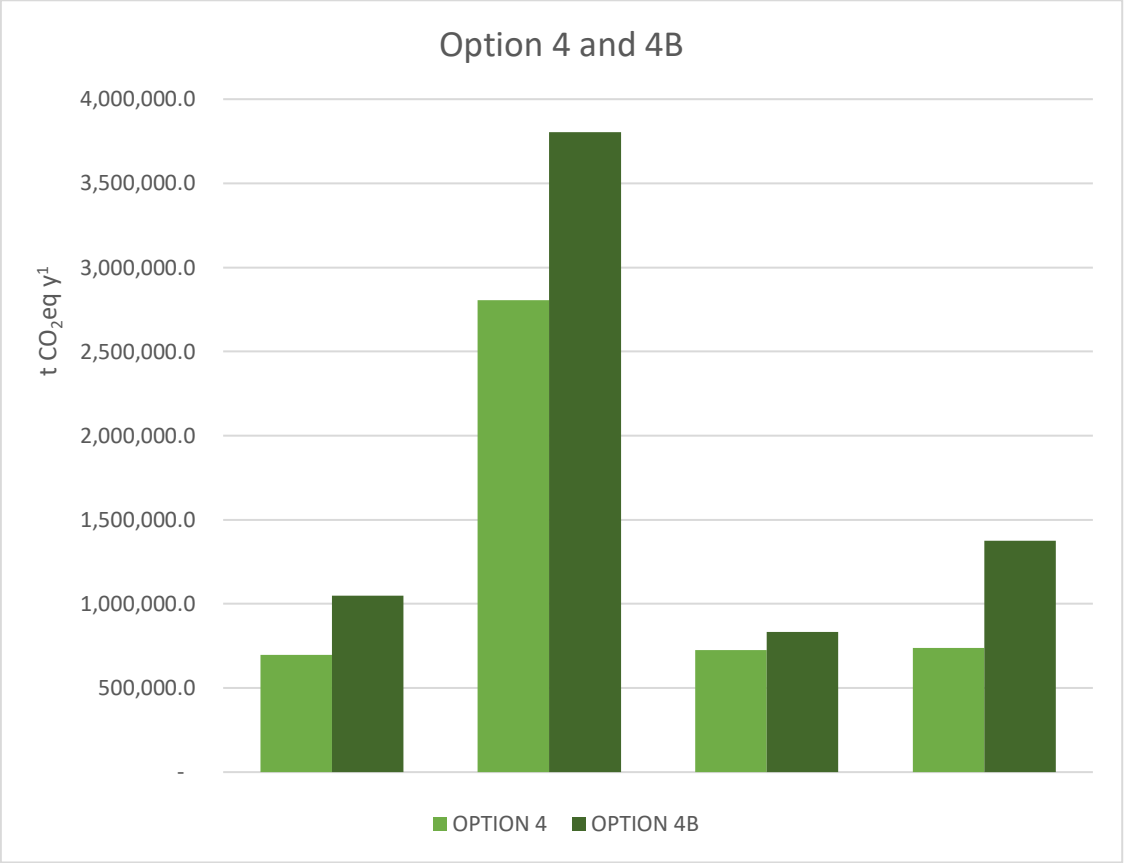
Option 4 Allocation Map



Option 4b Allocation Map (Redd Projects)



In the following chart and table, the results of the options I and Ib are detailed by project and comparing with the original baseline (in red) and the original baseline adjust to the current National FRL (in blue)



## OPTIONS 5 and 5B:

This option follows the original allocation method proposed in the document “Options to Allocate the FREL Draft Report” from October 2020. Including the following:

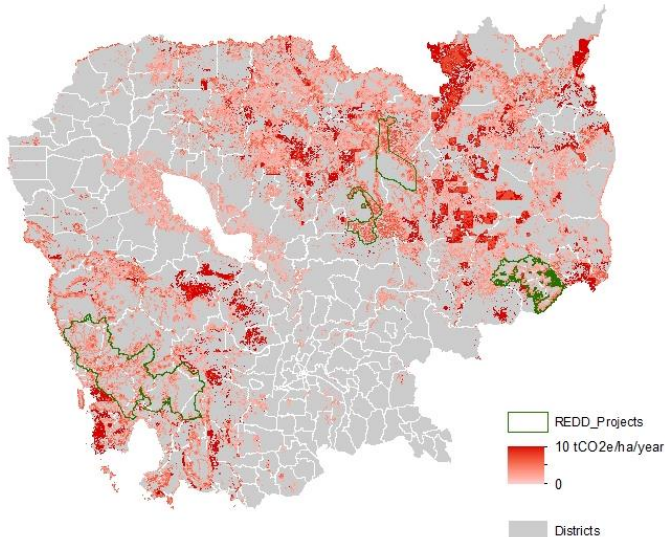
- Deforestation risk are estimated separately between Planned (inside concessions) and Unplanned.
- For Planned Deforestation, the annual deforestation rate by concession type was estimated for the period 2014-2018, and then applied for the crediting period over the forest inside concessions, by concession type, at a 1 ha scale.
- For Unplanned Deforestation, a regression model based on a spatial statistical analysis, was applied to project future potential deforested area by hectare.
  - The variables analysed were: Historical Deforestation, Forest Edge Adjusted with JICA Roads, Concessions, Roads (JICA), Villages, Rivers and Population Density.
  - The best model obtained was the combination between Historical Deforestation and Forest Edge Adjusted with JICA Roads.
- Both results were merge and multiplied by the carbon stock.
- Finally, the allocation equation included in the “Options to Allocate the FREL Draft Report” was applied.

In Option 5 the carbon stocks were derived from the national EFs.

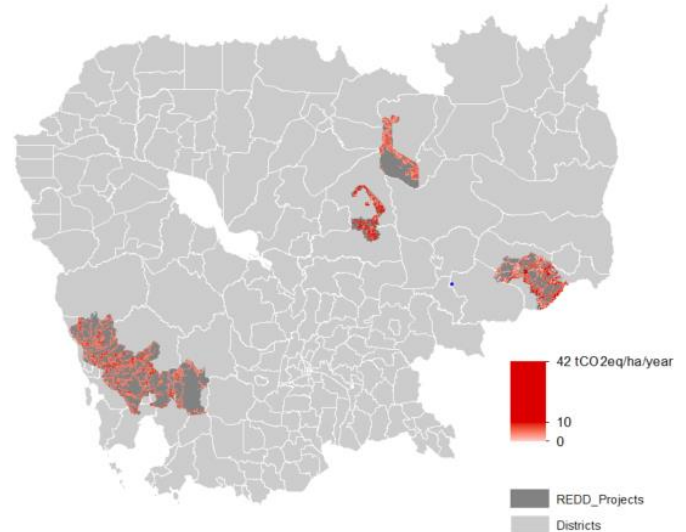
In Option 5b the carbon stocks for areas inside REDD+ projects were derived from the specific field data inventory

In the following figure the spatial distribution of allocation is shown for both options.

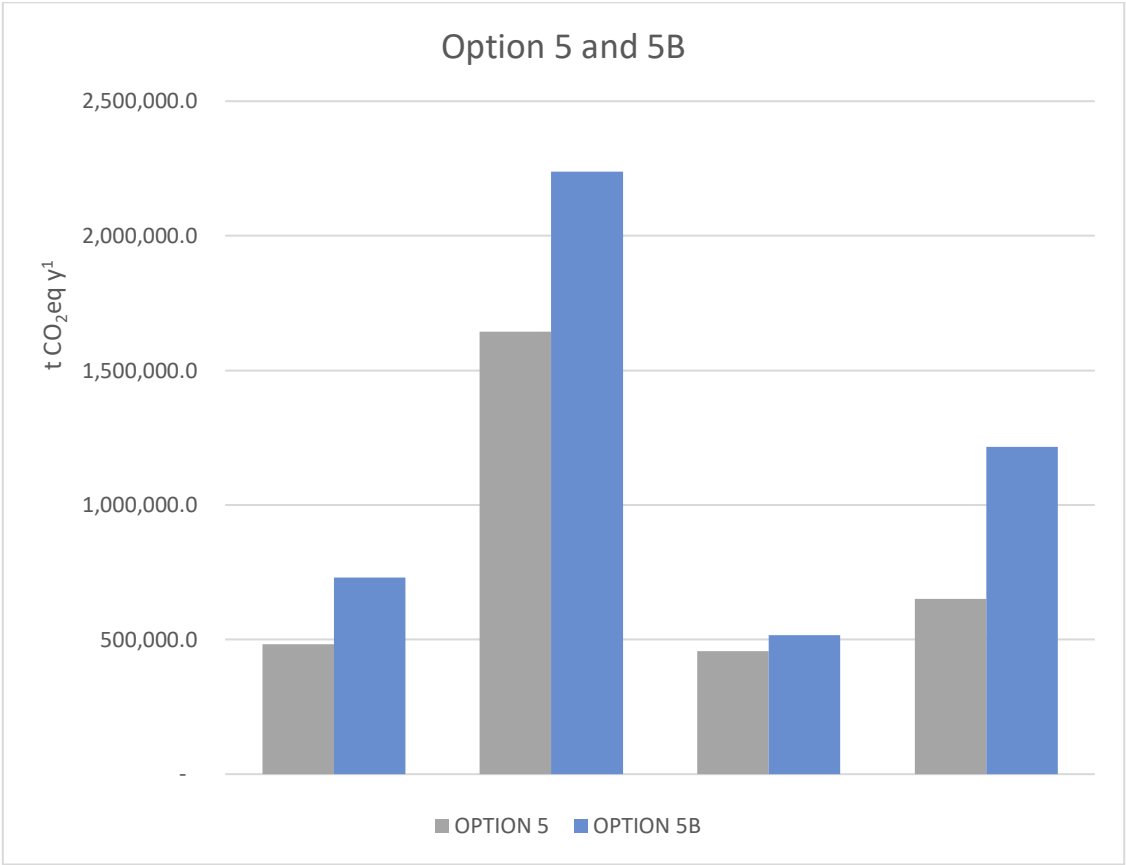
Option 5 Allocation Map



Option 5b Allocation Map (Redd Projects)



In the following chart and table, the results of the options I and Ib are detailed by project and comparing with the original baseline (in red) and the original baseline adjust to the current National FRL (in blue)



## OPTIONS 6 and 6B:

This option follows a variation from the allocation method proposed in the document “Options to Allocate the FREL Draft Report” from October 2020. Including the following:

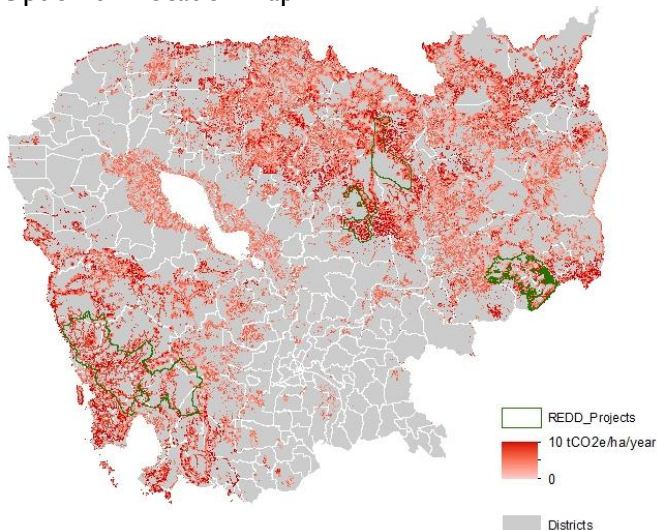
- Deforestation risk are estimated using the Unplanned Deforestation methodology for the total forest area in the country.
- A regression model based on a spatial statistical analysis, was applied to project future potential deforested area by hectare.
  - The variables analysed were: Historical Deforestation, Forest Edge Adjusted with JICA Roads, Concessions, Roads (JICA), Villages, Rivers and Population Density.
  - The best model obtained was the combination between Historical Deforestation and Forest Edge Adjusted with JICA Roads.
- Finally, the allocation equation included in the “Options to Allocate the FREL Draft Report” was applied.

In Option 6 the carbon stocks were derived from the national EFs.

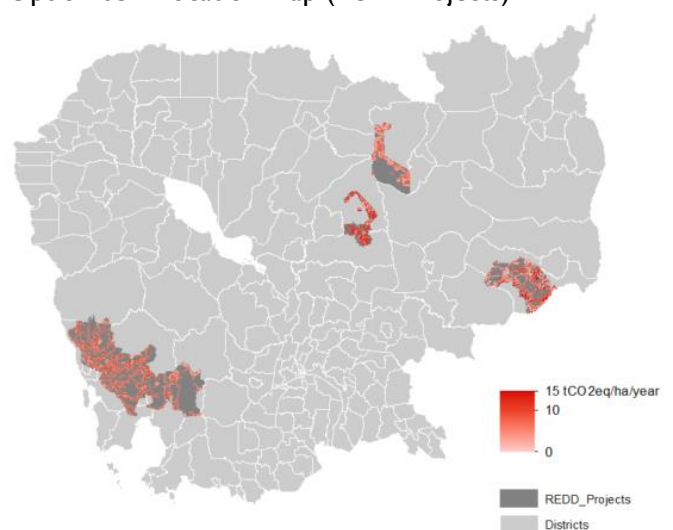
In Option 6b the carbon stocks for areas inside REDD+ projects were derived from the specific field data inventory

In the following figure the spatial distribution of allocation is shown for both options.

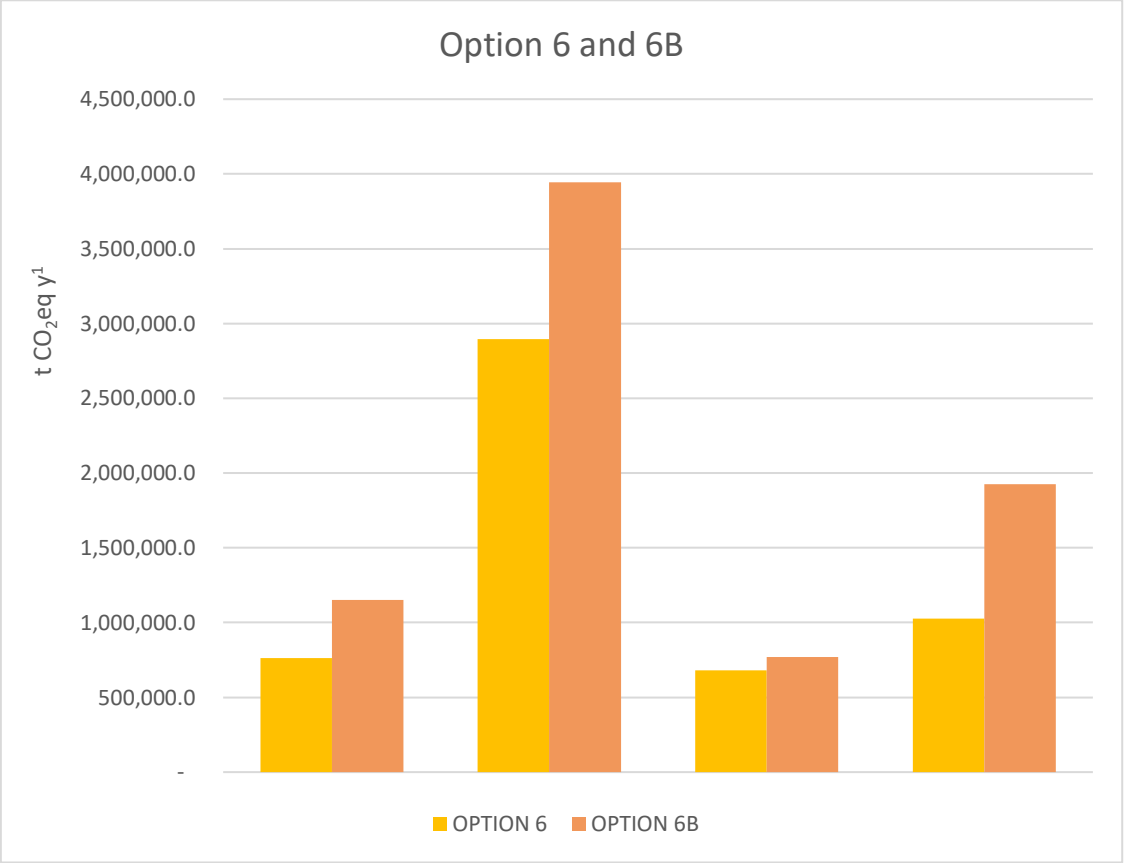
Option 6 Allocation Map



Option 6b Allocation Map (Redd Projects)



In the following chart and table, the results of the options I and Ib are detailed by project and comparing with the original baseline (in red) and the original baseline adjust to the current National FRL (in blue)





## OPTIONS 7 and 7B:

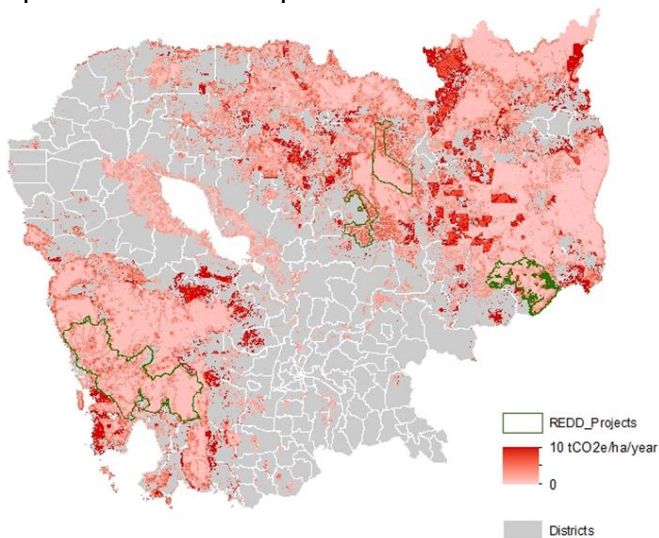
This option follows a variation from the original allocation method proposed in the document “Options to Allocate the FREL Draft Report” from October 2020. Including the following:

- Deforestation risk are estimated separately between Planned (inside concessions) and Unplanned.
- For Planned Deforestation, the annual deforestation rate by concession type was estimated for the period 2014-2018, and then applied for the crediting period over the forest inside concessions, by concession type, at a 1 ha scale.
- For Unplanned Deforestation, a regression model based on a spatial statistical analysis, was applied to project future potential deforested area by hectare.
  - The variables analysed were: Historical Deforestation, Forest Edge Adjusted with JICA Roads, Concessions, Roads (JICA), Villages, Rivers and Population Density.
  - The best model obtained was the combination between Historical Deforestation and Forest Edge Adjusted with JICA Roads.
- Both results were merge and multiplied by the carbon stock.
- A default deforestation rate (0.16% year<sup>-1</sup>) was estimated for the forest originally classified without risk by the regression model.
- Finally, the allocation equation included in the “Options to Allocate the FREL Draft Report” was applied.

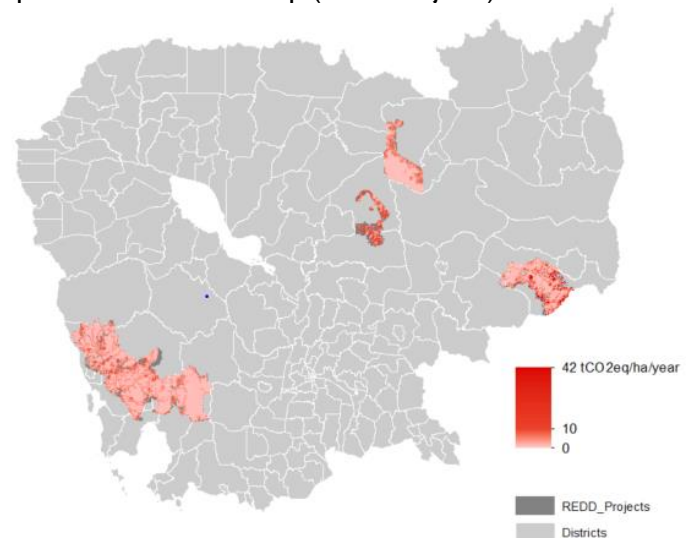
In Option 7 the carbon stocks were derived from the national EFs.

In Option 7b the carbon stocks for areas inside REDD+ projects were derived from the specific field data inventory

Option 7 Allocation Map

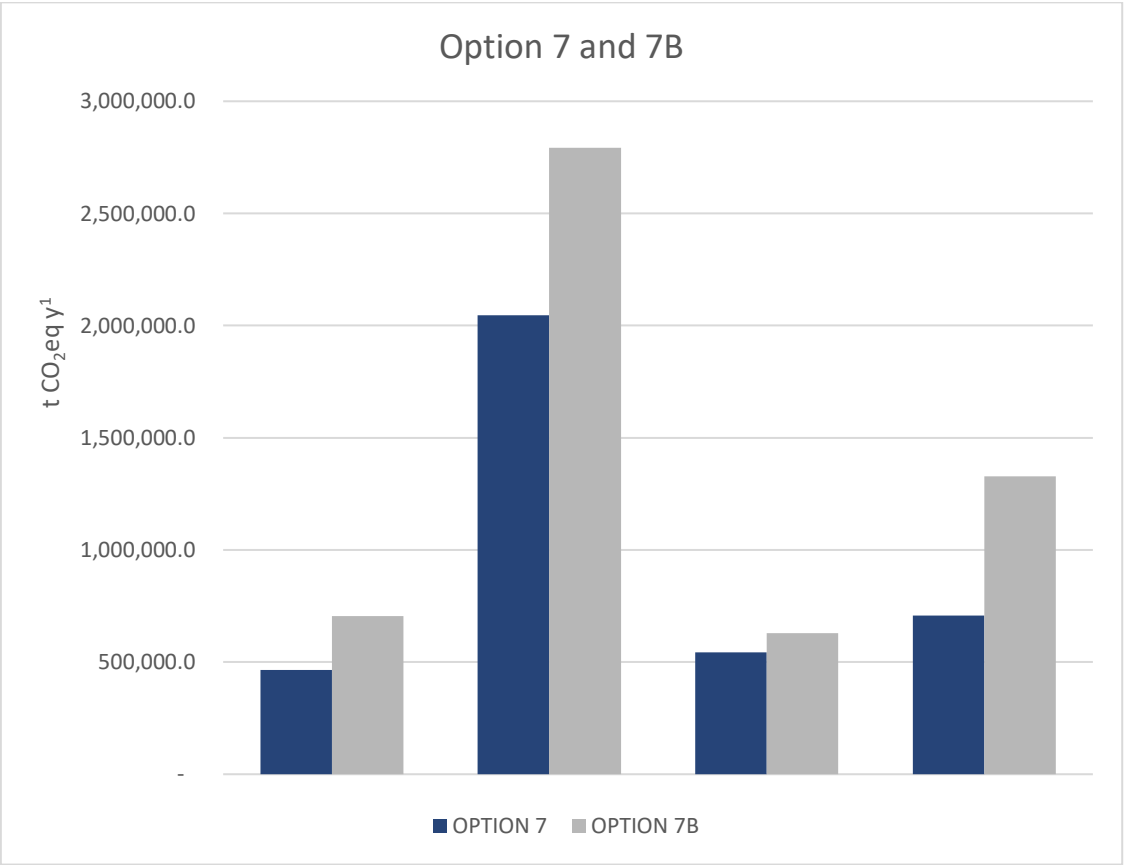


Option 7b Allocation Map (Redd Projects)





In the following chart and table, the results of the options I and Ib are detailed by project and comparing with the original baseline (in red) and the original baseline adjust to the current National FRL (in blue)



## OPTIONS 8 and 8B:

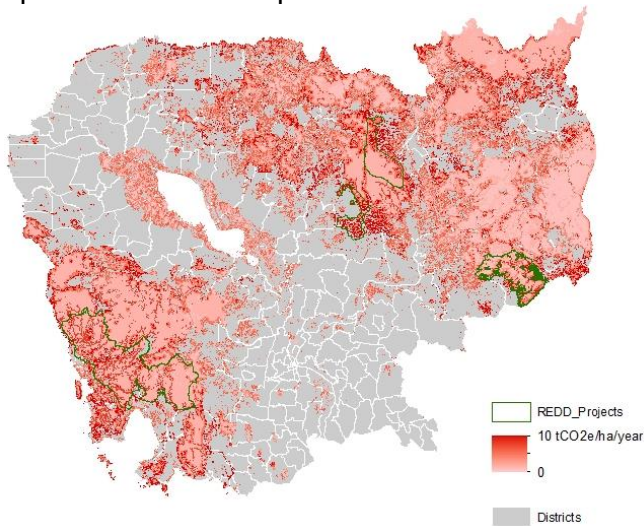
This option follows a variation from the original allocation method proposed in the document “Options to Allocate the FREL Draft Report” from October 2020. Including the following:

- Deforestation risk are estimated using the Unplanned Deforestation methodology for the total forest area in the country.
- A regression model based on a spatial statistical analysis, was applied to project future potential deforested area by hectare.
  - The variables analysed were: Historical Deforestation, Forest Edge Adjusted with JICA Roads, Concessions, Roads (JICA), Villages, Rivers and Population Density.
  - The best model obtained was the combination between Historical Deforestation and Forest Edge Adjusted with JICA Roads.
- Both results were merge and multiplied by the carbon stock.
- A default deforestation rate ( $0.22\% \text{ year}^{-1}$ ) was estimated for the forest originally classified without risk by the regression model.
- Finally, the allocation equation included in the “Options to Allocate the FREL Draft Report” was applied.

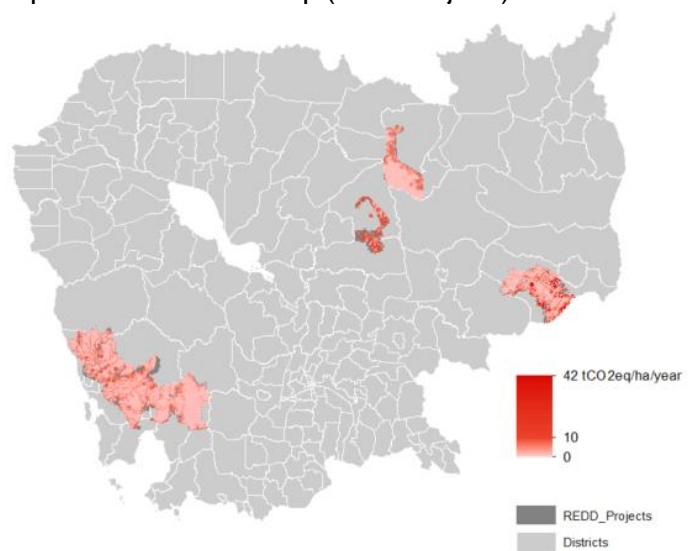
In Option 8 the carbon stocks were derived from the national EFs.

In Option 8b the carbon stocks for areas inside REDD+ projects were derived from the specific field data inventory

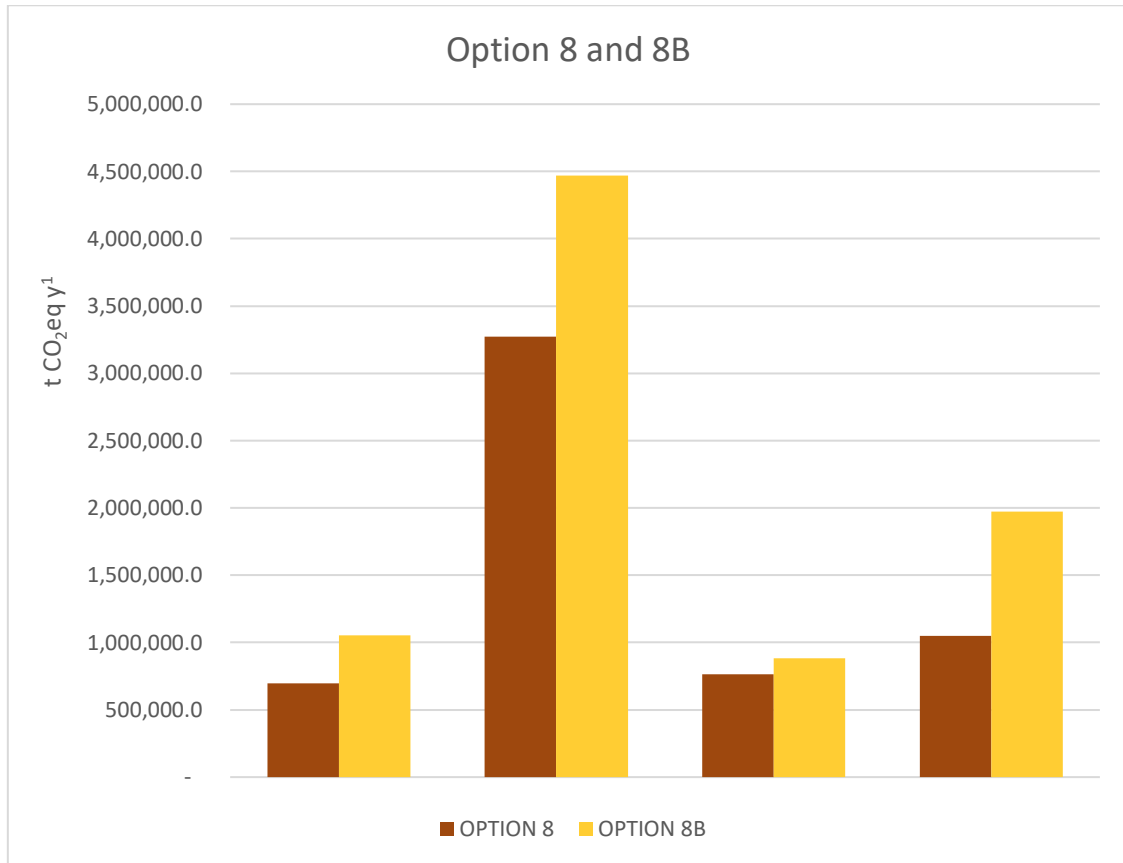
Option 8 Allocation Map



Option 8b Allocation Map (Redd Projects)



In the following chart and table, the results of the options I and Ib are detailed by project and comparing with the original baseline (in red) and the original baseline adjust to the current National FRL (in blue)



## SUMMARY

Figure 1 summarize the total emissions allocated by project considering the different options assessed.

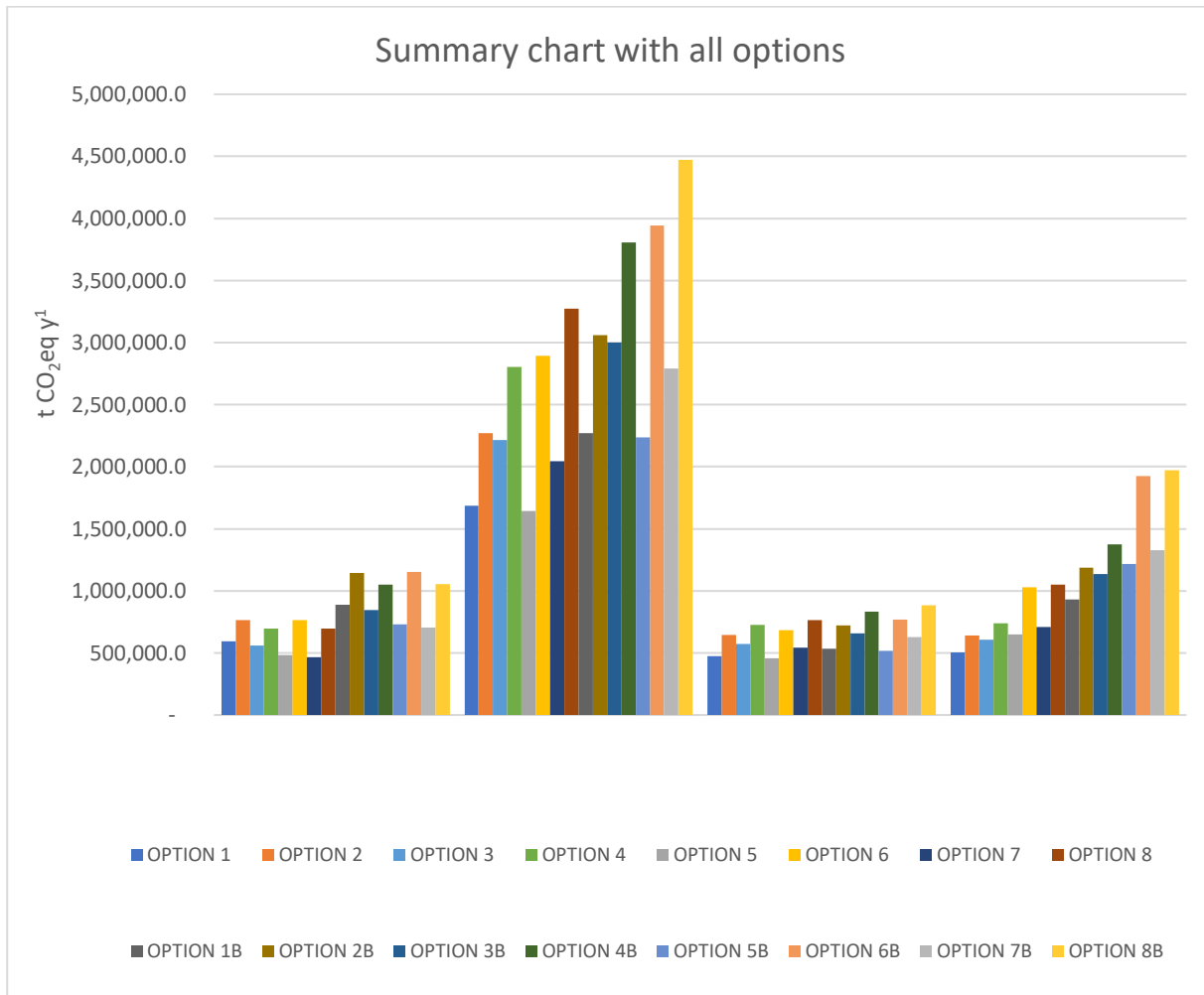


Figure 1. Summary of different options analysed.

In general, the most significant differences (Table 2) were found applying the different Deforestation stratification and Emissions Factors variations (average total emissions allocated to project differ in a 43,7 and 4,6% respectively). The emissions allocation difference is lower applying variations related to Default deforestation rate (14,2%) and using different Forest edge data sources (11,4%).

Table 2. Significance of variations analysed.

	Average emissions allocated (tCO <sub>2</sub> eq y <sup>-1</sup> )	Difference (%)
Planned & Unplanned	4.328.578	43,7%
Unplanned	6.222.065	
Def rate: 0%	4.925.850	14,2%
Def rate: 0.16 - 0,23%	5.624.793	
Original data	4.991.261	11,4%
Refined data	5.559.382	
National EFs	4.330.854	43,6%
Local Efs	6.219.789	

## CONSIDERATIONS

The analysis carried out raised some relevant considerations to have into account:

- The highest portion of FRL allocation happens avoiding the segregation between Planned and Unplanned deforestation. In this regards it is important to highlight that:
  - The National FRL do not discriminate between those types of deforestation.
  - The current available information is not updated.
  - There is no evidence to demonstrate that deforestation will happen during the crediting period.
- The use of site-specific emission factors has a relevant impact in the volume of emissions allocated to the projects. In this regard:
  - It is highly probable that this option would be allow by JNR 4.0, so if the option is chosen by Cambodia could be easily justified.
  - However, the site-specific carbon stock should be revised, and calculation harmonized by an independent third-party.
- The use of a default risk rate has not a major impact in the allocation, however, could be important to increase the protected area by projects providing a value (in terms of potential emission reductions) over all the forest land.
- The variation related to the adjustment of the forest edge dataset could be slightly risky:
  - The use of original datasets, in general, generates a higher level of trust internationally.
  - Additional suggestions could arise to include other datasets (p.e. rivers, small constructions, electric lines...) to adjust the forest edge.

From this analysis, up to date, my recommendation is to use the Option 4 but, considering the Option 4B once the data from site-specific carbon stocks will be available.

## Annex 1: Statistics for Unplanned Deforestation Regression models and Planned Deforestation rates

Options 1, 1b, 3 and 3b:

### Planned Deforestation Rate

DefRate_DIR_001.tif	DefRate_ELC.tif	DefRate_SLC.tif
4.53%	3.22%	4.56%
ForestArea_DIR_001.tif	ForestArea_ELC.tif	ForestArea_SLC.tif
51521.00 Ha	1089543.00 Ha	23817.00 Ha
DefRate_Mixed	ForestArea_Mixed	
12.50%	77.00 Ha	

### Unplanned Deforestation Regression Model:

Call:

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

Residuals:

Min	1Q	Median	3Q	Max
-422.02	-39.38	-11.41	-0.58	905.35

Coefficients:

	Estimate	Std. Error	t value	Pr(> t )	
rg_def_14_16_2000	0.020576	0.005142	4.001	8.94e-05 ***	
rg_non_forest_16_500	0.027626	0.010381	2.661	0.00844 **	
---					
Signif. codes:	0 '***'	0.001 '**'	0.01 '*'	0.05 '.'	0.1 ' ' 1

Residual standard error: 122 on 195 degrees of freedom  
Multiple R-squared: 0.6838, Adjusted R-squared: 0.6806  
F-statistic: 210.9 on 2 and 195 DF, p-value: < 2.2e-16

Options 2, 2b, 4 and 4b:

### Unplanned Deforestation Regression Model:

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

Options 5, 5b, 7 and 7b:

Planned Deforestation Rate:

DefRate_DIR_001.tif	DefRate_ELC.tif	DefRate_SLC.tif
4.72%	3.32%	4.65%
ForestArea_DIR_001.tif	ForestArea_ELC.tif	ForestArea_SLC.tif
49077.00 Ha	1050904.00 Ha	23246.00 Ha
DefRate_Mixed	ForestArea_Mixed	
12.50%	73.00 Ha	

Unplanned Deforestation Regression Model:

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

Residuals:
    Min       1Q   Median       3Q      Max
-346.43  -42.12  -15.43   -0.71   930.65

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
rg_def_14_16_2000    0.026484   0.004389   6.034 7.91e-09 ***
rg_non_forest_roads_16_500 0.014025   0.007691   1.824  0.0697 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 122 on 195 degrees of freedom
Multiple R-squared:  0.6839,    Adjusted R-squared:  0.6807
F-statistic: 210.9 on 2 and 195 DF,  p-value: < 2.2e-16
```

Options 6, 6b, 8 and 8b:

Unplanned Deforestation Regression Model:

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

Residuals:
    Min       1Q   Median       3Q      Max
-412.15  -65.17  -20.54   -0.84   749.08

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
rg_def_14_16_2000    0.031065   0.005087   6.107 5.39e-09 ***
rg_non_forest_roads_16_500 0.027015   0.008913   3.031  0.00277 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 141.3 on 195 degrees of freedom
Multiple R-squared:  0.744, Adjusted R-squared:  0.7414
F-statistic: 283.4 on 2 and 195 DF,  p-value: < 2.2e-16
```