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Deforestation in Myanmar – Land and Atmospheric Effects

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Potential Drivers of Deforestation and Forest Degradation

(1) Commercial timber extraction

(2) Agriculture expansion

(3) Shifting cultivation/Slash and burn

(4) Fuelwood production

(5) Charcoal burning

(6) Shrimp/fish farming activities

(7) Urbanization

(8) Local household/infrastructure needs

(9) Dam construction

(10) Wildfire

Potential Environmental Concerns of Deforestation and Forest Degradation

(1) Climate change/variation

(2) Carbon release

(3) Sea level rise

(4) Land slide

(5) Flood

(6) Water loss

(7) Low rainfall

(8) Global warming – high temperatures

(9) Drought

Background - Myanmar Forests

(1) Myanmar has been well known for its abundant forest resources that extend from tropical rainforests to alpine forests.

(2) The expensive forest in Myanmar not only makes a significant contribution to global carbon sequestration, but it has also been recognized for its high value for biodiversity conservation.

(3) Recently a considerable amount of pressure has been exerted on Myanmar's forest cover and conditions because of radical demographic, economic, and social changes in the country.

(4) The total forest area in Myanmar decreased from 56% in 1990 to 52.1% in 2000 (Htun, 2009).

(5) Myanmar Forest Resource Assessments indicate that the forest cover in 2010 was 317,730 km^2, representing 46.96% of the total country area (MOECAF, 2014).

(6) Agricultural expansion and logging are two major driving forces of deforestation in Myanmar (Leimgruber *et al.* 2005; Htun, 2009; Songer *et al.* 2009; Webb *et al.* 2014).

(7) Rapid deforestation in Myanmar has therefore attracted extensive attention. However, many studies have focused on deforestation conditions before 2000 (Leimgruber *et al.* 2005; FAO, 2000; FAO, 2010a; FAO, 2010b) or regional assessment (Songer *et al*. 2009; Renner *et al*. 2007; Htun *et al*. 2010; Mon *et al*. 2012).

(8) These studies have made significant contributions to our understanding of deforestation in Myanmar, but large discrepancies in results have been found.

(9) Little attention has been paid to the regional environmental consequences of deforestation in Myanmar.

Objectives

(1) This study aims to examine the spatio-temporal patterns of deforestation and forest carbon flux in the entire Myanmar between 2001 and 2010.

(2) The same spatio-temporal patterns were also observed by administrative divisions for a better sustainable management plan.

(3) The relationships between deforestation and carbon release, evapotranspiration (ET), and land surface temperature (LST) during the study period are also investigated.

Data and Study Area

(1) The Percent Tree Cover (PTC) layer in the MODIS Vegetation Continuous Fields (VCF) product (MOD44B).

(2) Annual Net Primary Productivity (ANPP) layer in the MODIS Net Primary Productivity (NPP) product (MOD17A3).

(3) 10-year time-series PTC and ANPP values were used as the dependent variable and analyzed against the year sequence (2001-2010) using ordinary least squares (OLS) regression.

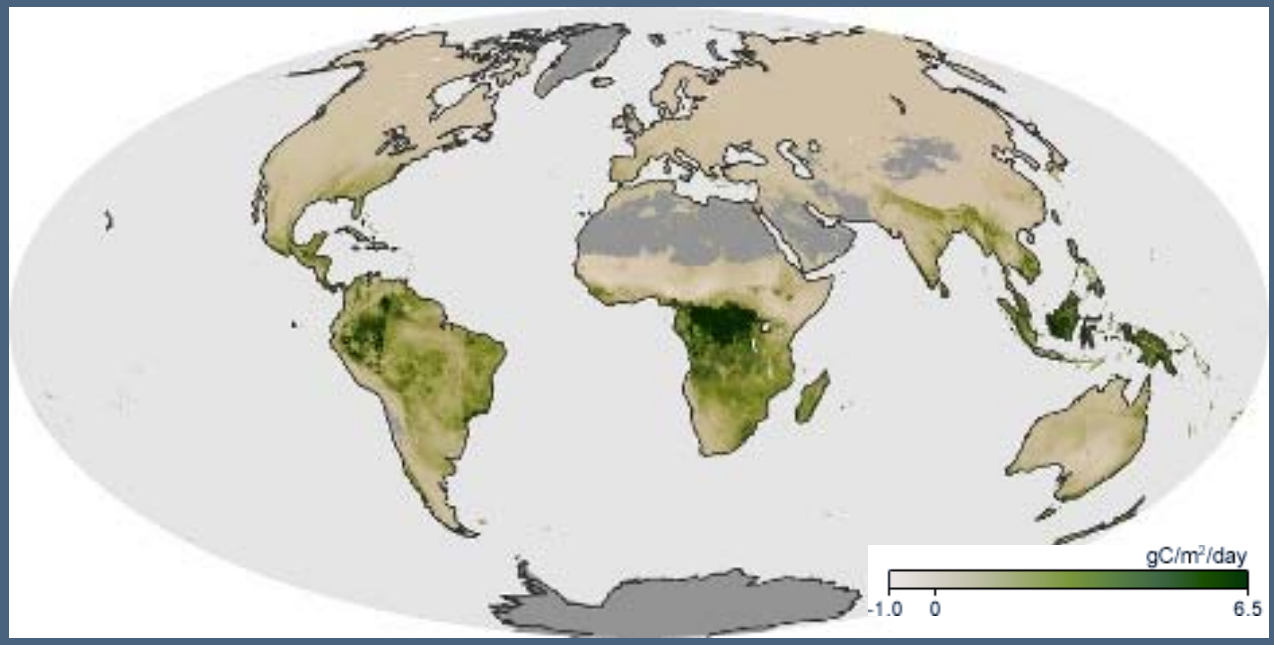
(4) Only pixels that have statistically significant changes ($p \leq 0.1$) were retained. The MODIS Land Cover (LC) type images (MCD12Q1) for 2001 and 2010 were also acquired to study deforestation for different forest types.

Net Primary Productivity (NPP)

Plants capture and store solar energy through photosynthesis. During photosynthesis, plants convert carbon dioxide in the air into sugar molecules they use for food. In the process of making their own food, plants also provide the oxygen we need to breathe.

The net primary productivity represents how much carbon dioxide vegetation takes in during photosynthesis minus how much carbon dioxide the plants release during respiration.

Example Global NPP

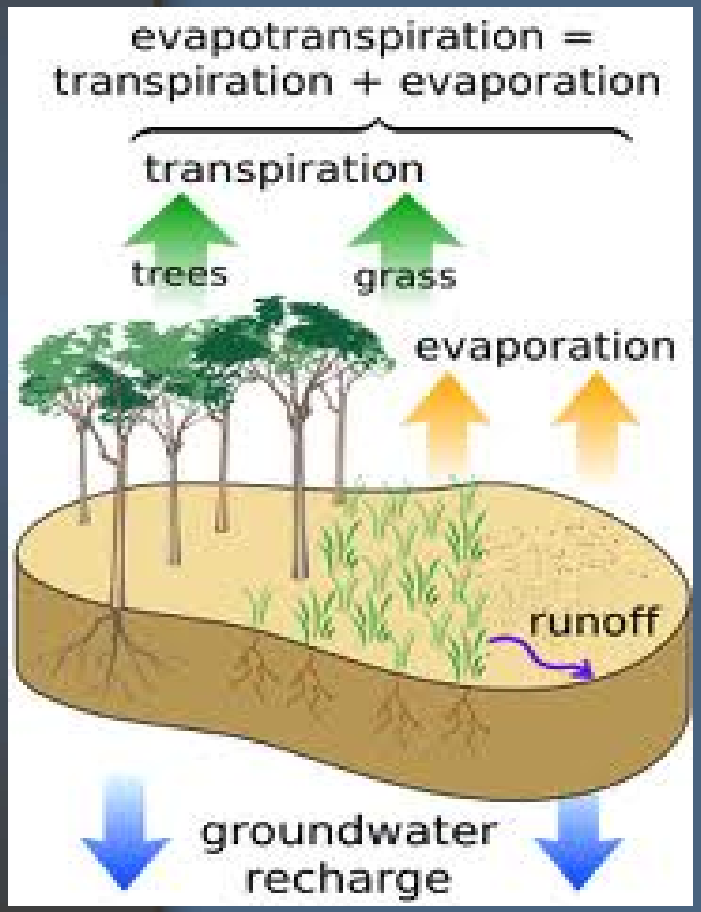


Values range from near 0 grams of carbon per square meter per day (tan) to 6.5 grams per square meter per day (dark green).

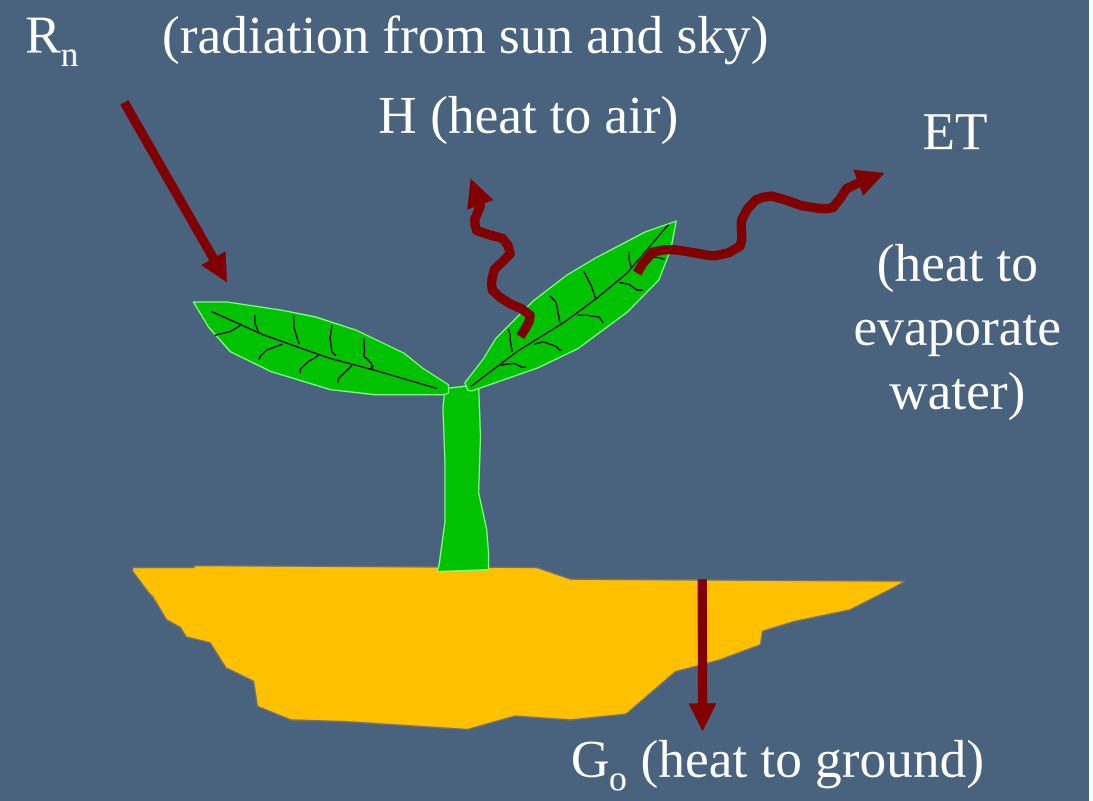
Negative values = More carbon was released to the atmosphere than the plants took in.

Evapotranspiration (ET)

ET from remote sensing: Surface Energy Balance



$$ET = \lambda LE = R_n - G - H$$



Method

(1) The masks of each forest type (ETF, EBF, DBF, and MF) were created from 2001 and 2010 land cover type images, and were used to mask 2001 and 2010 PTC and carbon stock values for every forest type for the entire country and for each administrative division in 2001 and 2010, respectively.

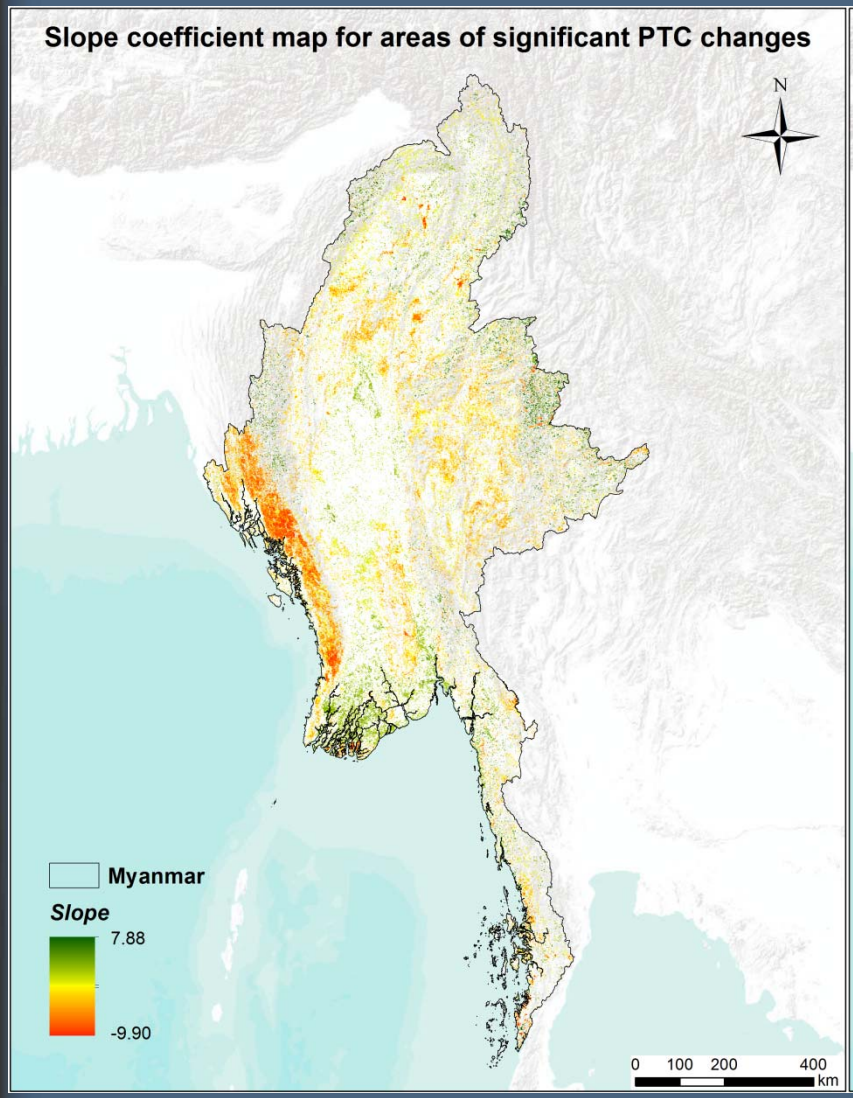
(2) The differences in forest area and carbon stock between 2001 and 2010 of each forest type in each administrative division were then calculated. The mean annual deforestation rate and carbon flux rate were therefore obtained.

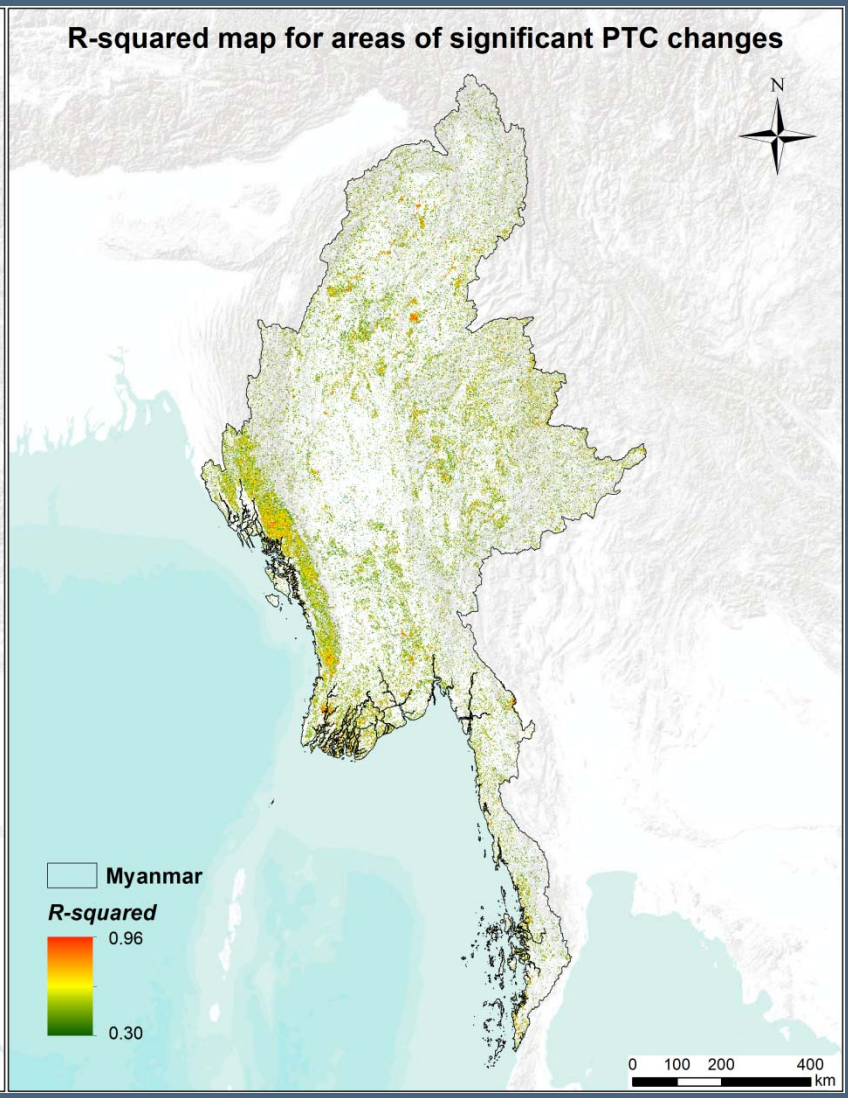
(3) A time-series trend analysis for PTC, carbon stock, ET, and LST image stacks was then performed. The 10-year pixel values from each image stack were used as the dependent variable and analyzed against the year sequence (2001-2010) with the use of ordinary least squares (OLS) regression.

(4) Only pixels that have statistically significant changes (p-value$\leq$0.05) were retained.

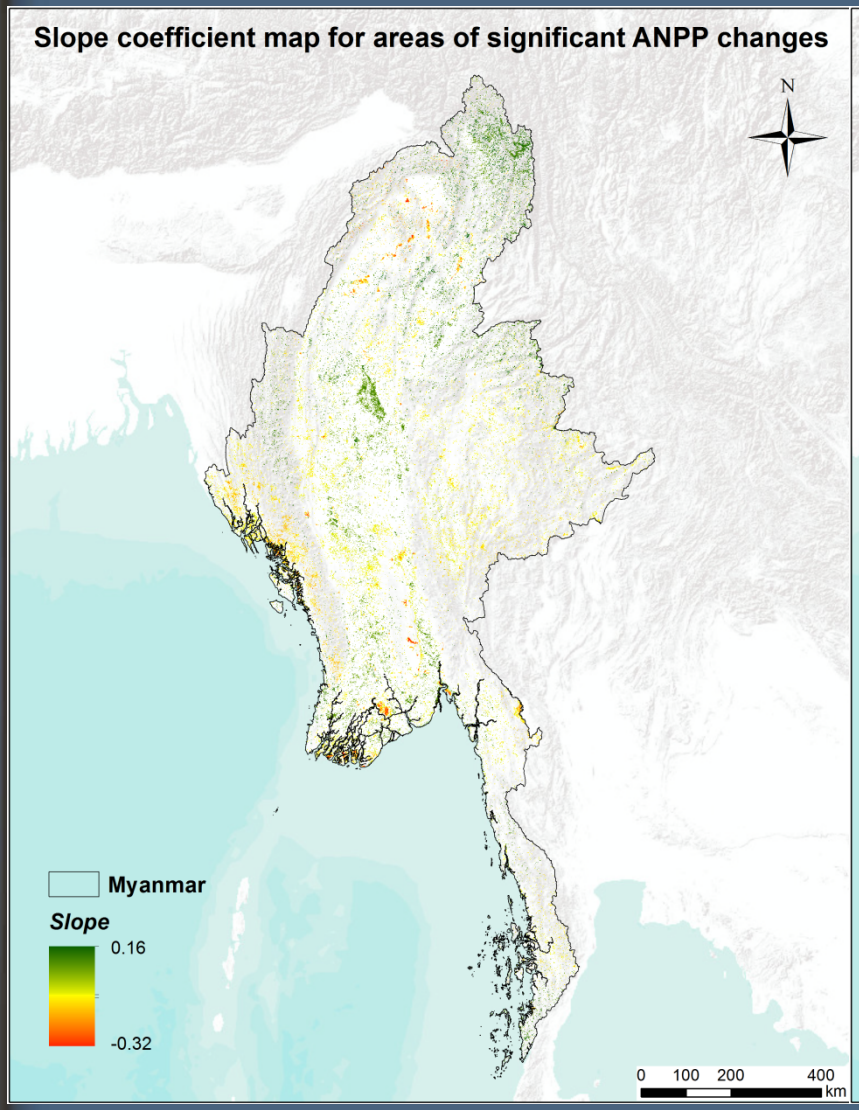
(5) A slope coefficient map was generated for each image stack.

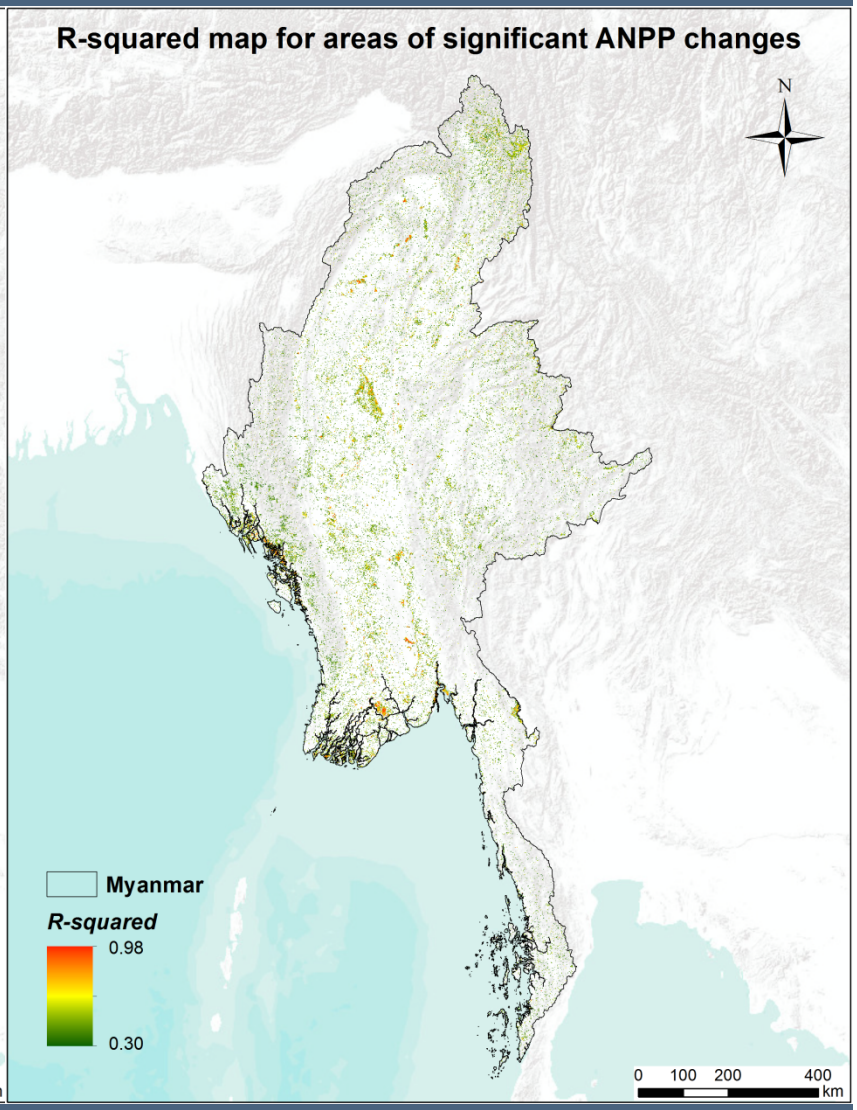
Results (Percent Tree Cover)



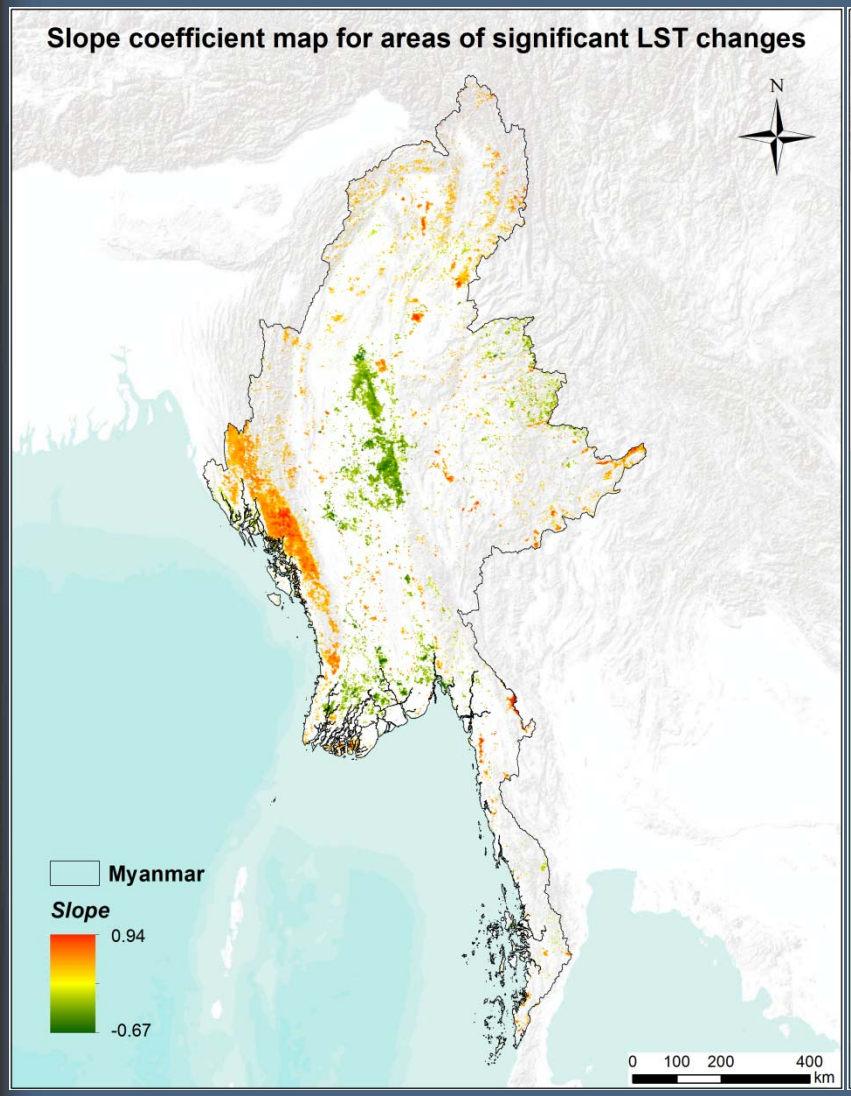


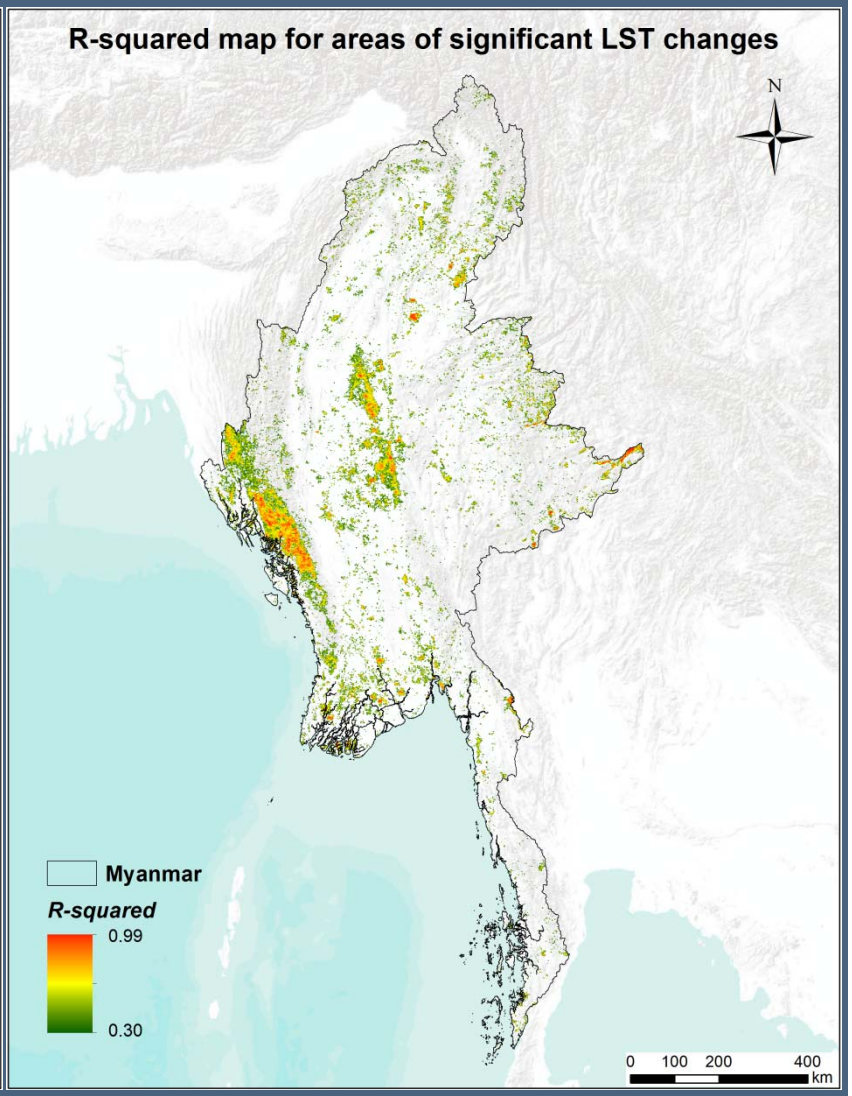
Results (Net Primary Productivity, Carbon ton/yr)



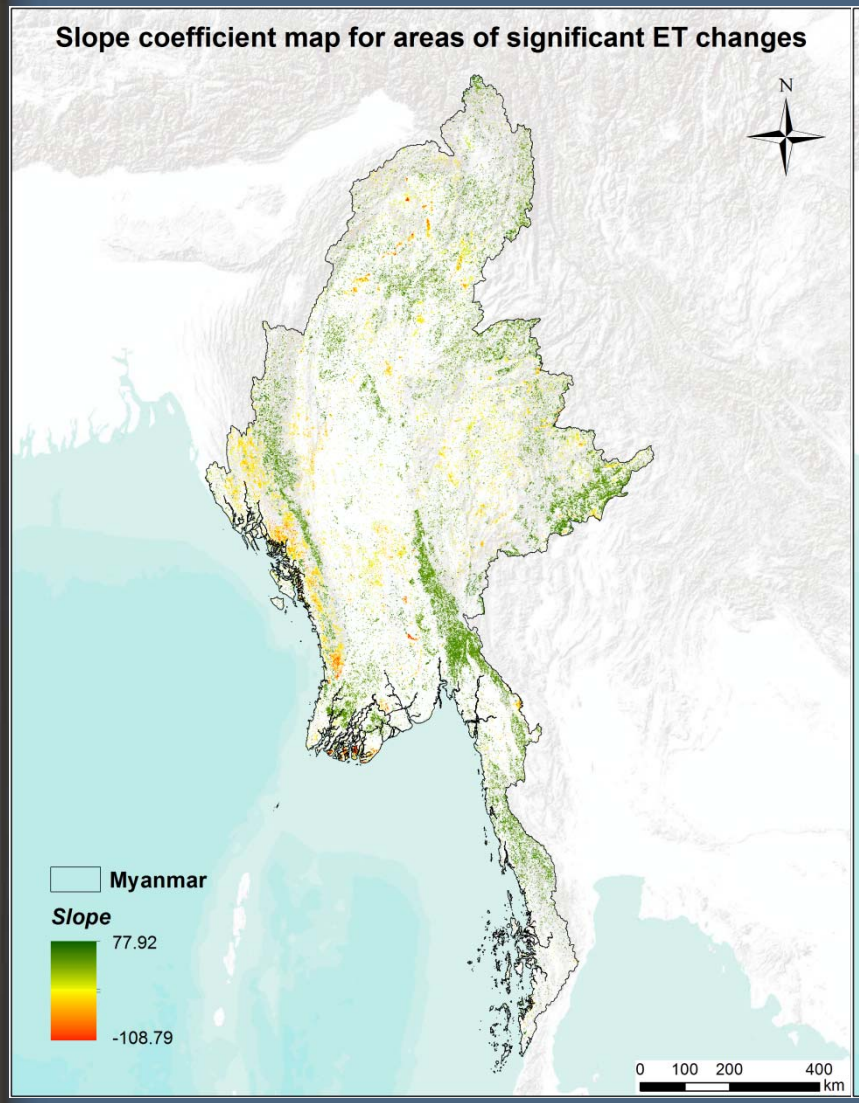


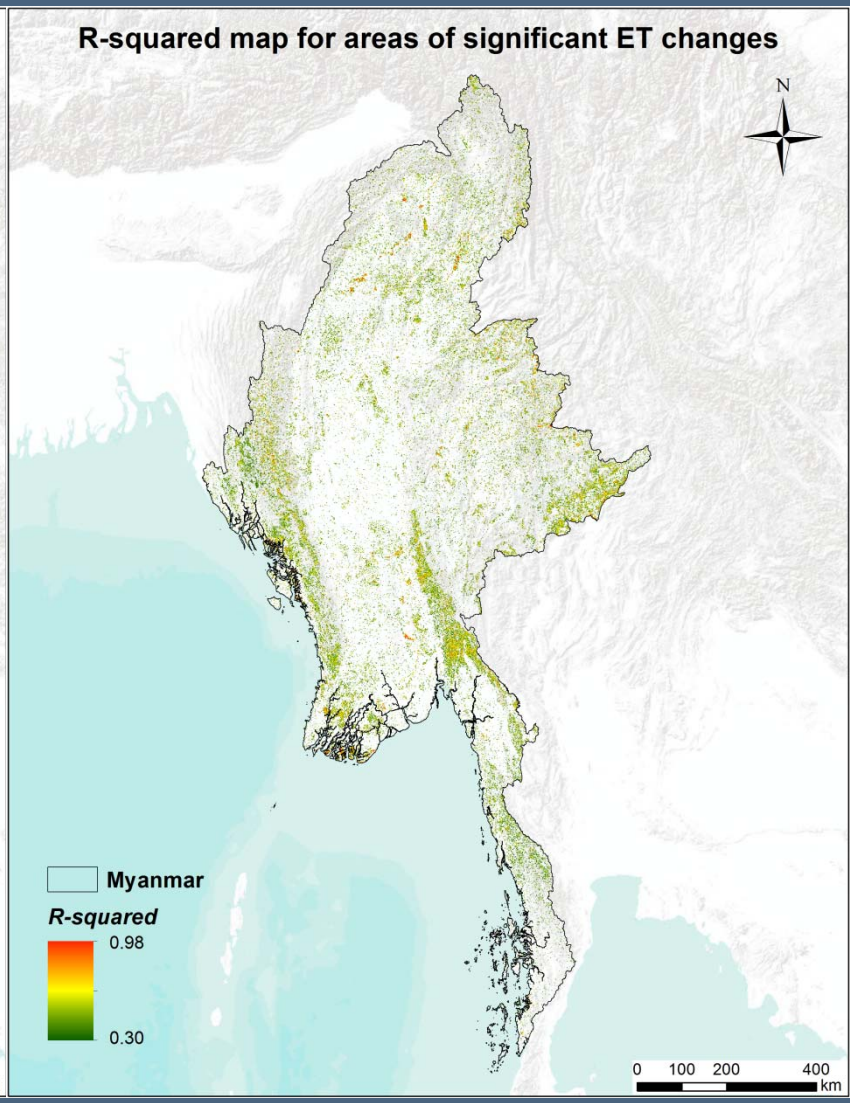
Results (Land Surface Temperatures)

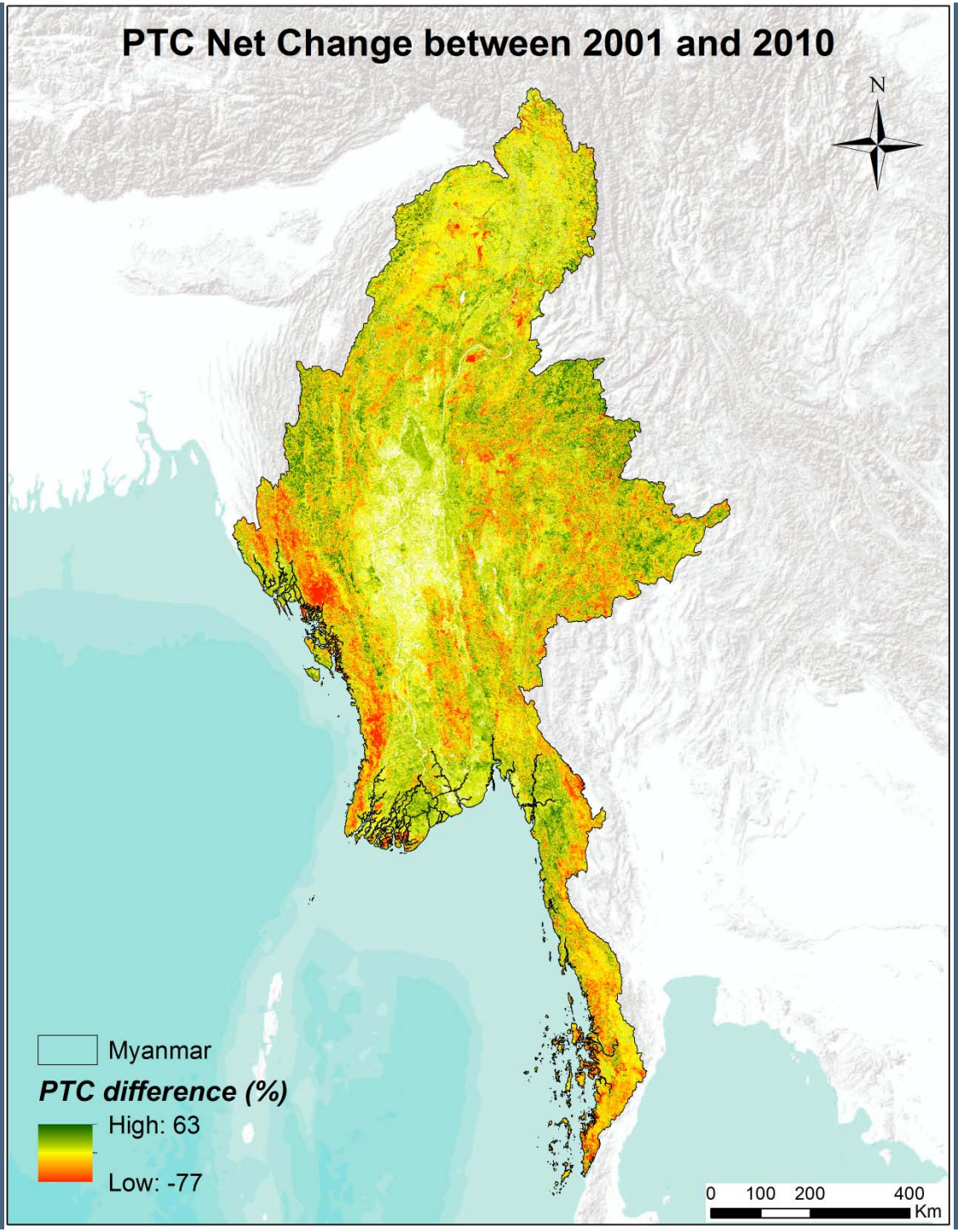


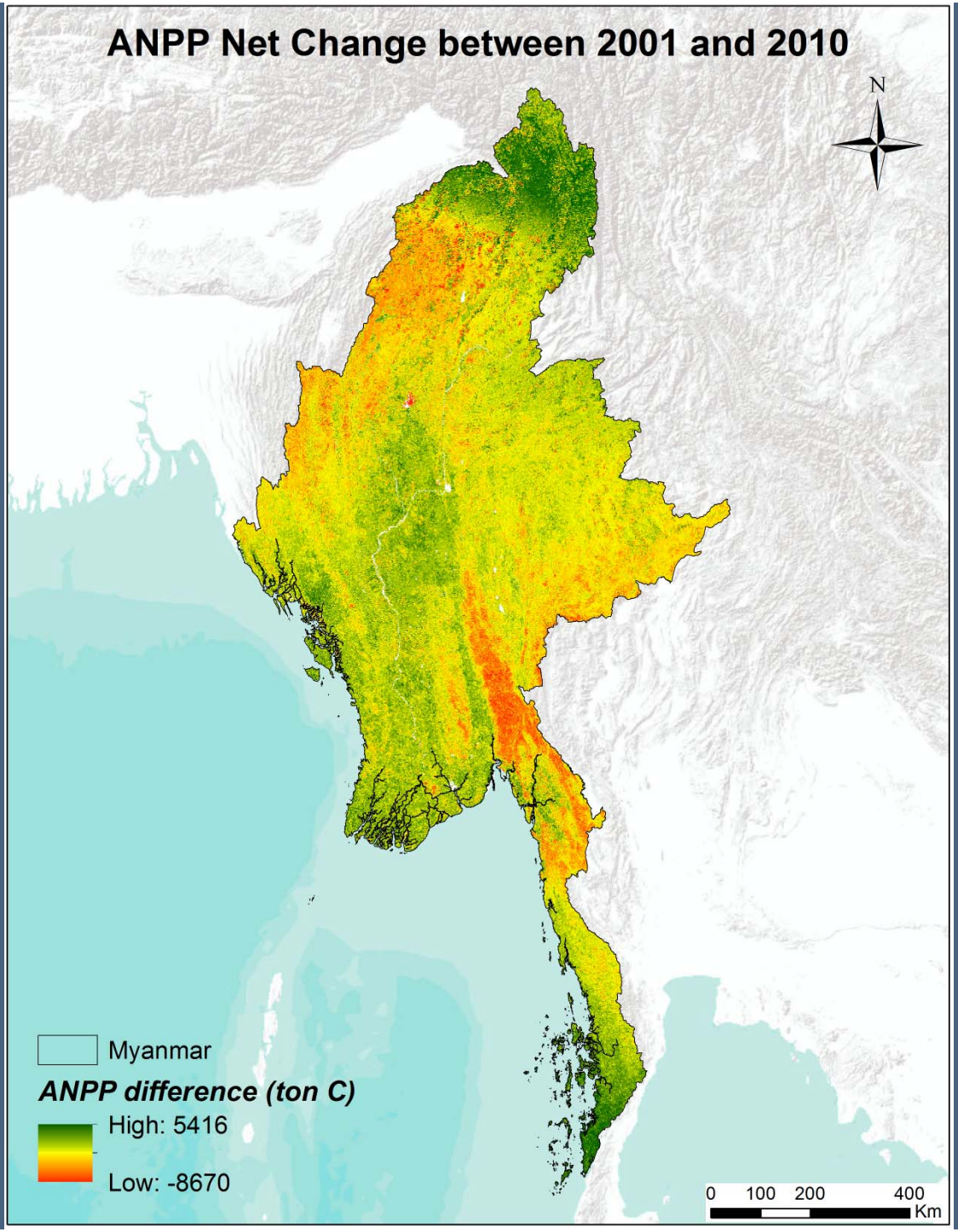


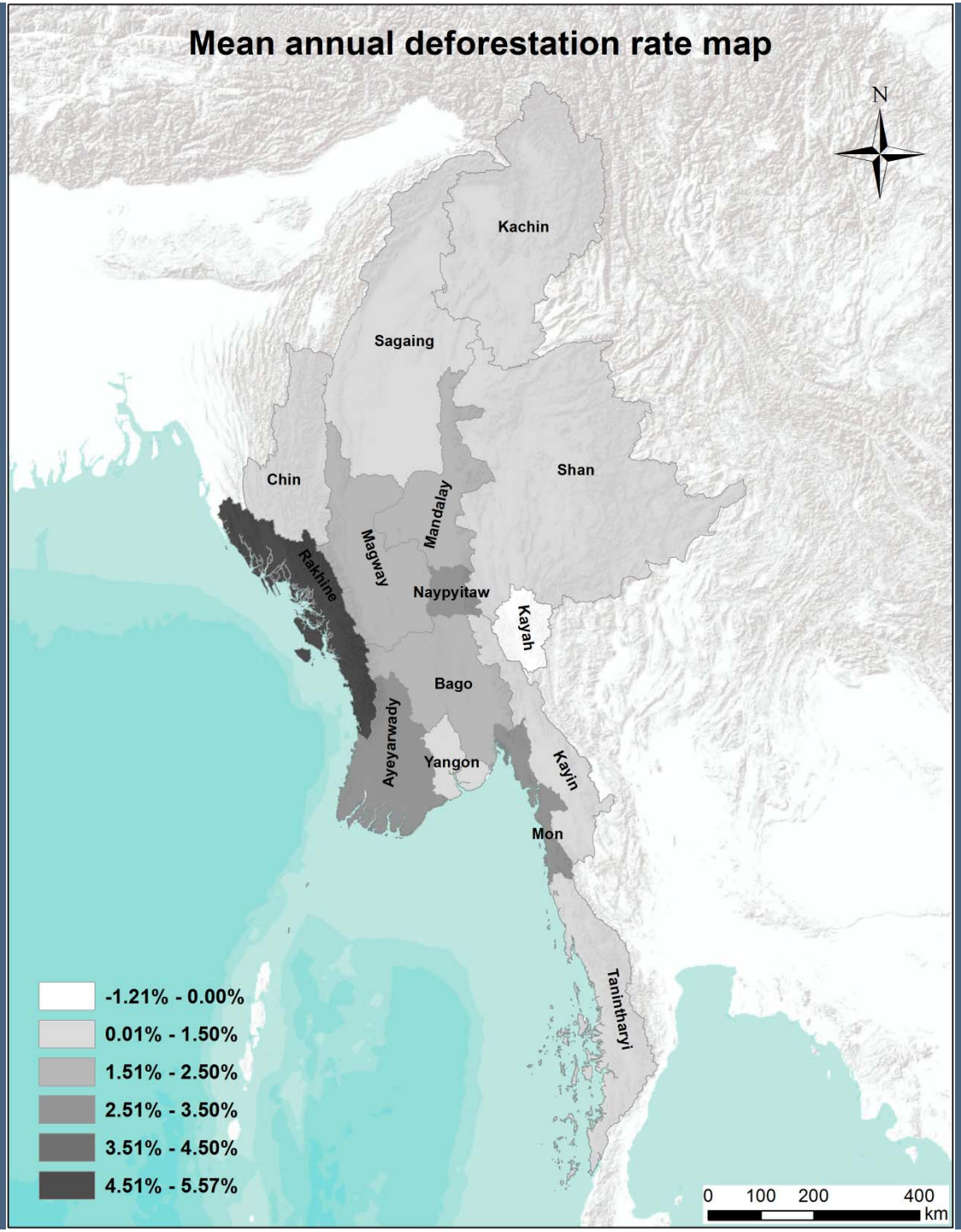
Results (Evapotranspiration – ET)

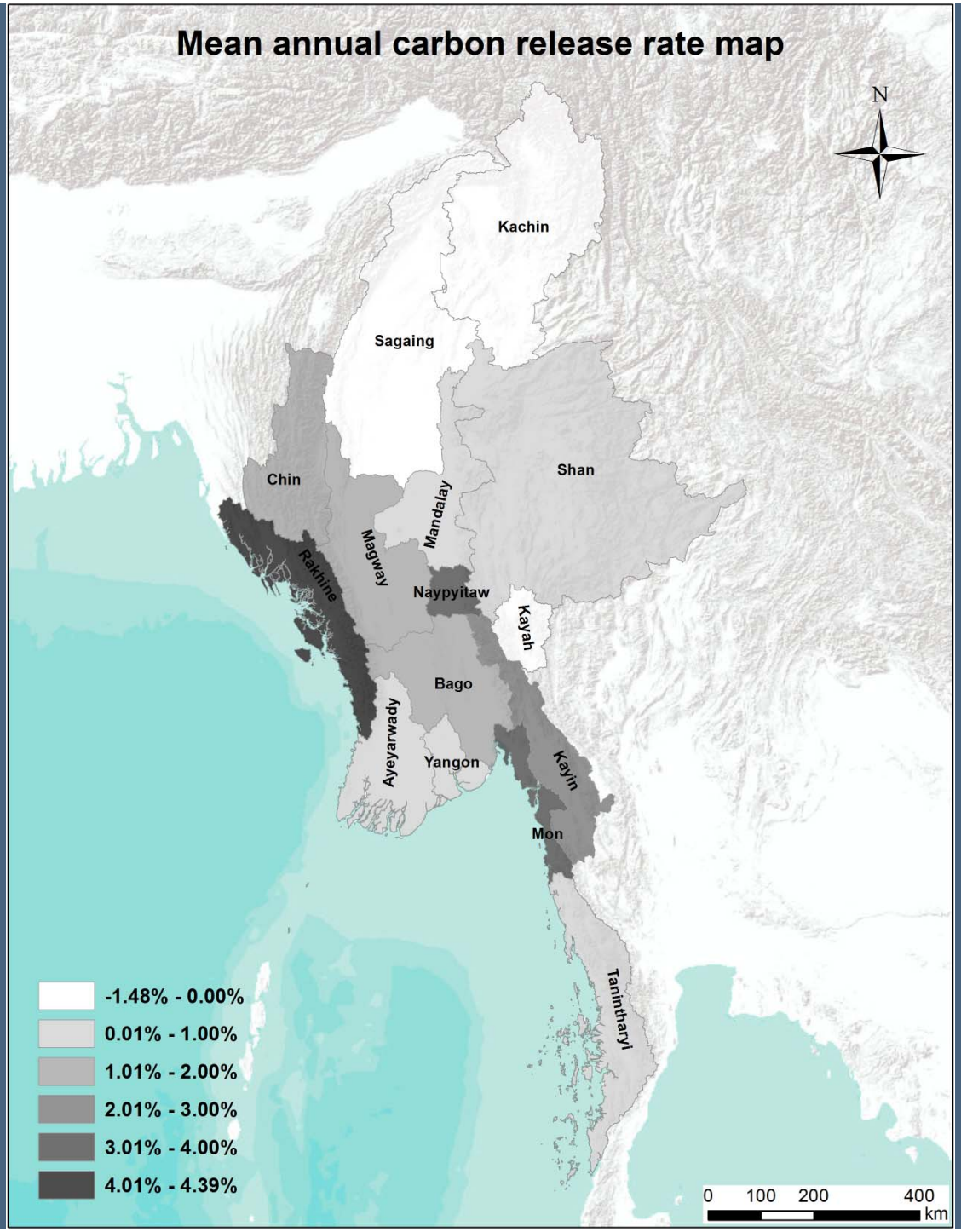





PTC Net Change between 2001 and 2010
N
Myanmar
PTC difference (%)
High: 63
Low: -77
0 100 200 400
Km


ANPP Net Change between 2001 and 2010
N
Myanmar
ANPP difference (ton C)
High: 5416
Low: -8670
0 100 200 400
Km


Mean annual deforestation rate map
N
Kachin
Sagaing
Chin
Shan
Mandalay
Magway
Rakhine
Naypyitaw
Kayah
Bago
Ayeyarwady
Yangon
Kayin
Mon
Tanintharyi
-1.21% - 0.00%
0.01% - 1.50%
1.51% - 2.50%
2.51% - 3.50%
3.51% - 4.50%
4.51% - 5.57%
0 100 200 400
km


Mean annual carbon release rate map
N
Kachin
Sagaing
Chin
Shan
Mandalay
Magway
Rakhine
Naypyitaw
Kayah
Bago
Ayeyarwady
Yangon
Kayin
Mon
Tanintharyi
-1.48% - 0.00%
0.01% - 1.00%
1.01% - 2.00%
2.01% - 3.00%
3.01% - 4.00%
4.01% - 4.39%
0 100 200 400
km

Deforestation and Carbon Release by Forest Types

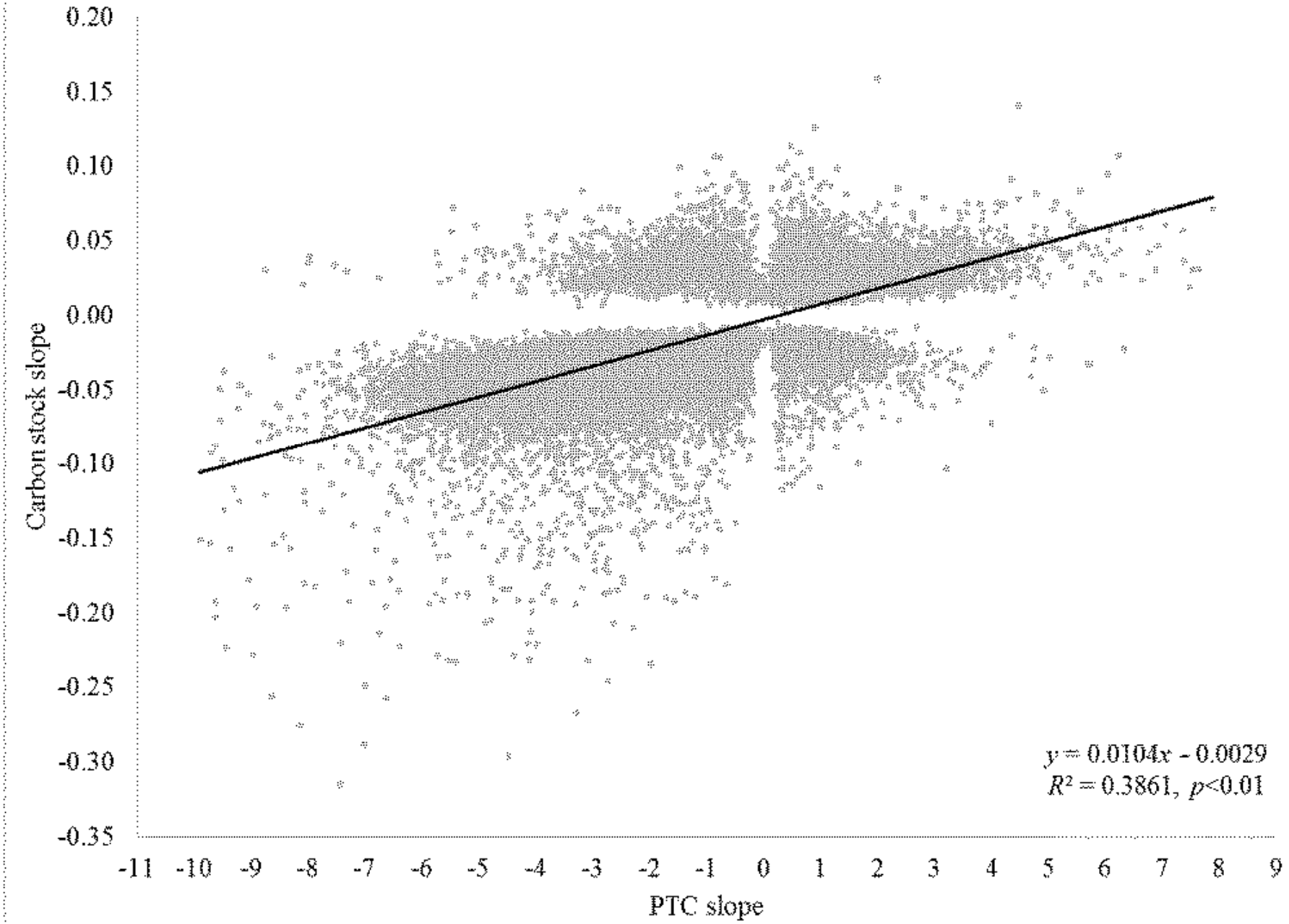
Forest type	Net forest area change (km^2)	Total deforestation rate (%)	Mean annual deforestation rate† (%)	Net carbon flux (ton)	Annual net carbon flux* (ton C yr^{-1})	Mean annual carbon flux rate* (%)
DBF	32.5	-1.33	-0.15	-963,261	-107,029	-0.81
EBF	-11,563.8	6.17	0.69	14,506,981	1,611,887	0.23
ETF	-1,491.9	57.41	6.38	2,339,424	259,936	5.99
MF	-6,183.0	15.48	1.72	28,598,846	3,177,650	2.00
Total	-19,206.2	8.26	0.92	44,481,990	4,942,443	0.55

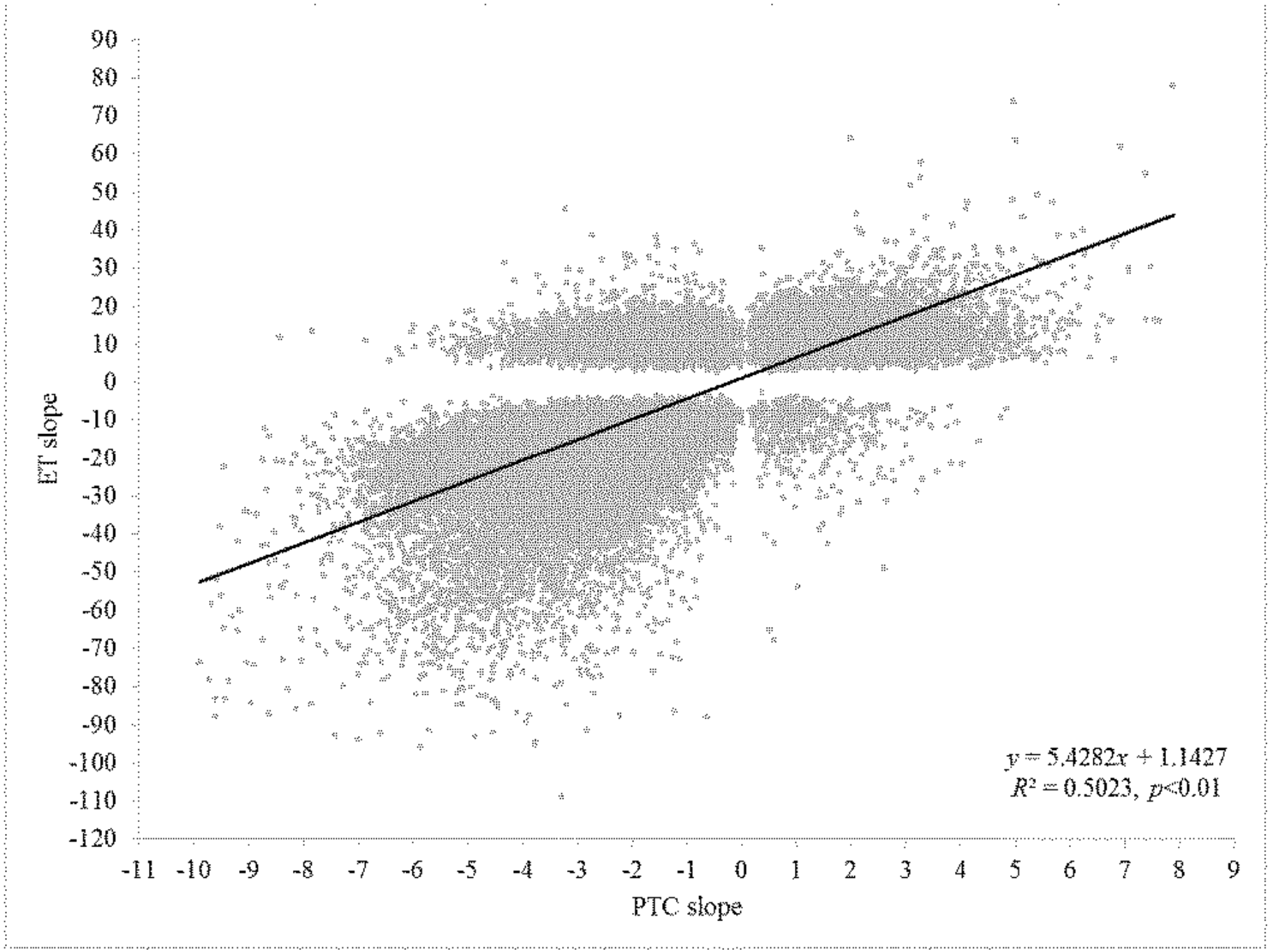
† A positive percentage indicates deforestation, whereas a negative percentage indicates reforestation or afforestation.

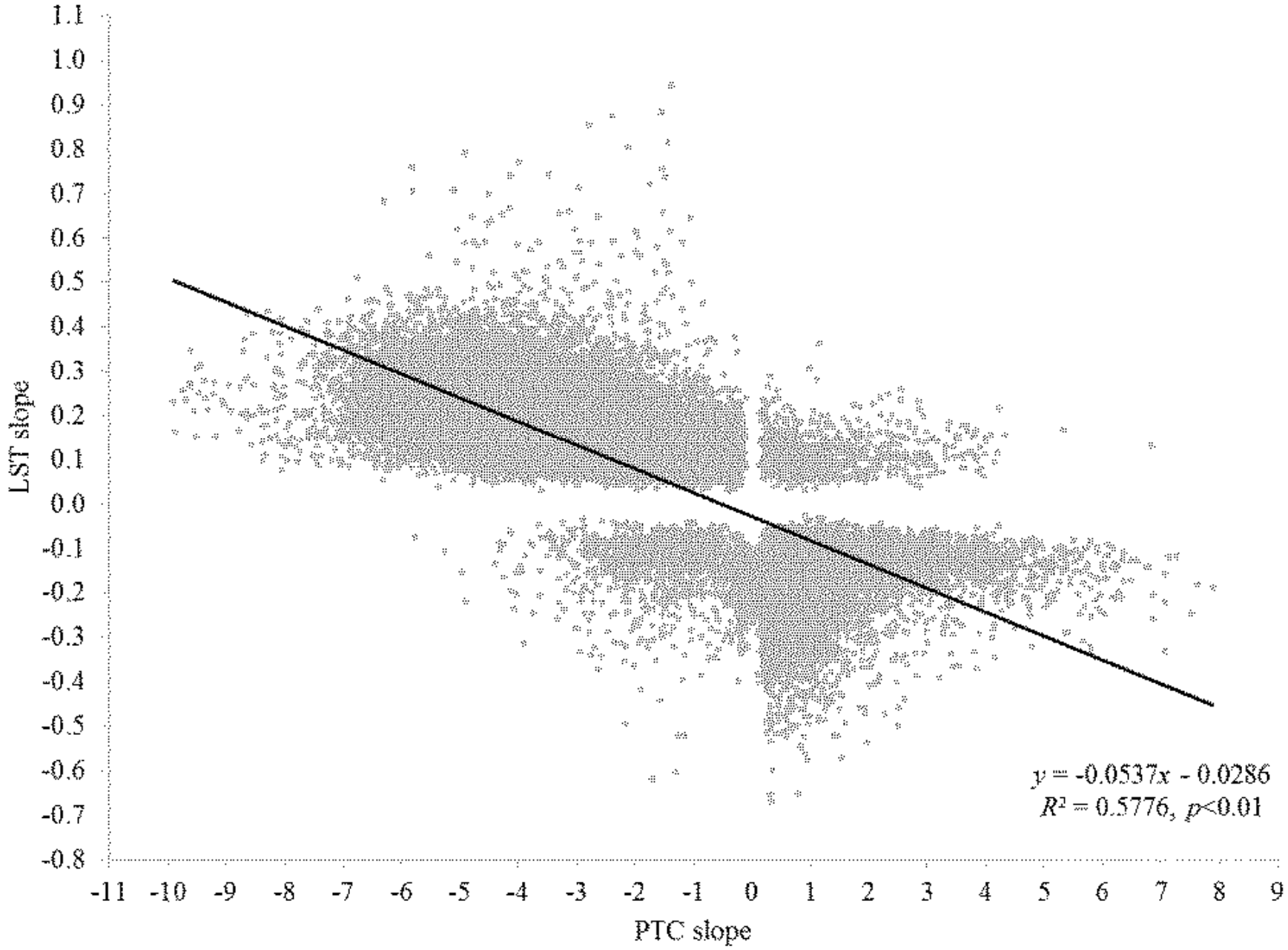
* A positive percentage indicates carbon release, whereas a negative percentage indicates carbon sequestration.

Deforestation and Carbon Release by State and Division

Administrative division	Net forest area change (km^2)	Mean annual deforestation rate*, † (%)	Annual net carbon flux** (ton C yr^{-1})	Mean annual carbon flux rate**, † (%)
Ayeyarwady	-585.3	[3] 2.96	77,726	[9] 0.79
Bago	-663.5	[7] 1.67	286,848	[5] 1.69
Chin	-1,714.9	[8] 1.21	700,530	[7] 1.06
Kachin	-1,241.0	[13] 0.20	-212,901	[13] -0.10
Kayah	232.3	[15] -1.21	-148,914	[15] -1.48
Kayin	-1,211.9	[9] 1.19	947,906	[4] 2.14
Magway	-546.1	[5] 2.10	213,150	[6] 1.65
Mandalay	-385.2	[6] 1.90	76,100	[9] 0.79
Mon	-481.4	[4] 2.69	288,017	[2] 3.44
Naypyidaw Union Territory	-238.8	[2] 3.17	103,083	[3] 3.34
Rakhine	-6,376.5	[1] 5.57	2,149,495	[1] 4.39
Sagaing	-245.0	[14] 0.07	-588,925	[14] -0.41
Shan	-3,702.4	[12] 0.89	760,224	[11] 0.36
Tanintharyi	-2,082.3	[11] 1.00	287,908	[12] 0.34
Yangon	-13.7	[10] 1.05	6,401	[8] 0.96


0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
-0.30
-0.35
Carbon stock slope
-11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9
PTC slope
y = 0.0104x - 0.0029
R² = 0.3861, p<0.01


ET slope
PTC slope
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-11
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
7
8
9
y = 5.4282x + 1.1427
R² = 0.5023, p<0.01


LST slope
PTC slope
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9
y = -0.0537x - 0.0286
R² = 0.5776, p<0.01

Conclusion

- According to Myanmar Forest Resource Assessments, the forest cover of the country in 2010 was 317,730 km^2 representing 46.96% of the country area. This study suggests that the total tree cover area in Myanmar was 308,758.92 km^2 in 2001 and 286,104.21 km^2 in 2010, representing 45.64% (2001) and 42.29% (2010) of the entire national territory area respectively.

- Rakhine not only had the highest deforestation rate (5.57%) and the largest deforested area (6,376.5 km^2), but also the largest amount of carbon release (2.1 million ton C yr^{-1}) and the highest carbon release rate (4.39%) among all the divisions. .

- Top three highest carbon flux rates are found in Rakhine (4.39%), Mon (3.44%), and Naypyidaw Union Territory (3.34%).

- Total forest carbon release was about 44.5 million ton between 2001 and 2010 (4.9 million ton C yr^{-1}) with a mean annual rate of 0.55%.

- Deforestation in Myanmar has caused forest carbon release, and can reduce ET and increase land surface temperatures.

- Specifically, a 1% decrease in PTC will result in an average forest carbon release of 0.0104 kg/m^2, an average decrease of 5.43 mm/year for ET, an average increase of 0.05°C for LST in Myanmar.

- From 1990 to 2000, the divisions with the highest deforestation rates were Ayeyarwady (1.2%), Mandalay (0.5%), and Sagaing (0.4%) (Leimgruber *et al*. 2005). Results from this study suggests that deforestation in Sagaing was somewhat alleviated, and the rate was reduced to 0.07% annually.

- By contrast, deforestation in Ayeyarwady and Mandalay was exacerbated, and the rates were accelerated to 2.96% and 1.90%, respectively.

- Although most of Myanmar had experienced forest carbon release, carbon sequestration can still be found in the Northeastern Himalayan mountainous regions in Kachin state and in the Central Burma Basin in Sagaing, whereas the largest carbon sequestration rate is in Kayah.

- 50% of the remaining forests in Myanmar are predicted to be destroyed by 2060 at the current deforestation rate that will release 0.2184 kg/m^2 forest carbon and increase average surface temperature at 1.05 °C.

Thank you!