

Warsaw University of Life Sciences WULS – SGGW
in Warsaw
Faculty of Forestry

Eberswalde University for Sustainable Development – HNEE
University of Applied Sciences
Faculty of Forest and Environment

Tobias Seydewitz
Album number SGGW: 178311
Album number HNEE: 15210024

Kompleksowa analiza wylesiania w krajach tropikalnych - bezpośrednie czynniki wylesiania, emisje dwutlenku węgla i równowaga wartości usług ekosystemów

A comprehensive study on deforestation in the tropics - direct deforestation drivers, carbon emissions and ecosystem service value balance

Master's Thesis
on the course of - Forestry

Thesis written under the supervision of
Dr. Prajal Pradhan
Potsdam Institute of Climate Impact Research
Research Domain II - Climate Climate Impacts & Vulnerabilities

Potsdam, 2018

Oświadczenie promotora pracy

Oświadczam, że niniejsza praca została przygotowana pod moim kierunkiem i stwierdzam, że spełnia warunki do przedstawienia tej pracy w postępowaniu o nadanie tytułu zawodowego.

Declaration of the promoter

I declare that this thesis was prepared under my supervision and I state that it meets the conditions for presenting such a body of work in the process of obtaining a professional title.

Erklärung des Betreuers

Hiermit erkläre ich, dass die vorliegende Arbeit, unter meiner Leitung erstellt wurde und ich bestätige, dass sie die Bedingungen zur Verleihung des Abschlussdiploms erfüllt.

| | |
|-------------|----------------------------------|
| Data | Podpis promotora pracy |
| Date | Signature of the promoter |
| Datum | Unterschrift des Betreuers |

Oświadczenie autora pracy

Świadom odpowiedzialności prawnej, w tym odpowiedzialności karnej za złożenie fałszywego oświadczenia, oświadczam, że niniejsza praca dyplomowa została napisana przeze mnie samodzielnie i nie zawiera treści uzyskanych w sposób niezgodny z obowiązującymi przepisami prawa, w szczególności ustawą z dnia 4 lutego 1994 r.o prawie autorskim i prawach pokrewnych (Dz. U. Nr 90 poz. 631 z późn. zm.).

Oświadczam, że przedstawiona praca nie była wcześniej podstawą żadnej procedury związanej z nadaniem dyplomu lub uzyskaniem tytułu zawodowego test. Lorem ipsum dolores anno sacntum

Oświadczam, że niniejsza wersja pracy jest identyczna z załączoną wersją elektroniczną. Przyjmuję do wiadomości, że praca dyplomowa poddana zostanie procedurze antyplagiatoowej.

Declaration of the author

Aware of the legal liability, including criminal liability for submitting a false statement, I declare that this thesis was written by myself alone and does not contain content obtained in a manner breaking applicable laws, in particular the Act of February 4, 1994 on copyright and related rights (Journal of Laws, no. 90, item 631, as amended).

I certify that the work has not previously been the basis for any procedure in connection with obtaining a diploma or professional title.

I declare that this version of the work is identical with the attached electronic version.

I acknowledge that the thesis is subject to anti-plagiarism procedures.

Erklärung des Autors

Gesetzlicher Haftpflicht, besonders der strafrechtlichen Verantwortlichkeit für Abgabe der falschen Erklärung bewusst, erkläre ich hiermit, dass vorliegende Diplomarbeit selbständig angefertigt wurde und keinen Inhalt enthält, der widerrechtlich erworben wurde, insbesondere nicht mit dem Gesetz über Urheberrecht vom 4. Februar 1994 (GB. Nr. 90, Pos. 631 mit späteren Änderungen) übereinstimmend.

Ich erkläre auch, dass die Arbeit bisher keiner anderen Prüfungsbehörde vorgelegt wurde.

Der Durchführung einer elektronischen Plagiatsprüfung stimme ich hiermit zu. Die eingereichte elektronische Fassung der Arbeit entspricht der eingereichten schriftlichen Fassung exakt.

| | |
|-------------|-------------------------------|
| Data | Podpis autora pracy |
| Date | Signature of the author |
| Datum | Unterschrift des Autors |

Streszczenie

Tytuł: Text

Text

Słowa kluczowe: Text

Summary

Title: Text

Text

Keywords: Text

Zusammenfassung

Titel: Text

Text

Schlüsselwörter: Text

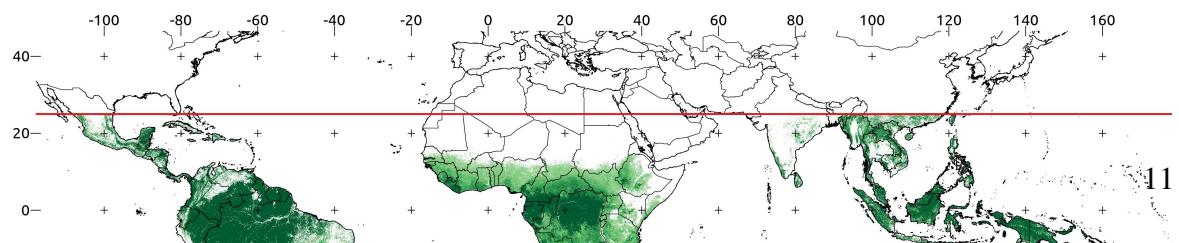
Contents

| | | |
|---------|--|----|
| 1 | Introduction | 11 |
| 1.1 | Tropical forest | 11 |
| 1.1.1 | Current state | 12 |
| 1.1.2 | Contribution to climate | 12 |
| 1.1.3 | Forest definitions | 12 |
| 1.2 | Deforestation | 12 |
| 1.2.1 | Land use and land cover change | 12 |
| 1.2.2 | Drivers of deforestation | 12 |
| 1.3 | Emissions through deforestation | 12 |
| 1.3.1 | Removal of AGB | 12 |
| 1.3.2 | Soil organic carbon change and soil dynamics | 12 |
| 1.4 | Ecosystem services | 12 |
| 1.4.1 | Ecosystem service values | 12 |
| 1.5 | Research objective and questions | 12 |
| 2 | Data and methods | 13 |
| 2.1 | Data | 13 |
| 2.1.1 | Spatial data | 13 |
| 2.1.1.1 | Global Forest Change | 13 |
| 2.1.1.2 | GlobeLand30 | 13 |
| 2.1.1.3 | Intact Forest Landscapes | 13 |
| 2.1.1.4 | Aboveground Woody Biomass | 13 |
| 2.1.1.5 | Global Soil Organic Carbon | 13 |
| 2.1.1.6 | Auxiliary | 14 |
| 2.1.2 | Empirical data | 14 |
| 2.1.2.1 | Soil Organic Carbon | 14 |
| 2.1.2.2 | Ecosystem Service Values | 14 |
| 2.2 | Methods | 14 |
| 2.2.1 | Pre-processing | 14 |
| 2.2.2 | Deforestation | 14 |
| 2.2.2.1 | Forest definition | 14 |
| 2.2.2.2 | Land use change driver | 14 |
| 2.2.2.3 | Accuracy assessment | 14 |
| 2.2.3 | Emissions | 14 |
| 2.2.3.1 | Above ground biomass | 14 |
| 2.2.3.2 | Soil organic carbon change | 14 |
| 2.2.4 | Ecosystem service values | 14 |
| 2.2.4.1 | Ecosystem service value loss | 14 |
| 2.2.4.2 | Ecosystem service value gain | 14 |
| 2.2.5 | Binning analysis | 14 |
| 3 | Results | 15 |
| 3.1 | Forest definition and accuracy assessment | 15 |
| 3.2 | Deforestation drivers | 16 |
| 3.2.1 | Global | 16 |

| | | |
|-------|---|----|
| 3.2.2 | Americas | 16 |
| 3.2.3 | Asia | 16 |
| 3.2.4 | Africa | 16 |
| 3.3 | Deforestation emissions | 22 |
| 3.3.1 | Global | 23 |
| 3.3.2 | Americas | 23 |
| 3.3.3 | Asia | 23 |
| 3.3.4 | Africa | 23 |
| 3.4 | Ecosystem service value balance | 23 |
| 3.4.1 | Global | 23 |
| 3.4.2 | Americas | 23 |
| 3.4.3 | Asia | 23 |
| 3.4.4 | Africa | 23 |
| 4 | Discussion | 24 |
| | Acknowledgements | 25 |
| | References | I |
| | List of Figures | II |
| | List of Tables | II |
| | List of Abbreviations | II |
| | Appendix | IV |

1 Introduction

1.1 Tropical forest



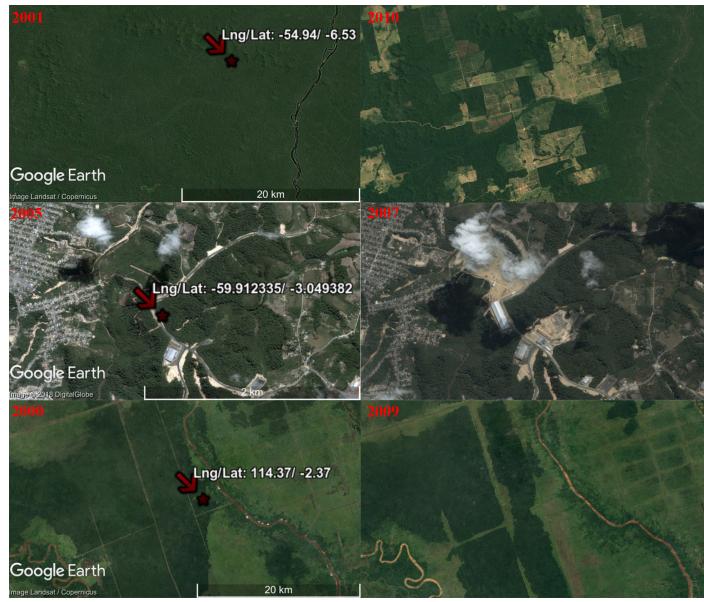


Figure 2: Upper Brazil agriculture, middle Brazil urbanization, lower Indonesia large scale palm oil plantations

1.1.1 Current state

1.1.2 Contribution to climate

1.1.3 Forest definitions

1.2 Deforestation

1.2.1 Land use and land cover change

1.2.2 Drivers of deforestation

1.3 Emissions through deforestation

1.3.1 Removal of AGB

1.3.2 Soil organic carbon change and soil dynamics

1.4 Ecosystem services

1.4.1 Ecosystem service values

1.5 Research objective and questions

2 Data and methods

2.1 Data

Table 1: Used datasets

| Name | Notes | Reference |
|--------------------------------|--|-----------|
| Global Forest Change | V1.0, treecover2000, lossyear and gain | |
| GlobeLand30 | 2000 and 2010 | |
| GSOCmap | V1.0 | |
| Intact Forest Landscapes | 2000 | |
| Aboveground live woody biomass | | |

Coordinate system:
WGS84 (EPSG:4326)
Sources:
GADM (2018), World Map Version 3.4

Figure 3: Study extent and raster image tiles

2.1.1 Spatial data

2.1.1.1 Global Forest Change

2.1.1.2 GlobeLand30

2.1.1.3 Intact Forest Landscapes

2.1.1.4 Aboveground Woody Biomass

2.1.1.5 Global Soil Organic Carbon

2.1.1.6 Auxiliary

2.1.2 Empirical data

2.1.2.1 Soil Organic Carbon

2.1.2.2 Ecosystem Service Values

2.2 Methods

2.2.1 Pre-processing

2.2.2 Deforestation

2.2.2.1 Forest definition

2.2.2.2 Land use change driver

2.2.2.3 Accuracy assessment

2.2.3 Emissions

2.2.3.1 Above ground biomass

2.2.3.2 Soil organic carbon change

2.2.4 Ecosystem service values

2.2.4.1 Ecosystem service value loss

2.2.4.2 Ecosystem service value gain

2.2.5 Binning analysis

3 Results

3.1 Forest definition and accuracy assessment

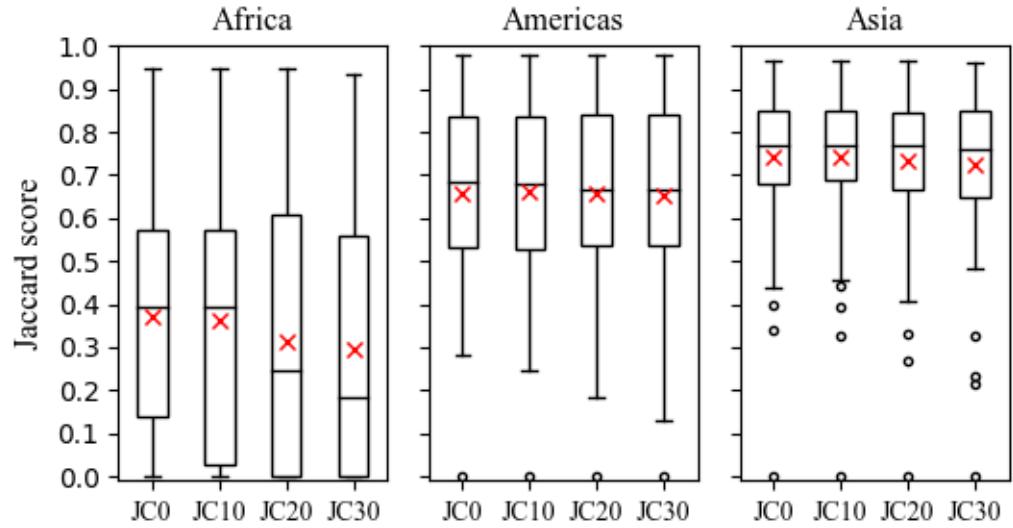


Figure 4: Jaccard score to determine tree cover similarity used to develop forest definition

Table 2: Confusion matrix for accuracy assessment

| Cls | Reference | | | | | | | | | Tot | UAc | Om |
|------------|-----------|------|------|------|------|-----|-----|-----|-----|------|------|-----|
| | 10 | 20 | 25 | 30 | 40 | 50 | 60 | 80 | 90 | | | |
| Prediction | 10 | 732 | 38 | 62 | 15 | 16 | 2 | 3 | 5 | 0 | .84 | .16 |
| | 20 | 42 | 751 | 57 | 189 | 31 | 12 | 0 | 17 | 4 | .68 | .32 |
| | 25 | 29 | 202 | 1155 | 173 | 22 | 10 | 5 | 11 | 4 | .72 | .28 |
| | 30 | 36 | 187 | 32 | 1466 | 73 | 21 | 0 | 17 | 0 | .80 | .20 |
| | 40 | 14 | 21 | 4 | 41 | 352 | 1 | 1 | 2 | 1 | .81 | .19 |
| | 50 | 0 | 5 | 3 | 10 | 4 | 50 | 0 | 1 | 0 | .68 | .32 |
| | 60 | 2 | 1 | 0 | 3 | 0 | 2 | 18 | 2 | 0 | .64 | .36 |
| | 80 | 3 | 4 | 0 | 1 | 1 | 1 | 0 | 50 | 0 | .83 | .17 |
| | 90 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 5 | .56 | .44 |
| Tot | 858 | 1209 | 1313 | 1899 | 499 | 99 | 27 | 108 | 14 | 6026 | | |
| PAc | .85 | .62 | .88 | .77 | .71 | .51 | .67 | .46 | .36 | | OvAc | |
| Com | .15 | .38 | .12 | .23 | .29 | .49 | .33 | .54 | .64 | | | .75 |

3.2 Deforestation drivers

3.2.1 Global

Table 3: Absolute in km²

| Type | Class | | Americas | Asia | Africa |
|----------------------|------------|------|----------|---------|----------|
| Agriculture | Cropland | rel. | 24.37 | 18.37 | 25.01 |
| | | abs. | 95908 | 38719 | 44368 |
| Forestry/Plantations | Grassland | rel. | 46.19 | 8.41 | 50.46 |
| | | abs. | 181781 | 17726 | 89516 |
| Urban/Mining | Regrowth | rel. | 14.40 | 70.27 | 18.61 |
| | | abs. | 56671 | 148111 | 33014 |
| Natural | Shrubland | rel. | 12.69 | 1.11 | 3.77 |
| | | abs. | 49941 | 2340 | 6688 |
| Forest loss | Artificial | rel. | 0.41 | 0.46 | 0.71 |
| | | abs. | 1614 | 970 | 1260 |
| Forest cover | Bareland | rel. | 0.10 | 0.03 | 0.09 |
| | | abs. | 394 | 63 | 160 |
| | Wetland | rel. | 1.50 | 0.97 | 1.23 |
| | | abs. | 5903 | 2045 | 2182 |
| | Water | rel. | 0.32 | 0.38 | 0.13 |
| | | abs. | 1259 | 801 | 231 |
| | | rel. | 3.87 | 4.68 | 1.69 |
| | | abs. | 393550 | 210774 | 177400 |
| | | abs. | 10223187 | 4457940 | 10496591 |

3.2.2 Americas

3.2.3 Asia

3.2.4 Africa

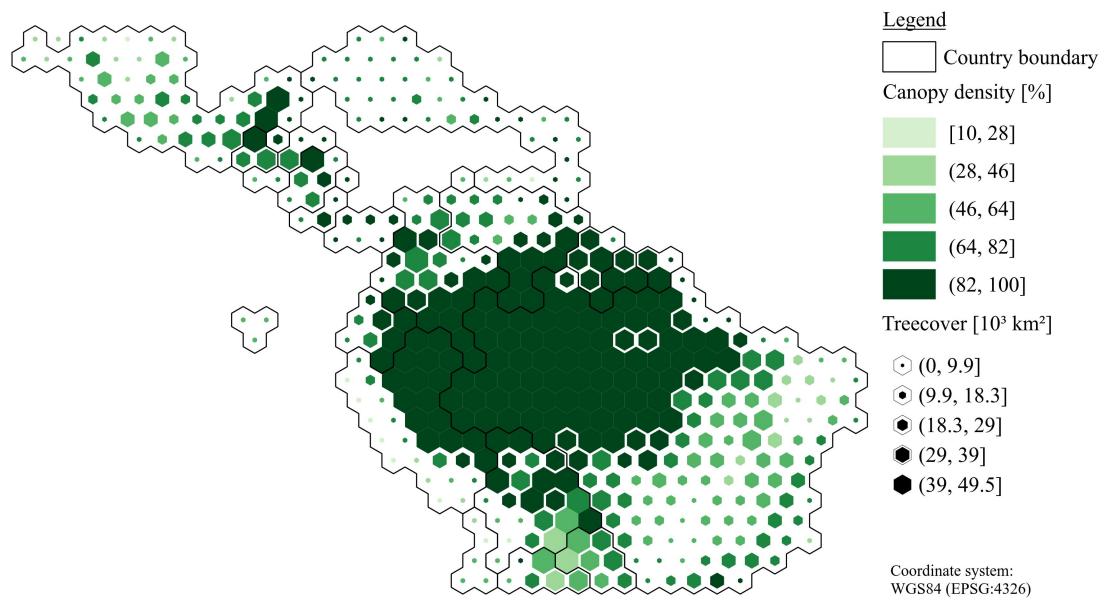


Figure 5:

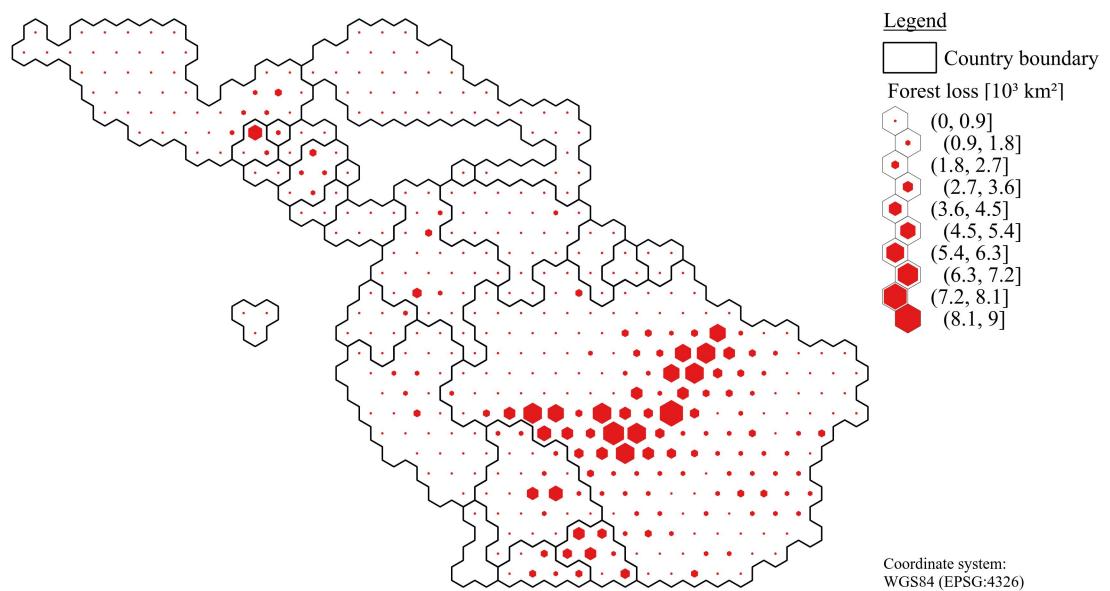


Figure 6:

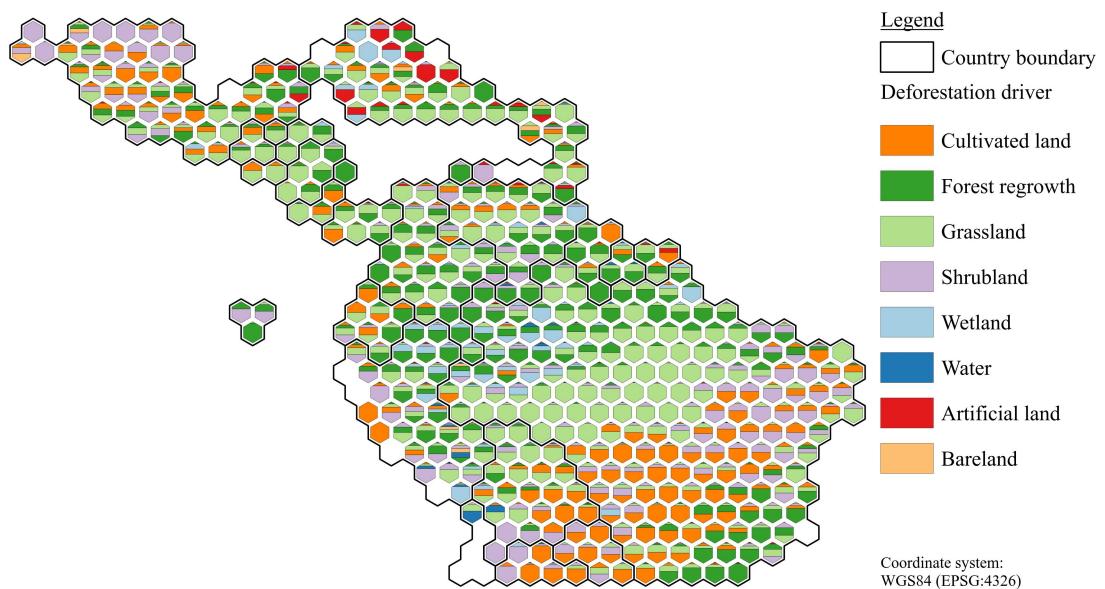


Figure 7:

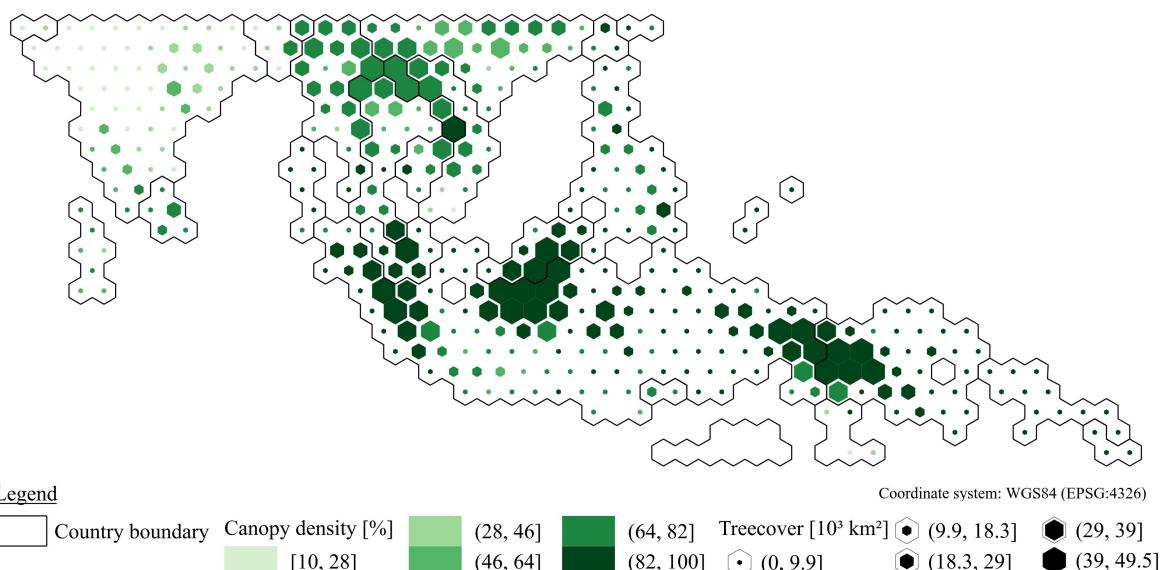


Figure 8:

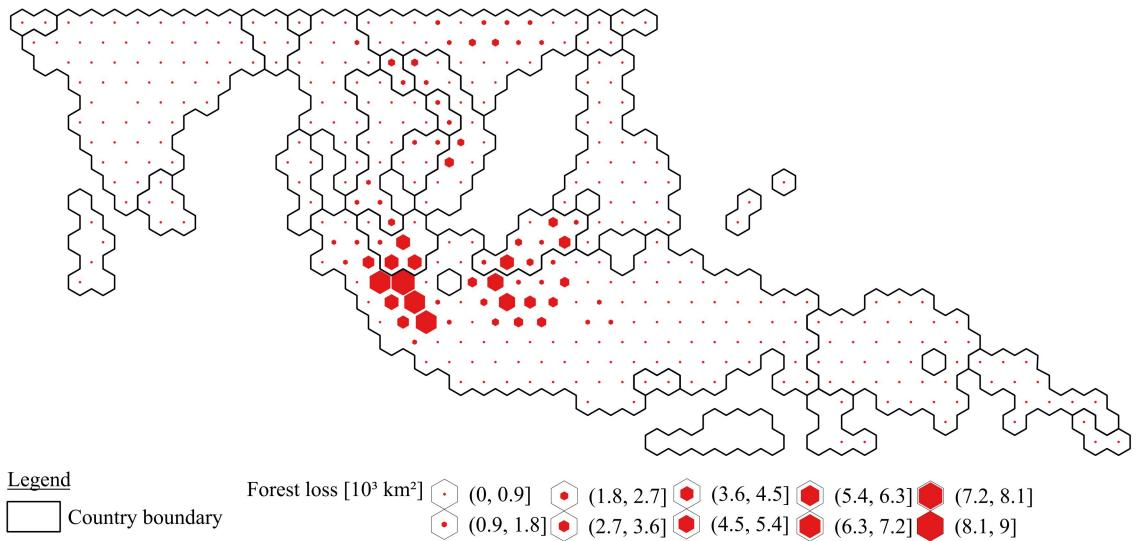


Figure 9:

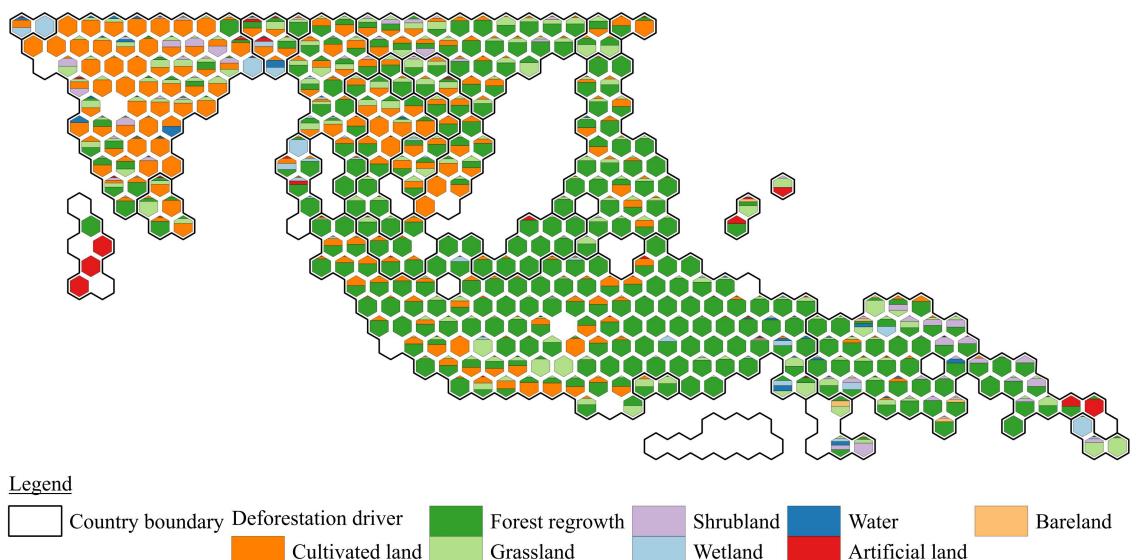


Figure 10:

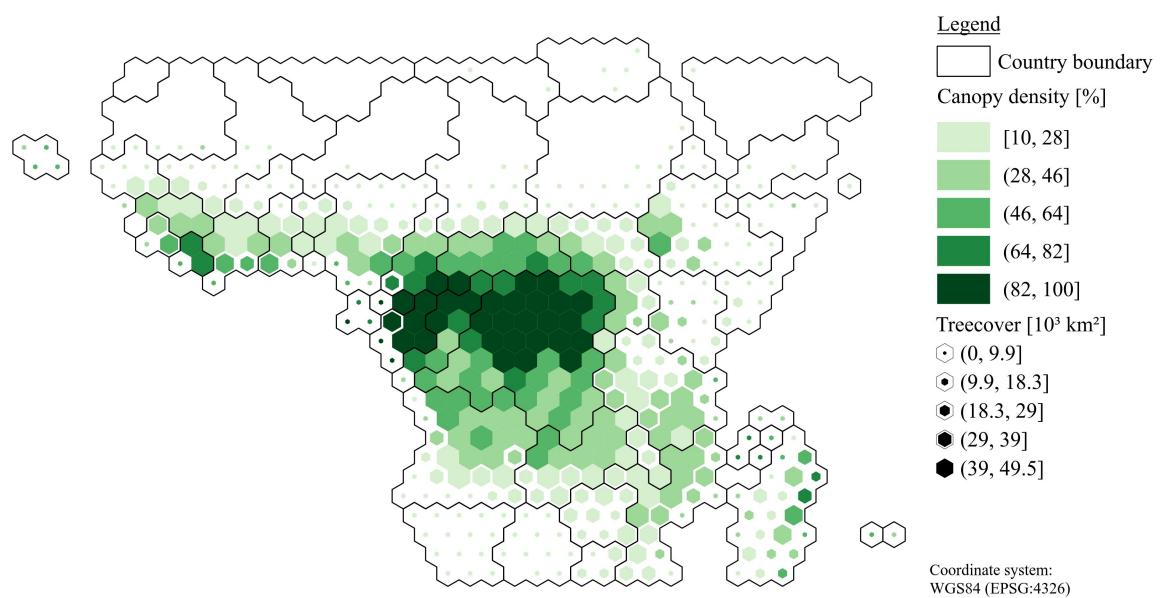


Figure 11:

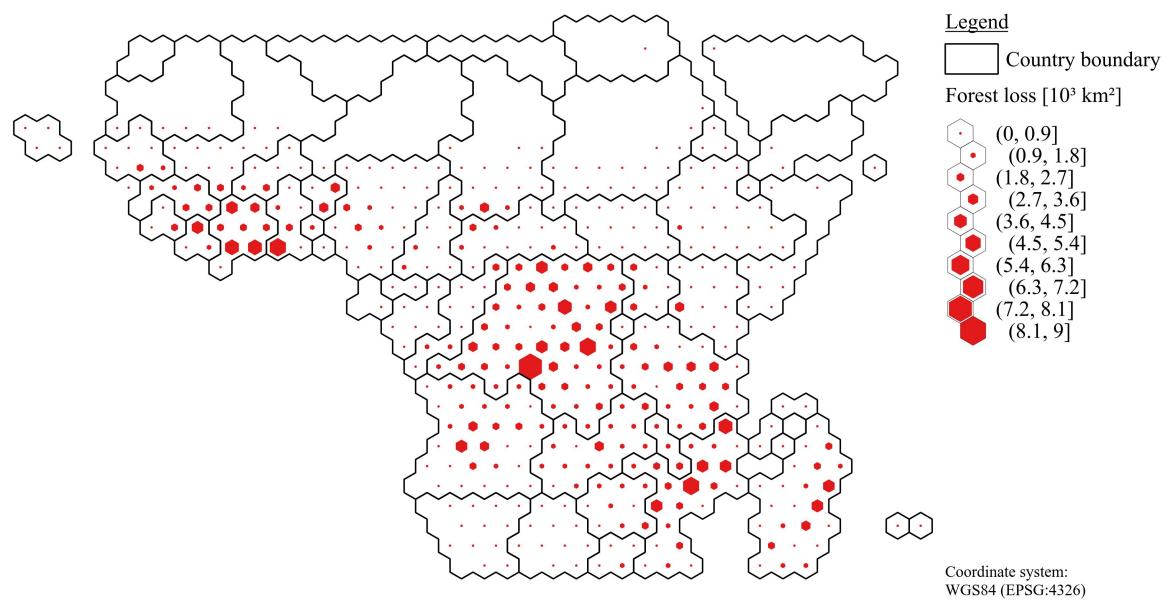


Figure 12:

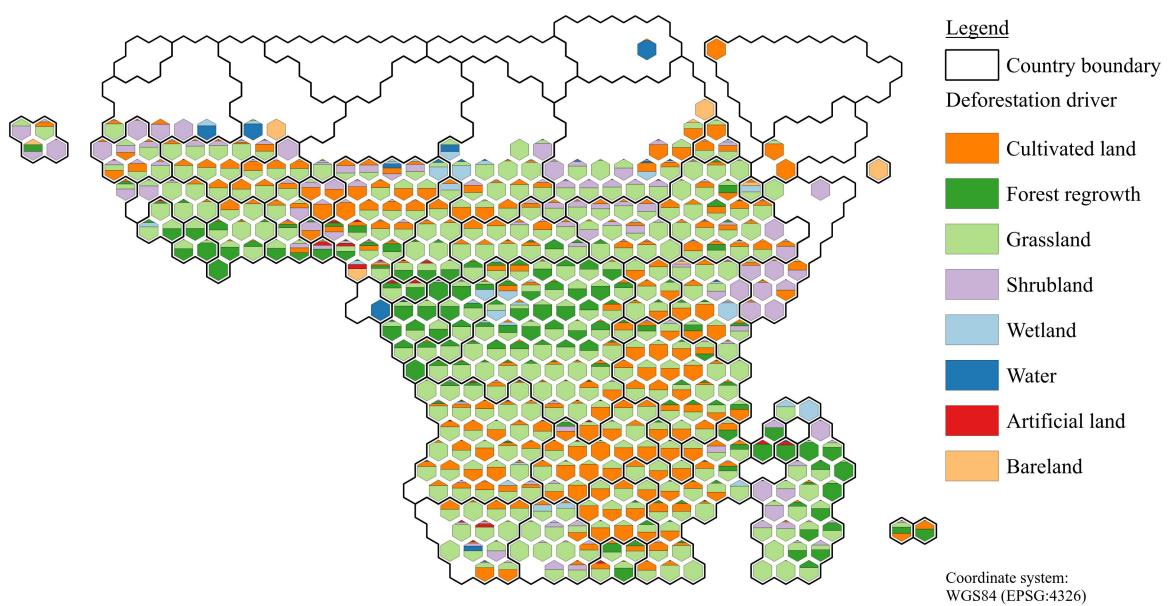


Figure 13:

3.3 Deforestation

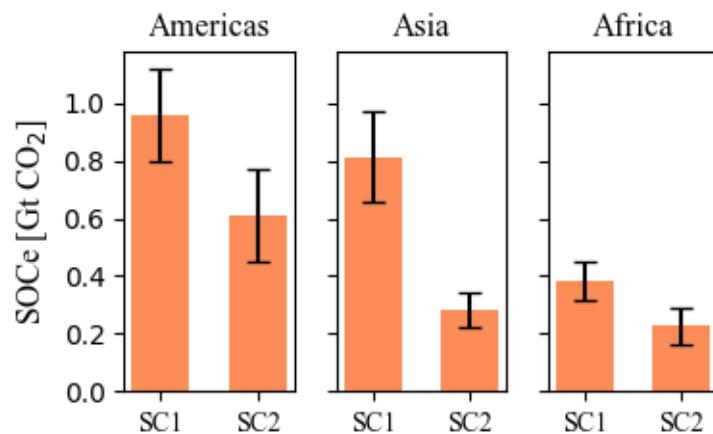


Figure 15:

Table 4: Soil organic carbon emissions

| Region | SC1 [Gt CO ₂] | | | SC2 [Gt CO ₂] | | | SC3 [Gt CO ₂] | | |
|----------|------------------------------|------|------|------------------------------|------|------|------------------------------|------|------|
| | min | mean | max | min | mean | max | min | mean | max |
| Americas | 0.80 | 0.96 | 1.12 | 0.45 | 0.61 | 0.77 | 0.43 | 0.59 | 0.76 |
| Asia | 0.66 | 0.81 | 0.97 | 0.22 | 0.28 | 0.34 | 0.22 | 0.28 | 0.33 |
| Africa | 0.32 | 0.39 | 0.45 | 0.17 | 0.23 | 0.29 | 0.16 | 0.23 | 0.29 |

3.3.1 Global

3.3.2 Americas

3.3.3 Asia

3.3.4 Africa

3.4 Ecosystem service value balance

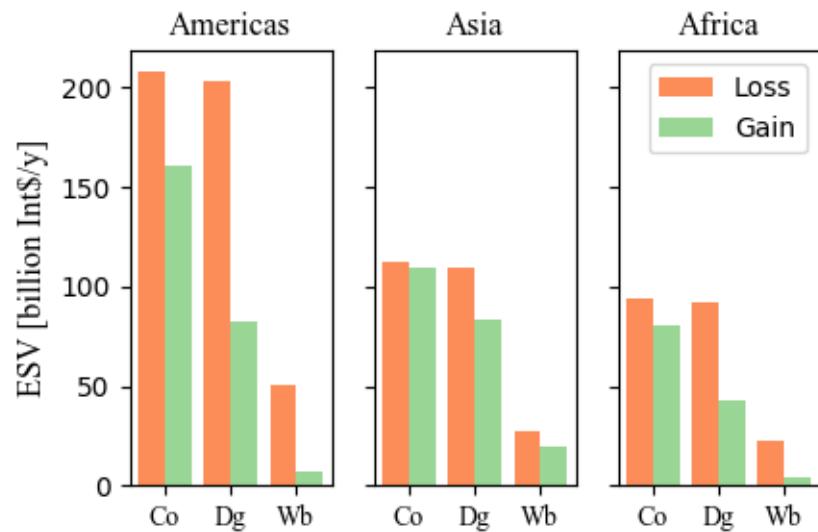


Figure 16:

3.4.1 Global

3.4.2 Americas

3.4.3 Asia

3.4.4 Africa

4 Discussion

Acknowledgements

References

- Chen J., Chen J., Liao A., Cao X., Chen L., Chen X., He C., Han G., Peng S., Lu M., Zhang W., Tong X., and Mills J. *30-meter Global Land Cover Dataset - Product Description*. National Geomatics Center of China, May 2014.
- Hansen M. C., Potapov P. V., Moore R., Hancher M., Turubanova S. A., Tyukavina A., Thau D., Stehman S. V., Goetz S. J., Loveland T. R., Kommareddy A., Egorov A., Chini L., Justice C. O., and Townshend J. R. G. High-Resolution Global Maps of 21st-Century Forest Cover Change. *Science*, 342(6160):850–853, November 2013a. doi: 10.1126/science.1239552.
- Hansen M. C., Potapov P. V., Moore R., Hancher M., Turubanova S. A., Tyukavina A., Thau D., Stehman S. V., Goetz S. J., Loveland T. R., Kommareddy A., Egorov A., Chini L., Justice C. O., and Townshend J. R. G. Supplementary Materials for: High-Resolution Global Maps of 21st-Century Forest Cover Change. *Sciene*, 342(6160):1–32, November 2013b. doi: 10.1126/science.1244693.
- Hosonuma N., Herold M., De Sy V., De Fries R. S., Brockhaus M., Verchot L., Angelsen A., and Romijn E. An assessment of deforestation and forest degradation drivers in developing countries. *Environmental Research Letters*, 7(4):1–12, October 2012. doi: 10.1088/1748-9326/7/4/044009.

List of Figures

| | | |
|----|-------------------------------------|----|
| 1 | Tropical zone | 11 |
| 2 | Deforestation examples | 12 |
| 3 | Study extent | 13 |
| 4 | Boxplot of Jaccard scores | 15 |
| 5 | Ecosystem service values | 17 |
| 6 | Ecosystem service values | 17 |
| 7 | Ecosystem service values | 18 |
| 8 | Ecosystem service values | 18 |
| 9 | Ecosystem service values | 19 |
| 10 | Ecosystem service values | 19 |
| 11 | Ecosystem service values | 20 |
| 12 | Ecosystem service values | 20 |
| 13 | Ecosystem service values | 21 |
| 14 | Ecosystem service values | 22 |
| 15 | Ecosystem service values | 22 |
| 16 | Ecosystem service values | 23 |

List of Tables

| | | |
|---|---|----|
| 1 | Used datasets | 13 |
| 2 | Accuracy assessment | 15 |
| 3 | Deforestation driver | 16 |
| 4 | Soil organic carbon emissions | 22 |

List of Abbreviations

| | |
|--------------|---|
| FAO | Food and Agriculture Organization of the United Nations |
| GFC | Global Forest Change |
| GIS | Geographic Information System |
| GLC30 | GlobeLand30 |
| GTiff | Geo-Tiff |
| IPCC | Intergovernmental Panel on Climate Change |
| LULC | Land Use/Land Cover |
| POK | Pixel-Object-Knowledge |
| R-PIN | Readiness Plan Idea Note |
| R-PP | Readiness Preparation Proposal |
| UTM | Universal Transverse Mercator |
| WGS84 | World Geodetic System 1984 |

Appendix

Wyrażam zgodę na udostępnienie mojej pracy w czytelniach Biblioteki SGGW w tym w Archiwum Prac Dyplomowych SGGW.

I agree to share my work in the reading rooms of the SGGW Library, including the SGGW Theses Archive.

Ich erteile meine Zustimmung zur Veröffentlichung meiner Arbeit in der Bibliothek der SGGW (Warschauer Naturwissenschaftliche Universität), einschließlich des Archivs der Diplomarbeiten.

.....
(czytelny podpis autora pracy)
(legible signature of the author)
(lesbare Unterschrift des Autors der Arbeit)