Using deep learning and remote sensing to map and track land use following deforestation across Africa

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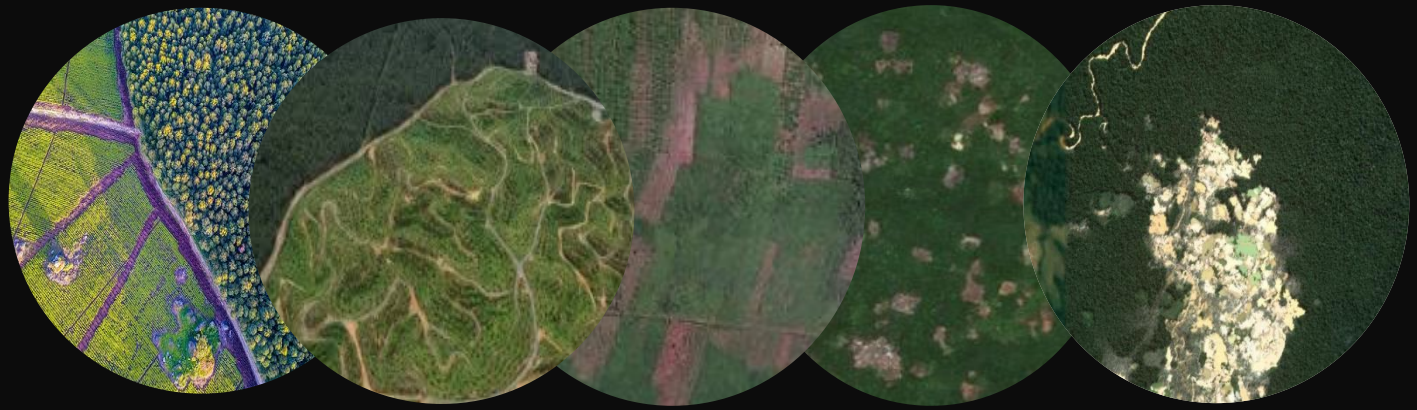
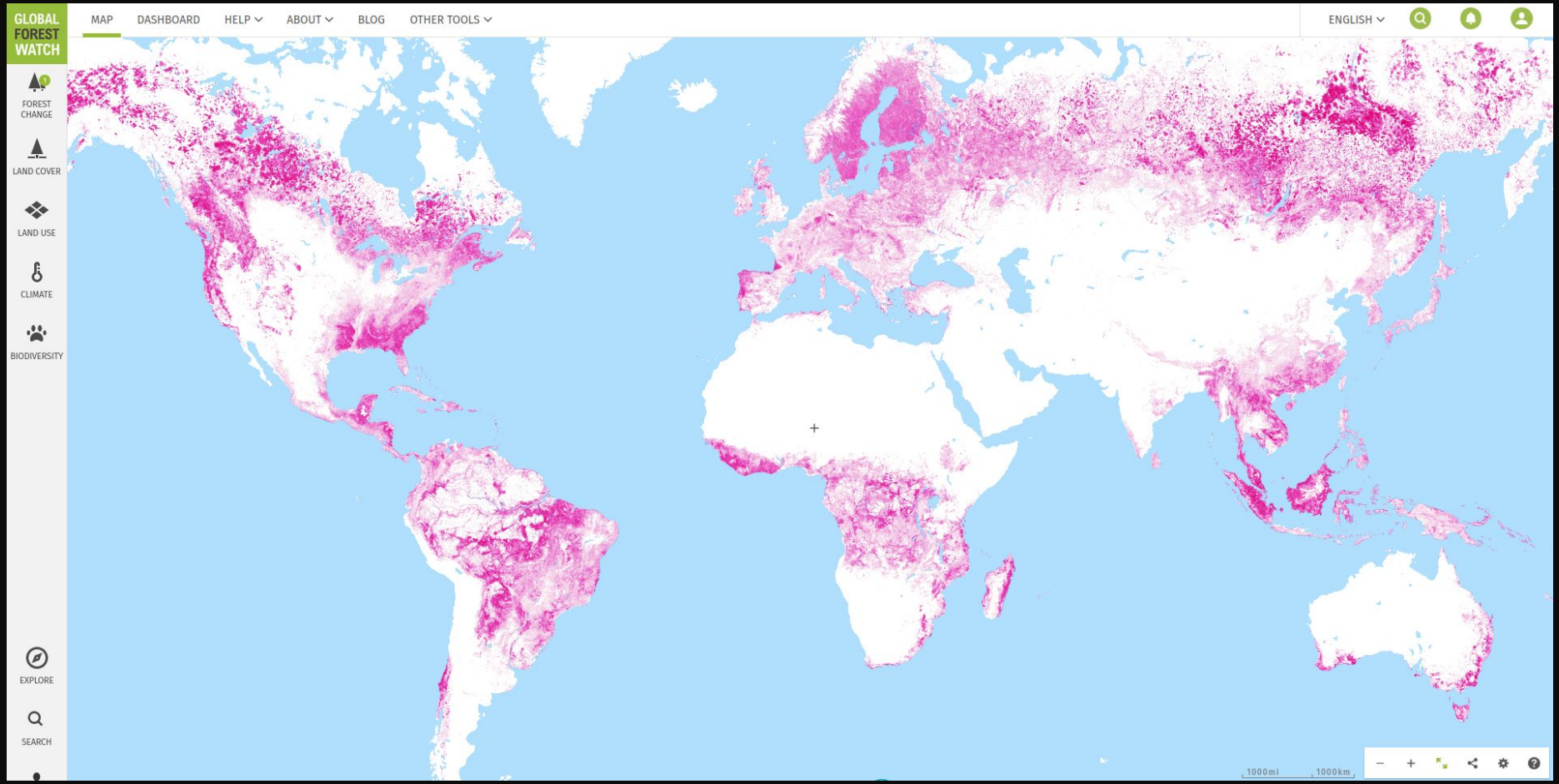



GLOBAL FOREST WATCH
MAP
DASHBOARD
HELP
ABOUT
BLOG
OTHER TOOLS
ENGLISH
FOREST CHANGE
LAND COVER
LAND USE
CLIMATE
BIODIVERSITY
EXPLORE
SEARCH
1000mi
1000km

Motivation

Knowing what causes this tree cover loss can help tackle deforestation

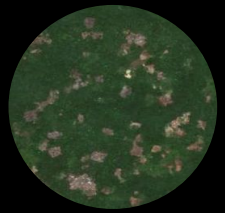
The underlying causes may be very complex, but we can at least see what happens with the land once it is deforested:

The Follow-up land use (FLU)

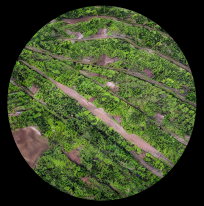
Land activities that follow deforestation

- Large scale cropland

- Small scale cropland



- Cacao



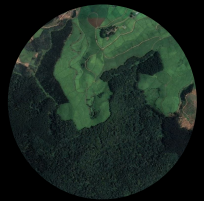
- Cashew

- Oil palm

- Rubber

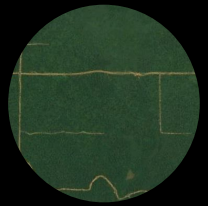
- Coffee

- Tea plantation

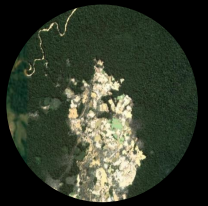


- Pasture

- Roads

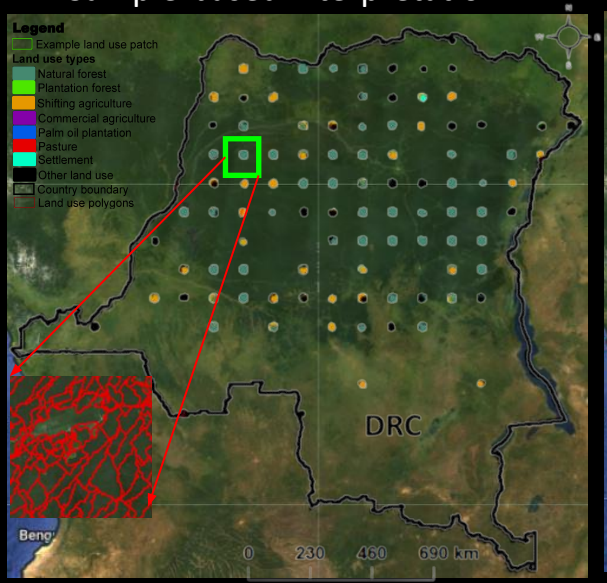


- Mining

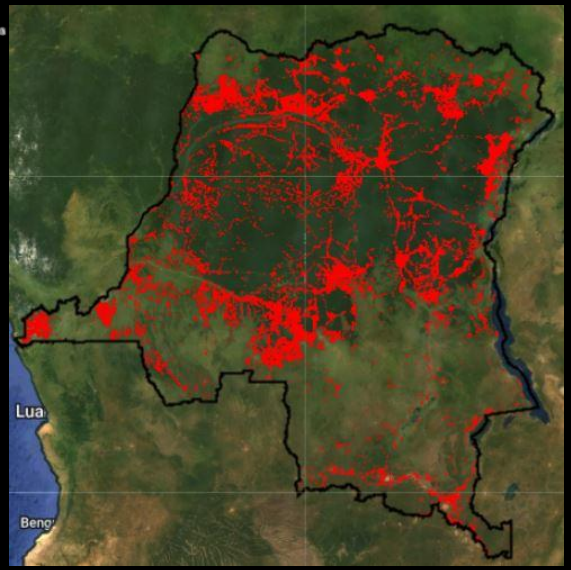


Need for automated large scale land use monitoring

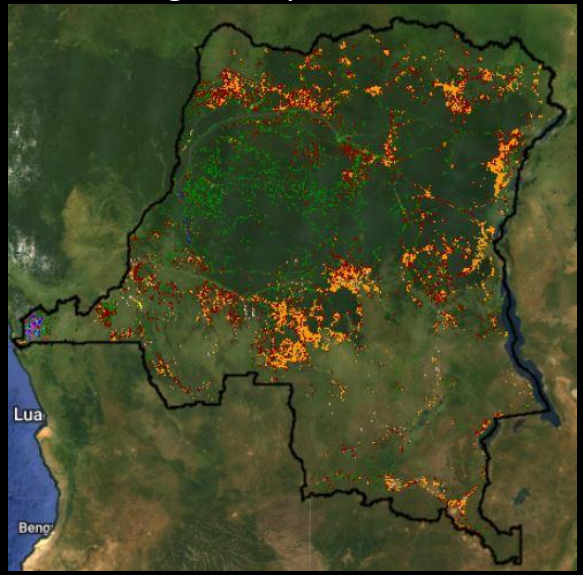
Sample-based interpretation



Forest loss



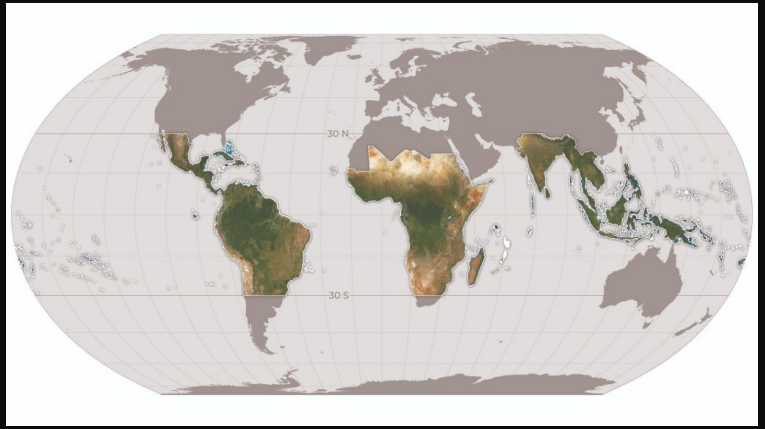
Large area prediction



Freely available data sources

- Landsat
  - 30 m resolution
  - Multispectral (12 bands)
  - Revisit time of 16 days
- Sentinel 2
  - 10 m resolution
  - Multispectral (10 bands)
  - Revisit time of 5 days

- Planet
  - 5 m resolution
  - RGB+NIR (4 bands)
  - Revisit time of 1 day
  - Norway pays for the tropical data! (NICFI)



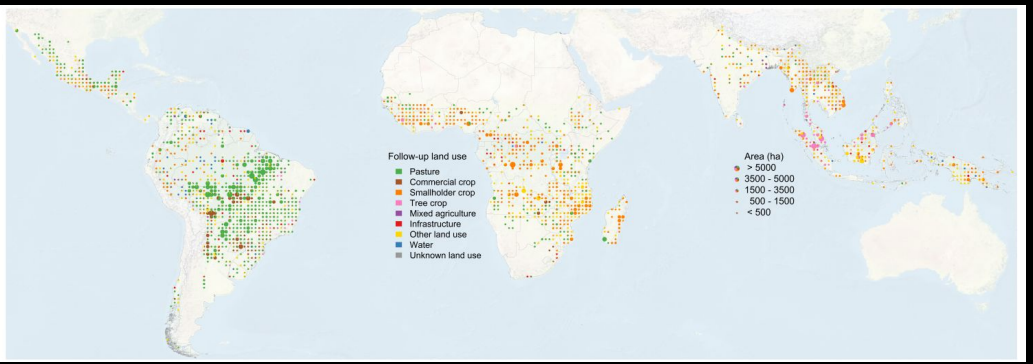
What deep learning architecture to use for assessing land-use following deforestation using remote sensing data?

1. CNN-MHSA
2. ConvLSTM
3. CNN-LSTM
4. 3D-CNN

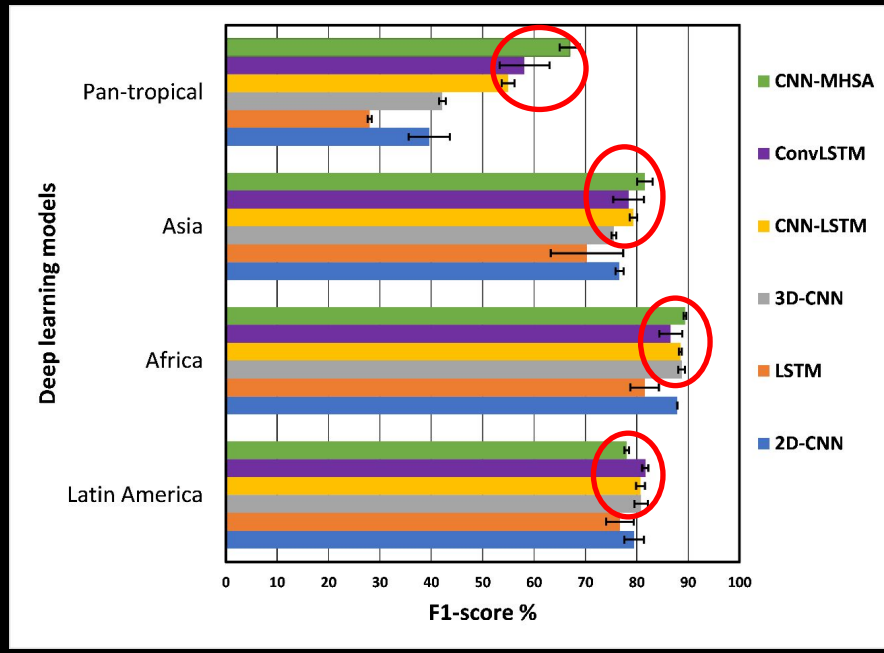
Spatial-temporal models

5. LSTM → Temporal models

6. 2D-CNN → Spatial models



FAO, (2000)



Spatial-temporal models (>=80%)

- CNN-MHSA
- ConvLSTM
- CNN-LSTM
- 3D-CNN

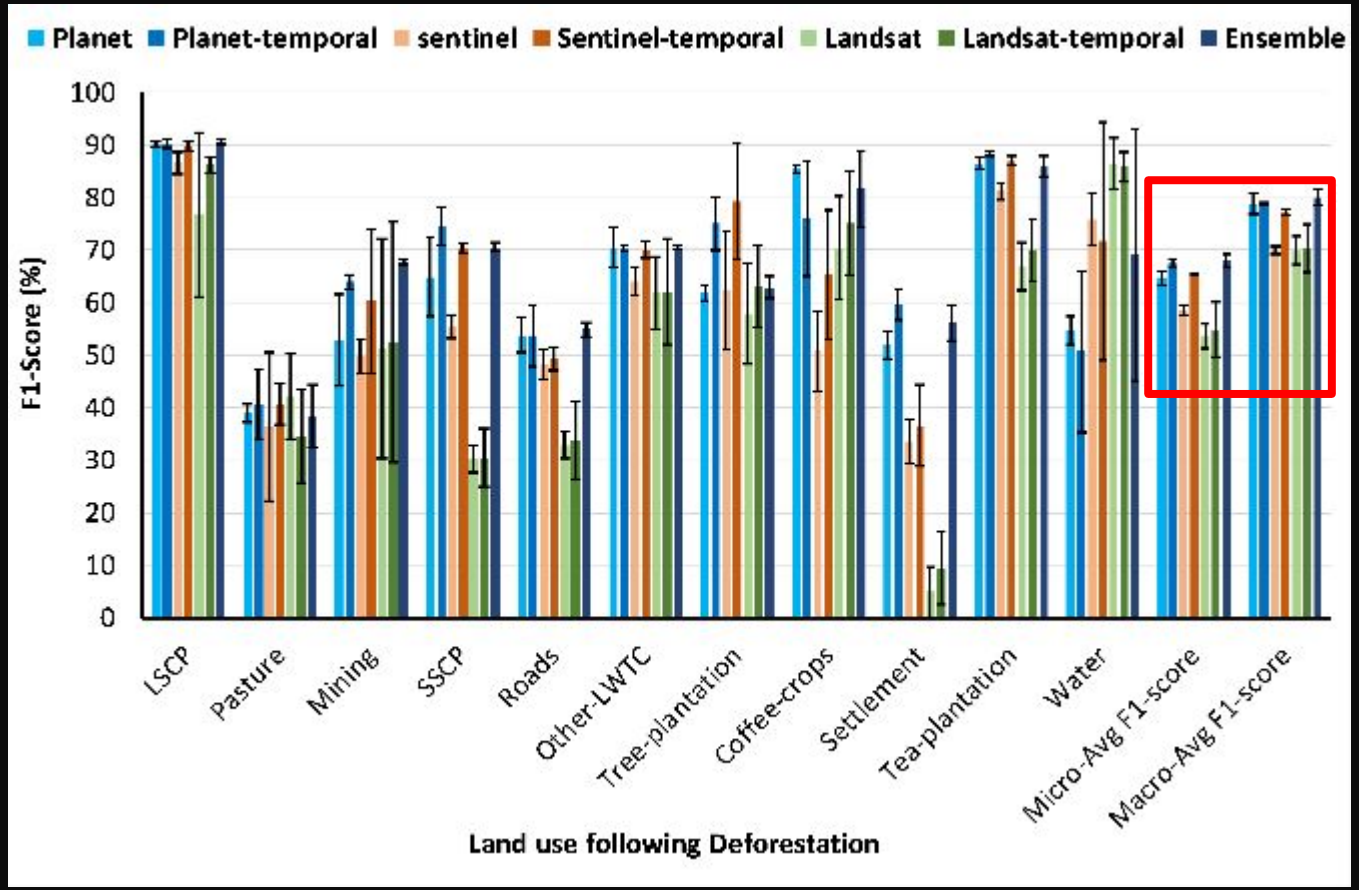
Temporal models <80%

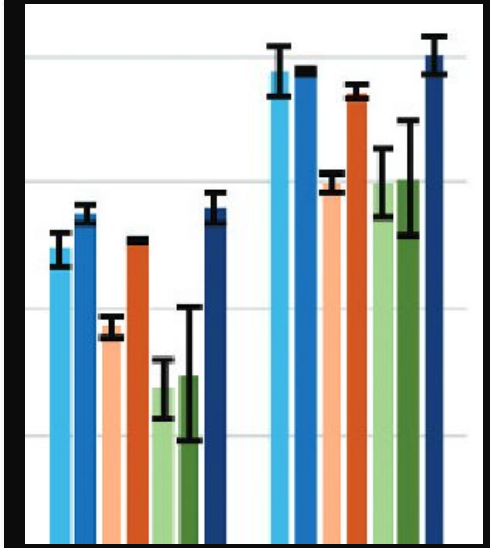
- LSTM

Spatial models=<80%

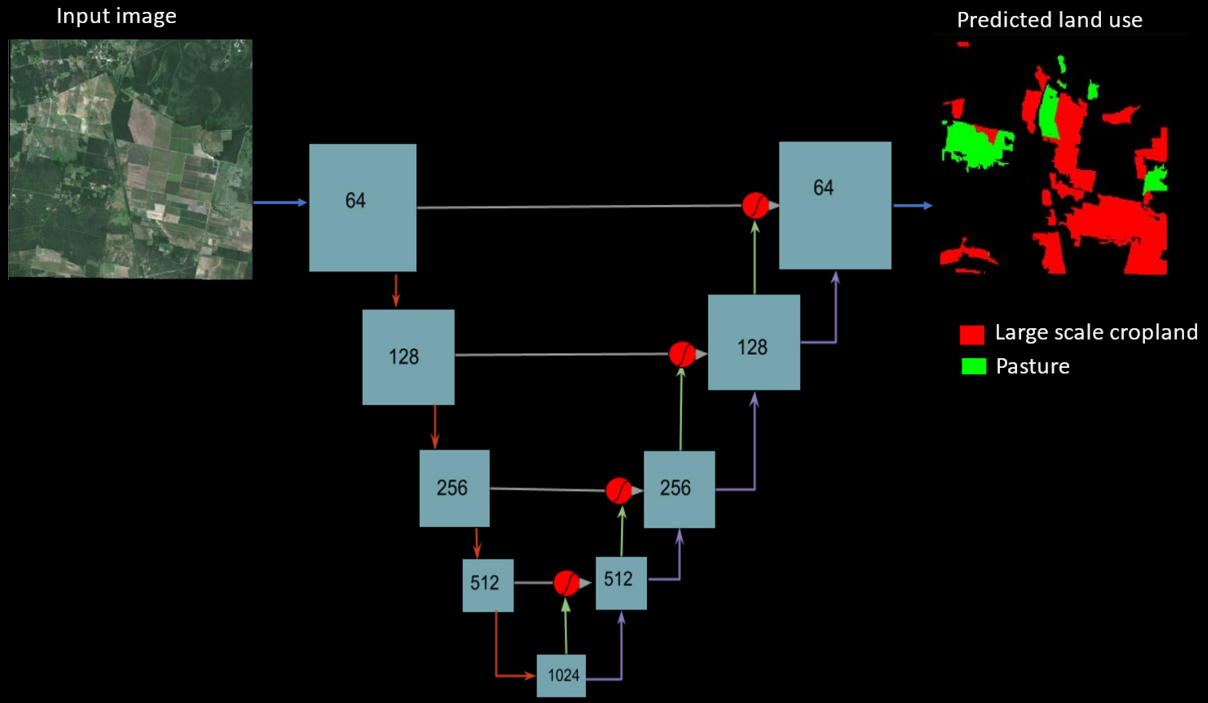
- 2D-CNN

And what data source?





Model: Attention U-Net



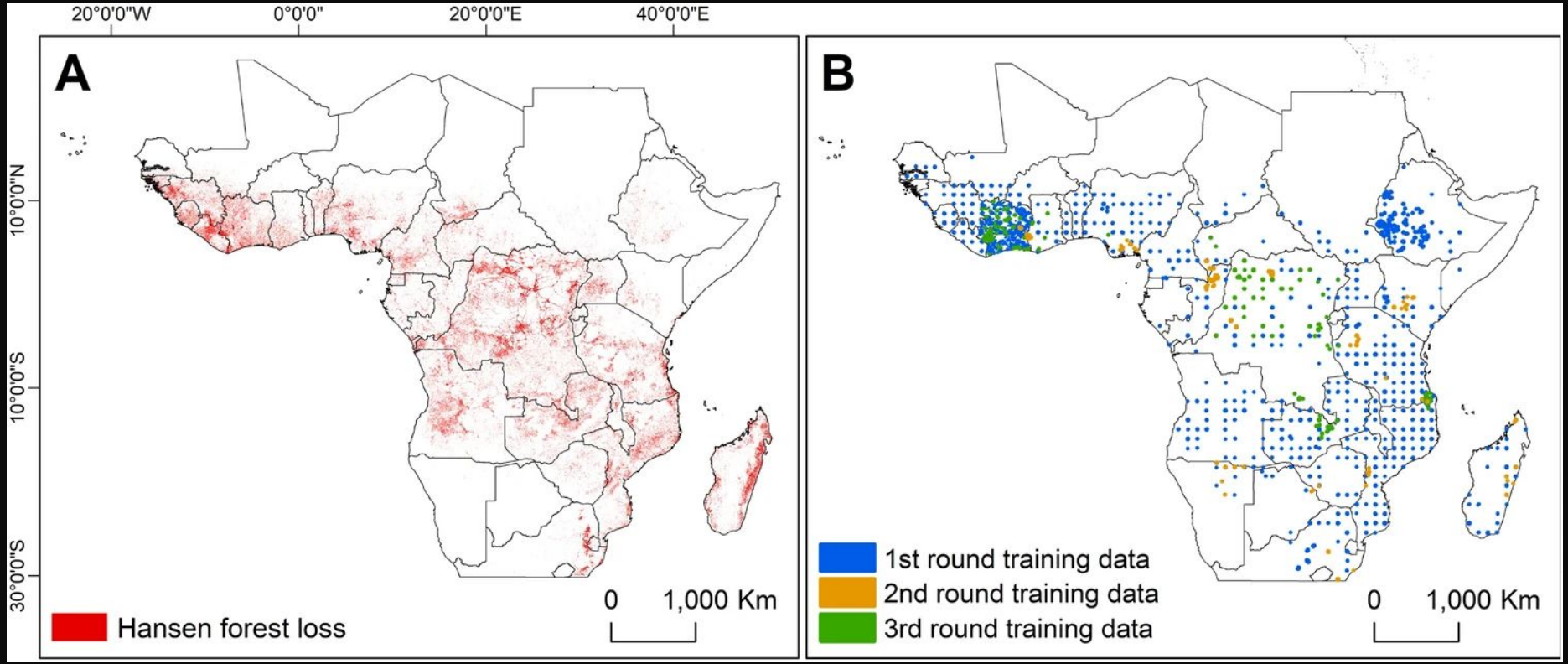
Labeled data sources

Data	LSCP	Pasture	Mining	SSCP	Roads	OLWTC	PF	Coffee	Settlement	TP	Water	OilPalm	Rubber	Cashew	Cacao
FAO 2010 global Remote Sensing Survey	x	x	x	x		x			x		x				
Crowdsourced deforestation drivers (IIASA) (Bayasa et al., 2022) http://pure.iiasa.ac.at/id/eprint/17539/)	x	x	x	x	x		x		x			x			
Masolele et al,. 2022 (Ethiopia)	x	x	x	x	x	x	x	x	x	x	x				
ICRAF, Econometric	x			x		x			x		x	x	x	x	x
NAFORMA (Tanzania)	x		x	x			x							x	
Large-scale farms and small holder (Jann et al,. 2018) (Zambia)	x			x											
Global Map of Oil Palm Plantations (Descale et al., 2021)												x			
Kenya GIS data (World Resources Institute - https://www.wri.org/data/kenya-gis-data)	x			x			x	x		x					
Namibia	X			X											
Ghana	x		x	x								x	x	x	x
Google research open-buildings dataset (https://sites.research.google/open-buildings/)									x						
https://ipisresearch.be/home/maps-data/open-data/ (Mining)			x												
Landuse data Nigeria (https://grid3.gov.ng/datasets)	x			x					x			x		x	x

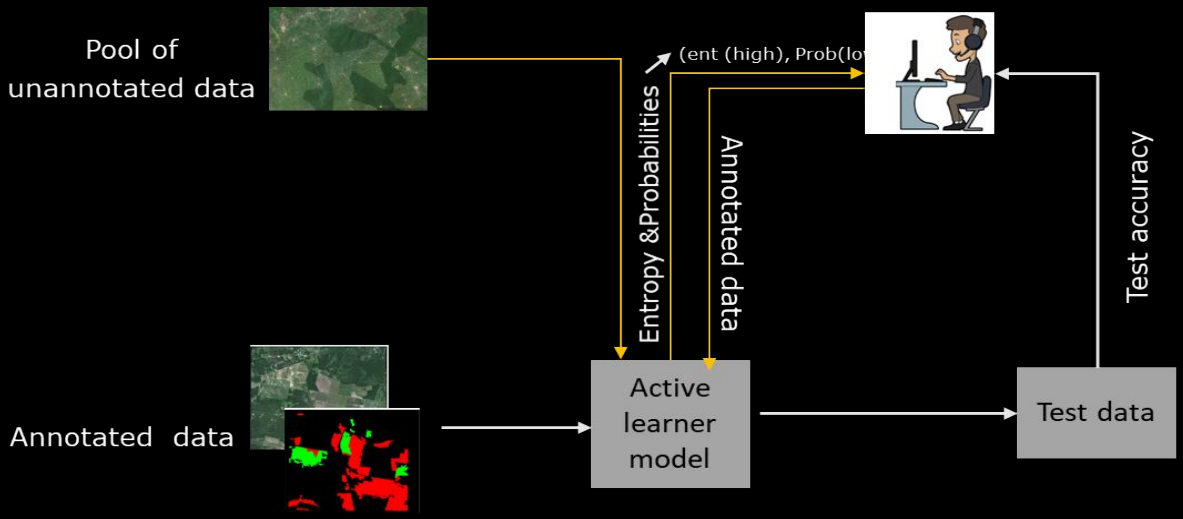
Results

Well, not good

The obtained labels were quite biased



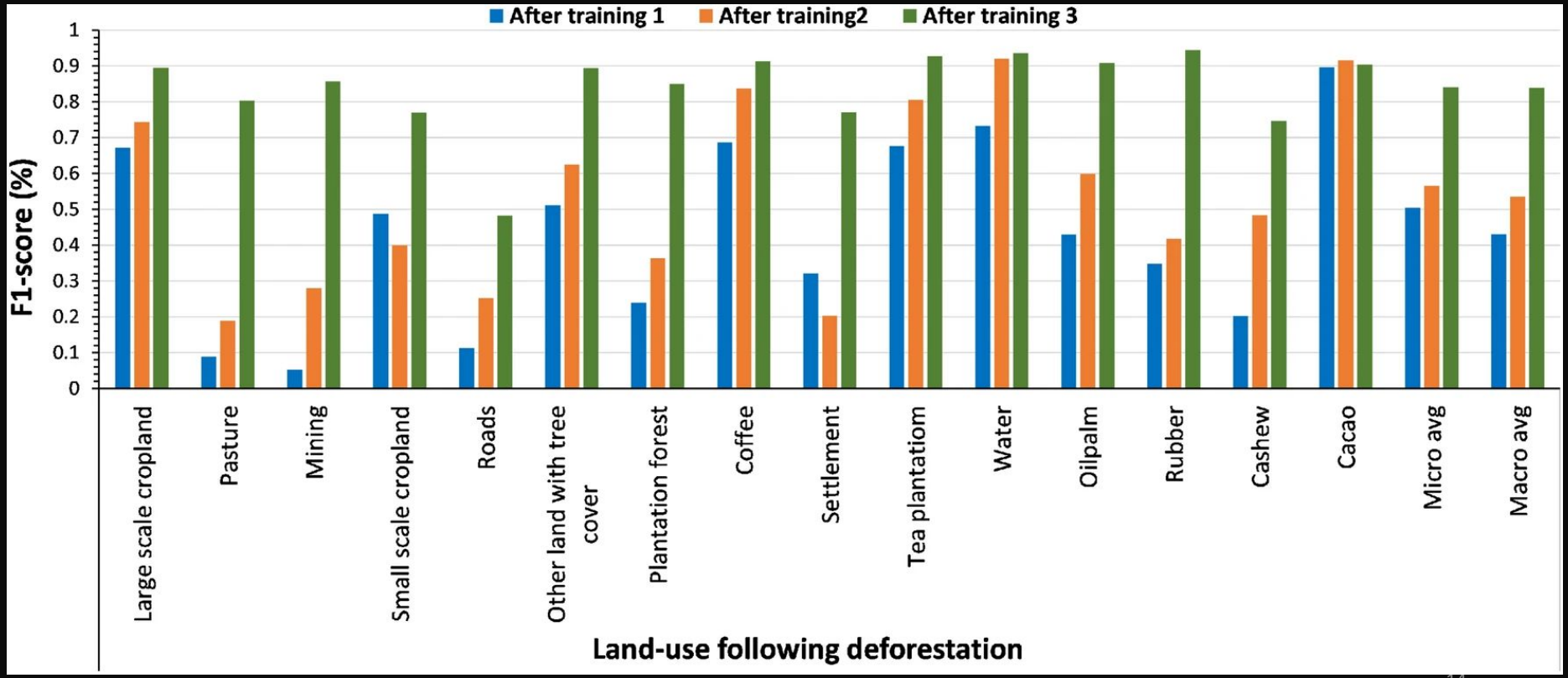
Active learning



Improvement of accuracies with active learning

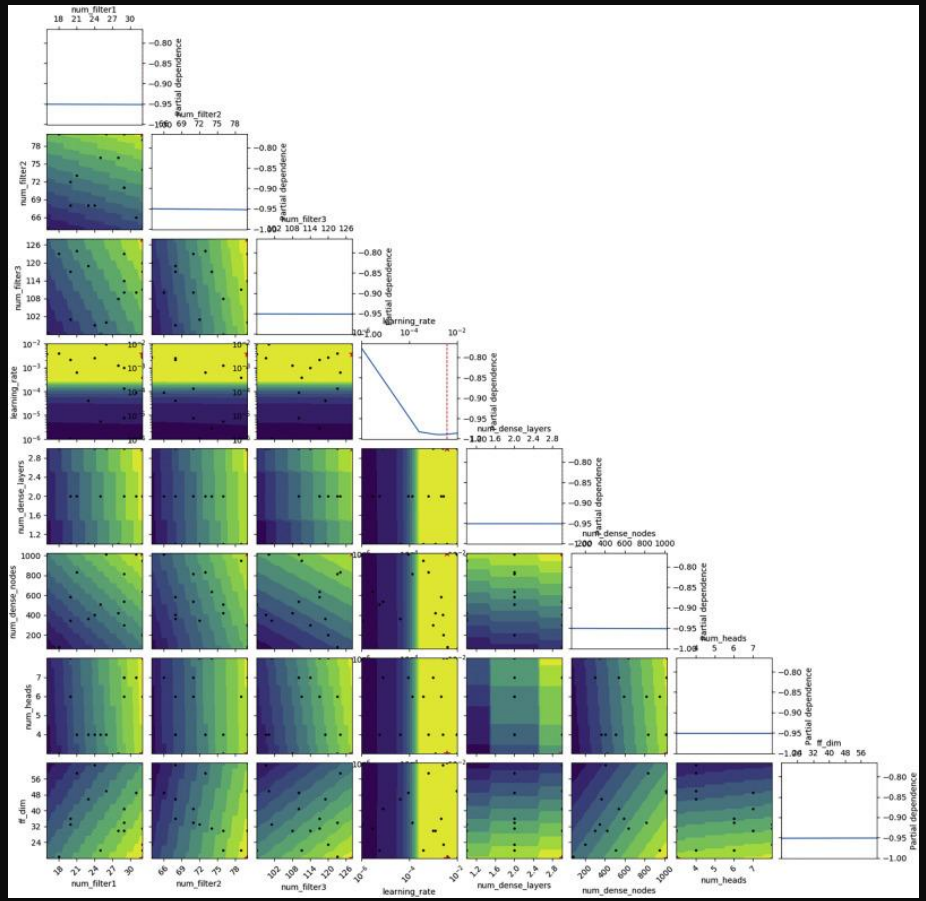
43% → 50% → 84%

Active learning



Hyperparameter optimization

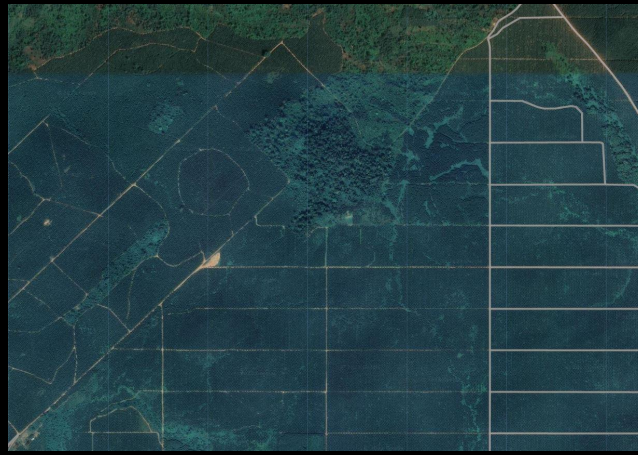
Partial Dependence plot, showing a matrix-plot of all combinations of searched hyperparameters via Bayesian optimization.



Results

Now yes!

D485
D486



KAYANZA
RUBANZA
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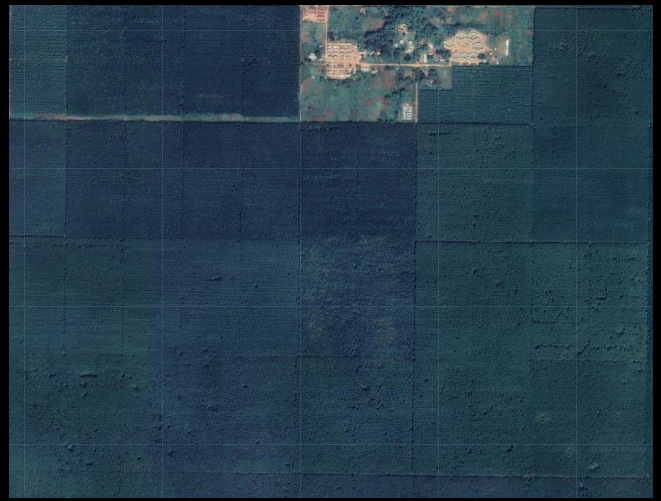
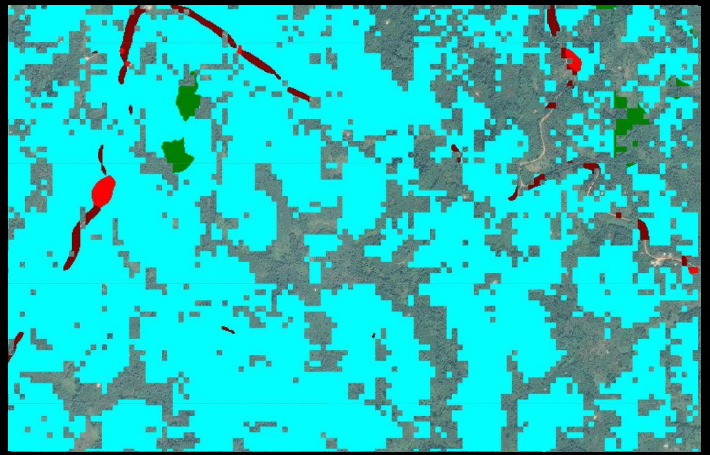
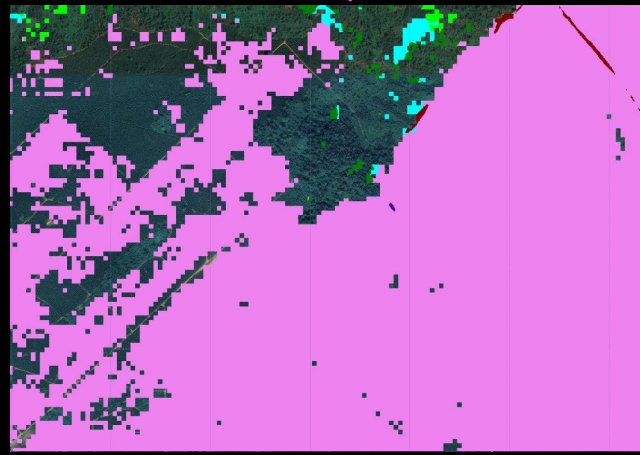


Large scale cropland

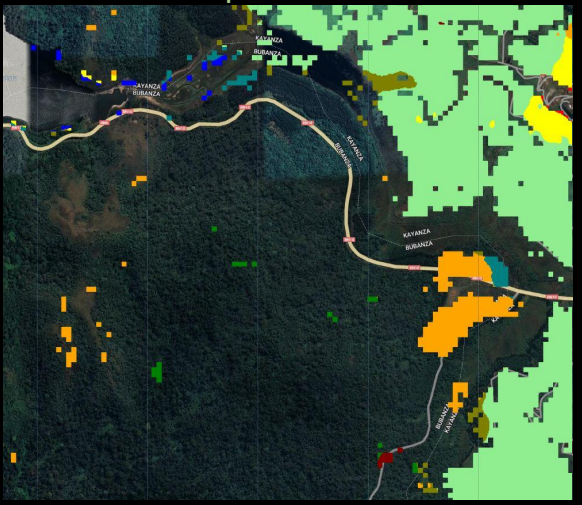
Cacao



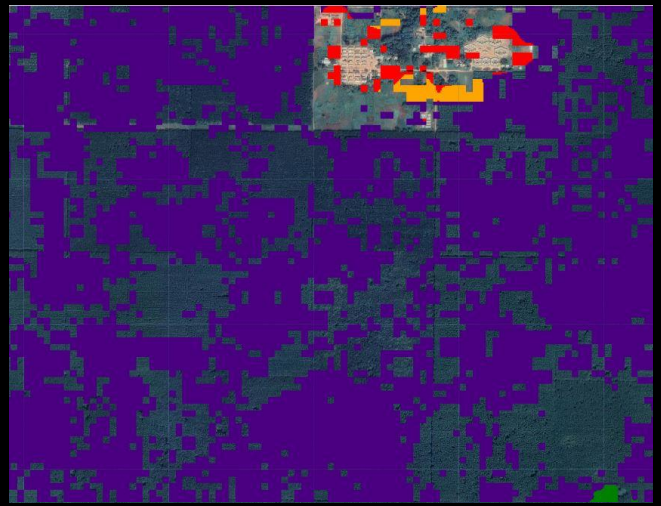
Oil palm



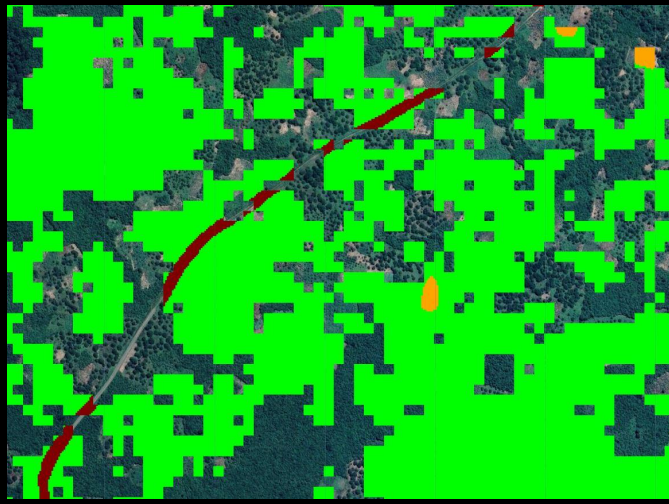
Tea plantation



Rubber



Cashew

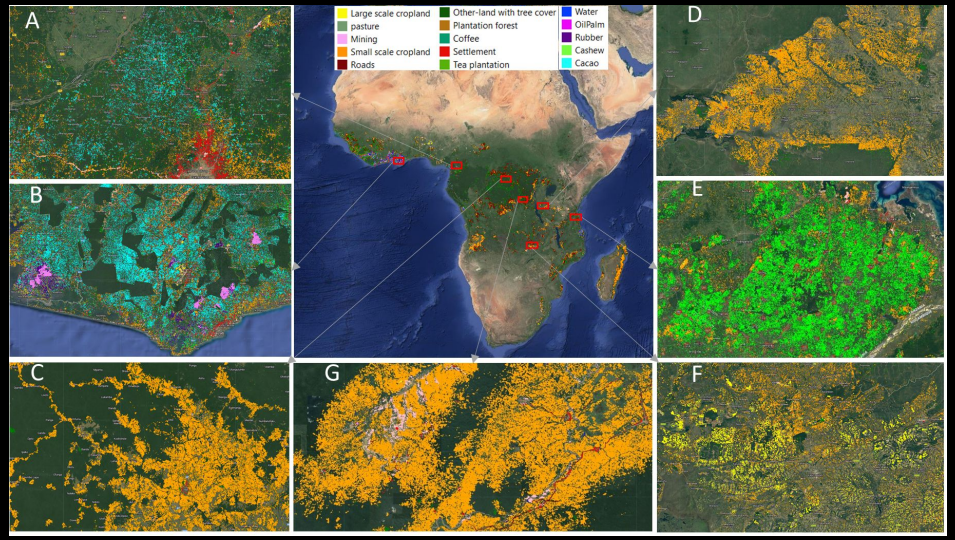


Results: Monitoring direct drivers of deforestation

- Annual follow-up land use 2001 - 2020 mapped at Hansen forest loss data (wall-to-wall for entire Africa)
- Planet NICFI data and deep learning approach used for mapping
- 15 land use classes
- High accuracies (82% average macro-F1, see next slides for more detail)

Direct Drivers of Deforestation (masolele et al. 2023)

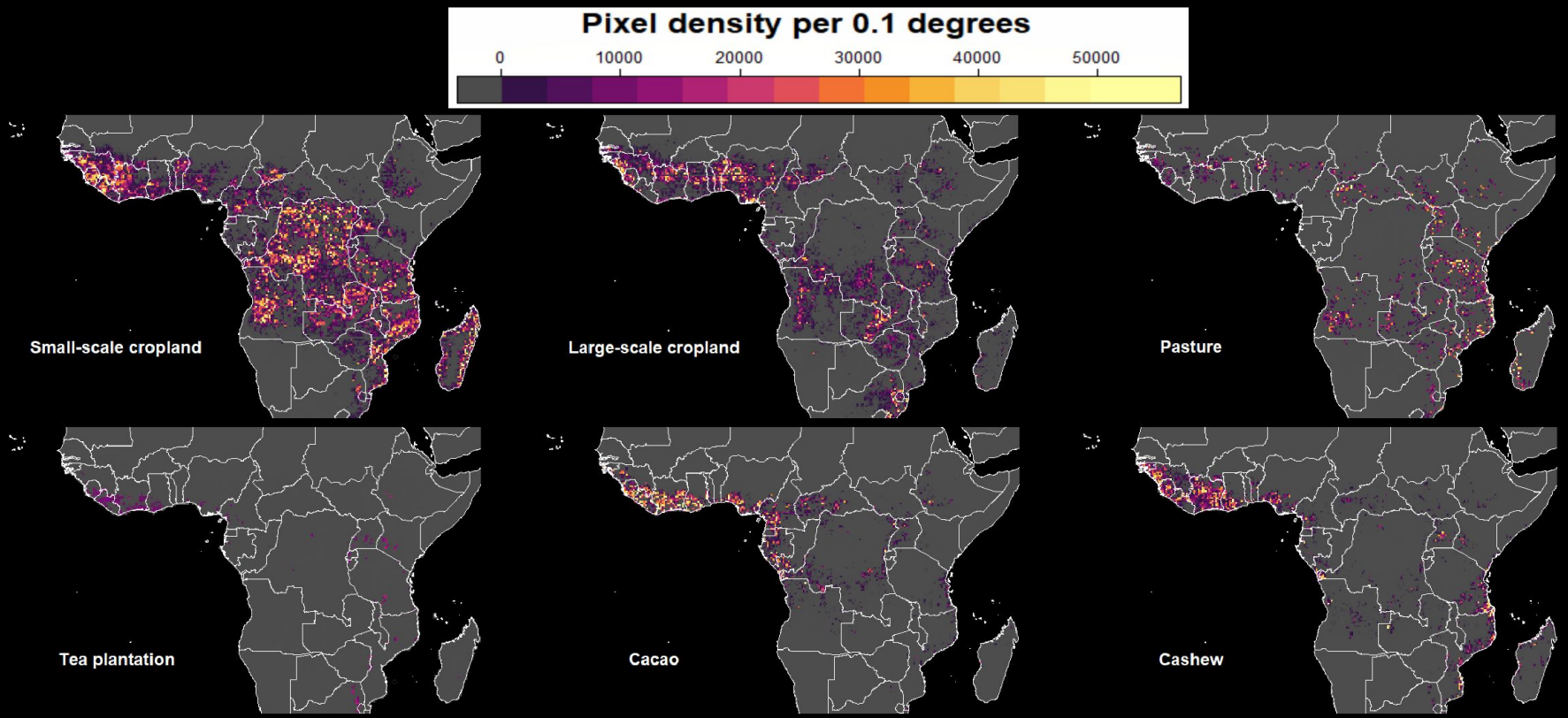
- No loss
- Larger-scale cropland
- Pasture
- Mining
- Small-scale cropland
- Roads
- Other land with tree cover
- Plantation forest
- Coffee
- Settlement
- Tea plantation
- Water
- OilPalm
- Rubber
- Cashew
- Cacao

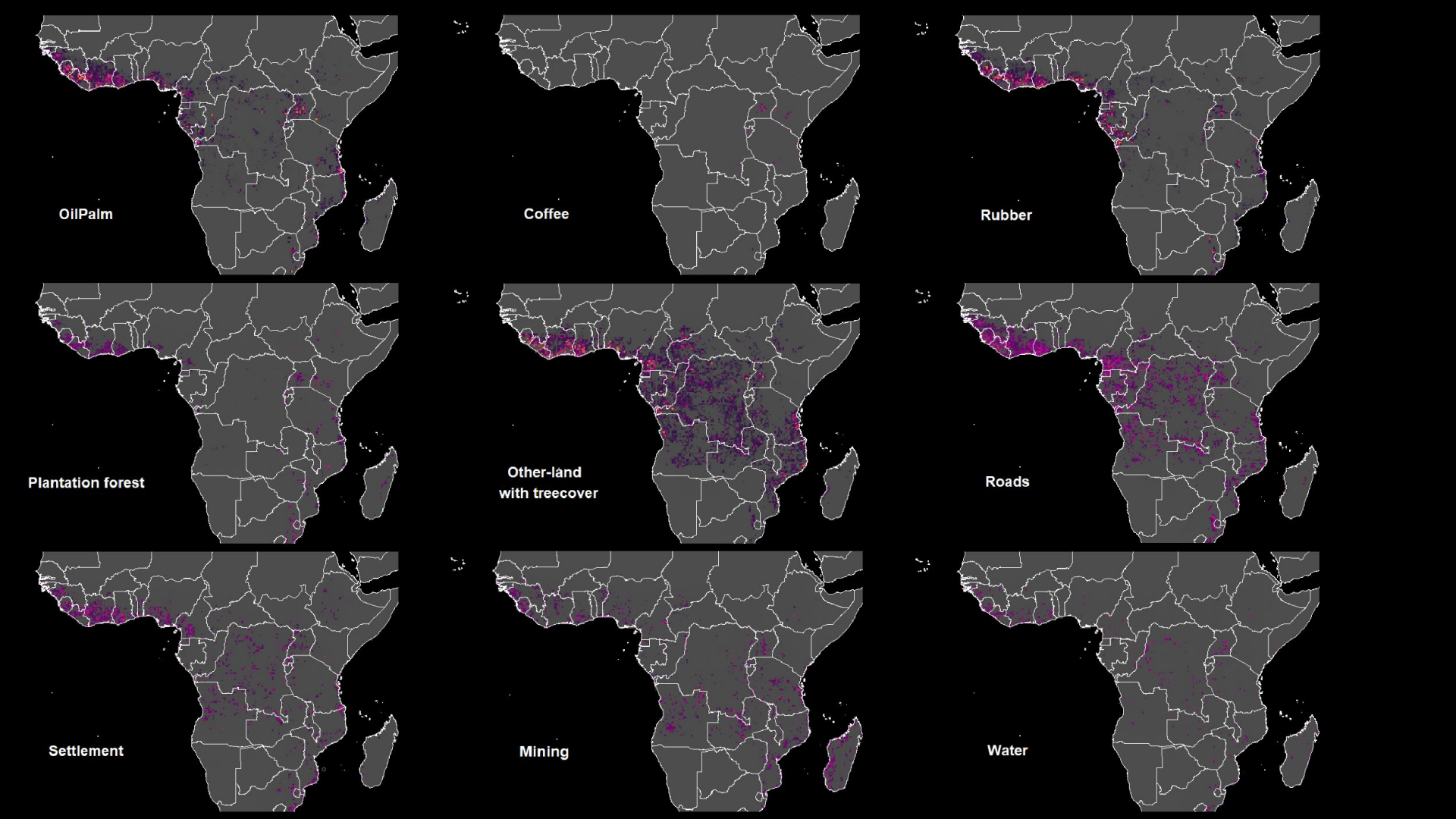


Masolele et al.,
under review in NSR

https://robertnag82.users.earthengine.app/view/africalu

Results: Hotspot of land use following deforestation (Africa)




OilPalm
Coffee
Rubber
Plantation forest
Other-land
with treecover
Roads
Settlement
Mining
Water