Cropland mapping using Landsat time series and land cover phenological pattern modelling

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Introduction

- Cropland mapping is important for food security and climate change study.
- Remotely sensed image data are being widely used for cropland mapping.
- This report presents a new method for cropland mapping using Landsat time series for period from 1985 to 2020.
- The Landsat data for each 5-year period is gathered according to the four seasons of the year.
- Cropland is classified based on seasonal phenological changes of land cover of the year.
- Case study was conducted in Houaphan (Laos PDR) and Son La (Vietnam) provinces. Cropland was mapped for 5-year sequence 1990, 1995, 2000, 2005, 2010, 2015 and 2020.
- This research was conducted under a project: Livelihoods across the border: The causes and impacts of the forest transition in a borderland region

Study sites

- Houaphan – Laos PDR
  - A mountainous province in the northeastern Laos covering an area of 16,500 square kilometers.
  - The terrain is rugged, with dense mountainous forest.
  - The population of the province, as of 2015, was 289,393
- Son La – Vietnam
  - is a province in the Northwest region of Vietnam which covers an area of 14,123.49 square kilometers.
  - The terrain is mountainous with average altitude of 600 m above sea level.
  - The population of Son La, as of 2019, was 1,248,415.

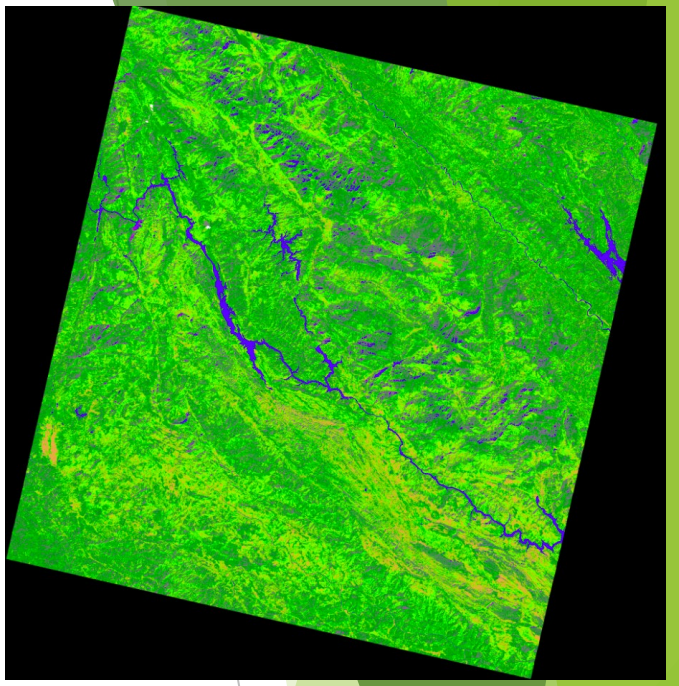
Landsat Time Series

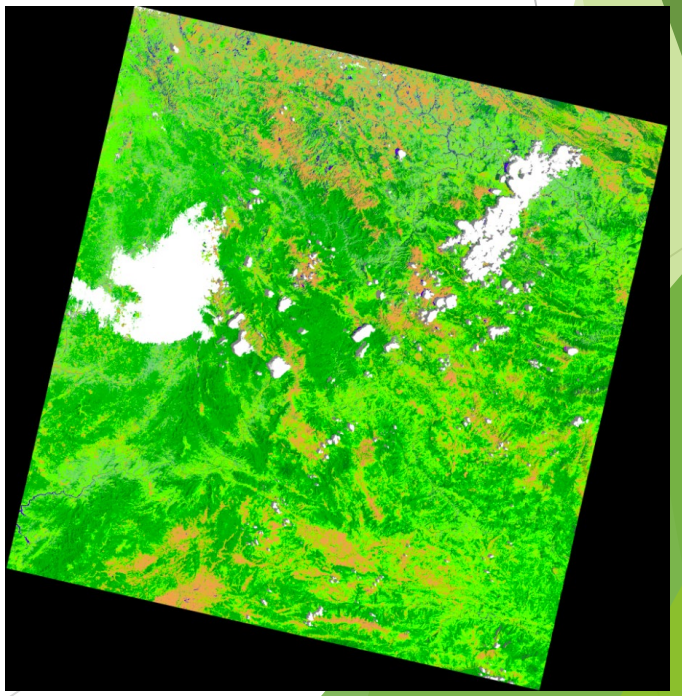
- The study area is covered by four Landsat scenes 127045, 127046, 128045 and 128046.
- Landsat images were available from year 1985. The Landsat collection 1 data was used.
- Number of selected images used for the research were 4229 and they are distributed among sensors as below:

Sensor	Path row number			
	127045	127046	128045	128046
L8	208	201	201	202
L7	361	356	383	375
L5	510	487	507	438
Total	1079	1044	1091	1015

Classification of Land Cover

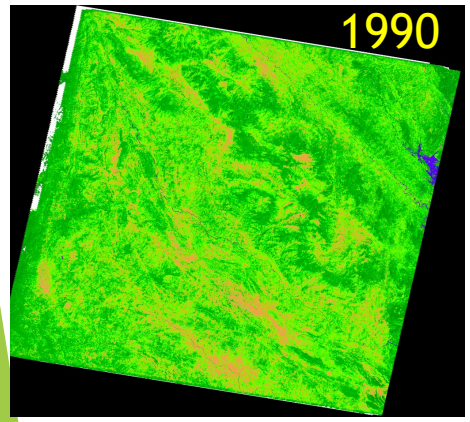
- Classification of land cover was carried out automatically using spectral pattern analysis method.
- In this method, each land cover class is defined by a shape of spectral pattern composed of the 6 spectral band values of TM, ETM+ and OLI.
- The shape of spectral pattern defined by a simplified spectral pattern consisted of 15 digits including: 0, 1, 2.
- The simplified spectral pattern (SSP) is constructed by non-repetitive pairwise comparison of reflectance values between two spectral bands.
- Before analysis, all Landsat image data were converted to top of atmosphere reflectance (TOA).
- Information of cloud and cloud shadow in BQA channel was used for cloud free image stacking.

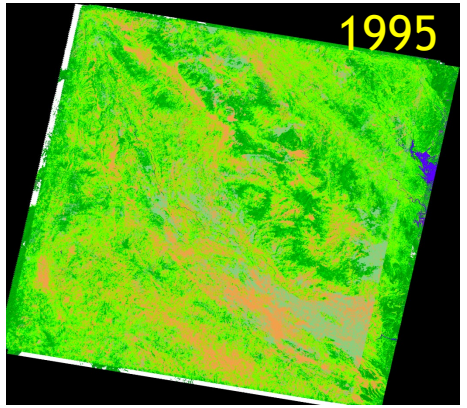


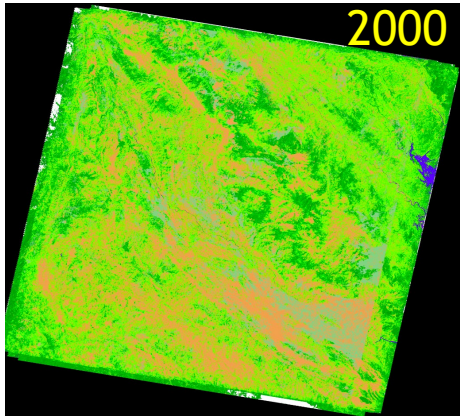


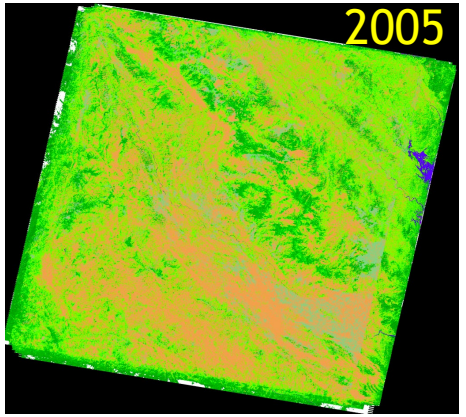
Human Activity Mask

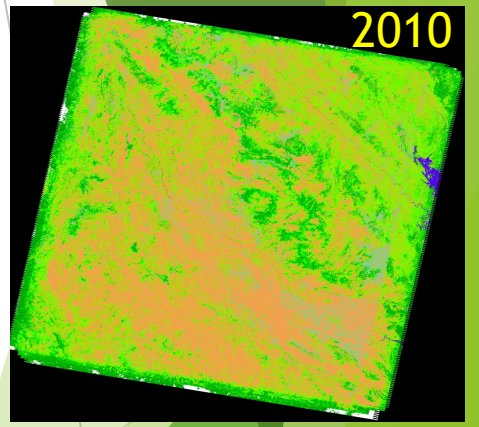
- Human activity mask HAM was developed to divide the study area to two separate parts: Intact area and area under various human activities as forest logging, cultivation, development etc.
- HAM is generated from the accumulation of bare land on classified images over time.

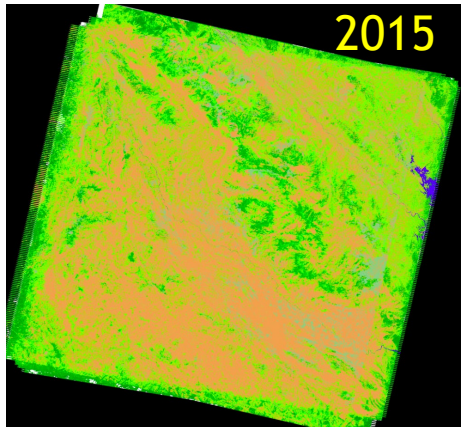


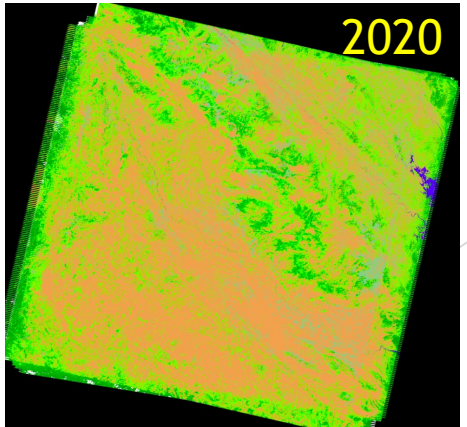






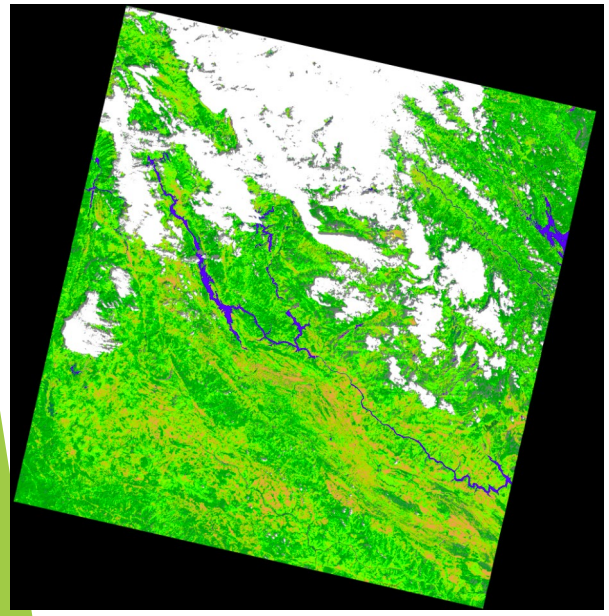






Land cover phenological pattern modeling (1)

- Land cover changes throughout the year, severely affected by clouds



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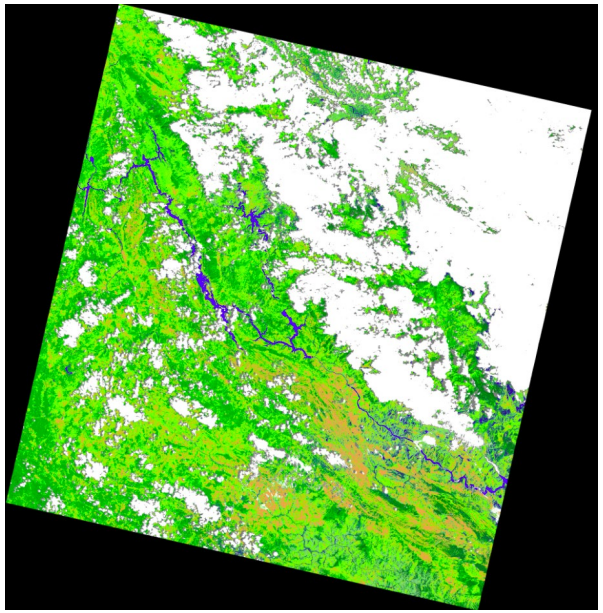

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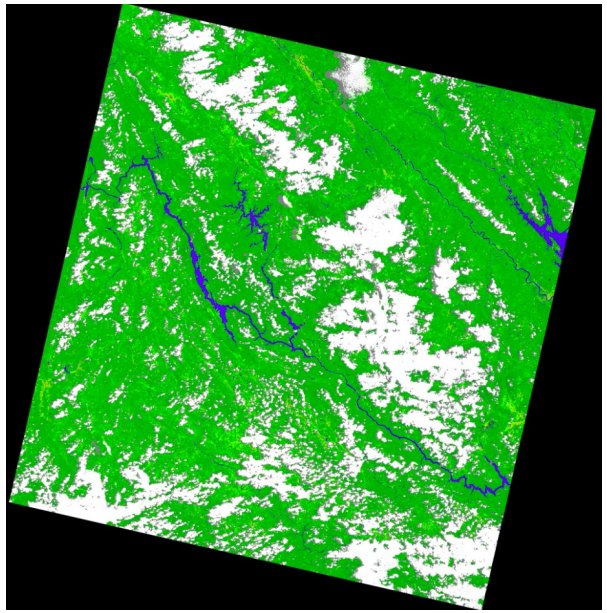
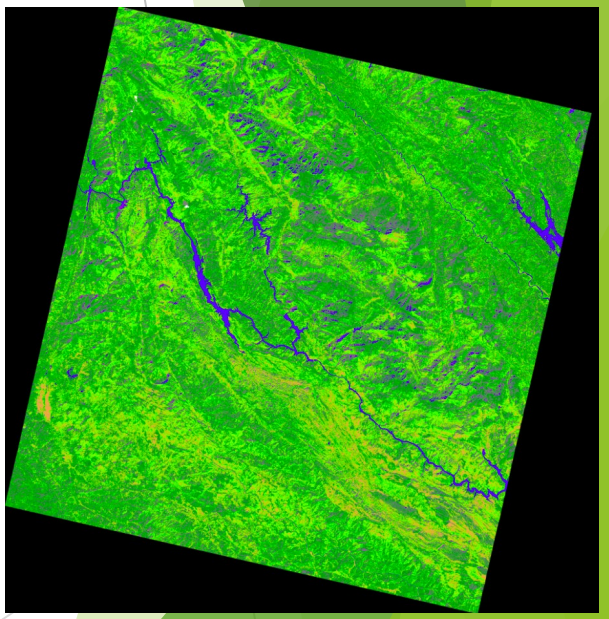


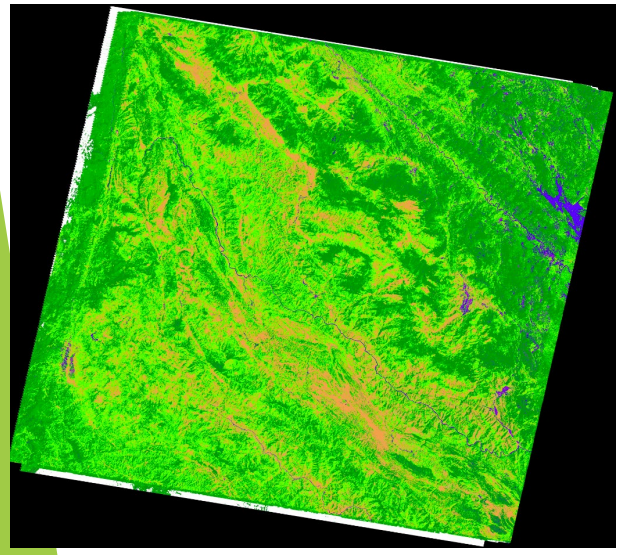
20170729



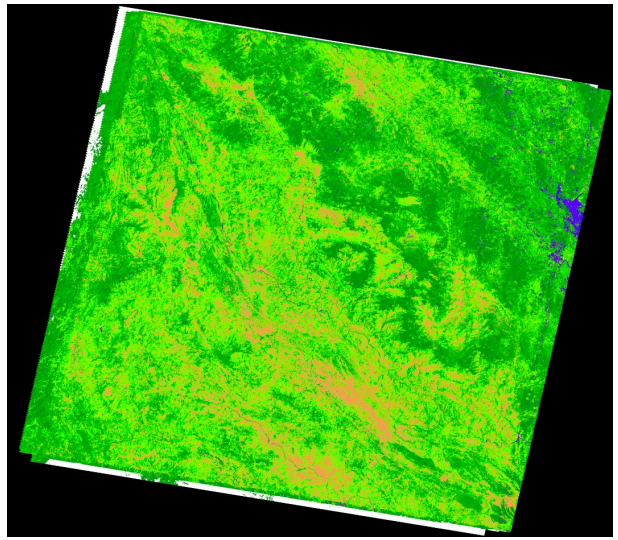
20171220

Land cover phenological pattern modeling (2)

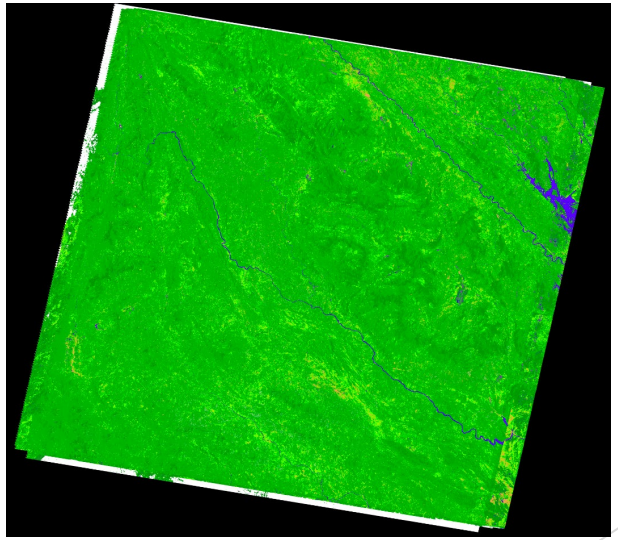
- The period of a year is divided into four quarters similar to the four seasons.
- Using the quarterly classified images for a five-year period we can create a cloud free classified image for each quarter. On these photos we can clearly see the changes in land cover according to each quarter of the year.



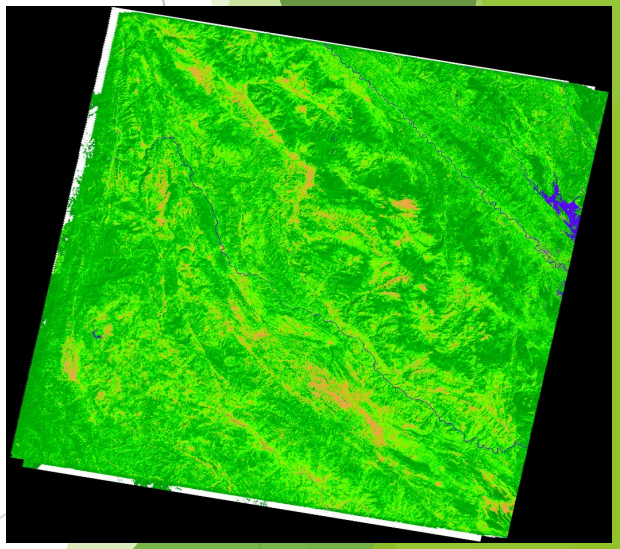
Q1 1990



Q2 1990



Q3 1990

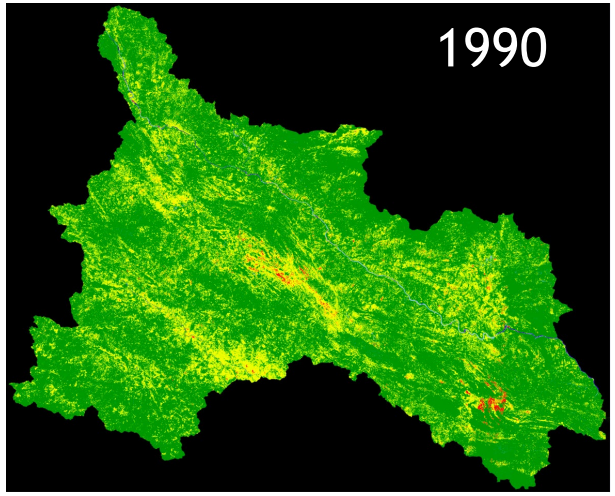


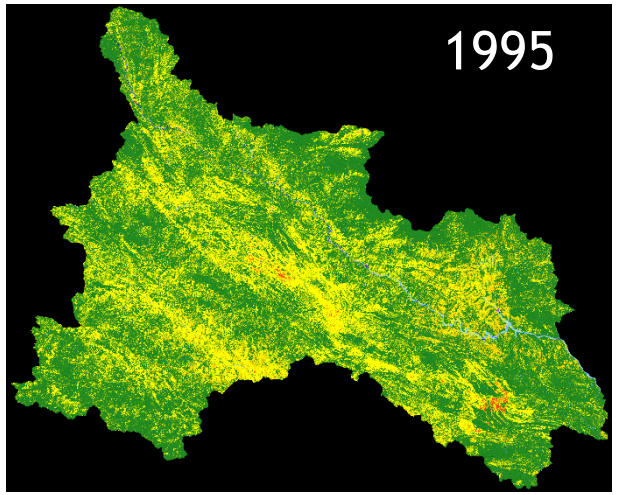
Q4 1990

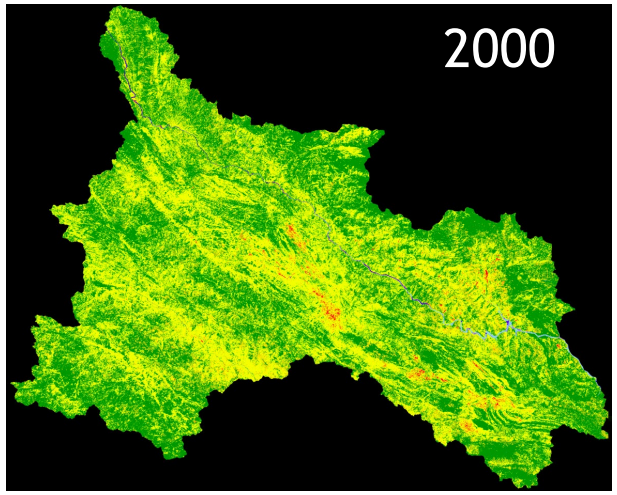
Land cover phenological pattern modeling (3)

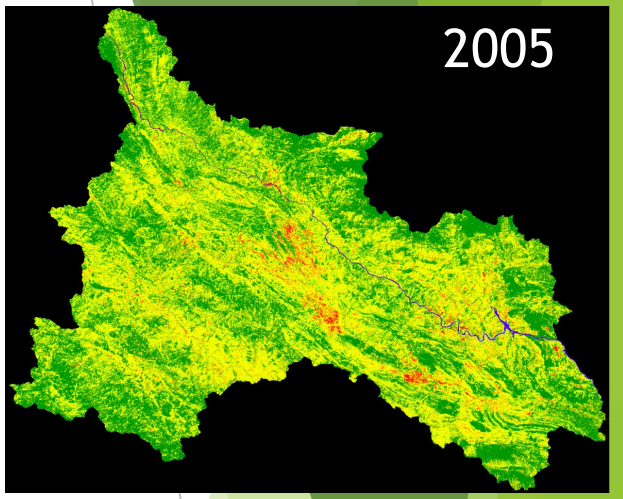
Q1	Q2	Q3	Q4	HAM	LC
WATER	WATER	WATER	WATER	WATER	WATER
FOREST	FOREST	FOREST	FOREST	FOREST	NATURAL EVEGREEN FOREST
FOREST	FOREST	FOREST	FOREST	BARE LAND	FOREST PLANTATION
BARELAND	GRASS	FOREST	BARELAND	BARELAND	CROPLAND
GRASS	GRASS	BARELAND	GRASS	BARELAND	CROPLAND
GRASS	BARELAND	GRASS	BARELAND	BARELAND	CROPLAND
GRASS	FOREST	FOREST	BARELAND	BARELAND	CROPLAND

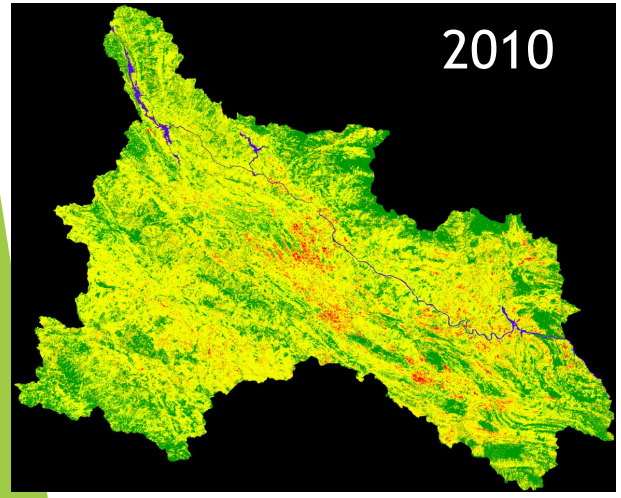
Results – Son La (1)

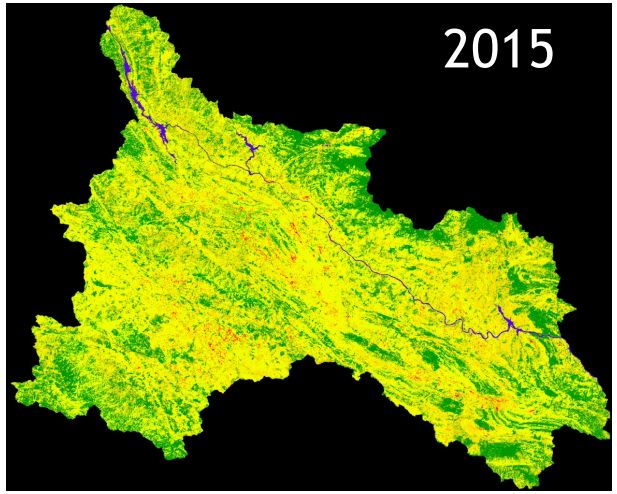


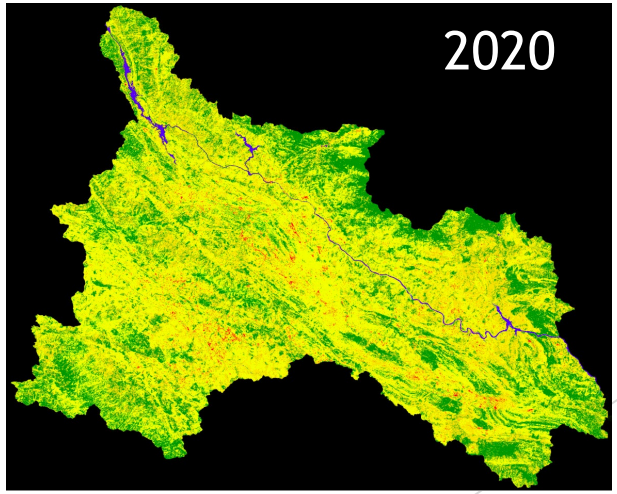








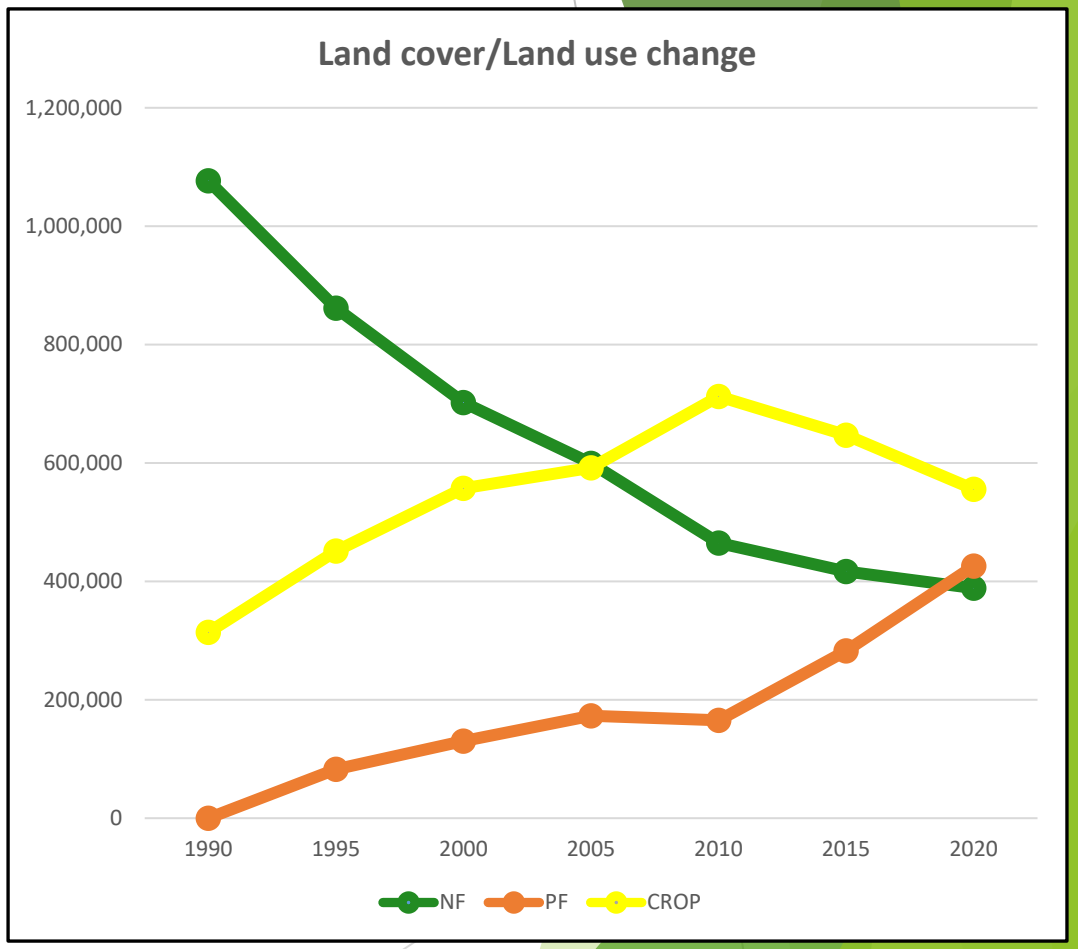




Natural forest Forest plantation Cropland

Results – Son La (2)

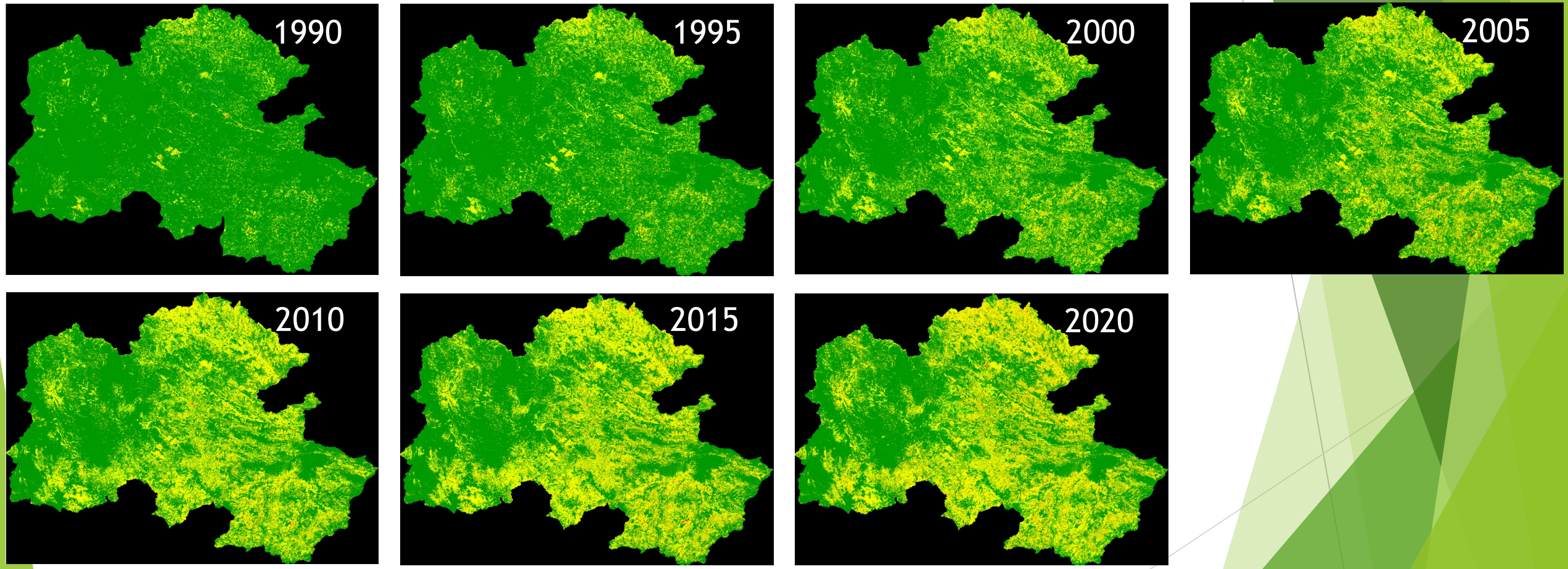
- Natural forests gradually decreased from 1,076,689 ha in 1990 to 388,550 ha in 2020. The total forest area has lost 63.9% at an annual rate of 2.1%.
- Planted forests have gradually increased since 1990 and have reached an area of 425,848 ha by 2020.
- Cropland has continuously increased from an area of 313,828 hectares in 1990 to an area of 555,505 hectares in 2020. The cropland peaked in 2010 with an area of 712,409 ha and then decreased due to changes in the crop structure converting to fruit trees and perennial trees.



Results – Son La (3) - Validation

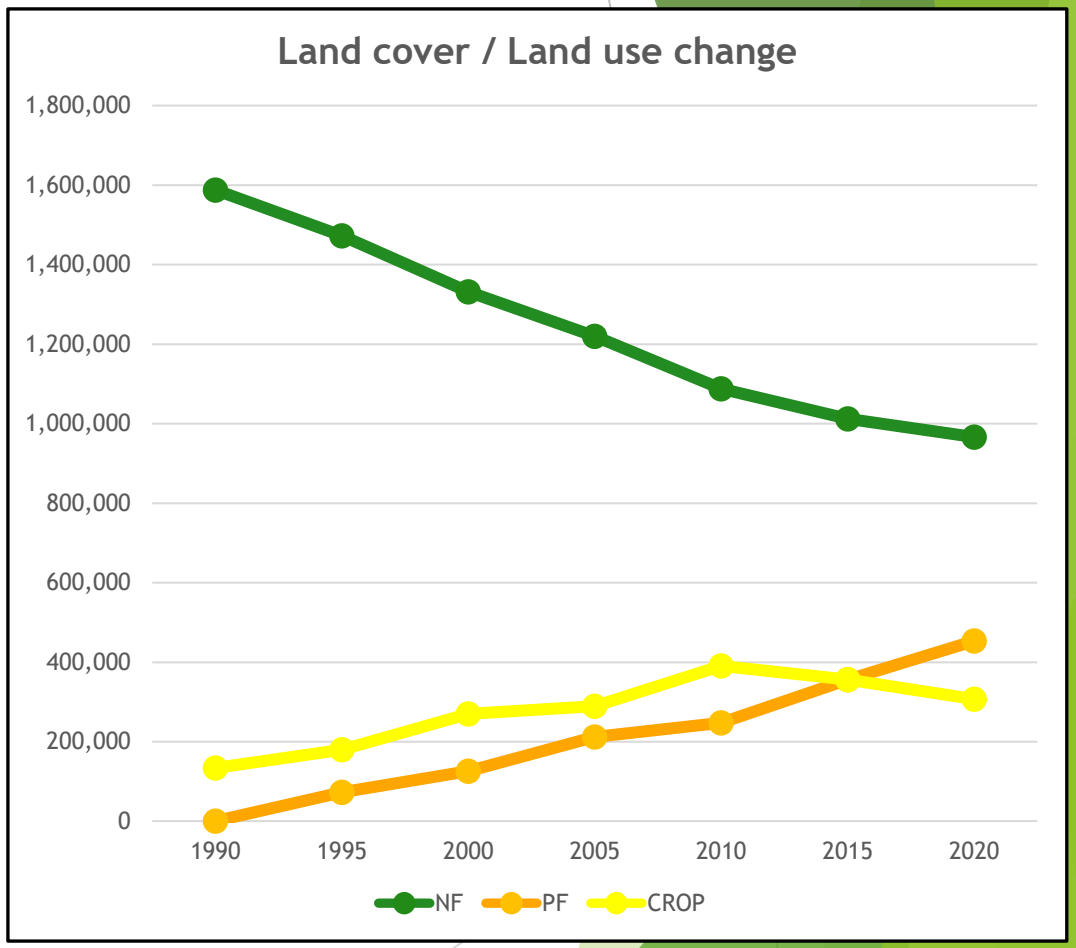
- Classification of cropland was validated for year 2020 using high resolution Google Earth images through 100 points randomly distributed in Son La.
- Overall accuracy 89.0,
- Producer accuracy Natura forest: 75.0, Cropland: 97.4, Forest plantation: 95.7
- Accuracy in natural forest classification is greatly affected by shifting cultivation and natural forest restoration.

Results – Houaphan (1)



Results – Houaphan (2)

- Natural forests decreased relatively slowly from an area of 1,587,764 ha in 1990 to 966,114 ha in 2020. Thus, the total area of natural forests has lost about 39.1% with an annual decline rate of 1.3%.
- Planted forests have also increased steadily every year since 1990 and have reached an area of 453,534 ha in 2020.
- Cultivated land annually increases slowly with an area of 133,901 ha in 1990 and reach an area of 306,730 ha in 2020. This is an increase of 2.3%.



Conclusion

- Cropland mapping is becoming increasingly important in the context of climate change and ensuring food security at the national level as well as on a global scale.
- Cropland mapping is a difficult problem when using Landsat time series data because cropland status changes according to the season of the year as well as the harvest.
- In this presentation, we have presented some of the first preliminary research results on cropland mapping based on Landsat time series data and seasonal land cover phenological patterns.
- Seasonal land cover patterns are built on the practice of local annual crops.
- The method we have developed allows us to build crop land distribution maps for every five years. Based on analysis of data series on the increase and decrease of crop land over the years, we can draw many conclusions related to food security, climate change and agricultural development trends in the study area.
- Most importantly, our method is completely automated, allowing the cropland mapping at regional and global scales in relatively short time.