DETECTION OF LAND COVER CHANGES BASED ON THE SENTINEL-2 MULTITEMPORAL DATA ON THE GEE PLATFORM

Rynkiewicz Alicja[1], Hościło Agata[1], Chmielewska Milena[1], Lewandowska Aneta[1], Aune-Lundberg Linda[2], Nilsen Anne B.[2]

[1]Institute of Geodesy and Cartography, Centre of Applied Geomatics, Warsaw, Poland

[2]Norwegian Institute of Bioeconomy Research, Norway

alicja.rynkiewicz@igik.edu.pl

INTRODUCTION

The World around us is constantly changing, and man contributes to many of these changes. Land cover and land use (LCLU) changes have a significant impact on the functioning of the Earth, particularly on climate change and global warming. The accurate and up-to-date information on LCLU status and changes is crucial for land management, monitoring the sustainable development of agriculture, forestry, rural areas, assessing the state of biodiversity and urban planning.

The aim of this study was to develop the algorithm for land cover change (LCC) detection based on the multitemporal Sentinel-2 data and machine learning approach. The study was conducted on the annual bases over the period 2018–2021 for the study area in Poland and Norway. The algorithm was developed using a cloud-based Google Earth Engine (GEE) platform.

The study was performed in the framework of the InCoNaDa project: **www.inconada.eu**

PROJECT InCoNaDa

InCoNaDa - *Enhancing the user uptake of Land Cover / Land Use information derived from the integration of Copernicus services and national databases* is funded by the Norway Grants via the Polish National Centre for Research and Development. The aim of the project is to improve the user uptake of land cover and land use information derived from the integration of Copernicus Land Monitoring Services (CLMS) and national databases.

Main objectives:

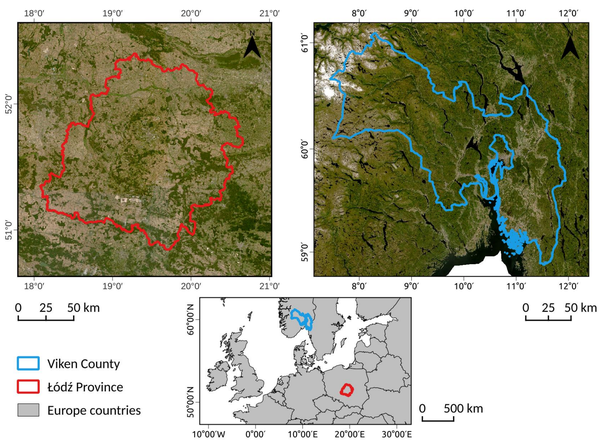
- to develop the land cover and land cover change algorithms based on Sentinel-2 data and machine learning approaches;
- to design and develop web-based application enabling to query the enhanced LCLU database as well as to integrate and extract statistics from the CLMS adjusted to the user needs;
- to assess the potential of CLMS products in spatial planning, agricultural management and environmental monitoring, as well as for reporting GHG emissions and removals from LULUCF.

STUDY AREA AND DATA

The study was conducted at the regional scale in Poland – the Łódź Province and in Norway – the Viken County including the city of Oslo.

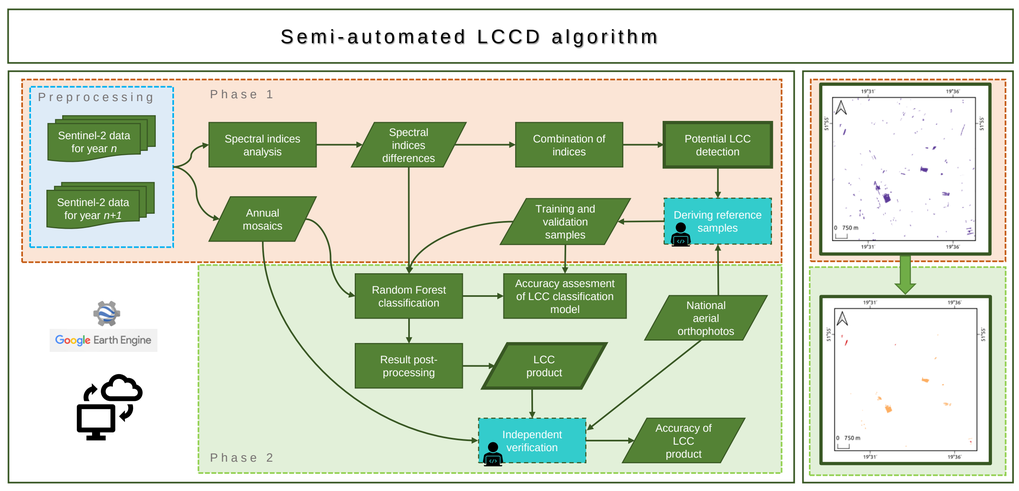
Detection of land cover changes (LCC) was performed using a time series of Sentinel-2 images acquired in the growing season from May to September over the period 2018–2021. The LCC were derived on the annual bases.

Independent verification of the results was conducted based on the national aerial orthophotos and annual Sentinel-2 mosaic.



METHODOLOGY

The detection of LCC consists of two phases. The phase 1 focuses on the quick analysis of a combination of spectral indices for two consecutive years. The aim of phase 1 is to derive the training samples for the phase 2, where the machine learning - Random Forest algorithm was applied to detect and classify the changes into the predetermined change type classes: (0) no-change, (1) woody coverage converted to non-woody vegetation i.e. clearcuts, arable land, (2) vegetated surfaces (woody and non-woody) converted to sealed surfaces like newly built-up areas or constructed sites.



RESULTS

The accuracy of the LCC classification results was assessed for each of the time interval for both study areas using the validation samples. The LCC results reached high accuracy – in both study areas for all time intervals the overall accuracy (OA) was equal to or greater than 0.97 and the Kappa coefficient greater than 0.95.

Accuracy assessment of the LCC classification model for Poland and Norway.

	OA	Kappa	User's accuracy			Producer's accuracy		
			Class 0	Class 1	Class 2	Class 0	Class 1	Class 2
Poland								
2018–2019	0.96	0.95	0.98	0.99	0.98	0.95	1.00	0.94
2019–2020	0.98	0.97	0.98	0.99	0.98	0.98	1.00	0.96
2020–2021	0.98	0.97	0.99	1.00	0.98	0.97	1.00	0.97
Norway								
2018–2019	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2019–2020	0.99	0.99	1.00	1.00	1.00	0.99	0.99	0.99
2020–2021	0.97	0.96	0.98	0.99	0.98	0.96	0.99	0.97

Example of LCC detected on the annual bases for the period 2018–2021 in Łódź Province (Poland) and Viken County (Norway). For Poland and Norway from the left to right: column 1 is the year *n* Sentinel-2 mosaic, column 2 is year *n+1* Sentinel-2 mosaic, column 3 is LCC for the time interval between year *n* and year *n+1*. The minimum mapping unit (MMU) was 0.2 ha.

Independent verification

was carried out for the period 2020–2021 based on visual inspection of the aerial orthophotos and Sentinel-2 mosaics. The overall accuracy for both study areas was equal to 0.94. The changes in class 2 reached slightly lower accuracy (precision around 0.83), and around 30 polygons of this class were misclassified as class 0 (no-change), mostly arable land.

Confusion matrix for the independent verification of LCC results 2020–2021

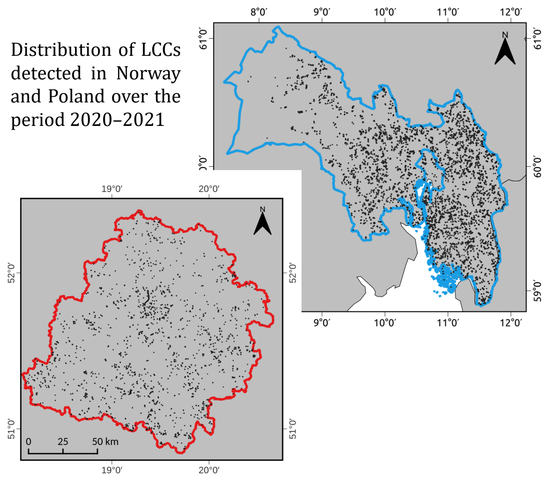
Poland		Actual			
		Class 0	Class 1	Class 2	Total
Prediction	Class 0	198	0	2	200
	Class 1	2	198	0	200
	Class 2	33	0	167	200
	Total	233	198	169	600
					OA = 0.94

Norway		Actual			
		Class 0	Class 1	Class 2	Total
Prediction	Class 0	197	2	0	199
	Class 1	1	196	2	199
	Class 2	30	3	165	198
	Total	249	189	158	596
					OA = 0.94

Statistics from the confusion matrix for the independent verification of results 2020–2021 for three classes in study area in Poland and in Norway.

	Precision	Recall	F1-Score	Misclassification rate	False positive rate	True negative rate
Poland						
Class 0	0.990	0.850	0.915	0.062	0.005	0.995
Class 1	0.990	1.000	0.995	0.003	0.005	0.995
Class 2	0.835	0.988	0.905	0.058	0.077	0.923
Average	0.938	0.946	0.938	0.041	0.029	0.971
Norway						
Class 0	0.990	0.864	0.923	0.055	0.005	0.995
Class 1	0.985	0.975	0.980	0.013	0.008	0.992
Class 2	0.833	0.988	0.904	0.059	0.077	0.923
Average	0.936	0.942	0.936	0.043	0.030	0.970

Distribution of LCCs detected in Norway and Poland over the period 2020–2021



CONCLUSION

- The two step's land cover change algorithm allows to detect changes with high accuracy at the regional scale.
- The independent verification performed in Poland and Norway proved the effectiveness and reliability of algorithm in detecting LCCs in different climatic zones.
- In general, the large proportion of detected changes in both countries was related to class 1 – converting the woody into non-woody vegetation or agricultural land, which is associated with forest management practices.
- The number of changes related to class 2: construction sites and newly built-up areas is larger in Poland than in Norway. The total area of changes in both classes decreased over time, except for class 2 for Norway. The high value of changes in class 2 for the period 2020–2021 in Norway was related to the massive clay landslide.
- The presented method showed its universality and adaptability, giving the possibility for further development.
- Further development: to examine model transferability in time and space and to verify the proposed approach over larger areas, with more diverse land cover change types.

ACKNOWLEDGMENTS

The research leading to these results has received funding from the Norway Grants 2014-2021 via the Polish National Center for Research and Development [grant no: NOR/POLNOR/InCoNaDa/0050/2019-00].

European Geoscience Union General Assembly 2023, 24-28.04.2023, Vienna, Austria

Sharing is encouraged