



GEOPROCESSING 2021

Thirteenth International Conference on Advanced Geographic Information Systems, Applications, and Services



Image Classification Methods Assessment for Identification of Small-Scale Agriculture in Brazilian Amazon

Flávia Domingos Pacheco^{1,2}, Máira Ramalho Matias¹, Gabriel Máximo da Silva¹, Anielli Rosane de Souza¹, Yosio Edemir Shimabukuro¹, and Maria Isabel Sobral Escada¹

¹ Earth Observation and Geoinformatics Division, Brazilian National Institute for Space Research

² flavia.pacheco@inpe.br



Flávia Domingos Pacheco

Bachelor's Degree in **Environmental Management** (Luiz de Queiroz School of Agriculture/ University of São Paulo, 2012-2017), with a period of studies at the University of Copenhagen/ Denmark (2015-2016), where I took Master's degree courses focused on **landscape transformation, ecological restoration, ethnobotany and conservation biology**.

After finishing my bachelor's degree, I worked as a **researcher of applied botany** (2018-2019) in a project of Urban forest management, funded by São Paulo Research Foundation.

I am currently a **Master's student in Remote Sensing** at the Brazilian National Institute for Space Research (2020-2022), her research is of land use and land cover changes in the Brazilian Amazon and I am member of the **Laboratory for investigation of Socioenvironmental Systems**.

Topics of research interest and current projects



Laboratory for investigation of
Socio-Environmental Systems

- › Land Use Change in Amazon: Institutional Analysis and Modelling at multiple temporal and spatial scales;
- › Scenarios for the Amazon: Climate, Biodiversity and Land use;
- › Environmental Monitoring of the Amazon Biome by Satellite.

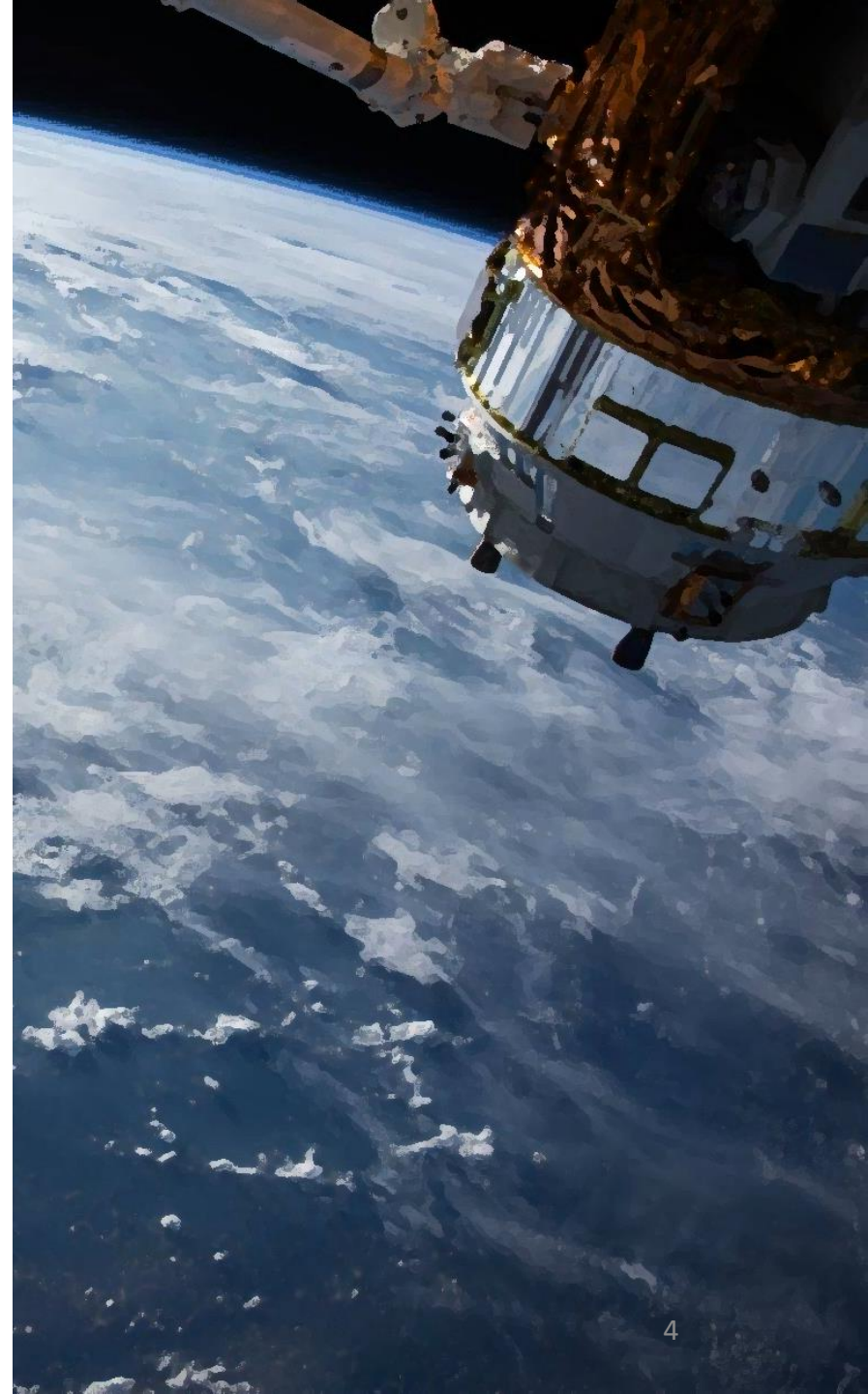
<https://www.lissinpe.com.br/>



- › Assessment of forest deforestation impacts;
- › Quantification of forest biomass and carbon stock;
- › Remote sensing mapping of burnt forests.

<http://www.treeslab.org/>

- 1 Introduction**
- 2 State of the art**
- 3 Material and methods**
- 4 Results and discussion**
- 5 Conclusion**



Small-scale agriculture



Food for local population



Income for families



Invisible



Cassava



Cassava



Black pepper



Papaya

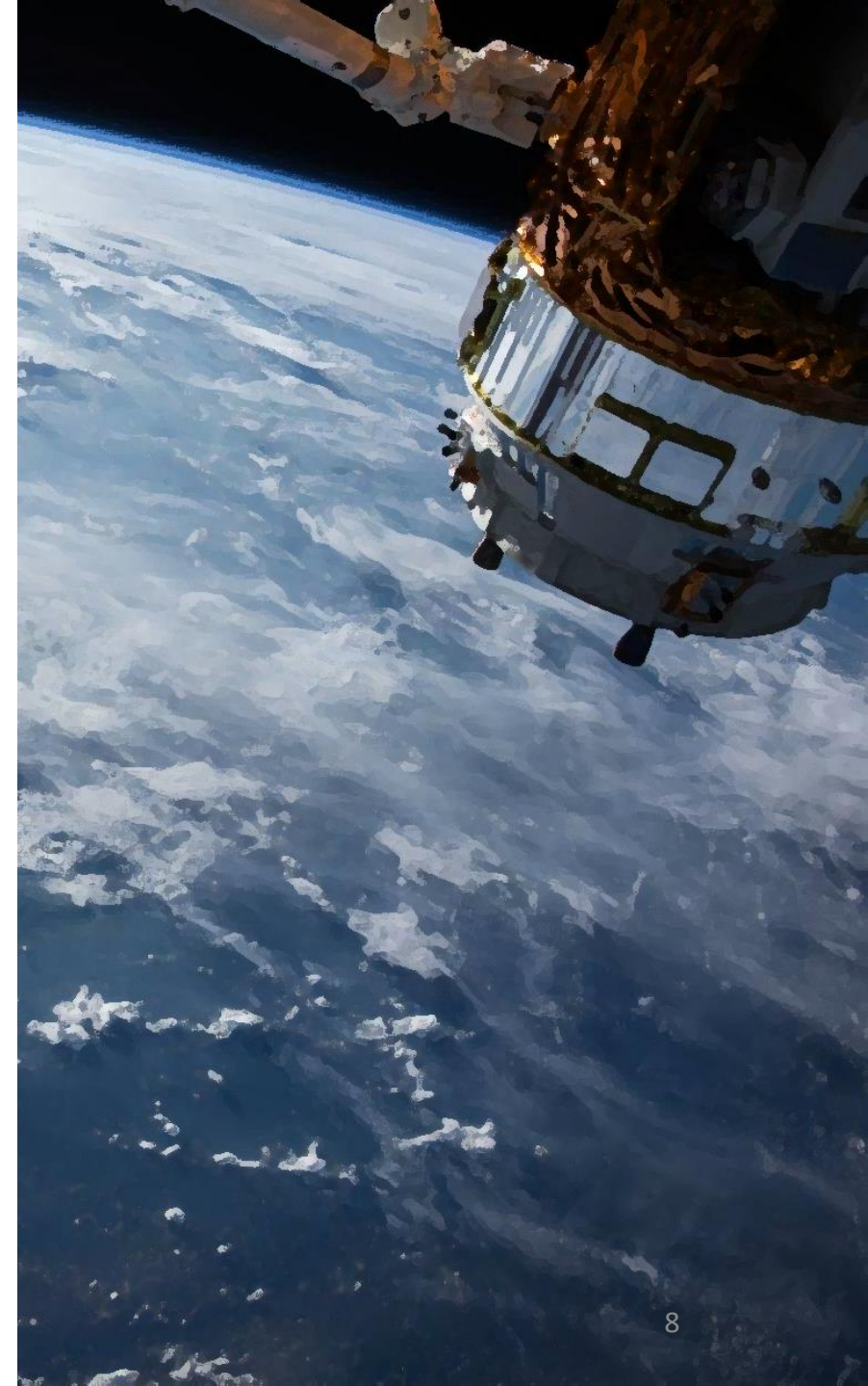
Images from:



Laboratory for investigation of
Socio-Environmental Systems

This paper aims to test different methods for image classification focusing on small-scale agriculture in the region of Mocajuba and Cametá, municipalities in the Northeast of Pará state, Brazil

- ➊ Introduction
- ➋ State of the art
- ➌ Material and methods
- ➍ Results and discussion
- ➎ Conclusion



What can we find about small-scale agriculture mapping by using remote sensing techniques?

1

Remote sensing techniques

In Brazilian Amazon, several studies on agriculture have been carried out. Yet, most of them addresses large-scale agriculture

2

Small-scale agriculture

Few studies can be found. On the other hand, there are plenty of techniques that can be tested for mapping this land use class

3

Contribution

Testing and evaluating techniques capable of detecting this type of agriculture, which is largely invisible, despite its importance to society, environment and economy

We could observe the combination of different techniques: in some studies, authors adapted and tested techniques used to large-scale agriculture, but considering the unique features of small-scale agriculture in Amazon.

**Maximum likelihood
+ neural networks**

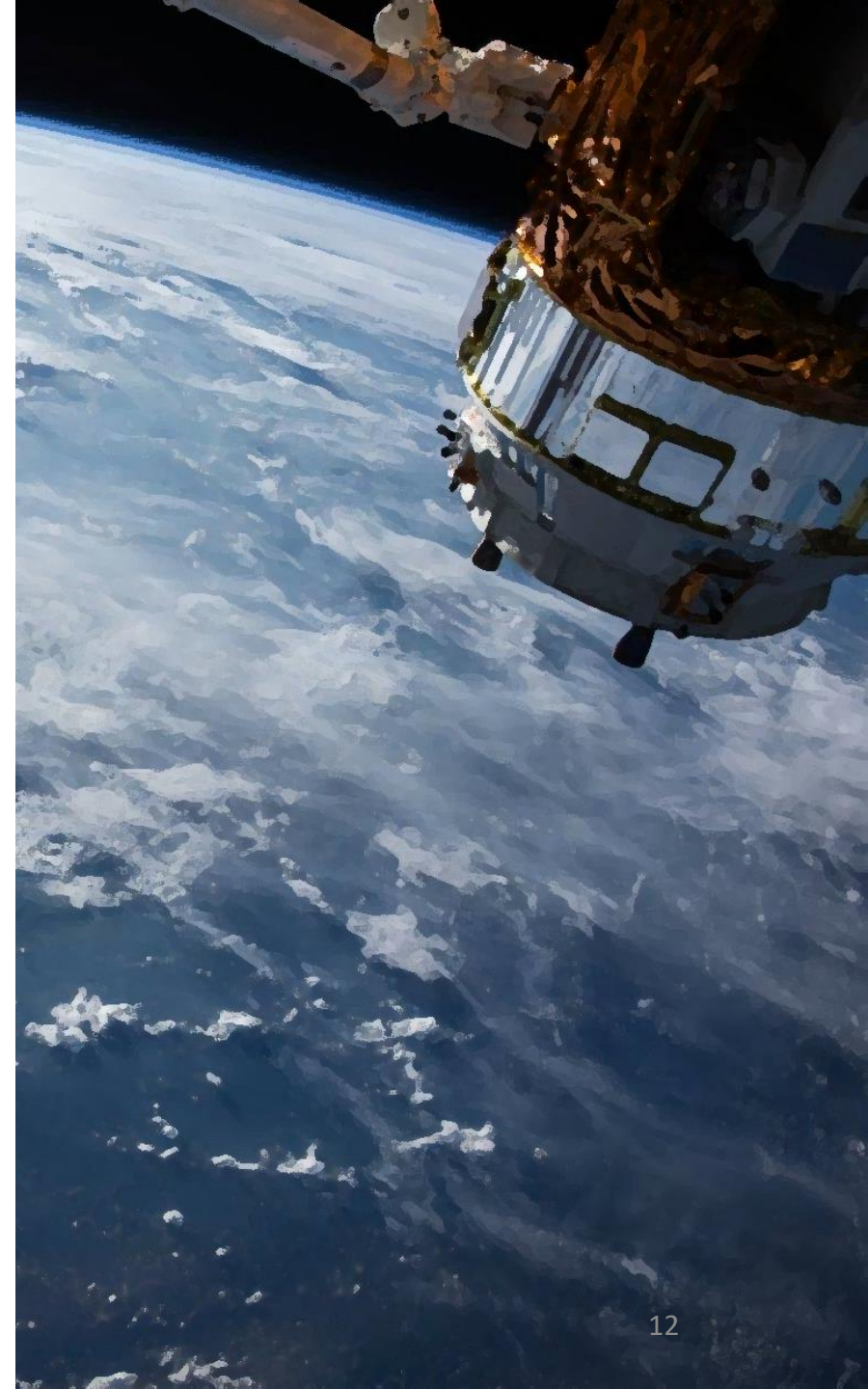
**Multiresolution segmentation
+ adapted nearest neighbor**

**Segmentation +
random forest**

Object-based analysis are broadly used in many studies: segmentation allows the use of more features, such as shape, texture and so on, rather than only spectral ones. Small-scale agriculture has specific shape and texture, and spectral mixture, so an object-based analysis unfolds as a key technique.

Inoue et al. (2007), Blaschke (2010), Dutrieux et al. (2015), Vogels et al. (2019), Souza et al. (2019), Nguyen et al. (2020)

- ➊ **Introduction**
- ➋ **State of the art**
- ➌ **Material and methods**
- ➍ **Results and discussion**
- ➎ **Conclusion**

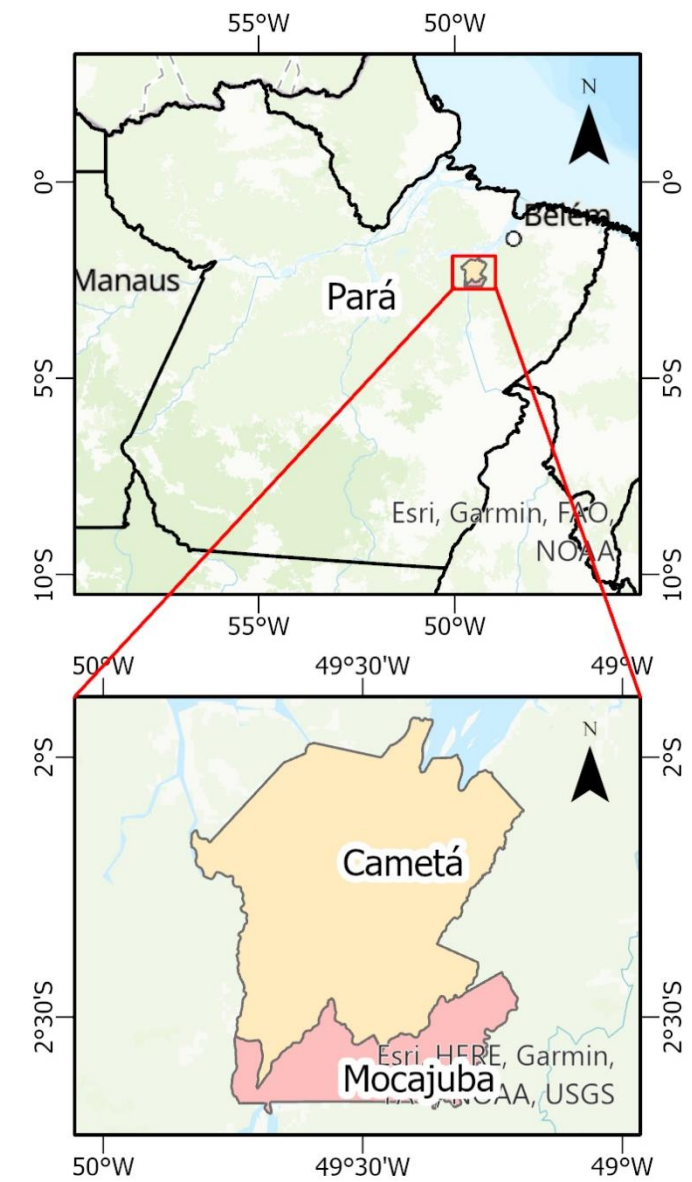
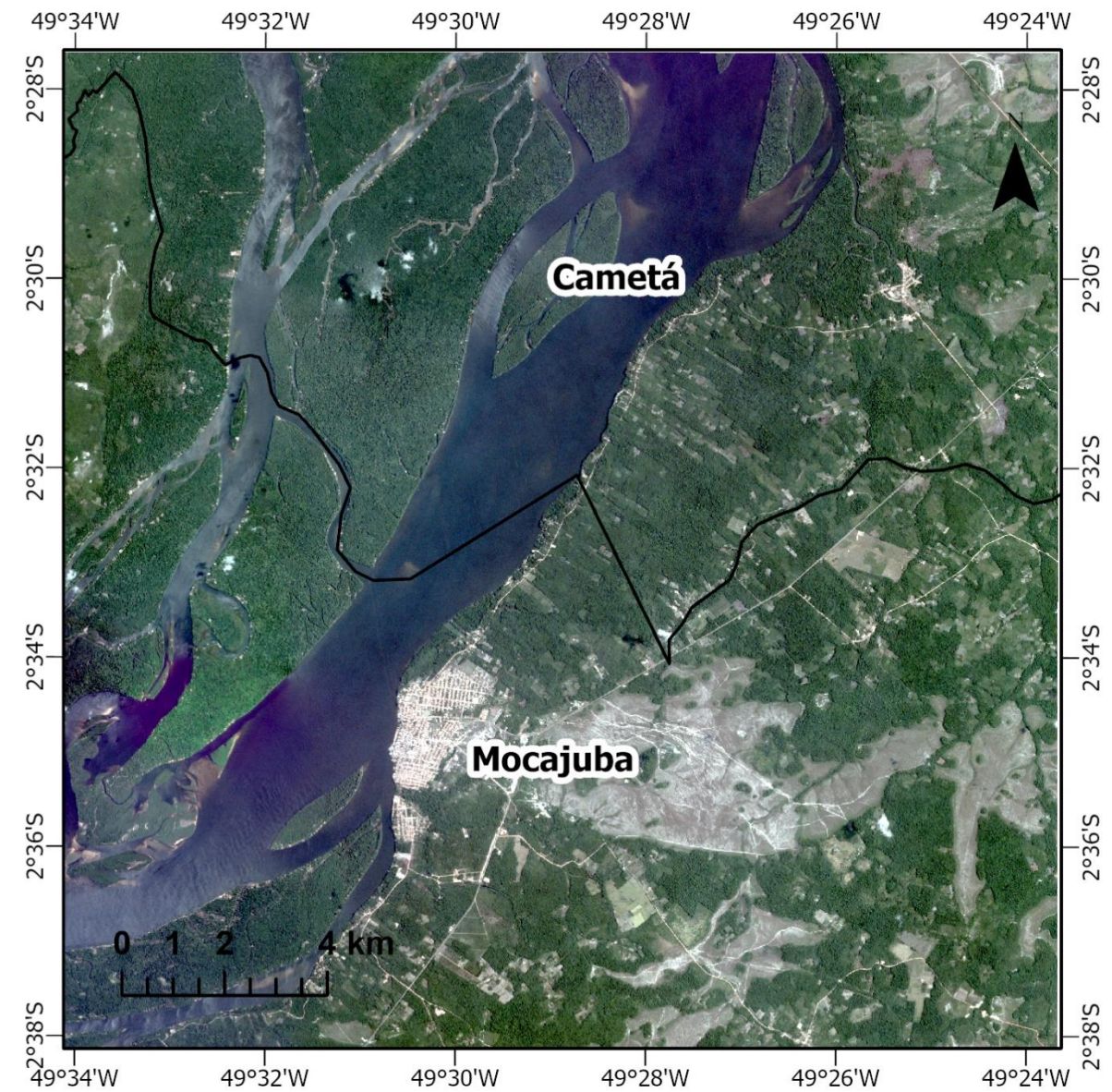


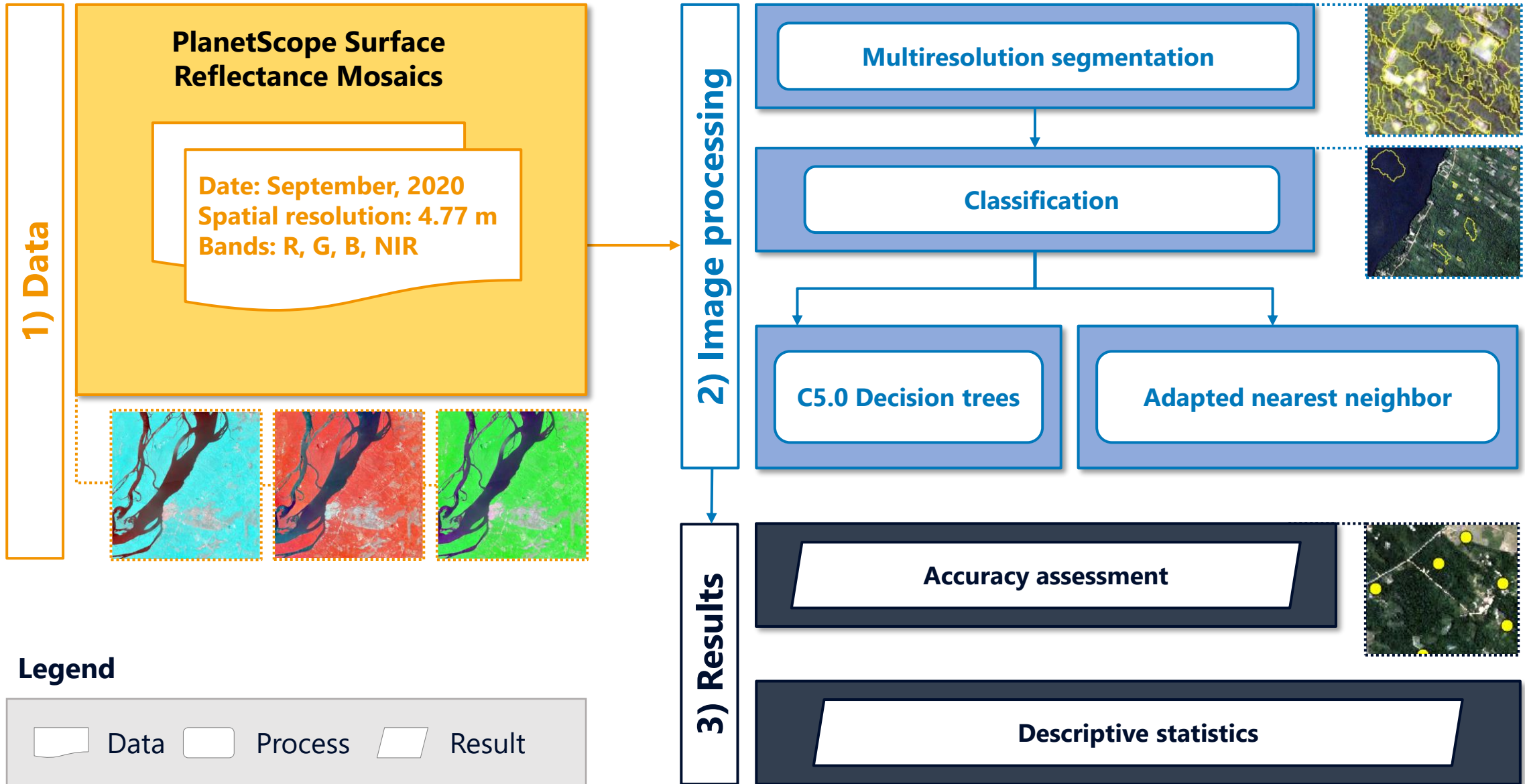
Brazilian Amazon: Mocajuba and Cametá municipalities, Baixo Tocantins region, Northeast of Pará State

Hotspot: smallholders and secondary vegetation

Shifting cultivation: system with swidden-fallow cycles

Main crops: cassava and açai







Water

Rivers, lagoons, etc.



Forest

Natural vegetation with predominance of trees



Secondary vegetation

Natural vegetation in regeneration emerged from previously deforested areas, with trees, shrubs and herbs



Urban areas

Built-up areas with population clusters: city, village and community



Pasture

Predominance of herbaceous and grassy vegetation, it may occur also sparse shrub vegetation and few arboreal individuals



Small-scale agriculture

Small agriculture lands with mainly annual crops



Others

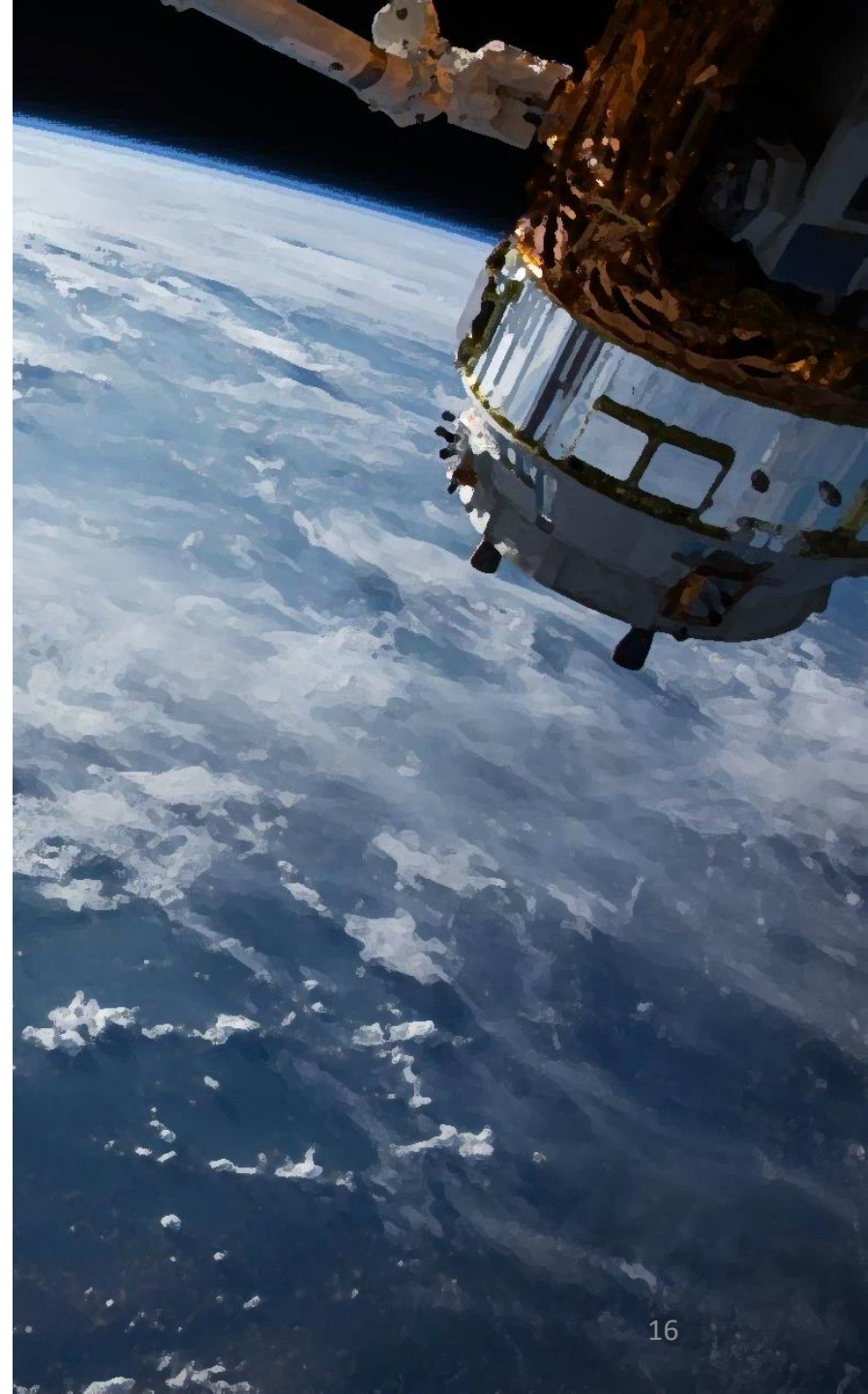
Aggregate of land use and land cover, such as rocky outcrops, sand banks



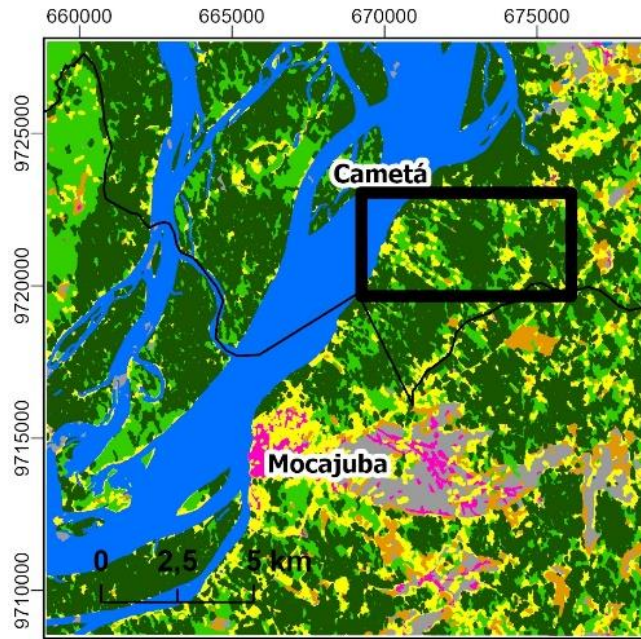
Non observed

Clouds and cloud shadows

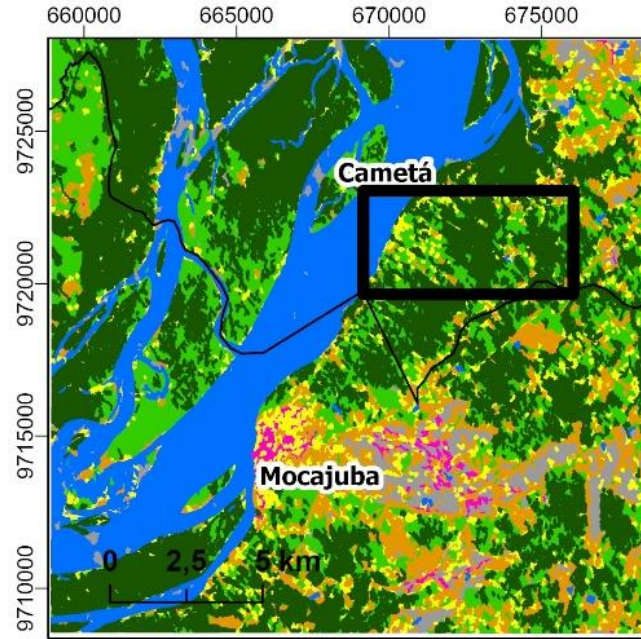
- ➊ **Introduction**
- ➋ **State of the art**
- ➌ **Material and methods**
- ➍ **Results and discussion**
- ➎ **Conclusion**



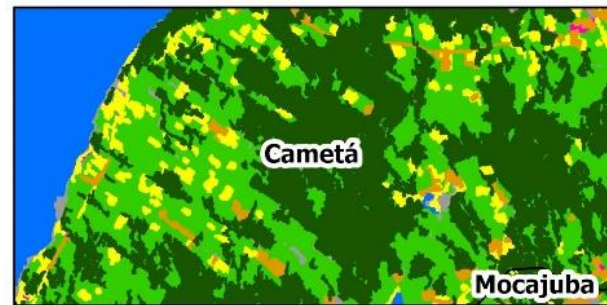
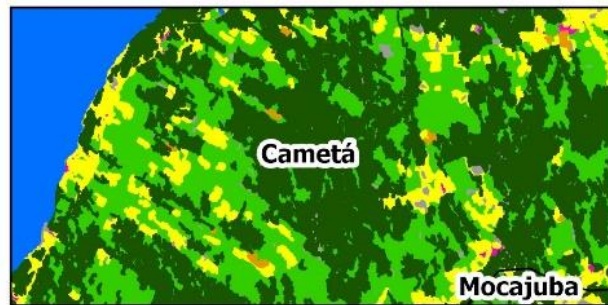
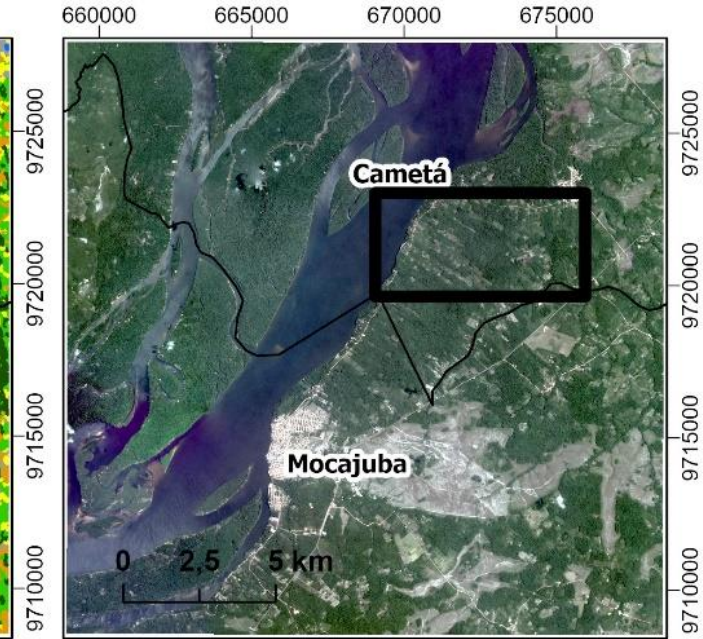
Adapted Nearest-neighbor



C.5.0 Decision Tree



PlanetScope Surface Reflectance Mosaic



- | | |
|----------------------|-------------------------|
| Municipal boundary | Urban Area |
| Water | Pasture |
| Forest | Small-scale Agriculture |
| Secondary Vegetation | Others |

Source: IBGE - Municipal maps, 2019.
 Planet Labs - Monthly Mosaic Planet Scope - Sep. 2020.
 R(3) G(2) B(1)
 Elaboration: Autors, 2020.
 UTM Projection/22S
 Datum SIRGAS 2000



DESCRIPTIVE STATISTICS FROM IMAGE CLASSIFICATION ACCORDING TO LAND USE AND LAND COVER, IN HECTARE

Classes	Adapted Nearest-neighbor					C5.0 Decision trees				
	μ	σ	σ^2	Total	%	μ	σ	σ^2	Total	%
Water	5.69	5.62	31.62	7,082.61	18.66	5.92	5.75	33.01	6,885.70	18.14
Forest	1.55	1.18	1.40	11,317.54	29.82	1.62	1.26	1.58	10,477.20	27.60
Secondary vegetation	1.71	1.27	1.61	11,182.62	29.46	1.58	1.18	1.39	11,934.05	31.44
Urban Area	0.69	0.60	0.36	633.66	1.67	0.70	0.63	0.40	537.14	1.42
Pasture	1.77	1.34	1.79	718.84	1.89	1.77	1.10	1.21	2,340.14	6.17
Small-scale agriculture	0.97	0.69	0.48	3,526.97	9.29	0.70	0.39	0.15	1,837.95	4.84
Others	1.22	1.37	1.88	3,493.84	9.20	1.38	1.38	1.92	3,943.92	10.39
Total	-	-	-	37,956.08	100	-	-	-	37,956.08	100

Units: hectare; μ = polygon mean area; σ = standard deviation; σ^2 = variance.

CONFUSION MATRIX FOR ADAPTED NEAREST-NEIGHBOR AND C5.0 DECISION TREES ALGORITHMS

		Adapted Nearest-neighbor							
		Reference							User's accuracy
%		(A)	(B)	(C)	(D)	(E)	(F)	(G)	
Classification	(A) Water	100	0	0	0	0	0	0	100
	(B) Forest	0	55	35	0	0	0	0	61
	(C) Secondary vegetation	0	40	60	0	0	15	0	52
	(D) Urban area	0	0	0	95	0	0	0	100
	(E) Pasture	0	0	0	0	50	10	10	20
	(F) Small-scale agriculture	0	5	5	0	50	65	0	81
	(G) Others	0	0	0	5	0	10	90	86
	Producer's accuracy	100	55	60	95	50	65	90	
Samples		20	20	20	20	2	20	20	
		<i>Kappa = 0,70</i>				<i>Overall accuracy = 75%</i>			

		C5.0 Decision trees							
		Reference							User's accuracy
%		(A)	(B)	(C)	(D)	(E)	(F)	(G)	
Classification	(A)	90	0	0	0	0	0	0	100
	(B)	0	50	30	0	0	0	0	63
	(C)	0	45	60	0	0	15	0	50
	(D)	0	0	0	85	0	0	5	94
	(E)	0	0	10	15	100	10	20	15
	(F)	0	0	0	0	0	75	0	100
	(G)	10	5	0	0	0	0	75	83
	Prod. acc.	90	50	60	85	100	75	75	
Samples		20	20	20	20	2	20	20	
		<i>Kappa = 0,68</i>				<i>Overall accuracy = 73%</i>			

High spatial resolution sensors are more adequate to improve classification accuracy due to the small-scale agriculture's size: our results presented mean area of **0.97 ha** \pm 0.69 ha for Adapted Nearest-neighbor and **0.70 ha** \pm 0.39 ha for C5.0 Decision trees.

Adapted Nearest-neighbor may be overclassifying small-scale agriculture: this method had a **commission error** of 19%, which means that a significant number of polygons were classified by mistake as small-scale agriculture, increasing the area of this class. These classification errors occurred due to confusion, especially with **secondary vegetation, forest, and others**.

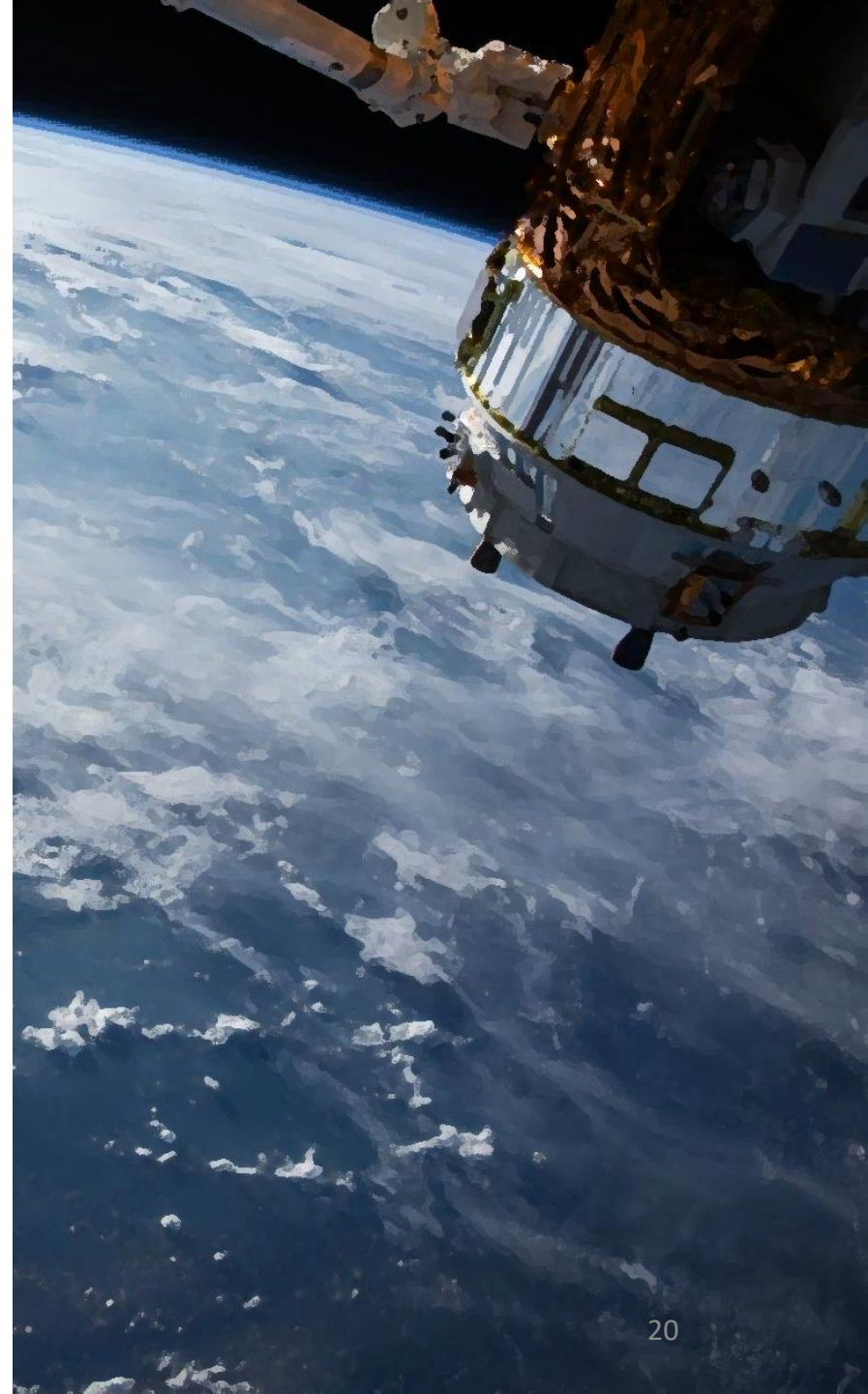
C5.0 Decision trees did not have commission error for small-scale agriculture class. In other words, this method is more conservative for mapping small-scale agriculture and did not include other classes in small-scale agriculture by mistake as Adapted Nearest-neighbor did.

Both algorithms had the same **omission errors** for small-scale agriculture regarding **secondary vegetation** (15%) and **pasture** (10%). **Adapted Nearest-neighbor** also had omission errors for small-scale agriculture with the class **others** (10%).

C5.0 Decision trees algorithm found better results when mapping small-scale agriculture (75%), compared to Adapted Nearest-neighbor (65%). This performance of Adapted Nearest-neighbor algorithm is corroborated with other studies that found around 62% of producer's accuracy for small-scale agriculture carried out in the same region of Brazilian Amazon.

Overall, the results for small-scale agriculture were adequate and despite the different accuracies, both methods showed limitations when differentiating this class from pasture and secondary vegetation.

- 1 Introduction**
- 2 State of the art**
- 3 Material and methods**
- 4 Results and discussion**
- 5 Conclusion**



Challenges: use of same training and test samples to promote an adequate comparison

Small-scale agriculture:



Future work

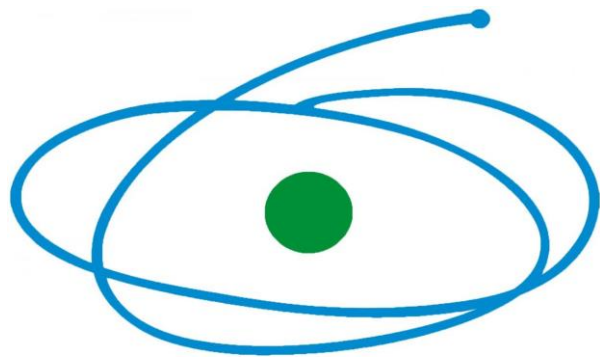
We recommend investigating which features are more significant for the identification of small-scale agriculture by C5.0. We suggest a systematic removal of features at the classification level and performing a sensitive analysis.

The inclusion of the temporal component coupled with machine learning and deep learning techniques may contribute for selecting other important variables for small-scale agriculture classification.

We recommend testing different sampling design to test better results and perform a sensitive analysis.

Acknowledgment

We would like to thank the following Brazilian institutes for the support and funding



C A P E S

Coordination of Superior
Level Staff Improvement
(Finance Code 001")



Brazilian National Council for Scientific
and Technological Development



Brazilian National Institute
for Space Research

Main literature

A. R. Souza, Economy and nature: land use and land cover patterns associated with agricultural and extractive activities in communities in the Southwest of Pará, *Economia e natureza: padrões de uso e cobertura da terra associados a atividades agropecuárias e extrativistas de comunidades do Sudoeste do Pará*, Brazilian National Institute for Space Research, 2016. [Online]. Available from: <http://urlib.net/8JMKD3MGP3W34P/3M8SD78>. 2021.06.13.

A. R. Souza, M. I. S. Escada, R. Marujo, and A. M. Monteiro, "Cartography of the invisible: unveiling small-scale agriculture with Rapideye Images in the Baixo Tocantins Region, Pará," "Cartografia do Invisível: Revelando a Agricultura de Pequena Escala com Imagens Rapideye na Região do Baixo Tocantins, Pará," *Revista do Departamento de Geografia*, v. 38, pp. 137–153, Dec. 2019, doi:10.11606/rdg.v38i1.151603.

T. Blaschke, "Object based image analysis for remote sensing," *ISPRS Journal of Photogrammetry and Remote Sensing*, vol. 65, n. 1, pp. 2–16, 2010. 10.1016/j.isprsjprs.2009.06.004.

G. J. Hay and G. Castilla, "Object-Based Image Analysis: Strengths, Weaknesses, Opportunities and Threats (SWOT)," *International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, vol. XXXVI-4/C42, pp. 4-5, 2006.

Norway's International Climate and Forest Initiative. *NICFI Data Program*. 2020. [Online]. Available from: assets.planet.com/docs/NICFI_General_FAQs.pdf. 2021.06.13.

J. Quinlan, *C4.5: programs for machine learning*, San Mateo, CA: Morgan Kaufmann, 1993.

M. Baatz and A. Schape, *Multiresolution Segmentation: An Optimization Approach for High Quality Multi-Scale Image Segmentation*. 2000. In: J. Strobl, T. Blaschke, and G. Griesbner, Eds., *Angewandte Geographische Informations-Verarbeitung*, XII, Wichmann Verlag, Karlsruhe, Germany, 12-23.

GeoDMA 2.0.1. São José dos Campos: Brazilian National Institute for Space Research (INPE), 2011. [Online]. Available from: <http://www.dpi.inpe.br/geodma>. 2021.06.13.

T. S. Korting, *GeoDMA: a toolbox integrating data mining with object-based and multi-temporal analysis of satellite remotely sensed imagery*, Brazilian National Institute for Space Research, 2012. [Online]. Available from: urlib.net/8JMKD3MGP7W/3CCH86S. 2021.06.13.

G. Banko, A review of assessing the accuracy of classifications of remotely sensed data and of methods including remote sensing data in forest inventory, *International Institute for Applied Systems Analysis*, 1998. [Online]. Available from: <https://www.researchgate.net/publication/23738314>. 2021.06.13.

R. G. Congalton and K. Gree, *Assessing the accuracy of remotely sensed data: principles and practices*. 2nd ed., Boca Raton: CRC Press, 2009.

C. Almeida et al., "High spatial resolution land use and land cover mapping of the Brazilian Legal Amazon in 2008 using Landsat-5/TM and MODIS data," *Acta Amazonica*, v. 46, pp. 291 – 302, Sep, 2016, doi:10.1590/1809-4392201505504.

Thank you for your attention!

Flávia Domingos Pacheco

flavia.pacheco@inpe.br



TREES
TRopical Ecosystems and
Environmental Sciences lab