Simpósio Nacional de Instrumentação Agropecuária

São Carlos

SIAGRO

Ciência • Tecnologia • Inovação • Mercado

14 a 16 de outubro de 2025 | Embrapa Instrumentação São Carlos - SP

Anais

Editores:

Paulo Sergio de Paula Herrmann Junior
Henriette Monteiro Cordeiro de Azeredo
Maria Fernanda Berlingieri Durigan
Luís Henrique Bassoi

ISSN 2358-9132

Embrapa
Instrumentação

ISSN 2358-9132

Empresa Brasileira de Pesquisa Agropecuária

Embrapa Instrumentação

Ministério da Agricultura, Pecuária e Abastecimento

Simpósio Nacional de Instrumentação Agropecuária 2025

Anais do SIAGRO

Ciência, Tecnologia, Inovação e Mercado

Paulo Sergio de Paula Herrmann Junior
Henriette Monteiro Cordeiro de Azeredo
Maria Fernanda Berlingieri Durigan
Luís Henrique Bassoi

Editores

Embrapa Instrumentação

São Carlos, SP

2025

Exemplares desta publicação podem ser adquiridos na:

Embrapa Instrumentação
Embrapa Instrumentação
Rua XV de Novembro, 1452
Caixa Postal 741
CEP 13560-970 São Carlos, SP
Fone: (16) 2107 2800
Fax: (16) 2107 2902
www.embrapa.br/instrumentacao
www.embrapa.br/fale-conosco/sac

Comitê Local de Publicações

Presidente: Daniel Souza Corrêa

Membros: Elaine Cristina Paris, Maria Alice Martins,
Cristiane Sanchez Farinas, Cínthia Cabral da Costa,
Carlos Renato Marmo, Paulo Renato Orlandi Lasso,
Maria do Socorro Gonçalves Souza Monzane

Capa - Desenvolvimento: NCO; criação: Andréa Lima
Editoração eletrônica: Valentim Monzane

1ª edição
Publicação digital (2025): PDF

Dados internacionais de catalogação (CIP)
Embrapa Instrumentação

S612 Simpósio Nacional de Instrumentação Agropecuária (5.: 2025 : São Carlos, SP).
Anais do SIAGRO: ciência, inovação e mercado 2025 – São Carlos, SP: Embrapa Instrumentação, 2025.

ISSN 2358-9132

1. Instrumentação agropecuária. 2. Automação de processos agrícolas. 3. Agricultura de precisão. 4. Sensores. 5. Equipamentos agrícolas. 6. Monitoramento. 7. Nanotecnologia. 8. Modelagem. 9. Métodos avançados. 10. Inovação. 11. Tecnologias convergentes. I. Herrmann Junior, P. S. P. II. Azeredo, H. M. C. III. Durigan, M. F. B. IV. Bassoi, L. H. V. Título.

CDD 21 ED 681.763

Vera Viana dos Santos Brandão (CRB – 8/7283)

IMAGE GEOPROCESSING AND VEGETATION INDEX GENERATION IN INTEGRATED SYSTEMS

Y. C. L. Oliveira[1], D.S. Rocha[2], J. R. M. Pezzopane[2], A. C. C. Bernardi[2]

[1] *Universidade Federal de São Carlos – UFSCar, São Carlos, SP, yasminclo@estudante.ufscar.br*
[2] *Embrapa Pecuária Sudeste, São Carlos, SP, alberto.bernardi@embrapa.br*

Abstract: This study was conducted at Embrapa Pecuária Sudeste, in São Carlos, SP, in an area under an Integrated Crop-Livestock-Forestry (ICLF) system, with the objective of evaluating the seasonal variation in vegetation using spectral indices. Drone images were collected on two distinct dates, and NDVI and MPRI indices were calculated and compared using the QGIS 3.0 and TerraView software. NDVI, based on the near-infrared (NIR) and red (RED) bands, and MPRI, based on RGB bands, were applied through supervised and unsupervised classifications and segmentations, allowing the analysis of forested and pasture areas. The results showed that during the dry season (July), the indices presented lower values, especially in pastures, indicating water stress. In the rainy season (November), index values increased, reflecting improved vegetation health. Pasture was identified as the predominant land cover, and both indices showed similar results, although MPRI stood out due to its economic feasibility. It is concluded that the ICLF system supports vegetation recovery and vigor, especially during periods of higher rainfall, and that MPRI is an efficient and accessible alternative for environmental monitoring via remote sensing.

Keywords: Integrated Crop-Livestock-Forestry; NDVI; MPRI; remote sensing; precision agriculture.

GEOPROCESSAMENTO DE IMAGENS E GERAÇÃO DE ÍNDICES DE VEGETAÇÃO EM SISTEMAS INTEGRADOS

Resumo: O presente estudo foi realizado na Embrapa Pecuária Sudeste, em São Carlos-SP, em uma área de Integração Lavoura-Pecuária-Floresta (ILPF), com o objetivo de avaliar a variação sazonal da vegetação por meio de índices espectrais. A partir de imagens obtidas por drone em duas datas distintas, foram calculados e comparados os índices NDVI e MPRI, utilizando os softwares QGIS 3.0 e TerraView. O NDVI, baseado na combinação da banda do infravermelho próximo (NIR) e da banda do vermelho (RED), e o MPRI, baseado em RGB, foram aplicados em classificações supervisionadas, não supervisionadas e segmentações, permitindo a análise de áreas de árvores e pastagem. Os resultados demonstraram que, no período seco (julho), os índices apresentaram valores mais baixos, principalmente nas pastagens, indicando estresse hídrico. Já no período chuvoso (novembro), houve elevação nos valores dos índices, refletindo a melhora na saúde da vegetação. Observou-se que a pastagem é a cobertura predominante e que ambos os índices apresentaram resultados semelhantes, embora o MPRI se destaque por sua viabilidade econômica. Conclui-se que o ILPF favorece a recuperação e o vigor da vegetação, especialmente em períodos de maior precipitação, sendo o MPRI uma alternativa eficiente e acessível para o monitoramento ambiental por sensoriamento remoto..

Palavras-chave: Integração Lavoura-Pecuária-Floresta; NDVI; MPRI; sensoriamento remoto; agricultura de precisão.

Introduction

The Integrated Crop-Livestock-Forestry (ICLF) system is a sustainable model integrating agricultural, livestock, and forestry production to optimize land use and promote animal welfare. In light of the degradation of approximately 12 million hectares of pastureland in Brazil (IBGE, 2019), ICLF has emerged as a promising alternative for land recovery and agricultural productivity (Pezzopane et al., 2019, 2020). The inclusion of native tree species in this system can generate multiple benefits, such as enhanced biodiversity, soil conservation, and carbon mitigation (Nicodemo et al., 2016).
Within this context, remote sensing was employed as a tool for vegetation analysis using the Normalized Difference Vegetation Index (NDVI), which measures vegetation density based on the reflectance of red and near-infrared light (Shimabukuro & Ponzoni &, 2017). NDVI is widely used for assessing plant health and is essential for agricultural monitoring and planning (Melo & Sales, 2011). Additionally, the study examined the Modified Photochemical Reflectance Index (MPRI), an alternative index based on RGB bands, which enables more affordable data collection using conventional camera systems (Yang et al., 2008;). Data analysis included supervised and unsupervised classification methods, which allow automatic labeling of image pixels based on spectral reflectance (Demarchi, Piroli, & Zimback, 2011). The main objective was to compare vegetation indices across two seasonal periods in 2022 using QGIS 3.0 and TerraView software platforms.

Material and Methods

The study was carried out at Embrapa Pecuária Sudeste (São Carlos, SP), within a 12-hectare area under an Integrated Crop-Livestock-Forestry (ICLF) system established in 2007 (Figure 1). The system comprises *Brachiaria* pastures managed through rotational grazing with Canchim cattle, interspersed with rows of native tree species and support species, all arranged in specific planting spacings. Multispectral imagery was collected on two distinct dates in 2022 (July 12 and November 28) using a DJI Matrice 210 drone equipped with a Sentera AGX710 sensor, which captured data in the RGB, Near-Infrared (NIR), and Red Edge spectral bands. The images were processed in QGIS 3.0, including RGB composition, for improved visualization and manipulation.
Following preprocessing, supervised and unsupervised classifications were conducted using the Dzetsaka plugin in QGIS, enabling the distinction between tree vegetation, pasture, and shadow areas. These classified rasters were then vectorized to generate specific land cover masks. Using these masks, the NIR and Red Edge bands were clipped, and both the Normalized Difference Vegetation Index (NDVI = [NIR – RED]/[NIR + RED]) and the Modified Photochemical Reflectance Index (MPRI = [GREEN – RED]/[GREEN + RED]) were calculated. The index values were categorized, and the resulting areas were quantified in square meters for each category using Excel. Subsequently, additional image segmentation was performed using TerraView software, enabling a second round of index computation based on the segmented regions, following the same methodology for clipping, calculation, and classification.

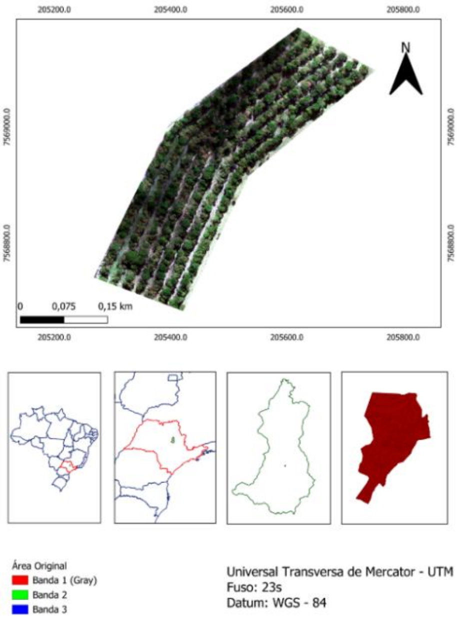

Figure 1 – Study Area in Embrapa, São Carlos – SP.

3. Results and Discussion

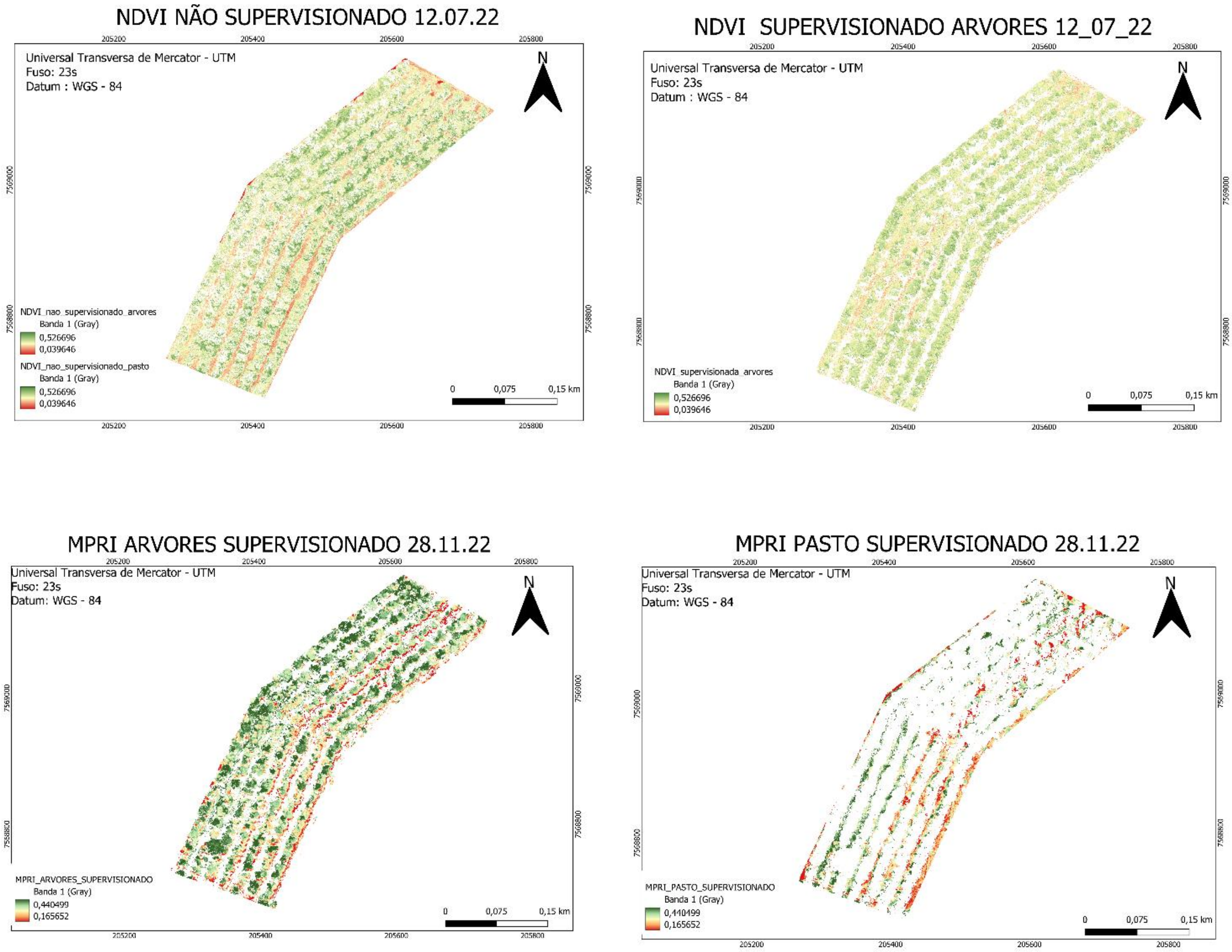

Figure 2 – Examples of the images generated for supervised MPRI and NDVI (28 Nov 2022) and unsupervised MPRI and NDVI (12 Jul 2022).

In the results, NDVI and MPRI behaved consistently on both survey dates (Figure 2). During the dry season (July 2022), water stress drove pasture NDVI below 0.30, whereas in November 2022—after 113.8 mm of rainfall—52 % of the pixels shifted into the 0.31–0.45 range, indicating canopy recovery; tree rows maintained intermediate values (0.31–0.45) in both seasons. Supervised classification in QGIS highlighted 88 % of pasture pixels between 0.15 and 0.30 in July; the unsupervised routine placed 60 % of tree pixels between 0.31 and 0.45, while TerraView's object-based segmentation assigned 59 % of tree pixels to 0.31–0.45 and 84 % of pasture pixels to 0.15–0.30. In November, all three workflows converged, with both trees and pasture clustering between 0.15 and 0.45. The RGB-based MPRI reproduced these variations (r ≈ 0.87) at 35 % lower cost than NDVI, corroborating previous findings (; Sampaio et al., 2020), although it remained more sensitive to shadowing, particularly under tree canopies. Geostatistical analysis revealed strong spatial dependence (IDE ≥ 0.79) for CEC and soil organic matter (Guimarães, 2004); low-index hotspots coincided with former cattle corrals (Demarchi et al., 2011) and phosphorus-deficient zones reported by the soil census (IBGE, 2019). Overall, the maps suggest that nutrient deficits—rather than shading—limit pasture vigor during dry periods, validating MPRI as a cost-effective substitute for NDVI in monitoring ILPF systems.

Conclusion

The comparison between vegetation indices and climatic conditions revealed that during the dry season (July 2022), water stress occurred, as indicated by the low NDVI and MPRI values. In contrast, during the rainy season (November), vegetation health improved, with an increase in both indices—especially within pasture areas. Both NDVI and MPRI showed similar patterns; however, MPRI, being based on RGB cameras, proved to be a more accessible and cost-effective alternative compared to NDVI, which relies on more expensive near-infrared sensors. Both methods confirmed that pasture was the predominant vegetation cover in the studied area. The overall analysis indicated that the Integrated Crop-Livestock-Forestry (ICLF) system promoted pasture development, particularly during the wet period. The highest values of NDVI and MPRI were recorded in November, highlighting the positive impact of rainfall on vegetation density and vigor.

Acknowledgments

The authors acknowledge the São Paulo Research Foundation (FAPESP) for financial support (Project 2023/02444-5). We also thank UFSCar and Embrapa Pecuaria Sudeste for providing infrastructure and technical assistance throughout the research.

References

Demarchi, J.C.; Piroli, E.L.; Zimback, C.R.L. Análise temporal do uso do solo e comparação entre os índices de vegetação NDVI e SAVI no município de Santa Cruz do Rio Pardo - SP usando imagens Landsat-5. Revista Ra'ega, v. 21, 2011, p.234-271. https://repositorio.unesp.br/server/api/core/bitstreams/f1d8e24f-2941-42f0-9a8f-f678e3dfe42c/content.
Guimarães, E. C. (2004). *Basic and applied geostatistics* (2nd ed.). UFU Press.
IBGE – INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. Censo agropecuário 2017: resultados definitivos. 2019. < https://biblioteca.ibge.gov.br/visualizacao/periodicos/3096/agro_2017_resultados_definitivos.pdf > .
INPE - Instituto Nacional de Pesquisas Espaciais. (2010) TerraView Project. http://www.dpi.inpe.br/terralib5/wiki/doku.php?id=start

Melo, E. T., Sales, M. C. L., & Oliveira, J. D. (2011). Aplicação do Índice de Vegetação por Diferença Normalizada (NDVI) para análise da degradação ambiental da microbacia hidrográfica do Riacho dos Cavalos, Crateús-CE. *Raega-O Espaço Geográfico em Análise*, ***23***(1), 520-533. https://revistas.ufpr.br/raega/article/viewFile/24919/16717.

Nicodemo, M. L. F., Muller, M. D., Porfirio-da-Silva, V., Carpanezzi, A. A., & Pezzopane, J. R. M. (2016). Growth of native trees in agroforestry systems. Revista Árvore, 40(4), 639–648. https://doi.org/10.1590/0100-67622016000400007

Pezzopane, J. R. M., Bernardi, A. C. C., Bosi, C., Oliveira, P. P. A., Marconato, M. H., de Faria Pedroso, A., & Esteves, S. N. (2019). Forage productivity and nutritive value during pasture renovation in integrated systems. *Agroforestry Systems*, **93**, 39-49. https://doi.org/10.1007/s10457-017-0149-7

PEZZOPANE, J. R. M.; BERNARDI, A. C. C.; AZENHA, M. V.; OLIVEIRA, P. P. A.; BOSI, C.; PEDROSO, A. F.; ESTEVES, S. N. Production and nutritive value of pastures in integrated livestock production systems: shading and management effects. Scientia Agricola, v. 77, n. 2, e20180150, 2020.

Sampaio, H. S., Bourscheidt, V., Sarracini, L. H., Jorge, L. D. C., Bettiol, G. M., & Bernardi, A. D. C. (2020). Comparação entre índices de vegetação obtidos por imagens aéreas com veículo aéreo não tripulado (VANT) e satélite. *Revista Brasileira de Engenharia de Biossistemas*, **14**(2), 111-124. https://doi.org/10.18011/bioeng2020v14n2p111-124

Shimabukuro, Y.E.; Ponzoni, F.J. *Spectral Mixture for Remote Sensing. Linear Model and Applications*; Springer Nature: Basel, Switzerland, 2017; p. 77. QGIS Development Team. (2023). QGIS 3.34 User Guide.

Yang, K., Pinker, R. T., Ma, Y., Koike, T., Wonsick, M. M., Cox, S. J., Zhang, Y., Stackhouse, P., . Evaluation of satellite estimates of downward shortwave radiation over the Tibetan Plateau. *Journal of Geophysical Research: Atmospheres*, ***113***(D17). https://doi.org/10.1029/2007JD009736