Multistep pasture vigor classification at the local scale: a comparative analysis in Guia Lopes da Laguna, MS

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Abstract

Accurate pasture mapping is essential for sustainable livestock management in Brazil, where degradation affects extensive areas. Tools like the *Atlas das Pastagens* provide large-scale data on pasture quality, but local-scale accuracy remains underexplored. This study assessed the accuracy of pasture vigor classification in the 2023 Atlas using 60 groundtruth points collected in Guia Lopes da Laguna, Mato Grosso do Sul, in June 2024. Field data were classified into High, Medium, or Low vigor and then grouped into a binary scheme: “non-degraded” (high vigor) and “degraded” (medium + low Vigor). A confusion matrix comparing reference (field) and estimated (Atlas) data revealed an overall accuracy of 73.3%. The method in Atlas performed better at detecting degraded areas (recall = 80.0%, precision = 70.6%, F1-score = 75.0%) than non-degraded areas (recall = 34.8%, precision = 47.1%, F1-score = 40.0%). While the binary approach improves overall accuracy, the Atlas still shows significant limitations in correctly identifying non-degraded (High Vigor) pastures at the municipal level, often underestimating their presence. Therefore, the Atlas is a useful tool for detecting degradation signs but should be used with caution in applications that require high local precision in distinguishing productive pasture areas.

Keywords: Pasture degradation, Atlas das Pastagens, Accuracy assessment.

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1. Introduction

Mapping and classifying pastures are key to sustainable land use management, particularly in Brazil, the world's leading beef exporter, where extensive livestock farming is dominant. Pastures cover approximately 21% of Brazil's territory (Parente et al., 2019), with a significant concentration in the Cerrado biome. However, pasture degradation, defined as the gradual decline in vigor, productivity, and regenerative capacity (Kichel et al., 1999), poses a major environmental and economic challenge. Recent estimates suggest that nearly 28 million hectares of moderately to severely degraded pastures could be either rehabilitated or repurposed for agriculture (Bolfe et al., 2024).

Monitoring pasture quality remains a significant challenge due to the diverse environmental conditions and the vast area these lands occupy (Parente et al., 2019; Chen et al., 2021; Fernandes et al., 2024). In this context, remote sensing has become an essential tool, enabling efficient large-scale assessments. Platforms such as MapBiomas and Atlas das Pastagens (LAPIG/UFG) provide valuable information on land use and cover and are widely used as references in agricultural and environmental studies (Parente et al., 2019; Souza Júnior et al., 2020). However, accurately distinguishing between different levels of pasture degradation - especially in complex ecosystems like the Cerrado - remains difficult due to the subtle spectral differences among classes (Chen et al., 2021; Fernandes et al., 2024).

Given the importance of accurate data for local planning and for evaluating initiatives such as the SEMEAR project, which aims, among other goals, to promote sustainable agricultural practices, it is crucial to assess the applicability of large-scale datasets at the municipal level. This study aimed to perform an exploratory accuracy assessment of the vigor and degradation levels proposed and implemented in the Atlas das Pastagens (Universidade Federal de Goiás, 2023), using field data collected in the municipality of Guia Lopes da Laguna (GLL), Mato Grosso do Sul, as a reference. The goal was to assess how accurately this data performs at the local scale when distinguishing between two pastures conditions: degraded (low and medium vigor) and non degraded (high vigor).

2. Methods

Guia Lopes da Laguna (GLL) is a municipality in southwestern Mato Grosso do Sul, Brazil, covering 1,215 km² with an estimated population of 9,772 (IBGE, 2025a; 2025b).

The climate is tropical with a dry winter (Aw, Köppen-Geiger), and average annual rainfall is 1,442 mm based on 24 years of CHIRPS data (Funk et al., 2015). The terrain ranges from flat to gently rolling.

To collect reference data, 60 pasture sites in GLL were assessed in situ in June 2024. At each site, geographic coordinates and photographic records were obtained. Field classification followed three vigor levels aligned with the Atlas methodology: high vigor (non-degraded), medium vigor (intermediate), and low vigor (severely degraded), based on indicators such as presence of invasive species, vegetation homogeneity, termite mounds, and bare soil exposure. For the binary analysis, field data were reclassified: points labeled as high or medium vigor were grouped as "non-degraded," while low vigor points were assigned to the "degraded" class.

For the binary accuracy analysis, field data were grouped into two classes: "non-degraded" (high vigor only) and "degraded" (medium and low vigor). The same grouping rule was applied to the original 2023 *Atlas das Pastagens* classification, where high vigor corresponds to "non-degraded" and medium/low vigor to "degraded". Atlas values were extracted at the field coordinates using spreadsheets and the Google Earth Engine platform (Gorelick et al., 2017). Accuracy was assessed through a 2x2 confusion matrix and calculation of overall accuracy, along with class-specific metrics: Precision, Recall, and F1-score.

3. Results and Discussion

The accuracy assessment of the binary classification ("non-degraded" vs. "degraded") from the *Atlas das Pastagens* compared to field data is summarized in the confusion matrix shown in Table 1. Class-specific performance metrics are detailed in Table 2.

Table 1. Confusion Matrix (Field × Atlas).

Field/Atlas	Non-Degraded (A)	Degraded (A)	Total Field
Non-Degraded (F)	8	15	23
Degraded (F)	9	36	45
Total Atlas	17	51	68

Table 2. Performance by class.

Class	Precision (%)	Recall (%)	F1-score (%)
Non-Degraded	47	35	40
Degraded	71	80	75

The overall accuracy of the Atlas das Pastagens in the binary classification was 73.3%, indicating moderate performance at the municipal scale in GLL (Figure 2). However, class-level analysis reveals uneven results. The “non-degraded” class (corresponding to high vigor in the field, Figure 1) remains a critical challenge for the Atlas. A recall of only 34.8% suggests that the Atlas correctly identified just one-third of truly non-degraded pastures, misclassifying the remaining 65.2% as degraded (false negatives). A precision of 47.1% indicates that, even when the Atlas labels an area as non-degraded, there is a 52.9% chance it is degraded (medium or low vigor). The low F1-score (40.0%) encapsulates this difficulty. Such performance may stem from generalized spectral thresholds adopted by the platform or from the spatial resolution of its base datasets-typically MODIS or Landsat-which may fail to capture finer-scale variations in pasture productivity (Reis et al., 2020).

Figure 1. Samples taken in the field: A) Sample no. 56: not degraded and classified by the atlas as not degraded; B) sample no. 47: not degraded and classified by the atlas as degraded; C) sample no. 53: not degraded and classified by the atlas as not degraded.

In contrast, performance in identifying the “degraded” class (combining medium and low vigor field observations) was considerably stronger. With a recall of 80.0%, the Atlas correctly identified the vast majority (36 out of 45) of pastures showing signs of degradation.

A precision of 70.6% indicates that most areas classified as degraded by the Atlas were indeed degraded, though false positives were still present—15 non-degraded points misclassified as degraded. The F1-score of 75.0% reflects this more robust performance for the aggregated degradation class.

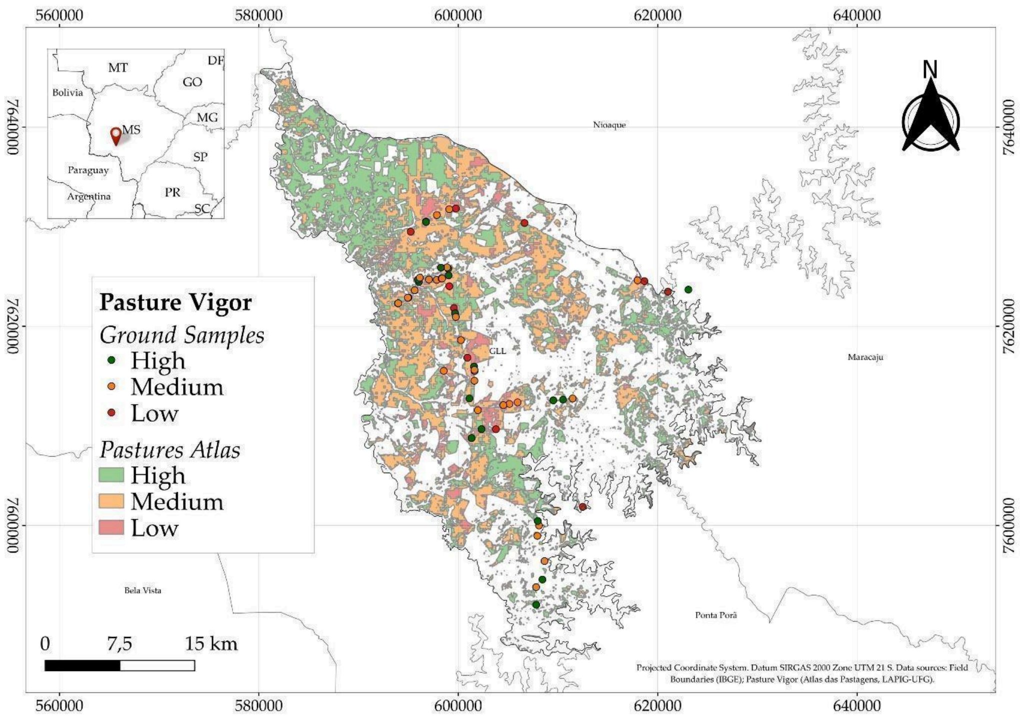

Figure 2. Sampling location map and Pasture Atlas.

These findings suggest that although overall accuracy improves when medium and low vigor are grouped, a key limitation remains at the local scale in GLL: the difficulty in accurately distinguishing high-vigor pastures from degraded ones. The Atlas methodology overestimated degradation in GLL, often labeling productive areas as being in intermediate or low vigor. This may be attributed to generalized spectral thresholds, coarse spatial resolution (Reis et al., 2020), the spectral complexity of tropical pastures (Chen et al., 2021; Fernandes et al., 2024), and potential temporal mismatches between field observations and satellite data.

4. Conclusion

The Atlas das Pastagens (2023) methodology showed moderate accuracy (73.3%) in distinguishing degraded from non-degraded areas in Guia Lopes da Laguna, MS. While its performance in identifying degraded pastures was satisfactory, the platform consistently misclassified a significant portion of high-vigor (productive) pastures as degraded. Despite improved agreement with the binary approach, limitations persist at the municipal scale. Caution is advised when using the Atlas as the sole source for detailed planning or local validation, especially where precise identification of non-degraded areas is critical. Complementary local data or tailored classifications are recommended, along with ongoing validation across seasons.

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References

BOLFE, E. L.; VICTORIA, D. de C.; SANO, E. E.; BAYAM, G.; MASSRUHÁ, S. M. F. S.; OLIVEIRA, A. F. de. Potential for agricultural expansion in degraded pasture lands in Brazil based on geospatial databases. **Land**, v. 13, n. 2, 200, Feb. 2024. DOI: https://doi.org/10.3390/land13020200.

CHEN, Y.; GUERSCHMAN, J.; SHENDRYK, Y.; HENRY, D.; HARRISON, M. T.. Estimating pasture biomass using Sentinel-2 imagery and machine learning. **Remote Sensing**, v. 13, n. 4, 603, Feb. 2021. DOI: https://doi.org/10.3390/rs13040603.

FERNANDES, M. H. M. da R.; FERNANDES JUNIOR, J. de S.; ADAMS, J. M.; LEE, M.; REIS, R. A.; TEDESCHI, L. O. Using Sentinel-2 satellite images and machine learning algorithms to predict tropical pasture forage mass, crude protein, and fiber content. **Scientific Reports**, v. 14, n. 1, 8704, 2024. DOI: https://doi.org/10.1038/s41598-024-59160-x.

FUNK, C.; PETERSON, P.; LANDSFELD, M.; PEDREROS, D.; VERDIN, J.; SHIKLA, S.; HUSAK, G.; ROWLAND, J.; HARRISON, L.; HOELL, A.; MICHAELSEN, J. The climate hazards infrared precipitation with stations - a new environmental record for monitoring extremes. **Scientific Data**, v. 2, 150066, 2015. DOI: https://doi.org/10.1038/sdata.2015.66.

GORELICK, N.; HANCHER, M.; DIXON, M.; ILYUSHCHENKO, S.; THAU, D.; MOORE, R. Google Earth Engine: planetary-scale geospatial analysis for everyone. **Remote Sensing of Environment**, New York, v. 202, p. 18-27, Dec. 2017. DOI: https://doi.org/10.1016/j.rse.2017.06.031.

IBGE. **Áreas Territoriais**. Available on: https://www.ibge.gov.br/geociencias/organizacao-do-territorio/estrutura-territorial/15761-areas-dos-municipios.html?t=acesso-ao-produto&c=5004106. Acessed on: May 4, 2025a.

IBGE. **Guia Lopes da Laguna**: panorama censo 2022 (extensões). Available on: https://cidades.ibge.gov.br/brasil/ms/guia-lopes-da-laguna/pesquisa/10105/293194. Acessed on: May 4, 2025b.

KICHEL, A. N.; MIRANDA, C. H. B.; ZIMMER, A. H. Degradação de pastagens e produção de bovinos de corte com a integração agricultura x pecuária. In: SIMPÓSIO DE PRODUÇÃO DE GADO DE CORTE, 1999, Viçosa. **Anais** [...]. Viçosa: UFV, 1999. p. 201-234.

PARENTE, L. L.; MESQUITA, V.; MIZIARA, F.; BAUMANN, L.; FERREIRA, L. Assessing the pasturelands and livestock dynamics in Brazil, from 1985 to 2017: a novel approach based on high spatial resolution imagery and Google Earth Engine cloud computing. **Remote Sensing of Environment**, v. 232, 111301, Oct. 2019. DOI: https://doi.org/10.1016/j.rse.2019.111301.

REIS, A.; WERNER, J.; SILVA, B.; FIGUEIREDO, G.; ANTUNES, J.; ESQUERDO, J.; COUTINHO, A.; LAMPARELLI, R.; ROCHA, J.; MAGALHÃES, P. Monitoring pasture aboveground biomass and canopy height in an integrated crop-livestock system using textural information from

PlanetScope imagery. **Remote Sensing**, v. 12, n. 2534, 2020. DOI: https://doi.org/10.3390/rs12162534.

SOUZA JÚNIOR, C. M.; SHIMBO, J. Z.; ROSA, M. R.; PARENTE, L. L.; ALENCAR, A. A.; RUDORFF, B. F. T.; HASENACK, H.; MATSUMOTO, M.; FERREIRA, L. G.; SOUZA-FILHO, P. W. M.; OLIVEIRA, S. W. de; ROCHA, W. F.; FONSECA, A. V.; MARQUES, C. B.; DINIZ, C. G.; COSTA, D.; MONTEIRO, D.; ROSA, E. R.; VÉLEZ-MARTIN, E.; WEBER, E. J.; LENTI, F. E. B.; PATERNOST, F.F.; PAREYN, F.G. C.; SIQUEIRA, J. V.; VIEIRA, J. L.; FERREIRA NETO, L. C.; SARAIVA, M. M.; SALES, M. H.; SALGADO, M. P. G.; VASCONCELOS, R.; GALANO, S.; MESQUISTA, V. V.; AZEVEDO, T. Reconstructing three decades of land use and land cover changes in Brazilian biomes with Landsat archive and Earth Engine. **Remote Sensing**, v. 12, n. 17, 2735, Sept. 2020. DOI: https://doi.org/10.3390/rs12172735.

UNIVERSIDADE FEDERAL DE GOIÁS. Laboratório de Processamento de Imagens e Geoprocessamento. **Atlas das Pastagens**. [Goiânia]. Available at: https://atlasdaspastagens.ufg.br/. Accessed on: May 4, 2025.