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# Evaluation of SAR and Optical Image Fusion Methods in Oil Palm Crop Cover Classification Using the Random Forest Algorithm


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## Introduction

Remote sensing is a science that studies different natural phenomena occurring on the Earth's surface using sophisticated techniques to capture information. The huge development of the oil palm agribusiness makes it necessary to find new methodologies based on geospatial Earth observation technologies that allow the establishment of the basis and criteria for achieving productive sectoral organization and, at the same time, environmentally sustainable development, as proposed in the elaboration of the agroecological zoning plans. The fusion image methods allow link reflectance information, captured by optical satellites, with information on texture/roughness, moisture content, geometry, and the orientation, captured by synthetic aperture radar (SAR) satellites, of the different coverages (Carolita *et al*., 2019). This provides more information on a given area, particularly oil palm coverage, than using both sources separately (Orynbaikyzy *et al.,* 2020). Remote sensing plays a vital role in carrying out studies on large extensions of territory and efficiently monitoring dynamic sectors, such as the oil palm agricultural sector (Sarzynski *et al.,* 2020). Therefore, this research aims to improve land cover classification, especially oil palm cover, using optical/SAR image fusion methods by implementing a random forest (RF) algorithm in cloud computing platforms.

## Materials and Methods

The project was conducted in the central oil palm region of Colombia, Palmar de la Vizcaína Experimental Station (CEPV) located in the municipality of Barrancabermeja, Santander, Colombia. Sentinel-2 optical image and Sentinel-1 SAR image were used, and the respective pre-processing was performed (Figure 1). The image fusion methods implemented were Brovey (BR), high-frequency modulation (HFM), Gram Schmidt (GS), principal components (PC), and the optical/SAR image stack. Random Forest (RF) algorithm was used for the land cover classification and evaluated by user (UA) and producer accuracy (PA), overall accuracy (UA), and kappa coefficient (KP).

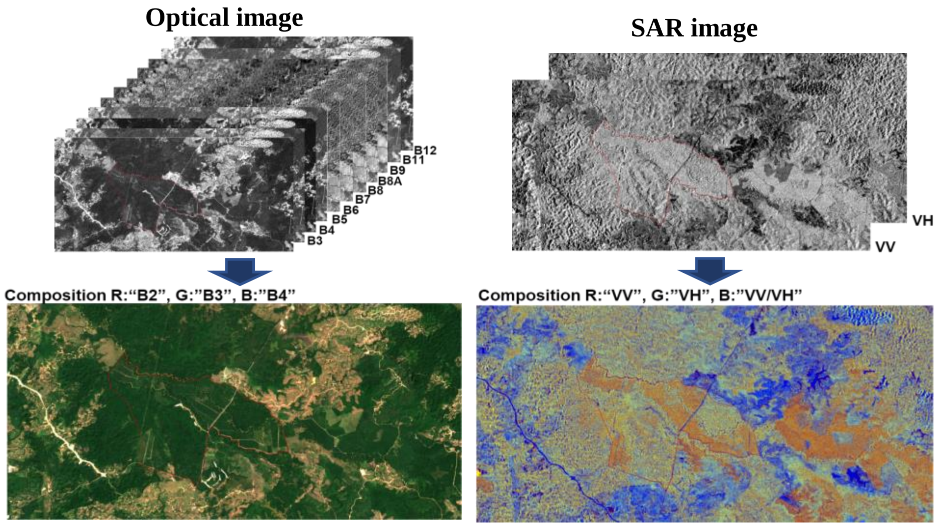


**Figure 1:** Optical and SAR images implemented in this research.

## Results

For adequate fusion, it was necessary to apply a multitemporal speckle reduction filter on the SAR image beforehand. The distortions were evaluated in each fused image, being higher in the BR method and lower in the HFM method (Table 1).

| Fusion Method | RMSE | SDT | PSNR | CC | ERGAS |
|---|---|---|---|---|---|
| BR | 0.00057 | 0.13503 | 12.60602 | 0.70102 | 0.32001 |
| HFM | **0.00002** | 0.03890 | **35.82745** | **0.92981** | **0.00979** |
| GS | 0.00003 | **0.03371** | 26.22411 | 0.68361 | 0.02747 |
| PC | 0.00005 | 0.03449 | 23.02522 | 0.23065 | 0.04880 |

**Table 1:** Results of statistical indicators of root mean square error (RMSE), standard deviation (SDT), peak signal to noise ratio (PSNR), correlation coefficient (CC), and relative global synthesis error (ERGAS) implemented to measure quality in fusion methods: Brovey (BR), high-frequency modulation (HFM), Gram–Schmidt (GS), and principal components (PC).

The classes identified were water bodies (lagoons with eutrophication processes), forest, oil palm, grassland, bare soil, and low vegetation (Figure 2). In all cases, the spectral signatures are not presented significative distortions in images fused.

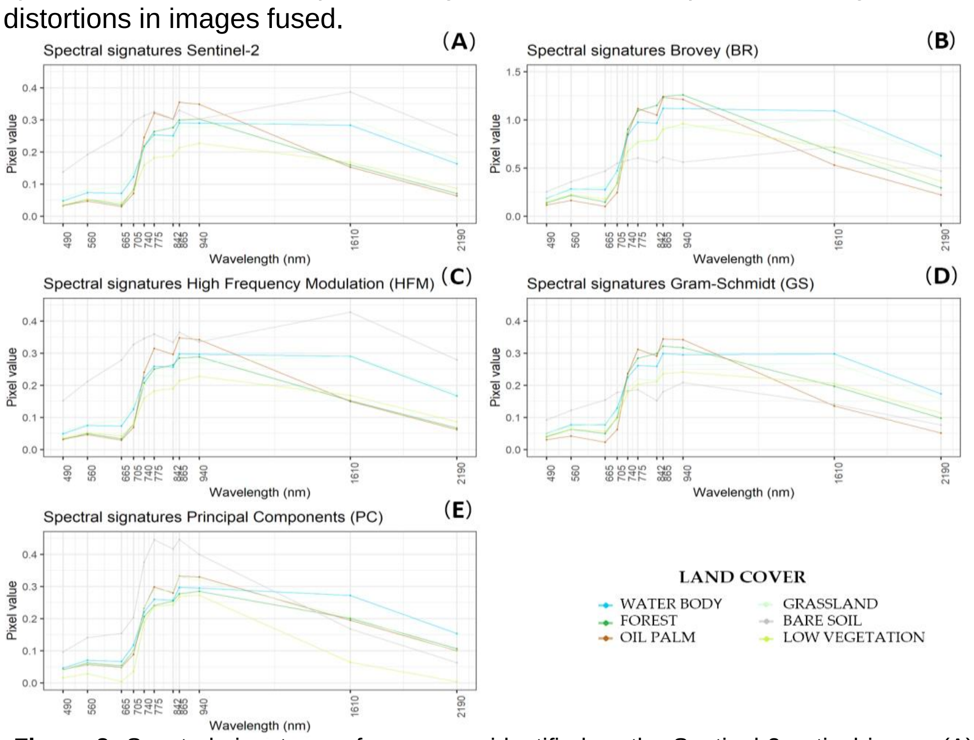


**Figure 2:** Spectral signatures of coverages identified on the Sentinel-2 optical image (A) and the images fused by the Brovey (BR) (B), high-frequency modulation (HFM) (C), Gram–Schmidt (GS) (D), and principal components (PC) (E) methods.

Figure 3 show the land cover classification. Confusion between oil palm and forest was evident in the optical image. These confusions were highly reduced in the SAR image, as well as in fused images, mainly BR and HFM methods. The optical/SAR image stack presented the most

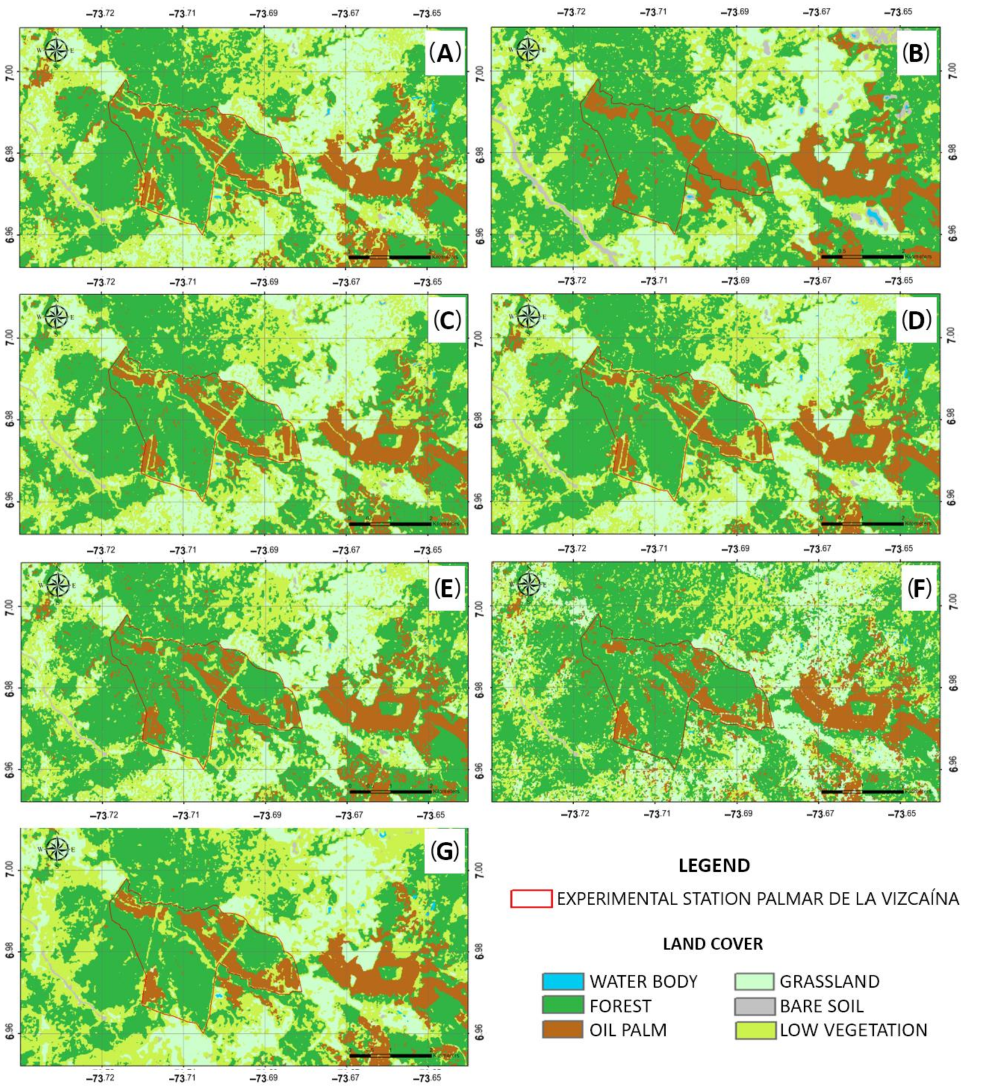


**Figure 3:** Results of land cover classifications using RF algorithm. Classification of optical (A) and SAR images (B). Classification images fused by BR method (C), HFM method (D), GS method (E), PC method (F), and optical/SAR image stack (G) respectively.

The highest value was achieved for the optical/SAR image stack, reaching 82.14% for the overall accuracy and 0.79 for the kappa coefficient (Figure 4). The OA obtained in the optical image classification was similar to that found in the HFM and BR methods, slightly higher by 3.81% and 3.10% respectively.

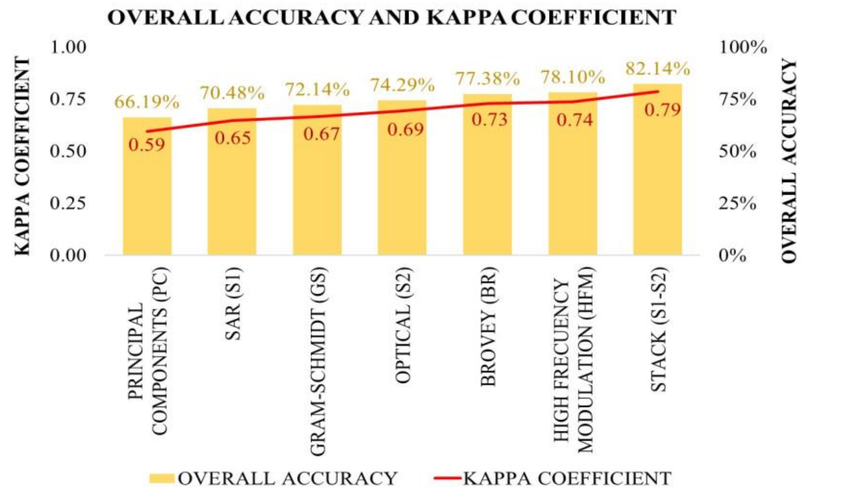


**Figure 4:** Comparison of overall accuracies and kappa coefficient for each of the images analyzed

## Conclusions

The use of optical and SAR images proved that they complement and provide more information about different land covers, improving your classifications using Random Forest (RF) algorithm. Better overall accuracy was presented for the optical/SAR image stack, being 11.66% higher compared with the SAR image and 7.85% higher compared with the optical image. The oil palm classification using only SAR images was very high, reaching 94,29%. This demonstrated the capacity of SAR systems in land cover mapping, capturing global information day and night without being affected by atmospheric conditions, which is a significant limitation in the use of optical satellites. High-frequency modulation (HFM) and Brovey (BR) image fusion methods presented better overall accuracy compared with optical image.

## Reference


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