ASEC 2025 Conference

The 6th International Electronic Conference on Applied Sciences

09–11 December 2025 | Online

MDPI

Adversarial U-Net Adaptation with Targeted Augmentation Boosts Crop Classification in Data-Scarce Regions

Nada Naili[1], Meziane Iftene [2], Mohammed El Amin Larabi [2],

1 Higher School of Computer Science (ESI-SBA), 22000 Sidi Bel Abbès, Algeria

2 Department of Scientific and Technological Watch, Algerian Space Agency, 16000 Algiers, Algeria

INTRODUCTION & AIM

Accurate crop maps are crucial for targeted agricultural management and global food security (SDG 2). However, deep learning models often fail when deployed in new geographic regions due to domain shift, a major barrier in nations like Algeria that lack large-scale labeled datasets. This study aims to address this challenge by developing a data-efficient semantic segmentation pipeline. Our goal is to effectively transfer knowledge from data-rich European regions to data-scarce Algerian environments for crop mapping using Sentinel-2 imagery. We propose an adapted Domain-Adversarial Neural Network (DANN) to achieve robust classification with very limited local data.

METHOD

This study addresses crop classification under domain shift from Europe (Estonia) to Algeria using a Domain-Adversarial Neural Network (DANN) built on a U-Net architecture with ResNet34 encoder. Two baselines—source-only and target-only—were trained to illustrate the effects of domain shift. The source dataset is EuroCropsML (Estonia), containing time-series Sentinel-2 imagery for multiple crop types, while the target Algerian dataset consists of 42 wheat and 62 potato field polygons collected via field surveys and satellite imagery. Sentinel-2 images were preprocessed using median composites for crop-specific growth stages, and four vegetation indices (NDVI, GNDVI, NDWI, MSAVI) were computed to enhance spectral information. Our approach incorporates a small set of labeled Algerian data, with targeted data augmentation applied to each sample before training. The model is trained with a combined loss: segmentation loss for both source and target data, plus a domain-adversarial loss to enforce domain-invariant feature learning. This methodology enables robust classification of wheat and potatoes across heterogeneous agricultural regions, despite limited local annotations.

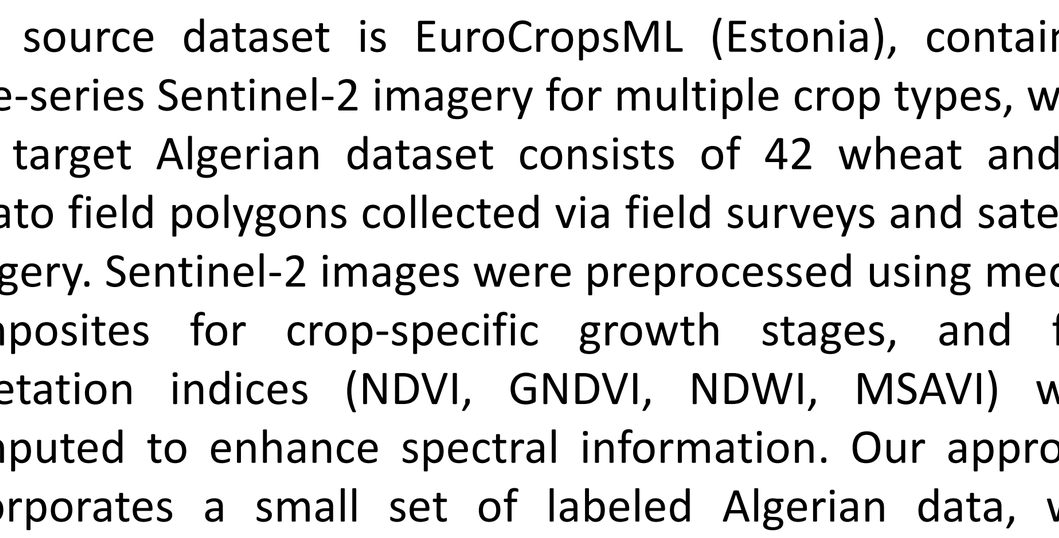
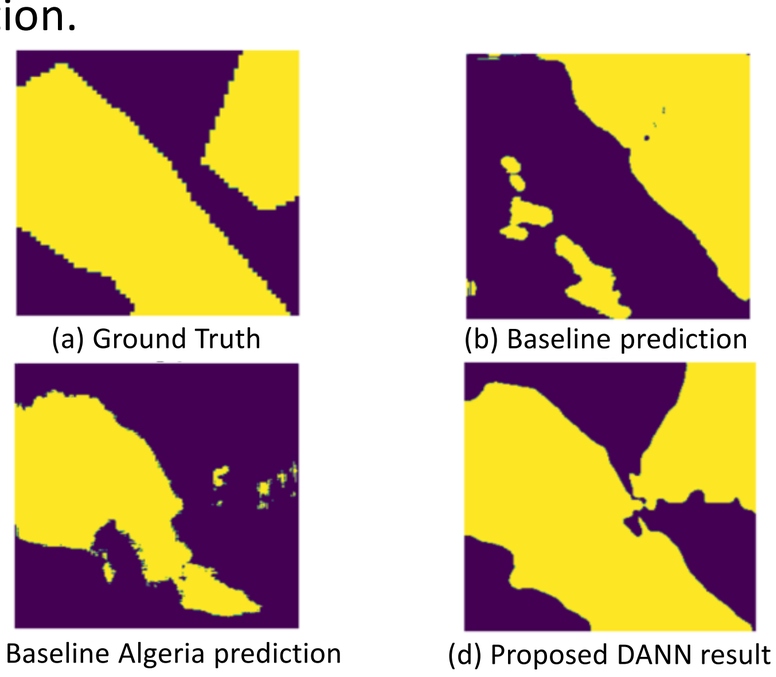


Figure 1: Architecture of the Domain-Adversarial U-Net for Crop Segmentation

RESULTS & DISCUSSION

The proposed model demonstrates significant performance gains, successfully overcoming the domain shift challenge. A baseline U-Net, trained only on European data, highlighted the problem by achieving just 62% accuracy on the Algerian test set.

In contrast, our adapted DANN model, trained with only 50% of the available Algerian labels, increased the overall accuracy to 89%. This data-efficient approach yielded high class-specific F1-Scores of 0.93 for wheat and 0.89 for potatoes. The visual results clearly show that our DANN model produces segmentation masks that are far more accurate and complete than the baseline, closely matching the ground truth. This confirms that our method effectively learns domain-invariant features for robust crop classification.



(a) Ground Truth (b) Baseline prediction

(c) Baseline Algeria prediction (d) Proposed DANN result

Figure 2: Qualitative Comparison of Segmentation Performance

CONCLUSION

Our proposed approach aimed not to revolutionize the field of domain adaptation, but rather to explore its practical applicability to the Algerian context, where limited labeled data and diverse agro-climatic zones pose unique challenges. One key contribution of this work is demonstrating how foundational concepts like transfer learning and domain confusion can be adapted and tuned,

FUTURE WORK / REFERENCES

Future works might include trying on different regions, different dataset, or including explainability (XAI) to enhance the understanding of the results produced by the models.

1. MOHAMMADI, Sina, BELGIU, Mariana, et STEIN, Alfred. A source-free unsupervised domain adaptation method for cross-regional and cross-time crop mapping from satellite image time series. Remote Sensing of Environment, 2024, vol. 314, p. 114385.