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INTEGRATING GEOGRAPHIC INFORMATION SYSTEMS AND ARTIFICIAL INTELLIGENCE FOR SUSTAINABLE AGRICULTURE: APPLICATIONS AND PERSPECTIVES IN ROMANIA AND EUROPE

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Introduction

The integration of Geographic Information Systems (GIS) and Artificial Intelligence (AI) offers new opportunities for improving agricultural productivity, resource efficiency, and environmental sustainability. GIS enables the spatial analysis of agricultural data, while AI supports predictive modelling, crop monitoring, and intelligent decision-making. In Romania and across Europe, these technologies can strengthen precision agriculture, optimize irrigation and land management, and support sustainable farming practices under changing climatic conditions. The integration of satellite imagery, soil data, GIS, and AI supports agricultural risk assessment, efficient resource management, and sustainable farming practices.

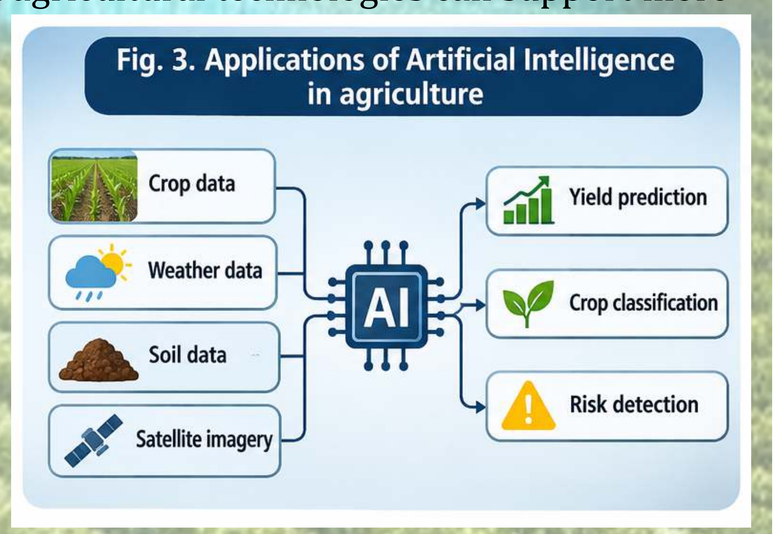
Material and method

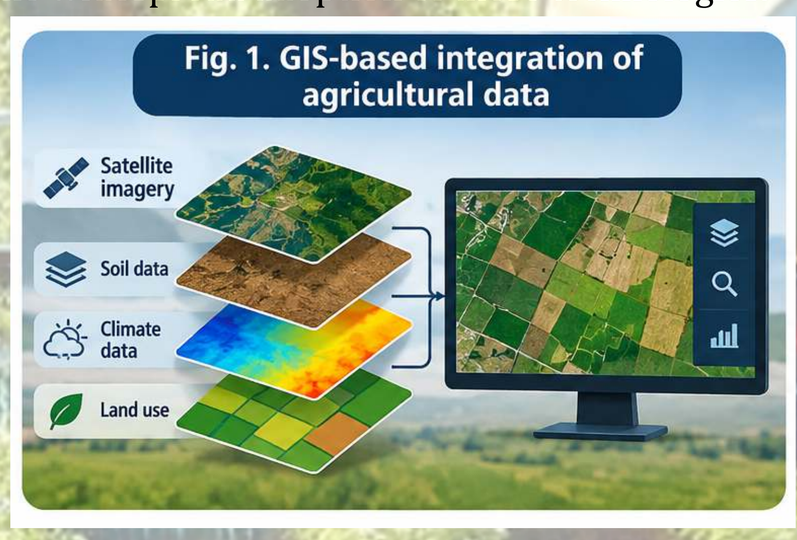
The study employs a qualitative and comparative approach based on scientific literature, agricultural technology reports, and European policy documents. The analysis focuses on GIS-based spatial data integration, Artificial Intelligence applications, remote sensing, precision farming, and environmental sustainability. A thematic comparison was used to assess technological opportunities, data reliability, implementation challenges, and the potential benefits of GIS–AI integration for sustainable agriculture in Romania and Europe. The methodological framework examines the integration of satellite imagery, soil characteristics, climatic data, and agricultural land-use information into GIS platforms. Particular attention is given to AI-based predictive modelling, data interoperability, technological accessibility, and the requirements for implementing sustainable precision farming solutions.

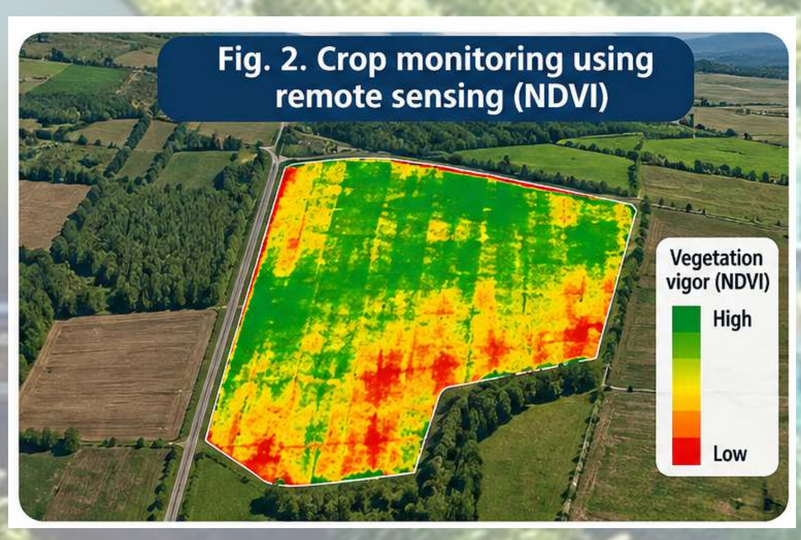
Result and discussions

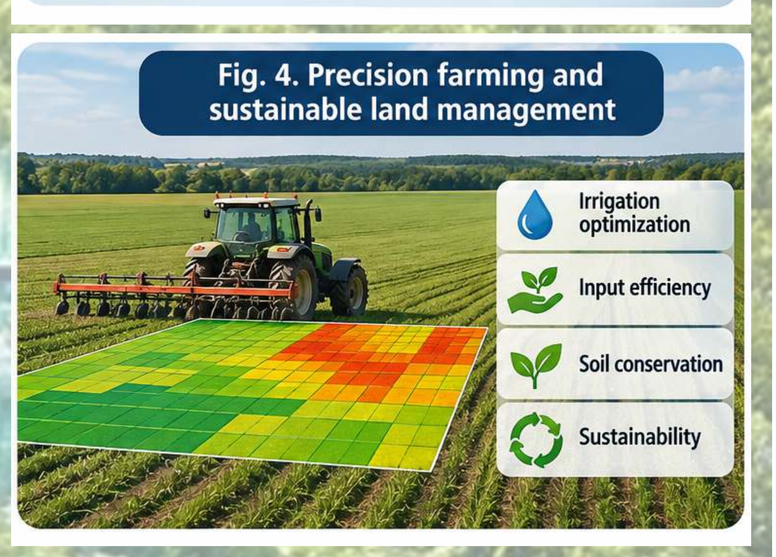
The comparative analysis highlights the potential of GIS and Artificial Intelligence to improve agricultural monitoring, spatial analysis, and sustainable resource management in Romania and Europe. GIS platforms integrate satellite imagery, soil characteristics, and climatic data, while AI supports crop classification, yield prediction, and agricultural risk assessment. Their combined application can improve irrigation planning, soil conservation, and precision farming practices. However, data quality, interoperability, investment costs, and limited digital infrastructure remain important challenges. The integration of reliable geospatial information, validated AI models, and modern agricultural technologies can support more efficient decision-making and sustainable agricultural development.

The integration of satellite imagery, soil characteristics, and climatic data into GIS platforms supports accurate spatial analysis and agricultural planning (Fig. 1). Remote sensing and NDVI-based vegetation monitoring enable the identification of crop variability and potential areas of agricultural stress (Fig. 2). Artificial Intelligence supports crop classification, yield prediction, and early detection of agricultural and environmental risks (Fig. 3). Precision farming combines GIS and AI technologies to optimize irrigation, improve resource efficiency, and support sustainable land management (Fig. 4). The comparative analysis highlights the potential of GIS–AI integration to improve agricultural decision-making and environmental sustainability in Romania and Europe. However, data quality, technological accessibility, investment costs, and digital infrastructure remain important challenges for the widespread adoption of these technologies.









Conclusions

The study highlights the importance of integrating GIS and Artificial Intelligence to improve agricultural efficiency, spatial analysis, and environmental sustainability. These technologies support crop monitoring, yield prediction, irrigation optimization, and sustainable land management. However, their successful implementation depends on reliable data, digital infrastructure, technical expertise, and financial resources. Strengthening technological innovation, professional training, and institutional cooperation can accelerate agricultural digitalization and promote sustainable development in Romania and Europe.

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