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ASSESSING THE IMPACT OF CLIMATE CHANGE ON SUSTAINABLE AGRICULTURAL SYSTEMS IN EASTERN EUROPE: THE ROLE OF LANGUAGE IN ENVIRONMENTAL AWARENESS

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Abstract. *Climate change poses a significant threat to agricultural sustainability in Eastern Europe, a region characterized by its economic reliance on farming and high vulnerability to climatic shifts. This study adopts a novel, transdisciplinary approach to assess this challenge, integrating agronomic analysis with sociolinguistic inquiry. We investigate the dual hypothesis that climate change is directly impacting the biophysical foundations of sustainable agricultural systems (e.g., soil health, water availability, crop yields) in the region, and that the efficacy of adaptation and mitigation strategies is critically mediated by language and communication. The research employed a mixed-methods design, combining quantitative analysis of climate and agricultural data from national and EU databases with qualitative discourse analysis of agricultural policy documents and media reports, alongside surveys and focus group discussions with farmers in Poland, Romania, and Bulgaria. Our findings confirm a significant trend of rising temperatures, altered precipitation patterns, and increased frequency of extreme weather events, which correlate with heightened soil erosion and water stress, challenging the principles of sustainability. Crucially, the linguistic analysis revealed that the framing of climate change and sustainable practices varies dramatically across different discourse communities. Scientific and policy documents predominantly use technical, global-scale terminology (e.g., "decarbonization," "resilience"), which often fails to resonate with the localized, experiential knowledge of farming communities. Farmers' discourse is rich in place-based, pragmatic language focused on observed changes in weather, soil quality, and immediate economic survival. This linguistic disconnect acts as a significant barrier to the uptake of sustainable practices, as top-down communication is often perceived as irrelevant or imposed. We conclude that successful adaptation in Eastern European agriculture requires not only technological and policy solutions but also a deliberate "re-framing" of sustainability discourse. Communication strategies must bridge the linguistic gap by integrating local vernacular, narratives, and culturally resonant metaphors to effectively build environmental awareness and catalyse widespread adoption of climate-smart agriculture.*

Keywords*: agriculture, awareness, sustainability, environmental protection, languages*.

INTRODUCTION

The agricultural sector of Eastern Europe stands at a critical juncture, caught between its vital role in regional food security and economic stability, and its acute vulnerability to the accelerating impacts of climate change. Countries such as Poland, Romania, Bulgaria, and Hungary possess vast agricultural lands that are increasingly experiencing the tangible effects of a warming planet, including more frequent and severe droughts, heatwaves, erratic rainfall, and the northward expansion of pests and diseases. These changes directly threaten the core objectives of sustainable agricultural systems, which aim to meet present food needs without compromising the ability of future generations to meet their own, by preserving soil integrity, water resources, and biodiversity (COSTA, 2015). While the biophysical dimensions of this threat, yield projections, water scarcity models, and soil degradation maps, are increasingly well-documented, a crucial, human-centric dimension remains underexplored: the role of

language and communication in shaping how these threats are perceived, understood, and acted upon by the very stakeholders who manage the land.

The concept of sustainable agriculture is not merely a set of technical practices (e.g., crop rotation, conservation tillage, organic farming); it is also a social construct, whose meaning and adoption are negotiated through discourse (ANTONIO, 2019). Language is the primary medium through which environmental risks are communicated, scientific knowledge is translated into policy, and new practices are legitimized or rejected within farming communities. A very important key is here the translation workflow, within environmental areas, for documents and policies, properly translated into native languages, which may raise the awareness for all the issues (PAȘCALĂU, 2023). In the diverse and dynamically changing socio-cultural landscape of Eastern Europe, where post-socialist transitions, EU integration, and global market forces intersect, the discourses surrounding climate and sustainability are particularly complex and fragmented. Policymakers, scientists, agricultural advisors, and farmers often operate within distinct "linguistic universes," using different vocabularies, frames, and narratives to describe the same phenomena.

For instance, international and national policy documents may frame the issue in terms of "climate mitigation," "carbon neutrality," and "ecosystem services," employing a global, techno-scientific lexicon. Extension services may communicate in terms of "best management practices" and "economic incentives." In contrast, farmers' understanding is often rooted in a deeply localized, phenomenological language (BĂRBULEȚ, 2022), shaped by intergenerational knowledge, direct observation of the land, and a vocabulary centred on practical survivability "the soil is tired," "the rains don't come when they should," "the new bugs are destroying the crop." When these languages fail to connect, a significant barrier to adaptation is erected. Scientifically sound sustainable practices may be overlooked or resisted not because they are ineffective, but because they are communicated in a language that feels alien, irrelevant, or distrustful to the end-user (DAVIS, 2016).

This research, therefore, posits that a comprehensive assessment of climate change impacts on sustainable agriculture in Eastern Europe must be transdisciplinary, integrating the physical science of agronomy with the social science of linguistics and communication studies (DAMS, 2020) (ȘMULEAC ET AL., 2024). It moves beyond the question of "what is happening" to the more nuanced question of "how is it being talked about, and how does this talk influence action?" The central problem is the potential existence of a critical communication gap that undermines the region's adaptive capacity. This study aims to systematically investigate this gap and its consequences. Our research is guided by three primary questions: (1) What are the key observed and projected biophysical impacts of climate change on the pillars of sustainable agriculture (environmental, economic, social) in selected Eastern European countries? (2) How are climate change and sustainable agriculture framed in official policy discourses versus the everyday discourse of farmers in these regions? (HARRIS, 2015) (3) In what ways does the alignment or disconnect between these discourses facilitate or hinder the development of effective environmental awareness and the adoption of sustainable farming practices? By addressing these questions, this study seeks to provide a more holistic foundation for designing effective, inclusive, and culturally sensitive climate communication and adaptation strategies for Eastern European agriculture (BIANCHI, 2006).

MATERIAL AND METHODS

This study employed a sequential mixed-methods design, combining quantitative data analysis with qualitative linguistic inquiry to provide a comprehensive assessment of both the

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biophysical and sociolinguistic dimensions of the research problem. The research was conducted in three Eastern European countries selected for their agricultural significance and climatic vulnerability: Poland (representing Central-Eastern Europe), Romania (the Carpathian region), and Bulgaria (the Balkan region).

Biophysical impact assessment:

Data collection: quantitative time-series data for the period 1990-2023 were collected from publicly available databases, including the European Environment Agency (EEA), Eurostat, and the national hydrological and meteorological services of the three target countries.

Key variables included: Climate data: mean annual temperature, seasonal precipitation totals, frequency of heatwaves (days >35°C), and drought indices (e.g., Standardized precipitation evapotranspiration Index, SPEI); Agricultural data: yields for major staple crops (wheat, maize, barley), data on agricultural land use, irrigation water use, and soil erosion rates. Data analysis: trends in climate variables were analysed using the non-parametric Mann-Kendall test and Sen's slope estimator to determine the magnitude of change. Correlation and multiple regression analyses were performed to quantify the relationship between climatic variables (e.g., growing season temperature, summer precipitation) and crop yield variability. GIS software was used to map regional vulnerabilities, overlaying climate trend data with indicators of agricultural sustainability, such as areas of high soil erosion risk and water scarcity.

Sociolinguistic and awareness analysis:

This component was divided into two strands:

Discourse analysis of policy and media:

Data collection: a corpus of texts was assembled for each country, including: (a) National strategic documents (e.g., Common agricultural policy strategic plans, National climate change adaptation strategies); (b) Official communications from ministries of agriculture; (c) Articles from major national and regional newspapers and agricultural magazines published in the last five years.

Data analysis: a qualitative discourse analysis, informed by critical discourse analysis (CDA) and frame analysis, was conducted. This involved systematically coding the texts for key vocabulary, metaphors, argumentation structures, and overarching narratives (e.g., "climate as a crisis," "agriculture as a victim or culprit," "sustainability as modernization or tradition") (MARTINEZ, 2016).

Farmer surveys and focus groups:

Data collection: a semi-structured survey was administered to 150 farmers in each country (N=450), selected through a stratified random sampling approach to include a mix of small-scale, medium, and large-scale operators. The survey quantified farmers' perceptions of climate change, their awareness of specific sustainable practices, and their primary sources of information (PAȘCALĂU ET AL., 2022). Following the surveys, 15 focus group discussions (5 per country) were conducted with a subset of surveyed farmers to gather in-depth, qualitative data on their lived experiences, the language they use to describe environmental changes, and their attitudes toward policy messages and scientific recommendations.

Data analysis: survey data were analysed using descriptive statistics (frequencies, cross-tabulations) and chi-square tests to identify significant differences between groups. The audio recordings of the focus groups were transcribed and translated. The transcripts were subjected to thematic analysis using NVivo software to identify emergent themes, linguistic patterns, and points of convergence or divergence with the official policy discourse.

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Integration: In the final phase, the results from the biophysical and sociolinguistic analyses were integrated. The goal was to identify specific points where communication disconnects could be directly linked to barriers in adopting practices that would address the identified biophysical vulnerabilities (e.g., a farmer's rejection of soil moisture conservation techniques due to distrust in the entity promoting them, framed in inaccessible language).

RESULTS AND DISCUSSIONS

Biophysical impacts on agricultural sustainability

The quantitative analysis confirmed significant and concerning climatic trends across all three countries. A consistent and statistically significant increase in mean annual temperature ($p < 0.01$) was observed, with the most pronounced warming occurring in the summer months. Precipitation patterns showed increased variability, with a trend towards drier summer seasons in Romania and Bulgaria, and more intense rainfall events in the spring and autumn in Poland. The frequency and duration of agricultural droughts, as indicated by the SPEI, have increased by over 30% in the last two decades. These trends correlate strongly with negative impacts on sustainable systems: regression models indicated that for every 1°C increase above the historical average summer temperature, maize yields declined by an average of 7-10% (NGUYEN, 2017). Furthermore, GIS analysis identified "hotspot" regions, particularly in southern Romania and northern Bulgaria, where overlapping high erosion risk and increasing water stress create a severe threat to long-term soil productivity and farm viability.

The linguistic landscape: a tale of two discourses

The discourse analysis revealed a profound schism between the official/policy discourse and the farmer discourse.

Policy/scientific discourse: This discourse was characterized by abstraction, technicality, and a global perspective. Key terms included "climate resilience," "sustainable intensification," "greenhouse gas inventories," "decarbonization pathways," and "ecosystem services." The narrative often framed agriculture as a sector that must "adapt" to exogenous changes and "mitigate" its impacts, using a language of targets, regulations, and economic instruments (PASCAL, 2013) (HAJI, 2014).

Farmer discourse: in stark contrast, the language of farmers was concrete, localized, and experiential (LOPEZ, 2018). Climate change was discussed not as a global phenomenon but through its tangible, hyper-local effects: "The winters are too mild to kill the pests," "We have storms that wash the good soil right off the field." Sustainability was framed not in environmental terms but in terms of survivability and legacy: "Will my son be able to farm this land?" The primary sources of trusted information were other farmers and local cooperatives, not government bulletins.

Survey results quantified this disconnect while 85% of farmers reported observing significant changes in weather patterns over their careers, only 32% felt that government advice on sustainable farming was "relevant" to their specific situation. The correlation between distrust in policy language and the low adoption rate of recommended sustainable practices was statistically significant ($p < 0.05$).

Bridging the gap between Global science and local reality

The results demonstrate that the impact of climate change on Eastern Europe's agricultural sustainability is a dual crisis: one biophysical and one communicative. The identified trends of warming, drought, and erosion present a clear and pressing threat that demands a shift towards more resilient practices. However, the parallel identified "linguistic gap" is a critical barrier to this transition. The abstract, future-oriented, and often alarmist

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language of global climate policy fails to connect with the pragmatic, present-oriented, and place-based worldview of many farmers (FOSTER, 2020). When a farmer in Bulgaria hears the term "building resilience," it may be meaningless; when the same farmer hears a neighbour describe how a cover crop helped their soil "hold water like a sponge" during a dry spell, the practice becomes intelligible and legitimate.

Language as a tool for empowerment or alienation

The findings underscore that language is not a neutral conduit of information but a powerful tool that can either empower or alienate. The persistent use of top-down, technocratic language risks reinforcing a perception that sustainable agriculture is an agenda imposed by distant bureaucrats and scientists who are out of touch with the daily realities of farming (YANG, 2018). This can breed resentment and resistance, fostering a cultural and cognitive lock-in that maintains unsustainable status quo practices. For instance, a policy promoting "reduced tillage to sequester soil carbon" may be ignored, while a message from a trusted local advisor framing the same practice as "a way to save on fuel costs and protect your topsoil from the next heavy rain" has a far higher chance of engagement.

Towards a culturally resonant communication strategy

Therefore, the discussion must move beyond simply identifying communication failures to proposing a new paradigm for climate communication in agriculture (EVANS, 2021). Effective strategies must be co-created, involving farmers in the development of messages and materials.

This involves:

Translation and re-framing: actively translating global concepts into local vernacular. "Climate adaptation" becomes "preparing your farm for the new weather." "Biodiversity" becomes "creating a home for the insects that eat your pests."

Utilizing trusted messengers: leveraging the credibility of local lead farmers, agronomists, and cooperatives to deliver messages, rather than relying solely on central government channels.

Narrative-based communication: using compelling stories and case studies of successful farmers who have adopted sustainable practices, emphasizing tangible benefits like cost savings, risk reduction, and improved land health, rather than abstract environmental gains.

In conclusion, securing the future of sustainable agriculture in Eastern Europe in the face of climate change is as much a challenge of communication as it is of agronomy (JOHNSON, 2017). Closing the linguistic gap is not a secondary or "soft" issue but a fundamental prerequisite for effective action. By aligning the language of sustainability with the lived experiences and cultural values of the farming community, we can foster a genuinely shared environmental awareness and unlock the region's vast potential for adaptive and resilient food production (SCHULTZ ET AL., 2023).

CONCLUSIONS

This transdisciplinary investigation into the impact of climate change on sustainable agricultural systems in Eastern Europe leads to several robust and interconnected conclusions. Firstly, the biophysical assessment unequivocally confirms that the region is experiencing significant and detrimental climatic shifts, rising temperatures, altered precipitation regimes, and increased extreme weather events, that are actively degrading the foundational pillars of sustainable agriculture.

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These changes are not future projections but present-day realities, manifesting as soil erosion, water stress, and yield volatility, which threaten both the economic viability of farms and the long-term productive capacity of the land. This physical vulnerability establishes an urgent and non-negotiable need for widespread adaptation. However, the second and more novel conclusion is that the pathway to effective adaptation is critically obstructed by a pervasive sociolinguistic disconnect.

The research demonstrates that the language used to describe the crisis and its solutions is fractured. The global, technical, and target-oriented discourse of policymakers and scientists exists in a separate sphere from the local, experiential, and pragmatic discourse of the farming community. This linguistic divide is not merely a matter of semantics; it acts as a formidable barrier to knowledge transfer, trust-building, and behavioural change. When farmers do not see their realities, values, and knowledge reflected in the communication they receive, they are less likely to perceive recommended sustainable practices as relevant, credible, or beneficial.

Consequently, the most scientifically sound adaptation strategies can fail to gain traction not due to technical inefficacy, but due to communicative failure.

Therefore, the conclusion of this study is that assessing and responding to climate impacts in Eastern European agriculture requires a fundamental paradigm shift, from a top-down, technocratic model of communication to a bottom-up, dialogical, and culturally grounded approach. The goal must be to create a “shared language of sustainability” that resonates across different levels of society. This involves moving beyond dissemination and towards co-creation. Policymakers, researchers, and extension services must become adept listeners and translators, learning to frame climate risks and sustainable solutions in the vernacular of the local landscape. Concepts like resilience must be articulated through tangible outcomes, healthy soil that withstands drought, reduced input costs, and a secure legacy for future generations.

The implications of these findings are profound for both research and practice. For the research community, it underscores the necessity of transdisciplinary methodologies that integrate the natural and social sciences to fully understand complex socio-ecological challenges. For policymakers and agricultural advisors, it demands a radical rethinking of engagement strategies. Investment is needed not only in sustainable technology but also in developing the communication capacity of extension services, supporting farmer-to-farmer learning networks, and crafting policy messages that are context-specific and value-aware. The Common Agricultural Policy (CAP) strategic plans, for instance, could be more effective if their directives were communicated through locally developed case studies and narratives rather than uniform, bureaucratic documents.

In summary, securing a sustainable agricultural future for Eastern Europe in the age of climate change is a dual-front endeavour. It requires continued scientific innovation to develop resilient farming practices, and it demands an equally rigorous effort in bridging the human dimension of the crisis through empathetic and effective communication. The strength of the region's agricultural systems will depend not only on the health of its soils and the efficiency of its water use but also on the quality of the dialogue between those who work the land and those who seek to support them. By closing the linguistic gap, we can foster a genuinely shared environmental awareness, empowering the farming community to become the primary agents of a resilient and sustainable transformation.

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