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Master Plan for nature-based regional ecometry in the Lower Danube Floodplains and Danube Delta

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Abstract This article explores a comprehensive Master Plan aimed at enhancing organic soil carbon sequestration and reducing greenhouse gas emissions in the Lower Danube Floodplains and Danube Delta. The plan integrates socio-economic factors and environmental concerns, focusing notably on biodynamic agriculture. It aligns with the European Union's goals for greenhouse gas reduction and emphasizes nature-based solutions, including precise land and forest management practices. The Master Plan leverages organic soil protection and carbon sequestration, contributing to targeted greenhouse gas mitigation. Highlighting the need for a multidisciplinary approach, the research connects environmental science, agriculture, and socio-economic aspects. It also examines the impact of implementing Biodynamic Regenerative Agriculture and Biophilia principles, aiming to significantly advance sustainable development in the region.

Keywords: Nature-based solutions, carbon sequestration, GHG reduction

1 Introduction

In response to the escalating challenges of climate change, the Danube Floodplain and Delta region has embarked on a visionary and transformative journey guided by a strategic masterplan (Lupu et al., 2022). This initiative seeks to rejuvenate and adapt the region's cities to confront the critical objectives of reducing greenhouse gas (GHG) emissions and effectively storing carbon in organic soils (Rocha et al., 2009). At the forefront of this endeavour stands Edaphic-Bloom Danube (EBD, EU project initiative "Edaphic-Bloom Danube" from 2020 to 2023; Edaphic-Bloom Danube, 2023), originally conceived to document the value derived from restoration initiatives (Mitsch and Gosselink 2015). Now evolved into a sophisticated Nature-based Regional Ecometry, this project emerges as a pivotal tool for the capture of soil organic carbon and the mitigation of greenhouse gas potentials.

Employing a cloud-based innovation and scientific methodology, EBD meticulously captures the comprehensive impact of restoration projects, integrating dimensions across the environmental, social, and economic spectra. This masterplan extends beyond governmental and regional realms, playing a pivotal role in shaping policy by actively engaging public sector stakeholders. EBD's transformative journey is grounded in a commitment to quantify and monetize the multifaceted benefits of nature-based solutions (NBS) and Biodynamic and Regenerative Agriculture (BRA) (Edaphic Bloom Danube Project, 2023).

Recognizing the imperative case for investing in NBS and BRA to mitigate GHGs and capture soil organic carbon amidst the climate change crisis, private companies and forward-thinking communities are embracing a perspective that views nature-based solutions as integral components of sustainability initiatives (Gumbricht et al., 2017). Such solutions are identified for their ability to yield superior environmental, financial, and social returns compared to conventional "grey infrastructure" projects (Nichersu et al., 2023).

Crucially, these proposals resonate with external stakeholders who grasp the direct link between environmental health and economic profits. EBD contends that truly sustainable solutions must deliver environmental, economic, and social benefits in tandem (Schlesinger and Bernhardt, 2013). The articulation of profitability in economic terms not only quantifies associated benefits but also underscores the integrated value that NBS bring to multiple stakeholders.

EBD emerges as a unique proponent of this integrated value, offering a three-dimensional analysis encompassing environmental, social, and economic considerations (Jungkunst et al., 2012). Beyond traditional cost/benefit analyses, EBD's evaluations incorporate offsets such as carbon, nitrogen, phosphorus, and water, providing a comprehensive understanding for a sustainable development in the wetland delta region driven by nutrient source availability (Keller and Medvedeff, 2016). Moreover, EBD's commitment extends to creating a globally accepted standard for minimizing the total GHG impact, involving both internal and external stakeholders through a Social Value Impact assessed by a framework of Key Performance Indicators.

This article seeks to delve into the strategic orientation and future-focused principles of EBD, emphasizing the significance of stakeholder involvement, risk management, and the creation of a global coalition. These principles, aligned with international standards and premises like Carbon Neutral 2050, foster integrated value creation, offering continuous reporting to both internal and external stakeholders (Bouckaert et al., International Energy Agency, IEA, 2021; see also Deloitte, 2015; Minerbo and Brito, 2022). In this pursuit, EBD plays a pivotal role in shaping a sustainable development cluster that unites regulators, investors, companies, standards agencies, economists, and non-governmental organizations worldwide.

Amidst this transformative landscape, wetlands emerge as crucial components of the biosphere, surpassing their external appearances. Unmanaged wetlands, identified as hotspots of biological diversity, ecosystem productivity, and economic activity, play key roles in regulating biogeochemical cycles, coastal erosion, and land stabilization (Junk et al., 2013). This study aims to explore the biogeochemical processes involved in carbon storage in wetlands and their contribution to greenhouse gas reduction, addressing fundamental questions about the effectiveness, ultimate effects, and viability of carbon sequestration in these vital ecosystems (Verhoeven and Setter, 2010; Becker et al., 2023).

Developing the masterplan for nature-based regional ecometry in the Lower Danube

Floodplains and Danube Delta encompasses five broader topics identifying "Sustainable Development" in the Lower Danube and Danube Delta. In this study sustainable development is understood as an holistic approach that seeks to balance between economic, social, and environmental considerations to promote long-term well-being for current and future generations in the Danube wetland area. The main topics of Economics and regional development, Economic sectors, Public policy issues, Energy policies, and Biosphere and carbon sequestration are all interconnected aspects of sustainable development, as they involve economic growth, resource management, environmental protection, and public policy considerations.

2 Methodologies

For developing the EBD masterplan aimed at Greenhouse Gas Mitigation in the Danube Delta, the following five broad aspects addressing economic analysis and policymaking were employed.

2.1 ECONOMETRICS AND REGIONAL DEVELOPMENT

1. Regional Econometric Models:

- Comprehensive econometric models were developed for specific regions. These models intricately incorporated variables such as industrial output, land use patterns, demographic shifts, and environmental factors. The objective was to predict and analyse the multifaceted economic impact of proposed sustainable practices, providing a nuanced understanding of regional dynamics.

2. Wetland Restoration Assessment:

- Advanced satellite monitoring techniques were deployed to assess the potential of wetland restoration as a robust carbon offsetting strategy. This involved a meticulous analysis of land use changes, carbon sequestration capacities, and biodiversity impacts. Strategies were developed that optimized wetland ecosystems for enhanced carbon capture, while also ensuring the preservation of biodiversity and ecosystem services.

3. Carbon Capture and Storage:

- A comprehensive investigation into various carbon capture methods, including storage, utilization, and removal, was conducted. The feasibility of implementing of Carbon Capture and Storage technologies in both industrial and energy sectors was evaluated, considering economic viability, environmental impact, and scalability. This involved exploring innovative approaches to carbon capture and assessing their potential integration into existing infrastructures.

2.2 ECONOMIC SECTORS

1. Sustainable Agriculture Practices:

- Close collaboration was established with local farmers to promote sustainable agriculture practices. This included advocating for the adoption of organic and regenerative farming techniques, evaluating the economic benefits for farmers, and conducting life cycle assessments to measure the reduction in carbon footprint associated with these sustainable practices.

2. Circular Business Models:

- Industries were engaged to foster the adoption of circular business models. This process involved not only encouraging sustainable production practices but also implementing strategies for waste reduction and efficient recycling.
- The economic feasibility of circular approaches was assessed, taking into account both short-term gains and long-term sustainability. Policies were developed to support their widespread implementation.

3. Resource Efficiency:

- A thorough analysis of resource efficiency was undertaken across diverse economic sectors.
- Areas for improvement in resource use, energy consumption, and waste generation were identified. Proposals for policies, incentives, and educational programs were made to businesses to enhance resource efficiency, promoting a more sustainable and responsible use of resources.

2.3 PUBLIC POLICY ISSUES

1. Clean Technology Research and Development:

- Increased public investment in research and development for clean technologies was advocated. Collaboration was established with research institutions and industries to facilitate technology transfer, ensuring that cutting-edge innovations contributed to sustainability goals.
- Policies were developed to incentivize private sector involvement in sustainable technology development.

2. Tax Policies for Sustainability:

- Collaboration with policymakers was undertaken to design tax policies that effectively encouraged sustainable practices. Innovative tax incentives for businesses adopting eco-friendly practices were explored, considering the broader economic and environmental impact.
- Thorough economic modelling was conducted to predict the outcomes of proposed tax reforms on carbon emissions and environmental conservation.

3. Spatial Policies:

- Extensive collaboration with urban and rural planning authorities was carried out to formulate spatial policies that created synergies between different territories. This included advocating for and implementing the development of green spaces, renewable energy projects, and sustainable infrastructure.
- Challenges related to land-use conflicts, urban sprawl, and regional planning were addressed to create a more sustainable and harmonized spatial environment.

2.4 ENERGY POLICIES

1. Renewable Energy Development:

- The development of renewable energy sources and technologies was facilitated, with a focus on the economic and environmental impact of integrating more renewable energy into the grid. Collaboration with stakeholders led to the creation of policies supporting decentralized energy systems, promoting energy resilience and sustainability.

2. Rural Solar Energy Hubs:

- The potential of rural areas as hubs for solar energy production was explored. Engagement with local communities was undertaken to establish solar energy projects.
- Challenges related to energy storage, distribution, and accessibility in rural regions were addressed, and comprehensive strategies were developed to maximize the economic benefits of these initiatives.

3. Energy Efficiency in Buildings:

- Efforts were focused on enhancing energy efficiency in both new and existing buildings. This included advocating for carbon-neutral building practices, promoting advanced heating and cooling technologies, and encouraging the adoption of sustainable building materials.
- Training programs for construction industry professionals were invested in, ensuring the widespread adoption of energy-efficient practices.

4. Fossil Fuel Transition:

- Strategies for a phased transition away from the use, import, and production of fossil fuels were developed.
- Opportunities for transitioning to greener and more sustainable energy sources were explored, taking into account the economic

implications and challenges of the fossil fuel phase-out.
- Consideration was given to the potential for job creation and economic growth within the green and renewable energy market.

2.5 BIOSPHERE AND CARBON SEQUESTRATION

1. Wetland Conservation and Carbon Sequestration:
- A significant emphasis was placed on wetland conservation efforts to enhance carbon sequestration capabilities. Field campaigns were organised to assess the climate change impact on carbon sequestration in soils in the Lower Danube Floodplains & Danube Delta (Figure 1)
- Collaboration with environmental organizations led to the implementation of measures for maintaining and restoring wetland ecosystems. Innovative economic incentives for wetland preservation were developed, recognizing their indispensable role in biodiversity conservation and climate change mitigation. This included the creation of conservation programs and financial mechanisms aimed at incentivizing local and regional stakeholders to prioritize wetland conservation.
- Further efforts were made to integrate wetland conservation into broader environmental policies, ensuring a sustainable approach that acknowledged the critical function of wetlands in carbon cycling and habitat protection.

2. Ecosystem Management:
- Adaptive ecosystem management approaches were supported, with extensive scientific studies conducted to unravel the complex interactions within the biosphere.
- Key intervention areas were identified to maintain ecological balance and biodiversity. Policies were developed that aligned economic activities with sustainable ecosystem management, advocating for long-term environmental health. These policies focused on balancing human needs with ecological sustainability, promoting practices that ensured the resilience and diversity of ecosystems.
- Special attention was given to vulnerable species and habitats, with strategies implemented to mitigate the impacts of climate change and human activity on these ecosystems.
- Collaborative efforts with various stakeholders, including government agencies, private sector entities, and local communities, were essential in fostering a holistic approach to ecosystem management.

3 Results

The study conducted in the Lower Danube Floodplains and Danube Delta employed socio-anthropological surveys and tailored methodologies, unveiling a complex interplay between local communities, environmental management, and economic factors. It revealed that stakeholder involvement in risk management was crucial, identifying a network of interactions among various local, regional, and national entities, and their impact on issues like flood risk and land use.

In collecting empirical data, the study meticulously examined viewpoints from diverse groups, including local representatives, NGOs, and governmental bodies, offering a rich tapestry of attitudes and practices concerning environmental management. This aspect of the study was pivotal in understanding the multifaceted nature of environmental perspectives within these communities.

The analysis of both formal and informal institutions provided insight into the complexities of management structures in the region. This exploration helped in understanding the official regulations and the unregistered, yet influential, informal practices that shape environmental management (**Fehler! Verweisquelle konnte nicht gefunden werden.**).

The development of the Integrated System-Cluster for Management was a significant step

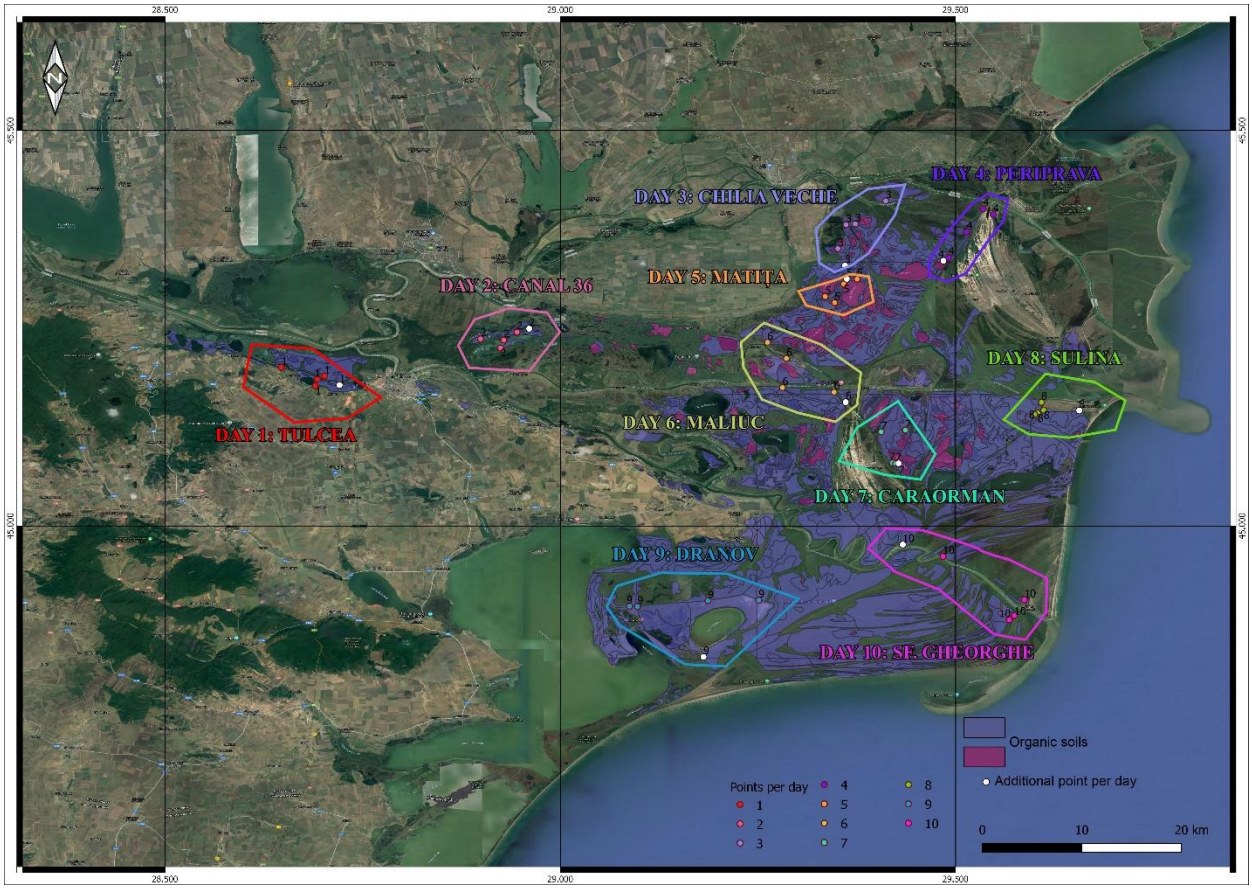

Figure 1: Map depicting July 2021 field campaign organised to assess the climate change impact on carbon sequestration in soils in the Danube Delta region.

towards improving practices in organic soil protection, carbon sequestration, and sustainable agriculture. This system focused on expanding research capabilities, enhancing regional risk assessments, and developing participatory approaches at the community level.

Conflicts regarding access to natural resources were identified as a key issue, highlighting disputes over land use and resource privatization. The study also shed light on the social dynamics at play, revealing conflicts between different groups and their economic and social implications (**Fehler! Verweisquelle konnte nicht gefunden werden.**).

Community dissatisfaction was another critical finding, with local populations expressing concerns over their exclusion from accessing natural resources. This aspect of the study emphasized the socio-economic challenges faced by these communities, bringing to the forefront issues of equity and access.

A conceptual model for environmental management was developed, incorporating principles of environmental protection, equity, economic prosperity, and motivation for eco-efficiency. This model offered a holistic view of the challenges and potential solutions for managing the region's environmental resources.

The identification of key stakeholders and relevant legislation provided a comprehensive overview of the environmental management framework in the region. This aspect of the study was instrumental in outlining the policy and legislative context within which environmental management operates.

Overall, the study's findings provide a detailed and nuanced understanding of the socio-

environmental dynamics in the Danube Delta and Meadow, forming a solid base for future decision-making and sustainable development strategies.

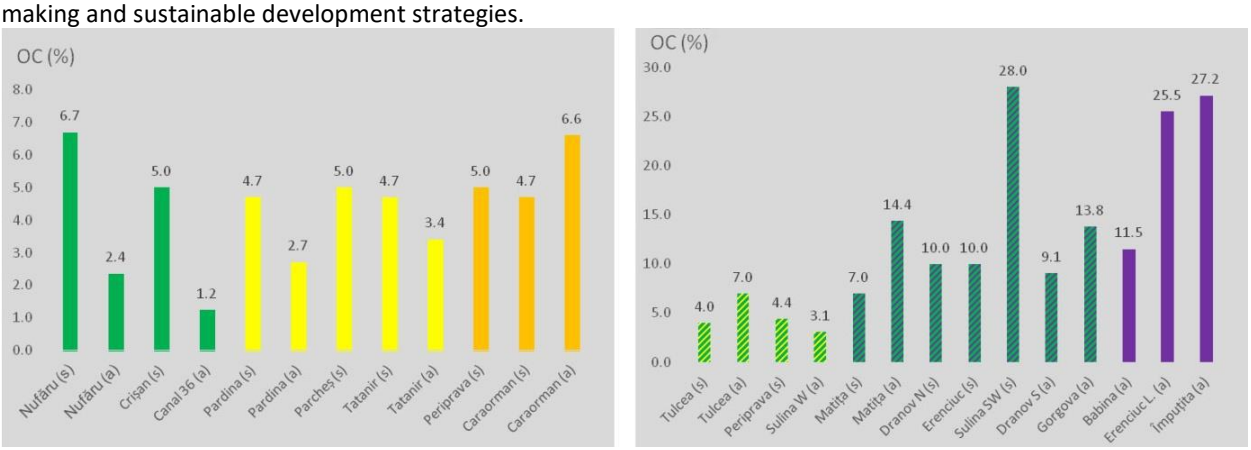

Figure 2: Organic Carbon concentration in the 10 cm surface layer of various soil types sampled in Danube Delta (source: Livanov et al., 2023).

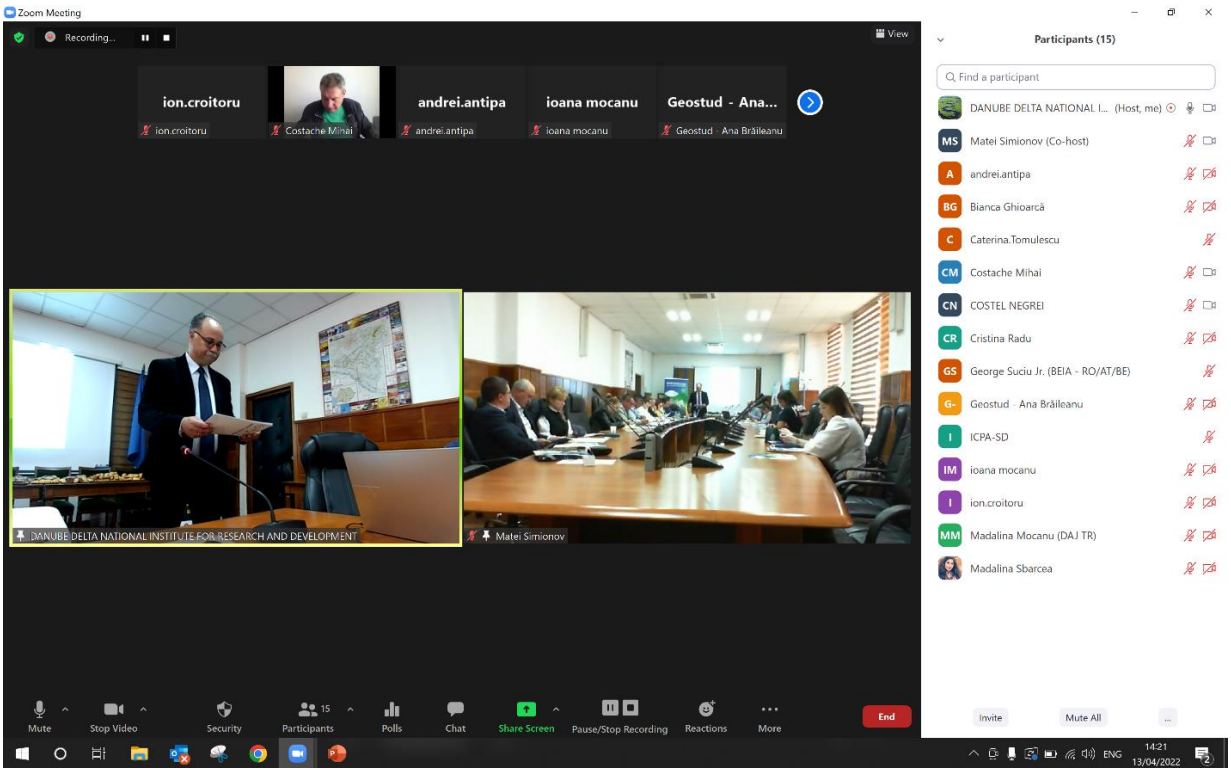

Figure 3: Screen capture from hybrid stakeholder engagement meeting organised in April 2022 in Giurgiu, Romania as part of Edaphic-Bloom Danube project activities.

3 Discussion

The study's extensive exploration into socio-anthropological surveys, stakeholder engagement, and local dynamics lays a solid foundation for addressing challenges in decarbonization. It offers a nuanced discussion on the strategic considerations vital for managing complex socio-ecological systems,

emphasizing the need for integrated policies that merge social and ecological elements. This holistic approach is crucial for aligning strategies with the reality of socio-ecological dynamics as it is also emphasized by other researchers (Söderlund and Newman, 2022; Geels et al., 2017). The study's examination of landscape anthropization provided valuable insights into how changes in land use and privatization were transforming the economic and environmental landscape. This analysis was crucial in understanding the impact of human activities on the region's natural ecosystem (Balaican et al., 2023).

The outline underscores the importance of developing advanced technologies like carbon capture and renewable energy for effective carbon emission reduction, highlighting a commitment to leveraging technology for environmental stewardship. Involving local communities and stakeholders in decision-making is identified as key, fostering a sense of ownership and responsibility, and recognizing the importance of local knowledge in sustainability efforts. This holistic approach is crucial for aligning strategies with the reality of socio-ecological dynamics, as supported by other researchers (Bistline and Blanford, 2021).

Raising public awareness is deemed essential for driving change, aiming to embed an understanding of socio-ecological connectivity and the importance of carbon emission reduction in the collective consciousness. The study stresses the need for international cooperation, acknowledging that global challenges require collaborative solutions, as exemplified by agreements like the Paris Agreement (2015).

The study also presents pragmatic scenarios for wetland utilization, showcasing their potential in decarbonization and promoting eco-friendly tourism as both environmentally beneficial and economically valuable for local communities.

4 Conclusions

Biodynamic agriculture, focusing on dematerialization and information intensification, offers a transformative approach to agricultural practices. It emphasizes knowledge over material inputs, aligning farming with natural rhythms and cycles. This method employs a heuristic, experiential learning process, deeply integrated with nature's biological and sidereal rhythms, making it a dynamic and responsive approach to agriculture. This personalized form of agriculture requires tailoring to specific spatial and temporal conditions, ensuring a close interaction between human activity and natural processes. The shift towards biodynamic methods necessitates a rethinking of agricultural goals, moving from a focus on private profit to a broader perspective that values social profit and environmental sustainability.

Integrating biodynamic agriculture into diverse food production models, especially in ecologically sensitive areas like the Lower Danube Floodplains and Danube Delta, is crucial. This integration should prioritize ecological and social vulnerabilities, making it an environmentally sensitive and socially beneficial approach.

For enhancing food security, biodynamic agriculture should capitalize on land resources more effectively, reducing reliance on intensive material and energy inputs. This approach requires increased investment not only in financial terms but also in knowledge and skills development. Such investments would lead to a more sustainable, efficient, and environmentally responsible food production system, contributing to a more secure and resilient food system.

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