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SECOND INTERNATIONAL SCIENTIFIC AGRI-BUSINESS CONFERENCE

PROCEEDINGS

Local Resources and Global Challenges: Integrated Approaches to Sustainable Rural Development in the Era of Climate Change

Editor: Dragan Cvetkovic

Kumanovo, 02-04 April 2026

SECOND INTERNATIONAL SCIENTIFIC AGRI-BUSINESS CONFERENCE
"AGRO MAK 2026"

”LOCAL RESOURCES AND GLOBAL CHALLENGES: INTEGRATED APPROACHES TO SUSTAINABLE RURAL DEVELOPMENT IN THE ERA OF CLIMATE CHANGE”

ВТОРА МЕЃУНАРОДНА НАУЧНО АГРО-БИЗНИС КОНФЕРЕНЦИЈА „АГРО МАК 2026“

„ЛОКАЛНИ РЕСУРСИ И ГЛОБАЛНИ ПРЕДИЗВИЦИ: ИНТЕГРИРАНИ ПРИСТАПИ КОН ОДРЖЛИВ РУРАЛЕН РАЗВОЈ ВО ЕРАТА НА КЛИМАТСКИТЕ ПРОМЕНИ“

PROCEEDINGS
ЗБОРНИК НА ТРУДОВИ

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ПРЕДГОВОР

Со особено задоволство и чувство на професионална одговорност го претставуваме овој **Зборник на научни трудови** од **Втората меѓународна научна агро-бизнис конференција AGROMAK 2026**, одржана во Куманово во периодот од 02 до 04 април 2026 година.

Конференцијата AGROMAK 2026 претставува значајна научна и стручна платформа која ги обединува академската заедница, научноистражувачките институции, носителите на јавни политики, претставниците на бизнис секторот, како и експертите од областа на земјоделството, руралниот развој и агро-бизнисот. Основната цел на оваа конференција е да поттикне интердисциплинарен дијалог, размена на научни сознанија и добри практики, како и создавање нови можности за соработка помеѓу науката, институциите и стопанството.

Во услови на динамични економски, технолошки и климатски промени, современото земјоделство и агро-бизнисот се соочуваат со бројни предизвици, но и со значајни развојни можности. Токму затоа, научните истражувања и иновациите претставуваат клучен фактор за унапредување на конкурентноста на земјоделското производство, одржливото управување со природните ресурси, развојот на руралните заедници и подобрувањето на квалитетот на живот во овие средини.

Во овој зборник се содржани научни и стручни трудови од автори од повеќе земји, кои преку своите истражувања и анализи придонесуваат кон подобро разбирање на современите трендови во агро-бизнисот, одржливото земјоделство, руралниот туризам, климатските предизвици, иновациите и развојните политики. Трудовите опфатени во зборникот се резултат на научна работа, практични искуства и институционални перспективи, што му дава на овој зборник значајна научна и применлива вредност.

Како уредник на овој зборник, изразувам искрена благодарност до сите автори за нивниот научен придонес, до членовите на Научниот и Организацискиот одбор за нивната посветеност и професионална поддршка, како и до сите институции и партнери кои го поддржаа организирањето на конференцијата AGROMAK 2026.

Се надеваме дека трудовите објавени во овој зборник ќе претставуваат значаен придонес кон понатамошниот развој на научната мисла и практичните решенија во областа на агро-бизнисот, како и поттик за нови истражувања, партнерства и иницијативи во насока на одржлив развој на земјоделството и руралните заедници.

Со почит,

Уредник:
Драган Цветковиќ
AGROMAK 2026

Куманово, 02-04. Април 2026 год.

FOREWORD

It is with great pleasure and a strong sense of professional responsibility that we present this **Proceedings of Scientific Papers** from the **Second International Scientific Agri-Business Conference AGROMAK 2026**, held in Kumanovo from **April 2 to April 4, 2026**.

The AGROMAK 2026 conference represents an important scientific and professional platform that brings together the academic community, research institutions, policy makers, representatives of the business sector, and experts in the fields of agriculture, rural development, and agribusiness. The main objective of the conference is to encourage interdisciplinary dialogue, the exchange of scientific knowledge and best practices, and the creation of new opportunities for cooperation between science, institutions, and the business community.

In a time of dynamic economic, technological, and climate changes, modern agriculture and agribusiness face numerous challenges, but also significant development opportunities. Therefore, scientific research and innovation represent key factors for improving the competitiveness of agricultural production, ensuring sustainable management of natural resources, supporting the development of rural communities, and enhancing the quality of life in these areas.

This proceedings volume contains scientific and professional papers authored by researchers and experts from several countries, who through their studies and analyses contribute to a better understanding of contemporary trends in agribusiness, sustainable agriculture, rural tourism, climate challenges, innovation, and development policies. The papers included in this volume are the result of scientific research, practical experience, and institutional perspectives, giving this publication significant scientific and practical value.

As the editor of this proceedings volume, I would like to express my sincere gratitude to all authors for their valuable scientific contributions, to the members of the Scientific and Organizing Committees for their dedication and professional support, as well as to all institutions and partners who supported the organization of the AGROMAK 2026 conference.

We hope that the papers published in this proceedings volume will represent a valuable contribution to the further development of scientific thought and practical solutions in the field of agribusiness, and will serve as an incentive for new research, partnerships, and initiatives aimed at the sustainable development of agriculture and rural communities.

Respectfully,

Editor:
Dragan Cvetković
AGROMAK 2026

Kumanovo, 02-04. April 2026

C O N T E N T S

INVITED SPEAKERS

PLENARY PRESENTATIONS

ORGANIC WASTE MANAGEMENT AS AN OPPORTUNITY FOR SUSTAINABLE RURAL TOURISM DEVELOPMENT

УПРАВЉАЊЕ ОРГАНСКИМ ОТПАДОМ КАО МОГУЋНОСТ ЗА ОДРЖИВИ РАЗВОЈ РУРАЛНОГ ТУРИЗМА

Marina Radović Jakovljević, Science Associate and Lecturer [22]
Sara Stanić Jovanović, Science Associate and Lecturer [23]
Milica Đeković Šević, Professor of Aplied Studies [26]

Abstract: *Organic waste in rural areas represents both a challenge and a potential resource for sustainable management. This review analyzes composting and anaerobic digestion, describing their phases, key success factors, and implementation challenges. Emphasis is placed on proper process management and community education to improve agriculture and environmental protection. In the context of rural tourism development, proper bio-waste management can contribute to environmental conservation and the improvement of the local economy by strengthening authentic tourism offerings of the local community. By integrating this practice into the local tourism offering through the concept of a circular economy, waste is transformed into resources, thereby reducing the negative impact on the environment and creating added value for the local community through the production of organic food, energy and educational content for visitors. Rural tourism based on the principles of sustainability is increasingly attracting modern tourist demand, which strives for an environmentally responsible experience.*

Key words: *organic waste, rural tourism*

Апстракт: *Органски отпад у руралним подручјима представља и изазов и потенцијални ресурс за одрживо управљање. Овај преглед анализира компостирање и анаеробну дигестију, описујући њихове фазе, кључне факторе успеха и изазове у имплементацији. Нагласак је стављен на правилно управљање процесом и едукацију заједнице ради унапређења пољопривреде и заштите животне средине. У контексту развоја руралног, односно сеоског туризма, правилно управљање биоотпадом може допринети очувању животне средине али и унапређењу локалне економије кроз јачање аутентичне туристичке понуде локалне заједнице. Интеграцијом ове праксе у локалну туристичку понуду кроз концепт циркуларне економије, на овај начин се отпад претвара у ресурс, чиме се смањује негативан утицај на животну средину и ствара додатна вредност за локалне заједнице кроз производњу органске хране, енергије и едукативних садржаја за посетиоце. Рурални туризам заснован на принципима одрживости све више привлачи савремену туристичку тражњу, која тежи еколошки одговорном искуству.*

Кључне речи: *органски отпад, рурални туризам*

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1. INTRODUCTION

Rural tourism has emerged as an important avenue for the development of countryside communities, particularly in regions experiencing population decline and limited employment opportunities (Lane, 2009; UNWTO, 2020). This form of tourism helps preserve local traditions, cultural heritage, and natural landscapes, while also contributing to income diversification and strengthening the resilience of rural communities (Patwa et al., 2020).
As tourism activities increase, so does the generation of waste, with organic waste constituting a significant portion in rural destinations (Hoornweg and Bhada-Tata, 2012). Improper management of this waste can lead to soil and water pollution, methane emissions, and unpleasant odors, reducing both the attractiveness of the destination and the quality of life for local residents (Patwa et al., 2020).

Organic waste, however, can also be viewed as a valuable resource that can be reused through processes such as composting and anaerobic digestion (Font and McCabe, 2017; Sgroi et al., 2020). These practices convert waste into compost, bioenergy, or biofertilizers, supporting the principles of circular economy and sustainable resource use. In rural settings, where agriculture is often closely linked to tourism, such practices enable the creation of closed-loop systems that minimize environmental impact while providing additional economic benefits to local households (Waste Framework Directive, 2008/98/EC).

Because of all this, the management of bio-waste becomes crucial for the preservation of natural resources and the quality of the tourist offer. Namely, in this way a direct link is established between tourism and the concept of circular economy, where tourist activities do not burden the environment, but actively participate in its preservation (Geissdoerfer at al., 2017).

Linking rural tourism and organic waste management enables the creation of unique, authentic and ecologically responsible local tourist products, which can meet modern tourist demand. Tourists are increasingly looking for destinations that implement sustainable practices, which makes the proper management of biowaste not only an environmental obligation, but also an important factor in the competitiveness and long-term development of rural areas (UNEP, 2019).

2. ORGANIC WASTE MANAGEMENT IN RURAL AREAS

In rural areas, municipal solid waste differs significantly from urban waste, as organic waste constitutes more than half of the total waste generated, while the remainder is largely inorganic, and the fraction of hazardous waste is minimal (Patwa et al., 2020). This waste composition sets specific requirements for collection and treatment, as inadequate systems often lead to informal disposal at improvised dumpsites or open burning of waste. Such practices contribute to soil degradation, water pollution, and pose risks to the health of local populations (Novarlić, Stević, 2024).

Due to these challenges, organic waste management in rural areas increasingly relies on local and decentralized approaches, which are more flexible and better suited to village conditions than the centralized systems typical of urban regions (Novarlić, Stević, 2024). These approaches may include local collection initiatives, communal disposal points, and small-

scale treatment systems that divert organic matter from unmanaged dumpsites and prepare it for further processing or valorization (Vinti, Vaccari, 2022; Novarlić, Stević, 2024). The implementation of these local and decentralized models enables communities to reduce the amount of waste ending up in informal dumpsites, organize waste flows at the local level, and establish a framework for sustainable practices in line with circular economy principles. Such approaches support the reuse and valorization of organic waste, thereby reducing environmental impacts while contributing to more efficient resource use in rural areas (Vinti, Vaccari, 2022).

This approach highlights the importance of active community participation in waste management, as decentralized systems provide greater flexibility, easier adaptation to local needs, and the potential for long-term sustainability and ecological resilience in rural areas (Novarlić, Stević, 2024). Considering the high proportion of organic waste in rural areas, techniques such as composting and anaerobic digestion represent essential methods for its valorization and efficient management, thereby supporting sustainable waste treatment.

3. COMPOSTING OF ORGANIC WASTE: PROCESS AND SIGNIFICANCE

Composting is a biological process in which microorganisms decompose organic matter into a humus-like material known as compost (Meena et al., 2021). This process serves a dual purpose: it addresses the problem of organic waste and produces a value-added product-compost, a nutrient-rich fertilizer that improves soil health. In rural areas, composting provides a practical solution to manage locally generated organic waste, contributing to nutrient recycling and sustainable agriculture.

The composting process can be categorized into several microbiologically distinct phases, each characterized by specific temperature ranges and dominant microbial communities. Under optimal aerobic conditions, composting typically progresses through four main stages: mesophilic, thermophilic, cooling, and maturation (curing). During the mesophilic phase, mesophilic microorganisms dominate and initiate the decomposition of readily degradable organic compounds, producing heat that raises the temperature of the composting mass (Azim et al., 2018).

As the temperature increases to the thermophilic range (generally above 45 °C), thermophilic microbes take over, accelerating the breakdown of more complex organic matter and contributing to pathogen reduction (Zhang et al., 2023). When easily degradable substrates are depleted and heat generation decreases, the compost temperature gradually drops, marking the cooling phase, during which mesophilic organisms become active again. The final maturation (curing) phase occurs at lower temperatures, in which the compost stabilizes, humification continues, and the material becomes suitable for soil application (Azim et al., 2018; Zhang et al., 2023).

3.1 Historical overview and application

Since the late 1980s, composting has increasingly been applied in Europe, alongside the development of separate collection systems for bio-waste. Only through such approaches is it possible to obtain compost of satisfactory quality, free from harmful contaminants such as heavy metals, suitable for agriculture and soil quality improvement. The majority of bio-

waste is treated through aerobic conversion, while anaerobic conversion is still applied to a limited extent due to high investment costs and the need to treat waste together with wastewater. Estimates indicate that approximately 40 % of municipal solid waste in Serbia consists of biological (organic) materials, including garden waste and food residues, providing a significant potential for composting (Ministry of Environmental Protection, 2022). This historical perspective highlights how policy, infrastructure, and public awareness have influenced the development and adoption of composting practices in Europe and Serbia.

3.2 Public awareness and global initiatives

Raising public awareness about composting and its environmental benefits is a key component of sustainable organic waste management strategies worldwide. Educational campaigns and initiatives have been shown to increase participation in composting programs, improve environmental literacy, and promote sustainable behaviors among communities (De Boni et al., 2022; Craveiro et al., 2025). One of the most prominent initiatives is International Compost Awareness Week (ICAW), first launched in Canada in 1995 by the Compost Council of Canada, now celebrated annually during the first full week of May. The aim of this week is to educate the public about the benefits of composting, including improving soil structure, enhancing water retention, increasing plant resilience, and reducing the use of synthetic fertilizers and pesticides (Compost Foundation, 2025).

In addition to campaigns like ICAW, scientific studies on community composting and educational programs have shown that active community engagement and educational support significantly increase the success of composting initiatives, thereby contributing to sustainable organic waste management (De Boni et al., 2022). Furthermore, the application of compost to soil has been scientifically proven to improve soil quality, enhance nutrient availability, and support water conservation, confirming multiple environmental benefits of integrating composting into waste management strategies (Craveiro et al., 2025). In rural areas, these initiatives not only support sustainable agriculture but also strengthen community involvement and environmental education, creating long-term benefits for local populations.

3.3 Factors affecting the composting process

Composting is influenced by several external factors that determine the rate and efficiency of organic matter decomposition. Proper management of these factors can significantly accelerate decomposition and improve compost quality. The most important parameters include: oxygen availability (aeration), temperature, pH, moisture content, and the carbon-to-nitrogen (C:N) ratio of the material.

Aeration provides microorganisms with oxygen, preventing anaerobic conditions that can generate unpleasant odors. Temperature affects microbial activity and decomposition rate. Optimal pH and moisture support efficient microbial metabolism, while the C:N ratio ensures a proper balance of nutrients and energy during composting. Monitoring these factors is particularly important in small-scale or rural composting systems to ensure efficiency and quality of the final product (Sharma et al., 2021). Maintaining optimal parameters ensures a faster process, higher nutrient retention, and pathogen reduction, making the compost safe and effective for agricultural use.

3.4 Composting challenges and their connection to rural areas

Despite its benefits, composting faces operational challenges that can affect both the quality of the resulting compost and process efficiency. Common issues include:
Odors-Poor ventilation, excessive moisture, or inadequate aeration can generate unpleasant smells, affecting workers and nearby residents (Ayilara et al., 2020).

Pathogen control- Organic waste may contain harmful microorganisms. If the thermophilic phase is insufficient, pathogens may survive, posing a health risk (Ayilara et al., 2020). Heavy metal contamination- Certain waste streams may contain metals like lead, cadmium, or arsenic. Accumulation in compost can limit its agricultural use (Awasthi et al., 2019). Quality standardization- Maintaining the correct balance of nutrients, C:N ratio, moisture, and other parameters is critical for producing stable, safe, and effective compost (Ayilara et al., 2020).

In rural settings, composting allows communities to convert local organic materials, such as agricultural residues and household waste, into nutrient-rich fertilizer. Proper monitoring, process control, and community education are essential to overcome challenges and ensure safe, high-quality compost, supporting sustainable agriculture and soil conservation (Awasthi et al., 2019; Ayilara et al., 2020). Overall, integrating composting with education and community participation ensures both environmental benefits and long-term sustainability in rural areas.

4. ANAEROBIC DIGESTION OF ORGANIC WASTE: PROCESS AND SIGNIFICANCE

Anaerobic digestion of organic waste is a sequential, multi-step biological process in which different microbial communities break down organic matter in the absence of oxygen, producing biogas-mainly methane and carbon dioxide and nutrient-rich digestate (Cao et al., 2025; Song et al., 2026). It is widely applied for the treatment of municipal organic waste, agricultural residues, livestock manure, and industrial food by-products. Unlike aerobic composting, anaerobic digestion provides both renewable energy and stabilized organic material, contributing to resource recovery and climate mitigation.

The anaerobic digestion process can be divided into four main stages, each with distinct microbial activity and biochemical transformations, as widely described in scientific literature (Mata-Alvarez et al., 2014; Chen et al., 2021):
Hydrolysis-Complex polymers such as carbohydrates, proteins, and lipids are broken down into soluble monomers (sugars, amino acids, fatty acids) by hydrolytic bacteria (Chen et al., 2021).
Acidogenesis-Fermentative bacteria convert soluble monomers into volatile fatty acids, alcohols, hydrogen, and carbon dioxide (Mata-Alvarez et al., 2014).
Acetogenesis-Acidogenic products are transformed into acetic acid, hydrogen, and carbon dioxide, which serve as substrates for methanogenic archaea (Chen et al., 2021).
Methanogenesis-Methanogenic microorganisms produce methane and carbon dioxide, completing the energy conversion process and stabilizing the digestate (Mata-Alvarez et al., 2014).

Proper control of temperature, pH, nutrient balance, and retention time is essential to optimize biogas yield, stabilize digestate, and maintain efficient microbial activity. Mesophilic (30-40 °C) and thermophilic (50-60 °C) operating conditions can significantly affect microbial community structure, reaction kinetics, and biogas composition (Chen et al., 2021).

4.1 Benefits and application in rural areas

In rural communities, anaerobic digestion of organic waste offers an effective solution for managing organic residues while producing local renewable energy. Biogas can be used for cooking, heating, or electricity generation, reducing dependence on fossil fuels. Digestate serves as a high-quality biofertilizer, improving soil fertility and supporting sustainable agriculture (Cao et al., 2025).

Small- to medium-scale anaerobic digestion systems are particularly suitable for farms and rural households, where organic residues are abundant and energy needs are localized. Training and education are critical to ensure stable operation, optimize biogas production, and safely apply digestate as fertilizer. Integration of anaerobic digestion into rural waste management allows communities to achieve energy self-sufficiency, reduce environmental pollution, and reinforce circular economy principles (Mata-Alvarez et al., 2014; Song et al., 2026).

5. THE IMPORTANCE OF ORGANIC WASTE MANAGEMENT IN RURAL TOURISM

Rural tourism differs from mass tourism in that it focuses on the quality of experience and sustainability rather than the quantity of visitors. Rural tourism encompasses a wide range of activities, including rural accommodation, agro-tourism, participation in agricultural work and visits to local artisans and cultural events (Jovanović, 2018). The sustainable development of rural tourism has become an important topic in contemporary research in recent years, especially in the context of rational resource management and environmental conservation of local communities. Interest in the development of rural or village tourism has grown in the years following the corona virus pandemic.

A review of the literature on the importance of organic waste management in rural tourism indicates a growing connection between sustainable development, environmental protection and the tourist competitiveness of rural destinations. The concept of sustainable tourism is based on the principle that it "satisfies the needs of current generations without endangering future ones", while including ecological, economic and social dimensions (WCED, 1987). In this framework, rural tourism is seen as an important instrument for revitalizing villages, preserving natural resources and strengthening the local economy, but also as an activity that can cause negative consequences if it is not managed adequately. (Stanić, Jovanović, 2016). It is particularly emphasized that waste management is one of the key factors in the development of tourist destinations, because inadequate disposal of waste leads to environmental degradation and a decrease in the quality of the tourist experience (UNWTO, 2018).

Contemporary research further emphasizes the importance of the circular economy in rural areas, where organic waste can be transformed into a resource through composting and reuse

in agriculture, thus contributing to sustainability and closing production cycles (European Commission, 2020). Also, the development of organic agriculture and agritourism confirms that the preservation of soil, water and biodiversity is the basis of the long-term development of rural tourism, emphasizing the interdependence of ecosystem health and tourist offer (Stanić Jovanović, Ilić, & Miletović, 2025). Overall, the literature indicates that effective management of organic waste is not only an environmental issue, but also a strategic element of sustainable and competitive rural tourism.

6. CONCLUSION

Organic waste management in rural areas represents both a challenge and an opportunity for sustainable development of local communities. Through methods such as composting and anaerobic digestion, organic waste can be transformed into valuable resources – nutrient-rich fertilizer and renewable energy – reducing environmental impact and supporting soil and water conservation. Community education and active involvement are essential for successful implementation, while decentralized approaches enable more flexible and efficient waste management. Integrating these strategies enhances the sustainability of rural tourism and agriculture, providing economic and ecological benefits to local households.

Organic waste management represents a significant development opportunity for improving the sustainable development of rural tourism, as it connects the ecological, economic and social aspects of the development of rural areas. Through the application of practices such as composting, recycling and reuse of organic resources, it is possible to reduce the negative impact on the environment and at the same time improve local agricultural production.

In this way, a synergy is created between tourism and agriculture, which contributes to strengthening the local economy and preserving the authenticity of the local tourist destination. Sustainable waste management also affects the quality of the tourist offer and the satisfaction of visitors, who increasingly recognize and value environmentally responsible destinations. In this context, organic waste should not be seen as a problem, but as a resource and potential for the development of innovative and sustainable solutions in rural tourism. In the long term, the integration of the principles of sustainability and circular economy in waste management represents a key step towards a more competitive, resilient and environmentally friendly rural tourism.

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