

SMART VILLAGE: INTELLIGENT SOLUTIONS FOR PROMOTING LOCAL PRODUCTS AND SUPPORTING LOCAL PRODUCERS

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RESEARCH ARTICLE

Abstract

This paper proposes an innovative model for the promotion and commercialization of local products in the rural areas of the territory of GAL Crișul Negru, Bihor County, through the establishment of a digitalized agricultural cooperative that utilizes a smart container equipped with intelligent lockers and Internet of Things (IoT) systems. The concept integrates modern technology into the short supply chain, providing local producers with an autonomous, round-the-clock platform for the direct marketing of traditional agricultural products.

The project is based on the European LEADER 2023–2027 funding framework, administered through AFIR and the CAP Strategic Plan 2023–2027, while also leveraging the resources and agricultural potential identified in the Local Development Strategy of GAL Crișul Negru. The proposed solution addresses the major challenges faced by small-scale producers, including limited market access, high distribution costs, and the lack of adequate marketing and sales infrastructure.

Keywords: Smart Village, cooperativă agricolă, produse locale, lanț scurt de aprovizionare, digitalizare rurală.

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INTRODUCTION

The Romanian rural environment faces profound structural challenges: an aging population, the migration of young workers to urban areas, the fragmentation of agricultural holdings, and the lack of modern marketing infrastructure.

Local producers in the Crișul Negru area, who cultivate vegetables, fruits, traditional dairy products, honey, and other agri-food products, face a major obstacle on a daily basis: the distance from sales markets and the inability to access modern commercial distribution channels in a competitive manner. (MADR-european funds for farmers)

The Smart Village concept represents the European response to these challenges. According to the European Network for Rural Development, a Smart Village is a rural community that uses innovative digital solutions to improve its services, quality of life, and economic sustainability. (FORNEY, 2014)

Within the framework of the CAP Strategic Plan 2023–2027, Smart Village interventions are explicitly funded and constitute one of the European Union's key rural development priorities. (ROMANIA'S CAP STRATEGIC PLAN 2023–2027)

This paper proposes a concrete and replicable model for implementing the Smart Village philosophy within the territory of GAL Crișul Negru through the establishment of an automated sales point a smart container equipped with intelligent lockers organized under the legal structure of an agricultural cooperative. This initiative represents both a practical solution for the commercialization of local production and a pilot project that can be expanded to other territories in Bihor County and throughout Romania.

The Smart Village concept emerged on the European policy agenda as a response to the growing awareness of the digital and economic disparities between urban and rural areas. The European Commission Communication on the EU Rural Vision (2021) and the Smart Villages policy framework define an integrated approach that combines the use of digital technologies, the valorization of local resources, and community involvement in the development process. (REGULAMENTATION (UE) 2021/2115)

The main components of a Smart Village include the digitalization of public and private services, the creation of smart local energy networks, the implementation of precision agriculture, the promotion of cultural and natural heritage through digital tools, and most

relevant to this paper the development of intelligent systems for the marketing and sale of local products. (FORNEY, 2014)

Within Romania's CAP Strategic Plan 2023–2027, the intervention dedicated to Smart Villages is recognized as a national priority. Local Action Groups (LAGs) may incorporate Smart Village components into their Local Development Strategies, thereby gaining access to dedicated funding through the LEADER/CLLD mechanism.

MATERIAL AND METHOD

The paper is based on a mixed methods research approach, combining systematic document analysis with elements of applied research aimed at identifying concrete funding and implementation opportunities within the GAL Crișul Negru area. This methodological approach was chosen because it enables both an understanding of the normative and strategic framework governing the activity of Local Action Groups and an assessment of the practical applicability of available funding instruments for Smart Village and agricultural cooperation initiatives.

The research draws on several categories of sources, organized according to their level of normative authority and relevance to the study's objectives. The primary document analyzed was the Local Development Strategy (LDS) 2023–2027 of GAL Crișul Negru, which outlines the directions of action, eligible measures, and allocated budgets for the covered territory. (GAL CRIȘUL NEGRU – Local Development Strategy 2023–2027)

The analysis of the LDS focused on identifying measures relevant to digitalization, agricultural cooperation, and rural innovation, as well as the selection criteria applicable to projects submitted under this strategy.

Applicant guides and funding guidelines published by Agenția pentru Finanțarea Investițiilor Rurale (AFIR) were also consulted, with particular emphasis on sub-measures directly relevant to the study's objectives, especially those targeting productive investments in agricultural holdings, the modernization of agri-food processing and marketing, cooperation among actors within the food supply chain, and basic services for the rural economy and population. (AFIR guidelines for interventions) (AFIR, agricultural processing)

European regulations applicable to the 2023–2027 programming period were

analyzed, in particular Regulation (EU) 2021/2115 concerning the Strategic Plans under the Common Agricultural Policy (CAP), (EUROPEAN COMMISSION) which establishes the specific objectives of the Common Agricultural Policy, the implementation architecture through national plans, and the eligibility conditions for interventions financed through the European Agricultural Fund for Rural Development (EAFRD). In addition, relevant horizontal regulations concerning the management and control of European funds were examined.

A third category of sources included documented case studies at both European and national levels regarding the implementation of the Smart Village concept. At the European level, examples from Member States with established experience in this field such as Austria, Ireland, and Finland were analyzed, where Smart Village initiatives have demonstrated the impact of rural service digitalization, participatory governance, and local data infrastructure. At the national level, pilot projects carried out within the Rețeaua Națională de Dezvoltare Rurală, as well as best practices documented by AFIR through previous LEADER project calls, were examined. (AFIR- Atypical measures)

Finally, the research was supported by academic literature and expert reports on agricultural cooperatives and the digitalization of agri-food supply chains. This includes studies on functional cooperation models within the context of small-scale European agriculture, as well as analyses of digital technology adoption at the level of farms and interprofessional organizations topics directly relevant to potential projects that can be developed by stakeholders in the GAL Crișul Negru territory.

RESULTS AND DISCUSSIONS

The Crișul Negru Local Action Group Association is a non-governmental organization established through a public-private partnership and funded under the LEADER Programme within the National Rural Development Programme. It operates according to the principles of the LEADER approach, promoting integrated local development through the active involvement of communities within its territory. (TREGEAR, 2011)

The territory of GAL Crișul Negru includes localities in Bihor County situated within the Crișul Negru River Basin, an area characterized by a strong agricultural profile and

longstanding traditions in crop cultivation, livestock farming, and the production of traditional food products. (ATKOČIŪNIENĖ, 2025) The Local Development Strategy (LDS) 2023–2027, developed under the LEADER programming framework, identifies the promotion of local products and the development of rural entrepreneurship as central priorities for the territory. (GAL CRIȘUL NEGRU – General information regarding the implementation of the Local Development Strategy 2023–2027)

The Crișul Negru area benefits from favorable soil and climatic conditions that support a wide variety of agricultural crops. The main categories of local products with significant commercialization potential include:

- Fresh vegetables and fruits: tomatoes, peppers, cucumbers, cabbage, apples, plums, and walnuts;
- Traditional dairy products: fresh milk, cheeses, sour cream, and homemade butter;
- Meat and processed meat products: free-range poultry, pork, and traditional cured meats;
- Apicultural products: polyfloral honey, propolis, and beeswax;
- Traditional bakery and pastry products: homemade bread, sweet bread (*cozonac*), and traditional pies;
- Pickled and preserved foods: vegetable spreads (*zacuscă*), tomato paste, marmalade, and artisanal jams;
- Medicinal and aromatic plants: linden flowers, chamomile, mint, and lavender.

The paradox of the current situation lies in the fact that, although the territory possesses valuable local agricultural production and there is genuine consumer demand for authentic products, the lack of adequate marketing infrastructure results in a large proportion of these products being either consumed within households or sold under unfavorable conditions, without traceability and at prices that are unsatisfactory for producers. (ATKOČIŪNIENĖ, 2025)

The project proposes the establishment of an agricultural cooperative within the territory of GAL Crișul Negru, whose primary asset is a smart container an autonomous modular unit equipped with individual smart lockers (similar to the EasyBox system), where cooperative member producers can store and sell their agricultural products directly to end consumers, 24 hours a day, 7 days a week.

The concept, illustrated in the project presentation image (Figure 1), consists of a

local products sales point (“Local Products”) equipped with multiple refrigerated and non-refrigerated modules, aesthetically integrated beneath a wooden roof with ambient lighting and located in an accessible public space. Each module (locker) is assigned to a producer and can be managed through a dedicated mobile application. (KURNIAWATI, 2025)

Compared to traditional marketplaces or conventional cooperatives, the smart container offers several distinctive advantages: autonomous operation without permanent staff, digital product traceability, real-time monitoring of inventory and sales, secure electronic payments, and automated notifications for producers.

The project proposes the establishment of an Agricultural Cooperative in accordance with Law No. 566/2004 on Agricultural Cooperatives, with a minimum of five founding members (agricultural producers from the GAL Crișul Negru territory). (LAW NO. 566/2004 ON AGRICULTURAL COOPERATIVES) The cooperative’s statutes will specify that each member is entitled to one or more lockers, proportionate to their contribution to the cooperative’s share capital and declared production volume.

The choice of the agricultural cooperative as the legal structure (rather than a limited liability company, association, or another entity) is justified by several factors: maximum eligibility for funding through AFIR (support rates of up to 90%), democratic member control, redistribution of benefits in proportion to each member’s activity, and a legally recognized identity in dealings with public authorities and consumers. (SAHANA, 2020)

The smart container is a prefabricated modular structure with standard dimensions of 6 m × 3 m × 2.5 m (or 12 m × 3 m for the extended version), constructed from galvanized steel and thermally insulated. The container is aesthetically integrated with natural elements, including wooden cladding and a timber roof equipped with warm LED lighting, ensuring an attractive appearance and a visual identity consistent with the concept of traditional local products. (SAHANA, 2020)

The container includes several modules and compartments:

- Refrigerated modules (temperature range: +2°C to +8°C) for dairy products, meat, eggs, vegetables, and short-shelf-life fruits;

- Ambient-temperature controlled modules for preserves, honey, bakery products, and dry goods;
- Payment and interaction module featuring a touchscreen interface, card/NFC reader, and security camera;
- Technical module housing IoT equipment (router, edge servers, temperature and humidity sensors, alarm system);
- Photovoltaic panels integrated into the roof to provide partial energy autonomy. (RAMADANI & LUTFI, 2024)

Each locker measures 40 cm × 40 cm × 60 cm (W × D × H) and is equipped with an electronic lock operated through a QR code, NFC, or PIN code, interior LED lighting, a weight sensor (to detect product presence), an individual temperature sensor, and a micro security camera. A standard container can accommodate between 24 and 48 lockers, each assigned to an individual producer or shared on a rotational basis. (RAMADANI, 2024)

The container will be installed in areas with high pedestrian traffic, such as in front of town halls, in village or town centers, near parks or existing marketplaces, in public parking areas, or at major intersections. The site will be secured through a local council resolution based on a loan-for-use agreement or concession contract with the cooperative. Access to the electrical grid (230V/400V), internet connectivity (fiber optic or 4G/5G), and running water (for sanitation purposes) will be ensured.

The digital system of the smart container is built on a three-layer IoT architecture:

1. Perception layer – sensors and actuators at the locker level;
2. Transport layer – communication via Wi-Fi, 4G/5G, and LoRaWAN technologies;
3. Application layer – cloud platform and mobile application.

All data are encrypted end-to-end and stored on cloud servers in compliance with GDPR requirements.

Mobile Application Features for Producers

- Real-time monitoring of locker inventory (weight, temperature, humidity);
- Push notifications regarding product collection, low stock levels, or temperature anomalies;
- Product pricing and availability management;
- Sales statistics with daily, weekly, and monthly reports by product;

- Access to financial reports, including revenues, cooperative commissions, and automated settlements;
- Scheduling functions for locker activation and deactivation;
- Chat functionality with the cooperative manager and other producers;
- Access to digital forms for product certification and traceability. (RAMADANI, 2024)

STRENGTHS	WEAKNESSES
-High and diversified agricultural potential -Strong tradition in the production of traditional food products -Existence of the Local Action Group (LAG) and experience in accessing LEADER funding -Attractive landscape and cultural heritage -Competitive prices compared to industrially produced goods	-Lack of marketing and sales infrastructure -Small-scale producers with limited bargaining power -Low level of association and cooperation among producers -Low level of digitalization among agricultural producers -Aging agricultural workforce
OPPORTUNITIES	THREATS
-LEADER 2023–2027 and CAP Strategic Plan funding opportunities -Growing demand for authentic local products -Expansion of the Smart Village concept across Europe -Accelerated digitalization of society -Proximity to Oradea, an important consumer market	-Competition from low-priced industrial products -Stringent sanitary and food safety regulations that may be difficult to comply with -Resistance to change among traditional producers -Dependence on seasonal production cycles -Climate-related risks and production fluctuations

Fig. 1. Analiza swot

Mobile Application Features for Consumers

- Container location services through an interactive map of all containers in the network;
- Real-time viewing of available products, including photos and prices;
- Product reservation for later pickup;
- Digital payment options, including bank cards, Apple Pay, Google Pay, and a dedicated e-wallet;
- Automatic generation of locker access codes (QR code or PIN);

- Producer ratings and reviews;
- Weekly or monthly subscription plans for customized local product baskets;
- Notifications regarding new products and special offers.

Cooperative Administration Platform

A dedicated web-based management platform will provide the cooperative manager with complete visibility over the activities of all lockers and producers. Key functionalities include:

- Consolidated sales reports;
- Monitoring of storage conditions;
- Management of members and locker allocation;
 - Automatic issuance of invoices and payment statements;
 - Communication tools for interaction with AFIR and GAL Crișul Negru;
 - Reporting modules for monitoring and evaluating project performance indicators.

TAB.1. THE COSTS OF THE PROJECT

Start-up expenses (direct costs)	
Establishment of the cooperative	500
Land concession	120/year
Equipment costs	
Container	3 500
POS	157
Lockers	15 000
Solar panels	2 000
Acquisitions and intangible assets	
Soft	1 000
Site web	1 000
Personnel expenses	
Salaries (1 employee)	38 000 employee (for 4 years)
From the cooperative's added value	
Revenue from subsidies	
Gal Crișul Negru	35 000
TOTAL	23 777 (without employee)
TOTAL	61 777 (With employee)

CONCLUSIONS

The Smart Village project, featuring a Smart Container within the territory of GAL Crișul Negru, represents an innovative solution that is both financially and technically well-founded for addressing one of the central challenges facing rural Romania: the efficient

commercialization of local production and the support of small-scale agricultural producers' incomes.

A Short Supply Chain (SSC) is a method of organizing the marketing of agri-food products in which the number of intermediaries between the producer and the final consumer is limited to a maximum of one entity. The concept is regulated at the European level through Regulation (EU) No. 1305/2013 and has been widely promoted within the Common Agricultural Policy as a tool for increasing farmers' incomes and improving transparency for consumers.

The implementation of a smart locker system for the commercialization of local products represents a modern, digitalized form of a short supply chain. Producers place their products directly into the lockers, consumers collect them using a code or mobile application, and payment is processed electronically. The intermediary the smart container and its digital platform does not introduce prohibitive costs; instead, it provides logistics, refrigeration, and visibility services that would otherwise be inaccessible to small producers.

The implementation of the smart agricultural cooperative within the GAL Crișul Negru territory will generate numerous positive economic effects, both direct and indirect.

At the direct level, local producers will benefit from increased revenues through the elimination of intermediaries and access to a modern distribution channel.

Estimates based on similar models implemented in Western Europe indicate that producers' incomes could increase by between 20% and 35% compared to traditional sales through intermediaries or occasional marketplaces.

At the indirect level, the project will create jobs including positions for cooperative managers and IoT technicians stimulate investment in local production, as producers gain confidence in a stable sales channel, and contribute to reducing food waste through real-time inventory monitoring systems.

Beyond its economic dimension, the project is expected to generate significant social benefits. The cooperative model promotes solidarity and collaboration among producers, counteracting the fragmentation and isolation often experienced by small farmers. Membership in a cooperative provides access to services such as accounting, marketing, and

legal consultancy, which individual producers would often be unable to afford on their own.

The project will also contribute to reducing the abandonment of agricultural activities among young people by demonstrating that traditional agriculture can be modernized and can provide sustainable and attractive incomes. Through partnerships with local schools and agricultural high schools, the smart container can also serve as an educational tool for the next generation of farmers.

The direct marketing system based on smart containers significantly reduces the carbon footprint compared to traditional distribution chains through reduced transportation requirements, lower reliance on industrial packaging, and decreased food waste. Local production systems, which are generally smaller in scale and more diversified, also tend to be more environmentally friendly than large-scale industrial monocultures.

The integration of photovoltaic panels into the smart container demonstrates a commitment to energy sustainability, while IoT-based temperature monitoring systems reduce energy consumption compared to conventional oversized refrigeration systems.

The proposed model has been designed to be highly replicable across other territories in

Bihor County and throughout Romania. A network of interconnected smart containers operated by agricultural cooperatives from multiple Local Action Group (LAG) territories could eventually form a regional or national platform for local products offering a Romanian alternative to large retail chains, with local producers at its core.

The scalability of the project is facilitated by its modular architecture. A second container can be added to the initial location, or a new location can be opened, without requiring a new funding application to AFIR. Expansion can instead be achieved through the admission of new cooperative members and investments financed from the cooperative's own revenues or through credit facilities.

Fig.2. Identified risk

Identified Risk	Probability / Impact	Mitigation Measures
Low adoption of the application by older producers	Medium / High	Digital training program; simplified user interface; on-site technical support
Technical issues (locker malfunctions, internet outages)	Low / High	Warranty and maintenance contract with the supplier; connectivity redundancy (fiber optic + 4G)
Irregular stocking of lockers	Medium / High	Internal regulations with clear obligations; penalty/reward system within the cooperative
Rejection of the AFIR funding application	Medium / High	Engage an experienced AFIR consultant; prepare alternative financing through the LAG or private funding sources
Vandalism or theft involving the container	Low / Medium	Video surveillance; installation in well-lit and highly frequented areas; insurance coverage
Insufficient consumer demand	Low / High	Intensive pre-launch marketing campaign; partnerships with local authorities, schools, and local businesses

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