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Modernization of the Agricultural Economy. Case Study: The Moldavian (Jijia) Plain

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INTRODUCTION

The Jijia Plain, a physical-geographical unit in north-eastern Romania located in the northern part of the Moldavian Plateau, covers approximately 8,000 km² (about 3.4% of the country's area) across Iași and Botoșani counties. Mollisols cover over 72% of its area, and at the 2021 Census the rural population exceeded half a million inhabitants. The same area, however, faces severe constraints: property fragmentation inherited from the post-1989 decollectivization, a climate with pronounced continental features, in which annual precipitation drops to about 490 mm in the south-east, and an agriculture dominated by small farms worked with simple means. Alongside these, there are a few holdings capable of integrating precision technologies, irrigation, their own storage facilities and direct market channels. The relationship between these "islands of modernity" and the traditional rural fabric is the central issue of this research.

The topicality of the subject stems from the requirements of the European Green Deal, the "Farm to Fork" Strategy and the CAP Strategic Plan 2023-2027; from the conclusion of the NRDP 2014-2020 and of the 2021-2022 transition period; from the 2022 energy and inflation crisis, which exposed the vulnerability of small and medium-sized farms to rising input costs; and from the war in Ukraine, which has brought food sovereignty back into the debate. The research also fills a gap: existing studies treat the soil, demographic, institutional and financial dimensions of the problem separately, without a synthesis that integrates them for the Jijia Plain.

The central research problem is formulated as follows: how and to what extent have the modernization processes of the agricultural economy, triggered by the post-communist transition and amplified by accession to the European Union, transformed the productive structure, economic performance and territorial disparities of the Jijia Plain, and which natural, structural, institutional and socio-demographic factors explain the uneven pace of these transformations at the sub-regional level? The thesis starts from the observation that the transition decade was a lost battle for agricultural modernization, and that the recovery after 2000 and 2007 was territorially uneven.

The aim of the thesis is to assess, from an integrated geographical perspective, the modernization of the agricultural economy of the Jijia Plain in the post-communist period, and to formulate an integrated modernization model tailored to the specific features of the region, drawing selectively on the agricultural innovation system promoted by the FAO, the Dutch model of precision agriculture and the Danish cooperative model. To achieve this aim, six specific objectives were set:

1. identifying the evolution of private forms of land management after Law 18/1991 and the region's position within the national typology of agrarian transition;
2. assessing natural suitability for agriculture through a regionally calibrated synthetic spatial indicator, and analyzing the correlation between this potential and actual agricultural output;
3. analyzing the dynamics of land structures and agrarian morphology based on Corine Land Cover data (1990-2018), satellite imagery and LPIS-IPA 2025 data;
4. assessing the impact of EU accession through the territorial distribution and outcomes of the measures accessed under the NRDP 2007-2013 and the NRDP 2014-2020, including the 2021-2022 transition;
5. diagnosing the current performance of the livestock and crop sectors, including processing and post-harvest infrastructure;
6. classifying the 121 administrative-territorial units (ATUs) by commercial profile (intensive, diversified, specialized) and estimating the gross value of agricultural production, in order to identify modernization hubs and formulate territorially differentiated recommendations.

The research rests on five hypotheses:

1. although it generated excessive fragmentation, Law 18/1991 was the indispensable first step toward modernization, as it re-established property within a market framework;
2. the main obstacle to modernization is not soil and climate conditions but structural, namely persistent land fragmentation;
3. modernization can be traced territorially through the ratio between individual holdings and farms with legal personality, which defines a geography of agricultural modernity;
4. EU accession and the two NRDPs generated structural polarization, with a small number of large holdings absorbing a disproportionate share of the funds;
5. overcoming structural bottlenecks requires combining association (cooperatives, producer groups) with land consolidation through leasing, as neither is sufficient on its own.

The associated research questions address the modernization cores already formed and the factors that favored them; the extent to which European funds have changed the production structure; the relationship between an ATU's commercial profile and its capacity to generate a reinvestable surplus; the interplay of natural, structural and socio-demographic factors; and the existence of a coherent spatial pattern of modernization.

The object of the research is the agricultural economy of the Jijia Plain (crop and livestock production, farms, processing chains and the institutional framework), while its subject is the modernization processes, examined over the period 1990-2025 and at the level of the 121 ATUs.

The plain is bounded by the Ibănești Cuesta to the north, the Suceava Plateau to the west, the Central Moldavian Plateau (along the Iași Cuesta) to the south and the Bălți Plain in the Republic of Moldova to the east. The territory includes the municipality of Iași (rank I), the municipalities of Botoșani and Dorohoi (rank II), seven towns, 111 communes and 441 villages. Reference periods vary by topic: 1990-2018 for land use (Corine Land Cover), 1995 and 2023 for satellite imagery, 2007-2013, 2014-2020 and 2021-2022 for European funds, the 2017-2021 averages for crops (Copernicus Crop Type and NDVI), 1992-2021 for population censuses, 2012-2024 for emigration and 2025 for the parcel structure (LPIS-IPA).

The methodology combines three levels: theoretical-conceptual (critical analysis of modernization theories and models and of agricultural policies), geographical-cartographic (GIS integration of the digital elevation model, the soil map, and climate, land-use, statistical, LPIS and AFIR data) and statistical-quantitative (descriptive analysis, spatial multi-criteria evaluation, fragmentation and concentration indicators, ATU classification and correlation analysis). The research was carried out in five stages: documentation, analysis of the study area, development of an integrated ATU-level database, data processing and interpretation of the results. Sources include the TEMPO database of the National Institute of Statistics (INS), the General Agricultural Censuses (2002, 2010, 2020), the population censuses (1992, 2021), data from the National Sanitary Veterinary and Food Safety Authority (ANSVSA), the Agency for the Financing of Rural Investments (AFIR) and the Payments and Intervention Agency for Agriculture (APIA), county council decisions on agricultural prices, Corine Land Cover, Copernicus Crop Type, CHELSA (1990-2020), SoilGrids, the ICPA soil map, the SRTM digital elevation model (30 m), the LPIS-IPA 2025 layer, Sentinel-2 imagery and the specialist literature.

The novelty of the thesis is conceptual, methodological and empirical. Conceptually, the integrated model brings together the institutional dimension (the agricultural innovation system), the organizational-economic dimension (the Danish cooperative model) and the technological dimension (the Dutch model), on the premise that none of them can bring about lasting transformation on its own. Methodologically, the thesis proposes a natural suitability indicator calibrated on nine variables, the integration of LPIS-IPA 2025 data with indicators drawn from land fragmentation theory and landscape ecology, and a multi-criteria methodology for classifying commercial profiles based on the Shannon and Herfindahl-Hirschman indices and on the share of niche crops. Empirically, the thesis provides original maps for all 121 ATUs.

The thesis acknowledges limitations related to the under-reporting of emigration, the resolution of Corine Land Cover data (minimum mapping unit of 25 ha), the partial temporal

coverage of Copernicus Crop Type data, the impossibility of rigorously assessing the most recent developments (the 2023-2027 CAP, the energy crisis, the war in Ukraine), and the merely tangential treatment of the cultural and identity dimensions of rural transformation. The six chapters of the thesis build a cumulative argument, moving from theory and the natural setting to land structures, public policies and current performance.

CHAPTER 1. THEORETICAL FRAMEWORK AND THE EVOLUTION OF AGRICULTURAL DEVELOPMENT POLICIES IN ROMANIA

1.1. AGRICULTURAL MODERNIZATION. THEORIES OF THE TRANSITION TOWARD SUSTAINABLE AGRICULTURE

The first chapter builds the interpretive framework of the research through a critical analysis of the literature on modernization, of contemporary models of agricultural transformation and of Romanian agricultural policies since 1989.

1.1.1. Theoretical foundations of the concept of modernization

The concept of modernization has evolved from the idea of a universal transition toward the Western model to an understanding of modernization as an open-ended process, with global regularities and local variations. Evolutionist theories describe it as a sequence of stages, a uniform, irreversible and progressive process; functionalist theory treats it as systemic change that spreads from one domain to another; neo-modernization theory sees it as an uneven and non-linear process, resulting from deliberate action and aimed at improving the quality of life. In the context of globalization, modernization becomes an interdependent phenomenon (Steger, 2017), while the concept of "multiple modernities" acknowledges that there are several paths to modernity. Current approaches emphasize the role of institutions, without which the process may stall (North, 1990; Acemoglu and Robinson, 2012).

1.1.2. Theoretical foundations of agricultural modernization

In agriculture, modernization refers to the shift from a labor-dependent system to a technology-based one, built on innovation, mechanization and digitalization (Huang, 2015; Fitishin, 2024; Vărzavu, 2025). The literature reviewed outlines seven strands: transition, agricultural policies and institutions (North, 1990; Sidhu and Mudahar, 1999), productivity (Lewis, 1954; Schultz, 1964), efficiency, mechanization and digitalization, environmental protection (Altieri, 2002) and the social dimension (Chaudhuri et al., 2020; Helfenstein et al., 2022). For Romania, the authors reviewed highlight the need for restructuring to achieve competitiveness (Vasile et al., 2011), the role of EU accession as a source of pressure for reform (Meiță and Cioca, 2015), the persistence of a dual agrarian structure and the potential of cooperatives (Wolz, Möllers and Micu, 2020), and the sustainability requirements of the CAP Strategic Plan 2023-2027 (Chițea, 2023). Digitalization can

raise productivity by up to 20% and reduce chemical inputs by about 15%, but upfront costs remain an obstacle for small farms (Șerban et al., 2024).

1.1.3. The evolution of theories on the modernization of the agri-food sector

Classical theory proposed a linear transition from traditional society to an industrial economy (Rostow, 1960), while Schultz (1964) argued that traditional farmers, "poor but efficient", need access to modern factors of production and to markets, an idea that underpinned the Green Revolution (Pingali, 2012). Theories of agricultural transition highlighted the role of agriculture in supplying food, labor and capital for industrialization (Johnston and Mellor, 1961), the stimulating effect of population pressure on intensification (Boserup, 1965) and the shift from productivism to post-productivism (Ilbery and Bowler, 1998; Wilson, 2001). The sustainable agriculture paradigm, from the concept of sustainable development (WCED, 1987) to sustainable intensification (Pretty, 2008) and climate resilience (Pingali, 2012), makes sustainability an inseparable component of modernization.

1.2. CONTEMPORARY MODELS AND APPROACHES TO THE MODERNIZATION OF THE AGRICULTURAL ECONOMY. APPLICABILITY IN THE JIJIA PLAIN

The linear knowledge-transfer model has been replaced by systemic models. The thesis examines three such frameworks and their potential for transfer to a region marked by land fragmentation, water scarcity and subsistence farming.

1.2.1. The Agricultural Innovation System (AIS)

The agricultural innovation system places farmers at the center of a network in which they interact in both directions with research, advisory services, the private sector, vocational training and civil society, within an enabling environment shaped by policies and legislation (TAP, 2016a; 2016b).

1.2.2. The Dutch model of precision agriculture

With only 1.8 million hectares of agricultural land, the Netherlands is the world's second-largest exporter of agri-food products by value (Van Berkum and Dengerink, 2016). The model combines precision agriculture, based on sensors, satellite imagery and variable-rate input application (Gebbers and Adamchuk, 2010), high-tech greenhouses and integration into export-oriented value chains.

1.2.3. The Danish cooperative model

Danish cooperatives, which emerged in the 1880s to give farmers market access and bargaining power (Hansen, 2021), operate on the principles of collective ownership, democratic governance (one member, one vote), the mutual obligation to deliver and to purchase, and profit distribution in proportion to the volume delivered. They control almost the entire pork and dairy sectors, and their success is explained by trust, supportive legislation and education.

1.2.4. An integrated model for the modernization of the agricultural economy in the Jijia Plain

None of the three models can address the region's challenges on its own. The proposed model, structured on six functional levels and geared toward sustainable rural development, brings together the institutional, organizational-economic and technological dimensions, which are considered interdependent: precision technologies remain out of reach without cooperative structures to share their costs, cooperatives do not generate added value without access to knowledge, and research and advisory services are ineffective without an institutional framework linking them to producers' needs. In the Jijia Plain, links between innovation actors are weak, and the agricultural advisory services in Iași and Botoșani have limited resources. From the Dutch model, systematic data collection, evidence-based decision-making and differentiated input application, including precision irrigation, can realistically be adopted, especially through shared investments. The Danish model has substantial potential (Boberg-Fazlic et al., 2023), but the distrust inherited from forced collectivization calls for long-term investment in education, transparency and demonstrating the benefits of association.

1.3. ANALYSIS OF THE EVOLUTION OF AGRICULTURAL DEVELOPMENT POLICIES IN ROMANIA

1.3.1. The context of the post-communist transition in Romanian agriculture

The post-1990 reforms sought to democratize land ownership but led to excessive land fragmentation and declining output (Otiman, 2012). Law 18/1991 restituted up to 10 ha per family and dissolved the cooperatives, but its implementation was often chaotic (Hirschhausen, 1997; Verdery, 1994), and the irrigation systems, which covered two million hectares in 1989, were abandoned. The corrections of 1997 and 2000 and the liberalization of land sales in 1998 did not prevent the existence, by the mid-2000s, of some 4.2 million individual holdings with an average

size below 2 ha (Otiman, 2012). In the typology of decollectivization, the Jijia Plain belongs to the collectivized areas with a moderate state presence, where the released land passed almost entirely to households (Rey et al., 2002), and in 2002 the average farm size was frequently below 3 ha (Rey et al., 2006).

1.3.2. The legislative framework and agricultural policies in the pre-accession period (1990-2006)

Pre-accession policies included the agricultural vouchers of 1998, the privatization of the former state agricultural enterprises (IAS) from 2001, direct subsidies from 2002, the new framework for agricultural cooperation of 2004, the agricultural life annuity scheme of 2005 and the SAPARD program, worth EUR 1.5 billion. Total subsidies rose from EUR 242 million in 2002 to over EUR 1 billion in 2007, but were mainly compensatory (Hubbard et al., 2014). In 2004, Iași and Botoșani counties belonged to the "peasant agriculture with widespread micro-holdings" type, with an average size of 1.6 ha and low mechanization (Rey et al., 2006), a gap that would later constrain the absorption of European funds.

1.3.3. Agricultural policies after EU accession (2007 – 2025)

After accession, Romania introduced the Single Area Payment Scheme, worth about EUR 440 million in 2007 (Munteanu, 2024), and between 2007 and 2020 accessed over EUR 34 billion through the EAGF and the EAFRD (Hicea, 2020). The state maintained transitional national aid and, after 2015, launched an irrigation rehabilitation program with limited results, while the new stage of the CAP is being implemented through the National Strategic Plan 2023-2027.

1.3.4. National strategies for the development of agriculture and the rural economy

National strategies adopted after 2000 show a shift from transition priorities to competitiveness and sustainability. The Strategy for the Development of the Agri-Food Sector, 2020-2030 Horizon, recognizes fragmentation and the aging of the rural population as major challenges and recommends farmer association and domestic processing of raw materials (MADR, 2015).

1.3.5. Territorial effects of agricultural policies

The territorial effects are ambivalent. Subsidies have strengthened large farms, such as Agricola 96 Țigănași, which receives over EUR 5.3 million in subsidies annually, but have also deepened the polarization of benefits: in Iași County, the top 1% of farms received over 11% of

APIA payments in 2023 (Ziarul de Iași, 2024). Subsistence farms have remained numerically dominant (Davidova et al., 2009), while program instability and bureaucracy have reduced the effectiveness of the measures (Hubbard et al., 2014; Munteanu, 2024). The chapter concludes that the modernization of Romanian agriculture remains an unfinished project that calls for policies tailored to local conditions.

CHAPTER 2. GEOGRAPHICAL AND SOCIO-ECONOMIC CHARACTERISTICS OF THE JIJIA PLAIN – PREREQUISITES FOR THE DEVELOPMENT OF THE AGRICULTURAL ECONOMY

The second chapter treats the characteristics of the geographical space as active factors that can accelerate or hinder modernization, and prepares the answer to the question of why a territory with favorable natural conditions performs below its agricultural potential.

2.1. Geographical position of the Moldavian Plain

The Jijia Plain occupies north-eastern Romania and the northern part of the Moldavian Plateau, covering about 8,000 km² between the Ibănești Cuesta, the Suceava Plateau, the Central Moldavian Plateau and the Bălți Plain (Băcăuanu, 1968; Roșu, 1980). Its southern boundary is marked by the Iași Cuesta, the most prominent alignment of structural escarpments in Moldavia, approximately 100 km long (Badea et al., 1992).

2.2. Physical-geographical subdivisions of the Jijia Plain

The north comprises the Upper Jijia and Bașeu Plain (with the Săveni Hilly Plain, the Ripiceni-Stânca ridges, the Dorohoi and Botoșani depressions and the Copălău-Gozancea-Guranda hills), and the south the Lower Jijia and Bahlui Plain (with the Iași Plain, the Prut Valley and contact depressions) (Badea et al., 1992; Băcăuanu, 1968).

2.3. Physical-geographical characteristics

The mean altitude is about 150 m, with 60% of the area lying between 100 and 200 m; however, 62.4% of agricultural land has slopes above 5% and 38% above 10%, which favors erosion and landslides. Mean annual temperature ranges between 9.6°C and 8°C, while precipitation decreases from 500-550 mm in the north, west and south to below 500 mm in the north-east and center-east; there are about 190 days without precipitation each year, grouped into 6-11 dry spells (Mihăilă, 2006). The roughly 320 ponds and the Stânca-Costești reservoir reflect adaptation to water scarcity (Badea et al., 1992; Pantazică, 1974), while the soils, dominated by mollisols, are eroded on the slopes.

2.4. The demographic situation of the rural area of the Jijia Plain

2.4.1. Population dynamics

The total population grew from over 1.02 million inhabitants in 1992 to 1.14 million in 2024 (+11.9%), and the rural population from 483,715 to 552,649 inhabitants (+14.2%), after a decline lasting until around 2000. The thesis attributes this growth to periurbanization around Iași, the return of some emigrants, remote work, birth rates in certain communes and support programs. Between the 1992 and 2021 censuses, however, there was a redistribution rather than general growth: gains were concentrated in periurban communes such as Valea Lupului (+12,432 inhabitants) and Lunca Cetățuii (+7,260).

2.4.2. Distribution of the resident population in the Jijia Plain

In 2021, Iași had 271,692 inhabitants, Botoșani 90,010 and Dorohoi 21,693, which points to an unbalanced urban system. The rural area divides into a deep rural zone in the center and north, with numerous villages of under 1,500 inhabitants that are isolated, aging and dependent on subsistence farming; an intermediate rural zone capable of supporting high-performing farms; and a periurban rural zone undergoing rapid transformation.

2.4.3. Emigration dynamics and its consequences for the agricultural sector

In Iași and Botoșani counties, the number of emigrants under 20 years of age rose from 1,989 in 2012 to 3,113 in 2024, and high values are also recorded for the 20-29 age group, the most receptive to innovation. The causes are mainly economic: 57% of young people whose incomes cover only bare necessities say they want to emigrate (Bîrsan, 2025), and unemployment among young people under 24 is close to 22% (Popa, 2024). Migration nonetheless has a dual effect, since returning emigrants bring capital and skills, which is why modernization strategies must explicitly take it into account.

2.4.4. Age structure and population aging

Among the rural male population, the share of young people aged 0-24 fell from 44.3% in 1992 to 30.3% in 2024, while that of the 25-65 age group rose from 44% to 59.1%. In 2021, the demographic aging index exceeded 163, peaking at 219.6 in the deep rural zone in the center and north of the plain, which overlaps with the ATUs with the steepest population decline. The aging of

farm managers limits access to age-conditioned funding and perpetuates conservative agrarian structures.

2.4.5. Analysis of current labor availability

The aging index of the working-age population (15-64 years) reaches its highest values (28.6-32.2) in the northern half, where the population declined over 2005-2021, and its lowest values in the periurban area of Iași. These territories need vocational training, support for young farmers and incentives for the intergenerational transfer of farms.

2.5. The settlement network

The network comprises 3 municipalities, 7 towns, 111 communes (62 in the Botoșani part and 49 in the Iași part) and 441 constituent villages. The urban system is polarized by Iași, with Botoșani and Dorohoi playing a balancing role in the north and north-west.

2.6. The agricultural potential of the region

The north of the plain is dominated by field crops (wheat, maize, sunflower, sugar beet), while the more fragmented south has higher shares of fruit growing, viticulture, vegetable growing and grassland, supported by the Iași market. Pastures and hayfields cover about 150,000 ha (19% of the agricultural area), but are affected by steep slopes and landslides. Vineyards cover about 14,000 ha, concentrated in the Iași and Cotnari wine-growing areas, while fruit growing is dominated by apple (39%) and plum (37%). Livestock farming combines improved and traditional breeds, including the Botoșani Karakul.

2.7. Problems and challenges in agricultural development

The shortcomings fall into three interdependent levels: structural (land fragmentation, incompatible with mechanization and crop rotation), economic (lack of capital and difficult access to finance) and human (skills shortages, poor infrastructure and a poorly organized market). Added to these are natural hazards, insufficient fertilization and population aging, with people over 65 accounting for 13.7% of the population in 2024. The chapter concludes that modernization requires simultaneous interventions at all three levels.

CHAPTER 3. ASSESSMENT OF NATURAL SUITABILITY FOR AGRICULTURE IN THE JIJIA PLAIN – A PREREQUISITE FOR THE MODERNIZATION OF THE AGRICULTURAL ECONOMY

Even in intensive agriculture, the distribution of output reflects physical geography (Brunet et al., 1993). The chapter analyzes relief, soils and climate, integrates them into a synthetic index and tests its relationship with agricultural production.

3.1. The geomorphological setting and its implications for agricultural use

Altitudes rise from about 25 m in the Prut floodplain to approximately 350 m in the north and north-west, with the 100-200 m range covering about 60% of the territory and the 125-150 m class being the most frequent (about 19%). Slopes below 2% (28.6%), of 2-5% (17.9%) and of 5-8% (16.8%) together account for approximately 63% of the area and favor mechanization (Daum et al., 2023). Slopes of 8-15% (25%) require selective mechanization and anti-erosion measures (Morgan, 2005), while those above 15% (11.6%) are borderline areas where soil conservation must take priority (FAO, 2011). The thesis regards land with steep and very steep slopes, about 37% of the area, as marginal and suited to alternative strategies such as organic farming. Floodplains have an ambivalent profile, with fertile soils that are nevertheless exposed to flooding and waterlogging.

3.2. Soil characteristics as the basis of agricultural productivity

3.2.1. Soil cover diversity and its agricultural implications

The ICPA soil map shows the dominance of mollisols (over 72%), especially cambic chernozems (32.3%, i.e. 212,928.7 ha) and chernozems (28.2%, i.e. 186,083.6 ha), found on broadly undulating interfluves, with a deep mollic horizon and good water-holding capacity; argic chernozems (5.2%) and gray soils (6.6%) complete the area with medium-to-high potential. Undeveloped, truncated or deep-plowed soils occupy 15.3% (including erodosols, 4.9%), humic gleysols and gleysols 6.3%, and solonetz and solonchaks, concentrated in the south-east, 3%. Over two thirds of the territory has highly fertile soils, but modernization must include anti-erosion works, drainage and desalinization.

3.2.2. Physical soil properties and their agro-productive implications

SoilGrids data for the 0-30 cm layer indicate a predominantly clay-loam texture, with good water-holding capacity but a risk of compaction where clay content exceeds 50-60%. Bulk density is high (over 141 cg/cm³) in the north and west (Dorohoi – Săveni – Mitoc), but overall falls within the optimal range of 120-140 cg/cm³. Repeated plowing and heavy machinery can increase compaction (Hamza and Anderson, 2005), which justifies a shift to minimum tillage or no-till.

3.2.3. Chemical soil properties and their agro-productive implications

Soil reaction is predominantly neutral to slightly acidic-neutral, with acidic areas in the north, center and south and alkaline areas in the south-east. Total nitrogen ranges between 1.96 and 4.43 cg/kg, with higher values in the north and north-west, while organic carbon exceeds 60-65 t/ha in the north-east and center-east and falls below 45 t/ha in the center and south. This chemical heterogeneity justifies variable-rate fertilization and the conservation of nitrogen and carbon stocks (Lal, 2004).

3.3. Analysis of the climatic component

CHELSA data (1990-2020) show a decreasing precipitation gradient from the north-west, with over 610 mm per year, to the south-east, with less than 490 mm. During the growing season (April-September), 300-385 mm of rain falls, which is barely sufficient for wheat but inadequate for maize and sunflower, while in the south-east, where it drops below 300 mm, the water deficit becomes severe. Water must be managed as a technological input, and the rehabilitation of irrigation becomes a precondition for modernization.

3.4. Integrating natural factors. The index of natural suitability for agriculture

The index of natural suitability for agriculture was constructed through GIS-based spatial multi-criteria evaluation using nine indicators: slope and the topographic wetness index (TWI) for relief; clay content, bulk density, pH, total nitrogen, cation exchange capacity and organic carbon for soil (0-30 cm); and mean growing-season precipitation (1990-2020) for climate. Soil types were not included directly, in order to avoid redundancy and the subjectivity involved in converting soil classes into scores. The indicators were standardized to the 0-1 range using optimal-range functions (pH, clay, TWI), min-max scaling or normalization to the regional maximum (precipitation, cation exchange capacity, nitrogen, carbon) and decreasing functions (bulk density, slope), and then

aggregated through a weighted linear combination, with weights based on the literature (Prăvălie et al., 2014; Aldababseh et al., 2018; Patriche et al., 2024): precipitation 0.25, TWI 0.15, slope, clay, bulk density and pH 0.10 each, nitrogen 0.08, cation exchange capacity 0.07 and organic carbon 0.05. The resulting index, with values between 0 and 1, was divided into five equal-interval classes: satisfactory, moderate, medium, high and optimal (Figure 1).

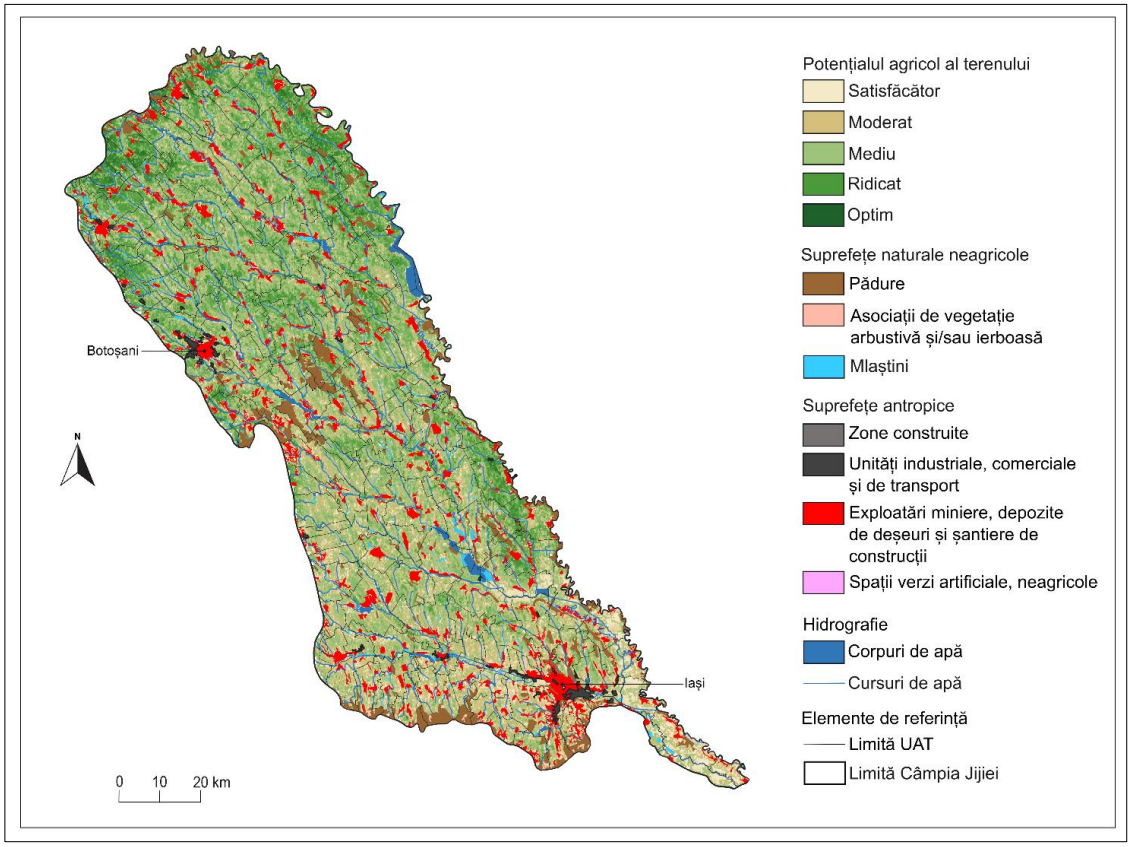

Figure 1. Index of natural suitability for agriculture

The upper classes occupy the central-northern and north-western interfluves, where clay-loam chernozems with neutral pH and good nitrogen and carbon stocks coincide with slopes below 5% and precipitation above 560 mm. The medium class forms a transition belt on 5-12% slopes, with at least one soil, morphometric or climatic constraint. The lower classes occur in the floodplains and low terraces of the Jijia and its tributaries, penalized by waterlogging and flood risk, and on slopes steeper than 15-18% in the west and north-west. The overall gradient follows a north-west – south-east axis, as does precipitation. The index thus becomes a prioritization tool: precision agriculture in favorable sectors, soil improvement in medium ones, and soil conservation and drainage in those with low suitability.

3.5. Correlation analysis of the relationship between natural suitability and agricultural production

Overlaying the index with the crop structure from the HRL Crop Type 2021 product, reclassified into eight functional classes, shows that cereals dominate in all classes (49.2% in the satisfactory class, 58.1% in the high class and 55.8% in the optimal class), followed by oilseeds (30-37%), while orchards and vineyards are better represented in the lower classes. Suitability therefore influences the degree of specialization, and the greater diversity in less favorable areas reflects adaptive strategies.

The relationship with production was tested at the ATU level using Pearson correlations between the mean index value and the mean yield per hectare, estimated from Copernicus crop areas and INS yields adjusted for NDVI, without assuming causality. The aggregate correlation is positive but weak to moderate ($r = 0.261$; $r^2 = 0.068$), so suitability explains only 6.8% of the variation in total yield. Three patterns emerge by crop: positive correlations for maize ($r = 0.418$; $r^2 = 0.174$) and rapeseed ($r = 0.511$; $r^2 = 0.262$); negative correlations for barley ($r = -0.537$; $r^2 = 0.288$), sugar beet ($r = -0.376$) and, more weakly, soybean ($r = -0.221$, significant only at $\alpha = 0.05$); and no correlation for wheat ($r = -0.003$), other cereals ($r = 0.043$) and sunflower ($r = 0.041$). Estimated mean yields for 2017-2021 are 5.59 t/ha for maize, 4.19 t/ha for wheat, 3.56 t/ha for barley and 3.01 t/ha for sunflower.

The explanation lies in territorial variability. Wheat and sunflower have the most uniform yields (coefficients of variation of 8.5% and 9.2%, respectively), as they are grown with standardized technologies across all suitability classes, while suitability itself varies very little between communes (mean 0.62; coefficient of variation 8.2%). The negative correlations appear to be spurious rather than causal, since high sugar beet and soybean yields occur on irrigated floodplain soils that are penalized by the index, which does not account for irrigation. Maize, which is also grown by households, follows the natural gradient in the absence of technological intervention, whereas rapeseed, a demanding crop grown by commercial farms on the best land, effectively capitalizes on favorable conditions. The weak negative correlation between suitability and NDVI ($r = -0.235$) in turn confirms that the vegetation index also reflects crop structure and farming practices, not just natural conditions. The central finding of the chapter is the quantification of the gap between natural potential and actual performance: the natural setting is a prerequisite, not a determining factor.

CHAPTER 4. THE EVOLUTION OF LAND STRUCTURES AND AGRARIAN MORPHOLOGY

4.1. Land-use change in the Jijia Plain

In Central and Eastern Europe, the post-socialist transition combined the abandonment of some land, the expansion of built-up areas and the intensification of arable use (Kuemmerle et al., 2008; Müller et al., 2009). This subchapter examines how these processes played out in the Jijia Plain.

4.1.1. Rationale for using Corine Land Cover data and for the selected time frame

Corine Land Cover data were preferred to administrative statistics because they provide a homogeneous cartographic representation that is comparable over time. The years 1990, 2000, 2006, 2012 and 2018 correspond to the stages of transition, pre-accession, accession and adaptation to the CAP.

4.1.2. Level of detail and reclassification of Corine Land Cover categories

Level 3 classes were aggregated into six categories: arable land, natural pastures, heterogeneous agricultural areas, built-up areas, forests and natural vegetation, and water bodies and wetlands.

4.1.3. Limitations of Corine Land Cover data

The 25 ha minimum mapping unit and possible errors in mixed agricultural areas mean that the results should be interpreted as general trends rather than as an exhaustive local inventory.

4.1.4. Statistical indicators used

For the arable area of each ATU, the net difference 2018-1990, the standard deviation and the coefficient of variation were calculated, with values below 5% indicating stability and those above 20% indicating major transformations (Rogerson, 2001; Brown and Duh, 2004).

4.1.5. Changes in the main land-use categories

Between 1990 and 2018, arable land increased from 342,725 ha to 373,452.1 ha (+30,727.1 ha; +9%) and natural pastures by 10,521.9 ha (+8.7%), while heterogeneous agricultural areas decreased by 19,837.5 ha (−24.4%) and water bodies and wetlands by 5,899.9 ha (−23.1%); built-up

areas grew by 5,529 ha (+8.7%) and forests by 1,438 ha (+3.9%). The rural mosaic has been simplified around land uses that are easy to manage from a production standpoint. The major leap in arable land occurred between 2000 and 2006 (+33,873.9 ha), followed by a correction (2006-2012) and stabilization (2012-2018). Across the 121 ATUs, arable land increased by 8.9%, with gains in 101 units and losses in 20; the largest increases occurred in Prisăcani (+1,705.8 ha), Brăești (+1,266.0 ha), Ungureni (+1,210.3 ha), Ion Neculce and Ungheni, and the largest decreases in Balș (−405.7 ha), Bălțați, Curtești, Iași and Sulița. The standard deviation (mean of 156.4 ha) reveals clusters of instability in Prisăcani, Brăești (Iași County) and Ungureni, where arable land underwent successive conversions and readjustments. The coefficient of variation has a mean of 7.3% and a median of 4.4%, with 65 ATUs below 5%. The highest values occur in the southern periurban area, where arable land is being converted to built-up land: in Tomești (75.7%) arable land fell from 84.8 ha to 19.4 ha, in Valea Lupului (38%) from 400.8 ha to 179.7 ha, and in the municipality of Iași (34.4%) from 662.9 ha to 338.0 ha. High coefficients also occur, however, where arable land expanded, as in Prisăcani (31.6%) or Aroneanu (24.6%), and a total of 25 ATUs have coefficients of at least 10%. The greatest stability is found in the center and north of the plain (Drăgușeni, Târgu Frumos, Santa Mare, Gropnița). The expansion of arable land confirms the post-socialist land transition (Kuemmerle et al., 2009), amplified by area-based payments, but stability may indicate either consolidation or stagnation, and landscape homogenization may reduce resilience (Plieninger et al., 2016). Land-use change is therefore not automatically equivalent to modernization.

4.2. Spatial analysis of changes in agrarian morphology based on satellite imagery

A comparison of satellite images from 1995 and 2023 shows that, instead of consolidation, many communes experienced increased fragmentation. Sixteen such localities were identified, the most affected being Plugari and Șipote (Iași) and Stăuceni, Trușești, Durnești, Ștefănești and Viișoara (Botoșani), where long and extremely narrow strips have formed. Truly visible consolidation occurred in only a few communes (Cristinești, Suharău, Văculești), while a partial transition toward a modern morphology can be seen in Hudești and Cordăreni. Of the 121 localities, 98 have largely retained their 1995 morphology. Compact land holdings, favorable to high-performance farming, mainly characterize the string of communes along the Prut Valley (including Rădăuți-Prut, Ripiceni, Bivolari, Trifești, Golăiești, Ungheni, Țuțora and Prisăcani), together with Popricani, Țigănași and Mihălășeni, whereas over 70 localities remain stagnant and fragmented.

Fragmentation is rooted in the land reforms of 1864, 1921, 1945 and 1991 (Ciobanu et al., 2010) and is sustained by egalitarian restitution, with plots of at least 0.5 ha even for very small owners and with no regard for productive structures (Hirschhausen, 1997), by the belated regulation of land leasing (1994), by inheritance-based subdivision (Simion, 2008), by the lack of alternative employment, by the emotional value attached to land and by reluctance to cooperate (Florea et al., 2019; Micu, 2015). The recommendations include fiscally incentivized consolidation (Rahoveanu, 2016), modernization of the cadastre (Păunescu, 2021), support for associations and adequate pensions for elderly landowners (Mihai et al., 2005).

4.3. The parcel mosaic of the Jijia Plain. Land fragmentation, agrarian structure and modernization potential

4.3.1. Theoretical foundations of land fragmentation and agrarian landscape analysis

Land fragmentation refers to a situation in which a farm consists of distinct and scattered parcels (King and Burton, 1982; Bentley, 1987; van Dijk, 2003), a multidimensional phenomenon (Demetriou, Stillwell and See, 2013) that may hinder modernization or, in certain contexts, help diversify risk (Ntihinyurwa and de Vries, 2021). Landscape ecology describes territory as a mosaic of patches and corridors (Forman and Godron, 1986), measured through FRAGSTATS-type metrics (McGarigal and Marks, 1995) and effective mesh size (Jaeger, 2000). The thesis combines the two traditions through a set of indicators along four axes: size (number and size of parcels), fragmentation (the Januszewski K index and effective mesh size, m_{eff}), shape (Mean Shape Index, MSI) and functional diversity (the Shannon index for arable land, permanent grassland and permanent crops).

4.3.2. Using LPIS in the analysis of agrarian structure

The main source is APIA's IPA 2025 layer, which is publicly available and increasingly used in European research (Sagris et al., 2013; Lüker-Jans et al., 2016). Because the data are anonymized, the indicators were calculated at the ATU level: they describe territorial parcel fragmentation, not the fragmentation of ownership or of farms.

4.3.3. The geography of land fragmentation. Indicators, contrasts and spatial patterns of the parcel structure

The analysis covered 168,959 parcels (301,524 ha), compared with the national database of 5,733,680 parcels (9,992,584 ha), in which the Jijia Plain accounts for 3.02% of the area. Arable

land accounts for 78.8% of the declared area, permanent grassland for 19.6% and permanent crops for 1.6%, the latter concentrated in Iași, Cotnari, Bălțați and Tomești. The overall median parcel size is only 0.70 ha (0.18 ha for permanent crops), while the median of the mean parcel size per ATU is 1.83 ha, 31% above the national value (1.39 ha), ranging from 0.58 ha in Tomești to over 11.7 ha in Țigănași, Probota and Movileni. Parcels under 0.1 ha account for 0.71% (1.40% nationally), and those over 5 ha for 6.05% (4.32% nationally).

The Januszewski index has a median of 0.0347, a value close to zero that indicates severe fragmentation, slightly above the national median (0.0313), while m_{eff} is 12.45 ha, compared with 9.85 ha nationally. The region is above the national average for three quarters of the consolidation indicators, but no ratio exceeds 1.5, so the relative advantage does not change the diagnosis: the Jijia Plain is a slightly more favorable version of a deeply fragmented Romanian agriculture. The two fragmentation indicators are complementary: Tomești appears consolidated according to the Januszewski index (K = 0.166, with only 43 parcels) but fragmented according to m_{eff} (0.9 ha), whereas Țigănași reaches the highest m_{eff} value (39 ha). Permanent crops, despite their very small parcels, are the most consolidated category (median K of 0.210, compared with 0.034 for arable land). The contrast between the two counties is clear: all of the 15 most fragmented ATUs are in Botoșani (Ungureni has 5,209 parcels), and 14 of the 15 most consolidated are in Iași; the mean number of parcels per ATU falls from 1,713 to 691, while the mean parcel size rises from 1.54 ha to 2.68 ha. The thesis attributes this difference to the reconstitution of ownership based on old titles in Botoșani and to a more concentrated structure in Iași, inherited from the former state farms and collective farms. According to the classes defined by the author, 74.4% of ATUs are “very fragmented” (82.2% nationally), 23.1% “fragmented” and 2.5% “medium”, with none reaching the consolidation threshold ($K \geq 0.20$).

Parcel shape reinforces the diagnosis: the median MSI is 2.05, well above the 1.2-1.5 values of regular modern parcels, while edge density reaches 416 m/ha; in the five most fragmented ATUs in Botoșani, the cumulative parcel perimeter exceeds 2,000 km. These values make the inherited geometry an obstacle to mechanization, even where leasing consolidates farms functionally. Functional diversity is moderate (Shannon 0.529, compared with 0.445 nationally), peaking in Iași, Comarna, Tomești, Hîrlău and Cotnari. Cotnari, with 17.1% permanent crops and only moderate fragmentation, illustrates the convergence of high-value specialization and a favorable land structure.

4.3.4. Tenure of the utilized agricultural area and the capacity for operational land consolidation

According to the 2020 General Agricultural Census, leasing accounts for 53.4% of the utilized agricultural area (137,901 ha), direct ownership for 31.8% and other forms for 14.8%. Indirect forms are widespread and spatially compact, with high shares in, among others, Rădăuți-Prut, Andrieșeni, Vlădeni, Bivolari, Trifești and Țigănași, whereas owner-operation dominates only in isolated ATUs such as Curtești, Tomești, Valea Lupului or Darabani. The share of indirect forms correlates moderately and positively with m_{eff} ($r = 0.37$) and with estimated production ($r = 0.35$), showing that performance depends more on the ability to pool land functionally than on legal ownership. Intensive ATUs use, on average, 44.94% of their area under lease and 16.88% under other indirect forms, and diversified ATUs 43.64% and 19.80%, respectively, whereas specialized ATUs rely more on direct ownership (54.41% of the area), as specialization is less dependent on land mobility. Modernization therefore does not require the disappearance of fragmented ownership, but rather the capacity to pool it functionally into viable farms.

4.3.5. Conclusions of the structural analysis and implications for modernization

Fragmentation remains a major obstacle, especially in Botoșani; the relative advantage over the national average has not yet translated into a qualitative transition; the contrast between the two counties calls for consolidation and association in Botoșani and for capacity-building investment in Iași; permanent crops mark modernization cores; and the agrarian structure is deeply differentiated, with favorable factors combining only in a few areas, such as Cotnari, Comarna or Hîrlău. Methodologically, the analysis confirms the value of LPIS-IPA data as research infrastructure.

CHAPTER 5. THE IMPACT OF ROMANIA'S ACCESSION TO THE EUROPEAN UNION ON THE MODERNIZATION OF THE AGRICULTURAL SECTOR IN THE JIJIA PLAIN

The rapid privatization after 1989 left behind small farms lacking machinery, infrastructure and access to markets and finance (Ianoș and Secăreanu, 2020), and European funds subsequently became the main instrument for modernizing farms and rural areas (Ilieș et al., 2024). The chapter analyzes the volume and territorial distribution of the agricultural funds attracted in the Jijia Plain.

5.1. Core principles and features of European Union policy on the development of the agricultural sector in the context of rural development

The Common Agricultural Policy rests on two pillars, financed through the EAGF (direct payments and market measures) and the EAFRD (rural development) (Dax et al., 2016), and its share of the EU budget has fallen from almost 87% in the 1970s to about 40%. After the SAPARD pre-accession program, Romania implemented the NRDP 2007-2013 and the NRDP 2014-2020; the latter had a budget of EUR 9.363 billion, supplemented during the 2021-2022 transition by EUR 2.15 billion from the 2021-2027 financial framework, EUR 0.69 billion from the EU Recovery Instrument and EUR 1.73 billion in national contributions. Between 2015 and 2024, AFIR signed contracts with 103,616 beneficiaries, totaling EUR 7.2 billion in non-reimbursable funding (AFIR, 2024).

5.2. Uptake of European agricultural funds in the Jijia Plain under the NRDP 2007-2013

Under the Axis 1 measures, 3,296 projects were funded in the region, with payments of EUR 76.13 million, i.e. only 2.6% of national public expenditure under Axis 1, while the measures for training, advisory services and the setting up of producer groups were not accessed at all. Measure 141, for semi-subsistence farms, accounted for 84.6% of projects (2,788) but only EUR 14.95 million, whereas Measure 121, for farm modernization, attracted the largest amount (EUR 27.66 million, 34.3%) through only 99 projects. Measure 123, for adding value, totaled EUR 18.7 million through 22 projects; Measure 112, for young farmers, 371 projects and EUR 8.81 million, i.e. only 3% of the 12,477 projects funded under this measure nationally; and Measure 125, for agricultural and forestry infrastructure, only 16 projects, worth EUR 10.51 million.

5.3. Territorial distribution of agricultural funding uptake in the Jijia Plain under the NRDP 2007-2013

Funding for young farmers (Measure 112) was concentrated in the south of the plain, where the share of older people is lower, peaking in Probota (19 projects, EUR 447,990), Andrieșeni (16) and Aroneanu (14), while 25 localities had a single project and 31 had none. The support, EUR 10,000, later raised to EUR 12,000, was aimed at farmers up to 40 years of age setting up for the first time on holdings of 6-40 ESU, but its distribution did not reflect the needs of the aging north. Measure 121 was accessed in 45 localities, most with one or two projects, with an average value of EUR 301,948 and a concentration in the east of the plain, where farmers' infrastructure, experience and co-financing capacity were better; the non-reimbursable support covered 40-75% of eligible costs, and the remainder was the main barrier. Measure 141 was accessed more intensively in the fragmented west and north, peaking in Cristinești (235 projects) and Andrieșeni (134), but the support of EUR 1,500 per year for up to five years was not enough to turn semi-subsistence farms into commercial holdings.

5.4. Uptake of agricultural funds in the Jijia Plain under the NRDP 2014-2020 and the transition period (2021-2022)

For the sub-measures dedicated to agriculture, the public allocation amounted to EUR 3,028.88 million, plus EUR 1,325.36 million during the transition. The Jijia Plain attracted payments of EUR 78.15 million, about 2.6% of the NRDP 2014-2020 allocation, and of 1,685 applications, 862 were funded (a success rate of 51.2%). Sub-measure 4.1 accounted for 41.2% of payments (EUR 32.17 million) through 70 projects, with an average value of about EUR 460,000, while sub-measure 6.3, for small farms, had the largest number of projects (449) and the highest success rate (57.1%), but only EUR 6.63 million. Young farmers received EUR 12.38 million through 294 projects (sub-measure 6.1), and processing and marketing EUR 19.99 million contracted through 31 projects (sub-measure 4.2), while access infrastructure (6 projects out of 29 applications), irrigation (5 projects) and producer groups (5 projects) remained marginal.

5.5. Territorial distribution of agricultural funding uptake in the Jijia Plain under the NRDP 2014-2020 and the transition period (2021-2022)

Sub-measure 4.1 was accessed in 41 localities; the territorial analysis identifies 59 projects, fewer than under Measure 121 but with a 44.1% higher total value (EUR 38.3 million) and an average of EUR 649,120. Funding was concentrated in the north-west and especially in the south-east, where a compact agrarian structure and co-financing capacity favored high-performing farms, peaking in Prisăcani (EUR 6.45 million), Ungureni (EUR 4.49 million) and Curtești (EUR 1.71 million); the center and north-east lagged behind because of co-financing requirements, the minimum threshold of 8,000 SO and viability requirements. Investments under sub-measure 4.2, exceeding EUR 18 million, targeted the establishment, extension and modernization of processing units for milk (Răchiți, Vlăsinești), meat (Roma) and bakery products (Iași), as well as storage capacities in Ungureni, Avrămeni and Broscăuți, where a silo worth over two million euros was built in 2018; these investments nonetheless remain insufficient relative to the region's potential. Access infrastructure was funded in only five communes, and irrigation exclusively in the Prut floodplain (Golăiești, Țuțora, Andrieșeni, Probota, Bivolari), covering a very small share of the agricultural area.

Unlike Measure 112, sub-measure 6.1 followed the demographic structure, favoring the aging center and north; Andrieșeni and Stăuceni had 13 projects each. Sub-measure 6.3 shows a balanced distribution, with a concentration in the north-west; it was implemented in 94 localities, yet its 449 projects represent only 16.3% of the number of grants awarded under Measure 141, with an average value of EUR 14,849; most grants went to the communes of Cristinești (42 projects), Andrieșeni (27) and Comarna (21). The interest in this sub-measure, which accounts for almost half of the projects submitted in the region, confirms the predominance of small farms. Implementation was hampered by the lack of cadastral registration of land (Felici et al., 2018), and absorption delays are due more to an inadequate allocation of resources than to a lack of demand (Rusu et al., 2022). Under sub-measure 9.1, only three producer groups were set up (Ion Neculce, George Enescu and Hudești) and two others were strengthened, an outcome attributed to the distrust inherited from collectivization, perceived bureaucracy and a lack of awareness of the advantages of association.

CHAPTER 6. CURRENT PERFORMANCE OF THE AGRICULTURAL SECTOR IN THE JIJIA PLAIN

The final chapter diagnoses the current performance of the agricultural economy as the outcome of the interaction between natural potential, inherited agrarian structures and modernization mechanisms, analyzing livestock farming and the crop sector separately, followed by commercial profiles and the gross value of production.

6.1. Performance of the livestock sector in the local and regional agricultural economy

Livestock farming has traditionally served to make use of crop surpluses and to provide for household consumption, becoming a survival strategy in the 1990s (Popovici et al., 2016), but it can also support local industries, as in the case of the mixed farm in Lișna (Suharău), with 55 dairy cows, which supplies milk to a factory in Dorohoi (Modiga, 2021a).

6.1.1. Livestock population dynamics (1990-2023)

ANSVSA data show a massive decline. Cattle numbers fell from about 288,722 head in 1990 to approximately 102,502 in 2023 (−65%); the herd had already halved by 1997, and after a slight recovery between 2010 and 2017 (from 129 thousand to 141 thousand head), probably explained by coupled support and demand for milk, the decline resumed, most likely as aging households gradually gave up keeping cows. Sheep numbers fell from 849,358 head in 1990 to 370,318 in 2010, recovered to about 473,000 in 2017, driven by exports (Sandu et al., 2015) and coupled support, and then dropped to 373,461 in 2023. Pigs experienced the most dramatic decline, from over 442,000 head to 46,184 (about −90%), owing to post-accession restructuring and African swine fever, which mainly affects small holdings (Stanciu, 2025).

6.1.2. Territorial distribution of livestock and regional livestock hubs

The decline in cattle numbers is not uniform: 95 ATUs recorded decreases and 26 increases, indicating selective concentration. The largest losses occur in Ion Neculce (−4,331 head), Holboca and Popricani, and the largest gains in Manoleasa (+2,060), Știubieni and Trifești. The current hubs are in northern Botoșani County (the Săveni-Darabani-Ungureni area) and north-eastern Iași County, with the largest herds in Trifești (3,652 head), Manoleasa (3,424), Știubieni and Vorniceni. Sheep numbers fell in 112 ATUs, with the largest losses in Movileni (−15,539 head) and Deleni; the current hubs are Lungani (13,900 head), Ungureni (11,650) and Ion Neculce (10,418), along with

leading farms such as the one in Plugari, with 2,000 Botoșani Karakul sheep (Modiga, 2021b). Pig numbers fell in 105 ATUs, the largest loss being in Tomești (−207,848 head), a sign of the disappearance of large-scale rearing facilities, and in 2023 the largest herds barely reached 1,000-1,500 head; new investments are isolated, such as the farm of the Hogs Farm Land Cooperative, with 306 breeding sows, co-financed through the NRDP (Nițu, 2022).

6.1.3. Post-production infrastructure: the dairy and meat supply chains

The Jijia Plain is a secondary milk collection hub, with collection centers overlapping the cattle-rearing cores, but processing capacity is limited, Dorohoi being the main hub, so a significant share of the milk is processed in other regions. The deficit is even more pronounced in the meat chain, where licensed units are rare, small (1-2 per locality) and scattered, Iași being the main local hub, and the lack of nearby slaughterhouses increases farmers' dependence on intermediaries and on transporting live animals to other counties. Added value leaves the region, and isolated investments in modern farms risk remaining “islands of modernity” without a regional industrial ecosystem.

6.1.4. Factors shaping the performance of the livestock sector

The thesis identifies four groups of factors. Support policies favored large farms through eligibility thresholds; coupled support for sheep, for example, was granted for flocks of 150 to 500 head (Dobre, 2018). Access to markets and processing was limited by the lack of nearby slaughterhouses and by raw milk standards, which after 2007 excluded many producers without cooling tanks; the Doly-Com slaughterhouse in Roma, expanded in 2023 with a new processing plant (BotosaniNews.ro, 2025), remains the main facility in the area licensed to high standards. Crises (African swine fever, falling domestic demand, the loss of the wool market, migration and rising input prices) caused sudden losses, while weak associative organization left small producers vulnerable. Revitalizing the sector requires genetic improvement, higher productivity per animal and integrated supply chains.

6.2. Performance of the crop sector in the local and regional agricultural economy

6.2.1. Changes in the areas under the main crops

A comparison between 1996-2000 (INS data) and 2017-2021 (Copernicus data) shows the relative stability of wheat (between 40,152 and 69,730 ha in the second period), the expansion of maize from 174,892-196,659 ha to a peak of 203,801 ha in 2021, the strong growth of sunflower, which was grown on only 28,869-32,343 ha in the 1990s, and the collapse of sugar beet, from

12,500-13,500 ha to just 1,609.23 ha in 2017, following the closure of the Bucecea and Ripiceni-Trușești sugar factories, around which up to 10,000 ha were once cultivated. Vegetable areas, which amounted to 10-13 thousand ha in the 1990s, have declined slightly, amid labor pressures and price volatility.

6.2.2. Crop structure and territorial distribution

On average over 2017-2021, cereals occupy over half of the field crop area in the vast majority of ATUs, with maize frequently accounting for 70-80% of cereals and sunflower for 70-85% of industrial crops, owing to its drought tolerance. The crop hubs are Bivolari (3,244 ha) and Coțușca (3,135 ha) for maize, Rădăuți-Prut (1,454 ha) for wheat, Coțușca (2,147 ha) and Belcești (1,688 ha) for sunflower, Belcești and Erbiceni for rapeseed, and Ungureni (912 ha) for soybean. Yields are mostly 5-6 t/ha for maize, 3.5-4.5 t/ha for wheat, 2-3 t/ha for sunflower and 1.5-2.5 t/ha for rapeseed. The thesis highlights the dual logic of crops: maize simultaneously supports household consumption and the volume production of commercial farms; sunflower is a safety net for small producers and a source of profit for large farms; and rapeseed, demanding and risky, marks the frontier between subsistence and commercial agriculture.

6.2.3. Post-harvest infrastructure. The network of agricultural warehouses and storage facilities

Data from the Ministry of Agriculture and Rural Development (MADR) for 2022 show that, compared with the major cereal-growing regions in the south and west, the Jijia Plain has a low density of storage points, predominantly small capacities and a high share of traditional barns, with potentially greater post-harvest losses. Many silos in the region are controlled by operators headquartered in Bucharest, Constanța or western Romania, indicating a dependence on extra-regional commercial capital similar to that seen in the livestock supply chains. Areas farmed through associative forms are rare, so coordinated investment in storage is needed, preferably through association.

6.2.4. Factors shaping the productivity and competitiveness of crop farms

Drought has become the norm: in 2020, 80% of the maize area in Botoșani County was declared a total loss, in 2022 wheat yields fell to 0.8-2 t/ha in several communes, and in 2024 the drought began as early as May (Zamfirache, 2024). Irrigation does not offset the risk. The distribution network was dismantled after 1990, irrigation is impractical at farm scale on sloping

land, and data from the National Agency for Land Reclamation (ANIF) for 2024 show large differences between the equipped area and the contracted area: the Tabăra-Trifești-Sculeni scheme is fully contracted (20,626 ha), whereas in Sculeni-Țuțora-Gorban 9,998 of 20,981 ha are contracted and in Horia-Liveni-Manoleasa 1,740 of 6,240 ha. The difficulty is therefore simultaneously morphological, economic and institutional, and modernization through irrigation also depends on farmers' ability to use the existing infrastructure. Case studies from the agricultural press outline three categories of farms that often coexist in the same commune: the subsistence farm of under 5 ha, which is numerically dominant; the family farm of 100-500 ha, where generational succession is most common; and the holding of over 1,000 ha. The economic and technological gap between the first and last categories is wider than at any point in the post-war period, and land concentration through leasing and sales will continue. Access to funding follows the same hierarchy, with small farms largely excluded, except in certain subsectors such as beekeeping. High oilseed prices have capitalized commercial farms, while farms disconnected from the market remain trapped in a vicious circle of low yields.

Technological indicators confirm the geography of modernization. Data from the 2020 General Agricultural Census (RGA) show the largest chemically fertilized areas in the Prut floodplain, in Bivolari (4,362 ha) and Țigănași (4,013 ha), and a second core, with shares of 56-73% of the utilized agricultural area, in the Coțușca-Manoleasa-Ungureni area. The 17 ATUs with over 73.2% of their area fertilized coincide almost entirely with the modernization cores, while the central-western zone remains locked in a subsistence logic. The thesis notes that these hubs of productivist modernity are candidates for a shift toward precision agriculture, in line with the eco-schemes of the 2023-2027 CAP. Organic farming is insular, concentrated in Vlădeni (3,910 ha, 22.5% of the utilized agricultural area), while Concești has the highest relative share (28.5%).

Technical equipment was analyzed using INS data, which are available only at county level. In Iași and Botoșani counties, between 1990 and 2024 the number of tractors rose from 5,323 to 10,178 (+91.2%), plows from 2,552 to 6,879 and seed drills from 1,792 to 3,580, whereas grain combine harvesters fell from 1,883 to 1,156 (−38.6%), and forage and potato machinery declined by 50-74%, in line with the decline of livestock farming and potato growing. The decrease in the number of combines does not necessarily signal regression, since a modern combine with a capacity of 12-25 t/h can replace 3-4 old ones. Tractor density (1.9 per 100 ha of arable land in Iași and 1.82 in Botoșani) and its growth rate (+2.23%/year in Botoșani, +1.61%/year in Iași) place the region in a better position than many cereal-growing counties in the south and west, such as Brăila, Constanța or Timiș, where the tractor fleet has shrunk. Combine numbers are falling everywhere, but Botoșani

has the slowest decline among the cereal-oriented counties (−0.99%/year), a sign that fragmentation has delayed the exclusion of small farmers from mechanized harvesting. Cooperatives could cut small farmers' mechanization costs by up to 40% (Wolz, Möllers and Micu, 2020).

6.3. Classification of the commercial orientation of the ATUs in the Jijia Plain

The classification was based on mean 2017-2021 areas for 15 crops (Copernicus Crop Type, 10 m resolution), grouped into cereals (mean share 56.3%), industrial crops (33.9%) and niche crops (9.8%, ranging from 1.2% in Ripiceni to 82.9% in Tomești). For each ATU, the Shannon index (mean 1.617), the Herfindahl-Hirschman index (mean 0.277) and the number of active crops (mean 9.79) were calculated, followed, after z-score standardization, by three composite scores: intensive (industrial crops 0.40, cereals 0.20, niche −0.25, Shannon −0.15), diversified (Shannon 0.50, number of crops 0.25, HHI −0.25) and specialized (niche 0.60, cereals −0.20, industrial crops −0.20). Each ATU was assigned the profile with the highest score.

Extreme values illustrate the contrasts: Bîrnova has the lowest diversity (Shannon 0.879) and the highest concentration (HHI 0.626), with 78.3% of its area under orchards, while Păltiniș has the highest diversity (2.527), with 11 active crops. The result is 61 intensive ATUs (50.4%), with 59.2% cereals, 36.4% industrial crops, 4.36% niche crops and a concentrated structure (Shannon 1.509; HHI 0.304); 47 diversified ATUs (38.8%), with the greatest diversity (Shannon 1.783; HHI 0.230); and 13 specialized ATUs (10.7%), with 37.6% niche crops, concentrated in one or two perennial crops.

6.4. Gross value of agricultural production. Territorial differences

Gross value was estimated by summing the products of the estimated mean output of each crop (2017-2021) and its average price (lei/tonne), based on MADR data and county council decisions, excluding costs, subsidies and profit. The 121 ATUs generate approximately 1.6 billion lei (1,599.1 million lei). Maize (32.9%) and sunflower (19.5%) together account for 52.4% of the value, cereals for 44.1%, oilseeds for 25.5%, perennial crops for 16.2%, horticulture for 13.2% and industrial crops for only 1.0%. High-value niches are underexploited: grapes (3,400 lei/t) fetch a price about 4.5 times higher than wheat (762 lei/t).

The distribution is highly unequal: the mean is 13.2 million lei per ATU, 58.7% of ATUs are below the mean, the lower quartile does not exceed 8.7 million lei, the upper quartile exceeds 16.2 million lei, and the ratio between the maximum and minimum is 24.8. Intensive communes achieve

high revenues through volume, as in the case of Coțușca (31.8 million lei) and Ungureni (29.0), but depend on maize, which frequently exceeds 40% of the value (51.4% in Hlipiceni), so fluctuations in its price are passed directly on to the commune's income. The diversified profile provides resilience, as shown by Prisăcani (17.5 million lei), where no single supply chain exceeds a quarter of the total, or Belcești, which generates almost 30 million lei from a combination of maize, sunflower, wheat, viticulture and vegetables. The specialized profile produces the highest surplus per unit of area: Cotnari reaches 53.3 million lei, four times the mean, of which viticulture generates 57.2% and fruit growing 23.0%, accounting on its own for 34.6% of the region's grape value, while Balș (65.6% of its value from grapes) and Comarna (61.4% from fruit) complete an arc of horticultural specialization in the south of the plain. In the logic of the income – investment – modernization relationship (OECD, 2026), the intensive profile provides the bulk of income but with narrow margins (Gavril, 2012; Popescu and Toma, 2023), the diversified profile protects capital, and the specialized profile can become the vanguard of modernization. The risk of deepening disparities justifies public policy intervention (Gavril and Bolohan, 2023) through advisory services, affordable agricultural credit and collection and storage infrastructure for communes without a surplus of their own.

CONCLUSIONS AND RECOMMENDATIONS

The overall finding of the research is that agricultural modernization in the Jijia Plain is profoundly territorialized: it advances through cores, axes and islands of performance, separated by large areas where long-standing structural vulnerabilities persist. The region does not lack resources, but it uses them unevenly and below their potential, and the main challenge is turning its agricultural vocation into stable, competitive and reinvestable economic value.

The first conclusion concerns the relationship between the natural setting and performance. The natural suitability index shows favorable conditions, especially on the central-northern and north-western interfluves, but explains only 6.8% of the variation in mean yield per hectare between ATUs. Suitability is a basic condition, not a guarantee of modernization, and public policies must activate it through infrastructure, association, irrigation, storage and market access.

The second conclusion concerns land structure. Fragmentation remains one of the main obstacles to modernization: the Januszewski index has a median of 0.0347, no ATU reaches the consolidation threshold, and the irregular shape of parcels limits mechanization. Fragmentation is, however, uneven, with the Botoșani part much more affected than the Iași part, while leasing, which covers 53.4% of the utilized agricultural area, produces in some areas a functional consolidation compatible with commercial agriculture.

The third conclusion concerns European funds. The region attracted only about 2.6% of public agricultural funding under each of the two NRDPs, and large grants were concentrated in ATUs with a compact structure and co-financing capacity, while small farms received numerous but low-value grants. The NRDP accelerated modernization where the preconditions already existed and, at the same time, produced territorial polarization.

The fourth and fifth conclusions concern the two sectors. Between 1990 and 2023, livestock farming lost 65% of its cattle and about 90% of its pigs, and its major problem is weak integration into local processing infrastructure. The crop sector is dominated by a cereal-industrial model, with maize and sunflower generating 52.4% of the gross value of crop production, a model consistent with the natural profile but vulnerable to prices, costs, drought and storage shortages. The classification of ATUs (61 intensive, 47 diversified and 13 specialized) reveals three possible modernization pathways: greater efficiency and drought adaptation for intensive ATUs, stronger resilience for diversified ones, and capitalizing on specialization through processing, certification and branding for specialized ones.

The hypotheses are validated with some nuances. The first is partially validated, as Law 18/1991 laid the foundation for private ownership, but also created a parcel structure poorly compatible with modern agriculture. The second is largely confirmed, the main obstacles being fragmentation, weak association, lack of infrastructure and limited investment capacity. The third is supported by the territorial logic of modernization, as areas with more commercial and better-capitalized agriculture have a greater capacity for modernization. The fourth is confirmed, as European funding has supported modernization without eliminating territorial disparities. The fifth is validated as a strategic direction, since neither cooperation without a coherent land base nor consolidation without economic integration is sufficient.

The original contributions consist of the integrated modernization model tailored to the Jijia Plain, the regionally calibrated natural suitability index, the quantitative analysis of the parcel structure based on LPIS-IPA 2025 data and benchmarked against the entire national database, the methodology for classifying commercial profiles, the estimation of the gross value of production at ATU level, and the original thematic maps. The results should be read within the stated limitations: LPIS indicators describe parcels at ATU level, not farms; production and gross value are estimates; data on technical equipment are available only at county level; and correlations do not indicate causal relationships.

The thesis puts forward eight recommendations: functional land consolidation through leasing, voluntary parcel exchange, long-term contracts and aligning the cadastre with agricultural reality; encouraging associative forms, presented as modern and voluntary economic instruments; rehabilitating irrigation where there is technical potential, local water storage and drought-adapted farming practices; developing post-harvest and post-production infrastructure (warehouses, silos, collection centers, slaughterhouses and processing units), aligned with commercial profiles; differentiating public policies according to territorial typology; directing European funds toward reducing disparities, through technical advice and local project offices; vocational training and knowledge transfer, through the regional adaptation of the agricultural innovation system; and supporting short supply chains and local value creation, connected to the urban markets of Iași, Botoșani and Suceava.

Future research directions concern the qualitative dimension of modernization, through interviews with farmers, cooperatives, public administrations and fund beneficiaries; the effects of the CAP Strategic Plan 2023-2027 and of the eco-schemes; and the impact of climate change on crop structure and farmers' decisions. Overall, the modernization of the agricultural economy of the Jijia Plain is an incomplete transition, in which structures of fragmentation coexist with new forms

of commercial agriculture, and the region's future depends on the capacity of local and regional actors to turn existing resources, vulnerabilities and initiatives into a coherent development project.

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