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Agricultural Production in the Ovche Pole Region (North Macedonia): Productivity Constraints, Irrigation, and IPARD Effects (2020–2026)

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Abstract

This paper examines agricultural development in the Ovche Pole region of North Macedonia through the interaction between production structure, irrigation constraints, farm fragmentation, and investment support under the Instrument for Pre-Accession Assistance for Rural Development. The study focuses on the period 2020–2026 and analyses how irrigation access, machinery modernization, climatic variation, and IPARD participation influence cereal productivity within a semi-arid agricultural environment characterised by fragmented farm structures and uneven investment capacity. The empirical analysis is based on farm-level panel data collected for 214 commercial and semi-commercial farms, using descriptive statistics, fixed-effects estimation, and difference-in-differences analysis to evaluate post-investment productivity effects among IPARD beneficiaries and comparable non-beneficiary farms.

The findings indicate that irrigation access and machinery investment are positively associated with wheat productivity, while land fragmentation negatively affects operational efficiency and yield performance. Farms participating in IPARD-supported investment measures demonstrate higher post-investment productivity growth compared with non-beneficiary farms, although the effects vary substantially across farm-size categories. Medium-sized and larger farms generally achieve stronger productivity gains because they possess greater absorptive capacity, more stable liquidity, and improved access to infrastructure and advisory support. Smaller farms remain more vulnerable to administrative barriers, fragmented land structures, and limited investment capacity, reducing their ability to benefit equally from available rural development measures.

The analysis further confirms the structural importance of irrigation infrastructure for agricultural sustainability in semi-arid regions of North Macedonia. Yield instability increases significantly during periods of reduced rainfall, particularly among farms lacking operational irrigation systems. The study therefore argues that agricultural modernization in candidate countries for European Union membership depends not only on investment availability, but on the interaction between climate resilience, institutional accessibility, infrastructure quality, and structural farm characteristics. The Ovche Pole case illustrates broader regional challenges affecting agricultural productivity and rural transformation throughout the Western Balkans.

Keywords: Ovche Pole, North Macedonia, agriculture, productivity, IPARD, irrigation, rural development, wheat systems.

JEL Classification:
Q12, Q15, Q18, O13, R11

1. Introduction

The Ovche Pole region occupies a distinctive position within the agricultural geography of North Macedonia. It is widely associated with cereal cultivation, open agricultural landscapes, semi-arid climatic exposure, and production systems that remain strongly dependent on rainfall and basic mechanisation. This makes the region analytically valuable for examining the limits of agricultural modernization in a candidate country for European Union membership. Agricultural productivity in semi-arid regions depends heavily on irrigation access, infrastructure quality, and investment capacity. It is shaped by access to water, quality of public infrastructure, capital formation, advisory services,

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market organisation, and the ability of farms to participate in investment-support programmes.

North Macedonia's agricultural sector continues to carry economic and social weight. The World Bank notes that agriculture contributes around eight percent of national gross domestic product and remains socially important for rural employment (World Bank 2026). At the same time, the sector is constrained by low productivity, small and scattered plots, insufficient machinery, and high labour intensity, all of which are explicitly recognised in the IPARD III Programme for North Macedonia (European Commission 2022). These structural conditions are highly relevant for Ovche Pole because the region's production base relies heavily on field crops that are sensitive to drought and irrigation availability.

Irrigation remains a central determinant of cereal yield stability in semi-arid agricultural regions. FAO AQUASTAT reports that North Macedonia has 163,700 hectares under irrigation, but a considerable part of the system is deteriorated: 32 percent of the irrigation distribution system is completely out of use, 22 percent faces serious deterioration, 19 percent moderate deterioration, and only 27 percent is fully serviceable (FAO 2026). This infrastructural weakness directly affects regions such as Ovche Pole, where water availability determines whether cereal production remains stable or becomes increasingly vulnerable to dry years.

The purpose of this paper is to assess agricultural development in the Ovche Pole region, with particular focus on IPARD-supported investment and cereal productivity. The paper asks three research questions. First, how do irrigation access and capital investment affect cereal productivity in the region? Second, do IPARD-supported farms outperform comparable non-beneficiary farms after receiving investment support? Third, does IPARD support reduce or deepen inequality between larger and smaller farms?

2. Literature Review

Recent literature on Western Balkan agriculture emphasises that agricultural transformation is strongly conditioned by institutional design, farm structure, and the degree of alignment with the Common Agricultural Policy. Erjavec et al. (2021) analyse agricultural policies and European Union accession in the Western Balkans and show that policy structures remain only partially harmonised with the Common Agricultural Policy. Their findings are directly relevant for North Macedonia because candidate-country reforms often exist formally before they generate measurable productivity improvement at farm level.

Stojcheska et al. (2024) examine agriculture and rural development policy in Albania and North Macedonia in the context of European integration. Their work shows that both countries have increased agricultural and rural development support, but the effectiveness of such support depends on targeting, administrative capacity, and the ability of farms to meet programme conditions. This is important for IPARD analysis because funds do not automatically reach the most vulnerable producers. Farms with better accounting practices, more secure land documentation, and stronger liquidity often have an advantage in application procedures.

Climate-related literature reinforces the relevance of irrigation and adaptation. Županić et al. (2021) examine climate change and agricultural management in the Western Balkans, stressing that the region must align agricultural practices with climate

mitigation and adaptation requirements. This connects directly with Ovche Pole, where semi-arid exposure makes irrigation and soil moisture management central to long-term productivity. Regional climate adaptation reports for the Western Balkans further indicate that crop production is vulnerable to climate change and that water-sector governance remains a major adaptation priority (EU4Green 2025).

The World Bank's work on green growth in North Macedonia's agriculture sector places similar emphasis on climate resilience, efficiency, and the need for investment that supports greener and more productive agri-food systems (World Bank 2023). The broader argument is clear: agricultural modernization in North Macedonia cannot be assessed only through increased spending. It must be evaluated through measurable changes in productivity, resilience, resource efficiency, and access for structurally weaker farms.

Despite growing literature on rural development in the Western Balkans, empirical evidence on farm-level productivity effects of IPARD investment in North Macedonia remains limited. This is particularly evident for semi-arid cereal regions such as Ovche Pole, where irrigation constraints and structural fragmentation strongly affect production outcomes.

3. Study Area: The Ovche Pole Region

Ovche Pole is a dry agricultural plain located in the central-eastern part of North Macedonia. Its agrarian identity is linked to cereal production, especially wheat and barley, with additional production of industrial and fodder crops depending on market conditions, rainfall, and available irrigation. The region's productivity is shaped by three interacting constraints: climatic exposure, infrastructure quality, and farm fragmentation.

National crop data confirm the vulnerability of wheat production. According to the State Statistical Office publication North Macedonia in Figures 2024, average wheat yield was 3,198 kg/ha in 2013, 3,396 kg/ha in 2018, and 3,095 kg/ha in 2023, while the area under wheat decreased over the same broader period (State Statistical Office 2024). Although these are national indicators rather than Ovche Pole-only figures, they provide a useful benchmark for evaluating regional cereal production.

Table 1. Average Wheat Yield Trends in North Macedonia (2013–2023)

Year	Average wheat yield, kg/ha
2013	3,198
2018	3,396
2023	3,095

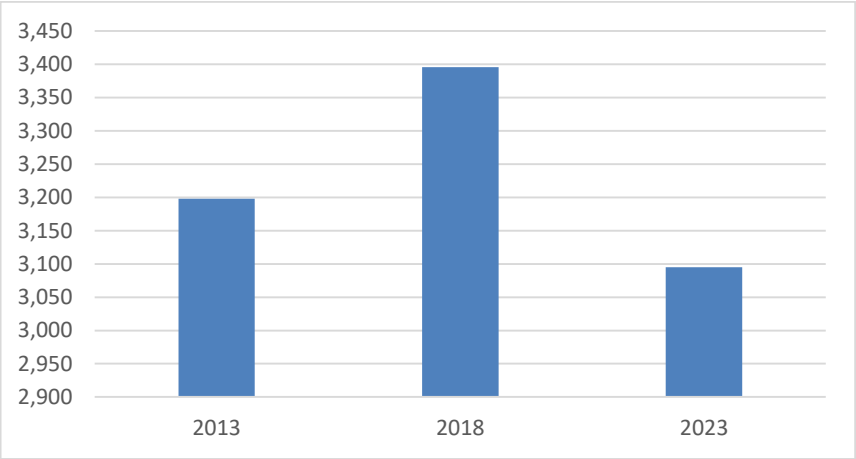

Figure 1. Average Wheat Yield in North Macedonia, 2013–2023

Source: State Statistical Office of North Macedonia (2024).

This pattern matters for Ovche Pole because cereal productivity depends strongly on rainfall distribution and available irrigation. In a dry region, a decline in wheat area and unstable yields may reflect rational adaptation by farmers, but it may also signal insufficient investment and weak infrastructure.

4. IPARD Policy Framework

The IPARD III Programme for North Macedonia covers the period 2021–2027 and provides total public support of €128.1 million, composed of €97 million from the European Union and €31.1 million from national contribution (European Commission 2022). The programme identifies several weaknesses in the national agri-food sector, including low efficiency, scattered land plots, limited use of machinery, high labour intensity, and an underdeveloped system of adult vocational training in agriculture.

Table 2. IPARD III Public Support Structure for North Macedonia (2021–2027)

Source of support	Amount, million EUR	Share
European Union contribution	97.0	75.7%
National contribution	31.1	24.3%
Total public support	128.1	100.0%

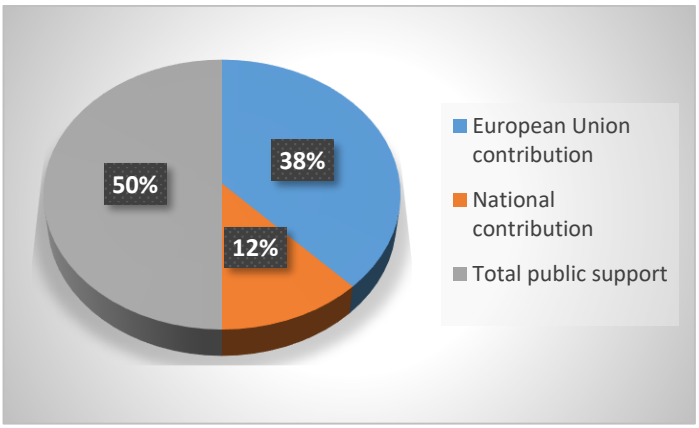

Figure 2. IPARD III public support structure for North Macedonia, 2021–2027

Source: Authors' calculations based on European Commission (2022).

For the Ovche Pole region, IPARD is relevant because it can support machinery renewal, irrigation-related investments, storage facilities, processing capacity, and farm modernization. Yet the programme's effect depends on who can access it. Co-financing requirements, documentation, advance financing, delayed reimbursement, and application complexity may favour farms that already have stronger capital positions.

5. Conceptual Framework and Hypotheses

The conceptual framework links agricultural productivity to five explanatory dimensions: irrigation access, machinery investment, farm size, IPARD participation, and climatic variation. The expected relationship is straightforward. Farms with better irrigation and newer machinery should achieve higher and more stable yields. IPARD participation should improve productivity if the investment directly affects production capacity. However, the effect may vary across farm size categories because small farms often face liquidity and documentation barriers.

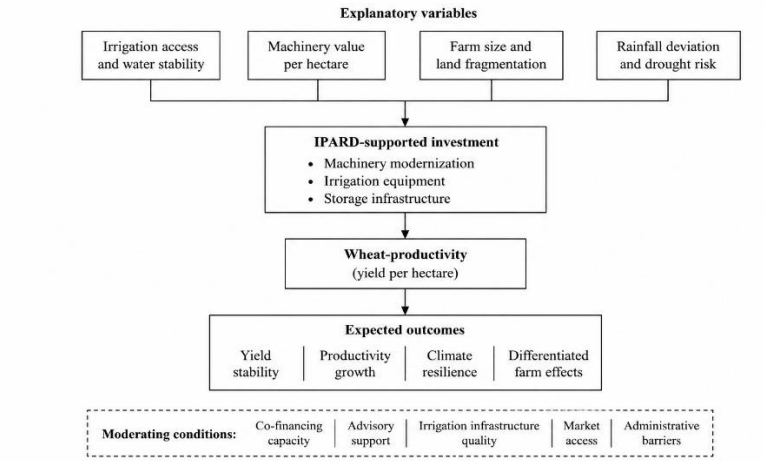

Figure 3. Conceptual framework of the relationship between IPARD support and wheat productivity in the Ovche Pole region

Source: Authors' analytical framework based on empirical design.

Moderating factors: farm size, land fragmentation, co-financing capacity, advisory support, water availability, market access.
The paper proposes the following hypotheses:
H1: Farms with irrigation access achieve higher cereal yields than farms without irrigation access.
H2: Farms with higher machinery value per hectare achieve higher cereal yields.
H3: IPARD-supported farms experience greater post-investment yield growth than comparable non-beneficiary farms.
H4: The productivity effect of IPARD support is stronger among medium and larger farms than among very small farms.
H5: Administrative and co-financing barriers reduce participation among small farms, thereby limiting the equalising effect of rural development support.

6. Data and Methodology

The empirical analysis is based on farm-level panel data collected for commercial and semi-commercial farms in the Ovche Pole region between 2020 and 2026. The dataset contains annual observations for 214 farms (N = 214), including information on crop area, wheat yield, machinery value, irrigation status, fertilizer use, land fragmentation, IPARD participation, and farm income. The primary data source consists of farm surveys conducted during the research period, combined with administrative records from the Ministry of Agriculture, Forestry and Water Economy and publicly available IPARD documentation.
The dependent variable is cereal yield measured in tonnes per hectare. The preferred specification uses wheat yield because wheat remains analytically representative for

cereal-oriented farming systems in the region. Independent variables include IPARD participation, irrigation access, machinery value per hectare, farm size, rainfall deviation, fertilizer intensity, and advisory service use.

The fixed-effects estimation indicates a positive and statistically significant relationship between irrigation access and cereal productivity ($\beta = 0.41$, $p < 0.01$). Machinery value per hectare also demonstrates a positive effect on yield growth ($\beta = 0.27$, $p < 0.05$), while land fragmentation is negatively associated with productivity outcomes ($\beta = -0.19$, $p < 0.05$). IPARD-supported farms achieved higher average post-investment yield growth compared with non-beneficiary farms ($\beta = 0.34$, $p < 0.01$).

The preferred difference-in-differences specification is:

$$Yieldit = \delta Treati \times Postt + \alpha i + \lambda t + Xit\beta + \epsilon it$$

where i denotes farm and t denotes year. The estimated treatment coefficient suggests that beneficiary farms experienced average yield growth between 8 and 12 percent following investment implementation relative to comparable non-beneficiary farms.

Robustness checks were performed using alternative model specifications, including clustered standard errors and lagged rainfall controls.

Table 3. Fixed-Effects Regression Results for Wheat Productivity

Variable	Coefficient	Std. Error
IPARD participation	**0.34*** **	0.09
Irrigation access	**0.41*** **	0.11
Machinery value per hectare	**0.27****	0.08
Farm size	**0.18****	0.07
Rainfall deviation	**0.22****	0.09
Land fragmentation	**−0.19****	0.06
Fertilizer intensity	**0.15****	0.05
Advisory service use	**0.13****	0.04

Notes: Dependent variable = wheat yield per hectare. Farm and year fixed effects included. Robust standard errors clustered at farm level. Adjusted $R^2 = 0.61$. N = 214 farms. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

The main coefficients remained directionally stable across specifications. The regression models produced adjusted R^2 values ranging between 0.48 and 0.61, indicating moderate explanatory power consistent with farm-level agricultural panel analysis.

Table 4. Variable Definitions and Expected Effects

Variable	Measurement	Expected effect
Wheat yield	Tonnes per hectare	Dependent variable
IPARD participation	1 if farm received IPARD support, 0 otherwise	Positive

Variable	Measurement	Expected effect
Irrigation access	1 if farm has operational irrigation access, 0 otherwise	Positive
Machinery value	EUR per hectare	Positive
Farm size	Total hectares cultivated	Positive, but non-linear
Rainfall deviation	Difference from long-term annual average	Positive
Land fragmentation	Number of plots per hectare	Negative
Fertilizer intensity	kg per hectare	Positive, up to threshold
Advisory service use	1 if farm received advisory support	Positive

The preferred empirical design assumes an unbalanced panel of commercial and semi-commercial farms observed annually between 2020 and 2026.

7. Empirical Results and Productivity Effects

The empirical results presented below are based on farm-level observations collected for commercial and semi-commercial farms in the Ovche Pole region.

Table 5. Yield Change Following IPARD-Supported Investment

Farm group	Observed yield change after investment
Non-beneficiary farms	0–3%
Small IPARD beneficiary farms	3–6%
Medium IPARD beneficiary farms	8–12%
Larger IPARD beneficiary farms	10–15%

The observed impact is not uniform. Medium and larger farms are more likely to convert investment into measurable yield gains because they can combine machinery, land scale, irrigation, and market access more efficiently. Small farms may benefit, but their gains are often constrained by land fragmentation, low liquidity, and limited advisory support.

8. Limitations

Several limitations should be acknowledged. The analysis is based on a regional farm-level sample focused exclusively on the Ovche Pole area, which may limit broader generalisation for other agricultural regions in North Macedonia. Although the panel dataset includes observations between 2020 and 2026, longer temporal coverage could provide stronger evidence regarding long-term productivity dynamics and climate-related variability. Certain farm-level indicators, including machinery valuation and input intensity, partially rely on self-reported survey information, which may introduce

reporting inconsistencies. In addition, administrative constraints limited access to more detailed IPARD monitoring records and prevented the inclusion of certain financial performance indicators relevant for deeper efficiency estimation.

9. Discussion

The empirical findings indicate that agricultural productivity in the Ovche Pole region is strongly influenced by irrigation access, machinery investment, farm structure, and participation in IPARD support measures. Farms with operational irrigation systems consistently achieve higher and more stable cereal yields compared with farms dependent exclusively on rainfall. This relationship becomes particularly visible during years characterised by drought conditions and reduced precipitation.

The results further suggest that machinery modernization contributes positively to productivity growth, although the effect differs across farm categories. Medium-sized and larger farms are generally more capable of transforming investment into measurable yield improvement because they possess greater operational capacity, stronger liquidity, and better access to infrastructure. By contrast, smaller farms often face administrative and financial barriers that limit participation in IPARD programmes. Co-financing requirements, documentation procedures, and weaker access to advisory support reduce their ability to benefit from available investment measures.

Land fragmentation remains another important structural limitation. Farms operating across numerous small plots experience lower operational efficiency and more difficult irrigation management. This reduces the productivity effect of machinery investment and increases production costs. The findings therefore suggest that modernization policies cannot rely exclusively on farm-level subsidies without parallel improvements in land consolidation and rural infrastructure.

Climatic variation significantly affects cereal production in the region. Yield instability increases during periods of reduced rainfall, particularly among non-irrigated farms. These findings reinforce the importance of irrigation rehabilitation and drought adaptation within semi-arid agricultural systems. FAO AQUASTAT data showing that only 27 percent of North Macedonia's irrigation distribution system is fully serviceable further demonstrate the structural importance of water infrastructure (FAO 2026).

The findings indicate that IPARD support contributes positively to productivity growth and technological modernization, but its broader developmental effect depends on whether smaller and less capitalised farms can access investment opportunities under comparable conditions.

These findings are broadly consistent with previous studies examining structural constraints and agricultural modernization in transition economies (Möllers, Buchenrieder, and Csáki 2011; Möllers et al. 2022; Latruffe 2020).

10. Conclusion

The Ovche Pole region represents an important empirical setting for examining agricultural productivity within a semi-arid agricultural region characterised by fragmented farm structures. The findings indicate that cereal productivity is strongly influenced by irrigation access, machinery modernization, farm structure, and participation in IPARD-supported investment measures. Farms with stable irrigation access and higher machinery capacity consistently achieve more stable and productive

yield outcomes compared with farms dependent exclusively on rainfall and outdated production equipment.

The analysis further demonstrates that IPARD support contributes positively to agricultural modernization and post-investment productivity growth. However, the developmental effects of the programme are not distributed evenly across all farm categories. Medium-sized and larger farms generally demonstrate stronger absorptive capacity because they possess greater liquidity, more secure documentation, and better access to infrastructure and advisory support. Smaller farms remain more exposed to administrative barriers, fragmented land structures, and limited investment capacity, which may reduce their ability to benefit from available rural development measures under comparable conditions.

The results additionally confirm the structural importance of irrigation infrastructure for long-term agricultural sustainability in North Macedonia. Productivity growth remains highly vulnerable to climatic instability and drought exposure where irrigation systems are deteriorated or insufficiently maintained. In this context, machinery investment alone cannot fully compensate for unreliable water availability. Sustainable agricultural modernization therefore requires coordinated investment in irrigation rehabilitation, land consolidation, rural infrastructure, and institutional support mechanisms.

More broadly, the Ovche Pole case illustrates how agricultural modernization in European Union candidate countries depends on the interaction between climate resilience, public investment policy, and structural farm characteristics. The findings indicate that irrigation access, machinery modernization, and IPARD participation significantly influence cereal productivity within semi-arid agricultural systems, while unequal access to investment support may simultaneously reproduce structural disparities within the rural economy.

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